Overvoltage protection for isolated DC/DC converter

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TEXAS INSTRUMENTS

Isolated power supply feedback operation

A typical isolated DC/DC converter has two sets of circuits as part of the power supply which are isolated from each other, the input side (primary) circuit and the converter output side (secondary) circuit as shown in Figure 1. The input circuit's primary function is to control turn ON & turn OFF times of power components like the transformer. The turn ON & OFF time values are decided by the converter based on various inputs to the primary circuit. The most critical input to the primary circuit is the feedback signal coming from the secondary side. The feedback signal always represents the current state of the isolated output voltage and is generated on the secondary side before it is passed onto the primary.

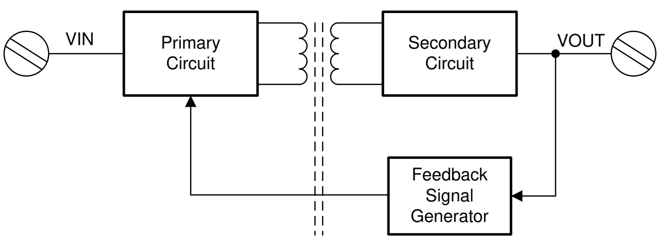

Figure 1. A typical isolated DC/DC converter block diagram

The feedback signal generator circuit on the secondary side is powered by the output voltage at the secondary as the secondary circuit is completely isolated from the primary side circuit. Under some fault conditions, there can be a situation when the output voltage goes outside the regulation range causing over-voltage or under-voltage. Under such situations, the feedback signal generator circuit might fail to operate normal and to represent the output state correctly. Hence, it becomes necessary to protect external loads and components powered by the isolated output from such fault conditions especially for overvoltage fault condition. There are many ways to protect loads and components from power supply overvoltage conditions and this document discusses one of the most effective methods.

Overvoltage protection and reset circulation

Zener diode is one of the most commonly used voltage clamping components to protect devices from overvoltage conditions. Though a Zener diode successfully clamps voltage to its clamping voltage, it doesn't eliminate or reset the overvoltage fault condition. Hence clamping the power supply output voltage alone may not be sufficient to restore the power supply to a normal operating state. Thus, it is important to employ a circuit to reset the power supply and bring it back to its normal operating state.

Operation

Figure 2 shows the schematic of overvoltage protection and reset circuit. It consists of two major components, a comparator with inbuilt voltage reference and a P-channel power MOSFET. The comparator continuously monitors the isolated DC/DC converter's scaled down output voltage and compares it with the preset reference thresholds. There are two reference threshold points, overvoltage threshold point (OVTP) and under-voltage threshold point (UVTP), created by connecting reference voltage and scaled down comparator output feedback to the positive input. When the isolated power supply voltage goes above OVTP, the comparator output goes LOW. This turns ON the PMOS shunting the power supply output voltage to GND and starts discharging the output bulk capacitor. The comparator keeps the PMOS ON till the power supply output voltage goes below UVTP. When power supply output voltage goes below UVTP, the comparator releases the PMOS so that the power supply is reset and has a fresh power-up cycle to come out of the fault condition.

While choosing the comparator, it is important to choose a comparator with wide operating power supply range spanning over both UVTP and OVTP. TLV3012 is one of the comparators that supports wide operating power supply range and has inbuilt voltage reference. Similarly, it is also important to make sure the gate-source threshold voltage of the P-channel MOSFET is much lower than UVTP threshold point. PMV30XPEA is one of the P-channel MOSFETs that supports very low gate-source threshold voltage (1 V typical).

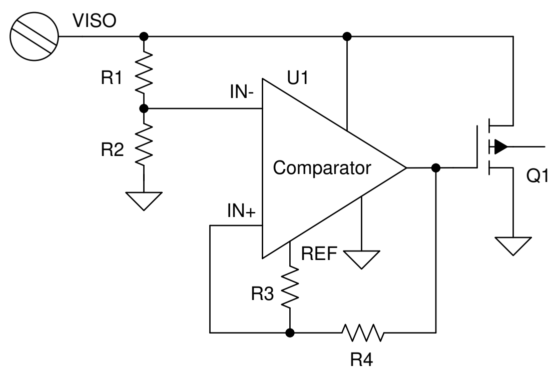

Figure 2. Schematic of overvoltage protection and reset circuit

Equation 1 and Equation 2 can be used to calculate OVTP and UVTP points for given resistor network.

$$UVTP = VREF * \frac{R4}{R3 + R4} * \frac{R1 + R2}{R2} \quad (1)$$

$$OVTP = VREF * R4 * \frac{R1 + R2}{R2R4 - R1R3} \quad (2)$$

Table 1 and Table 2 gives examples with resistor values and their corresponding UVTP & OVTP values calculated for a 5 V and 3.3 V output power supply overvoltage protection.

Table 1. Calculated UVTP and OVTP values for example resistor & VREF values for VISO = 5 V

Parameter	Value
R1	1800 Ω
R2	1500 Ω
R3	1200 Ω
R4	2700 Ω
VREF	1.25 V
VISO	5 V
OVTP	5.89 V
UVTP	1.90 V

Table 2. Calculated UVTP and OVTP values for example resistor & VREF values for VISO = 3.3 V

Parameter	Value
R1	1800 Ω
R2	1800 Ω
R3	2200 Ω
R4	6800 Ω
VREF	1.25 V
VISO	3.3 V
OVTP	3.70 V
UVTP	1.89 V

Table 3. Alternative Device Recommendations

Device	Optimized Parameters	Performance Trade-Off
ISOW7841	Reinforced digital isolator with integrated high-efficiency power converter	650 mW power output, fixed output ripple voltage, two output voltage options
SN6505A, SN6505B	Low-noise, low-EMI, push-pull transformer driver for small form-factor isolated power supplies	External transformer, 2.25 V to 5.5 V input supply range

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