



1 Introduction

In order to reduce the power consumption, size and cost of electronic devices, most semiconductor components are manufactured using a “low voltage” process resulting in a maximum operating voltage of 7 V or even less. Any overvoltage causes an excessive power dissipation on the chip quickly leading to damage, or even electrical breakdown. Portable electronic devices, such as cell phones, PDAs, MP3 players, digital cameras, etc. are normally powered from a Li-Ion or Li-Pol battery pack, which is recharged by an internal charger controller supplied by an external AC adapter, USB hub, etc. The failure of this adapter or accidental usage of another adapter with a higher voltage can damage the charger controller and lead to overvoltage on the battery, which may be very dangerous for the device and potentially even for the user.

To avoid this, some type of protective device is absolutely necessary.

One well known solution is a device known as a Transil™. It can be understood as a Zener diode, capable of withstanding high power dissipation. Although Transils are easy to use and relatively inexpensive, their threshold voltage is not very accurate and is dependent upon the current flowing through the Transil. For heavy overload, the voltage on the Transil can still be too large and, in addition, the high power dissipation can lead to high junction temperature, and in extreme cases the Transil and surrounding circuit board can be damaged. For this reason, there is often a fuse connected between the supply connector and Transil to break the circuit in case of extreme overload.

Other, modern and safe devices, are integrated circuits known as “Overvoltage Protection” (OVP) devices. The OVP device can be understood as a “firewall” between the application and the external world represented by the power supply (AC adapter, USB, etc.), allowing only the correct voltage to reach the application and preventing malfunction or damage resulting from the use of an illegal or broken power supply. It contains a voltage comparator and either a driver for external Power MOSFET, or even the Power MOSFET itself. In the event of overvoltage, the comparator turns off the MOSFET, disconnecting the application from the power supply. No excessive power dissipation is generated during overvoltage.

The first member of the STMicroelectronics™ OVP devices family is the STBP120, which will be described in this application note.

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2 Description

The STBP120 provides robust protection for positive input voltage up to +28 V and is capable of supporting current up to 2 A using a built-in low $R_{DS(on)}$ N-channel MOSFET and charge pump. The overvoltage thresholds currently available are 5.375 V, 5.50 V, 5.90 V and 6.02 V.

As additional protection, the STBP120 also monitors its own junction temperature and turns off the internal MOSFET if the temperature exceeds the specified threshold.

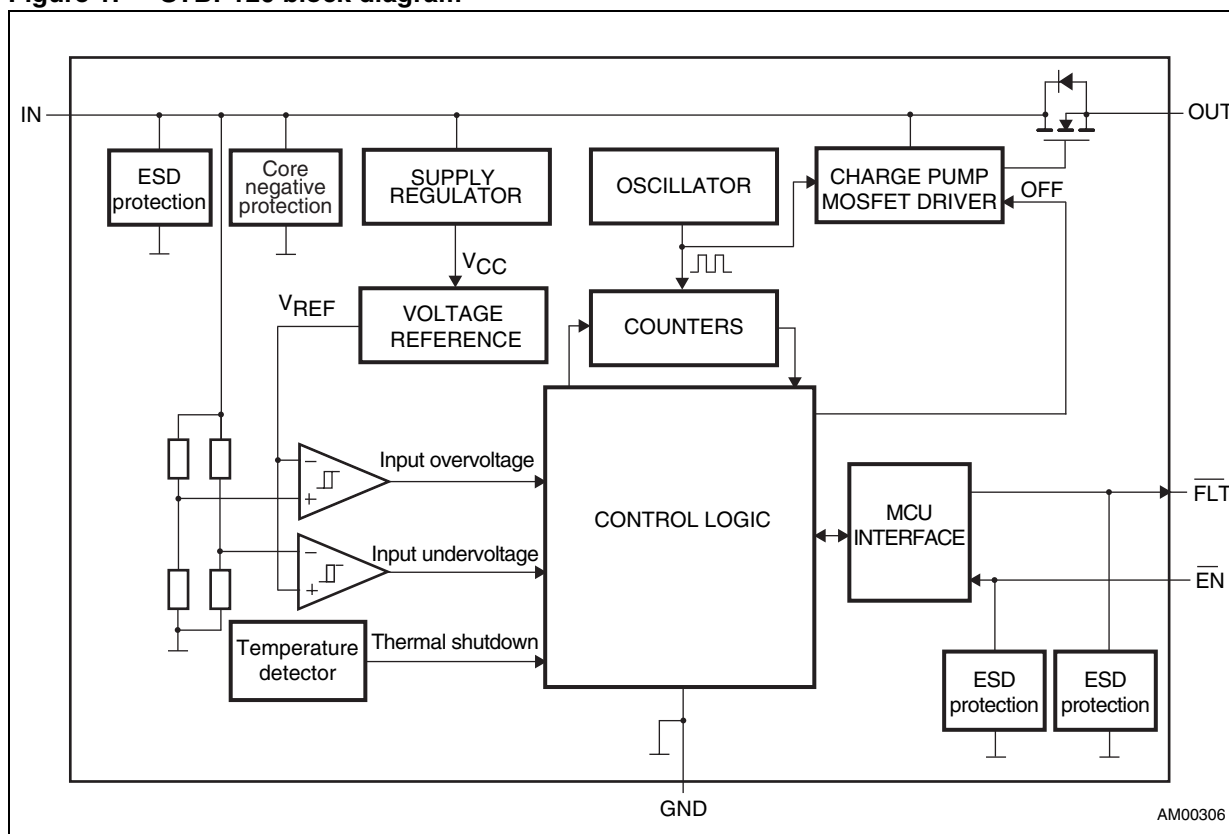
The STBP120 is equipped with the undervoltage lockout function preventing unreliable operation of the protected application for low input voltage.

