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Analog Switches with -2V Undershoot Protection

Abstract

System designs are continuously confronted with critical challenges such as impaired signal integrity and voltage and current excursions that inflict damage to integrated circuits. Unwanted voltage and current transients can damage electronic circuits, resulting in system malfunctions and costly repairs. This application note will discuss analog switches designed with Fairchild's Undershoot Hardened Control (UHC®) circuitry that provides protection from undershoot transients or negative voltage spikes. Past attempts at solving the problem of undershoot transients will also be explored for relative comparisons.

Undershoot Voltage Transients

Why should one be concerned about undershoot noise? Historically, undershoot noise in systems was always a concern for some specialized devices such as dynamic RAMs, microprocessors and ASICs that were sensitive to these signal excursions. Typically, solutions for addressing this problem involved using discrete components such as diodes, resistors and capacitors to damp out the noise. The effectiveness of this approach was limited and resulted in high component counts in the application. Figure 1 provides an illustration of an undershoot event.

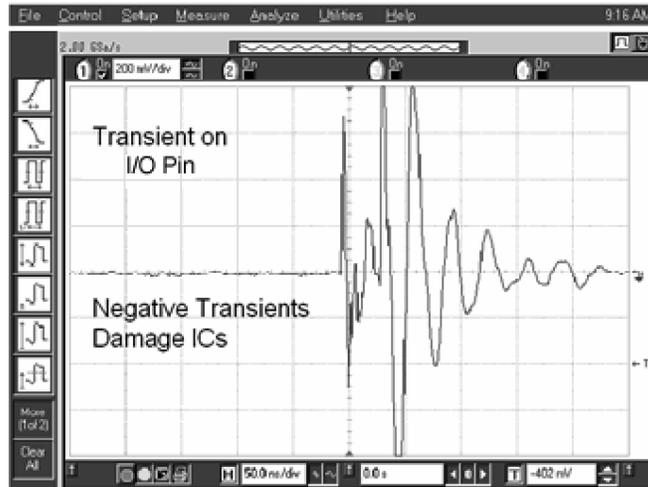


FIGURE 1. Illustration of a Voltage Undershoot Event

Reducing system-generated noise is one of the many challenges associated with optimizing system reliability and signal integrity. For example, noise generated from the printed circuit board (PCB) stackup which can manifest itself via the power distribution planes, crosstalk, decoupling noise, EMI and transmission line reflections. Fundamentally, system noise is a function of signal characteristics, such as edge rate, voltage swing, and frequency of operation. Varying approaches of protecting ICs from damage attributed to unwanted signal excursions and the cost effective design solution will be dictated by the system and application requirements.

Fairchild's analog switches with -2V undershoot protection employ UHC circuitry that monitors the voltage levels of the

input and output of the analog switch. This design solution eliminates any discrepancy in voltage levels when the analog switch is disabled, thus the undershoot energy will not cause the switch to turn on. Fairchild's design solution will work well with all -2V undershoot events regardless of the frequency. Without undershoot protection, the switch will turn on and the undershoot energy will be passed on to the ICs downstream, potentially damaging them. Refer to Figure 2 for a reference and schematic screen captures showing the effectiveness of the UHC circuitry on the NC7SBU3157.

When dealing with these types of design concerns we recommend using Fairchild's UHC solutions as a cost effective and reliable alternative.

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Undershoot Voltage Transients (Continued)

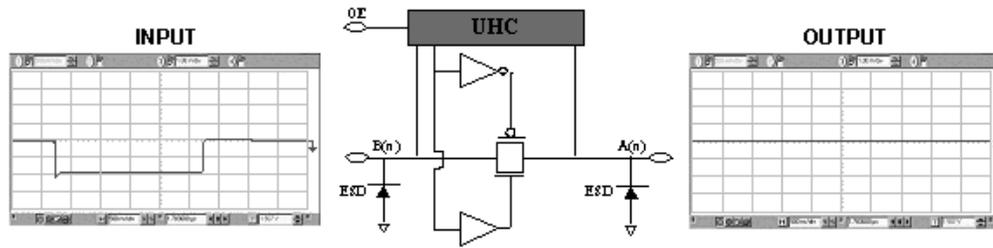


FIGURE 2. Fairchild's Analog Switches with UHC Circuitry

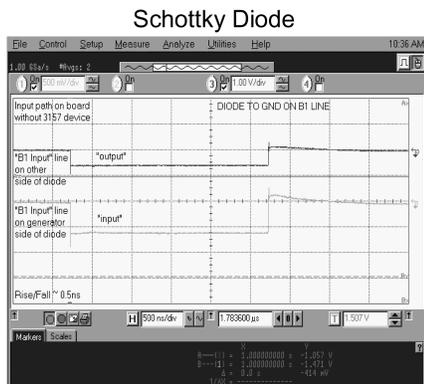
Comparison Between Design Solutions

As previously mentioned, Fairchild's analog switches are an alternative to the ineffectiveness of other design solutions using discrete components when dealing with undershoot problems in a system. We will explore these different design solutions which are the Schottky Diode Circuit, Filter Circuit and the Unprotected Analog Switch. Data (screen captures) are provided to illustrate the effectiveness (in dealing with undershoot) of each circuitry and compare to the UHC device solution. This is a representa-

