

EMIPAK 1B PressFit Power Module

650 V PFC and Full Bridge MOSFET, 25 A



EMIPAK 1B
(package example)

PRIMARY CHARACTERISTICS

QB1 - QB2 PFC MOSFET	
V_{DS}	650 V
$R_{DS(on)}$ typical at $I_C = 25$ A	59 m Ω
I_D at $T_{SINK} = 65$ °C	25 A
Q1 to Q4 FULL BRIDGE MOSFET	
V_{DS}	650 V
$R_{DS(on)}$ typical at $I_C = 25$ A	59 m Ω
I_D at $T_{SINK} = 65$ °C	25 A
DB1 - DB2 SILICON CARBIDE CLAMP DIODE	
V_{RRM}	650 V
V_{FM} typical at 12 A	1.52 V
I_F at $T_{SINK} = 69$ °C	12 A
Package	EMIPAK 1B
Circuit configuration	MOSFET dual boost PFC and MOSFET full bridge inverter
Type	Modules - MOSFET

FEATURES

- E series power MOSFET with fast body diode
- SiC diode technology
- Exposed Al_2O_3 substrate with low thermal resistance
- Low input capacitance
- Low switching and conduction losses
- Low figure-of-merit (FOM) $R_{on} \times Q_g$
- Ultra low gate charge Q_g
- Low internal inductances
- Qualified using AQG324 guideline as reference
- PressFit pins locking technology
PATENT(S): www.vishay.com/patents
- Material categorization: for definitions of compliance please see www.vishay.com/doc?99912



RoHS
COMPLIANT

DESCRIPTION

The EMIPAK 1B package is easy to use thanks to the PressFit pins. The exposed substrate provides improved thermal performance.

The optimized layout also helps to minimize stray parameters, allowing for better EMI performance.

ABSOLUTE MAXIMUM RATINGS ($T_J = 25$ °C unless otherwise noted)

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
QB1 - QB2 PFC MOSFET				
Drain to source voltage	V_{DS}		650	V
Gate to source voltage	V_{GS}		± 20	
Pulsed drain current	I_{DM}		49	A
Continuous drain current	I_D	$T_{SINK} = 25$ °C	29	A
		$T_{SINK} = 80$ °C	22	
Power dissipation	P_D	$T_{SINK} = 25$ °C	139	W
		$T_{SINK} = 80$ °C	78	
Single pulse avalanche energy	E_{AS}	$L = 10$ mH, $I_{AS} = 16$ A, $T_J = 25$ °C	1280	mJ
Pulsed source current (body diode)	I_{SM}		225	A

PATENT(S): www.vishay.com/patents

This Vishay product is protected by one or more United States and International patents.

**ABSOLUTE MAXIMUM RATINGS** ($T_J = 25\text{ }^{\circ}\text{C}$ unless otherwise noted)

Q1 to Q4 FULL BRIDGE MOSFET				
Drain to source voltage	V_{DSS}		650	V
Gate to source voltage	V_{GS}		± 20	
Pulsed drain current	I_{DM}	$V_{GS} = 10\text{ V}$	49	A
Continuous drain current	I_D	$T_{SINK} = 25\text{ }^{\circ}\text{C}$	29	A
		$T_{SINK} = 80\text{ }^{\circ}\text{C}$	22	
Power dissipation	P_D	$T_{SINK} = 25\text{ }^{\circ}\text{C}$	139	W
		$T_{SINK} = 80\text{ }^{\circ}\text{C}$	78	
Single pulse avalanche energy	E_{AS}	$L = 10\text{ mH}$, $I_{AS} = 16\text{ A}$, $T_J = 25\text{ }^{\circ}\text{C}$	1280	mJ
Pulsed source current (body diode)	I_{SM}		225	A
DB1 - DB2 SILICON CARBIDE CLAMP DIODE				
Cathode to anode voltage	V_{RRM}		650	V
Single pulse forward current	I_{FSM}	10 ms sine or 6 ms rectangular pulse, $T_J = 25\text{ }^{\circ}\text{C}$	85	A
Diode continuous forward current	I_F	$T_{SINK} = 25\text{ }^{\circ}\text{C}$	15	A
		$T_{SINK} = 80\text{ }^{\circ}\text{C}$	11	
Power dissipation	P_D	$T_{SINK} = 25\text{ }^{\circ}\text{C}$	44	W
		$T_{SINK} = 80\text{ }^{\circ}\text{C}$	25	

ELECTRICAL SPECIFICATIONS ($T_J = 25\text{ }^{\circ}\text{C}$ unless otherwise noted)

PARAMETER	SYMBOL	TEST CONDITIONS	MIN.	TYP.	MAX.	UNITS
QB1 - QB2 PFC MOSFET						
Drain to source breakdown voltage	BV_{DSS}	$V_{GS} = 0\text{ V}$, $I_D = 250\text{ }\mu\text{A}$	650	-	-	m Ω
Drain to source on resistance	$R_{DS(on)}$	$V_{GS} = 10\text{ V}$, $I_D = 25\text{ A}$	-	59	80	
		$V_{GS} = 10\text{ V}$, $I_D = 25\text{ A}$, $T_J = 150\text{ }^{\circ}\text{C}$	-	132	-	
Gate threshold voltage	$V_{GS(th)}$	$V_{DS} = V_{GS}$, $I_D = 250\text{ }\mu\text{A}$	1.8	2.9	4.4	V
Temperature coefficient of threshold voltage	$\Delta V_{GS(th)}/\Delta T_J$	$V_{DS} = V_{GS}$, $I_D = 250\text{ }\mu\text{A}$ ($25\text{ }^{\circ}\text{C}$ to $125\text{ }^{\circ}\text{C}$)	-	-10.8	-	mV/ $^{\circ}\text{C}$
Forward transconductance	g_{fs}	$V_{DS} = 20\text{ V}$, $I_D = 25\text{ A}$	-	31	-	S
Transfer characteristics	V_{GS}	$V_{DS} = 20\text{ V}$, $I_D = 25\text{ A}$	-	4.76	-	V
Zero gate voltage drain current	I_{DSS}	$V_{GS} = 0\text{ V}$, $V_{DS} = 650\text{ V}$	-	2	100	μA
		$V_{GS} = 0\text{ V}$, $V_{DS} = 650\text{ V}$, $T_J = 150\text{ }^{\circ}\text{C}$	-	700	-	
Gate to source leakage current	I_{GSS}	$V_{GS} = \pm 20\text{ V}$, $V_{DS} = 0\text{ V}$	-	-	± 150	nA
QB1 - QB2 PFC MOSFET BODY DIODE						
Source-to-drain voltage drop	V_{SD}	$I_{SD} = 25\text{ A}$, $V_{GS} = 0\text{ V}$	-	0.95	1.32	V
Q1 to Q4 FULL BRIDGE MOSFET						
Drain to source breakdown voltage	BV_{DSS}	$V_{GS} = 0\text{ V}$, $I_D = 250\text{ }\mu\text{A}$	650	-	-	m Ω
Drain to source on resistance	$R_{DS(on)}$	$V_{GS} = 10\text{ V}$, $I_D = 25\text{ A}$	-	59	80	
		$V_{GS} = 10\text{ V}$, $I_D = 25\text{ A}$, $T_J = 150\text{ }^{\circ}\text{C}$	-	132	-	
Gate threshold voltage	$V_{GS(th)}$	$V_{DS} = V_{GS}$, $I_D = 250\text{ }\mu\text{A}$	1.8	2.9	4.4	V
Temperature coefficient of threshold voltage	$\Delta V_{GS(th)}/\Delta T_J$	$V_{DS} = V_{GS}$, $I_D = 250\text{ }\mu\text{A}$ ($25\text{ }^{\circ}\text{C}$ to $125\text{ }^{\circ}\text{C}$)	-	-10.8	-	mV/ $^{\circ}\text{C}$
Forward transconductance	g_{fs}	$V_{DS} = 20\text{ V}$, $I_D = 25\text{ A}$	-	31	-	S
Transfer characteristics	V_{GS}	$V_{DS} = 20\text{ V}$, $I_D = 25\text{ A}$	-	4.76	-	V
Zero gate voltage drain current	I_{DSS}	$V_{GS} = 0\text{ V}$, $V_{DS} = 650\text{ V}$	-	2	100	μA
		$V_{GS} = 0\text{ V}$, $V_{DS} = 650\text{ V}$, $T_J = 150\text{ }^{\circ}\text{C}$	-	700	-	
Gate to source leakage current	I_{GSS}	$V_{GS} = \pm 20\text{ V}$, $V_{DS} = 0\text{ V}$	-	-	± 150	nA
Q1 to Q4 FULL BRIDGE MOSFET BODY DIODE						
Source-to-drain voltage drop	V_{SD}	$I_{SD} = 25\text{ A}$, $V_{GS} = 0\text{ V}$	-	0.95	1.32	V
DB1 - DB2 SILICON CARBIDE CLAMP DIODE						
Forward voltage drop	V_{FM}	$I_F = 12\text{ A}$	-	1.52	2.00	V
		$I_F = 12\text{ A}$, $T_J = 150\text{ }^{\circ}\text{C}$	-	1.92	-	
Breakdown voltage	V_{BR}	$I_R = 500\text{ }\mu\text{A}$	650	-	-	V
Reverse leakage current	I_{RM}	$V_R = 650\text{ V}$	-	1.8	100	μA
		$V_R = 650\text{ V}$, $T_J = 150\text{ }^{\circ}\text{C}$	-	600	-	



