SUNNY CENTRAL

Notes for grounded operation of the PV generator

1 Introduction

Some module manufacturers recommend or require positive or negative grounding of the PV generator when using thin-film and back-contact PV modules. In this case, the positive or negative pole of the generator output is grounded, regardless of the grounding of the module frame.

In case of the Sunny Central with the "GFDI negative ground" or "GFDI positive ground" insulation monitoring option, the grounding takes place within the device. The inverters are adapted for grounded operation of the PV generator. The connection to ground is established using a fuse, the GFDI (ground fault detection interruption).

This technical information complements the user manual and the installation guide for standard devices from the Sunny Central product range with important instructions and information on grounded operation.

2 Notes for Grounded Operation

The following safety precautions are to be observed in addition to the safety precautions from the standard Sunny Central documentation.

One of the poles in the PV generator is internally grounded by a fuse. The fuse is used to signal ground faults in the pole that is not grounded and can interrupt the resulting short-circuit to protect the system. This interrupts the grounding of the PV generator. After the grounding is interrupted, the full generator voltage can then arise at this pole, flowing to ground.

- The GFDI does not ensure personal protection, but merely system protection!
- The positive or negative pole of the PV generator is grounded in the inverter via the GFDI . The additional grounding within the PV generator or in the distributor boxes is not permissible.
- Only in the Sunny Central 500 / 560HE is the grounding of the PV generator interrupted by the DC main switch in the event of a "Stop" switch position, or a grid failure.
- The grounding of the PV generator can be automatically interrupted by the GFDI at any time. The PV positive and PV negative poles are live potentials!
- Any work to be carried out on the device is only permissible after all-pole DC and AC disconnection at the device's connection. Observe the safety precautions in the installation guide.
- The GFDI is rendered ineffective by a ground fault in the PV generator's grounded pole. The insulation of the grounded pole must be inspected at regular intervals.
- Operation of the Sunny Central is not permissible while the GFDI is triggered. This could damage the modules.
- The GFDI's maximum possible leakage current is doubled during Team operation.

2.1 GFDI

The GFDI is installed in the Sunny Central and connected between an input busbar and the PE bar. The GFDI consists of a high-performance circuit breaker equipped with an adjustable triggering current with K characteristics.

The GFDI can be disconnected for test purposes, and can switch the leakage current up to the inverter's maximum DC input voltage. The disconnection, or the triggering is signaled.

Max. permissible leakage current according to UL1741 table 2.1

DC nominal power	Cutoff limit
100 – 250 kW	4.0 A
> 250 kW	5.0 A

Other cutoff limits are possible, according to customer requirements.

3 Grounded Operation

The essential difference to the standard devices in the Sunny Central product range is that one of the PV generator's poles is centrally grounded in the Sunny Central by a fuse. This system concept was designed in the USA and has been used in the inverters for the American market since it was first commercialized.

There are no normative stipulations regarding this concept. Determination of the maximum leakage current, which causes the GFDI to disconnect the system, occurs in accordance with UL1741.

3.1 Behavior in case of Ground Fault

If a fault arises causing a ground fault to occur at the PV generator pole that is not grounded, the leakage current flows through the GFDI and back to the grounded pole, thus triggering the GFDI. The triggering of the GFDI interrupts the leakage current and the PV generator is not grounded by the ground fault (see figure 1, system example with a negative grounded pole). This interruption of the leakage current prevents damage to the system. The GFDI does not ensure personal protection. The "protection provided through the automatic disconnection of the power supply" is not technically possible at this time. This is due to the complex structure of the PV generator.

The period of time that passes before the fuse is triggered depends on the quantity of the leakage current, which itself depends on the DC voltage and the transition resistance of the ground fault. Please refer to the triggering characteristic curve of the GFDI for the triggering times (available upon request). If the leakage current is below the triggering threshold of the GFDI, the fuse is not triggered. This state can, for example, be set for high transition resistances or low radiation.

> Leakage current below the GFDI's triggering threshold can remain for an extended period of time and do not trigger the fuse.

The triggering of the GFDI is signaled by an indicator light, a relay output, and the display on the device. The signal occurs as a common fault, i.e. it can involve different fault causes. Please refer to the Sunny Central user manual for the overview of the possible faults.

When the GFDI is triggered, the monitoring causes the inverter to deactivate. After the disconnection, the insulation fault must be removed immediately.

Operation of the inverter with a triggered GFDI could damage the PV modules due to the absence of grounding. If, while in this state, a ground fault also occurs at the grounded pole, this creates a short-circuit (see figure 2) to which the inverter could feed current. This can damage the power module. Therefore, the inverter cannot be operated when the GFDI is triggered.

