Application Report
SLVAE29–March 2019

Discrete solution for TPS24711 to achieve insertion ON delay and fast turn OFF

Johnny Guo
Jack Chen

ABSTRACT

The TPS24711 is an easy-to-use, 2.5 V to 18 V, hot-swap controller that safely drives an external NMOS. The programmable current limit, MOSFET power limit and fault time protect the supply load and MOSFET at startup. While in some chassis Switch, Router and Server application, insertion turn ON delay and fast turn OFF feature is required due to input voltage ringing in insertion and removal. This application report introduces a performance-cost-optimization discrete solution with TPS24711 to achieve these features. Simulation and experiment test result is also given.

Contents

List of Figures

Trademarks

1 Introduction

In chassis applications, Hotswap is a typical requirement for higher system reliability. The TPS24711 is an easy-to-use, 2.5 V to 18 V, hot-swap controller that safely drives an external NMOS. The programmable current limit, MOSFET power limit and fault time protect the supply load and MOSFET at startup. Programmable power limiting ensures the external MOSFET operates inside its safe operating area (SOA) at all times. This allows the use of smaller MOSFET while improving system reliability.

While in some chassis application like Campus Switch, Edge Router and Blade Server, input voltage ringing brings risk to system working and MOSFET, which is a design consideration. Thus insertion turn ON delay and fast turn OFF feature is required. TPS24711 device does not have this feature, so a low cost discrete solution is designed and verified through simulation and bench test.

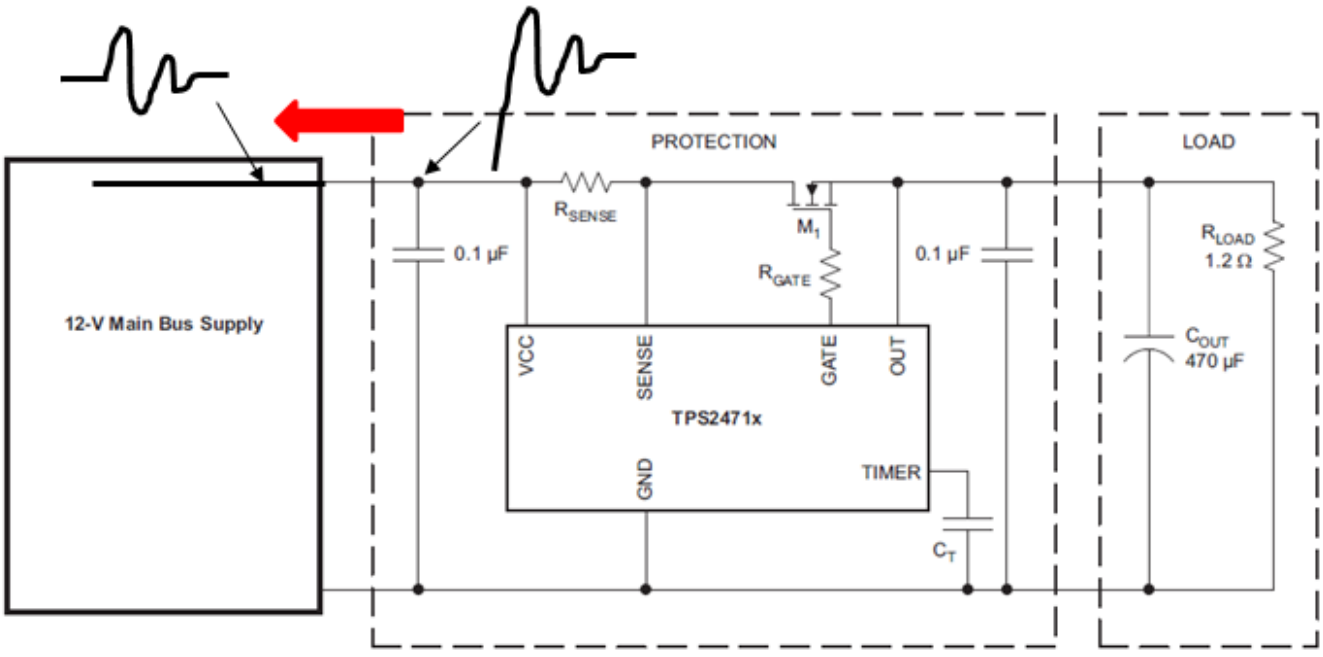
2 Application Problem in Insertion and Removal

During board insertion and removal, the board VIN and backplane bus voltage ringing is a normal phenomenon, and the ringing range, peak and valley depends on the backplane power stability, inserting board input capacitance and parasitic inductance in VIN/GND on-board routing.