SWITCHING CHARACTERISTICS (T _J = 25 °C unless otherwise noted)						
PARAMETER	SYMBOL	TEST CONDITIONS	MIN.	TYP.	MAX.	UNITS
QB1 - QB2 PFC MOSFET						
Total gate charge (turn-on)	Q _g	I _D = 24 A, V _{DS} = 480 V, V _{GS} = 10 V	-	190	-	nC
Gate to source charge (turn-on)	Q _{gs}		-	41	-	
Gate to drain charge (turn-on)	Q _{gd}		-	67	-	
Turn-on switching loss	E _{ON}	I _D = 25 A, V _{DD} = 325 V, V _{GS} = +10 V / -10 V, R _g = 4.7 Ω, L = 500 μH	-	0.11	-	mJ
Turn-on delay time	t _{d(on)}		-	14	-	ns
Rise time	t _r		-	9	-	
Turn-off switching loss	E _{OFF}		-	0.06	-	mJ
Turn-off delay time	t _{d(off)}		-	78	-	ns
Fall time	t _f		-	7	-	
Turn-on switching loss	E _{ON}	I _D = 25 A, V _{DD} = 325 V, V _{GS} = +10 V / -10 V, R _g = 4.7 Ω, L = 500 μH, T _J = 125 °C	-	0.12	-	mJ
Turn-on delay time	t _{d(on)}		-	12	-	ns
Rise time	t _r		-	9	-	
Turn-off switching loss	E _{OFF}		-	0.06	-	mJ
Turn-off delay time	t _{d(off)}		-	82	-	ns
Fall time	t _f		-	7	-	
Input capacitance	C _{iss}	V _{GS} = 0 V, V _{DS} = 100 V, f = 1 MHz	-	5900	-	pF
Output capacitance	C _{oss}		-	260	-	
Reverse transfer capacitance	C _{rss}		-	5	-	
Reverse bias safe operating area	RBSOA	T _J = 150 °C, I _D = 120 A, V _{DD} = 400 V, V _P = 600 V, R _g = 4.7 Ω, V _{GS} = +10 V / 0 V				
QB1 - QB2 PFC MOSFET BODY DIODE						
Diode reverse recovery time	t _{rr}	V _R = 400 V, T _J = 25 °C, I _S = 22 A, dI/dt = 100 A/μs	-	203	-	ns
Diode reverse recovery current	I _{rr}		-	16	-	A
Diode reverse recovery charge	Q _{rr}		-	1625	-	nC
Q1 to Q4 FULL BRIDGE MOSFET						
Total gate charge (turn-on)	Q _g	I _D = 24 A, V _{DS} = 480 V, V _{GS} = 10 V	-	190	-	nC
Gate-source charge	Q _{gs}		-	41	-	
Gate-drain charge	Q _{gd}		-	67	-	
Turn-off switching loss	E _{OFF}	I _D = 25 A, V _{DD} = 325 V, V _{GS} = +10 V / -10 V, R _g = 4.7 Ω, L = 500 μH	-	0.05	-	mJ
Turn-off delay time	t _{d(off)}		-	76	-	ns
Fall time	t _f		-	7	-	
Turn-off switching loss	E _{OFF}	I _D = 25 A, V _{DD} = 325 V, V _{GS} = +10 V / -10 V, R _g = 4.7 Ω, L = 500 μH, T _J = 125 °C	-	0.05	-	mJ
Turn-off delay time	t _{d(off)}		-	79	-	ns
Fall time	t _f		-	7	-	
Input capacitance	C _{iss}	V _{GS} = 0 V, V _{DS} = 100 V, f = 1 MHz	-	5900	-	pF
Output capacitance	C _{oss}		-	260	-	
Reverse transfer capacitance	C _{rss}		-	5	-	
Reverse bias safe operating area	RBSOA	T _J = 150 °C, I _D = 50 A, V _{DD} = 400 V, V _P = 600 V, R _g = 4.7 Ω, V _{GS} = +10 V / 0 V				
Q1 to Q4 FULL BRIDGE MOSFET BODY DIODE						
Diode reverse recovery time	t _{rr}	V _R = 400 V, T _J = 25 °C, I _S = 22 A, dI/dt = 100 A/μs	-	203	-	ns
Diode reverse recovery current	I _{rr}		-	16	-	A
Diode reverse recovery charge	Q _{rr}		-	1625	-	nC
DB1 - DB2 SILICON CARBIDE CLAMP DIODE						
Total capacitive charge	Q _C	V _R = 400 V, I _F = 12 A, dI/dt = 500 A/μs	-	29	-	nC

