EPCOS

Electronic Parts and Components

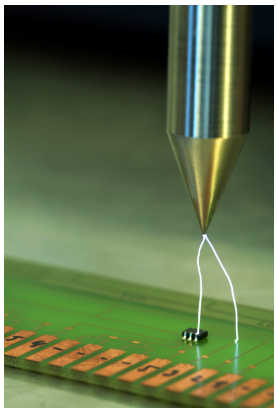
CeraDiode

for ESD Protection

Product Description

and

Application Examples



What is CeraDiode?

1. The CeraDiode is a ceramic component for ESD protection of data-, audio- and video lines, ICs and I/O ports in electronic devices.
2. The CeraDiode is a (cost-effective) alternative to semiconductor protection devices such as Zener and TVS diodes.
3. In many cases, the CeraDiode is a 1:1 replacement for these devices (F.F.F. fit form function).
4. The CeraDiode offers several technical advantages.

Benefits for customer applications

1. Bi-directional protection in a single component.

2. High ESD stability to IEC 61000-4-2, the international ESD standard
   All CeraDiodes satisfy the requirements to the IEC 61000-4-2 international ESD standard levels 1 to 4 and are tested within the scope of the human body model.

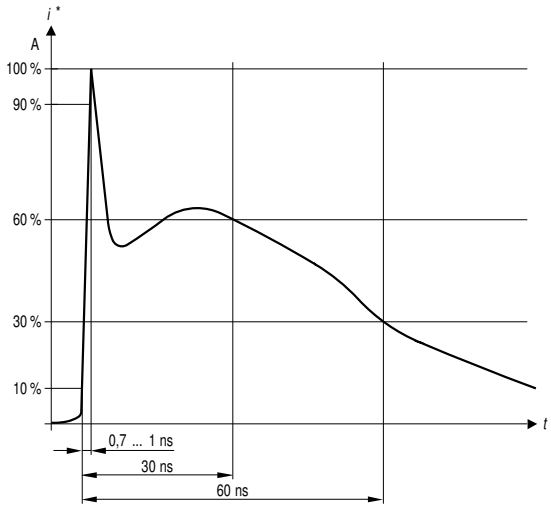


Fig. 1: ESD discharge current

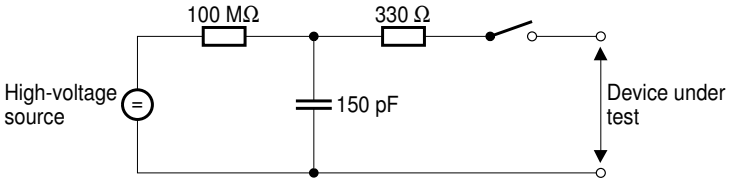


Fig. 2: ESD discharge generator (human body model)

IEC 61000-4-2 Test Level	Test voltage (contact discharge)	Test voltage (air discharge)
1	2 kV	2 kV
2	4 kV	4 kV
3	6 kV	8 kV
4	8 kV	15 kV

Fig. 3: ESD discharge levels

3. No change in ESD protection performance at temperatures > 25 °C
   Because it contains millions of pn-junctions, the CeraDiode offers a huge volume for energy absorption. This results in a constant high ESD protection performance up to 85 °C. In contrast, semiconductor diodes have only one pn-junction for energy absorption. Their ESD protection performance thus declines after 25 °C.

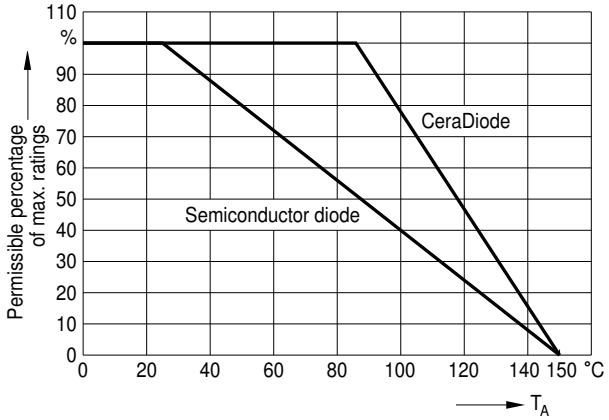


Fig. 4: Derating of ESD protection performance for CeraDiodes and semiconductor diodes

4. Use of parasitic capacitance for RFI suppression and HF filtering (replacement of additional MLCC)
   Thanks to their construction with internal electrodes, CeraDiodes offer both ESD protection and sufficient capacitance for RFI suppression and HF filtering. One CeraDiode can replace a semiconductor diode and a capacitor. Its HF behaviour is similar to a C0G ceramic capacitor. Moreover, there is no need for a series resistor to limit the current! The CeraDiode consequently saves both space and costs.

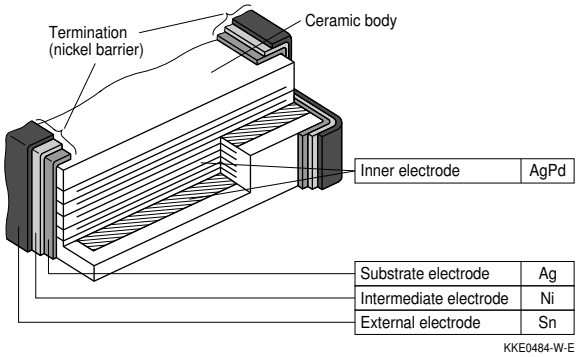


Fig. 5: Cross section through a CeraDiode

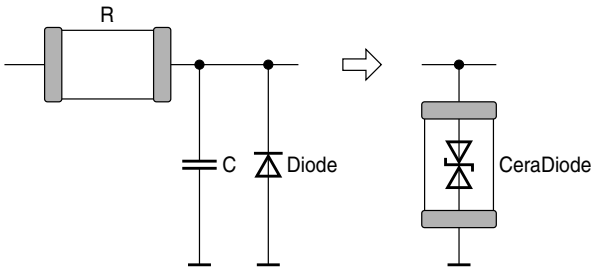


Fig. 6: Resistor + capacitor + semiconductor diode replaced by one CeraDiode

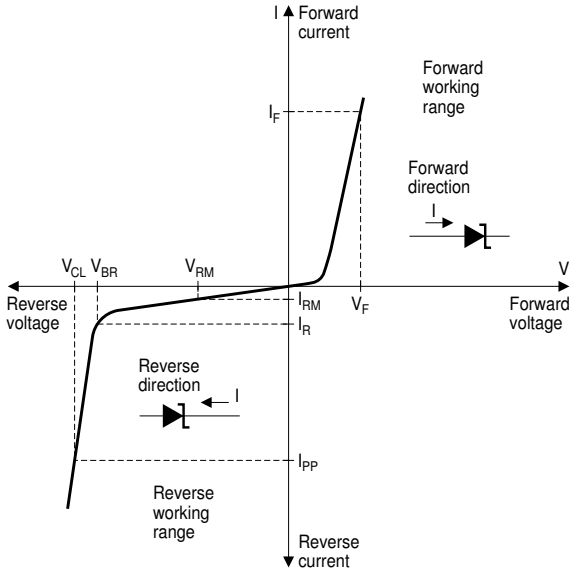
5. Ruggedness against surge currents
   CeraDiodes are designed for ESD protection. Depending on their individual construction, however, some of them can also withstand surge currents. The maximum permissible ratings for surge current and thus for energy absorption of these surge-current capable devices depend on the pulse shape, pulse duration and the number of times this load is repeated during the overall lifetime for both CeraDiodes and semiconductor diodes. A CeraDiode has a greater surge-current capability than semiconductor diodes.

6. Low leakage current

7. Fast response time < 0.5 ns

Difference between the characteristic curves of a semiconductor diode and a CeraDiode

Semiconductor diode



CeraDiode

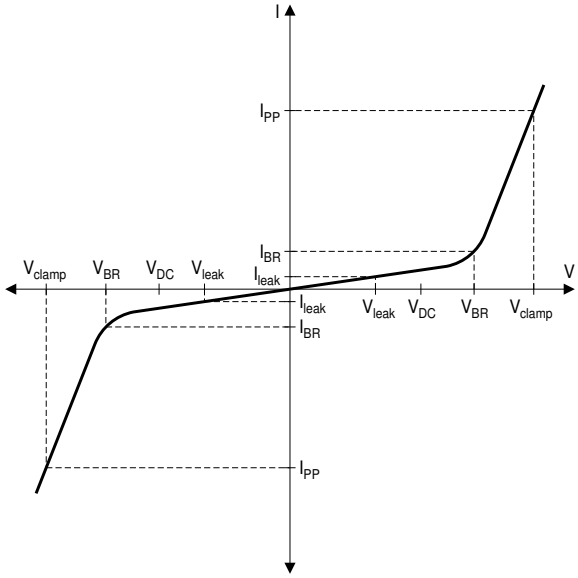


Fig. 7: Characteristic curves of semiconductor diode and CeraDiode

@ Semiconductor diode
A semiconductor diode is normally operated in the reverse direction (reverse working range). In normal use the diode has such a huge internal resistance that almost no current can flow through it. As the resistance is not infinite, however, a small current known as the leakage current I_{RM} flows through the diode. This leakage current is specified at a defined voltage V_{RM}.

