

Automotive Selection Guide

TVS & ESD / Diode Rectifier / Zener / MOSFET / BJT

AEC-Q101 Qualified

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強茂股份有限公司是一家致力於生產高品質半導體的國際公司，產品廣泛應用於消費性、綠能源、工業電子、汽車電子、網通、電腦運算等產品。我們的願景：
在半導體元件領域，站上世界第一，並成為環境，顧客與員工值得信賴的夥伴

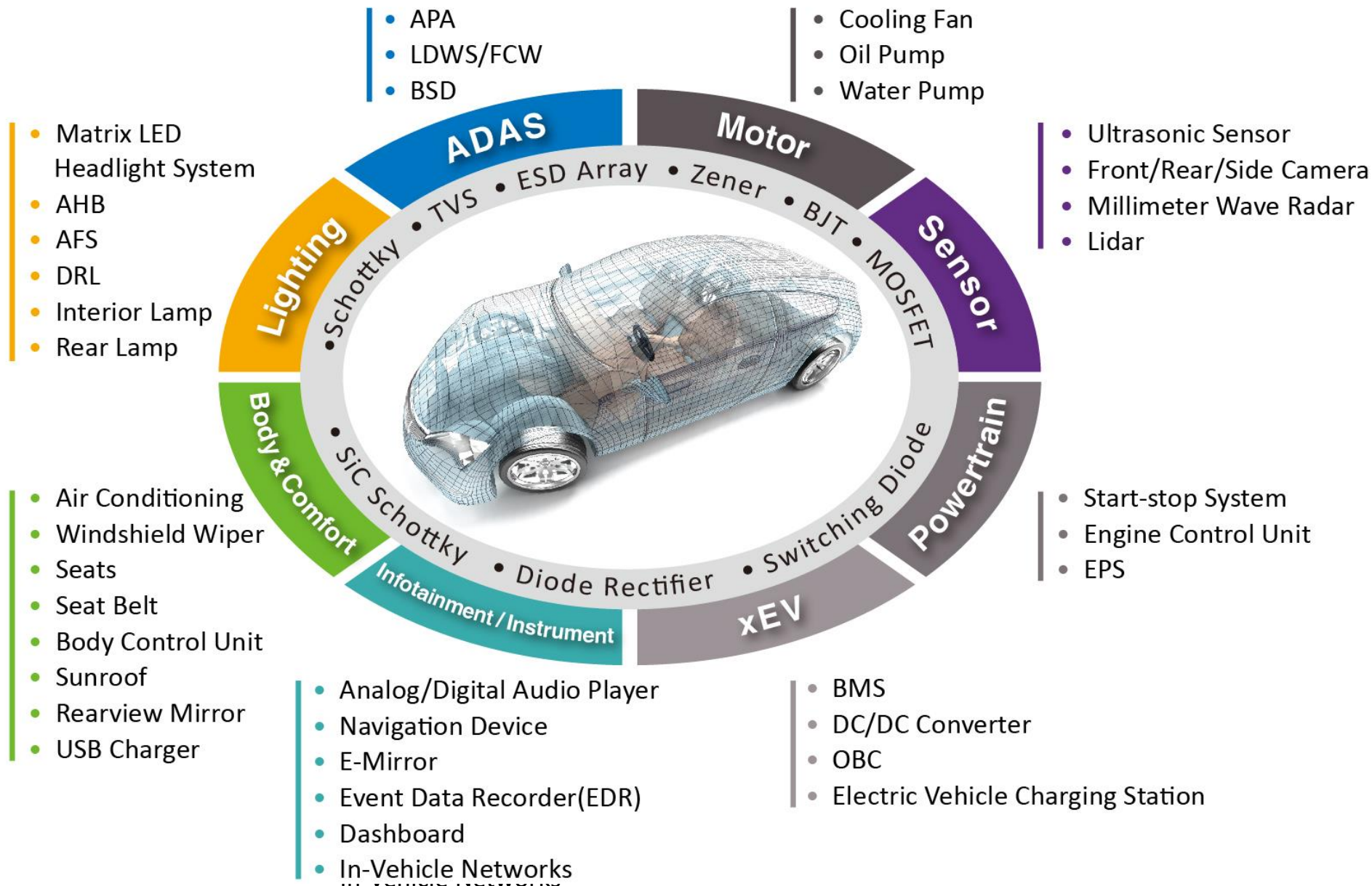
✓成立於: 1986

✓ TWSE: 2000 上市

✓全球員工數: 3,000



汽車應用分類





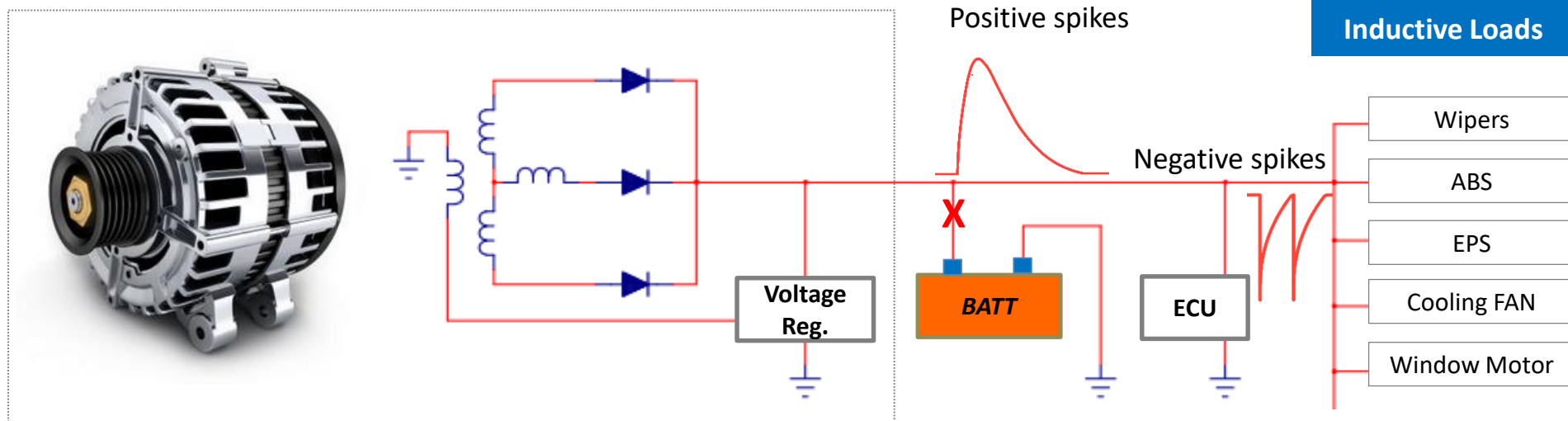
汽車電控單元浪湧防護介紹

ISO 7637-2 / ISO 16750-2 / ISO 10605

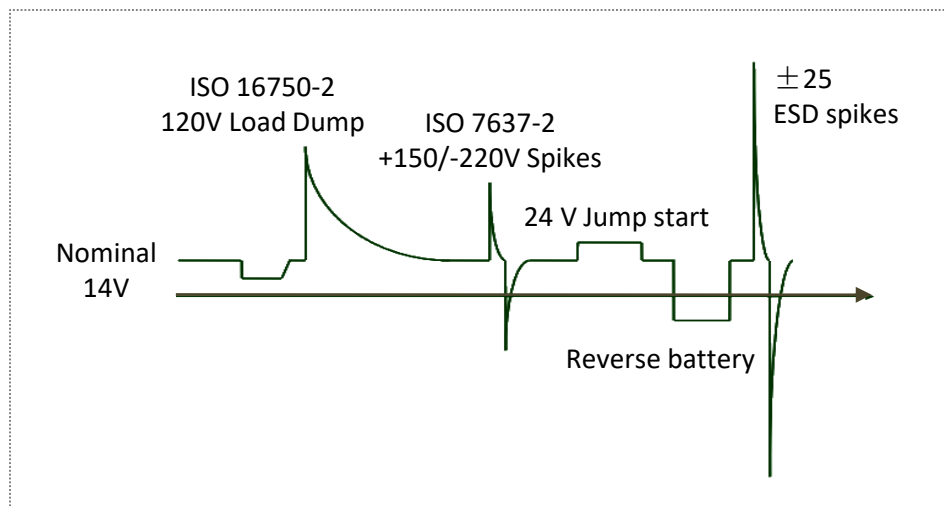
- 相關測試標準
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- 防逆二極體 IFSM 選型評估建議
- 強茂相關產品發展規劃

Where do Automotive Transients Surge Come From ?

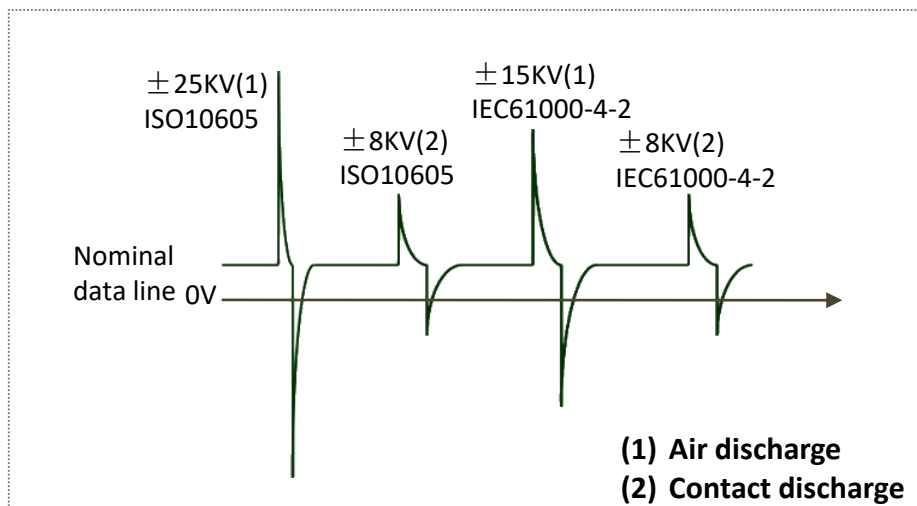
汽車瞬態浪湧來自何處？



Power Line Transient Surge Wave



Data Line Transient Surge Wave



Standard of Testing Criteria 相關測試標準

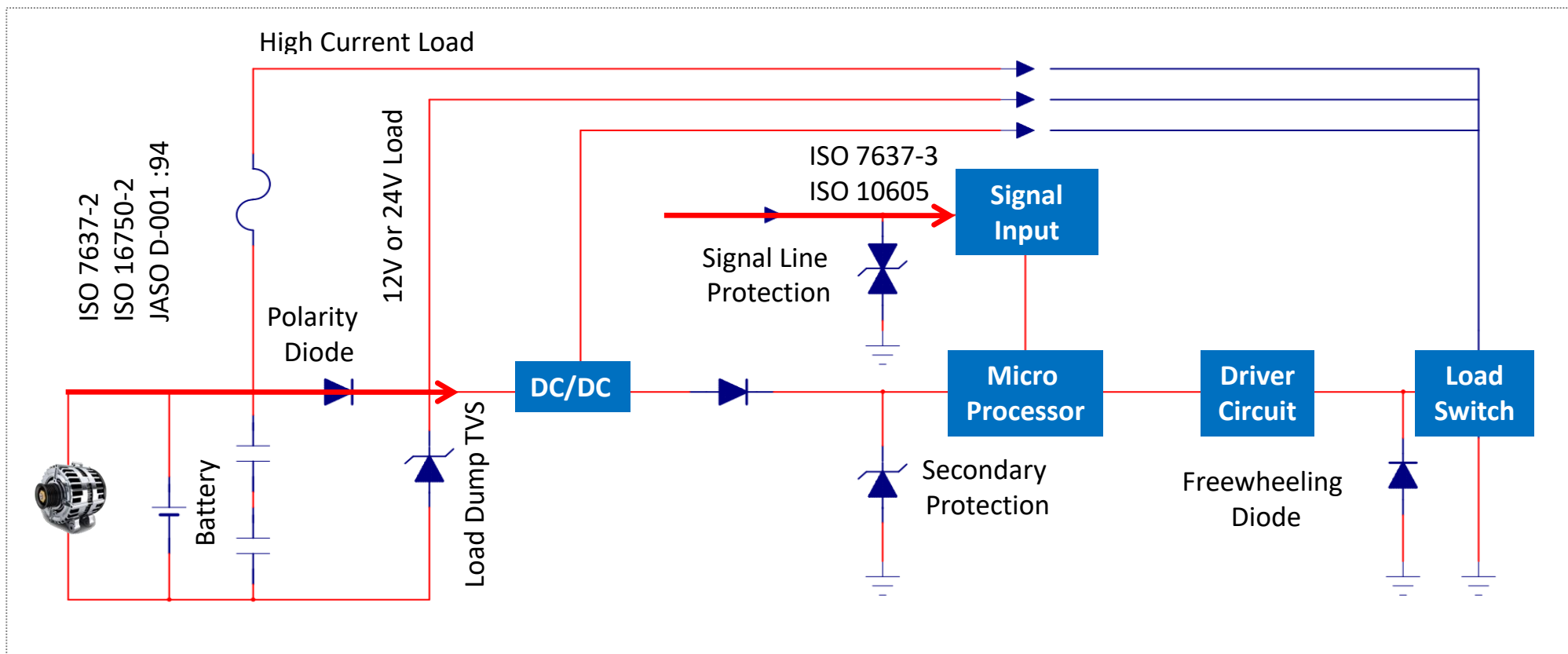
Related standards overview

Category	Standard types	Standard Number	Standard Titles
Electrical Loads	ISO	ISO 16750-2	Road vehicles -- Environmental conditions and testing for electrical and electronic equipment — Part 2: Electrical loads
	ISO	ISO 21848	Road vehicles -- Electrical and electronic equipment for a supply voltage of 42 V — Electrical loads
Electrical disturbances from conduction and coupling	ISO	ISO 7637-2	Road vehicles -- Electrical disturbances from conduction and coupling — Part 2 : Electrical transient conduction along supply lines only
	ISO	ISO 7637-3	Road vehicles -- Electrical disturbances from conduction and coupling — Part 3 : Electrical transient transmission by capacitive and inductive coupling via lines other than supply lines
ESD	ISO	ISO 10605	Road vehicles -- Test methods for electrical disturbances from electrostatic discharge

電力線傳導與耦合浪湧防護措施

TVS and diode solutions

- 電力線瞬態凸波衝擊，源自電源端因負載條件突變產生的低電壓高能量瞬態脈衝。標準：ISO7637-2，ISO16750-2，JASO D-001：94
- 數據線端的瞬態凸波干擾源，與汽車組件運行過程中產生的低能量高電壓瞬態脈衝，主要為ESD。相關標準有ISO7637-3，ISO10605，IEC61000-4-2



Automotive Environment Test Levels

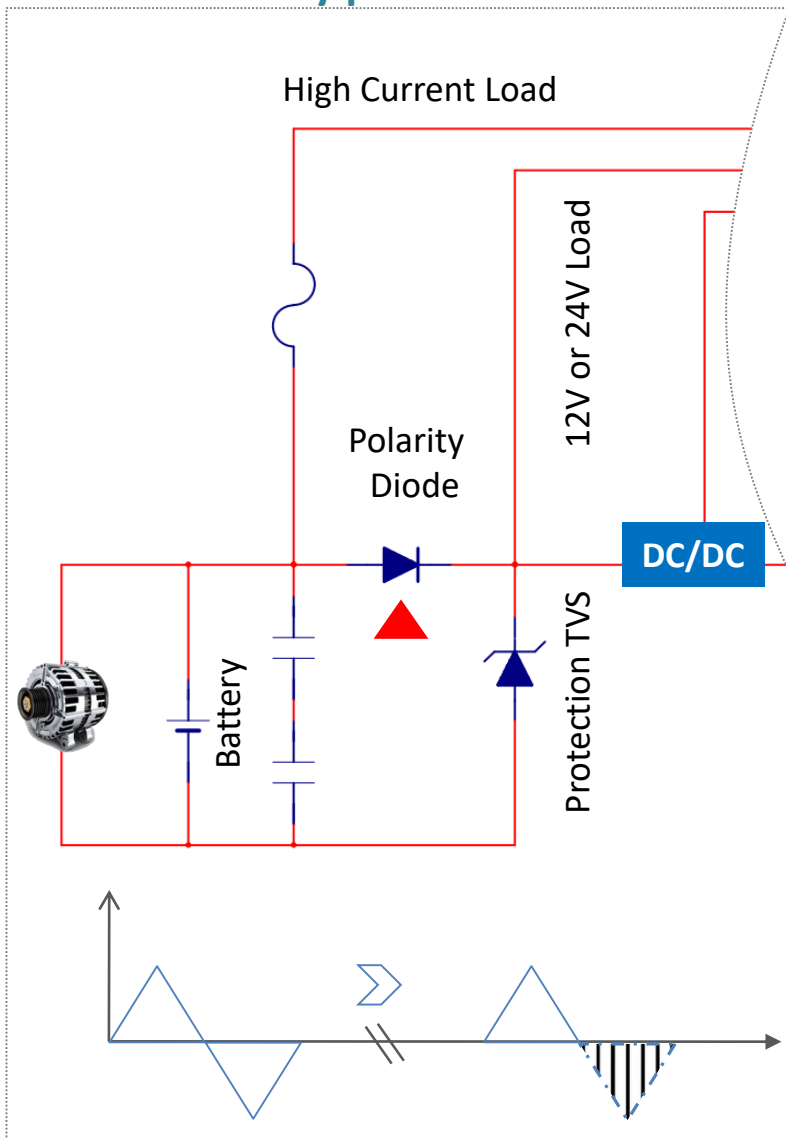
Power line specified in ISO 7637-2 2011(E) and ISO 16750-2

Test Pulse	12V System		24V System		Min. number of pulses or test time
	Test pulse severity level $U_s(V)$		Test pulse severity level $U_s(V)$		
	IV	III	IV	III	
1	-150	-112	-600	-450	500 pulses
2a	+112	+55	+112	+55	500 pulses
2b	+10	+10	+20	+20	10 pulses
3a	-220	-165	-300	-220	1h
3b	+150	+112	+300	+220	1h
4	6.5	5	--	10	1 pulse
5a	87V/Ri=0.5Ω/t _d =400mS	65V/Ri=4Ω/t _d =40mS	173V/Ri=1Ω/t _d =350mS	123V/Ri=8ΩS/t _d =100mS	10 pulses
5b	40V/Ri=0.5Ω/t _d =400mS	30V/Ri=4Ω/t _d =40mS	50V/Ri=1Ω/t _d =350mS	50V/Ri=8ΩS/t _d =100mS	10 pulses

- The test Pulse 4, 5a, and 5b have been removed from ISO 7637-2-2011, since they are specified in ISO 16750-2 2010 and ISO 21848.