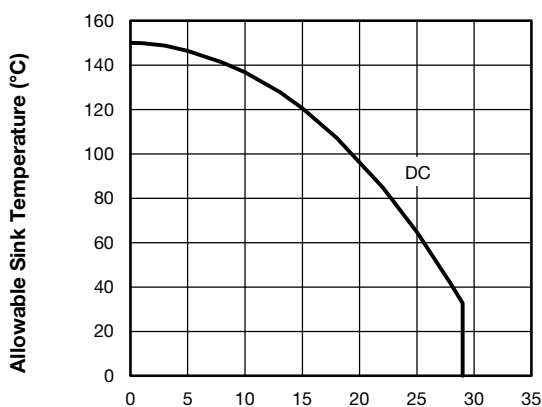
INTERNAL NTC - THERMISTOR SPECIFICATIONS				
PARAMETER	SYMBOL	TEST CONDITIONS	VALUE	UNITS
Resistance	R_{25}	$T_C = 25\text{ }^{\circ}\text{C}$	5000	Ω
	R_{100}	$T_C = 100\text{ }^{\circ}\text{C}$	$493 \pm 5\%$	
B-value	$B_{25/50}$	$R_2 = R_{25} \exp. [B_{25/50} (1/T_2 - 1/(298.15\text{ K}))]$	$3375 \pm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

**THERMAL AND MECHANICAL SPECIFICATIONS**

PARAMETER	SYMBOL	MIN.	TYP.	MAX.	UNITS
QB1 - QB2 PFC MOSFET - Junction to sink thermal resistance (per switch) ⁽¹⁾	R_{thJS}	-	0.75	-	°C/W
Q1 to Q4 FULL BRIDGE MOSFET - Junction to sink thermal resistance (per switch) ⁽¹⁾		-	0.75	-	
DB1 - DB2 SILICON CARBIDE CLAMP DIODE - Junction to sink thermal resistance (per diode) ⁽¹⁾		-	2.35	-	
Case to sink thermal resistance (per module) ⁽¹⁾		-	0.1	-	
Mounting torque (M4)		2	-	3	Nm
Weight		-	28	-	g

Note

⁽¹⁾ Mounting surface flat, smooth, and greased, $\lambda_{grease} = 0.67 \text{ W/mK}$



I_D - Continuous Drain Current (A)

Fig. 1 - Maximum MOSFET Continuous Drain Current vs. Sink Temperature

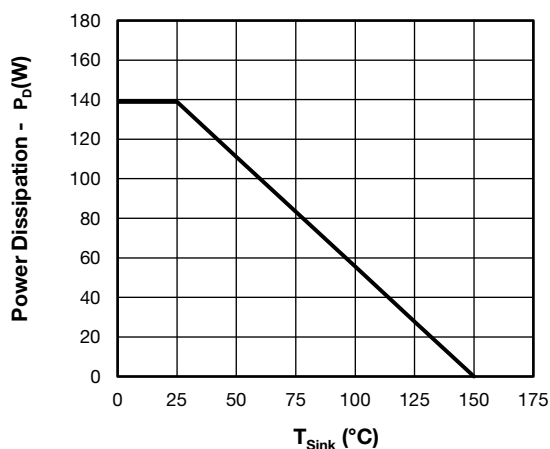


Fig. 2 - MOSFET Power Dissipation Curve

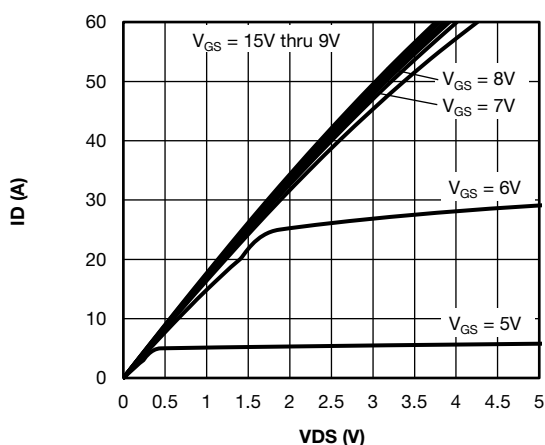


Fig. 3 - Typical MOSFET Drain-to-Source Current Output Characteristics at $T_J = 25^\circ\text{C}$

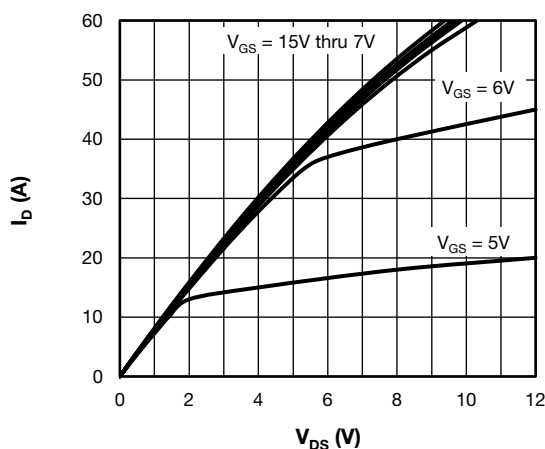


Fig. 4 - Typical MOSFET Drain-to-Source Current Output Characteristics at $T_J = 150^\circ\text{C}$