@ CeraDiode
As the CeraDiode is a bi-directional component it can be used in both forward and reverse directions with no difference. During normal operation, the internal resistance of the CeraDiode is so huge that almost no current can flow through it. As the resistance is not infinite, however, a small current known as the leakage current I_{leak} flows through the diode. This current is specified at a defined voltage V_{leak}.

@ Semiconductor diode
The voltage V_{RM} resembles the maximum acceptable operating voltage. The current I_{RM} that flows is called the leakage current.

@ CeraDiode
V_{DC} is the maximum operating voltage that can be applied to the CeraDiode. To minimize the leakage current, the maximum applied voltage should be in the V_{leak} range.

@ Semiconductor diode
If the diode voltage increases, e.g. due to an ESD pulse, the diode breaks down at the breakdown voltage V_{BR}. A current I_R then flows through the diode. The breakdown voltage V_{BR} is specified with a current I_R = 1 mA.

@ CeraDiode
If the diode voltage increases, e.g. due to an ESD pulse, the CeraDiode breaks down at a breakdown voltage V_{BR}. A current I_R then flows through the diode. The breakdown voltage V_{BR} is specified at a current of I_R = 1 mA.

@ Semiconductor diode
The diode restricts the overvoltage, which may be caused by an ESD pulse on the clamping voltage. This is the voltage which would drop across the diode in the event of an overvoltage. To describe the clamping behaviour of the diode, the voltage V_{CL} is specified with a current I_{PP} = 1 A. It is designated the clamping voltage in the glossary.

@ CeraDiode
The diode restricts the overvoltage, which may be caused by an ESD pulse on the clamping voltage. This is the voltage which would drop across the diode in the event of an overvoltage. To describe the clamping behaviour of the diode, the voltage V_{clamp} is specified with a current I_{PP} = 1 A. It is designated the clamping voltage in the glossary.

@ Semiconductor diode
As the semiconductor diode is a uni-directional component, it can be used even in forward direction (forward working range). When the diode operates in this range (e.g. for negative overvoltage pulses) it has to be ensured that the current through the diode does not exceed the maximum specified forward current. This current may have to be limited with a series resistor. In this operating range, the diode is characterized by the forward voltage V_F and the current I_F.

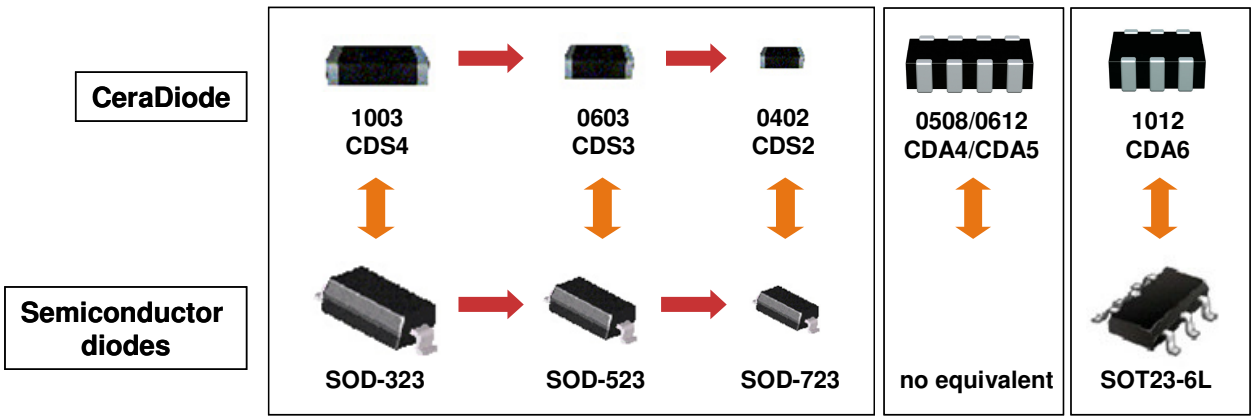
Glossary

	Semiconductor diode	CeraDiode
(Reverse) stand-off voltage, working voltage, operating voltage	V_{RM}, V_{RWM}, V_{WM}, V_{DC}	V_{DC}
(Reverse) current @ maximum reverse stand-off voltage, working voltage, operating voltage	I_{RM}, $I_{RM,max}$, $I_{RM,max}$ @V_{RM}	-
(Reverse) leakage current	I_{RM}	I_{leak}
(Reverse) voltage @ leakage current	V_{RM}, V_{RWM}, V_{WM}, V_{DC}	V_{leak}
(Reverse) breakdown voltage	V_{BR}	V_{BR}
(Reverse) current @ breakdown voltage	I_R, I_T	I_{BR}
Clamping voltage	V_{cl} , V_C	V_{clamp}
Current @ clamping voltage	I_{PP}	I_{PP}
Peak pulse power	P_{PP}	P_{PP}
Peak pulse current	I_P, I_{PP}	I_{PP}
Forward voltage	V_F	-
Current @ forward voltage	I_F	-

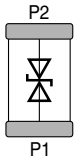
Product range

Packages

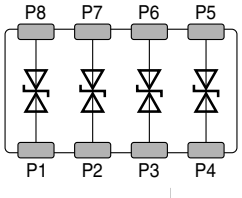
Single and array devices



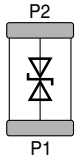
Standard single devices

Case size	EPCOS type code	Semi-diode package	Lines to protect	Device schematic	Pin description	V_{DC} [V]	$V_{BR, min}$ @ 1 mA [V]	$V_{clamp, max}$ @ 1 A [V]	$I_{pp, max}$ @ 8/20 [A]	C_{typ} [pF]
0402	CDS2C05GTA	SOD-723	1		**P1 GND** **P2 I/O Line**	5.6	6.4	24	10	180
0402	CDS2C15GTA	SOD-723	1			15	20	46	10	47
0603	CDS3C05GTA	SOD-523	1			5.6	6.4	19	30	470
0603	CDS3C09GTA	SOD-523	1			9	10	30	30	220
0603	CDS3C15GTA	SOD-523	1			15	22	42	30	160
0603	CDS3C20GTA	SOD-523	1			22	25	50	30	56
1003	CDS4C12GTA	SOD-323	1			12	16	46	20	82

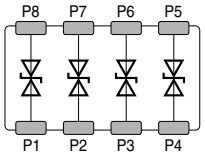
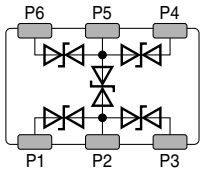
Standard array devices

Case size	EPCOS type code	Semi-diode package	Lines to protect	Device schematic	Pin description	V_{DC} [V]	$V_{BR, min}$ @ 1 mA [V]	$V_{clamp, max}$ @ 1 A [V]	$I_{pp, max}$ @ 8/20 [A]	C_{typ} [pF]
0508	CDA4C20GTA	-	4		**P1 GND** **P2 GND** **P3 GND** **P4 GND** **P5 I/O Line 1** **P6 I/O Line 2** **P7 I/O Line 3** **P8 I/O Line 4**	22	24	60	10	33
0612	CDA5C20GTA	-	4			22	25	50	30	56

High-speed single devices

Case size	EPCOS type code	Semi-diode package	Lines to protect	Device schematic	Pin description	V_{DC} [V]	$V_{BR, min}$ @ 1 mA [V]	$V_{clamp, max}$ @ 1 A [V]	C_{typ} [pF]
0402	CDS2C05HDMI1	SOD-723	1		**P1 GND** **P2 I/O Line**	5.6	tbd	-	0.6
0402	CDS2C15GTH	SOD-723	1			15	23	66	10
0402	CDS2C16GTH	SOD-723	1			16	65	290	2
0603	CDS3C16GTH	SOD-523	1			16	65	290	3
0603	CDS3C30GTH	SOD-523	1			30	50	120	10
1003	CDS4C16GTH	SOD-323	1			16	38	146	3

