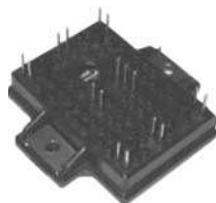


Dual Mode PFC, 60 A


EMIPAK2

FEATURES

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


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
Speed	30 kHz to 150 kHz
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, $L = 500$ μ H, $R_g = 22$ Ω , $T_J = 150$ °C



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	ΔBV _{CES} /ΔT _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	ΔV _{GE(th)} /ΔT _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 ($T_J = 25\text{ }^{\circ}\text{C}$ 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	$I_C = 70\text{ A}$ $V_{CC} = 400\text{ V}$ $V_{GE} = 15\text{ V}$	-	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}	$I_C = 50\text{ A}$ $V_{CC} = 400\text{ V}$ $V_{GE} = 15\text{ V}$ $R_g = 4.7\text{ }\Omega$ $L = 500\text{ }\mu\text{H}$ $T_J = 25\text{ }^{\circ}\text{C}^{(1)}$	-	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	-	

**SWITCHING CHARACTERISTICS** ($T_J = 25\text{ }^{\circ}\text{C}$ unless otherwise noted)

PARAMETER	SYMBOL	TEST CONDITIONS	MIN.	TYP.	MAX.	UNITS
Turn-on switching loss	E_{ON}	$I_C = 50\text{ A}$ $V_{CC} = 400\text{ V}$ $V_{GE} = 15\text{ V}$ $R_g = 4.7\text{ }\Omega$ $L = 500\text{ }\mu\text{H}$ $T_J = 125\text{ }^{\circ}\text{C}$ (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}	$V_{GE} = 0\text{ V}$ $V_{CC} = 30\text{ V}$ $f = 1\text{ MHz}$	-	9500	-	pF
Output capacitance	C_{oes}		-	780	-	
Reverse transfer capacitance	C_{res}		-	116	-	
Reverse bias safe operating area	RBSOA	$T_J = 150\text{ }^{\circ}\text{C}$, $I_C = 150\text{ A}$ $V_{CC} = 400\text{ V}$, $V_P = 600\text{ V}$ $R_g = 22\text{ }\Omega$, $V_{GE} = 15\text{ V to }0\text{ V}$	Fullsquare			

ANTIPARALLEL DIODE D1 - D2

Diode reverse recovery time	t_{rr}	$V_R = 200\text{ V}$ $I_F = 20\text{ A}$ $di/dt = 500\text{ A}/\mu\text{s}$, $T_J = 25\text{ }^{\circ}\text{C}$	-	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}	$V_R = 200\text{ V}$ $I_F = 20\text{ A}$ $di/dt = 500\text{ A}/\mu\text{s}$, $T_J = 125\text{ }^{\circ}\text{C}$	-	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}	$V_R = 200\text{ V}$ $I_F = 10\text{ A}$ $di/dt = 200\text{ A}/\mu\text{s}$, $T_J = 25\text{ }^{\circ}\text{C}$	-	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}	$V_R = 200\text{ V}$ $I_F = 10\text{ A}$ $di/dt = 200\text{ A}/\mu\text{s}$, $T_J = 125\text{ }^{\circ}\text{C}$	-	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 ($T_J = 25\text{ }^{\circ}\text{C}$ unless otherwise noted)

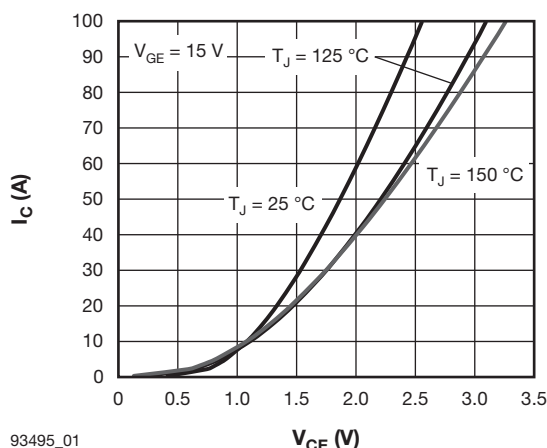
PARAMETER	SYMBOL	TEST CONDITIONS	MIN.	TYP.	MAX.	UNITS
Resistance	R_{25}		4500	5000	5500	Ω
	R_{100}	$T_J = 100\text{ }^{\circ}\text{C}$	468	493	518	
B value	B	$T_J = 25\text{ }^{\circ}\text{C}/T_J = 50\text{ }^{\circ}\text{C}$	3206	3375	3544	K

**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	$^{\circ}\text{C}/\text{W}$
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

