



**USB Upstream Port Filter & TVS  
For EMI Filtering and ESD Protection**

**STF202-22  
&  
STF202-30**

Objective - March 03, 2000

TEL:805-498-2111 FAX:805-498-3804 WEB:http://www.Semtech.com

**DESCRIPTION**

The STF202 is a combination EMI filter and line termination device with integrated TVS diodes for use on upstream USB ports. It is constructed using a proprietary technology that allows passive components and TVS diodes to be integrated in the same package. Each device will provide **termination, filtering, and ESD protection** for one upstream USB port. The STF202 is an easily implemented solution for meeting the requirements of revision 1.1 of the Universal Serial Bus specification.

USB line termination is achieved with series 22Ω or 30Ω resistors on both the D+ and D- USB lines. These resistors preserve signal integrity by matching the cable impedance to that of the differential driver. The 1.5kΩ pull-up resistor completes the termination circuit on each line. This resistor is required by the USB specification to identify the equipment as either a full-speed (connected to D+ line) or low-speed (connected to D- line) device. The 47pF capacitors are used to bypass high frequency energy to ground and for edge rate control of the USB signals. Finally, the STF202 contains TVS diodes for ESD protection of both (D+ & D-) data lines and the voltage bus (V<sub>BUS</sub>). The TVS diodes provide effective suppression of ESD voltages in excess of 15kV (air discharge) and 8kV (contact discharge) per IEC 1000-4-2, level 4.

The small size and integrated feature of the STF202 minimizes required board space and increases system reliability. The STF202 is suitable for use in USB hubs, computers, peripherals, and portable devices.

**FEATURES**

- Bidirectional EMI/RFI filtering and line termination with integrated ESD protection
- ESD protection for USB power (V<sub>BUS</sub>) and data lines (D+ & D-) to **IEC 1000-4-2 Level 4**
- Filtering and termination for two USB data lines
- Different series resistors for impedance matching
- Low TVS operating voltage (5.25V)
- Low leakage current
- Small SOT-23 6L package
- Solid-state technology

**MECHANICAL CHARACTERISTICS**

- EIAJ SOT-23 6L package
- Molding compound flammability rating: UL 94V-0
- Marking : Marking Code
- Packaging : Tape and Reel per EIA 481

**APPLICATIONS**

- USB Hubs
- Portable electronics
- Cellular Handsets
- Peripherals
- Servers, Desktop, Notebook, and Handheld Computers

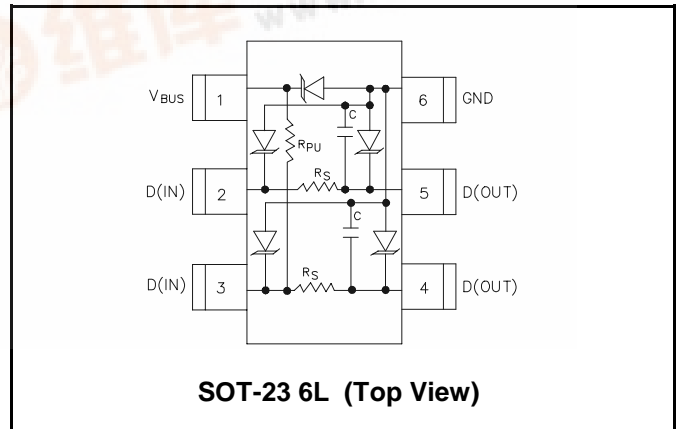
**ORDERING INFORMATION**

Part Number	Series Resistor	Qty per Reel	Reel Size
STF202-22.TC	22Ω	3,000	7"
STF202-30.TC	30Ω	3,000	7"

**COMPONENT VALUES**

	Series Resistor (R <sub>S</sub> )	Pull Up Resistor (R <sub>PU</sub> )	Termination Capacitor (C)
STF202-22	22Ω	1.5kΩ	47
STF202-30	30Ω	1.5kΩ	47
Tolerance	±10%	±10%	±20%

**SCHEMATIC & PIN CONFIGURATION**





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### MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Steady-State Power	P	100	mW
ESD Air Discharge per IEC 1000-4-2	V <sub>PP</sub>	16	kV
ESD Contact Discharge per IEC 1000-4-2	V <sub>PP</sub>	10	kV
Lead Soldering Temperature (10 seconds)	T <sub>L</sub>	260	°C
Operating Temperature	T <sub>slg</sub>	-40 to +125	°C
Storage Temperature	T <sub>j</sub>	-55 to +150	°C

