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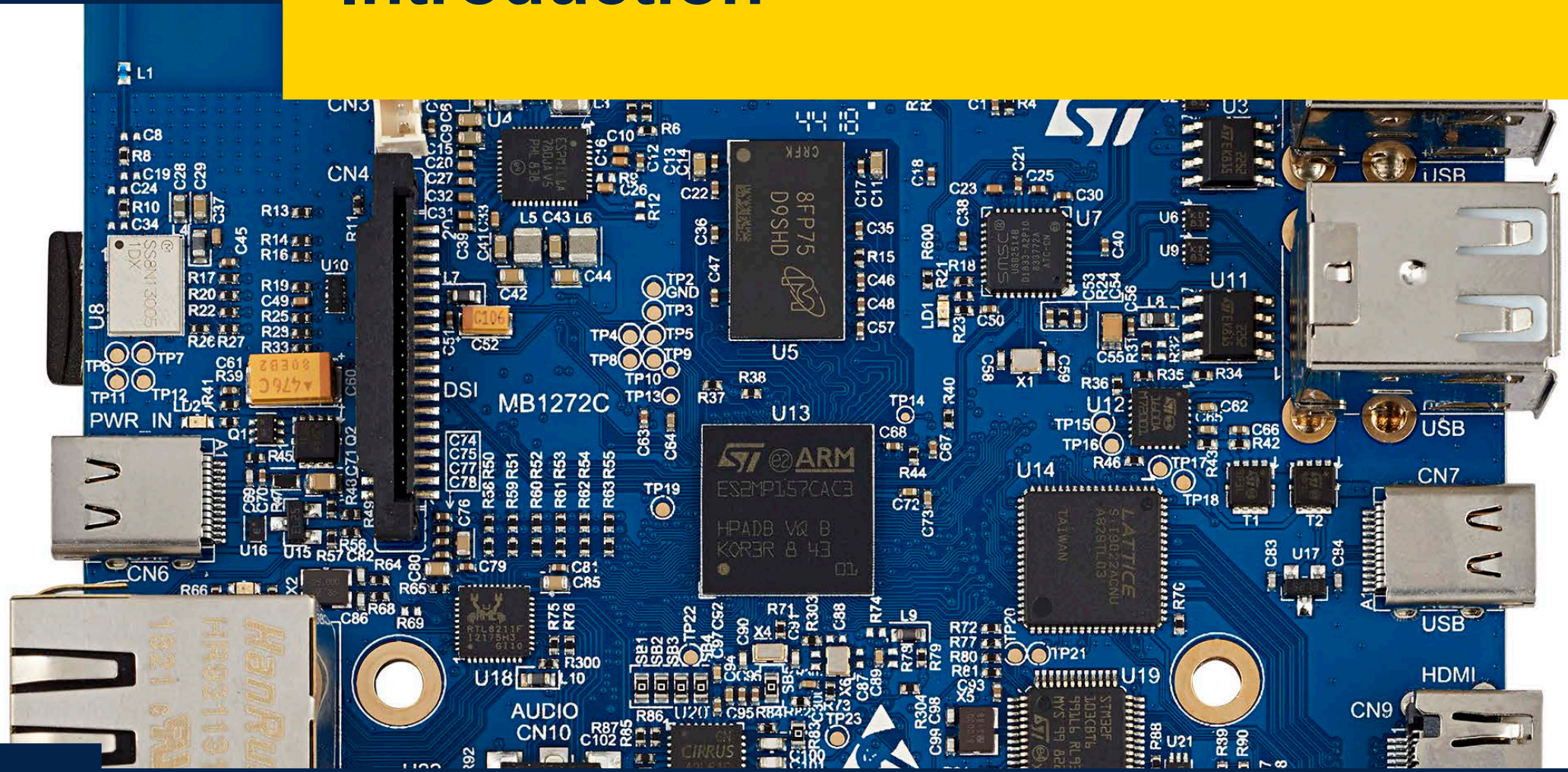
How to protect applications against ESD

EMC - system immunity against electrostatic discharges

January 2021

Introduction



Defining EMC immunity

What is EMC immunity ?

- EMC Immunity is the ability of an equipment to properly operate in its electromagnetic environment by limiting the interference of electromagnetic energy that may cause physical damage.

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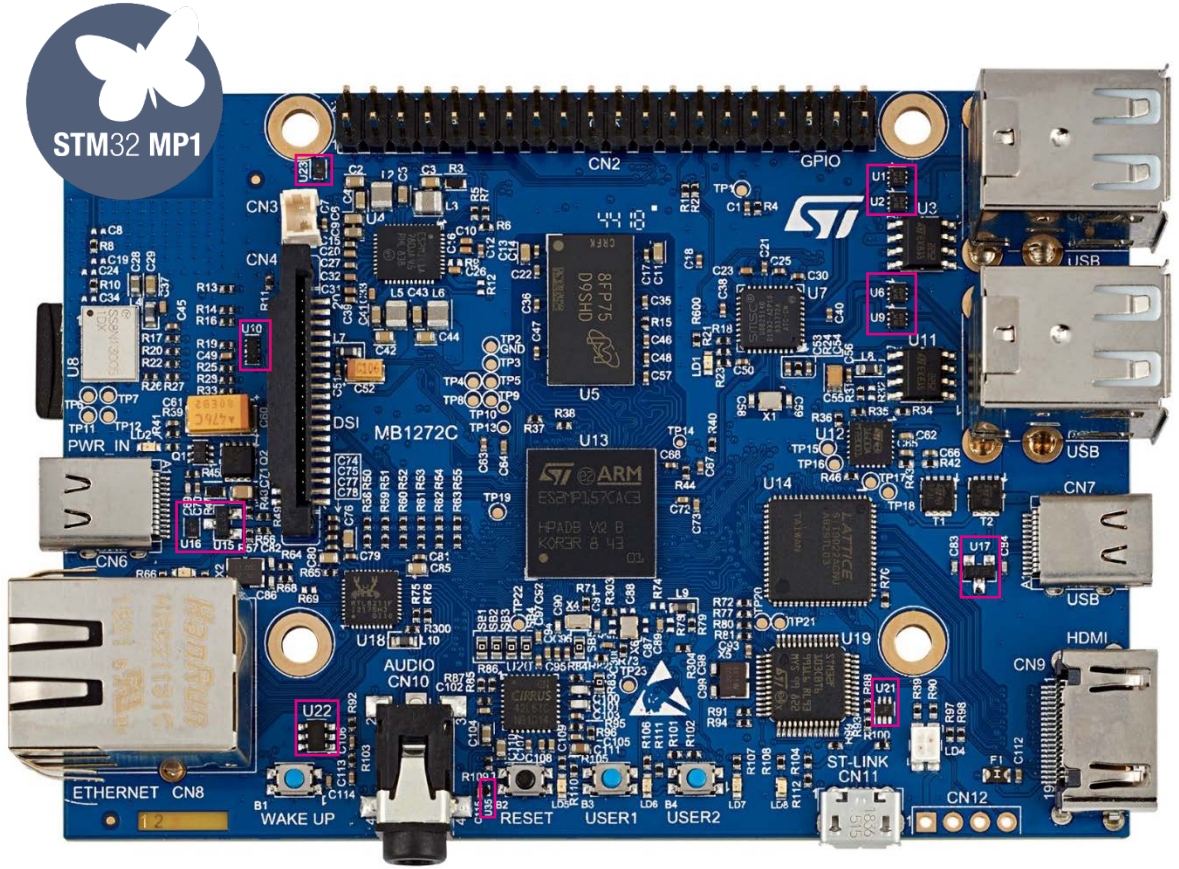
EMC immunity example discovery kit: STM32MP157A-DK1

MORPHO CONNECTOR
ESDA7P120-1U1M
5V Vin

MICRO SD CARD
HSP051-4M10 (x2)
SDMMC dataline

USB Type-C Power Delivery
ESDA7P120-1U1M, ESDA25L
VBUS
CC1, CC2

ETHERNET
HSP053-4M5



USB HOST x2 (Dual USB Type-A)
ESDA7P120-1U1M (x2), ECMF02-2AMX6 (x2)
VBUS
DP, DM

USB HOST x2 (Dual USB Type-A)
ESDA7P120-1U1M (x2), ECMF02-2AMX6 (x2)
VBUS
DP, DM

USB Type-C DRP (Source Only)
ESDA7P120-1U1M, ESDA25L, ECMF02-2AMX6
VBUS
CC1, CC2
DP, DM

HDMI
ECMF04-4HSWM10 (x2), ESDALC6V1-5M6
TMDS datalines
CEC, I2C, HPD

AUDIO
ESDA6V1BC6: 4-line ESD protection
OUTA, OUTB, MIC IN

USER BUTTONS
ESDALC6V1-1U2

ST-LINK USB CONNECTOR
USBLC6-2P6
DP, DM, VBUS

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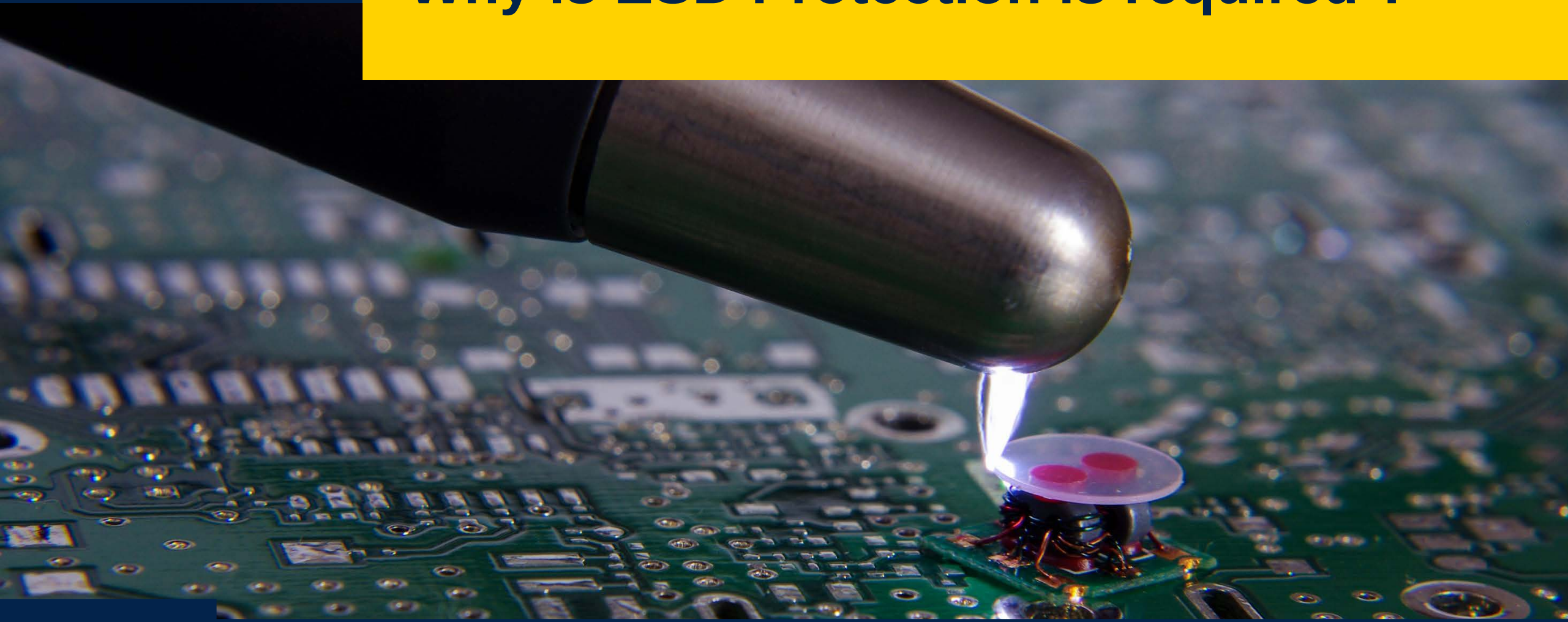
STM32 MPU by

Agenda

1. Why is ESD protection is required ?
2. How to select an ESD protection device ?
3. ESD layout guidelines
4. Application examples
5. Our ESD protection device portfolio

Why is ESD Protection is required ?



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How is ESD generated ?

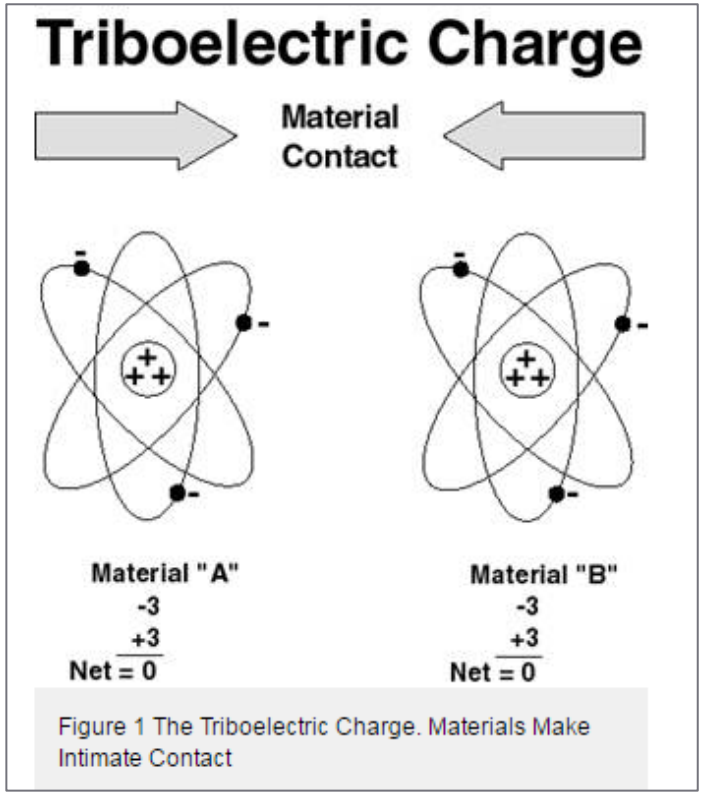


Figure 1 The Triboelectric Charge. Materials Make Intimate Contact

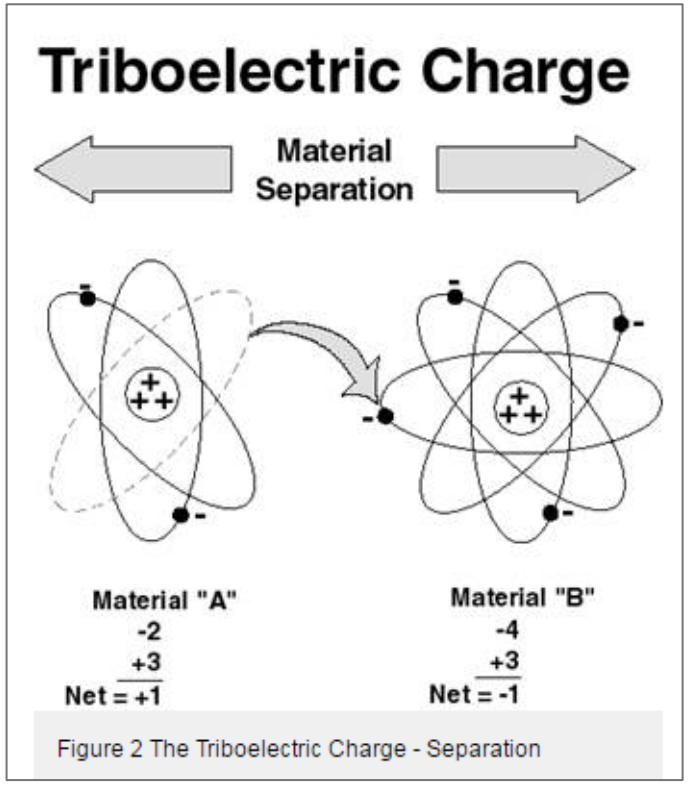


Figure 2 The Triboelectric Charge - Separation

Table 1 Examples of Static Generation - Typical Voltage Levels		
Means of Generation	**10-25% RH**	**65-90% RH**
Walking Across Carpet	35,000V	1,500V
Walking Across Vinyl Tile	12,000V	250V
Worker at a Bench	6,000V	100V
Poly Bag Picked up from Bench	20,000V	1,200V
Chair with Urethane Foam	18,000V	1,500V

Source: https://www.esda.org/about-esd/esd-fundamentals/part-1-an-introduction-to-esd/

ESD damage to ICs

White Paper on Electrical Overstress – EOS Industry Council on ESD Target Levels

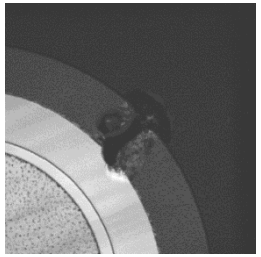
In preparation for this white paper, the Industry Council conducted a worldwide survey of the electronics industry concerning EOS. Results confirmed the long-held view that EOS is consistently one of the “high bars” on product failure Pareto charts. Looking at the EOS survey, respondents reported greater than 20% of total failures being EOS-related or **30% of total electrical failures being EOS-related**, making EOS the largest bar on the Pareto chart of that responder’s known causes of returns.