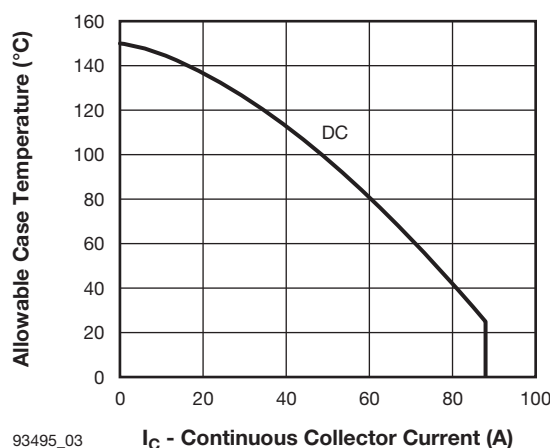
Note

(1) Mounting surface flat, smooth, and greased



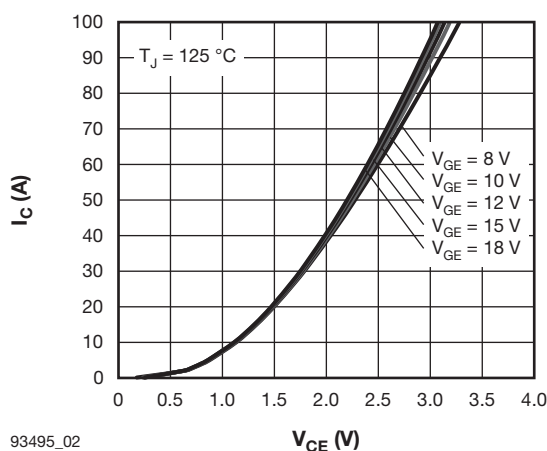
93495_01

Fig. 1 - Typical PFC IGBT Output Characteristics



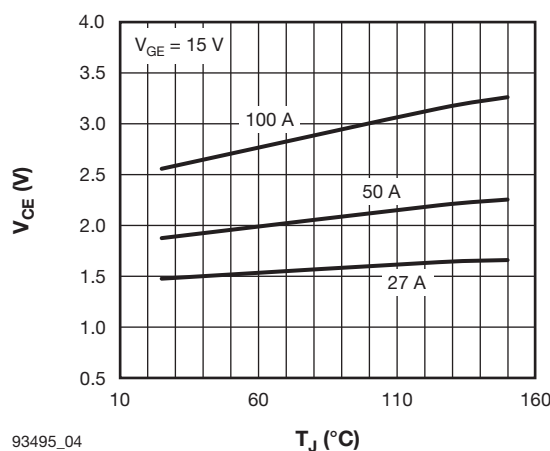
93495_03

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



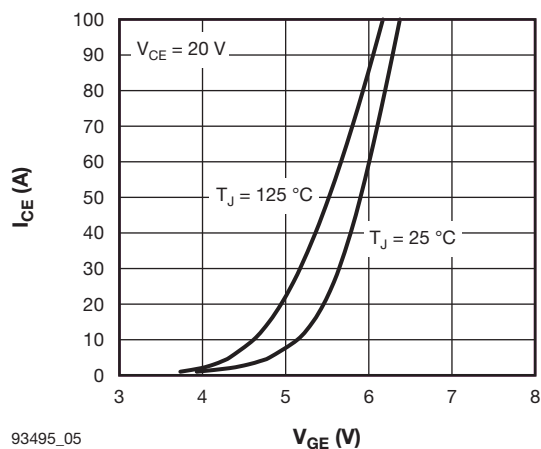
93495_02

Fig. 2 - Typical PFC IGBT Output Characteristics



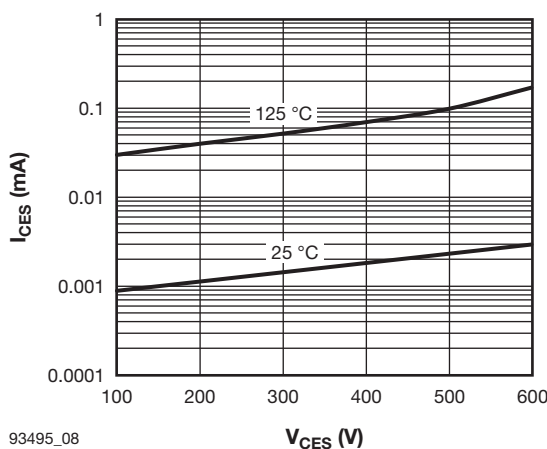
93495_04

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



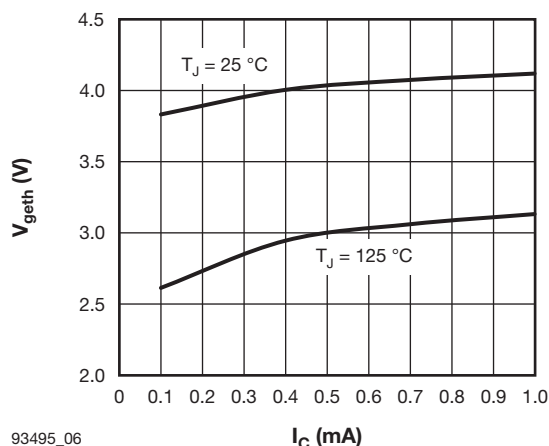
93495_05

Fig. 5 - Typical PFC IGBT Transfer Characteristics



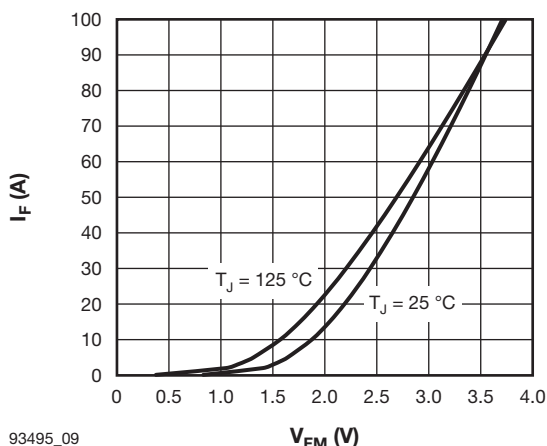
