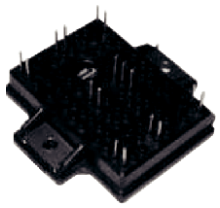
Dual Mode PFC, 60 A



EMIPAK2

FEATURES

- NPT Warp2 PFC IGBT with low $V_{CE(ON)}$
- Silicon carbide PFC diode
- Antiparallel FRED Pt® fast recovery
- Integrated thermistor
- Square RBSOA
- Operating frequency 60 kHz to 150 kHz
- Low internal inductances
- Low switching loss
- UL approved file E78996
- Material categorization: For definitions of compliance please see www.vishay.com/doc?99912

Pb-free

RoHS COMPLIANT

PRODUCT SUMMARY

V_{CES}	600 V
$V_{CE(ON)}$ typical at I_C = 50 A	1.8 V
I_C at T_C = 98 °C	50 A
Package	EMIPAK2
Circuit	Dual Mode PFC

DESCRIPTION

VS-EMG050J60N is an integrated solution for dual stage PFC converter in a single package. The EMIPAK2 package is easy to use thanks to the solderable terminals and provides improved thermal performance thanks to the exposed substrate. The optimized layout also helps to minimize stray parameters, allowing for better EMI performance.

ABSOLUTE MAXIMUM RATINGS

PARAMETER	SYMBOL	TEST CONDITIONS	MAX.	UNITS
Maximum operating junction temperature	T_J		150	°C
Storage temperature range	T_{Stg}		- 40 to 125	
RMS isolation voltage	V_{ISOL}	T_J = 25 °C, all terminals shorted, f = 50 Hz, t = 1 s	3500	V
PFC IGBT Q1 - Q2				
Collector to emitter voltage	V_{CES}		600	V
Gate to emitter voltage	V_{GES}		20	
Pulsed collector current	I_{CM}		150	A
Clamped inductive load current	I_{LM} (1)		150	
Continuous collector current	I_C	T_C = 25 °C	88	
		T_C = 80 °C	60	
Power dissipation	P_D	T_C = 25 °C	338	W
		T_C = 80 °C	189	
ANTIPARALLEL DIODE D1 - D2				
Diode continuous forward current	I_F	T_C = 25 °C	16	A
		T_C = 80 °C	11	
Single pulse forward current	I_{FSM}	10 ms sine or 6 ms rectangular pulse, T_J = 25 °C	59	
Power dissipation	P_D	T_C = 25 °C	29	W
		T_C = 80 °C	16	
PFC DIODE D3 - D4				
Repetitive peak reverse voltage	V_{RRM}		600	V
Diode continuous forward current	I_F	T_C = 25 °C	25	A
		T_C = 80 °C	17	
Single pulse forward current	I_{FSM}	10 ms sine or 6 ms rectangular pulse, T_J = 25 °C	140	
Power dissipation	P_D	T_C = 25 °C	74	W
		T_C = 80 °C	41	

Notes

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

(1) V_{CC} = 400 V, V_{GE} = 15 V, L = 500 µH, R_g = 22 Ω, T_J = 150 °C

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ELECTRICAL SPECIFICATIONS (T_J = 25 °C unless otherwise noted)						
PARAMETER	**SYMBOL**	**TEST CONDITIONS**	**MIN.**	**TYP.**	**MAX.**	**UNITS**
PFC IGBT Q1 - Q2						
Collector to emitter breakdown voltage	BV_{CES}	V_{GE} = 0 V, I_C = 500 µA	600	-	-	V
Temperature coefficient of breakdown voltage	$\Delta BV_{CES}/\Delta T_J$	V_{GE} = 0 V, I_C = 500 µA (25 °C to 125 °C)	-	0.1	-	V/°C
Collector to emitter voltage	$V_{CE(ON)}$	V_{GE} = 15 V, I_C = 27 A	-	1.44	1.75	V
		V_{GE} = 15 V, I_C = 50 A	-	1.8	2.1	
		V_{GE} = 15 V, I_C = 27 A, T_J = 125 °C	-	1.7	2.05	
		V_{GE} = 15 V, I_C = 50 A, T_J = 125 °C	-	2.2	2.5	
Gate threshold voltage	$V_{GE(th)}$	V_{CE} = V_{GE}, I_C = 250 µA	2.9	3.9	5.3	
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)	-	- 10	-	mV/°C
Forward transconductance	g_{fe}	V_{CE} = 20 V, I_C = 50 A	-	95	-	s
Transfer characteristics	V_{GE}	V_{CE} = 20 V, I_C = 50 A	-	5.9	-	V
Zero gate voltage collector current	I_{CES}	V_{GE} = 0 V, V_{CE} = 600 V	-	3	100	µA
		V_{GE} = 0 V, V_{CE} = 600 V, T_J = 125 °C	-	0.170	3	mA
Gate to emitter leakage current	I_{GES}	V_{GE} = ± 20 V, V_{CE} = 0 V	-		± 200	nA
ANTIPARALLEL DIODE D1 - D2						
Forward voltage drop	V_F	I_F = 20 A	-	2.19	2.4	V
		I_F = 20 A, T_J = 125 °C	-	1.93	2.15	
PFC DIODE D3 - D4						
Cathode to anode breakdown voltage	V_{BR}	I_R = 500 µA	600	-	-	V
Reverse leakage current	I_{RM}	V_R = 600 V	-	27	250	µA
		V_R = 600 V, T_J = 125 °C	-	0.1	1	mA
Forward voltage drop	V_F	I_F = 10 A	-	1.34	1.63	V
		I_F = 10 A, T_J = 125 °C	-	1.36	1.65	

