Applying Fault Indicators to Solar Photovoltaic Plants

Jerry Sauer

Introduction

The desire to reduce carbon emissions and help reduce dependence on oil has led to an increased demand for alternative energy sources, including solar power. This application note explores the application of faulted circuit indicators (FCIs) in solar photovoltaic plant installations.

Figure 1 Solar Photovoltaic Arrays

Basic Solar Photovoltaic Plant Configuration

Solar photovoltaic array dc outputs are converted to ac using an inverter. The inverter output is stepped up through a transformer and distributed underground to junction enclosures. The junction enclosure outputs are connected to a collector substation where the voltage may be stepped up again by the collector substation transformer to the utility transmission voltage.

Faulted Circuit Indicators

The loss of revenue due to a single cable fault can be substantial for a solar photovoltaic plant operator. Therefore, it is necessary to determine the fault location, isolate the faulted section, and restore the plant to normal operation as quickly as possible. SEL FCIs can help operations personnel quickly determine the fault location. As depicted in Figure 2, the terminations used for underground cables in the transformers and junction enclosures are excellent locations to install FCIs.

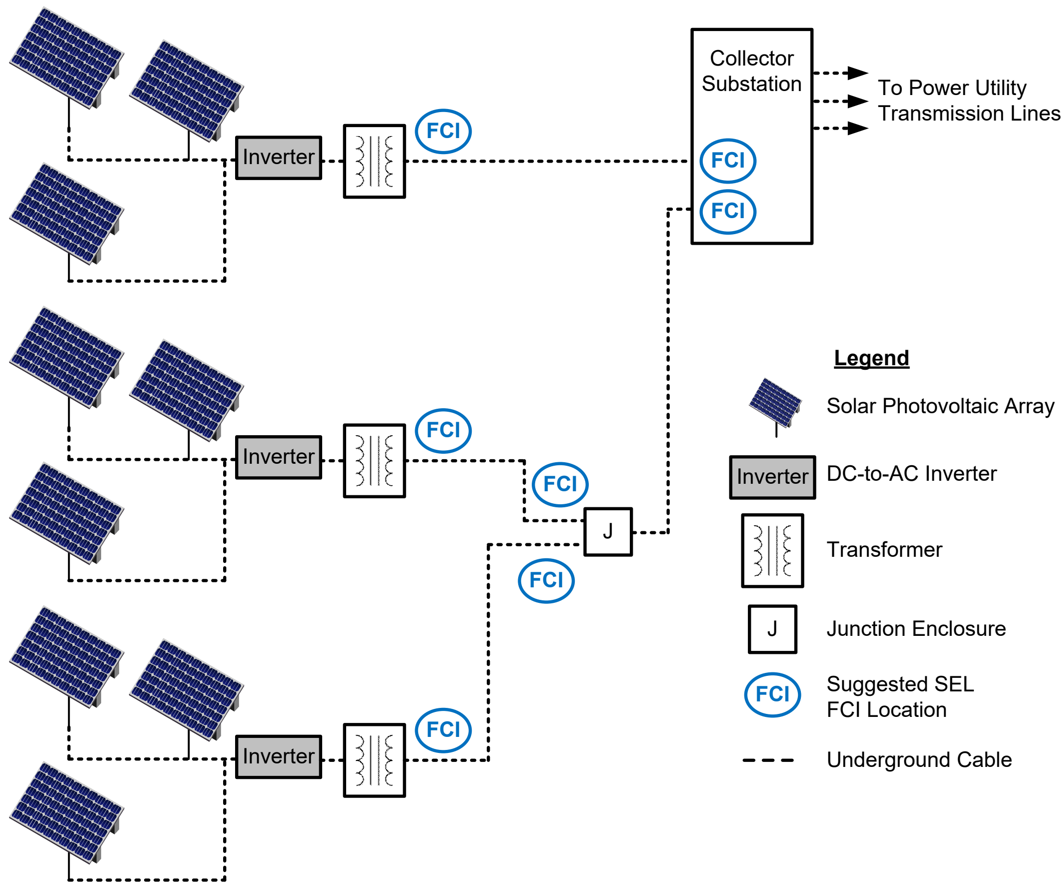

Figure 2 Typical Solar Photovoltaic Plant Diagram With Suggested FCI Locations

DETERMINING THE TRIP COORDINATION OF THE FCI

A traditional FCI application requires coordination of the trip value with the utility substation breakers, reclosers, and fuses. An FCI trip value should be lower, and its trip response time faster, than all of the upstream protective devices to ensure that the FCI activates before the fault is cleared.

Solar photovoltaic inverters introduce another source of energy that requires additional coordination. During a solar photovoltaic plant cable fault, the utility power system supplies higher fault currents for a longer duration as compared with those supplied by a set of solar inverters on a collector string. Directional fault indicators are not required for fault location if the coordination of the substation protection and the solar inverter fault contribution are understood.

