

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
- Al_2O_3 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	$I_C^{(1)}$	$T_C = 25\text{ }^{\circ}\text{C}$	492	A
		$T_C = 80\text{ }^{\circ}\text{C}$	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	$T_C = 25\text{ }^{\circ}\text{C}$	1363	W
		$T_C = 80\text{ }^{\circ}\text{C}$	864	
DIODE D2				
Chopper diode continuous forward current	I_F	$T_C = 25\text{ }^{\circ}\text{C}$	374	A
		$T_C = 80\text{ }^{\circ}\text{C}$	278	
Single pulse forward current	I_{FSM}	10 ms sine or 6 ms rectangular pulse, $T_J = 25\text{ }^{\circ}\text{C}$	1415	
Maximum power dissipation	P_D	$T_C = 25\text{ }^{\circ}\text{C}$	652	W
		$T_C = 80\text{ }^{\circ}\text{C}$	413	
DIODE D1				
Antiparallel diode continuous forward current	I_F	$T_C = 25\text{ }^{\circ}\text{C}$	192	A
		$T_C = 80\text{ }^{\circ}\text{C}$	142	
Single pulse forward current	I_{FSM}	10 ms sine or 6 ms rectangular pulse, $T_J = 25\text{ }^{\circ}\text{C}$	725	
Maximum power dissipation	P_D	$T_C = 25\text{ }^{\circ}\text{C}$	312	W
		$T_C = 80\text{ }^{\circ}\text{C}$	198	
RMS isolation voltage	V_{ISOL}	Any terminal to case ($V_{RMS}\text{ t} = 1\text{ s}$, $T_J = 25\text{ }^{\circ}\text{C}$)	3500	V
Storage temperature range	T_{STG}		-40 to 150	$^{\circ}\text{C}$
Operating junction temperature range	T_J		-40 to +175	$^{\circ}\text{C}$

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	ΔV _{GE(th)} /ΔT	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	-	ns
Turn-on switching energy	E _{on}	R _{g(on)} = 6.8 Ω I _C = 300 A, V _{CC} = 300 V, V _{GE} = ± 15 V, L = 500 μH, T _J = 25 °C	-	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 I _C = 300 A, V _{CC} = 300 V, V _{GE} = ± 15 V, L = 500 μH, T _J = 125 °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 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	$^{\circ}\text{C}$
Storage temperature range	T_{Stg}	-40	-	150	
Thermal resistance, junction to case per leg	Q1 IGBT	-	-	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

