

ESD & Surge

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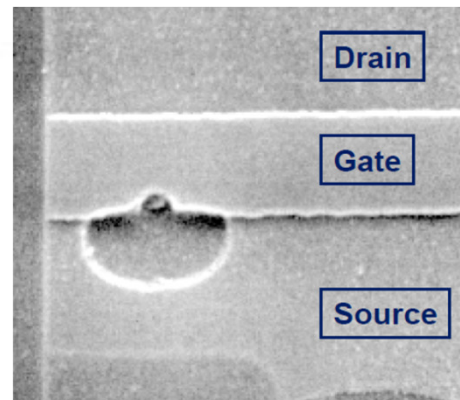
EMC-ESD Event

Agenda

- **Protection components overview**
- **ESD/Transient protection & Devices**
- **Selection of transient suppressor**
- **Applications**



ESD / Transient protection : Worst case



Affected target:

- Reset
- Interrupts
- Ctrl signals

Quelle: IBM

Types of overvoltage: characteristics of High-Voltage Transients

Transient	Voltage	Current	Key params		
			Rise Time	Pulse Width	Pulse Energy
Surge	0.5-2 kV	100÷1k A	1.25 µs	50 µs	10÷80 J
EFT (single pulse)	0.5-2 kV	10÷100 A	5 ns	50 ns	4 mJ
EFT (Burst)	0.5-2 kV	10÷100 A	n/a	15 ms	100÷1000 mJ
ESD	4-8 kV	1÷50 A	1 ns	60 ns	1÷10 mJ

Source: EMC Engineering - Henry W. Ott (Chapter #14-3 - Transient Immunity pag558)

Surge protection: Transient Suppression

Device overview



Device	Type	Response time	Capacitance	Pros	Cons	Type of transient	Typical Application
Gas Discharge Tubes (GDT)	Crowbar	μs range	1pF	Very High surge and robust	High cost High breakdown voltage Slow turn-on speed	Surge	Telecom, Outdoor
Metal Oxide Varistor MOV	Clamping	>25 ns	10 to 10k pF	Cost effective Large power handling	Higher clamping voltages Degrade due to surges	Surge	AC power line DC power line
Multilayer MOV	Clamping	<1 ns	70 to 14k pF	Fast response time Smaller size SMT mounting	Lower voltage rating Lower power handling	Surge E.F.T. E.S.D.	DC Power line I/O power protection
TVS Power Diodes	Clamping	<1 ns		High power handling SMT mounting	High Capacitance	E.F.T. E.S.D.	DC Power line Slow signal lines
TVS diode	Clamping	<1 ns	0.1 pF to 60 pF	Cost effective Low clamping voltages	Limited power handling I<100Amps	E.S.D. Surge (current limited)	Signal lines DC IC power lines
ESD Suppression beads	Clamping	<1 ns	0.2 pF to 100 pF	Fast response time Very small sizes	Very low power handling	E.S.D.	Signal lines

Source: EMC Engineering - Henry W. Ott (Chapter #14-3 - Transient Immunity pag571)

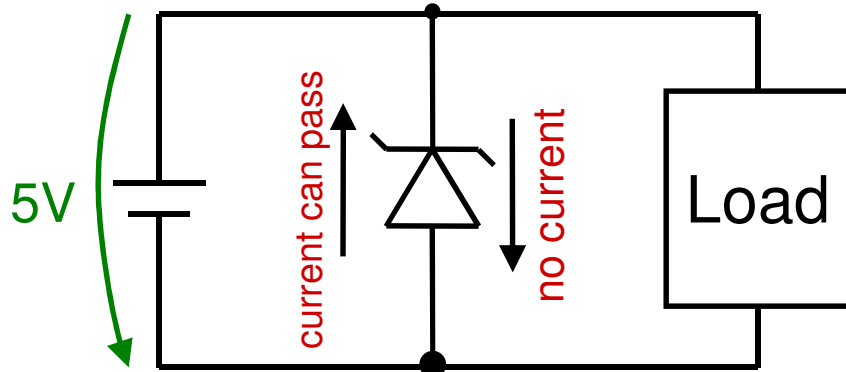
ESD / Transient protection : EN 61000-4-2

Typical Electrostatic Voltages comes from Triboelectric phenomena:

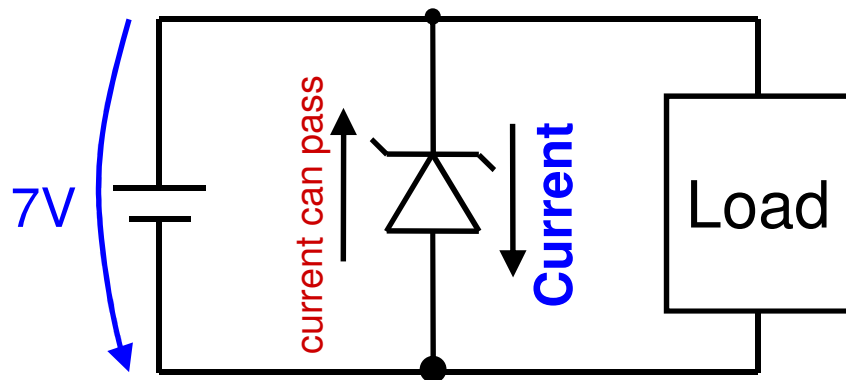
ESD source	ESD Voltage 10% to 20% Relative Humidity	ESD Voltage 60% to 90% Relative Humidity
Walking across carpet	35kV	1500V
Walking on vinyl floor	12kV	250V
Worker moving at bench	6kV	100V
Opening a vinyl envelope	7kV	600V
Picking up common polyethylene bag	20kV	1200V
Sitting on chair padded with polyurethane foam	18kV	1500V

ESD / Transient protection : TVS diodes

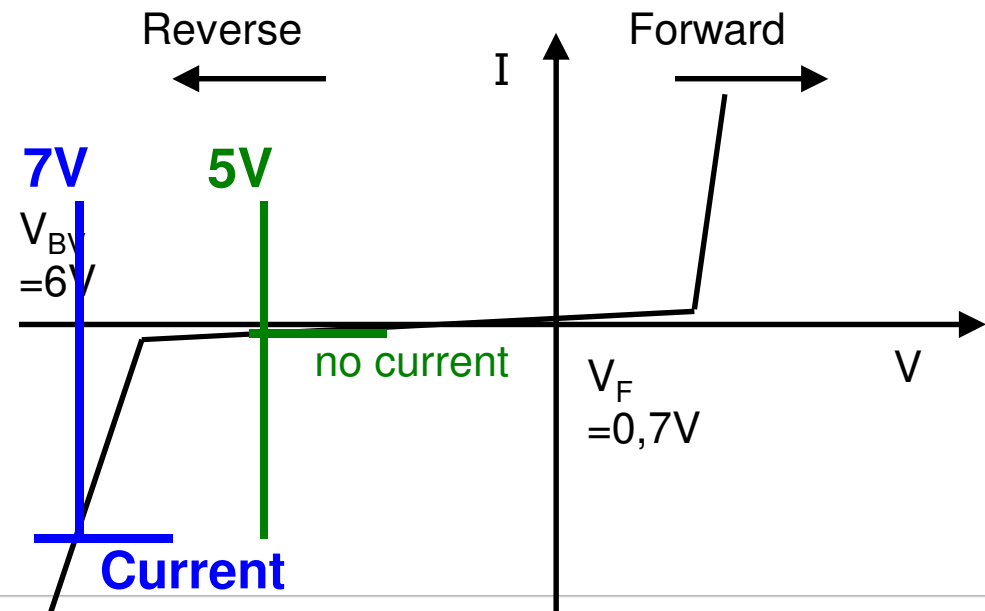
TVS Diodes are connected in reverse direction.



