Application Brief

Optimize your Design with Isolated RS-485 Transceivers with Integrated Power

RS-485 is a popular communications interface in industrial systems due to the robustness of operation. These systems often require communication over long distances and / or between sub systems with large voltage potentials, both of which create challenges for system designers. Isolating RS-485 bus from the rest of the system protects important circuitry, and in some cases human operators, from high voltages and any unwanted transients. In addition to protection from high voltages, galvanic isolation is also typically used for long distance communication in RS-485 systems to prevent ground loops that can cause noise and disrupt the data on the bus.

Traditional Discrete Solution

When galvanic isolation is needed for RS-485 communication, signal isolation is required to isolate the transmit, receive, and enable signals from the microcontroller to the transceiver. This is typically done with an isolated RS-485 transceiver or a digital isolator plus external transceiver. In addition to isolating the RS-485 data, isolated power must be supplied to the secondary side of the isolated transceiver. A DC-DC converter can be used in a variety of topologies including push pull, fly-back, and fly-buck for that purpose. Figure 1 shows an example of a transformer driver used with the external transformer to create the isolated power supply.

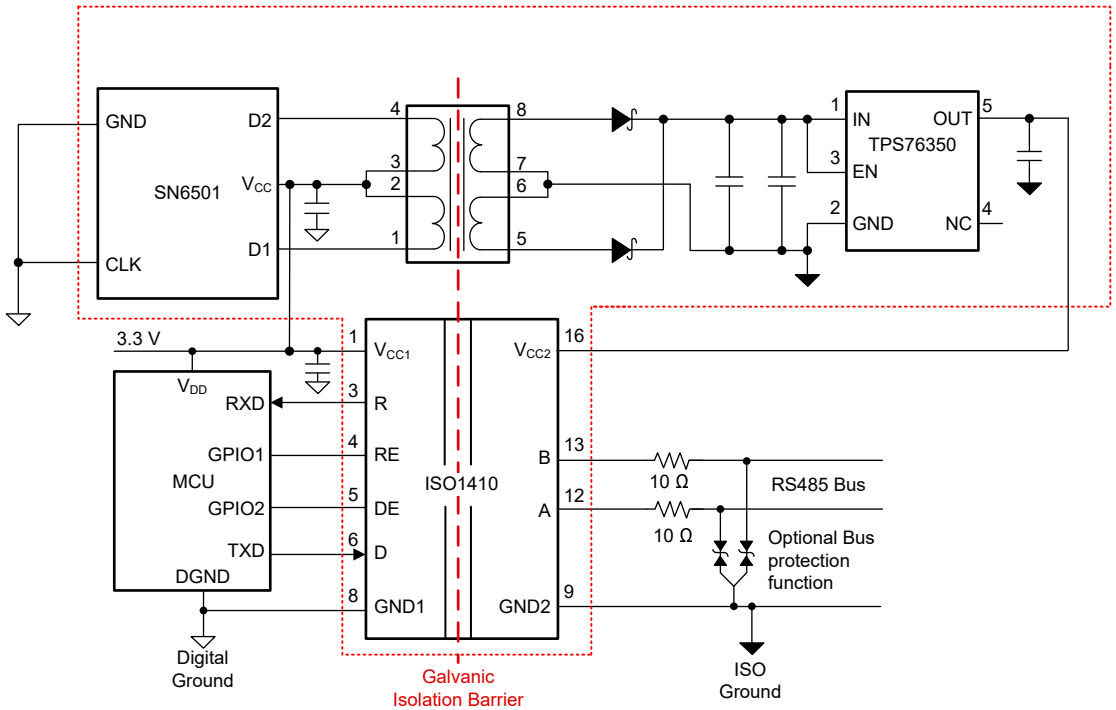

Figure 1. Isolated signal and power solution for RS-485 using ISO1410 and SN6501 transformer driver

Intergrated Solution

As an alternative to the discrete implementation, one may use an isolated RS-485 transceiver with integrated DC-DC, as shown in Figure 2. In this case, the complete functionality of the red highlight in Figure 1 is fully integrated into a single chip.