Power Line Transient Surge Protection

Reverse battery protection



Functional Definition 功能定義

- To Prevent polarity of circuit reversed and circuit reverse surge. 防止線路極性接反與線路反向凸波

Testing Standard 相關測試標準

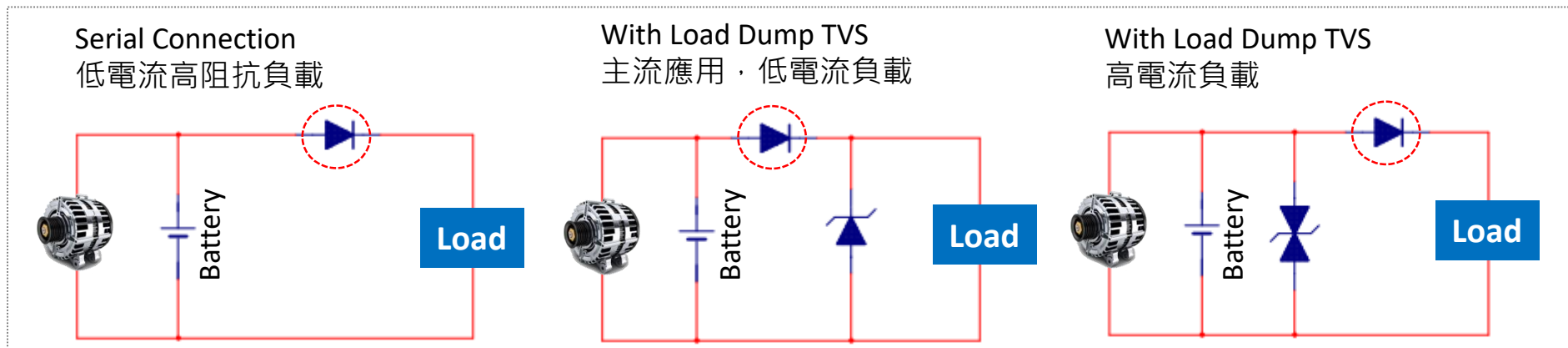
- ISO 7637-2 : 2011(E) pulse 1 and pulse 3a
 - 100V(pulse 1) and -150V (3a) for 12V Power train
 - 600V(pulse 1) and -200V (3a) for 24V Power train
- ISO 16750-2 : 4.7 Reversed Voltage
- JSAO D001:94
 - type B-1(-80V), B-2(-260V) for 12V Power train
 - type E(-320V) for 24V Power train

Key Parameters 防逆二極體關鍵參數

- Reverse breakdown voltage (VBR)
- Average forward current (IFAV/package/TR)
- Maximum forward current (IFSM)

Reverse Battery Protection with General Rectifier

Polarity diode connection type



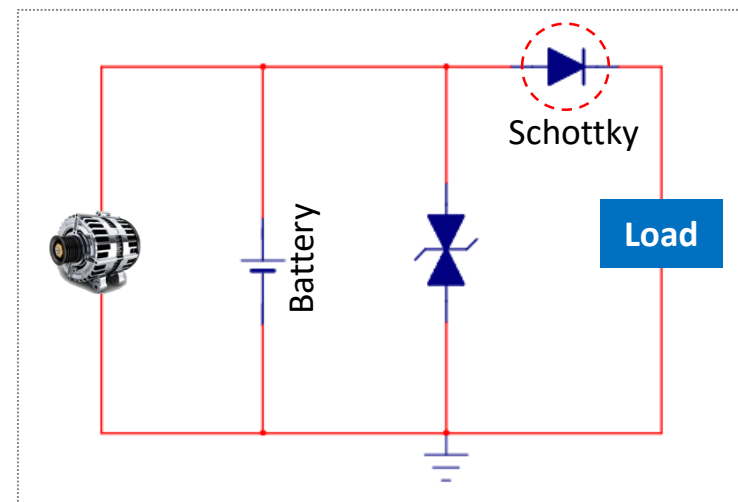
Recommend GPP for Polarity



Package	Current				
	1A	2A	3A	5A	8A
SOD-123FL/HE	GS1010FL-AU	GS2008HE-AU			
SMA	GS1M-AU				
SMB		S2M-AU			
SMC			S3M-AU	S5M-AU	S8M-AU

Reverse Battery Protection with Schottky Rectifier

- 負載電流較高的應用中，為降低電源端線損，可評估採用具低順向壓降（VF）的超級肖特基二極體取代傳統整流管。
- 根據不同應用系統和標準，建議採用60V-100V的肖特基二極體。
- 右圖接線方式確保ISO7637-2中脈衝1和脈衝3a負向脈衝衝擊不會超過肖特基的崩潰電壓而發生擊穿。



Recommend Planar Schottky for Polarity

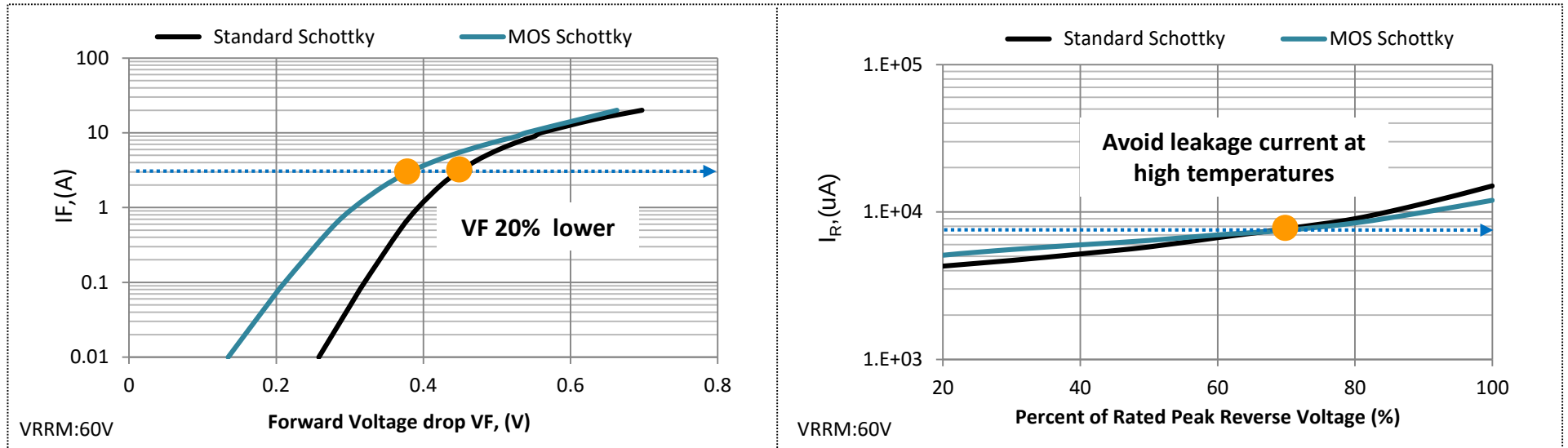
Wafer type	Package	Current			
		2A	3A	5A	8A
Planar	SMA	BR210-AU			
	SMB	BR310-AU			
	SMC	MB310-AU		MB510-AU	MB810-AU

Recommend Super Schottky for Polarity

Wafer type	Package	Current		
		10A	15A	20A
Trench	TO-252	SBT10100UYD-AU	SBT15100VYD-AU	SBT20100VYD-AU



Planar MOS Schottky Advantage

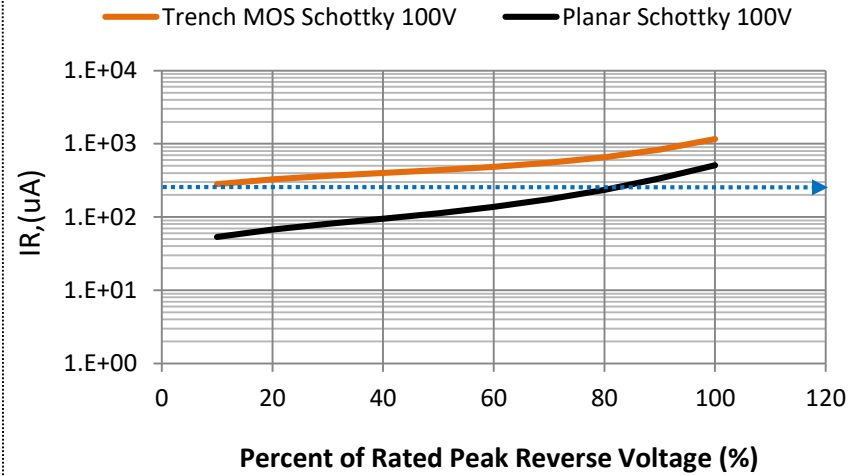
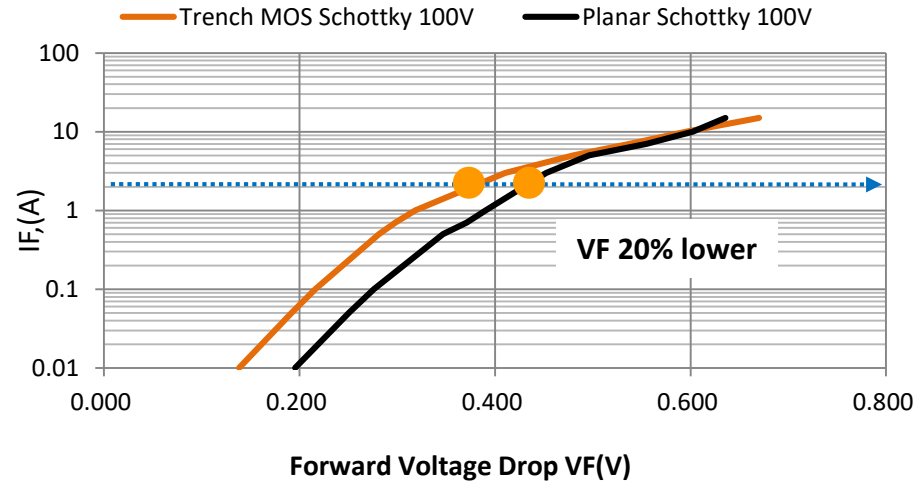


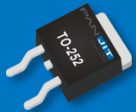
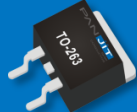
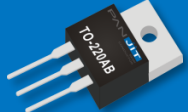
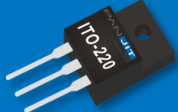
	DFN2L	SOD-323	SOD-323HE	SOD-123	SOD-123FL	SOD-123HE	SMAF	SMBF	SMEF
$I_{F_{AV}}$									
0.5A	●								
1A		●	●	●					
2A			●	●	●	●			
3A					●	●			
5A							●	●	
8A								●	
10A									●
15A									●
Series	SBAxxQ-AU	SBAxxCS-AU	SBAxxCH-AU	SBAxxAS-AU	SBAxxAL-AU	SBAxxAH-AU	SBAxxAF-AU	SRMxxF-AU	SBMxxxEF-AU

20V to 40V

40V to 60V

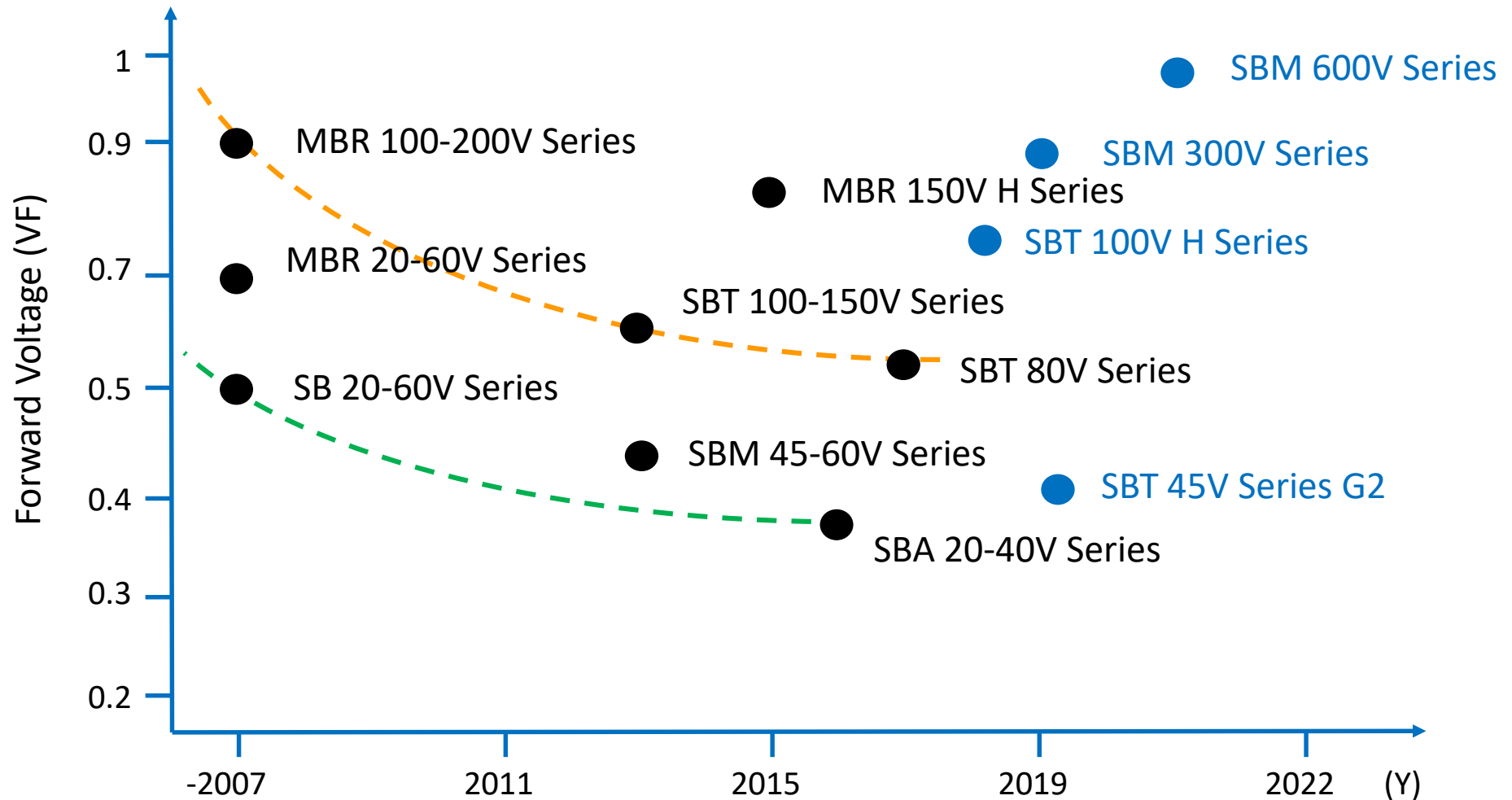
Trench MOS Schottky Advantage



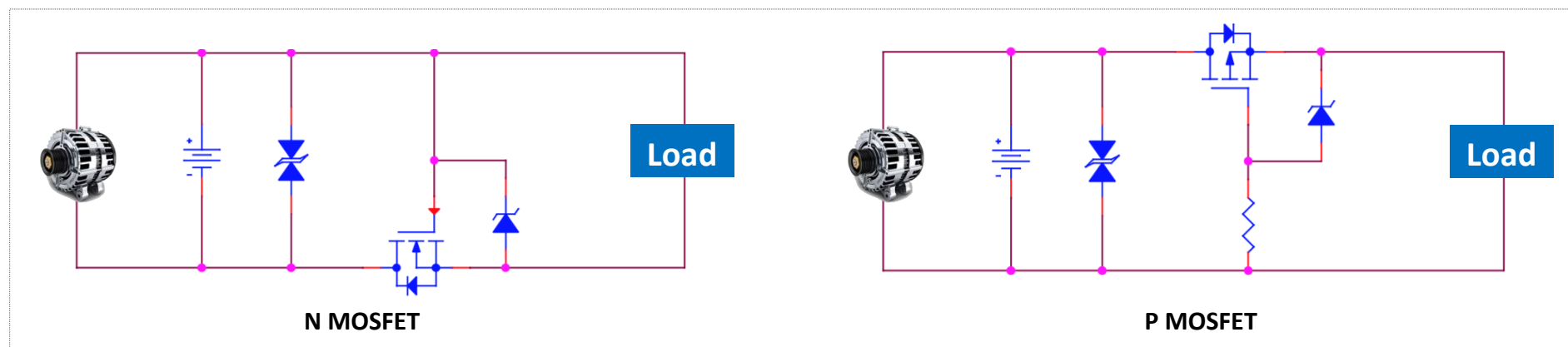
	SMAF	SMBF	DPACK	D ² PACK	TO-220AB	ITO-220AB
$I_{F_{AV}}$						
5A	●					
8A		●				
10A					●	●
15A			●		●	●
20A			●	●	●	●
30A				●	●	●
Series	SXTxxF-AU	SRTxxF-AU	SBTxxYD-AU	SBTxxCB-AU	SBTxxCT-AU	SBTxxFCT-AU

80V to 150V

Schottky Rectifier Technology Evolution

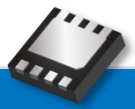
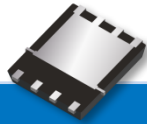


Reverse Battery Protection with MOSFET



- 在較大負載電流應用中，為改善傳統二極體防逆的固有缺陷，可以採用低 $R_{DS(ON)}$ 的MOSFET 代替傳統二極體作為防逆接保護。 $P_D = I_D * R_{DS(ON)}$ 遠低於二極體的 $I_F * V_F$
- N-MOS has lower $R_{DS(ON)}$ when compared to P-MOS at same chip size, however N-MOS control circuit is much simple.
- 建議採用60V-100V MOSFET 作為防逆MOSFET。前置 Load Dump TVS (雙向)，確保瞬態正負浪湧不超過 MOSFET 的 V_{DS} 。

Recommend MV MOSFET

V_{DS}	V_{GS}	Ch.	$R_{DS(ON)} 10V$	$R_{DS(ON)} 4.5V$			
V	V	N/P	(mΩ) max.		TO-252AA	DFN3333-8L	DFN5060-8L
-60	20	P	48	65	PJD16P06A-AU	PJQ4463AP-AU	PJQ5463A-AU
-60	20	P	68	85	PJD15P06A-AU		PJQ5465A-AU
60	20	N	12	15	PJD45N06A-AU		PJQ5462A-AU
60	20	N	17	20	PJD40N06A-AU	PJQ4464AP-AU	PJQ5466A1-AU
100	20	N	25	28.5	PJD50N10AL-AU		PJQ5476AL-AU

Power Line Transient Surge Protection

Definition 功能定義

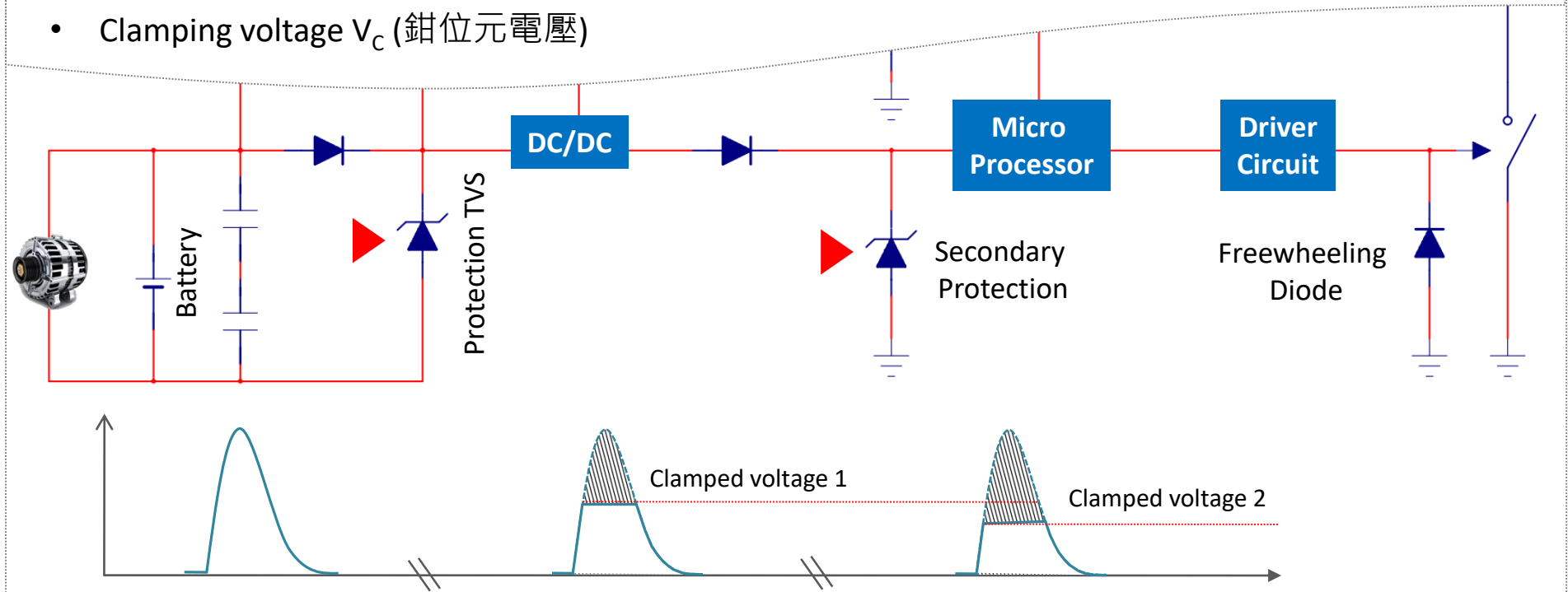
- To control the transient surge on power line/cable of the vehicle to protect the module.

