

# Bourns Automotive Solution

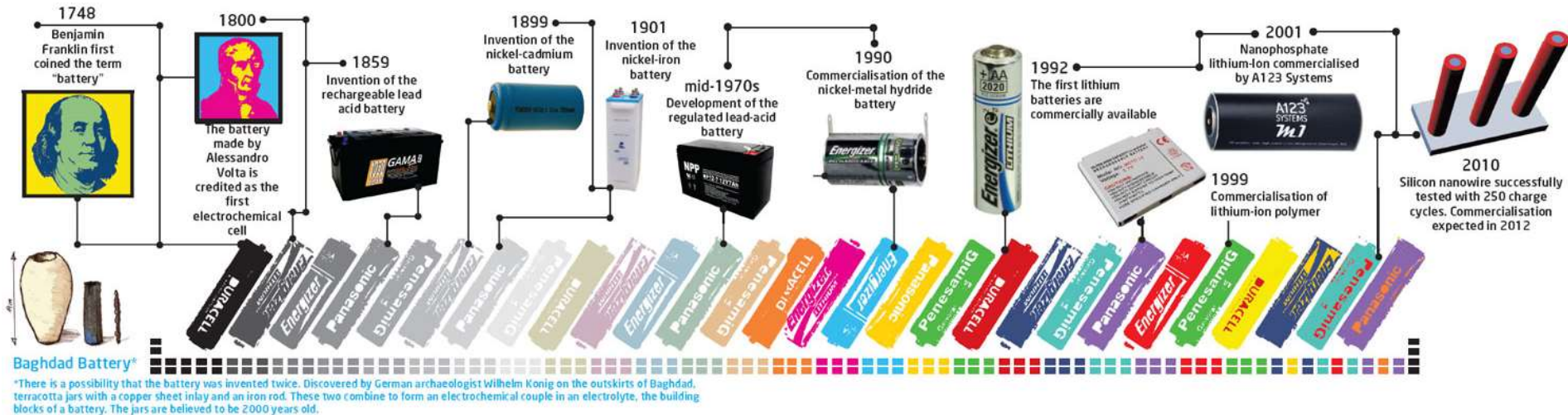
**BOURNS®**

# Outline

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- Background
- Bourns Solution for BMS
  - Overview
  - Power circuits
  - CANBUS/CANFD
  - Cell monitoring
- Q & A

# Background (History of Battery)



- **As the evolution of battery. Now, the most popular one was Li-ion battery because**

- High Energy Density
- High Open circuit voltage (3.7V~4.2V)
- High Output power
- No memory effect
- Charge/Discharge fast

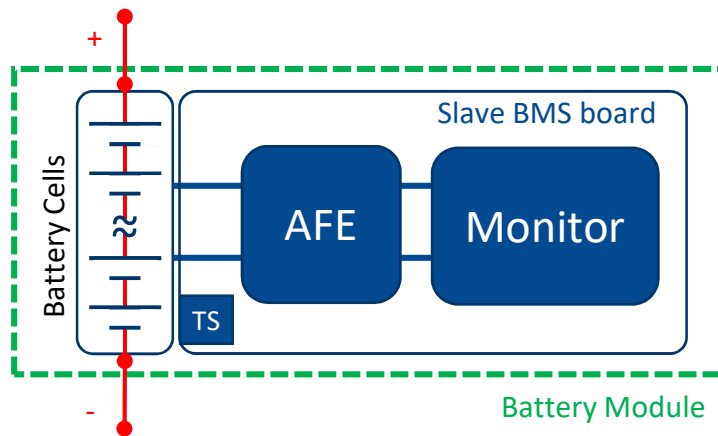
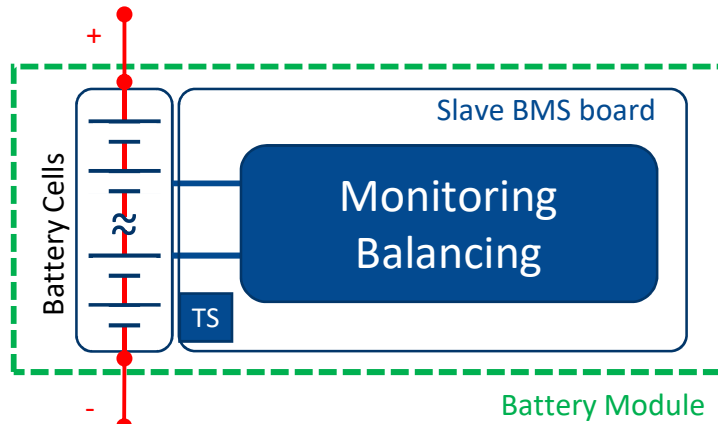
**Li-ion is not stable material, so we need multiple protection level to protect it**

# Background

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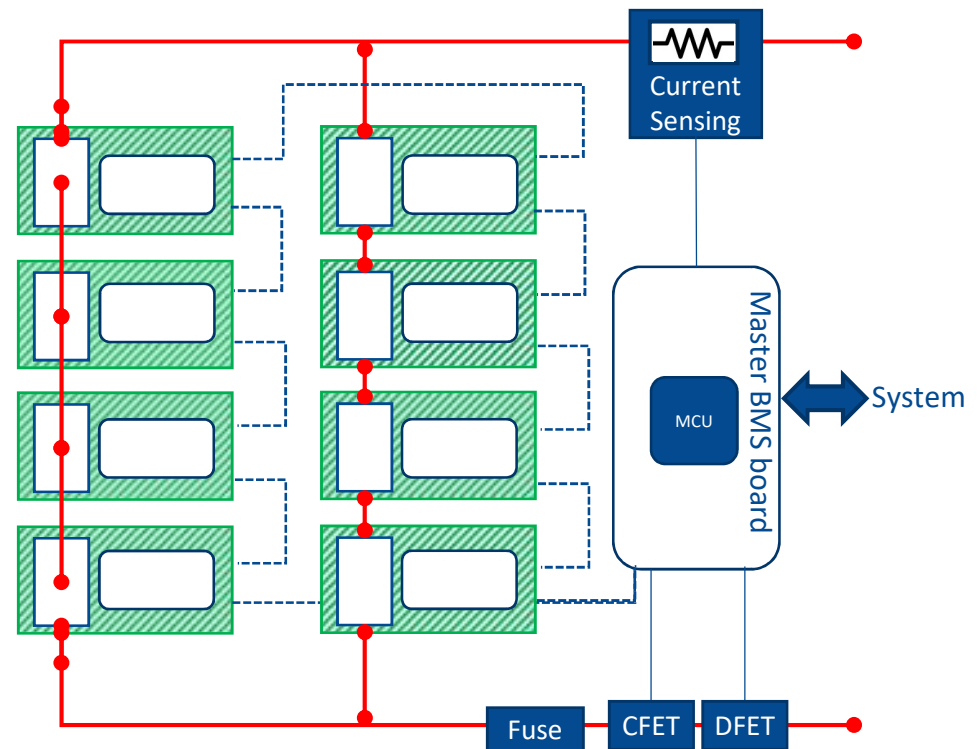
- What's BMS:
  - It is simply Battery Monitoring, keeping a check on the key operational parameters during charging and discharging
- Why need BMS
  - STATUS Monitor – Voltage/Current/Temperature
  - Cell Balance
  - Communication

# Background (Battery Pack Design)



## High-Voltage Battery Pack

- Advanced Battery Pack design
- Daisy-Chain for monitoring data transmission to MCU
- Complete battery management with Slave BMS & Master BMS
- Isolation is required

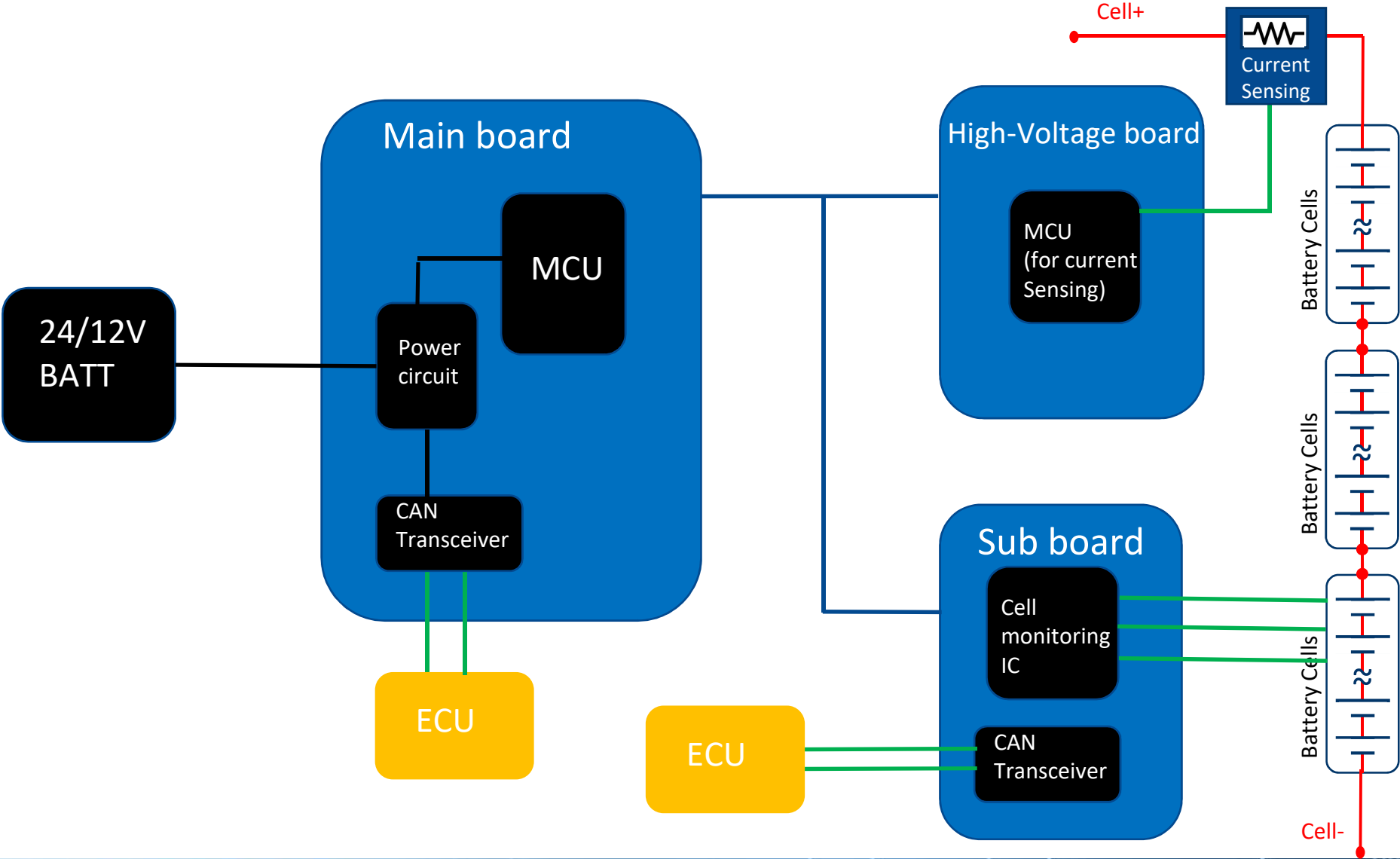


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  - **Overview**
  - Power circuits
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# BMS System Overview



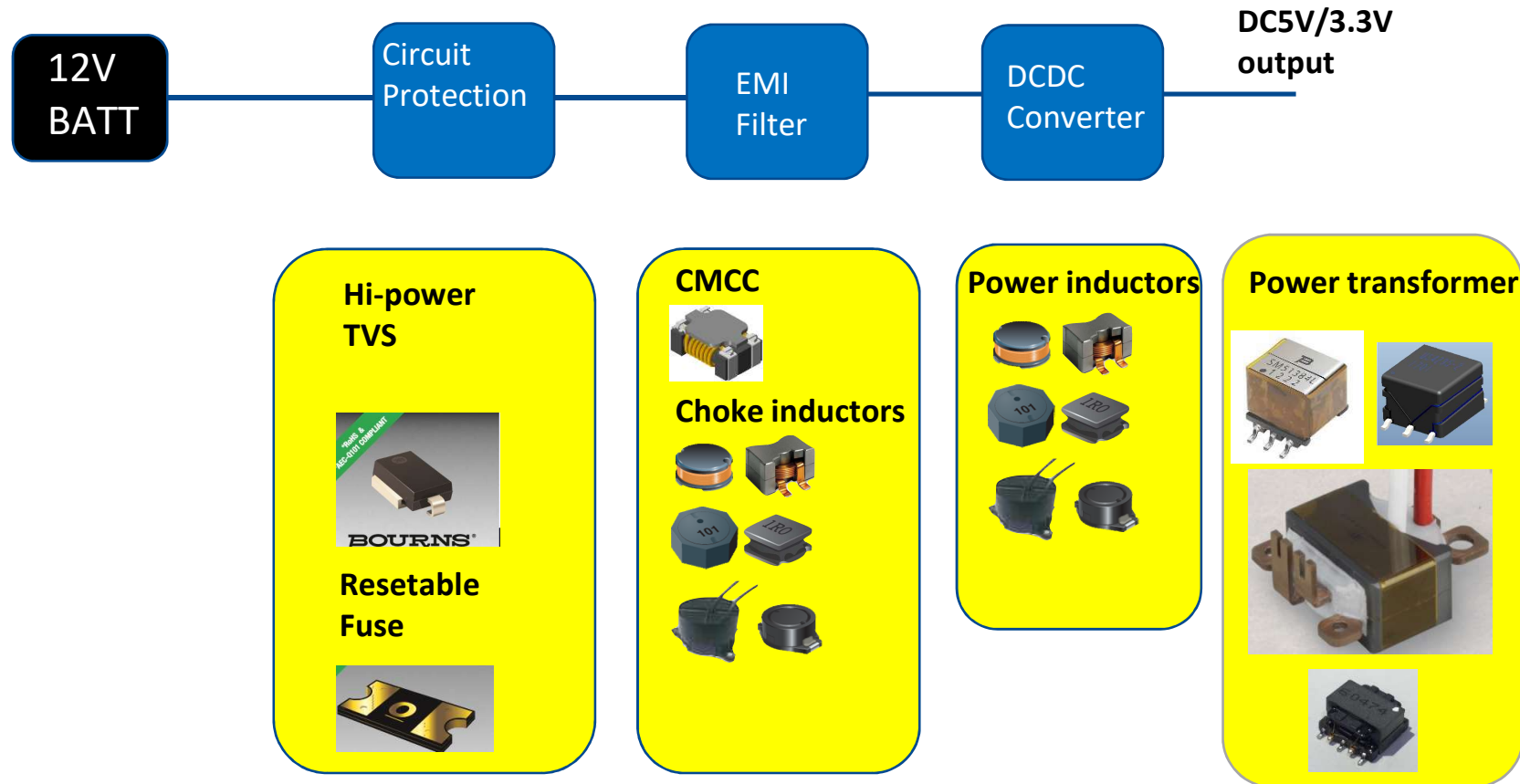
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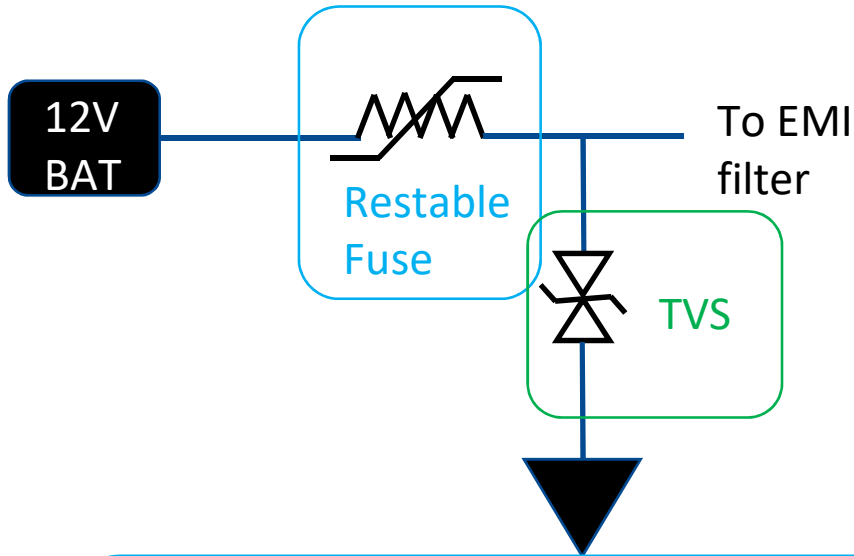


