EPCOS Product Brief 2012

Ceramic Transient Voltage Suppressors

Combined EMI Filtering and ESD Protection for High-Speed Bus Systems

Serial data bus systems such as CAN or FlexRay are state of the art for reliable communication in automotive applications, providing fast data transfer between all control units. The trend to add even more functions (e.g. for safety, comfort, engine and steering control) is far from over. Thus, the complexity of the bus systems is increasing and modern bus systems must provide high-speed data transfer at up to 100 Mbit/s. The bus systems must be properly protected in order to avoid increased vulnerability to electromagnetic interference (EMI) and electrostatic discharge (ESD).

Bus communication protection levels are defined and specified in the hardware requirements for bus interfaces in automotive applications that are issued by the OEMs.

EPCOS ceramic transient voltage suppressors (CTVS) represent the highest standard in ESD protection for the automotive industry.

With the wide portfolio of TDK and EPCOS data line chokes we are able to provide complete reliable EMC solutions for high-speed bus systems. Beside the single chip varistors, we also offer varistor array types, which combine ESD protection with effective EMI reduction for high-speed bus systems.

This Product Brief presents application examples of CTVS devices for bus systems with a focus on the new multilayer varistor array types. In addition, it provides a general overview of CTVS components for bus systems.

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Protective circuits for high-speed CAN and FlexRay systems

Currently CAN and FlexRay are the primary high-speed bus systems deployed in automotive networks. High-speed CAN provides data rates up to 1 Mbit/s, FlexRay up to 10 Mbit/s. Heavy use of the data lines makes them susceptible to transient emissions and noise.

- ESD protection

A protection level of >15 kV is recommended for all nodes of bus systems, especially for those connected to external interfaces. ESD events from external sources are often unpredictable and may easily exceed the minimum ESD protection level of semiconductor components used in bus systems. Efficient ESD protection with protection levels >15 kV (IEC 61000-4-2) can be provided both with single-chip MLV´s as well as with varistor arrays, which provide two varistors with a common ground in one component.

Examples of discrete and integrated ESD protection are shown in figures 1 and 2.

Figure 1

Typical protective circuit for high-speed CAN and FlexRay with discrete ESD solution using two discrete high-speed varistors (e.g. CT0603S14AHSG)

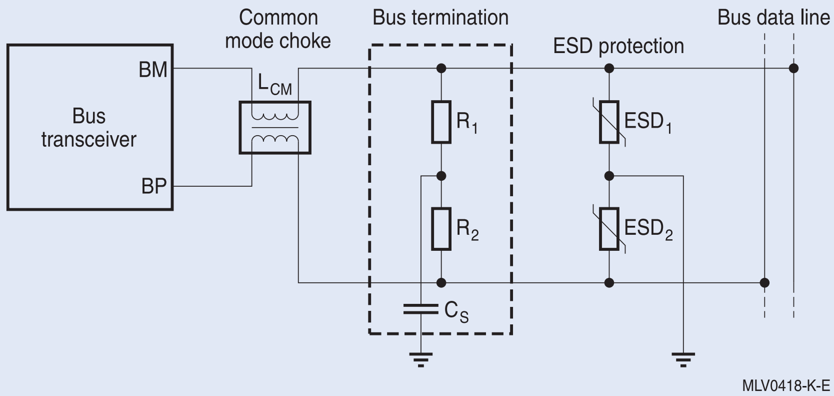
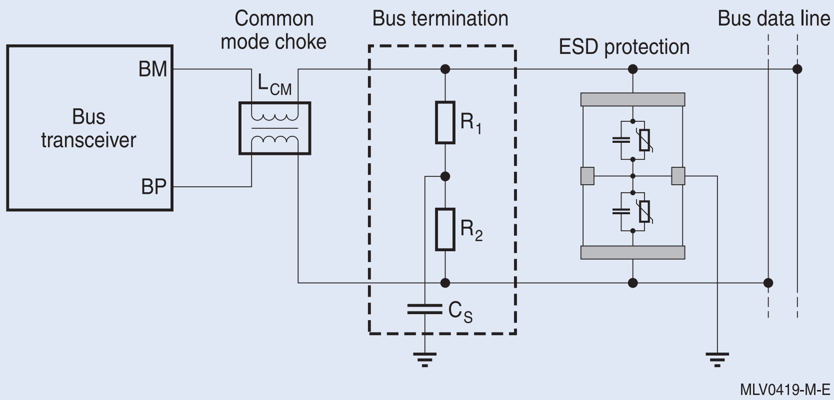