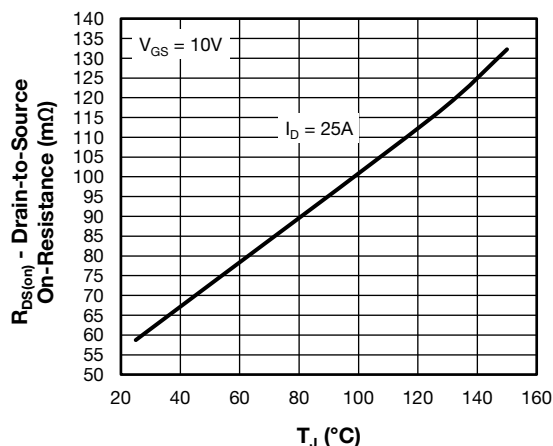


Fig. 5 - Typical MOSFET
Drain-to-Source On-Resistance vs. Temperature

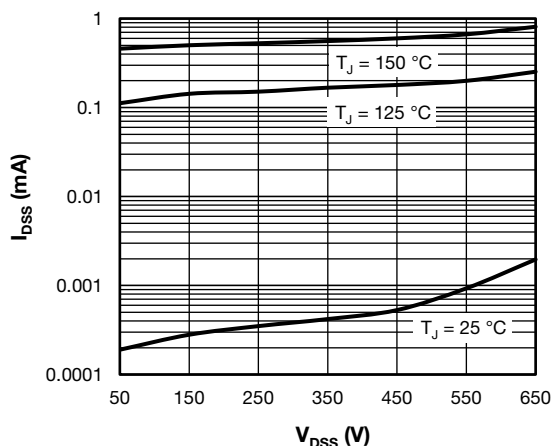


Fig. 8 - Typical MOSFET Zero Gate Voltage Drain Current

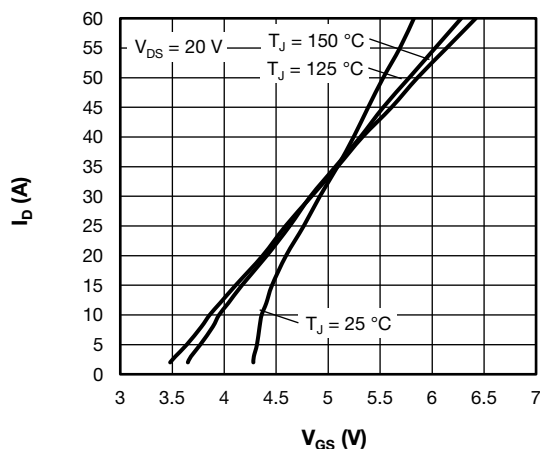


Fig. 6 - Typical MOSFET Transfer Characteristics

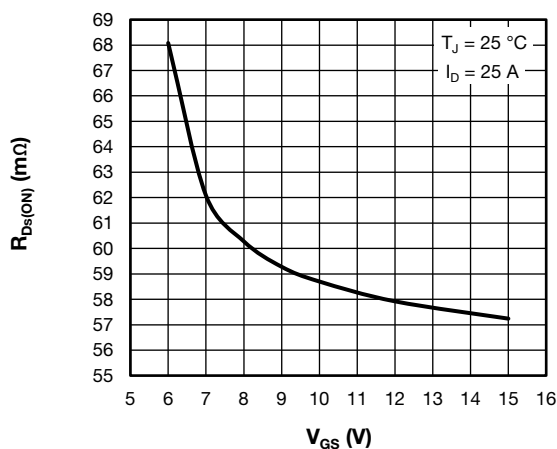


Fig. 9 - Typical MOSFET
Drain - State Resistance vs. Gate-to-Source Voltage

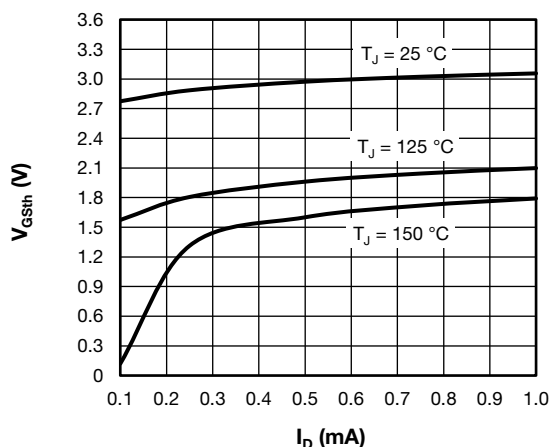


Fig. 7 - Typical MOSFET Gate Threshold Voltage Characteristics

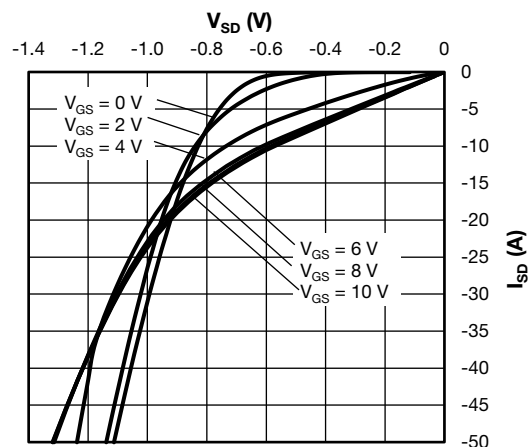


Fig. 10 - Typical MOSFET Source-to-Drain Current Characteristics
at $T_J = 25\text{ }^{\circ}\text{C}$

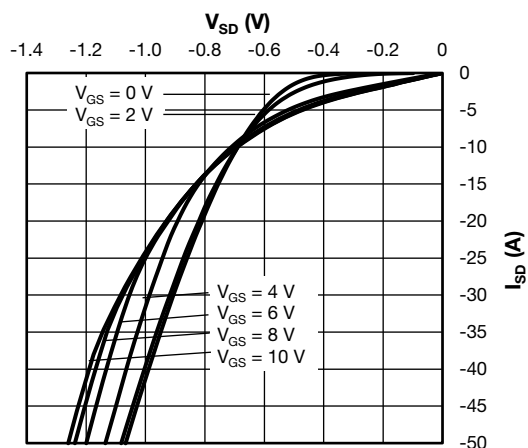


Fig. 11 - Typical MOSFET Source-to-Drain Current Characteristics at $T_J = 125\text{ }^{\circ}\text{C}$

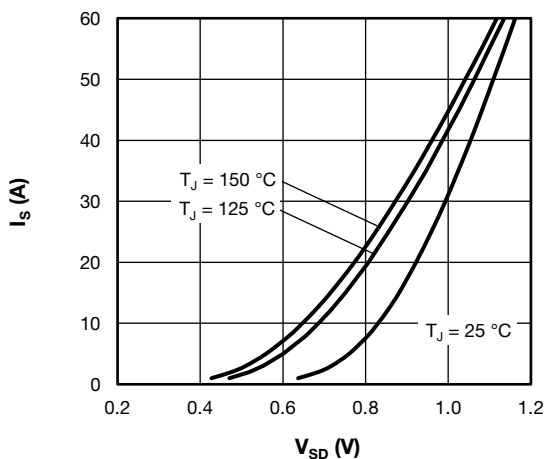


Fig. 12 - Typical MOSFET Body Diode Source-to-Drain Current Characteristics

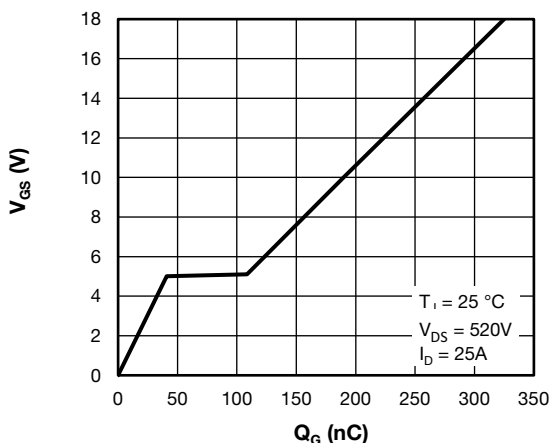


Fig. 13 - Typical MOSFET Gate charge vs. Gate-to-Source Voltage

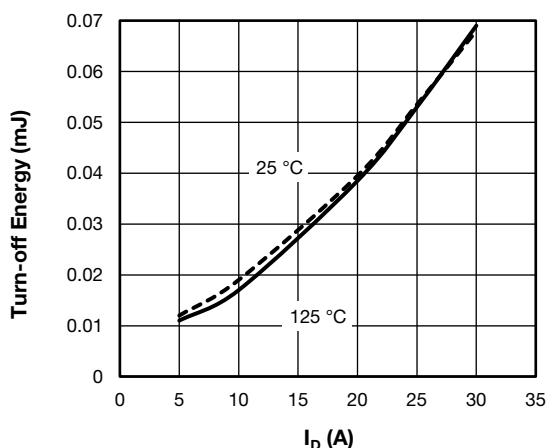


Fig. 14 - Typical Q1 to Q4 Turn-off Energy Loss vs. I_D
 $V_{DD} = 325\text{ V}$, $R_g = 4.7\text{ }\Omega$, $V_{GS} = \pm 10\text{ V}$, $L = 500\text{ }\mu\text{H}$

