Using TPS2471x/20 with GATE dv/dt Capacitor

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Abstract

In some cases, it is desired to configure the TPS2471x/20 to provide a linear dv/dt on Vout to accomplish a constant inrush current profile. Some designers may choose to add a gate capacitor (C_{GATE}) in series with a resistor to accomplish this. Note that this can cause undesired behavior when a Hot Short is applied to the output. This report describes this behavior and provides two simple solutions for existing and new designs.

Problem Description

TPS2471x/20 responds to a direct output short by pulling the GATE pin down quickly with a 1A current and holding GATE low for a brief period of time (~10µs). After ~10µs, then TPS2471x/20 will try to restart by ramping GATE back up in a power limited manner until the TIMER expires; then TPS2471x/20 will initiate a retry cycle or latch off.

As TPS2471x/20 tries to restart, any residual charge left on C_{GATE} can pull GATE up beyond the desired regulation point after the 1A current sink source is released. MOSFET current will overshoot the fast trip point and GATE will respond again by applying the hard pulldown current. This cycle will repeat periodically until C_{GATE} has decayed below the desired GATE regulation point. An illustration of this behavior is shown in Figure 1. Smaller values of C_{GATE} will result in much less restart chatter after a direct output short.

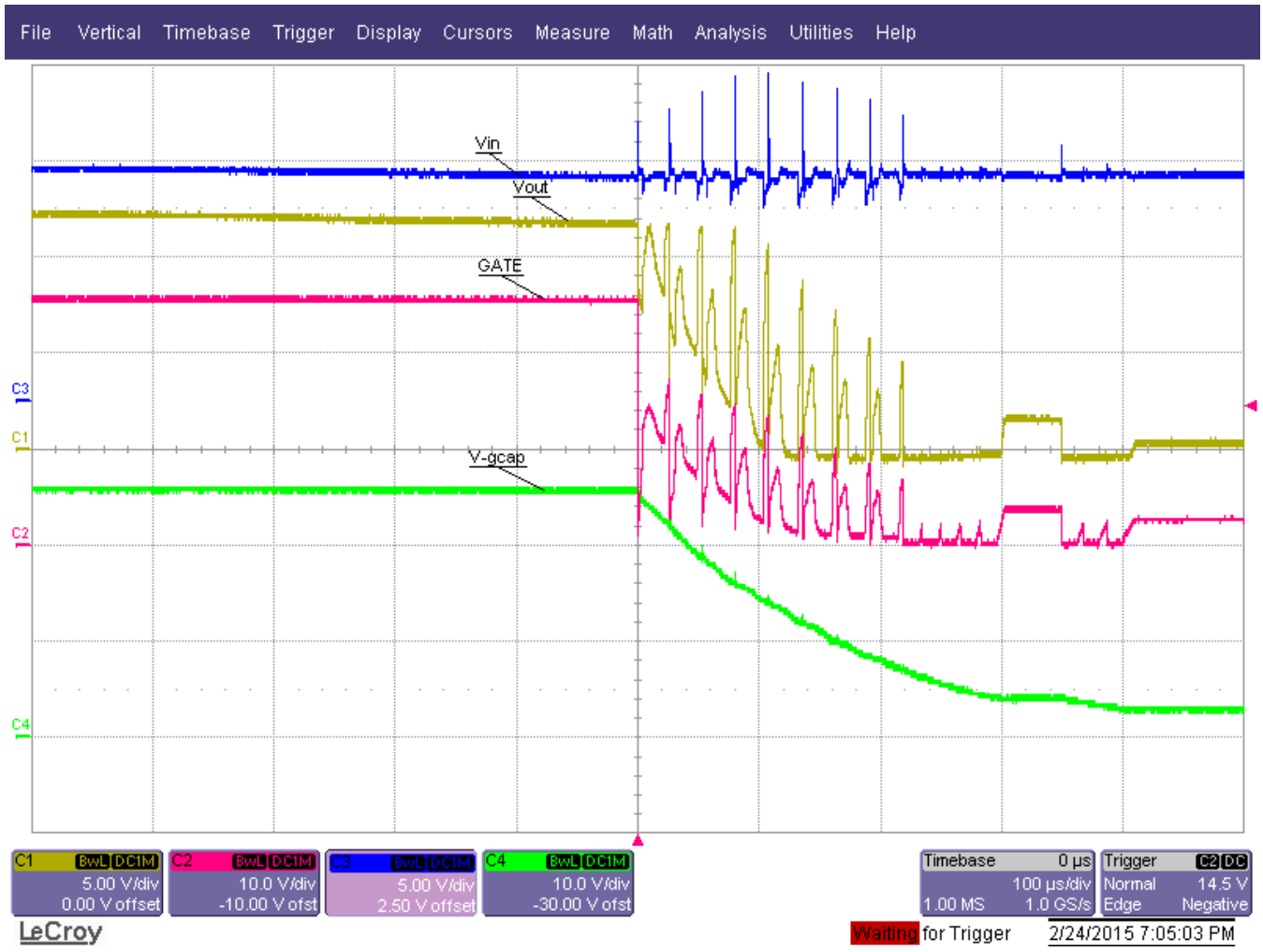

Figure 1. Response to a Hot-Short on Vout: 1kΩ resistor in series with C_{GATE} = 0.1µF

Normally, C_{GATE} will also have a 1kΩ resistor in series so that the transient response characteristic of the GATE pin during a fault will not be slowed. In Figure 1, there is a 1kΩ resistor in series with a 0.1µF capacitor. The R-C decay rate can be seen as channel four in Figure 1.

When the direct short fault occurs, GATE slews down very quickly to interrupt the flow of current. The response time can be seen in Figure 2.

Figure 2. GATE Transient Response Characteristic: 1kΩ resistor in series with C_{GATE} = 0.1µF

Alternate Circuit Solutions

The easiest approach is to remove the gate dv/dt circuit all together. Often times the designer adds this circuit to reduce the MOSFET stress during start-up. Both the TPS2471x/20 have FET SOA protection feature that will help manage the MOSFET stress during start-up. If there are system level considerations that require the inrush dv/dt control there are 2 other solutions for removing the chatter problem.

If the PCB layout cannot be changed, one simple solution is to reduce the value of the series resistor to take advantage of the 1A GATE current sink. This can help discharge C_{GATE} quickly but will slow down the transient response time of the TPS2471x/20. Reducing the series resistor to a short (zero Ω) can result in the response shown in Figure 3 and Figure 4.