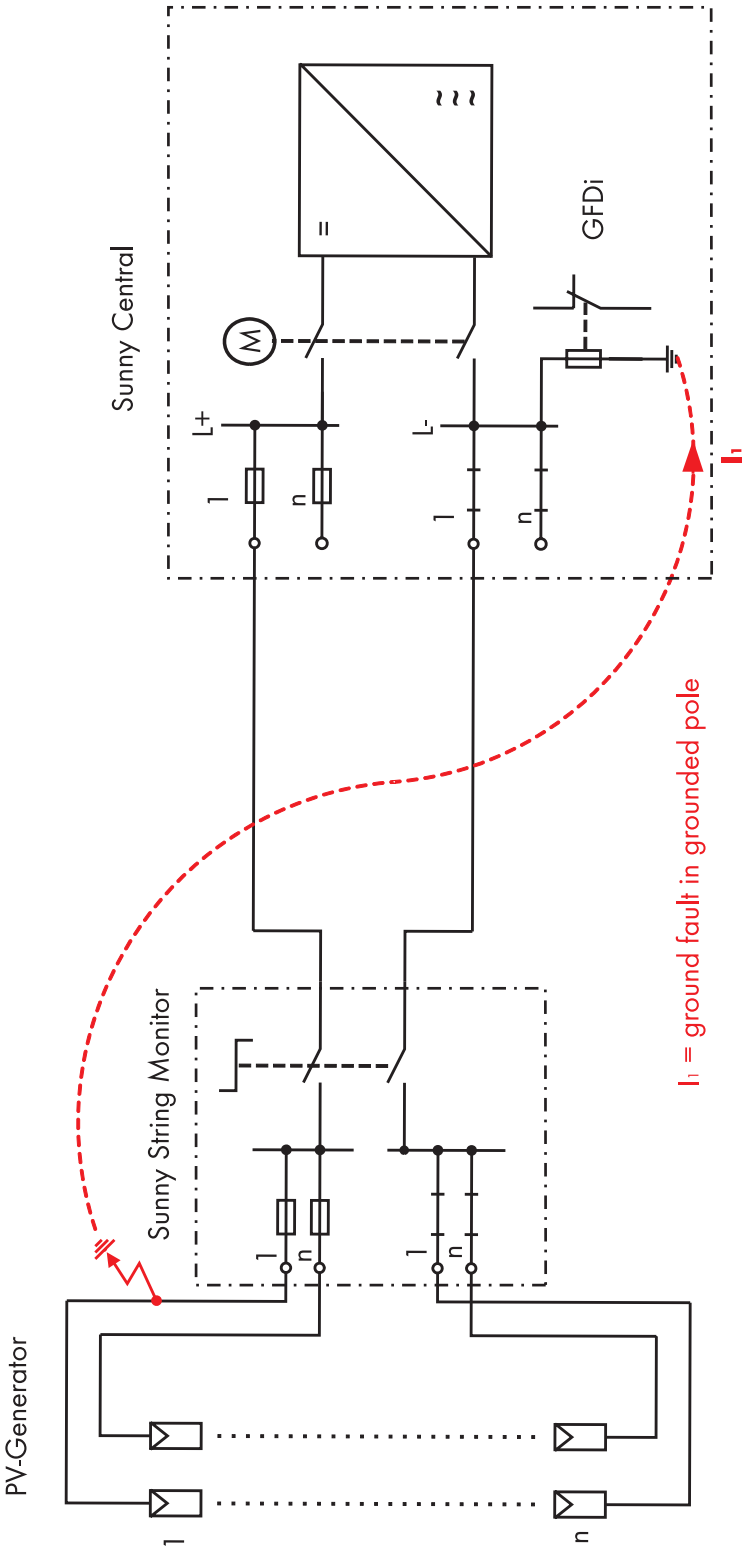

Figure 1: Ground fault L+ (negative pole grounded)