Test standard 相關測試標準

- ISO 7637-2, ISO16750-2, ISO 21848, JSO D001 : 94

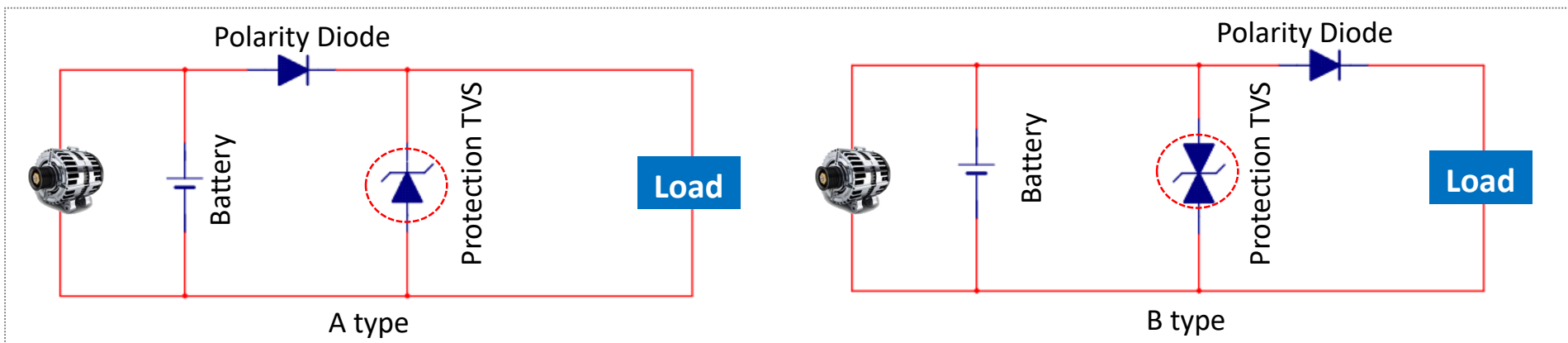
Key parameter 關鍵參數

- Max P_{pp} and Max I_{pp} 最大鉗制功率 P_{pp} 與最大鉗制電流 I_{pp}
- Safety threshold voltage V_{RWM} (安全閾值電壓)
- Clamping voltage V_C (鉗位元電壓)



Power Line Transient Surge Protection

Two types of TVS Protection



● TVS選擇與連接類型 (A type & B type)

根據設計與防護需要選擇單向TVS 和雙向TVS

- B type 則建議採用雙向TVS保護,因大電流負載正常負載電流較高。
- 一般選用崩潰電壓60V-100V 且VF值較低的二極體或者MOSFET 做防逆保護

● TVS鉗位元電壓 V_C

- 最大鉗位元電壓，必須低於受保護電子模組的最大耐受電壓，以確保受保護器件在高浪湧衝擊與Load Dump 測試條件下不會損壞。
- 建議選型時至少預留10% 的安全餘量

● TVS安全閾值電壓 V_{RWM}

- 必須確保 $V_{RWM} \geq$ 系統最大正常工作電壓以避免TVS在正常情況下誤動作
- 結合應用與測試條件，選擇合適的 V_C & I_{PP}

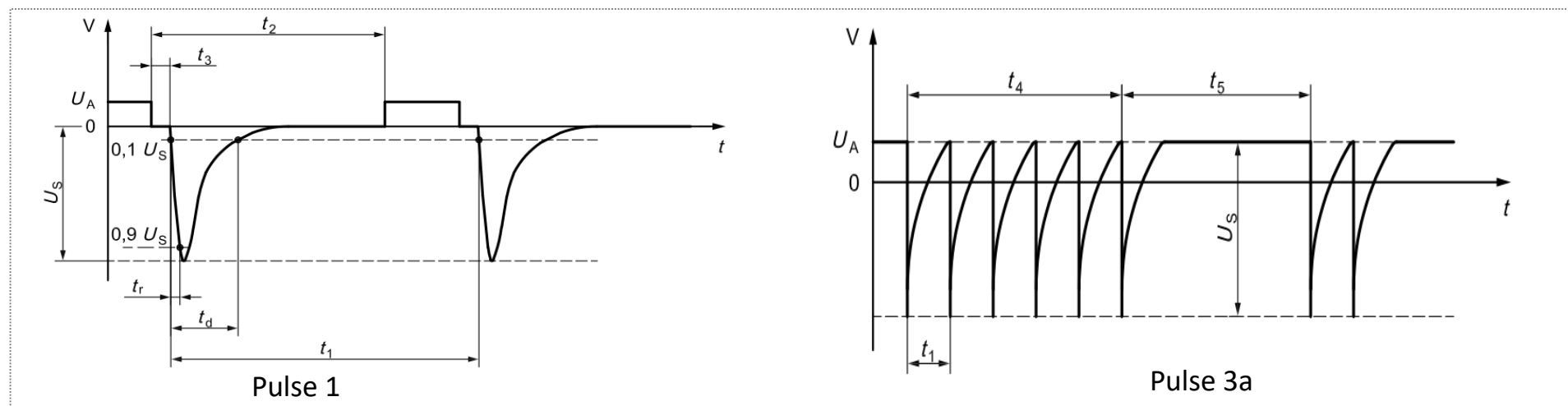
System U_N	12V	24V
Recommend TVS V_{RWM}	22V/24V/27V	30V/33V/36V

Automotive Power TVS

For ISO 7637-2 pulse 1 to pulse 3b Transients Protection

TVS series	Package	UNI / BI	P_D (W)	12V System Level IV (V)					24V System Level IV (V)				
				1	2a	2b	3a	3b	1	2a	2b	3a	3b
				-150	+112	+10	-220	+150	-600	+112	+20	-300	+300
P4FLxxA-AU	SOD-123FL	UNI	400	pass	pass	pass	pass	pass	pass	pass	pass	pass	pass
P4SMAJxxA-AU	SMA	UNI & BI	400	pass	pass	pass	pass	pass	pass	pass	pass	pass	pass
P6AFxxA-AU	SMAF	UNI	600	pass	pass	pass	pass	pass	pass	pass	pass	pass	pass
P6SMBJxxA-AU	SMB	UNI & BI	600	pass	pass	pass	pass	pass	pass	pass	pass	pass	pass
P6KExxA-AU	DO-15	UNI & BI	600	pass	pass	pass	pass	pass	pass	pass	pass	pass	pass
1.5SMCJxxA-AU	SMC	UNI & BI	1500	pass	pass	pass	pass	pass	pass	pass	pass	pass	pass

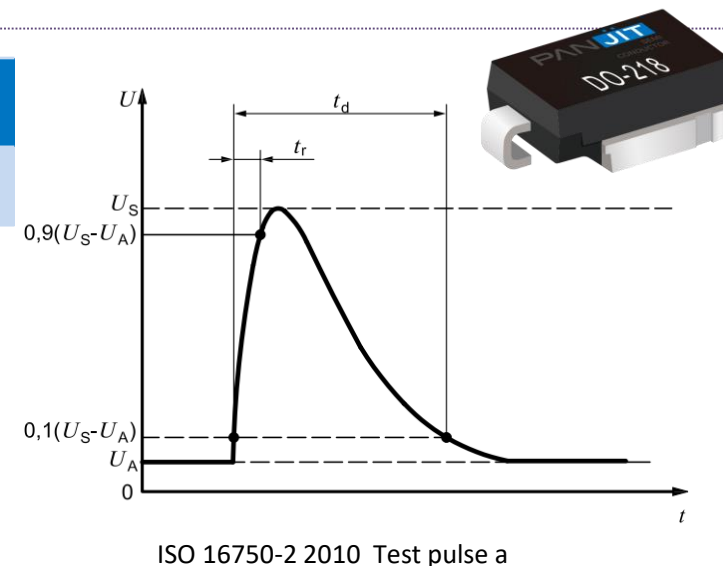
- Pulse 1 與 Pulse 3a 為負脈衝浪湧，如線路未加裝防逆二極體單向TVS 在浪湧期間，會處於順嚮導通狀態。持續的大電流會導致TVS 熱擊穿。如無防逆二極體，則建議採用600W 以上TVS 或者雙向TVS。



Automotive Power TVS

For ISO 7637-2 & ISO 16750-2 pulse 5a Load Dump Protection

Parameter	Type of System		ISO 16750-2	ISO 7637-2
	$U_N=12V$	$U_N=24V$	Pulses	Pulses
U_S (V)	$79 \leq U_S \leq 101$	$151 \leq U_S \leq 202$	10 Pulses at intervals of 1min	1Pulse
R_i (Ω)	$0.5 \leq R_i \leq 4$	$1 \leq R_i \leq 8$		
t_d (mS)	$40 \leq U_S \leq 400$	$100 \leq U_S \leq 350$		
t_r (mS)	10 (+0/-5)	10 (+0/-5)		

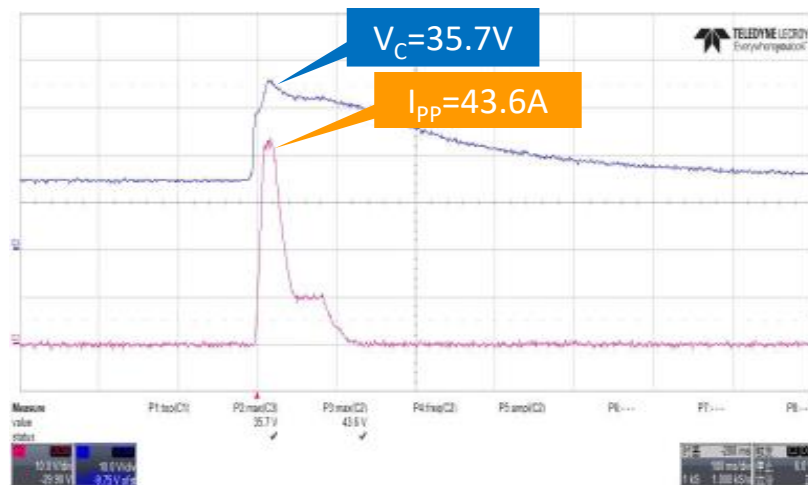


- ISO 16750-2 pulse a replaces ISO 7637-2 (2004) pulse 5a
- ISO16750-2 Pulse A 相較於ISO7637-2 (2004) 5a 更為嚴苛。測試脈衝次數由原來的單次衝擊，提升為10分鐘內測試10次。此條件要求Load Dump 保護器件和防逆接保護器件，具備更高的電流衝擊耐受能力。
- 連續大電流衝擊，且要求 Load Dump 保護器件和防逆接保護器件具備更高的結溫耐受能力。
- I_{pp} decided by V_C and test R_i : $I_{clamping} = (U_S - V_{clamping}) / R_i$
- For pulse 5a : 推薦選用PANJIT's DO-218 high power package: SM8SxxA-AU, SM6SxxA-AU, SM5SxxA-AU series products.

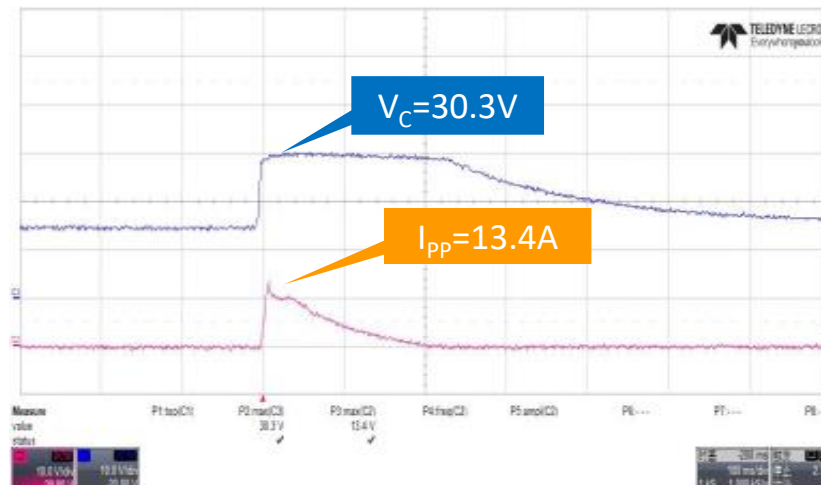
SMxSxxA-AU Load Dump TVS

In ISO 16750-2 5a Load Dump Surge Test

12V System SM5S24A-AU

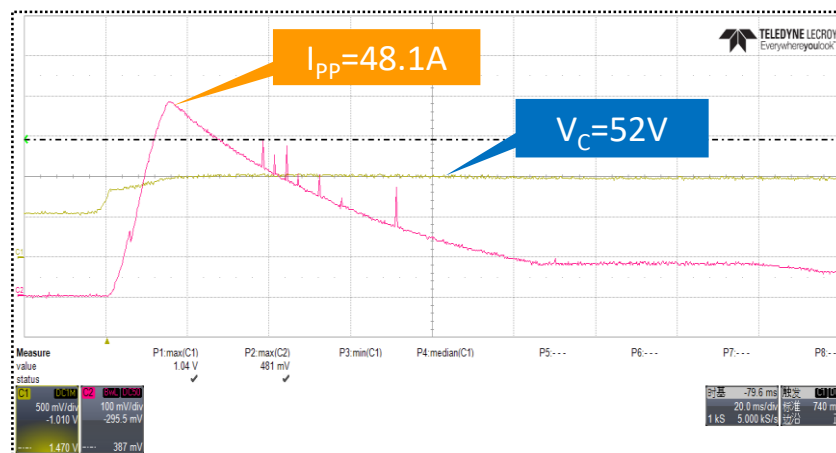


Test Condition $U_N = 12V$ $R_i = 0.5\Omega$ $U_S = 101V$ $t_d = 400ms$

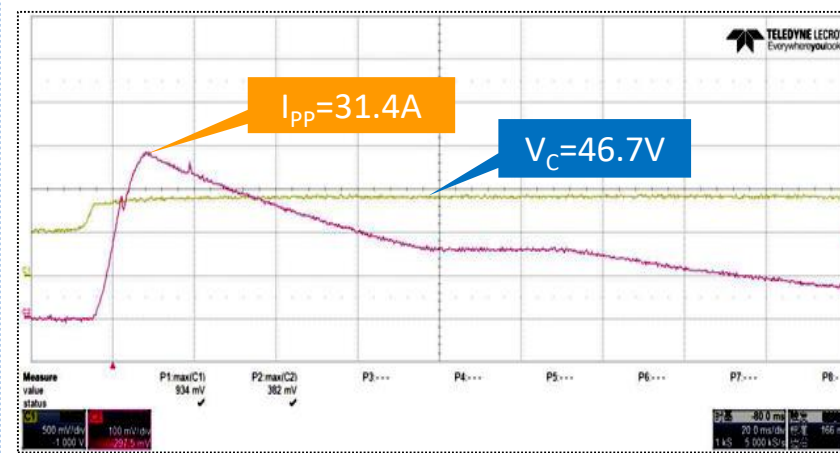


Test Condition $U_N = 12V$ $R_i = 5\Omega$ $U_S = 101V$ $t_d = 400ms$

24V System SM8S36A-AU



Test Condition $U_N = 24V$ $R_i = 3\Omega$ $U_S = 202V$ $t_d = 400ms$



Test Condition $U_N = 24V$ $R_i = 8\Omega$ $U_S = 202V$ $t_d = 400ms$

SMxSxxA-AU Load Dump TVS Series

PANJIT offers 3 series Load Dump TVS: SM5SxxxA-AU/SM6SxxxA-AU/SM8SxxxA-AU.

- 最大吸收功率分別為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 of 12V and 24V automotive.

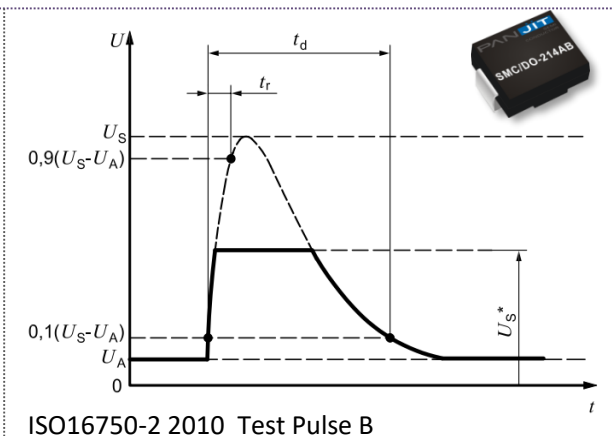
Part Number	P_D (W)	V_{RWM} (V)	$V_{BR}@I_T$		I_T (mA)	$I_R@V_{RWM}$	$V_C@I_{PP}$	I_{PP}	Application V_N (V)
			Min.	Max.					
SM5S20A-AU	3600	20	22.2	24.5	5	0.5	32.4	111	12
SM5S22A-AU	3600	22	24.4	26.9	5	0.5	35.5	101	12
SM5S24A-AU	3600	24	26.7	29.5	5	0.5	38.9	93	12
SM5S30A-AU	3600	30	33.3	36.8	5	0.5	48.4	74	24
SM5S33A-AU	3600	33	36.7	40.6	5	0.5	53.3	68	24
SM5S36A-AU	3600	36	40	44.2	5	0.5	58.1	62	24
SM6S20A-AU	4600	20	22.2	24.5	5	0.5	32.4	142	12
SM6S22A-AU	4600	22	24.4	26.9	5	0.5	35.5	130	12
SM6S24A-AU	4600	24	26.7	29.5	5	0.5	38.9	118	12
SM6S30A-AU	4600	30	33.3	36.8	5	0.5	48.4	95	24
SM6S33A-AU	4600	33	36.7	40.6	5	0.5	53.3	86	24
SM6S36A-AU	4600	36	40	44.2	5	0.5	58.1	79	24
SM8S20A-AU	6600	20	22.2	24.5	5	0.5	32.4	204	12
SM8S22A-AU	6600	22	24.4	26.9	5	0.5	35.5	186	12
SM8S24A-AU	6600	24	26.7	29.5	5	0.5	38.9	170	12
SM8S30A-AU	6600	30	33.3	36.8	5	0.5	48.4	136	24
SM8S33A-AU	6600	33	36.7	40.6	5	0.5	53.3	124	24
SM8S36A-AU	6600	36	40	44.2	5	0.5	58.1	114	24

-

Power TVS

For ISO 7637-2 & ISO 16750-2 Pulse 5b Load Dump Protection

Parameter	Type of System		ISO 16750-2	ISO 7637-2
	$U_N=12V$	$U_N=24V$	Pulses	Pulses
U_S (V)	$79 \leq U_S \leq 101$	$151 \leq U_S \leq 202$	5 Pulses at intervals of 1min	1pulse
$U_S * V$ (V)	35	65		
R_i (Ω)	$0.5 \leq R_i \leq 4$	$1 \leq R_i \leq 8$		
t_d (mS)	$40 \leq U_S \leq 400$	$100 \leq U_S \leq 350$		
t_r (mS)	10 (+0/-5)	10 (+0/-5)		

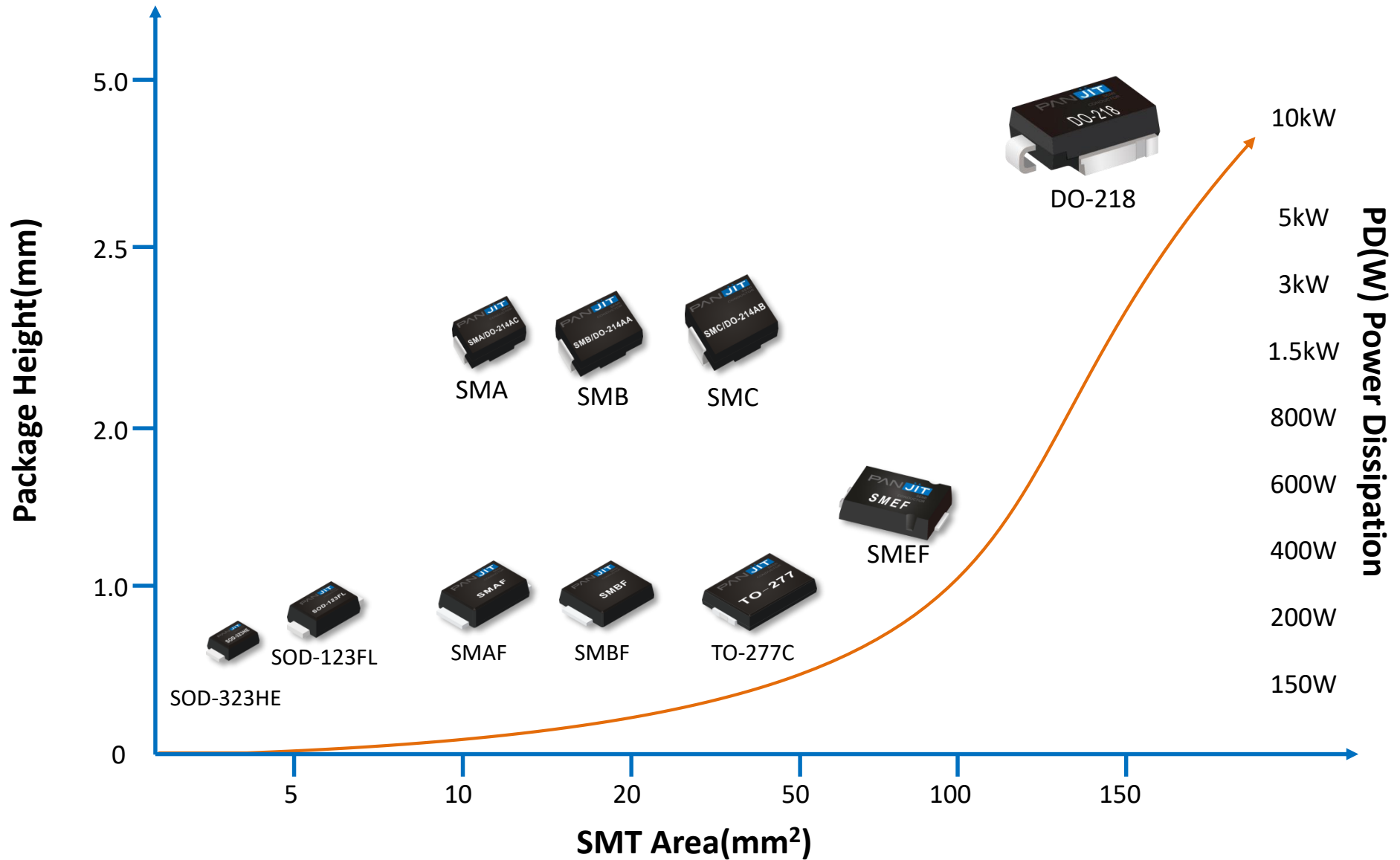


- ISO16750-2 Pulse B 替換 ISO7637-2 (2004) Pulse 5b
- ISO16750-2 Pulse B 相較於ISO7637-2 (2004) 5B 更嚴苛。測試脈衝次數由單次衝擊提升為5分鐘內連續測試5次
- Pulse B 根據不同應用條件，**建議選用P6SMBJxxA-AU/1.5SMCJxxA-AU/3.0SMCJxxA-AU/SM5xxA-AU 系列**