### ELECTRICAL CHARACTERISTICS (T = 25°C Unless Otherwise Noted)

STF202-xx						
Parameter	Symbol	Conditions	Minimum	Nominal	Maximum	Units
TVS Reverse Stand-Off Voltage	V <sub>RWM</sub>				5.25	V
TVS Reverse Breakdown Voltage	V <sub>BR</sub>	I <sub>t</sub> = 1mA	6			V
TVS Reverse Leakage Current	I <sub>R</sub>	V <sub>RWM</sub> = 5.25V, T=25°C Between V <sub>BUS</sub> pin and ground			5	µA
TVS Reverse Leakage Current	I <sub>R</sub>	V <sub>RWM</sub> = 3.3V, T=25°C Between any data (D+, D-) pin and ground			1	µA
Total TVS Junction Capacitance	C <sub>j</sub>	Between I/O pins and Gnd, each device V <sub>R</sub> = 0V, f = 1MHz		10		pF
Series Resistor (STF202-22)	R <sub>S</sub>	Each Line	20	22	24	Ω
Series Resistor (STF202-30)	R <sub>S</sub>	Each Line	27	30	33	Ω
Pull Up Resistor	R <sub>UP</sub>	Each Line	1.35	1.5	1.65	kΩ
Capacitor	C	Each Line		47		pF
Total Capacitance	C <sub>TOT</sub>	Between I/O pins and Gnd, each line V <sub>R</sub> = 0V, f = 1MHz		60		pF

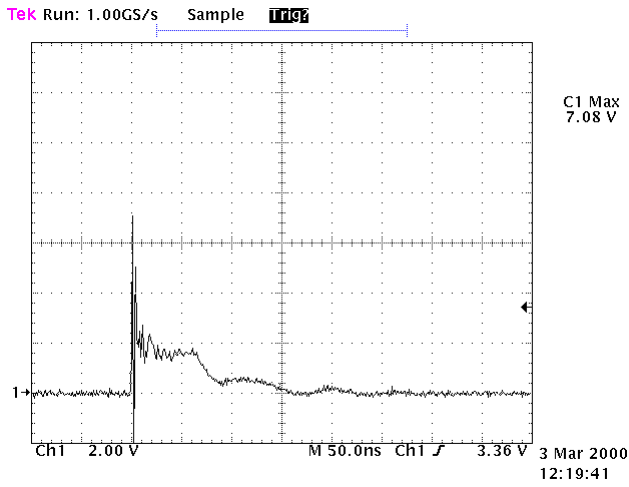
### MARKING CODES

Part Number	Marking Code
STF202-22	222
STF202-30	230

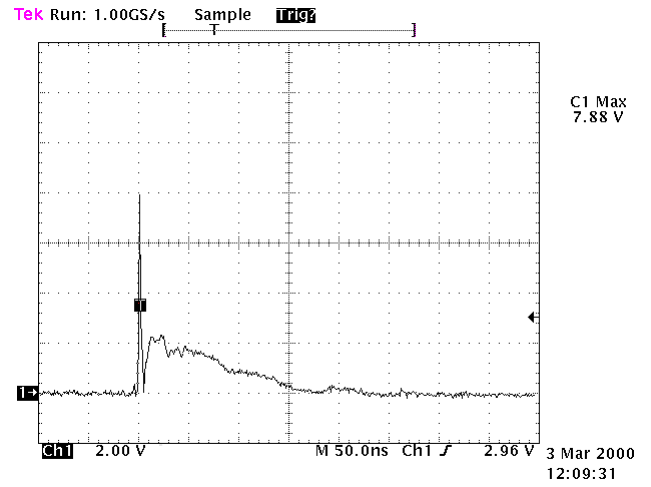
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**TYPICAL CHARACTERISTICS**