Source: esdindustrucouncil.org

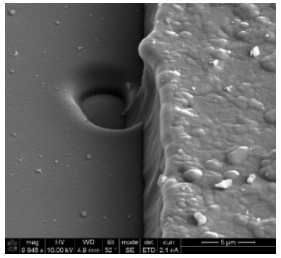
“30% of total electrical failure is EOS -related”

Source: STMicroelectronics

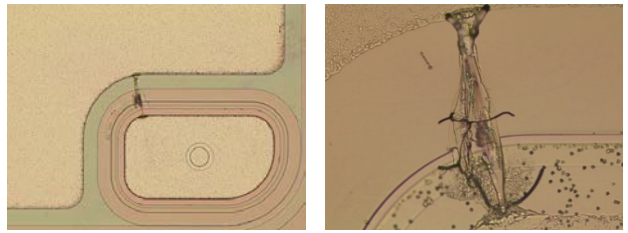
Silicon melting



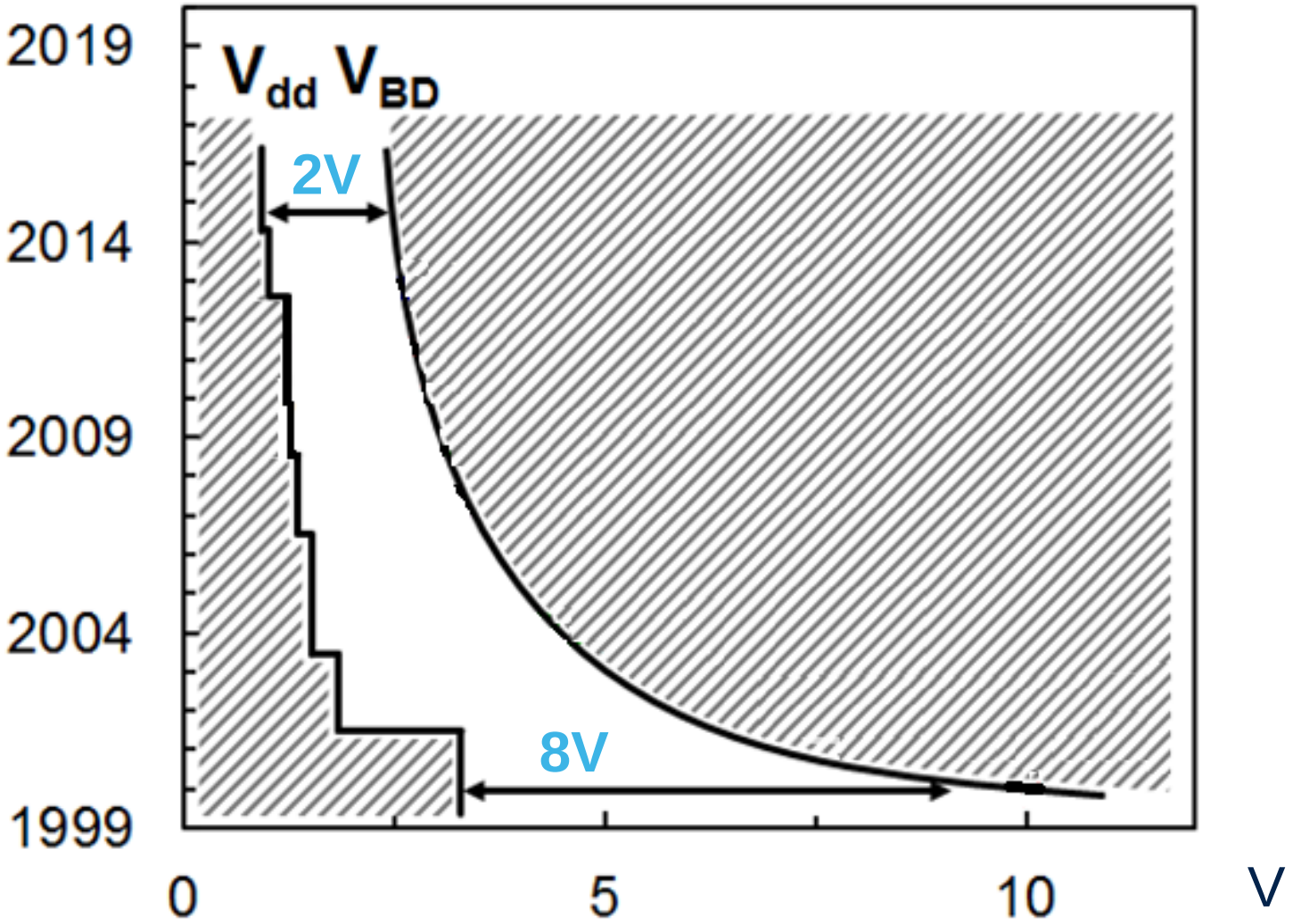
Hole in the oxide



Melting Flash

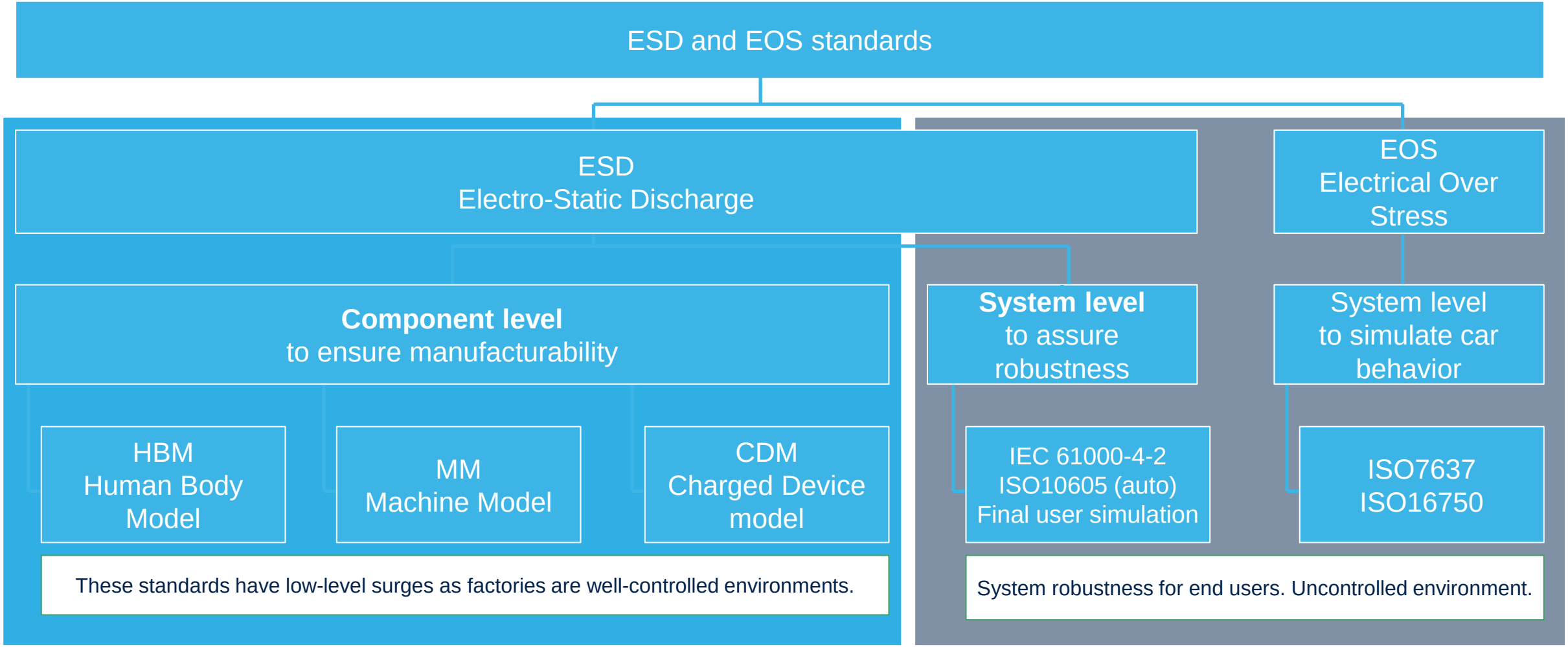


IC sensitivity to ESD is increasing



V_{dd} = power supply voltage
V_{BD} = breakdown voltage

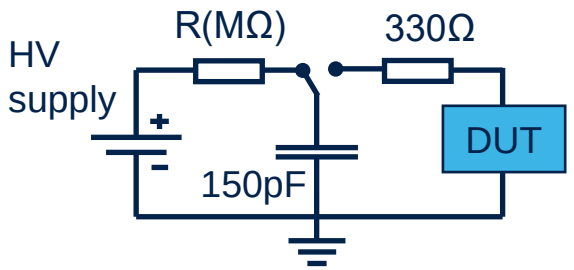
ESD and EOS standards



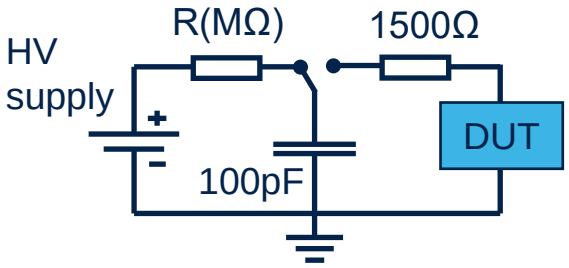
HBM and IEC standards

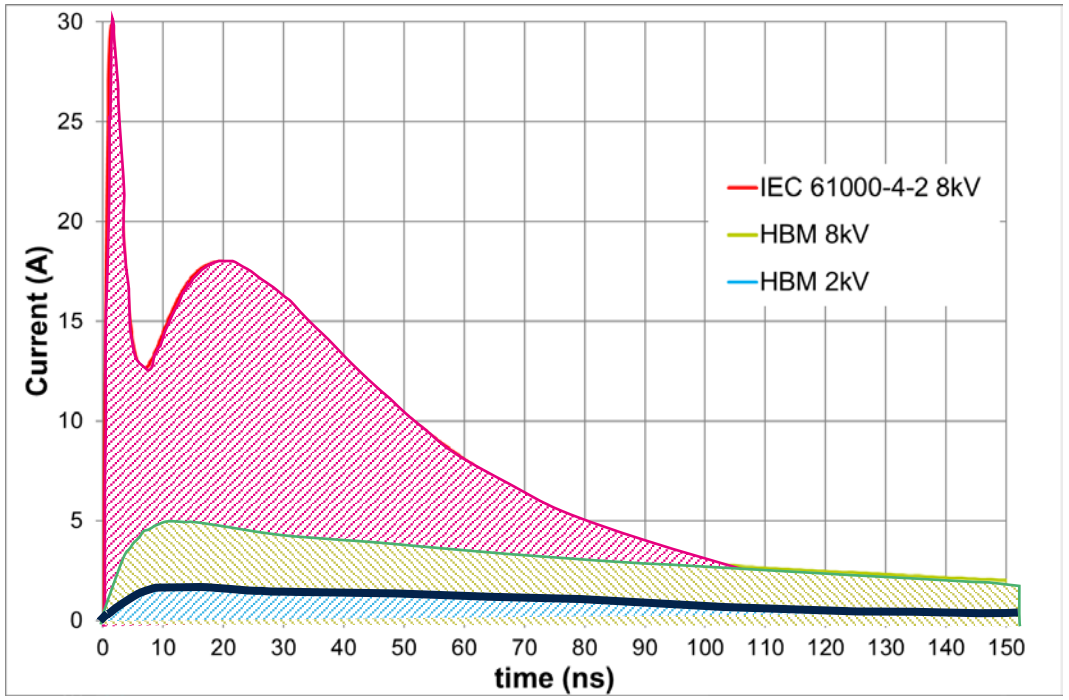
Difference in standards : IEC 61000-4-2 carries more energy than HBM

IEC 61000-4-2 for system
(+/-8kV for level 4)



Human Body Model for IC
(+/-2kV for most of IC)





Energy for 8kV IEC 61000-4-2

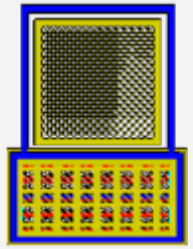
Energy for 8kV HBM

Energy for 2kV HBM

Component level vs system level silicon die area comparison

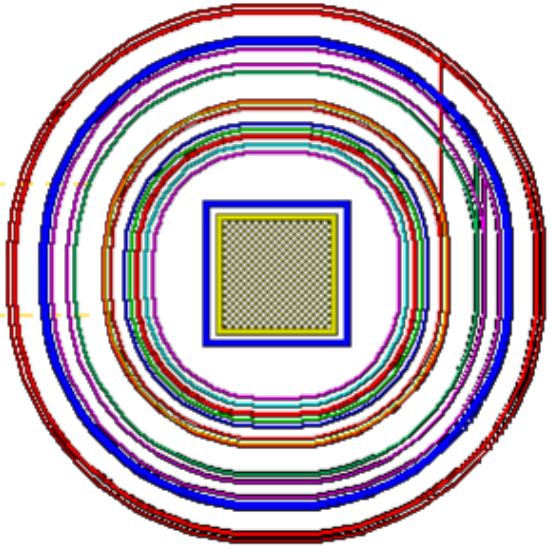
Silicon die area for component level ESD

(2 kV HBM)



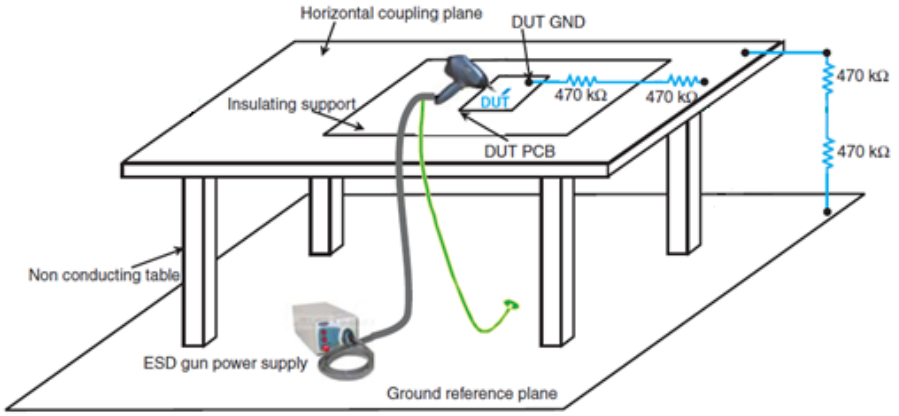
Silicon die area for system level ESD

(8 kV IEC contact)



System-level ESD protection standard IEC 61000-4-2 test bench

	Contact discharge	Air discharge	
Stress Level	Test Voltage (kV)	Test Voltage (kV)	Number of dischargeq
1	2	4	At least 10 single discharges at 1 Hz in the most sensitive polarity
2	4	6	
3	6	8	
4	8	15	



System state as a result of system–level ESD stress	
A	Normal performance
B	Temporary loss of function or degradation of performance which cease after the disturbance ceases. The DUT recover its normal performance , without operator intervention
C	Temporary loss of function or degradation of performance , the correction of which requires operator intervention
D	loss of function or degradation of performance, no recovery possible

Self-restored

Require a system reset

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ESD in automotive: ISO 10605

Configuration	Mode	Component acessible from:	Test (A= Air C= contact)	Capacitance	Resistance	Max test voltage	Operating conditions	Min number of discharges	Min. time interval	Max suggested severity levels (ISO10605 Annex C)
Component	Direct	Inside	A & C	330 pF	330 ohm	-	Powered	3	1s	15 kV C 25kV A
Component	Direct	Outside	A & C	150 pF	330 ohm	-	Powered	3	1s	15 kV C 25kV A
Component	Indirect	Inside	C	330 pF	330 ohm	-	Powered	50	50ms	20kV C
Component	Indirect	Outside	C	150 pF	330 ohm	-	Powered	50	1s	20kV C
Component packaging and handling	Direct	NA	A & C	150 pF	330 or 2000 ohm	-	Unpowered	3	1s	
Vehicle test	Direct	Inside	A & C	330 pF	330 or 2000 ohm	15 kV	Engine drive or idle	3	1s	8kV C 15kV A
Vehicle test	Direct	Outside	A & C	150 pF	330 or 2000 ohm	25 kV	Engine drive or idle	3	1s	8kV C 25kV A

How to select an ESD protection device?

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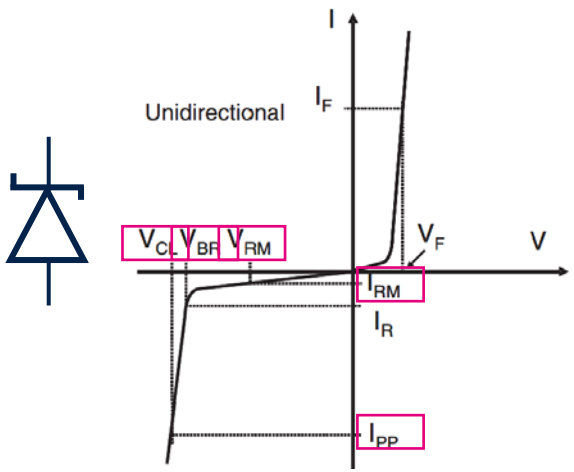
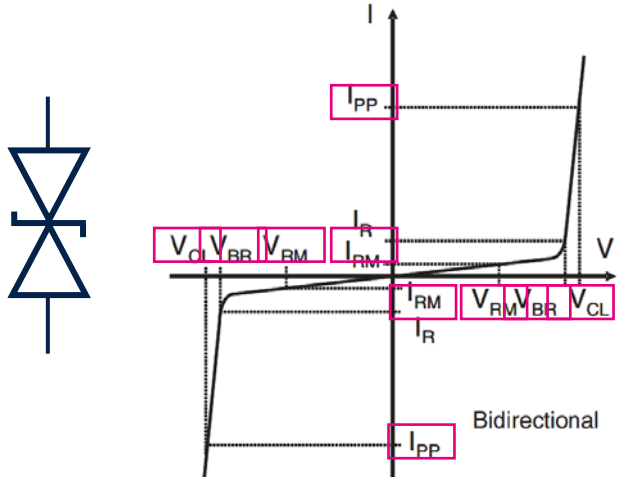
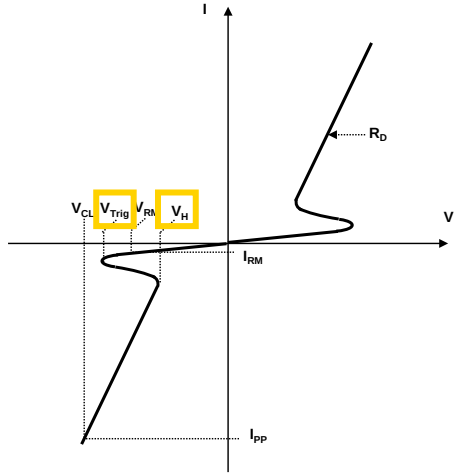
Key parameters

Parameters	Description
V_{RM}	Stand-off voltage (normal condition voltage)
I_{RM}	Leakage current
V_{BR}	Breakdown voltage (voltage when the ESD protection starts working)
V_{CL}	Clamping voltage (maximum voltage across the ESD protection)
I_{PP}	Peak Pulse Current (maximum current in the ESD protection)
C	Line capacitance (impacts signal integrity)
V_{trig}	Snap-back ESD protection turns-on at trigger voltage (VTrig). The protection voltage has a snap-back effect in order to lower the clamping voltage
V_H	Holding voltage (lowest voltage when the protection has turned-on and as consequence a lower voltage induce the turn-off of the protection)