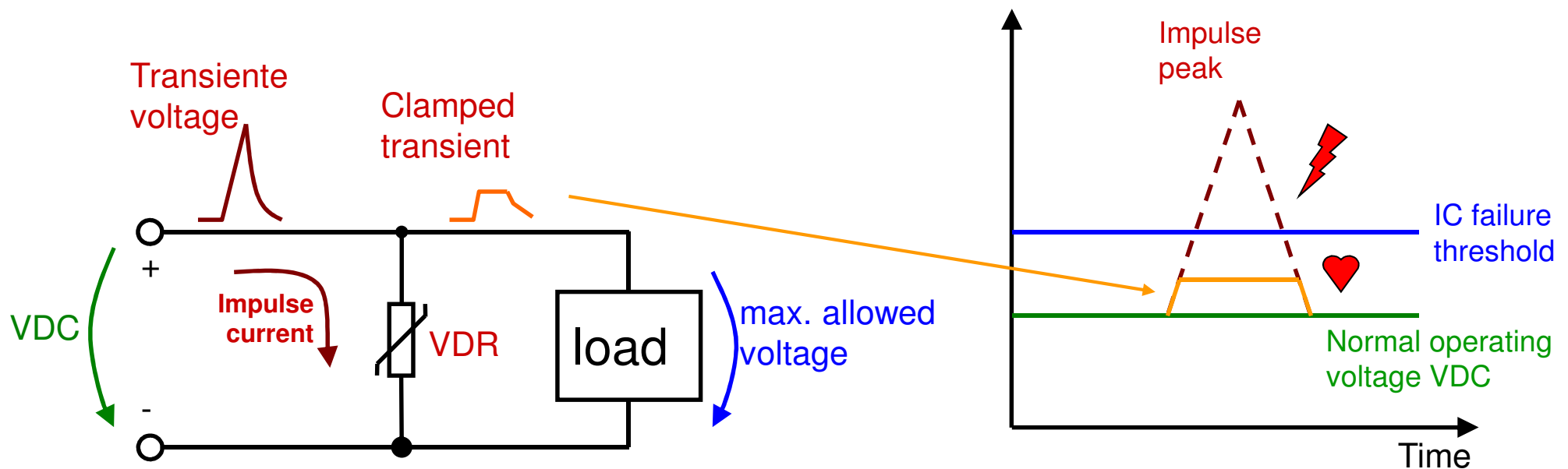
There's no current through the diode due to **breakdown voltage is not exceeded.**



If **voltage is larger than breakdown voltage** there is **current through diode.**



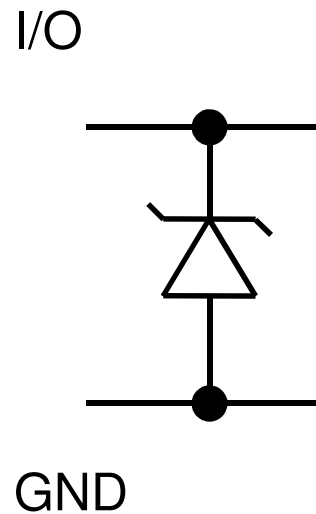
ESD / Transient protection : Scenario



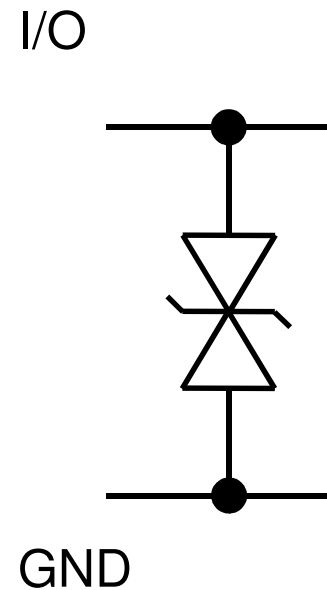
ESD / TVS device do not consist of zinc oxide but instead they are produced from silicon.
The section area of the junction gives the energy handling capability.