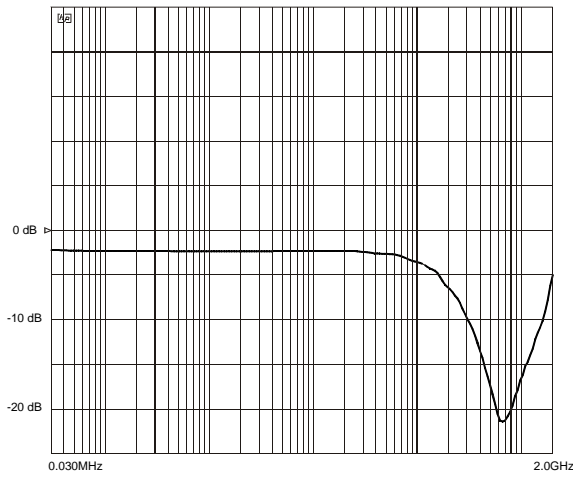
**ESD Clamping (8kV Contact)**



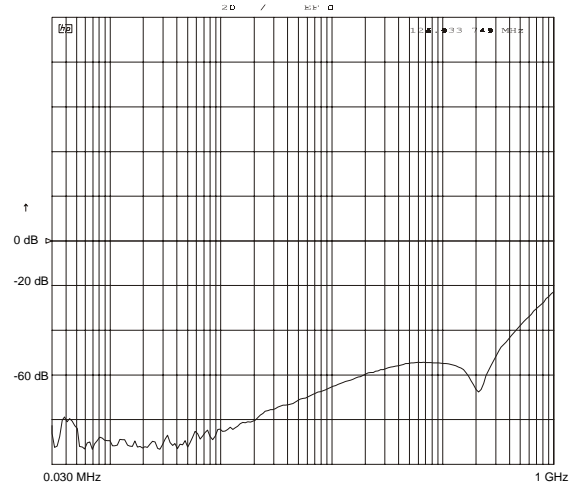
**ESD Clamping (15kV Air)**



**Insertion Loss Characteristics**



**Analog Crosstalk (D+ to D-)**



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## APPLICATIONS INFORMATION

### Device Connection

The STF202 is designed to provide termination, EMI filtering and ESD protection for two USB I/O lines. The equivalent circuit diagram is shown in Figure 1. The device is connected as follows:

- Full-Speed Devices:** For full-speed devices the pull-up resistor is connected to the D+ line. Pin 1 is connected to the voltage supply line ( $V_{BUS}$ ). The input of the D+ line is routed into pin 3 and out of pin 4. The input of the D- line is connected at pin 2 and the output at pin 5. Pin 6 is connected to ground.
- Low-Speed Devices:** For low speed devices the pull-up resistor is connected to the D- line. Pins 1 is connected to the voltage supply line ( $V_{BUS}$ ). The input of the D- line is connected at pin 3 with the output taken at pin 4. The input of the D+ line is connected to pin 2 and the output is at pin 5. Pin 6 is connected to ground.

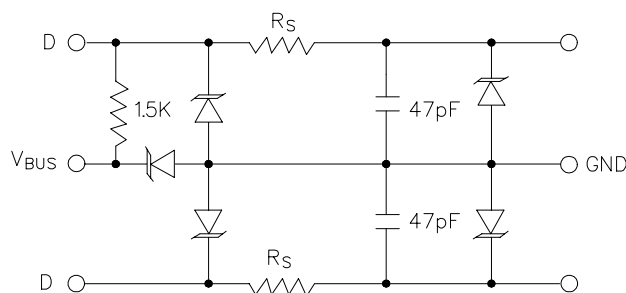
### USB Port Design Considerations

The Universal Serial Bus (USB) specification requires termination and filtering components for proper operation. In addition, an open USB socket is vulnerable to hazardous ESD discharges in excess of 15kV. These discharges can may occur on the data lines or the voltage bus. The STF202 is an easily implemented solution designed to meet the termination & EMI filter requirements of the USB specification revision 1.1. It also provides ESD protection to IEC 61000-4-2, level 4.

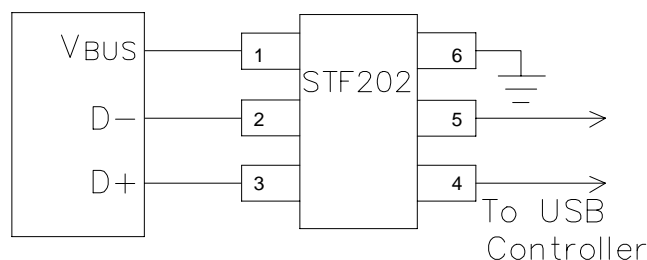
A simplified USB port is shown in Figure 3. USB line termination is achieved with series resistors on both the D+ and D- lines. These resistors preserve signal integrity by matching the cable impedance to that of the differential driver. 15k $\Omega$  pull-down resistors are used to identify a downstream port while an upstream port is identified with a 1.5K $\Omega$  pull up resistor on either the D+ (full speed devices) or the D- (low speed devices) data line. Capacitors are used to bypass high frequency energy to ground and for edge rate control of the USB signals. TVS diodes are added for ESD protection of both (D+ & D-) data lines and the voltage bus ( $V_{BUS}$ ). A power distribution switch and voltage regulator provide the power management functions of the port.

