EMIPAK-1B PressFit Power Module Neutral Point Clamp Topology, 30 A

EMIPAK-1B
(package example)

FEATURES

- Ultrafast Trench IGBT technology
- HEXFRED® and silicon carbide diode technology
- PressFit pins technology
- Exposed Al_2O_3 substrate with low thermal resistance
- Low internal inductances
- PressFit pins locking technology. Patent # US.263.820 B2
- UL approved file E78996
- Material categorization: for definitions of compliance please see www.vishay.com/doc?99912

RoHS COMPLIANT

DESCRIPTION

VS-ENQ030L120S is an integrated solution for a neutral point clamp topology in a single package. The EMIPAK-1B package is easy to use thanks to the PressFit pins and the exposed substrate provides improved thermal performance. The optimized layout also helps to minimize stray parameters, allowing for better EMI performance.

PRODUCT SUMMARY	
TRENCH IGBT 1200 V STAGE	
V_{CES}	1200 V
$V_{CE(ON)}$ typical at I_C = 30 A	2.12 V
I_C at T_C = 102 °C	30 A
TRENCH IGBT 600 V STAGE	
V_{CES}	600 V
$V_{CE(ON)}$ typical at I_C = 30 A	1.42 V
I_C at T_C = 106 °C	30 A
Speed	8 kHz to 30 kHz
Package	EMIPAK-1B
Circuit	3-levels neutral point clamp topology

ABSOLUTE MAXIMUM RATINGS

PARAMETER	SYMBOL	TEST CONDITIONS	MAX.	UNITS
Operating junction temperature	T_J		150	°C
Storage temperature range	T_{Stg}		-40 to +150	
RMS isolation voltage	V_{ISOL}	T_J = 25 °C, all terminals shorted, f = 50 Hz, t = 1 s	3500	V
Q1 - Q4 TRENCH IGBT 1200 V				
Collector to emitter voltage	V_{CES}		1200	V
Gate to emitter voltage	V_{GES}		± 30	
Pulsed collector current	I_{CM}		120	A
Clamped inductive load current	I_{LM} (1)		120	
Continuous drain current	I_C	T_C = 25 °C	61	A
		T_C = 80 °C	40	
		T_{SINK} = 80 °C	21	
Power dissipation	P_D	T_C = 25 °C	216	W
		T_C = 80 °C	121	

PATENT(S): www.vishay.com/patents
This Vishay product is protected by one or more United States and International patents.

ABSOLUTE MAXIMUM RATINGS				
PARAMETER	**SYMBOL**	**TEST CONDITIONS**	**MAX.**	**UNITS**
Q2 - Q3 TRENCH IGBT 600 V				
Collector to emitter voltage	V_{CES}		600	V
Gate to emitter voltage	V_{GES}		± 20	
Pulsed collector current	I_{CM}		130	A
Clamped inductive load current	I_{LM} (2)		130	
Continuous collector current	I_C	T_C = 25 °C	64	A
		T_C = 80 °C	42	
		T_{SINK} = 80 °C	25	
Power dissipation	P_D	T_C = 25 °C	174	W
		T_C = 80 °C	97	
D1 - D4 HEXFRED ANTIPARALLEL DIODE				
Single pulse forward current	I_{FSM}	10 ms sine or 6 ms rectangular pulse, T_J = 25 °C	180	A
Diode continuous forward current	I_F	T_C = 25 °C	46	A
		T_C = 80 °C	30	
		T_{SINK} = 80 °C	17	
Power dissipation	P_D	T_C = 25 °C	187	W
		T_C = 80 °C	105	
D2 - D3 SILICON CARBIDE ANTIPARALLEL DIODE				
Single pulse forward current	I_{FSM}	10 ms sine or 6 ms rectangular pulse, T_J = 25 °C	150	A
Diode continuous forward current	I_F	T_C = 25 °C	40	A
		T_C = 80 °C	28	
		T_{SINK} = 80 °C	20	
Power dissipation	P_D	T_C = 25 °C	140	W
		T_C = 80 °C	79	

Notes
- Absolute Maximum Ratings indicate sustained limits beyond which damage to the device may occur.

(1) V_{CC} = 600 V, V_{GE} = 15 V, L = 500 μH, R_g = 4.7 Ω, T_J = 150 °C

(2) V_{CC} = 300 V, V_{GE} = 15 V, L = 500 μH, R_g = 4.7 Ω, T_J = 150 °C

ELECTRICAL SPECIFICATIONS (T_J = 25 °C unless otherwise noted)						
PARAMETER	**SYMBOL**	**TEST CONDITIONS**	**MIN.**	**TYP.**	**MAX.**	**UNITS**
Q1 - Q4 TRENCH IGBT 1200 V						
Collector to emitter breakdown voltage	BV_{CES}	V_{GE} = 0 V, I_C = 100 μA	1200	-	-	V
Collector to emitter voltage	$V_{CE(ON)}$	V_{GE} = 15 V, I_C = 30 A	-	2.12	2.52	
		V_{GE} = 15 V, I_C = 30 A, T_J = 125 °C	-	2.31	-	
Gate threshold voltage	$V_{GE(th)}$	V_{CE} = V_{GE}, I_C = 1.0 mA	2.6	4.6	6.6	
Temperature coefficient of threshold voltage	$\Delta V_{GE(th)}/\Delta T_J$	V_{CE} = V_{GE}, I_C = 1 mA (25 °C to 125 °C)	-	- 14	-	mV/°C
Forward transconductance	g_{fe}	V_{CE} = 20 V, I_C = 30 A	-	36	-	S
Transfer characteristics	V_{GE}	V_{CE} = 20 V, I_C = 30 A	-	7.1	-	V
Zero gate voltage collector current	I_{CES}	V_{GE} = 0 V, V_{CE} = 1200 V	-	0.001	0.23	mA
		V_{GE} = 0 V, V_{CE} = 1200 V, T_J = 125 °C	-	0.5	-	
Gate to emitter leakage current	I_{GES}	V_{GE} = ± 30 V, V_{CE} = 0 V	-	-	± 200	nA

ELECTRICAL SPECIFICATIONS (T_J = 25 °C unless otherwise noted)						
PARAMETER	**SYMBOL**	**TEST CONDITIONS**	**MIN.**	**TYP.**	**MAX.**	**UNITS**
Q2 - Q3 TRENCH IGBT 600 V						
Collector to emitter breakdown voltage	BV_{CES}	V_{GE} = 0 V, I_C = 150 μA	600	-	-	V
Collector to emitter voltage	$V_{CE(ON)}$	V_{GE} = 15 V, I_C = 30 A	-	1.42	1.87	
		V_{GE} = 15 V, I_C = 30 A, T_J = 125 °C	-	1.56	-	
Gate threshold voltage	$V_{GE(th)}$	V_{CE} = V_{GE}, I_C = 1.4 mA	3.6	5.6	7.1	
Temperature coefficient of threshold voltage	$\Delta V_{GE(th)}/\Delta T_J$	V_{CE} = V_{GE}, I_C = 1 mA (25 °C to 125 °C)	-	-17	-	mV/°C
Forward transconductance	g_{fe}	V_{CE} = 20 V, I_C = 30 A	-	24	-	S
Transfer characteristics	V_{GE}	V_{CE} = 20 V, I_C = 30 A	-	10	-	V
Zero gate voltage collector current	I_{CES}	V_{GE} = 0 V, V_{CE} = 600 V	-	0.0003	0.23	mA
		V_{GE} = 0 V, V_{CE} = 600 V, T_J = 125 °C	-	0.028	-	
Gate to emitter leakage current	I_{GES}	V_{GE} = ± 20 V, V_{CE} = 0 V	-	-	± 200	nA
D1 - D4 ANTIPARALLEL DIODE						
Forward voltage drop	V_{FM}	I_F = 20 A	-	2.42	3.18	V
		I_F = 20 A, T_J = 125 °C	-	2.32	-	
D2 - D3 ANTIPARALLEL DIODE						
Forward voltage drop	V_{FM}	I_F = 20 A	-	1.54	1.8	V
		I_F = 20 A T_J = 125 °C	-	1.86	-	