ESD / Transient protection : Topologies

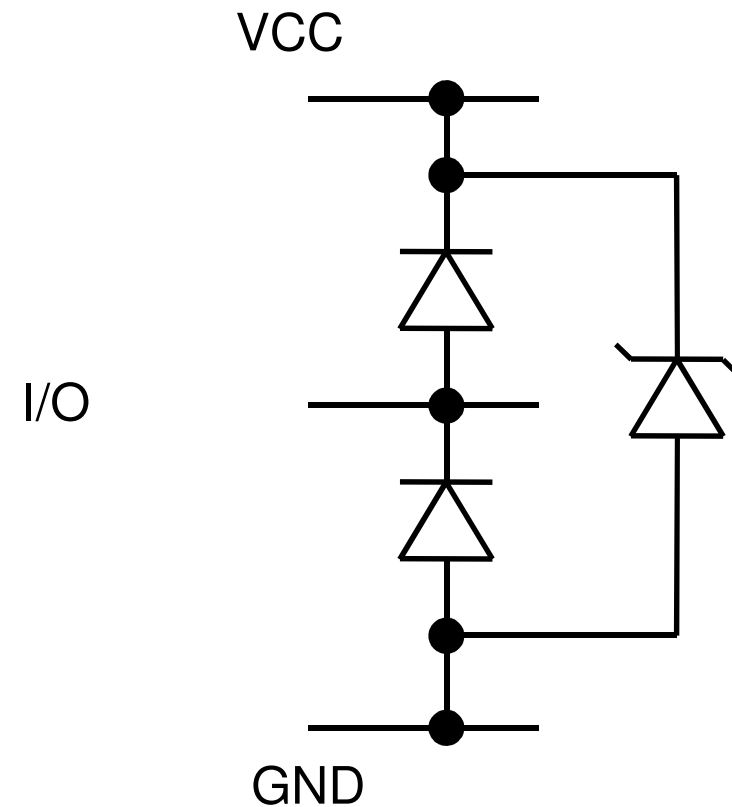
Uni-polar



Bi-polar



Rail-to-Rail

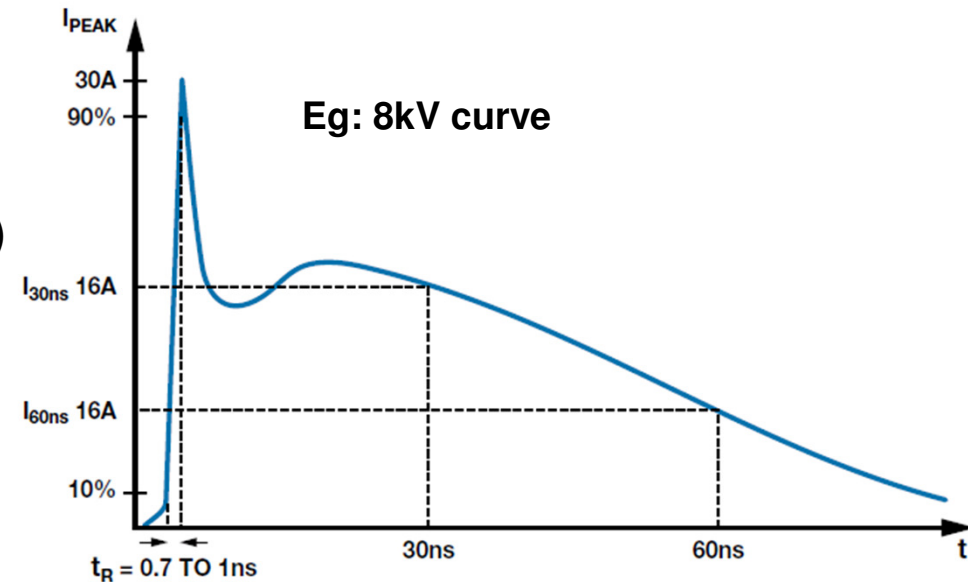
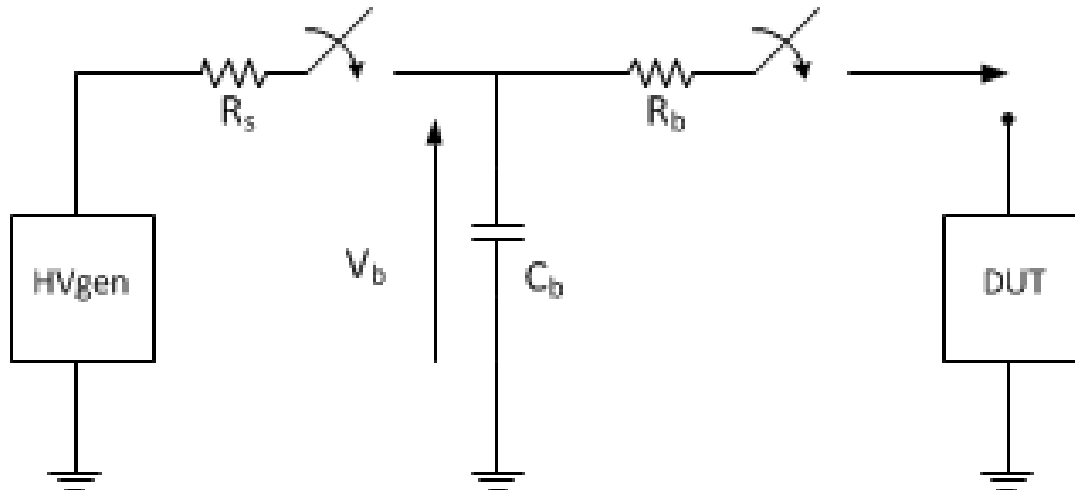


ESD / Transient protection : Topologies differences

Uni- / Bi-directional Protection 824 02x 824 04x	Rail-to-Rail Protection 824 00x 824 01x
Very good ESD Protection Capability	Very good ESD Protection Capability
Good Surge Protection Capability	Poor Surge Protection Capability
Medium- to High-Speed Data Lines	Ultra-High-Speed Data Lines
One Reference Voltage needed	Two Reference Voltages needed
Lower Price per Protected Line	Higher Price per Protected Line

ESD / Transient protection : Test Pulse Setup

- Surge Test Generator is able to produce:
 - Contact discharge/Air discharge
 - 10 positive and 10 negative strikes (int. std)
 Starting from lower level of pulse voltage.
- The curves come out from HBM circuit:



with values for EN 61000-4-2 => $R_s=50-100\text{M}\Omega$, $C_b=150\text{pF}$, $R_b=330\Omega$, $R_{DUT}=2\Omega$

ESD / Transient protection : Different Level V-I Pulse



IEC 61000-4-2 Voltage Levels and Current amount during a strike

Level	Contact Discharge		Air Discharge	
	Test Voltage kV	Peak Current (A) IEC 61000-4-2	Test Voltage kV	Peak Current (A) IEC 61000-4-2
1	2	7.5	2	7.5
2	4	15	4	15
3	6	22.5	8	30
4	8	30	15	-
X*	Special	Special	Special	Special

*: X is an open level. Must be specified in the dedicated equipment spec.
Special test equipment may be required.

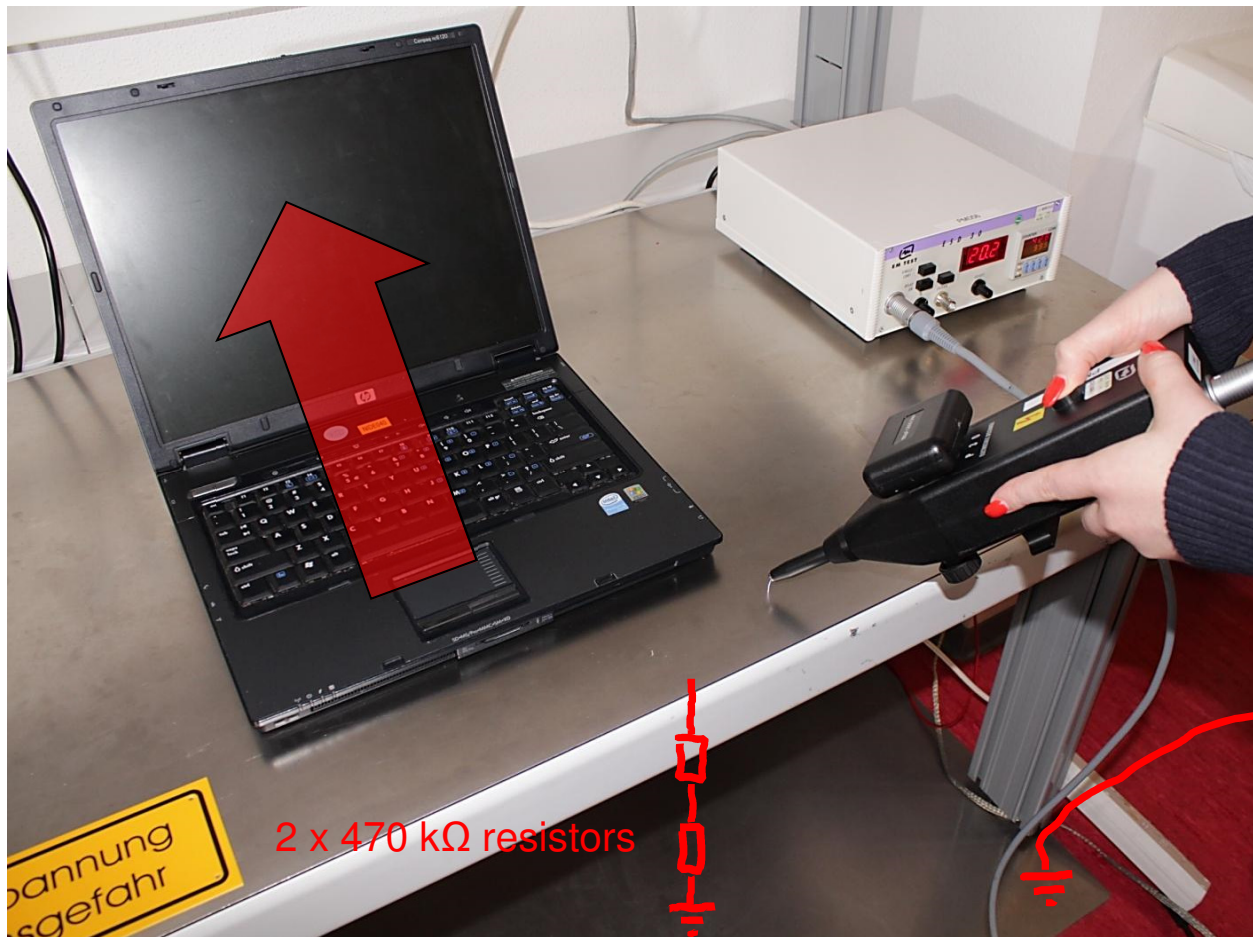
ESD / Transient protection : Test points