SWITCHING CHARACTERISTICS (T_J = 25 °C unless otherwise noted)						
PARAMETER	**SYMBOL**	**TEST CONDITIONS**	**MIN.**	**TYP.**	**MAX.**	**UNITS**
PFC IGBT Q1 - Q2 (WITH FREEWHEELING D3 - D4 PFC DIODE)						
Total gate charge (turn-on)	Q_g	I_C = 70 A V_{CC} = 400 V V_{GE} = 15 V	-	480	720	nC
Gate to emitter charge (turn-on)	Q_{ge}		-	82	164	
Gate to collector charge (turn-on)	Q_{gc}		-	160	260	
Turn-on switching loss	E_{ON}	I_C = 50 A V_{CC} = 400 V V_{GE} = 15 V R_g = 4.7 Ω L = 500 µH T_J = 25 °C (1)	-	0.155	-	mJ
Turn-off switching loss	E_{OFF}		-	0.471	-	
Total switching loss	E_{TOT}		-	0.626	-	
Turn-on delay time	$t_{d(on)}$		-	196	-	ns
Rise time	t_r		-	29	-	
Turn-off delay time	$t_{d(off)}$		-	220	-	
Fall time	t_f		-	67	-	

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SWITCHING CHARACTERISTICS (T_J = 25 °C unless otherwise noted)						
PARAMETER	**SYMBOL**	**TEST CONDITIONS**	**MIN.**	**TYP.**	**MAX.**	**UNITS**
Turn-on switching loss	E_{ON}	I_C = 50 A V_{CC} = 400 V V_{GE} = 15 V R_g = 4.7 Ω L = 500 µH T_J = 125 °C (1)	-	0.182	-	mJ
Turn-off switching loss	E_{OFF}		-	0.615	-	
Total switching loss	E_{TOT}		-	0.797	-	
Turn-on delay time	$t_{d(on)}$		-	198	-	ns
Rise time	t_r		-	29	-	
Turn-off delay time	$t_{d(off)}$		-	227	-	
Fall time	t_f		-	75	-	
Input capacitance	C_{ies}	V_{GE} = 0 V V_{CC} = 30 V f = 1 MHz	-	9500	-	pF
Output capacitance	C_{oes}		-	780	-	
Reverse transfer capacitance	C_{res}		-	116	-	
Reverse bias safe operating area	RBSOA	T_J = 150 °C, I_C = 150 A V_{CC} = 400 V, V_P = 600 V R_g = 22 Ω, V_{GE} = 15 V to 0 V	Fullsquare			
ANTIPARALLEL DIODE D1 - D2						
Diode reverse recovery time	t_{rr}	V_R = 200 V I_F = 20 A dI/dt = 500 A/µs, T_J = 25 °C	-	65	110	ns
Diode peak reverse current	I_{rr}		-	11	15	A
Diode reverse charge	Q_{rr}		-	350	825	nC
Diode reverse recovery time	t_{rr}	V_R = 200 V I_F = 20 A dI/dt = 500 A/µs, T_J = 125 °C	-	83	130	ns
Diode peak reverse current	I_{rr}		-	15	20	A
Diode reverse charge	Q_{rr}		-	587	1300	nC
PFC DIODE D3 - D4						
Diode reverse recovery time	t_{rr}	V_R = 200 V I_F = 10 A dI/dt = 200 A/µs, T_J = 25 °C	-	43	-	ns
Diode peak reverse current	I_{rr}		-	2.13	-	A
Diode reverse charge	Q_{rr}		-	45.5	-	nC
Diode reverse recovery time	t_{rr}	V_R = 200 V I_F = 10 A dI/dt = 200 A/µs, T_J = 125 °C	-	44	-	ns
Diode peak reverse current	I_{rr}		-	2.14	-	A
Diode reverse charge	Q_{rr}		-	46.5	-	nC

Note

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

THERMISTOR ELECTRICAL CHARACTERISTICS (T_J = 25 °C unless otherwise noted)						
PARAMETER	**SYMBOL**	**TEST CONDITIONS**	**MIN.**	**TYP.**	**MAX.**	**UNITS**
Resistance	R_{25}		4500	5000	5500	Ω
	R_{100}	T_J = 100 °C	468	493	518	
B value	B	T_J = 25 °C/T_J = 50 °C	3206	3375	3544	K

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THERMAL AND MECHANICAL SPECIFICATIONS					
PARAMETER	**SYMBOL**	**MIN.**	**TYP.**	**MAX.**	**UNITS**
Q1 - Q2 PFC IGBT - Junction to case thermal resistance (per switch)	R_{thJC}	-	-	0.37	°C/W
D1 - D2 AP diode - Junction to case thermal resistance (per diode)		-	-	4.29	
D3 - D4 PFC diode - Junction to case thermal resistance (per diode)		-	-	1.69	
Q1 - Q2 PFC IGBT - Case to sink thermal resistance (per switch)	R_{thCS} (1)	-	0.31	-	
D1 - D2 AP diode - Case to sink thermal resistance (per diode)		-	3.66	-	
D3 - D4 PFC diode - Case to sink thermal resistance (per diode)		-	1.1	-	
Mounting torque (M4)		2	-	3	Nm
Weight		-	39	-	g