The STBP120 device can be controlled (enabled / disabled) by the microcontroller and provides status information (input overvoltage, input undervoltage, thermal shutdown) to the microcontroller.

The STBP120 requires only one external component (1 μF input capacitor improving the ESD immunity and stability under input transients conditions), other components are optional (see [Figure 2](#)).

It is offered in a small, RoHS compliant 10-lead TDFN package of 2.5 x 2 mm dimensions. For more details, please refer to the STBP120 datasheet available on www.st.com.

Figure 1. STBP120 block diagram



4 Powering peripherals

In many applications, it is desirable to power external peripherals attached to the system connector. Proper voltage for these peripheral devices is usually generated by a DC/DC converter supplied by the battery (see [Figure 2](#)). This converter is enabled by the controller when power for the peripheral is requested. The output of the converter is connected to the output of the OVP device.

In the internal structure of STBP120 MOSFET, a diode (called reverse diode or body diode) between OUT and IN is present. This diode allows the convertor output voltage (decreased by the diode forward voltage drop, ca. 0.6 V) to appear at the STBP120 input. If this voltage is higher than the STBP120 undervoltage (UVLO) threshold, the MOSFET is turned on and the voltage drop across the STBP120 is reduced to a very small value, given by the STBP120 $R_{DS(on)}$ and peripheral current consumption.