- Example of **air** and **contact** discharge points



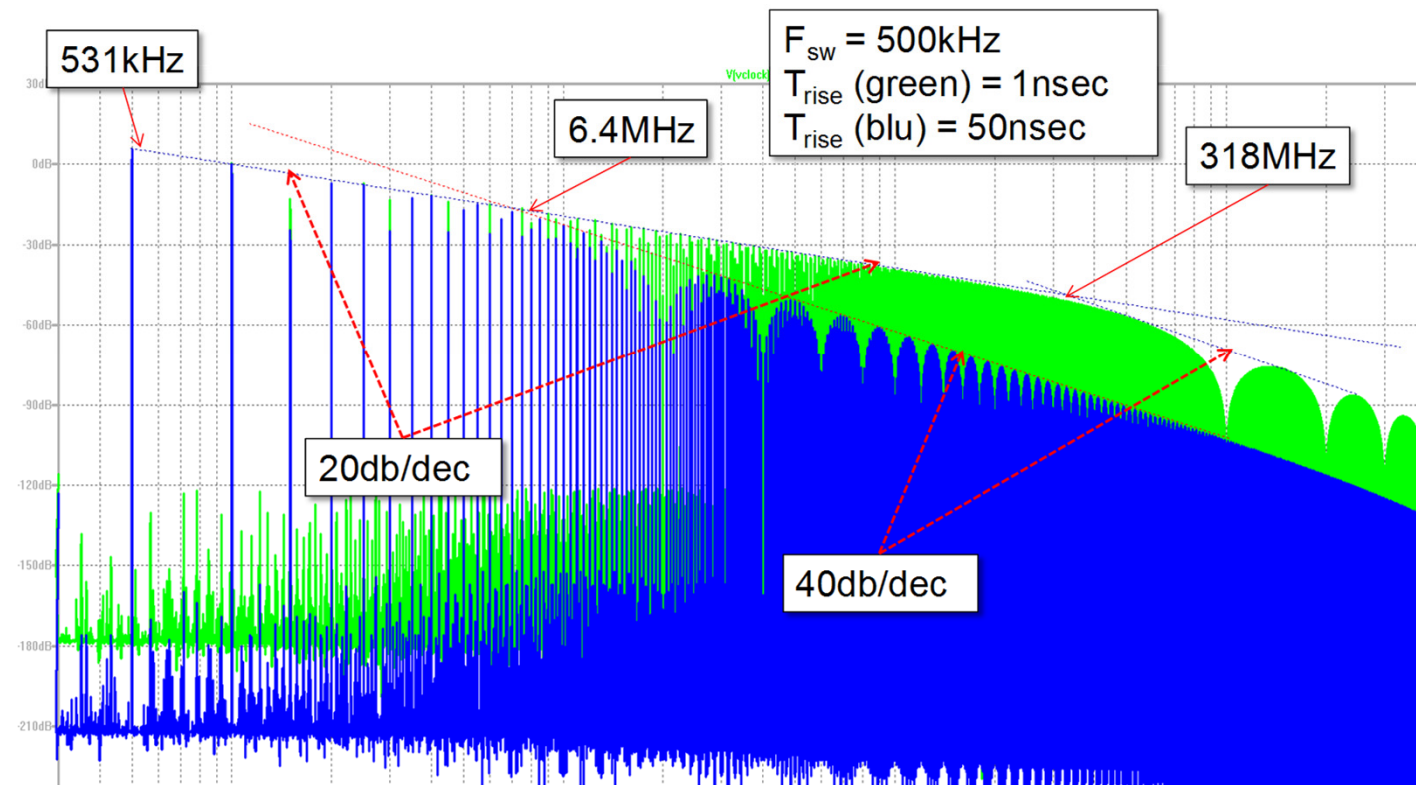
ESD / Transient protection : Coupling planes

- ESD, although applied as a contact discharge, due to the speed of the pulse it also produces a radiated E field from the Vertical or Horizontal Coupling plane.



ESD / Transient protection :

- Magnetics do not protect against ESD : Example LAN



ESD / Transient protection : WE products

WE-TVS

(Standard Series / High Speed / Super Speed)

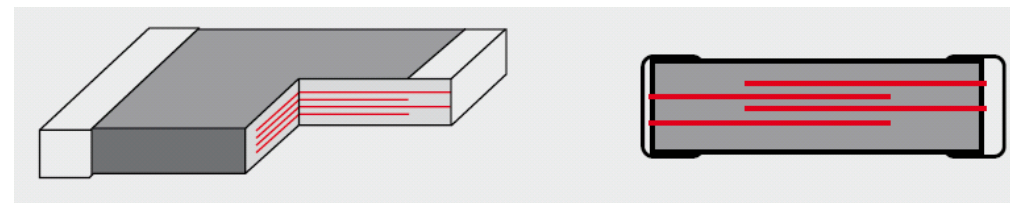


WE-TVSP

DC Power diodes



WE-VS / WE-VE(ULC)/ WE-VEA(ULC)



ESD / Transient protection: Selection process

ESD suppressor differ from SMD varistor in their lower and specified capacitance.

- 1. Determine the Operating Voltage**
Checking the typical application
- 2. Selection of the correct value of capacitance**
- 3. Checking the max clamping voltage**



The selection of a TVS diode is the same as above with the following differences:

- 1.** TVS can be uni or bi-directional
- 2.** V_{DD} pin has to be connected in some cases

ESD / Transient protection: Selection process

1. Determine the Operating Voltage Checking the typical application

Is it possible to choose a component with a higher permissible op Voltage: the leakage current will be lower but Clamping voltage higher.

Checking the application, will let the choice easier.