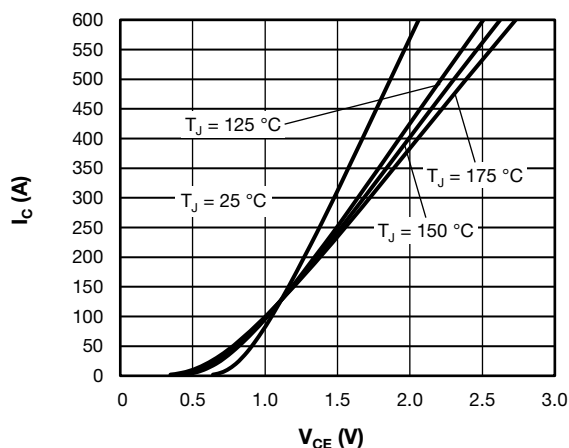


Fig. 1 - Typical IGBT Output Characteristics,
 $V_{GE} = 15\text{ V}$

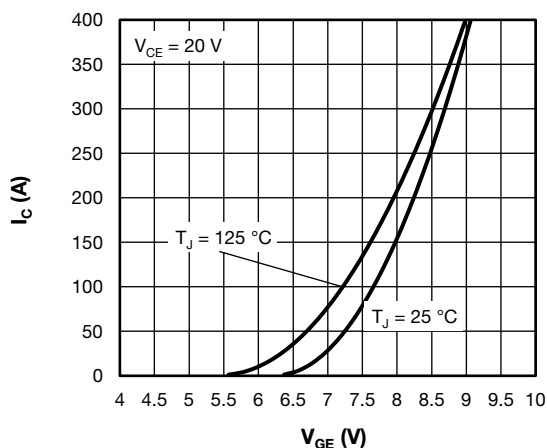


Fig. 4 - Typical IGBT Transfer Characteristics

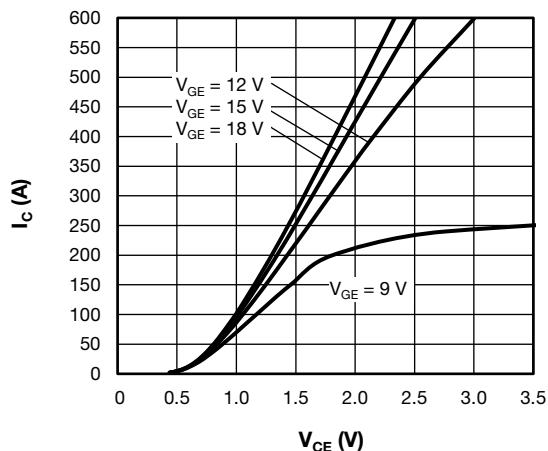


Fig. 2 - Typical IGBT Output Characteristics,
 $T_J = 125\text{ °C}$

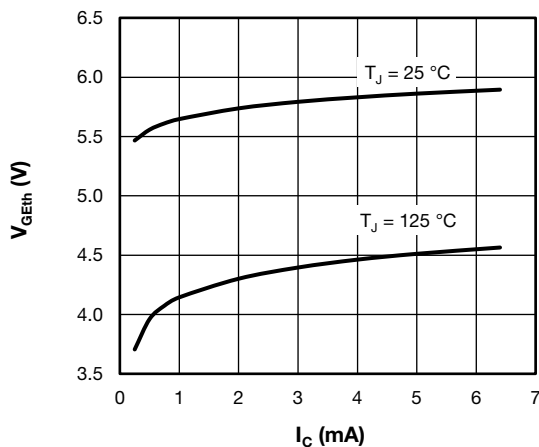


Fig. 5 - Typical IGBT Gate Threshold Voltage

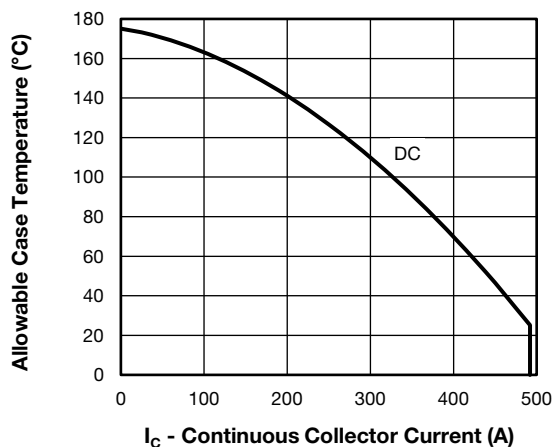


Fig. 3 - Maximum IGBT Continuous Collector Current vs.
Case Temperature

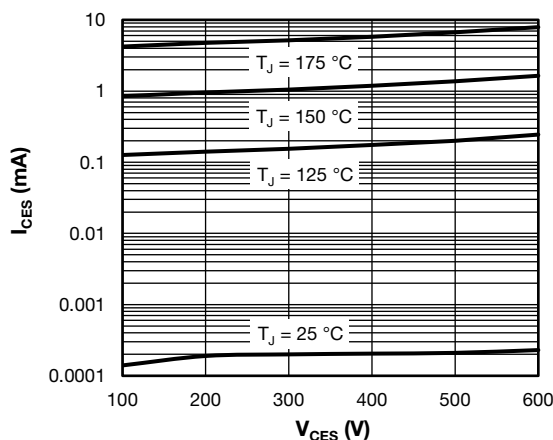


Fig. 6 - Typical IGBT Zero Gate Voltage Collector Current

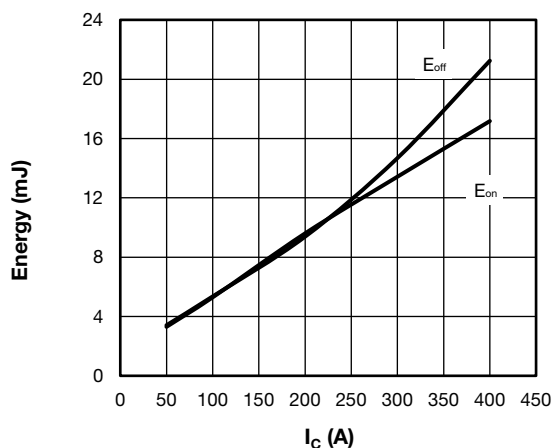


Fig. 7 - Typical IGBT Energy Loss vs. I_C with Freewheeling Diode