2.1 Board Insertion

Figure 1 is a typical plug-in board VIN and bus voltage ringing in insertion.

Figure 1. Board VIN and Backplane Bus Voltage Ringing in Insertion



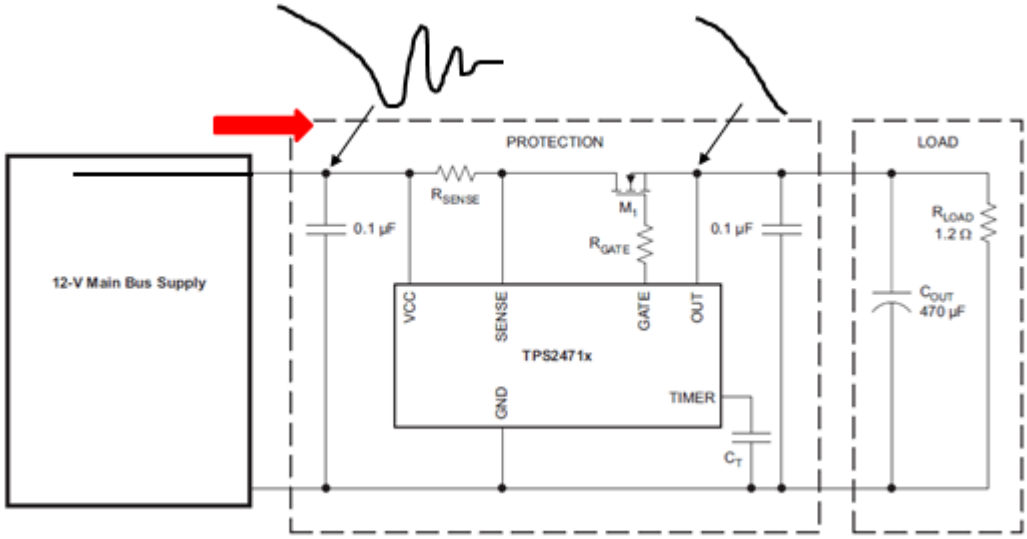
- When a board is inserted, the input capacitor is charged to bus voltage, pulling charge out of the bus and causing an LC ringing on the VIN of inserting board. A turn ON delay is recommended for inserting board.
- While on the backplane bus, the ringing appears because the CIN of inserting board is charged from existing board bus, causing bus ringing on backplane and existing board.
- The VIN valley drops to a low value and influence the bus voltage of existing board in chassis system, especially when the system power supply stability is not quite good, it may trigger VIN OFF threshold of existing board.

In order to ensure inserting board to turn ON after VIN becomes smooth and stable after ringing, insertion turn ON delay feature is required. Considering the backplane ringing valley voltage will influence other existing board, Hotswap OFF threshold should be set to a proper value.

2.2 Board Removal

Figure 2 shows a plug-out board voltage ringing in removal.

Figure 2. Board VIN and VOUT in Removal



- When the board is pulled out, the VIN and VOUT of removing board starts to drop from bus voltage to 0 V.
- At VIN side, mechanical contact between power connector and backplane will cause extra ringing.
- At this time, if Hotswap controller is still working and MOSFET is still ON. This mechanical contact caused ringing at VIN will bring high ΔV across MOSFET drain-to-source, which leads to a high peak current flowing through MOSFET. So MOSFET fast turn OFF when VIN reaches OFF threshold is required in system.

