

IXRFFB60110 Silicon Carbide Full Wave Bridge Rectifier

600 V
10 A

Features

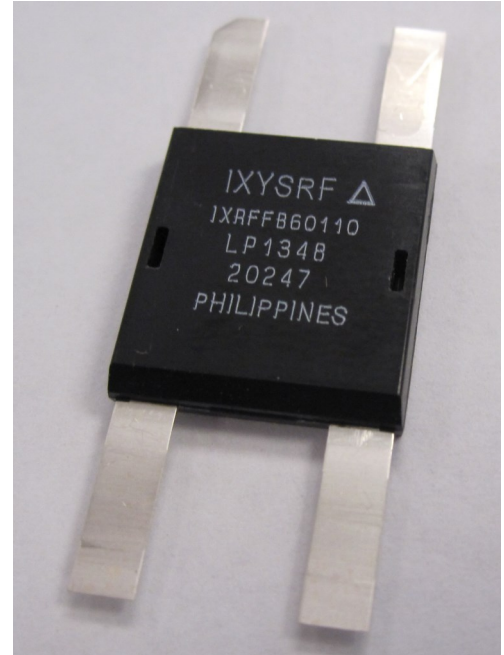
- Silicon carbide Schottky diodes
 - No reverse recovery for soft turn-off
 - Temperature independent switching behavior
 - Low leakage current
- Easy to mount, no insulators needed
- High power density
- Isolated substrate
 - High isolation voltage
 - Excellent thermal transfer
 - Increased temperature and power cycling capability
- Very low insertion inductance
- No Beryllium Oxide (BeO) or other hazardous materials
- RoHS compliant

Advantages

- Optimized for high speed
- Easy to mount, no insulators needed
- High power density

Applications

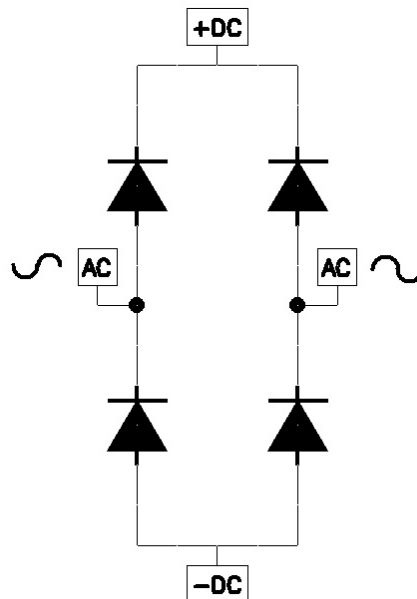
- Output rectifier for high frequency power converters
- General high speed rectifier circuits



Description

The IXRFFB60110 is a 600 V, 10 A silicon carbide diode full bridge rectifier packaged in IXYSRFs low-inductance RF package incorporating layout techniques to minimize stray lead inductances for optimum performance. The benefits of silicon carbide include faster operation due to the minimal reverse recovery from only the stored charge of the junction capacitance. The IXRFFB60110 takes advantage of silicon carbide’s high surge current capability, and is mounted in our RF package, to provide exceptional thermal resistance properties that enhance high frequency operation. It is a surface-mountable device.

Figure 1 Functional Diagram



Device Specifications

Symbol	Parameter	Test Conditions	Maximum Ratings	
V_{RRM}	Repetitive peak reverse voltage		600	V
V_{RSM}	Repetitive surge reverse voltage		600	V
V_{DC}	DC blocking voltage		600	V
$I_{F(AVG)}$	Average forward current (per diode)	$T_J = 175^\circ\text{C}$	10	A
I_{FRM}	Repetitive peak forward surge current (per diode)	$T_C = 25^\circ\text{C}$, $t_p = 10\text{ ms}$ Half sine wave	67	A
I_{FSM}	Non-repetitive peak forward surge current (per diode)	$T_C = 25^\circ\text{C}$, $t_p = 10\ \mu\text{s}$ Pulse	250	A
T_{OT}	Operating temperature		-40°C to 85°C	°C
T_{VJ}	Operating virtual junction temperature		-55 to +175	°C
T_{STG}	Storage temperature		-55 to +175	°C
P_{TOT}	Power total	$T_C = 25^\circ\text{C}$	160	W