 $T_J = 125^\circ\text{C}$, $V_{CC} = 300\text{ V}$, $R_{g(\text{on})} = 6.8\Omega$, $R_{g(\text{off})} = 1\Omega$
 $V_{GE} = +15\text{ V}/-15\text{ V}$, $L = 500\text{ }\mu\text{H}$

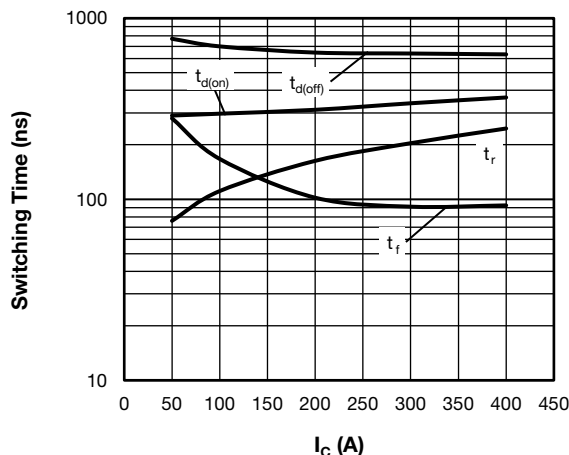


Fig. 8 - Typical Trench IGBT Switching Time vs. I_C with Freewheeling Diode
 $T_J = 125^\circ\text{C}$, $V_{CC} = 300\text{ V}$, $R_{g(\text{on})} = 6.8\Omega$, $R_{g(\text{off})} = 1\Omega$,
 $V_{GE} = +15\text{ V}/-15\text{ V}$, $L = 500\text{ }\mu\text{H}$

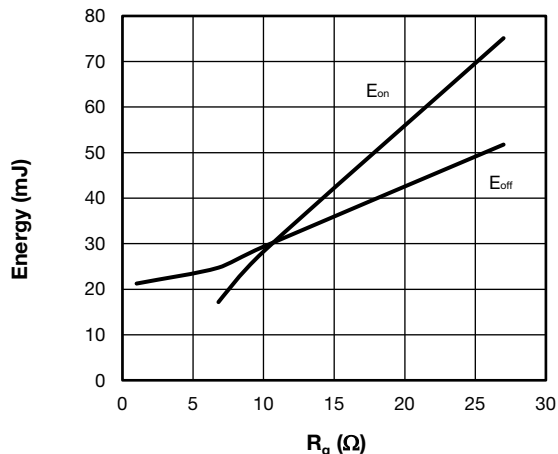


Fig. 9 - Typical Trench IGBT Energy Loss vs. R_g

with Freewheeling Diode
 $T_J = 125^\circ\text{C}$, $V_{CC} = 300\text{ V}$, $I_C = 400\text{ A}$, $V_{GE} = +15\text{ V}/-15\text{ V}$, $L = 500\text{ }\mu\text{H}$

