APPLICATION BRIEF

Bourns® TBU® High-Speed Protectors (HSPs) Trigger Under Square Wave Excitation

Bourns® TBU® High-Speed Protectors (HSPs) prevent overcurrent events within the specifications of the HSP from damaging the downstream electrical components that are critical to the user's circuits and systems. When voltage changes occur and the current in the circuit increases periodically when connected to circuits having square wave signals, placing a TBU® HSP in series blocks the current when it exceeds the designated trigger current value ($I_{trigger}$). The TBU® HSP senses the overcurrent event and protects the user's circuit very quickly before damage occurs.

The circuit in Figure 1 is constructed to impress a high voltage square wave on a load and to illustrate the TBU® HSP device's response time.

In the switching circuit, the N-channel and P-channel MOSFETs are arranged to connect positive and negative 40 volt power supplies to a test load with a Bourns® Model TBU-CA085-500-WH in series, with the minimum $I_{trigger}$ specified at 500 mA, typically between 600 mA and 900 mA.

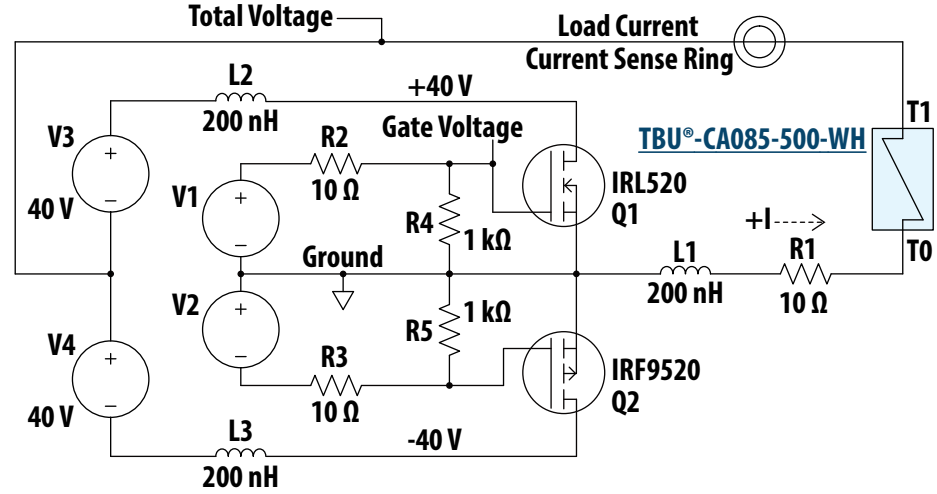

Figure 1: The switching circuit

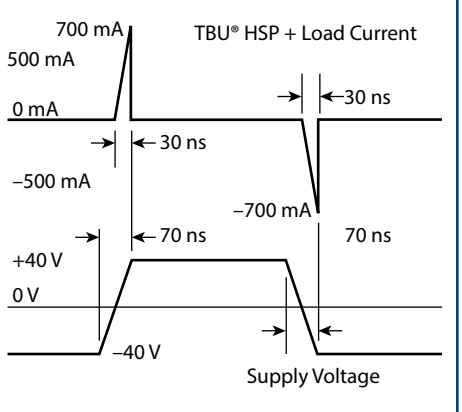

Figure 2: Resultant voltage and current waveforms

In this scenario, the typical timing diagrams for voltage and current are shown in Figure 2. The voltage switches from negative 40 volts to positive 40 volts in 70 ns (shown in the lower graph in Figure 2). Within 30 ns of sensing the overcurrent, the TBU® HSP reacts (shown in the upper graph in Figure 2) and the current is held below the TBU® device's $I_{trigger}$. Since the TBU® HSP is bidirectional, it performs identically when the voltage switches from positive 40 volts to negative 40 volts.

When the current through the TBU® HSP exceeds the trigger current, it switches to a high impedance state – just like opening a switch or relay contact. The voltage will rise sharply as the current will not stop instantaneously when moving through a series inductance. The TBU® HSP can withstand this increased voltage up to the rated peak impulse voltage shown on the data sheet, which for this model is 850 volts.

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Bourns developed a demo board to implement the circuit, as shown in Figure 3. Actual circuit performance and waveforms were measured on the demo board, as shown in Figure 4. The gate activation voltage for the MOSFET, the current through the series load and the TBU® device, and the voltage on the load and the TBU® device were all measured. The circuit includes wiring parasitic inductances (L1, L2, L3) in the connections, which delay the rising current and cause voltage overshoot when the current stops. The inductance causes the current to reverse direction, then ring and dampen out. The current reversal, ringing, and dissipation time can be minimized by careful circuit layout (i.e., minimizing parasitic inductance, resistance, etc.).