Figure 2

Typical protective circuit for high-speed CAN and FlexRay with integrated ESD solution using a varistor array, e.g. type CA05F2S10T100G with 2 × 10 pF



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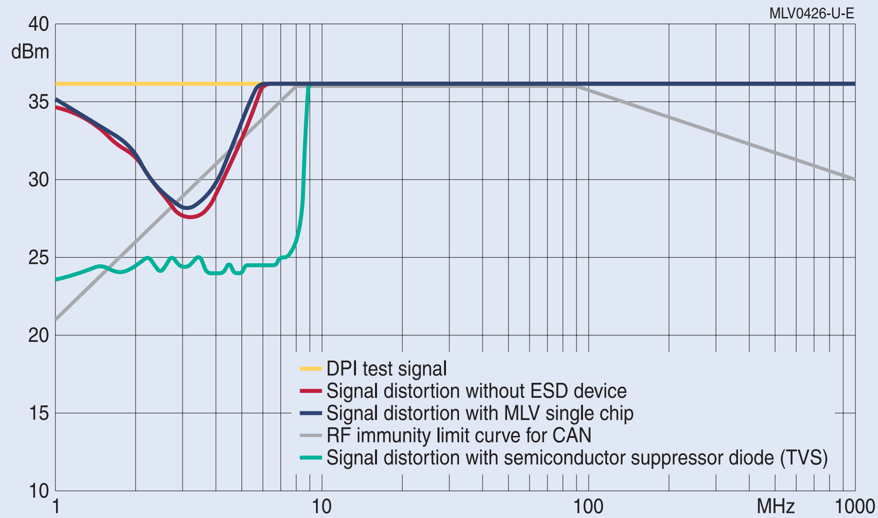
- EMC conformance

Beside the high ESD protection level, MLV offer further advantages to satisfy the EMC requirements of bus systems. Particularly the required immunity against RF disturbance is more stringent for high-speed bus systems, e.g. FlexRay.

Multilayer varistors fulfill the highest standards of RF immunity because of the high linearity of their V/I characteristic. They are transparent to the bus system and provide the full signal power transfer, while semiconductor suppressor diodes may cause significant power loss of the desired signal due to the nonlinearity of their V/I characteristic.

Figure 3

DPI measurements demonstrate immunity to RF disturbance with an MLV for ESD protection of bus interfaces. The DPI test limits[1] (in this example for high-speed CAN) are completely fulfilled with CT0603S14AHSG, while a comparative semiconductor suppressor diode violates DPI limits for CAN.



1) RF immunity limits acc. to hardware requirements for LIN, CAN and FlexRay interfaces in automotive applications, Version 1.1, 2009-12-02 / Audi, BMW, Daimler, Porsche, Volkswagen.

Combined EMI/ESD solution for FlexRay

An ideal combination of EMI filtering and ESD protection for high-speed bus systems, particularly for FlexRay, can be achieved with our new matched capacitance varistor array (MCVA). Like the arrays described before, they consist of two varistors with a common ground. While the capacitance of a varistor is normally considered just as a parasitic value, the capacitance of the MCVA is specifically set to higher values.

Thus the MCVA is able to act as a filter for undesirable RF emissions and eliminates the need for additional capacitors for RF-filtering. The matching of the capacitances C_1 and C_2 of the MCVA avoids crosstalk of RF disturbance between the bus data lines. The deviation ΔC is defined as $\Delta C = |C_1 - C_2| / \min\{C_1, C_2\}$. The specified values are ΔC_{typ} = 1% and ΔC_{max} <3%.

Figure 4a

Circuit of the matched capacitance varistor array (MCVA)

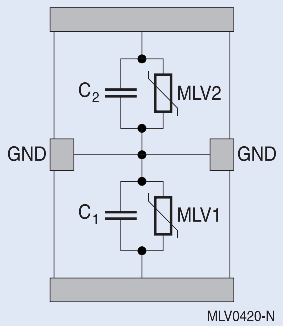
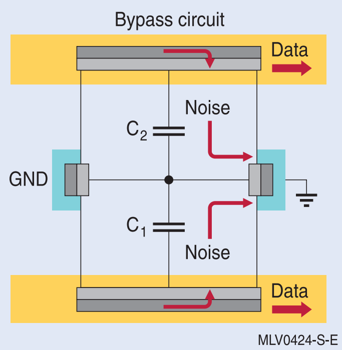


Figure 4b

Model of EMI filtering with the matched capacitances C_1 and C_2 of an MCVA



When the MCVA is directly integrated in the FlexRay termination (see figure 5), the ground capacitor C_S of the FlexRay termination is then in serial connection with each capacitance of the MCVA. Thus the ground capacitor reduces the parasitic capacitance to ground while the matched capacitances C_1 and C_2 (in this example 2 × 100 pF) of the MCVA provide effective EMI filtering of the bus data lines, especially for the frequency range 100 to 200 MHz.