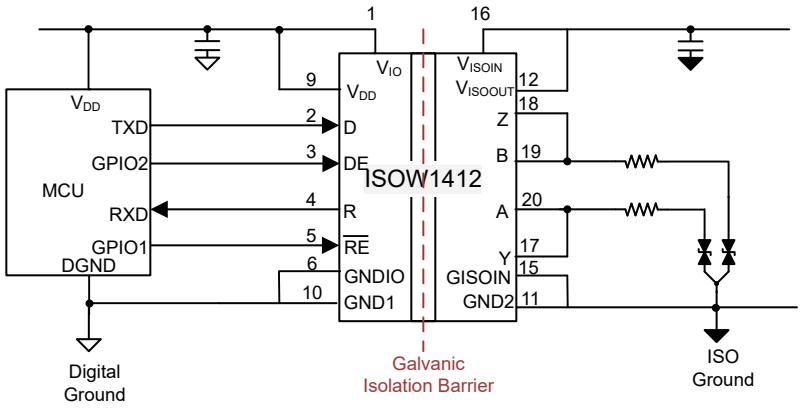

Figure 2. Integrated implementation of isolated RS-485 and isolated power

Single chip isolated transceivers help to solve several design challenges that system engineers face when designing products, including:

- **Board space savings.** One of the key benefits of a single-chip solution is the board space savings compared to other discrete implementations. As system designers look to reduce solution size and/or add functionality with each new product generation, incorporating a single chip solution for an isolated RS-485 can help to save 48% board space, as shown in Figure 3.

  In addition to the improvements in the x and y dimensions, there is also a significant savings in the height of the solution. Typical transformers can be two to three times thicker than the package height of a single chip device.

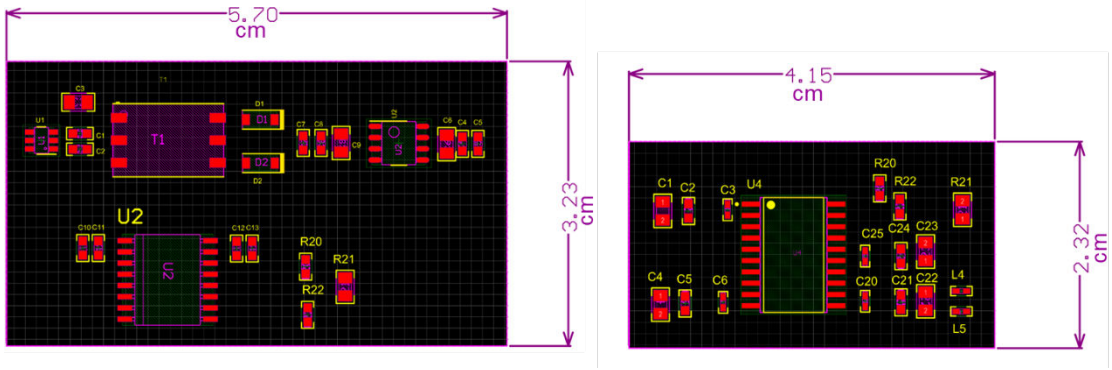

Figure 3. Board space comparison of discrete (left) and integrated (right) isolated RS-485 sub-systems

- **Ease of certifications:** Safety certifications can add time and effort on top of the already hectic process of releasing a product. Each isolation component in a system must be certified to component level standards, such as Verband der Elektrotechnik (VDE) 0884-11 or Underwriters Laboratories (UL) 1577. Finding the appropriate transformer with the right isolation ratings and certifications also adds complexity to the design process. Combining the signal and power isolation into a single chip solution allows for these elements to be certified together, resulting in a shorter certification process for the end product.
- **Simplicity and robust design:** By integrating the components used in Figure 1 into the single chip solution shown in Figure 2, board design becomes much simpler. In addition, bulky transformers can perform poorly in applications exposed to consistent vibration. By removing the transformer from the board, the system design becomes more reliable when using the single chip solution.