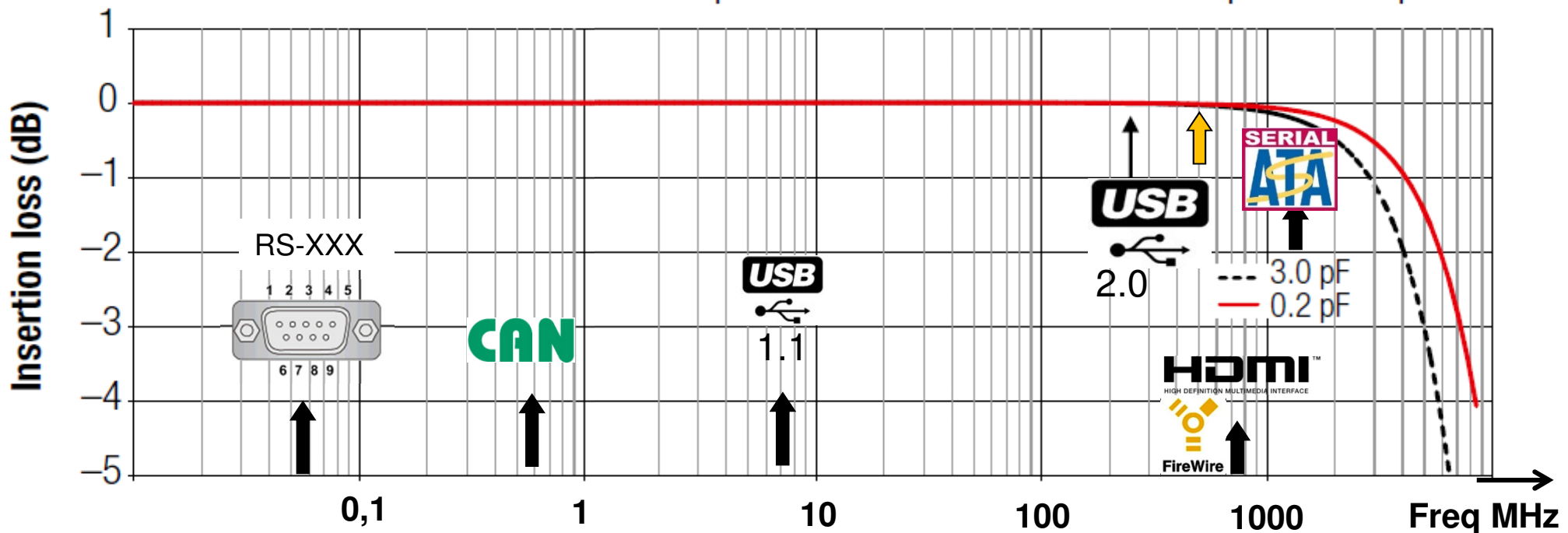
Electrical properties: Size 0402							
Order Code	V _{DC} (V)	C (pF)	V _C (V)	I _{Leak} (μA)	R (MΩ)	Typical Applications	Qty.
823 57 050 100	5	10	60	1	10	USB 1.1/RS-232/LAN 10 Mbit	10000
823 57 050 220	5	22	55			CAN Bus	
823 57 050 330	5	33	55			RS-422	
823 57 050 560	5	56	55			RS-422 & IrDA 1.0	
823 57 120 050	12	5	80			USB 1.1/USB 2.0	
823 57 120 100	12	10	60			USB 1.1/RS-232/LAN 10 Mbit	
823 57 120 220	12	22	55				
823 57 240 010	24	1	200				
823 57 240 030	24	3	180			USB 2.0/LAN 100 Mbit	

ESD / Transient protection: Selection process

2. Selection of the correct value of capacitance

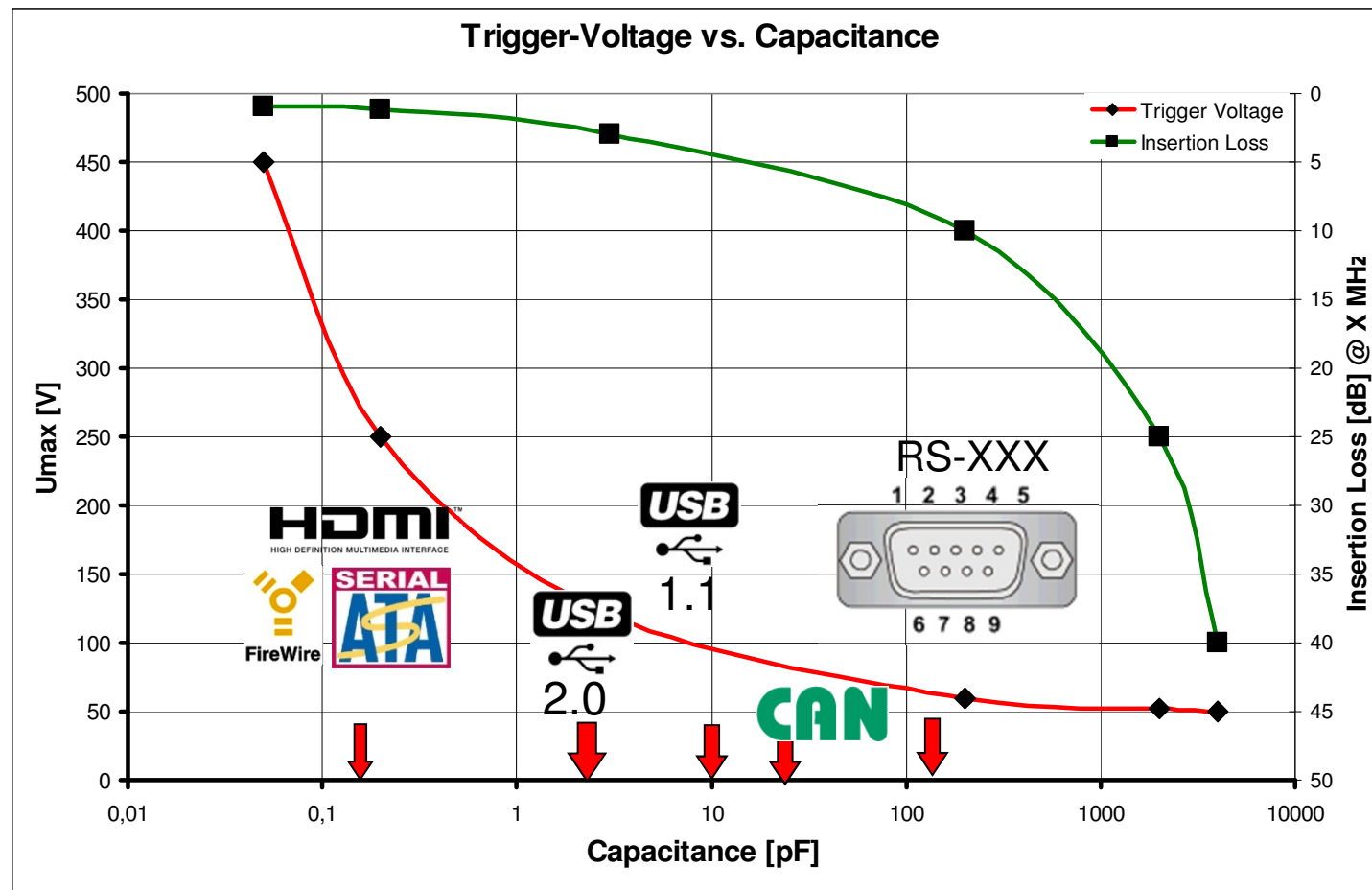
For signal integrity, it is important to select a capacitance to match the data rate.

Comparison of the insertion loss of 0.2 pF and 3.0 pF



ESD / Transient protection: Selection process

2. Selection of the correct value of capacitance



ESD / Transient protection: Selection process

3. Checking the max clamping voltage

The Clamping Voltage is a measure for the protection of the ESD suppressor. This should be lower than the voltage stability of the circuit to be protected.