# Power circuit



# Power circuit

Circuit protection:



## Features

- High power ratings
- Compliant with AEC-Q200 Rev-C- Stress Test Qualification for Passive Components in Automotive Applications
- Low profile
- Compatible with Pb and Pb-free solder reflow profiles
- RoHS compliant\* and halogen free\*\*
- Surface mount packaging for automated assembly
- Agency recognition:
- Standard 7555 mm (2920 mils) footprint

## MF-LSMF Series - PTC Resettable Fuses

### Electrical Characteristics

Model***	V max. Volts	I max. Amps	I <sub>hold</sub>		I <sub>trip</sub>		Resistance		Max. Time To Trip		Tripped Power Dissipation Watts at 23 °C
			Amperes at 23 °C		Ohms at 23 °C		Amperes at 23 °C	Seconds at 23 °C	Typ.		
			Hold	Trip	R <sub>Min.</sub>	R <sub>1Max.</sub>					
MF-LSMF185/33X	33.0	40	1.85	3.70	0.045	0.150	8.0	2.50	1.5		
MF-LSMF260X	24.0	20	2.60	5.20	0.020	0.075	8.0	5.00	1.5		
MF-LSMF300X	6.0	40	3.00	5.00	0.015	0.048	8.0	20.00	1.5		
MF-LSMF300/24X	24.0	20	3.00	5.20	0.020	0.075	8.0	5.00	1.5		
MF-LSMF400/12X****	12.0	20	4.00	8.00	0.005	0.050	8.0	15.00	1.5		

\*\*\* Features Multifuse® Free Expansion Design™ for MF-LSMF Series  
 \*\*\*\* UL approval pending.



## Features

- Maximum Peak Power Dissipation: 6600 watts
- Meets ISO7637-2 / ISO16750-2 Surge specification (varies by test condition)
- RoHS compliant\*
- AEC-Q101 compliant\*\*

## Applications

- High peak power applications (up to rated limits)
- High temperature applications (up to rated limits)
- Clamping diode
- Load switching and lighting

## SM8S-Q Transient Voltage Suppressor Diode Series

### General Information

Bourns offers Transient Voltage Suppressor Diodes for surge and ESD protection applications, in compact chip package DO-218 size format. The Transient Voltage Suppressor series offers a choice of Working Peak Reverse Voltage from 16 V up to 43 V. Typical fast response times are less than 1.0 picosecond from 0 V to Breakdown Voltage.













### Absolute Maximum Ratings (@ T<sub>A</sub> = 25 °C Unless Otherwise Noted)

Parameter	Symbol	Value	Unit
Maximum Peak Pulse Power Dissipation (10/1000 μs)	P <sub>PK</sub>	6600	W
Maximum Peak Pulse Power Dissipation (10/10000 μs)	P <sub>PK</sub>	5200	W
Power Dissipation with Infinite Heatsink (T <sub>C</sub> = 25 °C)	P <sub>D</sub>	8	W
Operating Temperature Range	T <sub>J</sub>	-55 to +175	°C
Storage Temperature Range	T <sub>STG</sub>	-55 to +175	°C

### Electrical Characteristics (@ T<sub>A</sub> = 25 °C Unless Otherwise Noted)

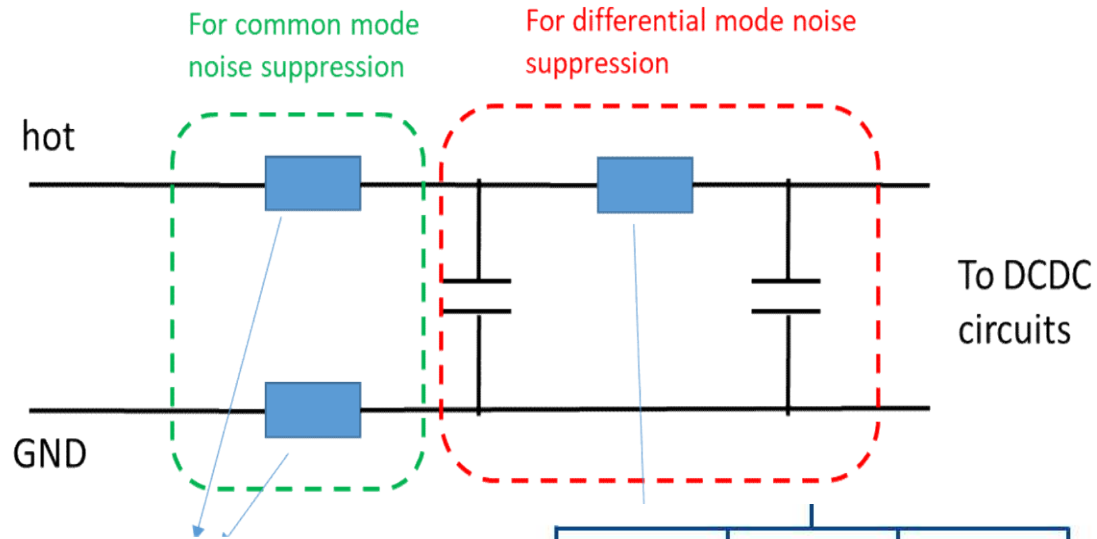
Part No.	Part No.	Breakdown Voltage V <sub>BR</sub> (Volts)			Working Peak Reverse Voltage V <sub>RWM</sub> (V)	Maximum Reverse Leakage @ V <sub>RWM</sub> I <sub>R</sub> (μA)	Maximum Reverse Voltage @ I <sub>RSM</sub> V <sub>RSM</sub> (V)	Maximum Reverse Surge Current I <sub>RSM</sub> (A)
		Min.	Max.	@ I <sub>T</sub> (mA)				
SM8S16A	SM8S16CA	17.80	19.70	5	16.0	10	26.0	254.0

# AEC-Q101 TVS Diodes

	CDSOT23 -TxxLC-Q	CDSOT23 -Txx(C)-Q	CDSOT23 -T24CAN- Q	CDSOD32 3-T05S-Q	CDSOD32 3-TxxC- DSL-Q	SMAJ-Q	SMBJ-Q	SMCJ-Q	SMLJ-Q	5.0SMDJ- Q	SM8S-Q	SM8SF-Q
Package												
Package Type	SOT-23	SOT-23	SOT-23	SOD323	SOD323	DO-214AC (SMA)	DO-214AA (SMB)	DO-214AB (SMC)	DO-214AB (SMC)	DO-214AB (SMC)	DO-218	0.41" x 0.32"
Peak Pulse Power (Watt) (10/1000 $\mu$ s)	(500W 8/20 $\mu$ s)	(500W 8/20 $\mu$ s)	(320W 8/20 $\mu$ s)	(500W 8/20 $\mu$ s)	(250W 8/20 $\mu$ s)	400	600	1500	3000	5000	6600	7000
Peak Pulse Current (A) (10/1000 $\mu$ s)	(42 ~ 9 8/20 $\mu$ s)	(43 ~ 9 8/20 $\mu$ s)	(8 8/20 $\mu$ s)	(42A 8/20 $\mu$ s)	(11 / 6 8/20 $\mu$ s)	20.1 ~ 4.3	30.2 ~ 6.5	75.4 ~ 16.1	150.6 ~ 32	252 ~ 72.1	95 ~ 254	180 ~ 120
Stand-Off Voltage (V)	5 ~ 36	3.3 ~ 36	24	5	12 / 24	12 ~ 58	12 ~ 58	12 ~ 58	12 ~ 58	12 ~ 43	16 ~ 43	24 ~ 36
Breakdown Voltage (V)	6 ~ 40	4 ~ 40	26.2	6	13.3 / 26.7	13.3 ~ 64.4	13.3 ~ 64.4	13.3 ~ 64.4	13.3 ~ 64.4	13.3 ~ 47.8	18.8 ~ 47.8	26.7 ~ 40

# Power circuit

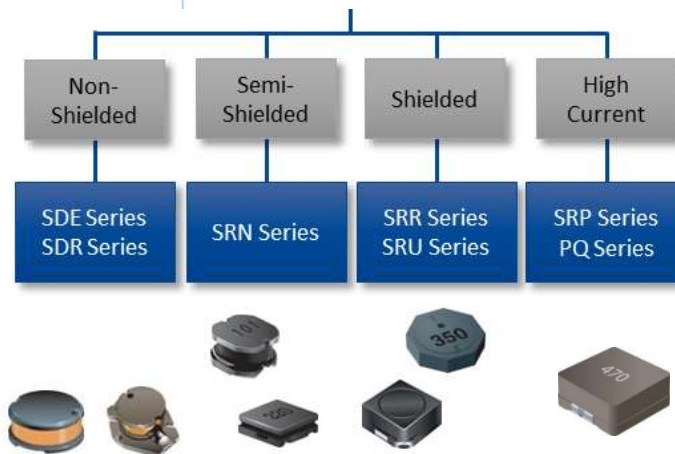
EMI filter:



1. CMCC for power line:  
7.0×6.0×3.5 (**SRF7038A**)  
9.0×6.5×4.5 (**SRF9045A**)  
12.5×11.0×6.5 (**SRF1206A**)



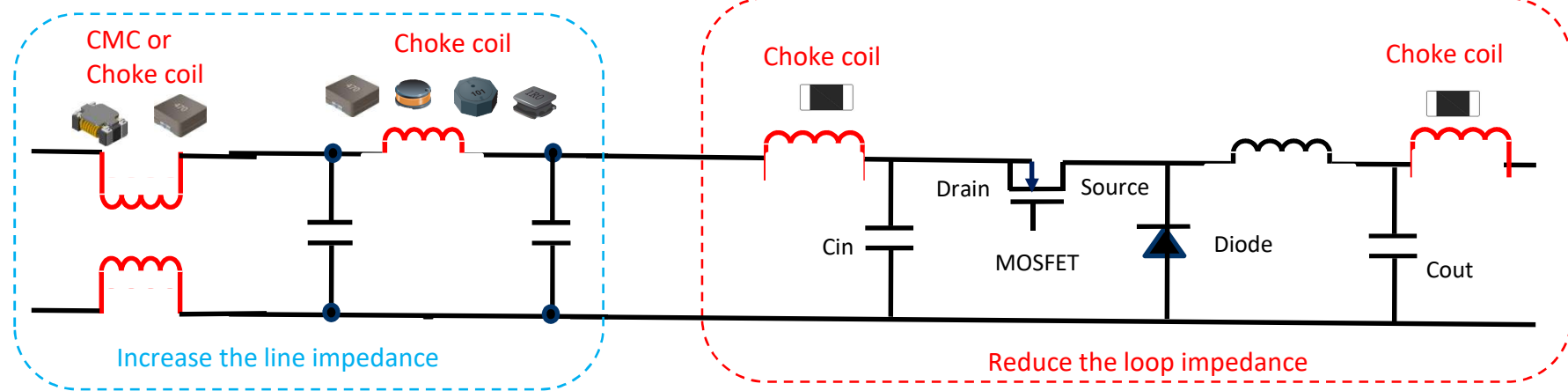
2. Choke inductor for power line:  
2.5×2.0×1.2 (**SRP2512A**)\*



\*For solution2, please contact with FAE for more detail technical support.