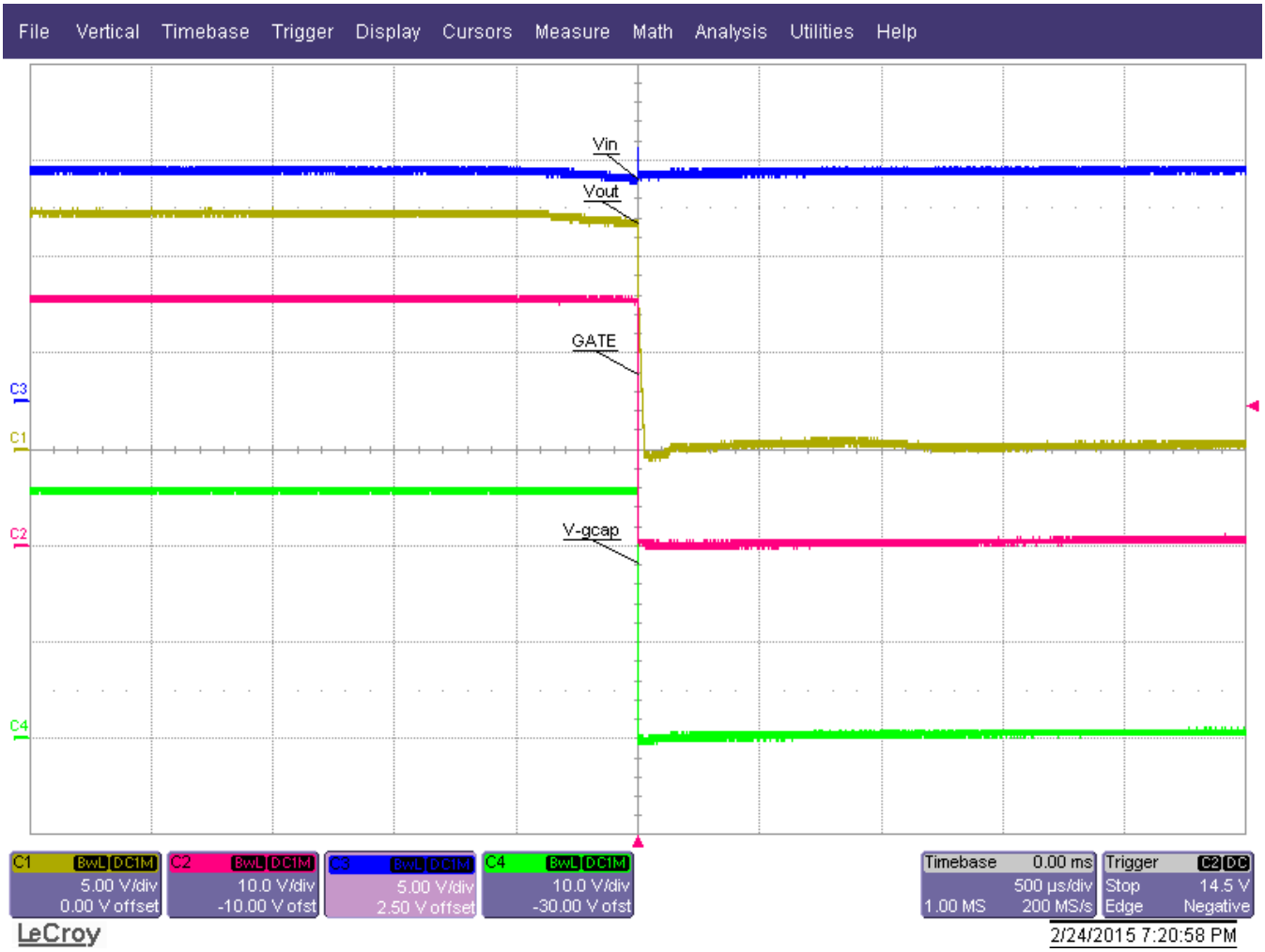

Figure 3. GATE Response Characteristic: 0-Ω resistor in series with C_{GATE} = 0.1µF