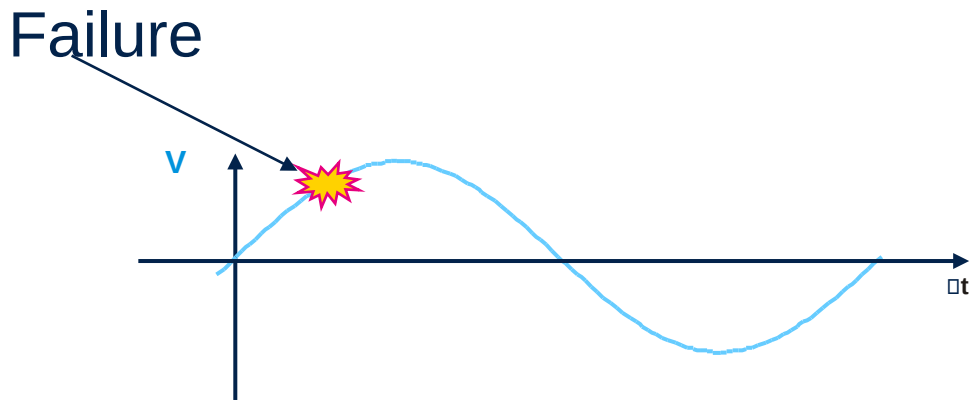




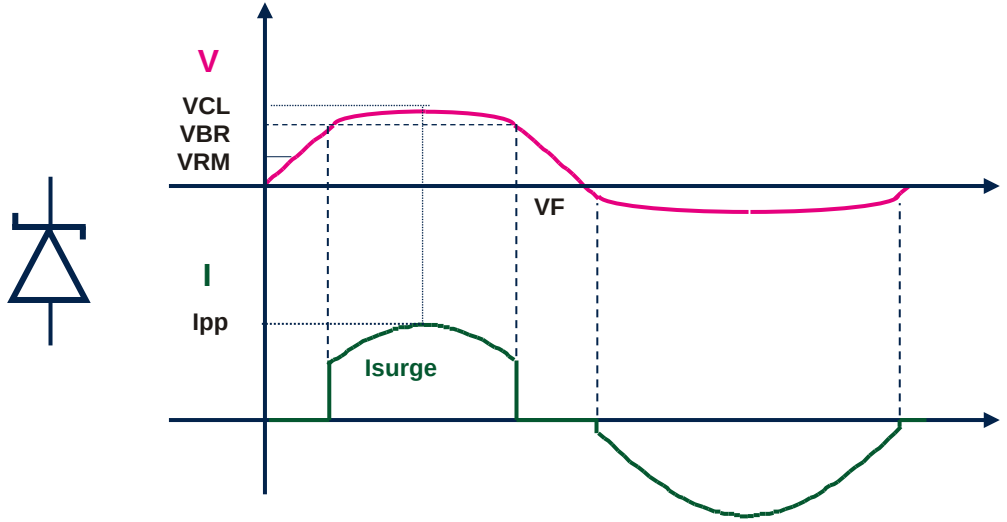


Protection selection key parameter: voltage

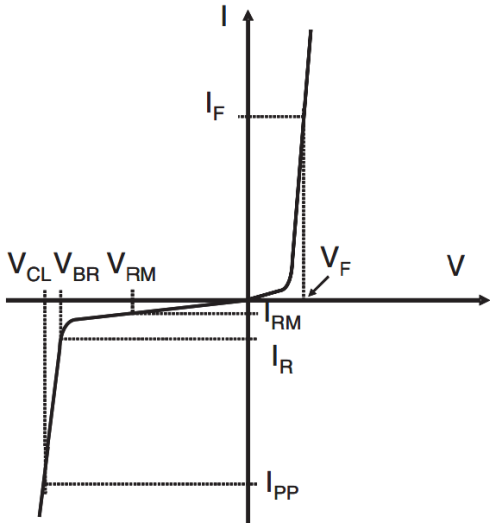
No TVS protection



With TVS protection

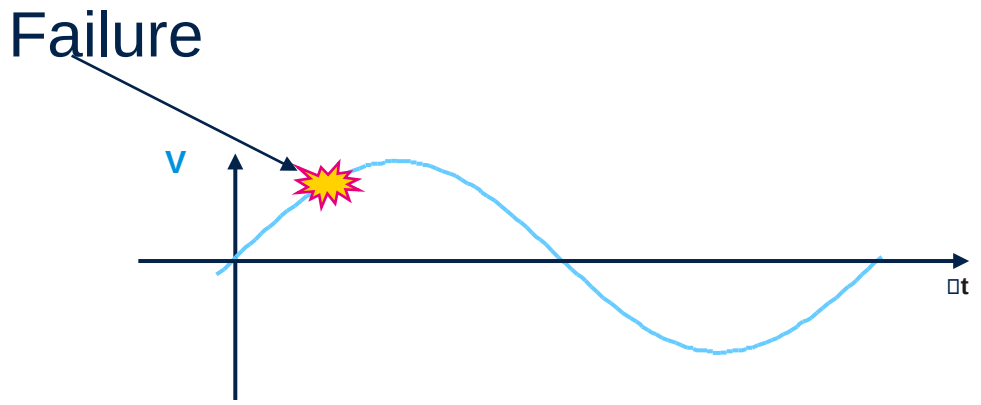


Uni-directional

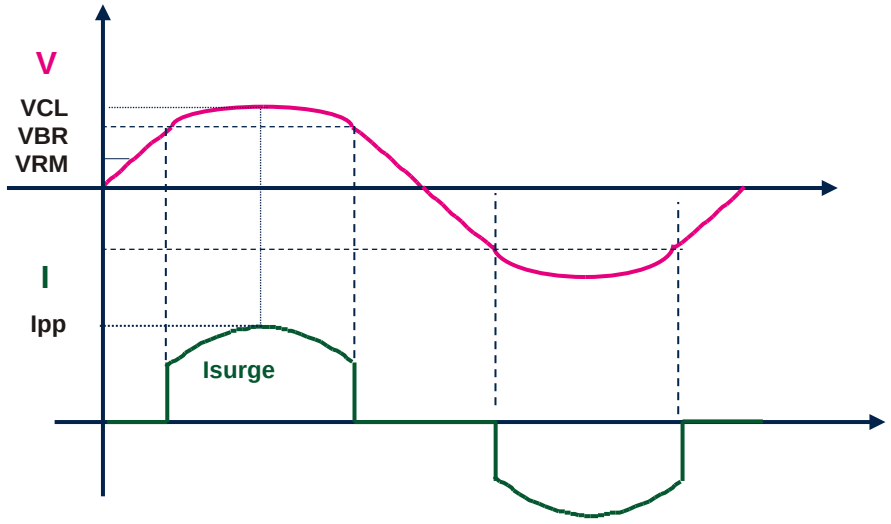


Key parameters voltage polarity

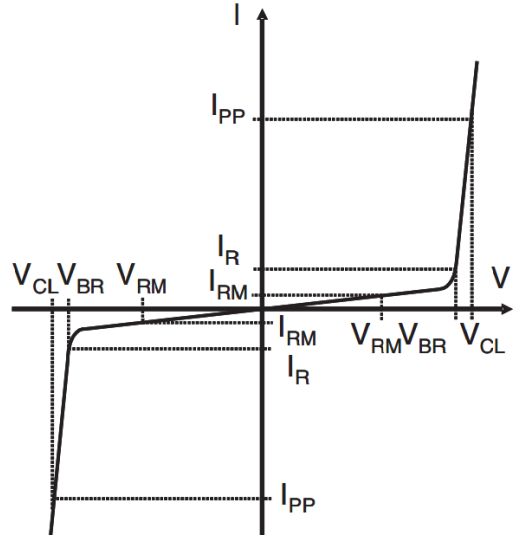
No TVS protection



With TVS protection



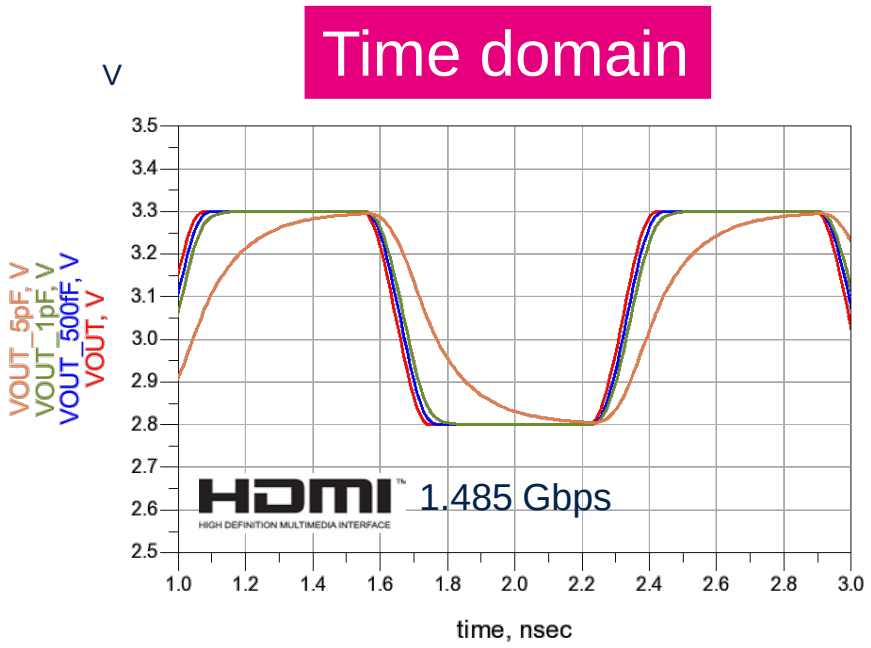
Bi-directional

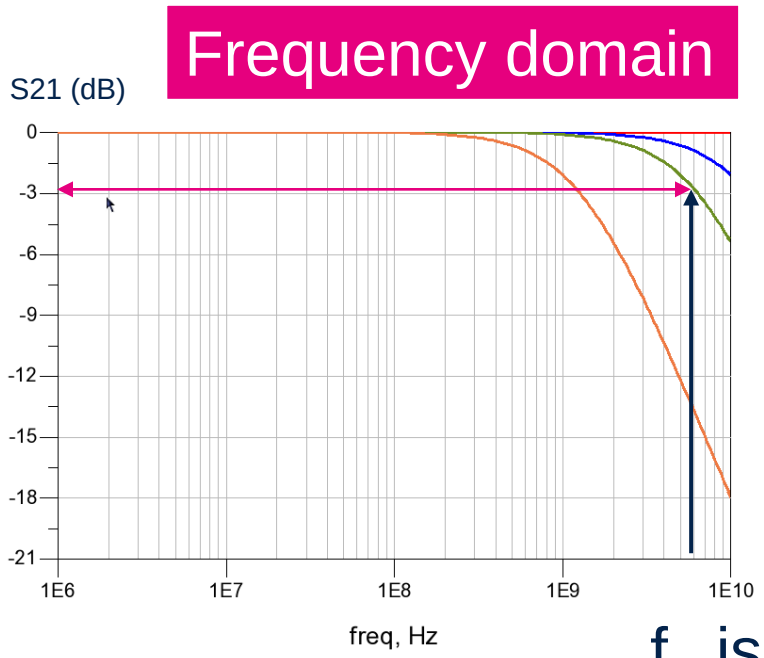


- Mandatory for audio and RF signals

Key parameters capacitance value

- Example of the impact of parasitic capacitance on high-speed signal simulated with discrete capacitance

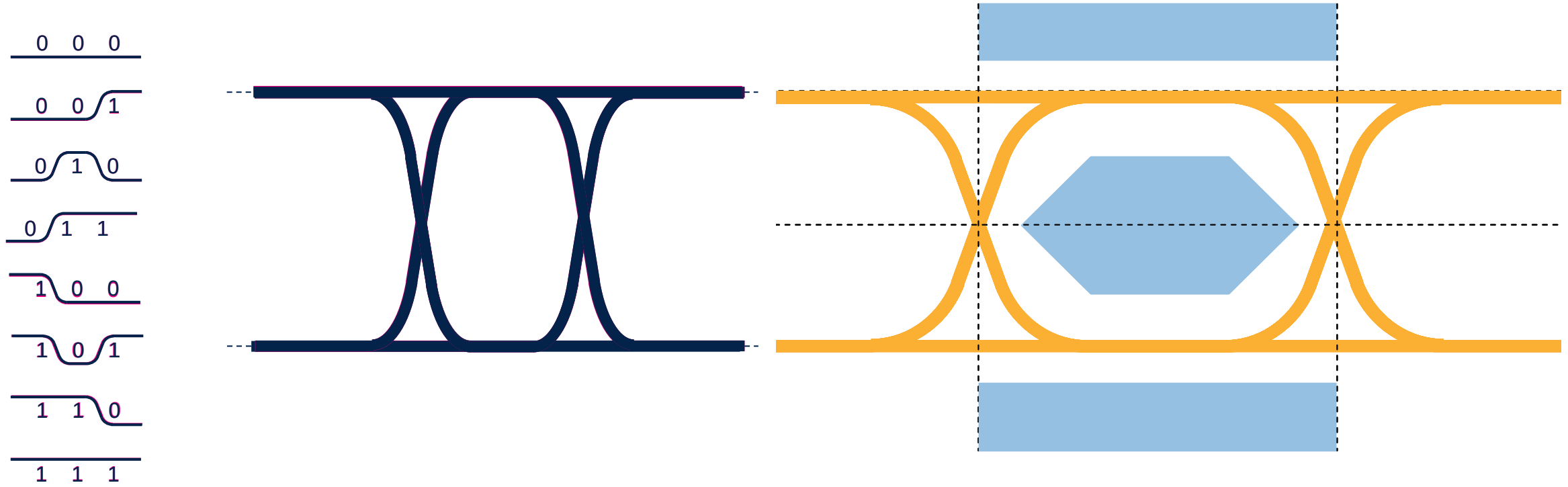




$$f_c = \frac{1}{\pi t_r}$$

f_C is high enough to comply with HDMI 1.485 Gbps

Eye diagram
What is an eye diagram?



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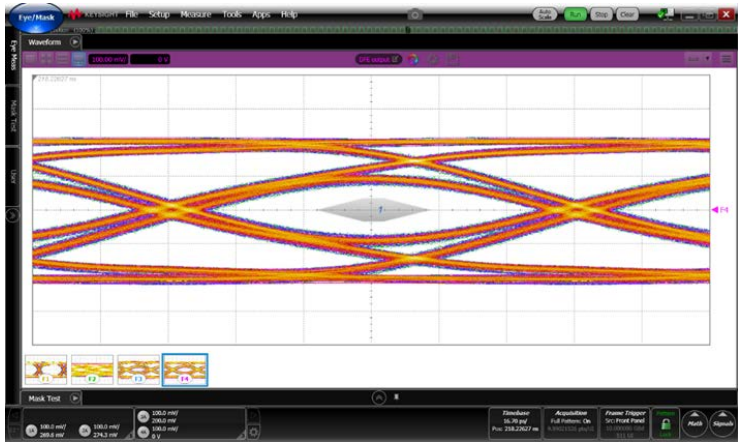
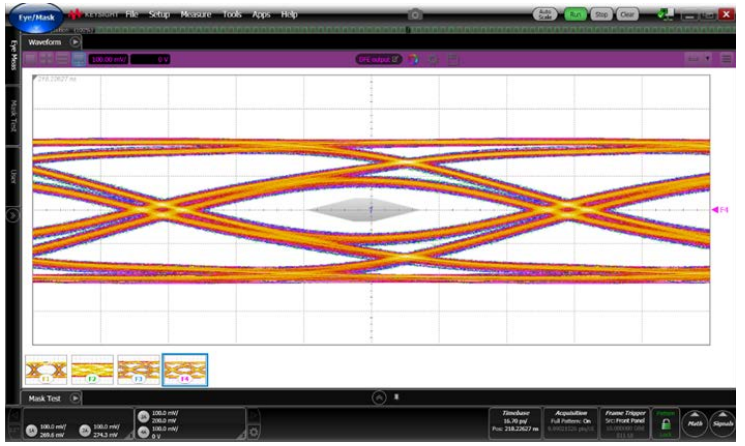
Impact on data-lines eye diagram integrity

- USB 3.1 Gen2 mask at 10.0 Gbps per channel
  (Type-C connector, reference cable, EQ with DC=6dB and DFE)



