Application Brief

Optimize 24-V Isolated Power Supply Designs in PLC I/O Modules with SN6507

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Introduction

Programmable logic controllers (PLC) are widely used in factory automation applications to enable intelligent, flexible, and efficient system designs. PLCs normally use power supplies that convert a line voltage, like 120 V or 240 V AC, into a DC voltage. The DC power supply, commonly 24 V, is used to power all of the components plugged into the backplane or rack of the PLC. Isolation is necessary in PLC I/O module power supplies to protect equipment and humans from high voltage surges. It is also needed to separate ground loops or potential differences between I/O modules and field supplies that are connected over large distances to ensure communication is reliable. An isolated DC/DC power supply solution is commonly used to convert 24 V power to an isolated voltage (15 V, 12 V or 5 V) for downstream circuit components, such as multiplexers, amplifiers, ADCs, and others as shown in Figure 1 and Figure 2.

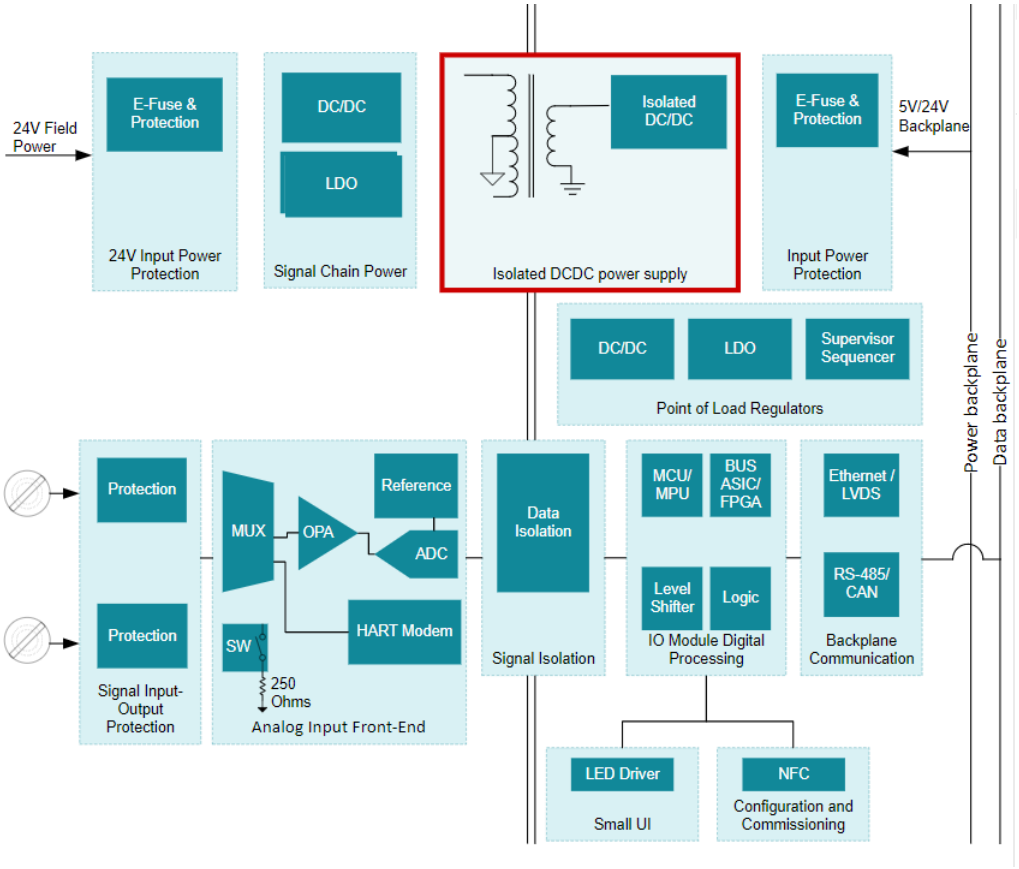

Figure 1. 24-V Isolated Power Supply of Analog Input Module in PLC Applications

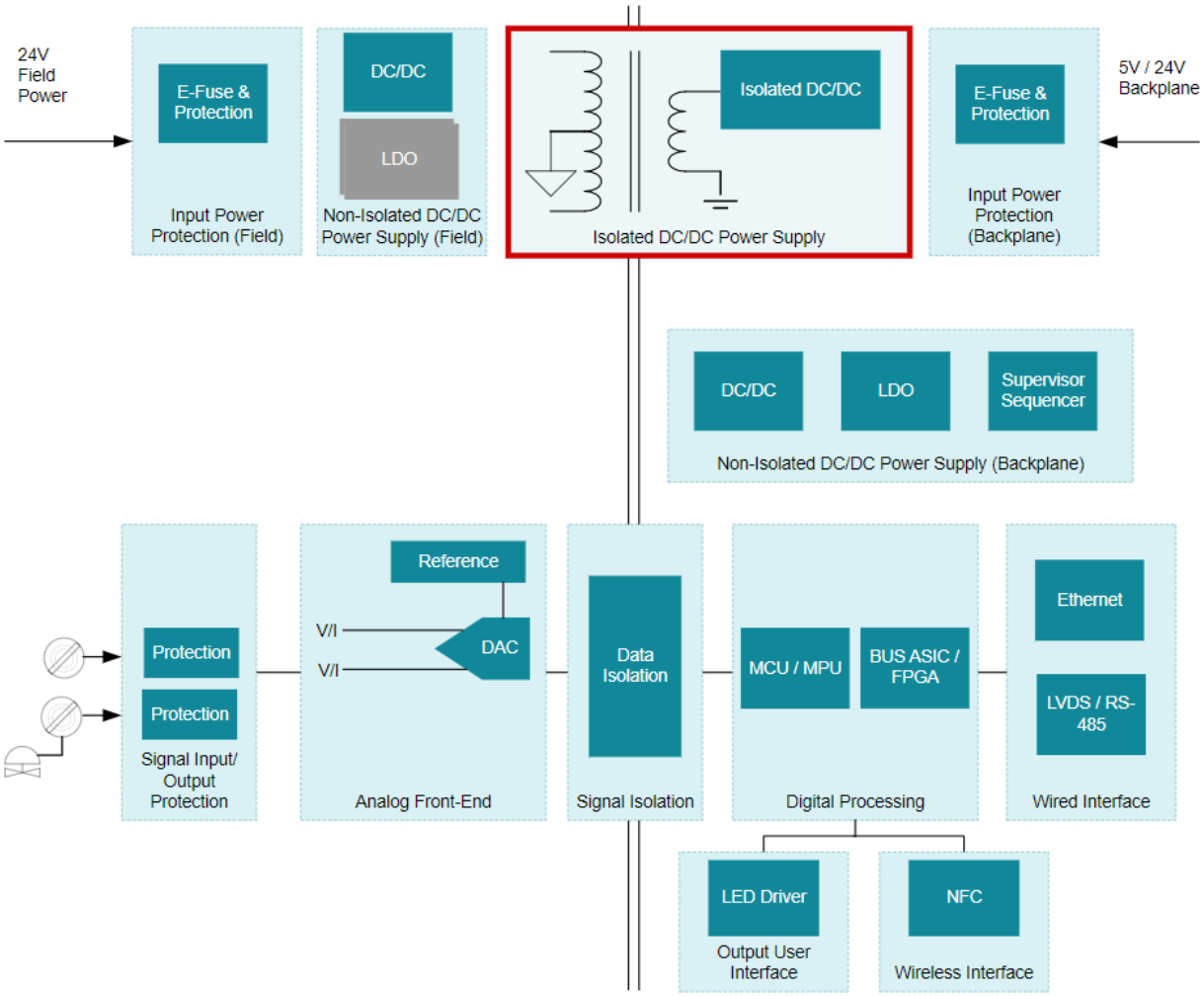

Figure 2. 24-V Isolated Power Supply of Analog Output Module in PLC Applications

TI's SN6507 push-pull isolation transformer driver enables high power delivery of up to 500 mA with 36-V inputs and is optimal for PLC applications due to the inherent high efficiency and EMC robustness push-pull isolated power topologies offer, and duty-cycle control for output regulation without an LDO, which is a benefit built into SN6507.