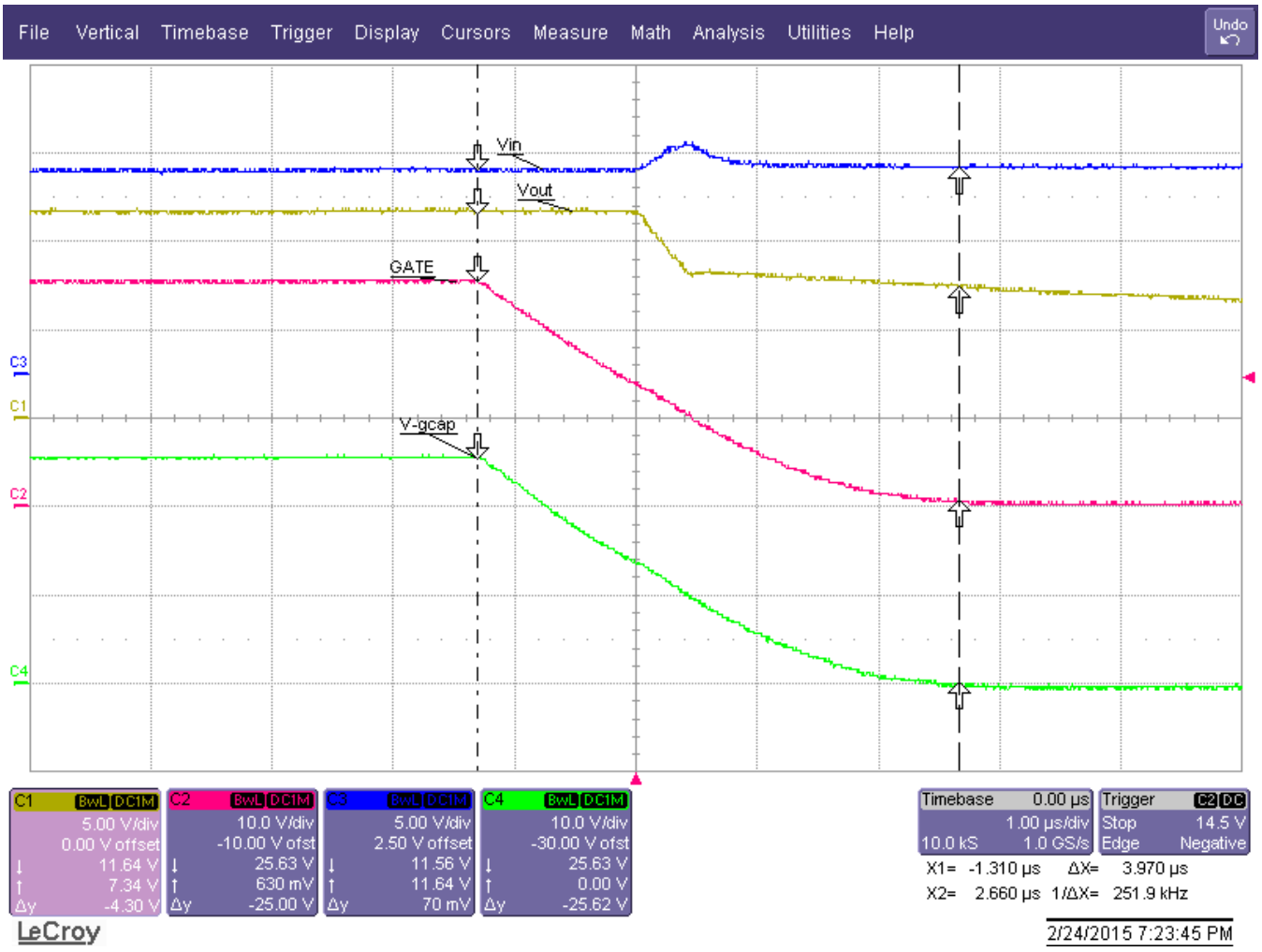

Figure 4. GATE Transient Response Characteristic: 0-Ω resistor in series with C_{GATE} = 0.1µF

To eliminate the chattering in a new design, the circuit shown in Figure 5 can be used. In this circuit, GATE charges C_{GATE} through the diode for a constant current inrush profile. When the output is directly shorted, GATE can respond quickly without being slowed by C_{GATE} due to the blocking action of the diode. When GATE is low, the PNP transistor is turned on through the 10kΩ resistor and quickly discharges C_{GATE} in order to prepare for the restart cycle.

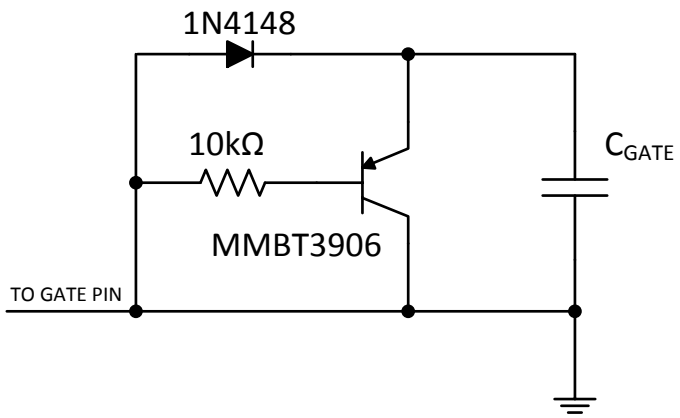

Figure 5. C_{GATE} Discharge Circuit

The response characteristic using the circuit in Figure 5 is shown in Figure 6 and Figure 7. There is clean shutdown and restart and the transient response time is not slowed.

