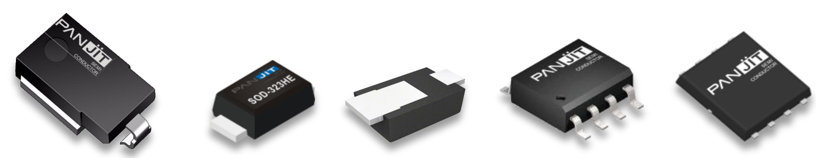
AEC-Q101 Qualified Devices

PANJIT Automotive Devices

for EV Battery Management System

TVS Diode/ Zener/ ESD Arrays/ Schottky Rectifier/ Mosfet



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Index

- *PANJIT Products for BMS*
- *Load Dump Protection (TVS)*
- *Hot Plug-in Overshoot Protection (Zener & TVS)*
- *Balance Switch Mid-Volt MOSFET*
- *MOSFET ESD and Overshoot Protection*
- *CAN Bus and I/O Connection ESD Protection*
- *DC FAN Driver Temperature Control*
- *Assistant Power Supply (TVS)*
- *Other Common Parts*
- *Quality Control For Automotive Parts*

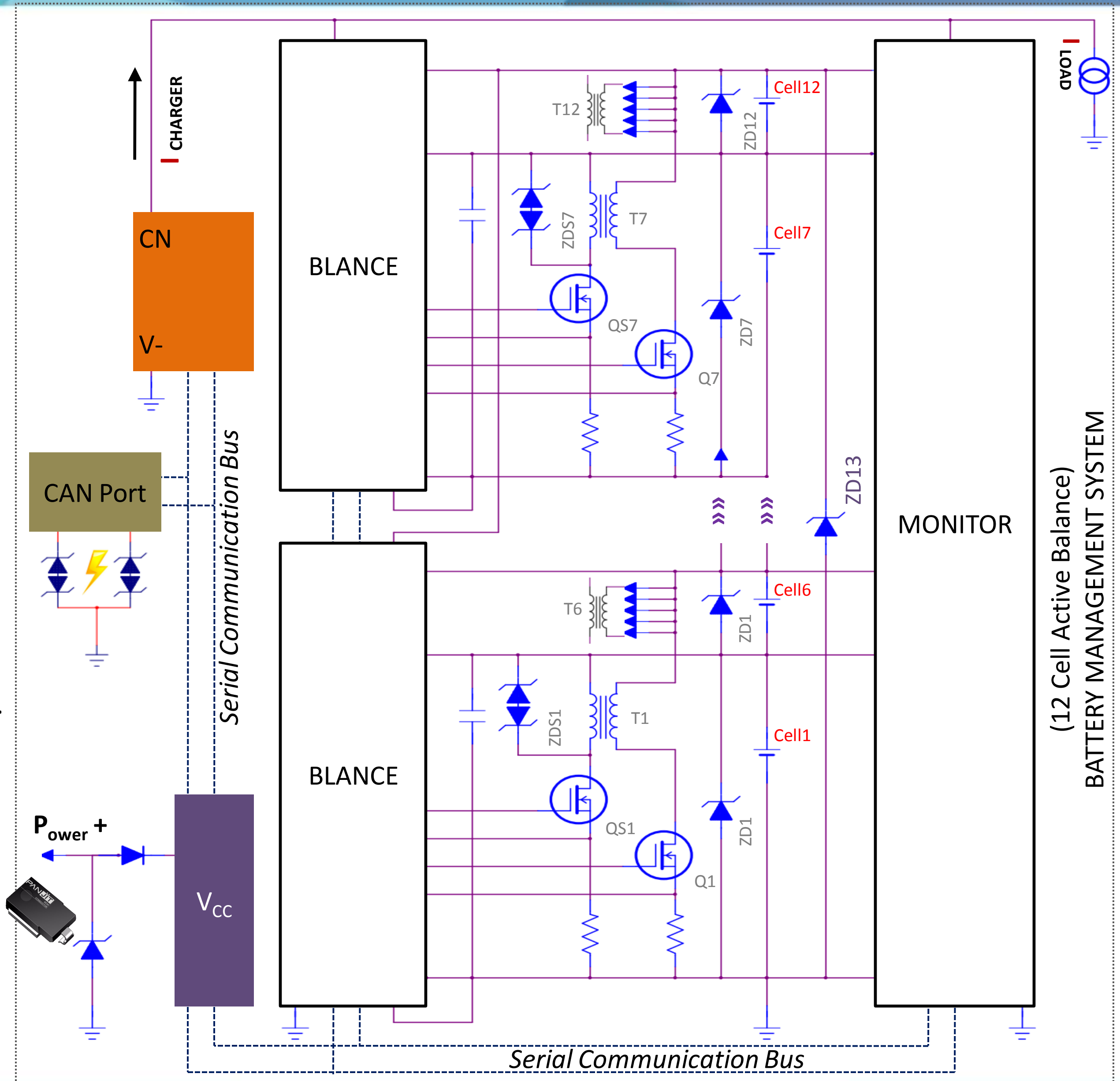
Products PANJIT Can Offer for BMS

PANJIT is able to provide various automotive grade products, such as TVS, Zener, LV MOSFET, Rectifier etc. for the Battery Management System (BMS).

Main product:

- Load Dump Protection TVS that is used in BMS to protect devices from the surge generated by power input. It is a power TVS in DO-218AC package that complies with ISO16750-2 Pulse A.
- Ultra low IR Zener and TVS for protecting the battery and balance IC from hot swap surge protection.
- MV MOSFET with low Rdson and Qj for charge/discharge balance switch.
- Bi-directional ESD protection products for CAN BUS.
- Schottky products for DC/DC converter.

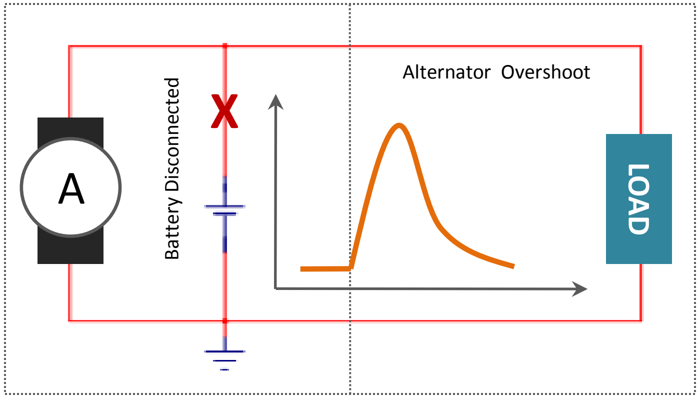
All products are AEC-Q101 qualified.



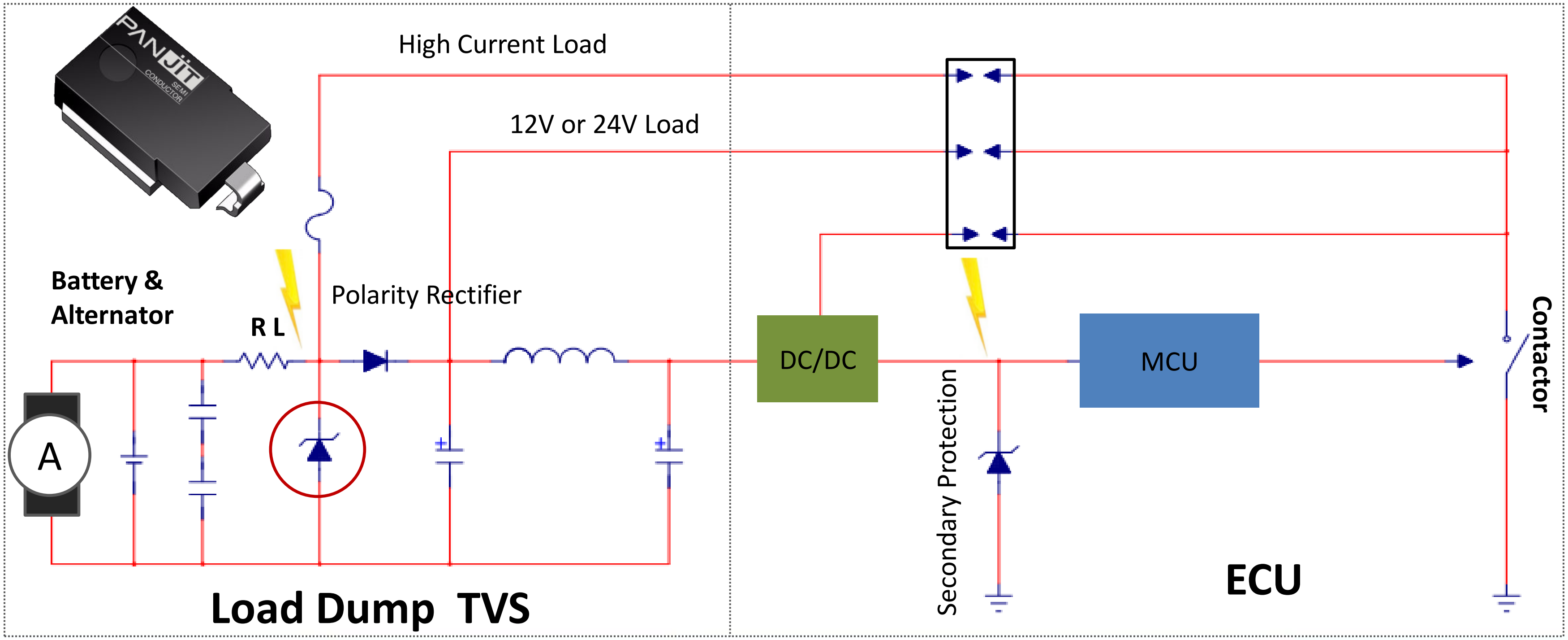
Load Dump Protection TVS

- Load dump TVS is an important protection device for automotive electrical module. It mainly protects the circuit by clamping down the surge voltage generated by the generator during load dump mode.
- When the battery of the automobile suddenly disconnects while the engine is running, the generator will cause an overshoot, which is called surge voltage. See the picture on the right.
- In order to assure the stability and reliability when the car is running, ECU needs to be anti-disturbance qualified. Currently, the automotive OEM refers to the following standards: **ISO7637-2-2004, ISO16750-2 2010(E), JASO and Toyota TC7001.**