# Power Circuit

## EMI filter total solution overview



	Bourns available part
CMC	SRF7038A-701Y SRF9045A-701Y SRF1206A-701Y & SRF1206A-102Y
Choke coil for common mode noise	SRP2512A-R33M SRP2512A-R47M SRP2512A-R68M SRP2512A-1R0M
Choke coil for differential mode noise	SRP series SDE series SRN series SRR series (inductance range 2.2uH-10uH)
Choke coil for loop impedance reducing	MH2029A-102Y SRP2512A-R33M SRP2512A-R47M SRP2512A-R68M

# Power circuit

## EMI filter: CMC comparison

### 7\*6mm size

<b>Bourns SRF7038A-701Y</b>	<b>TDK ACM70V-701-2P</b>
Rated current 4A	Rated current 4A
Common mode impedance 700ohm @ 100MHz	Common mode impedance 700ohm @ 100MHz
Cost <b>Low</b>	Cost High

### 12\*11mm size

<b>Bourns SRF1206A-701Y</b>	<b>TDK ACM12V-701-2P</b>
Rated current 8A	Rated current 8A
Common mode impedance 700ohm @ 100MHz	Common mode impedance 700ohm @ 100MHz
Cost <b>Low</b>	Cost High

### 9\*6.5mm size



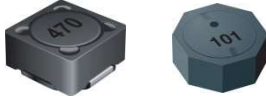

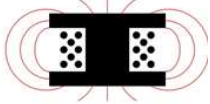

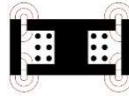
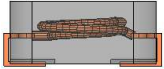
<b>Bourns SRF9045A-701Y</b>	<b>TDK ACM90V-701-2P</b>
Rated current 5A	Rated current 5A
Common mode impedance 700ohm @ 100MHz	Common mode impedance 700ohm @ 100MHz
Cost <b>Low</b>	Cost High

### 12\*11mm size

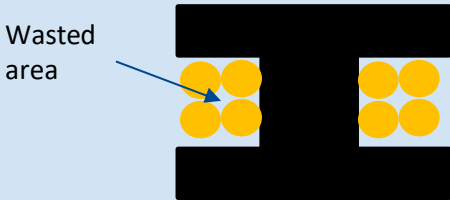

<b>Bourns SRF1206A-102Y</b>	<b>TDK ACM12V-701-2P</b>
Rated current 6A	Rated current 8A
Common mode impedance <b>1000ohm @ 100MHz</b>	Common mode impedance 700ohm @ 100MHz
Cost <b>Low</b>	Cost High

# Power circuit

## Power inductors

Inductor Model	SDE / SDR Non-shielded	SRN Semi-shielded	SRR / SRU Shielded	SRP / PQ High Current Shielded
Appearance				
Construction				<ul style="list-style-type: none"> <li>• Molding - SRP</li> <li>• Ferrite - PQ</li> </ul> 
Features	<ul style="list-style-type: none"> <li>• Ferrite core</li> <li>• Low cost</li> <li>• High saturation current</li> </ul>	<ul style="list-style-type: none"> <li>• Ferrite core</li> <li>• Semi-Shielded with epoxy resin</li> <li>• Lower radiation than non-shielded</li> <li>• Lower cost than shielded</li> </ul>	<ul style="list-style-type: none"> <li>• Ferrite core</li> <li>• Shielded</li> <li>• Low radiation</li> <li>• Low DCR</li> </ul>	<ul style="list-style-type: none"> <li>• Carbonyl / Alloy powder core -SRP</li> <li>• Ferrite - PQ</li> <li>• Shielded</li> <li>• Low radiation</li> <li>• Low DCR</li> <li>• High rated current</li> </ul>
Models Available	26	25	71	46
Footprint	3x3 to 22x22 mm	2x2 to 10x10 mm	3x3 to 18x18 mm	2x2 to 23x22 / 28x28 mm
Height	2.7 to 7 mm	0.8 to 6 mm	0.9 to 8.5 mm	1 to 7 / 19mm
Inductance	0.8 to 15,000 $\mu$ H	0.33 to 680 $\mu$ H	0.47 to 15,000 $\mu$ H	0.1 to 100 $\mu$ H
Rated Current	0.02 to 16 A	0.20 to 12 A	0.02 to 20 A	1.0 to 70 A / >100 A

# Higher Current Type Metal Inductor

SRP series	SRP_A/TA series	SRP_CA/FA series
Wire Type	 <p>Normal</p>	 <p>Flat Wire</p>
Rated Current	Normal	Higher
Rdc	Normal	Lower
Size	Normal	Smaller

We also provide the “Flat Wire” technology metal inductor for the further size-down proposal.



# Key Competitive Cross References

□ Bourns SMD Power Inductors cross to major inductor suppliers

<b>Bourns</b>	Vishay	Würth	Coilcraft	TDK	Chilisin	Cooper Bussman (Eaton)	Murata	Panasonic	Sumida	Delta Elect.	Taiyo Yuden
<b>SRP series</b>	IHLP	7443	MLC, XPL, XAL XFL, XTL, XEL	RLF,SPM	MHC,MHCC ,BMQA,BMCA	HCM,HCMA		ETQ	CDEP	HAU,HAL, HAH	MAM K MAKK
<b>SRN series</b>	IFSC	7440405XXXX		VLS	BWVF,BWV C		LQH6PP LQH_	ELL5PR		SIG	NR/N RS MDKK
<b>SRF series</b>	ICM	74476XXXX 74423xxxx 732xxxxx 7447XXXXX	HQ PDF DRQ HP	ACT,ACM, B82787C	BWCU	DRQ	DLW	EXC			CM01 U
<b>SDR(SDE) series</b>	IDCP,IDC	7445xxxxx	DO	VLP	SSL0,BPSL	LD1,4C,UP,UPS				CD,CDR	SISH,SI
<b>SRU series</b>	IDCS	744066XXXX 744045XXX	LPS/DR/DO	VLF /B82477R4	BPSC	DR				CDRH	SIL,SIQ
<b>SRR Series</b>	IDCS	74477XXXX	DS/DT MSS LPO LPS	SLF,VLCF CLF	SCDS	SD,DR	LQH_ MBH_	ELLCTP	CDRH	SIL,SIQ	NS

# Higher Current Type Metal Inductor

Comparison data with the competitor

SRP series	SRP6060FA-220M	Company M
Inductance	22uH	22uH
Core Material	Metal Alloy	Metal Alloy
Wire Type	<b>Flat Wire</b>	Normal
Size	<b>Max 6.8*6.6*6.0mm</b>	Max 11.2*10.3*4.0mm
Rated current (I <sub>rms</sub> )	<b>5.0A</b>	3.8A
R <sub>dc</sub>	<b>60.5mΩ</b>	70mΩ

Our “Flat Wire” technology metal inductor has higher rated current and lower R<sub>dc</sub>, smaller size compared with our competitors.

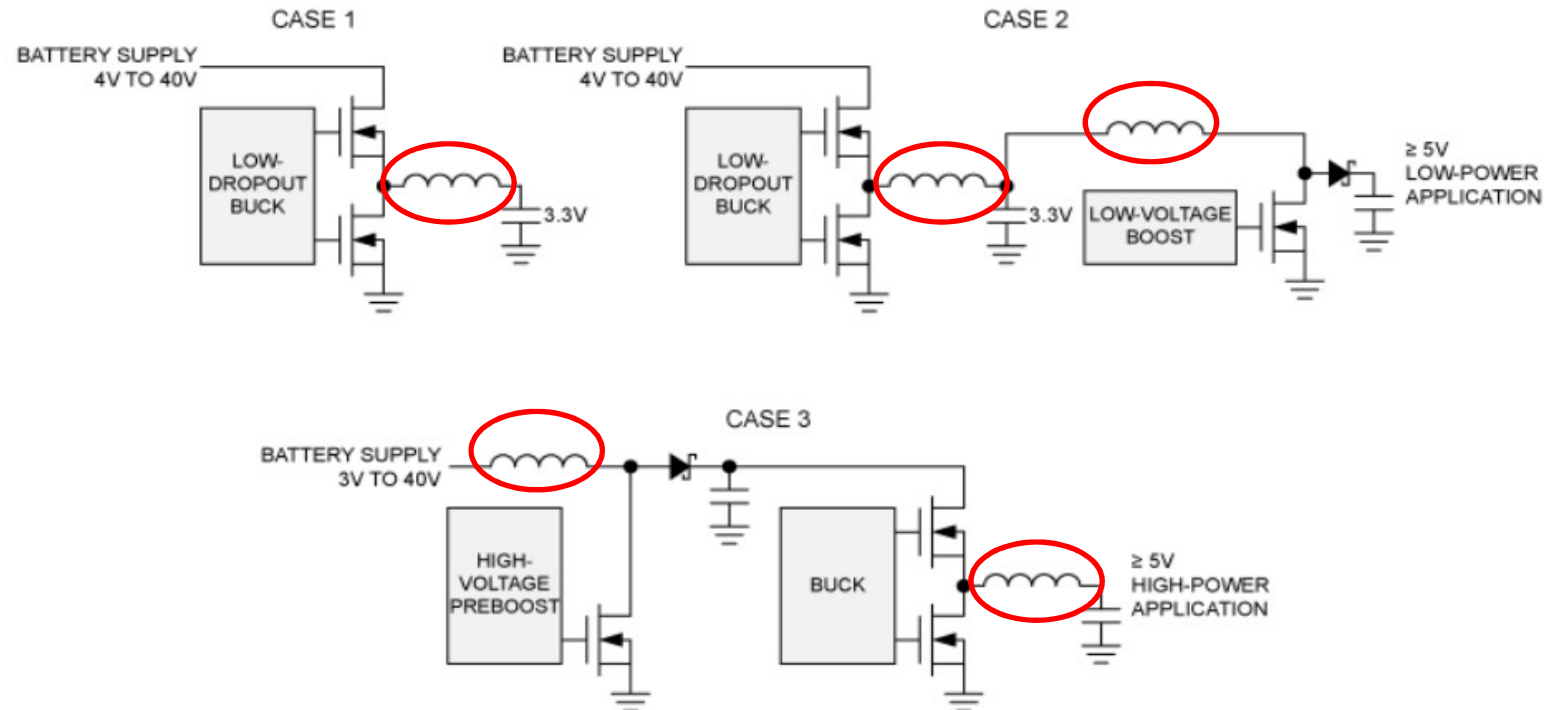
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<b>SRP series</b>	IHLP	7443	MLC, XPL, XAL XFL, XTL, XEL	RLF,SPM	MHC,MHCC ,BMQA,BMCA	HCM,HCMA		ETQ	CDEP	HAU,HAL,HAH	MAMK MAKK
<b>SRN series</b>	IFSC	7440405XXXX		VLS	BWVF,BWVC		LQH6PP LQH_	ELL5PR		SIG	NR/NRS MDKK
<b>SRF series</b>	ICM	74476XXXX 74423xxxx 732xxxxx 7447XXXXX	HQ PDF DRQ HP	ACT,ACM, B82787C	BWCU	DRQ	DLW	EXC			CM01 U
<b>SDR(SDE) series</b>	IDCP,IDC	7445xxxxx	DO	VLP	SSL0,BPSL	LD1,4C,UP,UPS				CD,CDR	SISH,SI
<b>SRU series</b>	IDCS	744066XXXX 744045XXX	LPS/DR/DO	VLF /B82477R4	BPSC	DR				CDRH	SIL,SIQ
<b>SRR Series</b>	IDCS	74477XXXX	DS/DT MSS LPO LPS	SLF,VLCF CLF	SCDS	SD,DR	LQH_ MBH_	ELLCTP	CDRH	SIL,SIQ	NS

# Power circuit

## Power inductors for DCDC circuit



### Recommended power inductors:

Metal alloy type:

SRP7050TA series: 7.6\*7.0\*5.0mm; 0.33uH to 68uH; **Irms max25A**

SRP6060FA series: 6.8\*6.6\*6.0mm; 4.7uH to 22uH; **Irms max11A**

SRP5030TA series: 6.0\*5.4\*3.0mm; 0.1uH to 10uH; **Irms max23A**

Ferrite type:

SRR3818A series: 4.0\*4.0\*2.0mm; 1uH to 100uH; **Irms max2.75A**

SRR6040A series: 7.0\*7.0\*4.0mm; 1uH to 100uH; **Irms max5A**

SRR0745A series: 7.5\*7.5\*4.7mm; 10uH to 1000uH; **Irms max 2.1A**

SRR1050A seires: 10.3\*10.5\*5.1mm; 0.68uH to 330uH; **Irms max9.5A**

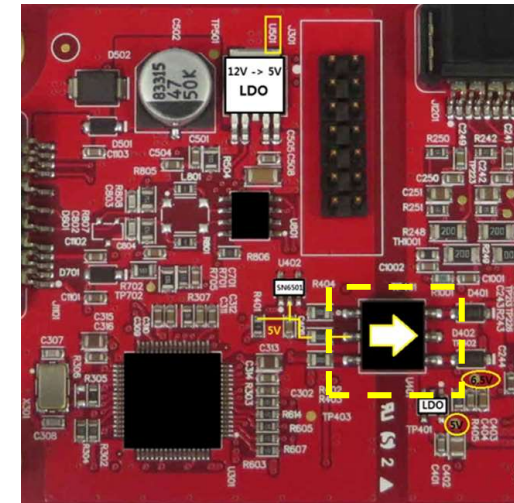
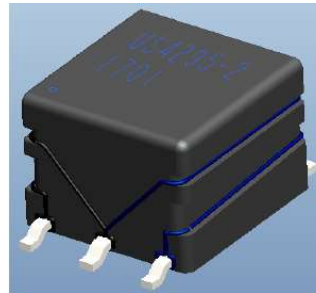


# Power circuit

## HCTSM80304BAL

### Features

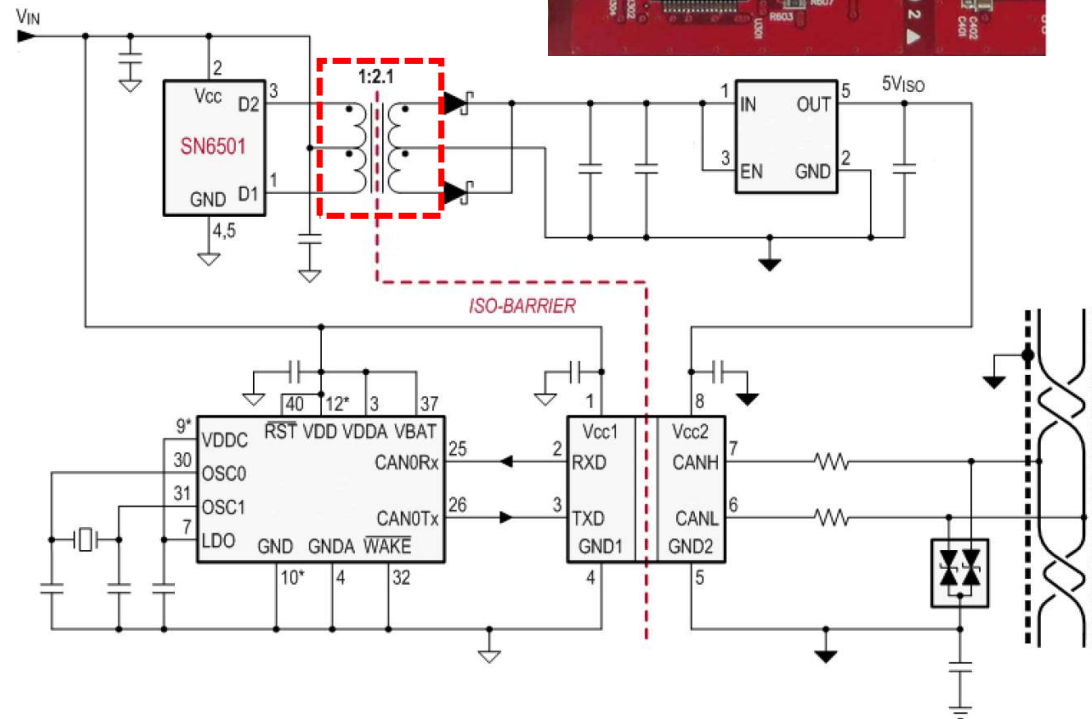
- Push-Pull Transformer
- Automotive-grade



### Applications

- Isolated Interface Power Supply for  
CAN  
SPI  
I2C

\*We can also provide the customized solution based on customer's request.