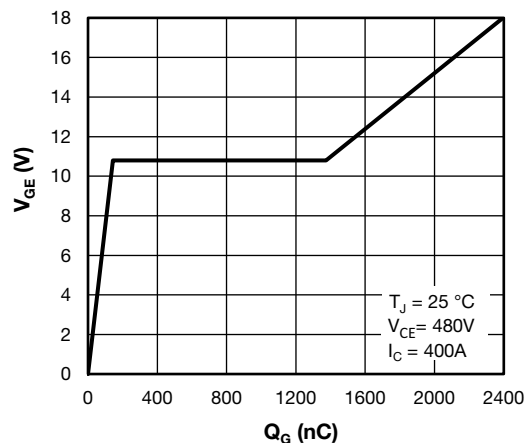


Fig. 10 - Typical Trench IGBT Gate Charge vs. Gate to Emitter Voltage

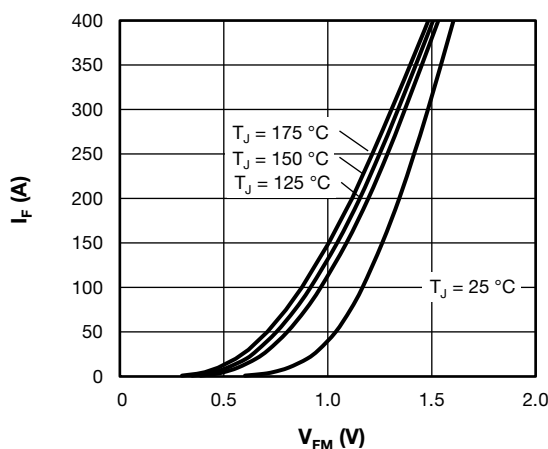


Fig. 11 - Typical D2 Diode Forward Characteristics

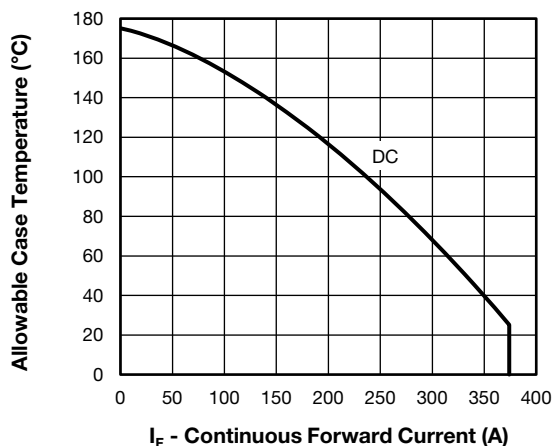


Fig. 12 - Maximum D2 Diode Continuous Forward Current vs. Case Temperature

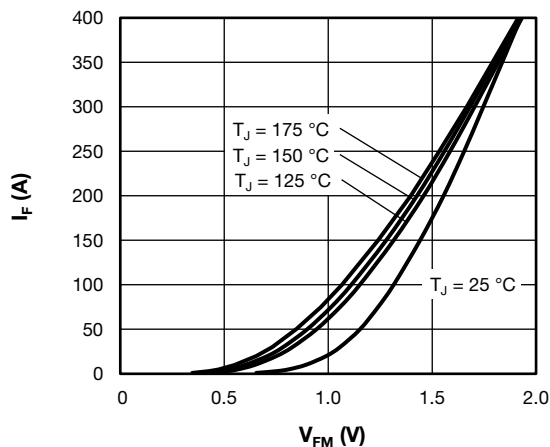


Fig. 13 - Typical D1 Diode Forward Characteristics

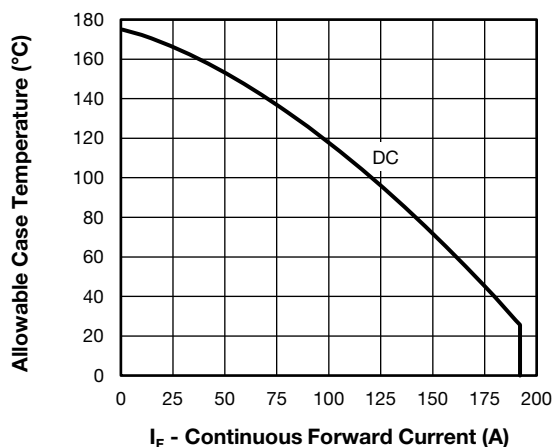


Fig. 14 - Maximum D1 Diode Continuous Forward Current vs. Case Temperature

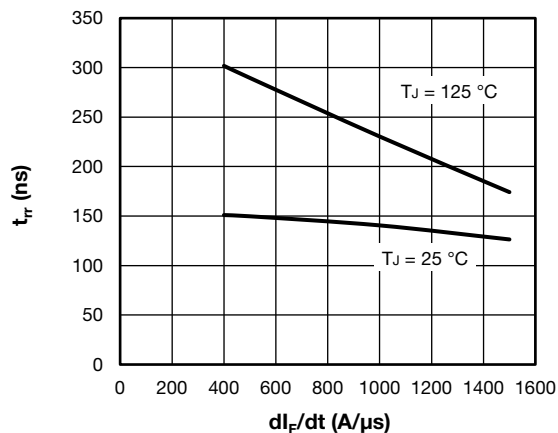


