ESD protection of STM32 MCUs and MPUs

Introduction

Electronic equipment using microcontrollers and microprocessors is more and more often exposed to a harsh electromagnetic environment. The designs become more complex and more integrated. The increasing number of interfaces through which the MCUs and MPUs interact with the external world multiply the paths for the interference to reach them. This raises plenty of design challenges in building robust equipment.

Among other electromagnetic disturbances, an electrostatic discharge (ESD) is one of the most harmful effects that designers must consider since the beginning of the design process.

STM32 MCU and MPU devices embed protection against ESD events during the device handling and assembly. Their ESD immunity is characterized according to ANSI/JEDEC standards and specified in their datasheet. The equipment manufacturing process must prevent them from any ESD stress exceeding that specification.

The electronic equipment design measures that allow protecting sensitive parts such as MCUs and MPUs include casing, shielding, wiring, filtering, PCB routing, and adequate protection components to dissipate ESD stress and keep it far from the sensitive parts. The MCU or MPU internal ESD protection then absorbs the remaining stress that might reach the device. EMC-aware design of an electronic equipment considers all paths for the ESD stress to reach components and provides an appropriate protective solution to each of them.

1 General information

This document applies to Arm®-based MCUs and MPUs.

Note: Arm is a registered trademark of Arm Limited (or its subsidiaries) in the US and/or elsewhere.

Table 1. Glossary of terms

Term	Developed form
ANSI	American national standards institute
BLE	Bluetooth® Low Energy
CDM	Charged-device model
CSI	Camera serial interface
DSI	Display serial interface
D-PHY	Physical layer option set by MIPI alliance
ECMF	EMI/RFI common mode filter
EMIF	Electromagnetic interference filter
ESDA	ESD association
ESD	Electrostatic discharge
GPIO	General purpose input/output
JEDEC	Joint electron device engineering council
JTAG	Joint test action group
HBM	Human body model
IEC	International electrotechnical commission
MM	Machine model
MIPI	Mobile industry processor interface
MOV	Metal oxide varistor
NFC	Near-field communication
PCB	Printed circuit board
SMC	Surface mounted component
SMPS	Switch mode power supply
SWD	Serial wire debug
TVS	Transient voltage suppressor
VBR	Voltage breakdown

Table 2. Reference documents

Reference number	Document title
[1]	*EMC design guide for STM8, STM32 and Legacy MCUs*, AN1709
[2]	*ESD considerations for touch sensing applications on MCUs*, AN3960

Table 3. Complementary literature available on www.st.com

Category	Document
EMIF	*HDMI ESD protection and signal conditioning products for STBs*, AN5121

Category	Document
EMIF	*IEC 61000-4-2 standard testing*, AN3353
	EMI filters for SD3.0 card high-speed SD card protection and filtering devices, AN4541
	LC filters for mobile phone LCD and camera links, AN3141
ECMF	*USB Type-C protection and filtering*, AN4871
	Antenna desense on handheld equipment, AN4356
	IEC 61000-4-2 standard testing, AN3353
	Common mode filters, AN4511
Protection	*Increasing the ST25DV-I2C series Dynamic NFC Tags ESD robustness on antenna using an external ESD protection*, AN5425
	3.3 V RS485 compatible with 1.8 V I/Os and selectable speed 20 Mbps or 250 kbps, AN5245
	Increasing the M24LRXXE-R family ESD robustness on antenna using an external ESD protection, AN4326
	Fundamentals of ESD protection at system level, AN5241
	USB Type-C protection and filtering, AN4871
	HDMI ESD protection and signal conditioning products for STBs, AN5121
	IEC 61000-4-2 standard testing, AN3353

2 Electrostatic discharge (ESD)

This section describes the electrostatic discharge phenomenon, its consequences to ICs and standards pertaining to ESD.

2.1 ESD phenomenon

Electrostatic discharge (ESD) is a sudden and momentary flow of electric current between two electrically charged objects. It is triggered upon contact, an electrical short, or dielectric breakdown.

On an electrical appliance, the most common entry points for ESD are interfaces such as connectors or human interface devices.

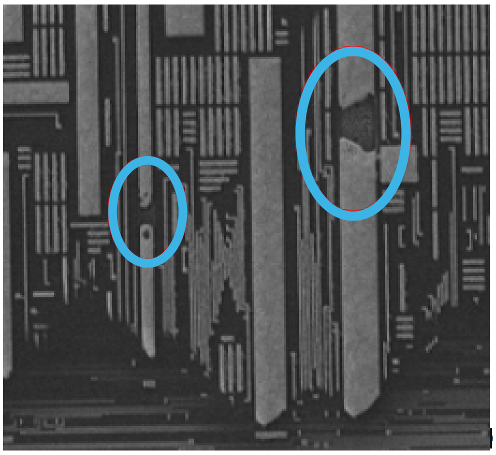
The ESD current induces high voltage spikes harmful to sensitive electronic devices such as microcontrollers. An ESD protection method or device adapted to their operating environment is used to prevent them from damage.

Electrostatic discharges exceeding the protective capabilities of the ESD protection may cause multiple types of failure, such as metallization defect, oxide breakdown, and burn defect.

Metallization defect

An excessive current through a metal track causes a local hot spot and melts the metal. This can create open circuits or/and shorts between metal tracks.

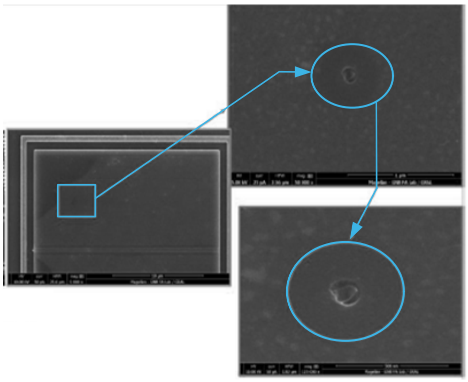
Figure 1. **Example of metallization defect**



Oxide breakdown defect

An excessive electric field damages the dielectric. This occurs when the voltage across the dielectric thickness exceeds 80-100 V. The damage to the dielectric usually causes permanent leakage that may induce sequential failures.

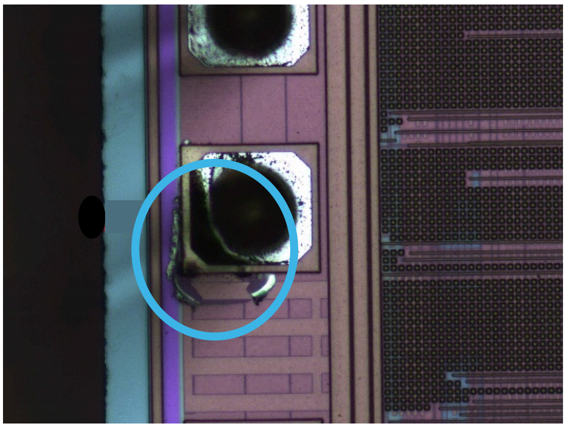
Figure 2. **Example of oxide breakdown defect**



Burn defect

Hot metal from the bonding pad, melted due to an ESD, leaks, and burns the silicon, bonding, or the pad.

Figure 3. **Example of burn defect**



These defects may cause the MCU/MPU to behave abnormally (soft failure) or to stop operating (hard failure). Damage in the device can be such as:

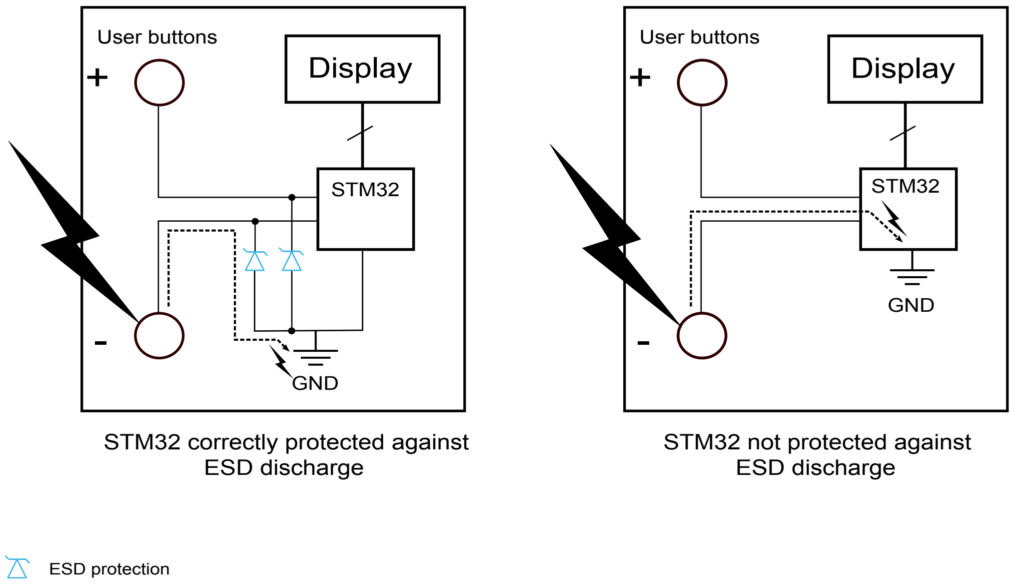
- short or open connection
- shift of impedances
- extra leakage
- overconsumption due to a resistive path to the ground or another internal structure

As a consequence, the application may lose a part of its functionality, or be completely down. The effect can be immediate or delayed, for example few power on/off cycles after the ESD stress.

STM32 devices embed protection to sustain standard factory manipulation and basic protection of external input/output pads. Embedded ESD protection consumes significant silicon area. At system level, it is sufficient to protect only the ESD entry points, as close as possible to the ESD source. Specific devices (from simple resistor to more complex low-impedance structure) are used to shunt the ESD current and protect the application circuitry, without impacting the application behavior.

The following figure shows two variants of a simple application with two user buttons, one protected, the other not protected. As the buttons are in direct contact with the user, they are a possible source of ESD.

Figure 4. Application variants with protected and unprotected STM32 device



2.2 ESD protection level quantification

International standards pertaining to the ESD protection come from the following bodies:

- *American national standards institute (ANSI)*
- *International electrotechnical commission (IEC)*
- *ESD association (ESDA)*
- *Joint electron device engineering council (JEDEC)*

There are three commonly used models:

- **Human body model (HBM)**, representing the manipulation of the product by humans
- **Charged-device model (CDM)**, representing conditions of manufacturing environment such as mechanical device handling
- **Machine model (MM)**, becoming obsolete due to similarity with HBM.

The JEDEC standard pertains to the manufacturing environment. It aims at protecting parts against ESD from the production machinery (CDM) and human manipulation (HBM).

The IEC 61000-4-2 standard aims at ensuring that the parts sustain the stress that they face in the electronic equipment in operation.