93495_08

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



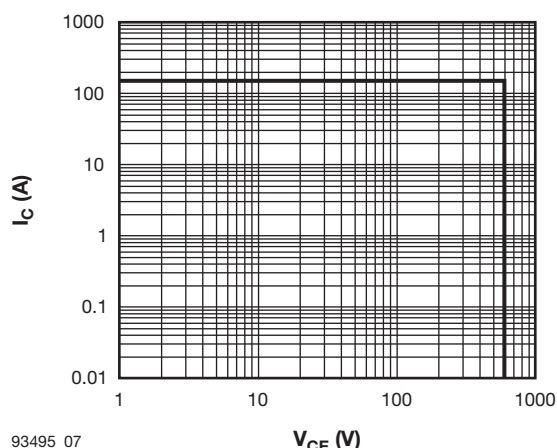
93495_06

Fig. 6 - Typical PFC IGBT Gate Threshold Voltage

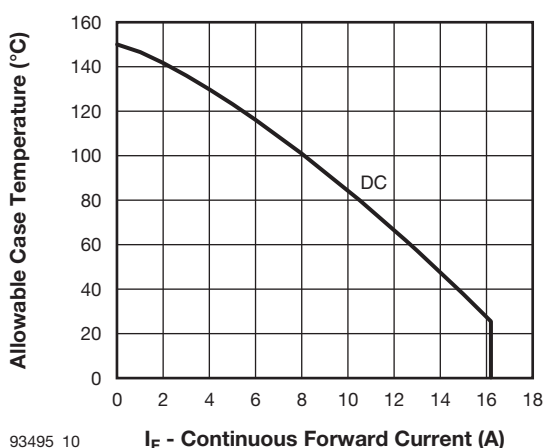


93495_09

Fig. 9 - Typical Antiparallel Diode Forward Characteristics

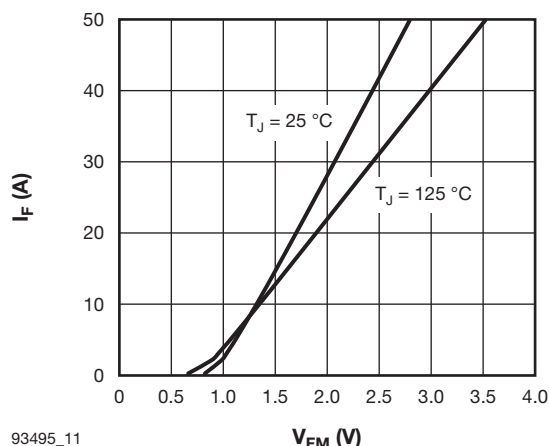


93495_07

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


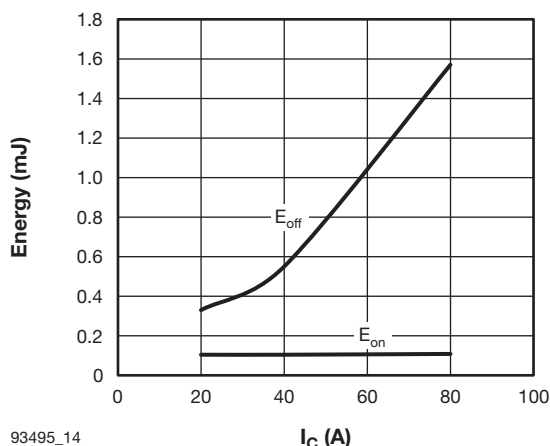
93495_10

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



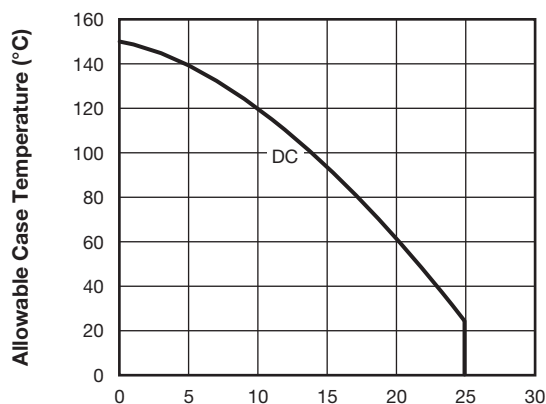
93495_11

Fig. 11 - Typical PFC Diode Forward Characteristics



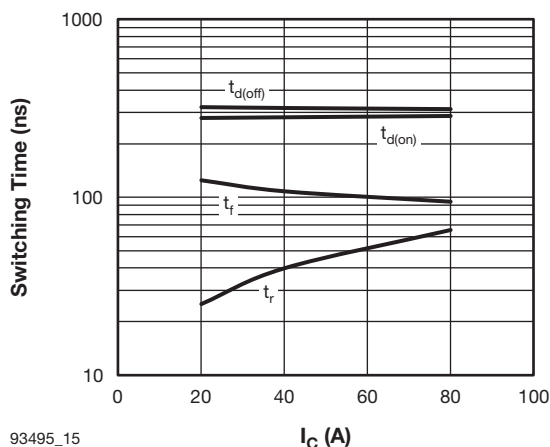