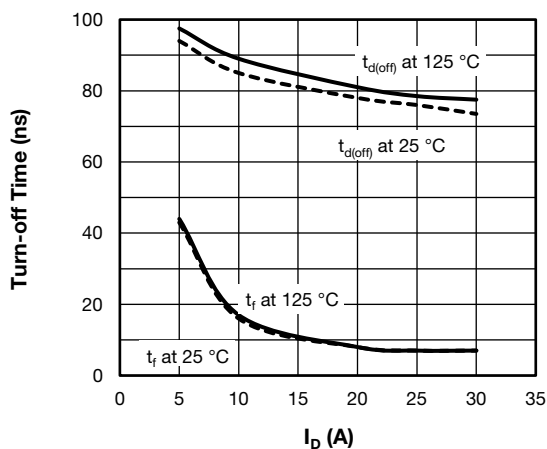


Fig. 15 - Typical Q1 to Q4 Turn-off Switching Time vs. I_D
 $V_{DD} = 325\text{ V}$, $R_g = 4.7\text{ }\Omega$, $V_{GS} = \pm 10\text{ V}$, $L = 500\text{ }\mu\text{H}$

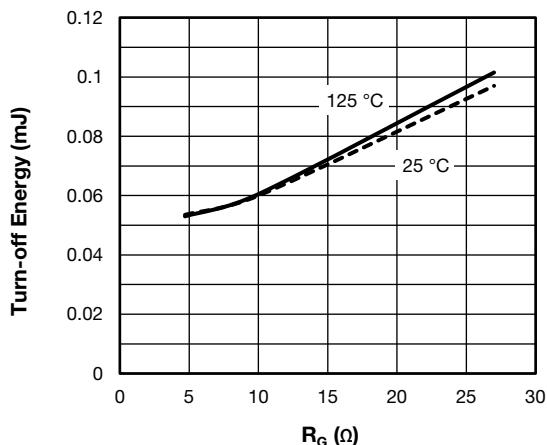


Fig. 16 - Typical Q1 to Q4 Turn-off Energy Loss vs. R_g
 $V_{DD} = 325\text{ V}$, $I_D = 25\text{ A}$, $V_{GS} = \pm 10\text{ V}$, $L = 500\text{ }\mu\text{H}$

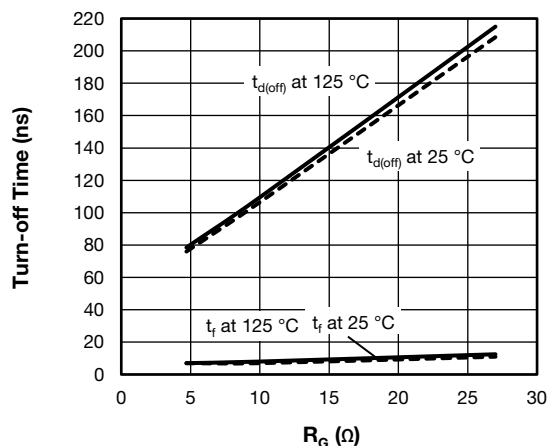


Fig. 17 - Typical Q1 to Q4 Turn-off Switching Time vs. R_g
 $V_{DD} = 325 \text{ V}$, $I_D = 25 \text{ A}$, $V_{GS} = \pm 10 \text{ V}$, $L = 500 \mu\text{H}$

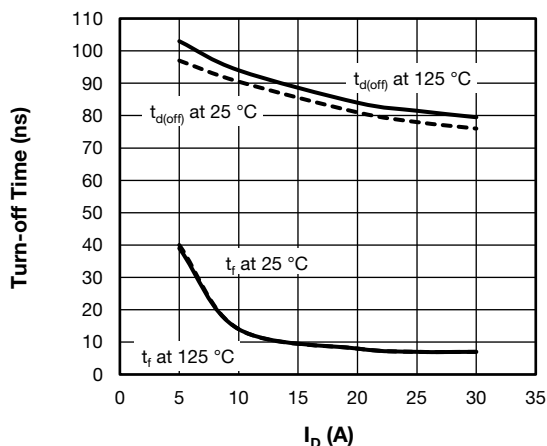


Fig. 20 - Typical QB1 to QB2 Turn-off Switching Time vs. I_D
 $V_{DD} = 325 \text{ V}$, $R_g = 4.7 \Omega$, $V_{GS} = \pm 10 \text{ V}$, $L = 500 \mu\text{H}$

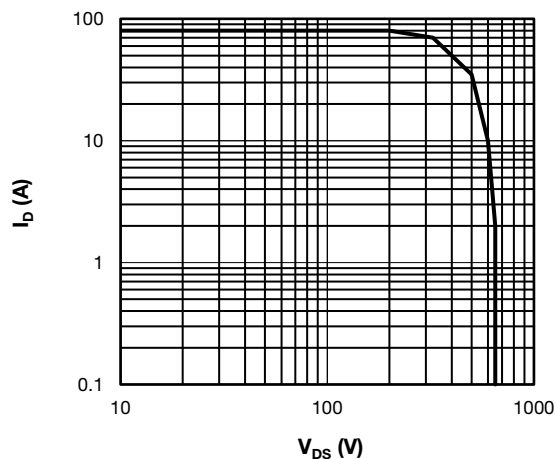


Fig. 18 - Q1 to Q4 Reverse BIAS SOA $T_J = 150 \text{ }^\circ\text{C}$, $V_{GS} = 10 \text{ V}$

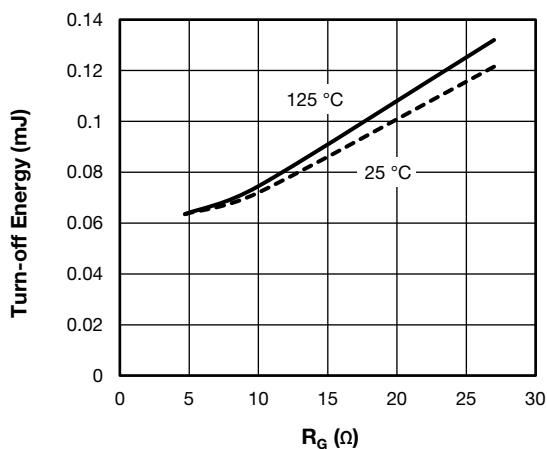


Fig. 21 - Typical QB1 - QB2 Turn-off Energy Loss vs. R_g

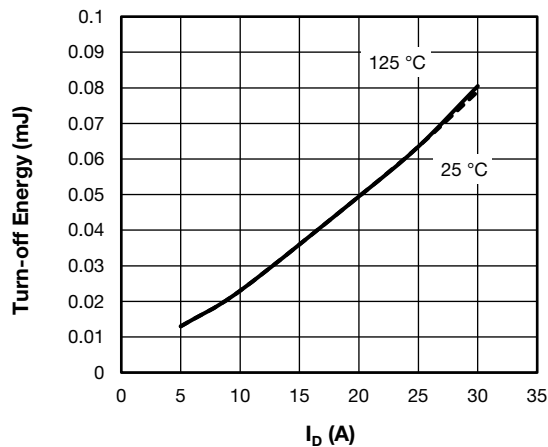


Fig. 19 - Typical QB1 - QB2 Turn-off Energy Loss vs. I_D
 $V_{DD} = 325 \text{ V}$, $R_g = 4.7 \Omega$, $V_{GS} = \pm 10 \text{ V}$, $L = 500 \mu\text{H}$