SWITCHING CHARACTERISTICS (T_J = 25 °C unless otherwise noted)						
PARAMETER	**SYMBOL**	**TEST CONDITIONS**	**MIN.**	**TYP.**	**MAX.**	**UNITS**
Q1 - Q4 TRENCH IGBT (WITH FREEWHEELING D1 - D4 ANTIPARALLEL DIODE)						
Total gate charge (turn-on)	Q_g	I_C = 30 A V_{CC} = 600 V V_{GE} = 15 V	-	157	-	nC
Gate to emitter charge (turn-on)	Q_{ge}		-	21	-	
Gate to collector charge (turn-on)	Q_{gc}		-	69	-	
Turn-on switching loss	E_{ON}	I_C = 30 A V_{CC} = 600 V V_{GE} = 15 V R_g = 4.7 Ω L = 500 μH (1)	-	0.52	-	mJ
Turn-off switching loss	E_{OFF}		-	0.9	-	
Total switching loss	E_{TOT}		-	1.42	-	
Turn-on delay time	$t_{d(on)}$		-	93	-	ns
Rise time	t_r		-	39	-	
Turn-off delay time	$t_{d(off)}$		-	133	-	
Fall time	t_f		-	156	-	
Turn-on switching loss	E_{ON}	I_C = 30 A V_{CC} = 600 V V_{GE} = 15 V R_g = 4.7 Ω L = 500 μH T_J = 125 °C (1)	-	0.64	-	mJ
Turn-off switching loss	E_{OFF}		-	1.61	-	
Total switching loss	E_{TOT}			2.24		
Turn-on delay time	$t_{d(on)}$		-	93	-	ns
Rise time	t_r		-	39	-	
Turn-off delay time	$t_{d(off)}$		-	136	-	
Fall time	t_f		-	193	-	
Input capacitance	C_{ies}	V_{GE} = 0 V V_{CC} = 30 V f = 1 MHz	-	3338	-	pF
Output capacitance	C_{oes}		-	124	-	
Reverse transfer capacitance	C_{res}		-	75	-	
Reverse bias safe operating area	RBSOA	T_J = 150 °C, I_C = 120 A, V_{CC} = 600 V, V_P = 1200 V, R_g = 4.7 Ω, V_{GE} = 15 V to 0 V	Fullsquare			

SWITCHING CHARACTERISTICS (T_J = 25 °C unless otherwise noted)						
PARAMETER	**SYMBOL**	**TEST CONDITIONS**	**MIN.**	**TYP.**	**MAX.**	**UNITS**
Q2 - Q3 TRENCH IGBT (WITH FREEWHEELING EXTERNAL TO-247 DIODE DISCRETE 30ETH06)						
Total gate charge (turn-on)	Q_g	I_C = 48 A V_{CC} = 400 V V_{GE} = 15 V	-	95	-	nC
Gate to emitter charge (turn-on)	Q_{ge}		-	28	-	
Gate to collector charge (turn-on)	Q_{gc}		-	35	-	
Turn-on switching loss	E_{ON}	I_C = 30 A V_{CC} = 300 V V_{GE} = 15 V R_g = 4.7 Ω L = 500 μH [(1)]	-	0.23	-	mJ
Turn-off switching loss	E_{OFF}		-	0.26	-	
Total switching loss	E_{TOT}		-	0.49	-	
Turn-on delay time	$t_{d(on)}$		-	70	-	ns
Rise time	t_r		-	31	-	
Turn-off delay time	$t_{d(off)}$		-	91	-	
Fall time	t_f		-	87	-	
Turn-on switching loss	E_{ON}	I_C = 30 A V_{CC} = 300 V V_{GE} = 15 V R_g = 4.7 Ω L = 500 μH T_J = 125 °C [(1)]	-	0.33	-	mJ
Turn-off switching loss	E_{OFF}		-	0.48	-	
Total switching loss	E_{TOT}		-	0.61	-	
Turn-on delay time	$t_{d(on)}$		-	70	-	ns
Rise time	t_r		-	31	-	
Turn-off delay time	$t_{d(off)}$		-	96	-	
Fall time	t_f		-	117	-	
Input capacitance	C_{ies}	V_{GE} = 0 V V_{CC} = 30 V f = 1 MHz	-	3025	-	pF
Output capacitance	C_{oes}		-	245	-	
Reverse transfer capacitance	C_{res}		-	90	-	
Reverse bias safe operating area	RBSOA	T_J = 150 °C, I_C = 130 A V_{CC} = 300 V, V_P = 600 V R_g = 4.7 Ω, V_{GE} = 15 V to 0 V	Fullsquare			
D1 - D4 ANTIPARALLEL DIODE						
Diode reverse recovery time	t_{rr}	V_R = 400 V I_F = 20 A dI/dt = 500 A/μs	-	103	-	ns
Diode peak reverse current	I_{rr}		-	16	-	A
Diode recovery charge	Q_{rr}		-	800	-	nC
Diode reverse recovery time	t_{rr}	V_R = 400 V I_F = 20 A dI/dt = 500 A/μs, T_J = 125 °C	-	135	-	ns
Diode peak reverse current	I_{rr}		-	21	-	A
Diode recovery charge	Q_{rr}		-	1412	-	nC
D2 - D3 ANTIPARALLEL DIODE						
Diode reverse recovery time	t_{rr}	V_R = 200 V I_F = 20 A dI/dt = 500 A/μs	-	30	-	ns
Diode peak reverse current	I_{rr}		-	4.8	-	A
Diode recovery charge	Q_{rr}		-	73	-	nC
Diode reverse recovery time	t_{rr}	V_R = 200 V I_F = 20 A dI/dt = 500 A/μs, T_J = 125 °C	-	31	-	ns
Diode peak reverse current	I_{rr}		-	5	-	A
Diode recovery charge	Q_{rr}		-	78	-	nC

Note

(1) Energy losses include “tail” and diode reverse recovery.