Integration Challenge

Despite the many benefits of single chip isolated RS-485 devices, historically, there have been performance trade-offs associated with the increased integration. In order to integrate a transformer small enough to fit inside the package, switching frequency has to be increased. This high frequency switching leads to higher power losses leading to lower efficiency. In addition, smaller transformer geometries lead to increased common-mode across the barrier parasitics that results in poor radiated emissions performance at the system level. The

radiated emissions of these devices can make it challenging to meet CISPR 32 or other common industry requirements. Additionally, these devices tend to be limited in load current which can be supported without increasing the junction temperature inside the device's package, presenting another limitation for environments where high ambient temperatures are expected.

TI Solution

TI's single chip isolated RS-485 transceivers with integrated DC-DC converters, ISOW1412 and ISOW1432, were designed to help overcome many of the common challenges that have made it difficult to use these single chip solutions in the past. The largest of these challenges, typically being meeting CISPR 32 or other radiated emissions level masks. Figure 4 shows an emissions comparison between ISOW1412 and the leading competition devices. The emissions were tested on 2-layer PCBs without any stitching or Y-capacitors across the isolation barrier. The devices were powered using a LDO, and a battery to keep input supply noise to a minimum. The PCBs contain ferrite beads at the inputs and the outputs of the devices. The results shown in Figure 4, with input voltage of 3.3 V and output voltage of 3.3 V, shows the ISOW1412 passing the CISPR32 standard with significant margin while the competitive solutions are close to the limit line or exceed the limits. The industry leading emissions performance on ISOW1412 and ISOW1432 can give system designers more margin at the system level to meet CISPR 32 class B or other radiated emissions standards which can be a challenge with the existing solutions on the market.