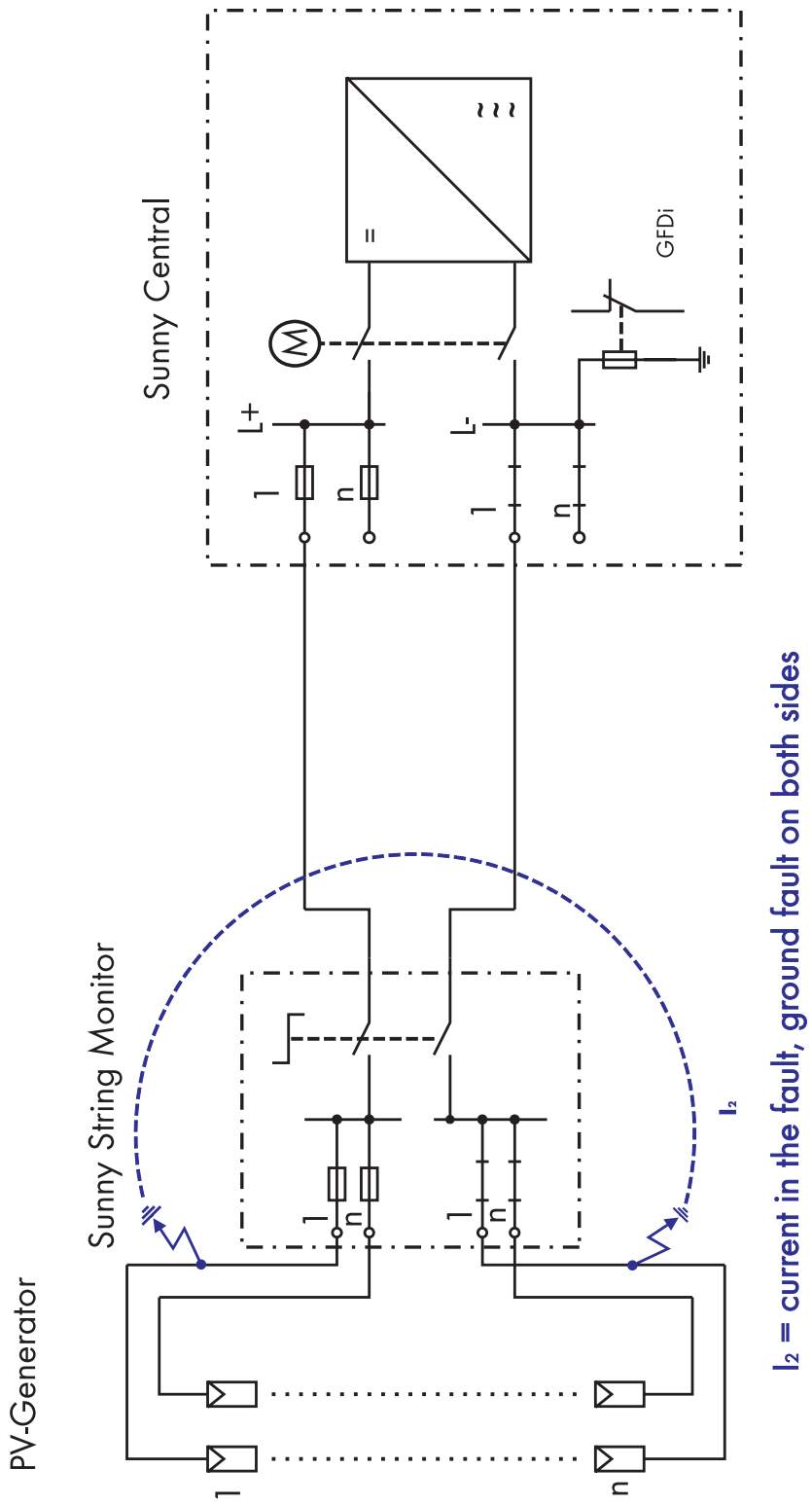

Figure 2: Ground fault on both sides

3.2 Behavior in case of Ground Fault in the Grounded Pole

- In case of faults
  - The GFDI is bypassed by a ground fault in the PV generator's grounded pole. The GFDI's protective function can no longer be ensured.
  - If, while the system is in this state, a ground fault occurs at the pole that is not grounded (see figure 2), the GFDI cannot interrupt the resulting leakage current. This can damage the system or building components.

To ensure the function of the GFDI, the insulation of the PV generator must be inspected at regular maintenance intervals!

- During operation
  - During operation, a ground fault in the PV generator's grounded pole causes some of the generator current to flow back to the solar generator via the GFDI (see figure 3). This can also trigger the GFDI.
  - If there is a poor connection through the electric bonding to the grounding of the GFDI, these currents can also flow through system components or the soil. This can damage the system and building components.