Note

(1) Mounting surface flat, smooth, and greased

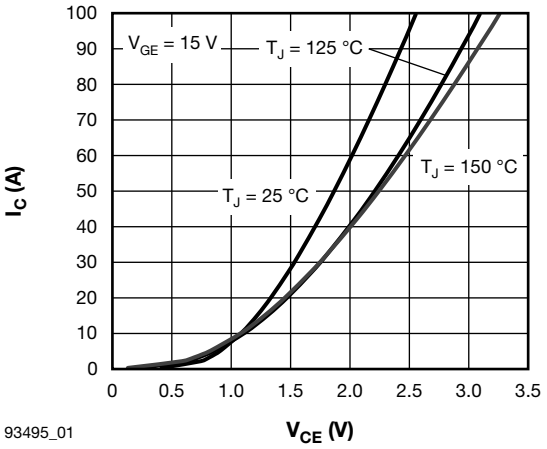

Fig. 1 - Typical PFC IGBT Output Characteristics

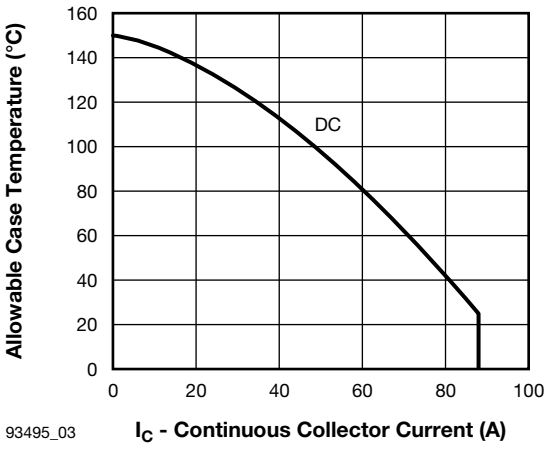

Fig. 3 - Maximum DC PFC IGBT Collector Current vs. Case Temperature per Junction

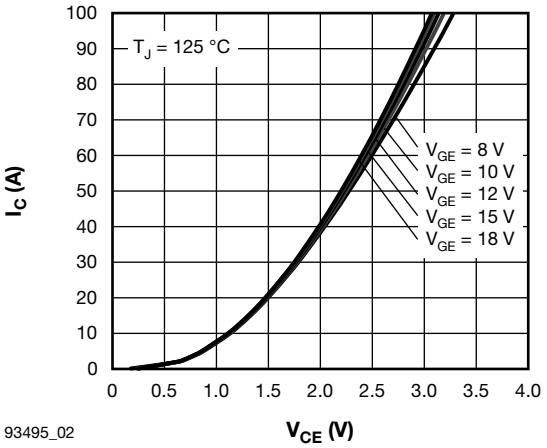

Fig. 2 - Typical PFC IGBT Output Characteristics

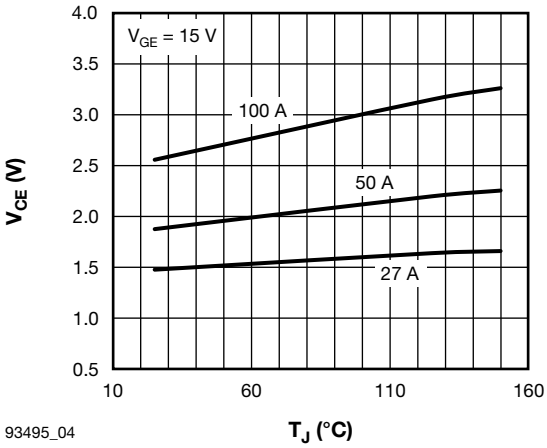

Fig. 4 - Typical PFC IGBT Collector to Emitter Voltage vs. Junction Temperature

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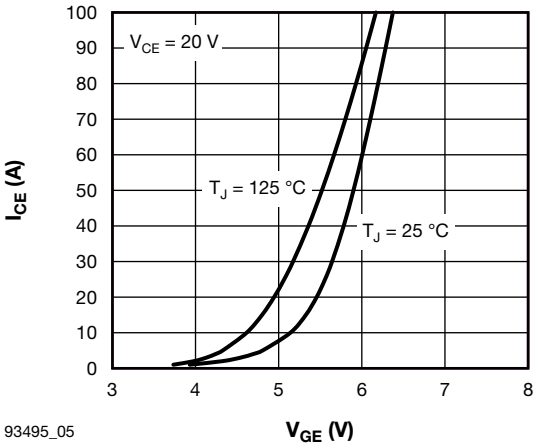