The great variety of different STM32 applications can expose the STM32 devices to very different conditions from the ESD stress perspective. It is not possible to compare system ESD robustness from an IC standpoint in such conditions. To guide users in targeting an IEC 61000-4-2 class, the device datasheet provides a value based on an estimated typical usage and PCB shapes. Relevant details are available in [1].

The STM32 device datasheet provides two types of data:

- **Absolute maximum rating:** based on JEDEC, performed on unpowered devices, functionality validated afterwards.
- **Functional susceptibility test:** based on IEC 61000-4-2, performed on devices in operation, highlighting the effective operation or self-recovery capabilities of a system.

Check for more details in [1].

2.3 ESD protection requirements in application

The electronic equipment must comply with applicable industry standards in term of robustness with stress induced by ESDs. The protection requirements for military and healthcare applications are more strict than to consumer applications.

The following table lists the ESD protection levels defined by IEC 61000-4-2 (HBM) and their equivalent test voltages.

Table 4. **Sensitivity classification for the HBM (IEC 61000-4-2)**

Test type	Level	Test voltage
Contact discharge	1	2 kV
	2	4 kV
	3	6 kV
	4	8 kV
Air discharge	1	2 kV
	2	4 kV
	3	8 kV
	4	15 kV

The air discharge model is generally used when the contact cannot be characterized.

Table 5. **ST classification of ESD consequences**

Class A	Class B	Class C	Class D
No failure detected	Failure detected but self-recovery after disturbance	Need an external user action to recover normal functionality	Normal functionality cannot be recovered

ESD protection cost and footprint are minor with regard to costs related to handling product failures in the field. Therefore, the equipment makers have the interest to assess the ESD exposure of their products and adequately protect them.

2.4 Choosing an optimum ESD protection method

MCU and MPU pins exposed to ESD from the external world require protection. These include inputs and outputs for interfaces such as:

- USB, HDMI, USART, Ethernet
- audio line, microphone, speaker
- joystick, touch sensor, mouse
- RF antenna, power plug

This section describes possible ESD protection methods, then focuses on the TVS devices.

2.4.1 ESD protection methods

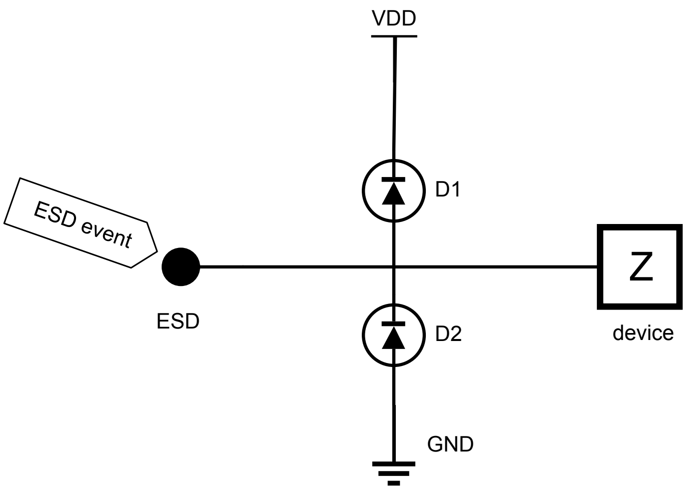
Using clamping diodes

Clamping diodes are most commonly used as IC ESD protection devices. Microcontrollers, digital signal controllers, and processors usually integrate ESD clamping diodes.

ICs without the embedded ESD protection can be protected with external clamping diodes, as shown in the following figure. For a standard GPIO, diodes clamping to V_{DD} and V_{SS} shunt the ESD stress to V_{DD} (positive polarity) or GND (negative polarity). A diode clamping to V_{DD} on a 5 V tolerant I/O prevents the I/O from being used as such.

Place a capacitor (for example 1 µF) between VDD and GND and as close as possible to the diodes, to absorb the ESD current.

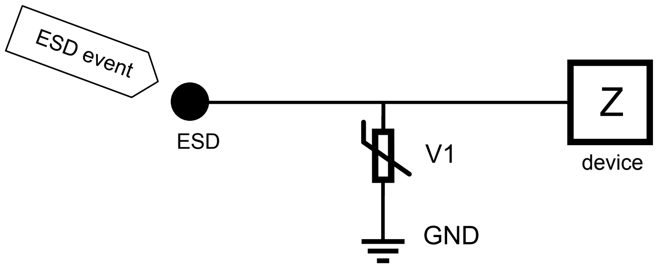
Figure 5. **Clamping diodes as ESD protection devices**



Using a varistor

The resistance of a varistor varies with the voltage across - the higher the voltage, the lower the resistance. This property makes them behave as clamps when exposed to ESD. Furthermore, varistors are low-capacity and low-cost devices. Their weak point is that their clamping voltage is usually too high to protect an I/O. Another drawback is that by their construction, these metal-oxide varistors (MOV) degrade when exposed to ESDs.

Figure 6. **Varistor as ESD protection device**



Using a capacitor

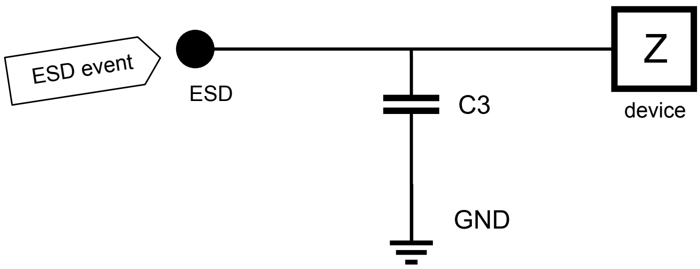
ESD is most commonly caused by humans, upon touching the electronic equipment. The IEC 61000-4-2 standard (HBM) categorizes the electronic equipment resistance to a 330 pF capacitor discharge, without damage. The 330pF value is considered as an equivalent of human body capacitance. The resistance is expressed in levels or in capacitor voltage prior to the discharge. It spans up to 8 kV.

Electrical terminals can be protected with a capacitor (usually 100 nF or more) that absorbs the charge of the human body transferred to the equipment upon the ESD. It scales down the voltage with the ratio of the two capacitances. For the protection to be effective, the protection capacitor must have a very low parasitic inductance, which is the property of high-frequency capacitors.

The solution is well adapted for protecting static ports such as power terminals, where a capacitor is also required for decoupling. To improve its ESD protection efficacy, a small transient voltage suppression (TVS) device added in parallel with the decoupling capacitor then suppresses peaks due to parasitic inductance.

The method is not suitable for protecting data ports as it degrades data rate or prevents data interfaces from operating.

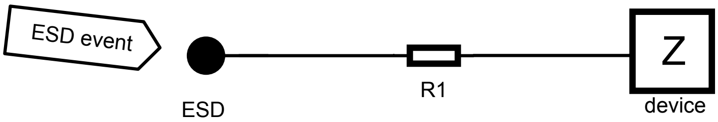
Figure 7. **Capacitor as ESD protection device**



Using a resistor in series

Resistors in series limit the current induced by the ESD. A resistor of several kΩ can effectively protect an I/O terminal of an IC. However, this solution is often inadequate to protect data transfer I/Os and it is not applicable to powering terminals. Standard resistors are not designed to sustain high voltage. Repetitive exposure to ESDs may alter their properties, which then can reduce their protective efficacy or impair the electronic equipment functionality. The application of a serial resistor as an ESD protection device must therefore properly be tested.

Figure 8. **Resistor in series as ESD protection device**



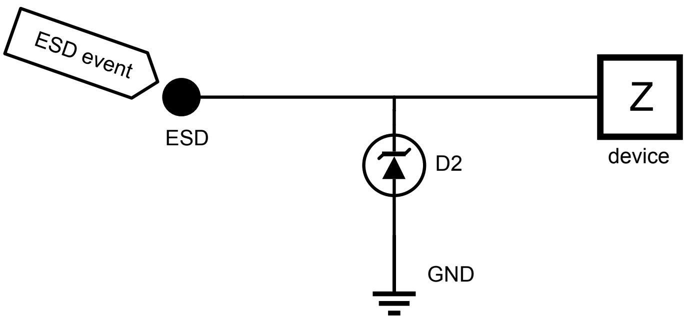
Using a transient voltage suppressor

Transient voltage suppressor (TVS) such as Transil™ is high-impedance until the voltage across reaches a breakdown level. Once its breakdown voltage is reached, the TVS acts as a clamp with a very short reaction time. There are unidirectional (see Figure 10) and bidirectional (see Figure 11) TVS devices.

A bidirectional TVS has a symmetrical voltage-current characteristic, presenting the same breakdown voltage on the negative and positive side of the voltage axis. It is well suited for protecting analog unbiased lines.

A unidirectional TVS has an asymmetrical voltage-current characteristic similar to a Zener diode. As it clamps negative disturbance to a lower level than a bidirectional TVS, it is better adapted for protecting terminals that only bear positive voltages.

Figure 9. **TVS as ESD protection device**



2.4.2 ESD protection with TVS

The rest of the document focuses on the ESD protection with TVS and in particular with ST TVS devices.

TVS devices offer a very fast response time, a sharp voltage-current characteristic, and robustness with ESDs. Additionally, their destruction upon an excess of their maximum allowed current usually transforms them into a short circuit. This is generally better than an open circuit leaving the equipment unprotected.

Unidirectional TVS devices typically protect electronic equipment (or an IC) supplied from positive voltage only, such as 3.3 V. Bidirectional TVS devices typically protect electronic equipment supplied from positive and negative voltages, such as 3.3 V and -3.3 V.

