AN1158

Super Barrier Rectifier (SBR®) improves automotive supply line protection to ISO7637

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Introduction

Electrical disturbances in an automotive environment present reliability and functional risks to the various electronic systems and components that may be exposed. Many modules, for example electronic control units (ECUs), have sensitive microcontrollers at their core and must be shielded to ensure reliable operation. Figure 1 shows a typical arrangement. High-voltage transient conduction can be introduced along supply lines by many sources including: ignition systems, inductive components, unexpected conditions such as faults, and connection/disconnection of loads. Depending on the severity these can cause anything from system malfunctions to irreparable component damage.

An additional risk to supply lines is posed by accidental reverse connection, such as during vehicle maintenance or breakdown/rescue situations.

Typical schematic

1. Supply line (12V /24V)
2. Introduced transient energy
3. Reverse voltage protection
4. Transient voltage suppression
5. Protected load circuit

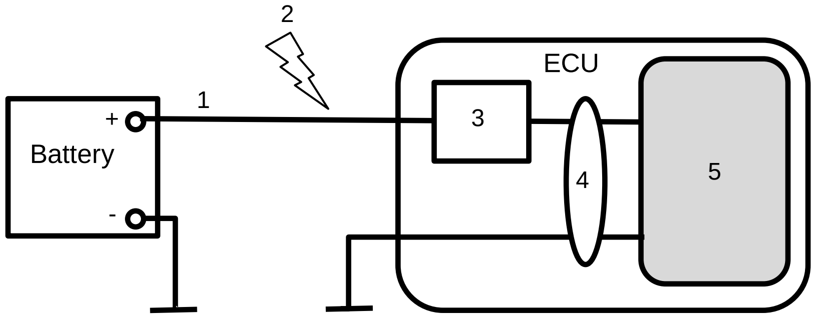

Figure 1. Sensitive load is protected from transient voltages and reverse supply

Reverse Protection

The simplest solution to provide reverse polarity protection, (for example from incorrect battery connection), is a series diode as shown in figure 2. The diode will block current in a reverse supply situation, protecting the load from damage.

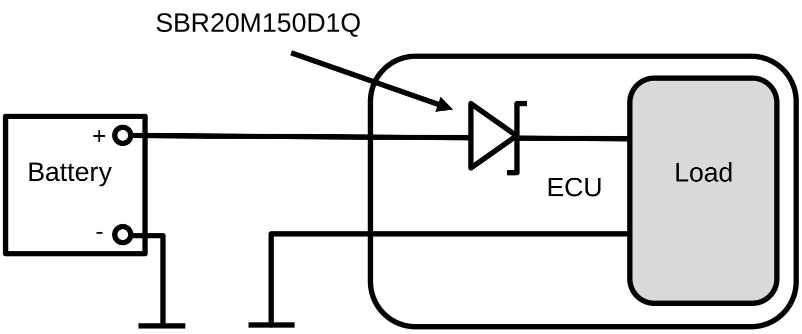

Figure 2. Low VF diode provides simple reverse protection

To maintain good power efficiency a diode with a low forward voltage drop (V_F) is required such as found with Schottky diodes. However, their reverse leakage current is sensitive to temperature and the low energy barrier metal design makes them more susceptible to thermal runaway at higher temperatures leading to potential damage to the device and, more importantly, the load.

SBR® parts have ultra-low V_F characteristics and are designed to maintain low reverse leakage current at high ambient temperatures (hot-leakage) typically found in automotive environments.

SBR® Technology

Super Barrier Rectifier (SBR®) is a proprietary and patented Diodes Incorporated technology that utilizes a Metal Oxide Semiconductor (MOS) manufacturing process to create a superior alternative to the Schottky diode. A MOSFET structure with connected gate (G) and source (S) provide the device's anode terminal and the drain (D) becomes the cathode terminal, shown in Figure 3.

SBR® devices are represented by the same electronic schematic symbol as the Schottky diode (Figure 4).