*** Pulse 5a/5b has been removed from the latest ISO7367-2 (2010)**

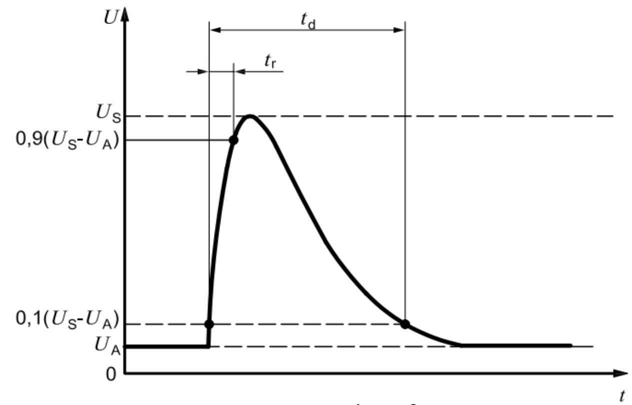


What is Load Dump ?



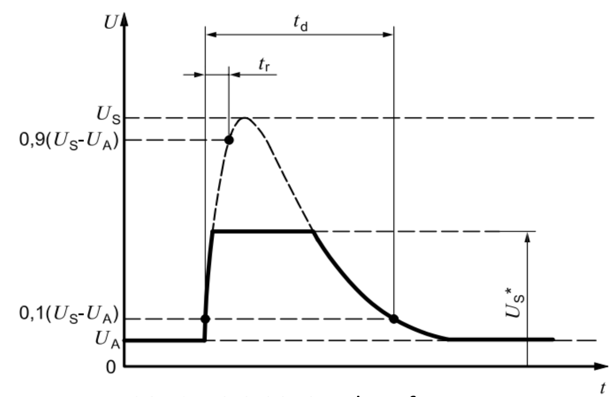
ISO16750-2 (2010) E Test A & B Method

Parameter	Type of System		Mini. Test Requirements
	U_N=12V	U_N=24V	
U_S (V)	79 ≤ U_S ≤ 101	151≤U_S≤202	10 Pulses at intervals of 1min
R_i (Ω)	0.5 ≤ R_i ≤ 4	1 ≤ R_i ≤ 8	
T_d (mS)	40 ≤ U_S ≤ 400	100 ≤ U_S ≤ 350	
T_r (mS)	10 (+0/-5)	10 (+0/-5)	



ISO16750-2 2010 Pulse of Test A

Parameter	Type of System		Mini. Test Requirements
	U_N=12V	U_N=24V	
U_S (V)	79 ≤ U_S ≤ 101	151≤U_S≤202	5 Pulses at intervals of 1min
U_S *(V)	35	65	
R_i (Ω)	0.5 ≤ R_i ≤ 4	1 ≤ R_i ≤ 8	
T_d (mS)	40 ≤ U_S ≤ 400	100 ≤ U_S ≤ 350	
T_r (mS)	10 (+0/-5)	10 (+0/-5)	



ISO16750-2 2010 Pulse of Test B

- **New test condition for Non-Central Load Dump Type Alternator Equipped Vehicles**
- **Replaced ISO7637-2 Pulse 5a**
- **Requires High Power load Dump Protection Device For Clamping Large Current**
- **Clamping Current is as:** $I_{clamping} = (U_S - V_{clamping}) / R_i$

Key Parameters of Load Dump TVS

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• Clamping Voltage

Load Dump TVS needs to sustain the surge impact and clamp the voltage at the same time, in order to protect the EUT from damage.

Maximum. input voltage of voltage regulators:

- Linear Type: 37V to 40V
- DC-DC Converter IC: 40V to 60V

Customer's Design Guide Line: 10% Margin Required.

• Stand-Off Voltage

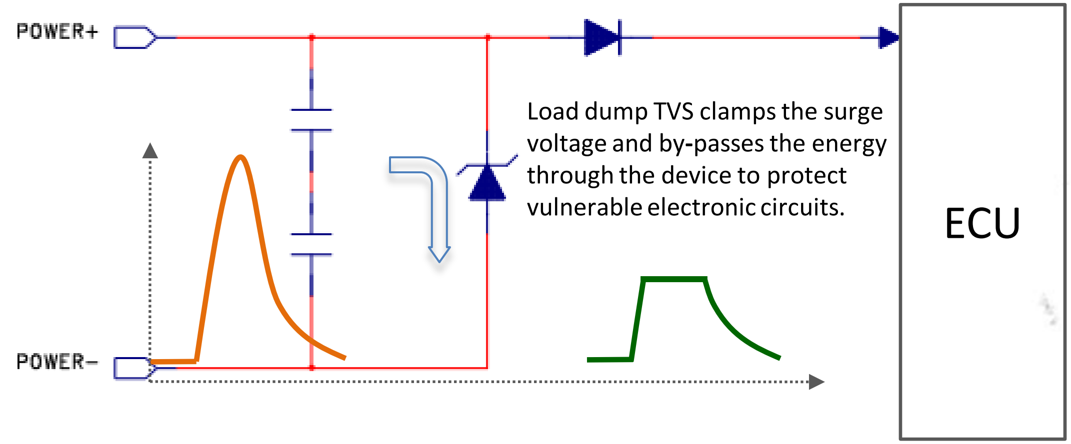
The V_{RWM} of the TVS needs to be higher or equal to the working voltage of the EUT, to assure the TVS would not fail or generate higher current load dump. Hence the V_{RWM} is a critical parameter when selecting the load dump TVS.

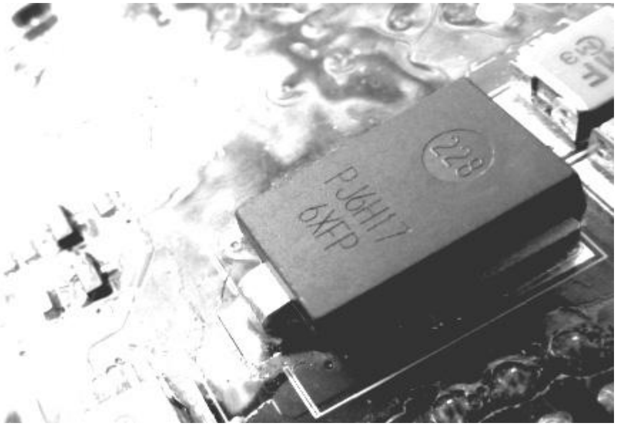
- Load Dump TVS Recommend for 12V system: V_{RWM}= 22V~24V
- Load Dump TVS Recommend for 24V system: V_{RWM}= 30V~36V

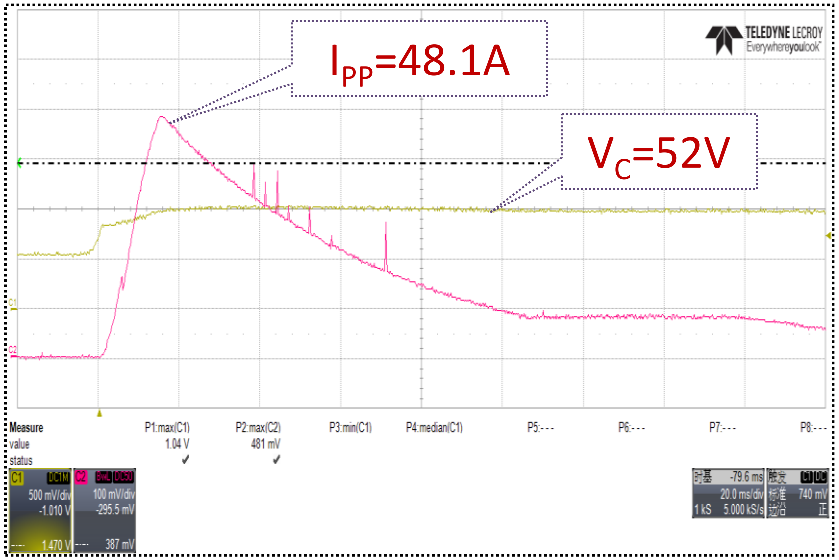
• ISO16750-2 Test Voltage Definition

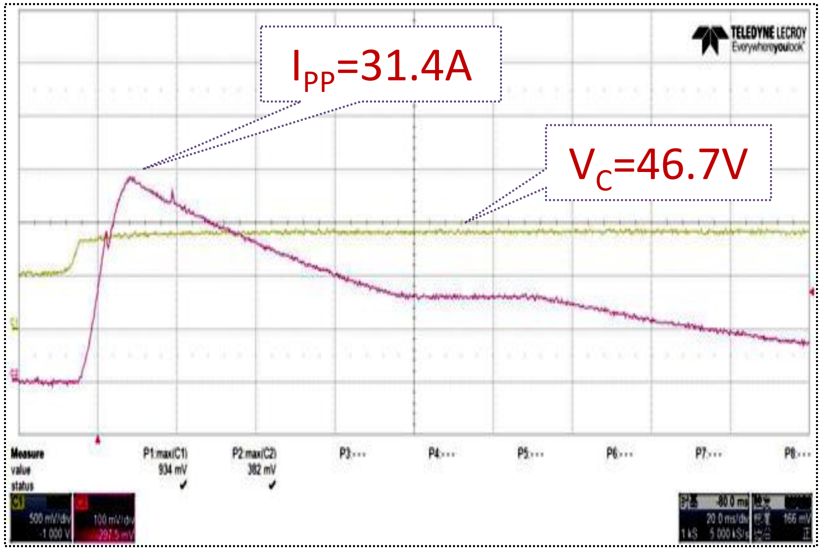
Nominal Voltage UN (V)	Test Voltage UA (V)
12	14
24	28

