Application Report
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Fault Handling Using TPS2660 eFuse

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ABSTRACT

The TPS2660 eFuse provides integrated protection to various system faults such as overcurrent, overvoltage, undervoltage, short-circuit, and reverse input polarity protection. Integrated reverse input polarity protection helps to protect electronic systems from reverse input supply due to miswiring. This application note describes methods to handle the fault of the TPS2660 by downstream circuits under a reverse input polarity condition.

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1 Introduction

A PLC system is usually powered by an external 24-V DC power supply to provide power to the controller unit, backplane, and I/O modules within the PLC system. Input protection circuits are required to protect the PLC system from system faults such as overcurrent, overvoltage, and overload. Because the input supply connectors are screw type, there can always be a possibility of reverse connections at the input supply.

The TPS2660 eFuse protects downstream circuits from various systems faults including integrated protection to reverse input supply conditions (see the TPS2660 reference design). This device provides status monitor functions like fault indication and load current monitor, which is used by a downstream microcontroller unit (MCU) to take control decisions or a DC/DC converter to do power sequencing.

2 Fault Status Monitoring Using TPS2660 eFuse

The FLTb signal of the TPS2660 combines power good indication along with system faults such as overload, overvoltage, undervoltage, and shutdown. This combination enables downstream loads like DC/DC converters to turn on heavy loads after power good indication. An application example where FLTb is directly connected to enable pin of a DC/DC converter is shown in Figure 1. During startup, FLTb is pulled low by the TPS2660 eFuse initially and is released after eFuse output is fully ON. Pullup resistor R4 and pulldown resistor R5 are used to scale down the pullup voltage and are chosen based on DC/DC converters' enable threshold voltage and its operating maximum rating.

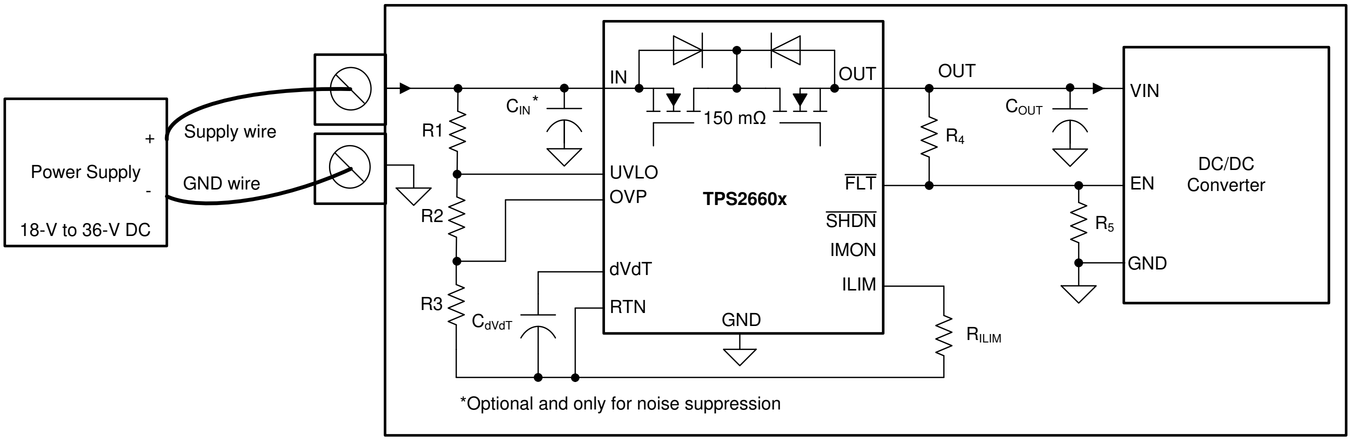

Figure 1. TPS2660 Power Good Indication Using FLTb

Alternatively, the FLTb signal can be used by an external MCU to take control decisions under various systems fault conditions. An application example where FLTb is directly connected to the IO pin of the MCU and pulled up to the 5-V IO supply is shown in Figure 2.

