



Automotive Load Dump Protection

Modern automotive designs use a mass of electronics, such as control units, infotainment systems and sensors, all being powered by the car battery and the alternator. During the standard operation, several unwanted EMI disturbances arise from the various sources such as alternator, ignition systems, inductive load switching and load dump transient surges, which can be harmful to vehicle electronic devices. They can degrade performance, lead to malfunction of sensors or even permanently destroy electronic devices which could affect complete system's reliability.

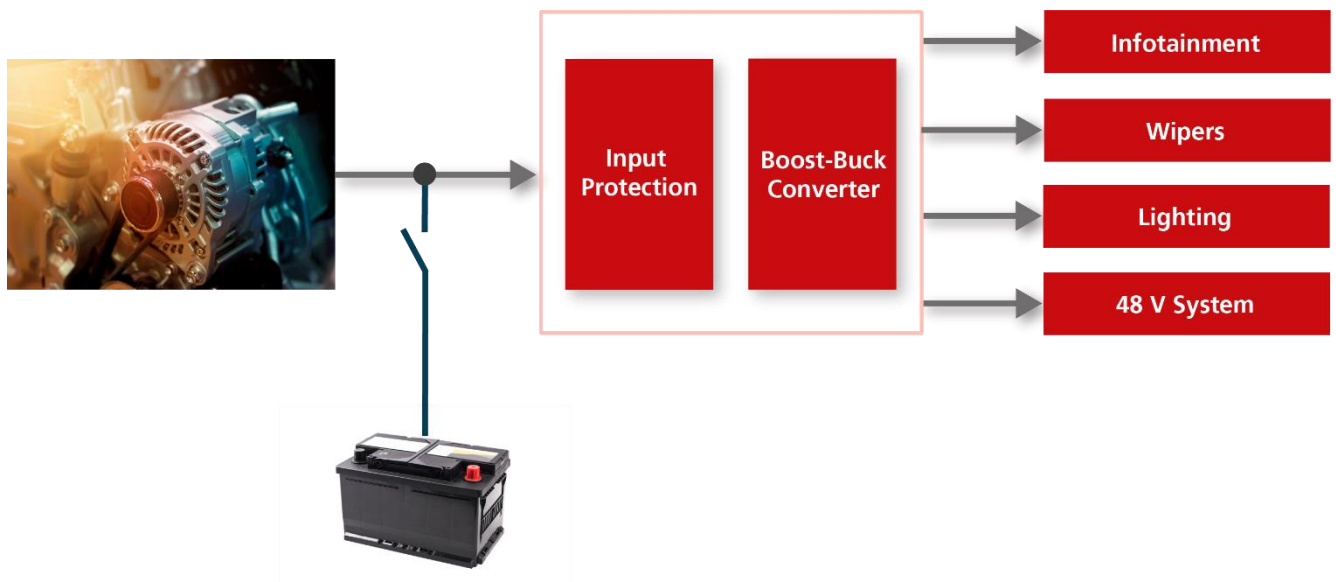
A major challenge out of these is to protect these electronics against the high energy load dump transient events, which is the most severe disturbance having large transient peaks, with duration of several milliseconds.

A load dump transient is the voltage surge generated when the battery is disconnected while the alternator is connected. This typically happens if a discharged car battery is powered up by a second one and afterwards jump leads are removed. The peak voltage of this surge may be as high as 120 V and the surge may take up to 400 ms to decay. It is typically clamped to 40 V in 12 V vehicles (cars) and about 60 V in 24 V systems (trucks).

Diodec offers various TVS product families for load dump protection according to ISO 16750-2:2012(E), both for applications without centralized load dump suppression (according to standard Table 5, Test A) and for those with centralized suppression (Table 6, Test B).

The new 6.6SM8Z series with 6.6 kW peak pulse power in DO-218AB is already available, it will soon be complemented by the 4.6SM6Z series with 4.6 kW. Both versions are qualified according to AEC-Q101. The 5KP represents an alternative in axial lead package, it allows up to 5 kW at the usual rating with 10/1000µs pulses. Classical alternator rectifier diodes in pressfit packages are the BYZ35 and BYZ50, which we offer especially for the after sales market. They offer a suppressor characteristic and thus provide alternator rectification and centralized suppression in one.