TVS series	Package	UNI/BI	P_D (W)	12V System Level IV (V)		24V System Level IV (V)	
				III	IV	III	IV
				30V/ $R_i=4\Omega$ $t_d=40mS$	40V/ $R_i=0.5\Omega$ $t_d=400mS$	50V/ $R_i=8\Omega$ $t_d=100mS$	50V/ $R_i=1\Omega$ $t_d=350mS$
P6SMBJxxA-AU	SMB	UNI / BI	600	PASS	FAIL	FALL	FAIL
1.5SMCJxxA-AU	SMC	UNI / BI	1500	PASS	FAIL	FAIL	FAIL
3.0SMCJxxA-AU	SMC	UNI / BI	3000	PASS	FAIL	FAIL	FAIL
SM5xxA-AU	DO-218AB	UNI	3600	PASS	PASS	PASS	PASS

Notes 12V System recommend TVS V_{RWM} : 22V/24V/26V/28V; 24V Recommend TVS V_{RWM} : 30V/33V/36V

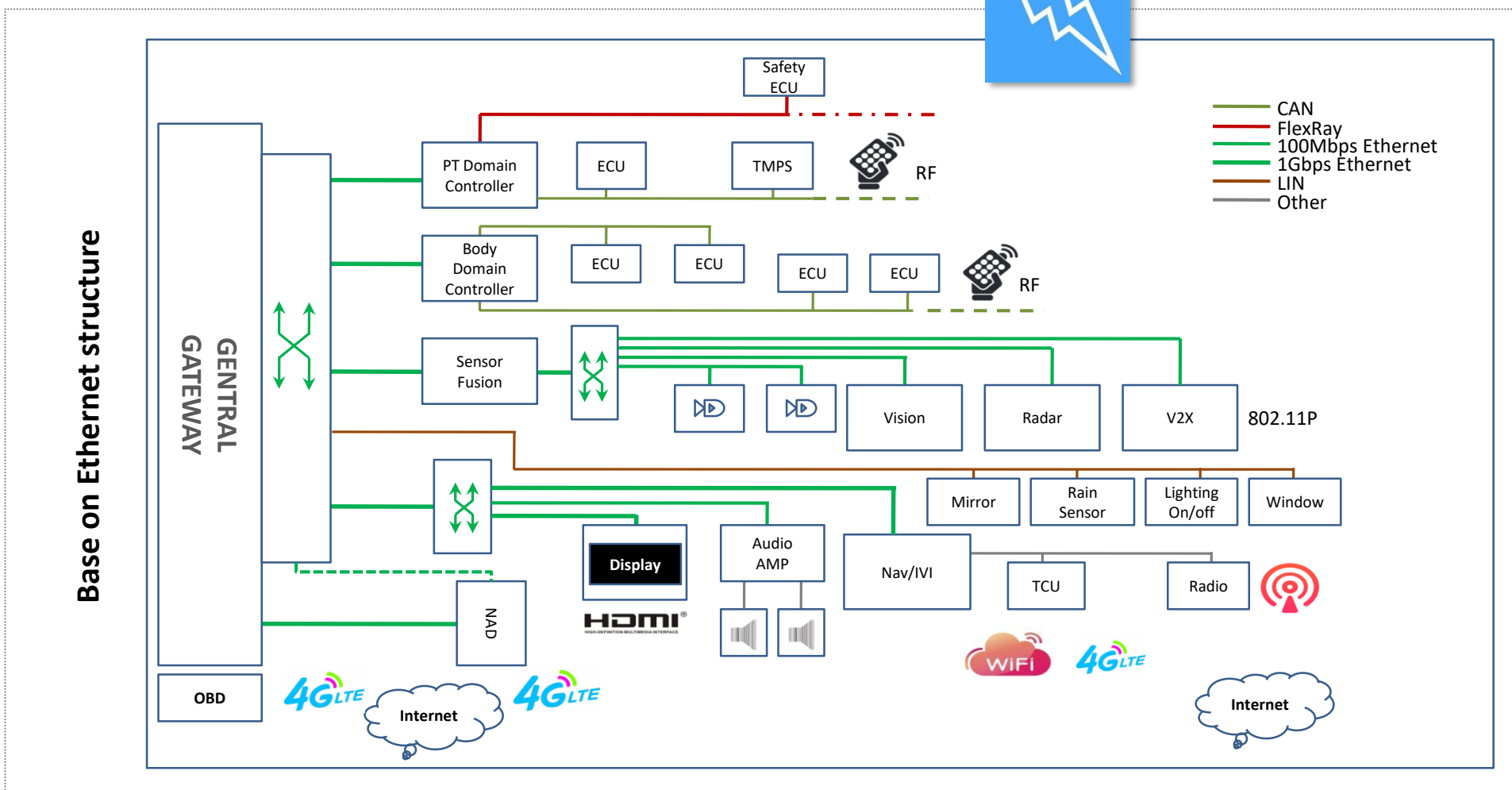
Automotive Grade Power TVS Road Map



Data Line Transients Protection

ESD and Electrical Transient Transmission Protection (ESD Array Solution)

- **In-Vehicle Networks:** LIN, CAN, FlexRay, MOST, Ethernet
- **Multimedia buses:** USB, APiX, HDMI, Etherent



Automotive Environment Test Levels

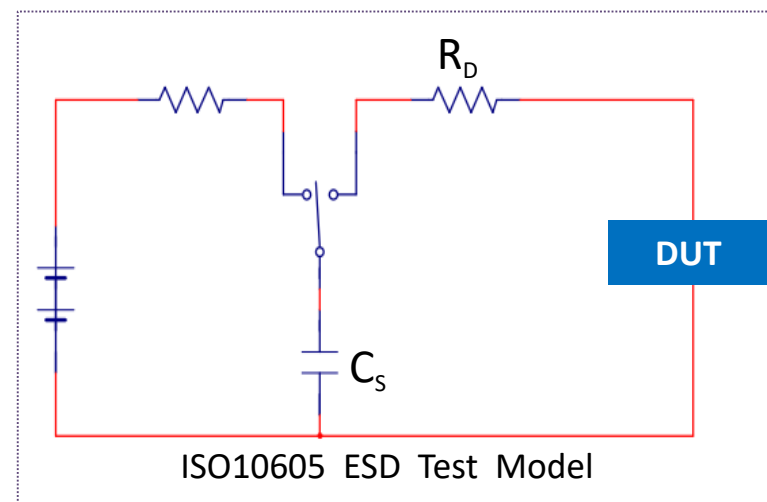
Data Line - ISO 10605 (ESD)

ISO 10605 Test models and conditions

Application	State	Discharge Position	Discharge Module		ESD Model
			C_s (pF)	R_D (Ω)	
ECU	Powered	Inside	330	330	Air & Contact
		Outside	150	330	Contact
ECU	Unpowered	Outside	150	330 or 2000	Air & Contact

ISO 10605 Test levels

State	ESD Model	Severity test levels				Min. number of pulses
		I	II	III	IV	
Powered	Air (kV)	± 4	± 6	± 7	± 8	>3
	Contact (kV)	± 4	± 8	± 14	± 15	
Unpowered	Air (kV)	± 4	± 6	--	± 8	
	Contact (kV)	± 4	± 15	--	± 25	



Automotive Environment Test Levels

Data Line - ISO 7637-3 (Electrical Transient Transmission)

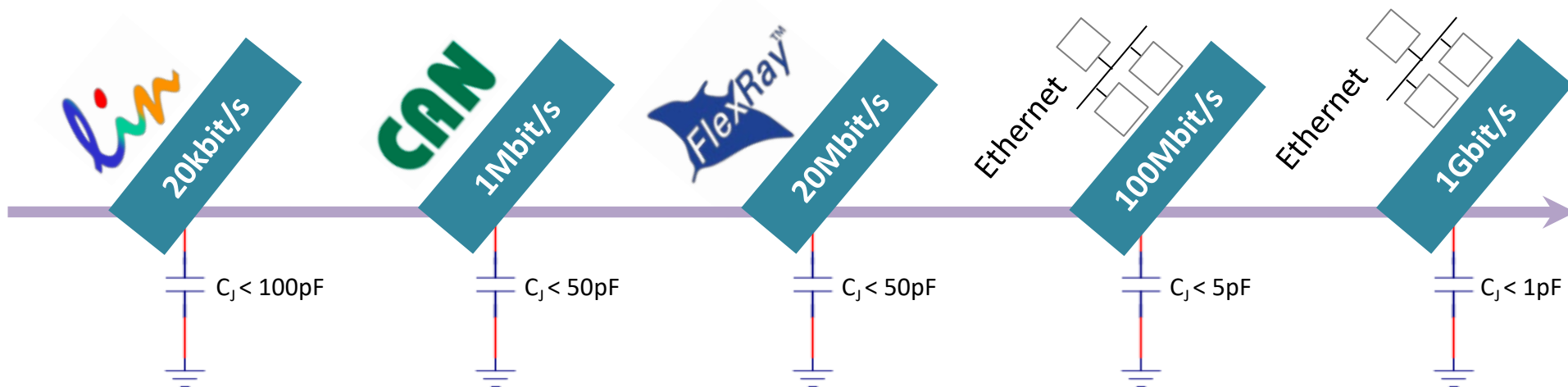
Test pulse	12V system test pulse severity levels U_s (V)				Test time (Minutes)
	I	II	III	IV	
Fast a (DCC and CCC)	-10	-20	-40	-60	10
Fast b (DCC and CCC)	+10	+20	+30	+40	10
DCC slow +	+8	+15	+23	+30	5
DCC slow -	-8	-15	-23	-30	5
ICC slow +	+3	+4	+5	+6	5
ICC slow -	-3	-4	-5	-6	5

Test pulse	24 V system test pulse severity levels U_s (V)				Test time (Minutes)
	I	II	III	IV	
Fast a (DCC and CCC)	-14	-28	-56	-80	10
Fast b (DCC and CCC)	+14	+28	+56	+80	10
DCC slow +	+15	+25	+35	+45	5
DCC slow -	-15	-25	-35	-10	5
ICC slow +	+4	+6	+8	+10	5
ICC slow -	-4	-6	-8	-10	5

Data Line Transient Surge Protection

In-Vehicle Networks

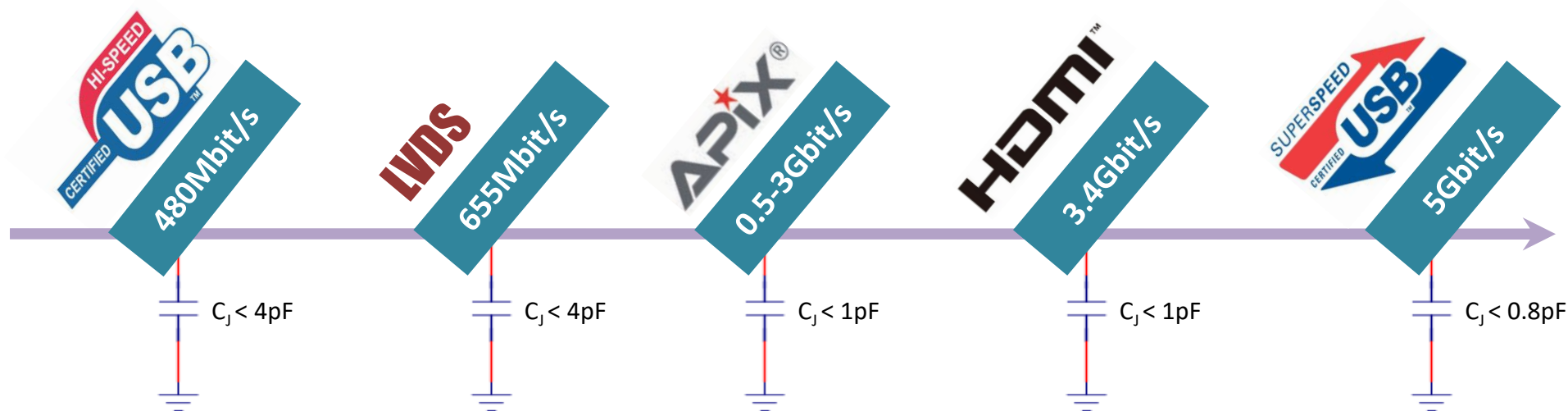
- **LIN (Local interconnect Network)** 低速串列通訊匯流排：主要應用如駕駛員輔助、自動門鎖或窗式升降器，與之通信各種智慧感測器。如：自動大燈、自動雨刮的光線感測器和雨量感測器。
- **CAN (Controller Area Network)** 高速串列通訊匯流排：主要應用於車身控制模組，如防抱死系統 (ABS)，發動機管理系統或電源控制。
- **FlexRay** 超高速串列通訊匯流排：資料速率20Mbit/S。應用於引擎控制、ABS、懸掛控制和線控轉向等。
- **Ethernet 車載乙太網(BroadR-Reach)**：傳輸速率高達100Mbit/S，滿足智慧汽車控制系統的高速資料傳輸和頻寬要求。主要應用於ADAS、全景視覺探測等。*隨著智慧汽車，車聯網等應用的高速發展，千兆乙太網技術有望成為下一代汽車的主流通訊匯流排。*



Data Line Transient Surge Protection

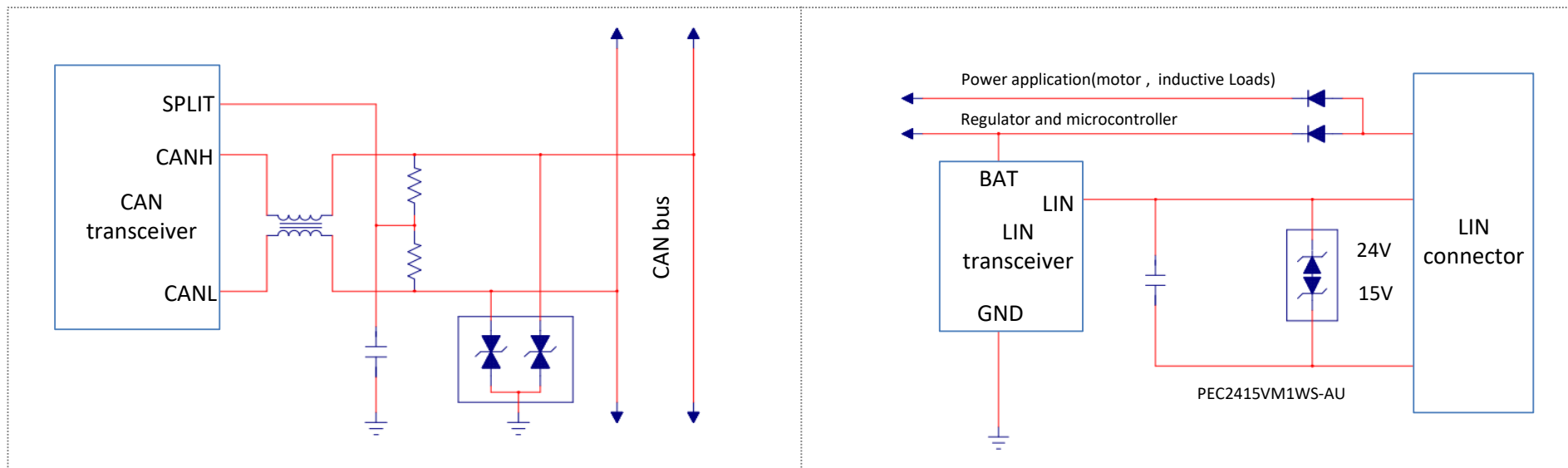
Multimedia Buses

- **USB2.0**：通用的資料傳輸埠。具傳送速率快，支援熱插拔和多個設備的特點。其最大傳送速率可達480Mbit/S 主要應用於車載充電埠，連接媒體播放機以及軟體更新。
- **LVDS (Low-Voltage Differential Signaling)** 低壓差分信號傳輸匯流排：具低功耗、低誤碼率、低串擾和低輻射等特點。傳送速率高達 655Mbit/S。應用於視訊訊號傳輸，主機板顯示和液晶顯示幕介面。
- **APIX (Automotive Pixel link)**：最大傳送速率可達3Gbit/S。主要用於傳輸影像或周邊資訊給顯示幕幕和攝影機
- **HDMI (High Definition Multimedia Interface)**：數位化視頻/音訊介面技術。適合影像傳輸的專用型數位化介面，可同時傳送音 頻和影像信號。HDMI2.0最高資料傳輸速度可達6Gbit/S。
- **USB Type-C**：消費性電子產品最新的連接標準。出現在部分汽車，其傳送速率高達5Gbit/S。兼具快速充電功能，可取代USB2.0 成為主流的車載標配埠。



In-Vehicle Networks ESD Protection

CAN and LIN Bus



- PANJIT has develop products with series of voltage and package which could be used on CAN bus and LIN bus accordingly. All products complies with IEC-61000-4-2 and ISO 10605 standard and are AEC-Q101 qualified.

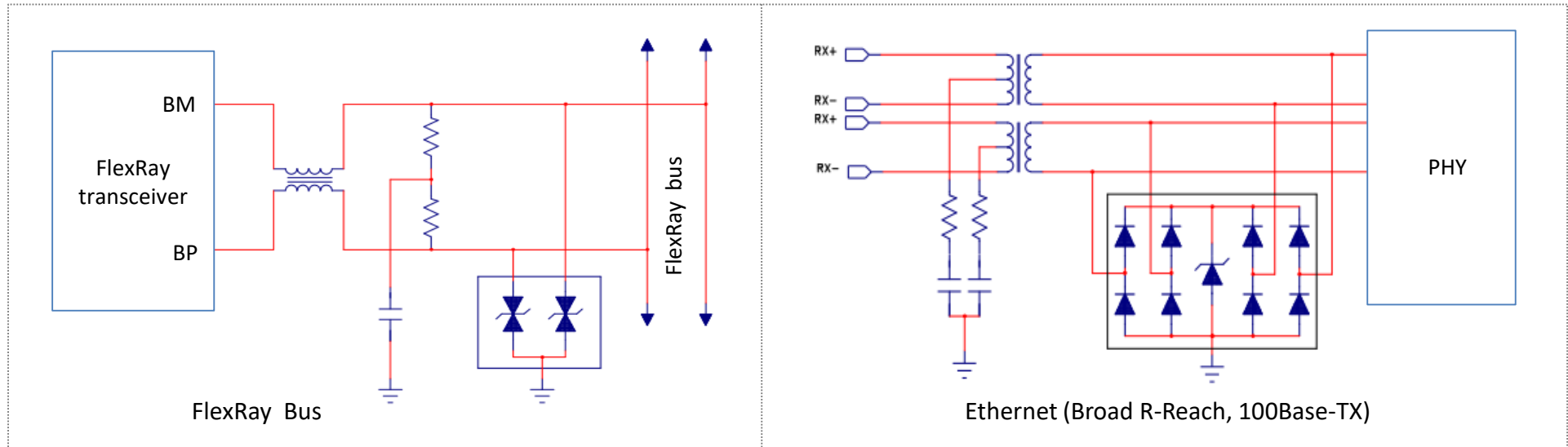
Recommend ESD Array for CAN & LIN

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}	C _J Max.	Package	Application
PEC3124C2A-AU	BI	2	24	25.4	30.3	50<	60	3	15	SOT-23	CAN
PEC3324C2A-AU	BI	2	24	26.2	30.3	50<	43	7	30	SOT-23	CAN
PJEC2415VM1WS-AU	BI	1	24/15	25.4/17.1	30.3/20.3	50<	50/35	3/5	17	SOD-323	LIN



In-Vehicle Networks ESD Protection

FlexRay and Ethernet Bus



- PANJIT has ESD products with 0.6 pF which could apply on FlexRay and Ethernet application and support transfer speed which exceed 100Mbit.