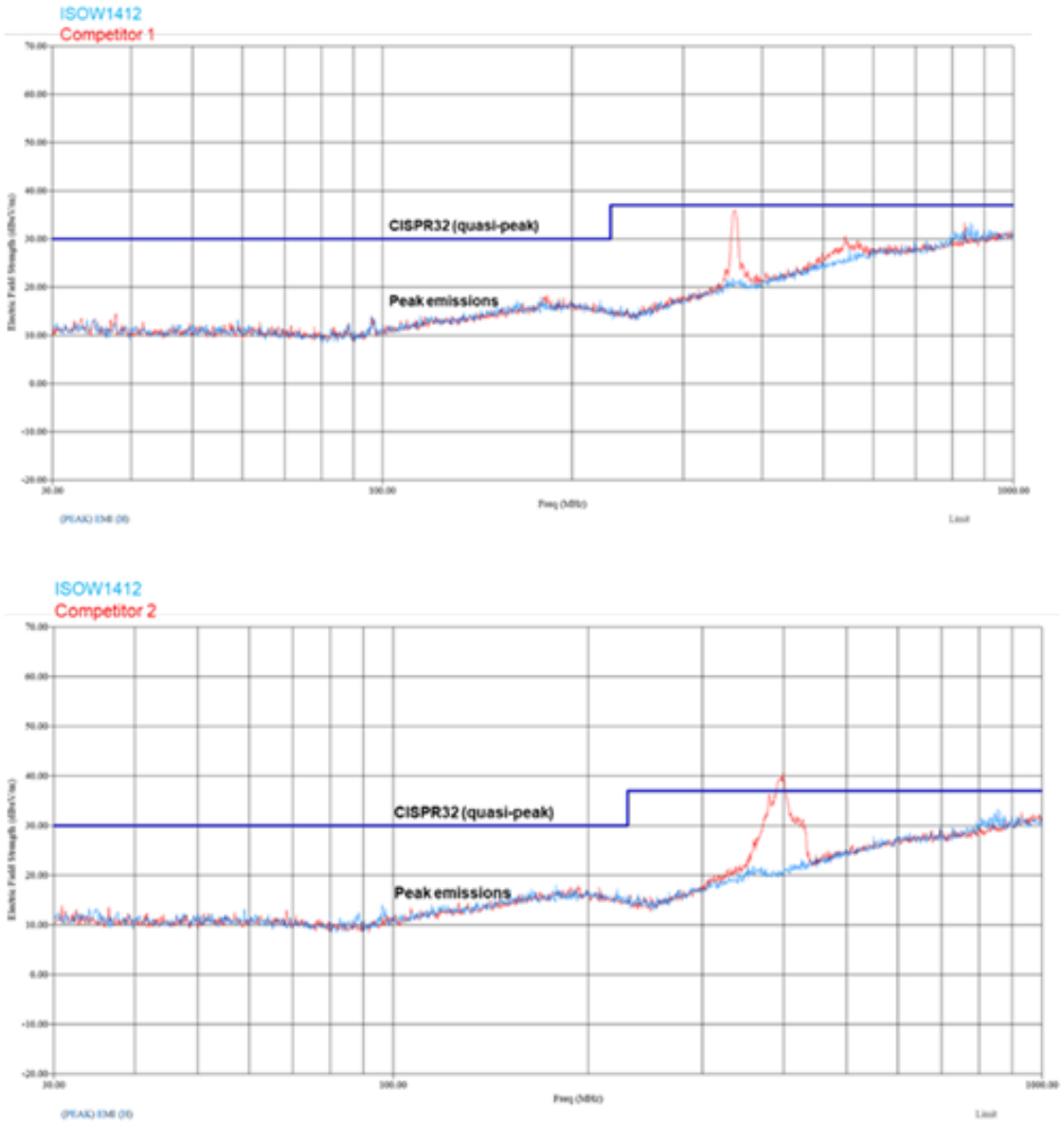

Figure 4. Emissions comparison of ISOW1412 and 2 competing devices. ISOW1412 meets CISPR 32 Class B emissions mask on a 2 layer board

Thermal performance is also another common challenge with highly integrated single chip solutions. The ISOW14xx family provides up to 47% efficiency to allow for lower power dissipation and higher ambient temperature range support. As shown in Figure 5, the ISOW1412 operates about 4 °C cooler compared to competition. This allows the ISOW1412 and ISOW1432 to operate in the full industrial temperature range from -40 °C to 125 C, as compared to competitive solutions that require the operation to be limited to 85 °C or 105 °C.