Figure 5

Application example with a matched capacitance varistor array (MCVA) as an integral part of the FlexRay termination.
Recommended type: CA05M2S14T101HG, case size 0508 with 2 × 100 pF

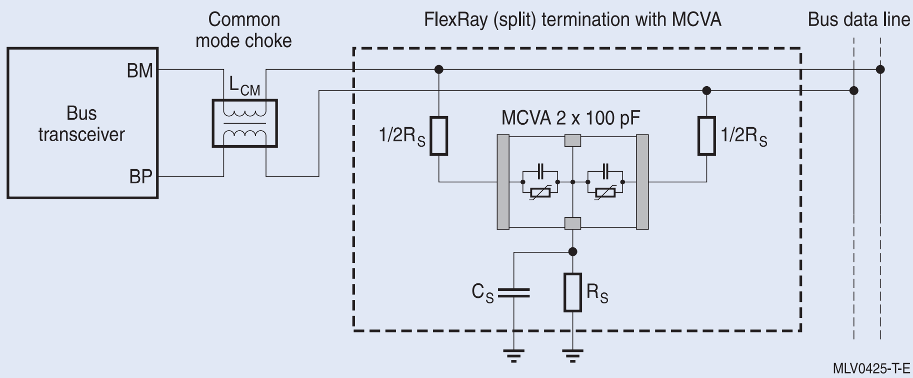


Figure 6

DPI measurements demonstrate immunity to RF disturbance. Signal distortion with an MCVA in a circuit acc. to figure 5 is nearly identical to the case without a protection circuit. Tested type: CA05M2S14T101HG, case size 0508 with 2 × 100 pF

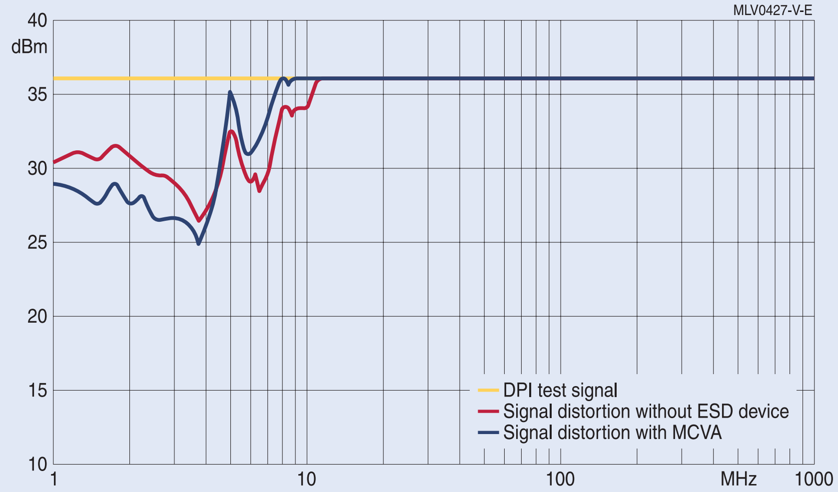
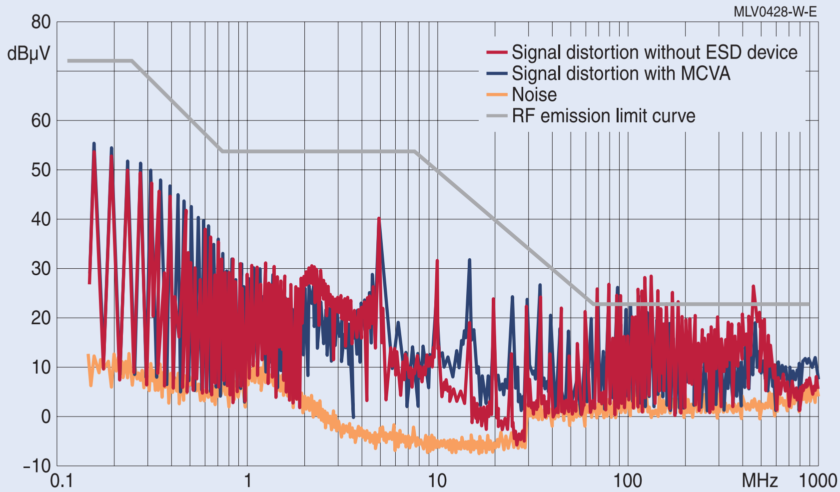