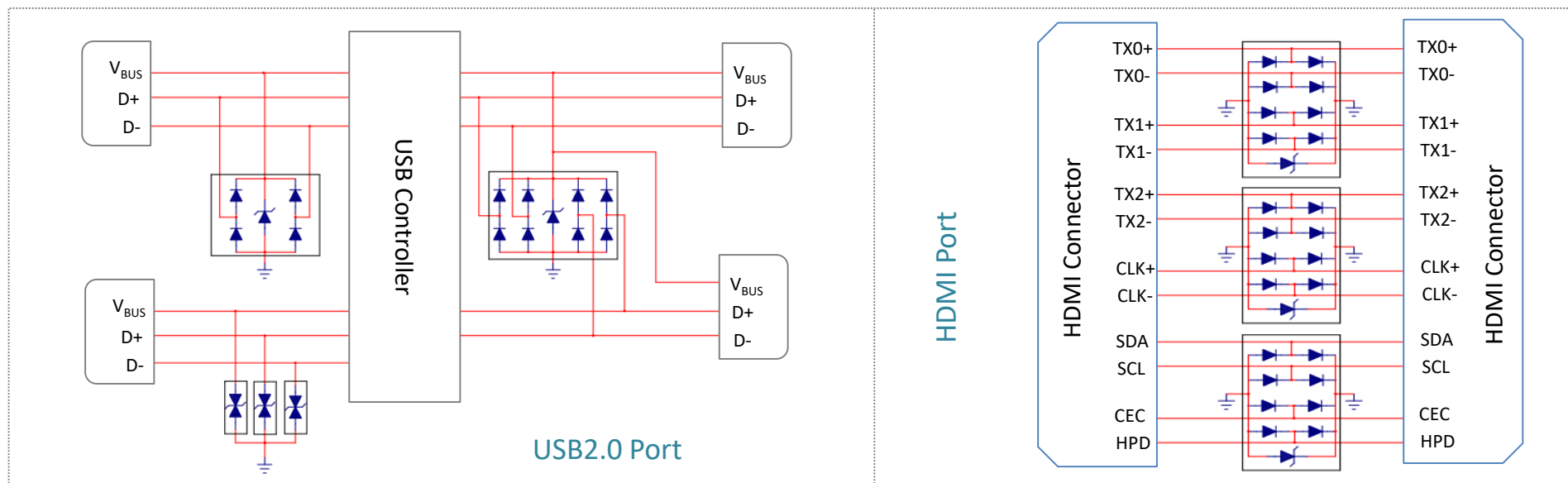
Recommend ESD Array



Part Number	UNI/BI	Ch.	V_{RWM} (V)	V_{BR} Min.(V)	$I_R@V_{RWM}$ nA	$V_C@I_{PP}$ Max.(V)	I_{PP}	CJ Typ.(Pf)	ESD IEC61000-4-2	Package	Application
PEC3324C2A-AU	BI	2	24	26.2	50<	43	7	25	±30KV	SOT-23	FlexRay
PEC3124C2C-AU	BI	2	24	25.4	50<	43	3	17	±30KV	SOT-323	FlexRay
PE1605C4A6-AU	UNI	4	5.5	6	1000<	15	4	0.6	±20KV	SOT-23 6L	Ethernet
PEC1605C4C6-AU	UNI	4	5.5	6	1000<	15	4	0.6	±20KV	SOT-363	Ethernet

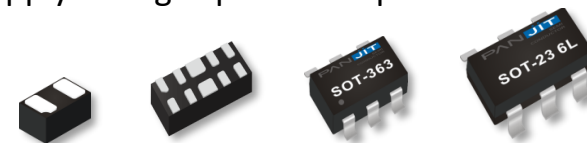
Multimedia and Infotainment Buses ESD Protection

LVDS, HDMI, USB2.0, APiX



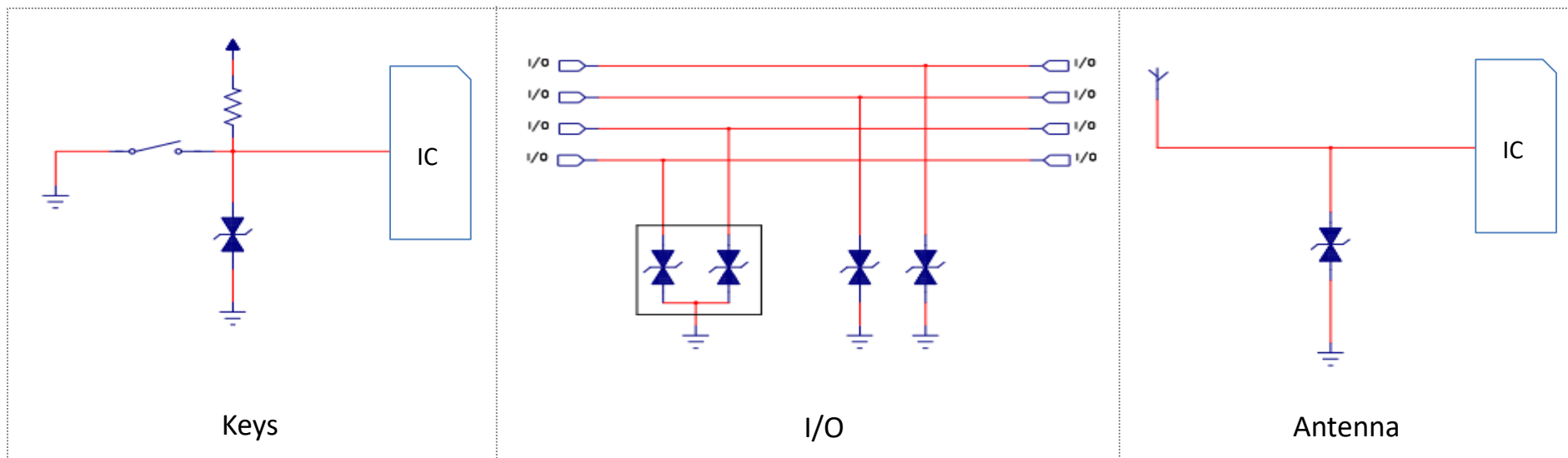
- PANJIT has series of ESD products, which the C_j is smaller than 0.8 Pf, that could apply on high speed data parts such as USB, HDMI, and can support transfer speed exceeding 1Gbit.

Recommend ESD Array



Part Number	UNI/BI	Ch.	V_{RWM} (v)	V_{BR} Min.(V)	$I_R@V_{RWM}$ nA	$V_C@I_{PP}$ Max.(V)	I_{PP}	C_j Typ.(Pf)	ESD IEC61000-4-2	Package	Application
PEC1605M1Q-AU	BI	1	5.5	6.8	75	12	1	0.6	$\pm 20KV$	DFN 2L	USB
PJE5V0U8TB-AU	UNI	2	5	5.8	1000	15	4	0.8	$\pm 18KV$	SOT-523	USB
PEC1605C4C6-AU	UNI	4	5.5	6	1000<	15	4	0.6	$\pm 20KV$	SOT-363	USB
PE1605C4A6-AU	UNI	4	5.5	6	1000<	15	4	0.6	$\pm 20KV$	SOT-23 6L	LVDS
PE1805M4Q-AU	UNI	4	5	6.5	100	20	5	0.8	$\pm 20KV$	DFN2510	HDMI

Keys, I/O, Antenna ESD Protection



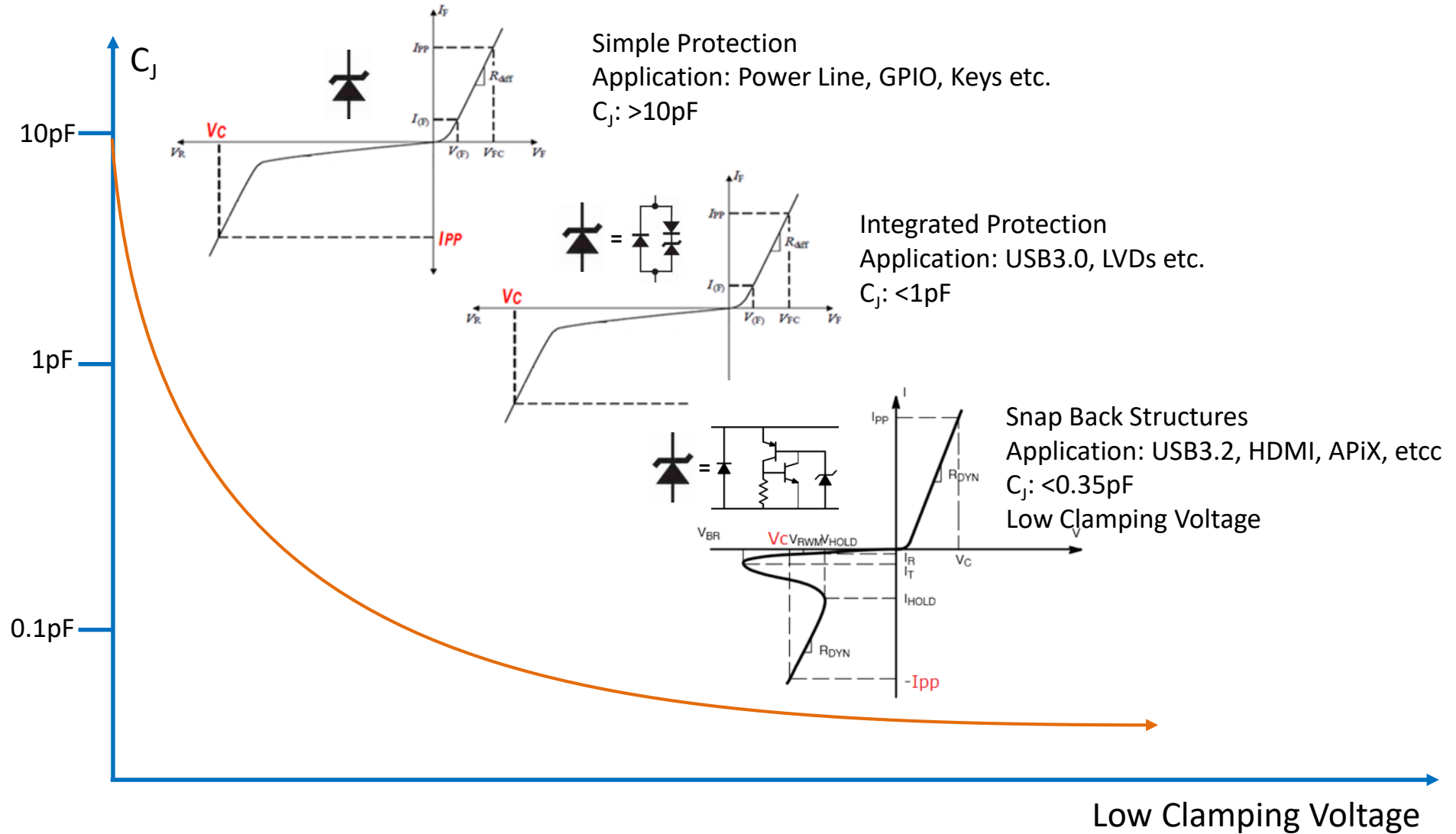
Recommend ESD Array



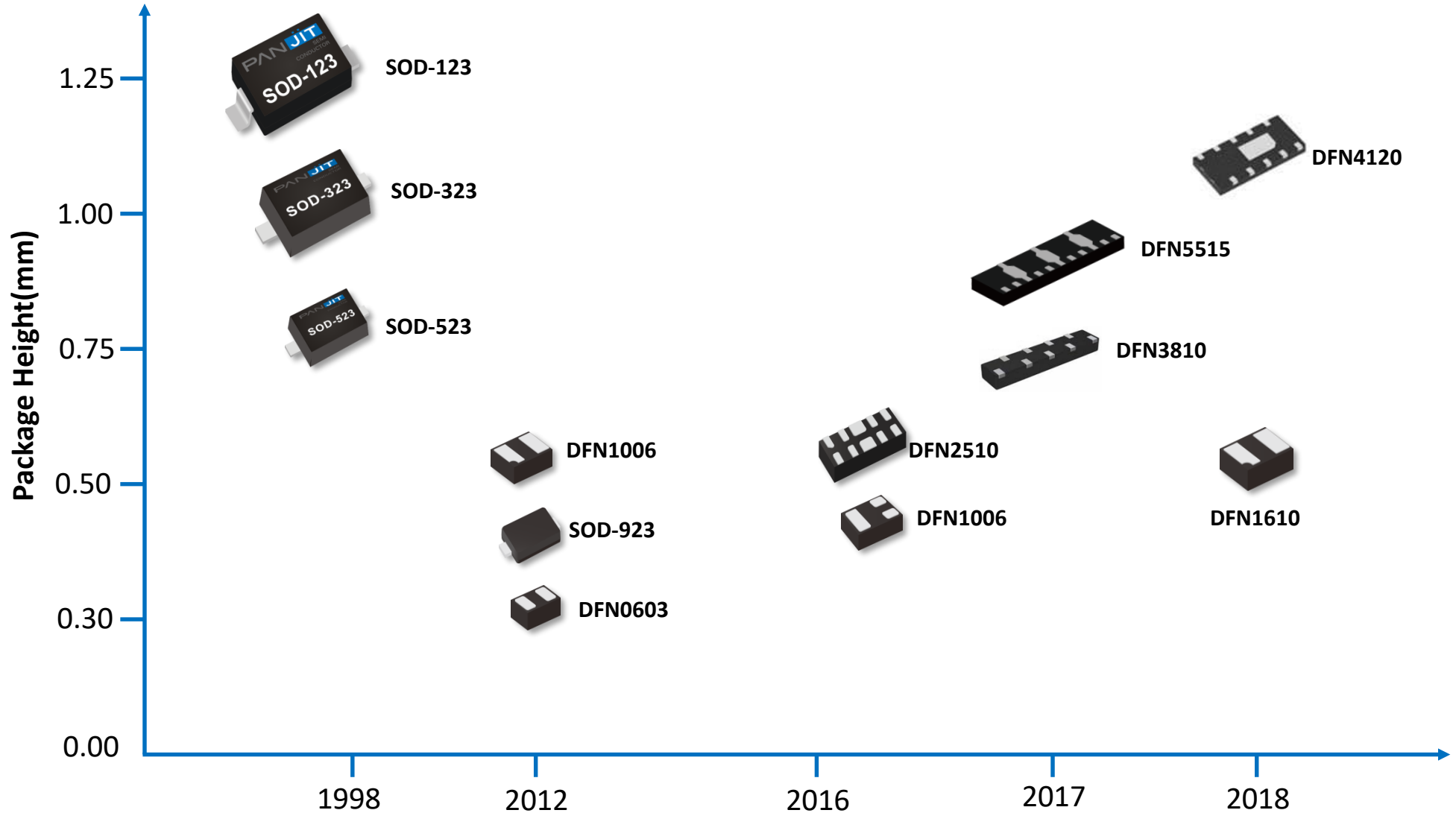
Part Number	UNI/BI	Ch.	V_{RWM} (v)	V_{BR} Min.(V)	$I_R@V_{RWM}$ nA	$V_C@I_{PP}$ Max.(V)	I_{PP}	CJ Typ.(Pf)	ESD IEC61000-4-2	Package	Application
PEC1605M1Q-AU	BI	1	5.5	6.8	75	12	1	0.6	±20KV	DFN 2L	Antenna
PEC3203S1Q-AU*	BI	1	3.3	3.5	500	9	10	20	±30KV	DFN0603-2L	Keys
PEC3205S1Q-AU*	BI	1	5	5.5	500	9	5	20	±30KV	DFN0603-2L	Keys
PEC3203S1Q-AU*	BI	1	3.3	3.5	500	9	10	20	±30KV	DFN0603-2L	GPIO
PEC3205S1Q-AU*	BI	1	5	5.5	500	9	5	20	±30KV	DFN0603-2L	GPIO

*In AEC-Q101 certification

ESD Technology Evolution



ESD Product Range Package



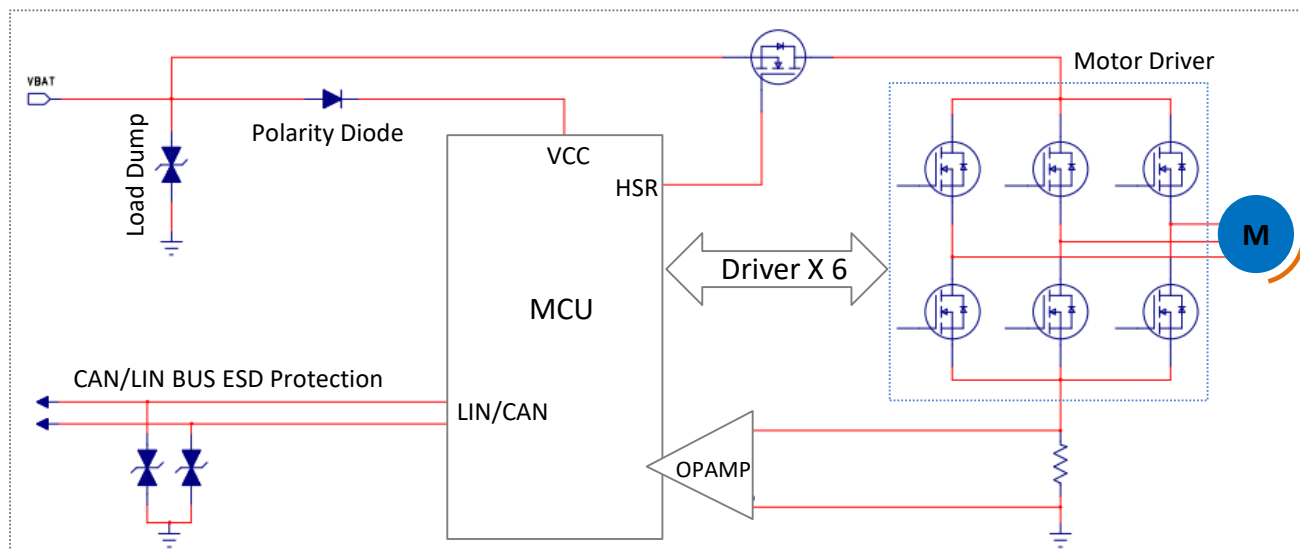


車載電子應用案例

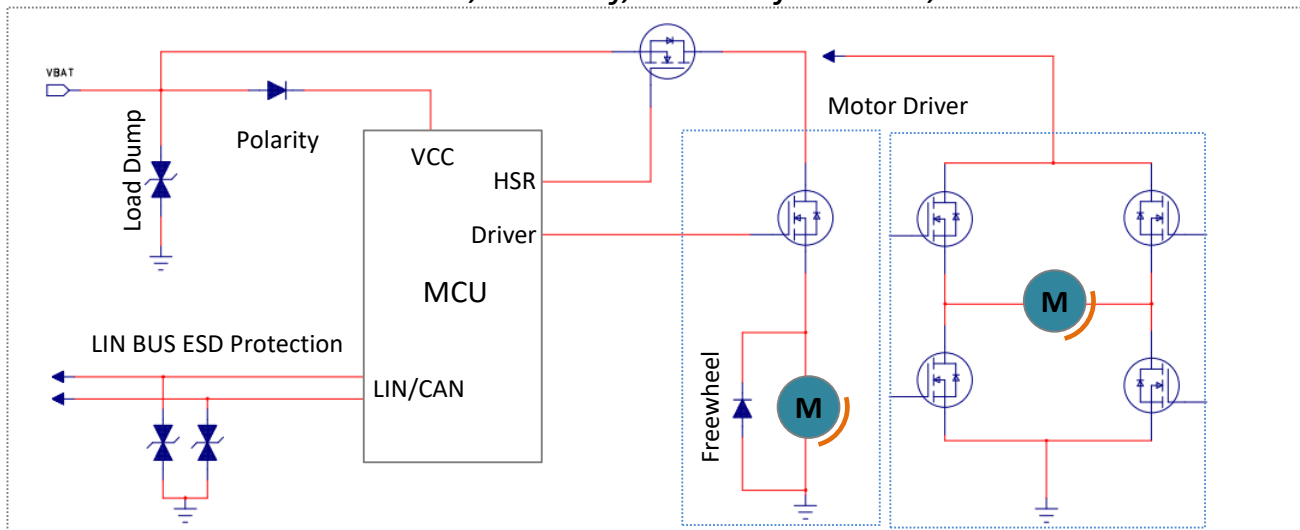
- 馬達控制 (油泵，水泵，散熱風扇，自動天窗...)
- LED車燈 (矩陣大燈，尾燈，氛圍燈...)
- 汽車電子喇叭
- New** • USB充電器
- New** • 無線充電收發器
- 強茂低壓與中壓車規 MOSFET 發展規劃

Automotive Motor Control 馬達控制

BLDC Motor: Cooling Fan, Oil Pump, Water Pump, Windows Lifter, HVAC etc.



BDC Motor: Mirror Control, Sunroof, Seat Adjustment, Value Shutters etc.