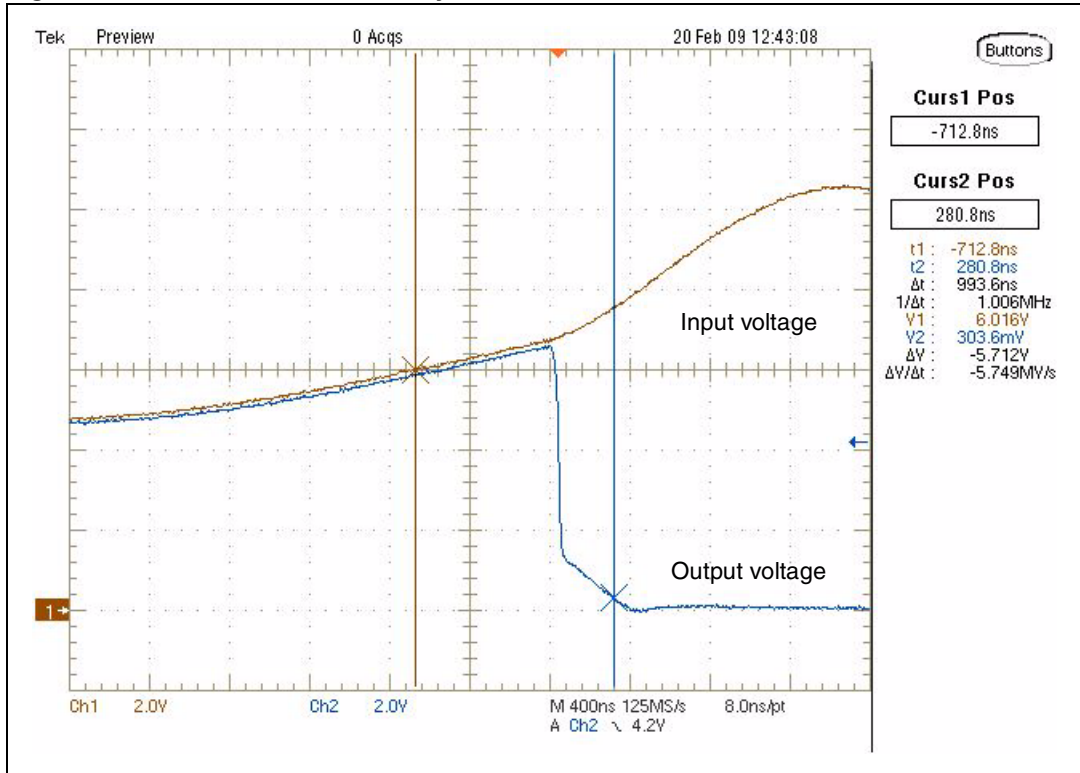
Note: For safety reasons, the charger IC used should NOT allow the reverse current (i.e. it should NOT contain the body diode between its output and input) to prevent the battery pack voltage from appearing on the system connector.

5 STBP120 highlights

The most important function of the OVP device is to disconnect the application from the power supply as fast as possible to avoid damage to the application components.

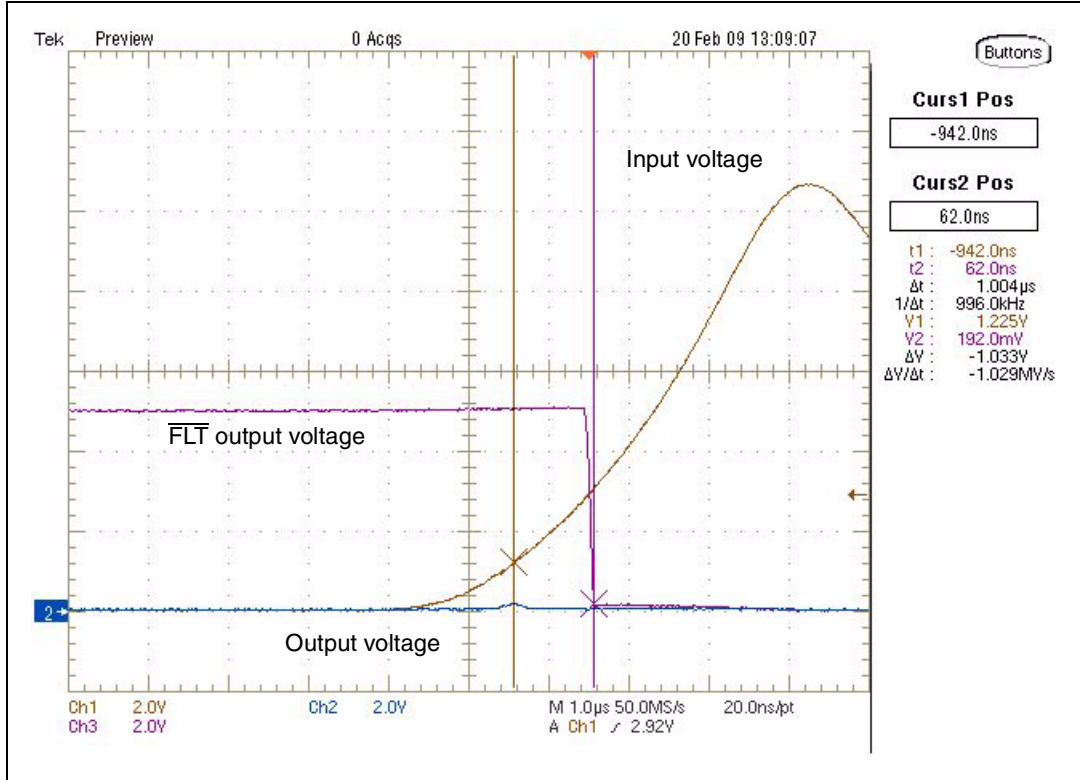
The STBP120 will disconnect the load in typically less than 1.5 μ s after the input voltage exceeds the overvoltage threshold.