Operation of Load Dump TVS









Test Rule: ISO16750-2 5a Test R_i=3Ω

ISO16750-2 5a Test R_i=8Ω

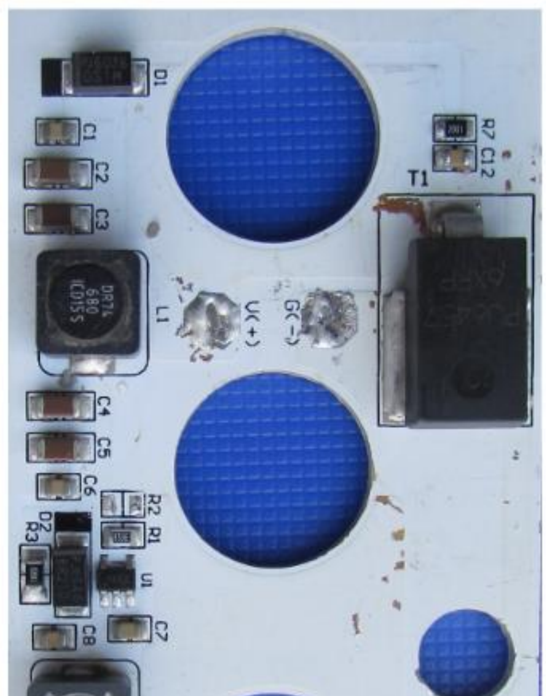
PCB Layout Advice

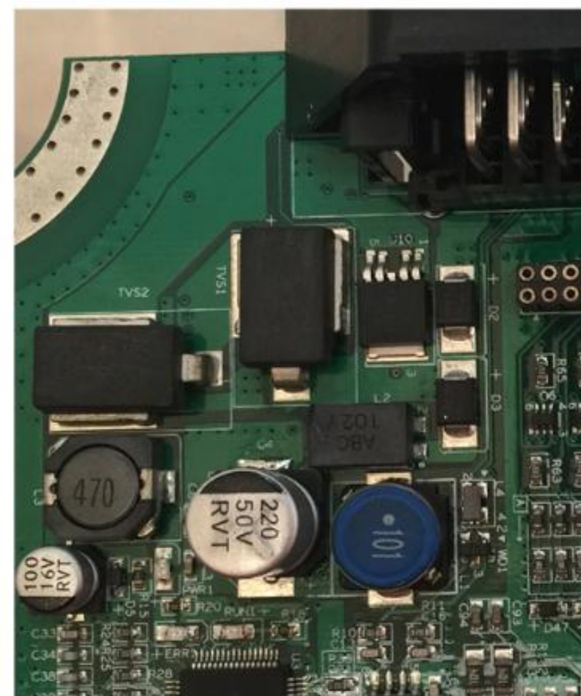
- TVS is suggested to be traced as close to the power input port as possible, because the inductance effect would be lower and the voltage clamping speed of the TVS would be faster.

- In the ECU, there are key components that need to be protected and the sensors that has bad surge sustainability. These devices should be traced as far to the load dump TVS and power input port as possible for decreasing the surge impact.

- The size of the pad layout on the PCB needs to match the heat sink of the DO-218AC package so the device could attach perfectly with the PCB after mounting. This could help reduce the thermal resistance between the TVS device and the PCB.

- When the load dump TVS clamps the voltage, it generates an energy, this energy then turns into thermal which dissipate through the PCB. Thus in order to improve the dissipation capability, it is suggest to efficiently utilize the PCB area.





PANJIT DO-218AC Package Advantage

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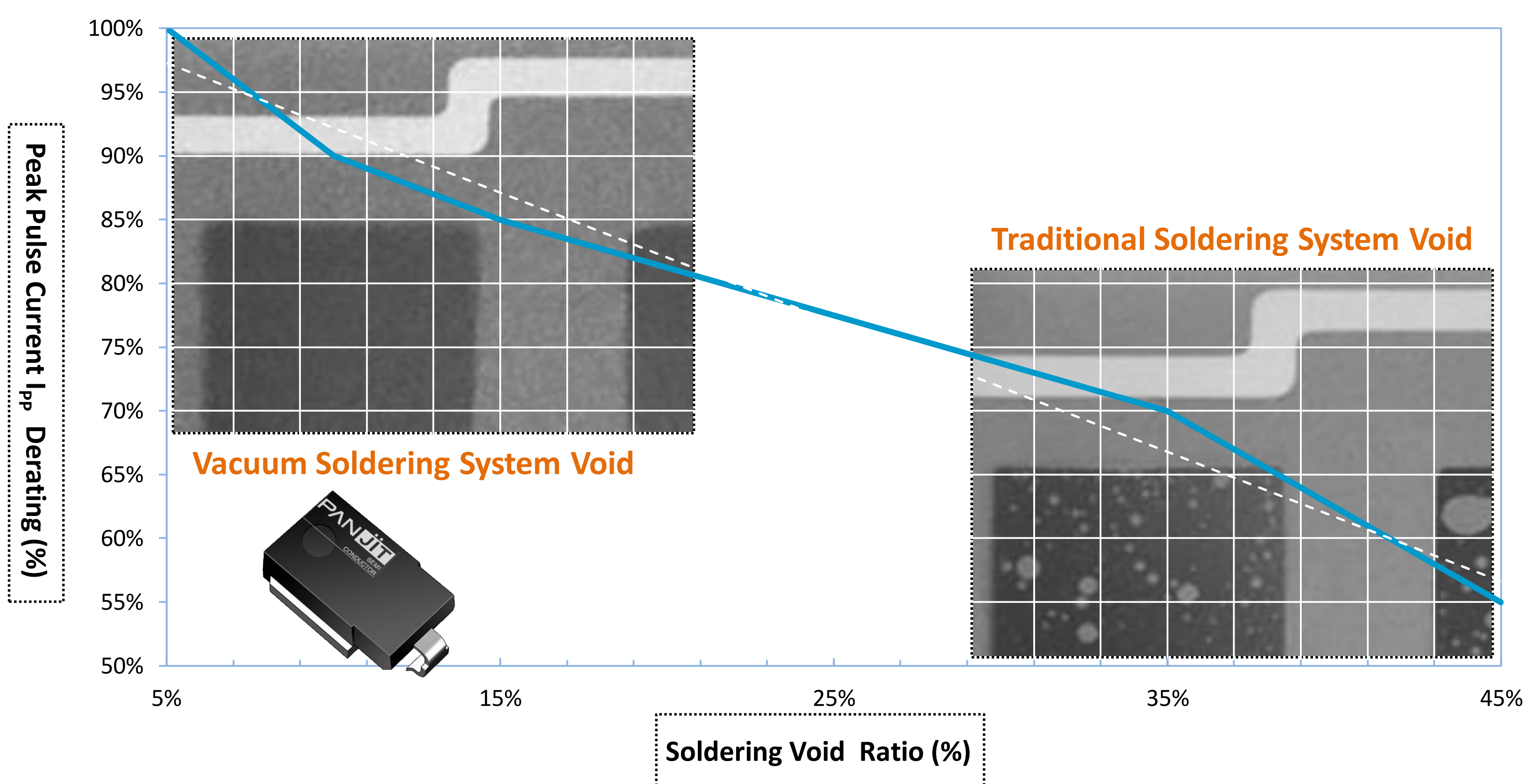
PANJIT uses automation vacuum soldering to assemble the DO-218AC package load dump TVS. Comparing with the traditional furnace soldering, automation vacuum soldering system helps reduce the soldering bias and void. The amount of the void effects the I_{PP} capability of the TVS, thus the lesser void on the die, the better IPP capability of the TVS; meanwhile the lower the thermal resistance is, the faster dissipation speed through thermal conduction.

PiNK® Void-Free Soldering System

PANJIT DO-218AC Package Advantage



I_{PP} Current & Soldering Void Derating Curve

The soldering void is a key point for power TVS products, the amount of the void effects the surge current capability of the TVS

PANJIT Load Dump Protection TVS Series

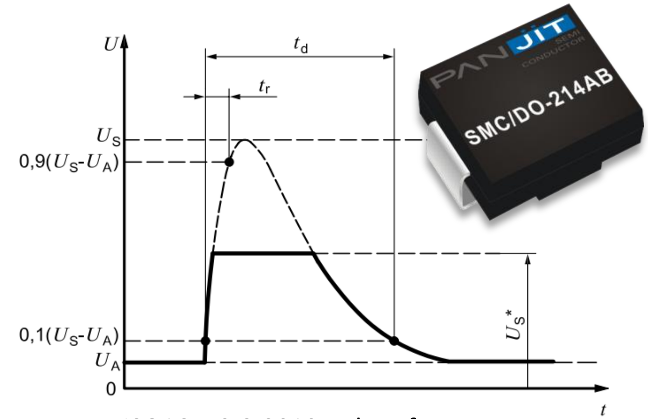
PANJIT offers 3 series load dump TVS: 3.6KS/4.6KS/6.6KS, the highest power absorption is 3600W, 4600W, 6600W respectively and the V_{RWM} range is from 14V to 43V. These 3 series TVS are mainly for the load dump protection and 12V and 24V automotive.