Figure 10. Unidirectional TVS voltage-current characteristic

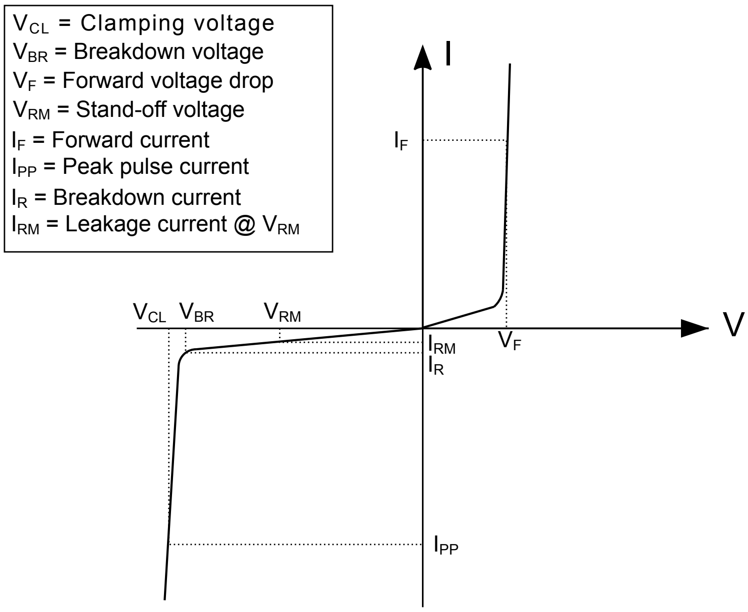
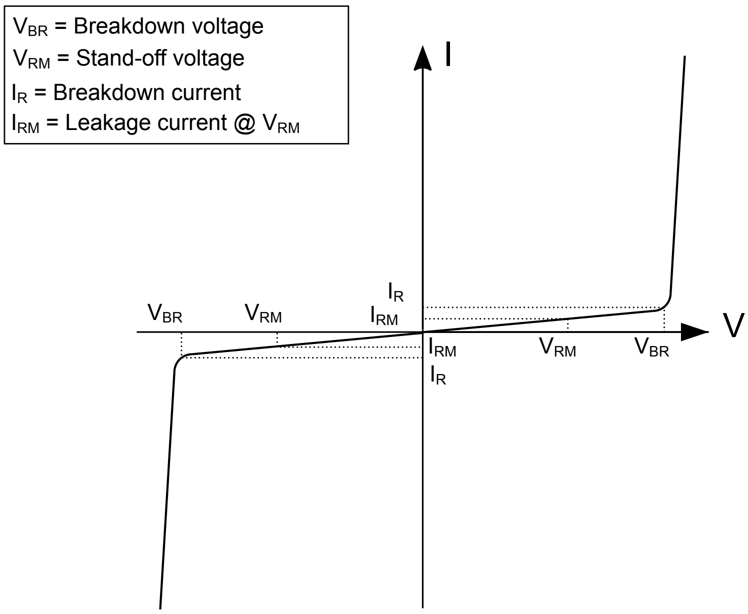


Figure 11. Bidirectional TVS voltage-current characteristic



2.5 Optimizing the application for ESD protection

If the protection device is too far from the discharge point, the discharge current may induce an excessive electric field. The induced electrical field can disturb other parts of the system by coupling phenomena. Keep the TVS device as close as possible to the expected point of electrostatic discharge.

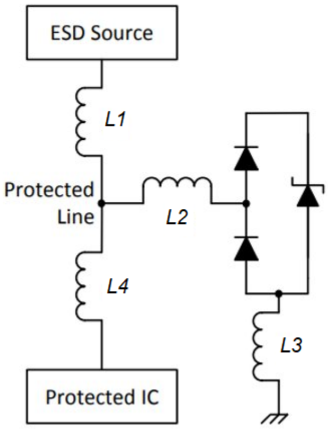
The voltage of the TVS-protected point during an ESD is a sum of:

- V_{BR} - the TVS device breakdown voltage
- V_R - voltage across a parasitic serial resistance R_d: $V_R = R_d \times I_{ESD}$.
- V_L - voltage across a parasitic inductance L: $V_L = L \times di/dt$.

The main challenge for a PCB routing is to ensure that most of the current flows through the TVS protection, thus unloading the ESD protection embedded in the STM32.

As every single track has an inherent inductance, the system can be schematized as follows:

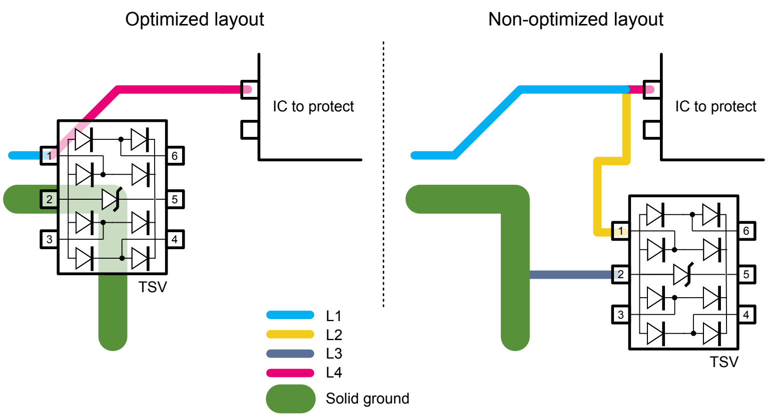
Figure 12. Schematic diagram of a TVS protected system



The inductance of the TVS path is L1 + L2 + L3 while the one towards the protected IC is L1 + L4. For the ESD current to flow to the TVS device, it is important to keep L2 and L3 as small as possible and the L4 greater than L1.

The following figure shows the principal PCB layout measures to reach that goal. With an optimized layout, the TVS device is placed directly on the PCB signal and ground tracks. In this way, it minimizes L2 and L3 parasitic inductances. Also, it is closer to the ESD source than to the IC to protect, thus maximizing the L4/L1 ratio.

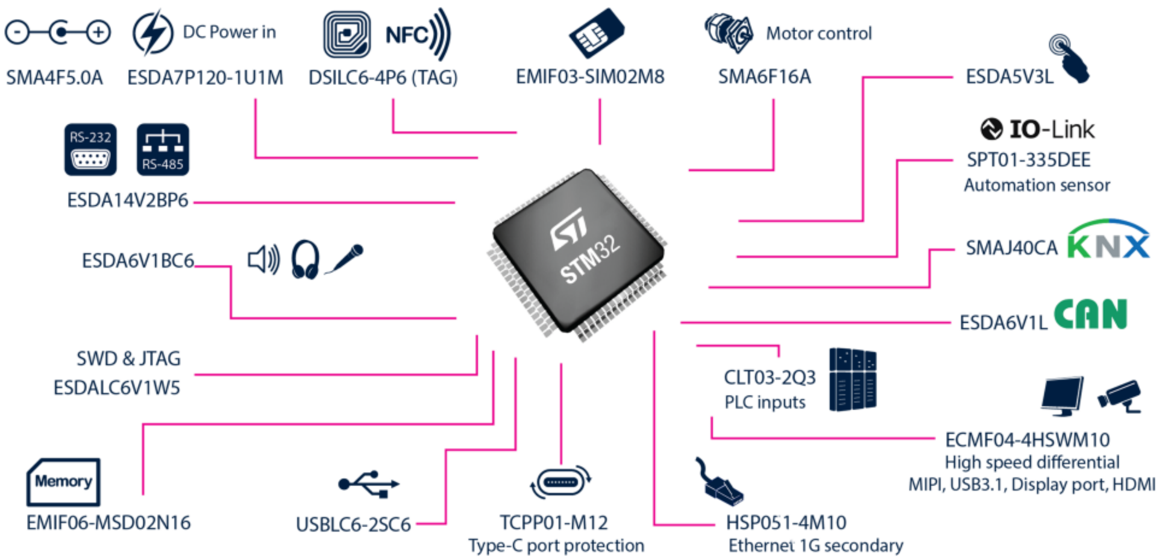
Figure 13. Optimizing PCB layout



3 ESD solutions in application

This section pertains to ESD protection solutions in various applications such as human interface, wired communication, or multimedia.

Figure 14. **Protection and filters around an MCU**



3.1 Human interface

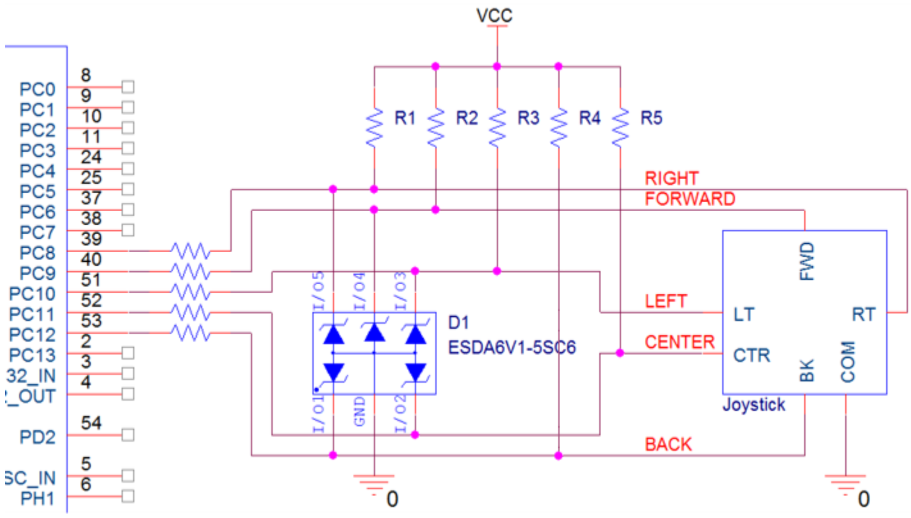
Most ESDs are caused by humans. The following sections pertain to ESD protection solutions for joystick, press button, and touch sensing.

Note: The STM32 peripherals involved are: ADC and GPIOs.

3.1.1 Joystick

A five-line protection component is ideal for the five buttons of a joystick. When the STM32 MCU is supplied from its maximum operating voltage 3.6 V, the absolute maximum voltage of the joystick sensing I/Os is well above the V_{BR} of the protection component (here 6.1 V). This headroom allows the use of a protection component with parasitic capacitance.

Figure 15. **Joystick port ESD protection**

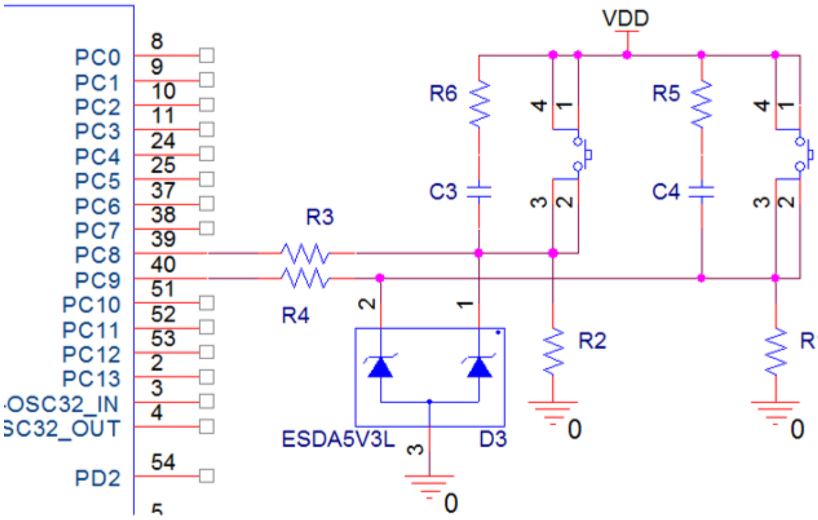


Refer to Transil (TVS) array for ESD protection (ESDA6V1-5SC6) page on www.st.com for more information on this ESD protection device.

3.1.2 Press button

For signal always at V_{DD}, use a low leakage protection component. This protection component respects the maximum voltage and frequency for a press button application, leaving a good margin on V_{BR}.