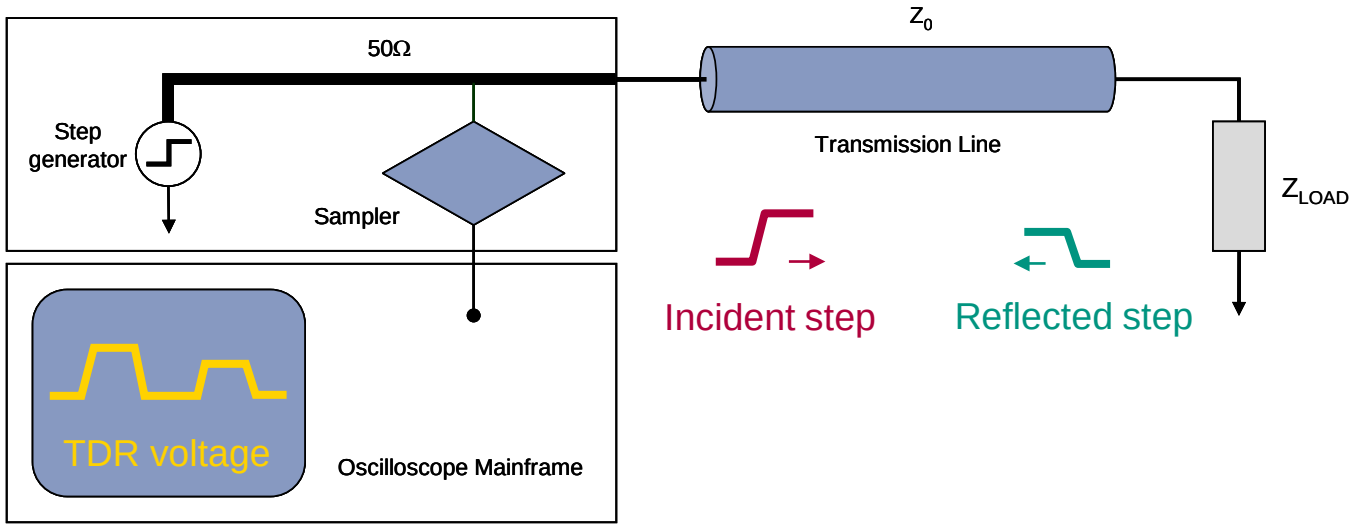
Line without HSP053-4M5

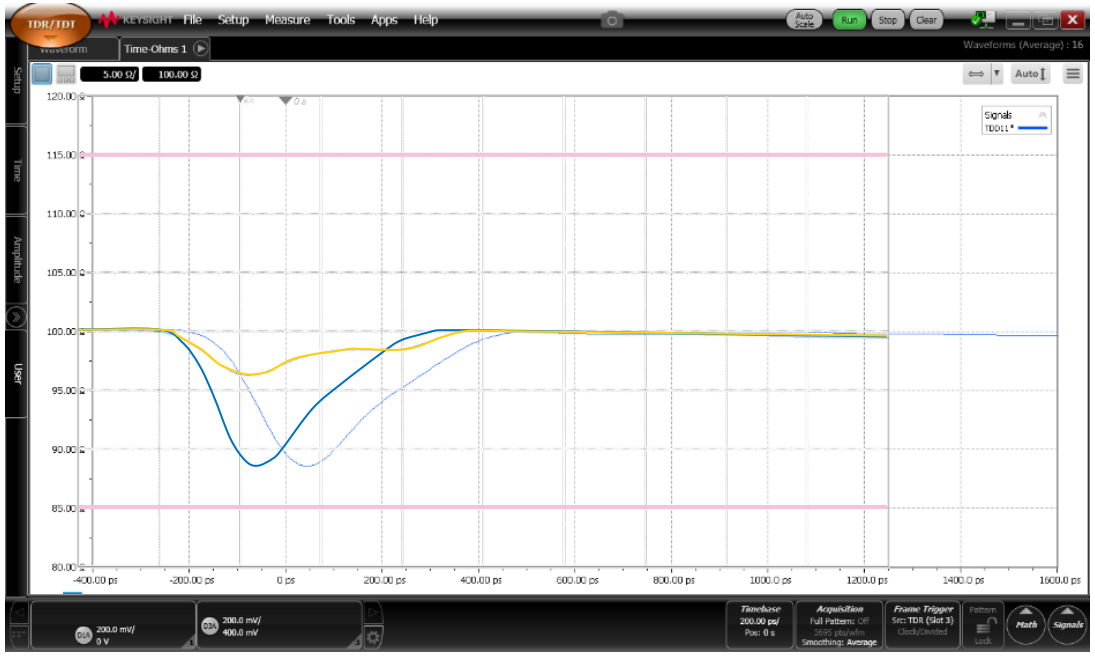


Line with HSP053-4M5

Impact on data-lines time domain reflectometer impedance

TDR with 200ps pule rise time impedance of 100Ω line without / with HSP053-4M5

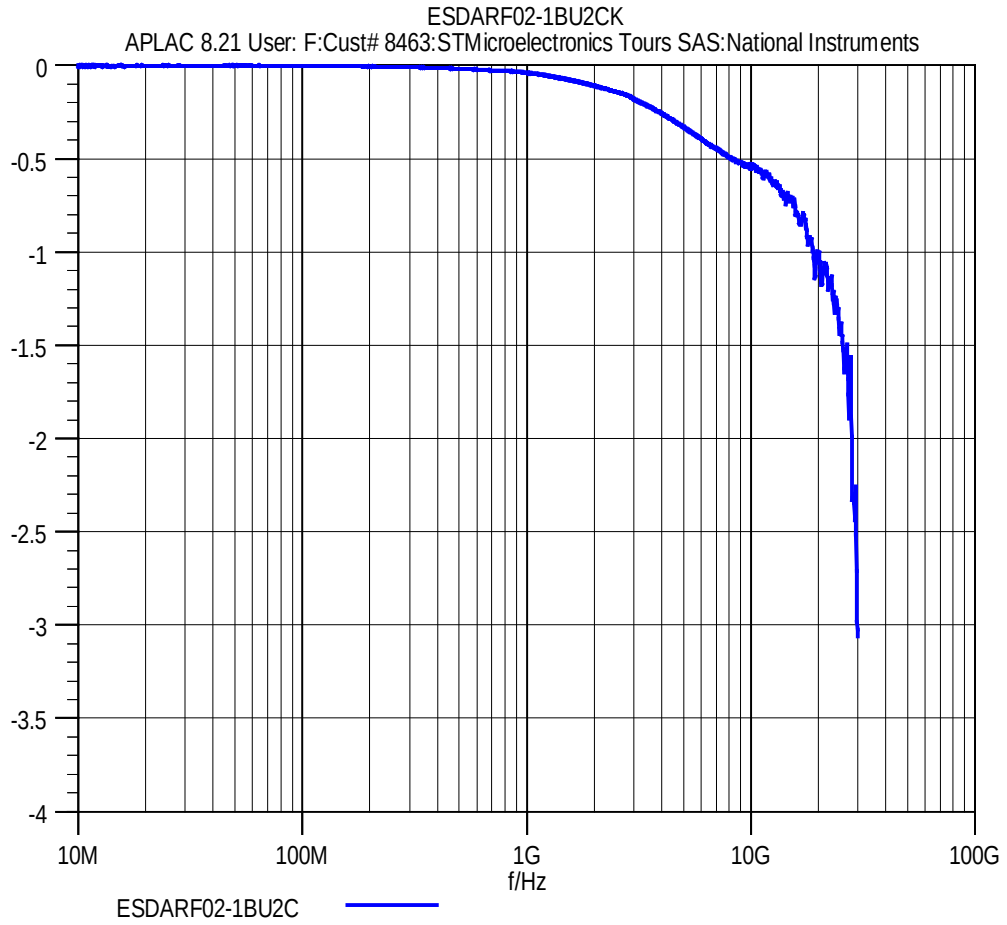




HDMI 2.0b TDR specification : 100Ω ±15Ω

Impact on rf-signal S21 attenuation

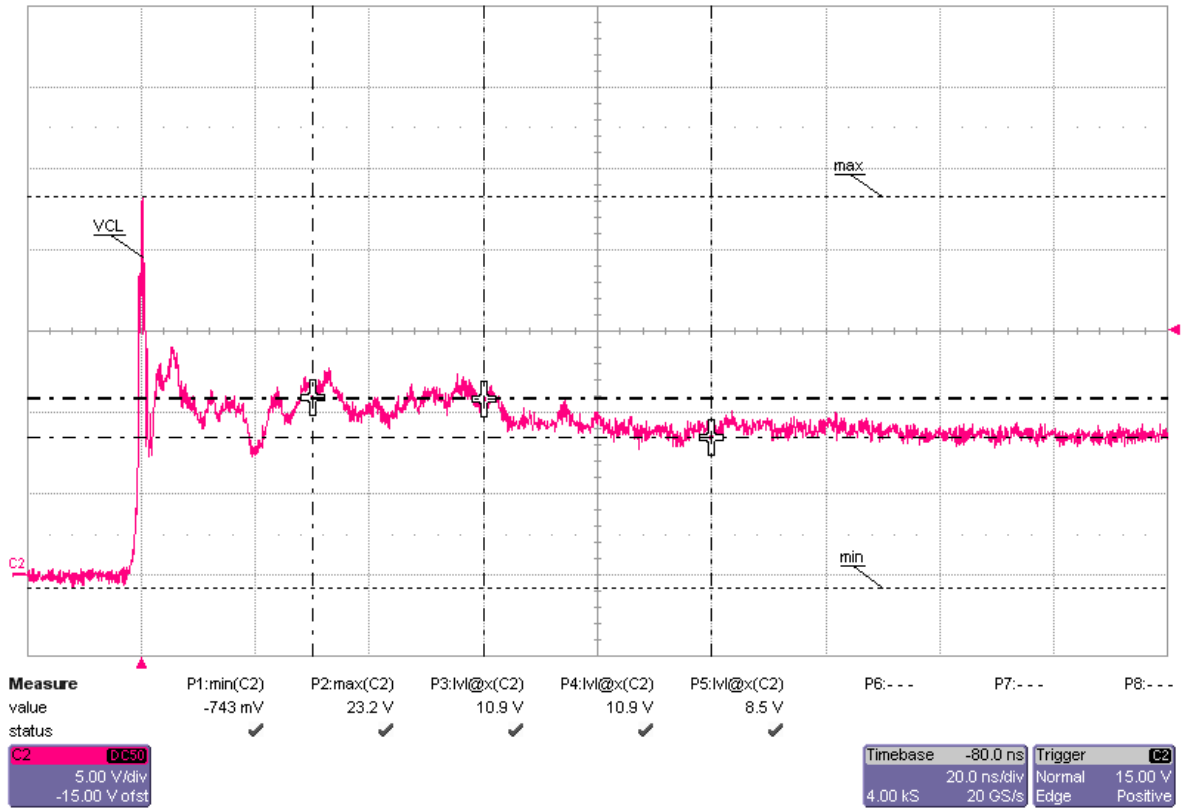
- Single-line bidirectional ESD protection diode (ESDARF02-1BU2CK) S21
  - 30 GHz at -3 dB
  - 8 GHz at -0.5 dB
- Negligible impact major frequencies for telecom
  - FM radio : 87.5 to 108.0 MHz
  - Numerical TV : 400 to 900 MHz
  - Cellular phones : 700 MHz to 4.7 GHz
  - GNSS : 1.6 GHz
  - Bluetooth : 2.4 GHz
  - Sub-GHz industrial : 400 MHz to 1.1GHz
  - Wi-Fi : 2.4 / 5.0 GHz



ESD protection
IEC 61000-4-2 ±8kv ESD response

- IEC 61000-4-2 response of low-clamping single-line bidirectional ESD protection diode (ESD051-1BF4) :
  - First peak : 23V (low energy, CDM like)
  - 30ns clamping : 11V (clamping voltage)

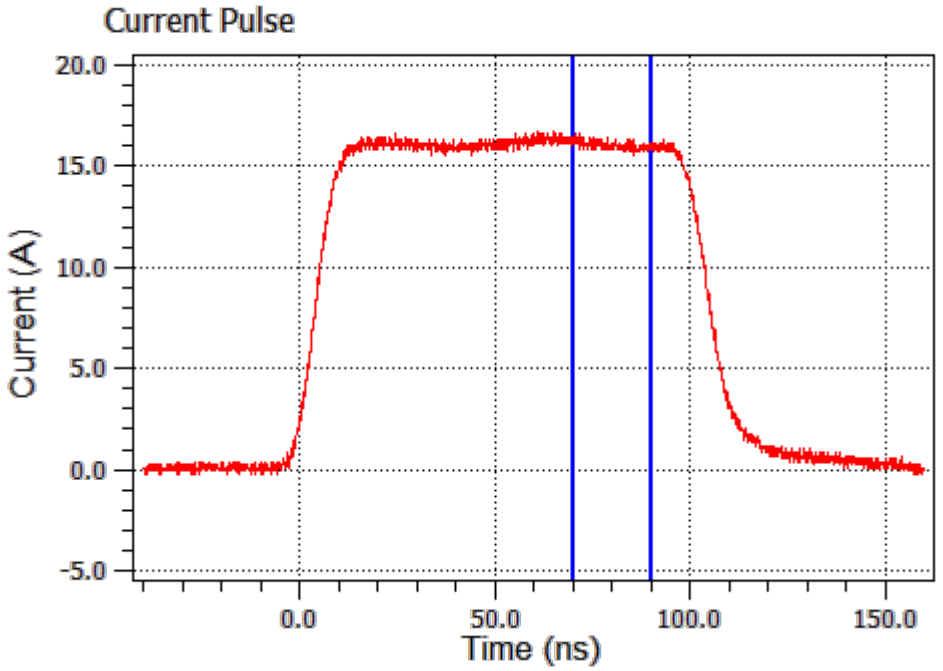
ESD051-1BF4 +8kV IEC 61000-4-2 response



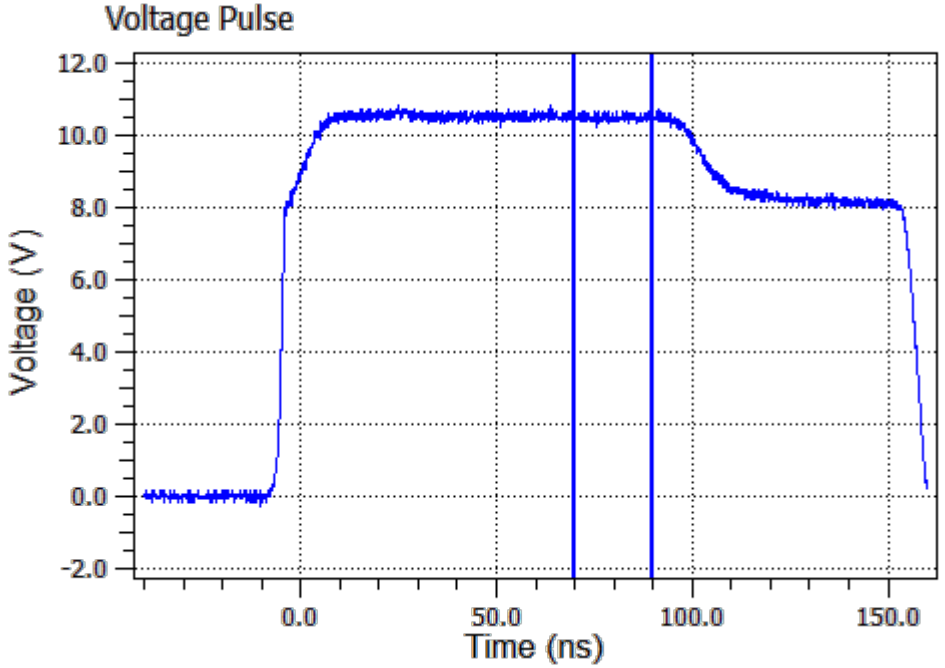
ESD protection transmission line pulse*

- IEC 61000-4-2 8 kV 30 ns clamping voltage ↔ TLP* 16 A 100 ns 70 - 90% voltage

Injected current :
16A – 100ns square current



Measured voltage on 70% – 90% windows on ESD051-1BF4 : 10.5V



*ANSI / ESD STM5.5.1-2014

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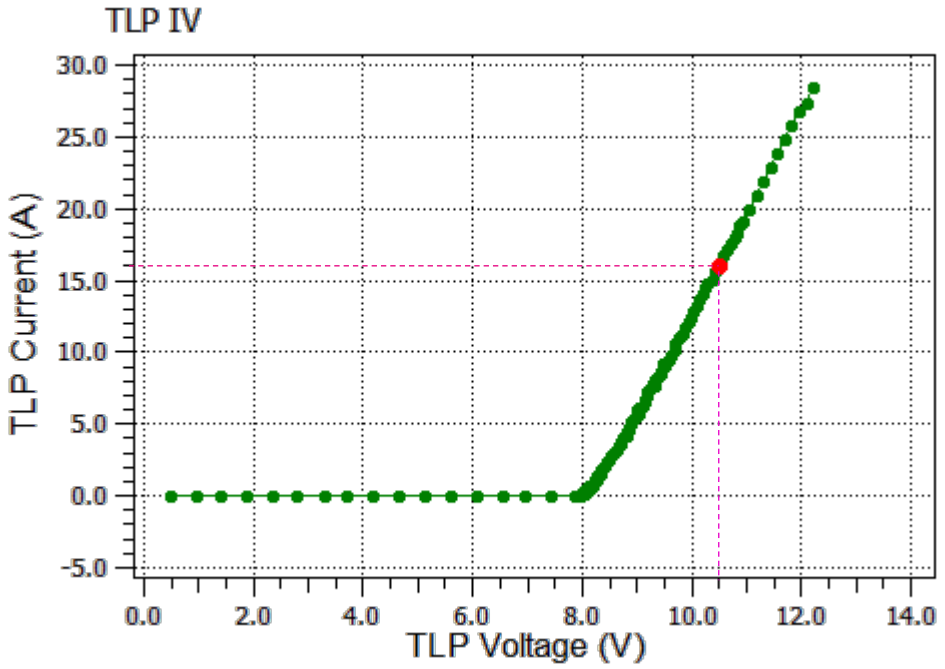
ESD protection transmission line pulse* I/V curve

- I/V TLP* curve is done with several pulses

ESD051-1BF4 TLP* I/V curve

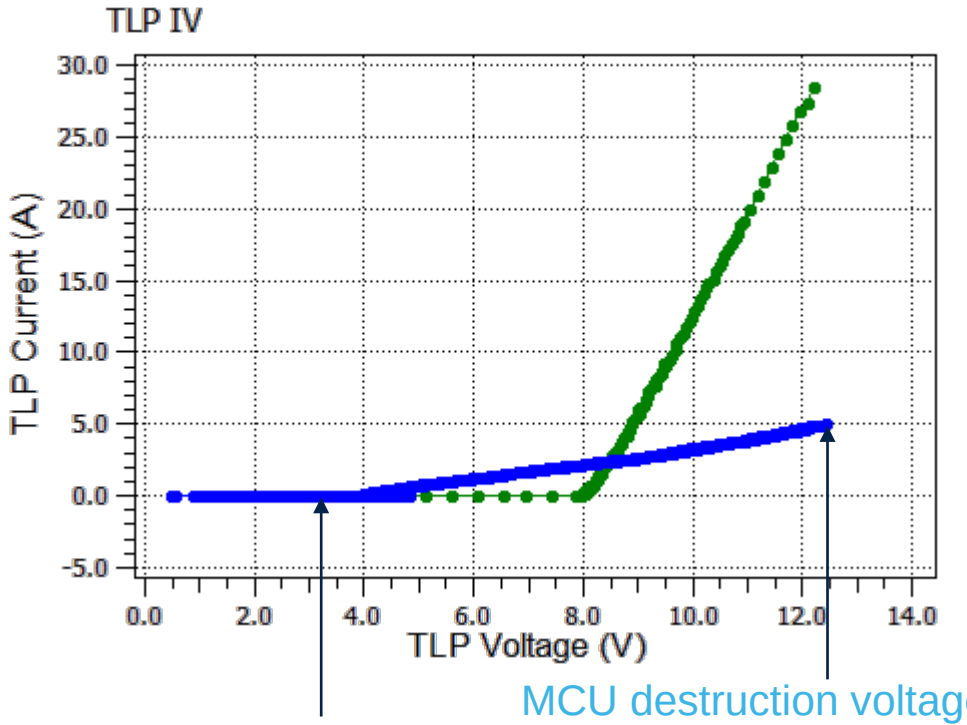


*ANSI / ESD STM5.5.1-2014

System-efficient ESD design methodology

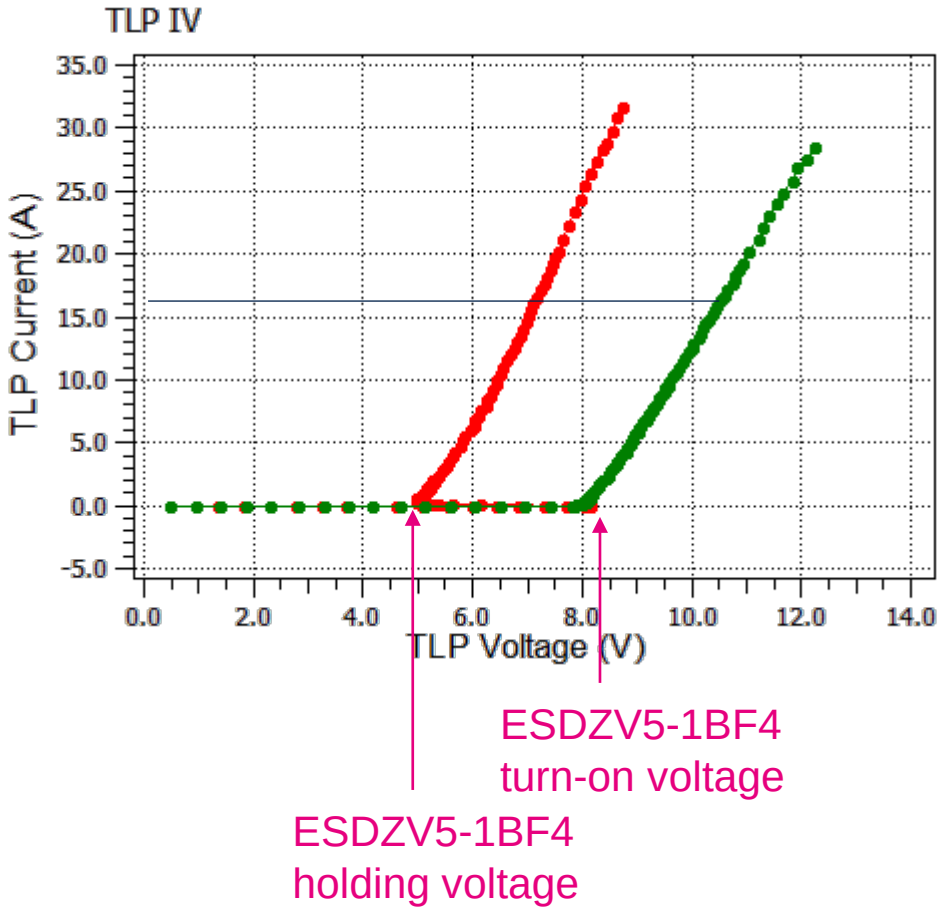
- TLP input current shared between high-performance MCU FT input and ESDA5-1BF4
- High-performance MCU + ESDA5-1BF4 robustness reach more than 8kV IEC 61000-4-2
  - Even if, ESD5-1BF4 clamping voltage is greater than high-performance MCU FT input AMR

- ESD051-1BF4
  - 11V clamping voltage at +8kV ESD 61000-4-2
- High Performance MCU FT input
  - 3.6 V max operating
  - 2 kV HBM ESD
  - 250 V CMD ESD
  - 5.5 V AMR



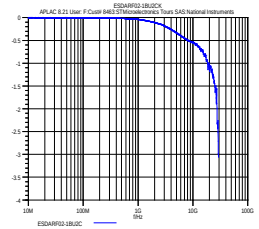
Snap-back protections system integration

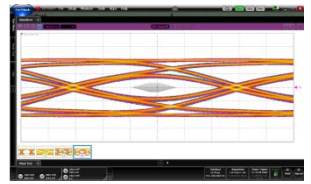
- Snap-back protection (ESDZV5-1BF4) clamping voltage lower than standard protection (ESD051-1BF4) clamping voltage
- Protected line DC voltage MUST be lower than holding voltage
  - To avoid protection latch-up
    i.e. continuous leakage current flowing into the protection