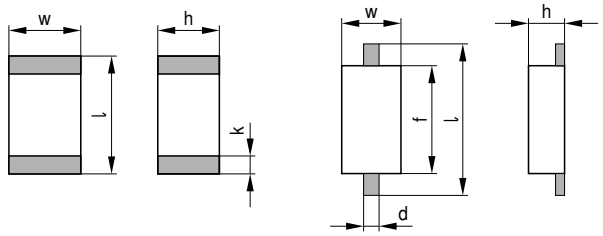
High-speed array devices

Case size	EPCOS type code	Semi-diode package	Lines to protect	Device schematic	Pin description	V_{DC} [V]	$V_{BR, min}$ @ 1 mA [V]	$V_{clamp, max}$ @ 1 A [V]	C_{typ} [pF]
0508	CDA4C16GTH	-	4		**P1 GND** **P2 GND** **P3 GND** **P4 GND** **P5 I/O Line 1** **P6 I/O Line 2** **P7 I/O Line 3** **P8 I/O Line 4**	16	22	66	10
0612	CDA5C16GTH	-	4			16	80	350	3
1012	CDA6C05GTH	SOT-23 6L	up to 4 data + 1 supply		**P1 I/O Line 1** **P2 GND** **P3 I/O Line 2** **P4 I/O Line 3** **P5 V_{DC}** **P6 I/O Line 4**	5.6	52	195	7

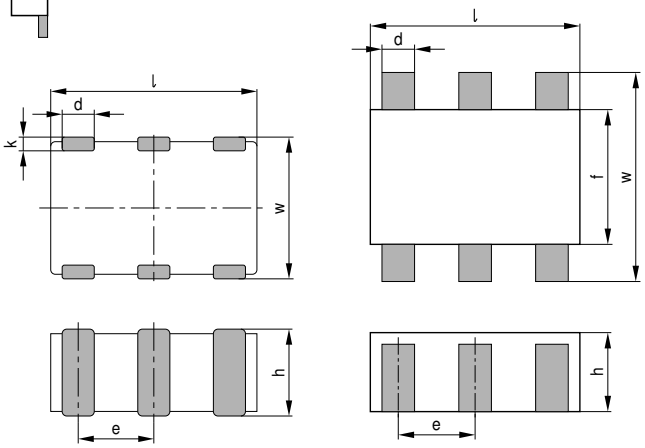
Case size and footprint dimensions of CeraDiodes and semiconductor diodes

Dimensions in mm

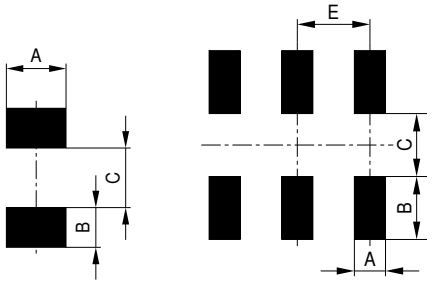
Case size	0402		SOD-723		0603		SOD-523		1003		SOD-323	
	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.
l	0.85	1.15	1.35	1.45	1.45	1.75	1.5	1.7	2.32	2.74	2.3	2.7
b	0.4	0.6	0.55	0.65	0.7	0.9	0.7	0.9	0.7	0.9	1.2	1.4
h	0.4	0.6	0.49	0.55	0.7	0.9	0.5	0.7	0.7	0.9	0.7	1.1
k	0.1	0.3	-	-	0.1	0.4	-	-	0.13	0.75	-	-
f	-	-	0.95	1.05	-		1.1	1.3	-	-	1.5	1.8
d	-	-	0.25	0.32	-		0.25	0.35	-	-	0.3	0.4



Case size	1012		SOT23-6L	
	Min.	Max.	Min.	Max.
l	2.90	3.50	2.80	3.05
w	2.25	2.75	2.6	3.0
h	-	1.2	-	1.3
d	0.35	0.65	0.35	0.5
e	0.8	1.1	0.85	1.05
k	-	0.45	-	-
f	-	-	1.5	1.75



Case size	0402	SOD-723	0603	SOD-523	1003	SOD-323	1012	SOT23-6L
A	0.6	0.45	1.0	1.0	0.8	0.8	0.7	0.7
B	0.6	0.5	1.0	0.6	0.8	0.8	1.0	1.0
C	0.5	0.6	1.0	1.1	1.45	1.45	1.4	1.4
E	-	-	-	-	-	-	0.95	0.95



Interfaces ESD protected by CeraDiode (examples)

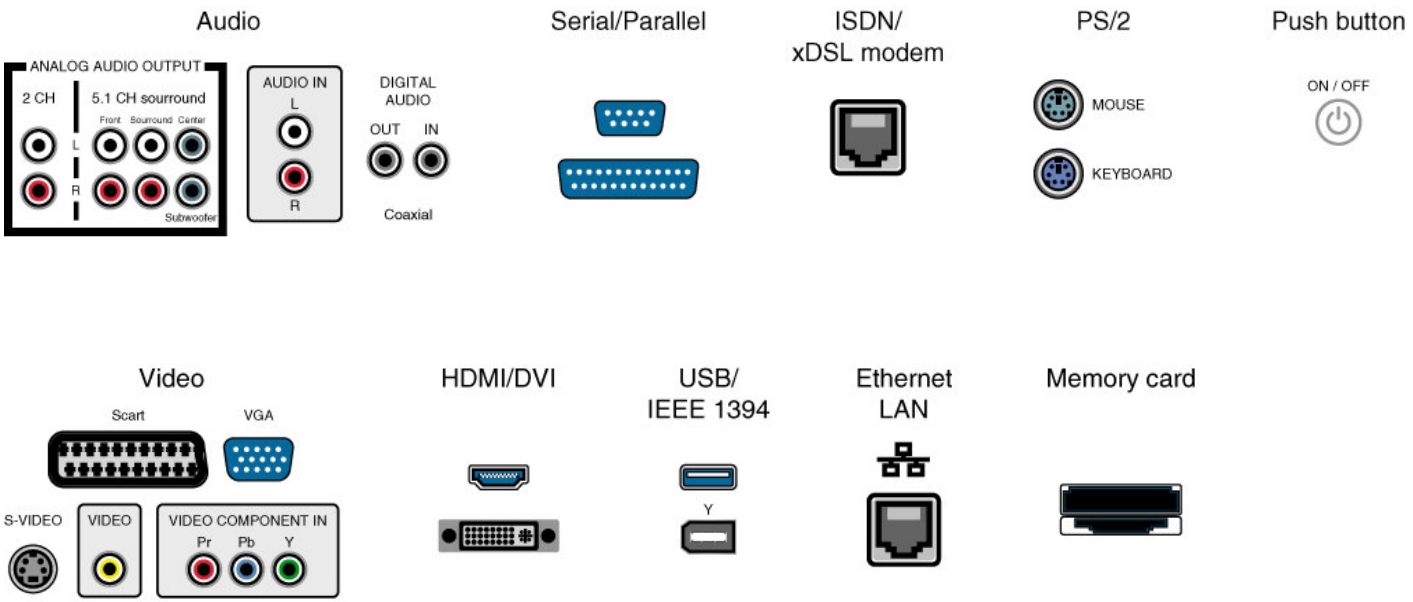


Fig. 8

Application matrix

Devices	Case size	EPCOS type code	Semi-diode package	Video analog (Scart, Composite, Component, S-Video, VGA)	Audio analog	Audio digital	DVI	HDMI	LCD	USB	IEEE 1394 (Firewire, DV, i.Link)	Ethernet	SATA	Serial port	Parallel port	Memory card	SIM card	Analog modem / ISDN	xDSL modem	Keyboard, Pushbuttons, PS/2
Single standard	0402	CDS2C05GTA	SOD-723		x	x [1]								x				x	x [1]	x
	0402	CDS2C15GTA	SOD-723		x	x [1]				x [2]				x				x	x [1]	x
	0603	CDS3C05GTA	SOD-523		x	x [1]								x				x	x [1]	x
	0603	CDS3C09GTA	SOD-523		x	x [1]								x				x	x [1]	x
	0603	CDS3C15GTA	SOD-523		x	x [1]				x [2]	x [2]			x				x	x [1]	x
	0603	CDS3C20GTA	SOD-523	x [1]	x	x [1]								x				x	x [1]	x
	1003	CDS4C12GTA	SOD-323		x	x [1]								x				x	x [1]	x
Array standard	0508	CDA4C20GTA	-	x [1]	x	x			x [1]	x [3]				x				x	x [1]	x
	0612	CDA5C20GTA	-	x [1]	x	x			x [1]	x [3]				x				x	x [1]	x
Single high-speed	0402	CDS2C05HDMI1	SOD-723				x	x			x	x								
	0402	CDS2C15GTH	SOD-723	x		x			x [1]	x	x				x	x	x		x	
	0402	CDS2C16GTH	SOD-723	x		x	x		x	x	x	x	x [1]		x	x			x	
	0603	CDS3C16GTH	SOD-523	x		x	x		x	x	x	x	x [1]		x	x			x	
	0603	CDS3C30GTH	SOD-523	x		x			x [1]	x	x	x [1]			x	x			x	
	1003	CDS4C16GTH	SOD-323	x		x	x		x	x	x	x	x [1]		x	x			x	
Array high-speed	0508	CDA4C16GTH	-	x		x			x [1]	x	x	x [1]			x	x	x		x	
	0612	CDA5C16GTH	-	x		x	x		x	x	x	x	x [1]		x	x			x	
	1012	CDA6C05GTH	SOT-23 6L	x		x				x	x	x	x [1]		x	x	x		x	

[1] Small data rates only
[2] Power line
[3] USB 1.1 only

Customer has to test and approve parts in the application.

