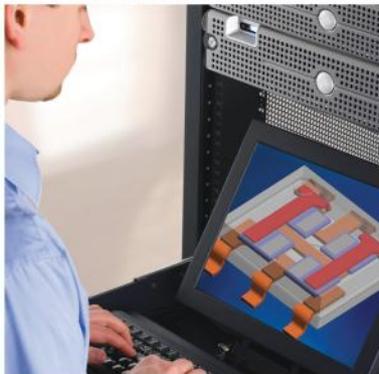


ESD SUPPRESSOR SELECTION GUIDE



Littelfuse Technologies: Switching Thyristors • Protection Arrays • Fuses • PTCs • Varistors • TVS Diodes • GDTs • ESD Suppressors • SIDACTor® Devices



Expertise Applied | Answers Delivered



Using the ESD Selection Guide

- Change to “presentation mode” to activate links
- The selection guide is driven from the next slide
- To learn about protection with a specific technology, click on the respective circuit in the “Applications and Circuits” column
- For an overview of each ESD technology, click on the respective technology link

**Click here to go to the
ESD selection chart**

ESD Selection Chart



| Protection Technology | Data Rate | Peak/clamp (8kV) | ESD Level | Discrete Options | Array Options | Applications and Circuits | Relative Cost | Key Advantage |
|-----------------------|-----------|------------------|-----------|--------------------------------------|---|---|---------------|--------------------------------------|
| MLV | <125 Mbps | Good | Good | 0201 0402 0603 0805 1206 | 1206 | Keypad/switch , audio , analog video , USB1.1 , RS232 | Best | Lowest cost; broad discrete offering |
| SPA | ≤5Gbps | Excellent | Excellent | 0402 (SOD723) 0201 (Flipchip) | SOIC MSOP SOT23 SC70 SOT553 SOT563 SOT953 μDFN | Keypad/switch , USB1.1 , USB2.0 , USB3.0 , Audio , Analog video , 1394 , HDMI , Ethernet , MMC interface , LCD module | Good | Lowest peak and clamping voltages |
| PGB | 10Gbps+ | Fair | Good | 0402 0603 | SOT23 | USB2.0 , 1394 , HDMI , RF antenna | Good | Lowest capacitance |



[MLV](#) = Multilayer Varistor [SPA](#) = Silicon Protection Array [PGB](#) = PulseGuard® suppressor



[Click here to return to ESD selection chart](#)



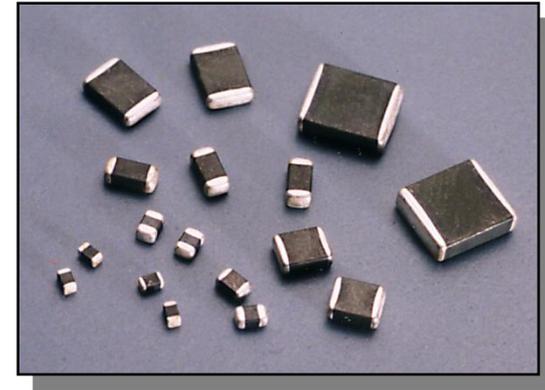
ESD suppressor introduction slides



[Return to Selection Chart](#)

Multilayer Varistor (MLV)

- Solution for ESD; can also provide limited (~20dB) EMI filtering
- Sizes range from 0201 to 1210
- Capacitance values from 3 pF to 4,500 pF
- Operating voltage from 5.5VDC to 120VDC
- Single-line and quad-channel packages
- Key feature is that a wide range of discrete form factors to match PCB real estate availability; capacitance values can be matched to the circuit to provide EMI filtering

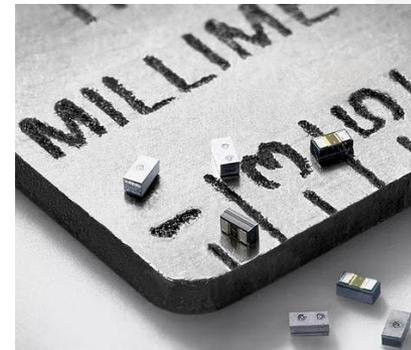
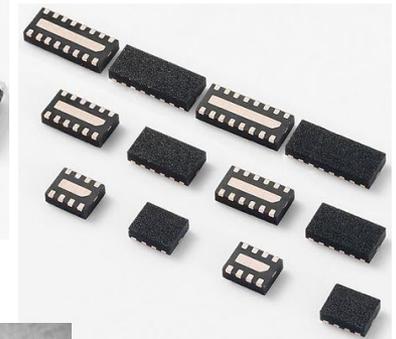
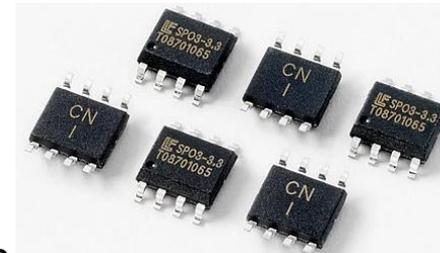
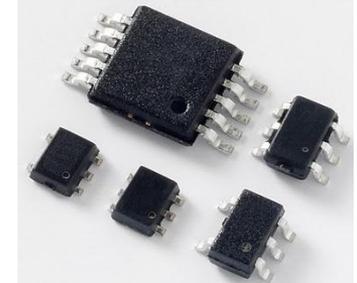




[Return to Selection Chart](#)

Silicon Protection Arrays

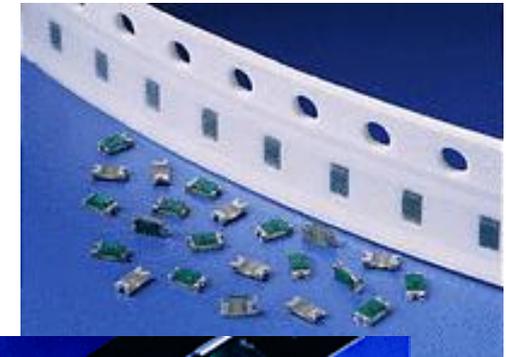
- Provides ESD protection
- Has the best ESD performance of the three ESD suppressor technologies
- Capacitance values from 0.40 pF to 30 pF
- Operating voltage from 5.5V_{DC} to 35V_{DC}
- Available in standard JEDEC outlines
 - SOIC, MSOP, SOT23, SC70, SOT5x3, SOT953, SOD723
- 1, 2, 3, 4, 5, 6, 14 channel packages available
- Key features are a large selection of package outlines (provide design flexibility) and best in class clamping performance to help protect ESD-sensitive circuits





PulseGuard® ESD Suppressor

- Solution for ESD protection
- Capacitance value of 0.05 pF
- Form factors include 0402, 0603 to SOT-23
- Operating voltage up to 24VDC
- Single and dual-channel packages available
- Key feature is that the ultra-low capacitance value will not distort high-speed data or high-frequency RF signals -- protection is provided and signal integrity is maintained





Silicon Protection Array slides

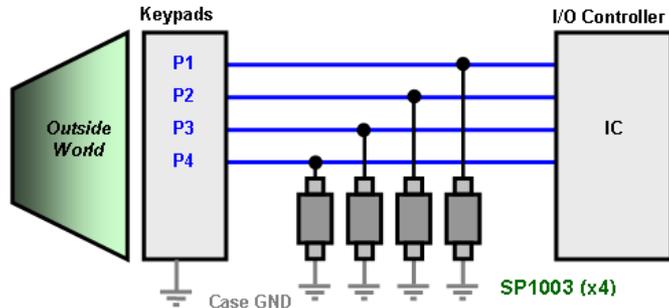
Circuit Protection of Keypads/Buttons

CIRCUIT
PROTECTION
SOLUTIONS



[Return to Selection Chart](#)

Dx: SP1003-01DTG Discrete 0402 Diodes



Design Notes:

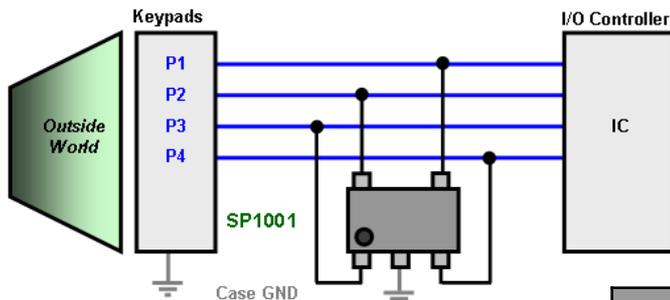
Protection Application: The keypads and various buttons found on a cell phone can be an entry way for ESD. These circuits are low-voltage DC switches, typically less than 5VDC.