Figure 7

Detector measurements of RF emissions demonstrate that no RF emission is caused by the MCVA, however existing RF disturbance - particularly between 100 and 200 MHz - will be filtered by the MCVA, whereby the FlexRay limits for RF emission will be fulfilled. Tested type: CA05M2S14T101HG (2 × 100 pF)



Glossary

CTVS: Ceramic transient voltage suppressor
MLV: Multilayer ceramic varistor
MCVA: Matched capacitance varistor array

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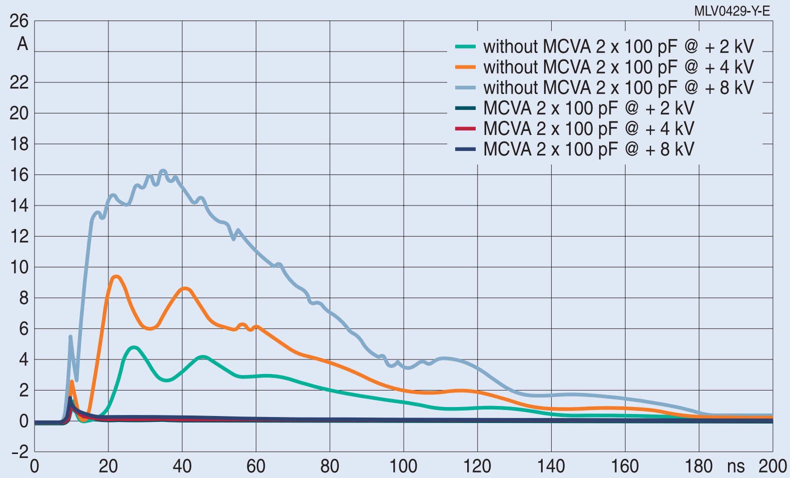
Figure 8

ESD discharge current measurements demonstrate the effective ESD suppression with matched capacitance varistor arrays (MCVA). Discharge currents of 2, 4 and 8 kV will be reduced to zero with minimum peaks below 2 A.
Tested type: CA05M2S14T101HG (2 × 100 pF)



Besides the EMI/ESD protection (ESD protection level of >15 kV) an MCVA furthermore withstands load dump pulses up to 27 V/ 0.3 s as well as jump start pulses up to 28 V/ 60 s. This makes the MCVA a highly suitable component for automotive applications.

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Overview of CTVS types for bus systems

Case size (EIA)	V_{RMS}	$V_{DC, max}$	C_{max} [pF]	Type		Ordering code
LIN (25 kbit/s) and CAN (25 to 125 kbit/s)						
0603	25	31	90	CT0603K25G	MLV, single chip	B72500E0250K060
0603	17	22	50	CT0603K17LCG	MLV, single chip	B72500E2170K060
0603	17	22	75	CT0603S17ALCG	MLV, single chip	B72500E2170S160
0603	17	22	75	CT0603S17BCCG	MLV, single chip	B72500E5170S260
CAN (125 kbit/s to 1 Mbit/s)						
0603	25	32	15	CT0603L25HSG	MLV, single chip	B72500E8250L060
0603	14	16	30	CT0603S14AHSG	MLV, single chip	B72500E8140S160
0508	10	12	2 × 15	CA05F2S10T100G	MLV, array	B72812F1120S160
0508	10	12	Matched capacitance 2 × 10 ΔC <3%	CA05M2S10T100HG	MCVA, array	B72812Q1120S160
0508	14	16	Matched capacitance 2 × 100 ΔC <3%	CA05M2S14T101HG	MCVA, array	B72812Q1160S160
MOST (25 Mbit/s to 150 Mbit/s)						
0603	25	32	15	CT0603L25HSG	MLV, single chip	B72500E8250L060
0603	14	16	30	CT0603S14AHSG	MLV, single chip	B72500E8140S160
FlexRay (10 Mbit/s)						
0603	25	32	15	CT0603L25HSG	MLV, single chip	B72500E8250L060
0508	10	12	2 × 15	CA05F2S10T100G	MLV, array	B72812F1120S160
0508	10	12	Matched capacitance 2 × 10 ΔC <3%	CA05M2S10T100HG	MCVA, array	B72812Q1120S160
0508	14	16	Matched capacitance 2 × 100 ΔC <3%	CA05M2S14T101HG	MCVA, array	B72812Q1160S160

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