General CeraDiode alternatives and 1:1 drop-in equivalents to semiconductor diodes

Case size	EPCOS type code	Semi-diode package	Semtech	ST Micro	OnSemi	Vishay	Rohm	Philips / NXP	Protek
Single standard									
0402	CDS2C05GTA	SOD-723		ESDA6V1L (SOD-523) ESDA5V3L (SOD-523)	**µESD3.3ST5G (1:1)**	GSOT03 (SOT-23) GSOT04 (SOT-23) GSOT05 (SOT-23) GSOT03C (SOT-23) GSOT04C (SOT-23) GSOT05C (SOT-23)			
0402	CDS2C15GTA	SOD-723	SD15C (SOD-323)	ESDA14V2L (SOD-523)	**µESD5.0ST5G (1:1)** **µESD12ST5G (1:1)**	GSOT08 (SOT-23) GSOT12 (SOT-23) GSOT15 (SOT-23) GSOT08C (SOT-23) GSOT12C (SOT-23) GSOT15C (SOT-23)		PESD15VL1BA	
0603	CDS3C05GTA	SOD-523	**SM05 (1:1)** **µClamp0501H (1:1)**	**ESDA5V3L (1:1)** **ESDA6V1L (1:1)**	**ESD5Z2.5T1 (1:1)** **ESD5Z3.3T1 (1:1)** **ESD5Z5.0T1 (1:1)**	**VESD05A1-02V (1:1)** **VESD01-02V (1:1)** **VESD03-02V (1:1)** **VESD05-02V (1:1)** GSOT03 (SOT-23) GSOT04 (SOT-23) GSOT05 (SOT-23) GSOT03C (SOT-23) GSOT04C (SOT-23) GSOT05C (SOT-23)	**RSB6.8S (1:1)**	**PESD5V0S1BB (1:1)** **PESD3V3S1UB (1:1)** **PESD5V0S1UB (1:1)**	
0603	CDS3C09GTA	SOD-523			**ESD5Z6.0T1 (1:1)** **ESD5Z7.0T1 (1:1)**	**VESD08-02V (1:1)** GSOT08 (SOT-23) GSOT08C (SOT-23)			
0603	CDS3C15GTA	SOD-523	**SDC15 (1:1)** **SM12 (1:1)** **SM15 (1:1)** **µClamp 1201H (1:1)** SD15C (SOD-323)	**ESDA14V2L (1:1)**		**VESD12-02V (1:1)** GSOT12 (SOT-23) GSOT15 (SOT-23) GSOT12C (SOT-23) GSOT15C (SOT-23)		**PESD12VS1UB (1:1)** **PESD15VS1UB (1:1)** PESD15VL1BA	
0603	CDS3C20GTA	SOD-523	**SM24 (1:1)** SD24C (SOD-323)	**ESDA25L (1:1)**		GSOT24 (SOT-23) GSOT24C (SOT-23)		PESD24VL1BA (SOT-523) PESD24VS1UB (SOT-523)	**RSB6.8S (1:1)** **PLW0501H (1:1)**
1003	CDS4C12GTA	SOD-323	**SD05C (1:1)** **SD12C (1:1)** **µClamp3301D (1:1)**		**SD05T1 (1:1)** **SD12T1 (1:1)**			**PESD5V0S1BA (1:1)** **PESD3V3L1BA (1:1)** **PESD5V0L1BA (1:1)** **PESD12VL1BA (1:1)**	**PSD03C (1:1)** **PSD05C (1:1)** **PSD08C (1:1)** **PSD12C (1:1)**
Array standard									
0508	CDA4C20GTA	-	SFC3.3-4 (MO-211) SMDA05C (SO-8) SMDA12C (SO-8) SMDA15C (SO-8) SMDA24C (SO-8) SMF3.3 (SC70-5L) SMF05 (SC70-5L) SMF12 (SC70-5L) SMS3.3 (SOT23-6L) SMS12 (SOT23-6L) SMS15 (SOT23-6L) SMS24 (SOT23-6L)	ESDA5V3SC5 (SOT23-5L) ESDA6V1SC5 (SOT23-5L) ESDA14V2SC5 (SOT23-5L) ESDA17SC6 (SOT23-5L) ESDA19SC6 (SOT23-6L) ESDA25SC6 (SOT23-6L) ESDA25W5 (SOT323-5L) ESDA6V1W5 (SOT323-5L)	SMF05C (SOT-363) SMF12C (SOT-363) SMF15C (SOT-363) SMF24C (SOT-363)		RSA6.1J4 (SC75A) RSA6.1EN (SOT-353)	BZA408B (SOT-457) PESD3V3L4UG (SOT-353) PESD5V0L4UG (SOT-353) PESD3V3L4UW (SOT-665) PESD5V0L4UW (SOT-665) BZA856A (SOT-353) BZA862A (SOT-353) BZA868A (SOT-353) BZA820A (SOT-353) BZA856AL (SOT-353) BZA862AL (SOT-353) BZA868AL (SOT-353) BZA418A (SOT-457) BZA420A (SOT-457) PESD3V3L5UY (SOT-363) PESD5V0L5UY (SOT-363)	
0612	CDA5C20GTA	-	SFC05-4 (MO-211) SFC05-5 (MO-211) SFC3.3-4 (MO-211) SMDA05C (SO-8) SMDA12C (SO-8) SMDA15C (SO-8) SMDA24C (SO-8) SMF3.3 (SC70-5L) SMF05 (SC70-5L) SMF12 (SC70-5L) SMS3.3 (SOT23-6L) SMS12 (SOT23-6L) SMS15 (SOT23-6L) SMS24 (SOT23-6L)	ESDA5V3SC5 (SOT23-5L) ESDA6V1SC5 (SOT23-5L) ESDA14V2SC5 (SOT23-5L) ESDA17SC6 (SOT23-5L) ESDA19SC6 (SOT23-6L) ESDA25SC6 (SOT23-6L) ESDA25W5 (SOT323-5L) ESDA6V1W5 (SOT323-5L)	SMF05C (SOT-363) SMF12C (SOT-363) SMF15C (SOT-363) SMF24C (SOT-363)		RSA6.1EN (SOT-353)	BZA408B (SOT457) PESD3V3L4UG (SOT-353) PESD5V0L4UG (SOT-353) PESD3V3L4UW (SOT-665) PESD5V0L4UW (SOT-665) BZA856A (SOT-353) BZA862A (SOT-353) BZA868A (SOT-353) BZA820A (SOT-353) BZA856AL (SOT-353) BZA862AL (SOT-353) BZA868AL (SOT-353) BZA418A (SOT-457) BZA420A (SOT-457) PESD3V3L5UY (SOT-363) PESD5V0L5UY (SOT-363)	
Single high-speed									
0402	CDS2C05HDMI	SOD-723							
0402	CDS2C15GTH	SOD-723	µClamp3301D (SOD-323)				**RSB6.8B (1:1)**		
0402	CDS2C16GTH	SOD-723	SL05 (SOT-23) SL12 (SOT-23) SL15 (SOT-23) SL24 (SOT-23)			GCDA15C-1 (SOT-143)			
0603	CDS3C16GTH	SOD-523	**SL05 (1:1)** **SL12 (1:1)** **SL15 (1:1)** **SL24 (1:1)**			GCDA15C-1 (SOT-143)			**GBLC03C (1:1)** **GBLC05C (1:1)** **GBLC08C (1:1)** **GBLC12C (1:1)** **GBLC15C (1:1)** **GBLC18C (1:1)**
0603	CDS3C30GTH	SOD-523	**SM36 (1:1)** **µClamp3301H (1:1)** SD24C (SOD-323) SDC36 (SOT-23)	ESDA25L (SOD-523)				PESD24VL1BA (SOT-523) PESD24VS1UB (SOT-523)	**PLW2.8 (1:1)** **ESOT3.3LCC (1:1)**
1003	CDS4C16GTH	SOD-323		ESDA6V1BC6 (SOT23-6L) ESDALC6V1P5 (SOT665) ESDALC6V1W5 (SOT323-5L)					
Array high-speed									
0508	CDA4C16GTH	-		ESDA6V1BC6 (SOT23-6L)	NZQA5V6AVX5 (SOT-553) NZQA6V8AVX5 (SOT-553) NZQA5V14AVX5 (SOT-553)			PESD5V0L4UG (SOT-353) PESD3V3L4UW (SOT-665) PESD5V0L4UW (SOT-665) PESD3V3V4UG (SOT-353) PESD5V0V4UG (SOT-353) PESD3V3V4UG (SOT-665) PESD5V0V4UG (SOT-665) BZA856AVL (SOT-353) BZA862AVL (SOT-353) BZA868AVL (SOT-353) PESD3V3L5UY (SOT-363) PESD5V0L5UY (SOT-363)	
0612	CDA5C16GTH	-							
1012	CDA6C05GTH	SOT-23 6L	**SMS3.3 (1:1)** **SMS05 (1:1)** **SRV05-4 (1:1)** **RClamp0504S (1:1)**	**ESDA6V1-4BC6 (1:1)** **ESDA5V3SC6 (1:1)** **ESDA6V1SC6 (1:1)** **ESDA14V2SC6 (1:1)** **ESDA6V1-5W6 (1:1)** **USBLC6-4SC6 (1:1)**					**PSMS05 (1:1)** **PSMS12 (1:1)** **ESDA05C-4 (1:1)** **ESDA05C-5 (1:1)** **ESOT3.3LC-2 (1:1)**

Customer has to test and approve parts in the application.