# HCT series push-pull transformer

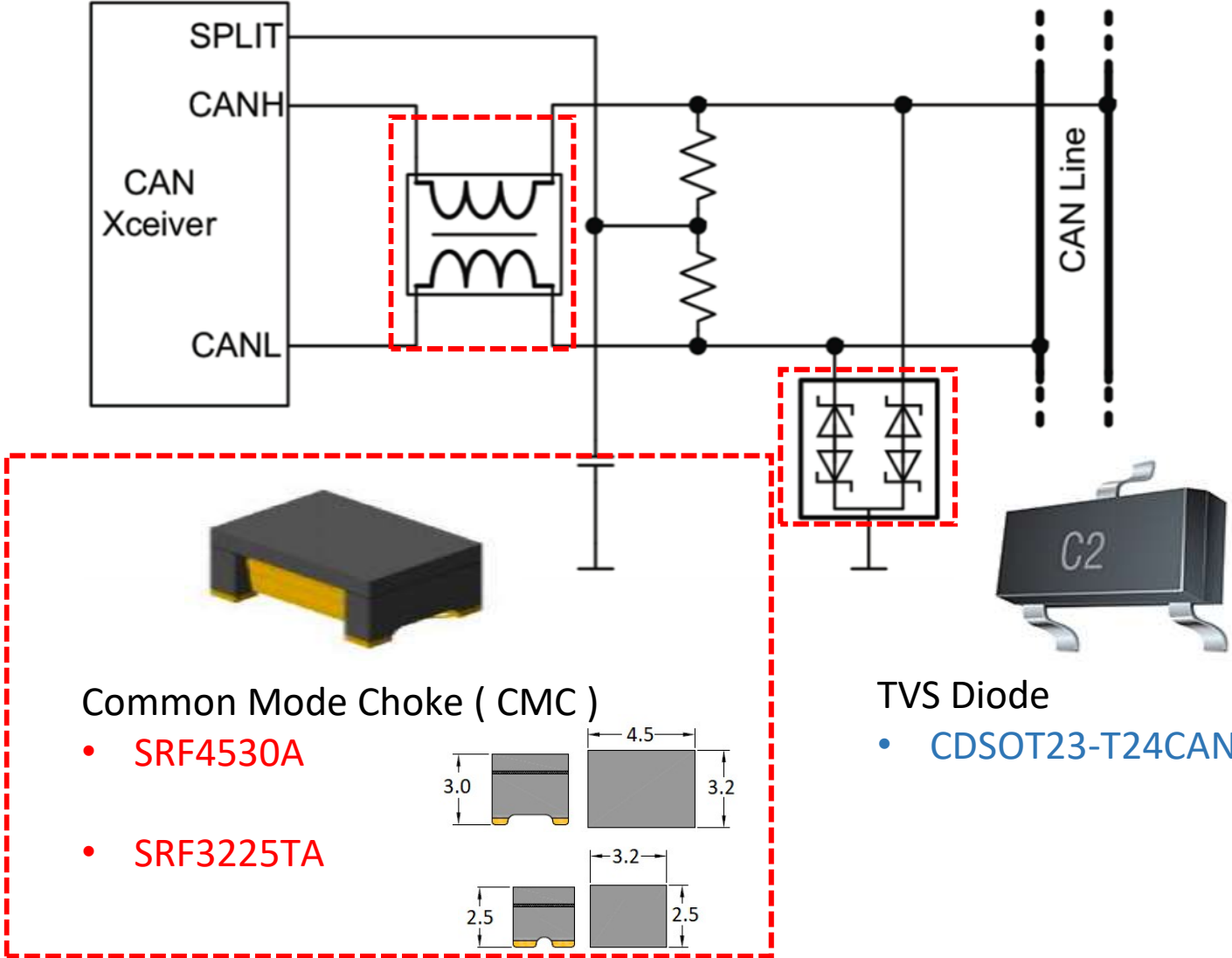
NO.	BOURNS BXL HCT series standard parts			Competitor	
	BXL P/N	Turn Ratio P(1-3):S(6-4)	Description	WE	PULSE
1	HCT9180101AL-E	1 : 1	High creepage(8mm) push pull transformer, turn ratio(P:S): 1 : 1		PH9384.011NL
2	HCT9180102AL-E	1 : 2	High creepage(8mm) push pull transformer, turn ratio(P:S): 1 : 2	750313626	PH9384.012NL
3	HCT9180201AL-E	2 : 1	High creepage(8mm) push pull transformer, turn ratio(P:S): 2 : 1		PH9384.021NL
4	HCT9180304AL-E	3 : 4	High creepage(8mm) push pull transformer, turn ratio(P:S): 3 : 4	750313638	PH9384.034NL
5	HCT9180305AL-E	3 : 5	High creepage(8mm) push pull transformer, turn ratio(P:S): 3 : 5		PH9384.035NL
6	HCT9180308AL-E	3 : 8	High creepage(8mm) push pull transformer, turn ratio(P:S): 3 : 8		PH9384.038NL
7	HCT9180403AL-E	4 : 3	High creepage(8mm) push pull transformer, turn ratio(P:S): 4 : 3		PH9384.043NL
8	HCT9180803AL-E	8 : 3	High creepage(8mm) push pull transformer, turn ratio(P:S): 8 : 3		PH9384.083NL
9	HCT9180809AL-E	8 : 9	High creepage(8mm) push pull transformer, turn ratio(P:S): 8 : 9		PH9384.089NL
10	HCT9180910AL-E	9 : 10	High creepage(8mm) push pull transformer, turn ratio(P:S): 9 : 10	750313734	
11	HCT9181017AL-E	10 : 17	High creepage(8mm) push pull transformer, turn ratio(P:S): 10 : 17	750313769	

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  - **CANBUS/CANFD**
  - Cell monitoring
- Q & A

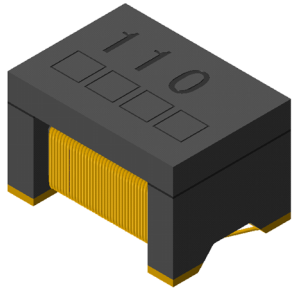
# CANBUS/CANFD





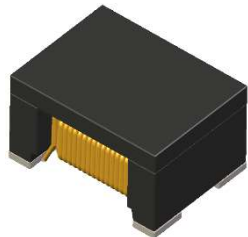
# CAN/CANFD

## 2018 NPI **Common Mode Line Filter** **SRF4530A**



- **Feature :**  
Ferrite Core Common Mode Filter
- **Application :**  
Automotive CAN bus
- **Size :** 4.5×3.2×3.2 mm

### **SRF3225TAC**



- **Feature :**  
Ferrite Core Common Mode Filter
- **Application :**  
Automotive CAN bus
- **Size :** 3.2×2.5×2.5 mm

**\*\*Both are AECQ 200 Compliant**

# CANBUS

## Parameter comparison (51uH)

### 4530 size

<b>Bourns SRF4530A-510Y</b>	<b>TDK ACT45B-510-2P</b>	<b>Murata DLW43SH510XK2</b>
Temperature <b>150C</b>	Temperature <b>150C</b>	Temperature 125C
Rated current <b>230mA</b>	Rated current 200mA	Rated current 230mA
Cost <b>Low</b>	Cost High	Cost Mid

### 3225 size

<b>Bourns SRF3225TAC-510Y</b>	<b>TDK ACT1210-510-2P</b>	<b>Murata DLW32SH510XK2</b>
Temperature <b>150C</b>	Temperature <b>150C</b>	Temperature 125C
Rated current 200mA	Rated current 200mA	Rated current 200mA
Cost <b>Low</b>	Cost High	Cost Mid

# CANFD

## Parameter comparison (100uH)

### 4530 size

<b>Bourns SRF4530A-101Y</b>	<b>TDK ACT45B-101-2P</b>	<b>Murata DLW43SH101XK2</b>
Temperature <b>150C</b>	Temperature <b>150C</b>	Temperature 125C
Rated current <b>200mA</b>	Rated current 150mA	Rated current <b>200mA</b>
Cost <b>Low</b>	Cost High	Cost Mid

### 3225 size

<b>Bourns SRF3225TAC-101Y</b>	<b>TDK ACT1210-101-2P</b>	<b>Murata DLW432SH101XK2</b>
Temperature <b>150C</b>	Temperature <b>150C</b>	Temperature 125C
Rated current 150mA	Rated current 150mA	Rated current 150mA
Cost <b>Low</b>	Cost High	Cost Mid

# CAN/CANFD

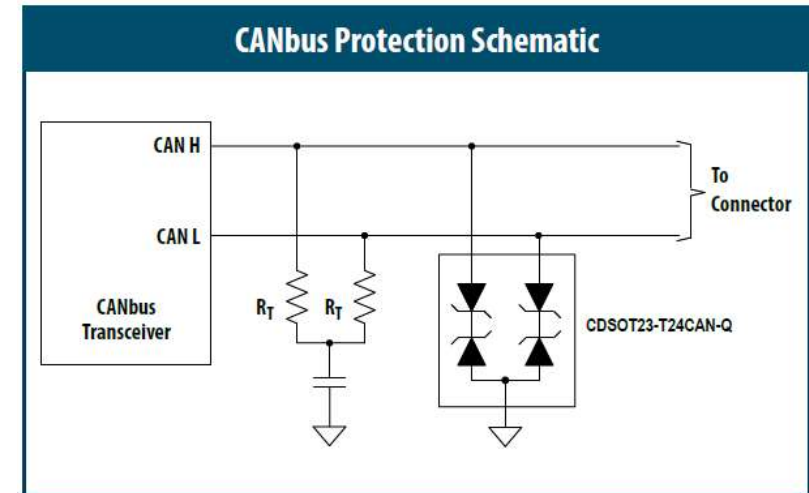
## CDSOT23-T24CAN-Q

### Features

- IEC 61000-4-2 30 kV ESD
- IEC 61000-4-5 (Level 1, CWG 1.2/50) 500 V Surge
- $V_{BR}$  26.2V compatible with transceivers with internal circuitry for 24V power supply miswiring

### Applications

- High Speed CANbus
- On-board diagnostics
- LED headlamp control
- BMS



Cross reference		
	Direct Cross	Lower Rating
ON Semi	NUP2105L	
STM		ESDCANxx series
Littelfuse	SM24CANB	SM24CANA
NXP		PESDxCAN series

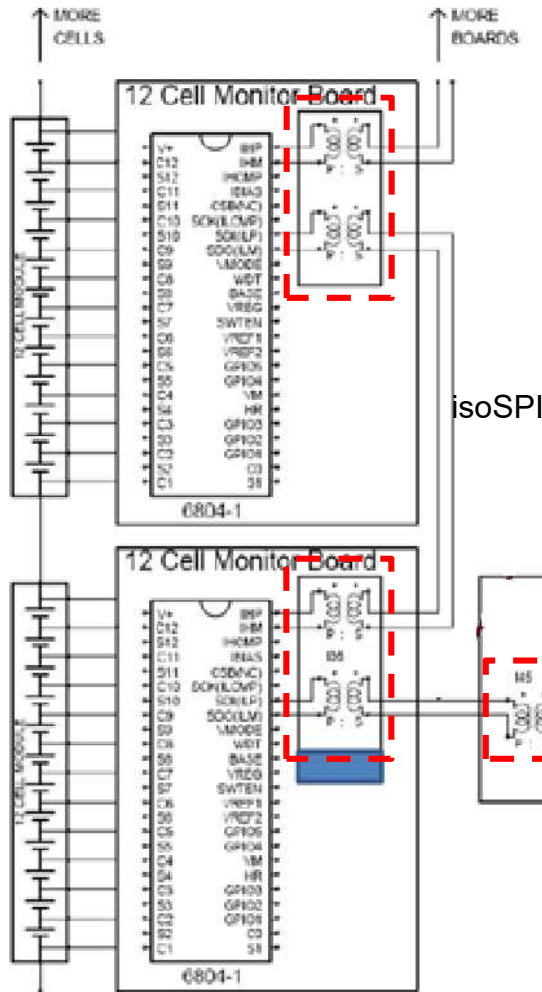
**\*\*Both are AECQ 200 Compliant**

# Outline

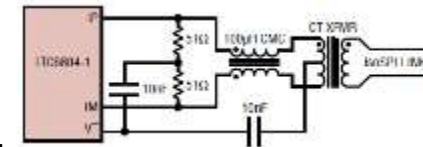
---

- Background
- Bourns Solution for BMS
  - Overview
  - Power circuits
  - CANBUS/CANFD
  - **Cell monitoring**
- Q & A

# Cell Monitoring (Daisy Chain Isolation)

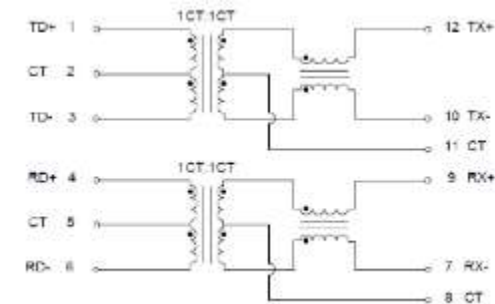
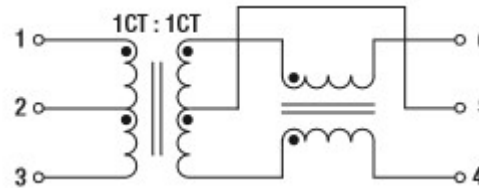


- Daisy Chain is for communication of battery monitor
- I2C, SPI & isoSPI
- isoSPI is applied in Linear LTC6811/LTC6813/LTC6804; NXP's MC33771C & MAXIM's MAX17823/17853 design;
- IsoSPI isolation transformer design
  - 1:1 Transformer for isolation
  - Common-Mode Choke for reducing noise
- SM91501AL/SM91502AL are automotive grade