93495_14

Fig. 14 - Typical PFC IGBT Energy Loss vs. I_C
(with Freewheeling D3 - D4 PFC Diode)

 $T_J = 125\text{ °C}$, $V_{CC} = 400\text{ V}$, $R_g = 4.7\text{ }\Omega$, $V_{GE} = 15\text{ V}$, $L = 500\text{ }\mu\text{H}$


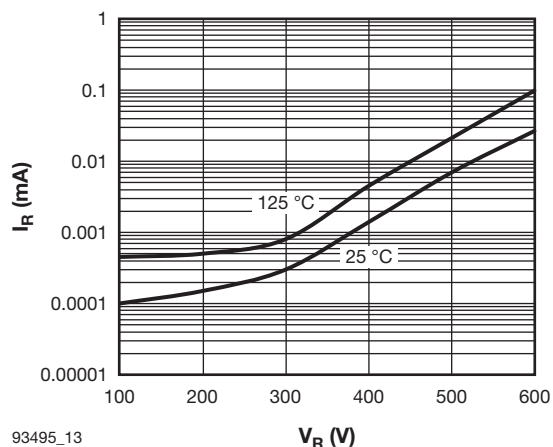
93495_12

 I_F - Continuous Forward Current (A)

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


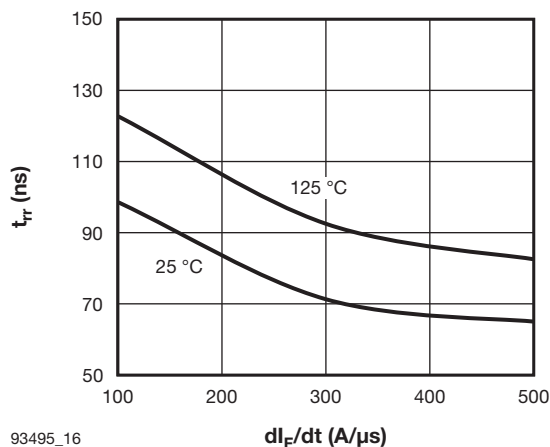
93495_15

Fig. 15 - Typical PFC IGBT Switching Time vs. I_C
(with Freewheeling D3 - D4 PFC Diode)

 $T_J = 125\text{ °C}$, $V_{CC} = 400\text{ V}$, $R_g = 4.7\text{ }\Omega$, $V_{GE} = 15\text{ V}$, $L = 500\text{ }\mu\text{H}$