CeraDiode 1:1 drop-in equivalents to semiconductor diodes

Case size	EPCOS type code	Semi-diode package	Semtech	ST Micro	OnSemi	Vishay	Rohm	Philips / NXP	Protek
Single standard									
0402	CDS2C05GTA	SOD-723			µESD3.3ST5G				
0402	CDS2C15GTA	SOD-723			µESD5.0ST5G µESD12ST5G				
0603	CDS3C05GTA	SOD-523	SM05 µClamp0501H	ESDA5V3L ESDA6V1L	ESD5Z2.5T1 ESD5Z3.3T1 ESD5Z5.0T1	VESD05A1-02V VESD01-02V VESD03-02V VESD05-02V	RSB6.8S	PESD5V0S1BB PESD3V3S1UB PESD5V0S1UB	
0603	CDS3C09GTA	SOD-523			ESD5Z6.0T1 ESD5Z7.0T1	VESD08-02V			
0603	CDS3C15GTA	SOD-523	SDC15 SM12 SM15 µClamp1201H	ESDA14V2L		VESD12-02V		PESD12VS1UB PESD15VS1UB	
0603	CDS3C20GTA	SOD-523	SM24	ESDA25L		VESD05A1B-02V			RSB6.8S PLW0501H
1003	CDS4C12GTA	SOD-323	SD05C SD12C µClamp3301D		SD05T1 SD12T1			PESD5V0S1BA PESD3V3L1BA PESD5V0L1BA PESD12VL1BA	PSD03C PSD05C PSD08C PSD12C
Array standard									
0508	CDA4C20GTA	-							
0612	CDA5C20GTA	-							
Single high-speed									
0402	CDS2C05HDMI1	SOD-723							
0402	CDS2C15GTH	SOD-723					RSB6.8B		
0402	CDS2C16GTH	SOD-723							
0603	CDS3C16GTH	SOD-523	SL05 SL12 SL15 SL24						GBLC03C GBLC05C GBLC08C GBLC12C GBLC15C GBLC18C PLW2.8
0603	CDS3C30GTH	SOD-523	SM36 µClamp3301H						ESOT3.3LCC
1003	CDS4C16GTH	SOD-323							
Array high-speed									
0508	CDA4C16GTH	-							
0612	CDA5C16GTH	-							
1012	CDA6C05GTH	SOT-23 6L	SMS3.3 SMS05 SRV05-4 RClamp0504S	ESDA6V1-4BC6 ESDA5V3SC6 ESDA6V1SC6 ESDA14V2SC6 ESDA6V1-5W6 USBLC6-4SC6					PSMS05 PSMS12 ESDA05C-4 ESDA05C-5 ESOT3.3LC-2

Customer has to test and approve parts in the application.

Application examples and ESD protection solutions for interfaces

Electronic systems and circuits containing integrated circuits (IC) are sensitive to overvoltage transients such as ESD (electro static discharge) pulses. These pulses can enter an electrical device when the port is touched or its connector is removed. Ports and connectors are probably the most common routes through which an ESD pulse can be introduced into a device. The pulse travels through the connector to the PC board. It then propagates down the data and/or power lines to the components on the board. Without sufficient protection, these components may become inoperable or may even be destroyed. In view if their great importance, ICs are of special concern to be protected.

The CeraDiodes listed in the application examples satisfy the typical requirements normally required by these applications. Customer has to test and approve parts in the application.

1. Video and audio

Despite the advent of digital interfaces such as DVI and HDMI, it is still the case that TV and DVD set, set-top boxes, etc. are most commonly linked by SCART, S-video, composite or component connectors. Video and audio connectors need ESD protection to prevent the destruction of downstream electronics due to the sensitivity of the ICs. Depending on the application, video and audio lines are connected via a single group of interfaces comprising S-video / composite video / audio connectors.

1.1. Video lines

Requirements on the CeraDiode:

- ESD protection to IEC 61000-4-2
- Low capacitance to prevent signal distortion

CeraDiodes (low frequencies):

- Single 0603 CDS3C20GTA (47 pF)
- Array 0612 CDA5C20GTA (56 pF)

CeraDiodes (high frequencies up to 200 MHz):

- Single 0402 CDS2C15GTH (10 pF)
- Single 0603 CDS3C30GTH (10 pF)
- Array 0508 CDA4C16GTH (10 pF)

CeraDiodes (high frequencies above 240 MHz):

- Single 0402 CDS2C16GTH (2 pF)
- Single 0603 CDS3C16GTH (3 pF)
- Single 1003 CDS4C16GTH (3 pF)
- Array 0612 CDA5C16GTH (3 pF)
- Array 1012 CDA6C05GTH (7 pF)

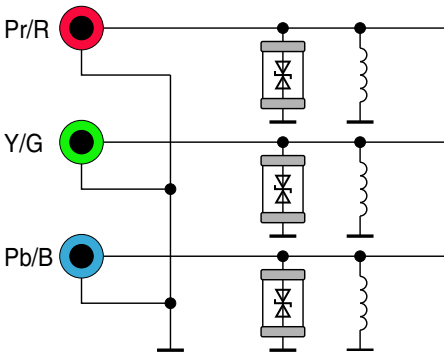


Fig. 9: CeraDiode protection for component / RGB video line

VGA ports are typical analog video connectors between computers and monitors. ESD protection is required for the graphic controller connected to the VGA port.

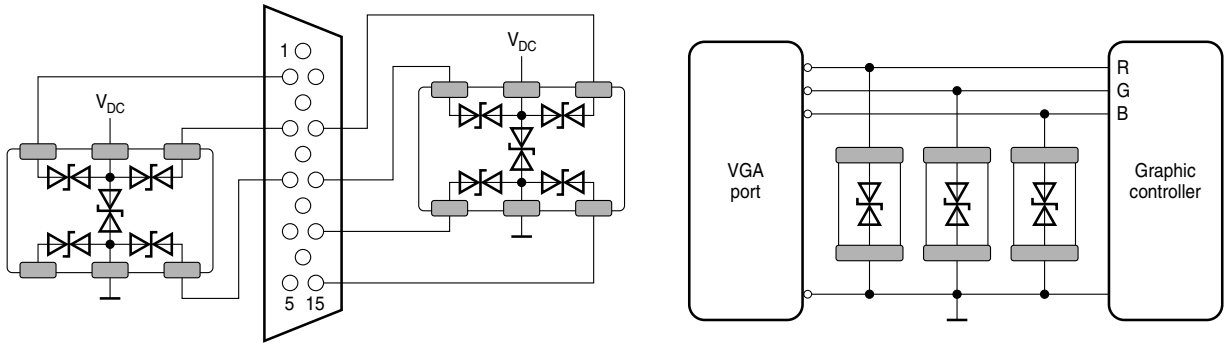


Fig. 10: CeraDiode for graphic controller protection at the VGA port

1.2. Audio lines

CeraDiodes satisfy the requirements on audio line protection devices for ESD and EMI in a single component.