3 Insertion Turn ON delay and Fast Turn OFF Circuit

According to the application problem analysis, the design requirements are listed below.

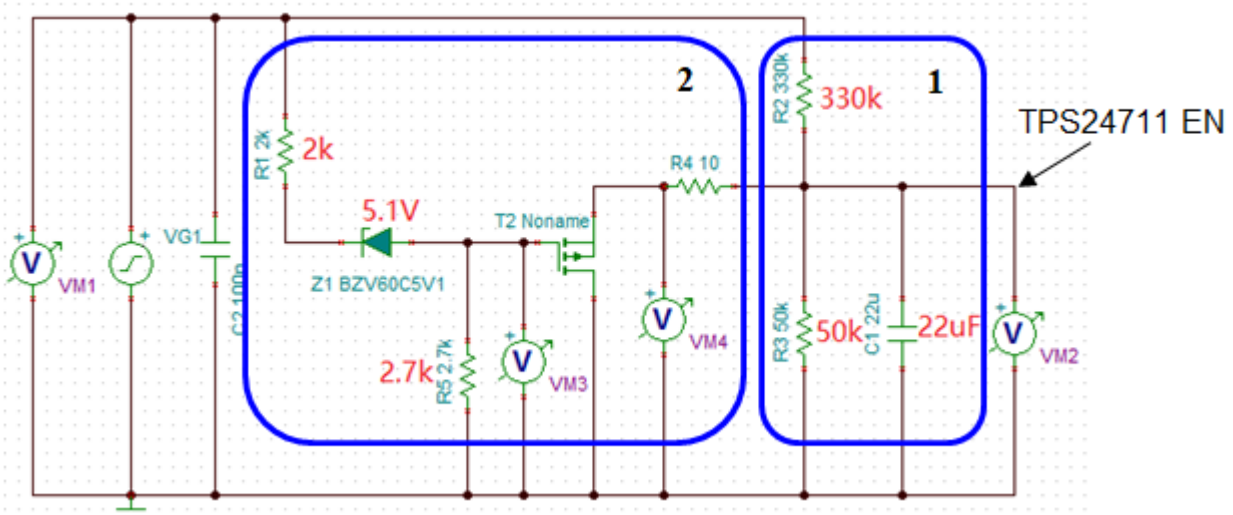
- A particular insertion turn ON delay should be designed.
- VIN OFF voltage should not be set too high to avoid existing board shutdown in insertion.
- A fast turn OFF control should be designed to avoid MOSFET high current in removal.

Below Hotswap design specification is raised based on chassis system.

- Turn ON delay after insertion: >= 1 s
- Hotswap ON/OFF threshold: VIN = 6.8 V / 6.65 V
- Hotswapturn OFF delay when EN drops below threshold: < 5 ms

Aiming to achieve above features, a discrete solution connected to TPS24711 EN pin is designed as shown in below Figure 3.

Figure 3. Simulation Circuit



The circuit 1 is a resistor divider and ceramic capacitor to achieve insertion turn ON delay function. When board is plugged in, TPS24711 EN pin voltage is controlled by R2, R3 and C1. EN typical rising threshold voltage is 1.3 V with 50 mV hysteresis.

When VIN drops to OFF threshold, the EN pin voltage may be still higher than EN falling threshold voltage 1.25 V due to slow discharge of existing big capacitor C1. The circuit 2 is designed for fast turn OFF after VIN falls to OFF threshold. A PMOS and 10 Ω resistor is used for discharging EN C1 capacitor voltage. And the discharging starting voltage is controlled by R1, R5 and 5.1 V Zener diode.

Figure 4 and Figure 5 shows the simulation result of Figure 3 circuit. 1.3 s turn ON delay and 2.56 ms turn OFF time is achieved.