Figure 16. Press button port ESD protection (two buttons)



Refer to DUAL TRANSIL ARRAY FOR ESD PROTECTION (ESDAL) (for two-button application) and Single-line low capacitance Transil for ESD protection (ESDALC6V1-1U2) (for one-button application) pages on www.st.com for more information on these ESD protection devices.

3.1.3 Touch sensing

For touch sensing application, refer to [2].

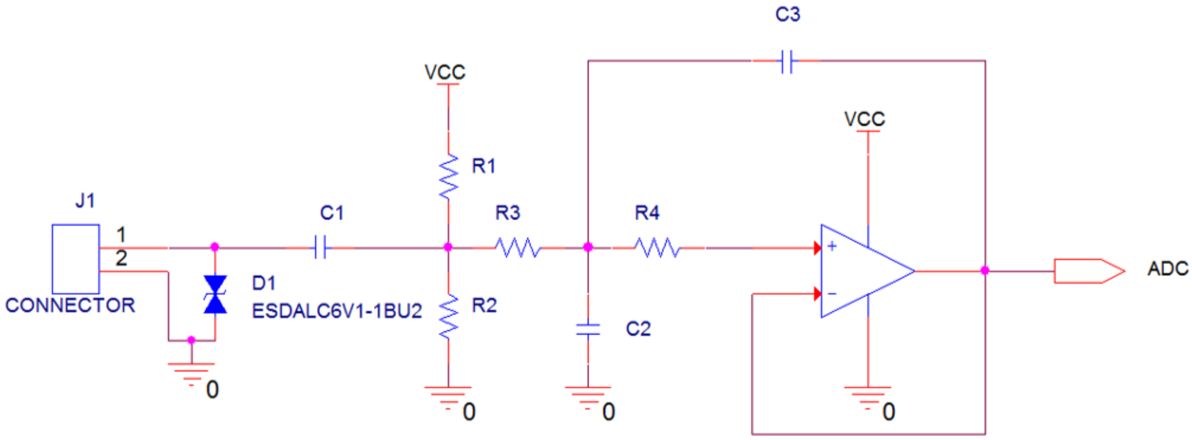
3.2 Analog and power

The following sections pertain to ESD protection solutions for analog signal monitoring, audio playback, and recording and power.

3.2.1 Analog signal monitoring

Analog signals and lines such as the battery voltage can be monitored by an ADC. The battery monitoring line, often coming from a mezzanine board, is sensitive to ESD and the input of the STM32 ADC must be protected.

Figure 17. Analog signal monitoring port ESD protection



Refer to Single-line low capacitance Transil for bidirectional ESD protection (ESDALC6V1-1BU2) page on www.st.com for more information on this ESD protection device.

Note: The STM32 peripherals involved are: ADC, OPAMP, COMP, and DAC.

3.2.2 Audio playback and recording

Consumer applications often provide an audio receptacle to plug a headphone or an external amplifier, and a microphone or another audio source. The STM32 device can be connected to an audio codec device that drives the audio signal externally. At the same time, the application can monitor the acoustic environment through analog or MEMS microphones to detect or cancel noise. As these signal lines face the environment through connectors, speakers, or microphones, they must be ESD-protected.

Figure 18. ESD protection of audio application with jack connectors

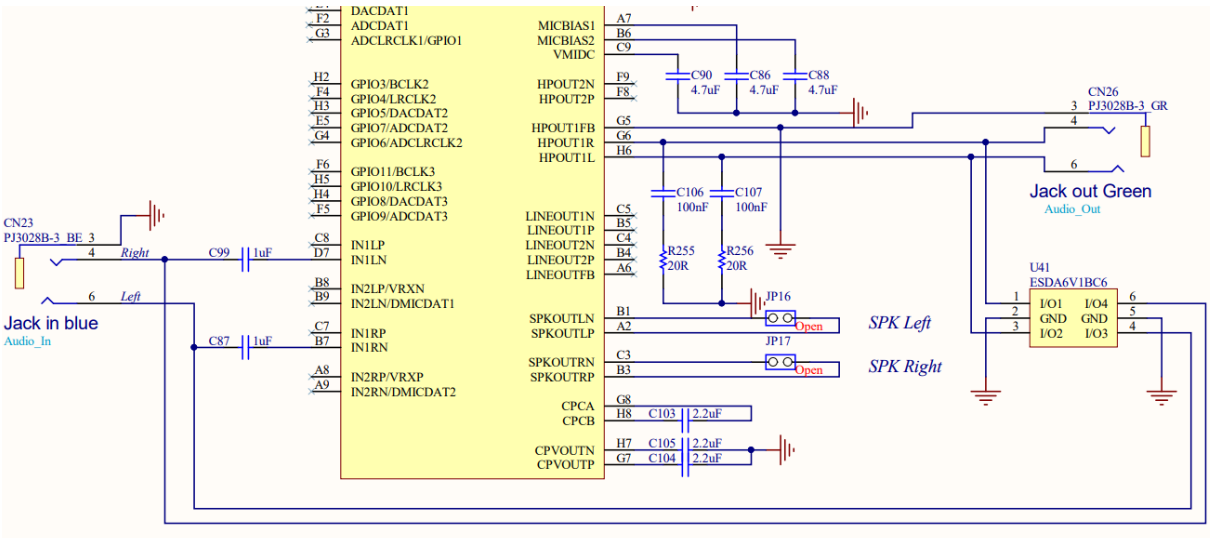
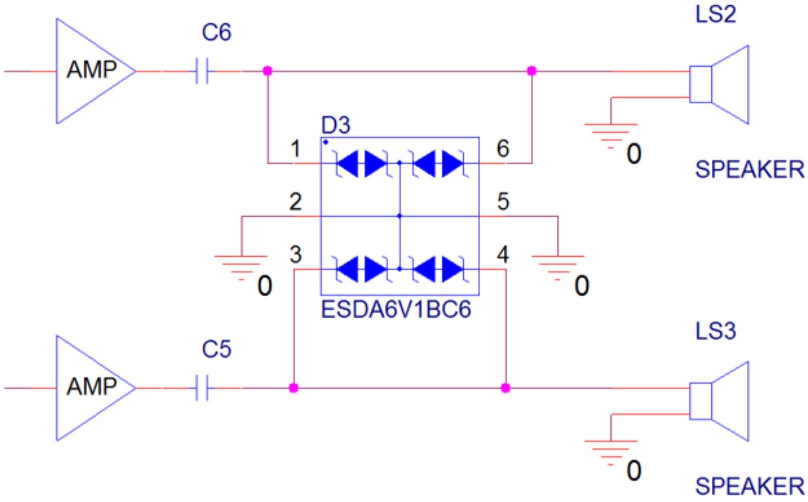
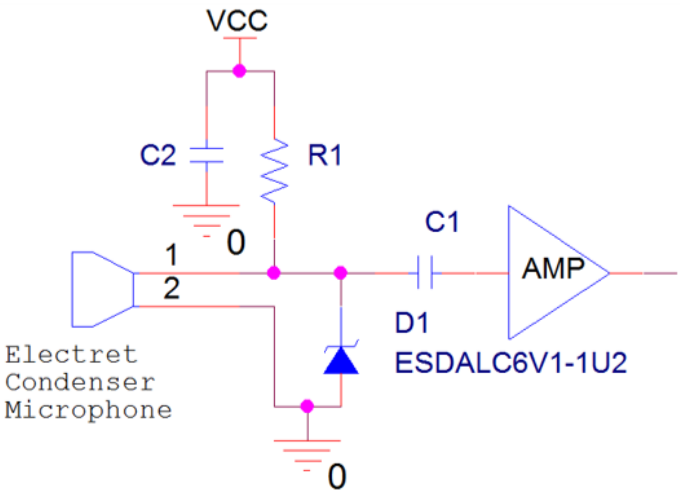


Figure 19. **ESD protection of audio amplifier application with speakers**



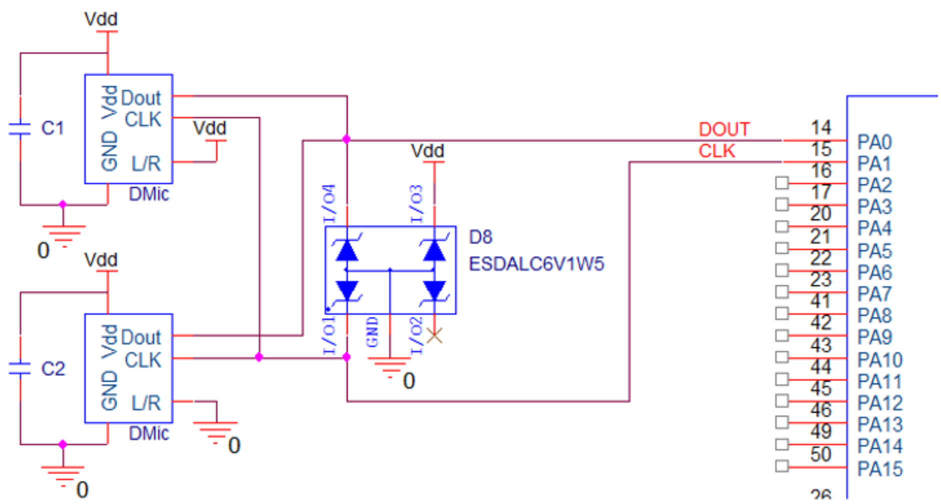
Refer to QUAD BIDIRECTIONAL TRANSIL SUPPRESSOR FOR ESD PROTECTION (ESDA6V1-4BC6) page on www.st.com for information on the appropriate protection device for this application.

Figure 20. **ESD protection of audio application with ECM**



Refer to Single-line low capacitance Transil for ESD protection (ESDALC6V1-1U2) page on www.st.com for information on the appropriate protection device for this application.

Figure 21. **ESD protection of audio application with digital microphone**



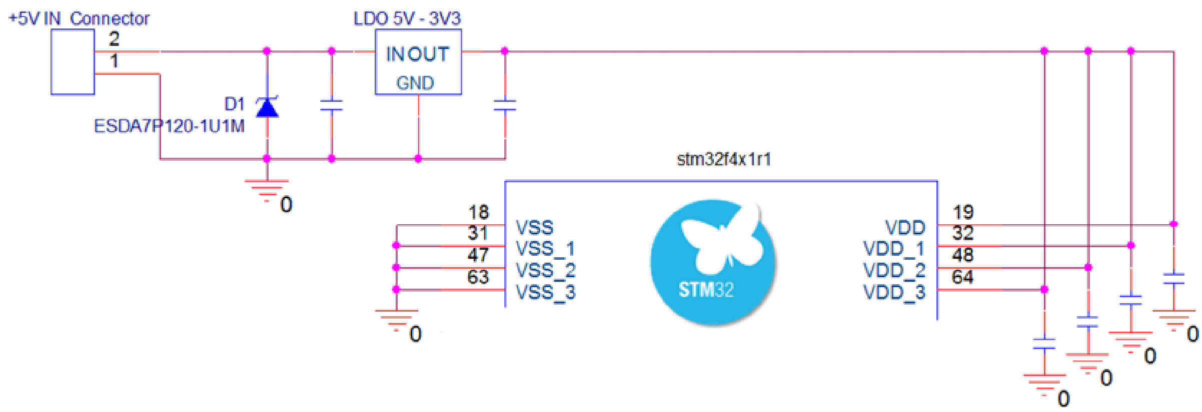
Refer to QUAD TRANSIL ARRAY FOR ESD PROTECTION (ESDALC6V1W) page on www.st.com for more information on this ESD protection device.