INTERNAL NTC - THERMISTOR SPECIFICATIONS				
PARAMETER	SYMBOL	TEST CONDITIONS	VALUE	UNITS
Resistance	R_{25}	T_C = 25 °C	5000	Ω
	R_{100}	T_C = 100 °C	493 ± 5 %	
B-value	$B_{25/50}$	$R_2 = R_{25}$ exp. [$B_{25/50}$ (1/T_2 - 1/(298.15 K))]	3375 ± 5 %	K
Maximum operating temperature			220	°C
Dissipation constant			2	mW/°C
Thermal time constant			8	s

THERMAL AND MECHANICAL SPECIFICATIONS					
PARAMETER	SYMBOL	MIN.	TYP.	MAX.	UNITS
Q1 - Q4 TRENCH IGBT 1200 V - Junction to case thermal resistance (per switch)	R_{thJC}	-	-	0.58	°C/W
Q2 - Q3 TRENCH IGBT 600 V- Junction to case thermal resistance (per switch)		-	-	0.72	
D1 - D4 AP diode - Junction to case thermal resistance (per diode)		-	-	0.67	
D2 - D3 AP diode - Junction to case thermal resistance (per diode)		-	-	0.89	
Q1 - Q4 TRENCH IGBT 1200 V - Case to sink thermal resistance (per switch)	R_{thCS} (1)	-	0.75	-	
Q2 - Q3 TRENCH IGBT 600 V - Case to sink thermal resistance (per switch)		-	0.77	-	
D1 - D4 AP diode - Case to sink thermal resistance (per diode)		-	0.78	-	
D2 - D3 AP diode - Case to sink thermal resistance (per diode)		-	0.65	-	
Case to sink thermal resistance (per module)		-	0.1	-	
Mounting torque (M4)		2	-	3	Nm
Weight		-	28	-	g

Note

(1) Mounting surface flat, smooth, and greased

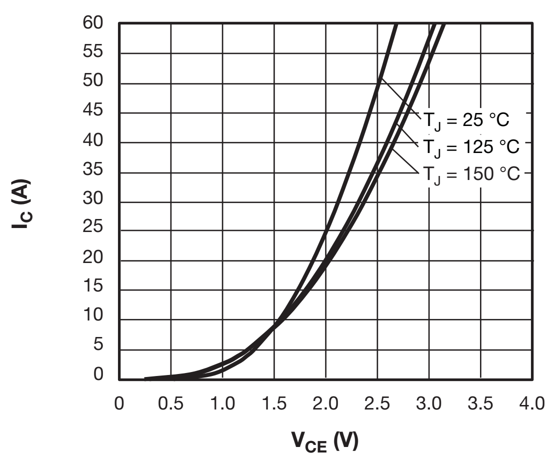


Fig. 1 - Typical Q1 - Q4 Trench IGBT 1200 V
Output Characteristics V_{GE} = 15 V

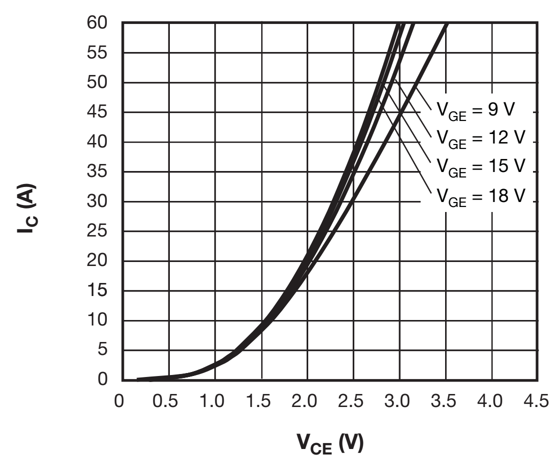


Fig. 2 - Typical Q1 - Q4 Trench IGBT 1200 V
Output Characteristics T_J = 125 °C

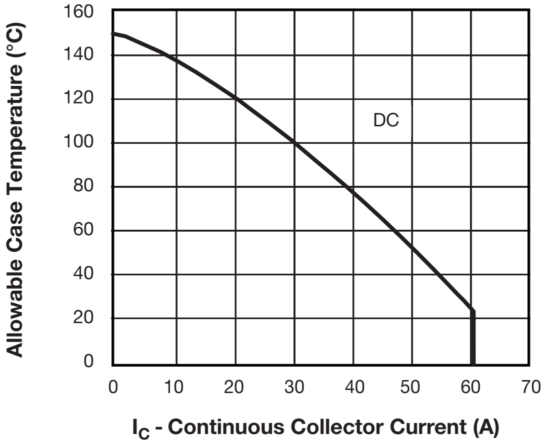


Fig. 3 - Maximum Q1 - Q4 Trench IGBT 1200 V
Continuous Collector Current vs. Case Temperature

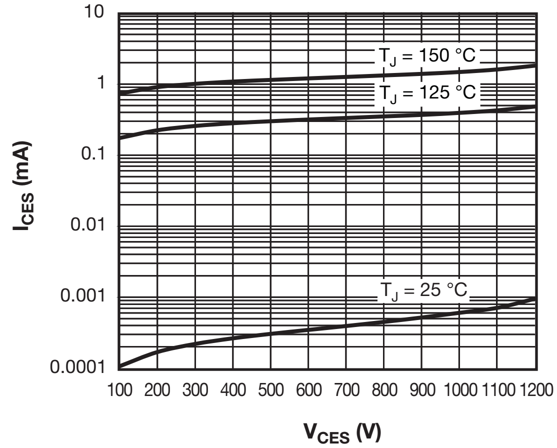


Fig. 6 - Typical Q1 - Q4 Trench IGBT 1200 V
Zero Gate Voltage Collector Current

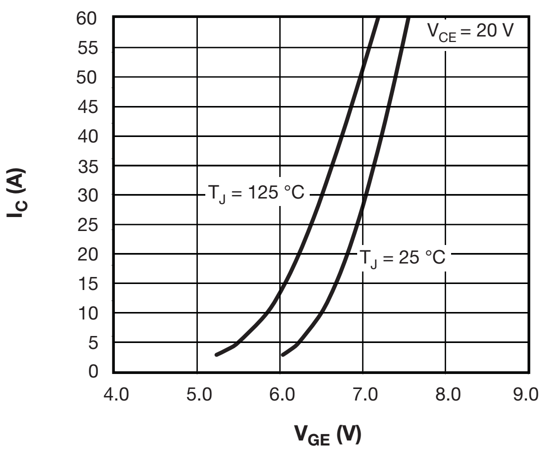


Fig. 4 - Typical Q1 - Q4 Trench IGBT 1200 V
Transfer Characteristics

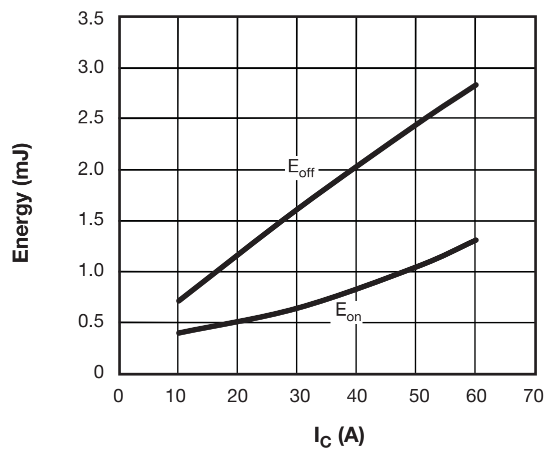


Fig. 7 - Typical Q1 - Q4 Trench IGBT 1200 V
Energy Loss vs. I_C (with D1 - D4 Freewheeling Diode),
T_J = 125 °C, V_{CC} = 600 V, R_g = 4.7 Ω, V_{GE} = 15 V, L = 500 μH