Fig. 5 - Typical PFC IGBT Transfer Characteristics

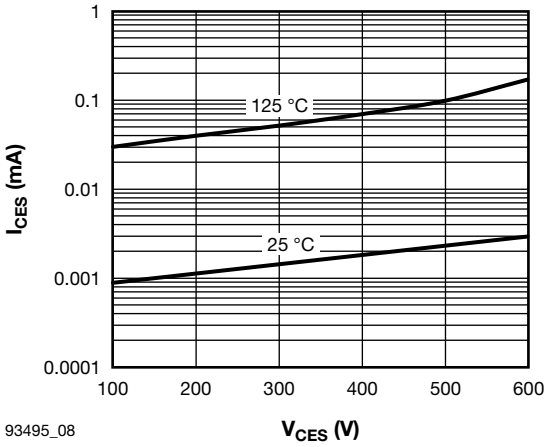

Fig. 8 - Typical PFC IGBT Zero Gate Voltage Collector Current

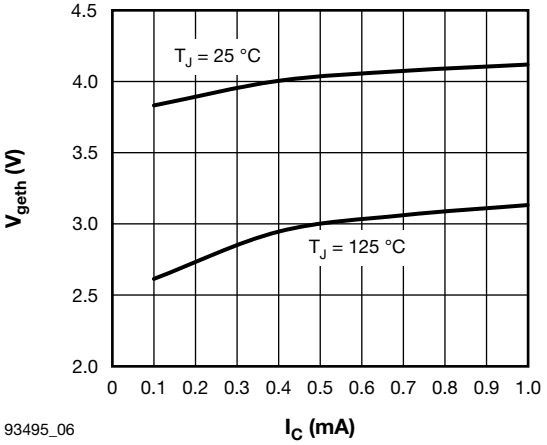

Fig. 6 - Typical PFC IGBT Gate Threshold Voltage

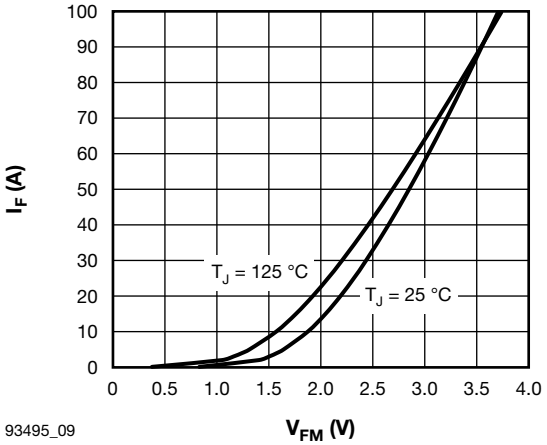

Fig. 9 - Typical Antiparallel Diode Forward Characteristics

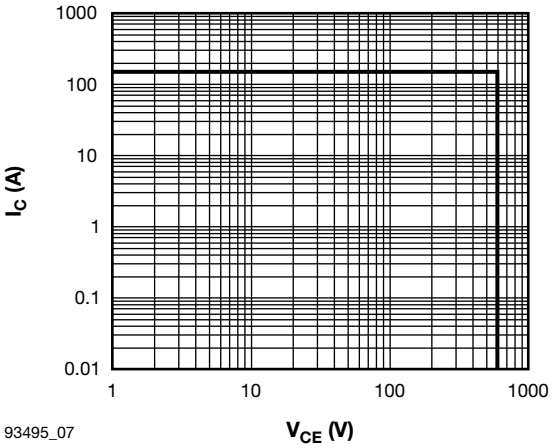

Fig. 7 - IGBT Reverse Bias SOA
T_J = 150 °C, V_{GE} = 15 V, R_g = 22 Ω

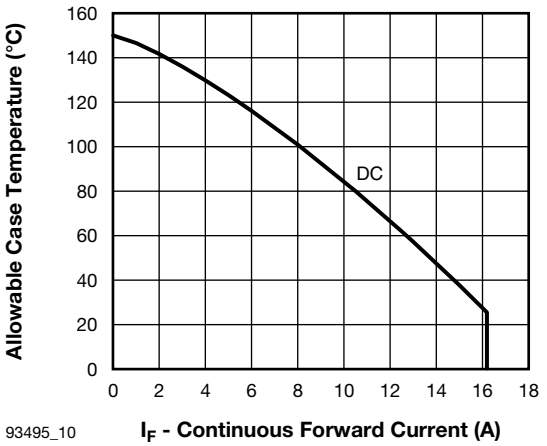

Fig. 10 - Maximum DC Antiparallel Diode Forward Current vs. Case Temperature per Junction

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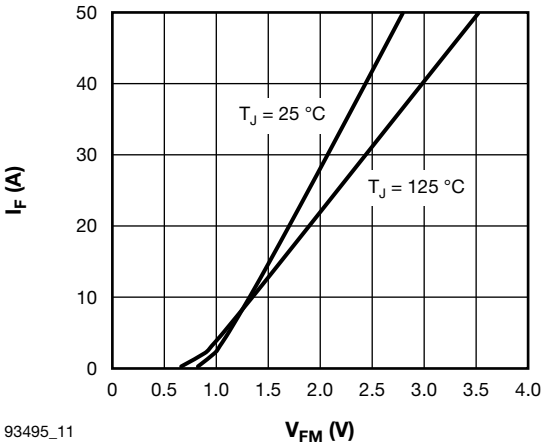

Fig. 11 - Typical PFC Diode Forward Characteristics

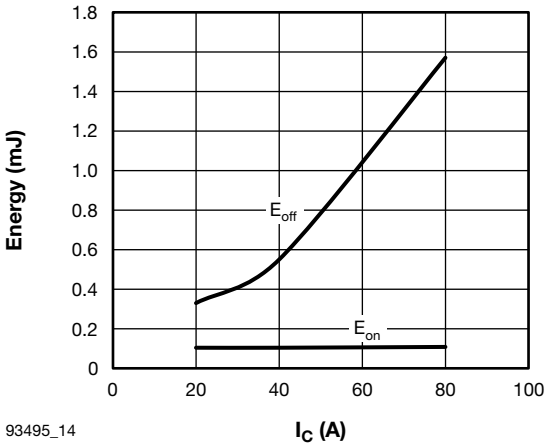

Fig. 14 - Typical PFC IGBT Energy Loss vs. I_C
(with Freewheeling D3 - D4 PFC Diode)
T_J = 125 °C, V_{CC} = 400 V, R_g = 4.7 Ω, V_{GE} = 15 V, L = 500 µH

