How to select power line polarity protection diodes

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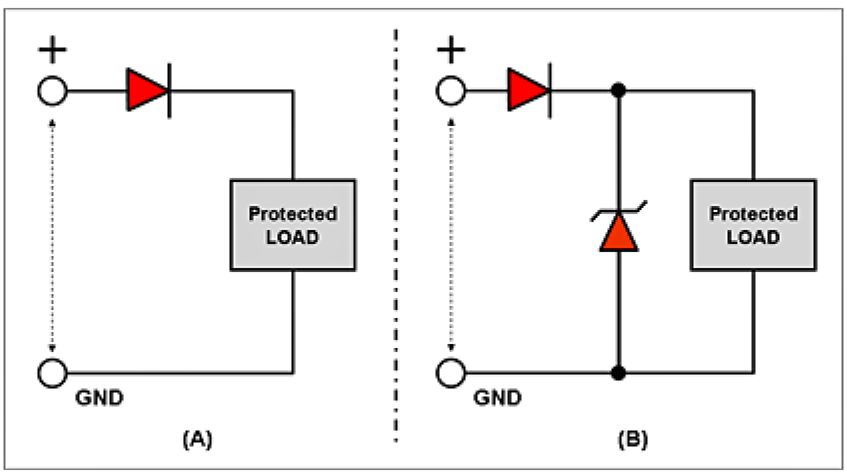
Diode rectifiers are ideal solutions for automotive electronic power line protection and have several important parameters for these applications, including: Forward current, repetitive reverse voltage, forward surge current, and fusing rate. A major challenge in automotive design is protecting electronics, such as control units, sensors, and entertainment systems, against damaging reverse voltages, voltage transients, electrostatic discharge (ESD), and noise that are present on the power line. Diode rectifiers are ideal solutions for automotive electronic power line protection and have several important parameters for these applications, including: Forward current, repetitive reverse voltage, forward surge current, and fusing rate.

Parameters in automotive electronic equipment test conditions and applications
Basic circuits for polarity protection are shown below. Circuit (A) offers polarity protection only, while Circuit (B) features polarity protection with load dump suppression.



Following are definitions for major parameters to consider when selecting a power line polarity protection diode for an automotive application.

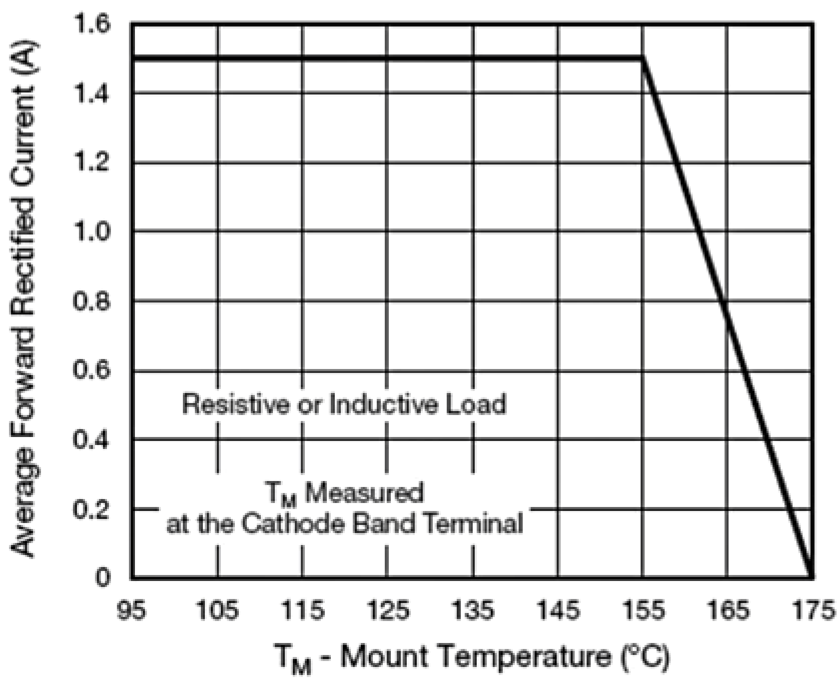
Maximum repetitive reverse voltage (V_{RRM})
The maximum repetitive reverse voltage is the maximum voltage that the diode can withstand in reverse bias mode. In reverse bias mode, leakage current through the diode can generate heat in the diode junction and lead to thermal runaway. Tests that simulate this condition include the U.S.'s ISO-7637-2 pulse 1 and 3a, and Japan's JASO D001-94, standard type B and E. Each peak voltage for these tests is specified in the following table.