Note: The STM32 peripherals involved are: ADC, OPAMP, COMP, DAC, DFSDM, SPDIF, SAI, and I2S.

3.2.3 Power

The SMC30J Transil series protects sensitive equipment against surges below 3000 W (10/1000 µs) and against ESD according to IEC 61000-4-2, and MIL STD 883, method 3015. It is compatible with high-end equipment and switch mode power supply (SMPS). These applications require an ESD protection component with low leakage current that is reliable and long-lasting at high junction temperature. SMC30J is packaged in a package with SMC footprint compliant with the IPC 7531 standard.

Figure 22. **Power supply line ESD protection**



Refer to High-power transient voltage supressor (TVS) (ESDA7P120-1U1M) page on www.st.com for more information on this ESD protection device.

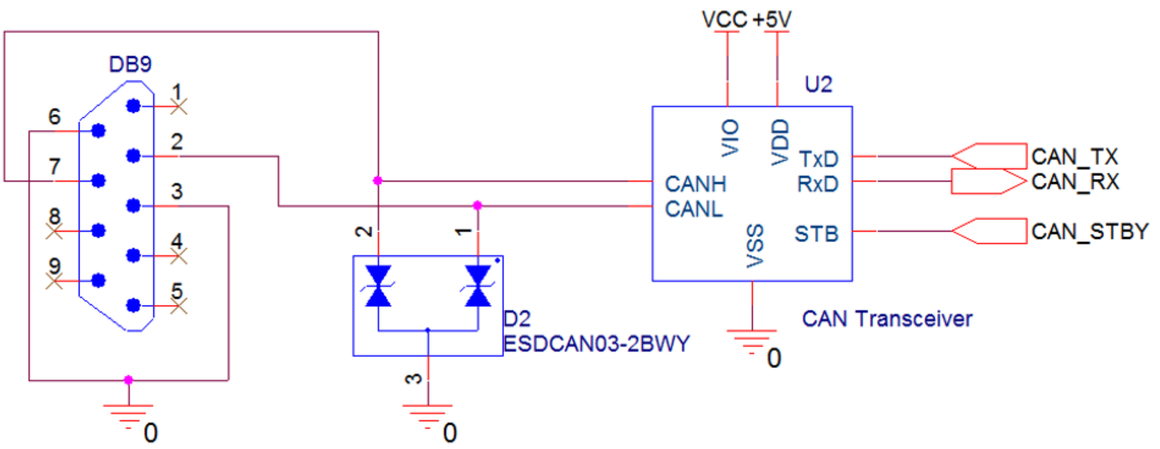
Note: The STM32 peripherals involved are: BOR, PVD, and PVM.

3.3 Wired communication

The following sections pertain to ESD protection solutions for CAN, Ethernet, serial interface protocols, RS-232 and RS-485.

3.3.1 CAN

Figure 23. CAN port ESD protection

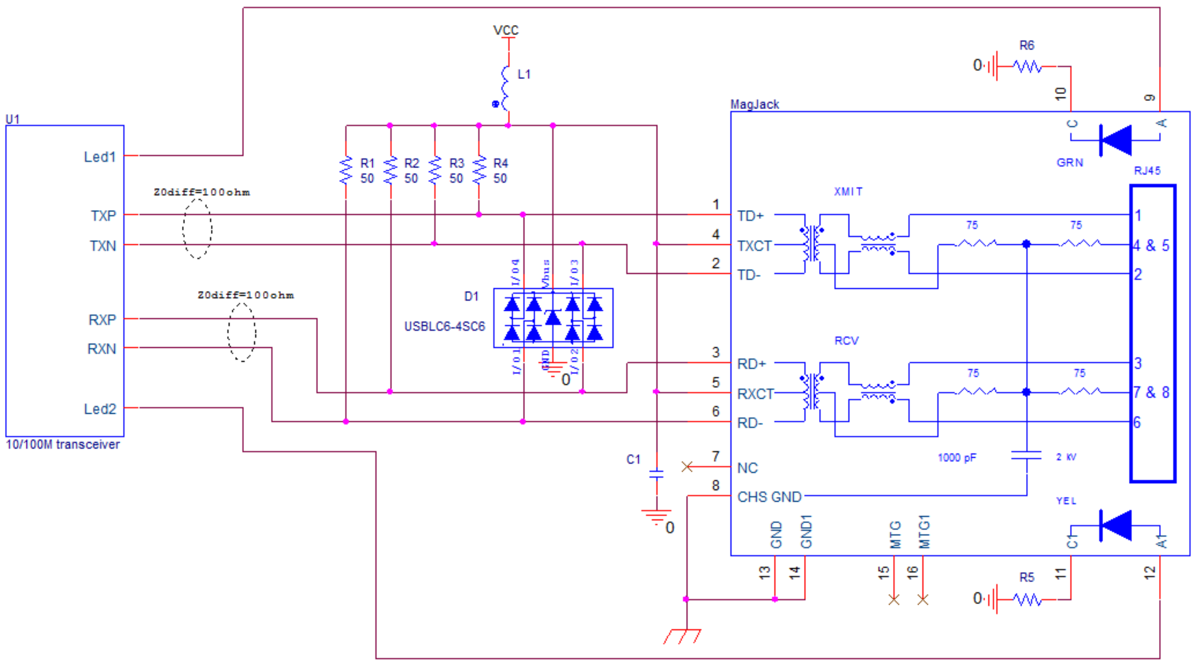


Refer to Automotive dual-line TVS in SOT323-3L for CAN bus (12 V system) (ESDCAN03-2BWY) page on www.st.com for more information on this ESD protection device.

Note: The STM32 peripherals involved are: CAN and FDCAN.

3.3.2 Ethernet

Figure 24. Ethernet port ESD protection



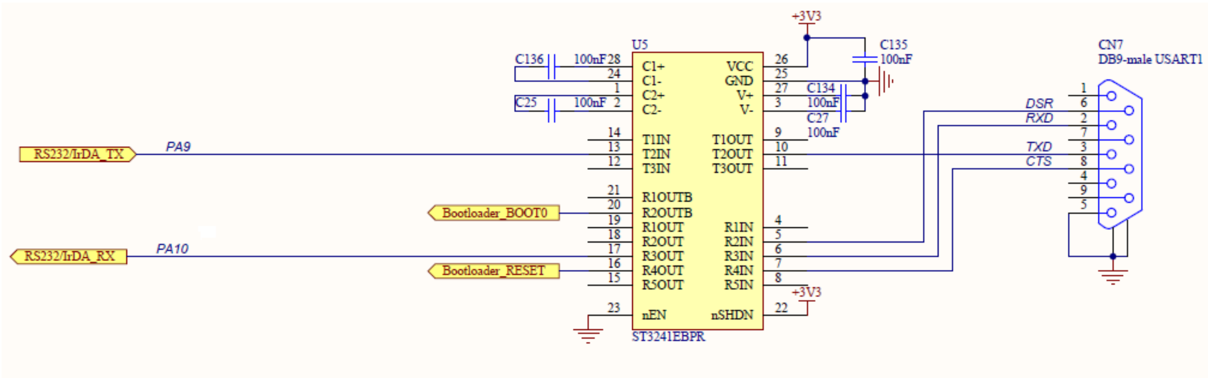
Refer to Very low capacitance ESD protection (USBLC6-4SC6) and 4-line ESD protection for high-speed lines (HSP053-4M5) pages on www.st.com for more information on these ESD protection devices. Consider the latter for gigabit Ethernet ports.

Note: The STM32 peripheral involved is the Ethernet MAC.

3.3.3 RS-232 and RS-485

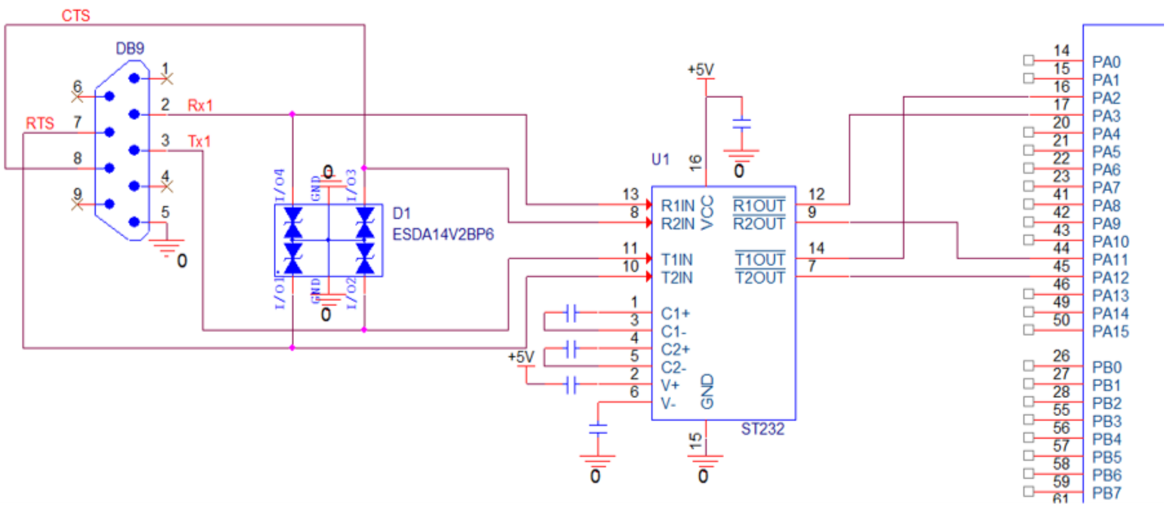
These serial ports can be ESD-protected through the use of a transceiver with embedded ESD protection, or with an extra ESD-protecting device.

Figure 25. RS-232 transceiver with embedded ESD protection



Refer to 15kV ESD protected 3 to 5.5V, 400kbps, RS-232 transceiver with auto power-down (ST3241EB) page on www.st.com for details.