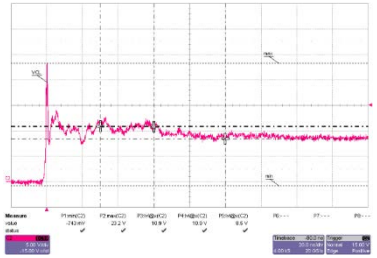
Recap
basics of ESD protection

- Transparency :
  - Capacitance must be in-line with application bandwidth / data rate





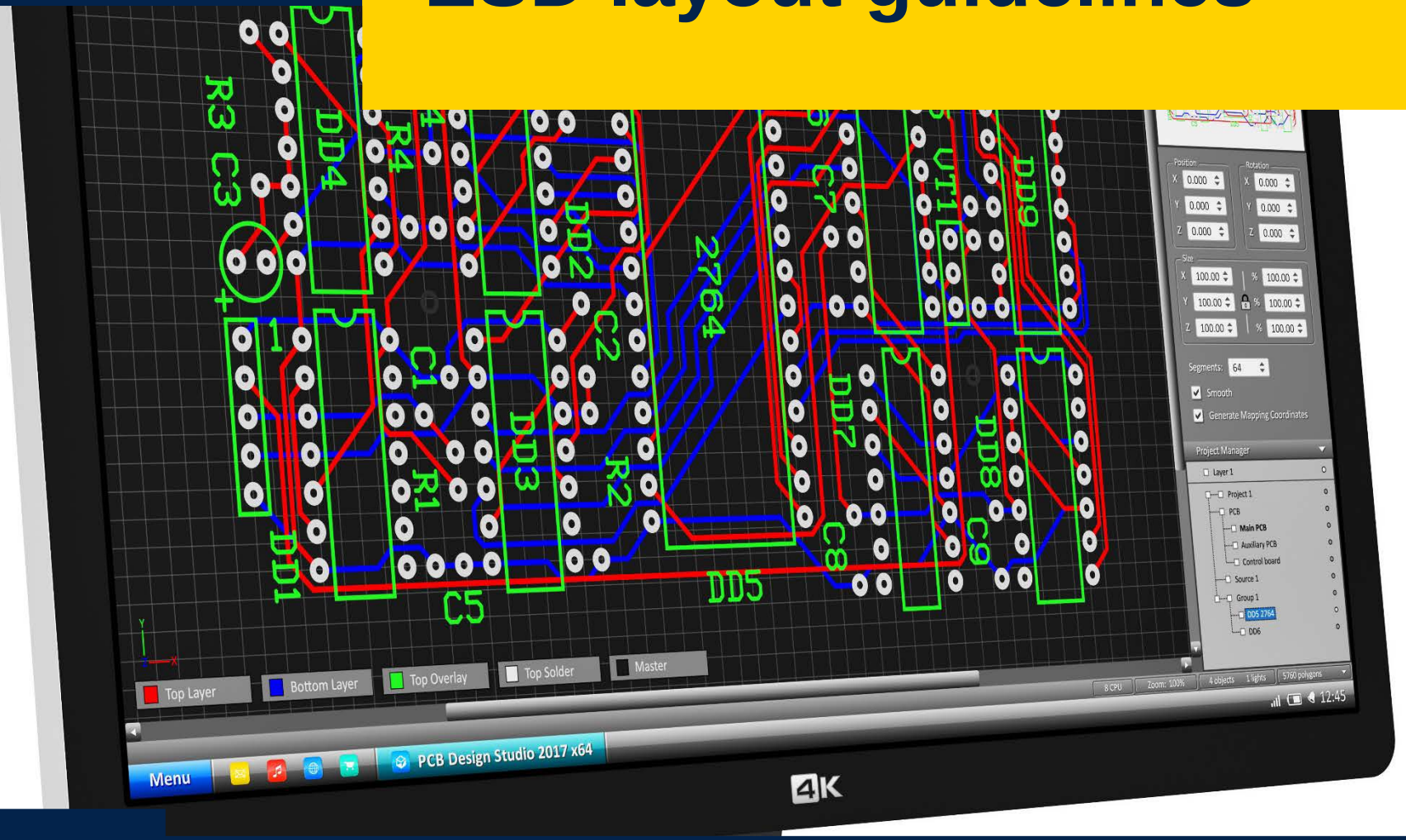
- Efficiency :
  - VRM must be slightly higher than maximum line voltage
    To obtain a low clamping voltage



- System integration of snap-back protection :
  - Holding voltage must be higher than DC voltage

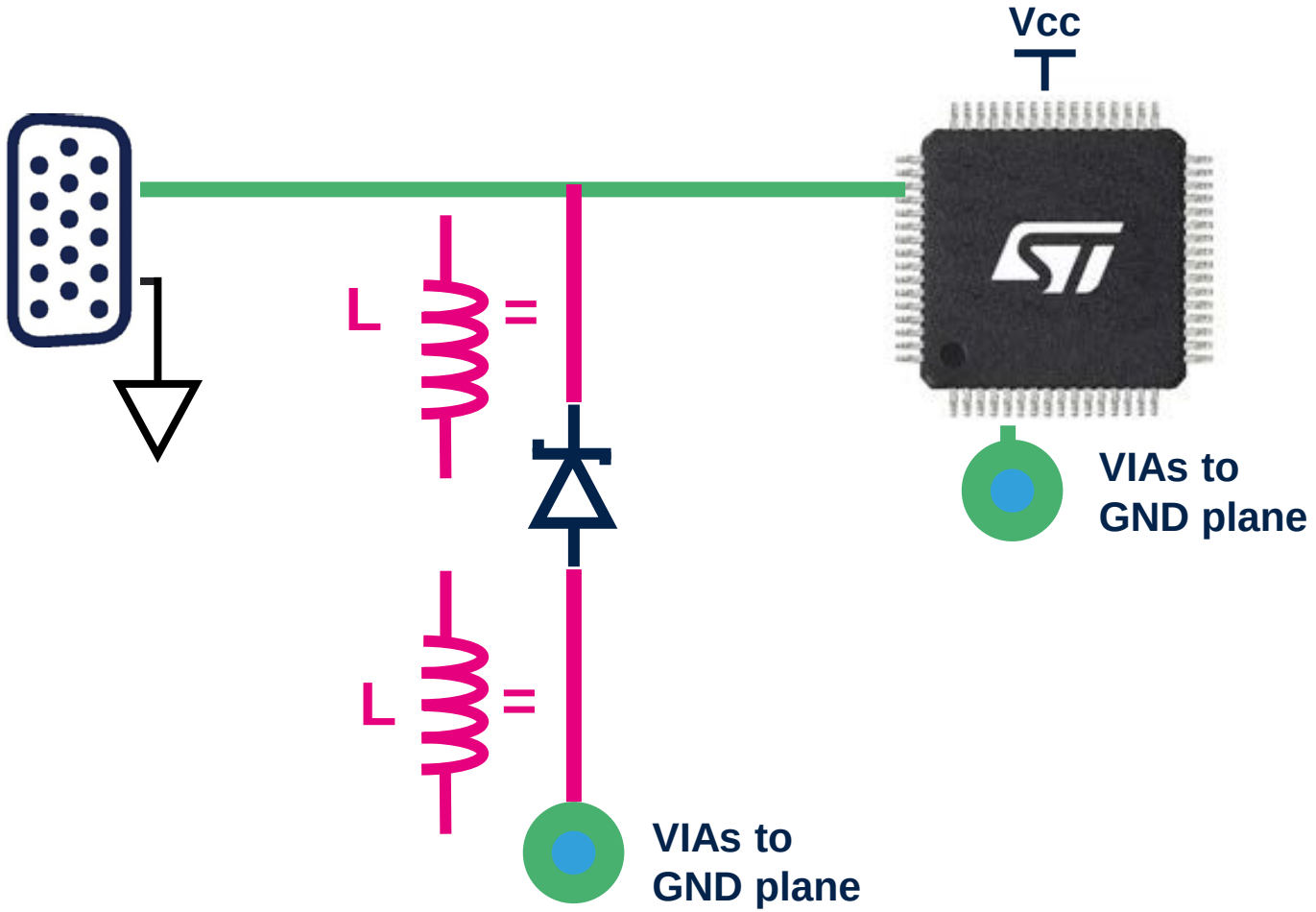
AN5241, Fundamentals of ESD protection at system level

ESD layout guidelines

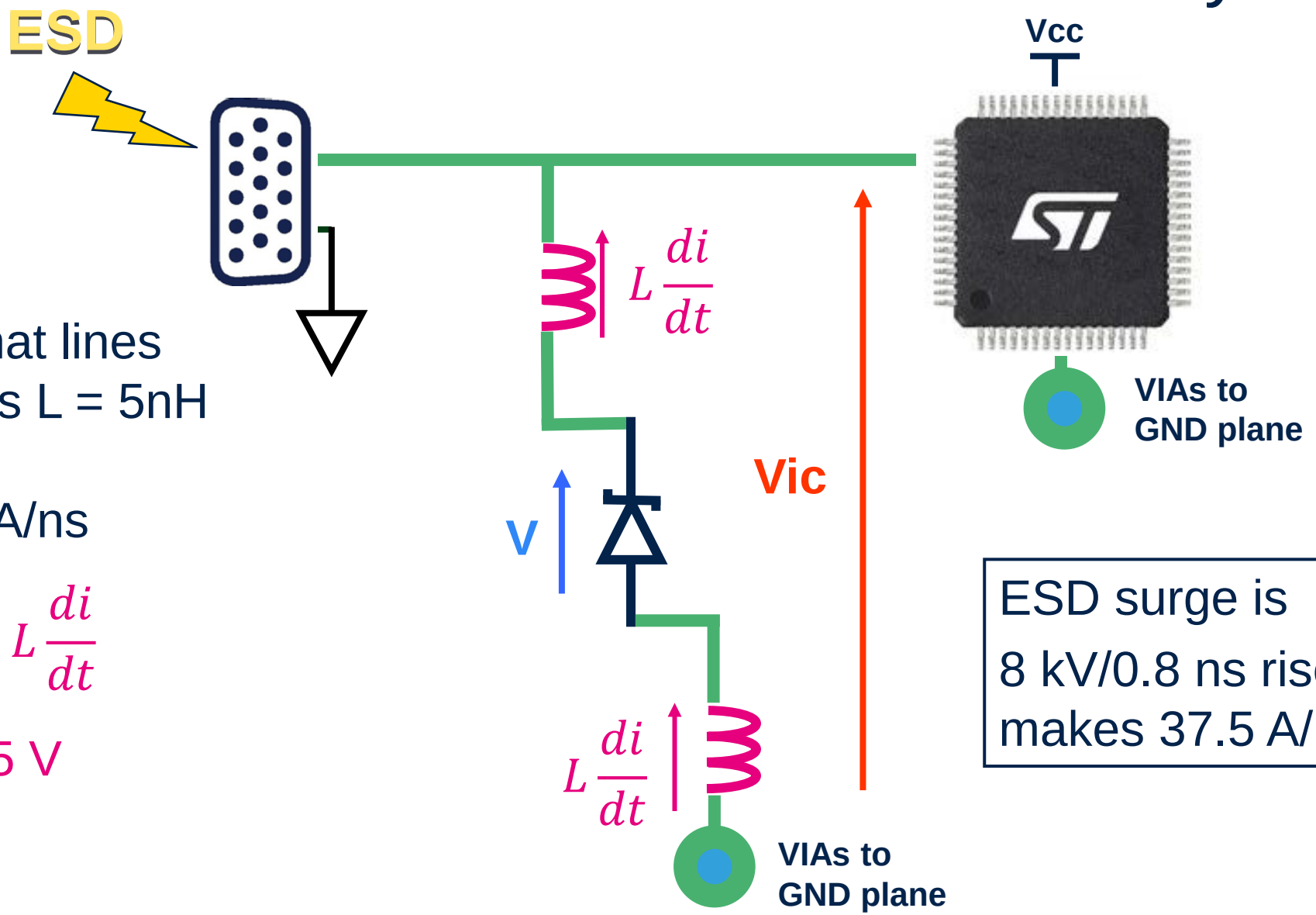


ESD robustness
PCB layout impact

- PCB Tracks must be under control!
- For protection device length connection of ~1cm from side to side, 35µm copper, 0.5mm wide (microstrip)
- 2 x L = 5 nH !