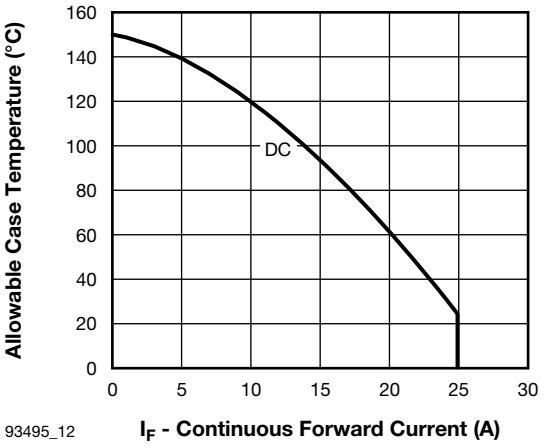

Fig. 12 - Maximum DC PFC Diode Forward Current vs.
Case Temperature per Junction

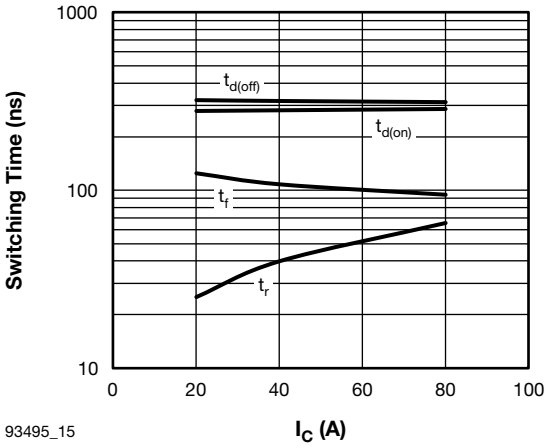

Fig. 15 - Typical PFC IGBT Switching Time vs. I_C
(with Freewheeling D3 - D4 PFC Diode)
T_J = 125 °C, V_{CC} = 400 V, R_g = 4.7 Ω, V_{GE} = 15 V, L = 500 µH

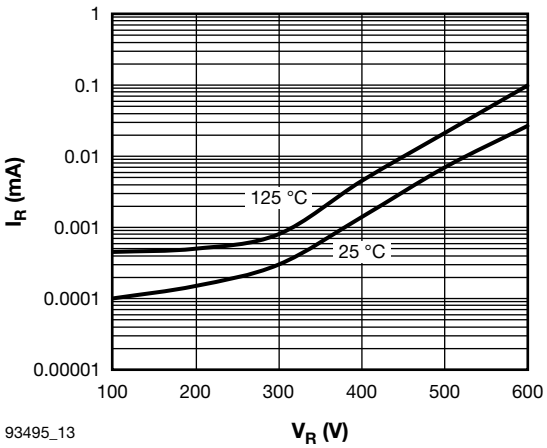

Fig. 13 - Typical PFC Diode Reverse Leakage Current

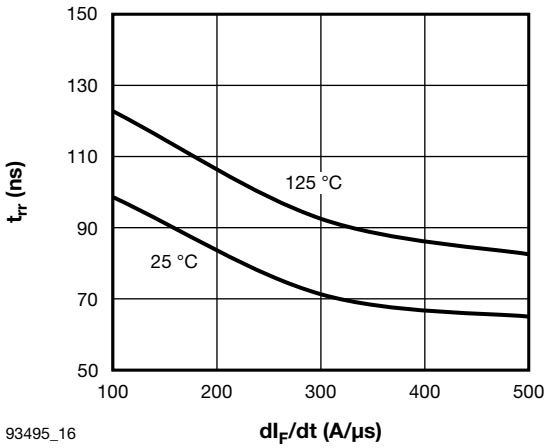

Fig. 16 - Typical Antiparallel Reverse Recovery Time vs. dI_F/dt
V_R = 200 V, I_F = 20 A

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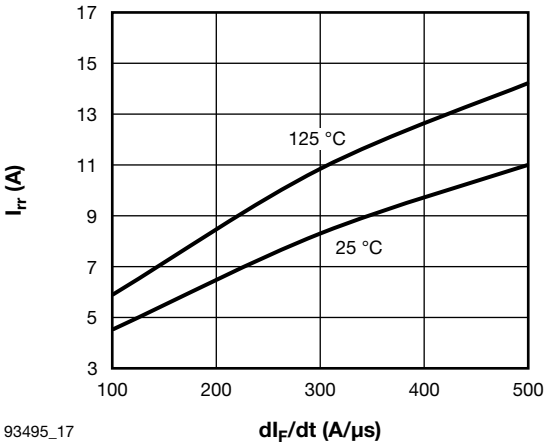

Fig. 17 - Typical Antiparallel Reverse Recovery Current vs. dI_F/dt
V_R = 200 V, I_F = 20 A