The following block diagram shows the typical current path from the alternator via battery to the stabilized DC voltage for the on-board electronics, including the option for a parallel 48 V system.



Block diagram for a modern automotive power supply circuit

Disclaimer

This application note describes device proposals and shall not be considered as assured and proven solution for any circuit. No warranty or guarantee, expressed or implied is made regarding the capacity, performance or suitability of any device, circuit etc.

Standards for the Protection of Automotive Electronics

ISO7637 and ISO 16750-2

This sequence of standards by the International Organization for Standardization is often considered as the “guideline” for automotive testing. ISO7637-2 and ISO 16750-2 were prepared by Technical Committee ISO/TC 22, Road vehicles, Subcommittee SC 3, Electric and electronic equipment. Both the standards describe the potential environmental stresses and specifies tests and requirements recommended for the specific mounting location on/in the road vehicle ^[1]

ISO 7637 stands for **Road vehicles-Electrical disturbances from conduction and coupling**, while the part 2 (ISO 7637-2) defined for the “Electrical transient conduction along supply lines only”. It is a test standard which primarily designated for **EMC**. ^[1]In 2011, the power supply tests which are not related to EMC, such as Load DUMP test, which includes pulse 5a and 5b to ISO16750.

ISO 16750 stands for **Road vehicles-Environmental conditions and testing for electrical and electronic equipment**, while the part 2 (ISO 16750-2), focus on the Electrical loads. It is a standard which provides guidance on the events related to power supply quality. ^[1]

Parameters	ISO7637-2			ISO16750-2		
	UN = 12 V	UN = 24 V	Min. Test requirements	UN = 12 V	UN = 24 V	Min. Test requirements
Us [V]	$65 \leq U_s \leq 87$	$123 \leq U_s \leq 174$	1 pulse	$79 \leq U_s \leq 101$	$151 \leq U_s \leq 202$	10 pulses at interval of 1 minute
Us* [V]	Defined by user	Defined by user		35	58	
UA [V]	13-14	26-28		14	28	
Ri [ohm]	$0.5 \leq R_i \leq 4$	$41 \leq R_i \leq 8$		$0.5 \leq R_i \leq 4$	$41 \leq R_i \leq 8$	
Td [ms]	$40 \leq t_d \leq 400$	$100 \leq t_d \leq 350$		$40 \leq t_d \leq 400$	$100 \leq t_d \leq 350$	
Tr [ms]	10 +0/-5	10 +0/-5		10 +0/-5	10 +0/-5	

Table 1: Pulses for Test A/Test B in systems with 12 V and 24 V nominal voltage

For simplicity, the further explanations focus on testing parts according to the standard ISO16750-2 and 12V systems (cars).

Alternators in the conventional automobiles could produce a large voltage surge during load dump, about 100V at 12V systems. Modern automobiles are already embedded with alternators providing additional clamping features, to limit the voltage surges. Having thus two different generations of alternators, ISO 16750-2 specifies load dump waveforms by Test A and Test B accordingly:

Test A – without centralized load dump suppression

Test B – with centralized load dump suppression

Test A – Without Centralized Load Dump Suppression

Figure 1. shows the high voltage load dump transient surge appearing when the battery is being disconnected while the alternator continues supplying power. Figure 1.1 shows the related unclamped waveform, described by Test A in ISO16750-2.