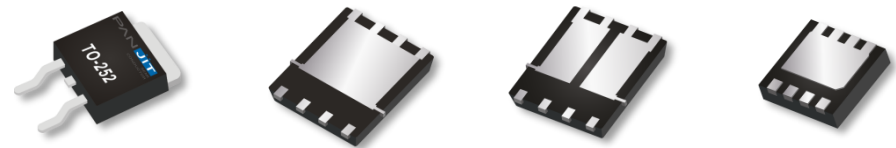


Solutions for Automotive Motor Control 馬達控制

Recommend MOSFET for Motor Driver

VDS (V)	VGS (V)	Channel	Rds(on)@10V (mΩ, max.)	Rds(on)@4.5V (mΩ, max.)	TO-252AA	DFN5060-8L	DFN5060B-8L (Dual Channel)	DFN3333-8L
40V Series, for 12V Automotive systems								
40	20	N	32	44	PJD25N04-AU	PJQ5450-AU	PJQ5850-AU	PJQ4450P-AU
40	20	N	12	17	PJD40N04-AU	PJQ5448-AU	PJQ5848-AU	PJQ4448P-AU
40	20	N	9.5	13.5	PJD50N04-AU	PJQ5446-AU	PJQ5846-AU	PJQ4446P-AU
40	20	N	6.5	8.5	PJD60N04-AU	PJQ5444-AU	PJQ5844-AU	PJQ4442P-AU
40	20	N	5.5	7	PJD80N04-AU	PJQ5442-AU		PJQ4444P-AU
40	20	N	3.8	5	PJD100N04-AU	PJQ5440-AU		
60V Series, for 24V Automotive systems								
60	20	N	34	40	PJD25N06A-AU	PJQ5468A-AU		PJQ4468AP-AU
60	20	N	21	24	PJD35N06A-AU	PJQ5466A-AU		PJQ4466AP-AU
60	20	N	17	20	PJD40N06A-AU	PJQ5466A1-AU	PJQ5866A-AU	PJQ4464AP-AU
60	20	N	12	15	PJD45N06A-AU	PJQ5462A-AU		

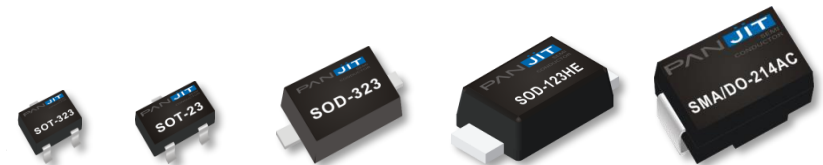
© for 175°C operating junction temperature



Solutions for Automotive Motor Control 馬達控制

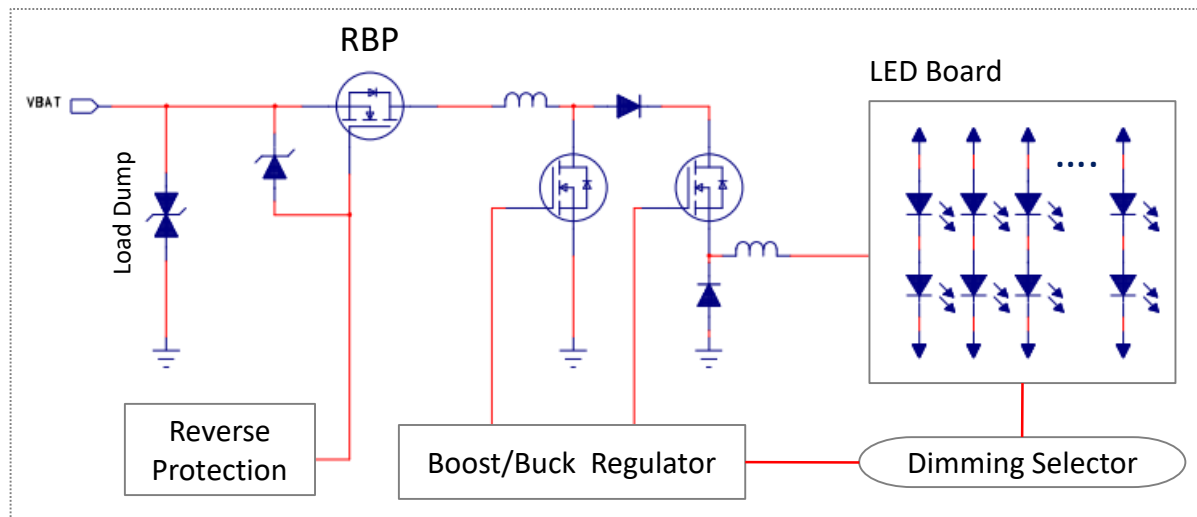
Recommend Diodes (TVS, ESD, Rectifier)

Part Number	Type	Specification Description	Package	Application
P6SMBJxxCA-AU	Power TVS	600W/24V/28V/33V /36V Bi-directional TVS	SMB	Transient Protection
PJEC2415VM1WS	ESD Array	Single Channel 24V/15V $\pm 30KV$ LIN Bi-directional ESD	SOD-323	LIN
PEC33324C2A-AU	ESD Array	Dual Channel 24V/ $\pm 30KV$ CAN Bi-directional ESD	SOT-23	CAN
GS1004FL-AU	General Rectifier	1A/400V	SOD-123FL	Polarity
ES1D-AU	Super Fast	1A/200V	SMA	Freewheel
SXM54ALF-AU	High performance Schottky	5A/45V $V_F < 0.5V$	SMAF	DC/DC
SB3H60AH-AU	High performance Schottky	3A/60V $V_F < 0.7V$	SOD-123HE	DC/DC , Polarity
SS30100HE-AU	Power Schottky	3A/100V $V_F < 0.8V$	SOD-123HE	DC/DC , Polarity
BAS316-AU	Switching	400mW, 100V/250mA $T_{rr} < 4nS$	SOD-323	Switching

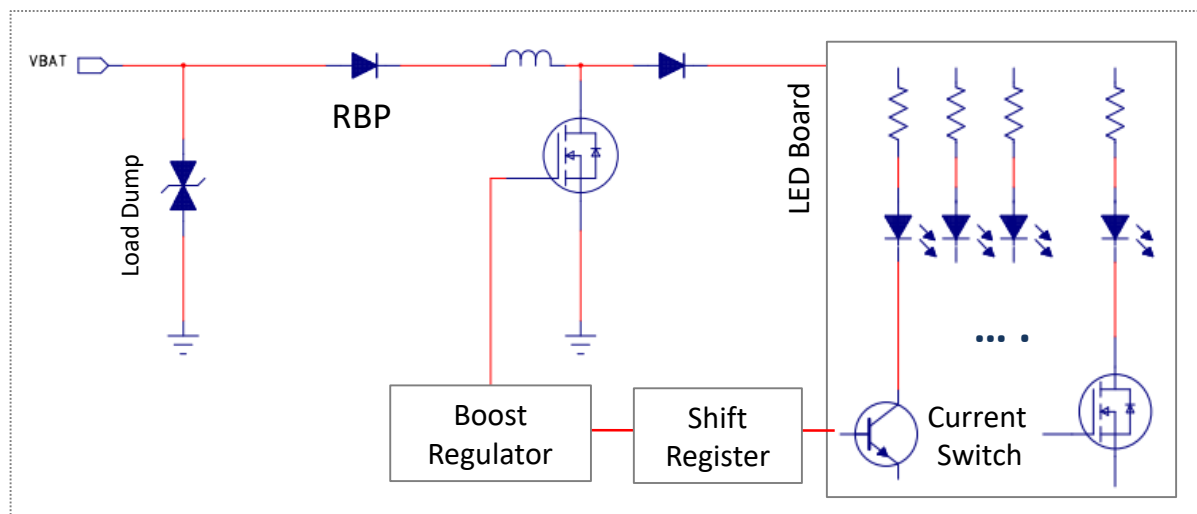


Automotive LED Lighting LED車燈

Front Lighting

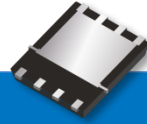
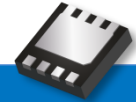


Rear Lighting and Interior Lighting



Solutions for Automotive LED Lighting LED車燈

Recommend LV & MV MOSFET

VDS	VGS	Channel	Rds(on) @10V	Rds(on) @4.5V	 SOT-223	 TO-252AA	 DFN5060-8L	 DFN3333-8L	Application
(V)	(V)		(mΩ, max.)						
40	20	N	9.5	13.5		PJD50N04-AU	PJQ5446-AU	PJQ4446P-AU	RBP
40	20	N	6.5	8.5		PJD60N04-AU	PJQ5444-AU	PJQ4442P-AU	
40	20	N	5.5	7		PJD80N04-AU	PJQ5442-AU	PJQ4444P-AU	
60	20	N	95	110	PJW4N06A-AU				Current Switch
60	20	N	75	90	PJW5N06A-AU	PJD11N06A-AU		PJQ4460AP-AU	Buck & Boost
60	20	N	50	60		PJD16N06A-AU			
60	20	N	34	40		PJD25N06A-AU	PJQ5468A-AU	PJQ4468AP-AU	
60	20	N	21	24		PJD35N06A-AU	PJQ5466A-AU	PJQ4466AP-AU	
60	20	N	12	15		PJD45N06A-AU	PJQ5462A-AU		
100	20	N	130	135	PJW5N10A-AU	PJD10N10-AU			Current Switch
100	20	N	50	55		PJD25N10-AU	PJQ5474A-AU		Boost
100	20	N	25	28.5		PJD50N10AL-AU	PJQ5476AL-AU	PJQ4476AL-AU	

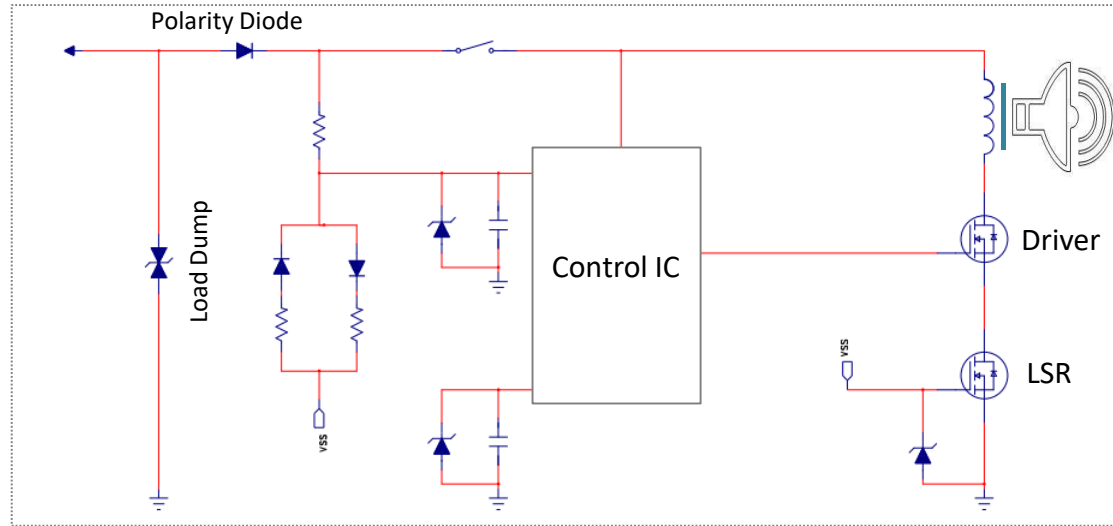
Solutions for Automotive LED Lighting LED車燈



Other Parts Proposals (TVS , ESD, Rectifier, BJT)

Part Number	Type	Specification Description	Package	Application
SxMSxxA-AU	Power TVS	3600W/4600W/6600W 20V-36V Meet ISO16750 5a/5b	DO-218AB	Load Dump
P6SMBJxxCA-AU	Power TVS	600W/24V/28V/33V /36V Bi-directional TVS	SMB	Load Dump
PJEC2415VM1WS-AU	ESD Array	Single Channel 24V/15V ±30KV LIN Bi-directional ESD	SOD-323	LIN
PEC33324C2A-AU	ESD Array	Dual Channel 24V/±30KV CAN Bi-directional ESD	SOT-23	CAN
SRM560VF-AU	High performance Schottky	5A/60V VF<0.52	SMBF	Boost
SS1060FL-AU	Power Schottky	1A/60V VF<0.7V	SOD-123FL	Buck
SS2060FL-AU	Power Schottky	2A/60V VF<0.7V	SOD-123FL	Buck
SB3H60AH-AU	Power Schottky	3A/60V VF<0.7V	SOD-123HE	Buck or RBP
BCP56-AU	BJT	1A/100V HFE=100-250 NPN Transistor	SOT-223	Current Switch
BCX56-AU	BJT	1A/100V HFE=100-250 NPN Transistor	SOT-89	Current Switch

Solutions for Automotive Electronic Horn 汽車電子喇叭



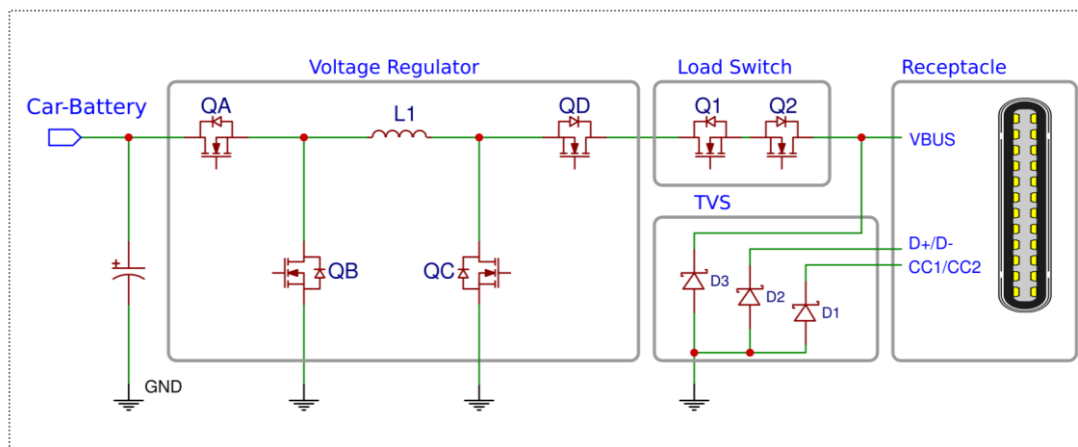
Recommend MV MOSFET

VDS (V)	VGS (V)	Channel	Rds(on)@10V (mΩ, max.)	Rds(on)@4.5V	TO-252AA	DFN5060-8L	DFN3333-8L	Application
100	20	N	50	55	PJD25N10-AU	PJQ5474A-AU		Driver
100	20	N	25	28.5	PJD50N10AL-AU	PJQ5476AL-AU	PJQ4476AL-AU	
30	20	N	7	10	PJD80N03-AU	PJQ5410-AU	PJQ4404P-AU	LSR
30	20	N	9	13	PJD55N03-AU	PJQ5420-AU	PJQ4408P-AU	

Recommend Diodes (TVS, Zener, Schottky)

Part Number	Type	Specification	Package	Application
P6SMBJxxCA-AU	Power TVS	600W/24V/28V/33V /36V Bi-directional TVS	SMB	Transient Protection
MB510-AU	Power Schottky	5A/100V VF < 0.8V	SMC	Polarity
BZT52-Cxx-AU	Zener Diode	500mW 2.4V to 7.5V $\pm 5\%$ Zener Diode	SOD-123	OVP

Solutions for USB Power Delivery Car Charging



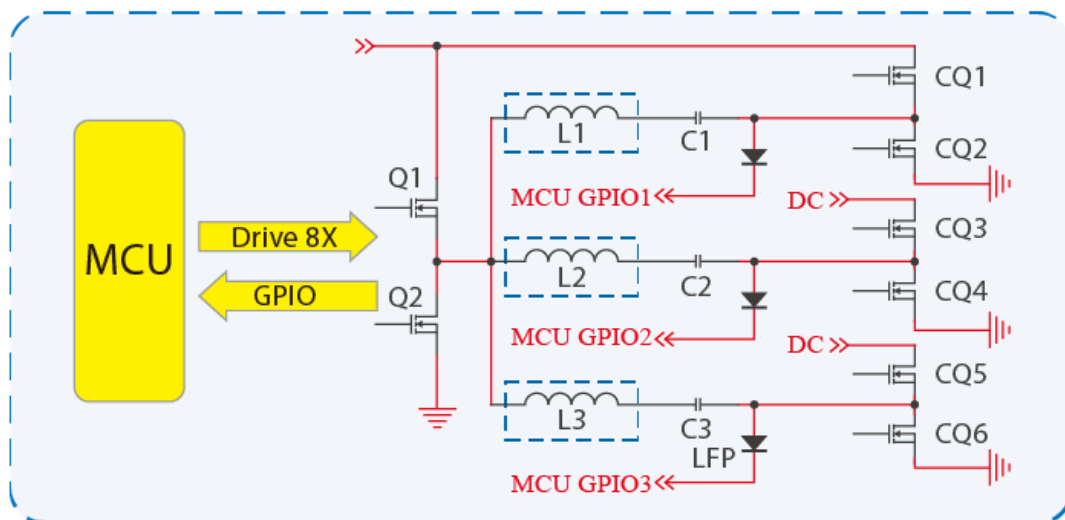
Recommend LV MOSFET

VDS (V)	VGS (V)	Channel	Rds(on)@10V (mΩ, max.)	Rds(on)@4.5V	DFN5060-8L	DFN3333-8L	Application
30	20	N	2.4	3.3	PJQ5426-AU	-	Load Switch / Voltage Regulator
30	20	N	3.8	5.5	PJQ5424-AU	PJQ4402P-AU	
30	20	N	6	9	PJQ5410-AU	PJQ4404P-AU	
40	20	N	5.5	7.5	PJQ5442-AU	PJQ4444P-AU	
40	20	N	6.5	9	PJQ5444-AU	PJQ4442P-AU	
40	20	N	9.5	14	PJQ5446-AU	PJQ4446P-AU	

Recommend Diodes (TVS,ESD Protection)

Part Number	Type	Specification	Package	Application
PE1605C4E6-AU	UNI	$V_{RWM} : 5.5V, C_j : 0.6pF, ESD : \pm 20KV$	SOT-563	TVS / ESD Protection
PEC1605M1Q-AU	BI	$V_{RWM} : 5.5V, C_j : 0.6pF, ESD : \pm 20KV$	DFN 2L	
P6AF12A-AU	UNI	$P_{PPM} : 600W, V_{RWM} : 12V, V_c@30.2A=19.9V$	SMAF	

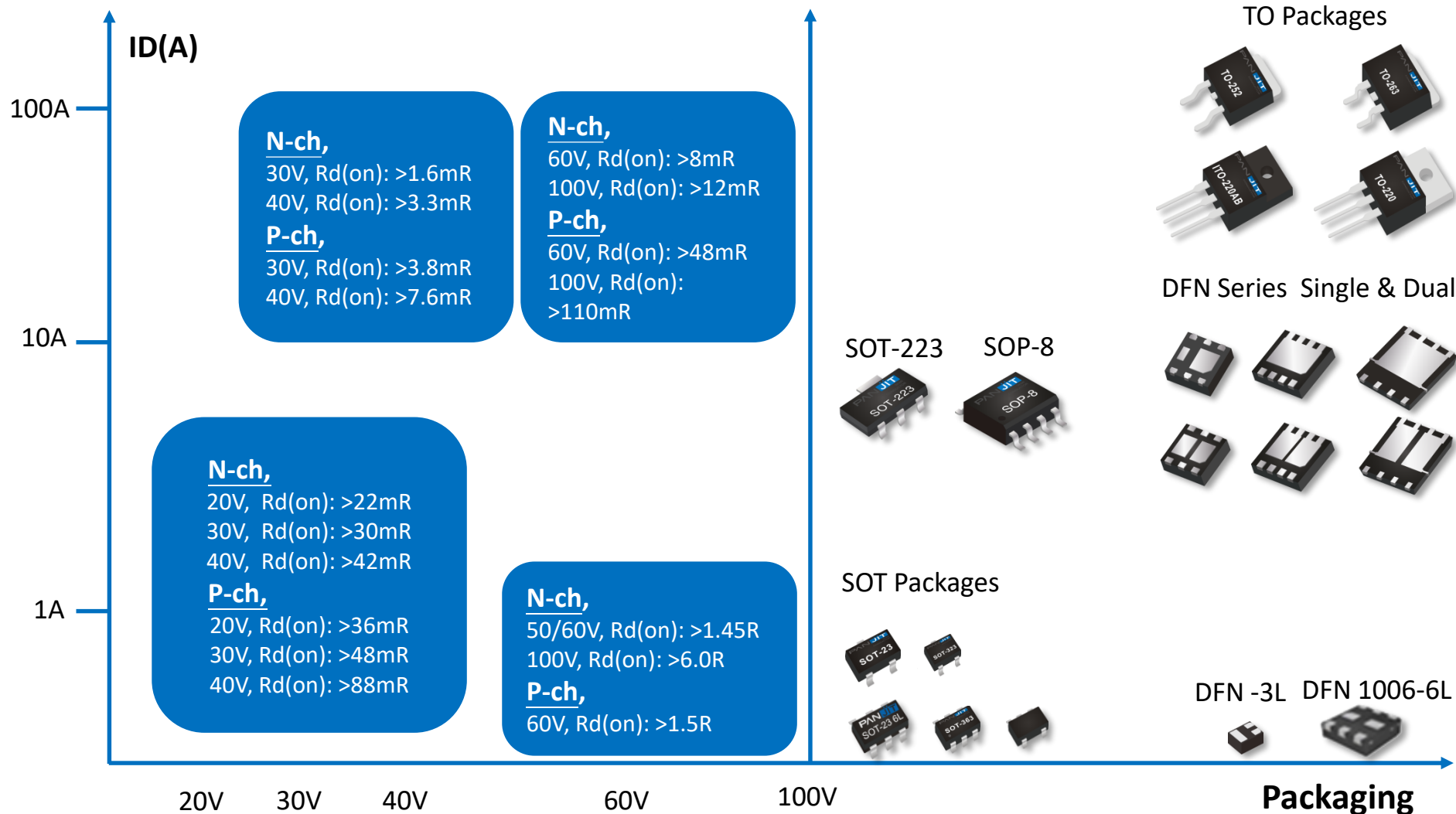
Solutions for Wireless Charging Transmitter