Solution Description: The examples shown at the left contain four lines for demonstration purposes. The actual number will vary by application. In the top example, discrete diodes are used to provide board layout flexibility. In the bottom example, a single diode array is used to reduce part count.

Companion Solutions: Other solutions within the LF portfolio exist in addition to these recommendations. For example, diode arrays with different channel counts (2 – 5 lines) can be used to match the actual conditions of the cell phone.

Regulatory Issues: The IEC 61000-4-2 will be the most appropriate standard that applies for these circuits. It supplies a test method for verifying that the end product is not susceptible to ESD events.

Dx: SP1001-04xTG SPATM



Potential Solutions

| Ordering Number | ESD Level | I/O Capacitance @ $V_R=2.5V$ | Channels | V_{RM} | Packaging |
|------------------------------|-----------|------------------------------|----------|----------|---------------|
| SP1001-04XTG | ±15kV | 8pF | 4 | 6V | SOT553 |
| SP1001-04JTG | ±15kV | 8pF | 4 | 6V | SC70-5 |
| SP1011-04UTG | ±15kV | 7pF | 4 | 6V | μDFN-6 |
| SP1003-01DTG | ±25kV | 17pF | 1 | 5V | SOD723 |
| SP1005-01WTG | ±30kV | 23pF | 1 | 6V | 0201 Flipchip |



Expertise Applied | Answers Delivered

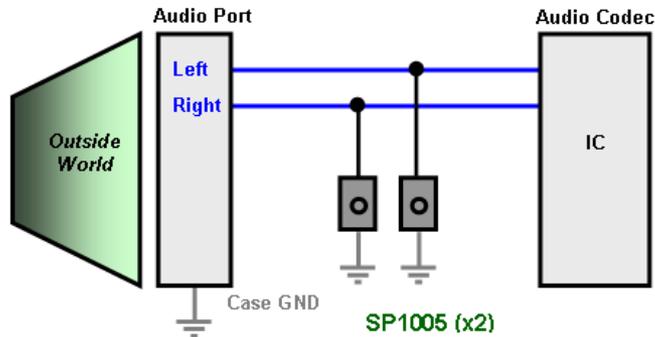
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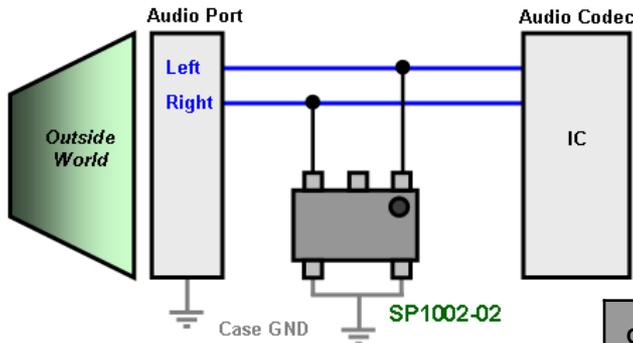


[Return to Selection Chart](#)

L/R: SP1005-01WTG Discrete 0201 Diodes



L/R: SP1001-02JTG SPATM



Design Notes:

Protection Application: For the audio lines, the typical signal has maximum value of 5.5 Vp-p, and has a maximum frequency less than 30kHz. At this frequency, the capacitance of the suppressor does not need to be taken into account. The electrical threat is ESD.

Solution Description: As shown at the left, silicon protection arrays or discrete diodes can be used for layout flexibility. Bi-directional devices are shown due to the analog nature of the audio signals. However, if the negative signal does not exceed -0.3V, a unidirectional device may be used.

Companion Solutions: Several unidirectional arrays exist if applicable.

Regulatory Issues: The IEC 61000-4-2 will be the most appropriate standard that applies for this port. It supplies a test method for verifying that the end product is not susceptible to ESD events.

Potential Solutions

| Ordering Number | ESD Level | I/O Capacitance @ $V_R=2.5V$ | Channels | V_{RM} | Packaging |
|------------------------------|-----------|------------------------------|----------|----------|---------------|
| SP1002-02JTG | ±8kV | 5pF | 2 | 6V | SC70-5 |
| SP1005-01WTG | ±30kV | 23pF | 1 | 6V | 0201 Flipchip |
| SP1007-01WTG | ±8kV | 3.5pF | 1 | 6V | 0201 Flipchip |
| SP1004-04VTG | ±8kV | 5pF | 4 | 6V | SOT953 |

Circuit Protection of Analog video

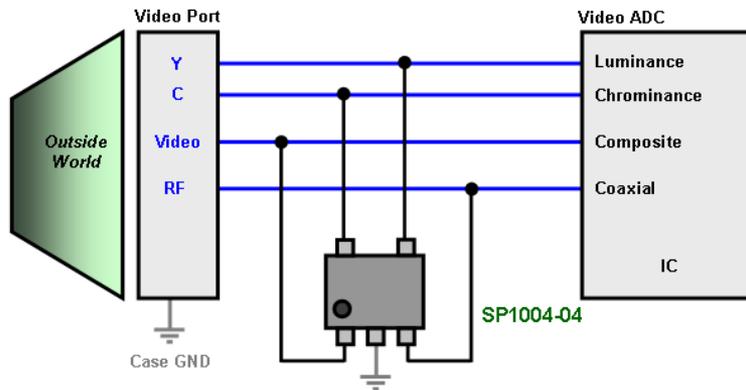
CIRCUIT
PROTECTION
SOLUTIONS



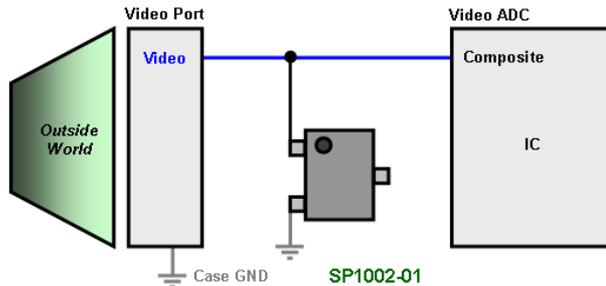
LCD TV, set top box

[Return to Selection Chart](#)

Analog video: SP1004-04VTG SPA™



Analog video: SP1002-01JTG SPA™



Design Notes:

Protection Application: The video signals used in S-video and Composite video formats vary between 0.5 and 2.0Vp-p, with a maximum frequency of 5MHz. At this frequency, the capacitance of the suppressor needs to be taken into account. The signal lines to be protected from ESD include Luminance and Chrominance for S-video, and the single conductor for Composite video.

Solution Description: As shown at the left, bi-directional diodes can be used to provide ESD protection to the video lines.

Companion Solutions: Other solutions within the LF portfolio exist in addition to these recommendations. For example, if the board space usage needs to be minimized, 0201 diodes can be used (SP1005 or SP1007).

Regulatory Issues: The IEC 61000-4-2 will be the most appropriate standard that applies for this port. It supplies a test method for verifying that the end product is not susceptible to ESD events.

Application Warnings: The F-type connector shown at the left is specifically for set top box-to-monitor video circuits. If the F-type connector is for CATV or Satellite inputs, then lightning surges become a concern and MLVs cannot be used. In this case, GDTs are required. See the page on CATV and Satellite inputs for more details.

Potential Solutions

| Ordering Number | ESD Level | I/O Capacitance @ $V_R=2.5V$ | Channels | V_{RW_M} | Packaging |
|-----------------|-----------|------------------------------|----------|------------|-----------|
| SP1002-01JTG | ±8kV | 5pF | 1 | 6V | SC70-3 |
| SP1002-02JTG | ±8kV | 5pF | 2 | 6V | SC70-5 |
| SP1004-04VTG | ±8kV | 5pF | 4 | 6V | SOT953 |



Expertise Applied | Answers Delivered

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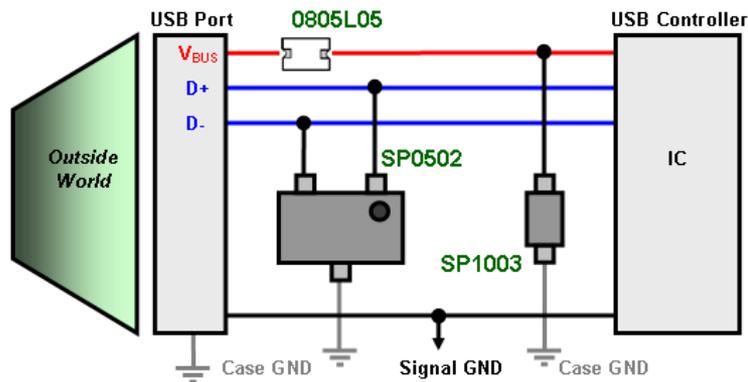
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Circuit Protection of USB 1.1 port



[Return to Selection Chart](#)

D+/D-: SP0502BAxTG SPA™



Design Notes:

Protection Application: The data signals used in a USB 1.1 port vary between -0.5V to +0.5V, with a maximum data rate of 12Mbps. At this data rate, the capacitance of the suppressor needs to be taken into account. The signal lines to be protected from ESD include D+ and D-. The 5VDC power bus should be protected against ESD and overcurrent events.