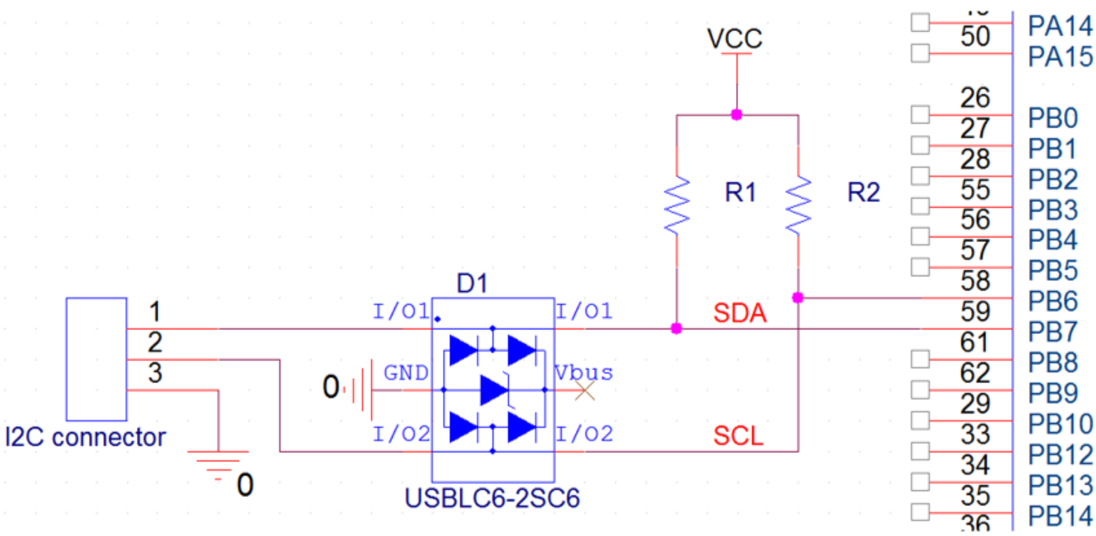
Figure 26. STM32 embedded RS-232 transceiver with external ESD protection



Refer to TRANSIL ARRAY FOR ESD PROTECTION (ESDAxxxP6) page on www.st.com for more information on this ESD protection device.

3.3.4 Other serial interfaces

Figure 27. I2C-bus port ESD protection



Refer to Very low capacitance ESD protection (USBLC6-4SC6) page on www.st.com for more information on this ESD protection device.

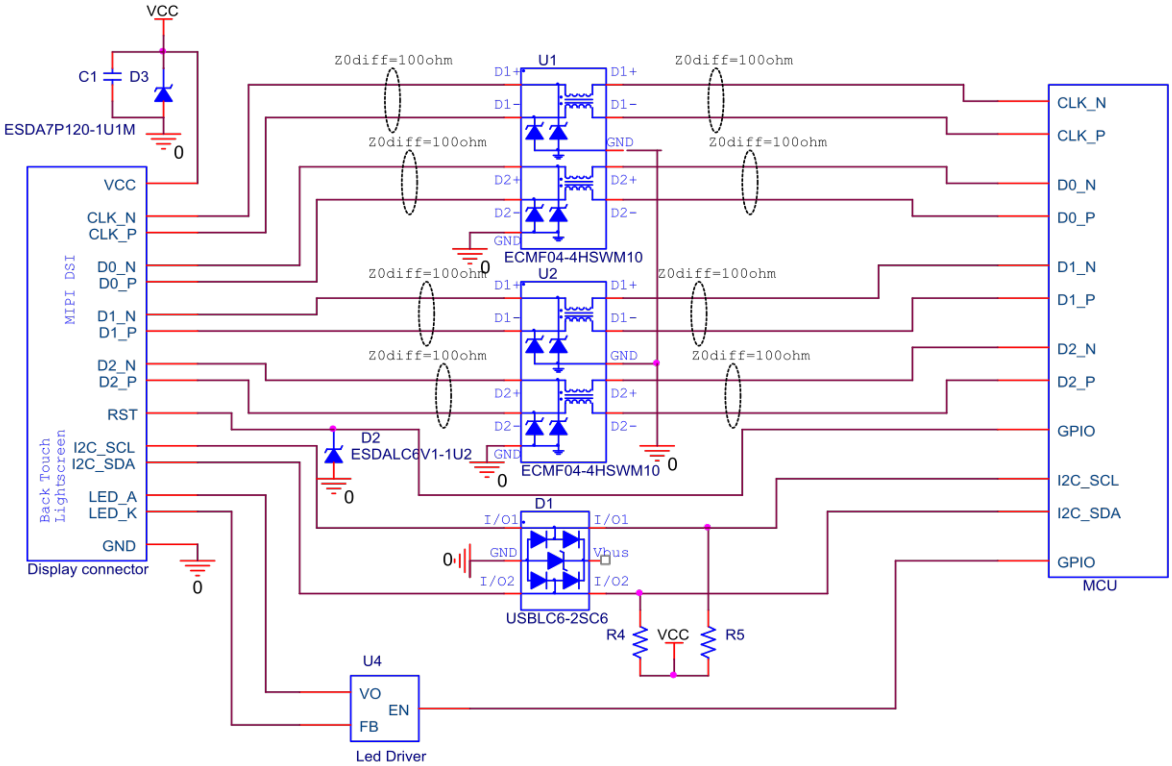
Note: Other STM32 peripherals such as FMP I2C, I2C, SPI, QUADSPI, OCTOSPI, UART, USART, and LPUART can be protected based on this example.

3.4 Multimedia

The following sections pertain to ESD protection solutions for MIPI D-PHY, parallel display interface, HDMI, USB 2.0 Full or High speed, and USB Type-C.

3.4.1 MIPI D-PHY (DSI and CSI)

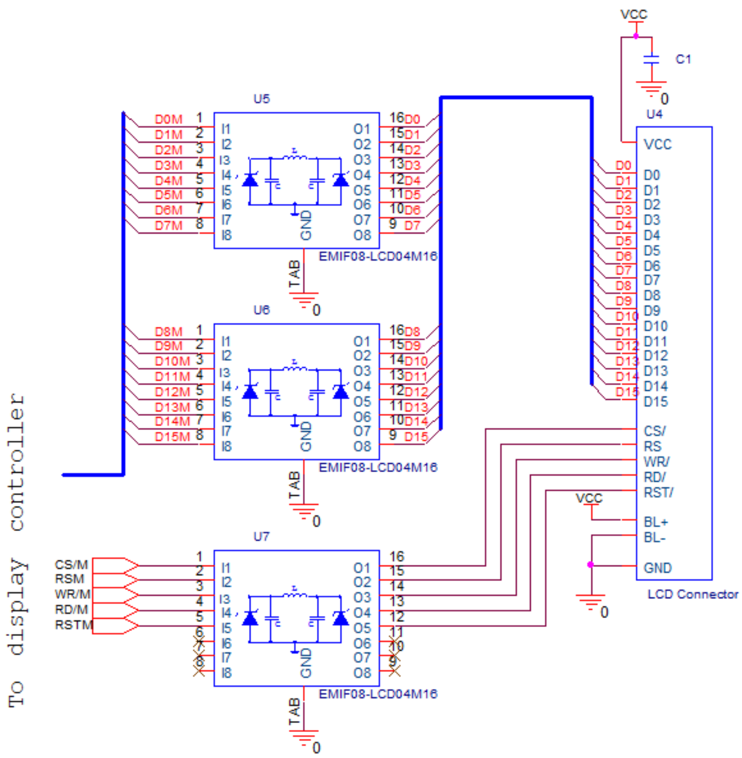
Figure 28. MIPI port ESD protection



Refer to Common mode filter with ESD protection in QFN-10L (ECMF04-4HSWM10) and Very low capacitance ESD protection (USBLC6-4) pages on www.st.com for more information on these ESD protection devices.

3.4.2 Parallel display interface

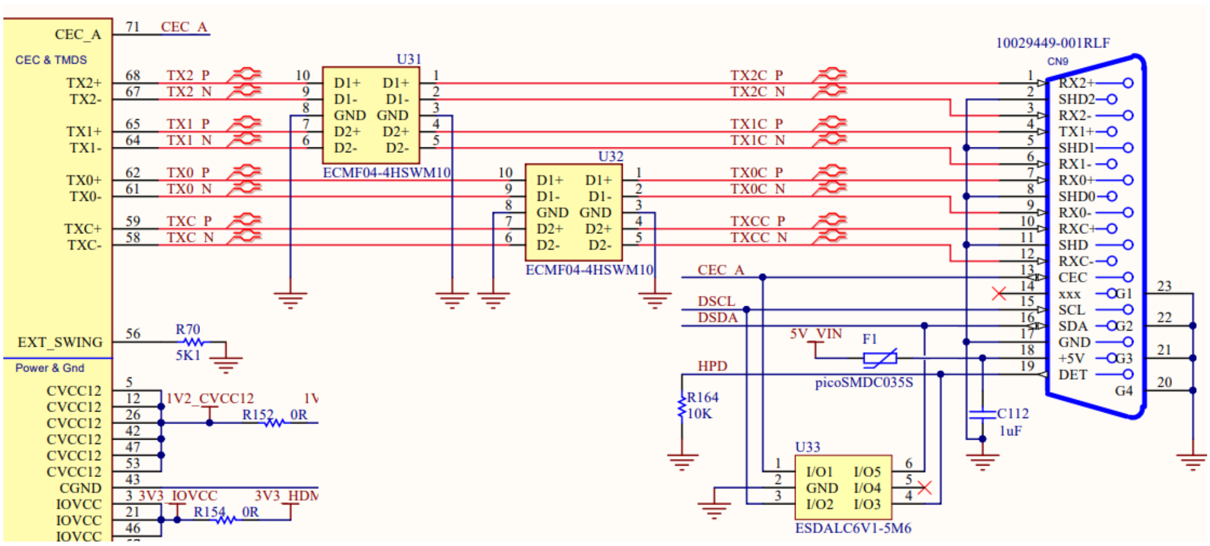
Figure 29. **Parallel display port ESD protection**



Refer to 8-line L-C EMI filter and ESD protection for display interfaces (EMIF08-LCD04M16) page on www.st.com for more information on this ESD protection device.