Part Number	P_D (W)	V_{RWM} (V)	$V_{BR}@I_T$		I_T (mA)	$I_R@V_{RWM}$ (uA)	$V_C@I_{PP}$ (V)	I_{PP} (A)	Application V_N (V)
			Min.	Max.					
3.6KSMJX14A-AU	3600	14	15.6	17.2	5	10	23.2	155	12
3.6KSMJX20A-AU	3600	20	22.2	24.5	5	10	32.4	111	12
3.6KSMJX22A-AU	3600	22	24.4	26.9	5	10	35.5	101	12
3.6KSMJX24A-AU	3600	24	26.7	29.5	5	10	38.9	93	12
3.6KSMJX33A-AU	3600	33	36.7	40.6	5	10	53.3	68	24
3.6KSMJX36A-AU	3600	36	40	44.2	5	10	58.1	62	24
4.6KSMJX14A-AU	4600	14	15.6	17.2	5	10	23.2	198	12
4.6KSMJX20A-AU	4600	20	22.2	24.5	5	10	32.4	142	12
4.6KSMJX22A-AU	4600	22	24.4	26.9	5	10	35.5	130	12
4.6KSMJX24A-AU	4600	24	26.7	29.5	5	10	38.9	118	12
4.6KSMJX33A-AU	4600	33	36.7	40.6	5	10	53.3	86	24
4.6KSMJX36A-AU	4600	36	40	44.2	5	10	58.1	79	24
6.6KSMJX14A-AU	6600	14	15.6	17.2	5	10	23.2	284	12
6.6KSMJX20A-AU	6600	20	22.2	24.5	5	10	32.4	204	12
6.6KSMJX22A-AU	6600	22	24.4	26.9	5	10	35.5	186	12
6.6KSMJX24A-AU	6600	24	26.7	29.5	5	10	38.9	170	12
6.6KSMJX33A-AU	6600	33	36.7	40.6	5	10	53.3	124	24
6.6KSMJX36A-AU	6600	36	40	44.2	5	10	58.1	114	24
6.6KSMJX43A-AU	6600	43	47.8	52.8	5	10	69.4	95	24

Notes: I_{PP} Test Pulse Waveform 10/1000uS

ISO16750-2 (2010) E Test B

Parameter	Type of System		Mini. Test Requirements
	U_N=12V	U_N=24V	
U_S (V)	$79 \le U_S \le 101$	$151 \le U_S \le 202$	5 Pulses at intervals of 1min
U_S *(V)	35	65	
R_i (Ω)	$0.5 \le R_i \le 4$	$1 \le R_i \le 8$	
T_d (mS)	$40 \le U_S \le 400$	$100 \le U_S \le 350$	
T_r (mS)	10 (+0/-5)	10 (+0/-5)	



ISO16750-2 2010 Pulse of Test B

The testing voltage of ISO16750 Pulse B is 35% of the maximum polygonal voltage of Pulse A, thus the surge sustainability required for load Dump TVS is much lower. So for products that is tested based on ISO 16750 Pulse B, PANJIT recommends to use TVS assembled in SMC package (1.5KW/3.0KW/5KW).

Part Number	P_D (W)	V_{RWM} (V)	$V_{BR}@I_T$		I_T (mA)	$I_R@V_{RWM}$ (uA)	$V_C@I_{PP}$ (V)	I_{PP} (A)	Application V_N (V)
			Min. (V)	Max. (V)					
1.5SMCJ22A-AU	1500	22	24.4	28	1	1	35.5	42.2	12
1.5SMJC24A-AU	1500	24	26.7	30.7	1	1	38.9	38.6	12
3.0SMCJ22A-AU	3000	22	24.4	28	1	1	35.5	74.4	12
3.0SMCJ24A-AU	3000	24	26.7	30.7	1	1	38.9	77.2	12
1.5SMCJ33A-AU	1500	33	36.7	42.2	1	1	53.3	28.1	24
1.5SMCJ36A-AU	1500	36	40	46	1	1	58.1	25.8	24
3.0SMCJ33A-AU	3000	33	36.7	42.2	1	1	53.3	56.2	24
3.0SMCJ36A-AU	3000	36	40	46	1	1	58.1	51.6	24
5.0SMCJ36A-AU	5000	36	40	46	1	1	58.1	86.1	24

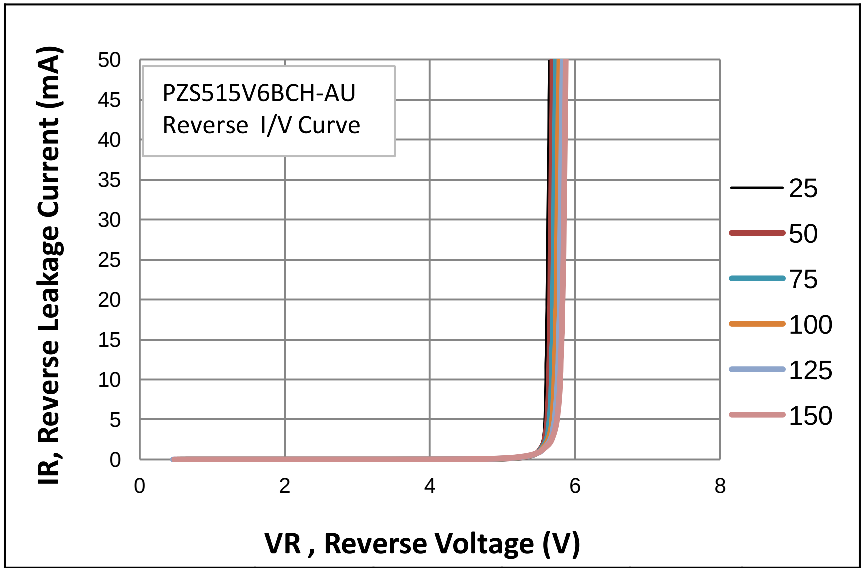
Hot Plug-In Overshoot Protection Zener

PANJIT's automotive grade Ultra low Zener products is specifically developed for BMS. The Zener diodes are in parallel connection with single battery pack and are in reverse mode.

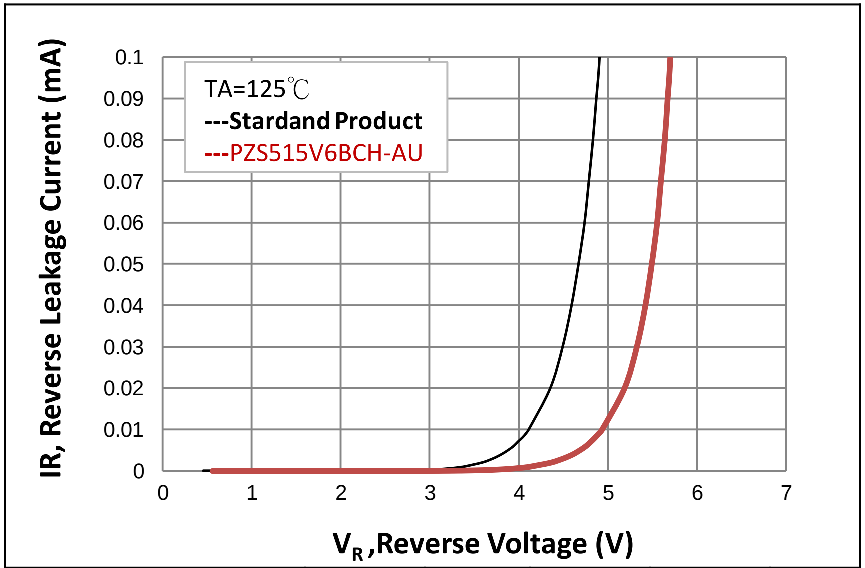
The range of the leakage current affects BMS' standby power dissipation. Meanwhile higher leakage current of Zener will impact the life time and reliability of battery.

The low voltage Zener (5.0~6.4V) from Panjit's ultra low IR series can fully meet TI's design requirements (IR<7uA@VR=4.2V) and ensure the lowest power dissipation of the protected device at standby mode.

Ultra Low IR Zener VS Standard



VR(V)	1.5	2.4	3.3	4.2	5
25° IR(uA)	0.00	0.01	0.03	1.0	7
125° IR(uA)	0.00	0.02	0.08	2	20



VR(V)	1.5	2.4	3.3	4.2	5
BZT52C5V6S (uA)	0.001	0.03	0.7	20	100
PZS515V6BCH-AU (uA)	0.00	0.02	0.08	2	20

PANJIT SEMI CONDUCTOR

TEXAS INSTRUMENTS

Chapter 2
SLUUAS6–December 2013

System Critical Circuits

This section describes circuits that are global in nature and require more than one device in the chipset.

2.1 Zener Diodes

Zener diodes are must be placed close to the external battery connection on the system PCB, with one Zener diode across each cell. The Zener diodes are required for the system and serve two functions:

1. Provide overvoltage protection to the AFE inputs
2. Provide a path for in-rush currents during hot plug-in

Figure 2-1 shows the Zener-diode schematic and shows the direct connection to the battery connection header.

The Zener diodes must be selected to ensure the following conditions are met:

1. The EMB1432 and EMB1433 inputs are protected from input voltage transients and kept below 6 V.
2. The Zener current (I_Z) at typical battery-cell voltage levels is as low as possible to keep the quiescent current low.