Recommend Devices

Power		PANJIT Part No.		
Watt	DFN5060-8L	DFN3333-8L	DFN2020B-6L	
5W	PJQ5410-AU	PJQ4413P-AU*	PJQ2407-AU*	
	PJQ5412-AU	PJQ4401P-AU*	PJQ2422-AU*	
	PJQ5420-AU*	PJQ4407P-AU*		
10W-15W	PJQ5462A-AU*	PJQ4408P-AU*		
	PJQ5466A-AU*	PJQ4410P-AU*		
	PJQ5466A1-AU*	PJQ4411P-AU*		
		PJQ4414P-AU*		
		PJQ4464AP-AU*		
		PJQ4466AP-AU*		
20W-30W	PJQ5424-AU*	PJQ4402P-AU*		
	PJQ5426-AU*			

Automotive Grade LV & MV MOSFET Roadmap





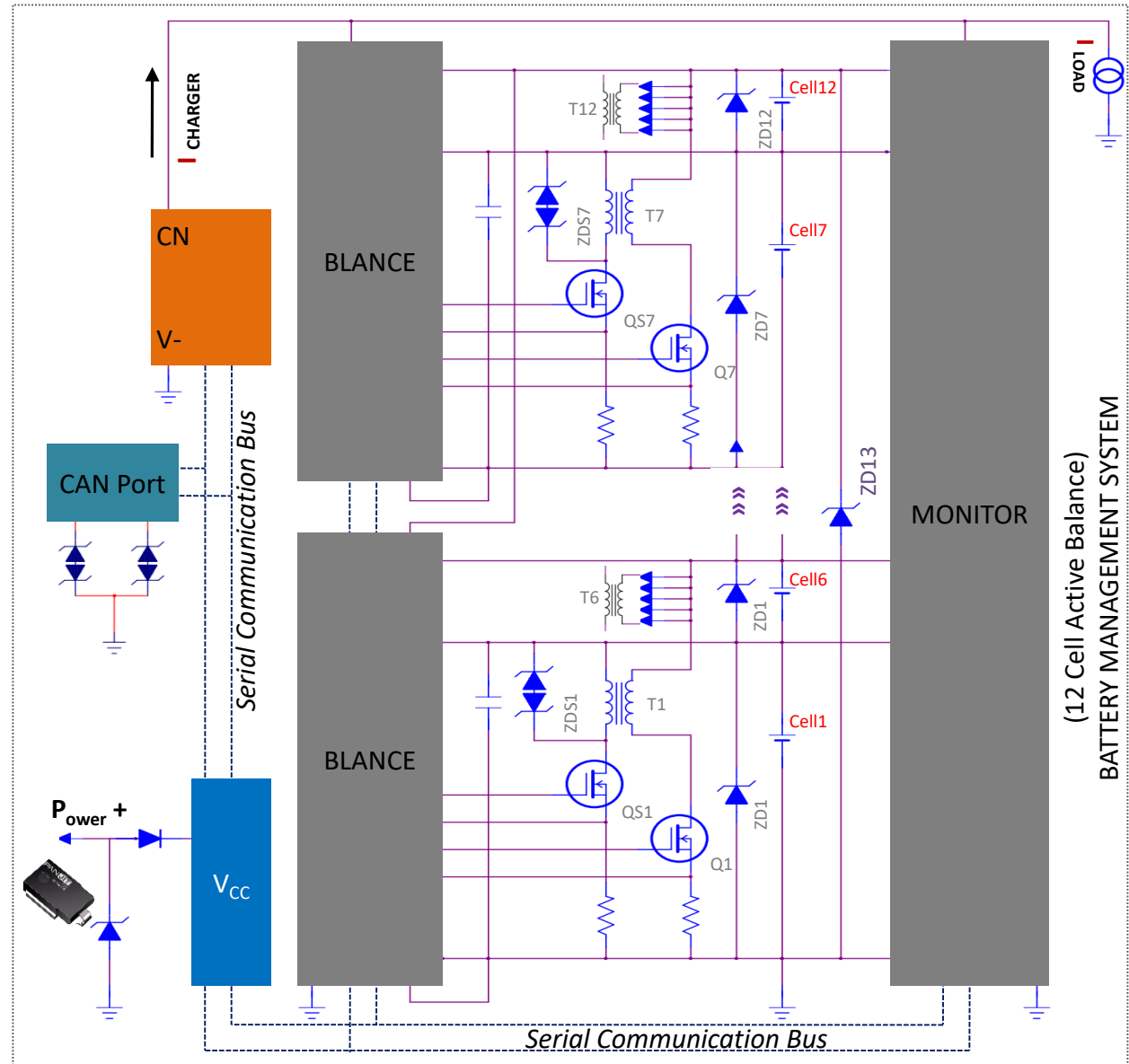
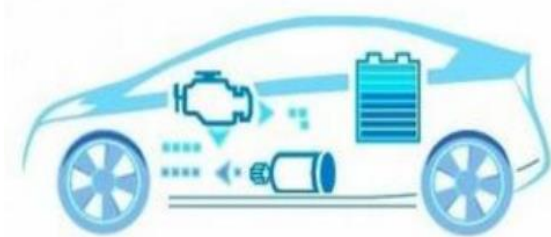
xEV Applications 電動汽車應用

- 電動汽車電池管理系統 (BMS)
- 直流充電樁
- 車載 DC/DC 轉換器
- 車載充電機 (OBC)

Solutions for xEV BMS

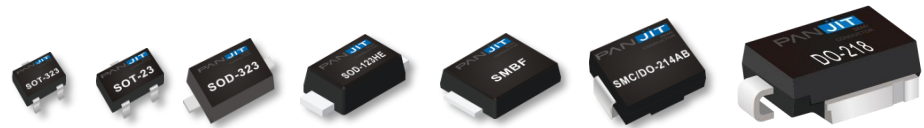
Main product

- Power TVS for power line transient surge protection.
- Zener and TVS diode for battery module hot plug-in protection
- Balancer switching MOSFET
- CAN port ESD protection array
- Schottky diodes for DC/DC converter



Recommend Diode for xEV BMS

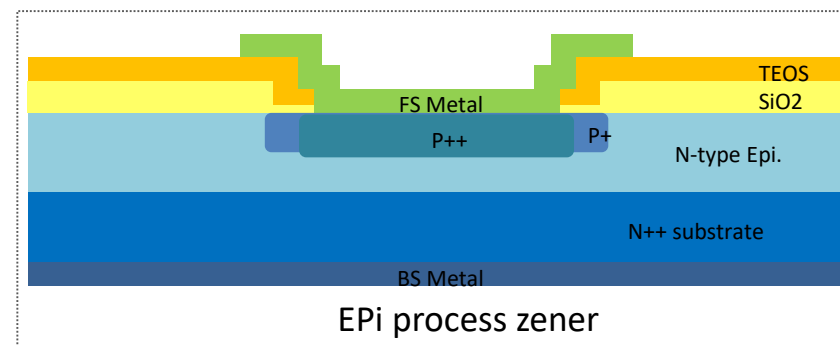
Part Number	Type	Specification Description	Package	Application
1.5SMCxxA-AU	TVS	22V-36V, 1500W,TVS Pass pulse 5b	SMC	Load Dump
SM8SxxA-AU	TVS	22V-36V ,6600W, TVS Pass pulse 5a,5b	DO-218AB	Load Dump
P4FL5.0A-AU	TVS	400W, 5.0V Ultra Low IR TVS	SOD-123FL	hot plug-in protection
P4SMAJxxA-AU	TVS	400W, 54-75V High Voltage TVS Uni / Bi	SMA	Battery Stack Protection
P6SMBJxxA-AU	TVS	600W, 54-75V High Voltage TVS Uni / Bi	SMB	Battery Stack Protection
P6AFxxA-AU	TVS	600W, 33-64V Low Profile TVS	SMAF	Battery Stack Protection
PEC3124C2A-AU	ESD Array	24V, 180W, ± 30 KV Bidirectional ESD protection	SOT-23	CAN Bus ESD Protection
PEC3324C2A-AU	ESD Array	24V, 300W, ± 30 KV Bidirectional ESD protection	SOT-23	CAN Bus ESD Protection
PEC3215C2A-AU	ESD Array	15V, 150W, ± 30 KV Bidirectional ESD protection	SOT-23	CAN Bus ESD Protection
PZS515V6BCH-AU	Zener	500mW, 5.6V Ultra Low IR	SOD-323HE	hot plug-in protection
PZS515V6BAS-AU	Zener	500mW, 5.6V Ultra Low IR	SOD-123	hot plug-in protection
PZS5112BCH-AU	Zener	500mW, 12V Ultra Low IR	SOD-323HE	MOS G/S ESD Protection
SS1040HE-AU	Power Schottky	1.0A, 40V, $V_F < 0.55$ V	SOD-123HE	DC/DC Converter
SS10100HE-AU	Power Schottky	1.0A, 100V, $V_F < 0.8$ V	SOD-123HE	DC/DC Converter
SS10150HE-AU	Power Schottky	1.0A, 150V, $V_F < 0.85$ V	SOD-123HE	DC/DC Converter
MB510-AU	Power Schottky	1.0A, 40V, $V_F < 0.55$ V	SMC	Polarity Diode
SRT8100UF-AU	High performance Schottky	1.0A, 40V, $V_F < 0.55$ V	SMBF	Polarity Diode



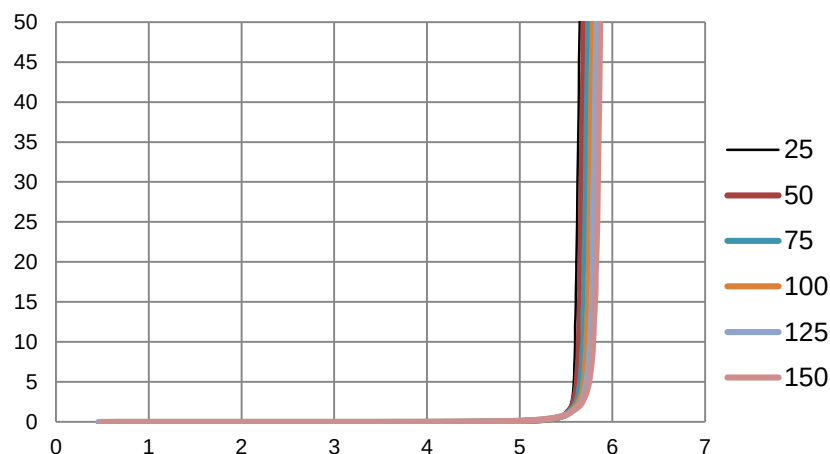
Ultralow I_R Zener for BMS Hot Plug-in Protection

EPI process Zener advantage

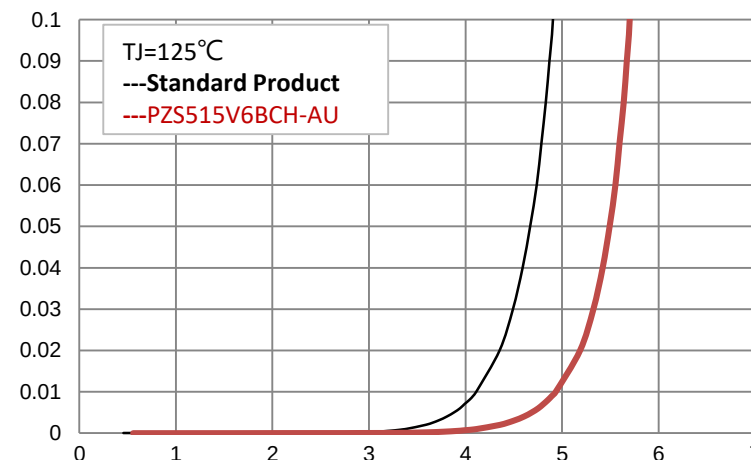
- PANJIT EPI 工藝超低反向漏電汽車級穩壓二極體，具有極低的高溫反向漏電特性，5.0V-6.2V 低壓段產品高溫125°反向漏電 $I_R < 3\mu A @ V_R = 4.2V$ 。
- 適合BMS電池監控埠熱插拔浪湧保護。可有效降低電池組的待機耗損，同時改善其SOC一致性。



Ultra Low I_R Zener VS Standard

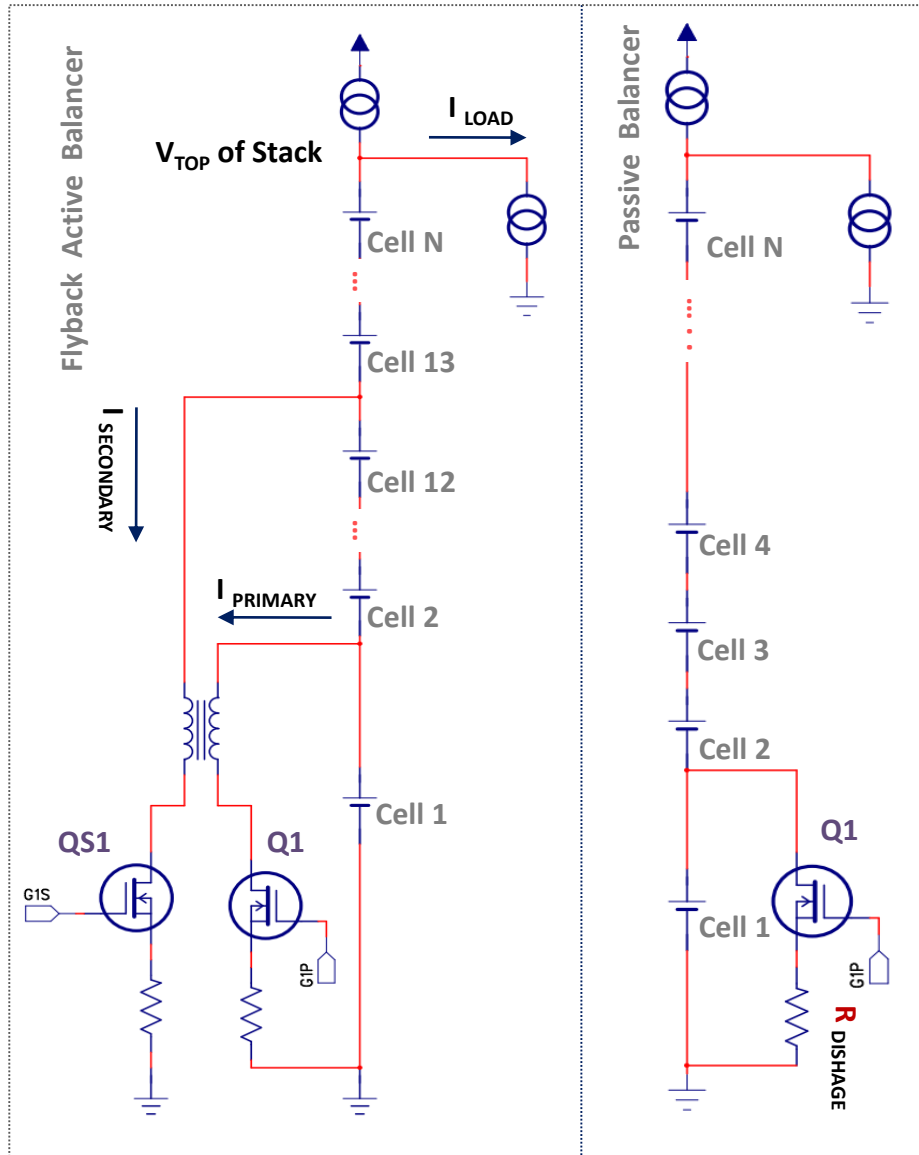


VR(V)	1.5	2.4	3.3	4.2	5
25° $I_R(\mu A)$	0.00	0.01	0.03	1.0	7
125° $I_R(\mu A)$	0.00	0.02	0.08	2	20



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

BMS Balancer MOSFET Selection Guide



How to select MOSFET V_{DS} for BMS balancer

- ✓ 針對帶變壓器的主動均衡開關MOSFET選擇，
(1)根據平衡電流及散熱條件選擇合適的MOSFET 封裝和電流外，(2)根據電池堆疊額定電壓和變壓器匝比來確定初級與次級MOSFET的 V_{DS} ，以確保MOSFET在運行過程的可靠性

Primary MOSFET VDS selection suggestion

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

Secondary MOSFET VDS selection suggestion

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

T: Turns ratio (primary and secondary)

S: The amount of battery stacked on the secondary

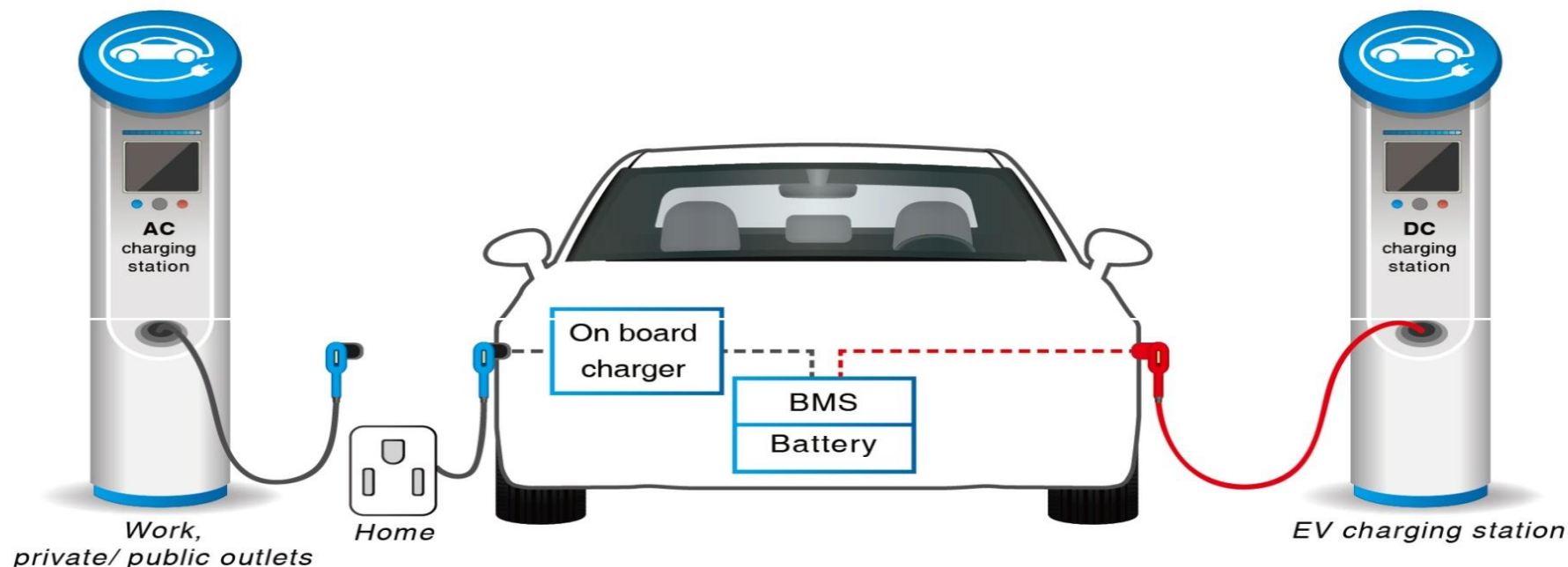
Passive balancer MOSFET VDS selection suggestion

- ✓ 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 .