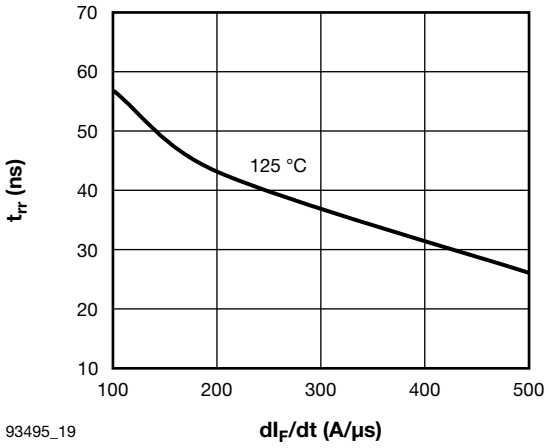

Fig. 19 - Typical PFC Diode Reverse Recovery Time vs. dI_F/dt
V_R = 200 V, I_F = 10 A

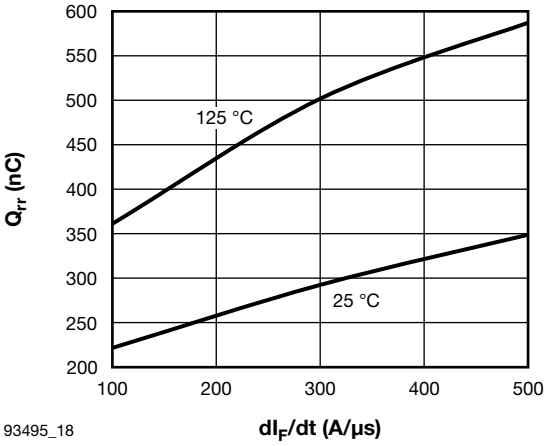

Fig. 18 - Typical Antiparallel Reverse Recovery Charge vs. dI_F/dt
V_R = 200 V, I_F = 20 A

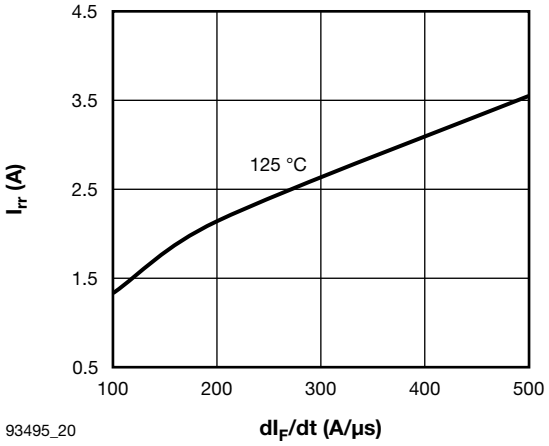

Fig. 20 - Typical PFC Diode Reverse Recovery Current vs. dI_F/dt
V_R = 200 V, I_F = 10 A

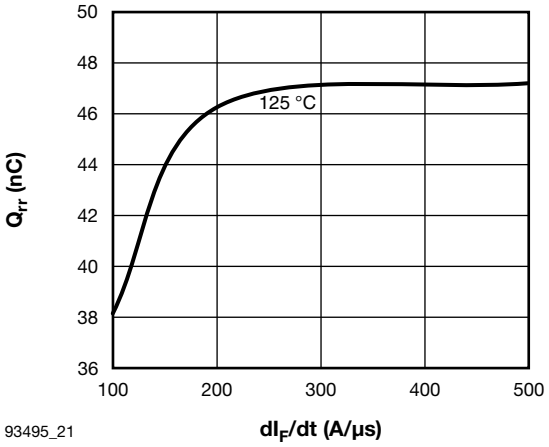

Fig. 21 - Typical PFC Diode Reverse Recovery Charge vs. dI_F/dt
V_R = 200 V, I_F = 10 A

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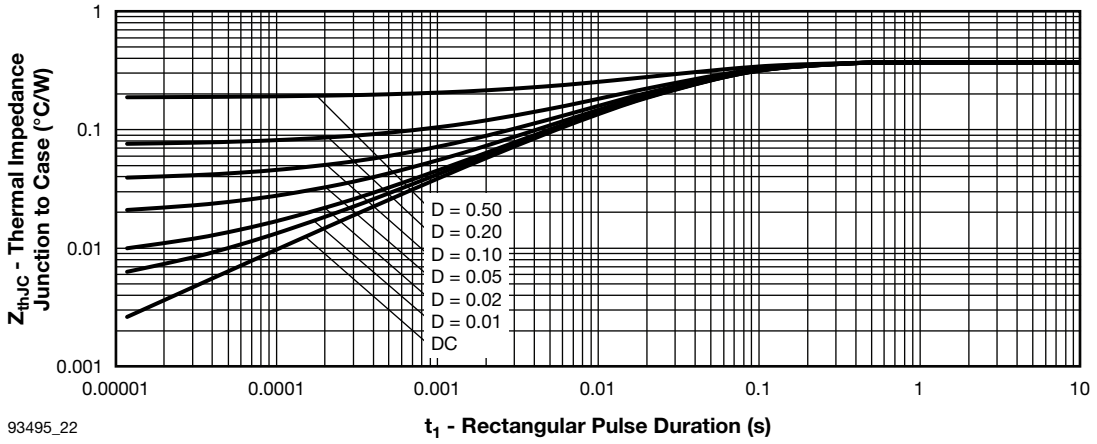

Fig. 22 - Maximum Thermal Impedance Z_{thJC} Characteristics (IGBT)