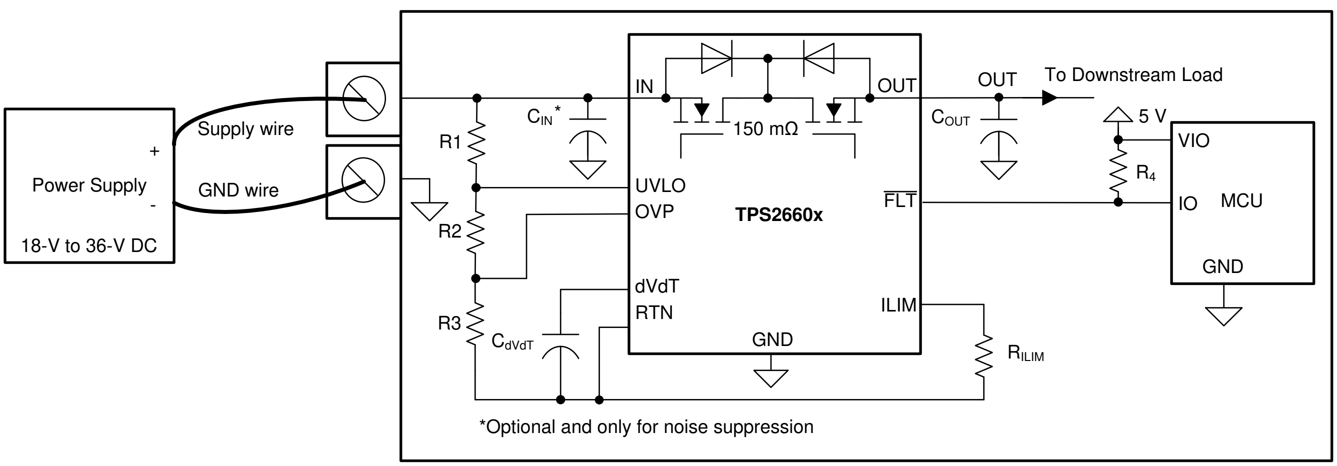

Figure 2. TPS2660 Fault Status Monitoring Using MCU

3 Fault Status Monitoring During Reverse Input Supply Connection

During a faulty reverse input supply connection, the FLTb pin of the TPS2660 can sink current more than its absolute maximum rating under certain power supply sequence. In particular, after a normal power-up and power-down sequence, FLTb pin remains pulled to RTN to indicate brownout faults. Now, if a reverse input supply is applied immediately, the FLTb pin sinks current back into the supply through an external DC/DC converter enable pin or MCU IO pin as it remains pulled to RTN. The current flow path during a reverse input supply connection is indicated in Figure 3.

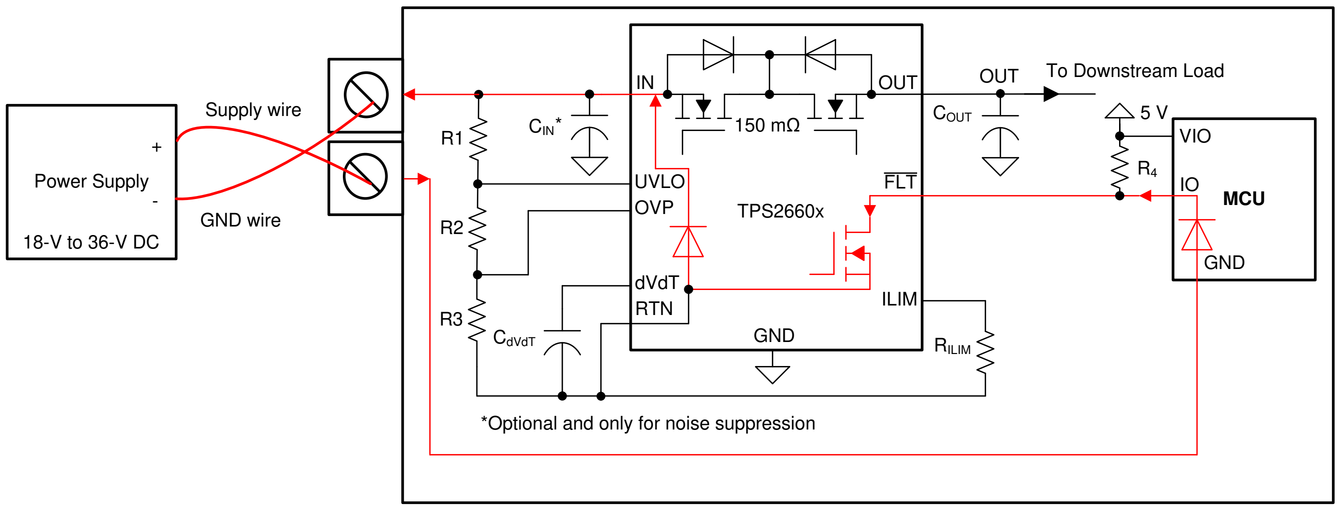

Figure 3. Fault Status During Reverse Input Supply Connection

A specific power supply sequence where FLTb sinks more current is shown in Figure 4 and described below.