Requirements on the CeraDiode:

- ESD protection to IEC 61000-4-2
- High-frequency noise filtering for high-quality audio signals
- Bi-directional operation and low line capacitance for the digital audio system

CeraDiodes:

- Single 0402 CDS2C15GTA (47 pF)
- Single 0402 CDS2C05GTA (180 pF)
- Single 0603 CDS3C15GTA (160 pF)
- Single 0603 CDS3C09GTA (220 pF)
- Single 0603 CDS3C05GTA (470 pF)
- Array 0508 CDA4C20GTA (33 pF)
- Array 0612 CDA5C20GTA (56 pF)

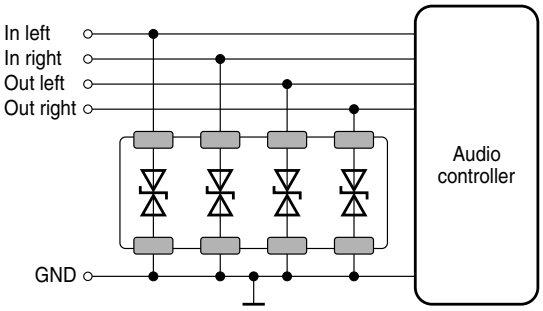


Fig. 11: Four ports can be protected with a single array component (e.g. CDA5C20GTA)

To obtain high-quality audio signals, high-frequency noise must be filtered out. CeraDiodes handle both RFI suppression and ESD protection. So it is sufficient for the application to use a single CeraDiode instead of a semiconductor diode and a capacitor. By using an array, up to four ports can be protected.

The audio leads in a digital audio system (e.g. Dolby Digital, DTS) cannot be protected by a uni-directional diode, as this would drive the negative component of the audio signal to saturation. CeraDiodes are even more attractive here thanks to their bi-directional operation. In contrast, the alternative bi-directional TVS diodes are large and expensive. Thanks to their bi-directional protection and integrated capacitance, CeraDiodes are the ideal protection for audio applications.

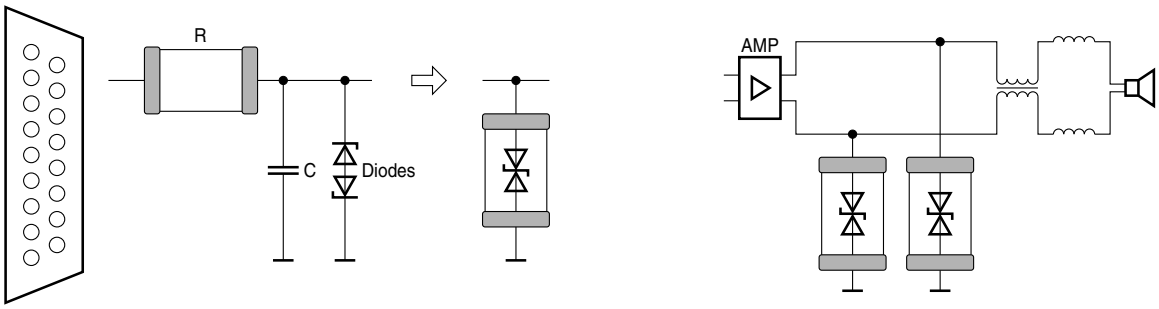


Fig. 12:
Left: Protection of audio lines (e.g. in SCART connector) with CeraDiodes
Right: Audio line and EMI protection in a single component for headset application with CDS3C05GTA (470 pF)

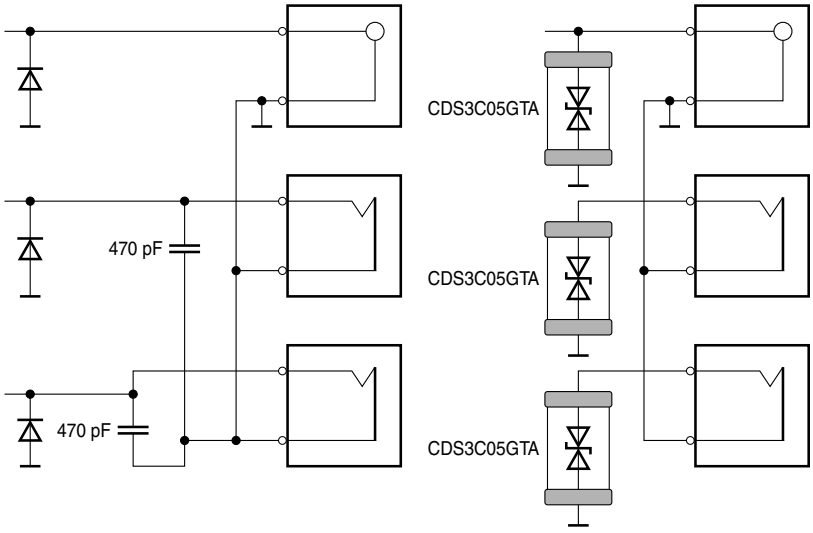


Fig. 13:
Protection of RCA connectors and audio lines with semiconductor diodes + capacitors (picture left) and CeraDiodes (picture right). Note the place saving due to less used components

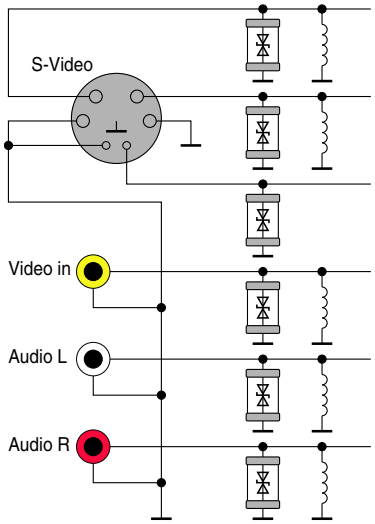


Fig. 11: Protection of the S-video, composite video and analog audio group with CeraDiodes

2. Fast data-transfer lines

2.1. USB

The Universal Serial Bus (USB) has become the standard interface for data systems. As data and consumer electronics have merged, USB has spread into more and more electronic devices. The USB is extremely sensitive to ESD. Data rates of up to 480 Mbit/s require a very low line capacitance to avoid signal distortion. USB uses two (high-speed) data lines.

Requirements on the CeraDiode:

- ESD protection for high-speed data transmission to IEC 61000-4-2, level 4
- EMI filtering
- Very low capacitance to prevent signal distortion on the data line

The following CeraDiodes passed the USB compliance test.

CeraDiodes (USB 1.1 data line):

- Single 0402 CDS2C15GTH (10 pF)
- Single 0603 CDS3C30GTH (10 pF)
- Single 1003 CDS4C12GTA (82 pF)
- Array 0508 CDA4C20GTA (33 pF)
- Array 0612 CDA5C20GTA (56 pF)

CeraDiodes (USB 2.0 data line):

- Single 0402 CDS2C15GTH (10 pF)
- Single 0402 CDS2C16GTH (2 pF)
- Single 0603 CDS3C16GTH (3 pF)
- Single 0603 CDS3C30GTH (10 pF)
- Single 1003 CDS4C16GTH (3 pF)
- Array 0508 CDA4C16GTH (10 pF)
- Array 0612 CDA5C16GTH (3 pF)

CeraDiodes (power line):

- Single 0402 CDS2C15GTA (47 pF)
- Single 0603 CDS3C15GTA (160 pF)
- Single 1003 CDS4C12GTA (82 pF)

CeraDiode (USB 2.0 data and power line):

- Array 1012 CDA6C05GTH (7 pF)

Single port protection

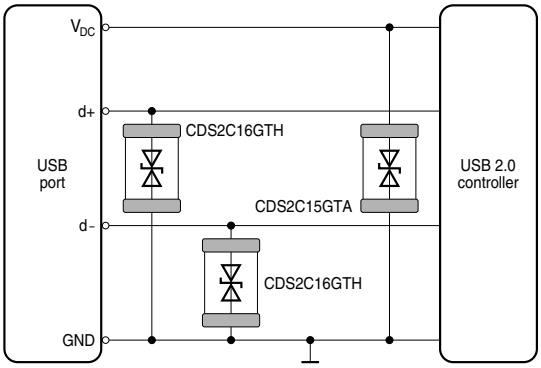


Fig. 15: USB single port protection with single CeraDiodes

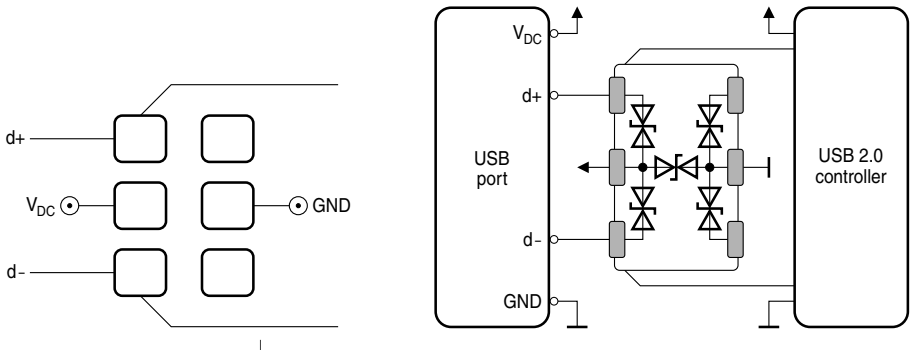


Fig. 16: USB single port protection with a high-speed array CDA6C05GTA

Dual port protection

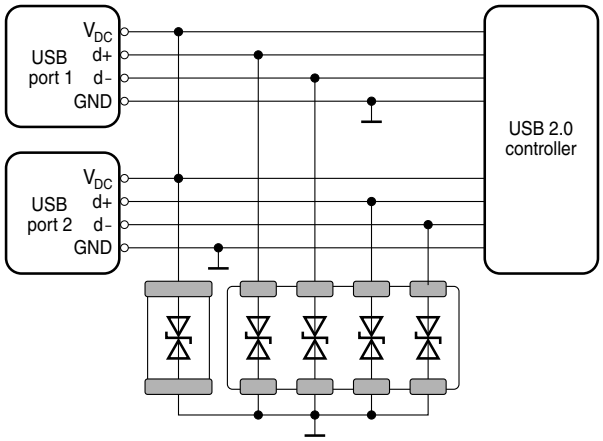


Fig. 17:
USB dual port protection with a single CDS2C15GTA or CDS3C15GTA and a CDA5C16GTH array