Semtech provides a complete solution to simplify USB port design (Figure 4). The STF201 & STF202

**Figure 1 - STF202 Circuit Diagram**



**Figure 2 - STF202 Connection Diagram (Full Speed Devices)**



integrate all of the components necessary for line termination, bidirectional EMI filtering, and ESD protection on downstream (STF201) or upstream (STF202) ports. The SC5826 is a dual port power switch that provides individual or ganged port switching, fault reporting, and inrush current limiting as required by the USB specification. The SC5205 ULDO provides a stable voltage to the USB controller.

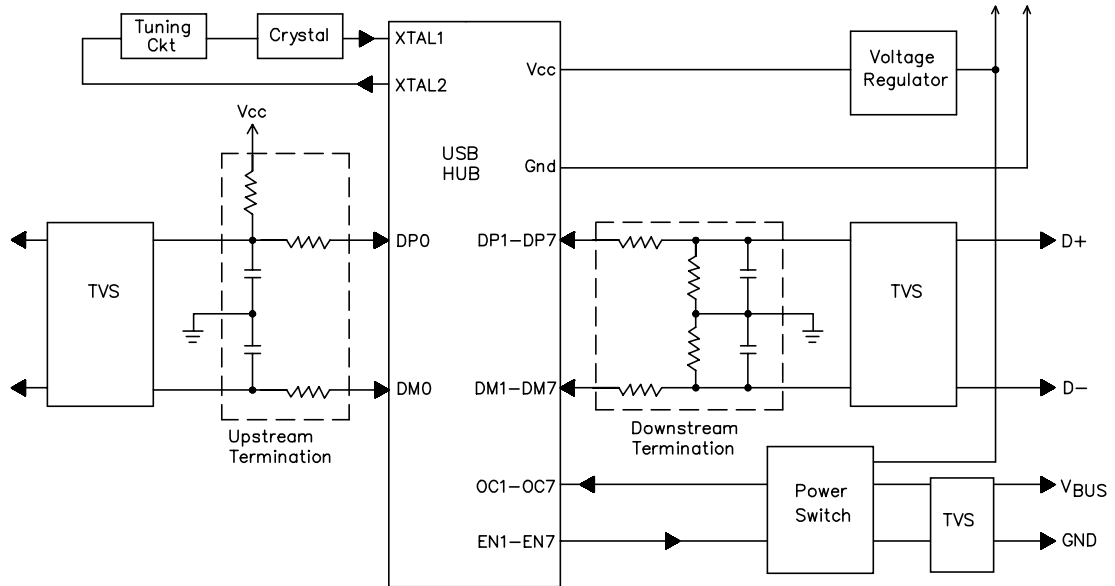
### Board Placement & Layout Guidelines.

Designing a USB hub to meet EMI & ESD immunity requirements requires a combination of optimum component placement, trace routing, and good circuit design practices. Some general guidelines are given below:

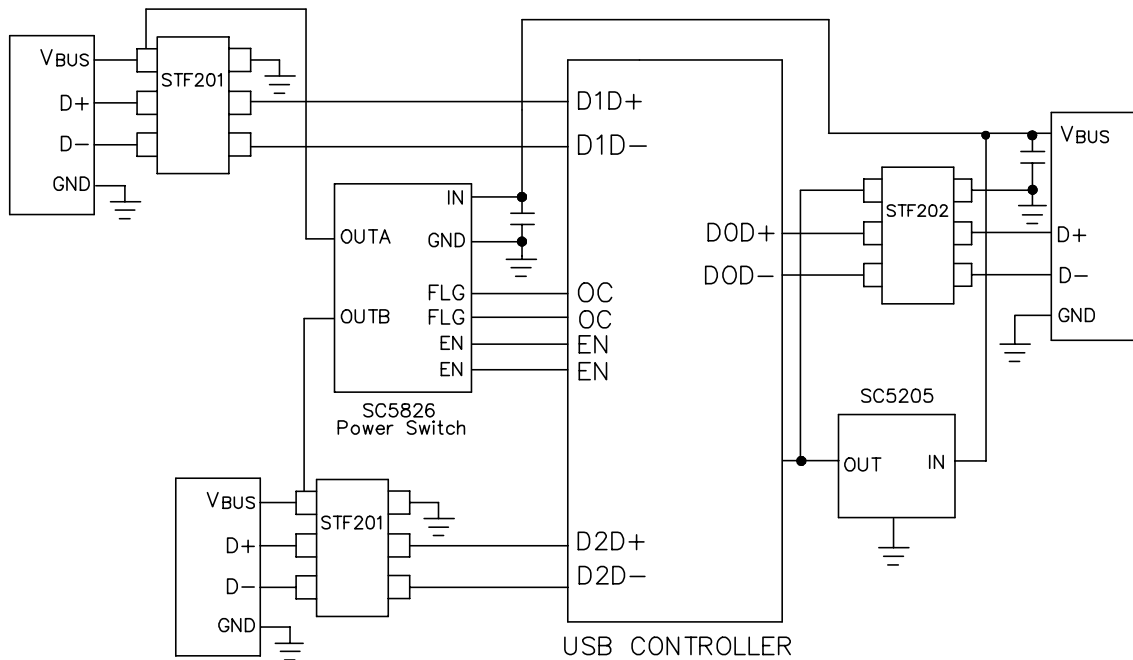
- Avoid running D+ & D- signal line traces near high speed clock lines or similar signal lines.
- Avoid running critical signal lines near board edges.
- Locate the USB controller chip near the USB connectors.
- Place the STF202 near the USB connector to restrict transient coupling.
- Minimize the path length between the USB connector and the STF202