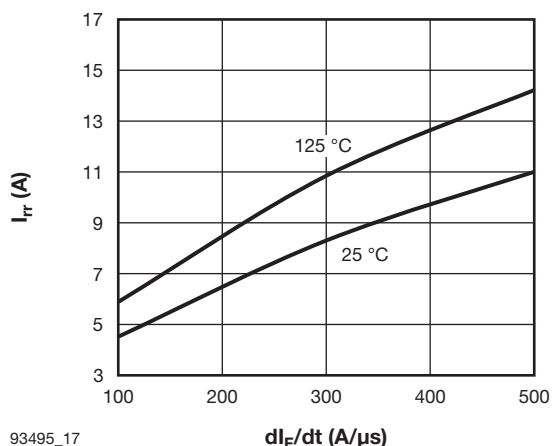
93495_13

Fig. 13 - Typical PFC Diode Reverse Leakage Current



93495_16

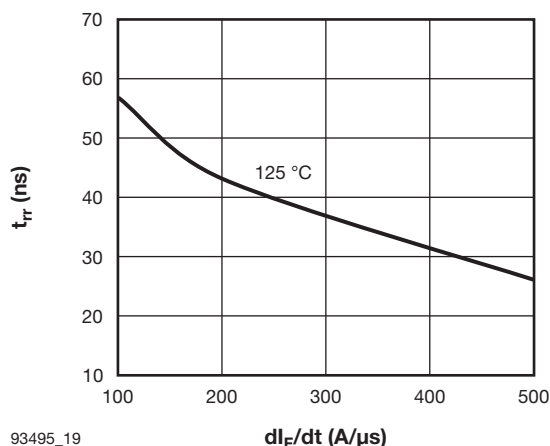
Fig. 16 - Typical Antiparallel Reverse Recovery Time vs. dI_F/dt
 $V_R = 200\text{ V}$, $I_F = 20\text{ A}$



93495_17

 dI_F/dt (A/μs)

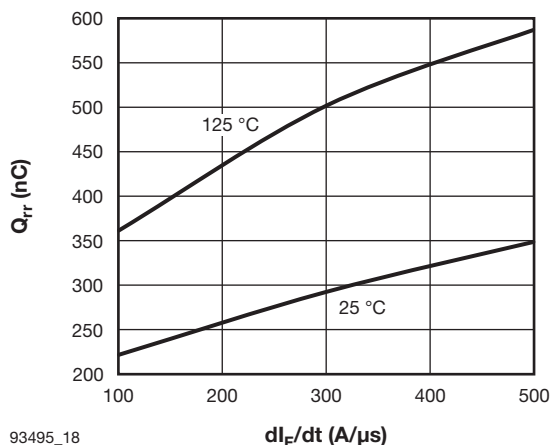
Fig. 17 - Typical Antiparallel Reverse Recovery Current vs. dI_F/dt
 $V_R = 200$ V, $I_F = 20$ A



93495_19

 dI_F/dt (A/μs)

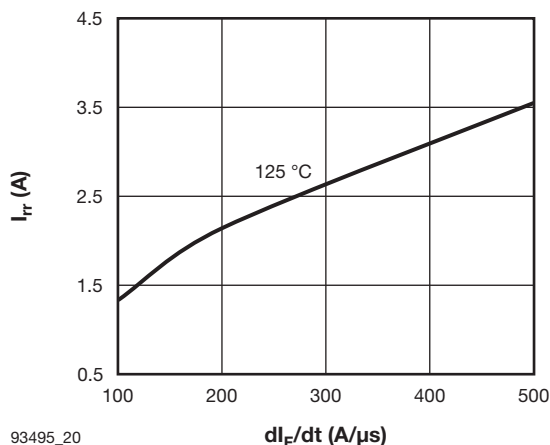
Fig. 19 - Typical PFC Diode Reverse Recovery Time vs. dI_F/dt
 $V_R = 200$ V, $I_F = 10$ A



93495_18

 dI_F/dt (A/μs)

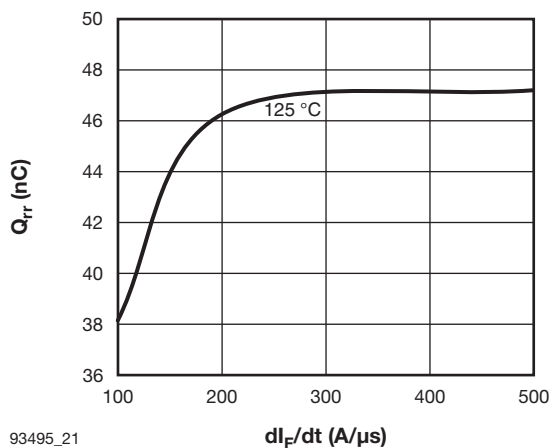
Fig. 18 - Typical Antiparallel Reverse Recovery Charge vs. dI_F/dt
 $V_R = 200$ V, $I_F = 20$ A



