Application Note

Shrink Your USB-C Fast Charging Design with Small Multiplexers

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Abstract

This application note covers how the TMUXHS221F can provide overvoltage protection (OVP) and surge protection in current USB charger designs, while maintaining a small design size and reducing overall bill of materials (BOM).

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1 Introduction

Modern USB chargers are decreasing in size while offering greater charging power. As a result, internal components must become smaller and more efficient. Traditional designs using multiplexers included a port protector and a translator to meet USB-C™ fast charging system requirements. While this design worked, it came with a large footprint size because it involves multiple components. Leveraging a multiplexer that can handle the port protection and lower logic control will be advantageous to shrink the design. Using a multiplexer, such as TMUXHS221F, with a protection component, provides a smaller design size while supporting the increased charging power. Implementing an ESD diode such as the ESD761 and a series resistor of 25Ω before the input of the multiplexer. This results in a system that can support USB-2, and USB-C charger requirements on OVP, IEC, and surge protection, while keeping the solution size small.

2 Application

Current designs of USB-C fast charging systems use a USB multiplexer with a translator to toggle channels and pass signals through. The translator is used to shift the voltage up to a threshold level where the multiplexer can switch its channels. This is due to the USB-C system operating at 1.2V, which is not supported by most multiplexers' logic. Moreover, a port protector device is required to cover OVP and surge events. These components together accomplish the USB-C fast charging system requirements, but with a large footprint size. In their stead, leveraging a USB OVP multiplexer such as the TMUXHS221F with a protection component is able to achieve the same solution with a fraction of its size and cost.

The TMUXHS221F is a USB mux with 1.2V Logic providing an extended overvoltage protection (OVP) up to 35V. The TMUXHS221F can also support the IEC61000-4-2 ESD ±8kV specification with a 25Ω resistor in series and a diode such as the ESD761 to ground. These are critical protection protocols that chargers must meet to protect the users, system, and downstream components.

Adding a multiplexer to the signal line results in additional parasitics degrading the signal integrity. They come from the resistance and capacitance of the part, of which details can be found in the datasheet. Though this is not a concern when implementing the mux in your design, the effect is so minimal the signal degradation would barely be noticeable. Figure 2-1 and Figure 2-2 show eye diagrams of a USB 2 signal passing through the calibration traces of the TMUXHS221EVM, versus the same signal passing through the TMUXHS221F.

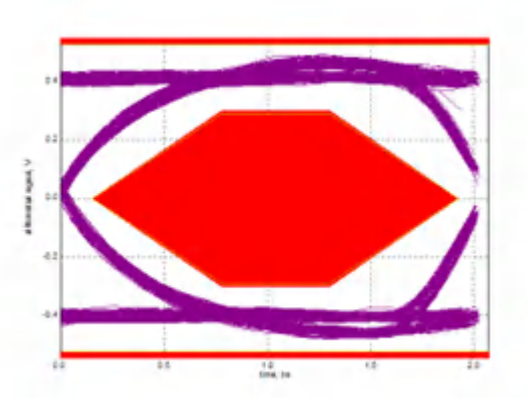


Figure 2-1. USB 2 Signal Through Calibration Traces

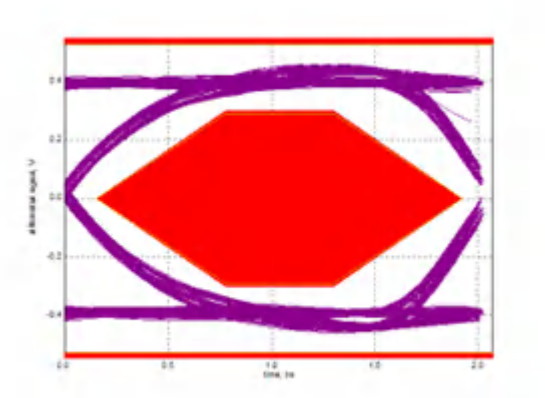


Figure 2-2. USB 2 Signal Through TMUXHS221F

Note with the series resistor implemented; the design can support up to the USB 2 Full Speed specification. Also, any signal attenuation can be recovered by adding a redriver to the signal lines of the system.