Figure 4. Insertion Turn ON Delay Simulation Result

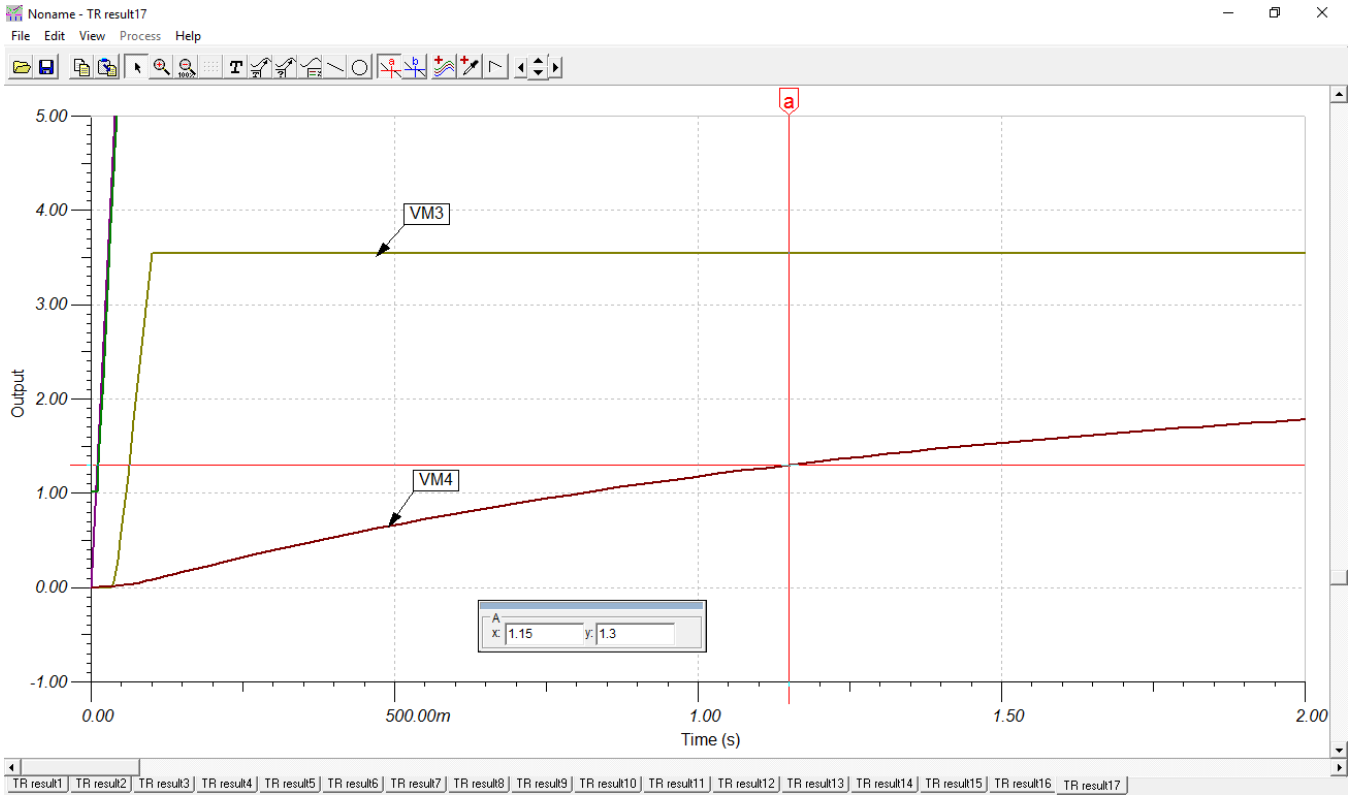
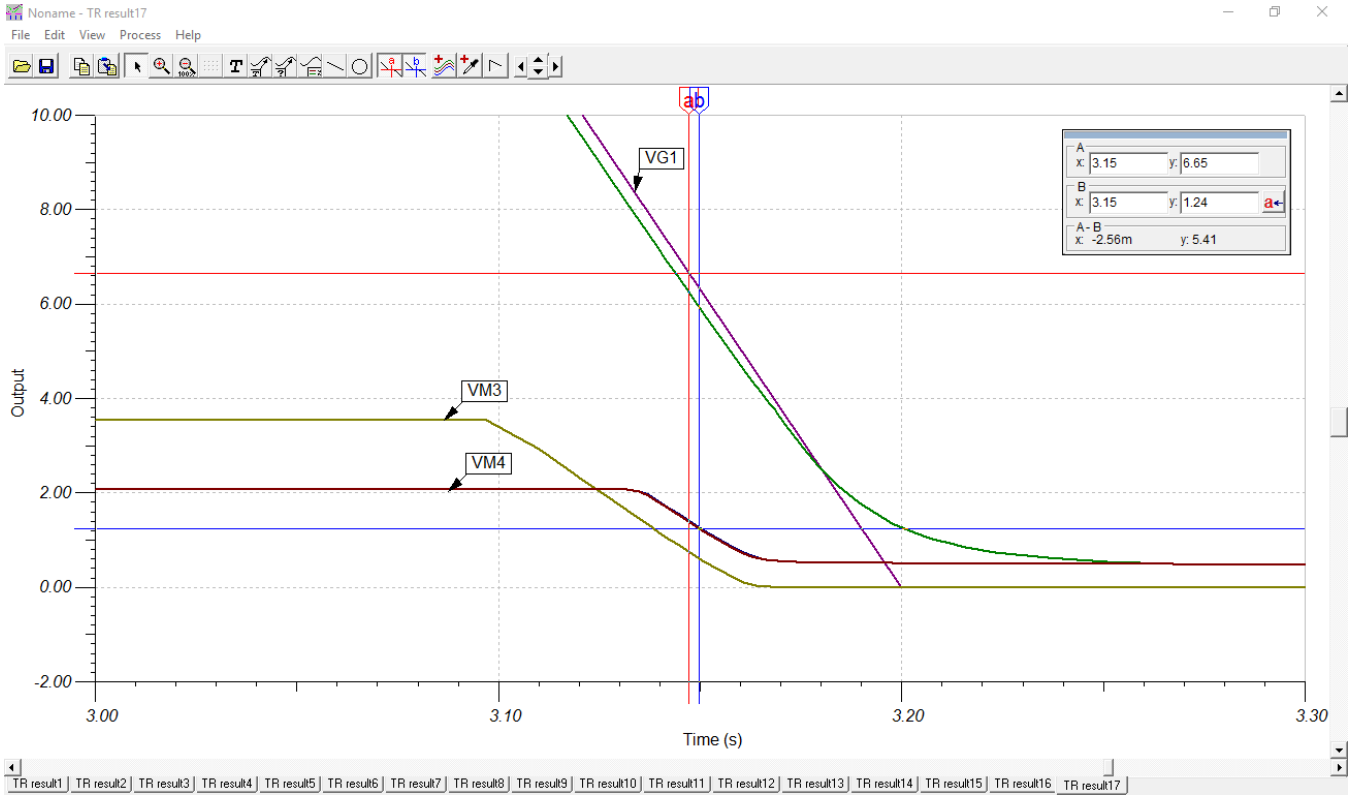