Solution Description: As shown at the left, a discrete diode is used on the power bus for ESD protection, and a PTC is used for resettable overcurrent protection. For the data lines, a two-channel array can be used for board layout flexibility.

Companion Solutions: Other solutions within the LF portfolio exist in addition to these recommendations. For example, if the operating current on the power bus is higher or lower, an appropriately rated PTC can be chosen.

Regulatory Issues: The IEC 61000-4-2 will be the most appropriate standard that applies for this port. It supplies a test method for verifying that the end product is not susceptible to ESD events.

Potential Solutions

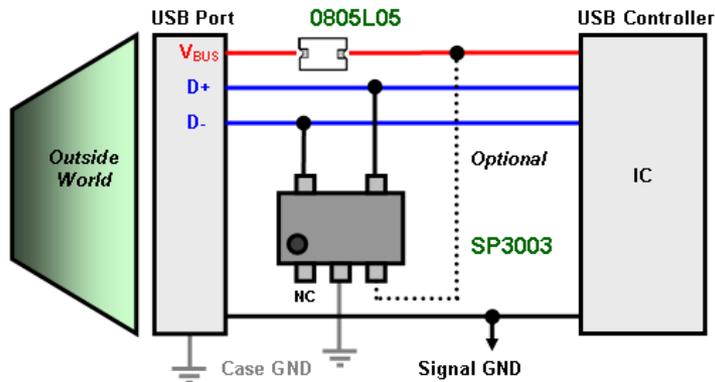
| Ordering Number | ESD Level | I/O Capacitance @ $V_R=2.5V$ | Channels | V_{RW_M} | Packaging |
|------------------------------|-----------|------------------------------|----------|------------|-----------|
| SP1001-02JTG | ±15kV | 8pF | 2 | 6V | SC70-3 |
| SP1001-02XTG | ±15kV | 8pF | 2 | 6V | SOT553 |
| SP1003-01DTG | ±25kV | 17pF | 1 | 5V | SOD723 |
| SP0502BAJTG | ±30kV | 30pF | 2 | 5.5V | SC70-3 |
| SP0502BAHTG | ±30kV | 30pF | 2 | 5.5V | SOT23-3 |

Circuit Protection of USB 2.0 port



[Return to Selection Chart](#)

D+/D-: SP3003-02xTG SPA™



Design Notes:

Protection Application: The data signals used in a USB 2.0 port vary between -0.5V to +0.5V, with a maximum data rate of 480Mbps. At this data rate, the capacitance of the suppressor needs to be minimized. The signal lines to be protected from ESD include D+ and D-. The 5VDC power bus should be protected against ESD and overcurrent events.

Solution Description: As shown at the left, a PTC is used for resettable overcurrent protection while the data lines and power bus are protected from ESD with a two-channel diode array (0.65pF).

Companion Solutions: Other solutions within the LF portfolio exist in addition to these recommendations. For example, if the operating current on the power bus is higher or lower, an appropriately rated PTC can be chosen.

Regulatory Issues: The IEC 61000-4-2 will be the most appropriate standard that applies for this port. It supplies a test method for verifying that the end product is not susceptible to ESD events.

Potential Solutions

| Ordering Number | ESD Level | I/O Capacitance @ V _R =1.65V | Channels | V _{RW} _M | Packaging |
|------------------------------|-----------|---|----------|------------------------------|-----------|
| SP3003-02JTG | ±8kV | 0.65pF | 2 | 6V | SC70-5 |
| SP3003-02XTG | ±8kV | 0.65pF | 2 | 6V | SOT553 |
| SP3002-04JTG | ±12kV | 0.85pF | 4 | 6V | SC70-6 |
| SP3004-04XTG | ±12kV | 0.85pF | 4 | 6V | SOT563 |

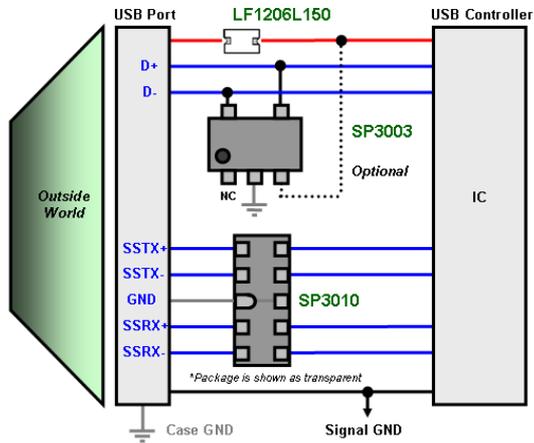
Circuit Protection of USB 3.0 port

CIRCUIT
PROTECTION
SOLUTIONS



[Return to Selection Chart](#)

D± & SSRX/TX±: SP3010-04UTG SPA™



Design Notes:

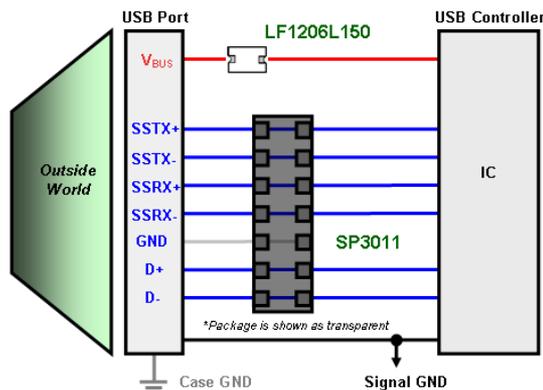
Protection Application: USB3.0 adds two new data pair to the legacy D+/D- pair namely SSTX+, SSTX-, SSRX+, and SSRX-. These new super-speed lines will operate at a maximum data rate of 5Gbps while the old D+/D- will operate at a maximum of 480Mbps. At these data rates, the capacitance of the suppressor needs to be minimized. The signal lines need to be protected from ESD, and the 5VDC power bus should be protected against ESD and overcurrent events.

Solution Description: As shown at the upper left, a PTC is used for resettable overcurrent protection while the super-speed data lines are protected with an ultra-low capacitance diode array. Furthermore, another diode array is used for ESD protection of D+/D- as well as the power bus.

Companion Solutions: Other solutions within the LF portfolio exist such a fully integrated six channel protection array (lower left) to further minimize part count and simplify the board design.

Regulatory Issues: The IEC 61000-4-2 will be the most appropriate standard that applies for this port. It supplies a test method for verifying that the end product is not susceptible to ESD events.