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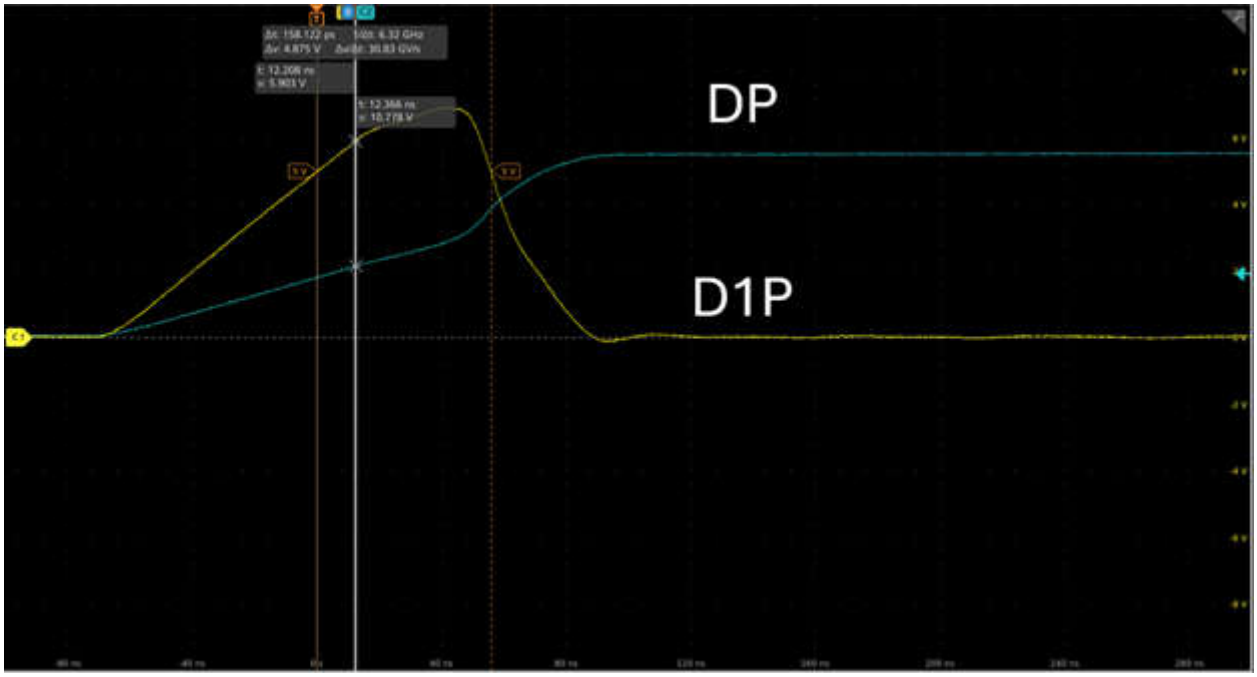


Figure 2-3. TMUXHS221F 28V OVP Performance

For additional protection such as surge events, a diode needs to be picked according to the surge current ratings. It is important to select a diode with clamping voltage within the extended OVP ratings of the TMUXHS221F. Figure 2-4 shows the performance of the multiplexer in an OVP event of 35V using the ESD761 with clamping voltage of 28V.