Electrical properties: Size 0402							
Order Code	V _{DC} (V)	C (pF)	V _C (V)	I _{Leak} (μA)	R (MΩ)	Typical Applications	Qty.
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823 57 050 220	5	22	55			CAN Bus	
823 57 050 330	5	33	55			RS-422	
823 57 050 560	5	56	55			RS-422 & IrDA 1.0	
823 57 120 050	12	5	80			USB 1.1/USB 2.0	
823 57 120 100	12	10	60			USB 1.1/RS-232/LAN 10 Mbit	
823 57 120 220	12	22	55				
823 57 240 010	24	1	200				
823 57 240 030	24	3	180			USB 2.0/LAN 100 Mbit	

ESD / Transient protection: TVS Selection process

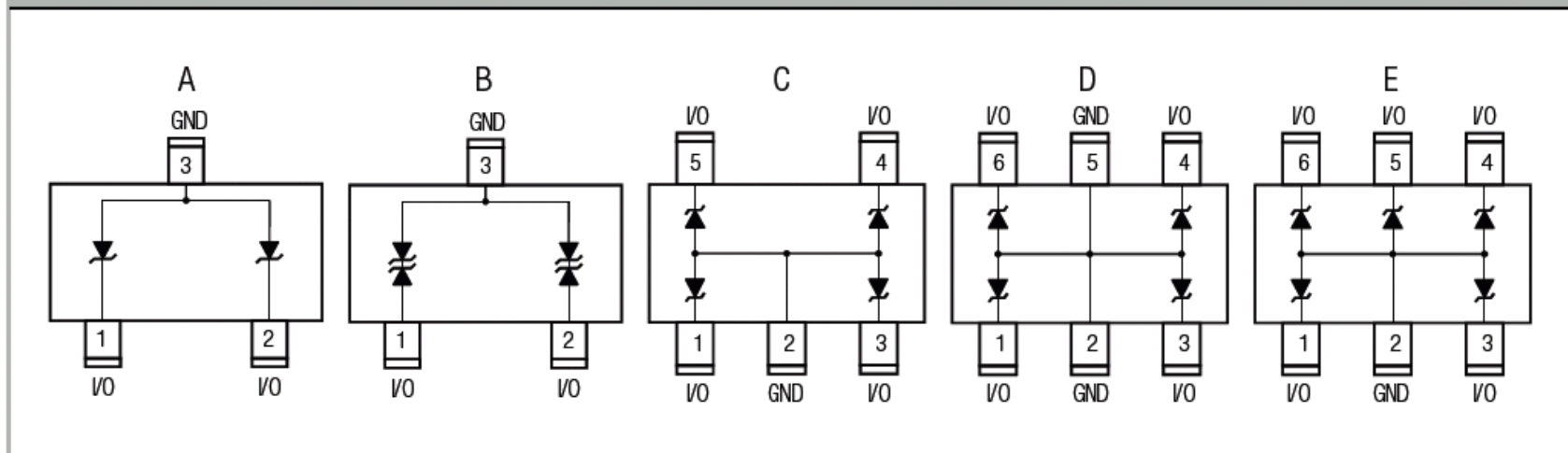
Electrical properties (3.3 V Operating Systems)

The selection could be done also for uni- or bi-directional behaviour.

Schematic A for unidirectional

Schematic B-C-D-E for bi-directional

Schematics



824 001	SOT23-6L	6.2	1.0	5	2	9.0	14	15/8
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ir/Contact
(V)

/24

ir/Contact
(V)

/12

/12

/12

ir/Contact
(V)

5/8

p ESD
(V)

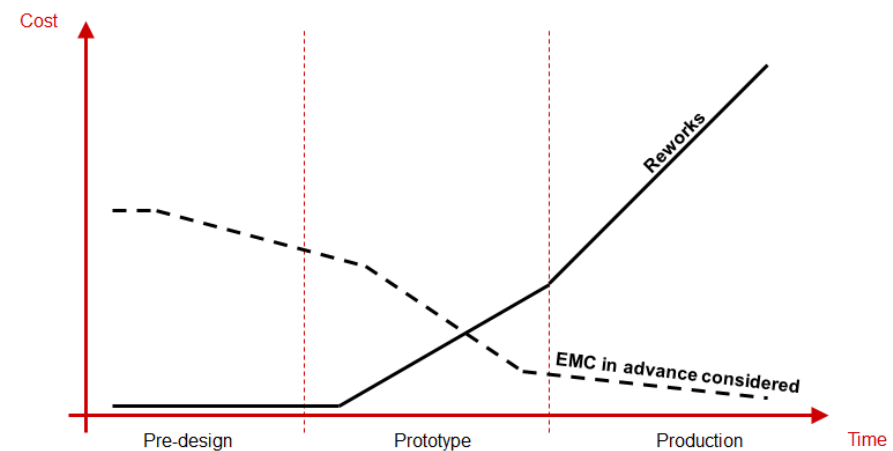
V_{ESD Air/Contact}
(kV)

16/12

20/12

ESD / Transient protection: Rationale

- ESD protection should be part of the original system design.
- ESD hardening of a system involves the electrical, mechanical.
- Digital circuits are more sensitive to ESD upset than analog circuits.
- ESD has a spectral content of 100÷4GHz freq range.
- Ribbon cables are especially susceptible to ESD (textile WE-TS could be useful).
- All loop areas on PCB should be kept as small as possible.
- Multilayer boards will be an order of mag less susceptible to ESD than double-sided boards.
- Ferrites can be effective in limiting ESD currents.





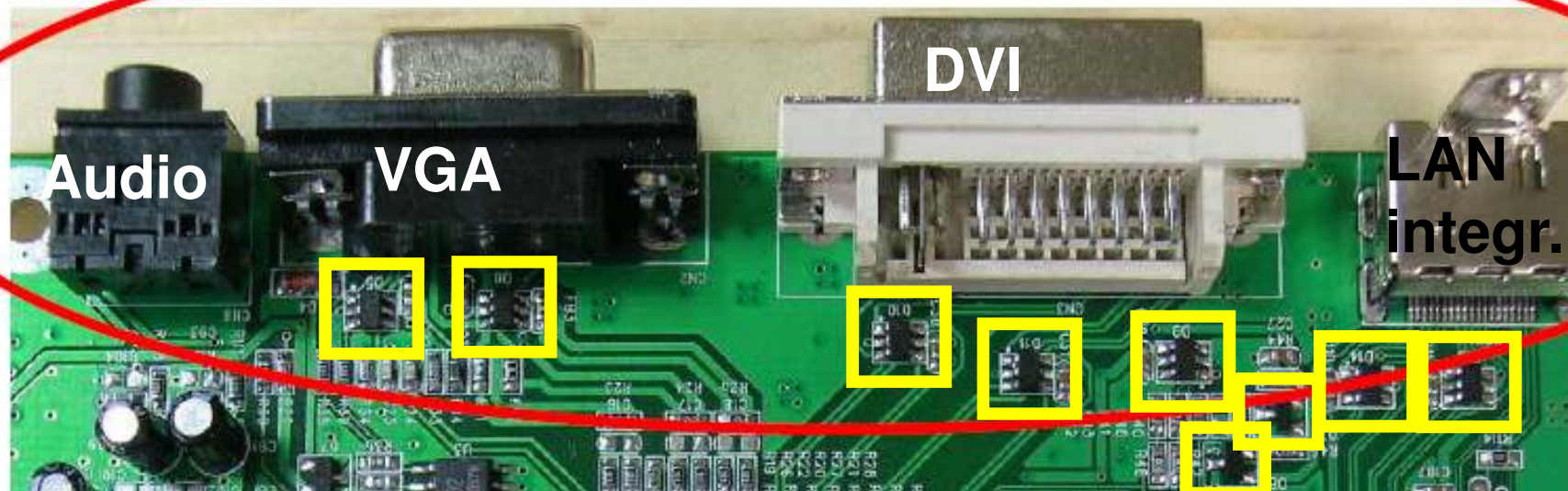
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PCB Layout recommendation