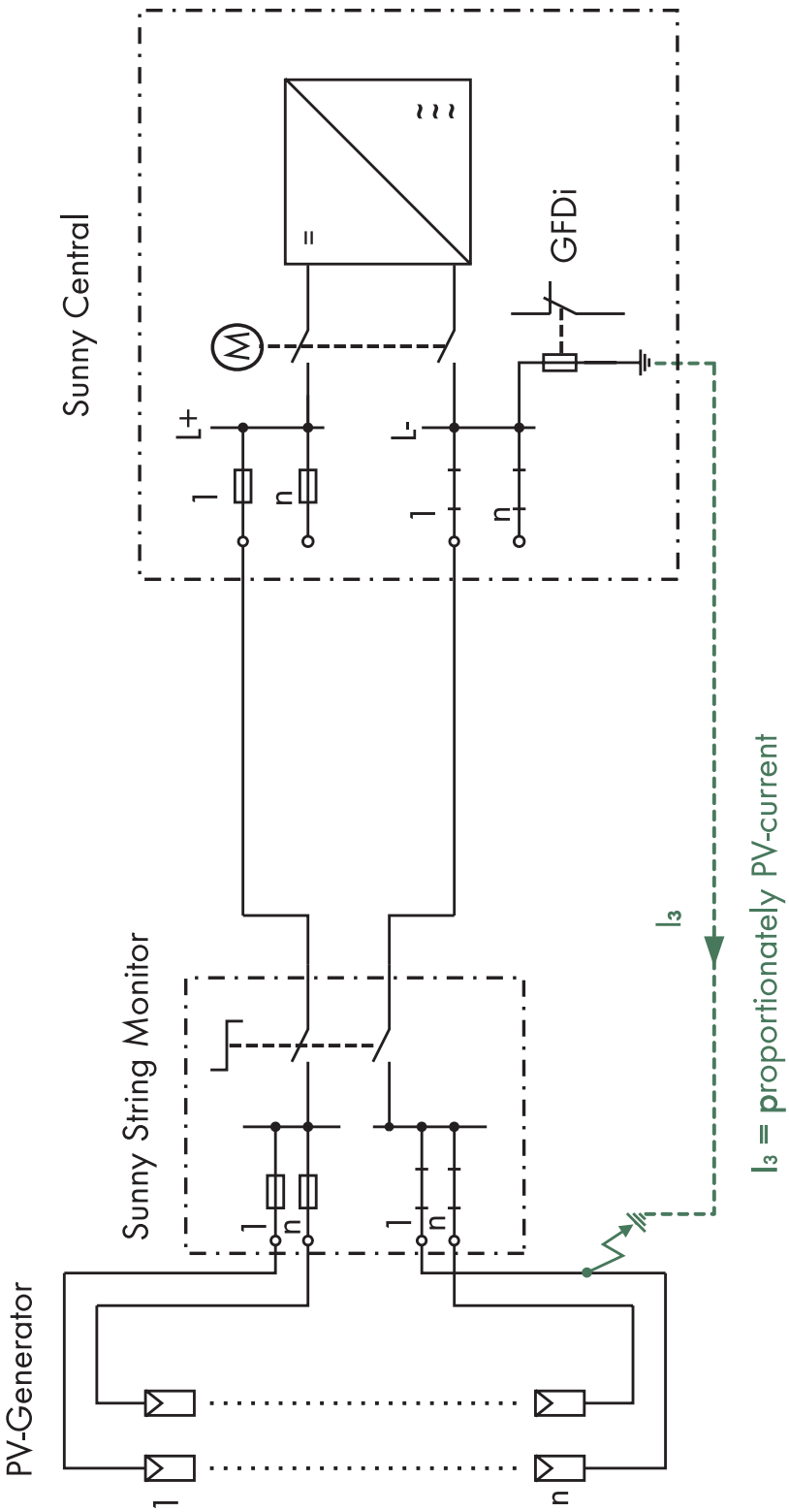

Figure 3: Ground fault in the grounded pole during operation

4 System Requirements

The system requirements that are required for operating a GFDI are described below:

- The PV generator is centrally grounded in the Sunny Central. Additional grounding within the system is not permissible.
- Both poles must be installed with protection against short-circuits and ground faults.
- Cable protection fuses should only be located in the pole that is not grounded.
- It should be possible to disconnect the grounded pole using disconnectors or isolating blades to take measurements under load-free conditions.
- Both poles are live potentials and must be protected against direct contact.

5 Modifications to the Standard Inverter

The modifications performed to the Sunny Central equipped with the "GFDI" option will be described below in comparison with the standard inverters.

- The inverter is no longer equipped with insulation monitoring.
- The PV generator is centrally grounded in the Sunny Central by the GFDI.
- The grounded pole is installed on an insulated busbar.
- The cable protection fuses are only located in the pole that is not grounded.
- The grounded pole can be disconnected using isolating blades, thus allowing work to be performed on the device or measurements to be taken under load-free conditions.
- The "R-Iso" spot value is no longer available as a measurement value, but it is still displayed in the "Other" menu.