D± & SSRX/TX±: SP3011-06UTG SPA™



Potential Solutions

| Ordering Number | ESD Level | I/O Capacitance @ V _R =1.65V | Channels | V _{RM} | Packaging |
|------------------------------|-----------|---|----------|-----------------|-----------|
| SP3010-04UTG | ±8kV | 0.45pF | 4 | 6V | μDFN-10 |
| SP3003-02XTG | ±8kV | 0.65pF | 2 | 6V | SOT553 |
| SP3011-06UTG | ±8kV | 0.40pF | 4 | 6V | μDFN-14 |



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Circuit Protection of 1394 port



[Return to Selection Chart](#)

T+/-; R+/-: SP3003-04xTG SPA™

Design Notes:

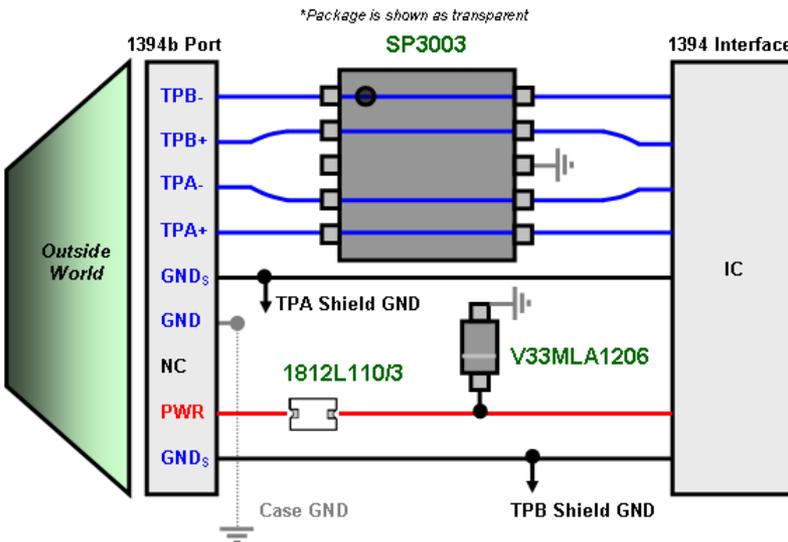
Protection Application: IEEE 1394 uses a low-voltage differential signaling system operating between 1.20V to 2.00V, with a maximum data rate of 400 Mbps (1394a) to 1,600 Mbps (1394b). At these data rates, the capacitance of the suppressor needs to be minimized. The signal lines to be protected against ESD include TPA+, TPA-, TPB+ and TPB-. The 30VDC power bus should be protected against ESD and overcurrent events.

Solution Description: As shown at the left, a multilayer varistor is used on the power bus for ESD protection, and a PTC is used for resettable overcurrent protection. For the data lines, SP3003-04 protection array can be used.

Companion Solutions: Other solutions within the LF portfolio exist in addition to these recommendations. For example, leaded PTCs can be substituted for the SMD versions, or PulseGuard suppressors can be used on the data lines if the capacitance needs to be reduced further.

Regulatory Issues: The IEC 61000-4-2 will be the most appropriate standard that applies for this port. It supplies a test method for verifying that the end product is not susceptible to ESD events.

Application Warnings: It is recommended that only resettable protection devices like PTCs be used on hot-plug ports like 1394.



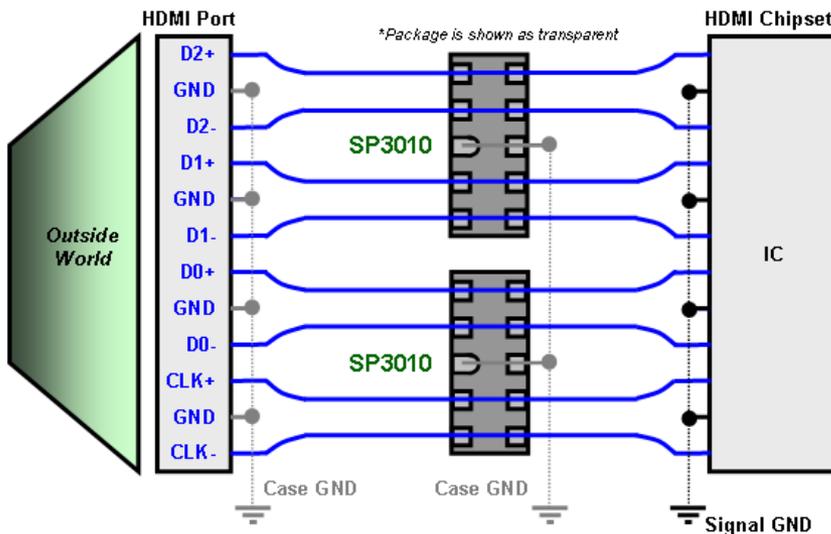
Potential Solutions

| Ordering Number | ESD Level | I/O Capacitance @ $V_R=1.65V$ | Channels | V_{RW_M} | Packaging |
|------------------------------|-----------|-------------------------------|----------|------------|-----------|
| SP3003-04ATG | ±8kV | 0.65pF | 4 | 6V | MSOP-10 |
| SP3003-04JTG | ±8kV | 0.65pF | 4 | 6V | SC70-6 |
| SP3003-04XTG | ±8kV | 0.65pF | 4 | 6V | SOT563 |



[Return to Selection Chart](#)

HDMI: SP3010-04UTG SPA™



Design Notes:

Protection Application: The data signals used in High Definition Multimedia Interface ports vary between approximately 2.5V and 3.5V, and have a data rate of 1,600Mbps. The signal lines to be protected from ESD include R+, R-, G+, G-, B+, B-, Cl+ and Cl-.

Solution Description: Due to the extremely high rate of data transfer, the capacitance of the ESD suppressor must be minimized. As shown at the left, low-capacitance (0.45pF) silicon protection arrays can be used.

Companion Solutions: PulseGuard ESD suppressors (0.05pF) can be substituted if the capacitance value needs to be reduced, and other 4 channel silicon protection arrays can be used if a different package option is required.

Regulatory Issues: The IEC 61000-4-2 will be the most appropriate standard that applies for this port. It supplies a test method for verifying that the end product is not susceptible to ESD events.

Potential Solutions

| Ordering Number | ESD Level | I/O Capacitance @ $V_R=1.65V$ | Channels | V_{RW} M | Packaging |
|-----------------|-----------|-------------------------------|----------|-----------------|-----------|
| SP3010-04UTG | ±8kV | 0.45pF | 4 | 6V | μDFN-10 |
| SP3003-04ATG | ±8kV | 0.65pF | 4 | 6V | MSOP-10 |
| SP3003-04XTG | ±8kV | 0.65pF | 4 | 6V | SOT563 |

Circuit Protection of Ethernet port (ESD Only)

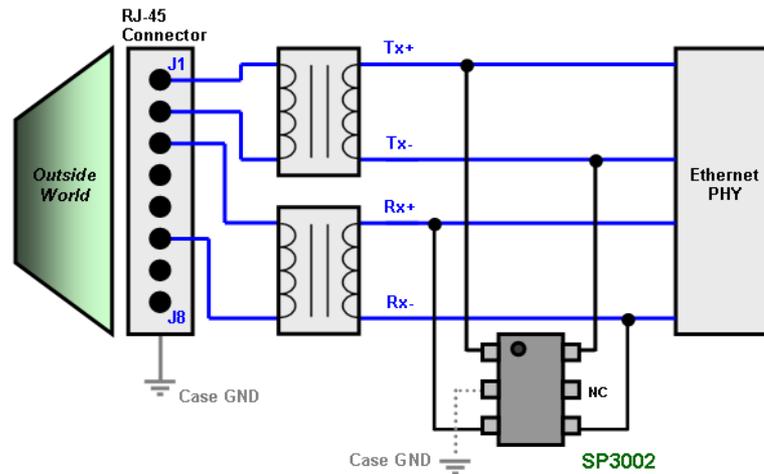
CIRCUIT
PROTECTION
SOLUTIONS



LCD TV, set top box

[Return to Selection Chart](#)

Ethernet (ESD Only): SP3002-04JTG SPA™



Design Notes:

Protection Application: The data signals used in an Ethernet port vary between 1.0V (100 and 1,000 BaseT) to 2.5V (10BaseT), with maximum data rates of 125Mbps and 12.5Mbps, respectively. At these data rates, the capacitance of the suppressor needs to be taken into account. The signal lines to be protected from ESD include T+/- and R+/-.

Solution Description: As shown at the left, a rail-clamp array can be used to protect the data lines of the Ethernet port from ESD.

Companion Solutions: Other solutions within the LF portfolio exist such as other potential four channel silicon protection arrays (listed below). Alternatively, if the design engineer knows that no additional capacitance can be added to the system, the PulseGuard® suppressor family can be consulted.

Regulatory Issues: The IEC 61000-4-2 will be the most appropriate standard that applies for this port.

Application Warnings: The top protection scheme is only for Ethernet ports that connect to a LAN and will only be exposed to ESD. If the Ethernet network will include access to the outside of the building, then more stringent standards apply to take into account lightning surges. Please see the next slide.