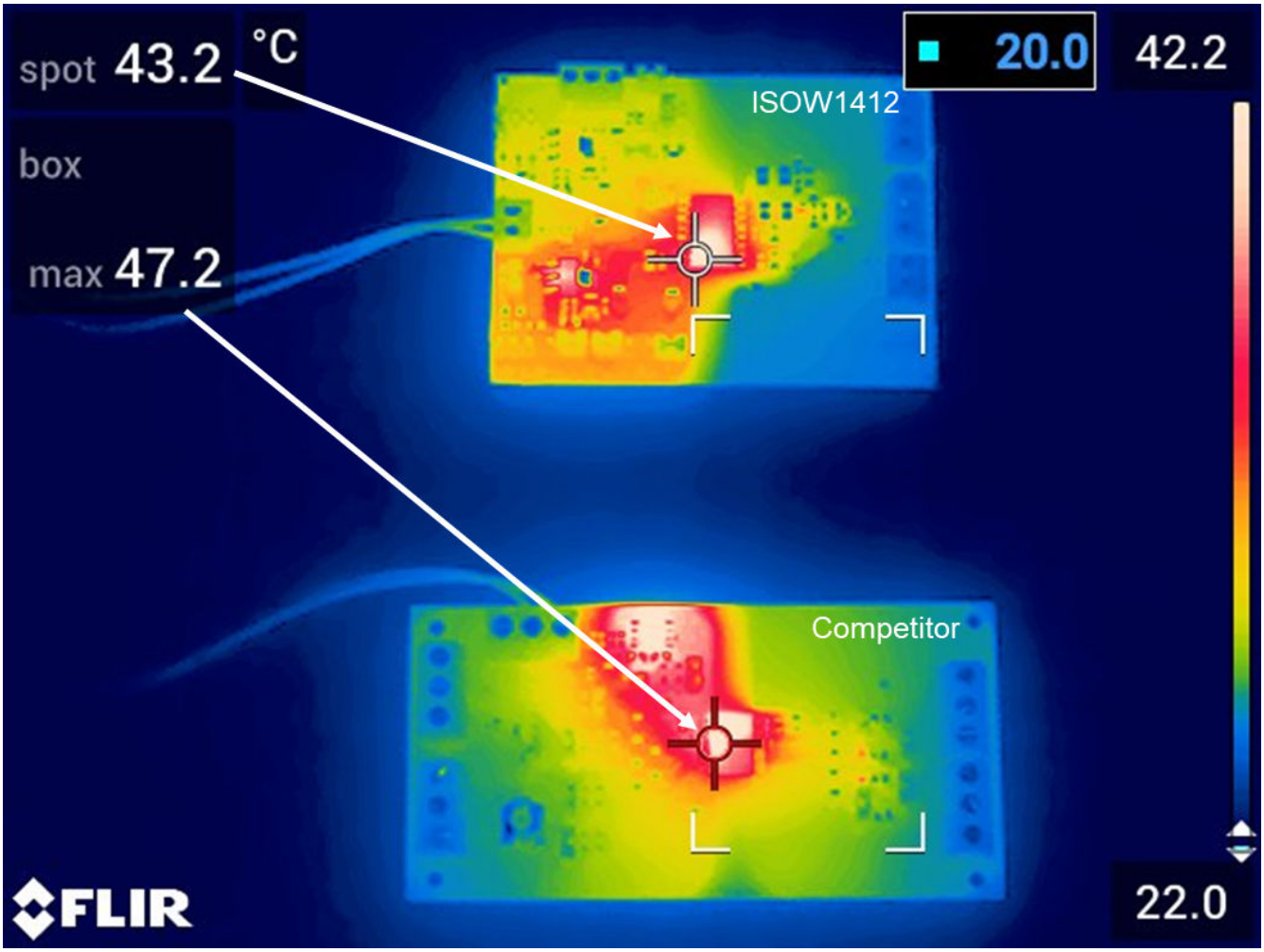

Figure 5. Thermal comparison between ISOW1412 (top) and leading competitor (bottom) for 5 V Vin and Vout with 60-Ohm RS-485 termination

ISOW1412 is a 500 kbps transceiver and ISOW1432 is a 12Mbps transceiver, both full duplex which can be configured as a half-duplex. The ISOW14xx family of devices have the option to support PROFIBUS using the mode pin to expand the bus voltage differential from 1.5 V to 2.1 V minimum, allowing better signal to noise ratio to ensure reliable communication in noisy environments. Additionally, both devices feature integrated IEC-ESD protection up to 8 kV on the bus to allow removal of TVS diodes on the bus that can add cost to the system. Both ISOW14xx devices also include an additional 1 Mbps GPIO channel for diagnostics, LED indication, or supply monitoring functions, removing the need for a separate digital isolator from the board. These devices can operate on a single 3 V or 5.5 V supply or have the option to use logic levels down to 1.8 V which can operate independently from the power converter.

Applications

1. **AC Motor Drive:** An alternating current (AC) motor drive, as shown in Figure 6, where the RS-485 interface communicates with the programable logic controller (PLC), potentially thousands of meters away. There can be a large ground potential difference between the ground of the control module on the AC drive and the bus side ground on the PLC which creates the need to isolate the transceiver to prevent ground loops which can corrupt the communication. ISOW14xx is the ideal device for this external communication use case since often times an isolated power supply is needed only for the isolated RS485 interface. In addition to the board space savings and simplicity, the PROFIBUS support improves SNR for better noise immunity, and the integrated ESD protection allows for TVS diodes to be removed from the bus.