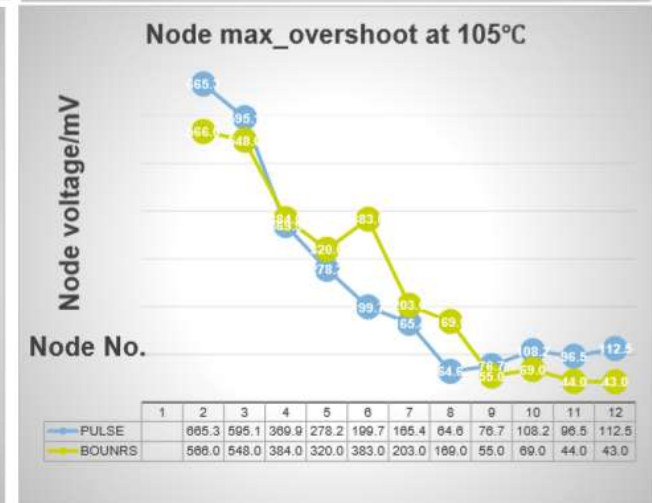
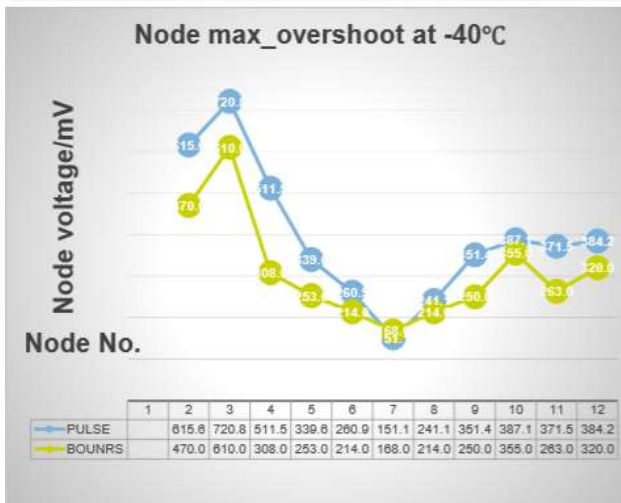
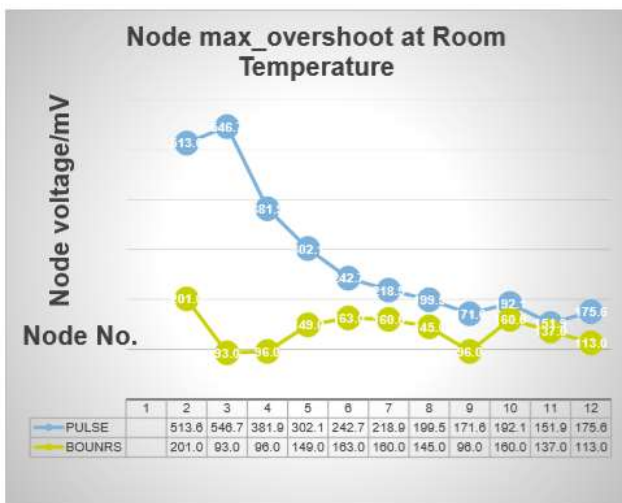
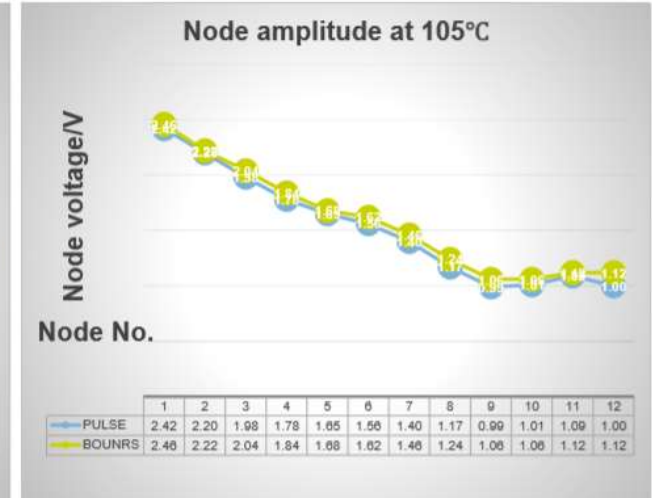
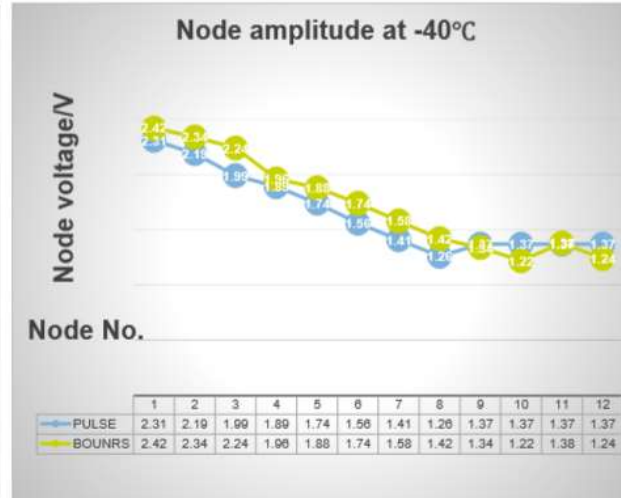
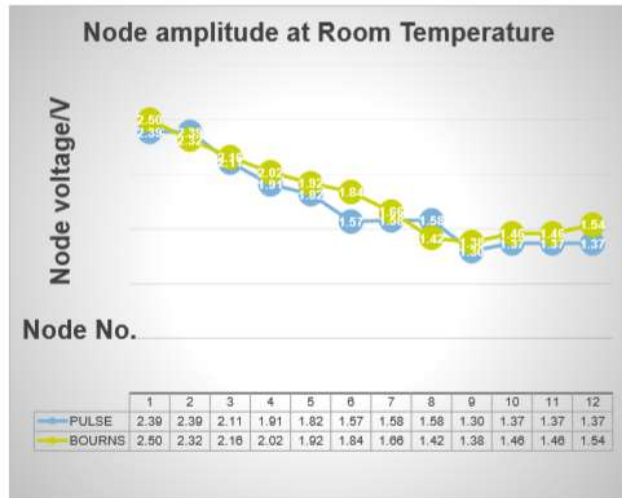
SM91502AL(Single ch)

SM91501AL(Dual ch)



# Cell Monitoring (Daisy Chain Isolation)

Parameter comparison (Bourns vs PULSE)



Our SM91502AL/SM91501AL has been qualified by NXP.

# Signal BMS Product Family

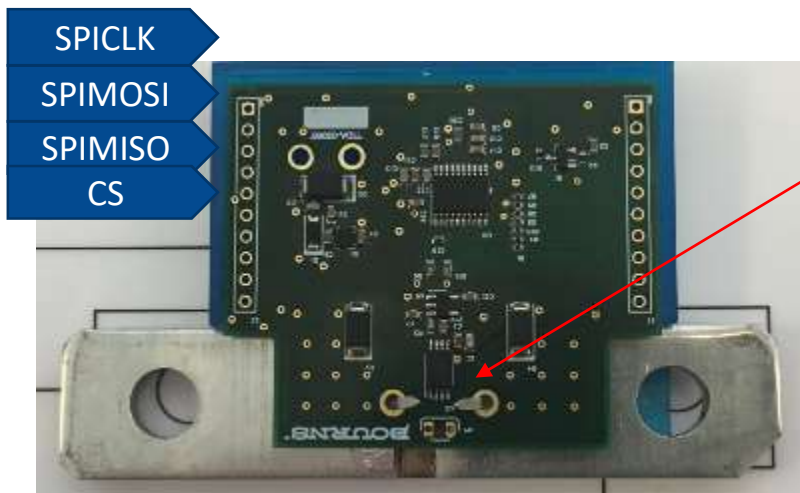
Bourns #	Chipset	Cross/De s	Workin g Voltage / Isolatio n	Creepa ge (mm)	Hi-PoT Isolatio n	Center Tap	Choke	AEC-Q200	Operation Temp
SM91071/072AL	LTC6804	HM1188NL	60-80Vdc/ Function	3	1500Vrms	Yes	Yes	Yes	-40~125°C
SM91073/074AL	LTC6804	HM1188/1198NL /FNL	60-80Vdc/ Function	3	1500Vrms	Yes	Yes	Yes	-40~125°C
SM91501AL	NXP3371 LTC6811&12&13	HM2102NL/ HMU2102NL	1600Vdc Max /Function	>10	4300Vdc	Yes	Yes	Yes	-40~125°C
SM91502AL	NXP3371 LTC6811&12&13	HM2103NL/ HMU2103NL	1000Vdc Max /Function	>5	3200Vdc	Yes	Yes	Yes	-40~125°C
SM91505AL	Intersil	package same with 501/ 300uHmin	1000Vdc Max /Function	>5	3200Vdc	Yes	Yes	Pending	-40~125°C
SM91506AL	NXP/LTC	same to 501	1600Vdc Max /Function	>12	3100Vrms	Yes	Yes	Pending	-40~125°C
SM91507AL	Maxim17823	HM1237NL	600Vdc Max /Function		2500Vrms	Yes	Yes	19Q1	-40~125°C
SM91508AL	Maxim	HM1238NL	1000Vdc Max /Function		4300Vdc	Yes	Yes	Q4	-40~150°C
SM91509AL	TIBQ79606	same layout 501/600uHmin	1000Vdc Max /Function		4300Vdc	Yes	Yes	19Q1	-40~125°C
SM91510AL	Maxim	500uH/HM1236 NL/4mm	600Vdc Max /Function	>7	3200Vdc	Yes	Yes	Pending	-40~125°C
SM91511AL	Stmicro	Stmicro						Pending	
SM91513AL	NXP/LTC	HMU1229NL	1000Vdc Max /Function	>5	3200Vdc	Yes	No		-40~125°C
SM91519AL	NXP/LTC	HMU21xxNL	1700Vdc Max /Reinformec ed	>22	5000Vdc	Yes	Yes		-40~125°C



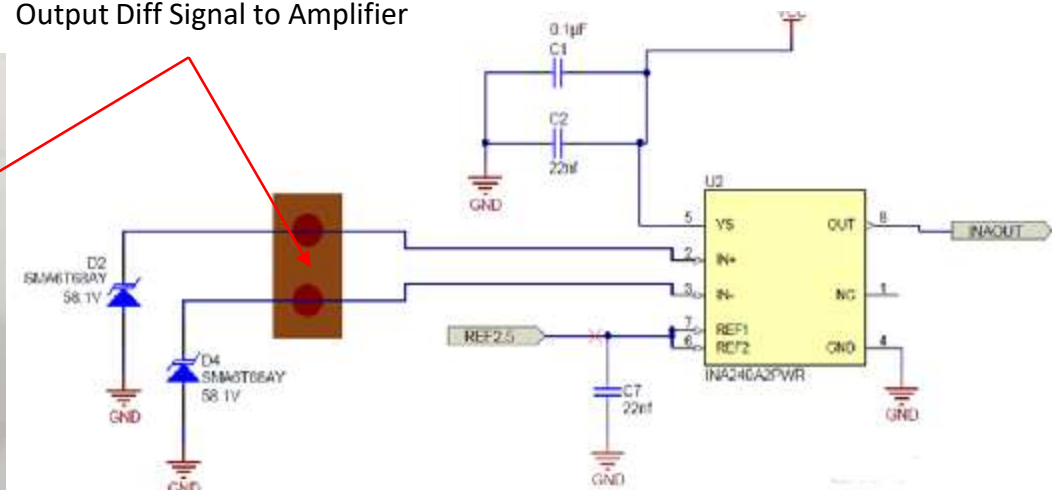
# Appendix

# Current Sensing (shun resistor)

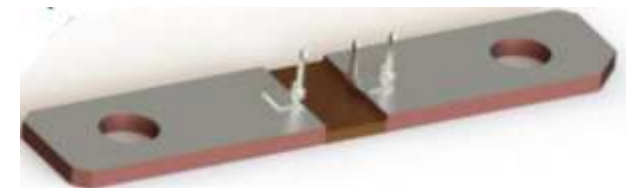
- For zero to 1000 Amps
- Shunt P/N CSM2F-8518 Shunt from Bourns and INA240 CS Amp (TI)
- ADS1259-Q1 Sigma Delta



Pins Welded to Shunt provide Output Diff Signal to Amplifier



- Bourns Shunt Resistor CSM2F-8518
  - Tin Plated Copper Terminals
  - 50µΩ or 100µΩ Resistance Values
  - CM2F-8518 is rated to 50% Full Power (25 Watts) at 125°
    - The Copper will heat up to 125°C at room Temperature at 50%
    - Continuous Current 500A
    - Pulsed Current 1000 A (30 minutes on/off)



# Current Sensing (shunt resistor)

**Model CSM2F-8518 Series Current Sense Resistor**

**Features**

- Up to 36 W permanent power
- Continuous current load up to 1800 A
- High pulse power rating
- Maximum fastening torque: 10 Nm
- Tinned terminals
- Customized versions available
- AEC-Q200 and RoHS\* compliant

**Applications**

- Battery management systems
- Current sensing for hybrid & electric vehicles
- Current sensing in bus bars
- Current sensing in welding equipment
- Frequency converters

**Model CSM2F-7036 Series Current Sense Resistor**

**Features**

- Up to 20 W permanent power
- Continuous current load up to 1000 A
- High pulse power rating
- Maximum fastening torque: 10 Nm
- Tinned terminals
- Customized versions available
- AEC-Q200 and RoHS\* compliant

**Applications**

- Battery management systems
- Current sensing for hybrid & electric vehicles
- Current sensing in bus bars
- Current sensing in welding equipment
- Frequency converters

**Model CSM2F-6918 Series Current Sense Resistor**

**Features**

- Up to 20 W permanent power
- Continuous current load up to 1000 A
- High pulse power rating
- Maximum fastening torque: 10 Nm
- Tinned terminals
- Customized versions available
- AEC-Q200 and RoHS\* compliant

**Applications**

- Battery management systems
- Current sensing for hybrid & electric vehicles
- Current sensing in bus bars
- Current sensing in welding equipment
- Frequency converters

**Electrical Characteristics**

Characteristic	Model CSM2F-6918 Series
Resistance Range / Power Rating	50 MicroOhms / 36 Watts
Operating Temperature Range	-40 °C to +175 °C
TCR (m / mW)	±200 PPM/°C
TCF Resistance Alloy***	< 50 PPM/°C
Thermal EMF (µV/°C)	< 0.25 for 50 MicroOhms
Resistance Tolerance	±0.5%

\*\*\* Terminal temperature  
\*\* For full TCR range, refer to TCR curve.

**Environmental Characteristics**

Characteristic	Test Condition	Typ. Max.
Thermal Shock	-55 to +150 °C / 1000 cycles	±0.5 %
Resistance to Soldering Heat	+235 °C / 10 seconds	±0.5 %
High Temperature Exposure	+175 °C / 2000 hours	±1.0 %
Low Temperature Storage	-65 °C / 24 hours	±0.5 %
Bias Humidity Test	+85 °C, 85 % RH, 10 % bias, 1000 hours	±0.5 %
Moisture Resistance	10 days with gold finish, no test	±0.5 %
Mechanical Shock	100 g, 6 milliseconds, 5000es	±0.5 %
Vibration, High Frequency	10-2000 Hz in 1 minute 3 directions, 12 hours	±0.5 %
Load Life	3000 hours at max. load, derated at 70 °C	±1.0 %
Solderability	J-STD-002	95 % coverage min.
Shorttime Overload	5 times rated power for 5 seconds	±0.5 %

Performance lead is ongoing.