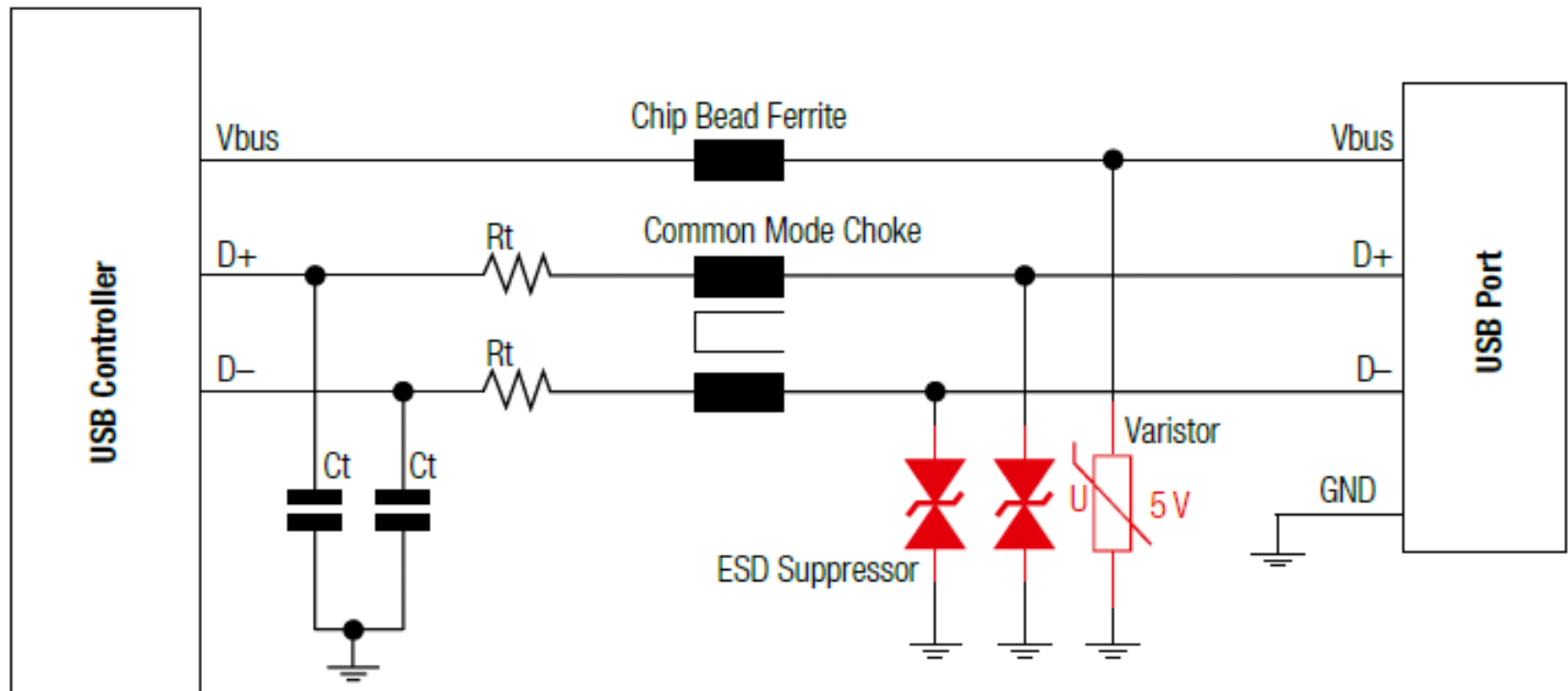
WE-TVS protect data lines from ESD

They are mounted close to connectors & antennas

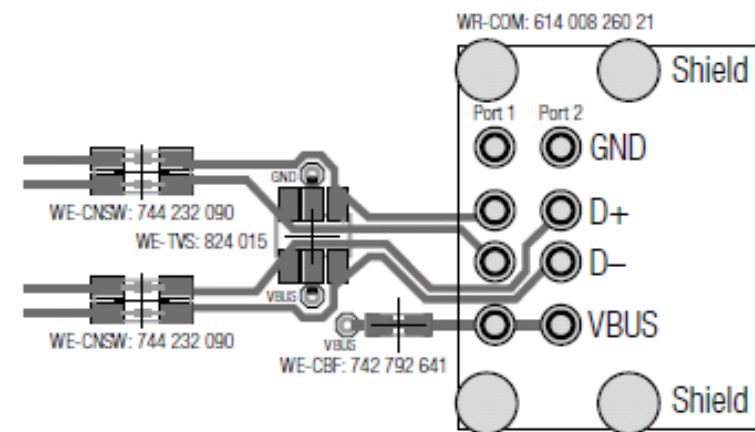
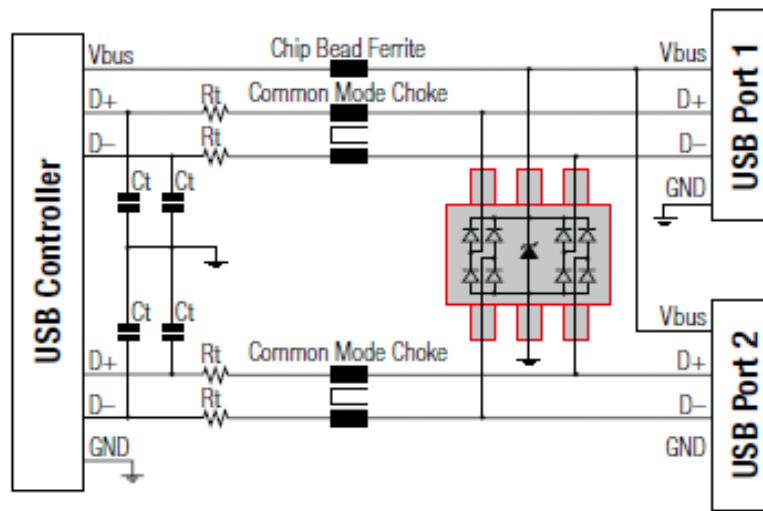
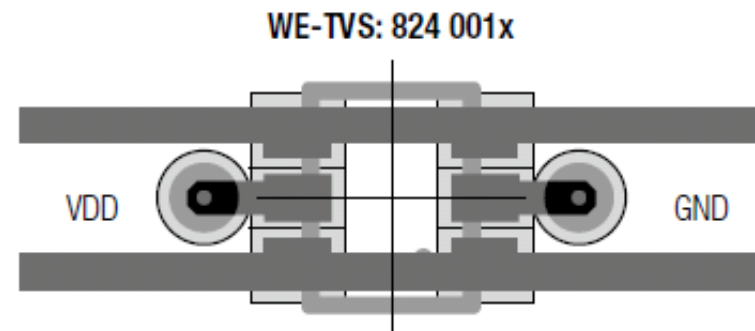
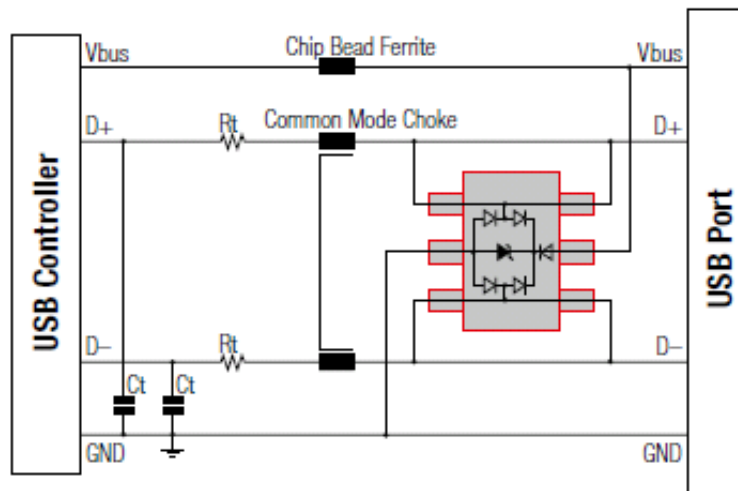
I/O ports