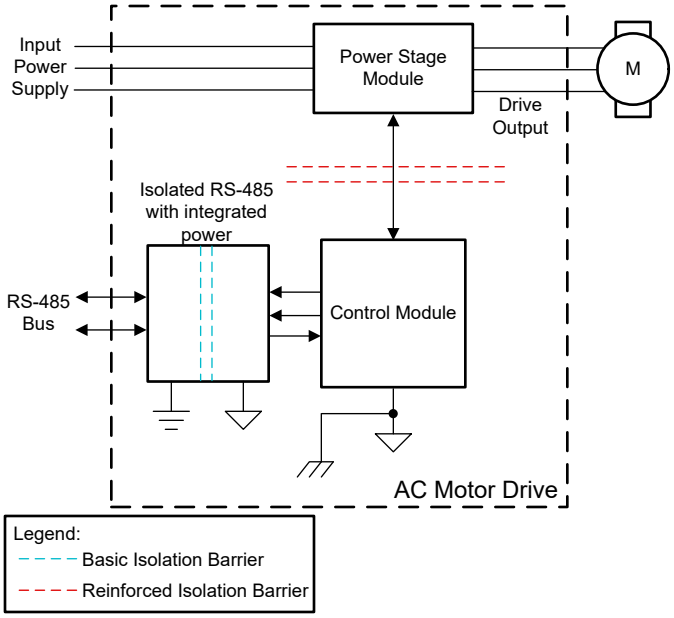

Figure 6. Typical block diagram of AC Motor drive

2. **Solar inverters:** Figure 7 shows a solar inverter block diagram. RS-485 interface is often used to communicate from control module to the control station. In this architecture, the control module is functionally isolated from the inverter stage. The trend of increasing the DC link voltages to improve efficiency of the inverters puts additional burden on selecting the isolated RS-485 to meet the higher isolation voltages. To account for the human safety in the control station, the isolated RS-485 also has to comply reinforced isolation standards. By employing the power supply from the DC link side, the ISOW14x2 devices provide 1500 V_{PK} working voltage and reinforced isolation making them ideal to communicate externally from the control module.