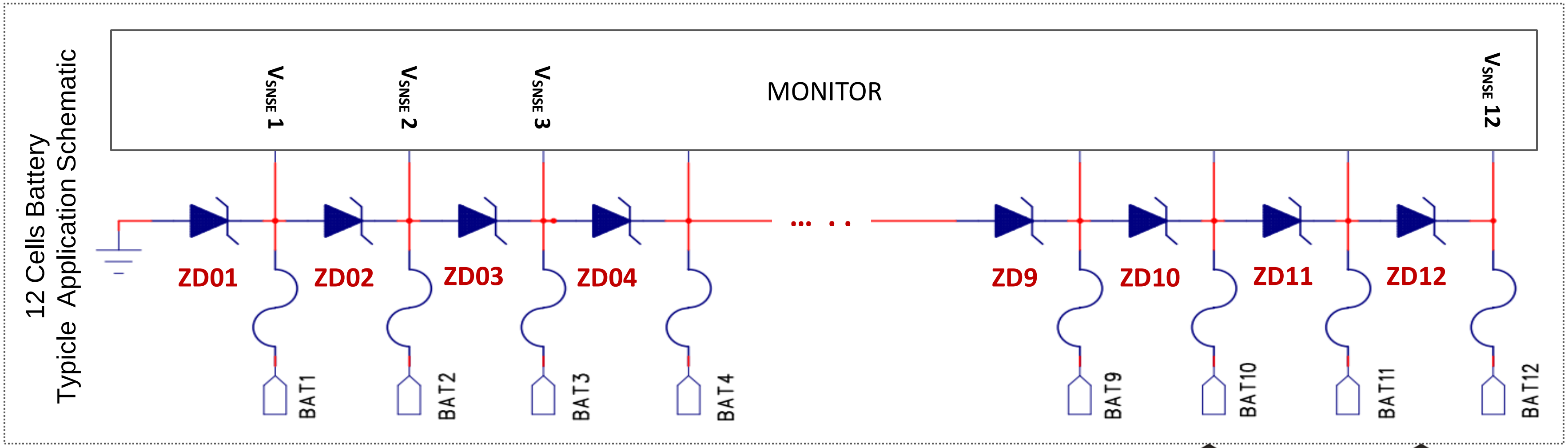
For example, the Zener diodes used in the active chipset reference schematic are 5.6 V, which has an Iz ≈ 7 µA at 4.2 V.

Hot Plug-In Overshoot Protection Zener

A 5.6V or 6.2V 500mW~1W Zener is recommended for protecting the connector from hot plug-in. They are in parallel connections with the batteries, thus the power dissipation of this Zener has to be as low as possible. To achieve that this Zener's reverse current has to be low (ref. to IR<7uA@VR=4.2V), and it has to have a strong ESD sustainability. **Below are the Zeners qualified with ESD IEC6100-4-2 Level 4.**

Recommend Zener Diode

Part Number	PD(W)	Parameter				Package
		VZ(V)	VZ(min.)	VZ (max.)	VR(V)	
PZS515V6BCH	0.5	5.6	5.32	5.88	5.1	SOD-323HE
PZS516V2BCH	0.5	6.2	5.89	6.51	5.6	SOD-323HE
PZ1AH5V6B-AU	1	5.6	5.32	5.88	5.1	SOD-123HE
PZ1AH6V2B-AU	1	6.2	5.89	6.51	5.6	SOD-123HE

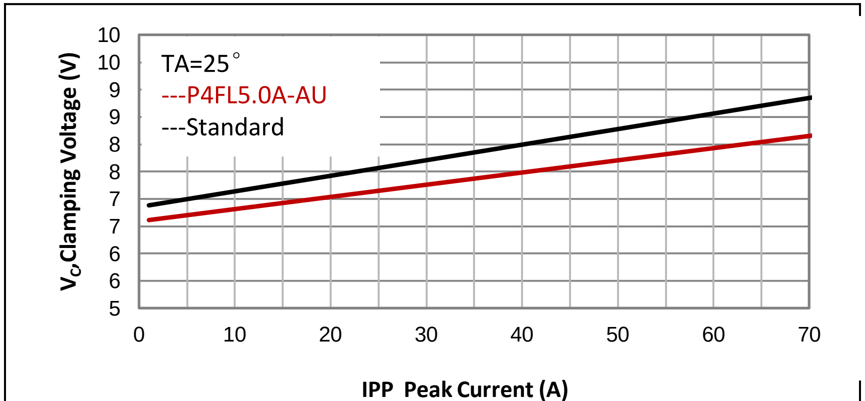


Hot Plug-In Overshoot Protection TVS

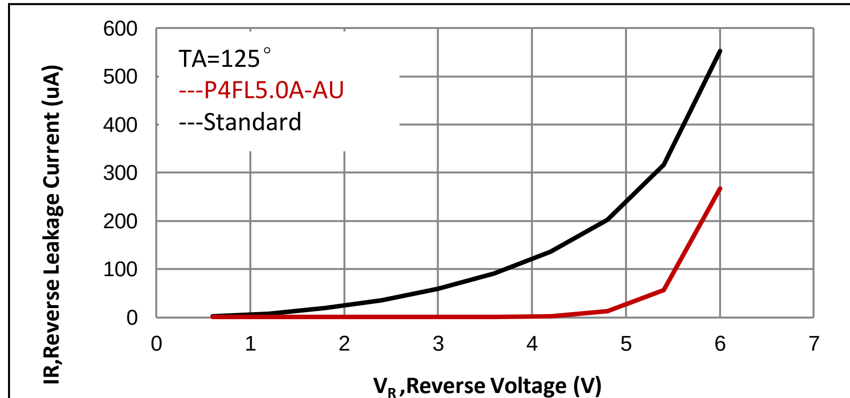
PANJIT SEMICONDUCTOR

Due to the design difference, some batteries in the BMS might have higher surge energy during hot plug. Zener with small power rating may not sustain this kind of surge, hence it is suggested to use 200W~400W ultra low IR TVS at the Vsense port for surge protection. PANJIT's automotive grade TVS wafer uses EPI technology, by using this technique the clamping surge ability is better, and the IR rating would be lower than using Planar technology. With lower IR, the power dissipation could be reduced during standby mode, which improves the power dissipation of the BMS under standby mode.

Planar TVS vs. EPI TVS (V_C and I_R comparison)



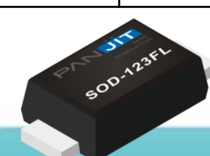
IPP(A)	1	5	10	20	30
Standard	6.87	7.12	7.31	7.65	7.93
P4FL5.0A-AU	6.61	6.73	6.89	7.16	7.43



VR(V)	2.4	3	3.6	4.2	4.8
Standard	37.5	63.23	97.8	145	216
P4FL5.0A-AU	0.0967	0.1930	0.551	2.353	11.22

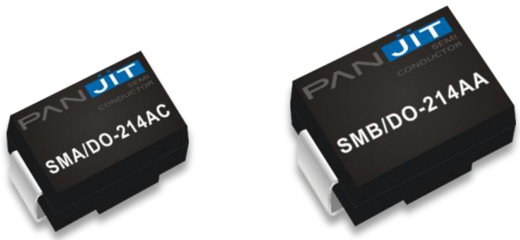
Recommend TVS Diode

Part Number	P_D(W)	V_{RWM} (v)	I_T(mA)	$I_R@V_{RWM}$	$V_C@I_{PP}$	I_{PP} (A)	Package
P2AL5.0A-AU	200	5.0	1	25	9.2	21.7	SOD-123FL
P4FL5.0A-AU	400	5.0	1	25	9.2	43.5	SOD-123FL



Battery Stack Protection TVS Selection

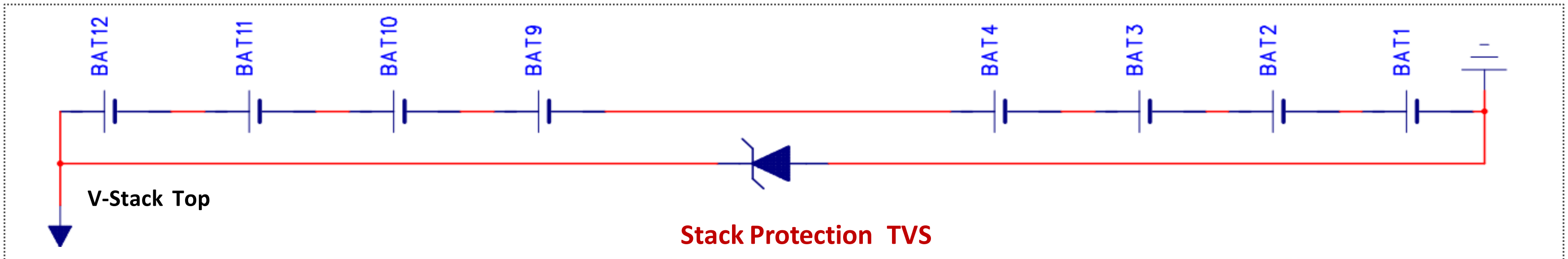
For battery stack protection, it is recommended to use a 600W TVS. And the recommended VRWM is $VRWM > V_{CELL} * S * 1.1$($V_{CELL}$ is the voltage of the batter, S is the number of the battery stack)



Recommend TVS Diode

Part Number	P_D(W)	V_{RWM} (v)	$I_R@V_{RWM}$	$V_C@I_{PP}$	I_{PP}	Package
P4MA54A-AU	400	54	0.1	87.2	4.6	SMA
P4MA60A-AU	400	60	0.1	96.8	4.1	SMA
P4MA64A-AU	400	64	0.1	103	3.9	SMA
P4MA75A-AU	400	75	0.1	121	3.3	SMA
P6MB54A-AU	600	54	0.1	87.2	6.9	SMB
P6MB60A-AU	600	60	0.1	96.8	6.8	SMB
P6MB64A-AU	600	64	0.1	103	5.8	SMB
P6MB75A-AU	600	75	0.1	121	4.9	SMB