Benefit One: Inherent Efficiency

In push-pull converters, current is drawn from the supply during both halves of the switching period by an alternating pair of transistors. Current is drawn half the time by each transistor except for the deadtime, so push–pull drivers have steady input current and create less noise on the input power supply line. Due to low magnetizing currents, the peak current through both the power switches and the transformer windings is only slightly higher than the load current compared to Flyback and H-bridge. Lower peak currents result in lower conduction losses (which are proportional to the square of the current), and therefore higher efficiency is achieved. Efficiency measurements of the SN6507 EVM are shown in Figure 3 and can be further optimized through the selection of passive components in the power supply.

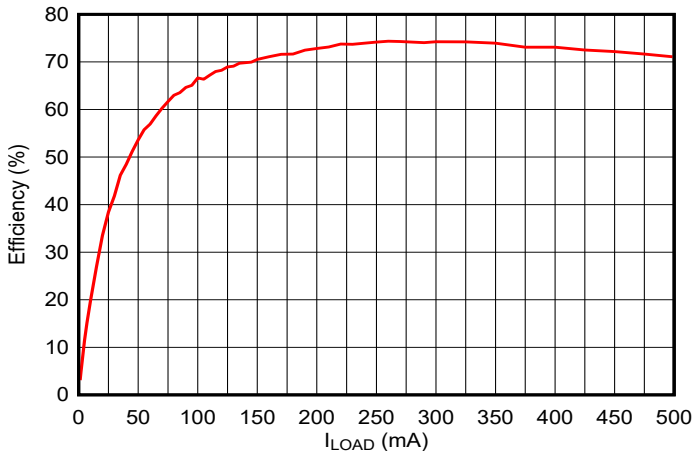

Figure 3. Measured Efficiency of SN6507DGQEVM at 24-V Input to 15-V Output with Wurth Transformer 750319696

Benefit Two: Built-In Line Regulation

To improve output regulation for wide-input voltage applications, such as 24-V I/O modules in PLCs where the input power supply can vary from 18 V to 30 V, SN6507 offers a Duty Cycle Control (DCC) feature. This feature dynamically adjusts the switching duty cycle to compensate for input voltage variations as shown in Figure 4. It removes the need for pre-regulation to this device if the input variation is within ±35%, and in conditions where the input variation is wider than this regulation range, it can reduce the size and power loss of the output-side LDO.

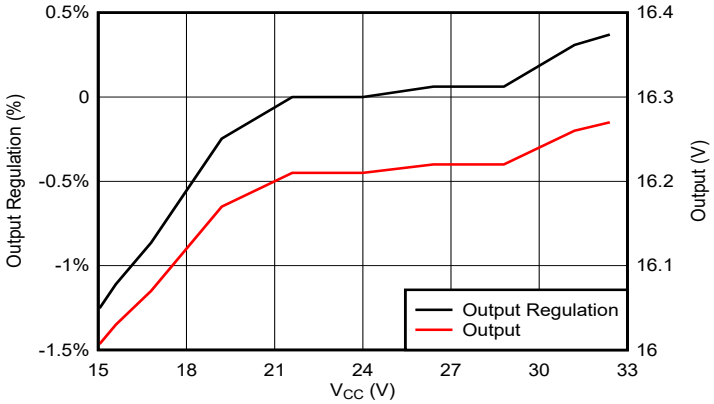

Figure 4. Measured Line Regulation at 24-V Input to 15-V Output with Wurth Transformer 750319696 and 200mA load

Benefit Three: Low Radiated Emissions

Push-pull power supplies are inherently low-noise and low-EMI due to their symmetric topologies. The two identical low-side switches, the center-tapped transformer, and full-bridge rectifier diodes make the push-pull structure completely symmetric, which reduces the low peak current and net common-mode current across the barrier. Therefore, the electromagnetic emissions in double-ended fully-symmetric push-pull drivers are normally lower compared to single-ended non-symmetric topologies like flyback, and double-ended non-symmetric topologies like H-bridge. In SN6507, conducted and radiated emissions are further reduced by slew rate control of the output switch voltages and through Spread Spectrum Clocking (SSC).