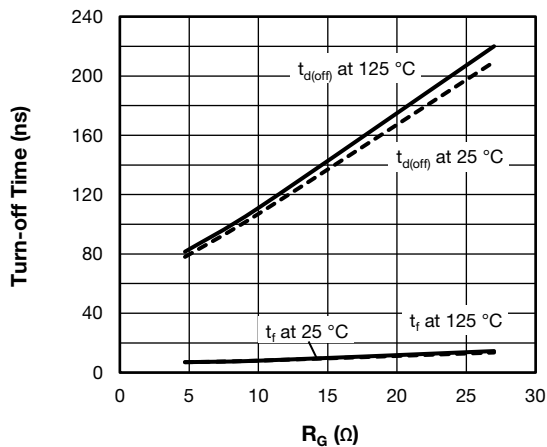


Fig. 22 - Typical QB1 - QB2 Turn-off Switching Time vs. R_g

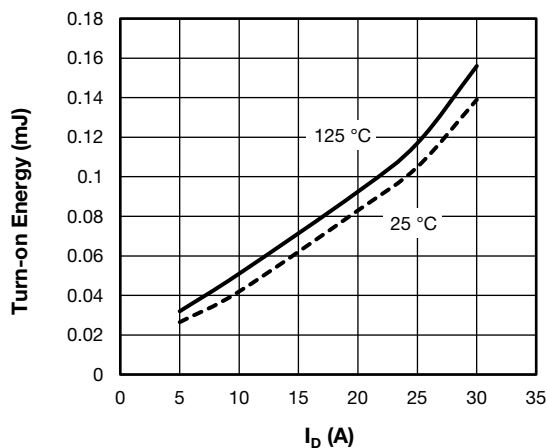


Fig. 23 - Typical QB1 - QB2 Turn-on Energy Loss vs. I_D
 $V_{DD} = 325 \text{ V}$, $R_g = 4.7 \text{ } \Omega$, $V_{GS} = \pm 10 \text{ V}$, $L = 500 \text{ } \mu\text{H}$

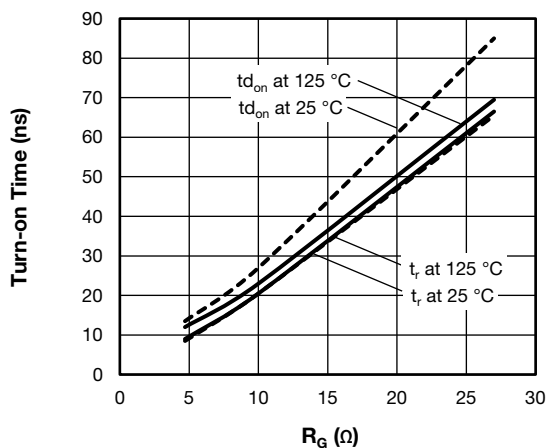


Fig. 26 - Typical QB1 - QB2 Turn-on Switching Time vs. R_g
 $V_{DD} = 325 \text{ V}$, $I_D = 25 \text{ A}$, $V_{GS} = \pm 10 \text{ V}$, $L = 500 \text{ } \mu\text{H}$

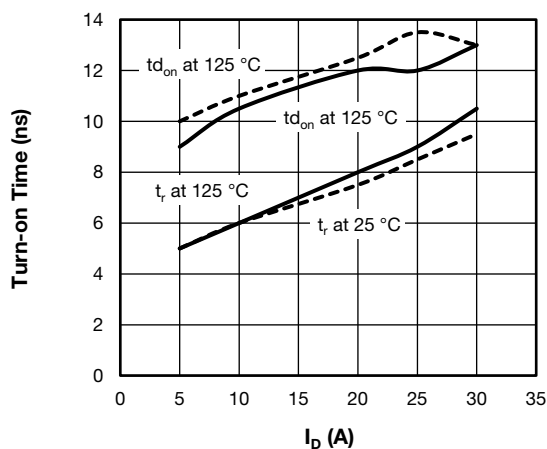


Fig. 24 - Typical QB1 - QB2 Turn-on Switching Time vs. I_D
 $V_{DD} = 325 \text{ V}$, $R_g = 4.7 \text{ } \Omega$, $V_{GS} = \pm 10 \text{ V}$, $L = 500 \text{ } \mu\text{H}$

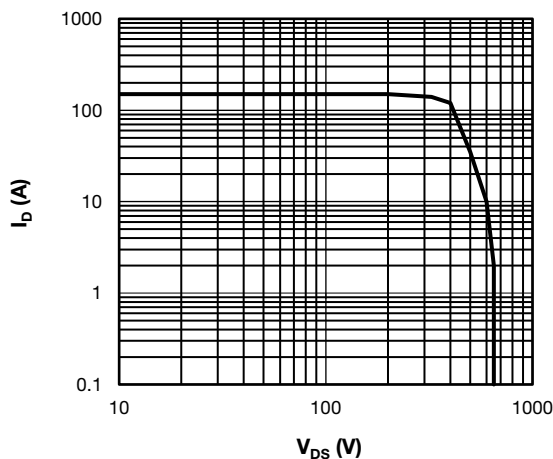


Fig. 27 - QB1 - QB2 Reverse BIAS SOA
 $T_J = 150 \text{ } ^\circ\text{C}$, $V_{GS} = 10 \text{ V}$

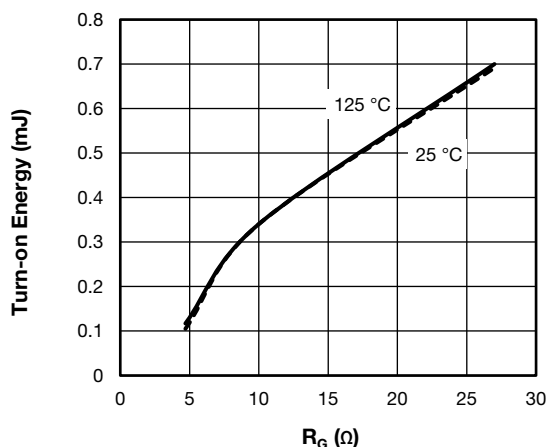


Fig. 25 - Typical QB1 - QB2 Turn-on Energy Loss vs. R_g
 $V_{DD} = 325 \text{ V}$, $I_D = 25 \text{ A}$, $V_{GS} = \pm 10 \text{ V}$, $L = 500 \text{ } \mu\text{H}$