3.4.3 HDMI

Figure 30. **HDMI port ESD protection**

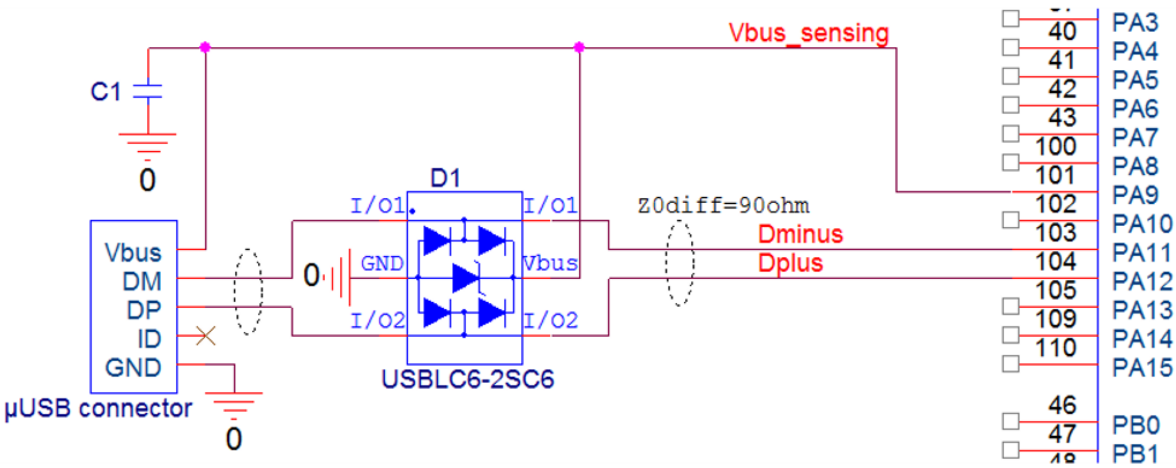


Refer to Common mode filter with ESD protection in QFN-10L (ECMF04-4HSWM10) and 5-line low capacitance Transil arrays for ESD protection (ESDALC6V1-5M6) pages on www.st.com for more information on these ESD protection devices.

Note: On STM32 devices, the I/Os to protect against ESD are those of the HDMI CEC port.

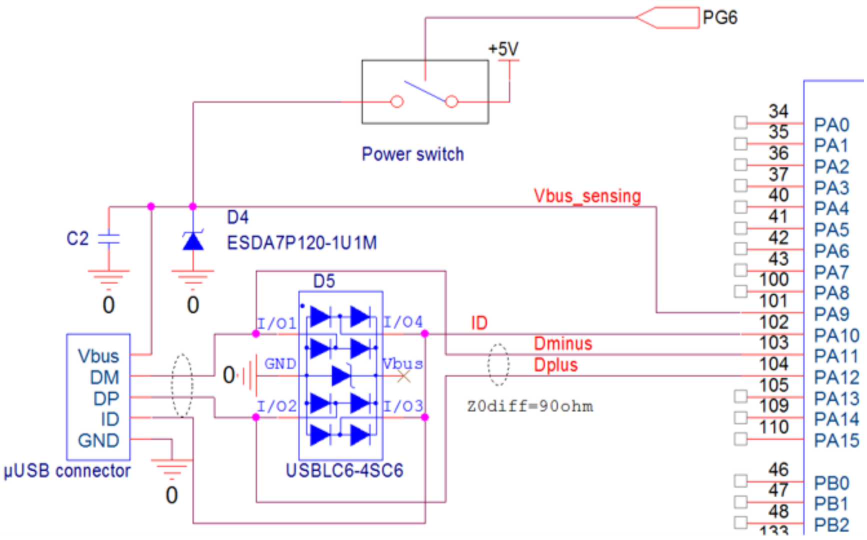
3.4.4 USB

Figure 31. USB 2.0 full-speed port ESD protection



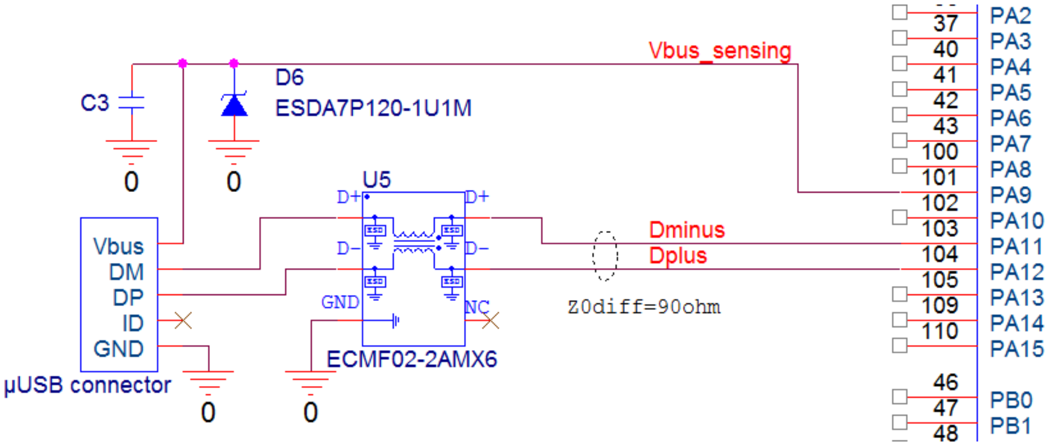
Refer to ESD Protection for USB 2.0 High Speed (USBLC6-2) page on www.st.com for more information on this ESD protection device.

Figure 32. USB 2.0 full-speed OTG port ESD protection



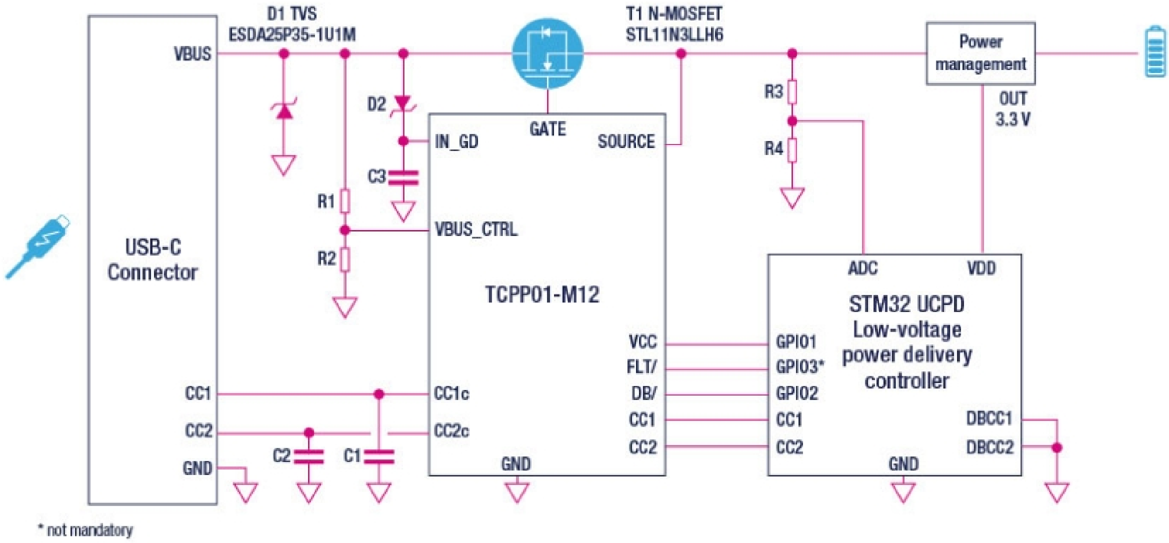
Refer to Very low capacitance ESD protection (USBLC6-4) page on www.st.com for more information on this ESD protection device.

Figure 33. **USB 2.0 high-speed port ESD protection**



Refer to Common-mode filter and ESD protection for USB 2.0 and MIPI/MDDI interfaces (ECMF02-2AMX6) page on www.st.com for more information on this ESD protection device.

Figure 34. **USB Type-C® port ESD protection**



Refer to USB Type-C Port Protection for Sink application (TCPP01-M12) page on www.st.com for more information on this ESD protection device.

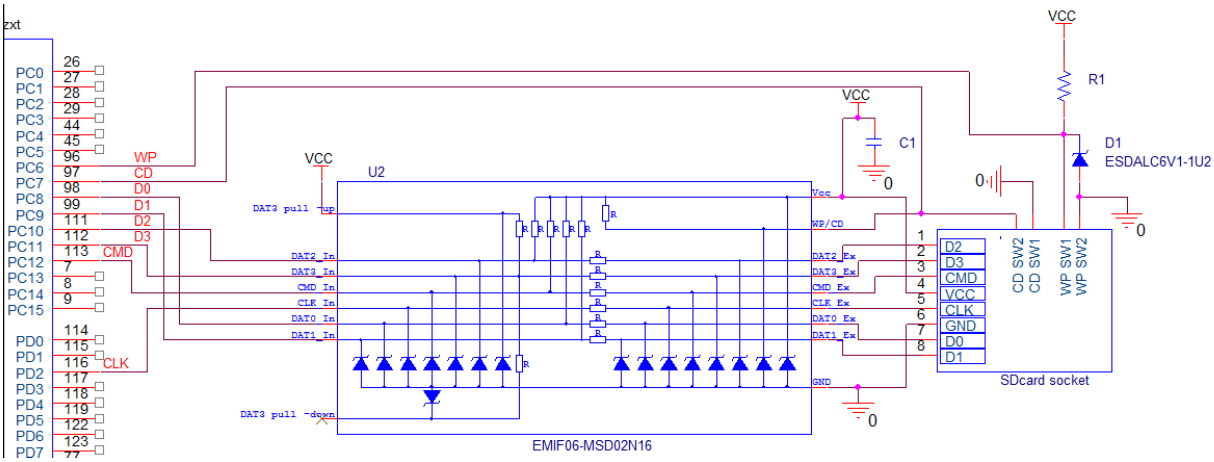
Note: On STM32 devices, the I/Os subject to be ESD-protected are those of the USB, USB OTG_FS, USB OTG_HS, and UCPD ports.

3.5 Storage

The following sections pertain to ESD protecting SD card and smartcard.

3.5.1 SD card 2.0

Figure 35. SD card 2.0 port ESD protection

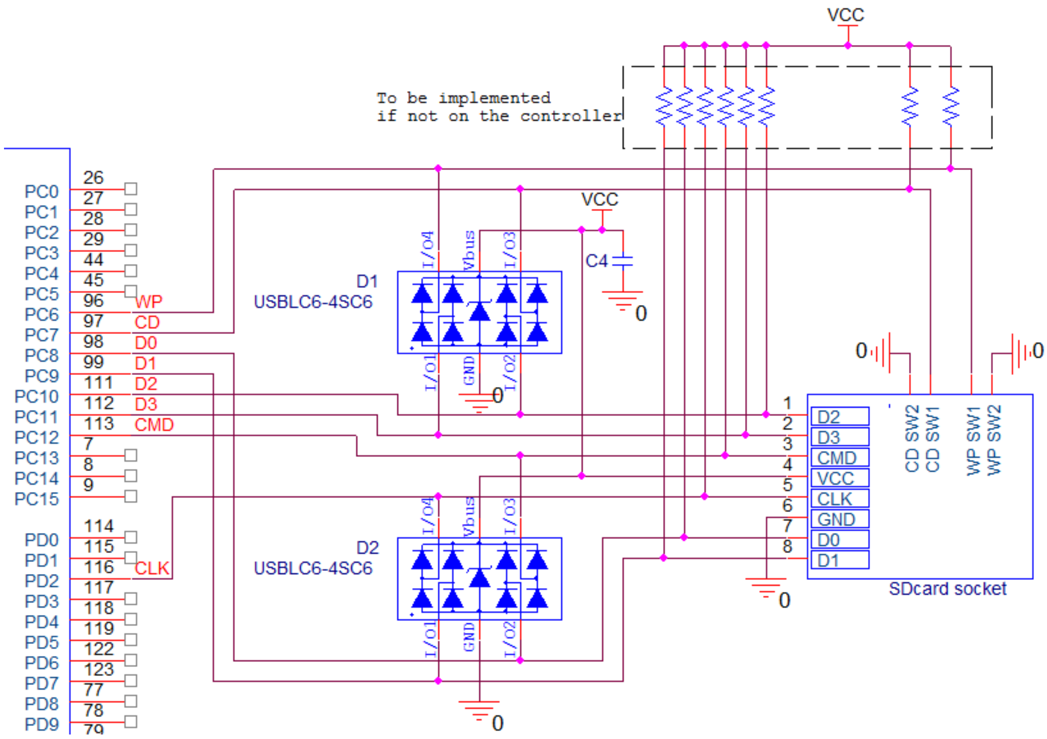


Refer to 6-line EMI filter and ESD protection for T-Flash and micro SD card™ interfaces (EMIF06-MSD02N16) page on www.st.com for more information on this ESD protection device.