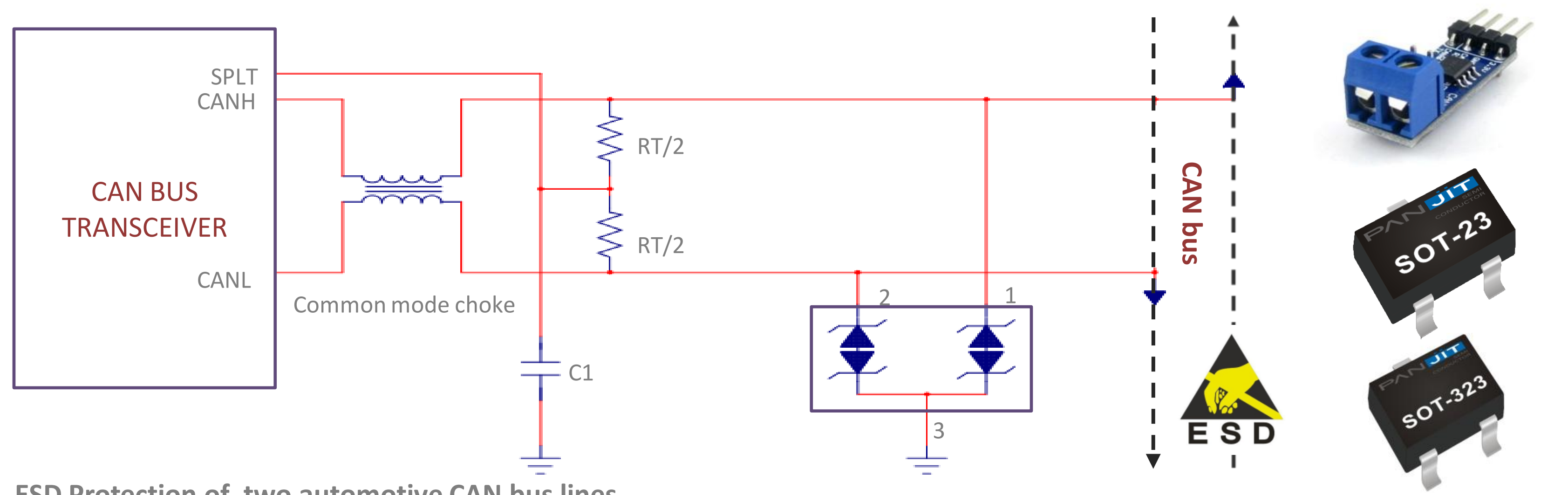
Typicle Application 12 Cells Balancing Stack



CAN bus ESD Protection

PANJIT's PEC3124C2A-AU and PEC3124C2ATS-AU are bi-directional ESD products specifically designed for CAN bus usage. These bi-directional devices could protect the high speed CAN lines and fault-tolerant CAN lines from the ESD and transient surge impact. The maximum surge impact that these devices could sustain per direction is 180W 8/20 us, the ESD capability is IEC61000-4-2 qualified and is assembled in SOT-23 and SOT-323 respectively .

Typical Application Schematic



ESD Protection of two automotive CAN bus lines

PEC3124C2A-AU

PEC3124C2C-AU

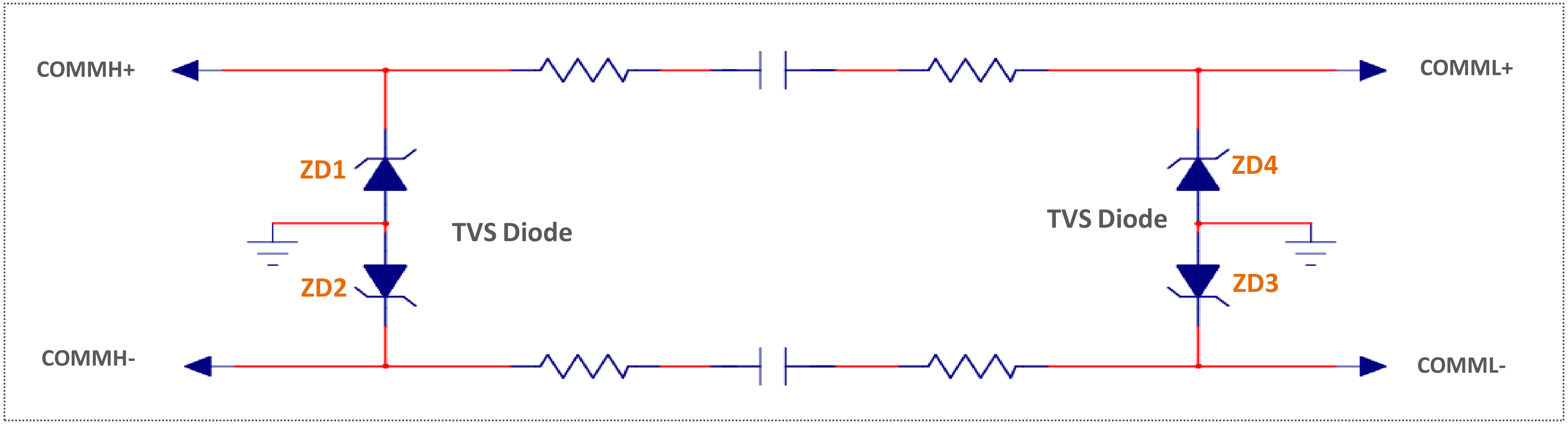
Recommend ESD Array

Part Number	UNI/BI	Ch.	V_{RWM} Max.	V_{BR} Min.	V_{BR} Max.	$I_R@V_{RWM}$ nA	$V_C@I_{PP}$ Max.	I_{PP}	CJ Max.	Package
PEC3124C2A-AU	BI	2	24	25.4	30.3	50<	60	3	15	SOT-23
PEC3124C2C-AU	BI	2	24	25.4	30.3	50<	50	3	15	SOT-323

I/O Sensor Protection

When the amount of battery used in a BMS becomes more and more, a single BMS needs to have at least 2 battery management ICs to manage the signal. High transient voltage is generated during hot plug, if this signal isn't clamped down , it will disturb the communication, hence it is suggested to mount a ESD diode between the I/O port (see below pic.) to absorb the transient surge. When selecting the ESD diode, the Cj needs to be as low as possible since the capacitance of the circuit influences the rise time of the communication signal.

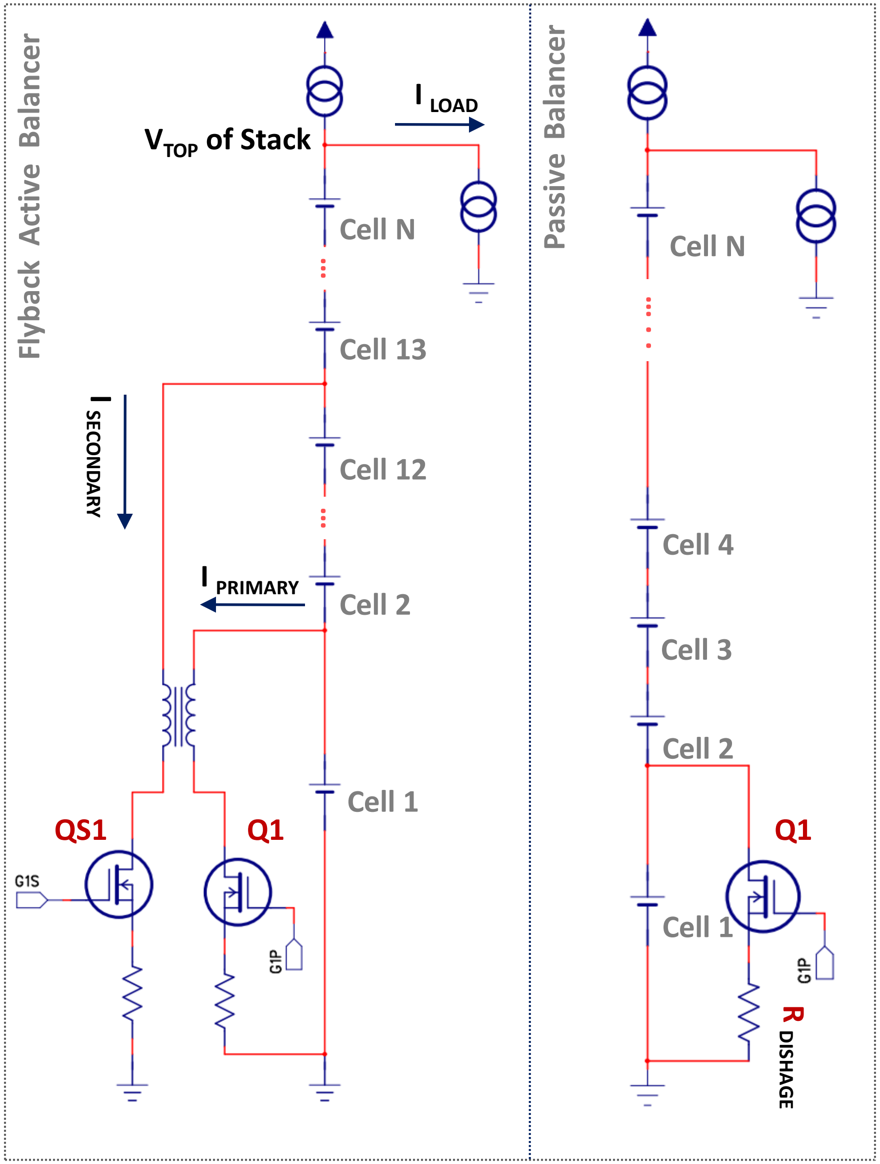
PANJIT has developed low Cj ESD diodes (PJDLC05-AU) for I/O port protection. This device could sustain 400W 8/20uS transient surge impact and the max. Cj is <1pF, which has very low impact on the signal transmission.