Fig. 15 - Typical Diode Reverse Recovery Time vs. di_F/dt

$I_F = 400 \text{ A}$, $V_{CC} = 400 \text{ V}$

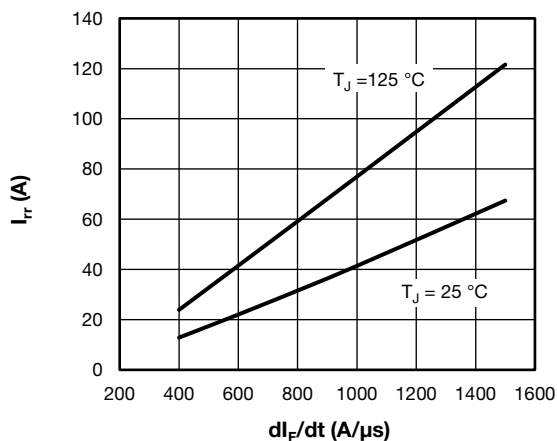


Fig. 16 - Typical Diode Reverse Recovery Current vs. di_F/dt
 $I_F = 400 \text{ A}$, $V_{CC} = 400 \text{ V}$

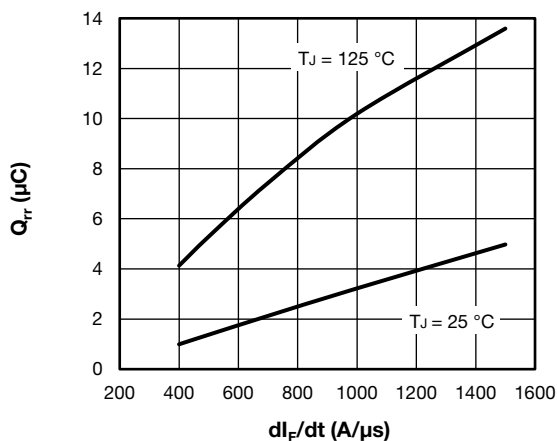


Fig. 17 - Typical Diode Reverse Recovery Charge vs. di_F/dt
 $I_F = 400 \text{ A}$, $V_{CC} = 400 \text{ V}$

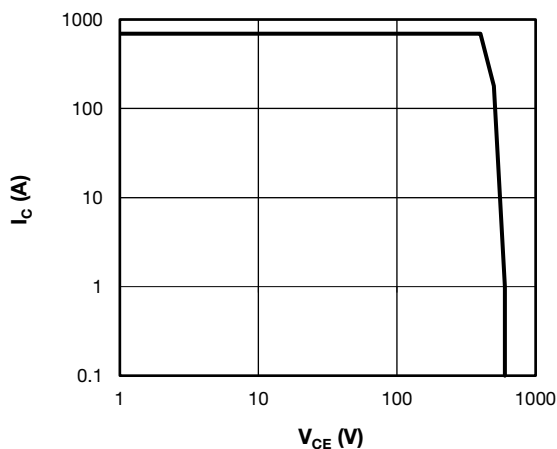


Fig. 18 - IGBT Reverse BIAS SOA
 $T_J = 175 \text{ °C}$, $I_C = 693 \text{ A}$, $R_g = 10 \text{ } \Omega$, $V_{GE} = +15 \text{ V} / 0 \text{ V}$,