ESD robustness
PCB layout impact



Assuming that lines inductance is L = 5nH

di/dt = 37.5 A/ns

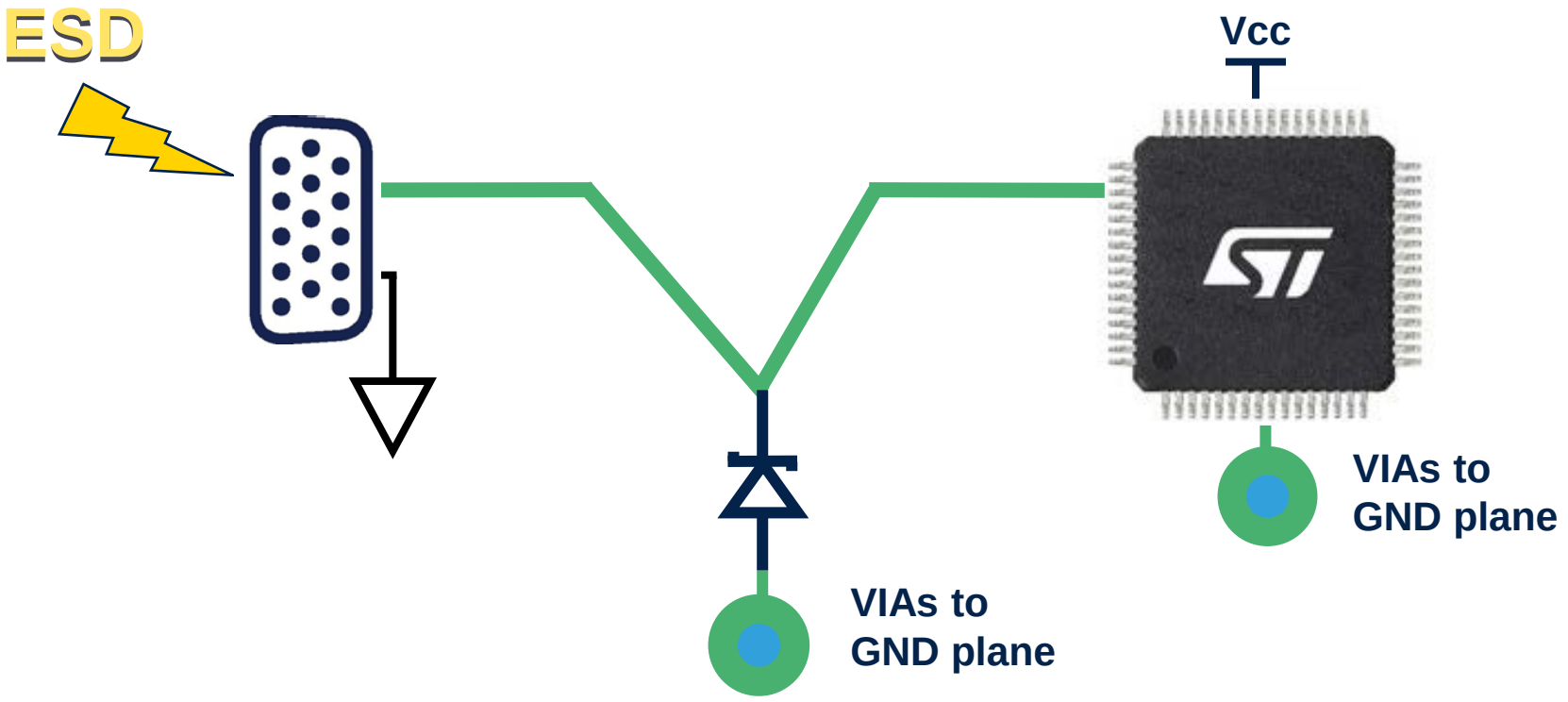
Vic= V + 2 x $L\frac{di}{dt}$

Vic= V + 375 V

ESD surge is

8 kV/0.8 ns rise time, this makes 37.5 A/ns

ESD robustness
PCB layout recommendations

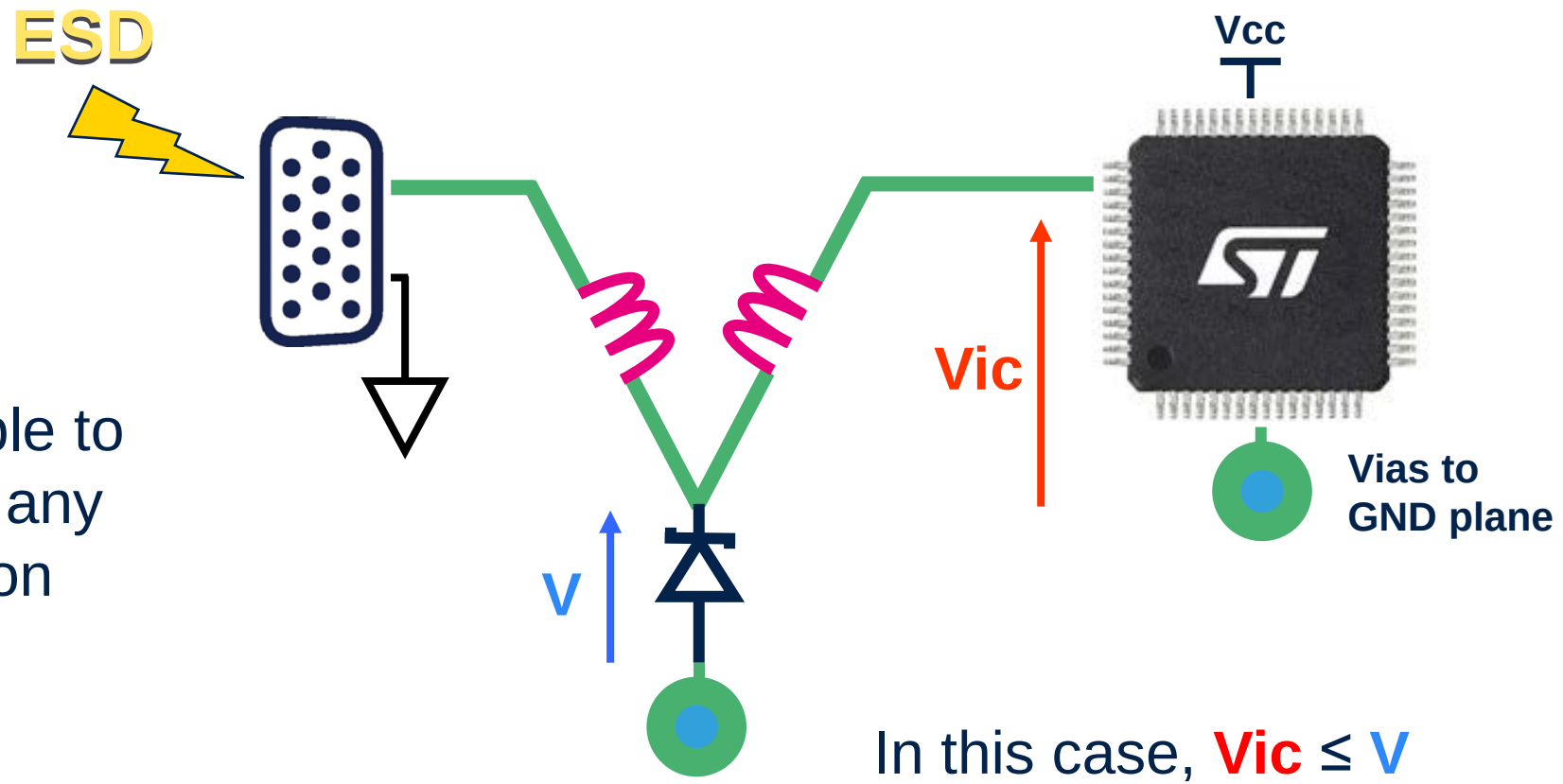


VIAs to GND plane as close as possible to the product GND

ESD robustness
PCB layout recommendation

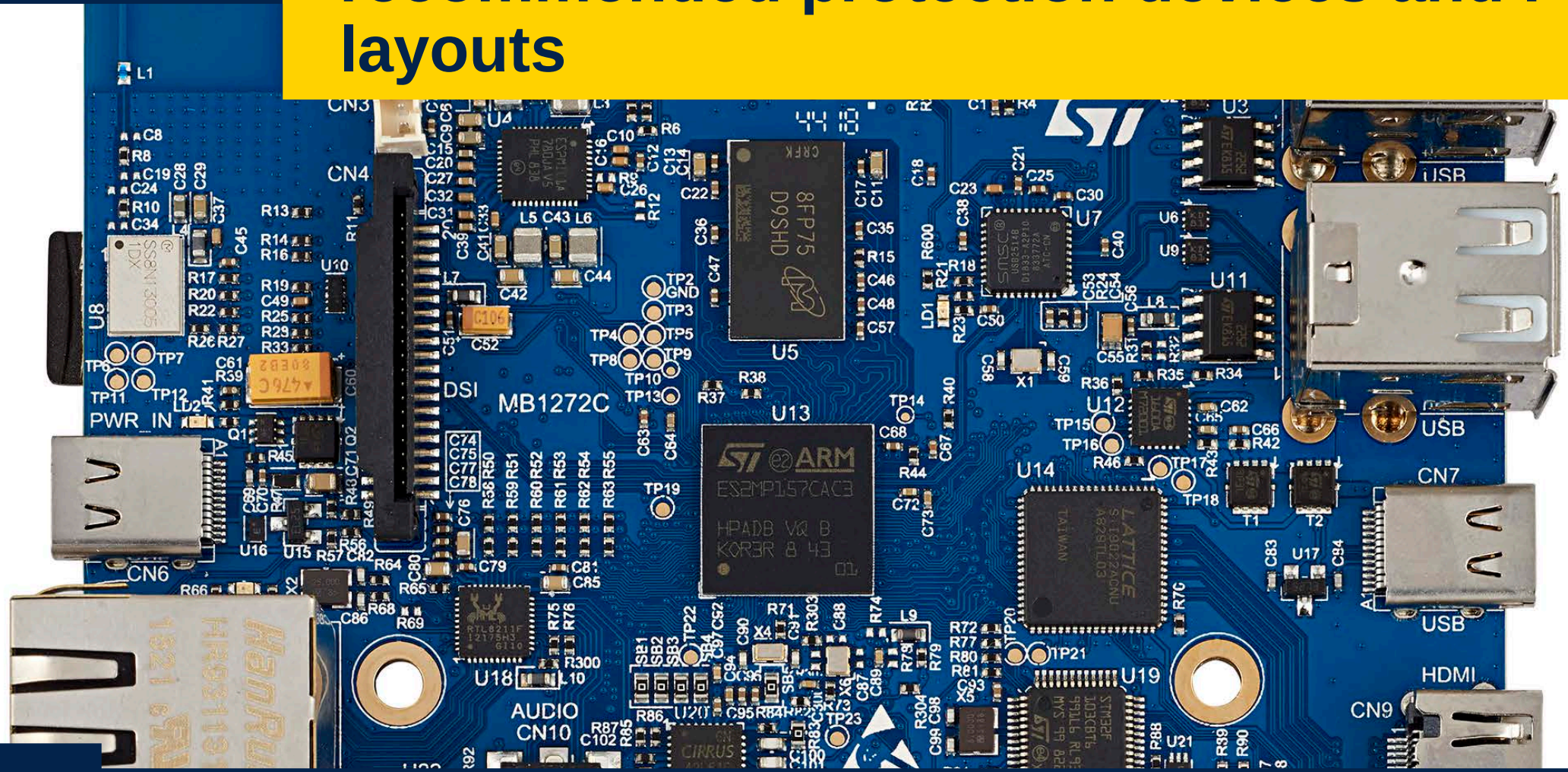
- PCB Layout recommendations in Application note AN1751

- ESD protection must be placed as close as possible to the ESD source, to avoid any coupling between tracks on the PCB.

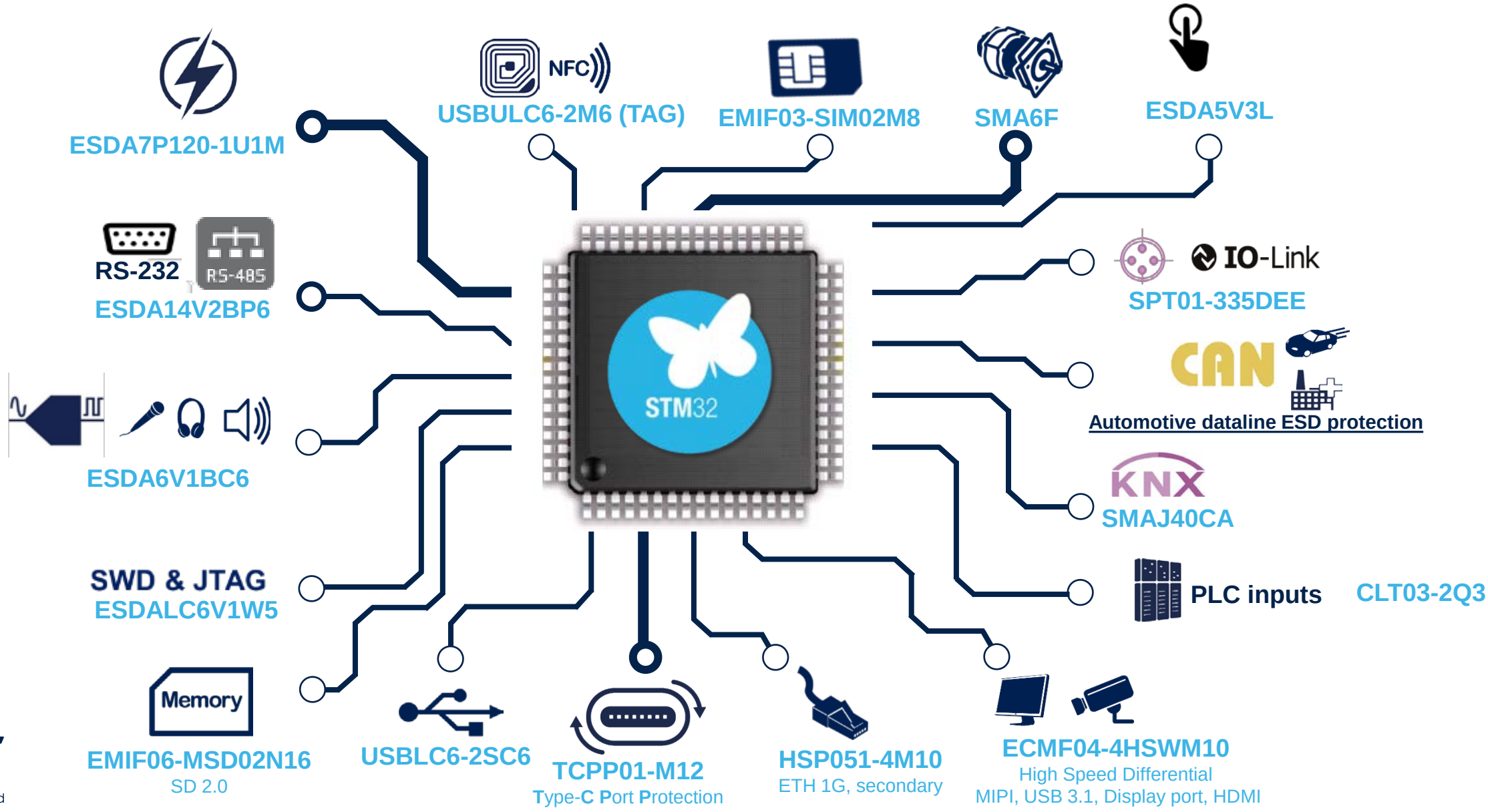


In this case, **Vic** ≤ **V**

Application examples recommended protection devices and PCB layouts



Protections and filters around MCUs



USB ESD Protection example

- Complete solution portfolio for USB granting flexibility in design
- All sockets are ESD protected according to IEC 61000-4-2 level 4

Needs for USB2.0 (D+/ D-)	**Product key parameters**	**ST solutions**
Voltage ≤ 3.6V	V_{RM} ≥ 3.6V	USBLC6-2SC6 ESDAXLC5-1U2
Positive signal	Unidirectional (bidirectional also suitable)	
Data rate: 480 Mbps	Bandwidth 2.6 GHz	
Avoid to disturb LTE and Wifi antennas	CMF Rejection (700 MHz to 2.4 GHz and 5 GHz)	ECMF02-2HSMX6

Needs for USB OTG and type-C (Vbus)	**Product key parameters**	**ST solutions**
Voltage ≤ 22V	V_{RM} ≥ 5V	ESDAxP series
Positive signal	Unidirectional	
Need to withstand 8/20 µs surge (IEC 61000-4-5)	I_{PP} up to 120A	
Type-C maximum operating voltage compatibility	V_{RM} ≥ 22V	ESDA25P35-1U1M

Needs for USB type-C (sink)	**Product key parameters**	**ST solutions**
Voltage ≤ 5V (CC lines)	OVP against short to Vbus + ESD protections	TCPP01-M12
Vbus < max voltage supported by application	OVP on Vbus against charger fault	
Avoid to disturb WiFi, Bluetooth reception	SSTx and SSRx lines CMF Rejection of 2.4 GHz and 5 GHz	ECMF4-2450A60N10

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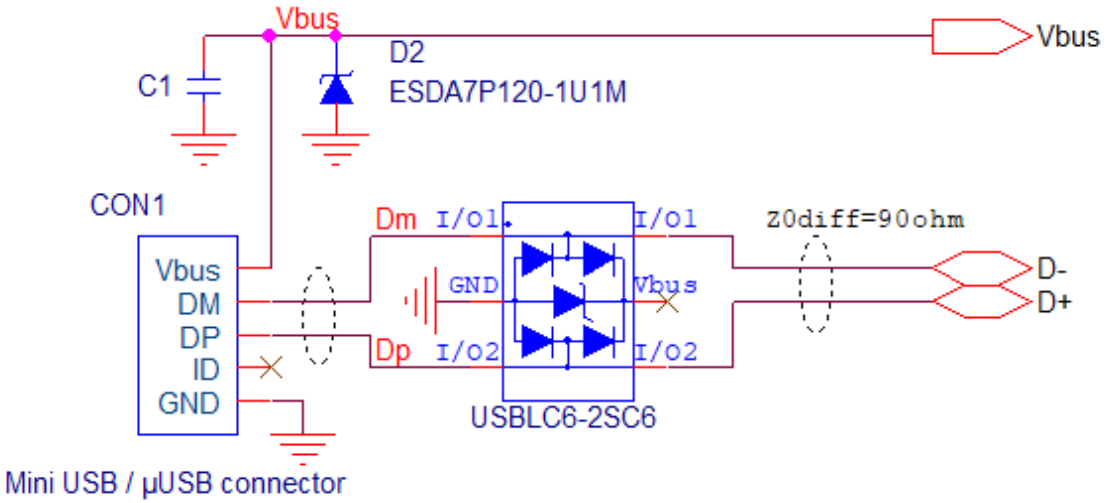
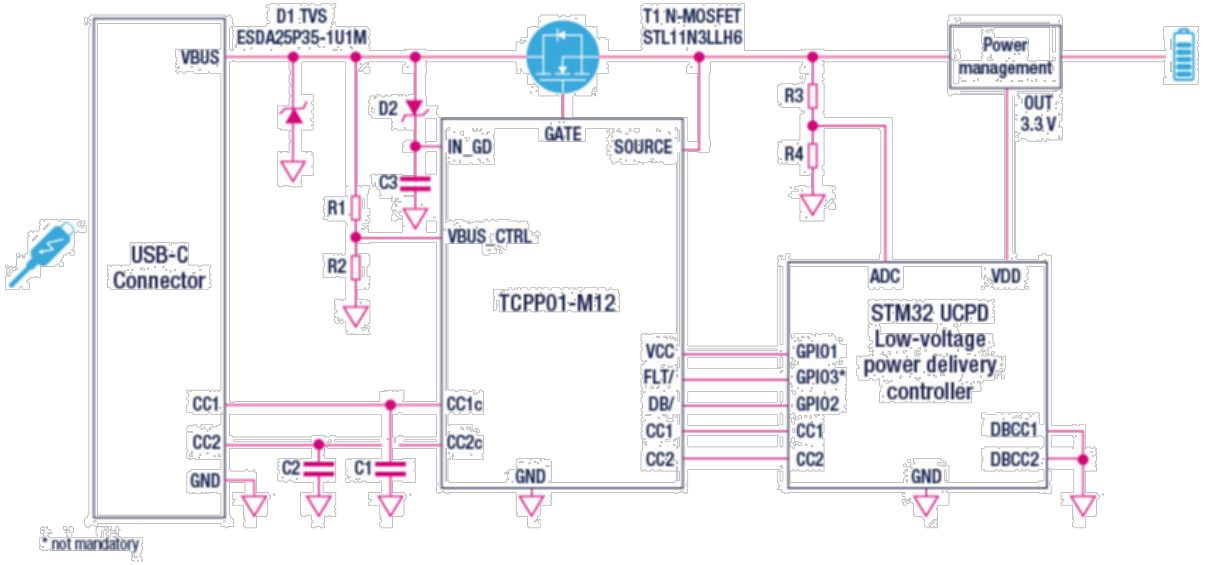
USB ESD Protection example Schematics



USB type A / B / µB



USB type-C (sink)

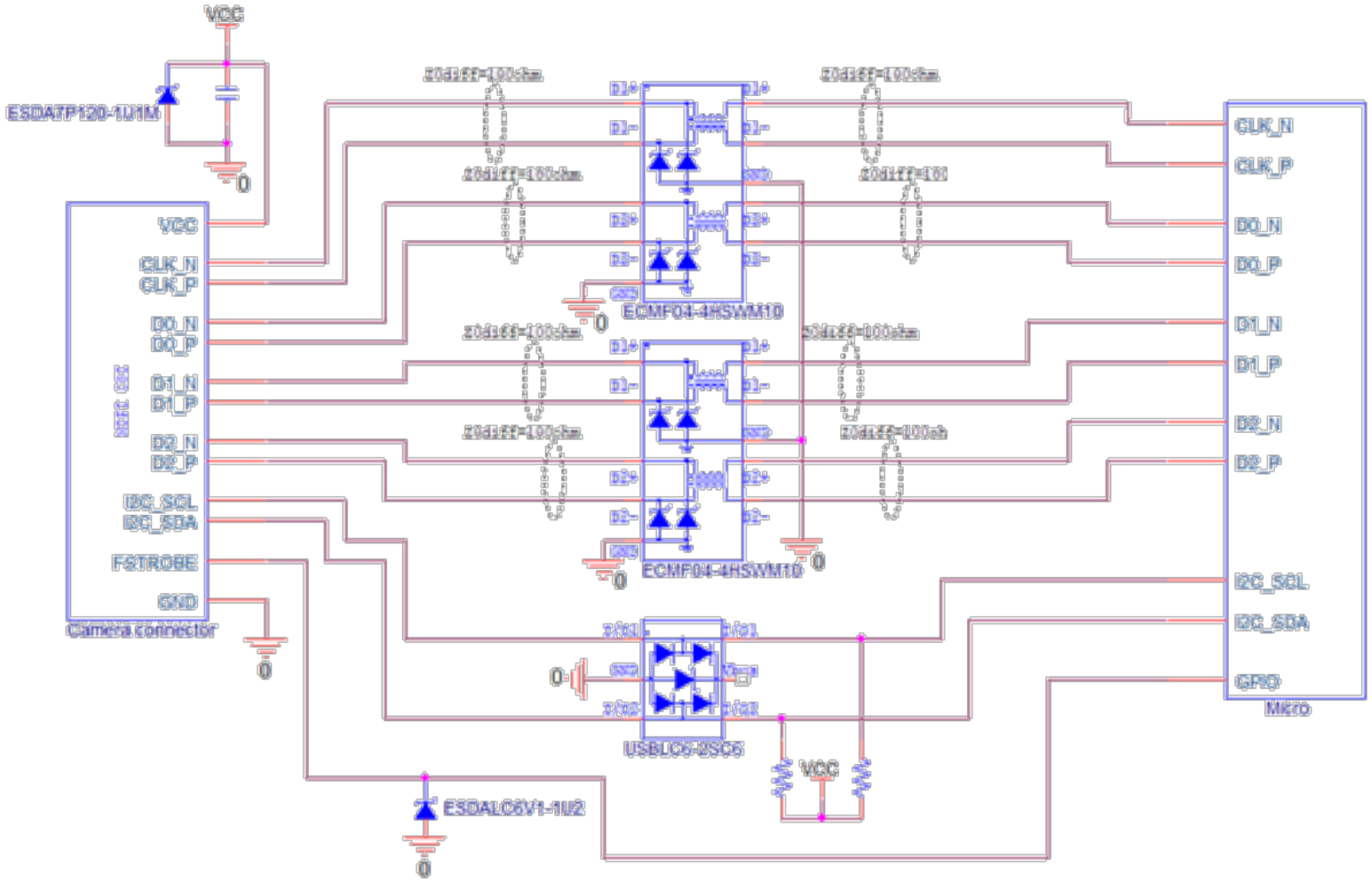
ESD Protection for camera

- Integration with a single device
- Flexibility with single line product

Needs for Data / Clock	Product key parameters	ST solutions
Voltage ≤ 385 mV (high speed HS) Voltage ≤ 1.3V (low power LP)	V_{RM} ≥ 3.3V	ESDZX051-1BF4 HSP051-4M5
Positive signal	Unidirectional (bidirectional also suitable)	
Data rate up to 1.5 Gbps	Bandwidth > 5 GHz	
Avoid to disturb WiFi, Bluetooth reception	CMF Rejection of 2.4 GHz and 5 GHz	ECMF4-2450A60N10
IEC 61000-4-2 level 4	Contact discharge: 8 kV - Air discharge: 15 kV	-

Needs for I2C	Product key parameters	ST solutions
Line voltage range: 0 to 3.3V	V_{RM} ≥ 3.6V	USBLC6-2SC6 ESDZV5-1BF4 ESDZL5-1F4
Positive signal	Unidirectional (bidirectional also suitable)	
Small consumption on digital communication	Capacitance <10 pF to reduce consumption	
Data rate: 3.4 Mbps	Bandwidth : > 700 MHz	
IEC 61000-4-2 level 4	Contact discharge: 8 kV - Air discharge: 15 kV	

ESD Protection for camera Schematic



ESD Protection for microSD cards

- Complete product offer for SD card protection
- Integrated EMI and ESD solution
- Flexibility brought by ESD standalone products