Potential Solutions

| Ordering Number | ESD Level | I/O Capacitance @ $V_R=1.65V$ | Channels | V_{RW} M | Packaging |
|------------------------------|-----------|-------------------------------|----------|---------------|-----------|
| SP3002-04JTG | ±12kV | 0.85pF | 4 | 6V | SC70-6 |
| SP3003-04JTG | ±8kV | 0.65pF | 4 | 6V | SC70-6 |
| SP3003-04XTG | ±8kV | 0.65pF | 4 | 6V | SOT563 |
| SP3004-04XTG | ±12kV | 0.85pF | 4 | 6V | SOT563 |



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Circuit Protection of Ethernet port (Lightning)

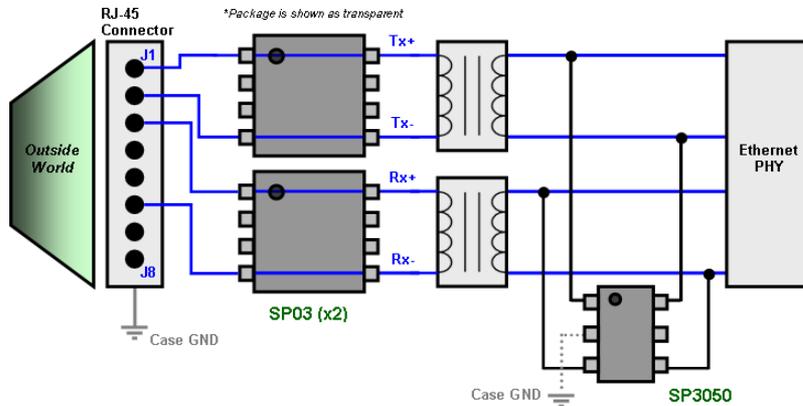
CIRCUIT
PROTECTION
SOLUTIONS



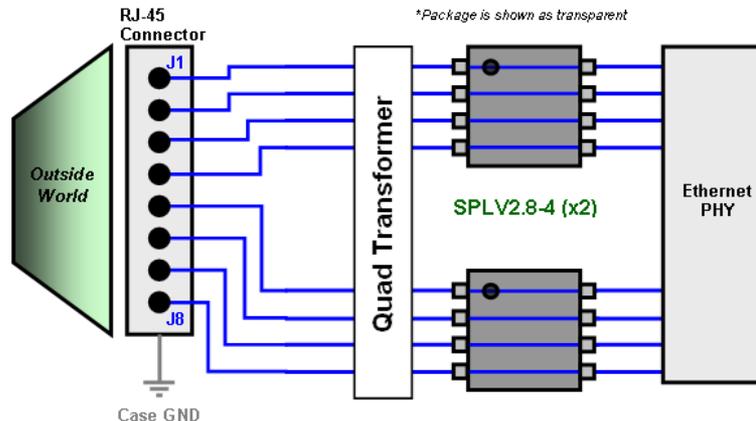
LCD TV, set top box

[Return to Selection Chart](#)

Ethernet (Lightning): SP03-xBTG SPA™



Ethernet (Lightning): SPLV2.8-4BTG SPA™



Design Notes:

Protection Application: The data signals used in an Ethernet port vary between 1.0V (100 and 1,000 BaseT) to 2.5V (10BaseT), with maximum data rates of 125Mbps and 12.5Mbps, respectively. At these data rates, the capacitance of the suppressor needs to be taken into account. The signal lines to be protected from lightning induced surges include T+/- and R+/-.

Solution Description: As shown at the left, a rail-clamp array can be used for primary protection of the Ethernet port from lightning per the GR-1089 intra-building standard. Additionally, a low capacitance diode array is used for secondary protection to suppress any let through energy that gets coupled through the transformer.

Companion Solutions: Other solutions within the LF portfolio exist in addition to these recommendations such as the SPLV2.8-4 series shown at the bottom left which uses the transformer to suppress the initial surge.

Regulatory Issues: Many standards could apply depending upon the end equipment usage such as GR-1089 or the IEC61000-4-5. Please consult Littelfuse for application support.

Potential Solutions

| Ordering Number | Surge ($t_p=8/20\mu s$) | I/O Capacitance @ $V_R=0V$ | Channels | V_{RWM} | Packaging |
|------------------------------|---------------------------|----------------------------|----------|-----------|-----------|
| SP03-3.3BTG | 150A | 16pF | 2 | 3.3V | SOIC-8 |
| SP03-6BTG | 150A | 16pF | 2 | 6V | SOIC-8 |
| SP3050-04HTG | 10A | 2.4pF | 4 | 6V | SOT23-6 |
| SPLV2.8-4BTG | 24A | 3.8pF | 4 | 2.8V | SOIC-8 |



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Circuit Protection of MMC interface

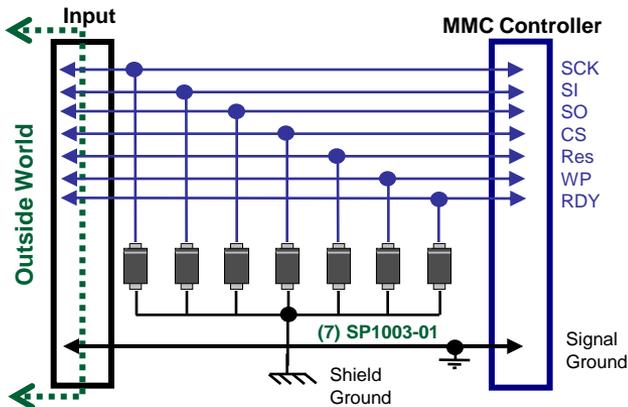
CIRCUIT
PROTECTION
SOLUTIONS



Cell phone

[Return to Selection Chart](#)

Dx: SP1003-01DTG Discrete 0402 Diodes



Design Notes:

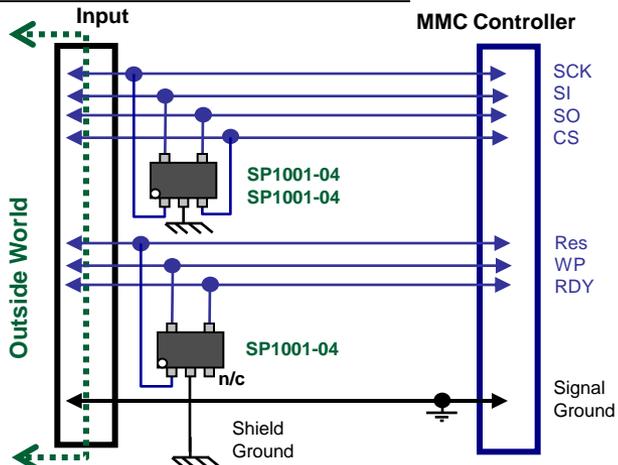
Protection Application: For typical Multi Media Card (MMC) circuits, the data transfer rate is less than 20 Mbps, so protection devices with capacitance values less than 40 pF can be used. The lines to be protected against ESD include SCK, SI, SO, CS, Reset, WP and Ready..

Solution Description: As shown at the left (top), discrete diodes can be used for layout flexibility. However, if part count reduction or board space savings are most important, then TVS diode arrays can also be used.

Companion Solutions: If the data rate will be greater than 200 Mbps, then low capacitance (0.65pF) arrays should be used.

Regulatory Issues: The IEC 61000-4-2 will be the most appropriate standard that applies for this port. It supplies a test method for verifying that the end product is not susceptible to ESD events.

Dx: SP1001-04xTG SPATM



Potential Solutions

| Ordering Number | ESD Level | I/O Capacitance @ $V_R=2.5V$ | Channels | V_{RW_M} | Packaging |
|------------------------------|-----------|------------------------------|----------|------------|-----------|
| SP1003-01DTG | ±25kV | 17pF | 1 | 5V | SOD723 |
| SP1001-04XTG | ±15kV | 8pF | 4 | 6V | SOT553 |
| SP1001-04JTG | ±15kV | 8pF | 4 | 6V | SC70-5 |
| SP3001-04JTG | ±8kV | 0.65pF | 4 | 6V | SC70-6 |
| SP3002-04JTG | ±12kV | 0.85pF | 4 | 6V | SC70-6 |



Expertise Applied | Answers Delivered

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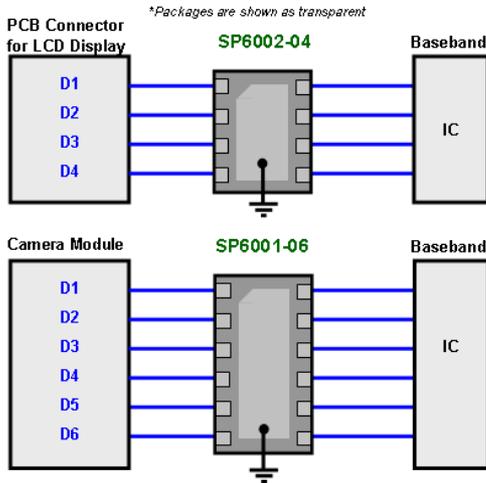
Circuit Protection of LCD Module

CIRCUIT
PROTECTION
SOLUTIONS

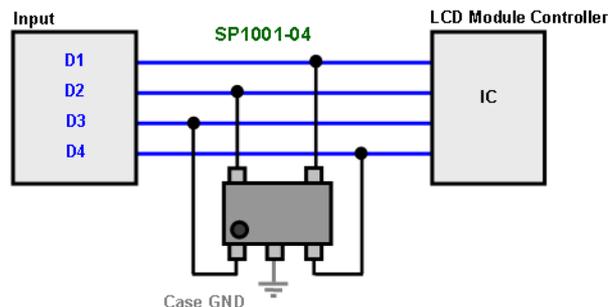


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Dx: SP600x-0xUTG-1 EMI Filter, SPAT™



Dx: SP1001-04xTG SPAT™



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Design Notes:

Protection Application: For typical LCD modules, the data transfer rate is less than 20 Mbps, so protection devices with capacitance values less than 40 pF can be used. The electrical threat is ESD and potentially EMI (Electromagnetic Interference).