Figure 3. STBP120 turn-off delay



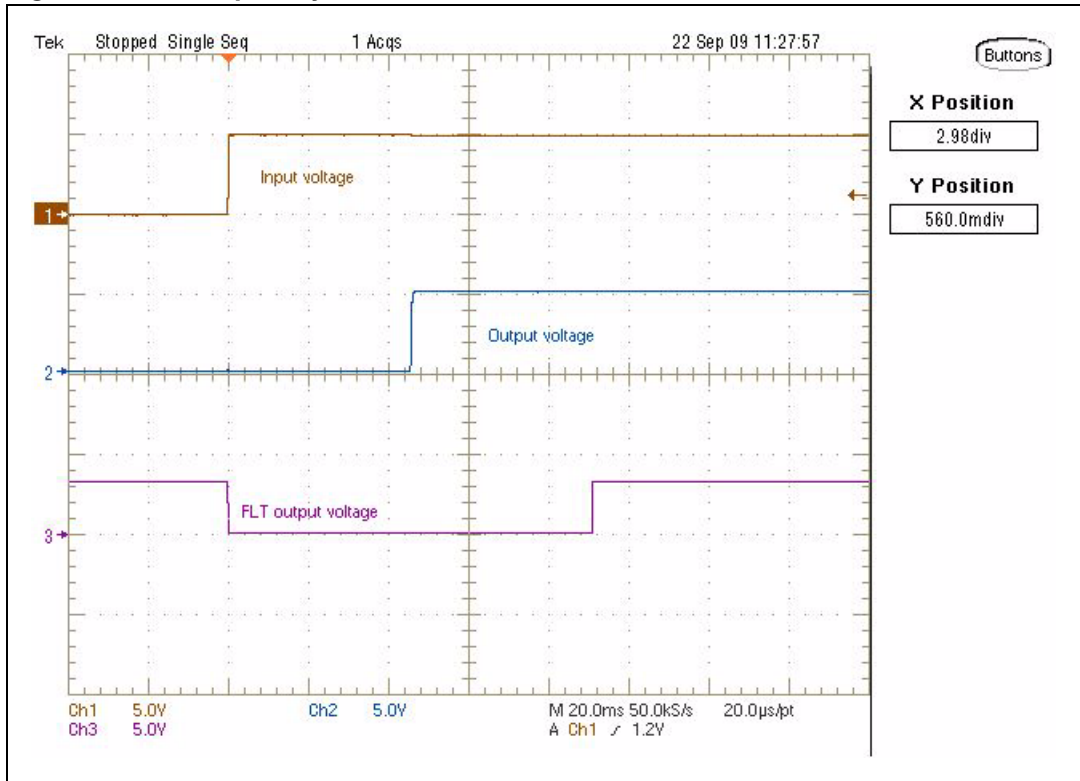
Overvoltage protection is especially necessary in order to avoid damage in the event of inadvertently connecting an illegal power supply (with higher than specified voltage) to the application. In this case, the OVP device must block the excessive input voltage even during its own power-up period. As illustrated on [Figure 4](#), STBP120 correctly performs this task. In addition, it provides the status information to the microcontroller as soon as the input voltage exceeds the 1.2 V.