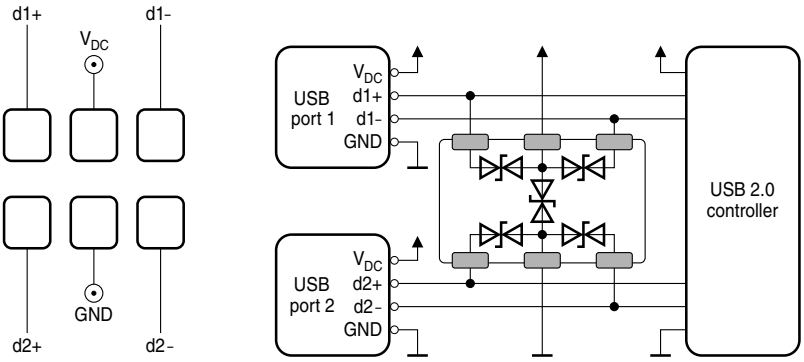
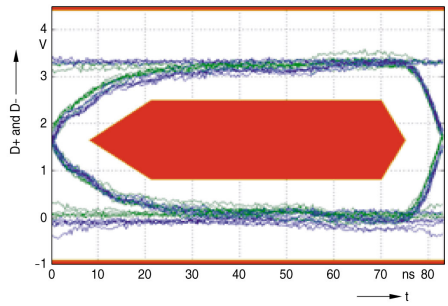


Fig. 18: USB dual port protection with high-speed array CDA6C05GTH

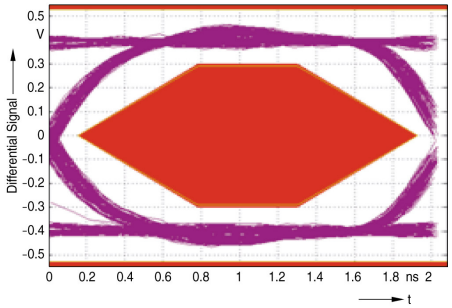
USB compliance test

Representative for other CeraDiodes which has passed the USB compliance test see below the so called eye diagrams of three selected types.

Full-speed measurement (12 Mbit/s) with CDS4C12GTA



High-speed measurement (480 Mbit/s) with CDS2C16GTH



High-speed measurement (480 Mbit/s) with CDA6C05GTH

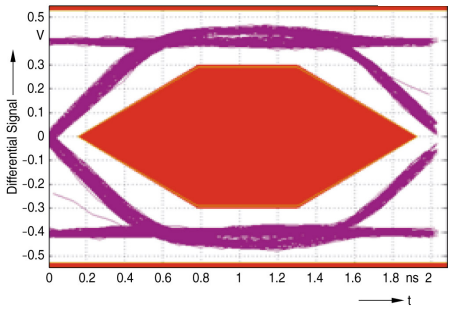


Fig. 19: USB compliance test results of three representative types

2.2. IEEE 1394 (Firewire, DV)

IEEE 1394 interfaces are better known as Firewire connectors in computers or as DV digital connectors between camcorders and DVD players and recorders. There are two versions with 6 and 4 lines respectively. Their data transfer rate of 400 Mbit/s is comparable to that of USB 2.0. The new IEEE 1394b standard specifies a data rate of 800 Mbit/s.

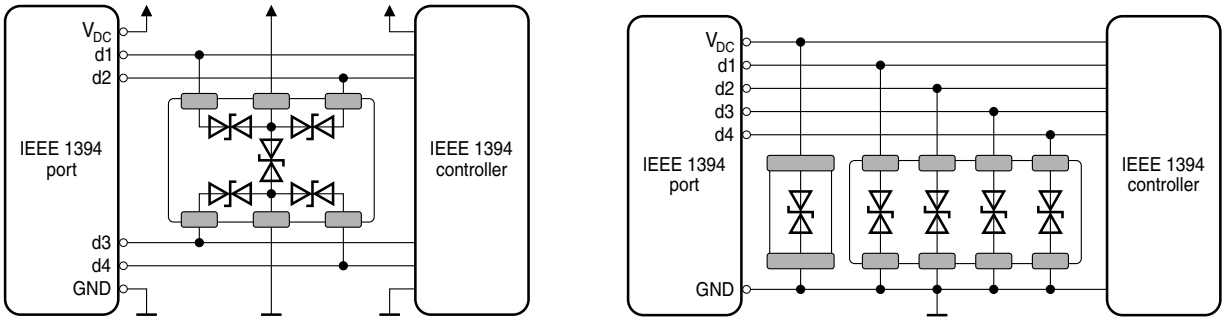


Fig. 20:
Left: IEEE 1394 line protection with high-speed array CDA6C05GTH
Right: IEEE 1394 line protection with single (e.g. CDS3C15GTA) and array (CDA5C16GTH) CeraDiodes

CeraDiodes (data line):

- Single 0402 CDS2C05HDMI1 (0.6 pF)
- Single 0402 CDS2C15GTH (10 pF)
- Single 0402 CDS2C16GTH (2 pF)
- Single 0603 CDS3C16GTH (3 pF)
- Single 0603 CDS3C30GTH (10 pF)
- Single 1003 CDS4C16GTH (3 pF)
- Array 0508 CDA4C16GTH (10 pF)
- Array 0612 CDA5C16GTH (3 pF)

CeraDiodes (power line):

- Single 0402 CDS2C15GTA (47 pF)
- Single 0603 CDS3C15GTA (160 pF)
- Single 1003 CDS4C12GTA (82 pF)

CeraDiode (data and power line):

- Array 1012 CDA6C05GTH (7 pF)

2.3. Ethernet

The 10/100/1000 Ethernet is standard for LAN connections.

Requirements on the CeraDiode:

- ESD protection for high-speed data according to IEC 61000-4-2, level 4
- Very low capacitance to prevent signal distortion

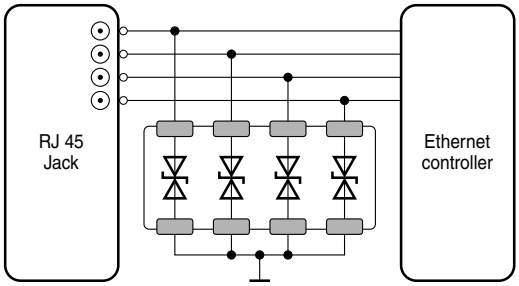


Fig. 21: Protection with CeraDiode array

CeraDiodes:

- Single 0402 CDS2C05HDMI1 (0.6 pF)
- Single 0402 CDS2C15GTH (10 pF)
- Single 0402 CDS2C16GTH (2 pF)
- Single 0603 CDS3C16GTH (3 pF)
- Single 0603 CDS3C30GTH (10 pF)
- Single 1003 CDS4C16GTH (3 pF)
- Array 0508 CDA4C16GTH (10 pF)
- Array 0612 CDA5C16GTH (3 pF)

2.4. DVI and HDMI

With the advent of flat panel displays (LCD and plasma), DVI and HDMI have become established as the digital audio and video interfaces between computers and monitors (DVI) and between DVD players / recorders, set-top boxes, etc. and TV sets (HDMI). Their high-frequency operation requires a very low / an ultra low line capacitance to avoid signal distortion.