Figure 5. Fast Turn OFF Simulation Result



4 Experiment Test Result

Based on discrete circuit design, parameter calculation and simulation result, below Figure 6 and Figure 7 is bench test result of turn ON delay and fast turn OFF.

From test waveform, the insertion turn ON delay is 1.31 s, the fast turn OFF delay after EN drops below OFF threshold is 0.5 ms.

Figure 6. Insertion Turn ON Delay Test Result

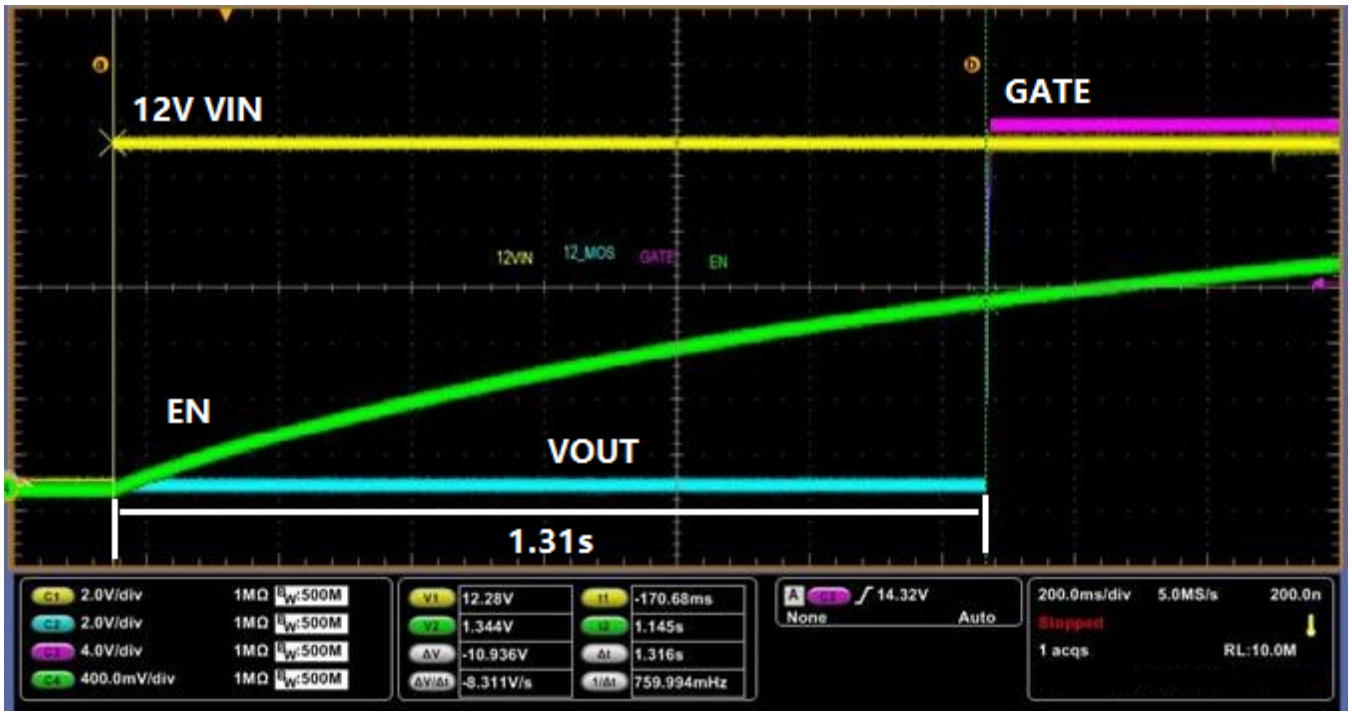
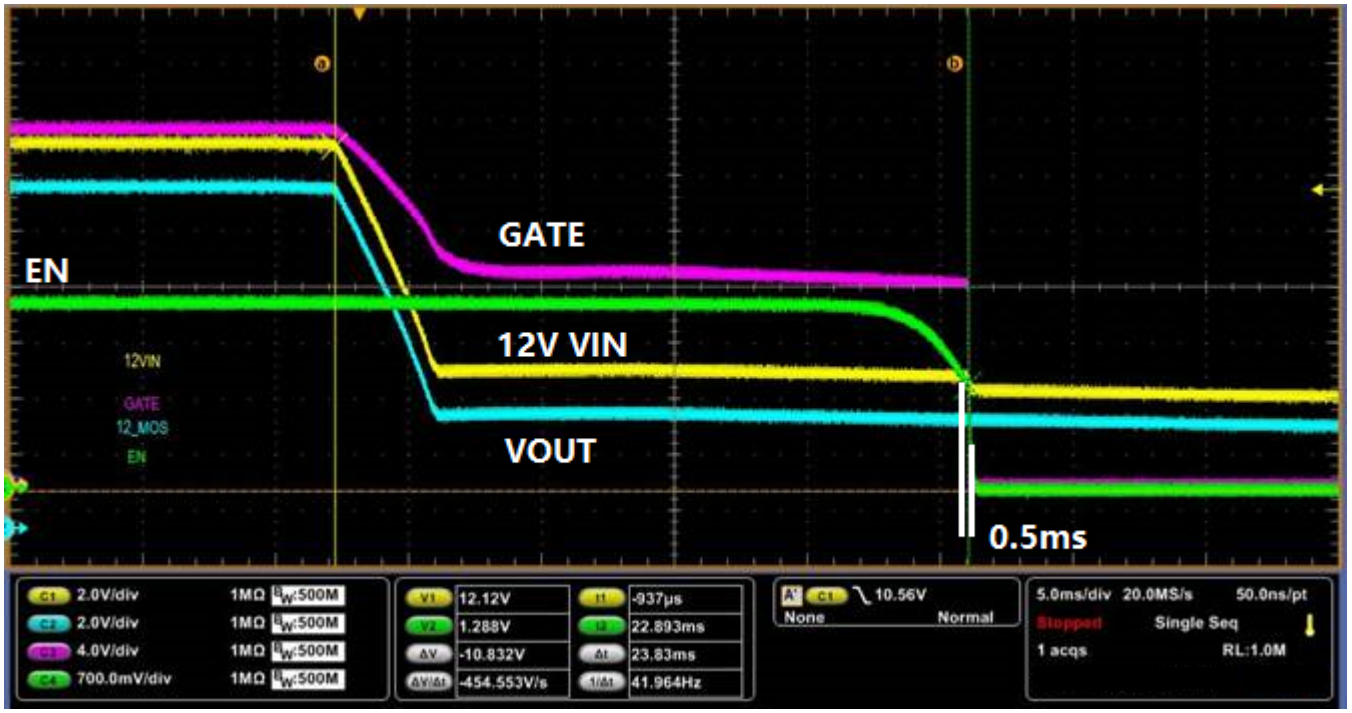