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

LV & MV MOSFET for balancer

VDS (V)	VGS (V)	Channel	Rds(on)@10V (mΩ, max.)	Rds(on)@4.5V	SOT-23	SOT-223	TO-252AA	DFN5060-8L	DFN3333-8L
30	10	N(ESD)		700/1200	PJA3428-AU				
50	20	N(ESD)	960/1600	1250/2500	PJA138K-AU				
50	20	N(ESD)	1200/1450	1300/1950	PJA3438-AU				
60	20	N(ESD)	-/3000	-/4000	2N7002K-AU				
Passive Balancer									
30	20	P	110	150	PJA3409-AU				
60	20	P	190	240	PJA3461-AU				
100	20	P	650	700	PJA3471-AU				
DC/DC, Power Control, Active Balancer									
60	20	N	95	110	PJW4N06A-AU				
60	20	N	75	90	PJW5N06A-AU	PJD11N06A-AU			PJQ4460AP-AU
60	20	N	50	60		PJD16N06A-AU			PJQ4464AP-AU
60	20	N	34	40		PJD25N06A-AU	PJQ5468A-AU		PJQ4468AP-AU
60	20	N	21	24		PJD35N06A-AU	PJQ5466A-AU		PJQ4466AP-AU
60	20	N	17	20		PJD40N06A-AU	PJQ5466A1-AU		PJQ4464AP-AU
100	20	N	310	320	PJW3N10A-AU	PJD6N10A-AU			
100	20	N	195	210		PJD8N10A-AU	PJQ5470A-AU		PJQ4470AP-AU
100	20	N	115	120		PJD13N10A-AU	PJQ5472A-AU		
100	20	N	50	55		PJD25N10-AU	PJQ5474A-AU		
100	20	N	25	28.5		PJD50N10AL-AU	PJQ5476AL-AU		PJQ4476AL-AU
-60	20	P	110	130	PJW4P06A-AU	PJD14P06A-AU	PJQ5461A-AU		
-60	20	P	68	85	PJW5P06A-AU	PJD15P06A-AU	PJQ5463A-AU		
-60	20	P	48	65		PJD16P06A-AU	PJQ5465A-AU		
-100	20	P	210	230	PJW3P10A-AU	PJD10P10A-AU			
-100	20	P	140	170		PJD14P10A-AU			
150	20	N	65	--		PJD30N15-AU			
150	20	N	35	--		PJD40N15-AU	PJQ5494-AU		



AC Charging (Normal Charging)

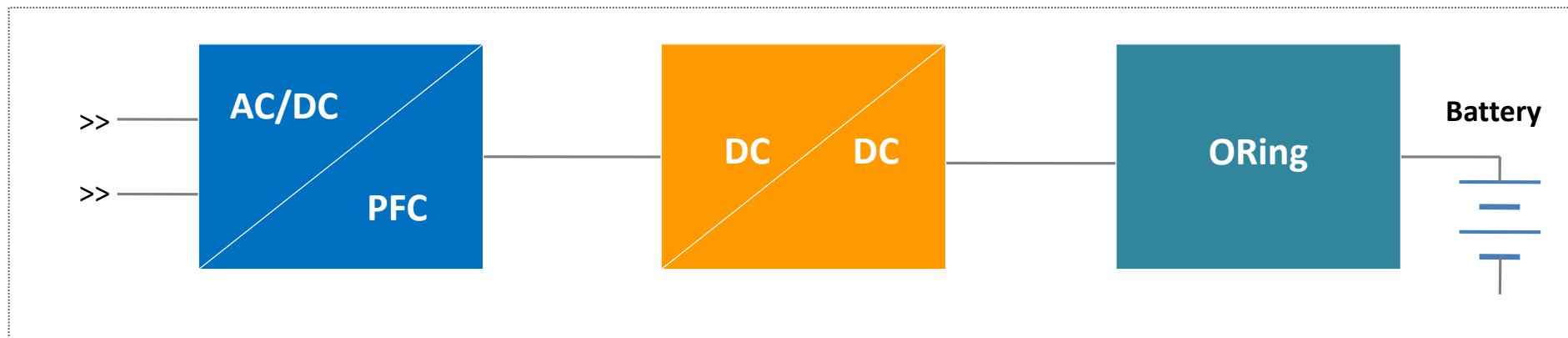
利用電動汽車自帶的車載充電機(OBC)，將交流 220V 雙相或者380V 三相電引入後AC/DC 轉換後對動力電池包充電。主要適用於家庭住所，辦公商超等泊車充電。**OBC 主流充電功率 3.3KW/6.6KW，充電時間比較慢。**

DC Charging (Fast Charging)

利用多個直流充電模組（10KW-20KW）組合成功率超過60KW 的充電樁直接對汽車動力電池包充電，充電速度比AC充電快4-10倍，主要應用於市政，公路等大型充電站。

EV/HEV Charging System

EV/HEV Charging System Block Diagram



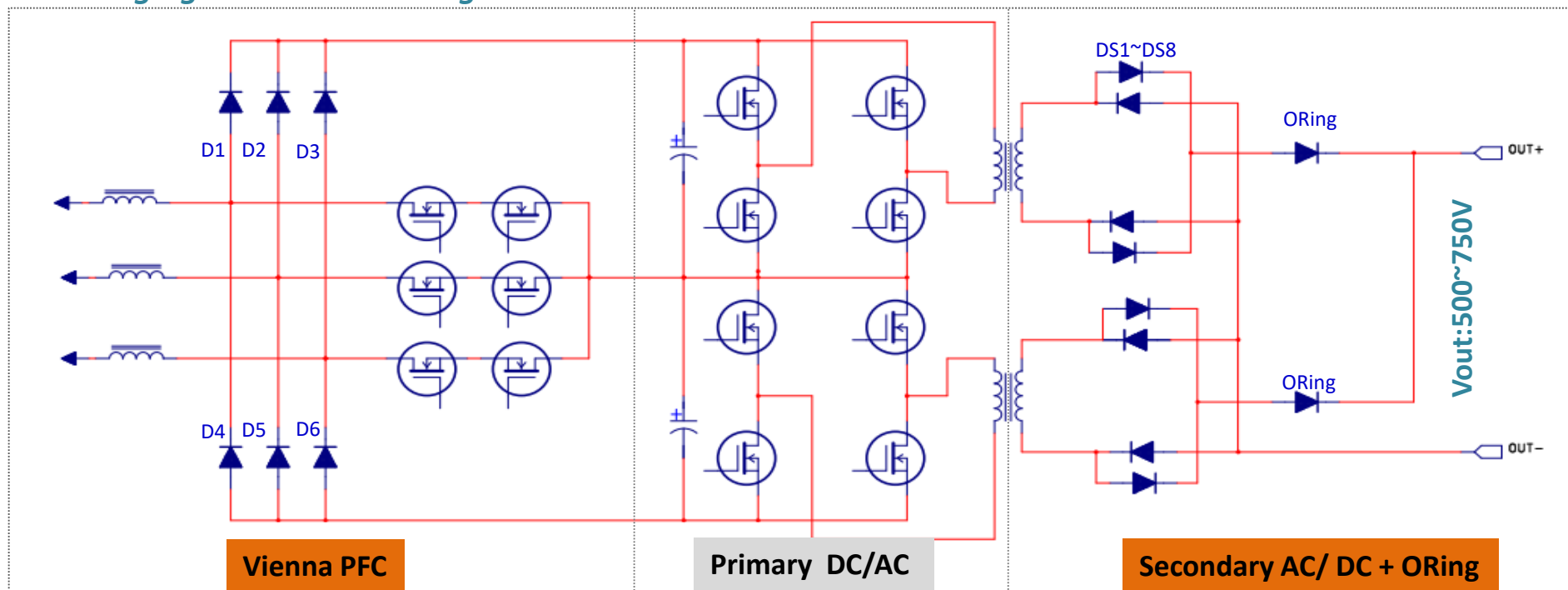
- 600V/1000V/1200V QRT series FRED
- 650V/1200V SiC Schottky

- 600V/1000V/1200V QRT series FRED
- 650V/1200V SiC Schottky

- KBJ series power Bridge

EV/HEV Charging Station

EV Charging Station Block Diagram

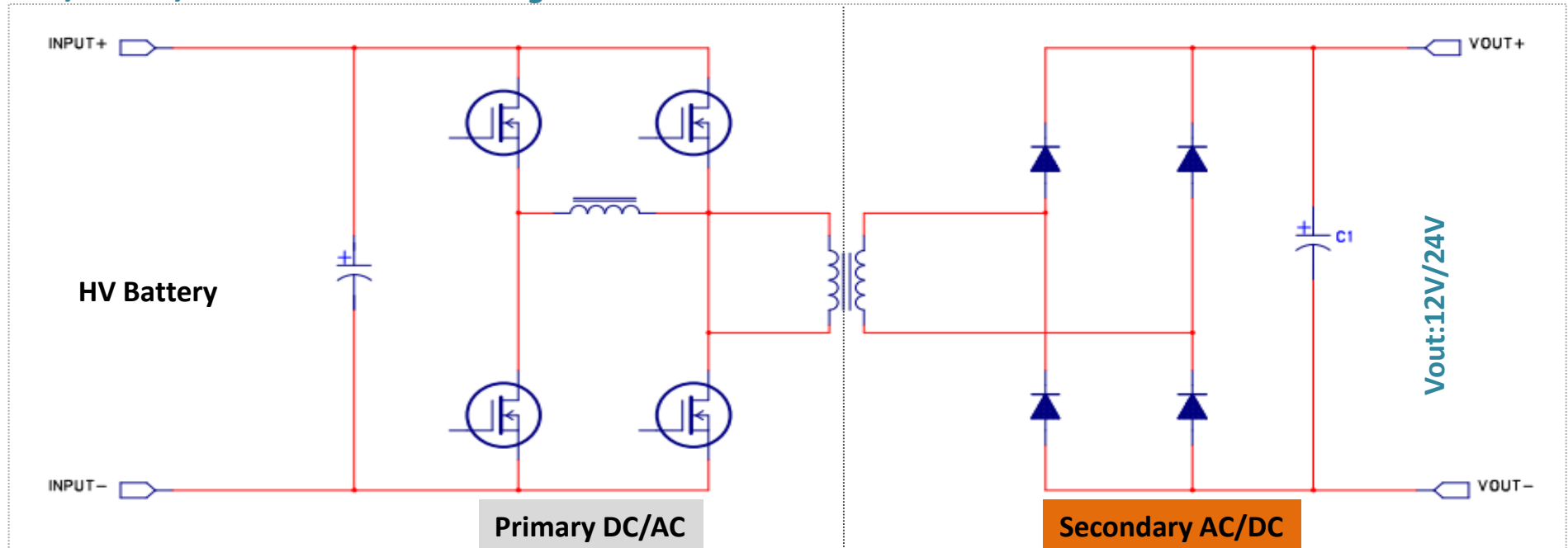


Application-AU	Type	Part Number	Rating	Package	Ref.
Vienna PFC	Superfast Soft Recovery Rectifier	QRT3012P	30A/1200V	TO-247AD 2L	D1-D6
		QRT6012P*	60A/1200V	TO-247AD 2L	
Secondary AC/DC	Superfast Soft Recovery Rectifier	QRT3006	30A/600V	TO-220AC	DS1-DS8
		QRT3006P	30A/600V	TO-247AD 2L	
		QRT6006P	60A/600V	TO-247AD 2L	
ORing Diode	Bridge	KBJ3510	35A/1000V	KBJ	ORing

**In development*

EV/HEV DC/DC Converter

HEV/EV DC/DC Converter Block Diagram

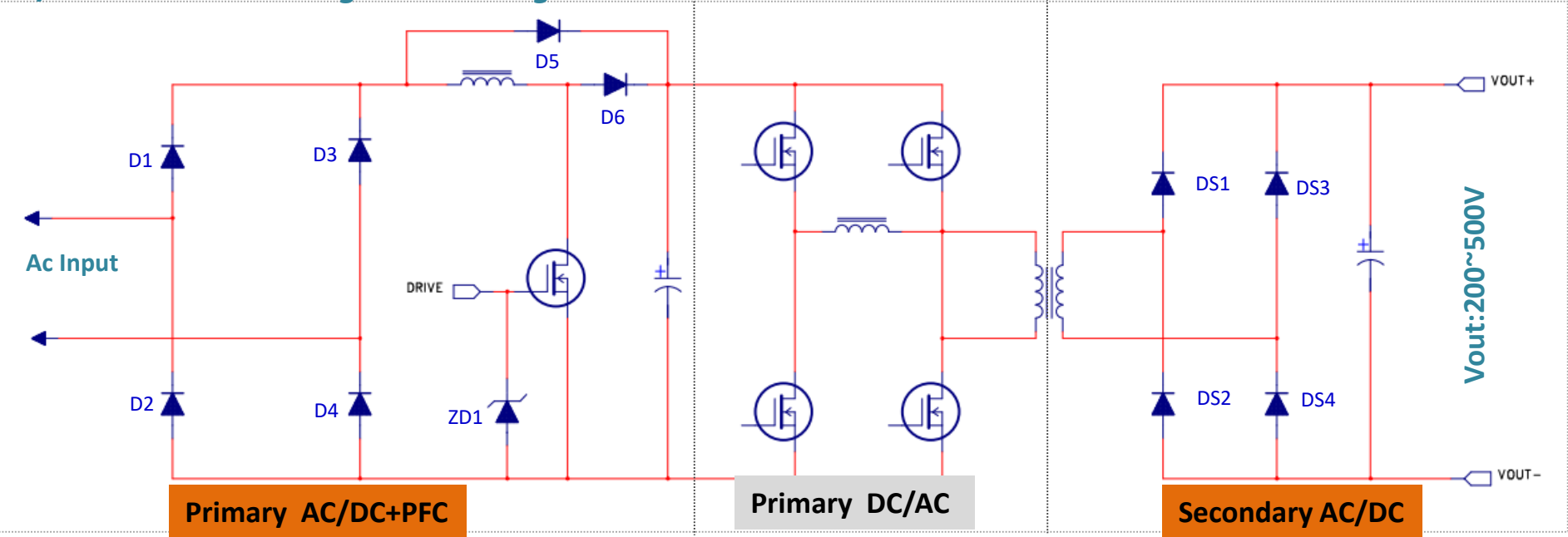


Application	Type	Part Number	Rating	Package
12V Secondary AC/DC	Low VF Schottky	SBT30100VCB-AU*	30A/100V	D ² PACK
	Low VF Schottky	SBT60100CB-AU*	60A/100V	D ² PACK
	Low IR Schottky	MBR60100PT-AU*	60A/100V	TO-3P-3L
	Low VF Schottky	SBT40100UCT-AU*	40A/100V	TO-220AB
	Low IR Schottky	MBR40100PT-AU*	40A/100V	TO-3P-3L
24V Secondary AC/DC	Low VF Schottky	SBT30150VCT-AU*	30A/150V	TO-220AB
	Low VF Schottky	SBT30150VPT-AU*	30A/150V	TO-220AB

**In AEC-Q101 certification*

EV On Board Charger

EV/HEV On Board Charger Block Diagram



Application-AU	Type	Part Number	Rating	Package	Ref.
PFC	SiC Schottky	SiC10A065T-AU	10A/650V	TO-220AC	D6
PFC MOSFET Protection	Power TVS	P4SMAJ15CA-AU	400W/15V	SMA	ZD1
Secondary AC/DC	Super fast Soft Recovery Rectifier	QRT3006-AU	30A/600V	TO-220AC	DS1-DS4
		QRT3006P-AU	30A/600V	TO-247AD 2L	
		QRT6006P-AU	60A/600V	TO-247AD 2L	

Quality Management Systems



PANJIT's well-established Quality Management Systems allows the company to collaborate efficiently and structurally manage its quality-related activities in order to provide its customers with defect-free products and services at the right time.

The QMS engages its employees in creating values for themselves and therefore to our customers.

Automotive Quality

- **AUTOMOTIVE QUALITY PRINCIPLES**

At Panjit, Quality is an integral part of the entire product life cycle which begins from product conceptualization to manufacturing and to other associated services. That is why we drive continuous improvement in our processes , building Quality in the manufacturing floors, laboratories and offices.

- **International Standards Certification**

Our manufacturing sites that produced automotive products are certified to IATF 16949 and OHSAS 18001 thus ensuring our workforce are protected while producing products of highest quality and reliability.

- **Product and Process Development**

The key to deliver reliable and superior product is on robust design practices and world-class process control. Our APQP process adopts a structured approach from product design to qualification. Focusing on prevention at design stage and best practices standardization on mass production.

- **Automated processes and dedicated people**

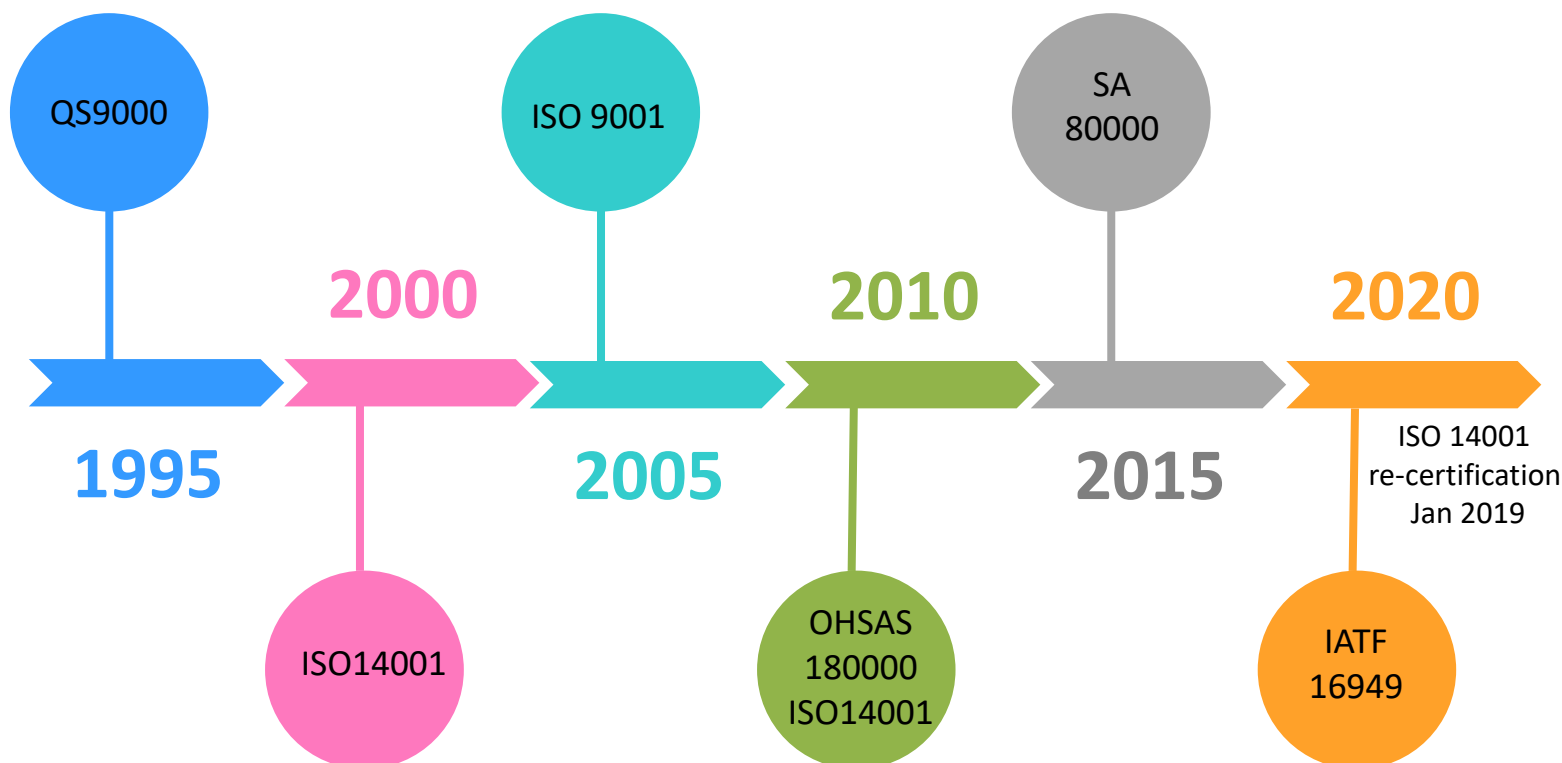
The manufacturing processes are equipped with best-in-class equipment, automated systems and controlled by our highly skilled employee. The performance at every stage of the process is monitored electronically to ensure process stability in order to meet our goal of zero-defect product.

- **Quality Mindset**

All employees are expected to act as quality advocate at their respective area. We are sensitive to abnormality and engage team to detect the underlying root cause and implement robust solution. Thus, the Quality mindset of 'ZERO DEFECT' is ingrained throughout the whole organization.

PANJIT Quality Milestones

Through the years, PANJIT continuously upgrades the quality and sustainability management systems in order to keep its promise of delivering defect-free product to customer through engaged workforce with zero impact to environment.



** The above certifications is for PANJIT Gangshan but equivalent quality roadmap is available for Pynmax and PANJIT Wuxi as requested.*

More Product Information, Please Visit PANJIT Website

www.panjit.com

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