CeraDiodes (data line):

- Single 0402 CDS2C05HDMI1 (0.6 pF)
- Single 0402 CDS2C16GTH (2 pF)
- Single 0603 CDS3C16GTH (3 pF)
- Single 1003 CDS4C16GTH (3 pF)
- Array 0612 CDA5C16GTH (3 pF)

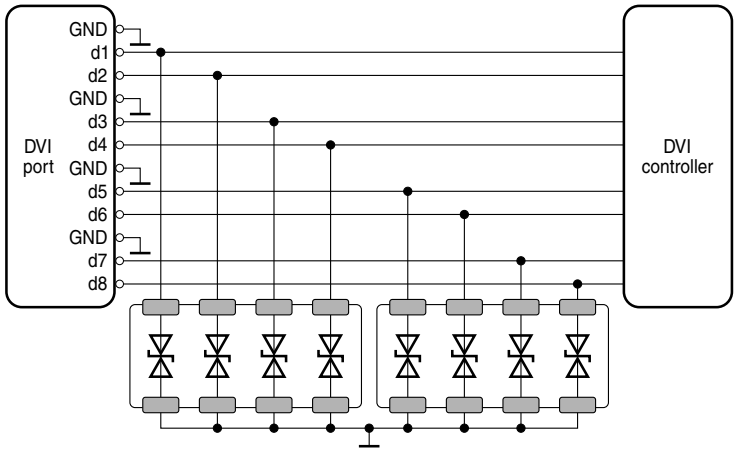


Fig. 22: DVI line protection with two arrays

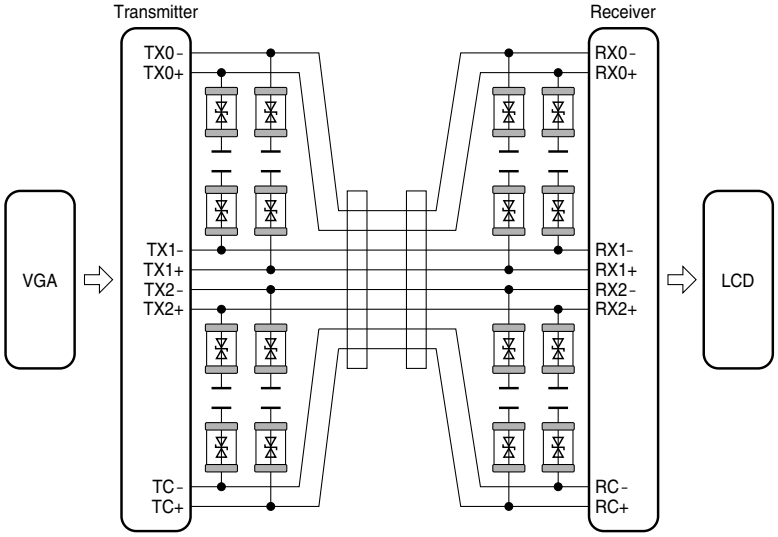


Fig. 23: DVI / HDMI line protection with CDS2C05HDMI1

3. Other applications to be protected

3.1. SIM card

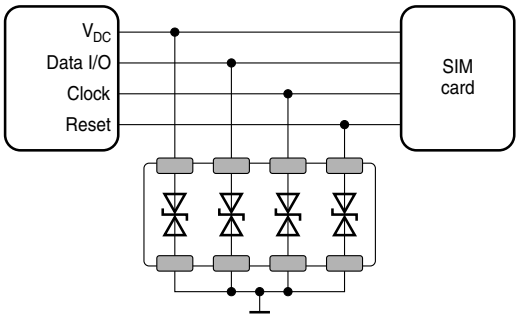


Fig. 24: SIM card protection with CeraDiode (e.g. CDA5C16GTH)

3.2. Keypads, keyboards, pushbuttons

In addition to connectors, pushbuttons offer another access route into the sensitive electronics of a TV set, DVD player, etc. An electrostatic discharge may consequently strike through them when they are touched and destroy the electronics inside. Therefore it is imperative to protect pushbutton lines (about 10 – 100 kΩ), including Channel Up/Down and Sound Volume Up/Down lines connected to microcontroller IC.

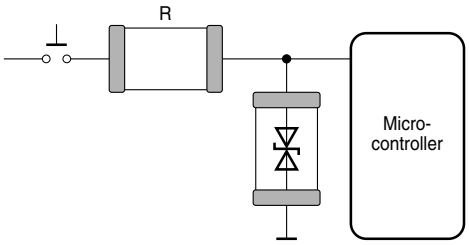


Fig. 25: Pushbutton line protection with CeraDiode

CeraDiodes, e.g.:

- Single 0402 CDS2C15GTA (47 pF)
- Single 0603 CDS3C20GTA (47 pF)
- Single 1003 CDS4C12GTA (82 pF)

3.3. IR line of pre-amplifier

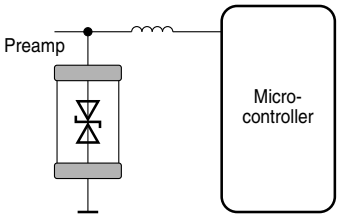


Fig. 26: Protecting the IR line of the pre-amplifier with CeraDiode

CeraDiodes, e.g.:

- Single 0606 CDS3C20GTA (47 pF)
- Single 1003 CDS4C12GTA (82 pF)

3.4. RF inputs / outputs

The protection device should have very low cap value and insertion loss.

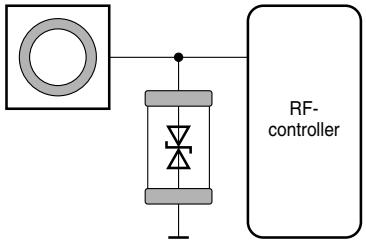


Fig. 27: RF controller protection with CeraDiode

CeraDiodes:

- Single 0402 CDS2C16GTH (2 pF)
- Single 0603 CDS3C16GTH (3 pF)

3.5. LCD data line

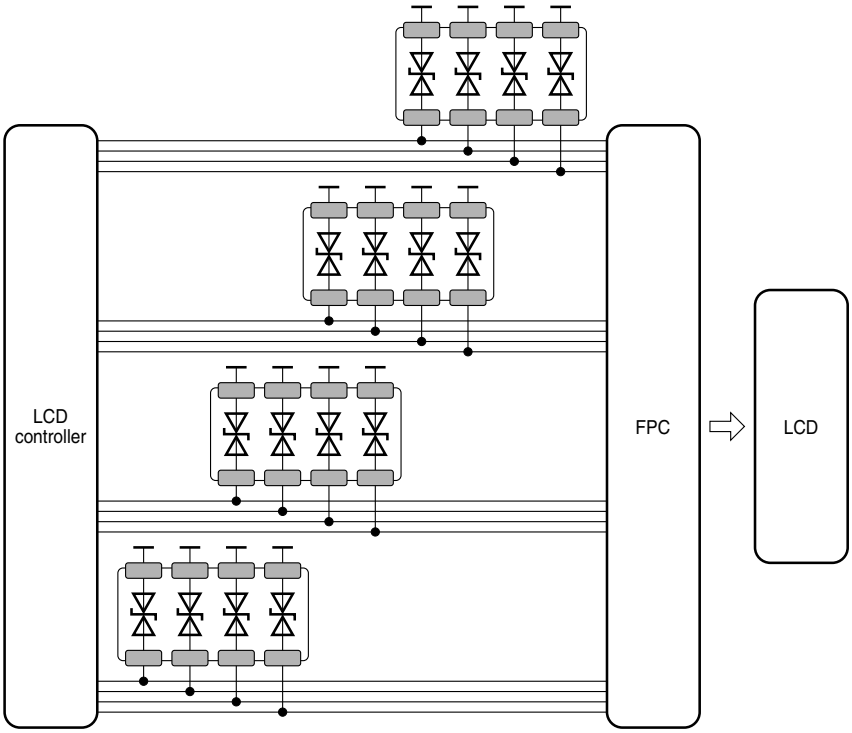


Fig. 28: Space-saving ESD protection of LCD data lines with a CeraDiode array

CeraDiodes:

- Array 0612 CDA5C20GTA (56 pF)
- Array 0612 CDA5C16GTH (3 pF)

3.6. Disc-drive units and hard-disk drives

CeraDiode:

- Single 0603 CDS3C20GTA (56 pF)
- Single 0402 CDS2C05HDMI1 (0.6 pF)
- Single 0402 CDS2C15GTH (10 pF)
- Single 0402 CDS3C16GTH (3 pF)
- Single 0402 CDS4C16GTH (3 pF)
- Array 0402 CDA5C16GTH (3 pF)
- Array 0402 CDA6C05GTH (7 pF)

3.7. Docking station and cradles

Docking stations and cradles are widely used for portable devices such as PDAs, MP3 players, notebooks, etc. The docking station and cradle is the primary connection for both the data transfer between the portable device and the host computer and for charging the battery.

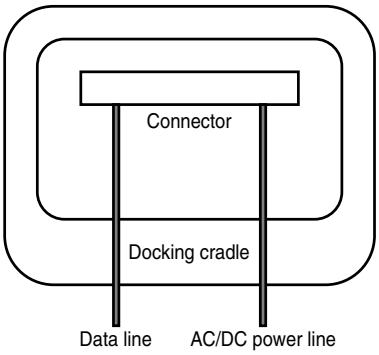


Fig. 29: Block diagram of docking station / cradle for portable devices

CeraDiodes for data line protection depends on the type of connection (USB, Ethernet, Firewire, etc.), see sections above.