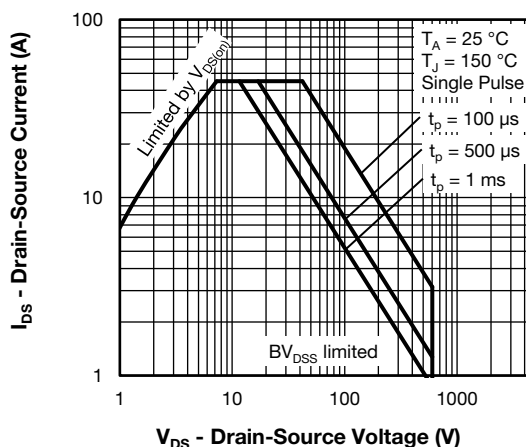


Fig. 28 - MOSFET Safe Operating Area

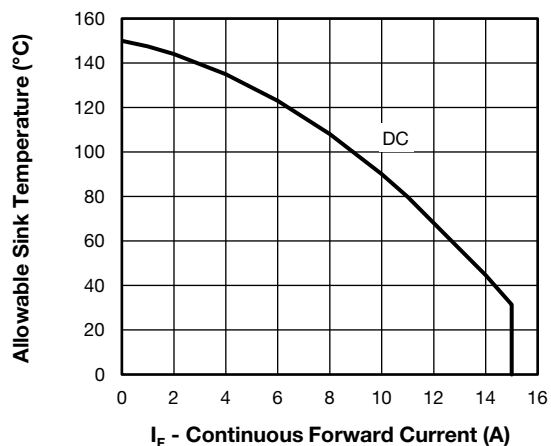


Fig. 29 - Maximum DB1 - DB2 Continuous Forward Current vs. Sink Temperature

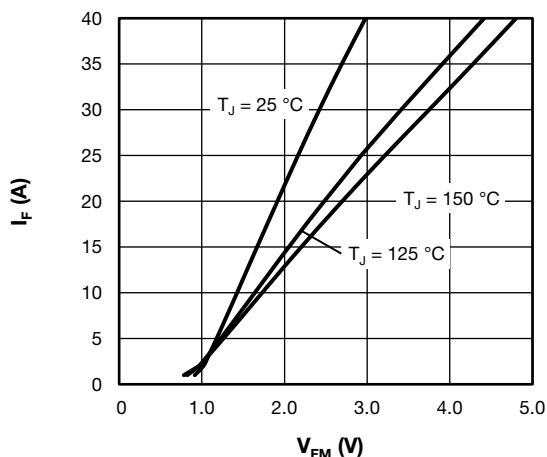


Fig. 30 - Typical DB1 - DB2 Diode Forward Characteristics

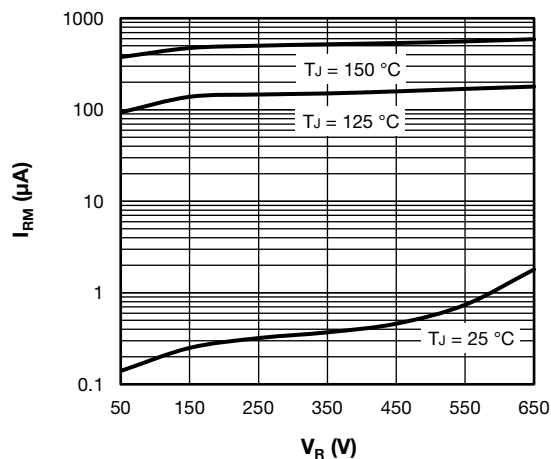


Fig. 31 - Typical DB1 - DB2 Reverse Leakage Current

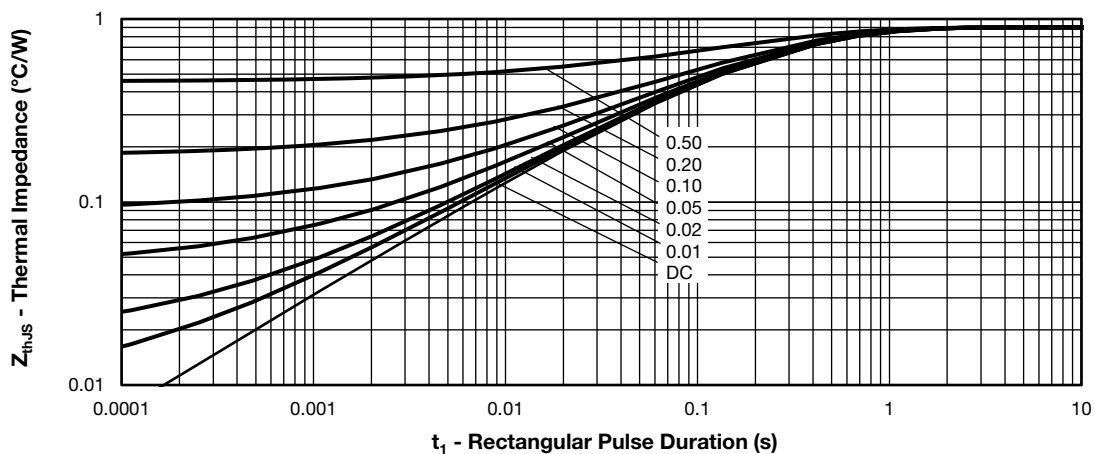
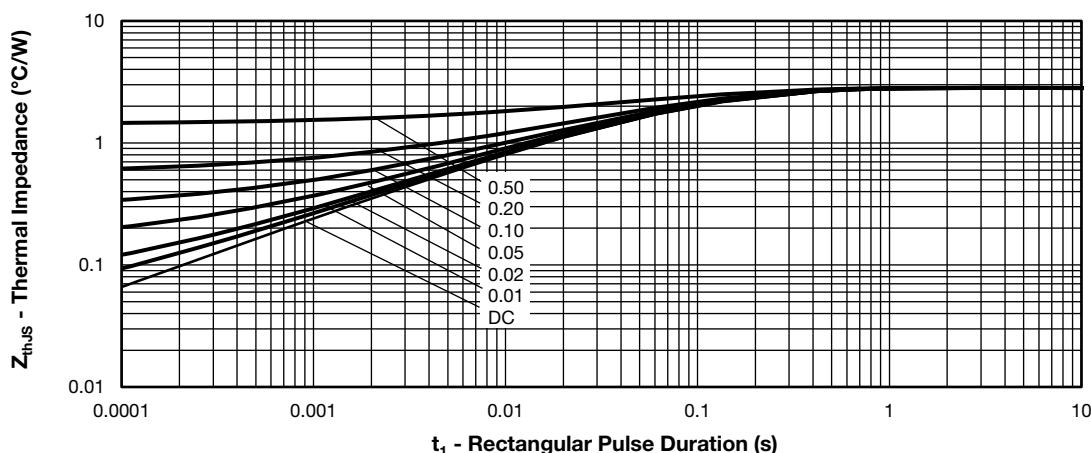