Device Performance

Symbol	Parameter	Test Conditions	Characteristic Values		
			Typ.	Max.	Units
$T_J = 25^\circ\text{C}$ unless otherwise specified per diode					
V_F	Forward voltage	$I_F = 5\text{ A}$, $T_J = 25^\circ\text{C}$ $T_J = 175^\circ\text{C}$	1.6 2	1.8 2.4	V
I_R	Reverse current	$V_R = 600\text{ V}$, $T_J = 25^\circ\text{C}$ $T_J = 175^\circ\text{C}$	10 20	50 200	μA
C_J	Junction capacitance	$f = 1\text{ MHz}$, $V_R = 0\text{ V}$ $V_R = 200\text{ V}$ $V_R = 600\text{ V}$	485 85 80		pF
R_{THJC}	Thermal resistance		0.94		°C/W
T_L	Lead soldering temperature	1.6 mm (0.063 in) from case for 10 s	300		°C
Isolation	Pin to substrate Pin to pin		>1800 >1500		V_{RMS}
C_{stray}	Stray capacitance	$f = 1\text{ MHz}$ Any one pin to the metallized back	46		pF
Weight			2		g

Note: All performance characteristics are per diode in bridge

Note: All charts are per diode in bridge

Fig. 2

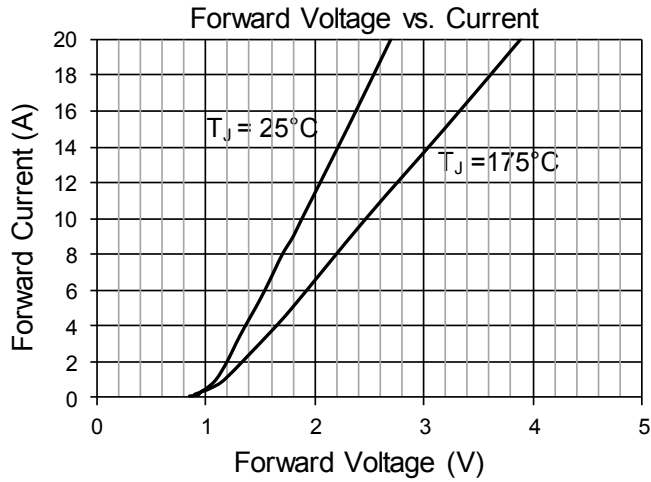


Fig. 3

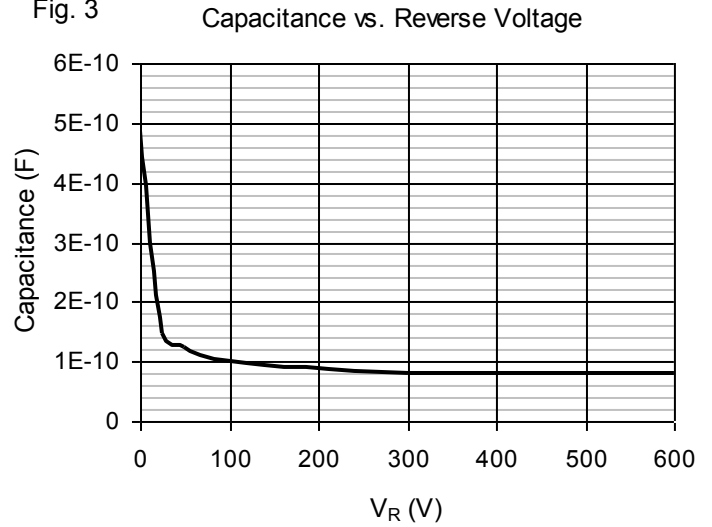


Fig. 4

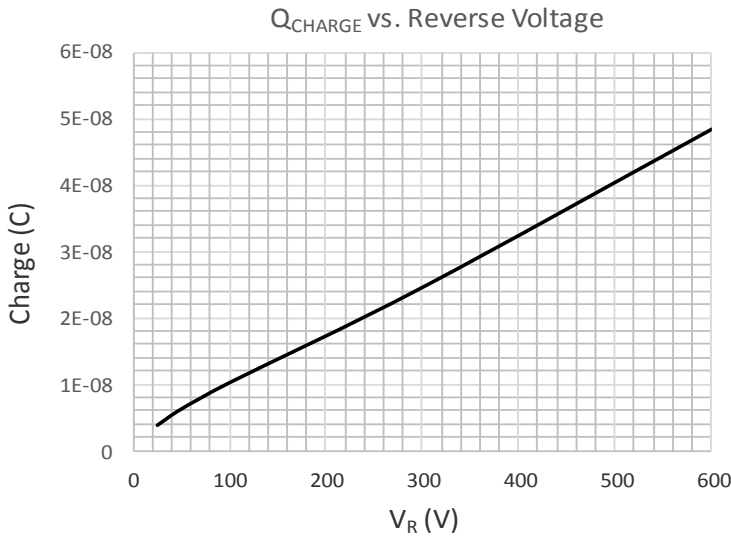


Fig. 5

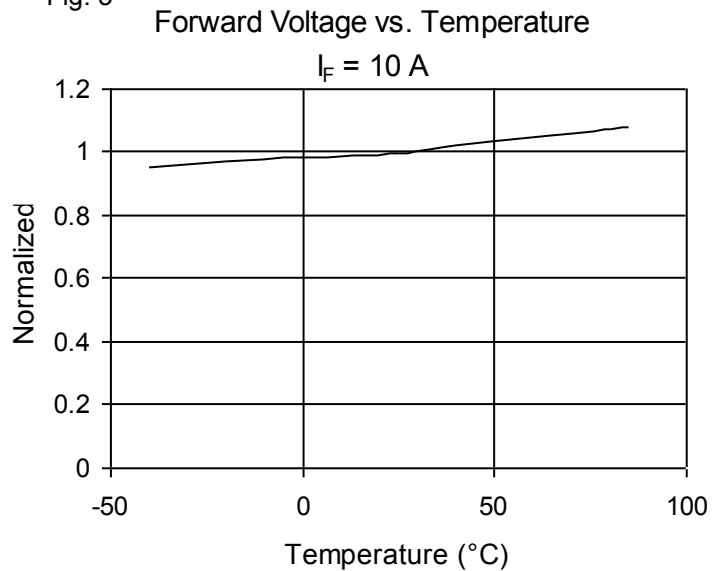


Fig. 6

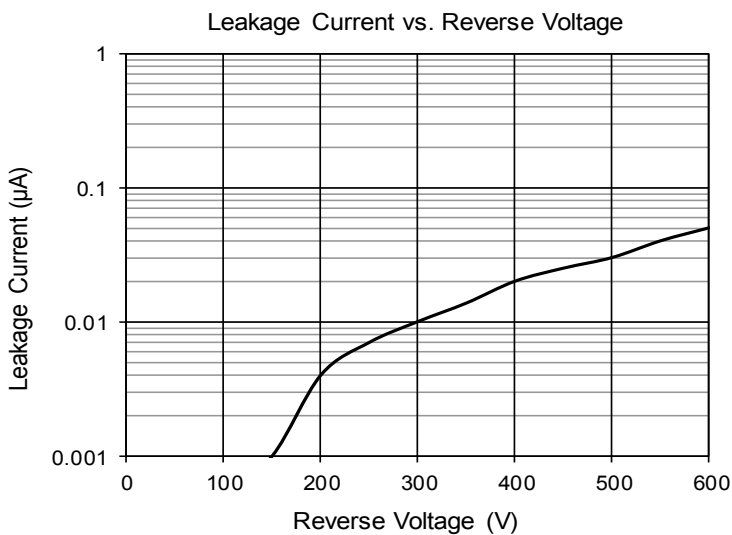
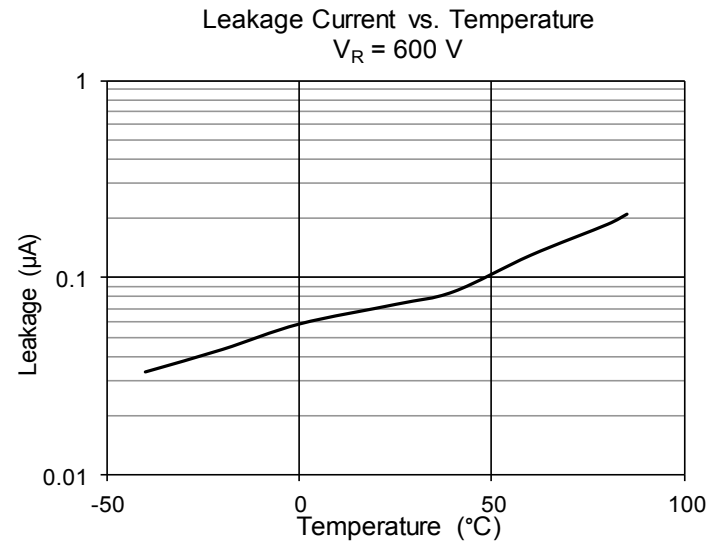