Solution Description: As shown at the top left, a multi-channel EMI Filter can be used for ESD protection and filtering of frequencies in the cellular band (800-3000MHz).

Companion Solutions: Other solutions within the Silicon Protection Array portfolio exist. For example, if EMI is not a concern, then any multi-channel silicon protection array can be used or ESD protection (bottom left). Furthermore, if data transfers (e.g. MDDI) take place at high speeds (>1,000 Mbps), then a silicon protection array with low capacitance should be used to maintain signal integrity (i.e. SP300x).

Regulatory Issues: The IEC 61000-4-2 will be the most appropriate standard that applies for this port. It supplies a test method for verifying that the end product is not susceptible to ESD events.

Potential Solutions

| Ordering Number | ESD Level | Line Capacitance @ $V_R=2.5V$ | Channels | V_{RW} M | Packaging |
|-----------------|-----------|-------------------------------|----------|-----------------|-----------|
| SP6001-04UTG-1 | ±30kV | 24pF | 4 | 6V | μDFN-8 |
| SP6001-06UTG-1 | ±30kV | 24pF | 6 | 6V | μDFN-12 |
| SP6001-08UTG-1 | ±30kV | 24pF | 8 | 6V | μDFN-16 |
| SP6002-04UTG-2 | ±30kV | 30pF | 4 | 6V | μDFN-8 |
| SP6002-06UTG-1 | ±30kV | 30pF | 6 | 6V | μDFN-12 |
| SP1001-04XTG | ±15kV | 8pF | 4 | 6V | SOT553 |
| SP1001-04JTG | ±15kV | 8pF | 4 | 6V | SC70-5 |

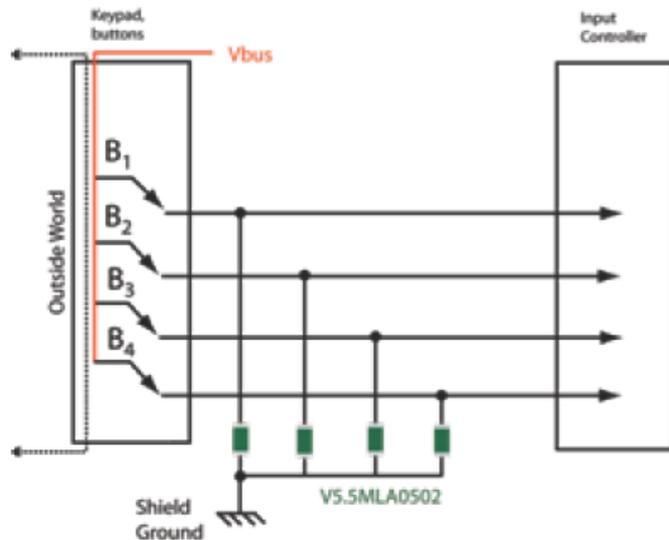


Multilayer varistor slides



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Possible solution: V5.5MLA0502 multilayer varistor (220 pF)



Design Notes:

Protection Application: The keypads and various buttons found in various applications can be an entry way for ESD. These circuits are low-voltage DC switches, typically less than 5VDC.

Solution Description: The examples shown at the left contain four lines for demonstration purposes. The actual number will vary by application. In this example, discrete multilayer varistors are used to provide board layout flexibility.

Companion Solutions: Other solutions within the LF portfolio exist in addition to these recommendations. For example, MLV arrays (4 lines) can be used to reduce part count and save board space.

Regulatory Issues: The IEC 61000-4-2 will be the most appropriate standard that applies for these circuits. It supplies a test method for verifying that the end product is not susceptible to ESD events.

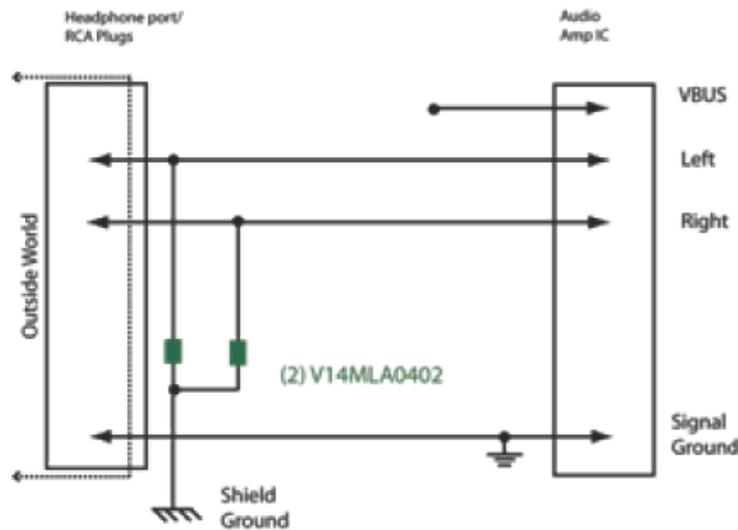
Unique Features: Does not apply.

Application Warnings: Does not apply.



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Possible solution: L/R: V14MLA0402 multilayer varistor (70 pF)



Design Notes:

Protection Application: Audio signals can have a maximum value of 12Vp-p, and a maximum frequency less than 30kHz. At this frequency, the capacitance of the suppressor does not need to be taken into account. The signal lines to be protected from ESD are the left and right channels.

Solution Description: As shown at the left, discrete multilayer varistors can be used for layout flexibility. Due to the analog nature of the audio signals, uni-polar TVS diode arrays are recommended only if the negative part of the signal is -0.5V or less since they may clip this part of the audio signal if the magnitude is larger.

Companion Solutions: Other solutions within the LF MLV portfolio exist in addition to these recommendations. For example, if the manufacturing process cannot handle 0402-size components, devices with the same characteristics can be found in 0603-size.

Regulatory Issues: The IEC 61000-4-2 will be the most appropriate standard that applies for this port. It supplies a test method for verifying that the end product is not susceptible to ESD events.

Unique Features: Does not apply.

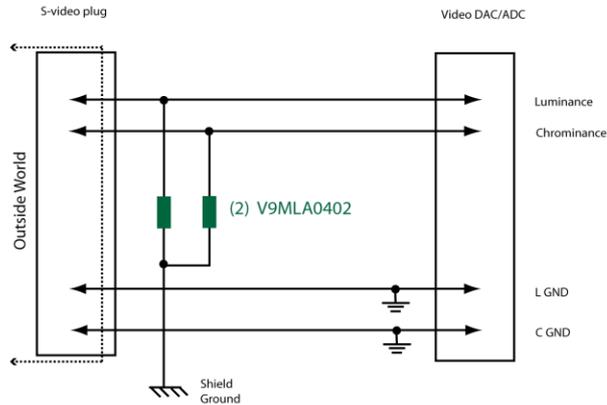
Application Warnings: Does not apply.