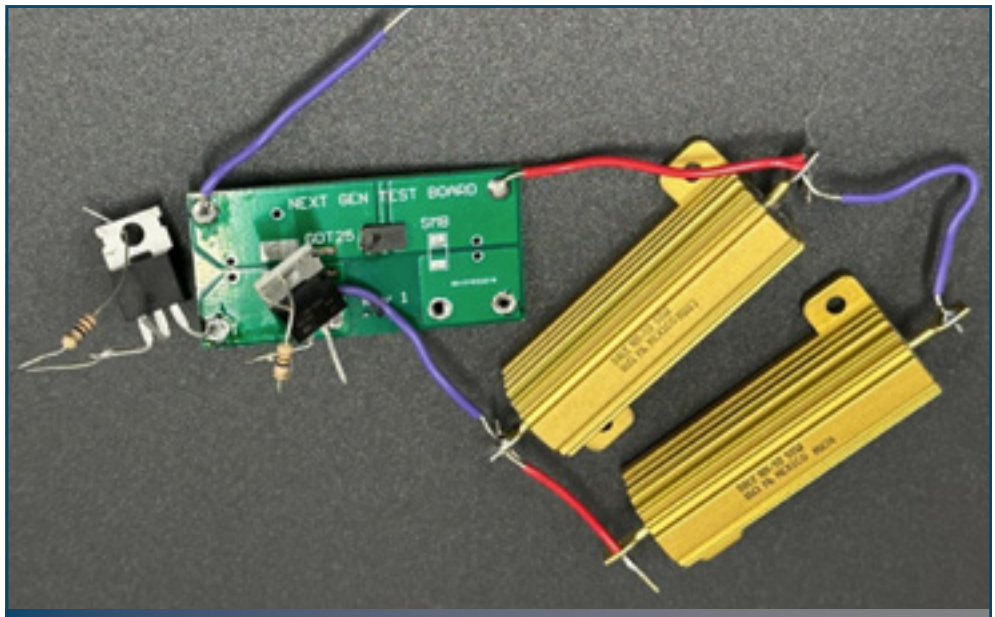

Figure 3: . Demo switching board

Conclusion

When a Bourns® TBU® HSP is used in series with an application, it will protect the application in accordance with the applicable datasheet within 30 ns and typically in less than 10 ns.

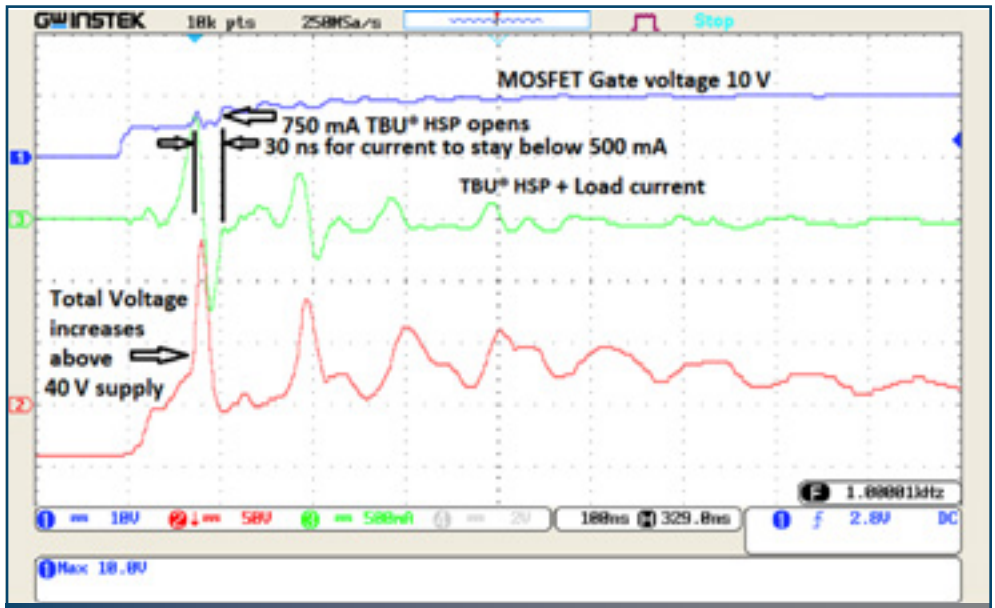

Figure 4: Measured waveforms

Additional Resources

For more information on how Bourns® TBU® HSPs can be used for effective overcurrent protection, please visit:

- Bourns® TBU® HSP Technical Libary

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