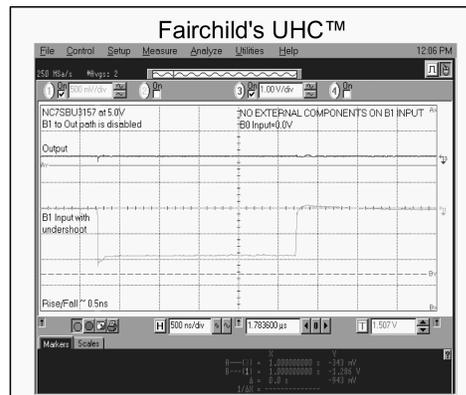
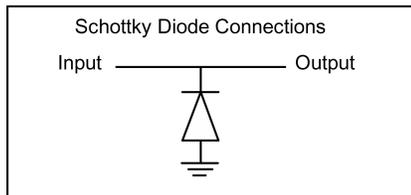
tion of laboratory test setups and performance may vary with specific application conditions.

Schottky Diode Solution

This technology was designed for high voltage, low current events such as Electrostatic Discharge (ESD). Schottky diodes will not turn on under low voltage, high current conditions. Their turn-on speed of 2-4 nanoseconds is too slow for the Schottky device to clamp the negative transient. Refer to the following screen capture (Figure 3) for a comparison between the solutions.



• Schottky diode connects -750mV to the output



• Fairchild's analog switch with UHC protects internal circuitry from the same input signal

Analog Switch with UHC Connections

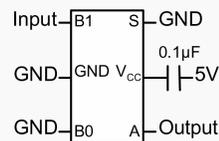


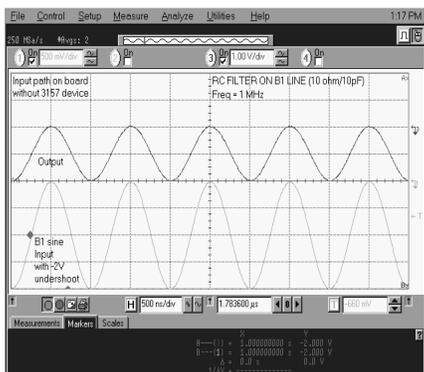
FIGURE 3. Schottky Diode Solution vs. UHC Solution

Filter Protection

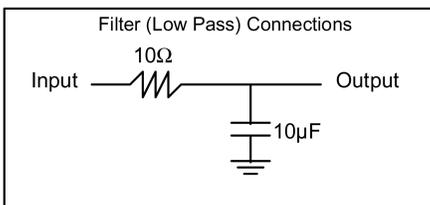
This technology works well in a preset frequency range, but outside the predesigned frequency range this approach

does not filter out the negative transients to ground passing the transients to the unprotected IC's. Refer to Figure 4 for a relative comparison of the effectiveness of the isolation.

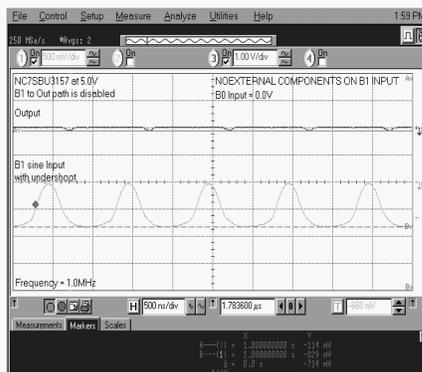
Unprotected Analog Switch



- Unprotected switch connects -2V to the output



Fairchild's UHC™



- Fairchild's analog switch with UHC protects internal circuitry from the same input signal

Analog Switch with UHC Connections

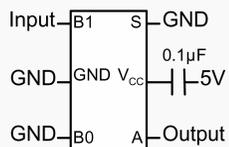


FIGURE 4. Low Pass Protection Solutions vs. Fairchild's UHC Solution

Unprotected Analog Switch

When an unprotected analog switch is disabled or has an unselected channel, a negative voltage excursion will forward bias the internal NMOS diode turning the switch on.

This will connect the undershoot energy to the unprotected internal circuitry potentially damaging or shortening the life of the IC. Refer to Figure 5 for a relative comparison between solutions.