An EMI test performed on SN6507 using the SN6507 EVM with Wurth 750319696 transformer, in a fully comlpliant, 10 m CISPR32 Class B setup yielded the results shown in Figure 5 and Figure 6. This data shows that at 1 MHz switching frequency and 24 V in, emissions are within CISPR 32 class B limits with margin up to the EVM's full 500 mA load without snubber circuits, Ferrite Beads, or Y-capacitors. Therefore, SN6507 is a perfect solution for low-emission applications while maintaining a low-cost and small-form factor.

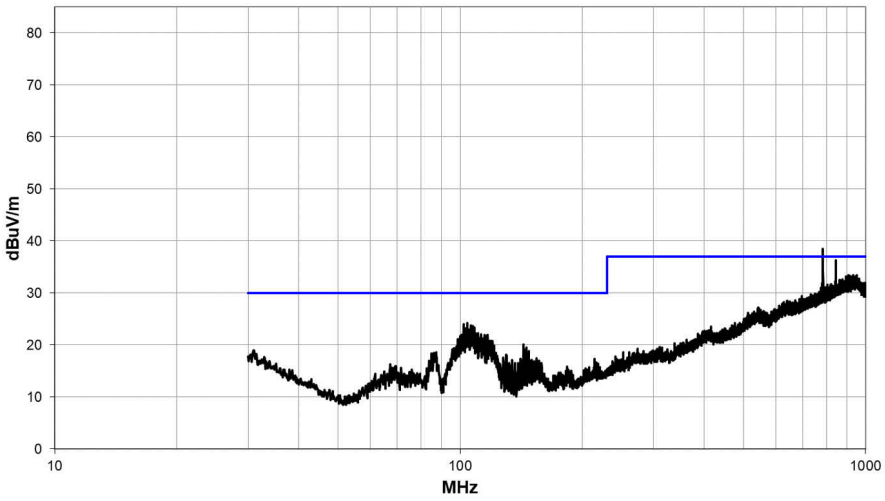

Figure 5. Measured EMI at 24-V Input to 15-V Output, 1 MHz, 200 mA Load with Wurth Transformer 750319696

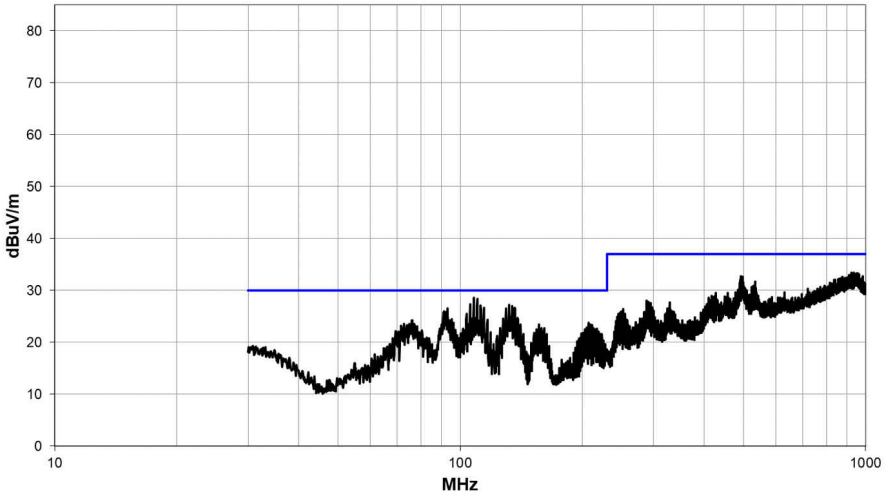

Figure 6. Measured EMI at 24-V Input to 15-V Output, 1 MHz, 500 mA Load with Wurth Transformer 750319696

Conclusion

Isolated power supplies are common in industrial applications to reduce large noise disturbances, ESD events, ground bounces and ground potential differences. The SN6507 push-pull solution offers the valuable benefits of efficiency, low emissions, and small solution size, making it a particularly good fit for 24-V PLC I/O modules.

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