93495_20

 dI_F/dt (A/μs)

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



93495_21

 dI_F/dt (A/μs)

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

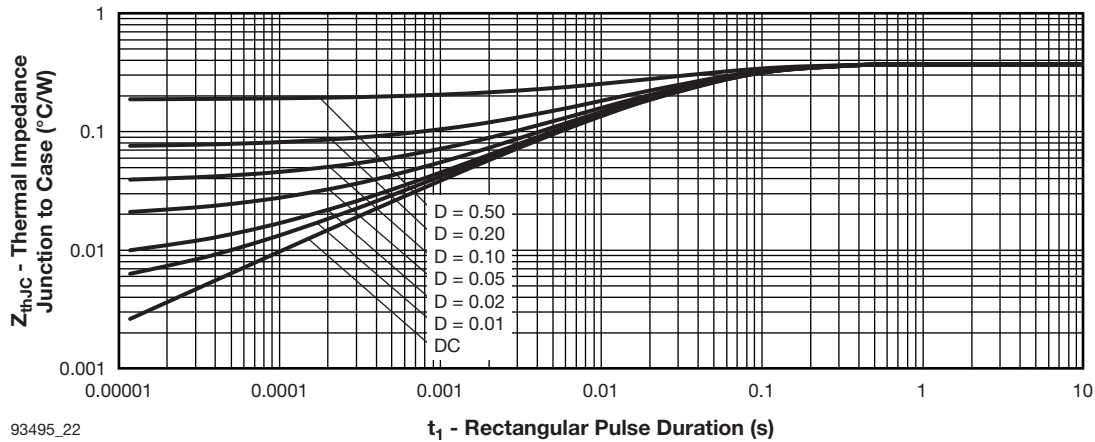


Fig. 22 - Maximum Thermal Impedance Z_{thJC} Characteristics (IGBT)

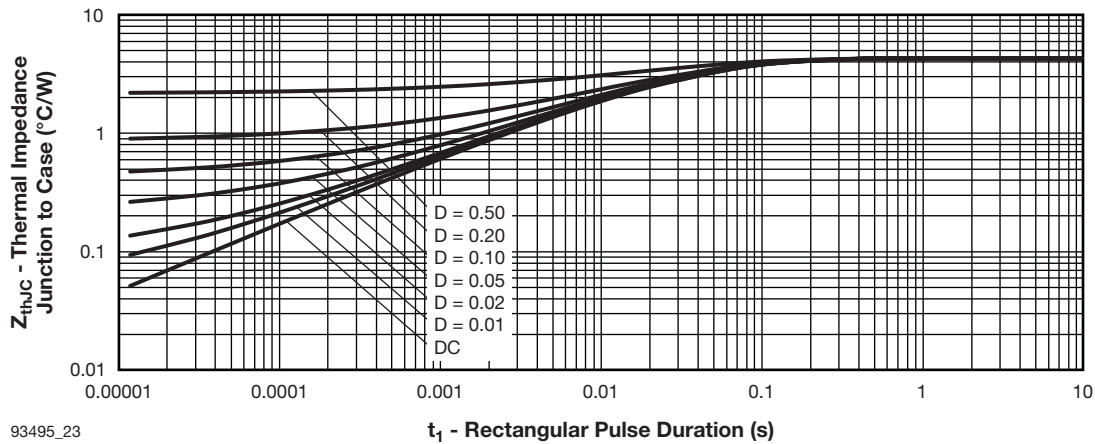


Fig. 23 - Maximum Thermal Impedance Z_{thJC} Characteristics (Antiparallel Diode)