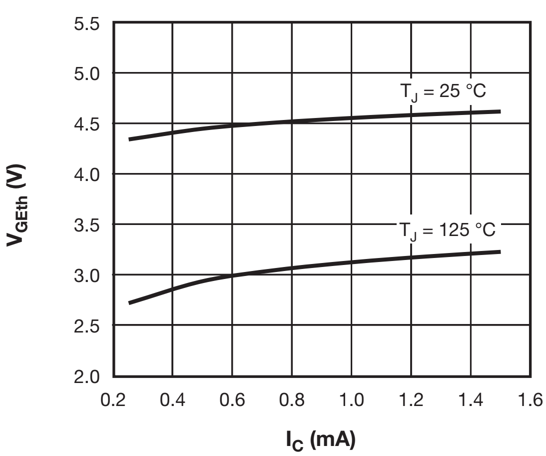


Fig. 5 - Typical Q1 - Q4 Trench IGBT 1200 V
Gate Threshold Voltage

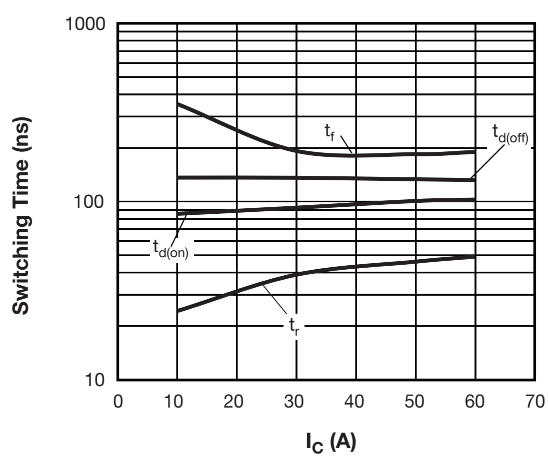


Fig. 8 - Typical Q1 - Q4 Trench IGBT 1200 V
Switching Time vs. I_C (with D1 - D4 Freewheeling Diode)
T_J = 125 °C, V_{CC} = 600 V, R_g = 4.7 Ω, V_{GE} = 15 V, L = 500 μH

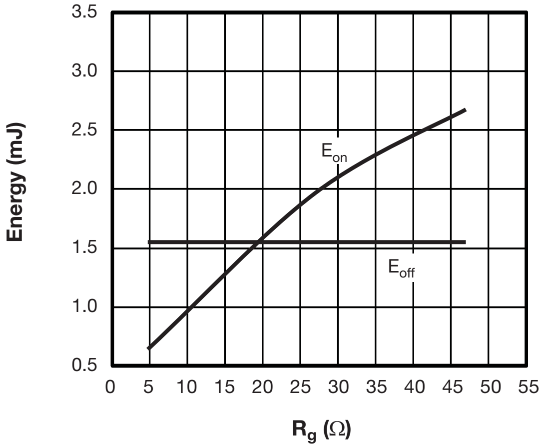


Fig. 9 - Typical Q1 - Q4 Trench IGBT 1200 V
Energy Loss vs. R_g (with D1 - D4 Freewheeling Diode)
T_J = 125 °C, V_{CC} = 600 V, I_C = 30 A, V_{GE} = 15 V, L = 500 μH

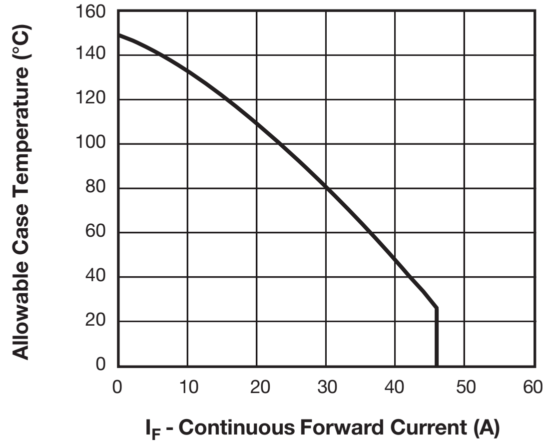


Fig. 12 - Maximum D1 - D4 Antiparallel Diode
Forward Current vs. Case Temperature

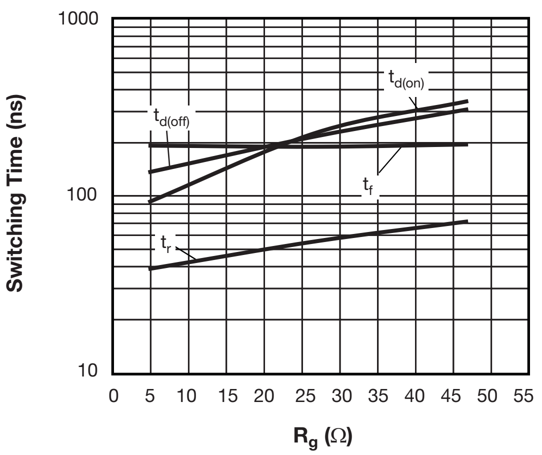


Fig. 10 - Typical Q1 - Q4 Trench IGBT 1200 V
Switching Time vs. R_g (with D1 - D4 Freewheeling Diode)
T_J = 125 °C, V_{CC} = 600 V, I_C = 30 A, V_{GE} = 15 V, L = 500 μH

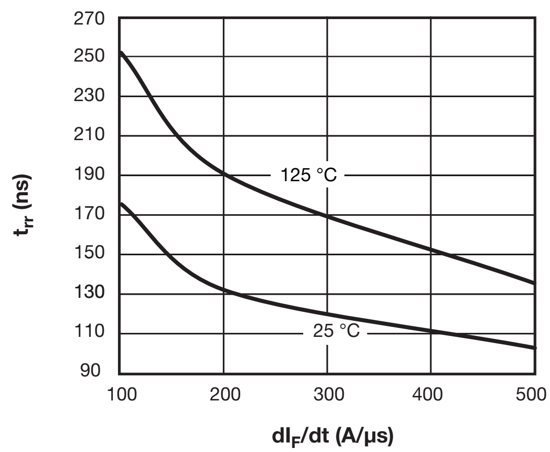


Fig. 13 - Typical D1 - D4 Antiparallel Diode
Reverse Recovery Time vs. dI_F/dt
V_{rr} = 400 V, I_F = 20 A

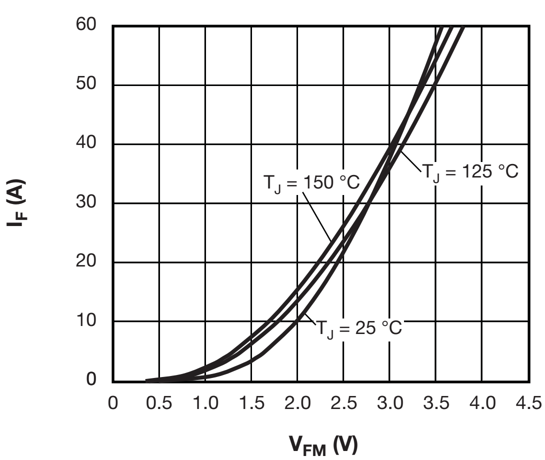


Fig. 11 - Typical D1 - D4 Antiparallel Diode Forward Characteristics

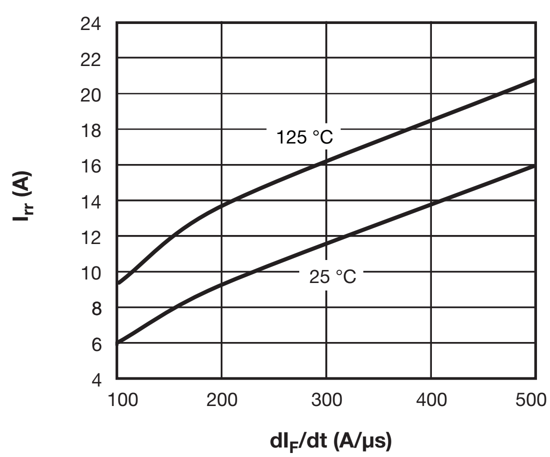


Fig. 14 - Typical D1 - D4 Antiparallel Diode
Reverse Recovery Current vs. dI_F/dt
V_{rr} = 400 V, I_F = 20 A