$$V_{CC} = 400 \text{ V}, V_p = 600 \text{ V}$$

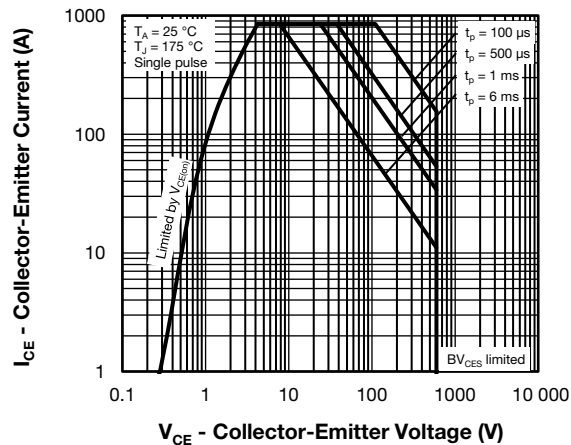
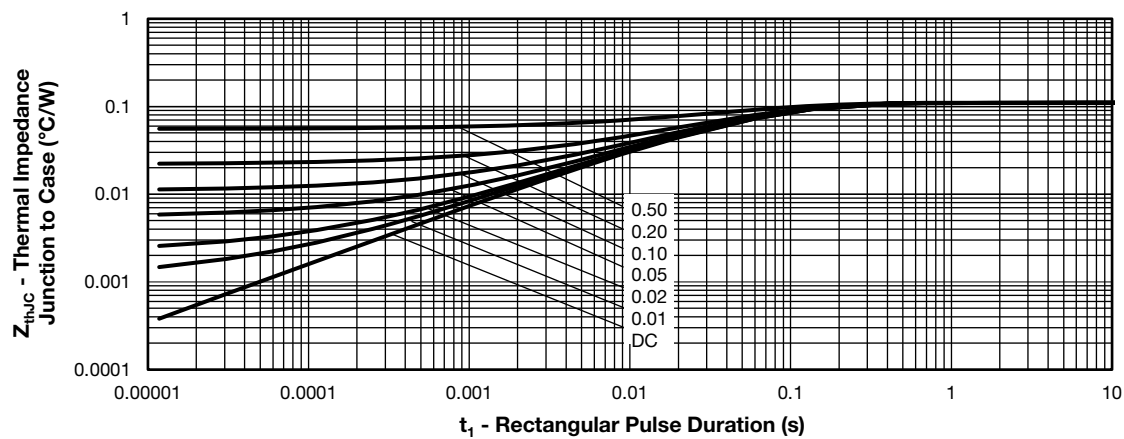
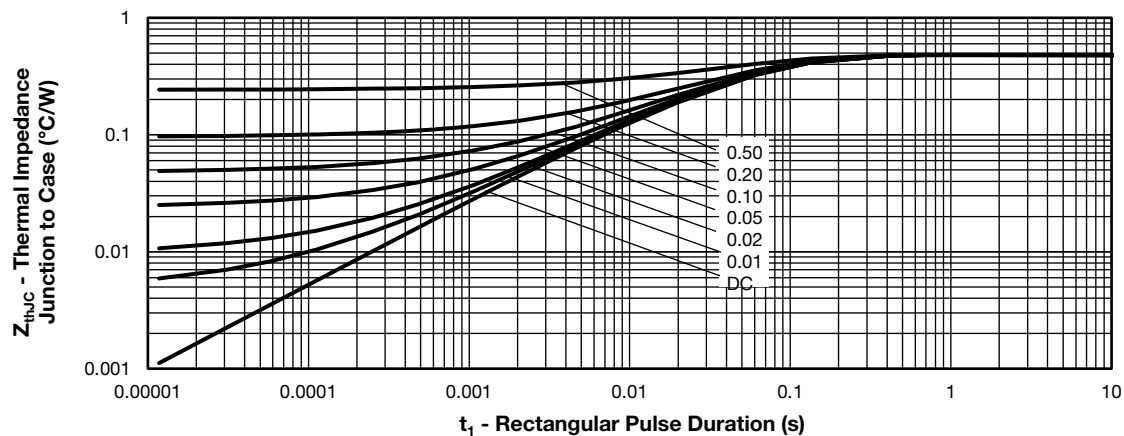