Needs for Data / Clock	Product key parameters	ST solutions
Voltage ≤ 3.3V	V_{RM} ≥ 3.3V	-
Positive signal	Unidirectional (bidirectional also suitable)	
IEC 61000-4-2 level 4	Contact discharge: 8 kV - Air discharge: 15 kV	
SD 2.0: Cmax = 40pF (including card cap. ~10pF)	C < 20pF	EMIF06-MSD02N16
Avoid to disturb LTE, WiFi, Bluetooth antennas	Peak rejection frequency > 1950 MHz	
SD 3.0: Cmax = 21pF (including card cap. ~10pF)	C < 0.6pF Minimize Cline in order to give room for SD card	ESDARF02-1BU2CK HSP051-4M5

Needs for V_{CC}	Product key parameters	ST solutions
Voltage ≤ 5V	V_{RM} ≥ 5V	ESD051-1F4
Positive signal	Unidirectional (bidirectional also suitable)	
IEC 61000-4-2 level 4	Contact discharge: 8 kV - Air discharge: 15 kV	

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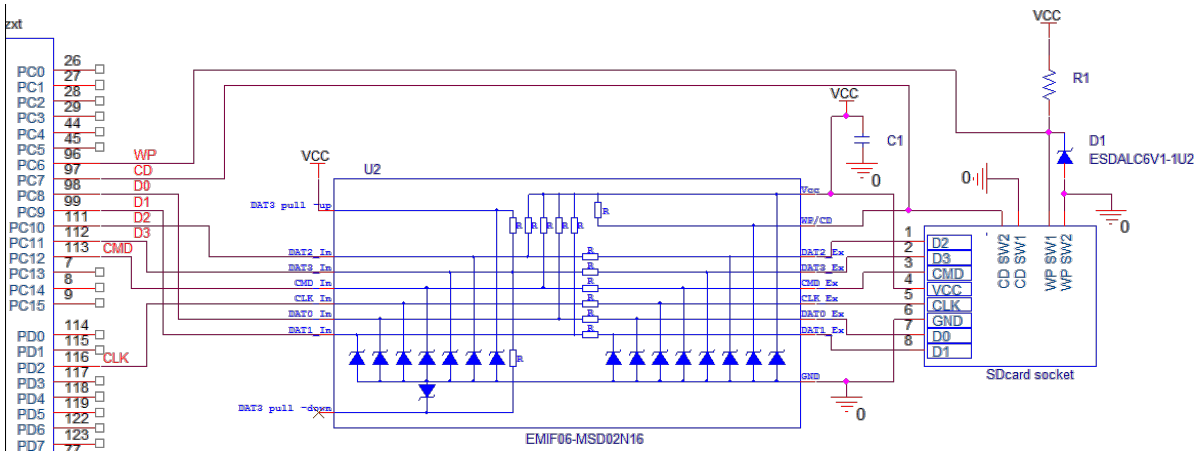
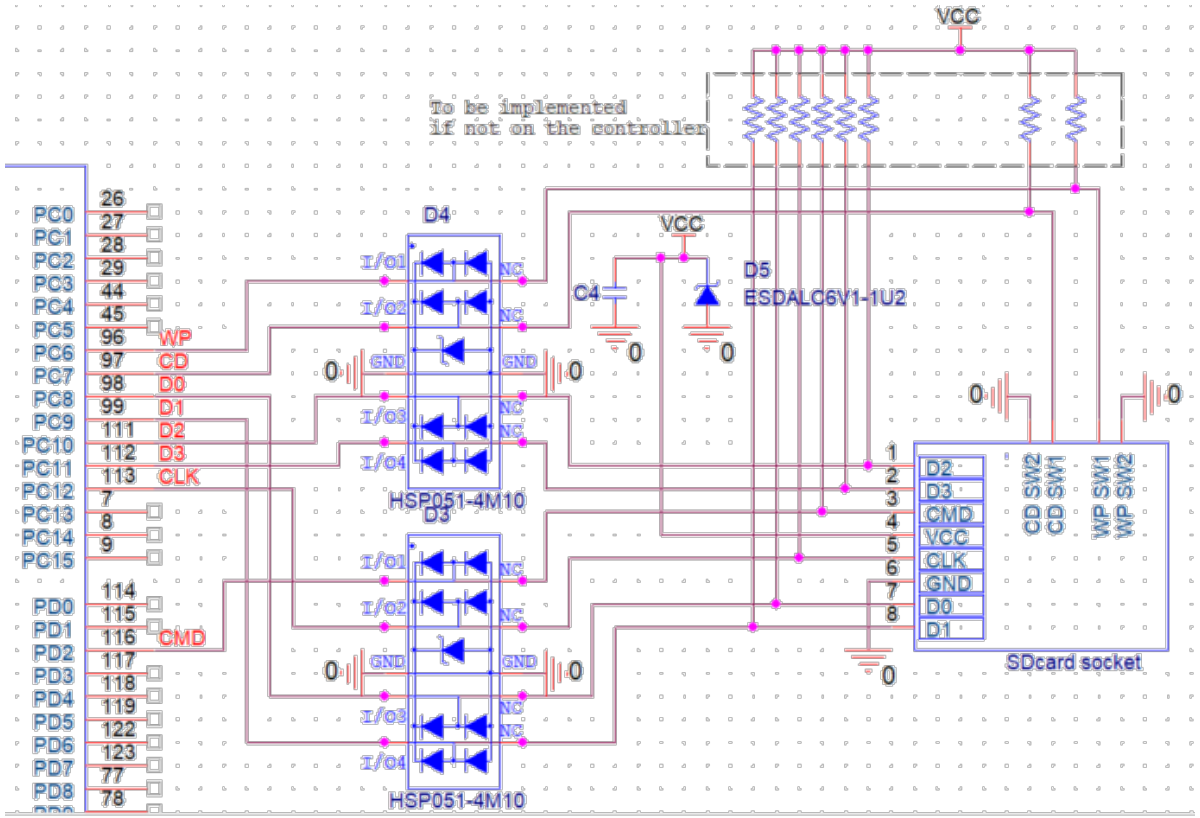
ESD Protection for microSD cards Schematics



SD Card 2.0 with CD switch



SD card 3.0

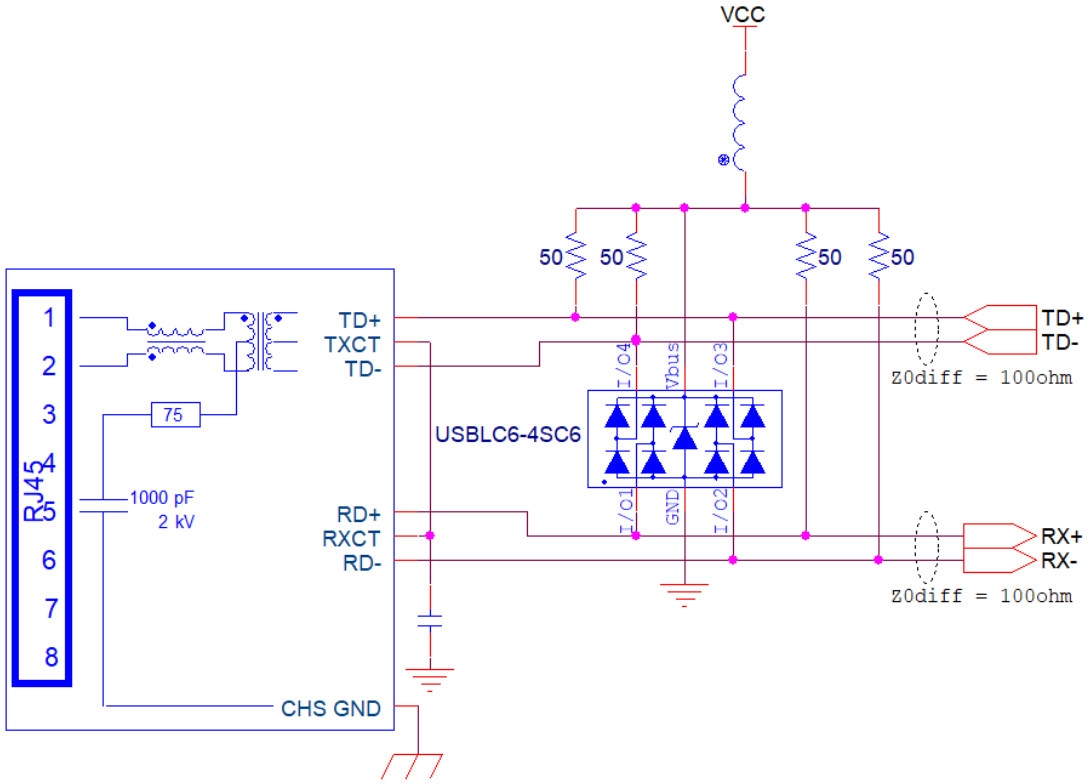
ESD protection for 1G/10G Ethernet

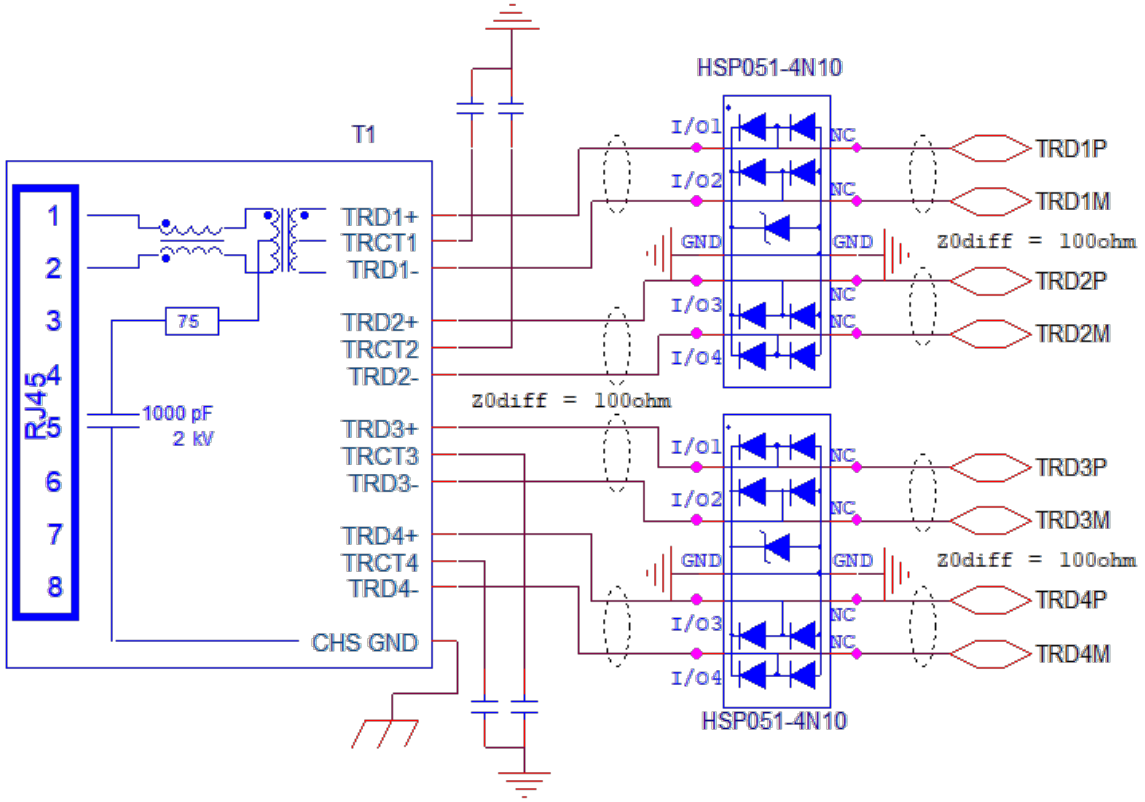
- HSP series is compliant with all Ethernet lines
- All sockets are ESD protected according to IEC 61000-4-2 level 4

Needs for Ethernet 10/100M	Product key parameters	ST solutions
Voltage: ≤ 3V	V_{RM} ≥ 3V	USBLC6-4SC6 HSP051-4M5
Positive signal	Unidirectional	
Data rate: up to 100 Mbps	Bandwidth up to 8.7GHz	

Needs for Ethernet 1G/10G	Product key parameters	ST solutions
1GEthernet voltage: 2.5V 10GEthernet voltage: 1.0V	V_{RM} ≥ 3V	HSP051-4M5 HSP031-1BM6
Positive signal	Unidirectional (bidirectional also suitable)	
Data rate: up to 10 Gbps	Bandwidth > 8.7 GHz	

ESD protection for 1G/10G Ethernet Schematics





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STM32MP1-DK2 discovery

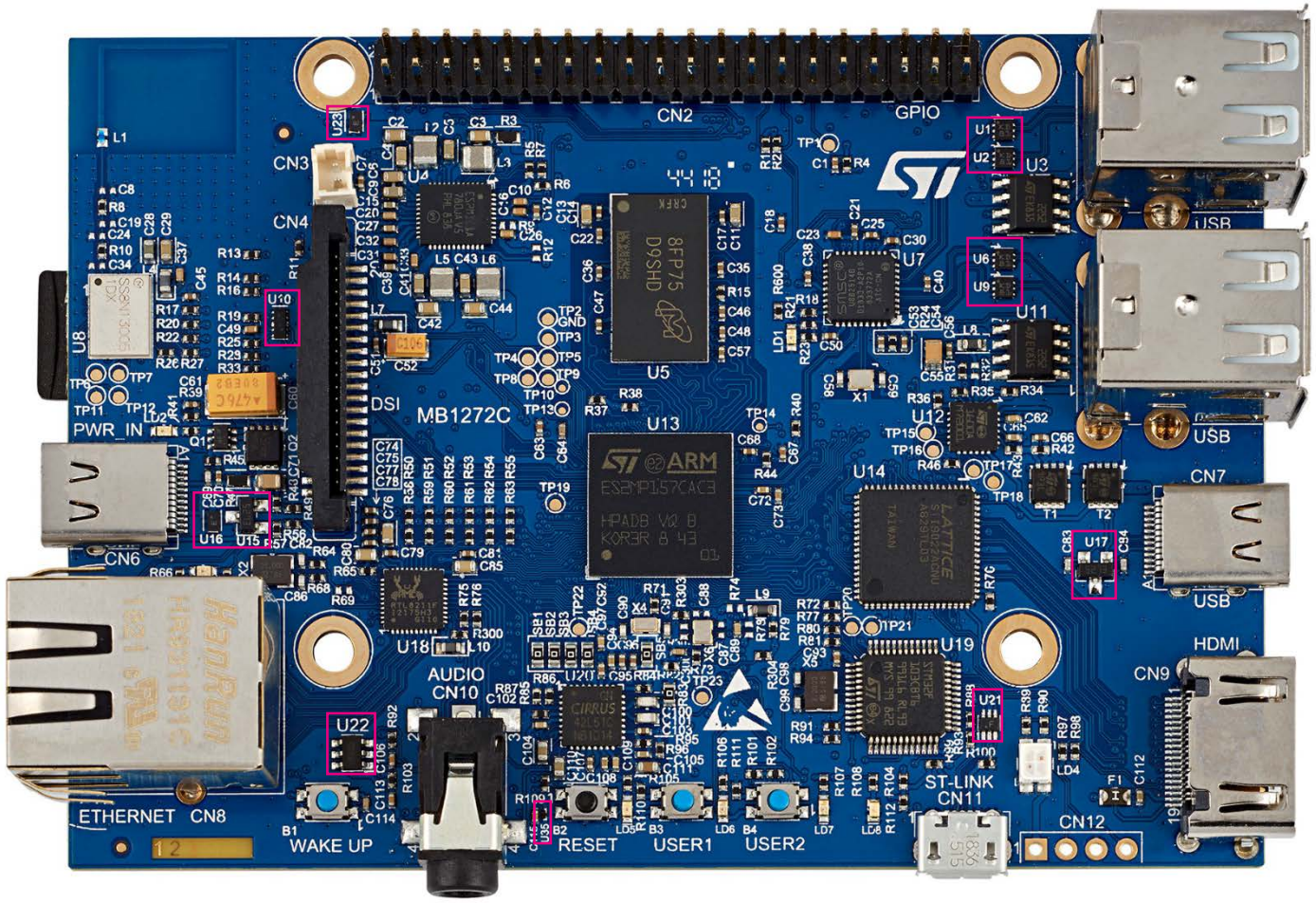
ESD Protections & Filters

MORPHO CONNECTOR
ESDA7P120-1U1M
5V Vin

MICRO SD CARD
HSP051-4M10 (x2)
SDMMC dataline

USB Type-C Power Delivery
ESDA7P120-1U1M, ESDA25L
VBUS
CC1, CC2

ETHERNET
HSP053-4M5



USB HOST x2 (Dual USB Type-A)
ESDA7P120-1U1M (x2), ECMF02-2AMX6 (x2)
VBUS
DP, DM

USB HOST x2 (Dual USB Type-A)
ESDA7P120-1U1M (x2), ECMF02-2AMX6 (x2)
VBUS
DP, DM

USB Type-C DRP (Source Only)
ESDA7P120-1U1M, ESDA25L, ECMF02-2AMX6
VBUS
CC1, CC2
DP, DM

HDMI
ECMF04-4HSWM10 (x2), ESDALC6V1-5M6
TMDS datalines
CEC, I2C, HPD

AUDIO
ESDA6V1BC6: 4-line ESD protection
OUTA, OUTB, MIC IN

USER BUTTONS
ESDALC6V1-1U2

ST-LINK USB CONNECTOR
USBLC6-2P6
DP, DM, VBUS

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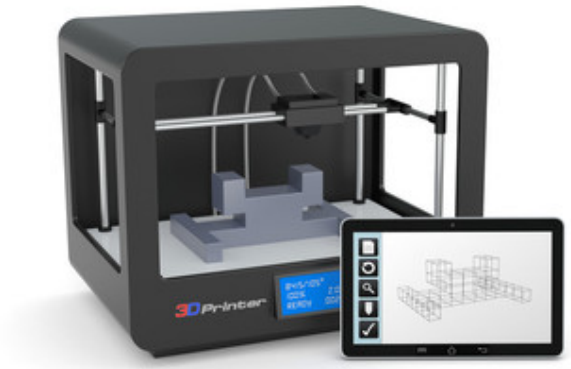
Any electronic board must be protected 3D printer control board

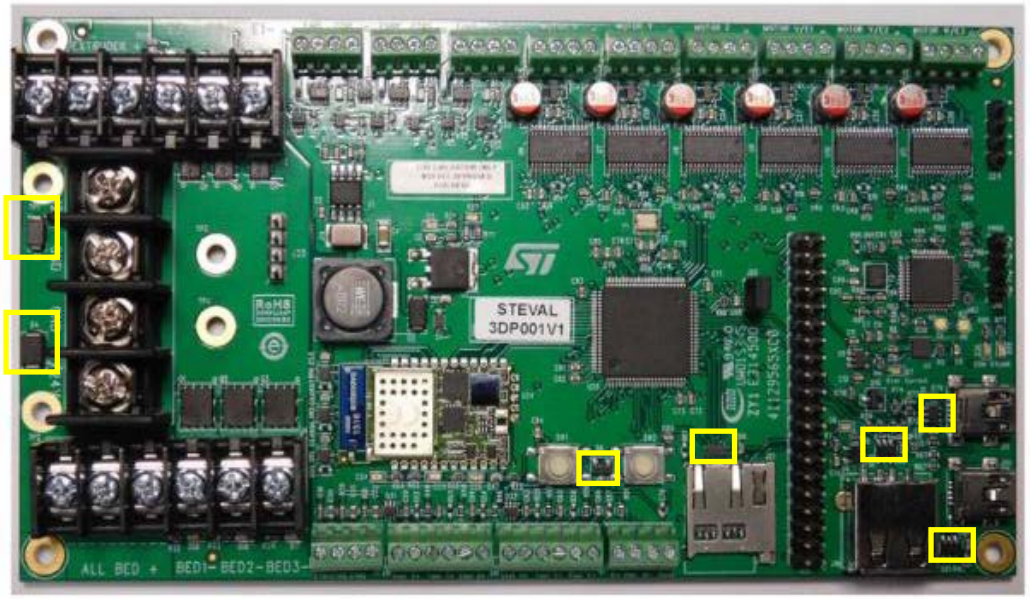


SMA4F12A

SMA6F24A

Memory

EMIF06-MSD02N16



ESDA5V3L

3x USBLC6-2SC6

- Protections on the application PCB
  - Power lines → surge protection : IEC 61000-4-5
  - Connector
  - Button
  - SD card