The SEL solution to solar photovoltaic plant fault location is to select FCIs with a trip value and response time that exceed the solar photovoltaic array current contribution magnitude and duration. This method prevents the FCI from responding to fault-level energy supplied by the solar photovoltaic plant. A 1,200 A trip-level FCI with the SEL delayed trip option allows the additional time needed for the solar inverter fault currents, which may be higher than the 1,200 A trip level, to collapse. The only source available to trip the device is the energy being back fed from the utility power system through the collector substation to the fault. This source provides the higher currents needed to trip the 1,200 A FCIs at a longer duration than the solar photovoltaic plant contribution.

This fault location method is similar to the method performed on typical utility distribution circuits, only the fault indicators are tripped between the breaker and the fault. This nondirectional fault indication method reduces confusion during field patrol and speeds the fault location process, because the number of FCIs tripped during the fault is limited to only the ones between the breaker and the fault. The SEL coordination method described provides a simple, practical fault location solution for solar photovoltaic plant applications.

SEL Solar Photovoltaic Plant Solutions

The SEL Test Point Reset FCI (part number TPR#K69N) is the suggested solution for solar photovoltaic plant applications using terminations equipped with capacitive test points located on the T-body of 600 A terminations.

Note: For terminations that do not have capacitive test points located on the T-body, consider SEL Three-Phase Voltage Reset devices (part number 3VRPV1500IRDT9).

Test Point Reset FCI (TPR#K69N) features and benefits include the following:

- Batteries are not required; being line powered means a longer life and limited maintenance.
- A high 1,200 A current trip value with a delayed trip response time option coordinates with most systems.
- A remote display indicates status quickly without opening the enclosure, which helps avoid exposure to arc-flash hazards.
- They are easy to install on terminators having capacitive test points.
- Integrated junction shields ensure adjacent phase immunity in junction enclosure applications.
- They are applicable in both transformers and junction enclosures to help avoid installation errors.
- An auxiliary contact output option is available for connection to a supervisory control and data acquisition (SCADA) system for remote monitoring.
- A 15-year life design is backed by a 5-year warranty.

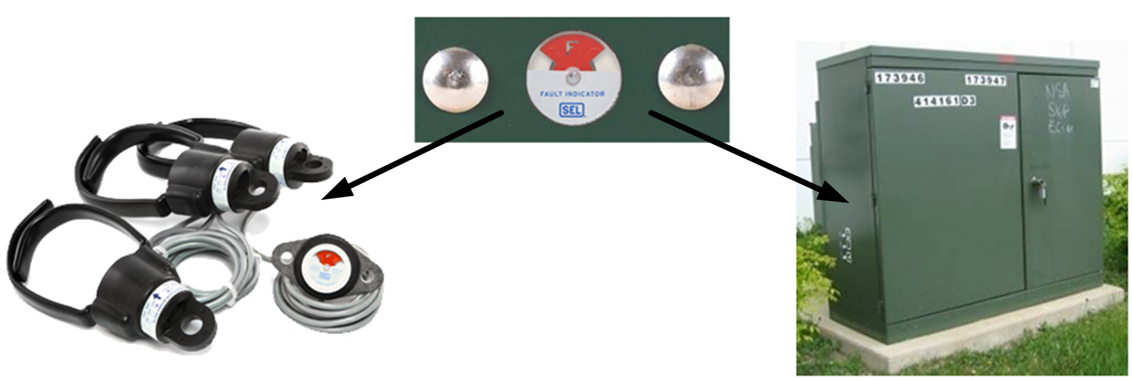

Figure 3 Typical Test Point Reset FCI (TPR#K69N) Installation

Three-Phase Voltage Reset FCI (3VRPV1500IRDT9) features and benefits include the following:

- Batteries are not required; being line powered (from the capacitive test point location on the basic insulating plug) means a longer life and limited maintenance.
- They have a current trip value up to 1,500 A with a delayed trip response time.
- A remote display option quickly indicates status without the need to open high-voltage compartments, which helps avoid exposure to arc-flash hazards.
- They are easy to install on separable connector components with capacitive test points.
- They can be installed in transformers, switches, and junction enclosures.
- They work with cold-shrink silicone high-voltage terminations.
- Auxiliary contact output options are available for connection to SCADA systems for remote monitoring.
- A 15-year life design is backed by a 5-year warranty.

Figure 4 Typical Three-Phase Voltage Reset (3VRPV1500IRDT9) Installation

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SCHWEITZER ENGINEERING LABORATORIES, INC.
2350 NE Hopkins Court • Pullman, WA 99163-5603 USA
Tel: +1.509.332.1890 • Fax: +1.509.332.7990
www.selinc.com • info@selinc.com