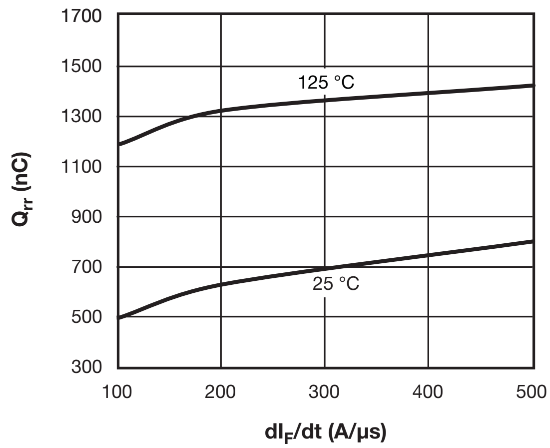


Fig. 15 - Typical D1 - D4 Antiparallel Diode
Reverse Recovery Charge vs. dI_F/dt
V_{rr} = 400 V, I_F = 20 A

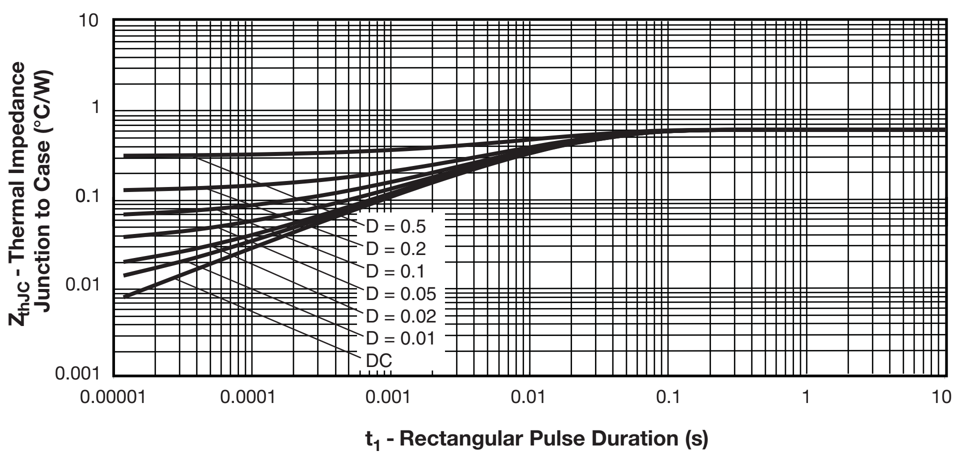


Fig. 16 - Maximum Thermal Impedance Z_{thJC} Characteristics (Q1 - Q4 Trench IGBT 1200 V)

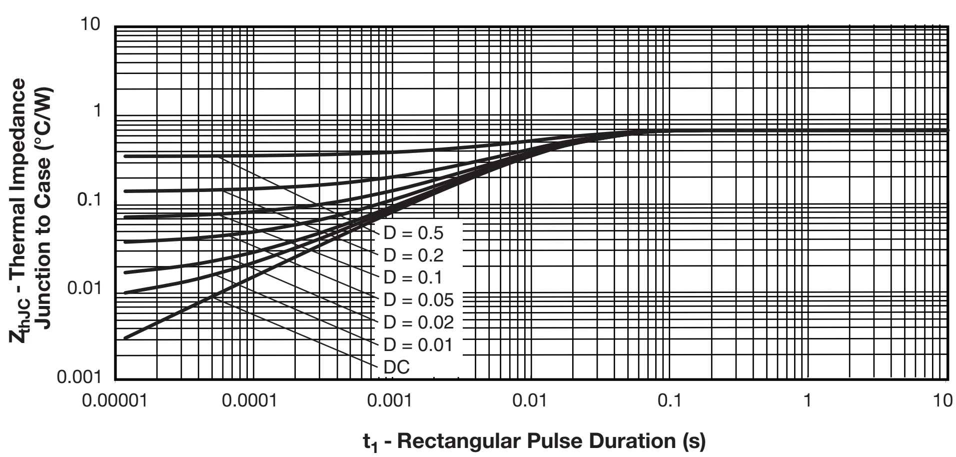


Fig. 17 - Maximum Thermal Impedance Z_{thJC} Characteristics (D1 - D4 Antiparallel Diode)