Figure 4. Startup into overvoltage condition



During a hot insertion of the power supply connector to the application, a transient is generated due to the supply cable inductance, capacitance and resistance. For this reason, the STBP120 has a built-in 50 ms startup delay to let the input voltage to stabilize before the MOSFET is turned on to continue power-on of the application. After this, an additional 50 ms delay is inserted to let the application properly start before the FLT output sends an “OK” (See [Figure 5](#)) signal to the application microcontroller.

Figure 5. Startup delays



Usually, there are some large decoupling capacitors connected to the application supply rails. To avoid instability caused by the power supply current limiter when attempting to charge these capacitors, it is useful to equip the OVP device with a soft-start circuit, limiting this inrush current. The STBP120 implements a soft-start by turning the MOSFET on slowly. This is done by limiting the current charging the MOSFET gate capacitance. This simple approach provides very good results for load capacitance up to 47 μF . Its performance is illustrated in *Figure 6*, *Figure 7* and *Figure 8*, where various load capacitors were connected in parallel with the load resistor of 5 Ω , providing a steady current of 1 A.

Figure 6. Typical STBP120 soft-start performance, $C_{\text{Load}} = 22 \mu\text{F}$

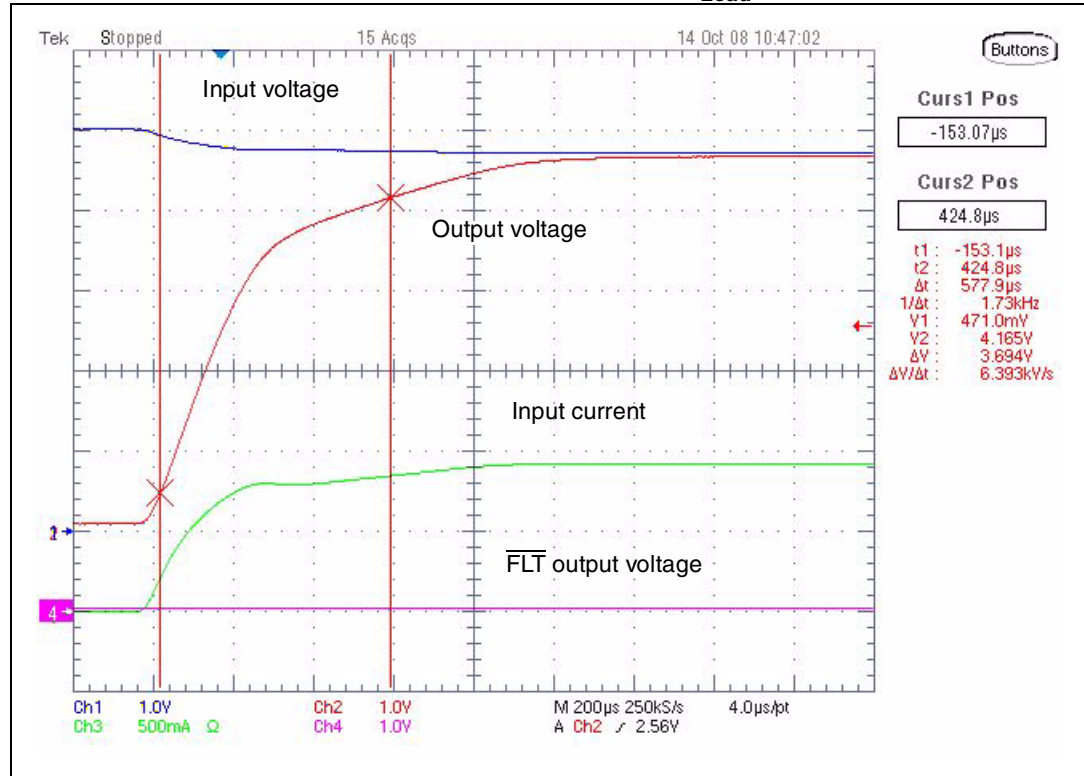


Figure 7. Typical STBP120 soft-start performance, $C_{Load} = 47 \mu F$

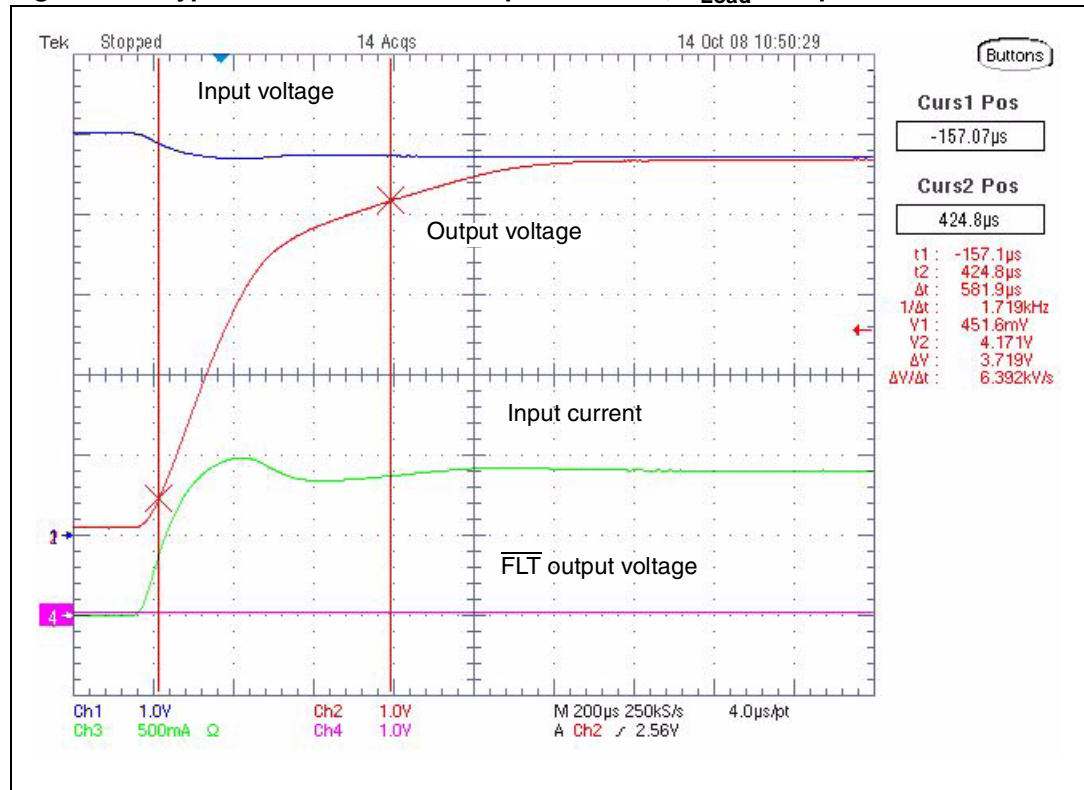
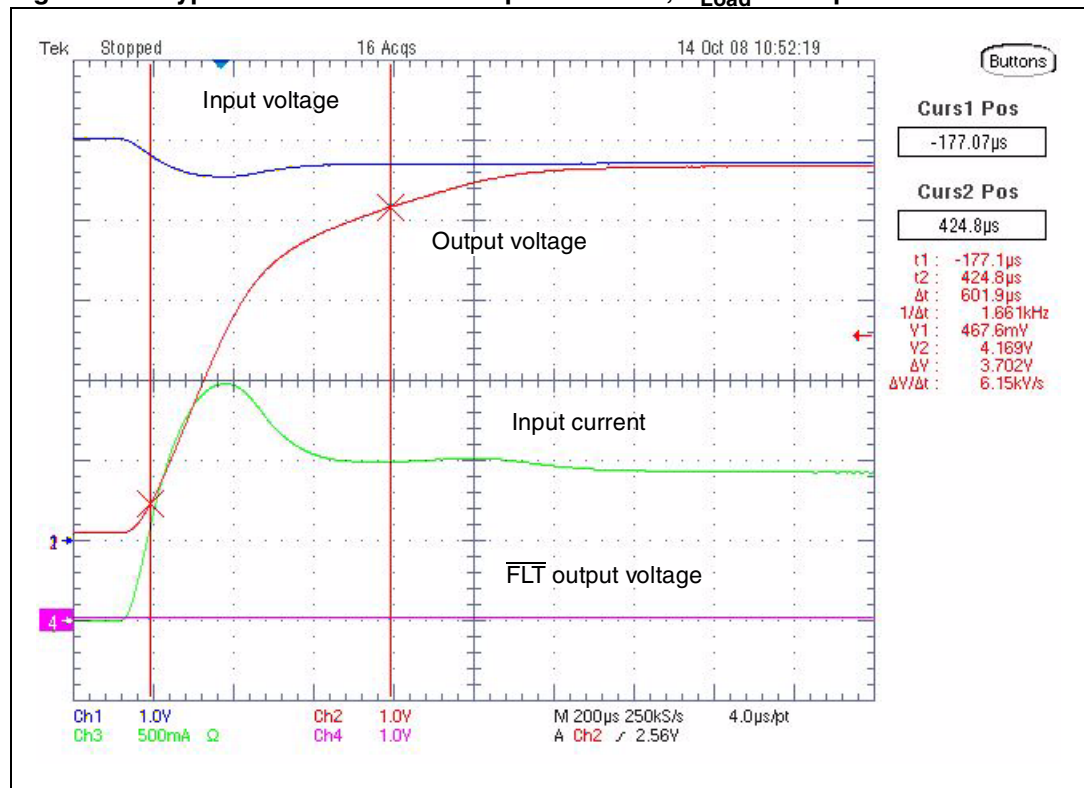