- A normal power up is followed by a normal power down.
- The FLTb switch is pulled low to RTN due to a reverse current blocking fault or undervoltage fault.
- A reverse input supply is applied with a slew rate of –50 µV/µs > dVIN/dt > –500 mV/µs within 15 minutes.
- The FLTb switch remains pulled low to RTN and results in a current conduction path shown in Figure 3.

During this reverse input supply sequence, a 60-mA ±20% DC current can flow through the ESD structure of the IO pin of the MCU or the enable pin of the DC/DC converter for a 24-V reverse supply. Table 1 shows the maximum DC current that can flow through the FLTb pin for various power supply voltages. Also note that this DC current does not flow for subsequent reverse supply connections because the FLTb switch is opened after the first reverse supply is removed.

Table 1. Maximum DC Current versus Reverse Supply Voltage

Parameter	Reverse Supply Voltage		
	–18 V	–24 V	–36 V
Maximum DC current through FLTb	45 mA ±20%	60 mA ±20%	90 mA ±20%

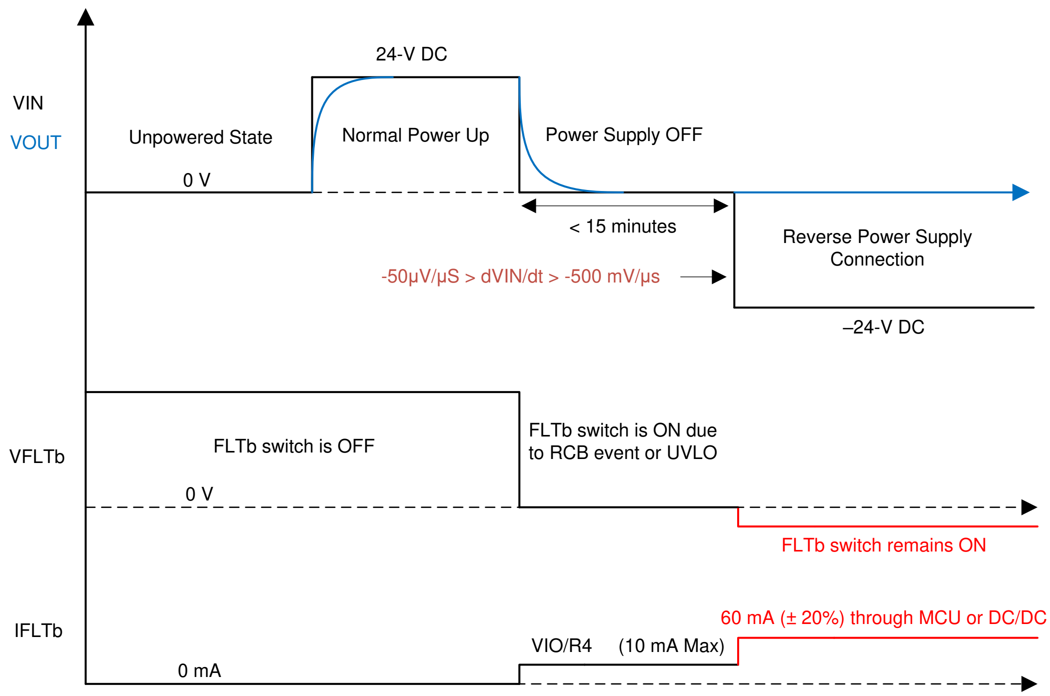

Figure 4. Power Supply Sequence Where FLTb Sinks More Current

4 Suggested Fault Handling Methods

Generally, ESD structures of MCUs or DC/DC converters can take 60 mA of current for a short period during their operating life without degradation in performance. However, if the ESD structures are not able to handle 60 mA of current during a faulty reverse input supply, the current through FLTb needs to be limited by external means.

Adding a current limit resistance of R5 > V_{INMAX}/2 mA between FLTb and IO of MCU as shown in Figure 5 limits current through ESD structure to be less than 2 mA. R5 can be chosen so that current through the ESD structure is less than the absolute maximum ratings of the IO pin of the MCU or the enable pin of the DC/DC converter, and current through the FLTb pin of the TPS2660 is always less than its absolute maximum rating of 10 mA.