Fig. 19 - IGBT Safe Operating Area


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

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

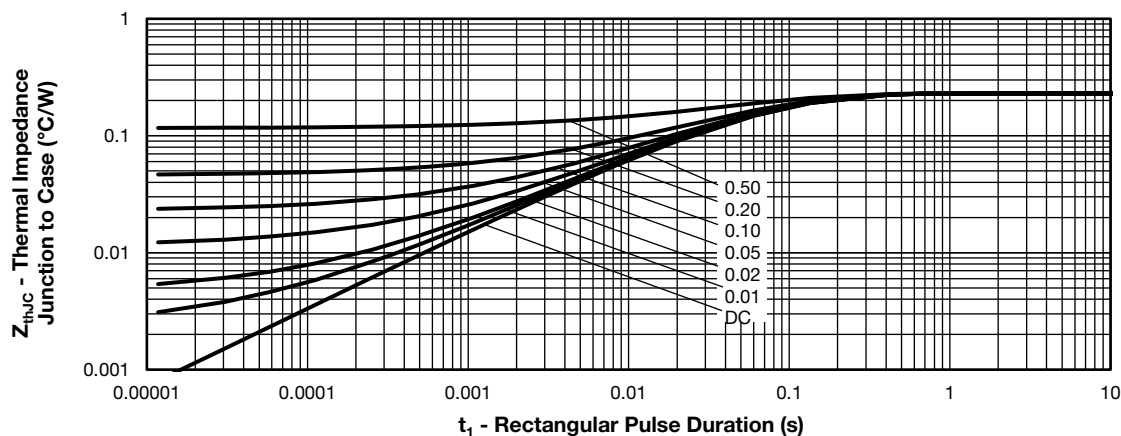


Fig. 22 - Maximum D2 Diode Thermal Impedance Z_{thJC} Characteristics

ORDERING INFORMATION TABLE

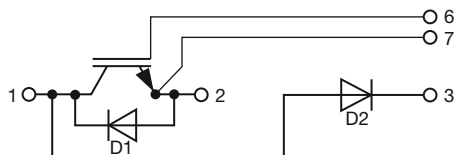
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	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-

- 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

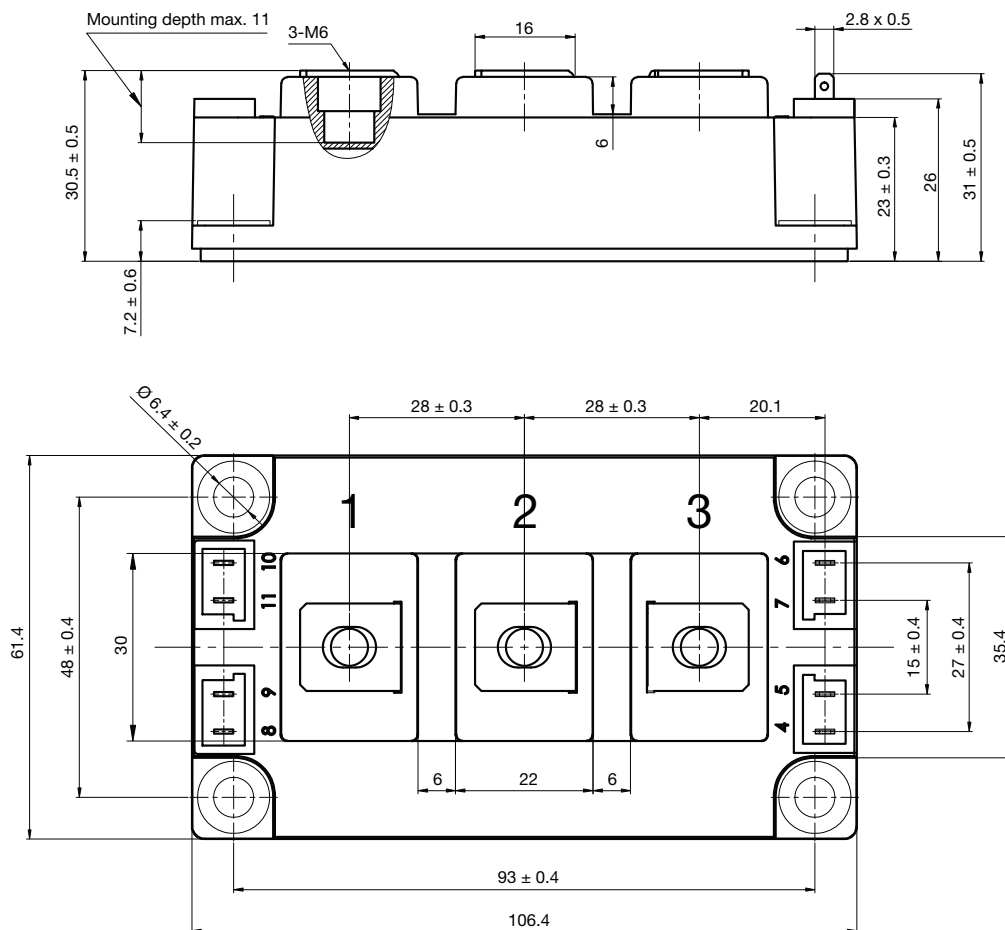
LINKS TO RELATED DOCUMENTS	
Dimensions	www.vishay.com/doc?95525
Application Note	www.vishay.com/doc?95553