Note: On STM32 devices, the I/Os to protect against ESD are those of the SDMMC peripheral.

3.5.2 SD card 3.0

Figure 36. SD card 3.0 port ESD protection

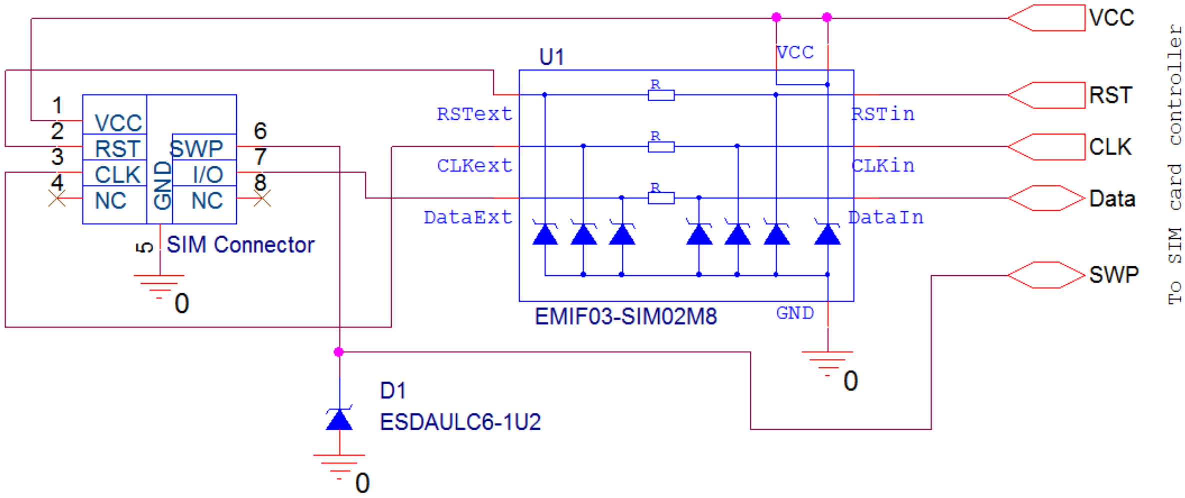


Refer to Very low capacitance ESD protection (USBLC6-4) page on www.st.com for more information on this ESD protection device.

Note: On STM32 devices, the I/Os to protect against ESD are those of the SDMMC peripheral.

3.5.3 Smartcard (ISO-7816)

Figure 37. Smartcard interface ESD protection



Refer to 3-line EMI filter and ESD protection for SIM card interfaces (EMIF03-SIM02M8) and Single-line unidirectional ESD protection for high speed interface (ESDAULC6-1U2) pages on www.st.com for more information on these ESD protection devices.

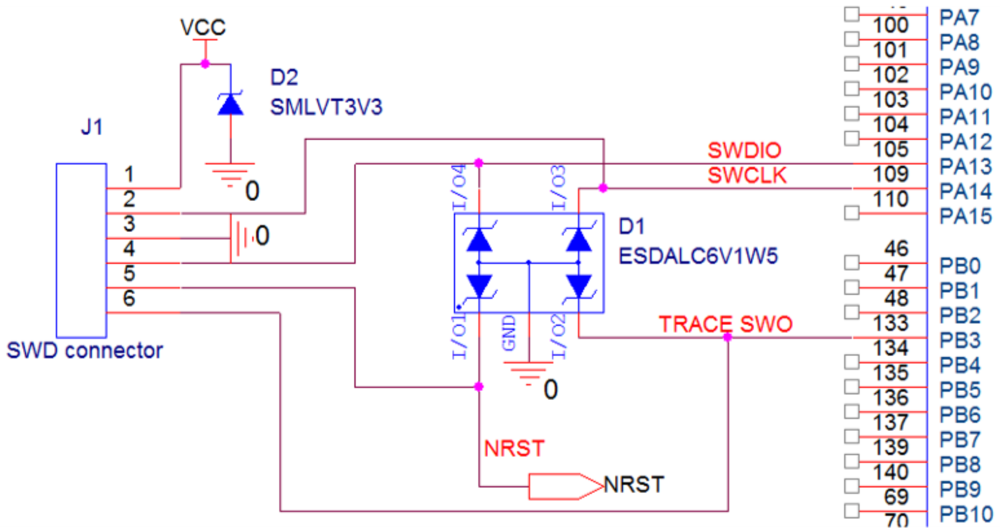
Note: On STM32 devices, the I/Os to protect against ESD are those of the USART peripheral.

3.6 Debug and programming

This sections pertain to ESD protecting SWD and JTAG interfaces.

3.6.1 SWD

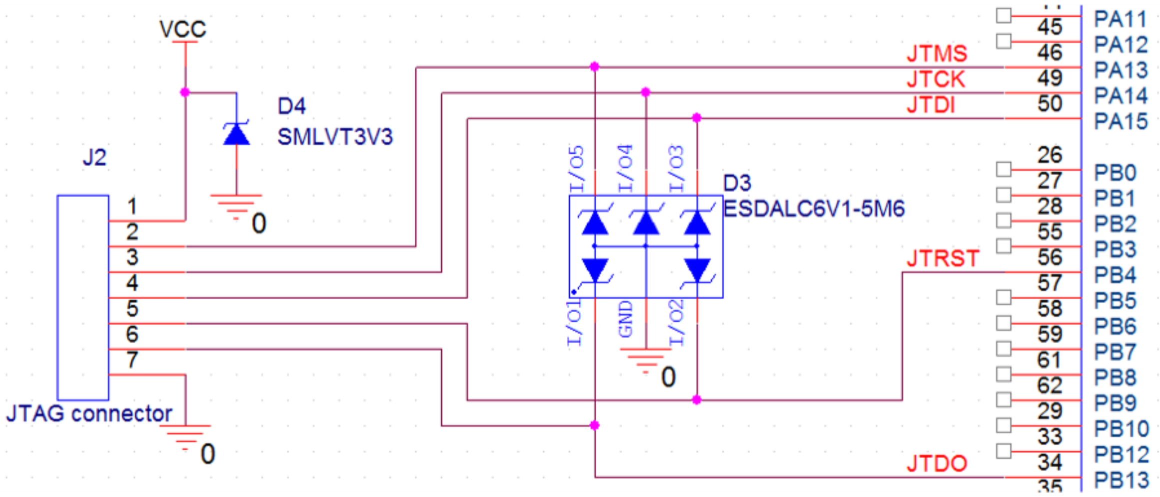
Figure 38. SWD interface ESD protection



Refer to 600 W, 3.3 V TVS in SMB (SMLVT3V3) and QUAD TRANSIL ARRAY FOR ESD PROTECTION (ESDALC6V1W) pages on www.st.com for more information on this ESD protection device.

3.6.2 JTAG

Figure 39. JTAG interface ESD protection



Refer to 600 W, 3.3 V TVS in SMB (SMLVT3V3) and 5-line low capacitance Transil™ arrays for ESD protection (ESDALC6V1-5M6) pages on www.st.com for more information on this ESD protection device.

3.7 Summary

The following table summarizes the ESD protection components presented in the previous sections.

Application	ESD protection device
Human interface	
Joystick or Keypad	ESDA6V1-5SC6
Press button (one button)	ESDALC6V1-1U2
Press button (two buttons)	ESDAL
Analog and power	
Analog signal monitoring (positive-only)	ESDALC6V1-1U2
Analog signal monitoring (bi-directional)	ESDALC6V1-1BU2
Audio application with two jack connectors or speakers	ESDA6V1-4BC6
Audio application with ECM	ESDALC6V1-1U2
Audio application with digital microphone	ESDALC6V1W5
Power line	ESDA7P120-1U1M
Wired communication	
CAN port	ESDCANxx-2BWY
Ethernet port	USBLC6-4 HSP053-4M5
RS-232 / RS-485 port	ESDAxxxP6
Other serial interfaces	USBLC6-4
Multimedia	
MIPI D-PHY (DSI / CSI)	ECMF04-4HSWM10 USBLC6-4
Parallel display interface	EMIF08-LCD04M16

Application	ESD protection device
HDMI	ECMF04-4HSWM10 (data lines, with common mode choke) HSP053-4M5 (data lines, protection only) ESDALC6V1-5M6 (CEC lines)
USB 2.0 FS	USBLC6-2
USB 2.0 FS OTG	USBLC6-4
USB 2.0 HS	ECMF02-2AMX6
Storage	
SD card 2.0	EMIF06-MSD02N16
SD card 3.0	USBLC6-4
Smartcard (ISO-7816)	EMIF03-SIM02M8 (with filter) ESDALC6V1W5 (without filter) ESDAULC6-1U2
Debug interfaces	
SWD	SMLVT3V3 ESDALC6V1W5
JTAG	SMLVT3V3 ESDALC6V1-5M6
RF interfaces	
NFC tag	DSILC6-4xx
NFC reader	ESDAXLC18-1BF4
Bluetooth, Sub-GHz (SigFox, LoRa, 169-433 MHz)	ESDARF02-1BU2CK

Note: The list is not exhaustive. For more information on ST ESD protection components, refer to and/or contact your local ST sales office.

4 Conclusion

This document, in parallel with [1], the product data sheet, and the IEC61000-4-2 standard, helps designers in the selection of adequate ESD protection components to protect effectively the STM32 device.

Many parameters come into account for protecting a system against ESD, such as PCB housing, board shielding and coating, and PCB routing and technology. However, TVS is the most effective and easy-to-implement protection device for the majority of applications.

Revision history

Table 6. **Document revision history**

Date	Version	Changes
02-Jun-2022	1	Initial release.

Contents

List of tables

List of figures