Recommend ESD Array

Part Number	UNI/BI	Ch.	VRWM MAX.	V_{BR} Min.	IR(uA)@VRWM Max.	V_C@IPP Max.	I_{PP}	C_J Max.	Package
PJE5V0U8TB-AU	UNI	2	5	5.8	10.2	15	4	0.8	SOT-523
PJDLC05-AU	UNI	2	5	6	20	11	5	1	SOT-23

Balancer External MOSFET Selection



External MOSFET Selection

PANJIT has developed 40V, 60V, 100V and 150V mid. voltage MOSFETs for the BMS balancer, these MOSFETs are of low Rdson and low Qg and come with packages like DFN5X6, TO-252, SO-8 etc..

The MOSFET selection for active balancing is not only based on the balancing current and heat radiation, but also the turns ratio and the power voltage of the stacked battery. These conditions will define the VDSS of the primary and secondary and its reliability

Primary MOSFET VDS selection suggestion

$$V_{DS}(\text{min.}) > \mathrm{V_{CELL}} * (1 + \frac{\mathrm{S}}{\mathrm{T}})$$

Secondary MOSFET VDS selection suggestion

$$V_{DS}(\text{min.}) > \mathrm{V_{CELL}} * (\mathrm{T} + \mathrm{S})$$

T: *Turns ratio (primary and secondary)*
S: *The amount of battery stacked on the secondary*

As for choosing the balancing MOSFET for Passive balancer, the V_{DSS} is suggested to be 10% more above the voltage of the stacked battery.

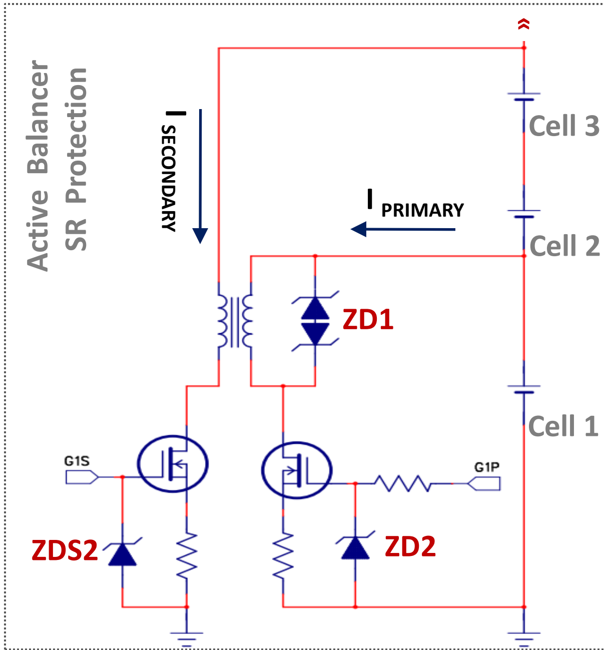
$$V_{DS}(\text{min.}) > \mathrm{V_{CELL}} * \mathrm{S} * 1.1$$

Balancer External MOSFET Selection

Recommend MV MOSEFT

V_{DS}	V_{GS}	Ch.	R_{DS}(ON) 10V	R_{DS}(ON) 4.5V	TO-252AA	SOP-8	SOP-8 Dual	DFN5060-8L Single	DFN5060-8L EP2
V	V	N/P	(mOhm) max.						
40	20	N	35	45	PJD25N04-AU	PJL9428-AU	PJL9850-AU	PJQ5450-AU	PJQ5850-AU
			12	17	PJD40N04-AU	PJL9426-AU	PJL9852-AU	PJQ5448-AU	PJQ5848-AU
			9.5	13.5	PJD50N04-AU	PJL9424-AU	PJL9854-AU	PJQ5446-AU	
			6.5	8.5	PJD60N04-AU	PJL9422-AU		PJQ5444-AU	
			5.5	7	PJD80N04-AU			PJQ5442-AU	
			3.8	5	PJD100N04-AU			PJQ5440-AU	
60	20	N	34	40	PJD25N06A-AU	PJL9438A-AU		PJQ5468A-AU	
			21	24	PJD35N06A-AU	PJL9436A-AU		PJQ5466A-AU	
			12	15	PJD45N06A-AU	PJL9434A-AU		PJQ5462A-AU	
			9.5	10.8	PJD60N06A-AU			PJQ5464A-AU	
			5	6	Development	Development		Development	
100	20	N	90	100	PJD15N10A-AU				
			50	55	PJD25N10A-AU	PJL9454A-AU		PJQ5474A-AU	
			25	28.5	PJD50N10AL-AU	PJL9458AL-AU		PJQ5476AL-AU	
			20	22	PJD55N10A-AU	PJL9460A-AU			
			16	17	PJD60N10A-AU	PJL9462A-AU		PJQ5480A-AU	
			8.4	13	PJD80N10A-AU	PJL9550A-AU		PJQ5570A-AU	
150	20	N	65		PJD30N15-AU	PJL9480-AU		PJQ5492-AU	
			35		PJD40N15-AU			PJQ5494-AU	

External MOSFET Overshoot and ESD Protection



A transformer is installed in the active balancer. This transformer stack, which is compatible with the MOSFET, triggers power flyback while switching on and off at high speed. At the moment the MOSFET is switched off, the power in the secondary winding will flow to the primary winding through the winding coupled, if this power isn't been clamped, the MOSFET will then be damaged. Therefore, it is better to add a snubber TVS at the primary winding (see ZD1).

Currently, most of the medium voltage MOSFETs on the market do not have ESD protection ability, thus it is suggested to add a Zener or ESD diode at the GS of the SR MOSFET (ZD2 and ZDS2). This helps assure that the MOSFET will not be damage by overshoot or the ESD that was generated due to the hot plug.

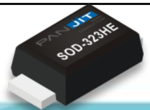
Recommend to use PANJIT's Zener and TVS device to balance the surge of the MOSFET for ESD protection

ESD Protection Zener

Part Number	P_D(W)	VRWM(V)	$V_{BR}@I_T$		I_T(mA)	$I_R@V_{RWM}$	$V_C@I_{PP}$	I_{PP}	Package	Position
			Min.	Max.						
P4SMAJ6.5CA-AU	400	6.5	7.22	9.14	1	200	11.2	35.7	SMA	ZD1

Snubber TVS Diode

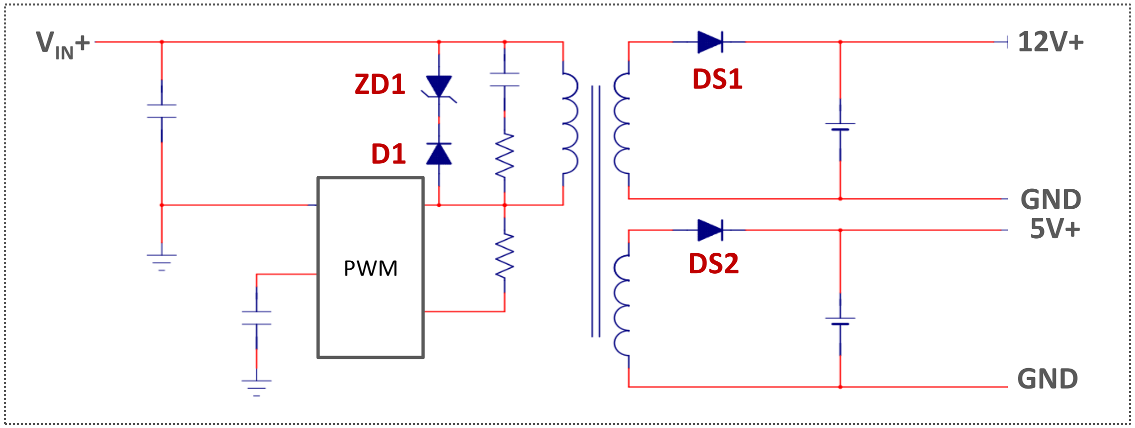
Part Number	P_D(W)	Parameter							Package	Position
		V_Z(V)	V_Z(min.)	V_Z (max.)	I_{ZT}(mA)	Z_{ZT}(Ω)	I_R(uA)V_R	V_R(V)		
PZ15CHEWS-AU	0.5	15	14.25	15.75	5	15	0.1	10.5	SOD-323HE	ZD12,ZDS2



Assistant DC to DC Power Supply

PANJIT SEMI CONDUCTOR

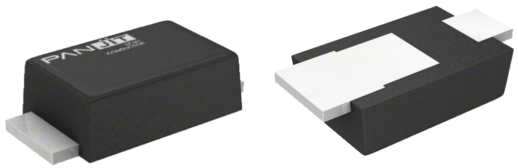
12V & 5V Output Isolated Flyback DC/DC Converter



There are varies ICs are on the BMS module to manage different power demands, normally an auxiliary power is added on the module to provide VSS to each ICs. PANJIT could offer automotive grade Schottky and TVS for the DC/DC converter.

The Schottky is assembled in a SOD-123HE package. The dissipation of this package is better because of the larger heat sink. The TJ could reach to 150 ℃, and could assure a stable performance under high temperature working environment.