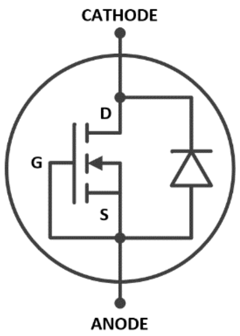

Figure 3. Simplistic internal arrangement

Figure 4. SBR® schematic symbol

SBR® devices are characterized by ultra-low forward voltage drop (V_F) values and low reverse leakage (I_R) current which, unlike Schottky diodes, is maintained at high temperature. The MOS gated PN junction, in place of a Schottky barrier, improves ruggedness to high-voltage transients.

SBR® Avalanche Capability

To safely handle relatively large reverse power levels, (for example those seen in transient pulses), the maximum reverse avalanche rating, P_{ARM} (T_J), is used to determine a power diode's ability.

Due to the absence of a metal barrier, the SBR® has a significantly greater avalanche capability compared with the standard Schottky diode. This significantly increases the reliability of the SBR® diodes against large reverse surge currents.

The unique structure with a guard ring matrix within the chip area enhances avalanche current transport providing protection for the MOS gate cells (Figure 5).

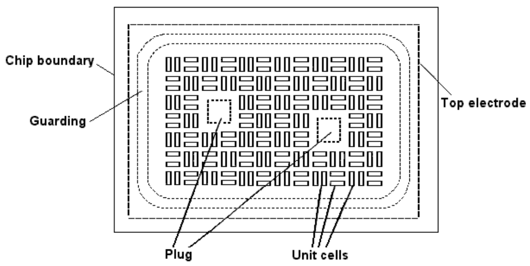

Figure 5. SBR® Cellular design MOS chip - thousands of individual devices work in parallel

The reverse avalanche capability of the SBR20M150D1Q rectifier drastically outperforms Schottky rectifier technology which significantly increases the reliability of the SBR® diodes against any large reverse transient surge currents.

Transient pulse testing to ISO7637-2

The supply lines, in both 12V and 24V based systems, run throughout the vehicle to provide the necessary power to the connected systems. Vulnerable systems, such as ECUs, are immunity tested in accordance with ISO7637-2.

Unwanted transient voltages can be introduced on to these supply lines from various sources including:

- Alternator, ignition system, HID lighting, motors, actuators and relays
- During different engine run conditions including cold cranking, idle, fast and stop/start
- Maintenance and jump-start conditions – manual connection/disconnection of cables
- Disconnection due to blowing or pulling out fuses
- Distributed capacitance and inductance of the wiring harness
- Faults

To evaluate automotive electronic systems for their immunity to supply line transients the automotive standard ISO7637-2 defines voltage transient emission testing methods and sets out several transient pulse types, for both 12V and 24V automotive environments:

Pulse 1 - Transients due to supply disconnection from inductive loads

Pulse 2a - Transients due to sudden interruption of currents in a device connected in parallel

Pulses 3a/b - Transients which occur as a result of switching processes

The pulses vary between 12V and 24V systems as shown in Figure 6.