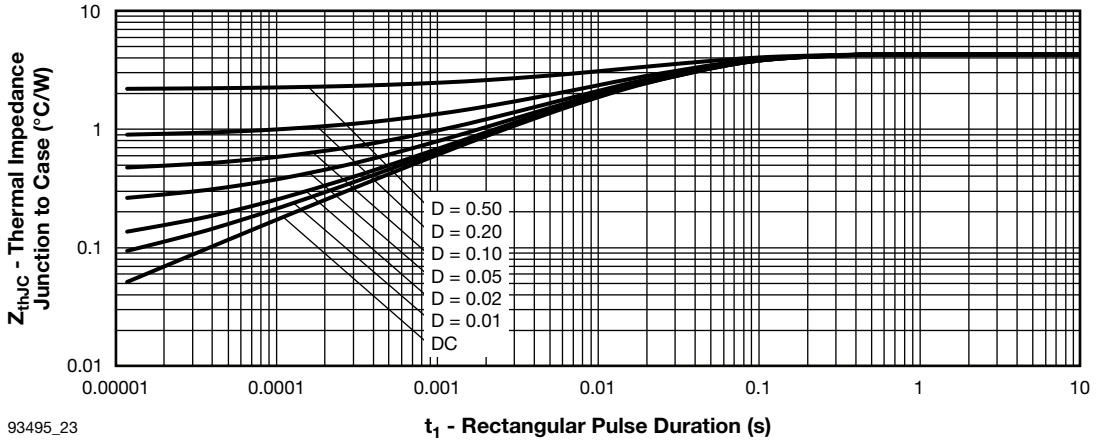

Fig. 23 - Maximum Thermal Impedance Z_{thJC} Characteristics (Antiparallel Diode)

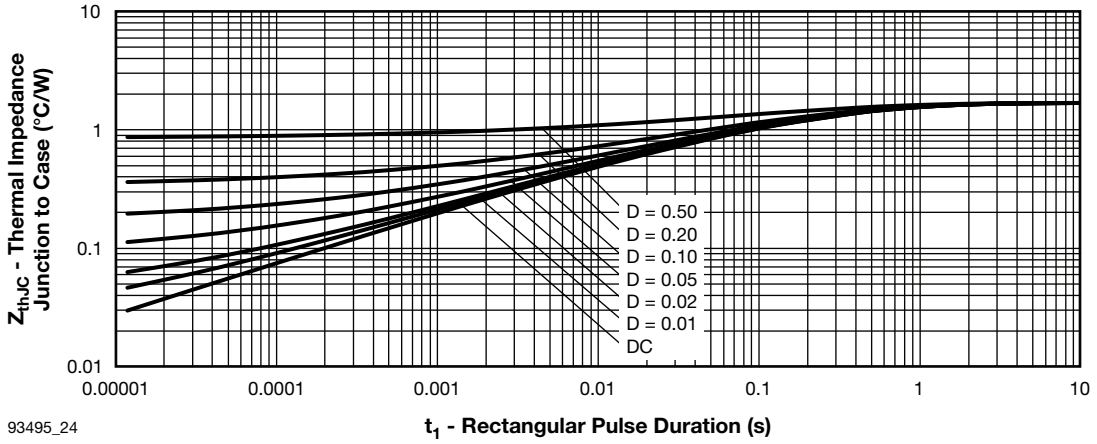

Fig. 24 - Maximum Thermal Impedance Z_{thJC} Characteristics (PFC Diode)

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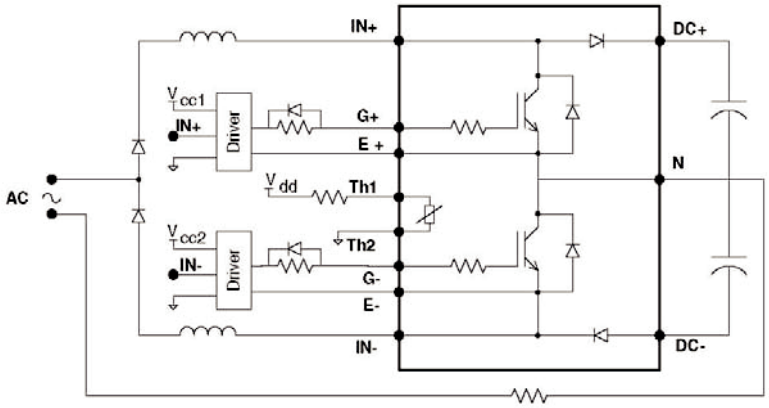
ORDERING INFORMATION TABLE

Device code

VS-	EM	G	050	J	60	N
1	2	3	4	5	6	7

- 1 - Vishay Semiconductors product
- 2 - Package indicator (EM = EMIPAK2)
- 3 - Circuit configuration (G = Dual mode PFC)
- 4 - Current rating (050 = 50 A)
- 5 - Die technology (J = Warp2 IGBT)
- 6 - Voltage rating (60 = 600 V)
- 7 - N = Ultrafast

TYPICAL CONNECTION



Note

- Please refer to lead assignment for correct pin configuration. This diagram shows electrical connections only.