Fig. 7



Lead description

SYMBOL	FUNCTION	DESCRIPTION
+ DC	Positive DC	Positive DC output of bridge rectifier
- DC	Negative DC	Negative DC output of bridge rectifier
AC IN	AC input	AC input to bridge rectifier
AC IN	AC input	AC input to bridge rectifier

Figure 8 Package drawing

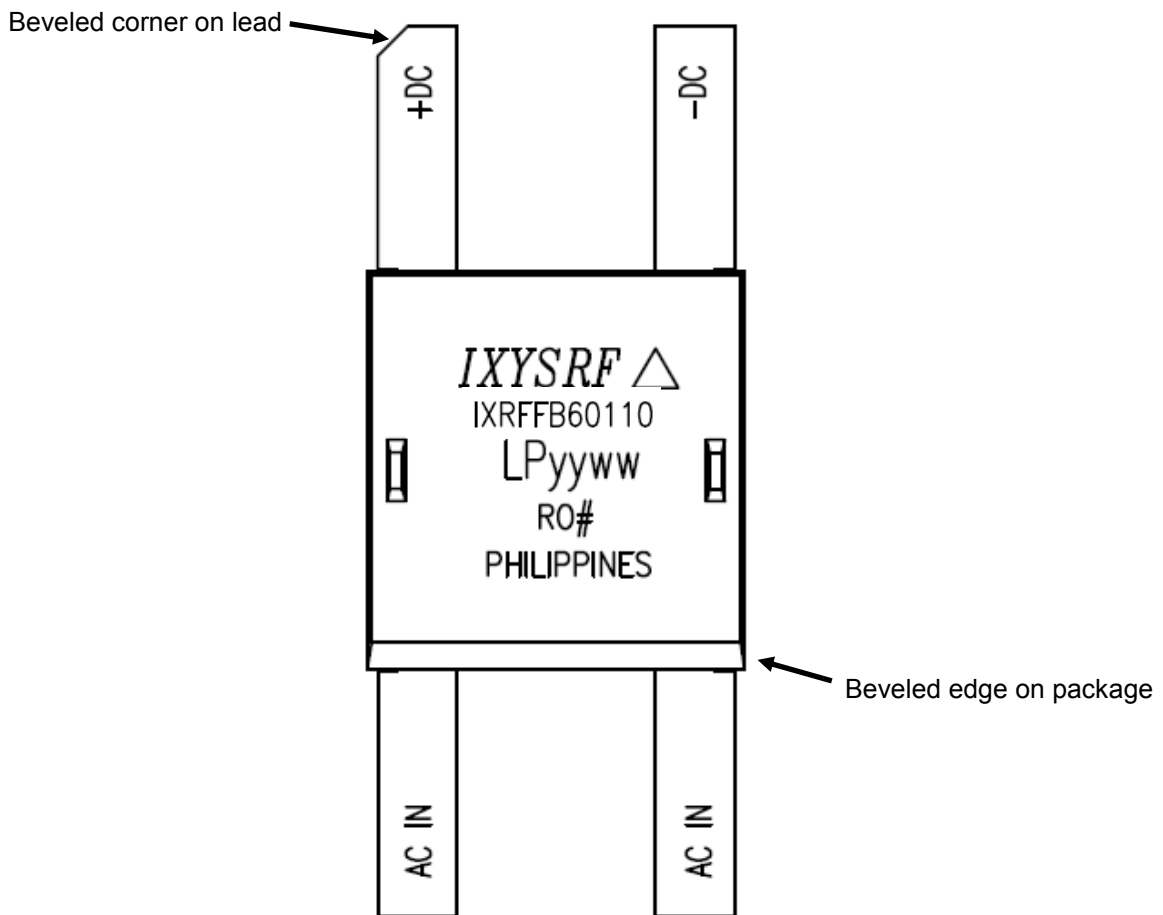
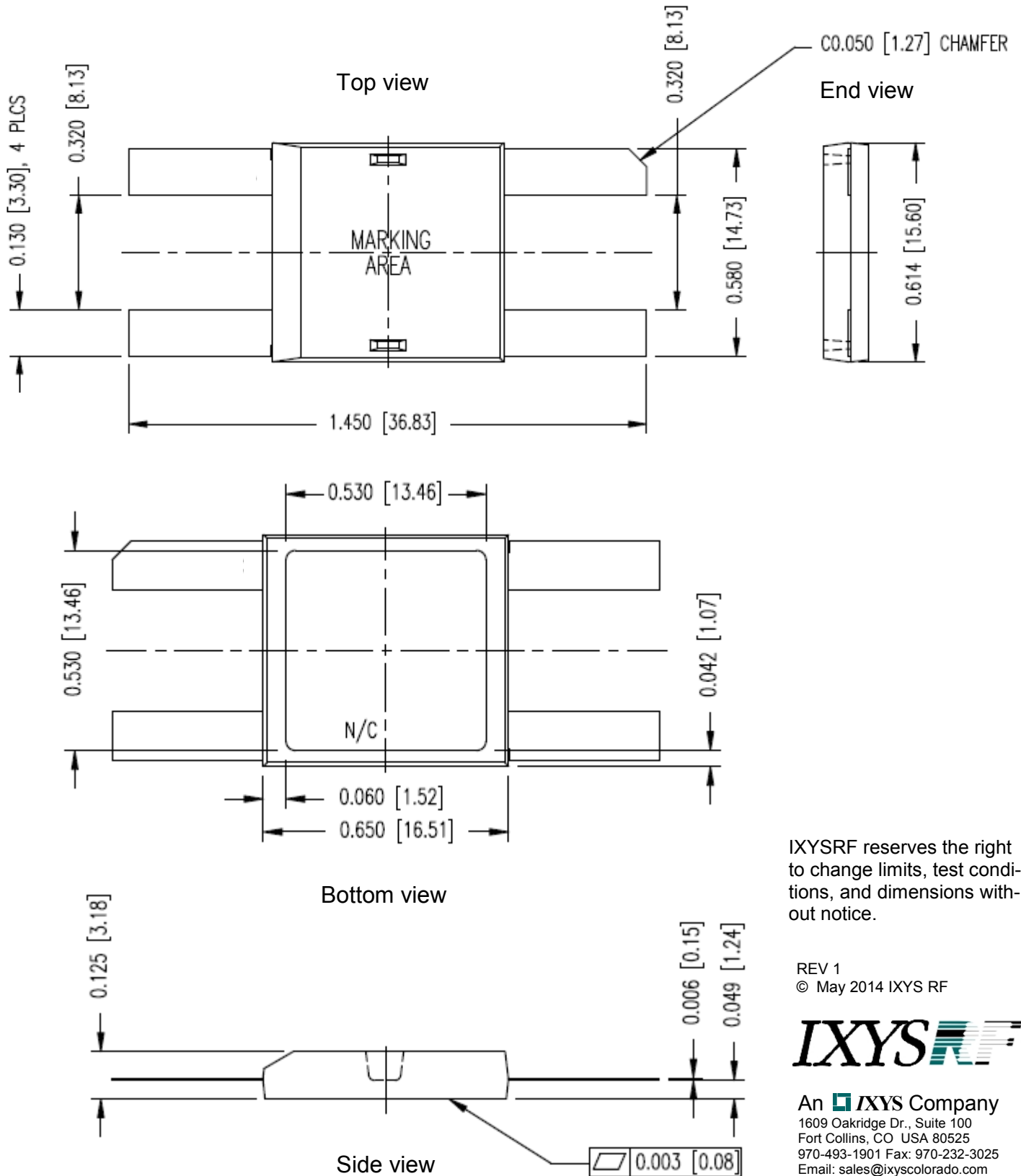