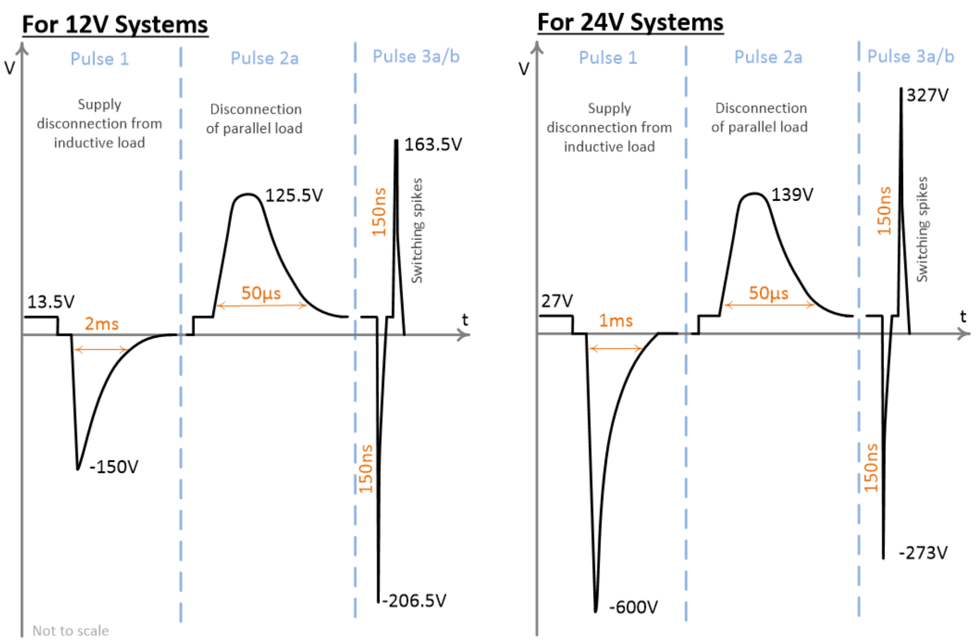

Figure 6. Transient high voltages pulses

ISO Test Condition

Pulses are introduced to the device under test (DUT) with a pulse generator as shown in figure 7.

1. Pulse generator
2. DUT
3. TVS* to protect against positive pulses (SMCJ26AQ)
4. Load

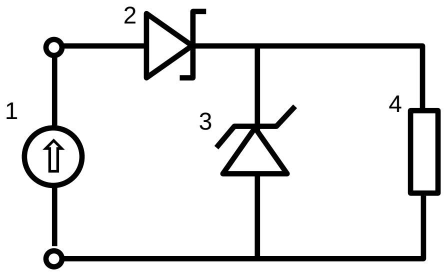

Figure 7. DUT circuit configuration.

Note a TVS device is present to represent necessary load protection for positive pulses

Pulse specification

Test pulse nominal 24V system			
Test pulse	Test pulse (severity level IV) Us (V)	Min. number of pulses or test time	Burst cycle/pulse repetition time
1	-600	500 pulses	1s
2a	+112	500 pulses	0.5s
3a	-300	1 h	100ms
3b	+300	1 h	100ms

Results

Part Name	Package	Test Result	Pulse 1	Pulse 2a	Pulse 3a	Pulse 3b
			Us=-600V Ri=50Ω Tr=3µs Td=1000µs, T1=1s count:500	Us=+112V Ri=2Ω Tr=1µs Td=1000µs T1=0.5s count:500	Us=-300V Ri=50Ω Tr=5ns Td=100ns T1=0.1s T:3600s	Us=300V Ri=50Ω Tr=3.5ns Td=100ns T1=0.1s T:3600s
SBR20M150D1Q	TO252-3L	PASS	PASS	PASS	PASS	PASS

Note: Us: Peak Amplitude
Ri: Internal Resistance
Td: Pulse Duration
T1: Pulse Repeat Interval Time
Count: Test Cycle number

Conclusion

Exposure of sensitive electronic systems to high-voltage transients and reverse voltage situations will result in a risk of system malfunctions and potential irreparable component damage. Consequently, it is vital to the reliability and safety of these applications that appropriate safeguarding against these risks is undertaken. ISO testing methods seek to ensure robustness of protection devices in supply lines for automotive applications and means designers need to pay careful consideration to specifying parts that are appropriately rated. For example, avalanche rating, for parts handling transient voltages, and DC blocking parts for reverse connection protection.

SBR® technology provides high-performance parts to meet these demanding requirements.

The Diodes Inc. SBR20M150D1Q automotive grade rectifier is rated to give both effective reverse DC protection, with low V_F and low I_R, and avalanche rating to pass tests pulses 1, 2a, 3a and 3b as defined in ISO7637-2 third edition, for both 12V and 24V systems.

Further reading

Immunity against transient voltages may be achievable by a number of circuit design approaches and device selection combinations as part of an overall protection strategy.

Application notes:

- **TVS in Automotive Applications AN1142**
- **Automotive Reverse Battery Protection Diode AN1101**
- **SBR® Avalanche Energy AN1010A**

INTERNATIONAL STANDARD

- **ISO7637-2 Third edition (2011-03-01)**
  Road vehicles — Electrical disturbances from conduction and coupling —
  Part 2: Electrical transient conduction along supply lines only

Designed to meet customers' requirements

For more information and to discuss your circuit testing needs, including customer specific testing, contact your Diodes Inc. representative.

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