	CSS	CSM
Construction	EB welded Mn/Cu alloy	
Low Resistance	0,1 to 5 mOhms	0,05 to 5 mOhms
High power rating	1 to 15 W	1 to 50 W
Low TCR	±75 to 150 ppm/°C	±150 ppm/°C

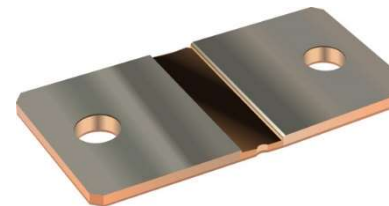
3 standard sizes:



CSM2F-6918



CSM2F-6918

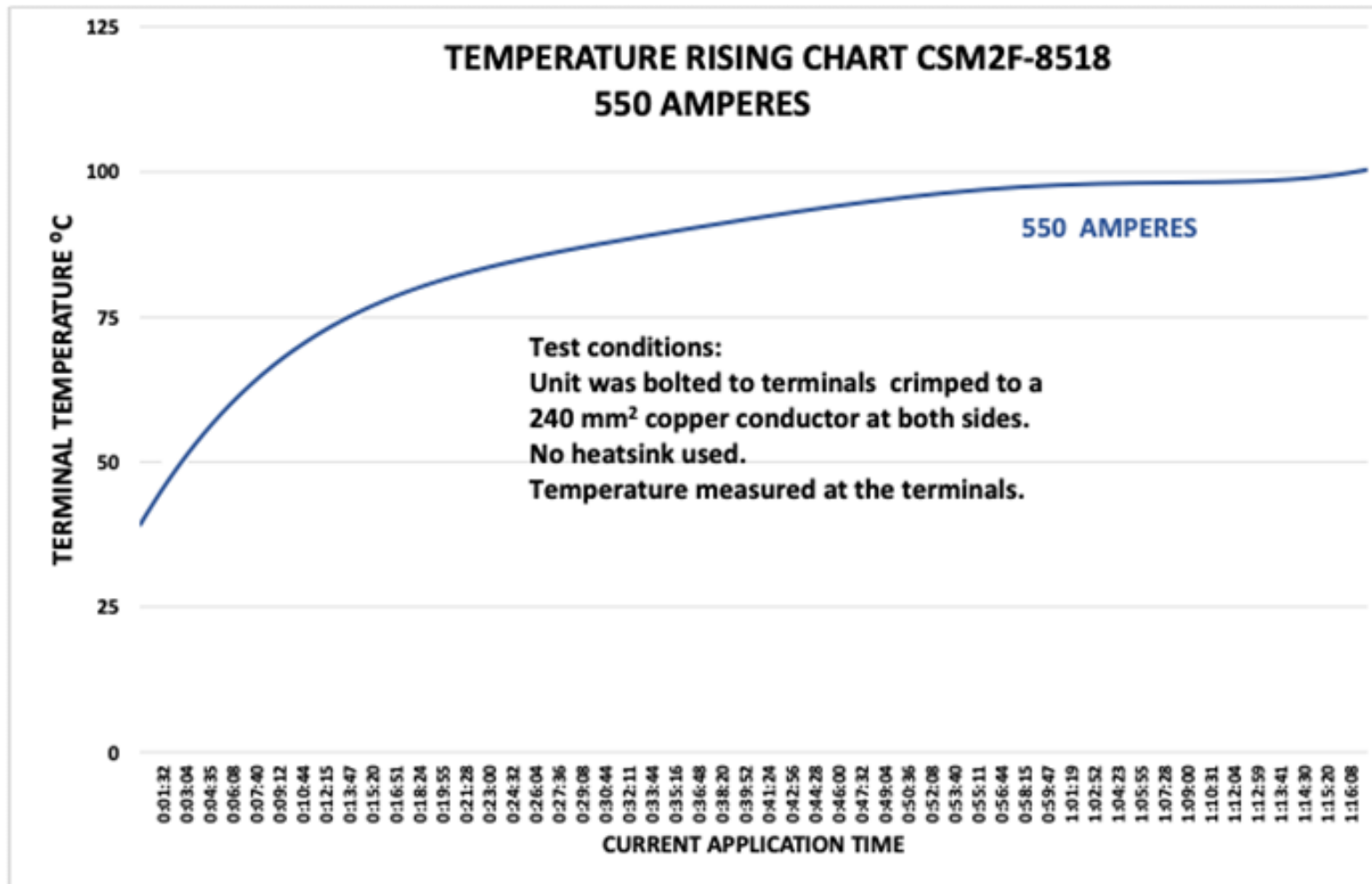


\*RoHS Directive 2002/95/EC, Jun. 27, 2002, including annex and RoHS Recast 2015/863/UE Annex 8, 2015. Specifications are subject to change without notice.  
The above characteristics and parameters in this data sheet cannot be used in any different applications and actual device performance may vary over time. Users should verify actual device performance in their specific applications.

# Current Sensing Performance

**BOURNS®**

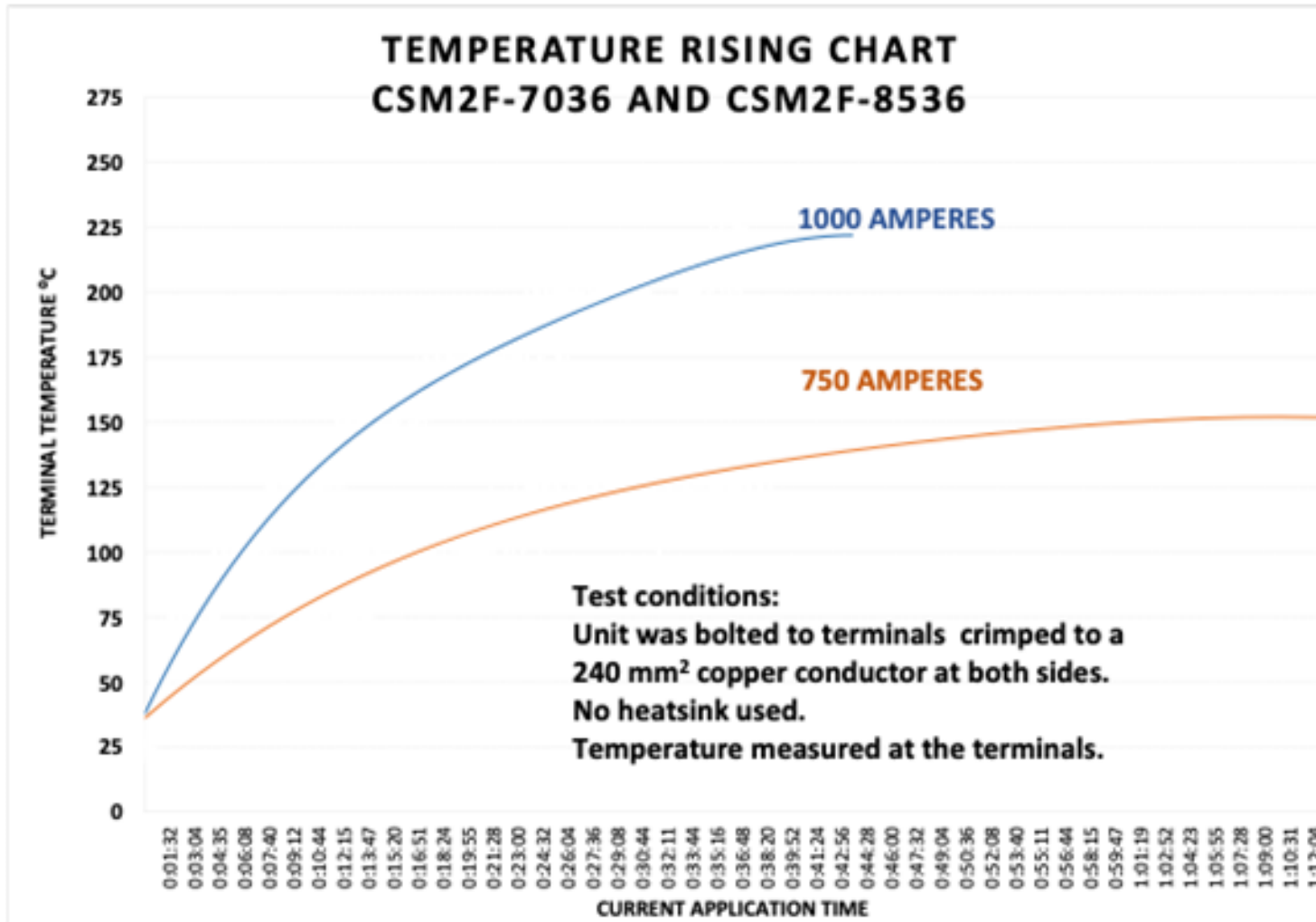
**TEST DATA**



# Current Sensing Performance

**BOURNS®**

**TEST DATA**

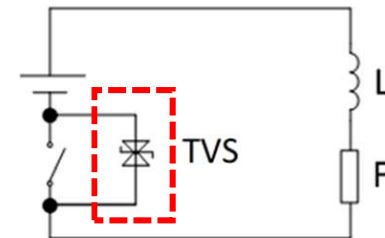
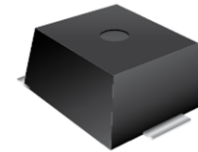


# High Current Battery MOSFET Protection

The parasitic inductance of power cables is sufficient to develop a high back-EMF and damage high-cost MOSFETS in high-capacity, high-current battery systems.

MIL-STD-1275E defines such a disconnect test. (Commercial equivalent exists, e.g. Volvo requirements on 48V battery disconnect switch. Battery disconnect safety devices are becoming standard, these disconnects high currents in less than one ms after an electric signal is triggered such as following a crash)

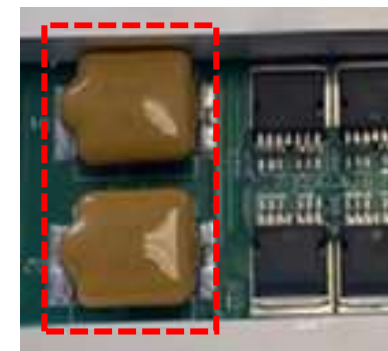
Such battery systems are found in electric-vehicles and energy storage systems, for e.g.



Overcoat  
ed for  
15kA



Overcoat  
ed for  
3~10kA



# High Current Battery MOSFET Protection

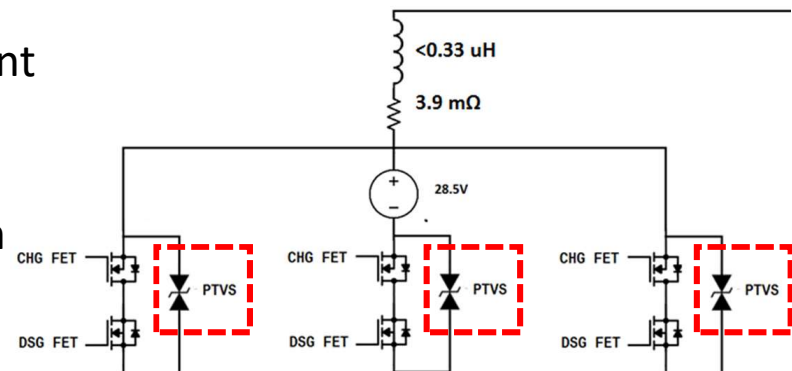
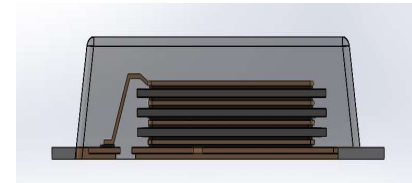
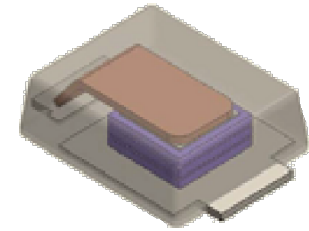
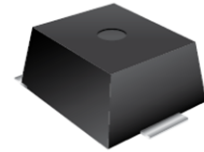
**Bourns PTVS devices are currently rated to 8/20 $\mu$ s current impulse.**

**It is critical to define with customer,**

- L – Line inductance
- Peak Current – Line voltage,  $V_{\text{clamp}}$  required, Load resistance
- Above would determine the impulse current waveform (decay time)

**Bourns PTVS devices are easily customized for**

- By determining the customer impulse current waveform, we can simulate, design and characterize appropriate products
- $V_{\text{RWM}}$  – Working voltage is achieved through changing the number of chips stacked.
- $I_{\text{pp}}$  – Current rating is achieved through the surface area of the chips used.



# TBU® High-Speed Protectors

## Applications

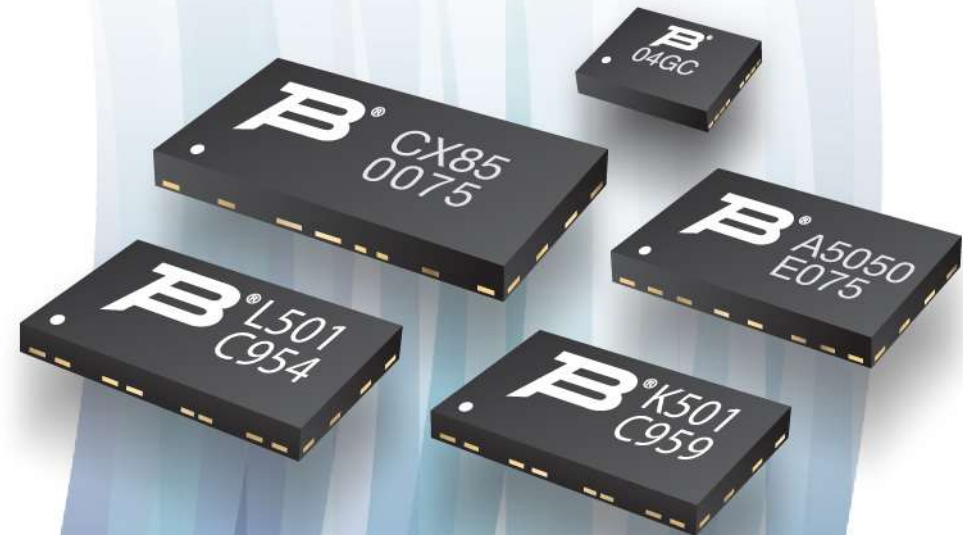
- POTS linecards
- VoIP equipment
- ONUs and ONTs
- Gateways and modems
- 10/100 & Gigabit Ethernet
- VDSL interfaces
- Remote metering & surveillance
- Avionics (DO160)
- Rail and mass transit
- Industrial automation
- Test equipment
- RS-232, RS-422, RS-485, CANbus and LVDS
- Sensors

## Features

- Extremely high-speed performance
- Blocks high voltages & currents
- Exceptionally low let-through energy
- Very high bandwidth, GHz compatible
- UL recognized components
- Programmable
- RoHS compliant\*

## Types

- Surface mount
- Bi- and unidirectional single TBU® protectors
- Unidirectional dual TBU® protectors

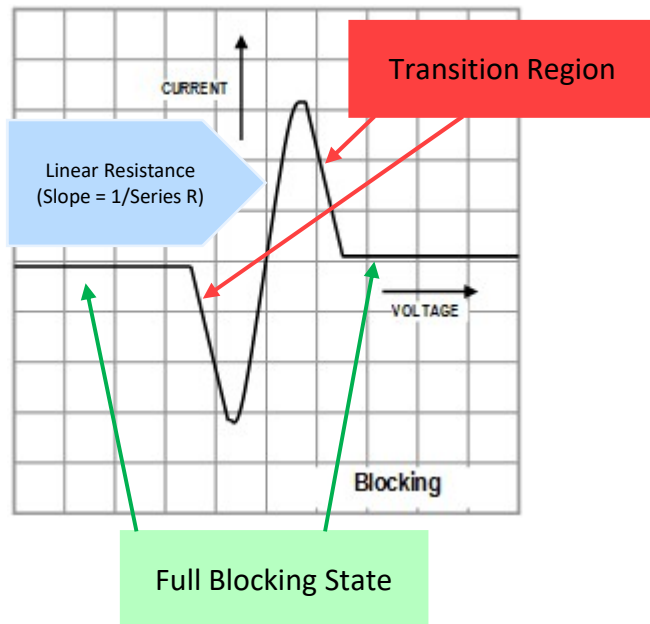
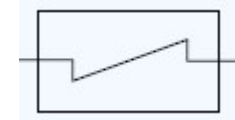


\*RoHS Directive 2002/95/EC Jan. 27, 2003 including annex and RoHS Recast 2011/65/EU June 8, 2011.