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**APPLICATIONS INFORMATION**

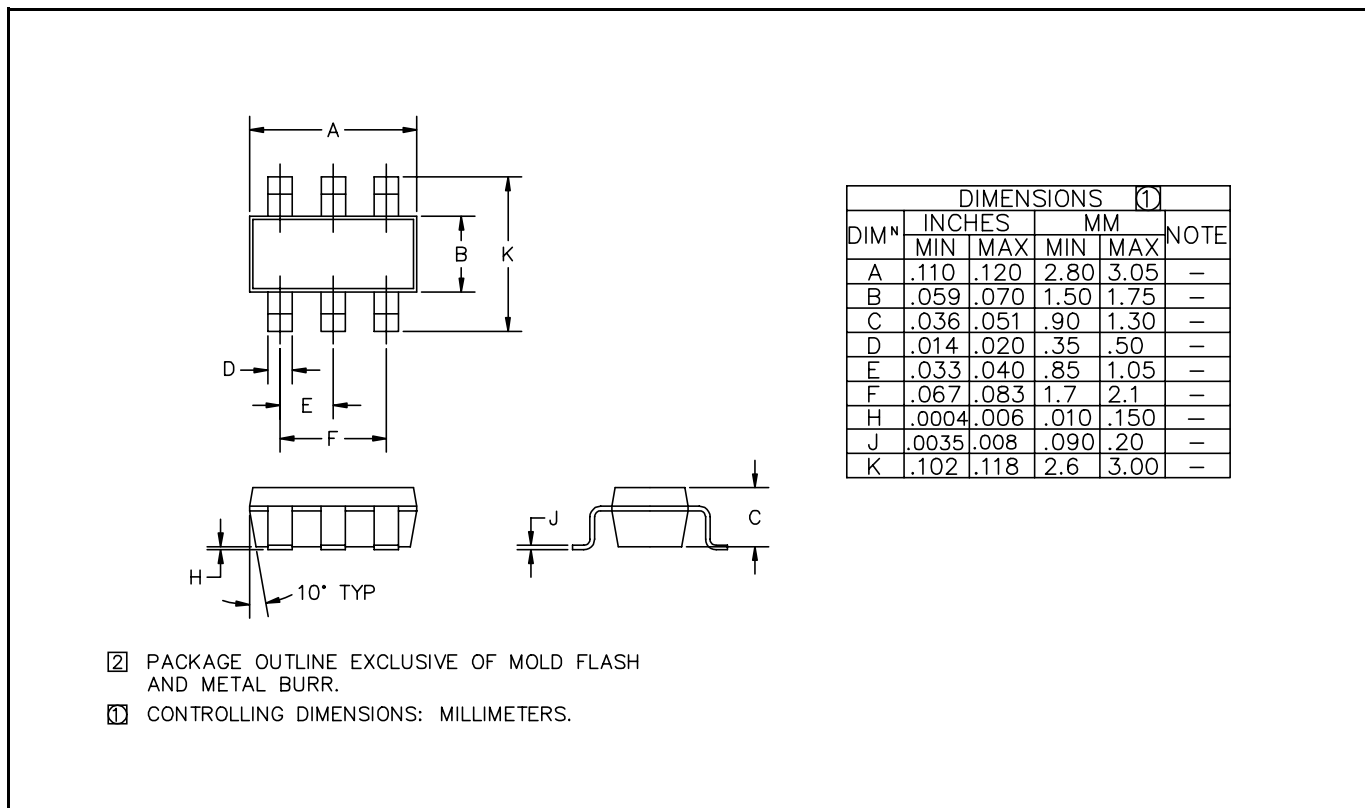


**Figure 3 - USB Port Components**



**Figure 4 - Typical USB Hub Design**

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**OUTLINE DRAWING SOT23-6L**

**LAND PATTERN SOT23-6L**