SOD-123HE



Secondary Schottky Rectifier

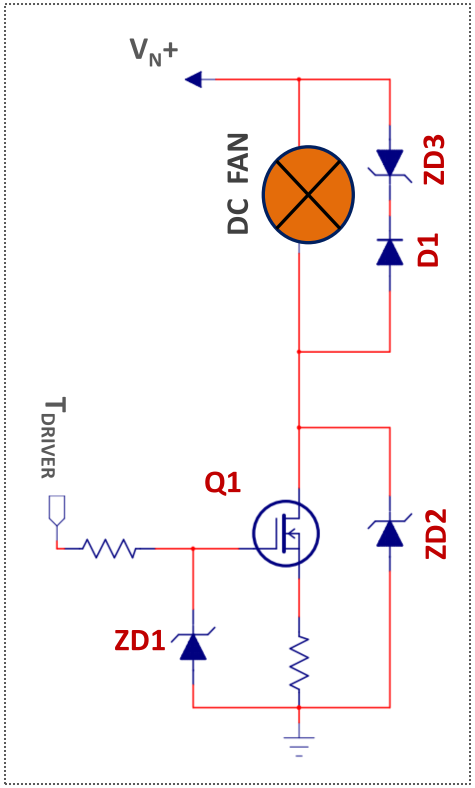
Part Number	Io (A)	I_{FSM}(A)	V_{RRM}(V)	Typ. V_F(V) @IF(A)		Typ. I_R(uA) @VR(V)		T_J max(℃)	Package Outlines	Position
SS1040HE-AU	1.0	30	40	0.55	1.0	15	40	150	SOD-123HE	DS2
SS10100HE-AU	1.0	30	100	0.8	1.0	0.1	100	150	SOD-123HE	DS1
SS10150HE-AU	1.0	30	150	0.85	1.0	0.1	150	150	SOD-123HE	D1

Snubber TVS Diode

Part Number	P_D(W)	V_{RRM} Max.	V_{BR}@I_T		I_T	I_R@V_{RWM} Max	V_C@I_{PP} Max.	I_{PP}	Package	Position
		V	Min.	Max.	mA	uA	V	A		
P2L15A-AU	200	15	16.7	18.5	1	0.1	24.4	8.2	SOD-123FL	ZD1
P4FL15A-AU	400	15	16.7	18.5	1	0.1	24.4	16.4	SOD-123FL	ZD1

Battery Pack Cooling DC FAN Driver

PANJIT SEMI CONDUCTOR



The performance of the battery varies by temperature. The best operating temperature for Lithium-ion batter is 25~40 ℃. The temperature affects the SOC, off-load voltage, resistance, the power and even the life time of the battery. BMS could stabilize the temperature of the working environment, and improve the performance of the battery. Currently water cooling and wind cooling are the two major cooling method on the market.

PANJIT's offers MOSFET to switch on the DC FAN driver, TVS and schottky for snubber.

Recommend Rectifier and Protection TVS & Zener

Part Number	Parameter	Package	Position
BR510-AU	5A/100V SMC VF<0.8V/TJ -50~175° Schottky Rectifier	SMC	D1
BX310F-AU	3A/100V SMC VF<0.8V/TJ -50~175° Schottky Rectifier	SMAF	D1
P6MB54A-AU	600W/54V SMB Valmp<38.9v@IPP=15.4A TVS Diode	SMB	ZD2
P6MB24A-AU	600W/24V SMB Valmp<87.1v@IPP=6.9A TVS Diode	SMB	ZD3
PZ15CHEWS-AU	15V (VZ:14.25~15.75) 500mW SOD-323HE Zener Diode	SOD-323HE	ZD1

Recommend MV MOSFET

P/N	Type	V_{DS}	V_{GS}	I_D	V_{TH}(min)	V_{TH}(max.)	R_{DS}@10V	R_{DS}@4.5V	Ciss	Qg	Package	position
		V	V	A	V	V	mΩ	mΩ	PF	nC		
PJQ5570A-AU	N	100	±20	110	1.0	3.3	8.4	13	3870	48	DFN5*6	Q1
PJD80N10A-AU	N	100	±20	110	1.0	3.3	8.4	13	3870	48	TO-252	Q1

Other Common Parts

Schottky Barrier Rectifier

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Schottky Diode

Part Number	Io (A)	I_{FSM}(A)	V_{RRM}(V)	V_F Maz.(V) @I_O	I_R Max.(uA)@V_{RRM}	T_J max(℃)	Package
SS1040HEWS-AU	1.0	22	40	0.52	100	150	SOD-323HE
SS2040HE-AU	2.0	50	40	0.55	100	150	SOD-123HE
SS2040FL-AU	2.0	50	40	0.5	100	150	SOD-123FL
SS3040HE-AU	3.0	80	40	0.52	160	150	SOD-123HE
SXM34AVF-AU **	3.0	150	45	0.47	210	150	SMAF
SX54AF-AU	5.0	100	45	0.55	200	150	SMAF
SK54-AU	5.0	100	40	0.55	200	150	SMC
SK54L-AU **	5.0	100	40	0.44	500	150	SMC
SS1060HEWS-AU	1.0	22	60	0.68	100	150	SOD-323HE
SS2060FL-AU	2.0	50	60	0.7	40	150	SOD-123FL
SS3060HE-AU	3.0	80	60	0.65	100	150	SOD-123HE
SXM36VF-AU **	3.0	80	60	0.5	220	150	SMAF
SX36-AU	3.0	80	60	0.75	50	150	SMA
BR36-AU	3.0	80	60	0.8	50	170	SMB
SX56F-AU	5.0	100	60	0.66	100	150	SMAF
SV560L-AU **	5.0	120	60	0.67	150	150	TO-277
BR210-AU	2.0	50	100	0.8	50	170	SMA
BX310F-AU	3.0	100	80	0.8	50	170	SMAF
BR310-AU	3.0	100	80	0.8	50	170	SMB
MB510-AU	5.0	100	100	0.8	50	170	SMB
SVT12100V-AU	12	200	100	0.67	100	150	TO-277

Note :** Low Forward Voltage Drop Schottky Diode

Small Signal Device

Switching Diode

Part Number	V_{RRM}	P_{TOT}	T_{RR} Max.	I_{FSM}@T_P		V_F Maz.@I_F		I_R Max.@V_{RRM}	C_J Max.	T_J max.	Package
	V	mW	nS	A	mS	V	mA	uA	pF	℃	
1N4148WS-AU	100	250	4.0	4.0	0.001	1.25	150	2.5	1.5	150	SOD-323
1N448WS-AU	100	250	4.0	4.0	0.001	1.0	100	2.5	4	150	SOD-323
1N4148W-AU	100	410	4.0	4.0	0.001	1.25	150	2.5	1.5	150	SOD-123
1N4448W-AU	100	500	4.0	4.0	0.001	1.0	100	2.5	4	150	SOD-123
BAS16TS-AU	100	200	6.0	4.0	0.001	0.885	10	1.0	2	150	SOD-523
BAV99-AU	100	250	4.0	4.0	0.001	1.25	150	2.5	1.5	150	SOT-23
BAV99W-AU	100	250	4.0	4.0	0.001	1.25	150	2.5	1.5	150	SOT-323
BAV56W-AU	100	200	4.0	4.0	0.001	1.25	150	2.5	1.5	150	SOT-323
BAV56-AU	100	200	4.0	4.0	0.001	1.25	150	2.5	1.5	150	SOT-23
BAV70W-AU	100	200	4.0	4.0	0.001	1.25	150	2.5	1.5	150	SOT-323
BAV70-AU	100	200	4.0	4.0	0.001	1.25	150	2.5	1.5	150	SOT-23
BAS70WS-AU	70	225	--	4.0	1	1.0	15	10	2.0	150	SOD-323

MOSFET

P/N	Type	V_{DS}	V_{GS}	I_D	V_{TH}(min)	V_{TH}(max.)	R_{DS}@10V	R_{DS}@4.5V	Ciss	Qg	Package
		V	V	mA	V	V	Ω	Ω	PF	nC	
2N7002K-AU	N	60	±20	115	1.0	2.5	3.0	4.0	35	0.8	SOT-23
2N7002KW-AU	N	60	±20	115	1.0	2.5	3.0	4.0	35	0.8	SOT-323
PJT7802-AU	N	20	±12	500	0.4	1.0	0.4	--	39	0.9	SOT-363

TVS and Zener Diode

200W to 3000W TVS Diode

Part Number	P_D(W)	V_{RWM}(V)	UNI/BI	Description	Package
P2ALxxA-AU Series	200	5.0 to 60	UNI	Ultra Low IR 200W Unidirection Transient Voltage Suppressors	SOD-123FL
P4FLxxA-AU Series	400	5.0 to 40	UNI	Ultra Low IR 400W Unidirection Transient Voltage Suppressors	SOD-123FL
P4MAxxA-AU Series	400	5.0 to 64	UNI	Ultra Low IR 400W Unidirection Transient Voltage Suppressors	SMA
P4SMAJxxA –AU Series	400	9.0 to 220	UNI/BI	600W Unidirection Transient Voltage Suppressors	SMA
P6AFxxA-AU Series	600	5.0 to 64	UNI	Ultra Low IR 600W Unidirection Transient Voltage Suppressors	SMAF
P6MBxxA-AU Series	600	5.0 to 64	UNI	Ultra Low IR 600W Unidirection Transient Voltage Suppressors	SMB
P6SMBJxxA-AU Series	600	9.0 to 220	UNI/BI	600W Unidirection Transient Voltage Suppressors	SMB
1.5SMCJxxA-AU Series	1500	5.0 to 220	UNI/BI	1500W Unidirection Transient Voltage Suppressors	SMC

200mW to 1W Zener Diode

Part Number	P_D(mW)	V_{RWM}(V)	Description	Package
BZT52-BxxS-AU Series	200	5.0 to 75	200mW ±2% Precise Zener Diodes	SOD-323
BZT52-Bxx-AU Series	410	5.0 to 68	410mW ±2% Precise Zener Diodes	SOD-123
PZS51xxBCH-AU Series	500	3.9 to 43	500mW ±2% Precise Zener Diodes	SOD-323HE
PZS51xxBAS–AU Series	500	3.9 to 43	500mW ±2% Precise Zener Diodes	SOD-123
PZ1AHxxB-AU Series	1000	3.6 to 75	1000mW ±2% Precise Zener Diodes	SOD-123HE
PZ1ALxxB-AU Series	1000	3.6 to 75	1000mW ±2% Precise Zener Diodes	SOD-123FL

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