Figure 9 IXRFFB60110 package dimensions



IXYSRF reserves the right to change limits, test conditions, and dimensions without notice.

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Frequency estimations

The maximum frequency is estimated indirectly through the power dissipation P_d of the device, which is a combination of conduction and switching losses.

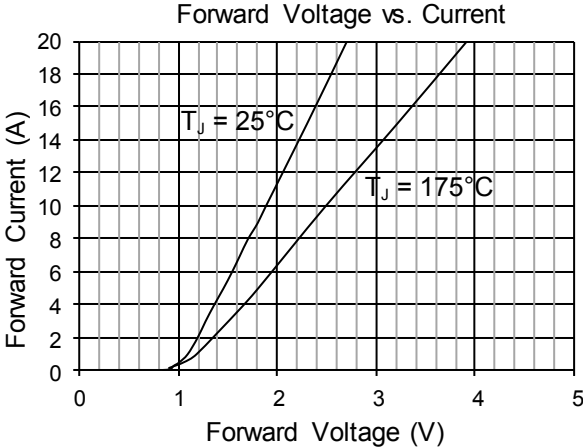
$$P_d = P_{cond} + P_{switching}$$

Conduction losses P_{cond}

Two steps are performed to determine the P_{cond} conduction losses:

Step 1, map out forward voltage versus current in an oven at 175° C, which is the maximum die temperature. These values are plotted in the chart below for a single diode.

Step 2, apply DC current until the forward voltage matches the value at 175° C while maintaining a 25° C case temperature. During testing it was determined that 173.75 W of forward power was needed to reach the forward voltage found in step 1 above. A rounded value of 160 W is used for calculations and was entered on this datasheet for parameter P_{TOT} .



Expressing P_{cond}

$$P_{cond}(T_J) = V_{TO}(T_J) * I_{F(AVG)} + R_D(T_J) * I_{F(RMS)}^2$$

On the above chart, the forward voltage and current characteristics, V_F and I_F , can be approximated by a straight line defined by the threshold voltage V_{TO} and the dynamic resistance R_D . These quantities are determined from the chart for two forward current levels I_{F1} and I_{F2} at a given junction temperature T_J and are used in the P_{cond} calculations.

$$V_F(I_{F1}, T_J) = V_{TO}(T_J) + R_D(T_J) * I_{F1}$$

$$V_F(I_{F2}, T_J) = V_{TO}(T_J) + R_D(T_J) * I_{F2}$$

Derive the below expressions using the above equations:

$$R_D(T_J) = \frac{V_F(I_{F2}, T_J) - V_F(I_{F1}, T_J)}{I_{F2} - I_{F1}}$$

$$V_{TO}(T_J) = \frac{V_F(I_{F1}, T_J) * I_{F2} - V_F(I_{F2}, T_J) * I_{F1}}{I_{F2} - I_{F1}}$$

For convenience in determining $I_{F(AVG)}$ and $I_{F(RMS)}$, a sinusoidal waveform is applied for rectification through the full-wave bridge. We can write the following equations for a rectified sine-wave, where I_{MAX} is the rated current of the device at the maximum junction temperature. The duty-cycle $d = 1$ for a full-wave bridge meaning that the bridge is conducting for the full period of the input signal.

Formulas for the average and RMS full-wave current:

$$I_{F(AVG)} = \frac{2 I_{MAX}}{\pi} * d \qquad I_{F(RMS)} = I_{MAX} * \sqrt{\frac{d}{2}}$$

For $d = 1$

$$I_{F(AVG)} = \frac{2 I_{MAX}}{\pi} \qquad I_{F(RMS)} = \frac{I_{MAX}}{\sqrt{2}}$$

Resulting average and RMS values when calculated with the rated current of 10 A at maximum temperature

Part number	I_{MAX} (A)	$I_{F(AVG)}$ (A)	$I_{F(RMS)}$ (A)
IXRFFB60110	10	6.37	7.07

R_D and V_{TO} values where V_1 , I_1 , and V_2 , I_2 are points along the 175° C plot

Part number	I_2 (A)	I_1 (A)	V_2 (V)	V_1 (V)	R_D (Ω)	V_{TO} (V)
IXRFFB60110	10	4	2.5	1.65	0.142	1.08

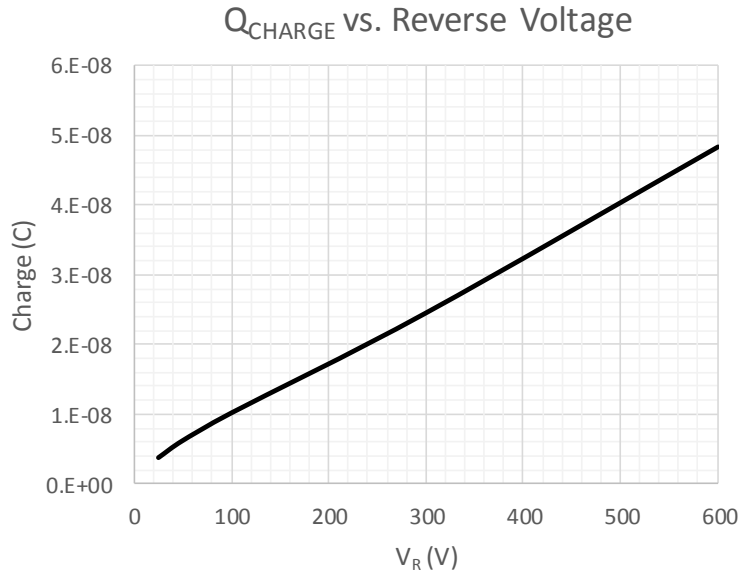
Conduction losses are now calculated- $P_{cond}(T_J) = V_{TO}(T_J) * I_{F(AVG)} + R_D(T_J) * I_{F(RMS)}^2$

