

Six Easy Steps to Select the Right Digital Isolator for Solar-inverter Applications



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With the [solar inverter](#) market growing at a fast rate based on data from International Energy Agency (IEA), it is imperative that designers be able to design their systems faster to meet the market's needs. But the high voltages of these types of systems require additional care in component selection and system design to develop equipment that operates safely. With system voltages of 1,000 V_{RMS} and 5 V microcontrollers (MCUs) coexisting in solar-inverter systems, isolation between the high- and low-voltage sides is a given. The engineer's selection of the right [digital isolators](#) can help ensure the stability of these systems.

[Figure 1](#) shows a simplified system block diagram of a transformerless grid-tied solar power conversion system. The solar power is harvested by a photovoltaic (PV) panel and processed by post-stage DC/DC and DC/AC converters. The DC/DC converter implements maximum power-point tracking (MPPT) of the solar energy. The DC/AC inverter converts DC power to AC power for interfacing to a utility grid.

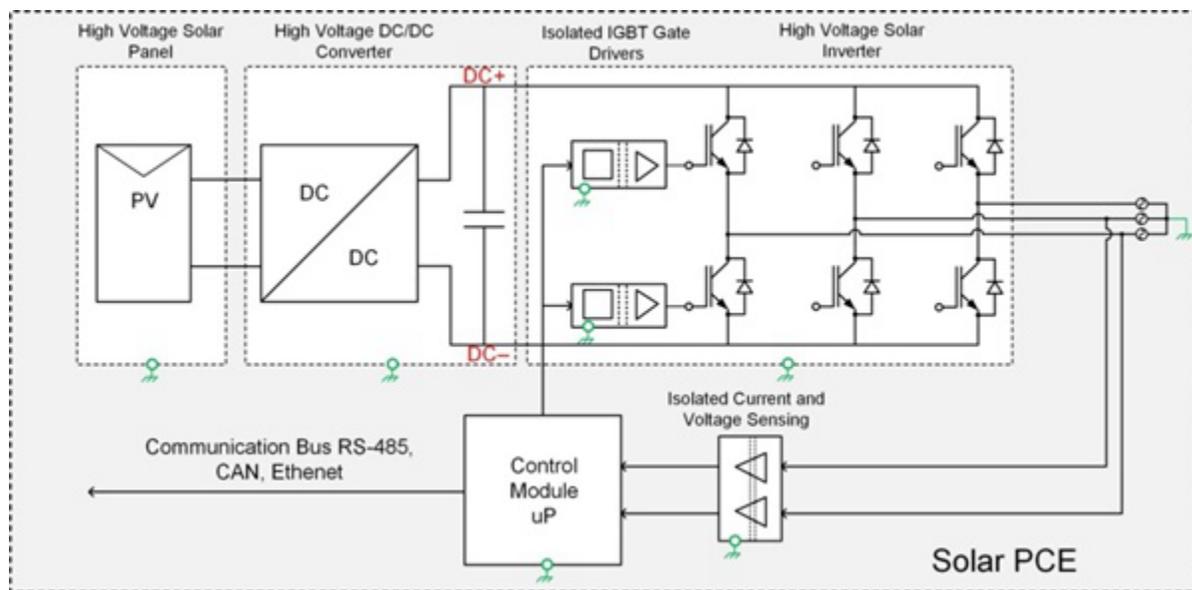


Figure 1. Typical System Block Diagram of a Transformerless Solar Power Conversion System

A control module processes the feedback signals from the voltage and current sensors, and provides the right sequence and frequency of pulse-width modulated (PWM) control signals to the insulated gate bipolar transistors (IGBT)/ silicon carbide (SiC) MOSFET gate drivers to regulate the voltages and currents of the power converters. The voltage and current regulations are intended to realize MPPT and power-flow control to the grids. The control module interfaces with the rest of the control network through standard communication interfaces such as RS-485, control area network (CAN) or industrial Ethernet.

Additionally, the control module has parts that are accessible to humans; for example, the connectors of the communication interface. Sufficient safety isolation is required between these exposed parts and the high-voltage circuits (circuitry connected to the DC buses and utility grids). [Isolated gate drivers](#), [isolated voltage amplifiers](#) and [current-sense amplifiers](#) can achieve this isolation. In [Figure 1](#), which shows a human-accessible control module, the input side of the isolated gate drivers and the input side of the isolated amplifiers are

referenced to ground, which is safety-isolated from the high-voltage systems. Figure 2 shows how to introduce additional isolation between the control module and communication interface.