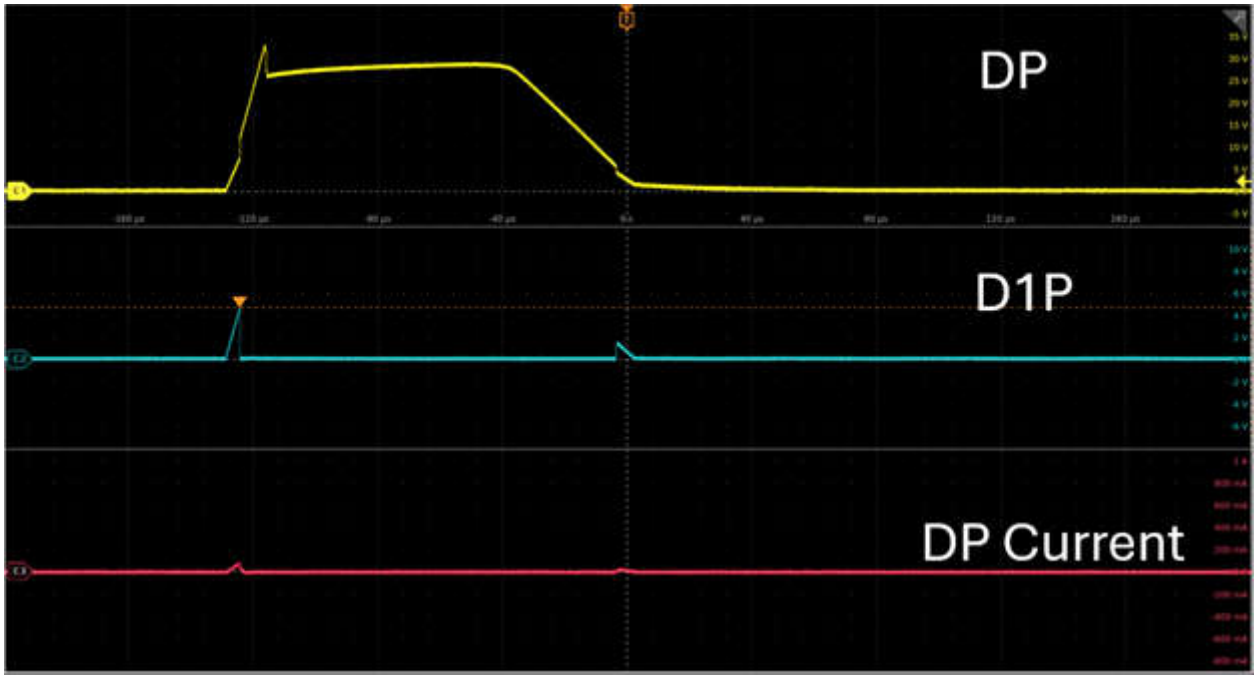


Figure 2-4. TMUXHS221F 35V Extended OVP Performance

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To meet the majority of the protection protocols in USB 2 systems, we recommend leveraging the TMUXHS221F with a protection diode as shown in Figure 2-5. This can be designed in USBC fast charging systems supporting Notebooks and Laptops, where the charging power can be up to 120W, or 24V of VBUS.

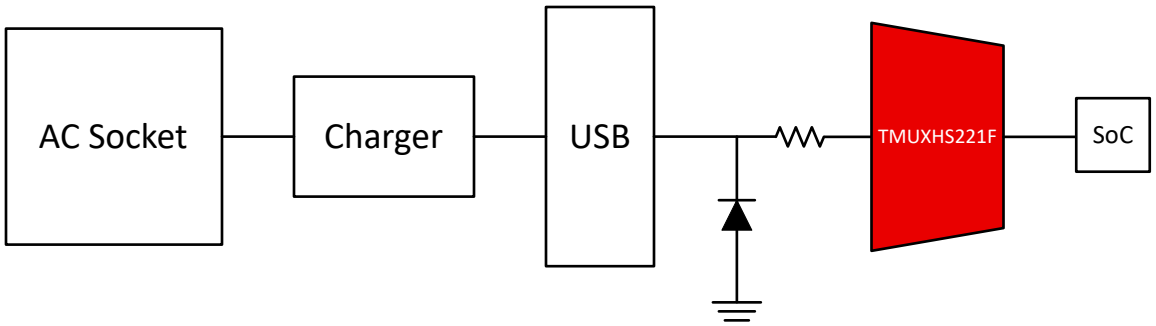


Figure 2-5. TMUXHS221F Diode Design

Comparing this design size to what is traditionally designed shows the designer can save approximately four times the space. Implementing the TMUXHS221F and a diode, instead of multiple components accomplishes the same goal, but with a much smaller design. Figure 2-6 shows footprint area comparison between the two designs. The area was calculated using industry standard components and packages.

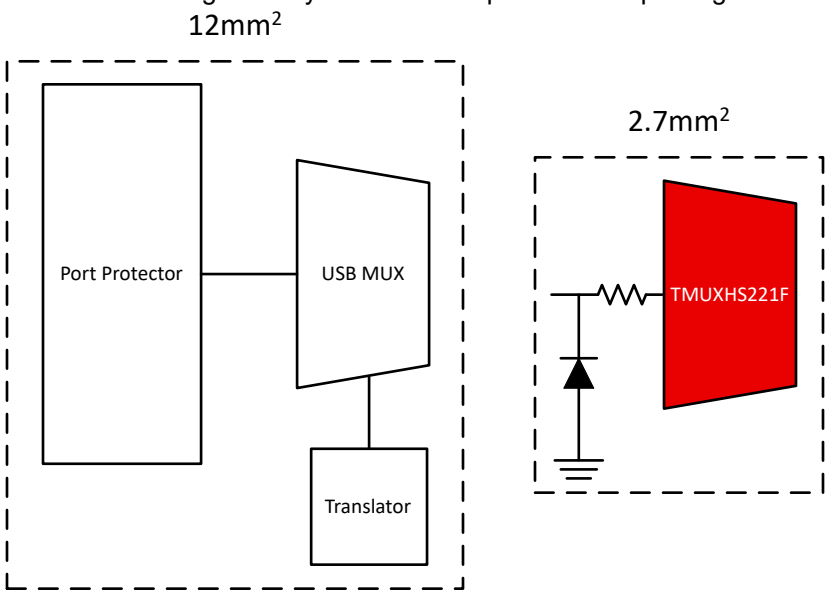


Figure 2-6. Footprint Area Comparison

3 Summary

TMUXHS221F offers a low-cost and small-size design for fast charger designs. Providing OVP, meeting surge and IEC protection requirements, and increasing space savings, this device effectively meets current and future system design requirements.

4 References

- Texas Instruments, *TMUXHS221F Dual 2:1 USB 2.0 Mux/DeMux With 30V Overvoltage Protection and 1.2V Logic*, datasheet
- Texas Instruments, *TMUXHS221/LV Evaluation Module*, user's guide
- Texas Instruments, *ESD751 and ESD761 24-V 1-Channel ESD Protection Diodes*, datasheet

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5 Revision History

Changes from Revision * (September 2026) to Revision A (October 2026)	Page
• Updated the numbering format for tables, figures, and cross-references throughout the document	2

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