Figure 7. Fast Turn OFF Test Result



5 Conclusion

Hotswap insertion turn ON delay and fast turn OFF feature is required in some chassis system. A low-cost discrete solution is proposed to achieve this feature. Simulation and experiment result shows the solution works well. Besides, thousands of board insertion and removal test shows that the reliability of this discrete solution is high.

6 Reference

1. TPS2471x 2.5-V to 18-V High-Efficiency Power-Limiting Hot-Swap Controller, TI Datasheet
2. Using the TPS24700EVM-001, TPS24701EVM002, TPS24710EVM-003 and the TPS24711EVM004, TI User's Guide
3. Handling System Transients in Hot Swap Applications, TI Application Report

IMPORTANT NOTICE AND DISCLAIMER

TI PROVIDES TECHNICAL AND RELIABILITY DATA (INCLUDING DATA SHEETS), DESIGN RESOURCES (INCLUDING REFERENCE DESIGNS), APPLICATION OR OTHER DESIGN ADVICE, WEB TOOLS, SAFETY INFORMATION, AND OTHER RESOURCES “AS IS” AND WITH ALL FAULTS, AND DISCLAIMS ALL WARRANTIES, EXPRESS AND IMPLIED, INCLUDING WITHOUT LIMITATION ANY IMPLIED WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE OR NON-INFRINGEMENT OF THIRD PARTY INTELLECTUAL PROPERTY RIGHTS.

These resources are intended for skilled developers designing with TI products. You are solely responsible for (1) selecting the appropriate TI products for your application, (2) designing, validating and testing your application, and (3) ensuring your application meets applicable standards, and any other safety, security, regulatory or other requirements.

These resources are subject to change without notice. TI grants you permission to use these resources only for development of an application that uses the TI products described in the resource. Other reproduction and display of these resources is prohibited. No license is granted to any other TI intellectual property right or to any third party intellectual property right. TI disclaims responsibility for, and you will fully indemnify TI and its representatives against, any claims, damages, costs, losses, and liabilities arising out of your use of these resources.

TI’s products are provided subject to TI’s Terms of Sale or other applicable terms available either on ti.com or provided in conjunction with such TI products. TI’s provision of these resources does not expand or otherwise alter TI’s applicable warranties or warranty disclaimers for TI products.

TI objects to and rejects any additional or different terms you may have proposed.

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265