Figure 8. Typical STBP120 soft-start performance, $C_{Load} = 100 \mu F$



The soft-start circuit is very useful for USB-powered applications due to USB power limitations. The USB specification allows a maximum inrush current equivalent to a value generated by a 10 μF capacitor directly connected between V_{BUS} and GND rails. The STBP120 softstart feature allows an even larger capacitor value to be connected to the STBP120 output, providing better decoupling and higher reservoir of energy to cover possible current peaks, without affecting this requirement. Maximum capacitance proven with a standard 2 m USB cable is 100 μF . Higher capacitance can lead to a oscillation due to USB cable impedance and the capacitor inrush current, leading the input voltage to drop below the UVLO threshold during the start-up. The input capacitor value can be 1 - 10 μF .

6 STBP120 versus Transil

Transils are well-known and very useful protection devices for ESD events and overvoltage transients. As mentioned in the [Section 1](#), they can be understood as high-speed, high-power Zener diodes. Based on manufacturing process, they can achieve very high impulse durability making them ideal for protecting e.g. AC or phone lines, or very low capacitance making them ideal for protecting sensitive data and high frequency lines.

On the other hand, these devices are not very suitable for protection against steady-state overvoltage on supply lines generated e.g. by connecting an illegal AC adaptor to the application supply input, because the steady-state overvoltage generates high power dissipation on the Transil.

Following table shows the key benefits of STBP120 device over Transils.

Table 1. Key benefits of STBP120 device over Transils

	Transil device	STBP120 device
Overvoltage threshold accuracy and stability	Widely dependent on current, temperature, time and process variations	As good as $\pm 2.3\%$
Power dissipation when active	Potentially extremely high in overvoltage	Almost zero (output is safely disconnected)
Undervoltage lockout	Not available	3.25 V typ.
Thermal protection	Not available	145 °C typ.
Status indication	Not available	$\overline{\text{FLT}}$ output
Enable input	Not available	$\overline{\text{EN}}$ input