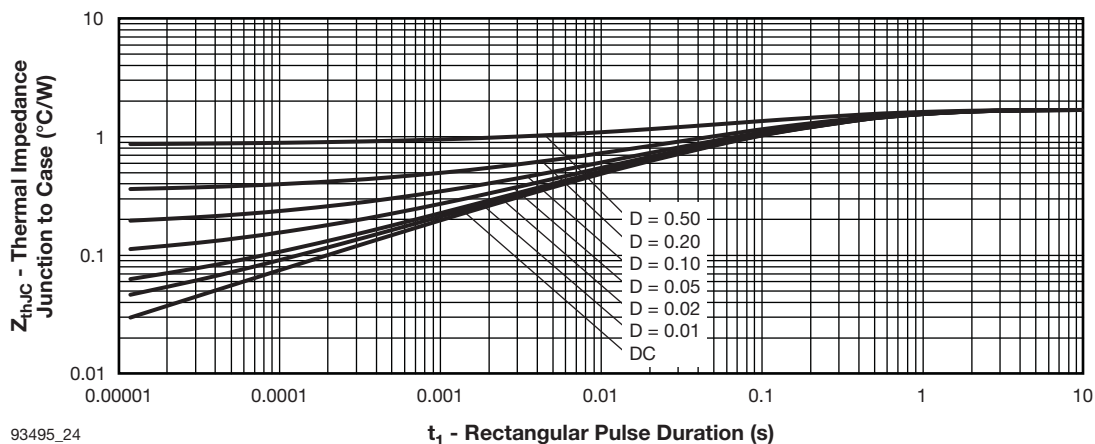
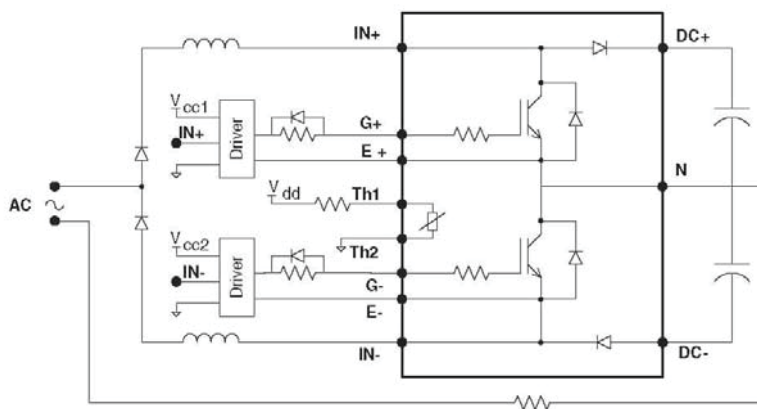


Fig. 24 - Maximum Thermal Impedance Z_{thJC} Characteristics (PFC Diode)

ORDERING INFORMATION TABLE

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

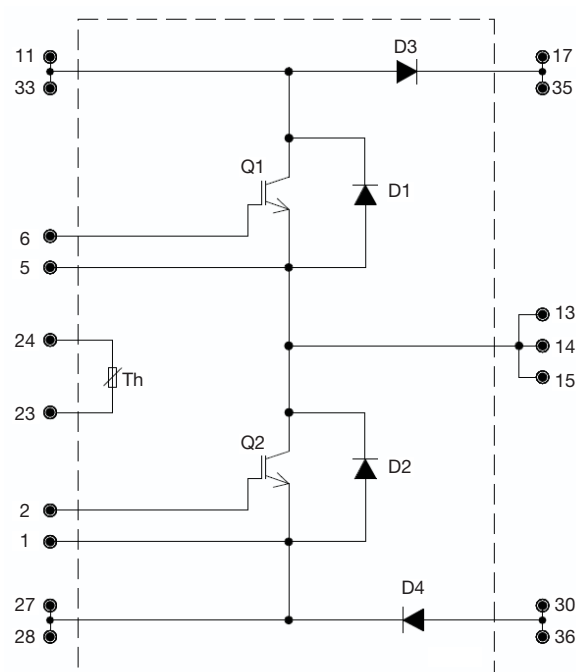
- 1** - Vishay Semiconductors product
- 2** - Package indicator (EM = EMIPAK2)
- 3** - Circuit configuration (G = Dual mode PFC)
- 4** - Current rating (050 = 50 A)
- 5** - Die technology (J = Warp2 IGBT)
- 6** - Voltage rating (60 = 600 V)
- 7** - N = Ultrafast

TYPICAL CONNECTION

Note

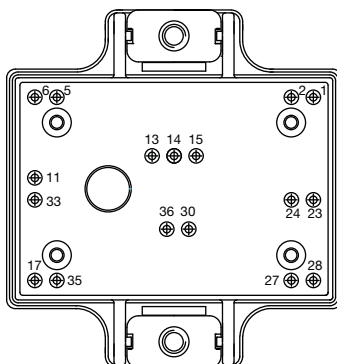
- Please refer to lead assignment for correct pin configuration. This diagram shows electrical connections only.