CIRCUIT CONFIGURATION



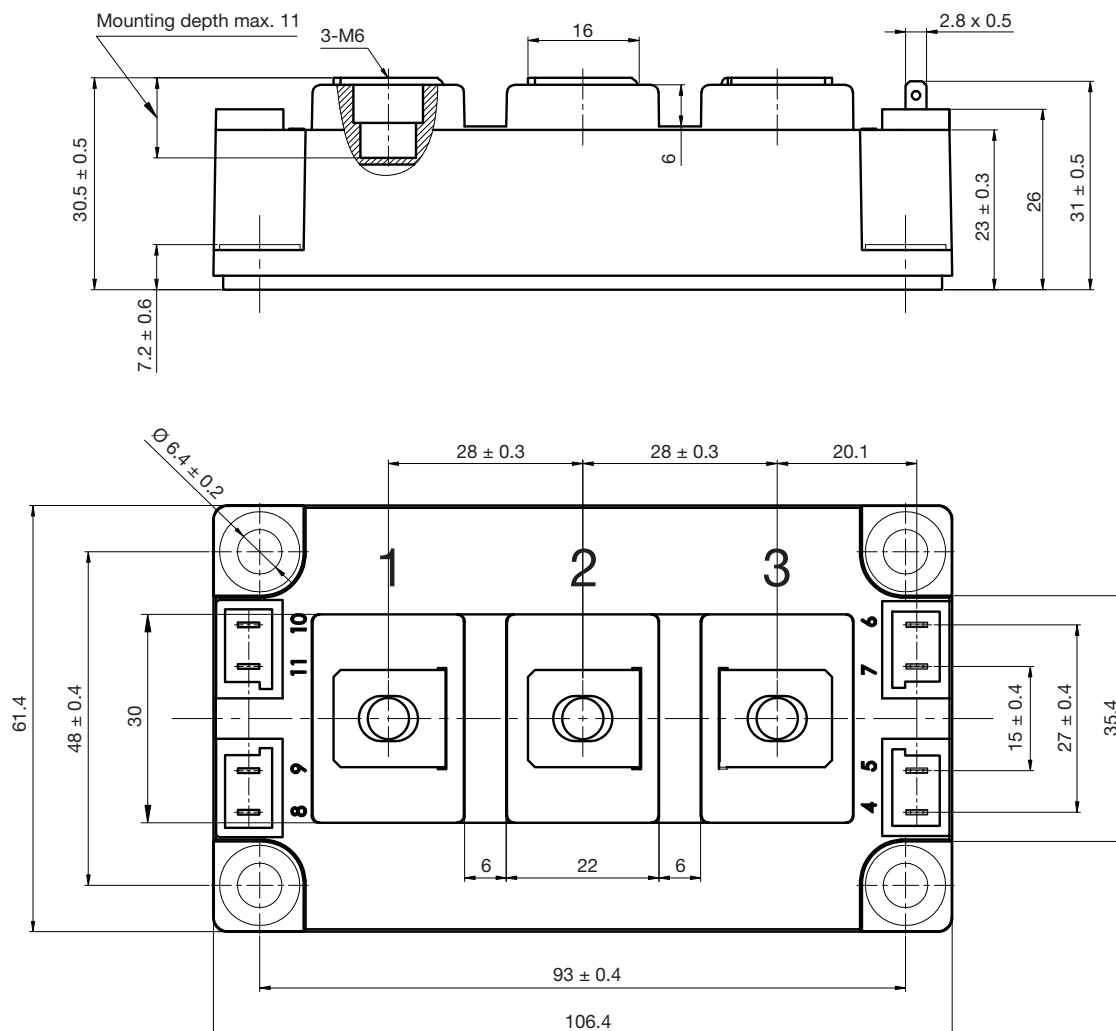
DIMENSIONS in millimeters





Double INT-A-PAK

DIMENSIONS in millimeters (inches)





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