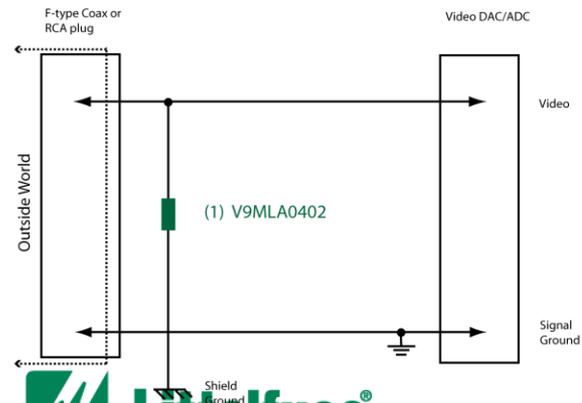
[Return to Selection Chart](#)

Video In/Out

Possible solution: S-video: V9MLA402 multilayer varistor (120 pF)



Possible solution: Composite video: V9MLA402 multilayer varistor (120 pF)



Design Notes:

Protection Application: The video signals used in S-video and Composite video formats vary between 0.5 and 2.0Vp-p, with a maximum frequency of 5MHz. At this frequency, the capacitance of the suppressor needs to be taken into account. The signal lines to be protected from ESD include Luminance and Chrominance for S-video, and the single conductor for Composite video.

Solution Description: As shown at the left, discrete multilayer varistors are recommended for protection. Due to the analog nature of the video signals, uni-polar TVS diode arrays are not recommended as they may clip the negative part of the video signal.

Companion Solutions: Other solutions within the LF MLV portfolio exist in addition to these recommendations. For example, if the manufacturing process cannot handle 0402-size components, devices with the same characteristics can be found in 0603-size components.

Regulatory Issues: The IEC 61000-4-2 will be the most appropriate standard that applies for this port. It supplies a test method for verifying that the end product is not susceptible to ESD events.

Unique Features: Does not apply.

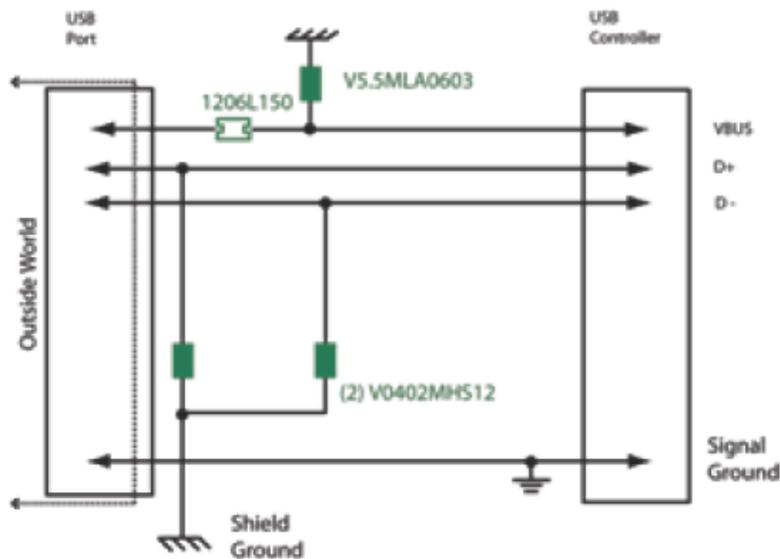
Application Warnings: The F-type connector shown at the left is specifically for set top box-to-monitor video circuits. If the F-type connector is for CATV or Satellite inputs, then lightning surges become a concern and MLVs cannot be used. In this case, GDTs are required. See the page on CATV and Satellite inputs for more details.

Circuit Protection of USB 1.1 port



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Possible solution: D+/D-: V0402MHS12 multilayer varistor (12 pF)



Design Notes:

Protection Application: The data signals used in a USB 1.1 port vary between -0.5V to +0.5V, with a maximum data rate of 12Mbps. At this data rate, the capacitance of the suppressor needs to be taken into account. The signal lines to be protected from ESD include D+ and D-. The 5VDC power bus should be protected against ESD and overcurrent events.

Solution Description: As shown at the left, a multilayer varistor is used on the power bus for ESD protect, and a PTC is used for resettable overcurrent protection. For the data lines, discrete multilayer varistors can be used for board layout flexibility, or to reduce part count, a single Diode array can be used.

Companion Solutions: Other solutions within the LF portfolio exist in addition to these recommendations. For example, if the operating current on the power bus is higher or lower, an appropriately rated PTC can be chosen.

Regulatory Issues: The IEC 61000-4-2 will be the most appropriate standard that applies for this port. It supplies a test method for verifying that the end product is not susceptible to ESD events.

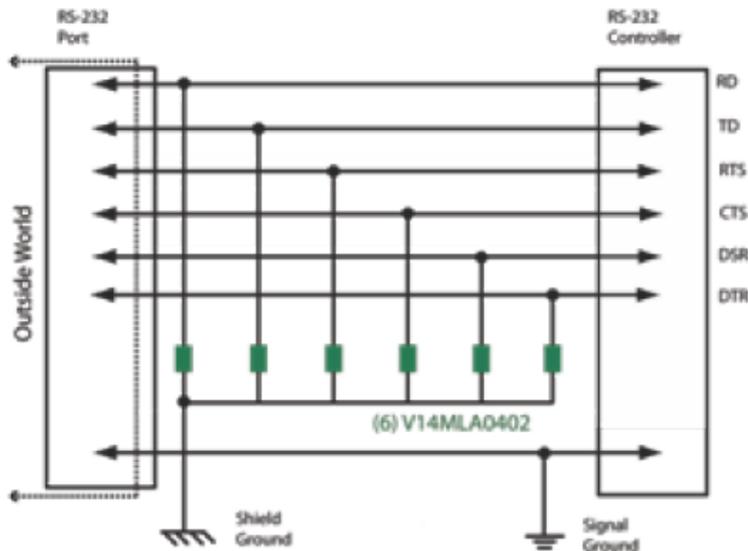
Unique Features: Does not apply.

Application Warnings: Does not apply.



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Possible solution: V14MLA0402 multilayer varistor (70 pF)



Design Notes:

Protection Application: The signals used in an RS-232 port can vary between -12V to +12V, with a maximum data rate of 256kbps. Since this is a low-speed system, the capacitance of the suppress is not a concern. The signal lines to be protected from ESD include RD, TD, RTS, CTS, DSR and DTR.

Solution Description: As shown at the left, discrete multilayer varistors can be used for board layout flexibility, or to reduce part count, a single rail clamp device can be used.

Companion Solutions: Other solutions within the LF portfolio exist in addition to these recommendations. For example, if the signal voltages will be limited in the range from -5V to +5V, then an MLV with a lower operating voltage can be chosen.

Regulatory Issues: The IEC 61000-4-2 will be the most appropriate standard that applies for this port. It supplies a test method for verifying that the end product is not susceptible to ESD events.

Unique Features: Does not apply.

Application Warnings: Does not apply.



PulseGuard[®] suppressor slides

Circuit Protection of 1394 port

CIRCUIT
PROTECTION
SOLUTIONS



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Design Notes:

Protection Application: IEEE 1394 uses a low-voltage differential signaling system operating between 1.20V to 2.00V, with a maximum data rate of 400 Mbps (1394a) to 1,600 Mbps (1394b). At these data rates, the capacitance of the suppressor needs to be minimized. The signal lines to be protected against ESD include TPA+, TPA-, TPB+ and TPB-. The 30VDC power bus should be protected against ESD and overcurrent events.

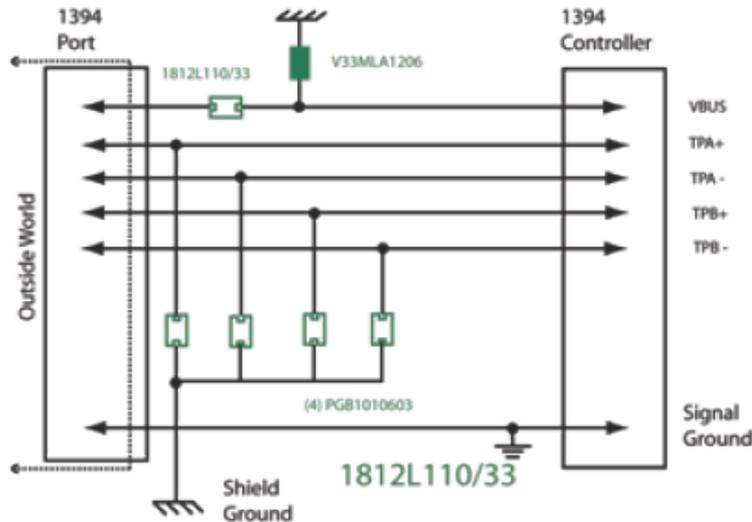
Solution Description: As shown at the left, a multilayer varistor is used on the power bus for ESD protection, and a PTC is used for resettable overcurrent protection. For the data lines, discrete PulseGuard® suppressors can be used for board layout flexibility, or to reduce part count, a single PulseGuard array can be used.