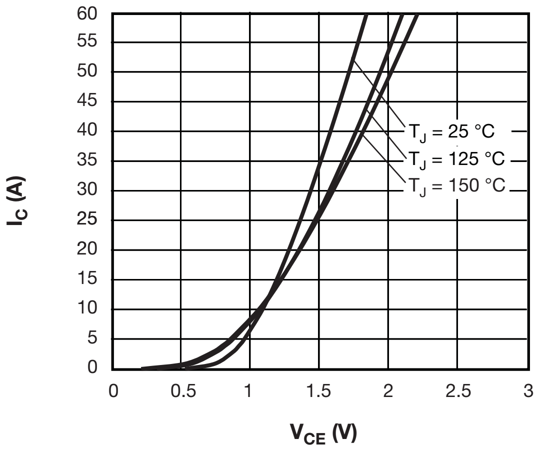


Fig. 18 - Typical Q2 - Q3 Trench IGBT 600 V Output Characteristics
V_{GE} = 15 V

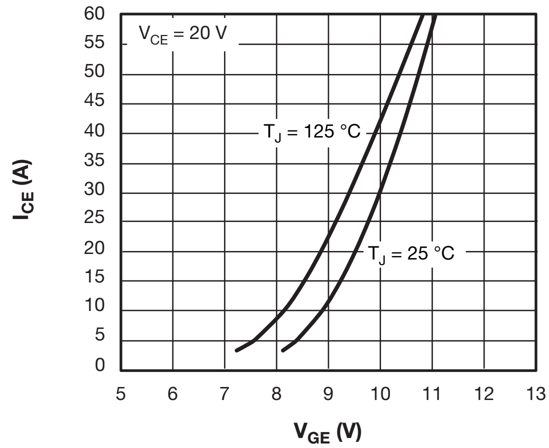


Fig. 21 - Typical Q2 - Q3 Trench IGBT 600 V
Transfer Characteristics

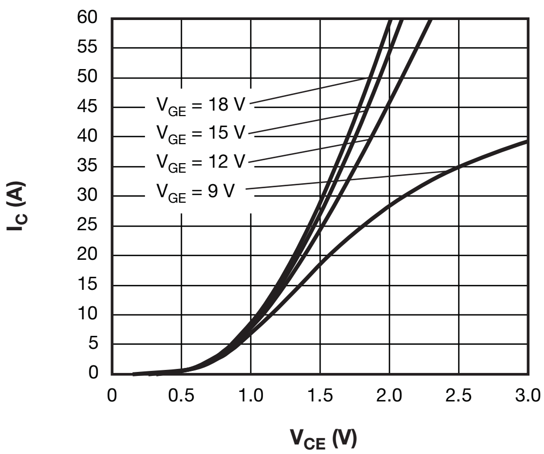


Fig. 19 - Typical Q2 - Q3 Trench IGBT 600 V Output Characteristics
T_J = 125 °C

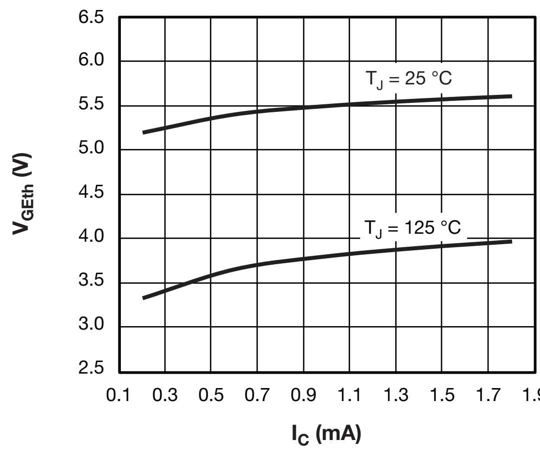


Fig. 22 - Typical Q2 - Q3 Trench IGBT 600 V
Gate Threshold Voltage

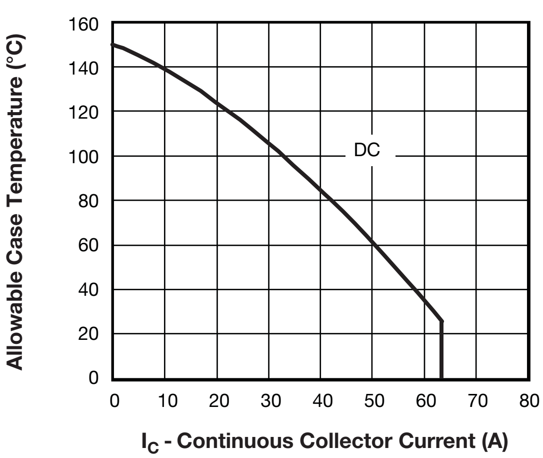


Fig. 20 - Maximum Q2 - Q3 Trench IGBT 600 V
Continuous Collector Current vs. Case Temperature

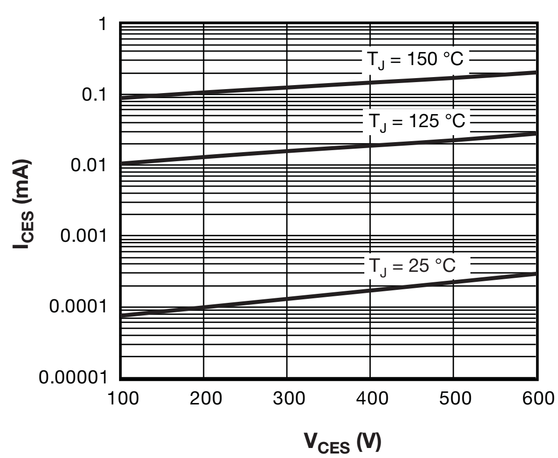


Fig. 23 - Typical Q2 - Q3 Trench IGBT 600 V
Zero Gate Voltage Collector Current

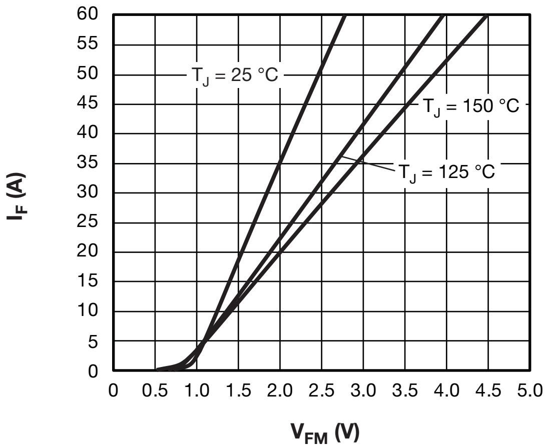


Fig. 24 - Typical D2 - D3 Antiparallel Diode Forward Characteristics

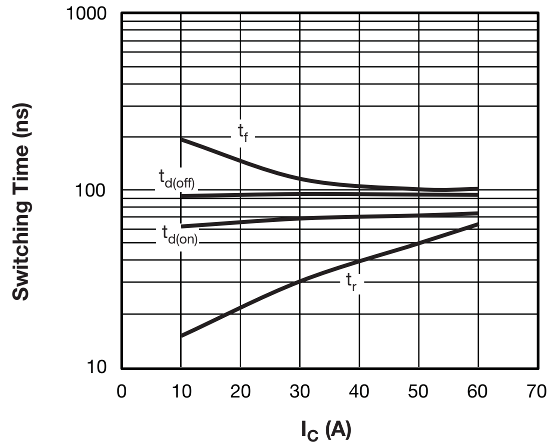


Fig. 27 - Typical Q2 - Q3 Trench IGBT 600 V Switching Time vs. I_C (with Freewheeling External TO-247 Diode Discrete 30ETH06) T_J = 125 °C, V_{CC} = 300 V, R_g = 4.7 Ω, V_{GE} = 15 V, L = 500 μH

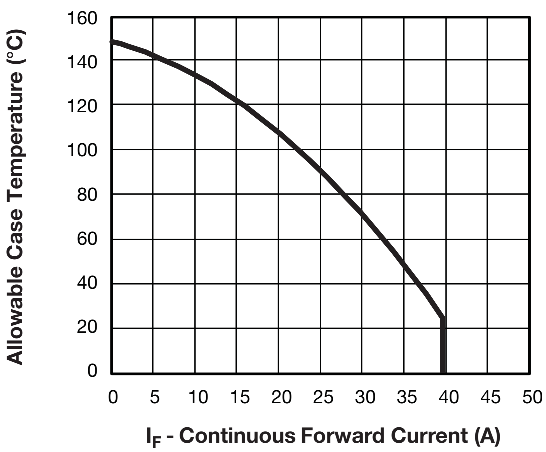


Fig. 25 - Maximum D2 - D3 Antiparallel Diode Forward Current vs. Case Temperature

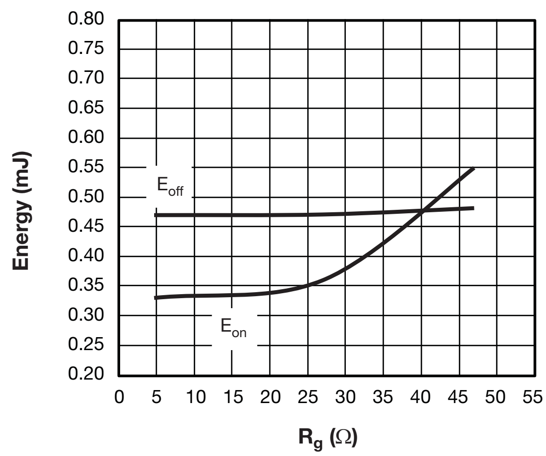


Fig. 28 - Typical Q2 - Q3 Trench IGBT 600 V Energy Loss vs. R_g (with Freewheeling External TO-247 Diode Discrete 30ETH06) T_J = 125 °C, V_{CC} = 300 V, I_C =30 A, V_{GE} = 15 V, L = 500 μH

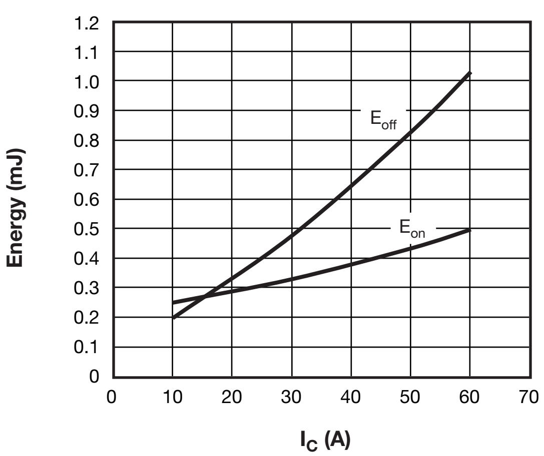


Fig. 26 - Typical Q2 - Q3 Trench IGBT 600 V Energy Loss vs. I_C (with Freewheeling External TO-247 Diode Discrete 30ETH06) T_J = 125 °C, V_{CC} = 300 V, R_g = 4.7 Ω, V_{GE} = 15 V, L = 500 μH