5.1 GFDI in the Sunny Central 500 / 560HE

Due to the two DC inputs, the GFDI is installed behind the main switch in the Sunny Central 500 / 560HE. This means that in "Stop" mode, in case of faults or in the event of a grid failure, the grounding of the PV generator is interrupted by the main switch.

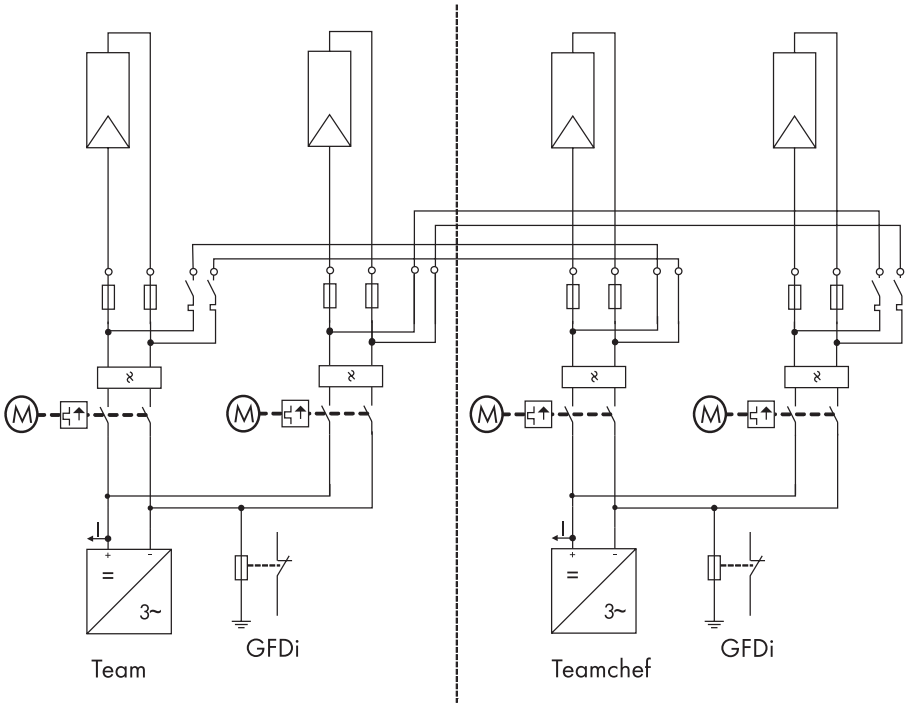

Figure 4: Position of the GFDI in the Sunny Central 500 / 560HE

If the DC main switch is switched off, the PV generator becomes an IT network. In this mode, any ground fault that occurs will not be signaled. The signaling and triggering of the GFDI only occurs once the Sunny Central is switched on, and enters the “Wait” operating mode.

5.2 Team Mode

Two PV generators are connected in parallel via the Team contactor. This means that during Team mode, two GFDIs are connected in parallel (see figure 4).

In the event of a fault, the leakage current will in the most unfavorable case divide over both GFDIs. If triggering occurs, the Team contactor is switched off. If the GFDI is triggered, Team mode is disabled.

> In the event of a fault, both GFDIs may be triggered during Team mode. This brings both Sunny Centrals to a standstill!

5.3 GFDI Signaling

If the GFDI is triggered, this causes the Sunny Central to be deactivated. The Sunny Central switches to "Failure" mode. The power module's quick-stop is activated, and the DC switch, the Team contactor, and the AC grid contactor are switched off.

Signaling occurs via the Sunny Central Control and the fault indicator light on the Sunny Central. The signaling is accompanied by the cabinet overtemperature fault message “Failure 201, Ground Fault 2, or system temp. too high”.

> Ground, and not GFDI, is signaled in the fault message.

6 Servicing and Maintenance

Additional servicing and maintenance instructions

In order to maximize the operating safety of the Sunny Central, the maintenance work listed in the Sunny Central user manual and the maintenance manual must be performed at regular intervals. This facilitates early detection of defective system components and their exchange before a failure occurs. Further, the function of security-related components is ensured.

The GFDI is subject to aging caused by the wearing of the contact, each time it is triggered. This reduces the sensitivity. We therefore recommend replacing the GFDI after it has been triggered approximately 100 times.

The following additional maintenance work must be performed on the inverters for grounded operation:

Maintenance work	Maintenance interval
Switching the GFDI Mechanical inspection to determine whether the inverter and the signaling are functioning correctly when the inverter is switched off. Visual inspection of the GFDI.	Annually
Replacing the GFDI If it does not pass the mechanical or visual inspection.	At the latest after 100 ground faults have occurred, which in turn triggered the GFDI.
Inspection of the PV generator's and the connected Sunny Central's insulation.	Determined by the system operator.