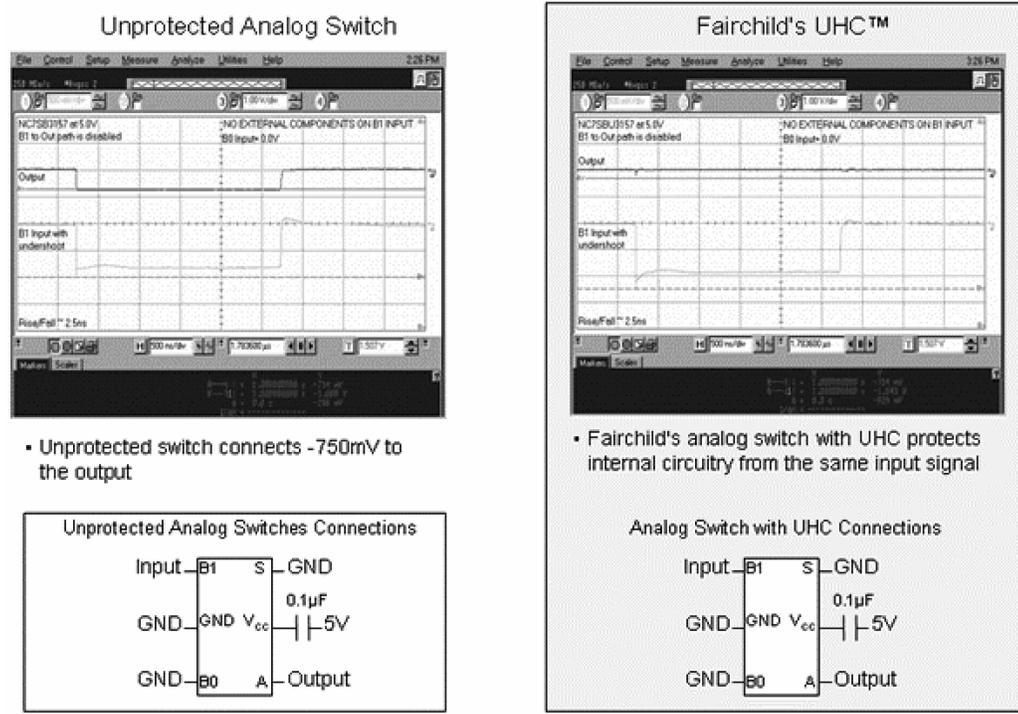


FIGURE 5. Schottky Diode Solution vs. UHC Solution

Summary

Since the complete elimination of system-generated noise is often not possible, controlling and managing the noise is critical for reliable system operation. This application note explored some different approaches for dealing with unwanted noise routinely found on signals in an electronic system. Protecting integrated circuits from harmful voltage transients can be addressed at the system level or at the IC

device level. Fairchild Semiconductor offers UHC analog switches as well and other components for cost effective solutions for protection against negative signal excursions, which could potentially, damage devices that are sensitive to these events. Visit Fairchild Semiconductor's web site at <http://fairchildsemi.com> for more information on UHC devices.

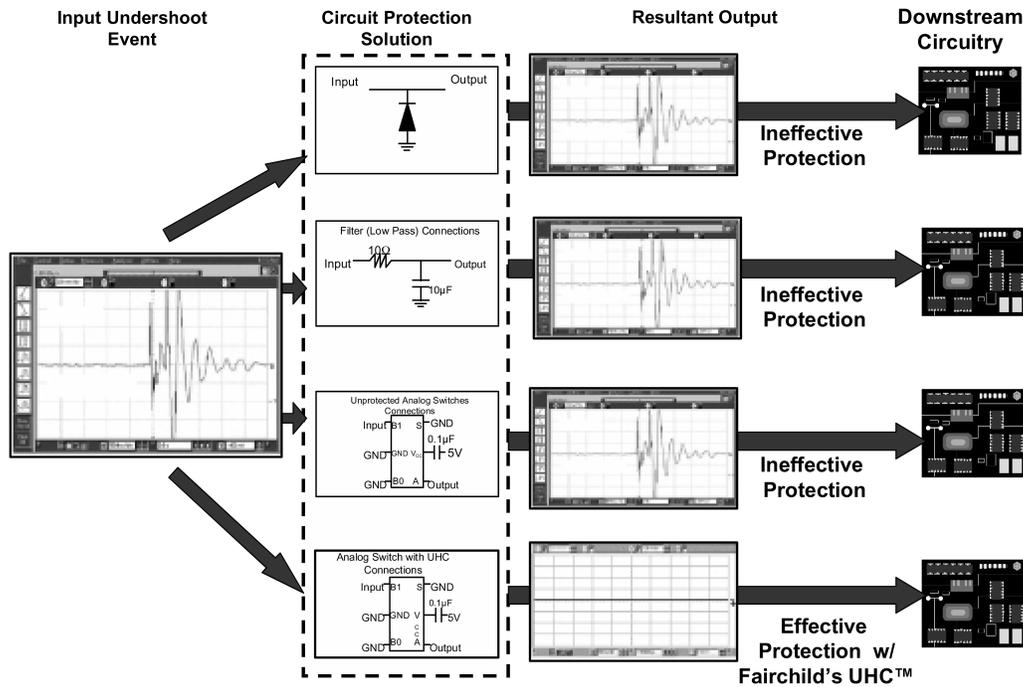


FIGURE 6. Relative Comparison of UHC Against Design Alternatives

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