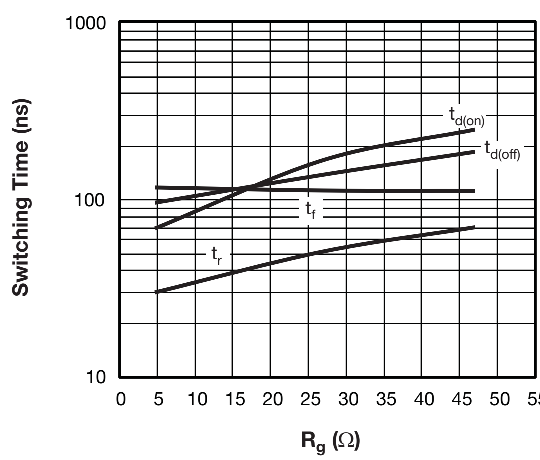


Fig. 29 - Typical Q2 - Q3 Trench IGBT 600 V Switching Time vs. R_g (with Freewheeling External TO-247 Diode Discrete 30ETH06) T_J = 125 °C, V_{CC} = 300 V, I_C = 30 A, V_{GE} = 15 V, L = 500 μH

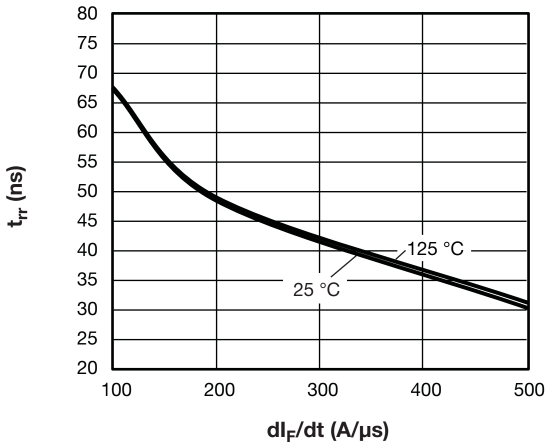


Fig. 30 - Typical D2 - D3 Antiparallel Diode
Reverse Recovery Time vs. dI_F/dt
V_{rr} = 200 V, I_F = 20 A

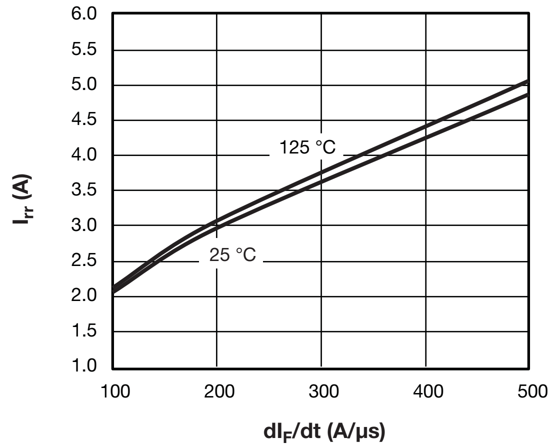


Fig. 31 - Typical D2 - D3 Antiparallel Diode
Reverse Recovery Current vs. dI_F/dt
V_{rr} = 200 V, I_F = 20 A

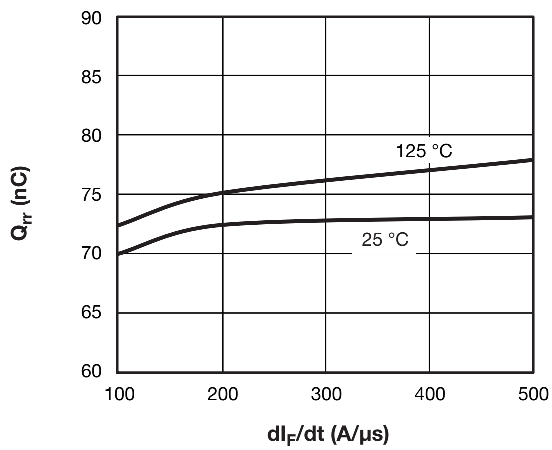


Fig. 32 - Typical D2 - D3 Antiparallel Diode
Reverse Recovery Charge vs. dI_F/dt
V_{rr} = 200 V, I_F = 20 A

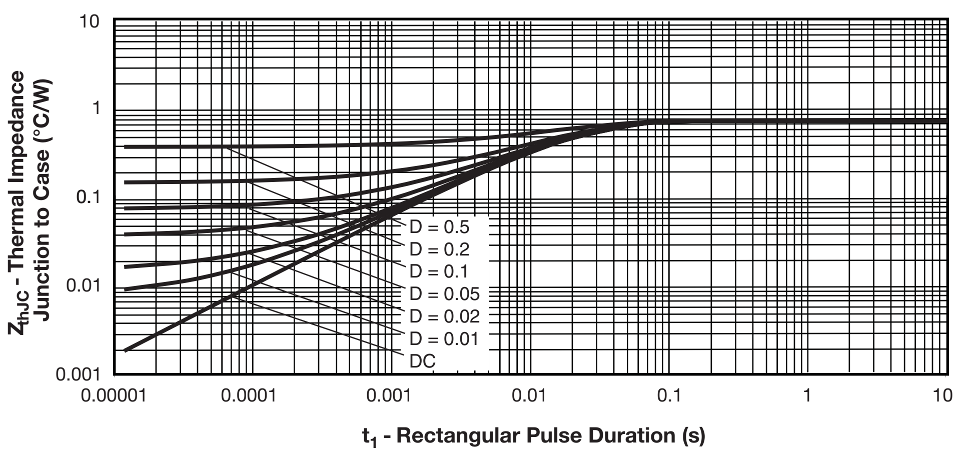


Fig. 33 - Maximum Thermal Impedance Z_{thJC} Characteristics (Q2 - Q3 Trench IGBT 600 V)