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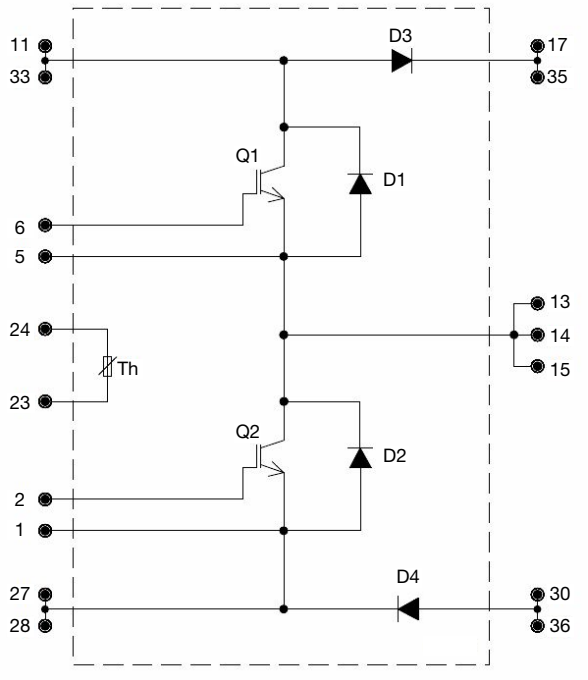
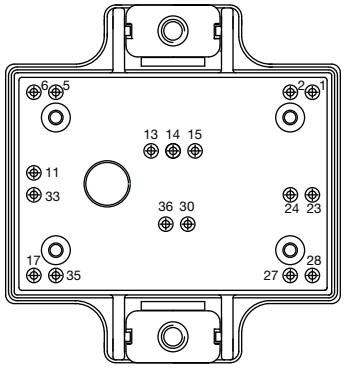
CIRCUIT CONFIGURATION



PACKAGE



LINKS TO RELATED DOCUMENTS	
Dimensions	www.vishay.com/doc?95436

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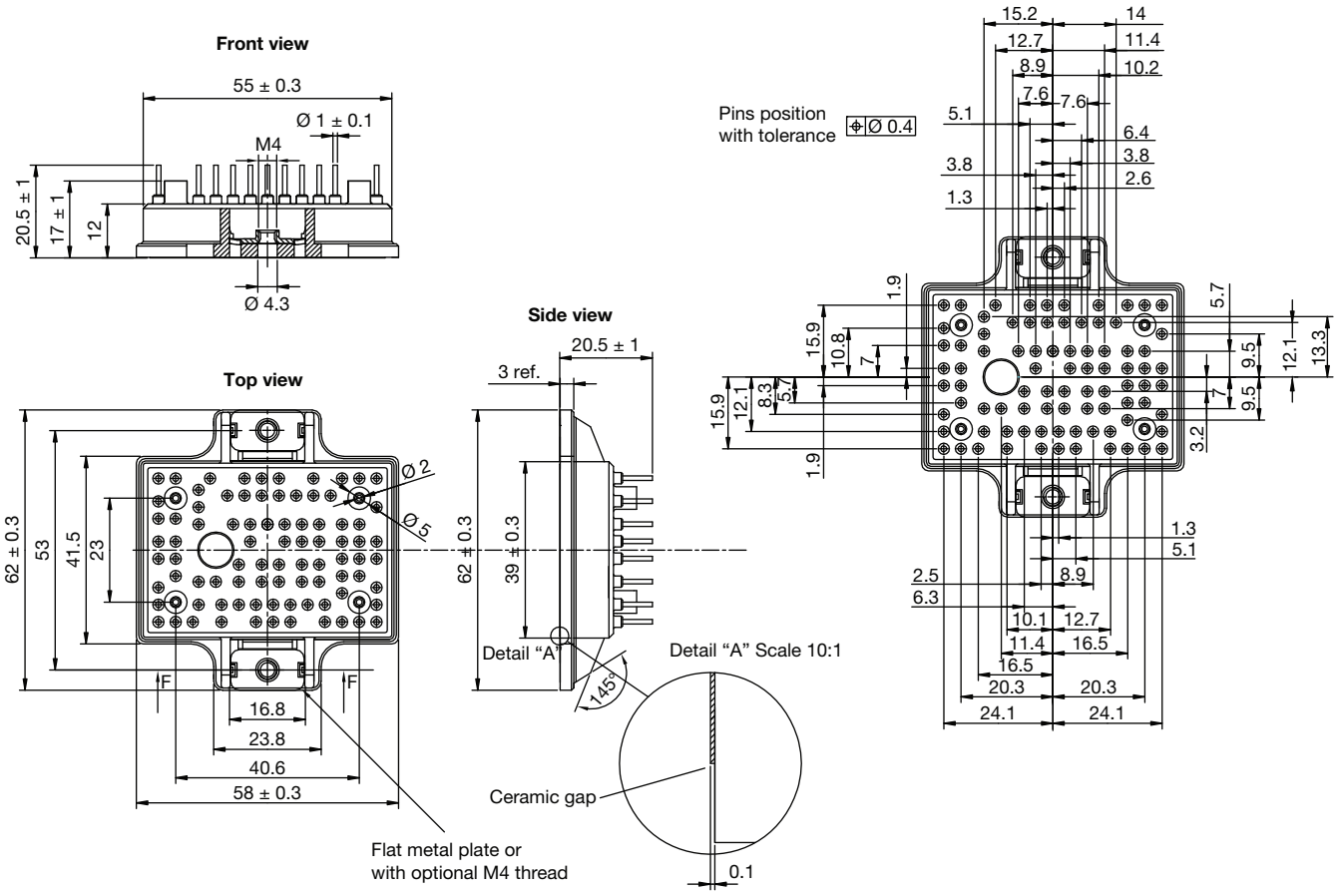
EMIPAK2

DIMENSIONS in millimeters



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