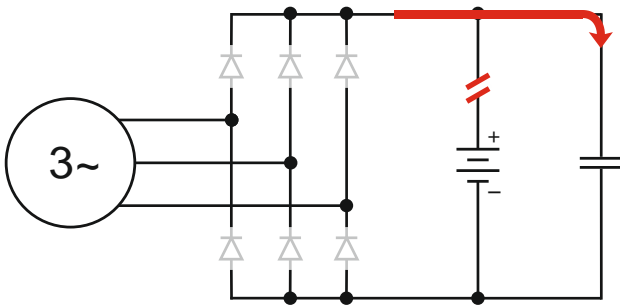


Figure 1: Alternator without load dump suppression

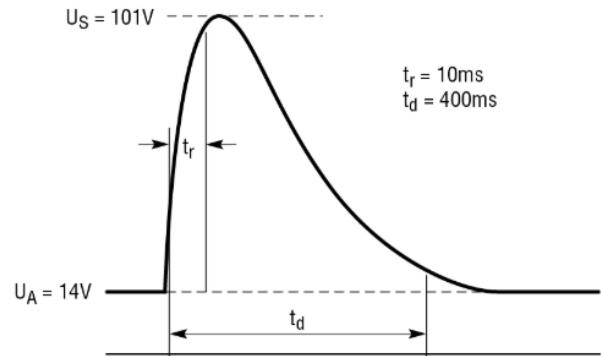


Figure 1.1: Pulse Test A – unclamped load dump

Test B – With Centralized Load Dump Suppression

Figure 2 shows the alternator output voltage with centralized load dump suppression, e. g. by rectifier diodes with clamping characteristic. Figure 2.1 shows the clamped waveform described by Test B in ISO16750-2.

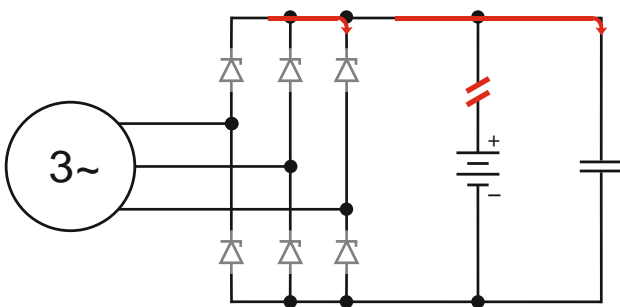


Figure 2: Alternator with load dump suppression

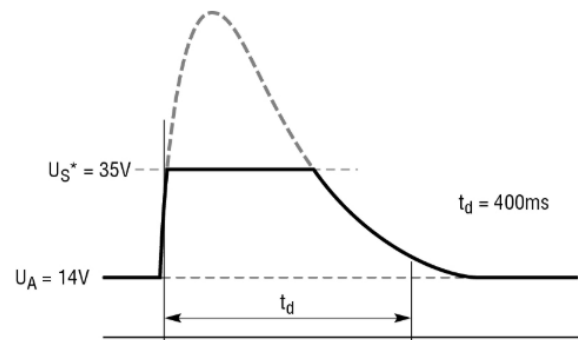
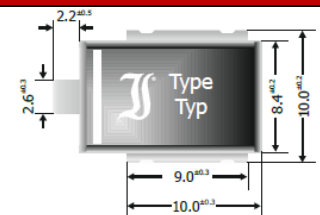


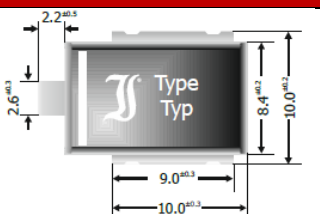
Figure 2.1: Pulse Test B – clamped load dump

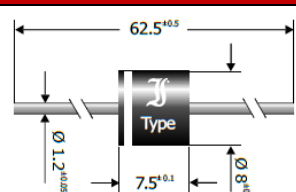
Load Dump Protection Diodes passing Test A and Test B

► **Components to provide a Centralized Load Dump Suppression!**

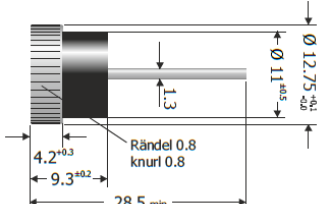
Protection only (12 V system | 24 V system)

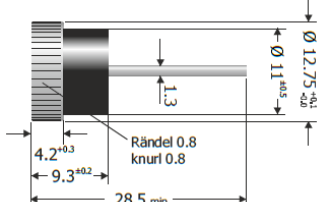
Part No.	Package	P _{PPM}	V _{WM}	V _{BR}
6.6SM8Z... AEC-Q101		6600 W	10 ... 43 V	11.1 ... 52.8 V

Part No.	Package	P _{PPM}	V _{WM}	V _{BR}
4.6SM8Z... AEC-Q101		4600 W	10 ... 43 V	11.1 ... 52.8 V

Part No.	Package: D8 x 7.5	P _{PPM}	V _{WM}	V _{BR}
5KP... Qualification planned		5000 W	28 ... 40 V 48 ... 60 V	33 ... 47 V 56 ... 68 V