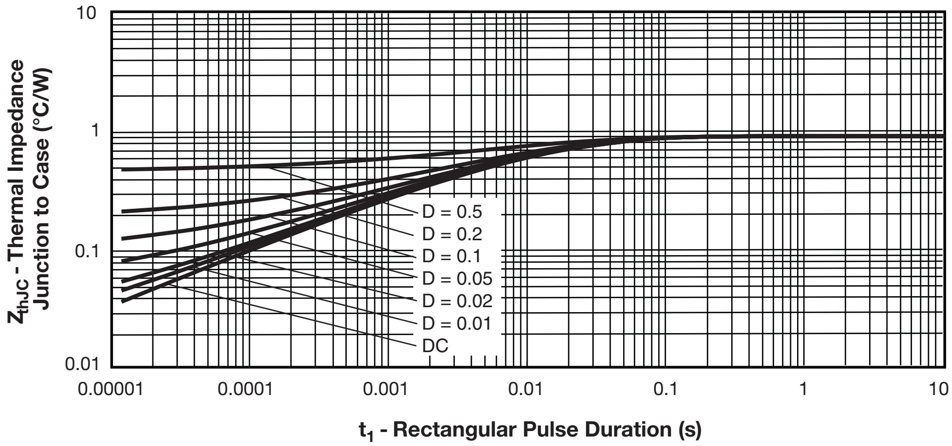


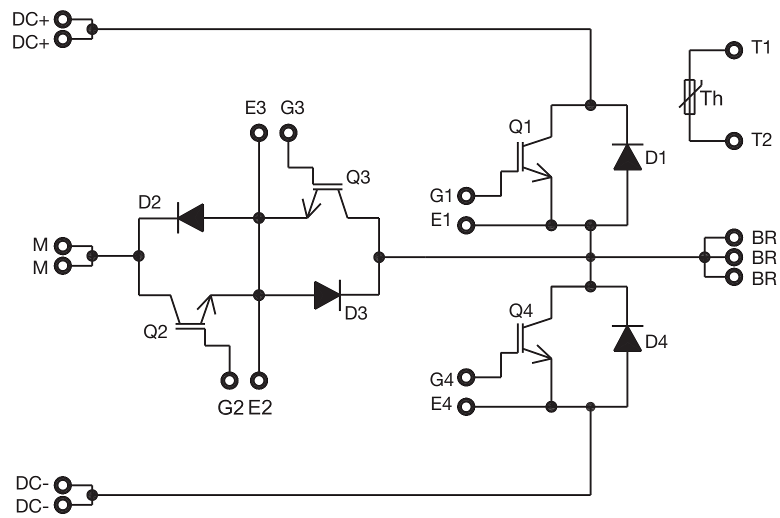
Fig. 34 - Maximum Thermal Impedance Z_{thJC} Characteristics (D2 - D3 Antiparallel Diode)

ORDERING INFORMATION TABLE

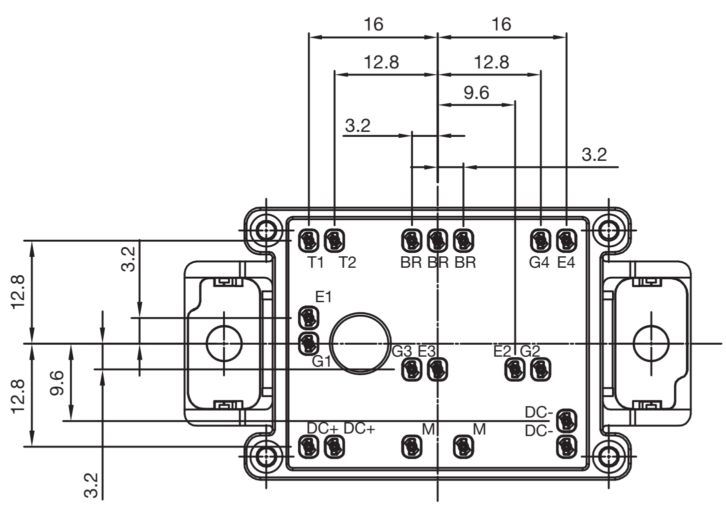
Device code	VS-	EN	Q	030	L	120	S
	1	2	3	4	5	6	7

1 - Vishay Semiconductors product
2 - Package indicator (EN = EMIPAK-1B)
3 - Circuit configuration (Q = neutral point clamp topology)
4 - Current rating (030 = 30 A)
5 - Switch die technology (L = ultrafast Trench IGBT 1200 V and Trench IGBT 600 V)
6 - Voltage rating (120 = 1200 V)
7 - Diode die technology (S = SiC diode)

CIRCUIT CONFIGURATION



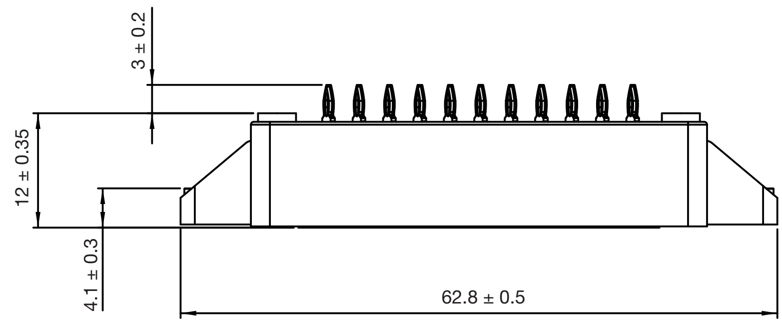
PACKAGE

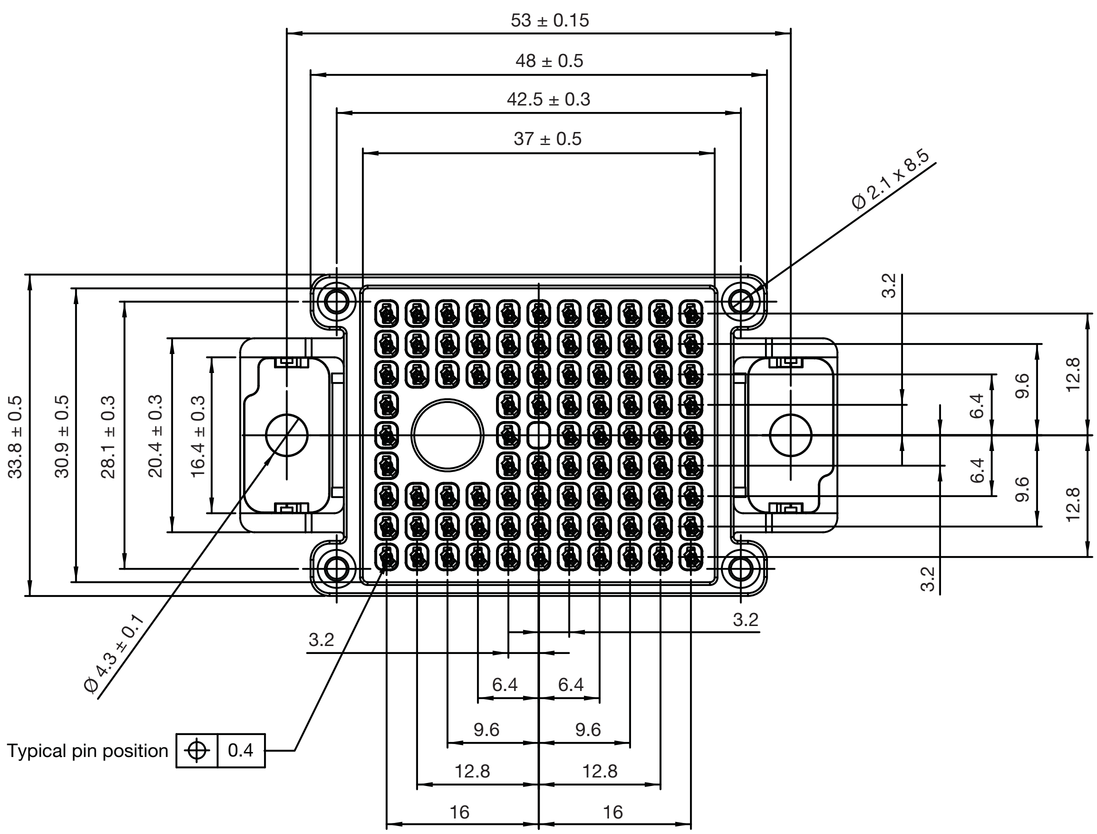


LINKS TO RELATED DOCUMENTS	
Dimensions	www.vishay.com/doc?95558

EMIPAK-1B PressFit

DIMENSIONS in millimeters





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