Part number	P_{cond} (W) full wave
IXRFFB60110	13.98

Switching losses $P_{switching}$

$P_{switching} = Q_c * V_o * F_s$ where Q_c is the capacitive charge in nanocoulombs, V_o is the output voltage, and F_s is the switching frequency.

The following chart represents the total capacitive charge, Q_c , of the bridge with two series strings in parallel that results in a total charge calculated as a single diode.



Power available for switching $P_{\text{switching}} = P_d - P_{\text{cond}}$

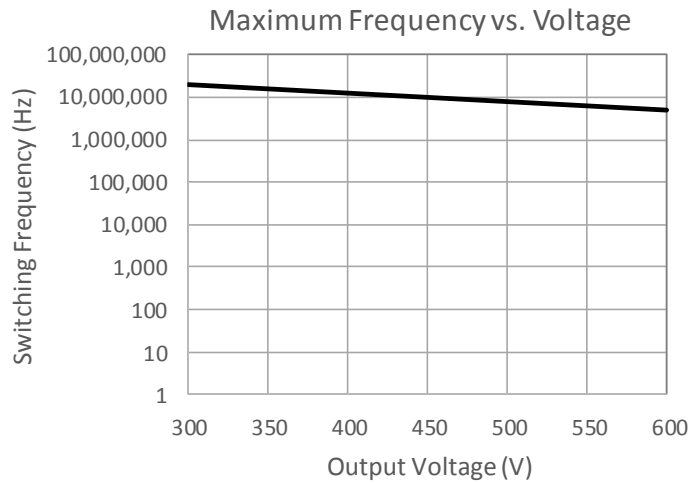
Part number	Pd	P _{cond} (W) full wave	P _{switching} (W) full wave
IXRFFB60110	160	13.98	146.02

Switching frequencies

$P_{\text{switching}} = Q_c \cdot V_o \cdot F_s$ or $F_s = (P_{\text{switching}}) / (Q_c \cdot V_o)$

Part number	P _{switching} (W) full wave	V _o (V)	Q _c (nC)	F _s (Hz)
IXRFFB60110	146.02	300	25	19469333
		600	48	5070138

In using the maximum heat capacity of the package with the four diodes in the bridge configuration, the calculated switching frequency can range greater than 19 MHz depending on the operating voltage.



The above chart plots potential switching frequencies for the IXRFFB60110 when utilizing all four diodes to heat the device package until the 175°C maximum die temperature is reached while maintaining a 25°C case temperature. Derating for higher case temperatures is calculated by using the standard power formula to find the new power limit.

$$\text{Power capacity (W)} = \frac{\text{Max die temp } (^{\circ}\text{C}) - \text{Case temp } (^{\circ}\text{C})}{\text{Thermal resistance of package } \left(\frac{^{\circ}\text{C}}{\text{W}}\right)} = \frac{175^{\circ}\text{C} - \text{Case temp } ^{\circ}\text{C}}{0.94 \frac{^{\circ}\text{C}}{\text{W}}}$$

If it is not possible to maintain a case temperature of 25° C, a new power limit can be calculated and a new frequency limitation determined.

From the pure calculation sense the smaller the stored charge and lower operating voltage, the higher the switching frequency. However, when used at high frequencies the parasitic components will impact operation. Inductance of the device package and circuit board must be considered in the final design to achieve optimum operation. It is important to make circuit board layouts as compact as possible to minimize the impact of the parasitic inductance. The junction capacitance also impacts high frequency operation as the junction impedance loads the circuit, resulting in a reduce rectified voltage. In a practical application, best operation is achieved when frequency of operation is below 8 MHz.