# Transient Blocking Units

## General Characteristics (Bidirectional Device)

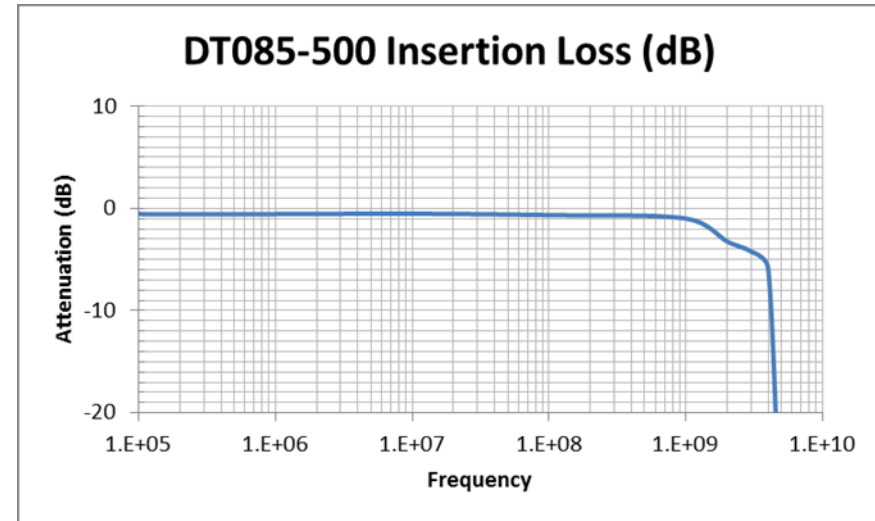
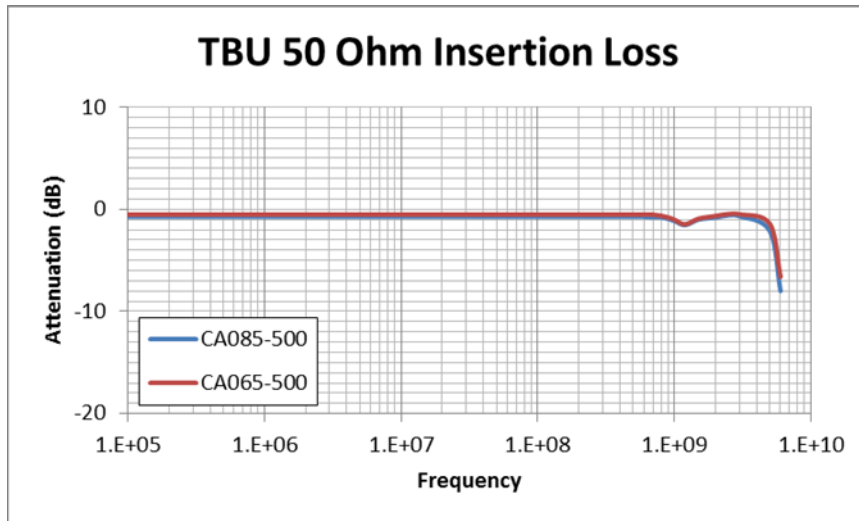


Bidirectional Device

- Linear Resistance Region
  - Linear response when not triggered
  - Behaves like a resistor
  - Operating below trip current level
- Transition Region
  - Begins when trip current level is reached. As voltage rises the device transitions toward the full blocking state
  - In general, the device should not be continuously operated in this region
    - Power dissipation is the primary concern
- Full Blocking State
  - Voltage across device is  $> V_{reset}$
  - Low quiescent current
  - Provides voltage withstand up to rated voltage

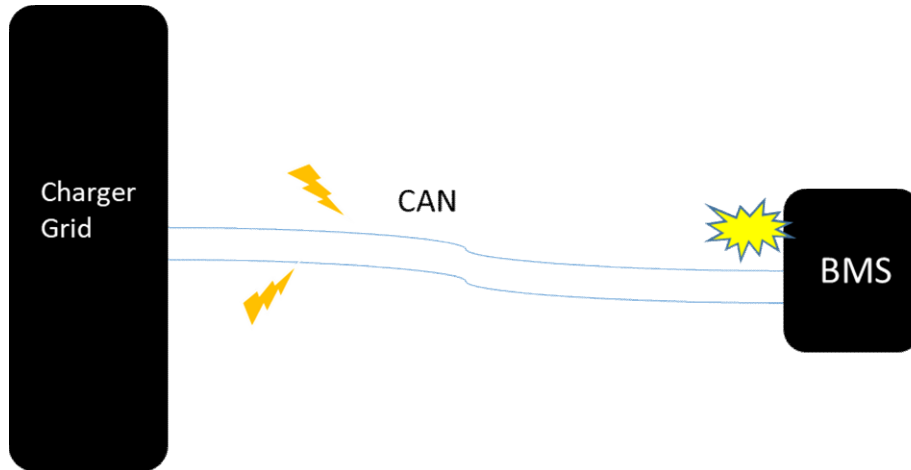
# A TBU has excellent High Frequency Characteristics

## 50 Ohm Insertion Loss

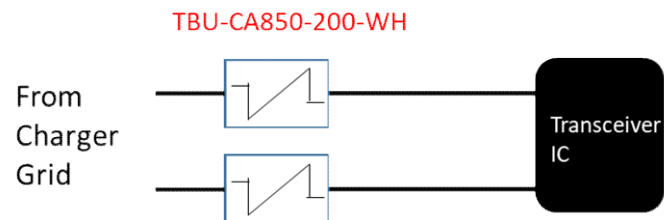


Note that the response remains flat until frequencies above 1 GHz.

\*There is one of the CAN cable connecting the BMS and the charger grid, and there will be the high risk that the surge noise generated from the charger grid and conducts to the BMS through the CAN cable.



So this time we also promoted our [TBU-CA850-200-WH](#) on the CAN cable to suppress this surge noise.



# TBU® High-Speed Protectors

•TBU-DF Series - Dual, Bi-directional

•TBU-DB-Q Series - Dual, Bi-directional, AEC-Q101, Low Reset Voltage

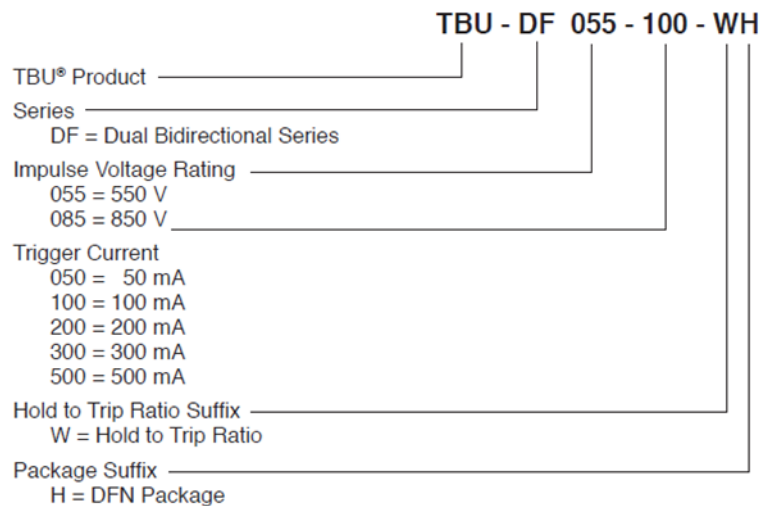
•P40 Series - Dual, Bi-directional, Low Voltage

•TBU-DT Series - Dual, Uni-directional

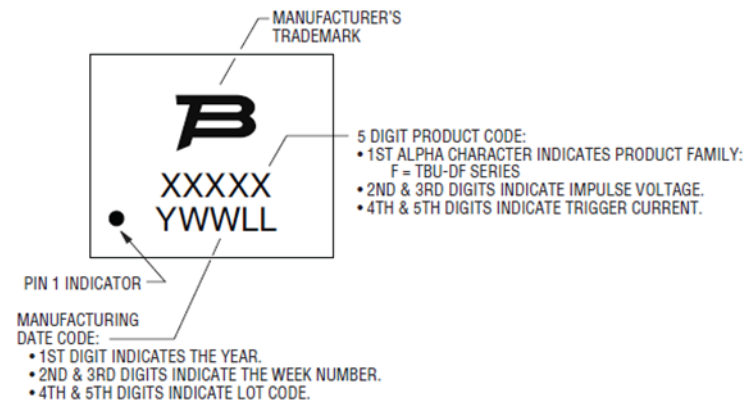
•TBU-CA Series - Single, Bi-directional

•TBU-PL Series - Dual, Bi-directional, 50 Ohm with voltage trigger

## How to Order



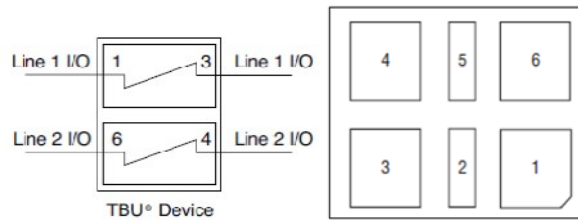
## Typical Part Marking



# TBU® High-Speed Protectors - Low Series

## Resistance

TBU-DF0xx-xxx-WH  
Dual Bidirectional



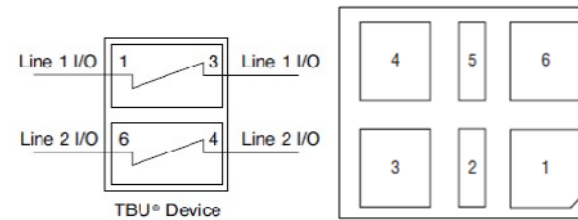
### TBU-DF

# Channels: 2

# Pins: 6

Size: 6.5 x 5.5 mm

TBU-DB0xx-xxx-WH  
Dual Bidirectional



### TBU-DB

# Channels: 2

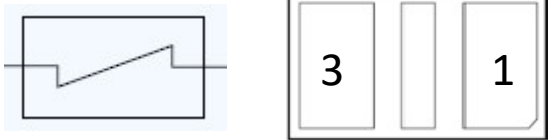
# Pins: 6

Size: 6.5 x 5.5 mm

# TBU® High-Speed Protectors - Low Series

## Resistance

TBU-CA0xx-xxx-WH  
Single Bidirectional



### TBU-CA

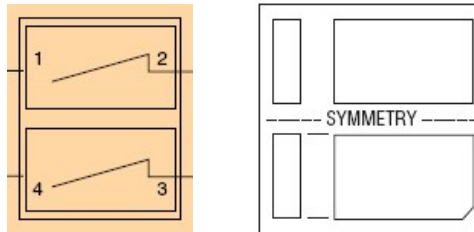
# Channels: 1

# Pins: 3 ( 1 No Connect)

Size: 6.5 x 4.0 mm

Theta j-l: 98 °C/W

TBU-DT0xx-xxx-WH  
Dual Unidirectional



### TBU-DT

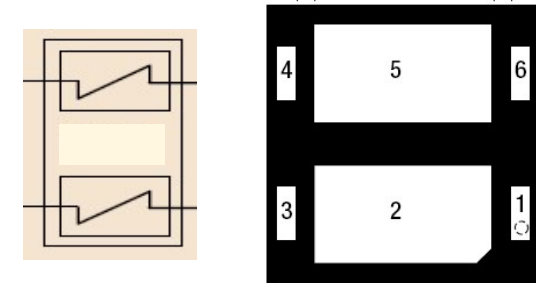
# Channels: 2

# Pins: 4

Size: 5.0 x 5.0 mm

Theta j-l: 116 °C/W

P40-G240-WH  
Low voltage, Dual Bidirectional



### P40-G

# Channels: 2

# Pins: 6 (2 No Connect)

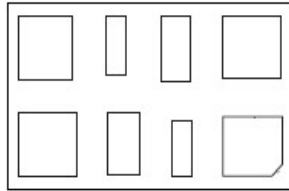
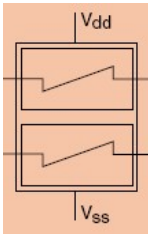
Size: 4.0 x 4.0 mm

Theta j-l: 180 °C/W

# TBU® High-Speed Protectors - 50 Ohm Series

## Resistance

TBU-PL0xx-xxx-WH  
Dual 50 Ω Bidirectional  
w/Voltage Control



### TBU-PL

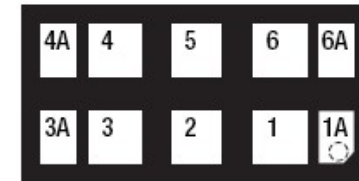
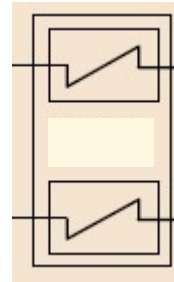
# Channels: 2

# Pins: 8 ( 2 no Connect)

Size: 6.5 x 4.0 mm

Theta j-l: 110 °C/W

P850-Gxxx-WH  
Dual 50 Ohm Bidirectional



### P850-G <sup>(1)</sup>

# Channels: 2

# Pins: 10 (2 No Connect)

Size: 8.25 x 4.0 mm

Theta j-l: 119 °C/W

1. Pads 1A and 1 are internally connected; the same for pads 3A with 3, 4A with 4, and 6A with 6.

# Transient Surge

- Transient surges are almost caused by Inductive Flyback in the circuit

$L$  comes from wire, motor or other inductive loads.

comes from **switches, relays, fuses, loose connections, or plugging cables.**

- Transient surges can be
  - **ESD (Electrostatic Discharge)**
  - **EFT (Electrical Fast Transients)**
  - **Load dump transit**
- **ISO 7637-2 & ISO-16750** have more clear description in definition and test conditions.
- Protect Solution for Transient issue
  - ⑨ **TVS Diode**