Standard name	Test	For 12 V system	For 24 V system
ISO-7637-2	Pulse 1	- 75 V to - 150 V	- 300 V to - 600 V
	Pulse 3a	- 112 V to - 220 V	- 150 V to - 300 V
JASO D001-94	Type B-2	- 250 V	
	Type E		- 320V

According to the above test conditions, the V_{RRM} of a diode for power line protection should be 300 to 400V for a 12V power train and 600V for a 24V power train.

Forward current ($I_{F(AV)}$)

The specification for forward current in datasheets usually means the maximum average forward current the diode can handle in the forward bias state—given the thermal limitations of the package. This parameter is related to the current usage of the circuit in operation.



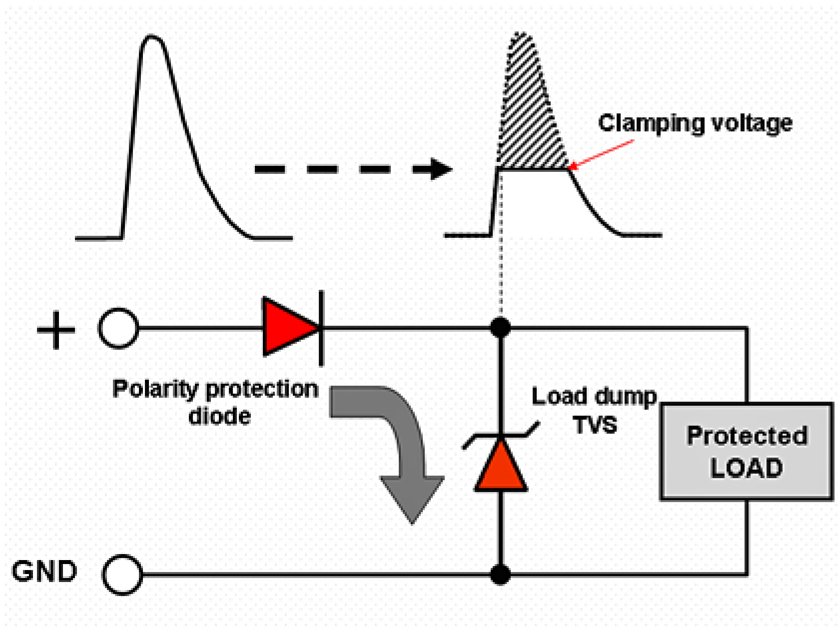
The maximum forward current derating curve of a rectifier on a 5 mm x 5 mm Cu pad with a FR-4 PCB drops off above a given temperature limit.

The forward current capability varies by the temperature of the diode's junction, as shown above. Other related parameters include thermal resistance.

Forward surge current (I_{FSM})

The specified forward surge current in a datasheet is the maximum peak current the diode can handle in the forward bias state within specified time and pulse conditions. This rating is limited by the diode's thermal capacity.

The forward surge current specification is related to two major operations and is simulated in the ISO-16750-2 and JASO D001-94 automotive standards. The first operation is protecting circuitry against the high currents that occur during the load dump condition. The second operation is simulated by ISO-7637-2 test pulse 2a and 3b, consisting of 50 ms and 100 ms pulse widths and 2Ω and 50Ω line impedance, respectively. This is a relatively small amount of energy when compared to the forward surge current at the load dump test condition.



Load dump suppression (figure above) is simulated by tests such as ISO-16750-2 test A and B, JASO standard type A and D, and others.