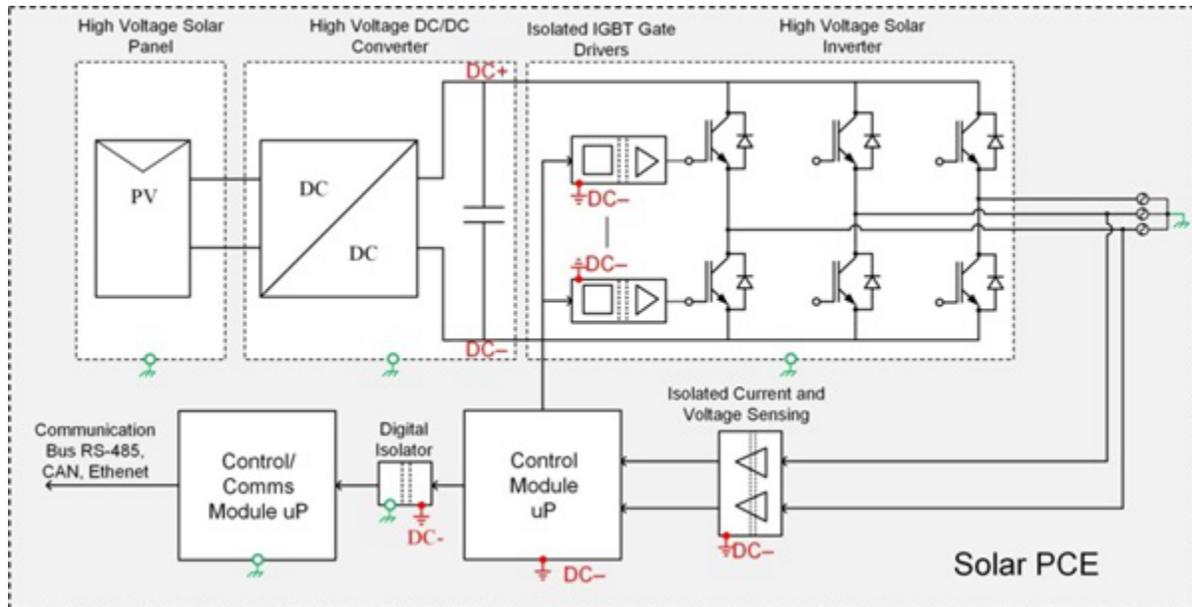


Figure 2. Alternative System Block Diagram of a Transformerless Solar Power Conversion System

The International Electrotechnical Commission (IEC) 62109-1 is a safety standard for solar power converters. This standard defines the minimum requirements for the design and manufacture of power-conversion equipment (PCE) for protection against electric shock, energy, fire, mechanical and other hazards. How do you pick the right isolator to address the isolation requirements stipulated by the IEC62109-1 standard? Here's a simple six-step process that you can follow.

Step 1: Identify the isolators present in the system and determine if each needs functional, basic or reinforced isolation.

Safety isolation is possible through either two basic isolators in series or one reinforced isolator. In Figure 1, the isolated gate drivers, and isolated voltage and current-sensing circuits both need to support reinforced isolation. In Figure 2, the digital isolator needs to support reinforced isolation because the isolated gate drivers and amplifiers are referenced to DC-, and only functional isolations are implemented.

Step 2: Determine the system voltage.

System voltages for PV and grid-tied circuits are defined separately. For PV circuits, the system voltage is the open circuit voltage of the PV panels. For grid-tied circuits, the system voltage depends on the earthing scheme. A three-phase 400 V_{RMS} Terra Neutral (TN) grid voltage that is neutral-earthed has a system voltage of 230 V_{RMS}. Interpolation of the system voltage is not allowed for the grid-tied circuits; thus, you will need to use the next-higher system voltage. For example, a system voltage of 230V_{RMS} is treated as a 300V_{RMS} based on IEC62109-1. A three-phase 480V_{RMS} corner-earthed system has a system voltage of 480V_{RMS}.

Step 3: Determine the requirement for temporary overvoltage and impulse/surge voltage for each isolator according to the IEC62109-1 standard.

You can determine the temporary voltage and impulse voltage requirement based on the pre-determined system voltages and overvoltage category, while obeying the rules defined in IEC62109-1. For reinforced isolation, you will need to use the next-higher level of impulse voltage while doubling the temporary overvoltage requirement.

Step 4: Determine the clearance required from every isolator used in the design.

You can derive the clearance based on the impulse voltage and temporary overvoltage, as determined in Step 4 and the pollution degree while following the rules defined in IEC62109-1. For reinforced isolation, you will need to use the next-higher impulse voltage and 1.6 times the overvoltage.

Step 5: Determine the working voltage (both peak and RMS) based on the actual operating condition of the isolator.

Determining the working voltage is not straightforward, and depends on the system voltage, system configuration and operation modes. For example, the working voltage of the DC/AC inverter depends on the modulation index. A higher modulation index means a higher working voltage. You can treat the DC bus voltage as the working voltage for the worst-case consideration.

Step 6: Determine creepage based on the working voltage according to IEC62109-1.

You can determine the creepage based on the working voltage, pollution degree and package mold compound material while following the rules defined in IEC 62109-1. For reinforced isolation, you will need to double the creepage requirement.

When you choose an isolator, make sure that it meets the surge voltage, temporary overvoltage, working voltage, creepage and clearance requirements obtained in the preceding steps. With these six steps checked off, you should be in a good position to design a robust solar-inverter system. Check out [TI reference designs](#) relating to solar inverters to get started quickly on your system design.

Additional Resources

- View TI's entire [isolation portfolio](#).
- Download the white paper, "[Isolation in solar power converters: Understanding the IEC62109-1 safety standard](#)."
- Learn more about isolation testing in the white paper, "[High-voltage reinforced isolation: Definitions and test methodologies](#)."
- Consult the [Isolation Glossary](#) to learn the meaning of isolation terminology used in this post.

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