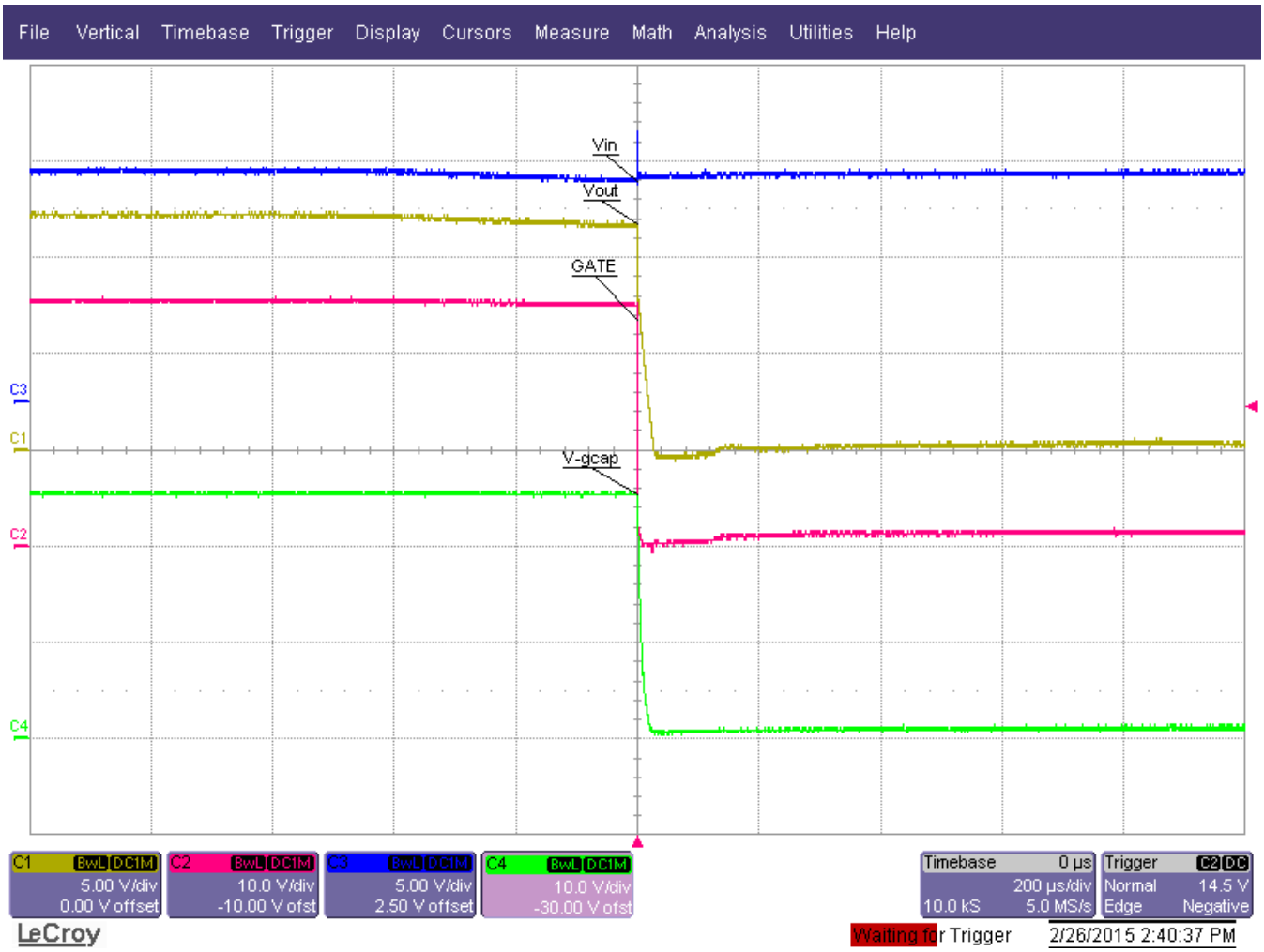

Figure 6. GATE Response Characteristic: Figure 5 circuit, C_{GATE} = 0.1µF

Figure 7. GATE Transient Response Characteristic: Figure 5 circuit, C_{GATE} = 0.1µF

Conclusion

Two simple solutions are provided to address TPS2471x/20 chattering after a direct short when GATE dV/dt control is employed. The solutions can be applied for existing or new designs when a solution to the chattering is required.

References

1. Data Sheet: TPS2471x/20 2.5-V to 18-V High-Efficiency Power-Limiting Hot-Swap Controller (SLVSAL2F)

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