USB 2.0 : discrete parts

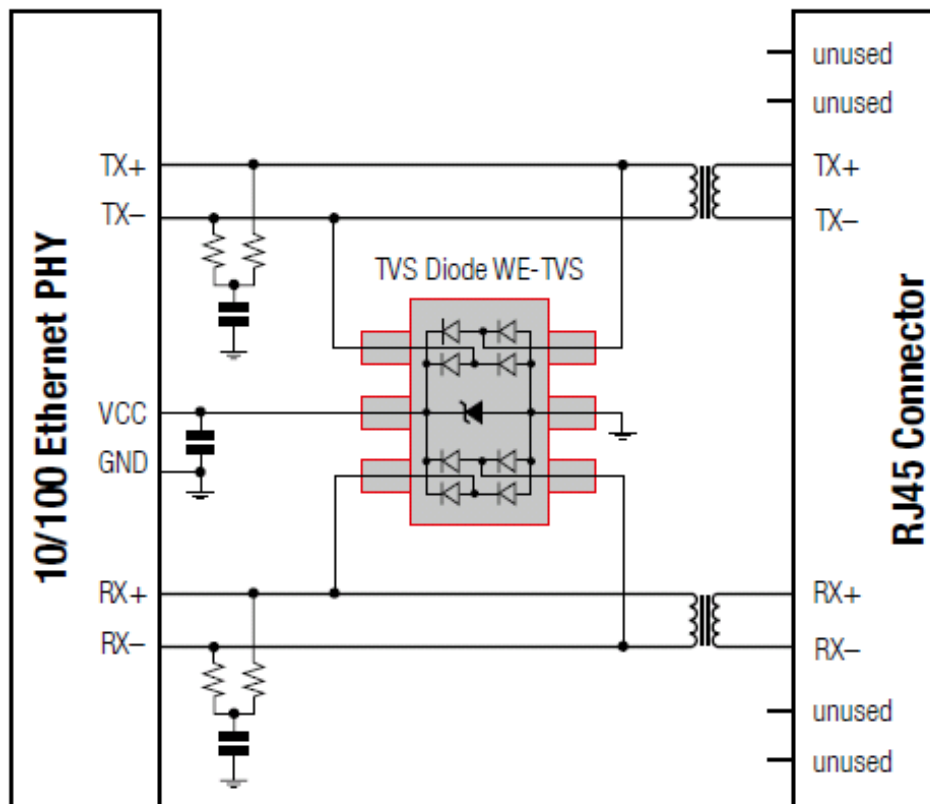


USB 2.0 : With TVS

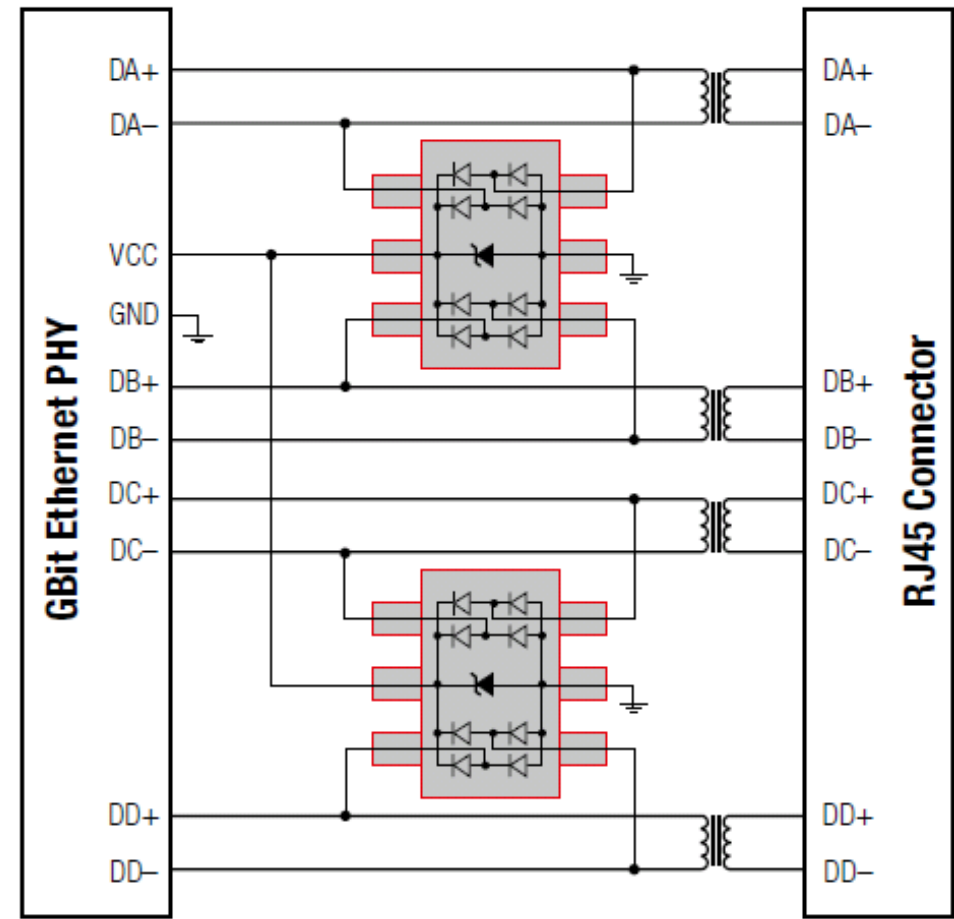


Ethernet: with TVS

10/100BaseT



1000BaseT





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