ESD protections for system: IEC 61000-4-2

  - Integrated on all IC's → ESD protection for manufacturing is JEDEC HBM

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Our ESD portfolio

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Our ESD portfolio

General-purpose ESD protection

Low capacitance ESD protection < 1pF

Automotive ESD protection

- IEC 61000-4-2 compliance
- Protection efficiency with low clamping voltage
- Protection reliability with low leakage current
- Signal integrity with ultralow capacitance and ultrawide bandwidth
- AEC-Q101 qualified version available

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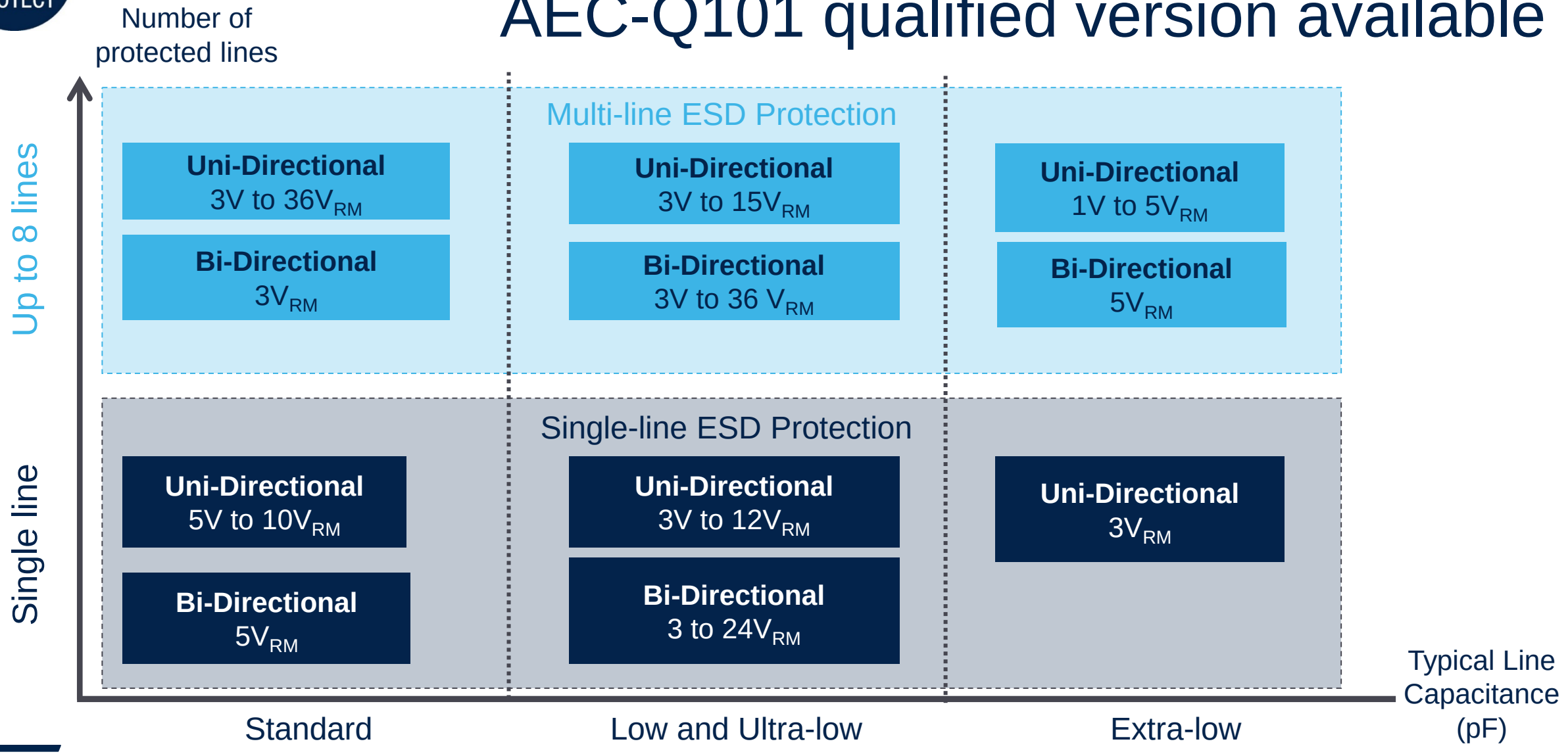
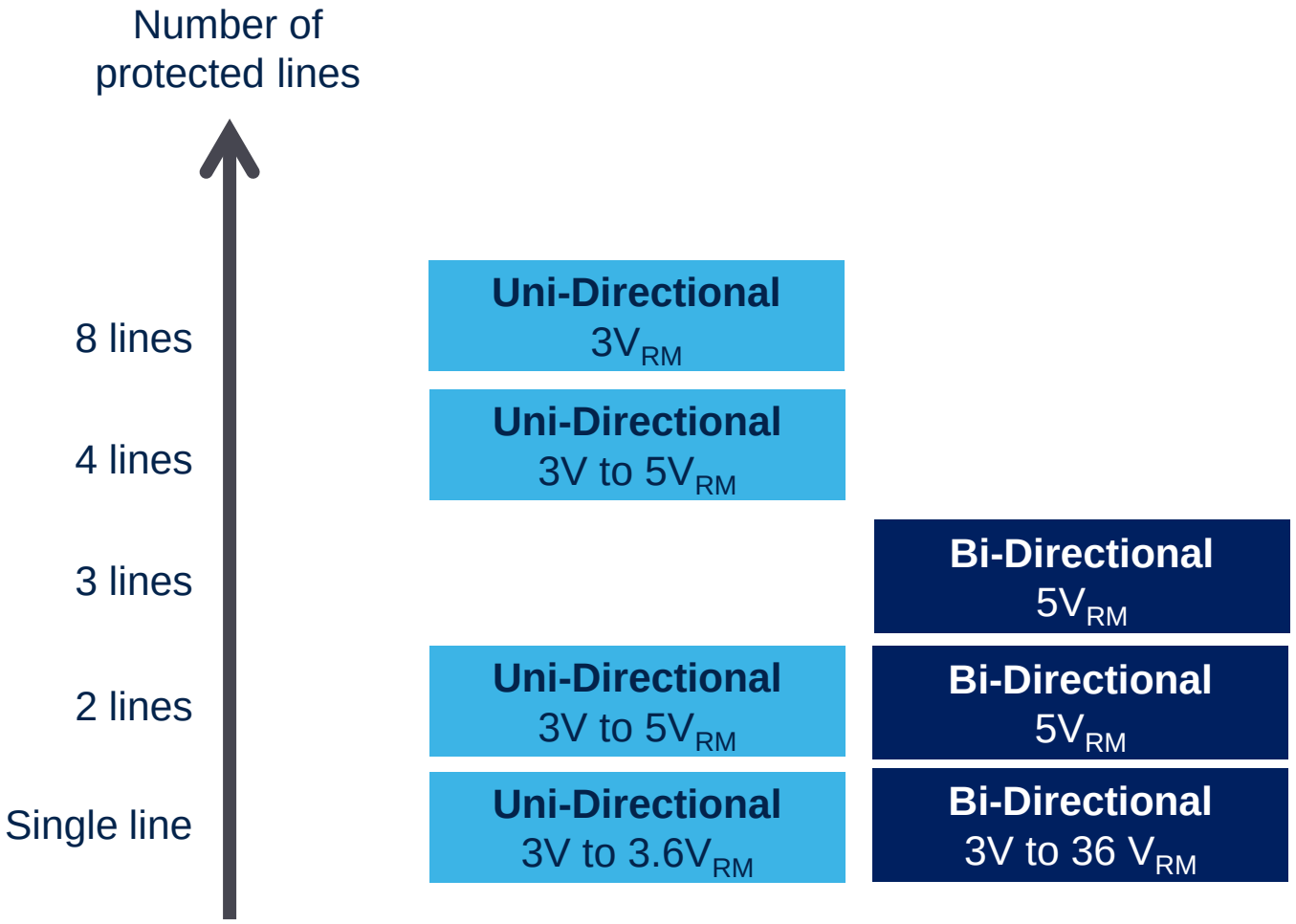
General-purpose ESD Protection
AEC-Q101 qualified version available



Low capacitance ESD protection <1pF AEC-Q101 qualified version available



Resources
Application notes and Videos

- AN5241, Fundamentals of ESD protection at system level
- AN4871, USB Type-C protection and filtering
- AN5121, HDMI ESD protection and signal conditioning products for STBs
- AN3353, IEC 61000-4-2 standard testing
- AN2689, Protection of automotive electronics from electrical hazards, guidelines for design and component selection
- AN1826, TRANSIENT PROTECTION SOLUTIONS: Transil™ diode versus Varistor
- AN5241 : Fundamentals of ESD Protection
- Video - ESD Protection: why and how to protect microcontrollers efficiently

ST protection finder mobile app

- ST PROTECTION FINDER is a mobile app for Android™ and iOS™ that allows you to explore ST's TVS product portfolio.
  - Parametric or series search engine
  - Efficient part number search engine

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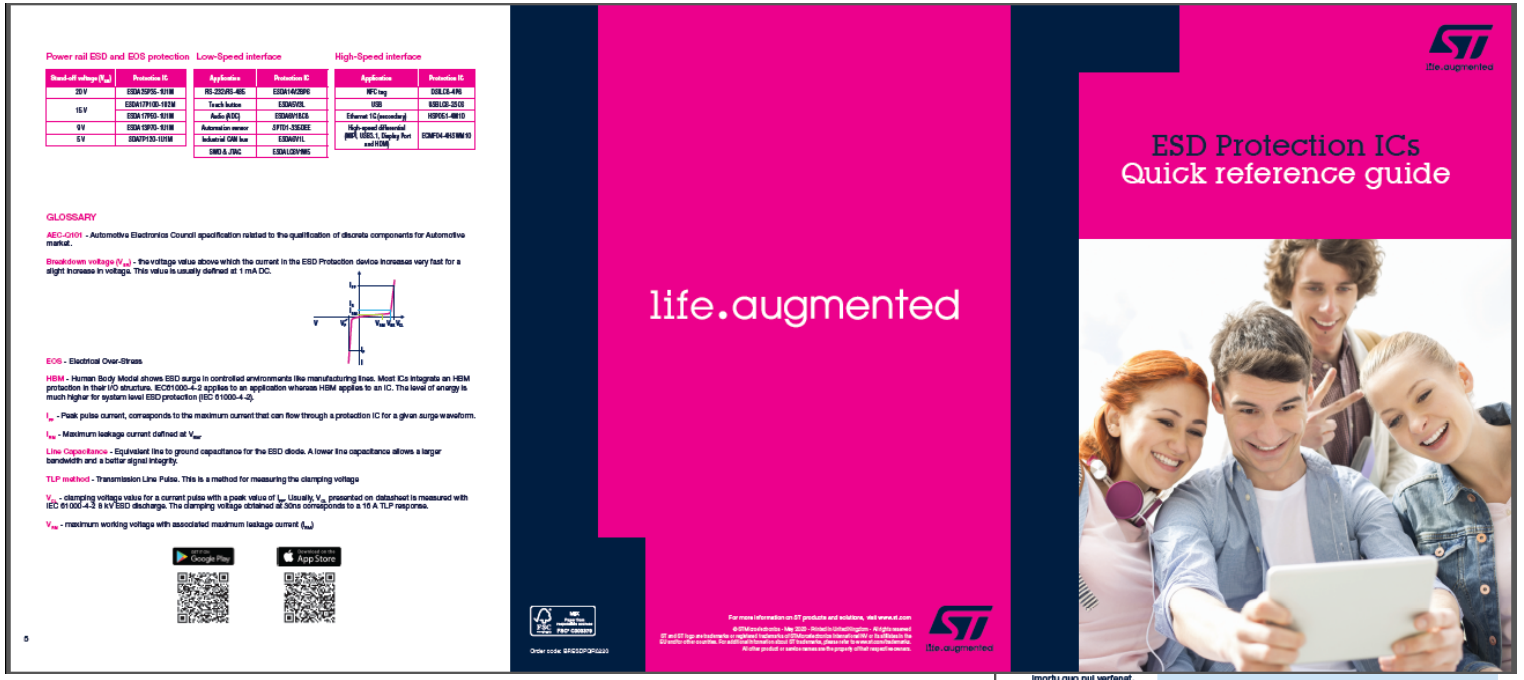
New ESD quick selection guide



Power rail ESD and EOS protection

Stand-off voltage (V_{RM})	Protection IC
20 V	ESDA15P35-1U1M
15 V	ESDA17P100-1U1M
	ESDA13P50-1U1M
9 V	ESDA13P70-1U1M
5 V	ESDA7P120-1U1M

Low-Speed interface

Application	Protection IC
RS-232/RS-485	ESDA14V2BP6
Touch button	ESDA6V1L
Audio (I2C)	ESDA6V1BC6
Automotive sensor	SPTD1-3V3CDEE
Industrial CAN bus	ESDA6V1L
SWD & JTAG	ESDALC6V1W6

High-Speed interface

Application	Protection IC
NFC tag	DSBLC6-4P6
USB	USBLC6-2SC6
Ethernet 1G (secondary)	HSP051-4M10
High-speed differential (MIPI, USB3.1, Display Port and HDMI)	ECMF04-4HSWM10

GLOSSARY

AEC-Q101 - Automotive Electronics Council specification related to the qualification of discrete components for Automotive market.

Breakdown voltage (V_{BR}) - the voltage value above which the current in the ESD Protection device increases very fast for a slight increase in voltage. This value is usually defined at 1 mA DC.

EOS - Electrical Over-Stress

HBM - Human Body Model shows ESD surge in controlled environments like manufacturing lines. Most ICs integrate an HBM protection in their I/O structure. IEC61000-4-2 applies to an application whereas HBM applies to an IC. The level of energy is much higher for system level ESD protection (IEC 61000-4-2).

I_{pp} - Peak pulse current, corresponds to the maximum current that can flow through a protection IC for a given surge waveform.

I_{RM} - Maximum leakage current defined at V_{RM}

Line Capacitance - Equivalent line to ground capacitance for the ESD diode. A lower line capacitance allows a larger bandwidth and a better signal integrity.

TLP method - Transmission Line Pulse. This is a method for measuring the clamping voltage

V_{CL} - clamping voltage value for a current pulse with a peak value of I_{PP}. Usually, V_{CL} presented on datasheet is measured with IEC 61000-4-2 8 kV ESD discharge. This clamping voltage obtained at 30ns corresponds to a 16 A TLP response.

V_{RM} - maximum working voltage with associated maximum leakage current (I_{RM})

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Order code: BRESDPQR0520

ESD Protection ICs
Quick reference guide

Imortu quo pui verfenat,
unc redicis condes

ELECTRO-STATIC DISCHARGE (ESD)

Electro-Static Discharge (ESD) is defined by the ESD Association as "the rapid, spontaneous transfer of electrostatic charge induced by a high electrostatic field". ESD surge waveforms are specified in IEC 61000-4-2. An ESD can be caused by various objects such as production line machines but is mostly generated by human contact. Three major failure mechanisms have been identified:

Silicon Melting | Hole in the oxide | Melting Flash

With their increased sensitivity, the implementation of miniature components has raised the risk of ESD. It is essential to protect industrial, automotive and IoT applications having connectors exposed to human contact. Furthermore, the Industry Council Worldwide Survey shows that 30% of IC field returns are due to ESD.
It therefore seems necessary to protect ICs with external ESD protections.

Ordering code BRESDPQR0520

HOW TO CHOOSE THE RIGHT ESD PROTECTION IC FOR AN APPLICATION ?

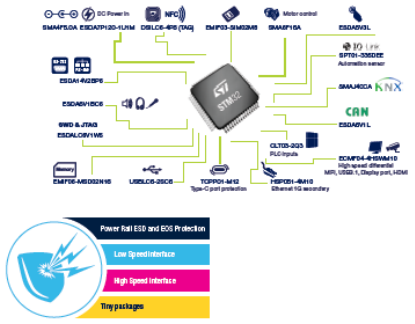
We have put together a list of criteria to help you select the appropriate ESD protection IC for your device.

- Transparency
  During normal operation (no surge event), the ESD protection IC must have the least possible impact on the system's performance (such as power consumption or frequency bandwidth).
  - V_{RM}: standoff voltage. It defines the normal operating voltage for the protection. V_{RM} must be higher than the application's maximum operating voltage, otherwise the protection will clamp the application voltage.
  - Directionality: If the signal to be protected is negative and positive, protection must be bi-directional to avoid the rectifier phenomenon. If the signal to be protected is only positive, then a unidirectional protection should be preferred to avoid a negative ESD clamping voltage. However, a bidirectional protection can also be implemented.
  - C_{line}: line capacitance to ground. The ESD protection diode behaves like a capacitance when high frequencies are rectified. This capacitance defines a cut-off frequency that can impact the application's signal integrity. The ESD protection line's capacitance is a key parameter for high-speed interfaces (digital or RF lines).
- Efficiency
  - V_{CL}: Clamping voltage. This is the maximum voltage across the ESD Protection. When an ESD surge occurs, the ESD protection must lower this surge voltage as close as possible to the V_{RM} in order to protect the IC placed behind the ESD protection.

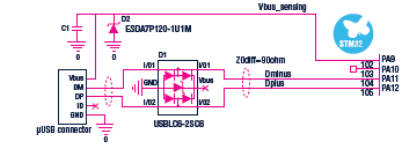
WHAT ARE THE MAIN BENEFITS OF ST'S SOLUTIONS?

ST's solutions offer quality and reliability. IEC 61000-4-2 Level 4 specifies up to ±8 kV contact discharge. ESD protection decreases this ±8 kV ESD transient surge down to a residual transient voltage that is harmless for the application. Reduced ppm rate in field return and cost-efficient maintenance ensure products are safely designed for customers.
Easily select components by using ST-PROTECTION-FINDER mobile app available for Android™ and iOS™ to enter the protection key criteria values (V_{RM} and C_{IO-gnd}) and choose the most appropriate package.

RECOMMENDED ESD IC PROTECTION FOR MCU INTERFACES:



Example of application USB 2.0 Full speed without OTG:



Design tip: Use a Transient Voltage Suppressor (TVS) to protect against 8/20 µs surges on DC power rails.

Featured products:

USBLC6-2SC6 + ESDA7P120-1U1M
- Compliant with USB2.0 eye diagram
- ESD robustness: 15 kV contact discharge IEC61000-4-2

SOD323-5L

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Thank you

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