Companion Solutions: Other solutions within the LF portfolio exist in addition to these recommendations. For example, leaded PTCs can be substituted for the SMD versions, or a TVS diode can be substituted for the MLV.

Regulatory Issues: The IEC 61000-4-2 will be the most appropriate standard that applies for this port. It supplies a test method for verifying that the end product is not susceptible to ESD events.

Unique Features: Does not apply.

Application Warnings: It is recommended that only resettable protection devices like PTCs be used on hot-plug ports like 1394.



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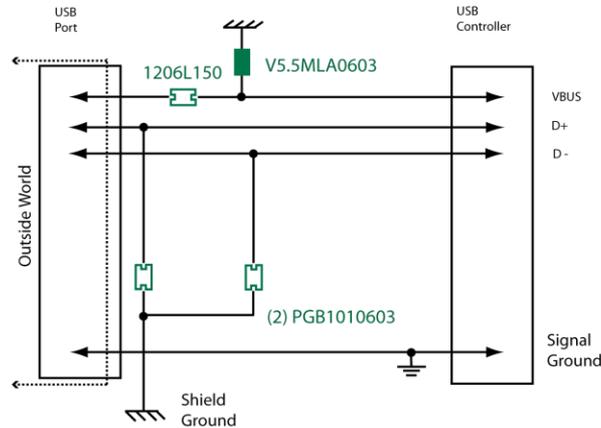
Circuit Protection of USB 2.0 port



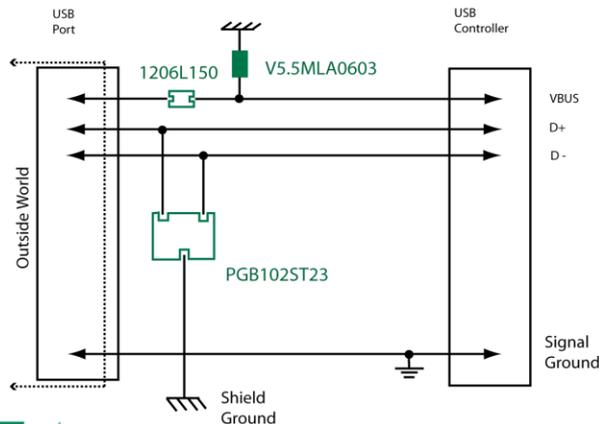
USB 2.0 Port

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Possible solution: D+/D-: PGB1010603 polymeric suppressor (0.05 pF)



Possible solution: D+/D-: PGB102ST23 polymeric suppressor (0.05 pF)



Design Notes:

Protection Application: The data signals used in a USB 2.0 port vary between -0.5V to +0.5V, with a maximum data rate of 480Mbps. At this data rate, the capacitance of the suppressor needs to be minimized. The signal lines to be protected from ESD include D+ and D-. The 5VDC power bus should be protected against ESD and overcurrent events.

Solution Description: As shown at the left, a multilayer varistor is used on the power bus for ESD protect, and a PTC is used for resettable overcurrent protection. For the data lines, discrete PulseGuard® suppressors can be used for board layout flexibility, or to reduce part count, a single PulseGuard array can be used.

Companion Solutions: Other solutions within the LF portfolio exist in addition to these recommendations. For example, if the operating current on the power bus is higher or lower, an appropriately rated PTC can be chosen.

Regulatory Issues: The IEC 61000-4-2 will be the most appropriate standard that applies for this port. It supplies a test method for verifying that the end product is not susceptible to ESD events.

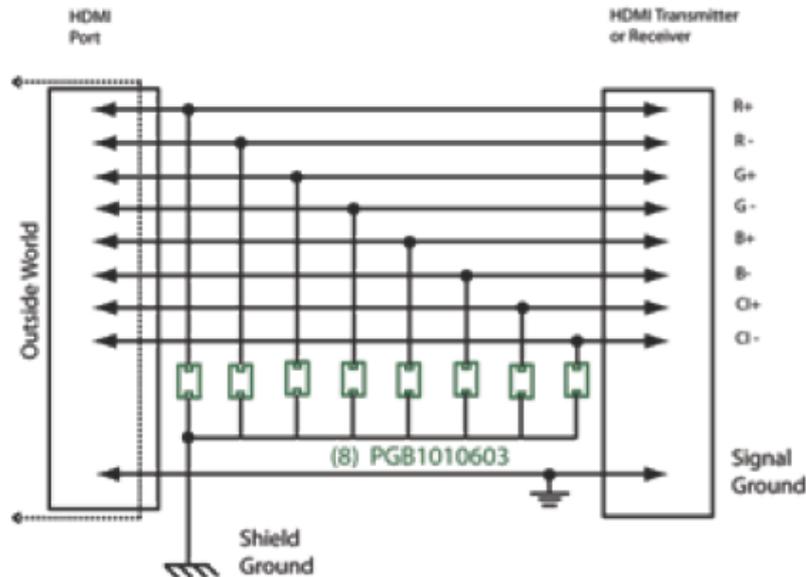
Unique Features: Does not apply.

Application Warnings: Does not apply.



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Possible solution: TX+/-, TC+/-: PGB1010603 (0.05 pF)



Design Notes:

Protection Application: The data signals used in High Definition Multimedia Interface ports vary between approximately 2.5V and 3.5V, and have a data rate of 1,600Mbps. The signal lines to be protected from ESD include R+, R-, G+, G-, B+, B-, Cl+ and Cl-.

Solution Description: Due to the extremely high rate of data transfer, the capacitance of the ESD suppressor must be minimized. As shown at the left, discrete PulseGuard® suppressors can be used for board layout flexibility, or to reduce part count, array versions can be used.

Companion Solutions: Does not apply.

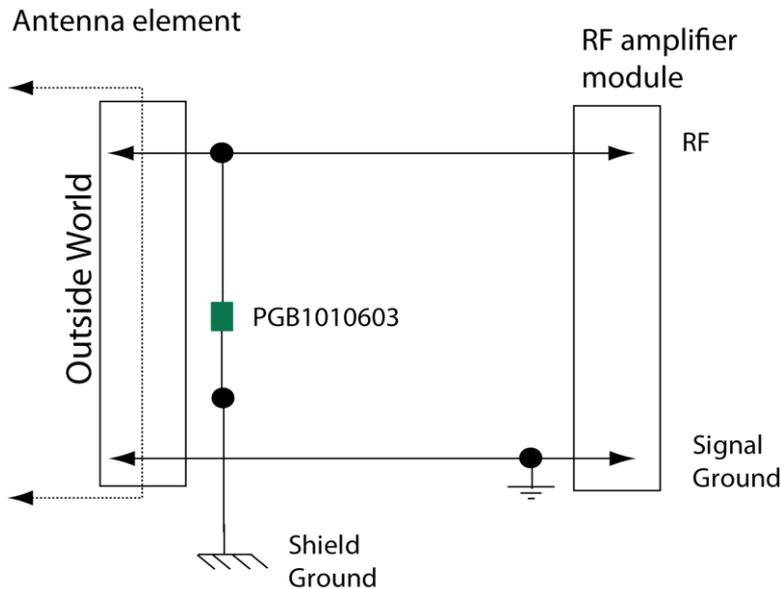
Regulatory Issues: The IEC 61000-4-2 will be the most appropriate standard that applies for this port. It supplies a test method for verifying that the end product is not susceptible to ESD events.

Unique Features: The PulseGuard solution has the industry's lowest capacitance value. This feature ensures that it will maintain the signal integrity of high-speed data ports.

Application Warnings: Does not apply.



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Design Notes:

Protection Application: The communication signals carried by the antenna operate in the radio frequency ranges of 800 – 950 MHz and 1,800 – 1,900 MHz, and are less than 1.0 V_{p-p} in magnitude. Due to the high frequency nature of these signals, the capacitance of the suppressor must be taken into account to avoid signal attenuation. The electrical threat will be ESD.

Solution Description: As shown at the left, a single PulseGuard® suppressor is used to protect the antenna element.

Companion Solutions: Does not apply.

Regulatory Issues: The IEC 61000-4-2 will be the most appropriate standard that applies for this circuit. It supplies a test method for verifying that the end product is not susceptible to ESD events.

Unique Features: Does not apply.

Application Warnings: Does not apply.