Protection and Rectification = Protectifiers® (12 V system | 24 V system)


Part No.	Package: D12.75 x 4.2 / Press-fit	I _{FAV}	V _{WM}	V _{BR}
BYZ35... For after sales market		35 A*	17.8 ... 26.8 V 31.6 ... 38.1 V	22 ... 33 V 39 ... 47 V


Part No.	Package: D12.75 x 4.2 / Press-fit	I _{FAV}	V _{WM}	V _{BR}
BYZ50... For after sales market		50 A*	17.8 ... 26.8 V 31.6 ... 38.1 V	22 ... 33 V 39 ... 47 V

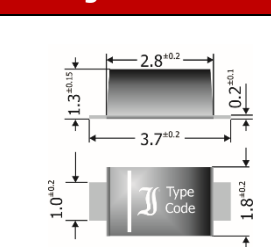
Load Dump Protection Diodes passing Test B

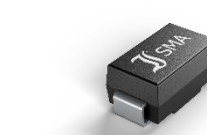
► **Components to be used at Centralized Load Dump Suppression Systems!**

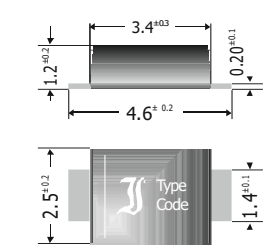
Centralized load dump suppression limits the voltage surge to 35 V (**12 V system**) respectively 58 V (**24 V system**). In consequence, TVS diodes with a clamping voltage >> 35 V (58 V) can be used to protect the on-board electronics. The maximum level of clamping voltage is determined by the ability of the circuits to be protected.

Part No.	Package DO-213AA	P _{PPM}	V _{WM}	V _{BR}
TGL34... Qualification planned		150 W	28.2 ... 40.2 V 47.8 ... 58.1 V	33 ... 47 V 56 ... 68 V

Part No.	Package DO-213AB	P _{PPM}	V _{WM}	V _{BR}
TGL41... TGL61... (under development) Qualification planned		400 W 600 W	28.2 ... 40.2 V 47.8 ... 58.1 V	33 ... 47 V 56 ... 68 V

Part No.	Package: SOD-123FL	P _{PPM}	V _{WM}	V _{BR}
SMF... Qualification planned		200 W	28 ... 40 V 48 ... 60 V	33 ... 47 V 56 ... 68 V


Part No.	Package DO-214AC	P _{PPM}	V _{WM}	V _{BR}
P4SMAJ... AEC-Q101		400 W	28 ... 40 V 48 ... 60 V	33 ... 47 V 56 ... 68 V


Part No.	Package: SOD-123FL	P _{PPM}	V _{WM}	V _{BR}
TPSMA6L... AEC-Q101		600 W	28 ... 40 V 48 ... 60 V	33 ... 47 V 56 ... 68 V


Load Dump Protection Diodes passing Test B


► ***Components to be used at Centralized Load Dump Suppression Systems!***

Centralized load dump suppression limits the voltage surge to 35 V (**12 V system**) respectively 58 V (**24 V system**). In consequence, TVS diodes with a clamping voltage >> 35 V (58 V) can be used to protect the on-board electronics. The maximum level of clamping voltage is determined by the ability of the circuits to be protected.

Part No.	Package DO-214AA	P _{PPM}	V _{WM}	V _{BR}
P6SMBJ... 1.0SMBJ... <i>(under development)</i> AEC-Q101		600 W 1000 W	28 ... 40 V 48 ... 60 V	33 ... 47 V 56 ... 68 V

Part No.	Package DO-214AB	P _{PPM}	V _{WM}	V _{BR}
1.5SMCJ... AEC-Q101		1500 W	28 ... 40 V 48 ... 60 V	33 ... 47 V 56 ... 68 V

Part No.	Package DO-214AB	P _{PPM}	V _{WM}	V _{BR}
3.0SMCJ... AEC-Q101		3000 W	28 ... 40 V 48 ... 60 V	33 ... 47 V 56 ... 68 V

Part No.	Package DO-214AB	P _{PPM}	V _{WM}	V _{BR}
5.0SMCJ... AEC-Q101		5000 W	28 ... 40 V 48 ... 60 V	33 ... 47 V 56 ... 68 V