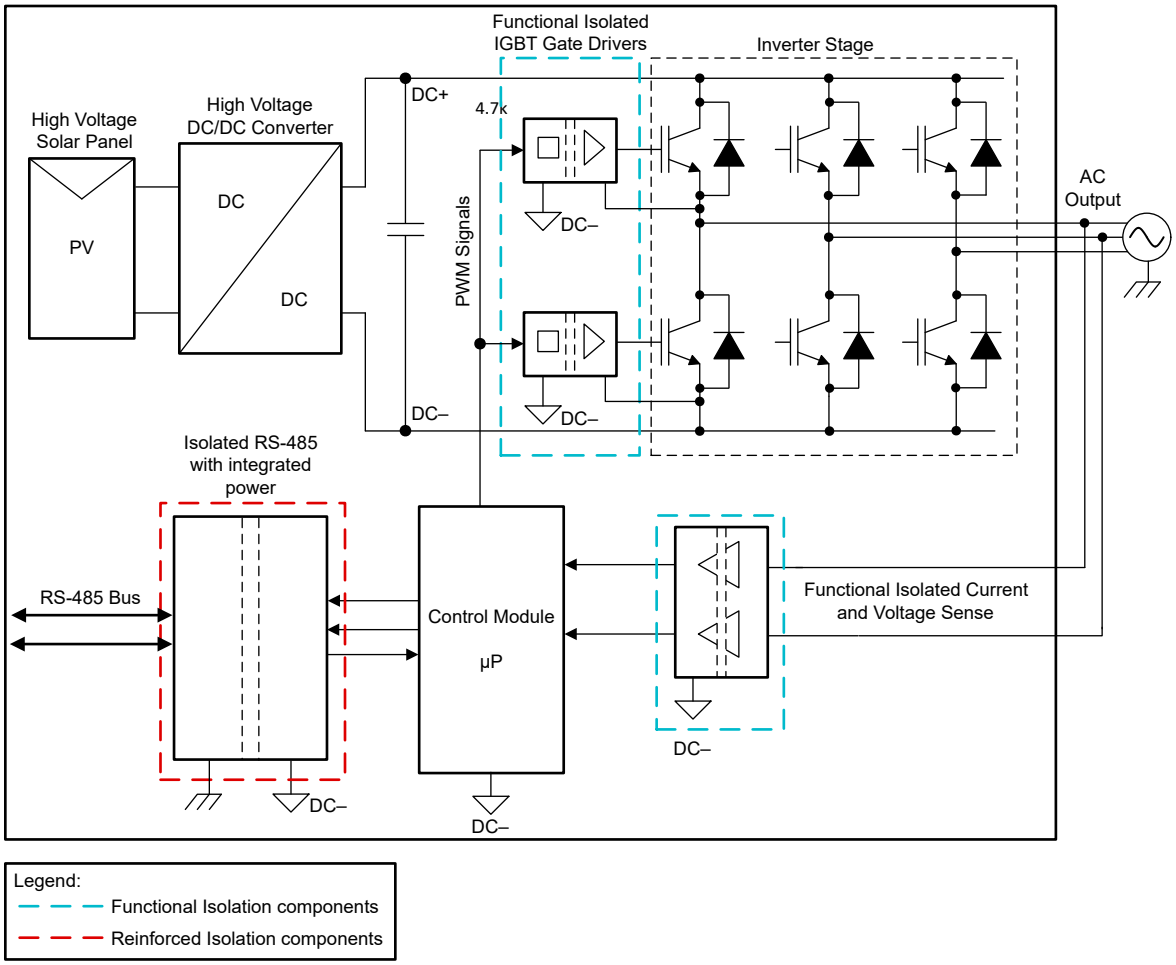

Figure 7. Solar inverter block diagram

3. **Factory automation, Building automation:** In some factory automation or building automation applications, isolated RS-485 is often used for fieldbus communication. In some cases, diagnostic signals are transmitted from the bus side to the micro-controller side to monitor the presence of power on the bus side or health of the isolation barrier. This can be accomplished by a discrete optocoupler or digital isolator but this adds extra discrete components to the design and consumes more board area. The ISOW14x2 devices have an integrated GPIO channel, as shown in Figure 8, that eliminates the need for this discrete implementation for the diagnostic monitoring signal.

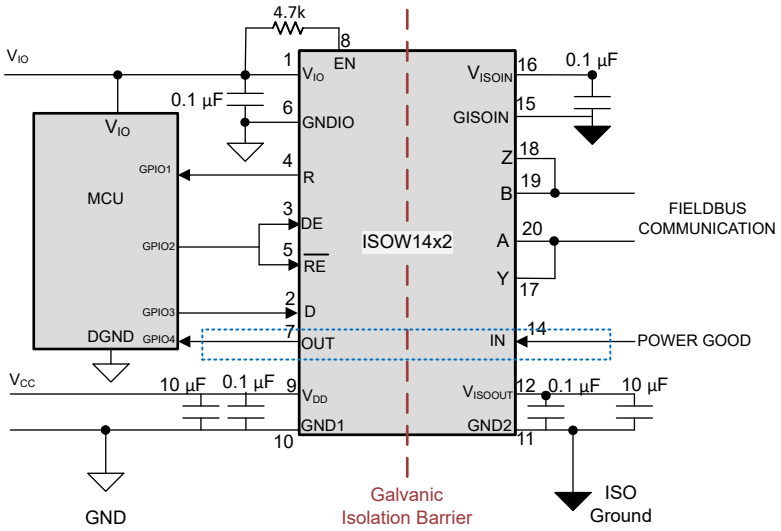

Figure 8. Use of GPIO channel for diagnostic signal transfer

Conclusion

Single chip isolated RS-485 transceivers with integrated power provide an ideal solution for a variety of industrial applications whether functional isolation is needed to prevent ground loops or thousands of volts of protection are needed in high voltage systems. ISOW1412 and ISOW1432 feature TI's high quality SiO_2 based high voltage isolation technology combined with an industry leading DC/DC core for best in class radiated emissions performance to simplify the design process and save board space.

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