Standard	Test	U_S	U_B	U_{Sa}	R_i	P_d	Pulses
		V	V	V	Ω	ms	
ISO-16750-2	Pulse A	79 – 101	12	N/A	0.5 – 4	40 – 400	10
	Pulse B			35			5
	Pulse A	151 – 201	24	N/A	1 – 8	100 – 350	10
	Pulse B			65			5
JASO D001-94	Type A-1	70	12	N/A	0.8	200	1
	Type D-1	110	24		1.5	400	1

In this situation, high surge current is passing through the polarity protection diode, and it requires a high enough forward surge capability to avoid failure. Estimating the surge current value in load dump suppression tests can be accomplished with the equation:

$I_{peak} = (V_{peak} – V_F d - V_{clamping}) / (R_i + R_{zd})$

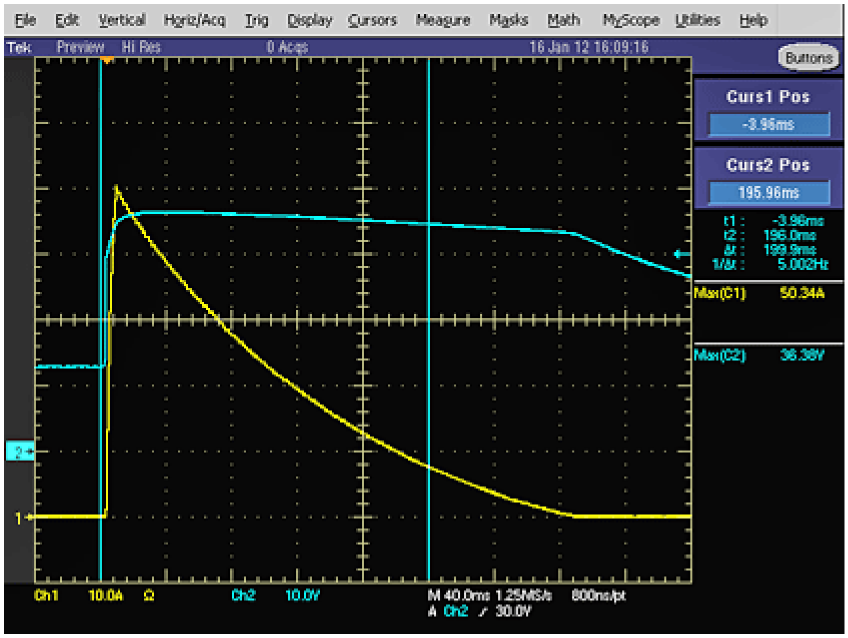
V_{peak}: *Surge voltage*

$V_{clamping}$: *Clamping voltage*

$V_F d$: *Forward voltage drop of polarity protection diode*

R_i: *Line impedance*

R_{zd}: *Resistance of clamping device*



With the applied condition of 101V Us, 12V UB, and 1.5Ω line impedance, as specified by ISO-16750-2 test A, the peak current is 51.3A and the actual clamped current is 50.3A.

(For a detailed explanation of load dump protection, please refer to ***http://www.vishay.com/docs/88490/tvs.pdf****.)*

ESD

ESD influences the operating stability and lifetime reliability of electronic modules in vehicles. ISO-10605 and JASO standard 5.8 specify testing conditions for this parameter.

Non-repetitive avalanche energy (E_{AS})

This non-repetitive avalanche energy of a diode specifies the maximum energy it can absorb in the reverse bias state to protect circuits from inductive kick back transients from motors and solenoids, or induced high reverse voltages. There is no automotive standard for this specification.

Temperature conditions for automotive electronics and components

The JASO specifies the operating temperature range for automotive electronics as – 40 to +100C based on their location, such as the trunk, engine, or other places.

Conclusion

By attention to diode rectifier characteristics, automotive polarity circuit protection can be ensured.

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ISO-10605: 2001: Road vehicles – Test methods for electrical disturbances from electrostatic discharge

ISO-16750-2: 2010: Road vehicles – Environmental conditions and testing for electrical and electronic equipment

ISO-7637-2: 2010: Road vehicles – Electrical disturbance by conduction and coupling – Part 2: Electrical transient conduction along supply lines only

JASO D001-94: Japanese automobile standard – General rules of environmental testing methods for automotive electronic equipment

IEC 61000-4-2: 1995 Electromagnetic compatibility (EMC) – Part 4: Testing and measurement techniques – Section 2: Electrostatic discharge immunity test