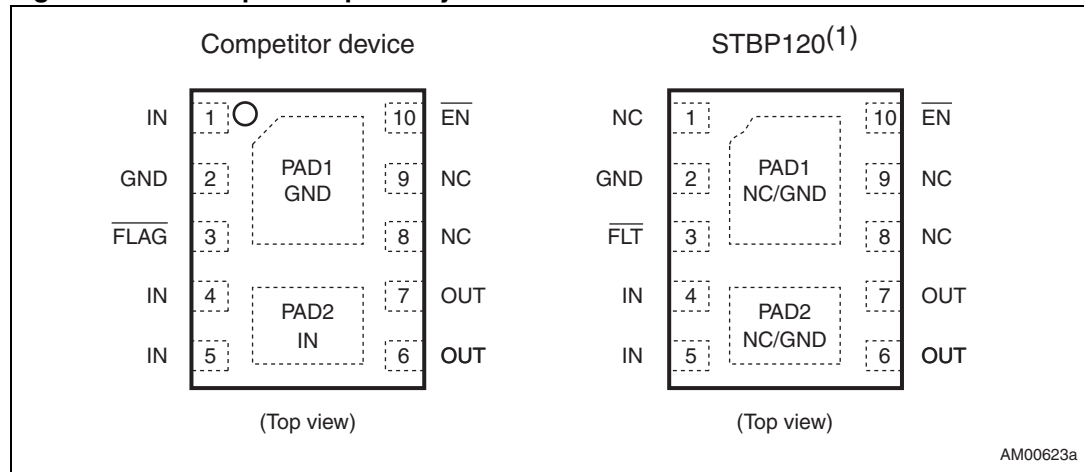
7 Compatibility of STBP120 with other OVP devices

The STBP120 is compatible with other the well known and widely used OVP devices.

The STBP120 provides the customer with the following benefits:

- Both exposed thermal pads are electrically isolated. This allows both pads to be connected to the PCB ground plane, leading to better thermal conductivity.
- The device is equipped with a thermal shutdown feature, improving the overall application safety.

Figure 9. Pin to pin compatibility of the STBP120

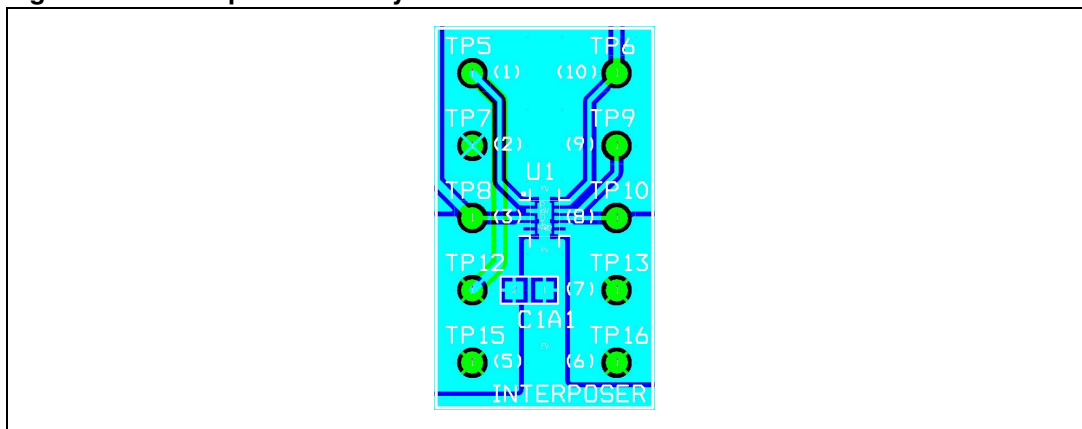


1. STBP120 Pin 1, PAD1 and PAD2 are not internally connected and may be tied to IN or GND.

8 PCB layout recommendations

- This device is intended as a protection device to the application from overvoltage. It must be ensured that the clearances between PCB tracks satisfy the high voltage design rules.
- Input capacitor, C1, should be located as close as possible to the STBP120 device. It should be a Low-ESR ceramic capacitor. Also the protective resistors RFLT, REN (if used) should be located close to the STBP120.
- For good thermal performance, it is recommended to connect the STBP120 exposed thermal pads with the PCB ground plane. In most designs, this requires thermal vias between the copper pads on PCB and the ground plane.

Figure 10. Example of PCB layout



9 Conclusion

The STBP120 device significantly increases the safety of portable electronic devices powered (or recharged) from an external power supply by implementing fast and reliable protection from input overvoltage. In addition it allows the system to power external peripherals through the system connector thanks to its reverse current capability. The STBP120 is pin to pin compatible with frequently used devices and outperforms their safety level using the thermal shutdown protection.

10 Revision history

Table 2. Document revision history

Date	Revision	Changes
18-Nov-2009	1	Initial release.

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