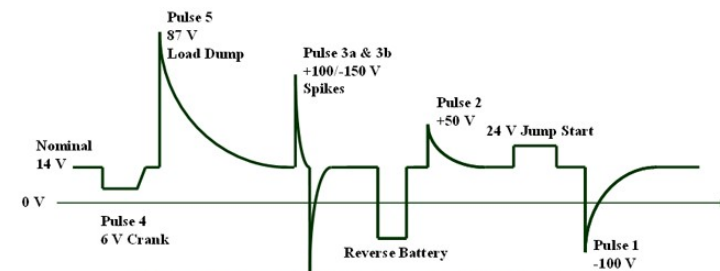


Figure 1: ISO7637-2 and main surges on automotive power rail

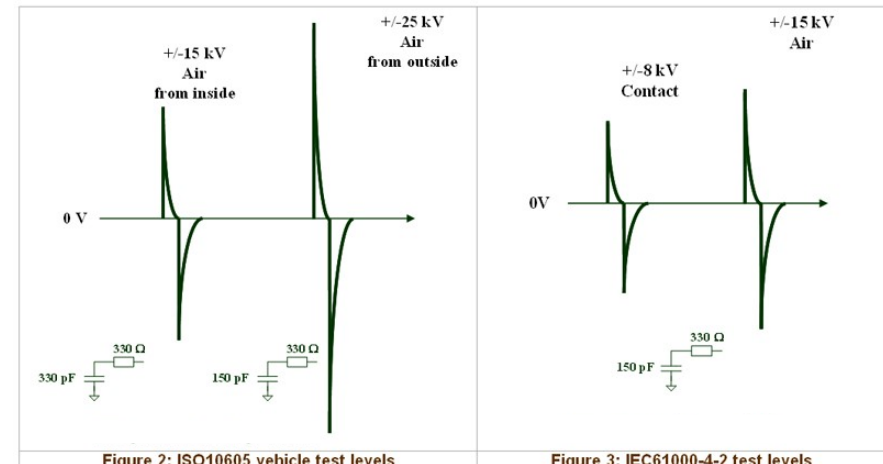


Figure 2: ISO10605 vehicle test levels

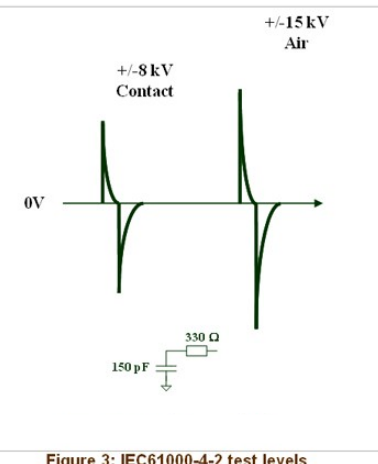


Figure 3: IEC61000-4-2 test levels



# ESD

- ESD (Electrostatic Discharge) is discharging power by voltage difference during contact ( human to vehicle )

- ESD Standards

Object	Standard	Evaluation	Cause
Electronic Equipment	IEC 61000-4-2	Malfunction	Human body
Vehicle Components	ISO 10605	Malfunction Break	Human body
Vehicle Components	SAE J1113-13	Malfunction Break	Human body
Electronic Components *	IEC 61340-3-1 IEC 61340-3-2	Break	Human body Machine
Semi-conductor *	IEC 60749-26 IEC 60749-27	Break	Human body Machine

\* Similar to MIL, JEDEC, ANS, ESDA, etc

- ISO-10605 is based on part of IEC 61000-4-2 and describes vehicle-specific requirements.

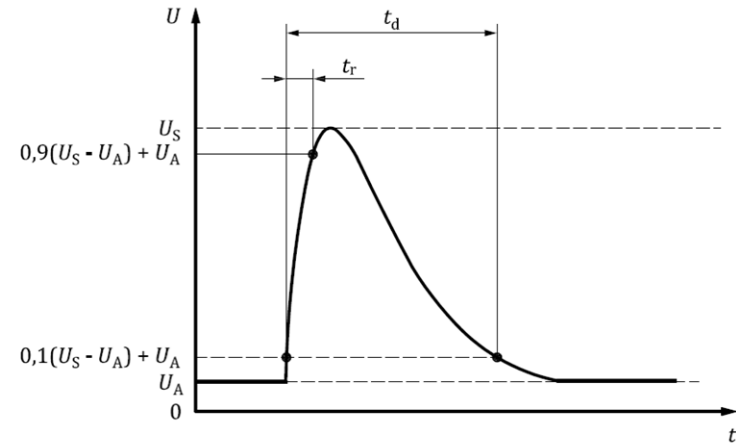
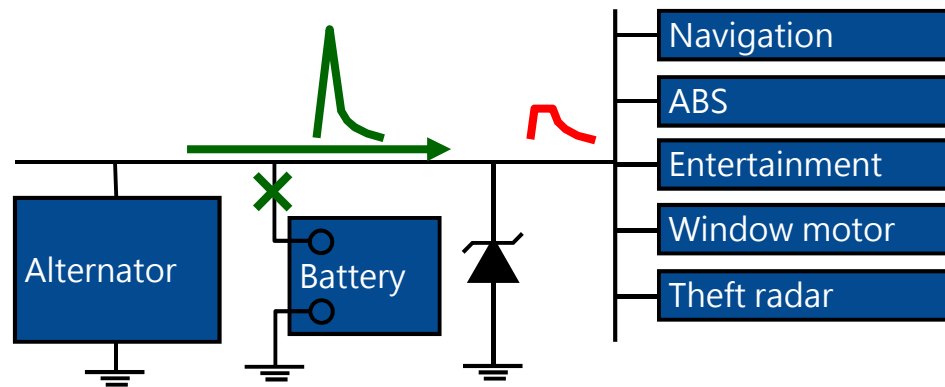
Direct Contact Discharge			
Level	Category 1	Category 2	Category 3
1	2kV	2kV	5kV
2	4kV	4kV	6kV
3	6kV	8kV	8kV
4	8kV	8kV	15kV

Indirect Contact Discharge			
Level	Category 1	Category 2	Category 3
1	2kV	2kV	4kV
2	4kV	4kV	8kV
3	6kV	8kV	15kV
4	8kV	15kV	20kV

Direct Air Discharge			
Level	Category 1	Category 2	Category 3
1	2kV	4kV	6kV
2	4kV	6kV	8kV
3	8kV	8kV	15kV
4	15kV	15kV	25kV










- Protect Solution for Transient issue ⑨ TVS Diode

# Load Dump Standard



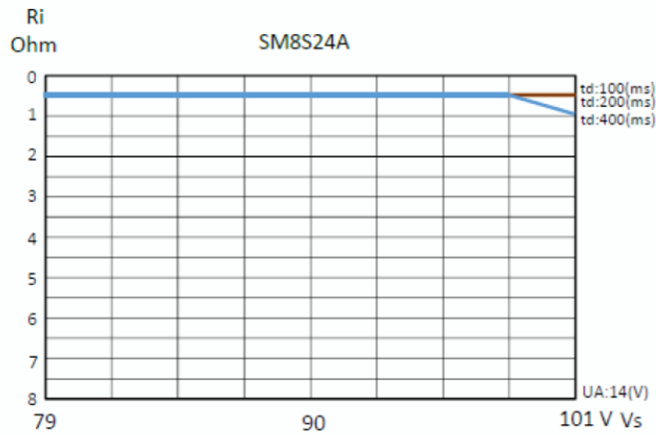
	(Old)	(New)
Standard	ISO7637-2	ISO 16750-2
Parameter	24V system	24V system
U <sub>s</sub>	123V to 174V	151V to 202V
R <sub>i</sub>	1Ω to 8Ω	1Ω to 8Ω
t <sub>d</sub>	100ms to 350ms	100ms to 350ms
t <sub>r</sub>	10 / +0 / -5 ms	10 / +0 / -5 ms
pulse	1 pulse	10 pulses 1 pulse/min.

# Automotive TVS Diode

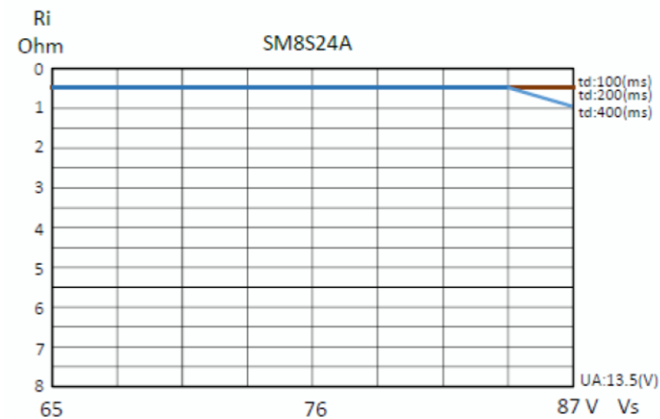
	CDSOT23-T24CAN-Q	CDSOD323-TxxC-DSL-Q	SMAJ-Q	SMBJ-Q	SMCJ-Q	SMLJ-Q	5.0SMDJ-Q	SM8SF33CA-Q	SM8S-Q
Package									
Package Type	SOT-23	SOD323	DO-214AC (SMA)	DO-214AA (SMB)	DO-214AB (SMC)	DO-214AB (SMC)	DO-214AB (SMC)	0.41" x 0.32"	DO-218AB
Peak Pulse Power (Watt) (10/1000 μs)	-	-	400	600	1500	3000	5000	6600	6600
Peak Pulse Current (A) (10/1000 μs)	8 (8/20μs)	11 / 6 (8/20μs)	20.1 ~ 4.3	30.2 ~ 6.5	75.4 ~ 16.1	150.6 ~ 32	252 ~ 72.1	132	95 ~ 254
Stand-Off Voltage (V)	24	12 / 24	12 ~ 58	12 ~ 58	12 ~ 58	12 ~ 58	12 ~ 43	33	16 ~ 43
Breakdown Voltage (V)	26.2	13.3 / 26.7	13.3 ~ 64.4	13.3 ~ 64.4	13.3 ~ 64.4	13.3 ~ 64.4	13.3 ~ 47.8	36.7	17.8 ~ 52.8

# SM8S-xx(C)A-Q - Load dump performance

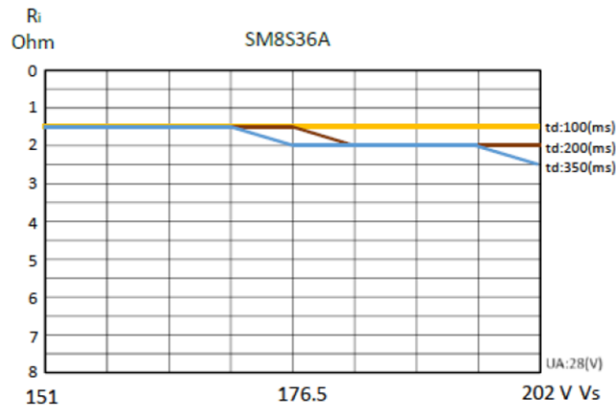
ISO 16750-2 Test A (10 Pulse) - SM8S24A



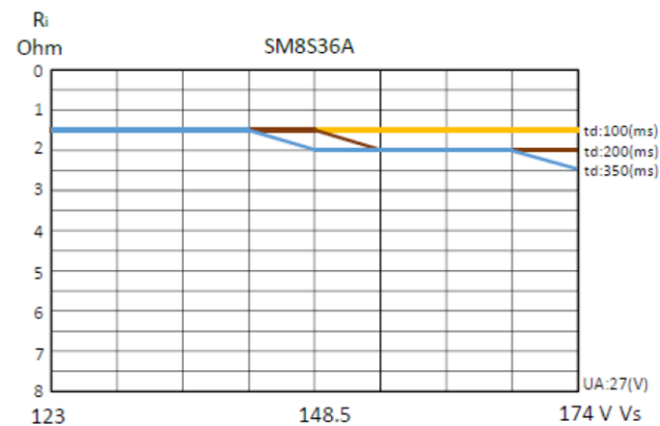
ISO 7637-2 5a (1 Pulse) - SM8S24A



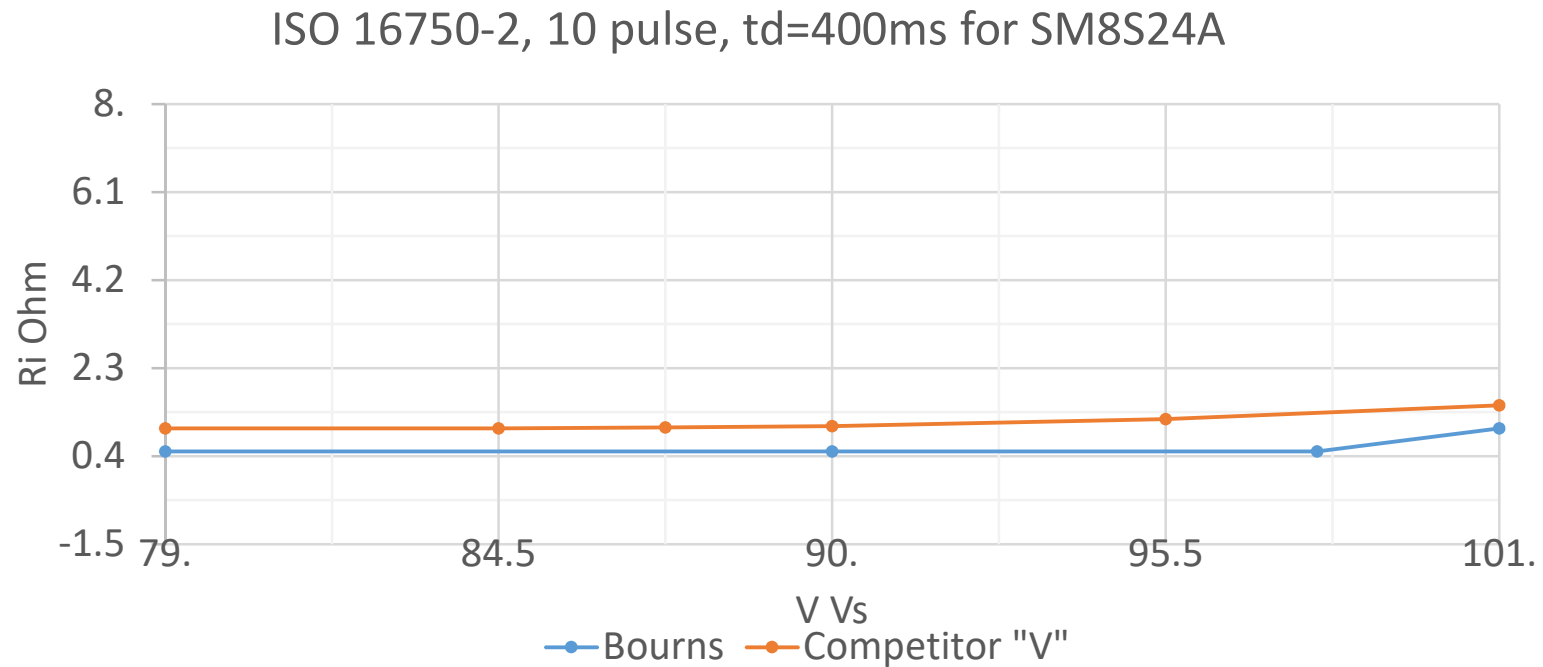
ISO 16750-2 Test A (10 Pulse) - SM8S36A



ISO 7637-2 5a (1 Pulse) - SM8S36A



# Load dump performance comparison:



# Q & A

Thank you!

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