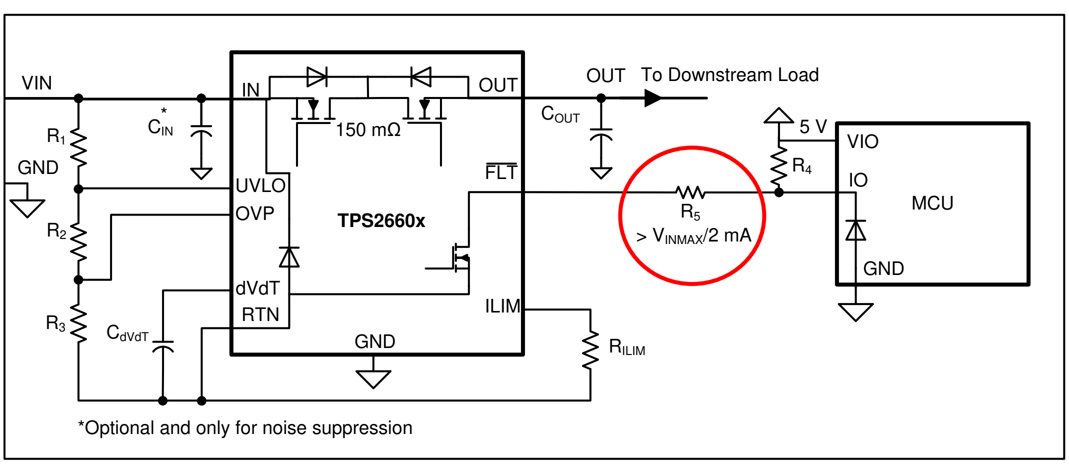

Figure 5. Proposed System Fix With Series Current Limiting Resistor

Sometimes it is not feasible to place a resistor in series to FLTb. Consider the system shown in Figure 1 where FLTb signal provides power good indication to the DC/DC converter. Pullup and pulldown resistors R4 and R5 must be scaled up if a 40-kΩ resistor is added in series to FLTb. For example, on a 24-V power supply application with a range of 18 V to 36 V, R4 and R5 are 70 kΩ and 5 kΩ, respectively, for 1.23 V of an enable threshold and 0.5 V of a shutdown threshold. Now with a 40-kΩ series in place to limit current through FLTb, R4 and R5 must be scaled to 2.8 MΩ and 200 kΩ, respectively, to meet both the enable and shutdown thresholds. This scaling is not always possible because the current through R4 and R5 are 12 µA at maximum and can become comparable to a leakage current > 1 µA of the enable pin of DC/DC converter. Furthermore, a shift in the threshold across temperature can be very wide due to the variation of leakage current over temperature.

In this case, it is recommended to place D1, a 60-V rated blocking diode like 1N4148WS as shown in Figure 6, to block the current through FLTb and modify R4 and R5 to accommodate for the forward drop of D1.

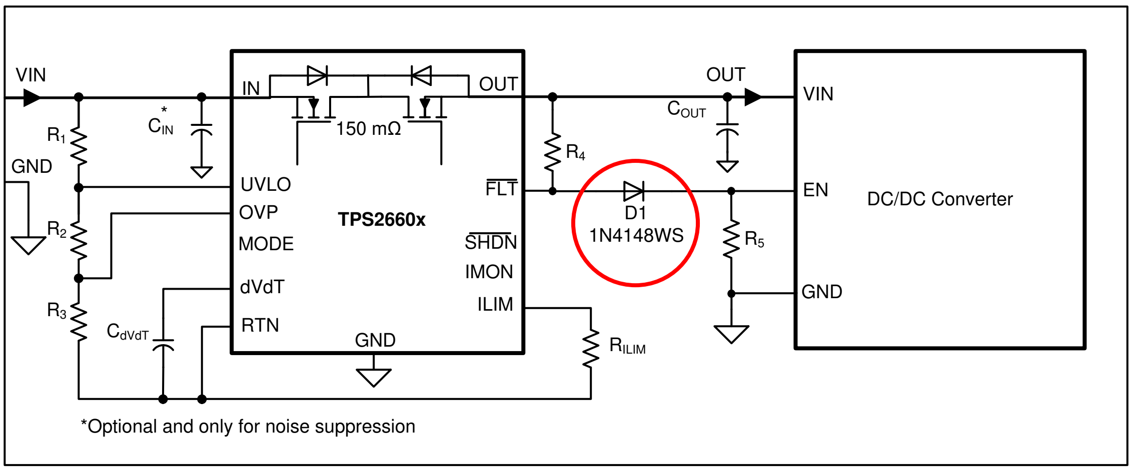

Figure 6. Proposed System Fix With Blocking Diode

5 Conclusion

In a PLC system, possible system issues with the TPS2660 fault handling during a specific reverse power supply sequence are highlighted, and two methods to overcome—using a current limiting resistor or a blocking diode—are discussed in this application note.

NOTE: The proposed fix either with a blocking diode or with a current limiting resistor is not required for devices with date code value ≥ 2013. It is only required for devices with date code value < 2013.

Date code of the device can be found on packaging label of the device.

Revision History

NOTE: Page numbers for previous revisions may differ from page numbers in the current version.

Changes from Original (November 2017) to A Revision **Page**

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