CIRCUIT CONFIGURATION



PACKAGE



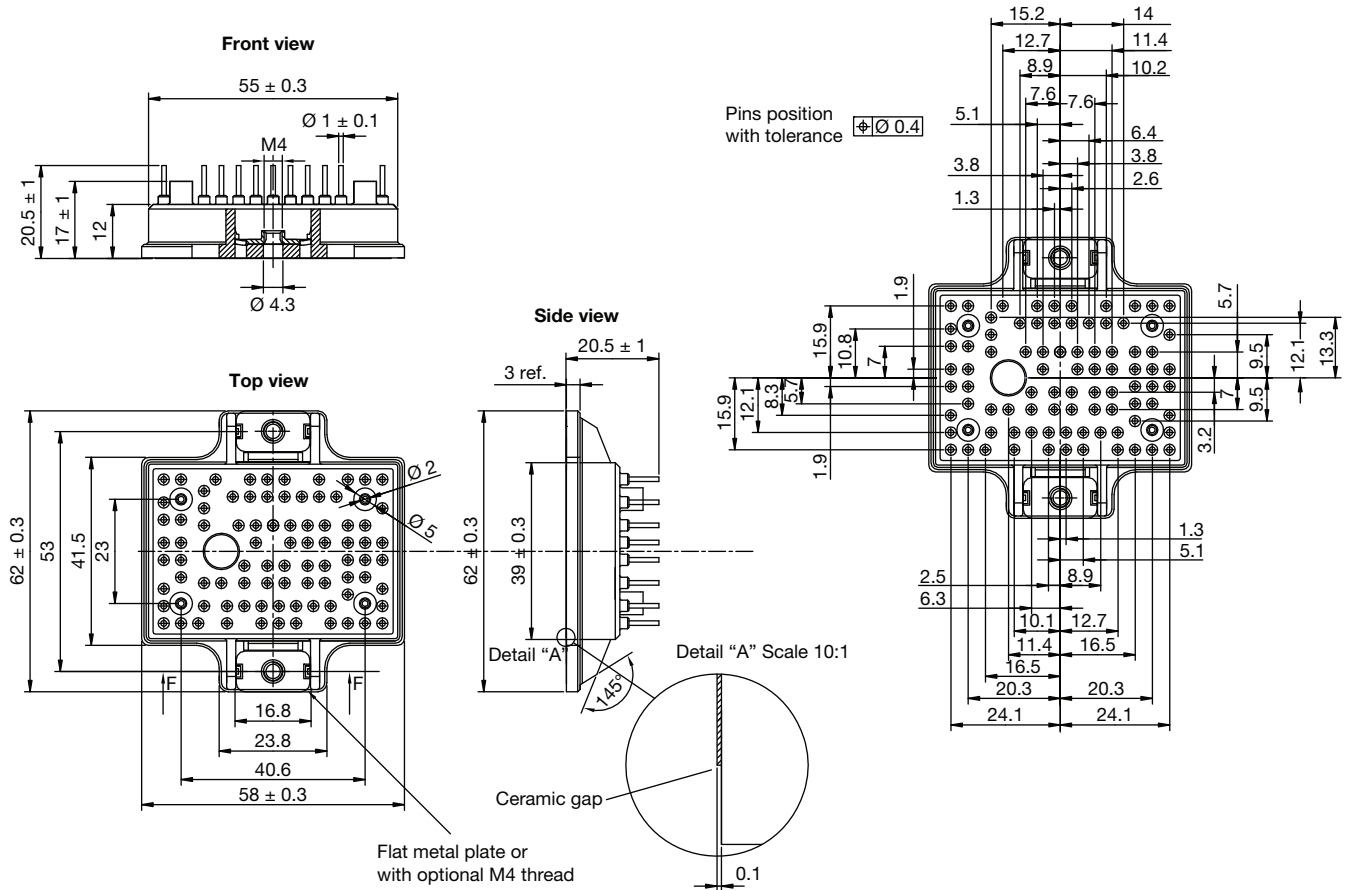
LINKS TO RELATED DOCUMENTS

Dimensions

www.vishay.com/doc?95436

EMIPAK2

DIMENSIONS in millimeters





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Please note that some Vishay documentation may still make reference to RoHS Directive 2002/95/EC. We confirm that all the products identified as being compliant to Directive 2002/95/EC conform to Directive 2011/65/EU.

Vishay Intertechnology, Inc. hereby certifies that all its products that are identified as Halogen-Free follow Halogen-Free requirements as per JEDEC JS709A standards. Please note that some Vishay documentation may still make reference to the IEC 61249-2-21 definition. We confirm that all the products identified as being compliant to IEC 61249-2-21 conform to JEDEC JS709A standards.