Fig. 32 - Maximum MOSFET Z_{thJS} Thermal Impedance Characteristics


Fig. 33 - Maximum Diode Z_{thJS} Thermal Impedance Characteristic

ORDERING INFORMATION TABLE

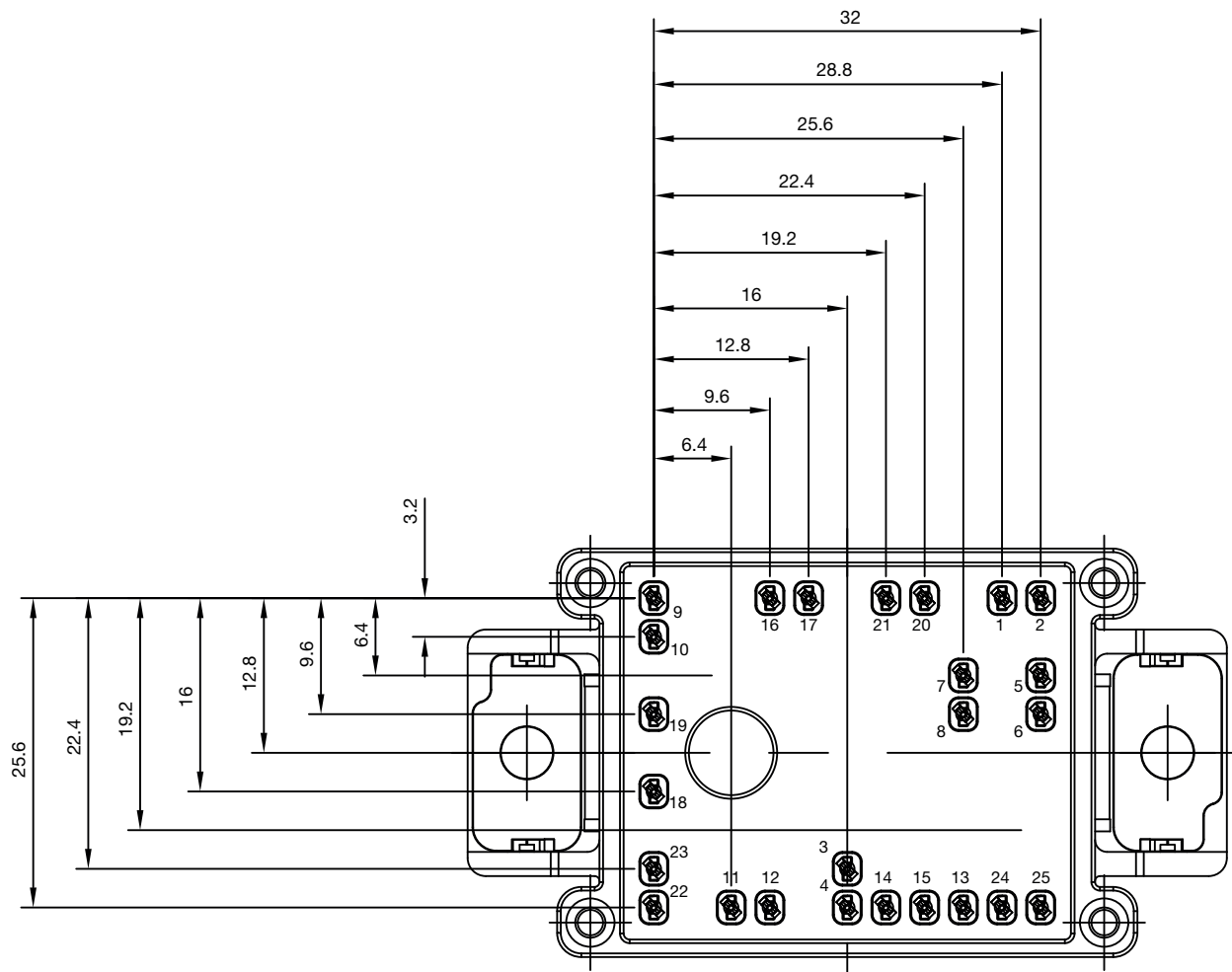
Device code	VS-	EN	K	025	C	65	S
	1	2	3	4	5	6	7

- 1** - Vishay Semiconductors product
- 2** - Package indicator (EN = EMIPAK 1B)
- 3** - Circuit configuration (K = MOSFET dual boost PFC and MOSFET full bridge inverter)
- 4** - Current rating (025 = 25 A)
- 5** - Switch die technology (C = PowerMOS)
- 6** - Voltage rating (65 = 650 V)
- 7** - Clamp diode technology (S = Silicon Carbide diode)

CIRCUIT CONFIGURATION		
CIRCUIT	CIRCUIT CONFIGURATION CODE	CIRCUIT DRAWING
MOSFET dual boost PFC and MOSFET full bridge inverter	K	



PACKAGE

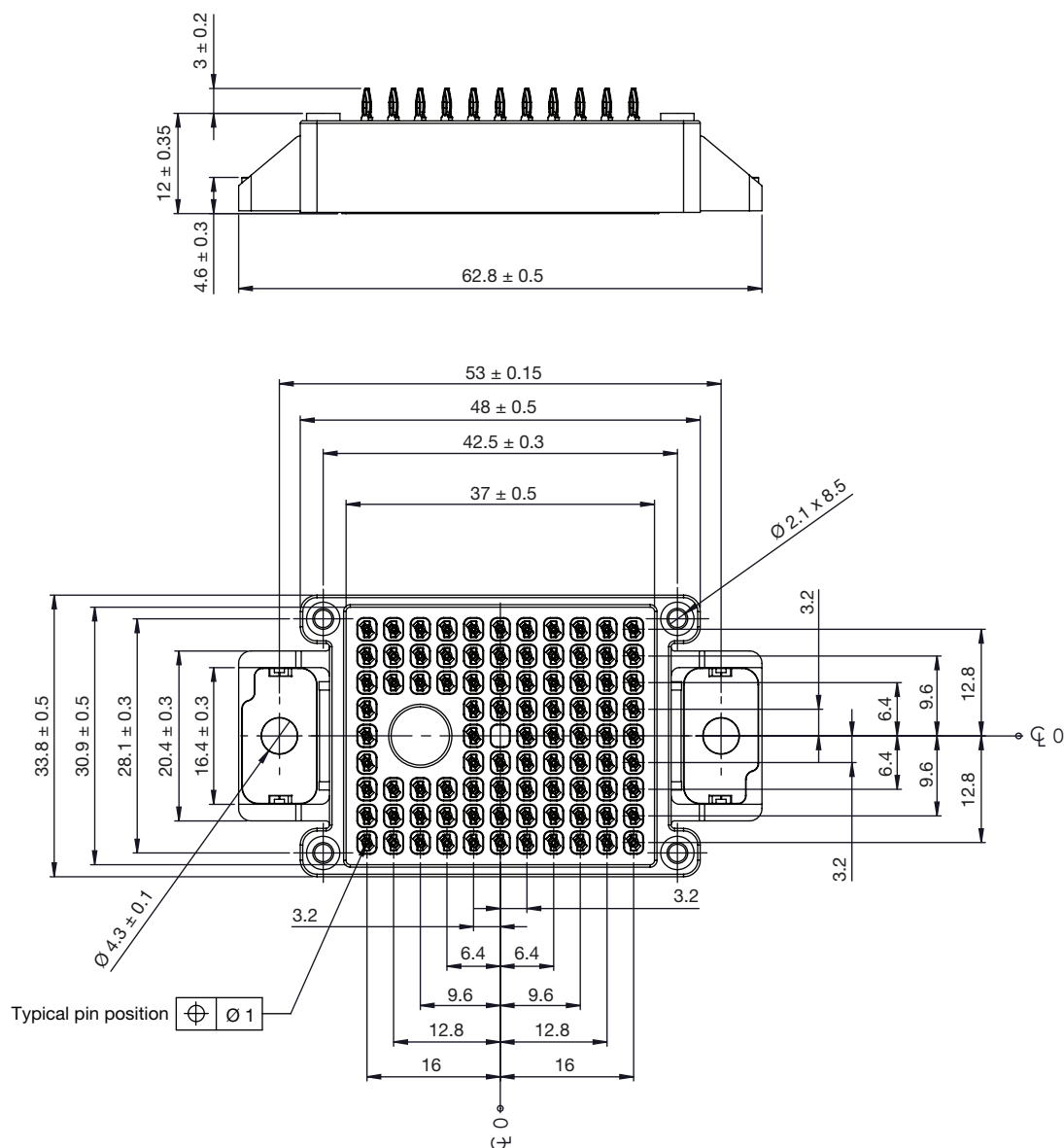


LINKS TO RELATED DOCUMENTS

Dimensions	www.vishay.com/doc?95558
Application Note	www.vishay.com/doc?95580

EMIPAK-1B PressFit

DIMENSIONS in millimeters





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