Services and Solutions for Photovoltaic Systems

Electromagnetic interference in photovoltaic systems

Photovoltaic (PV) systems require special know-how and specially developed products. The purpose of this white paper is to propose solutions:

- **to reduce electromagnetic interference (EMI) from equipment such as switching power supplies, charge controllers and inverters used in photovoltaic systems;**
- **to reduce line noise coming in the photovoltaic systems from power or control or DC lines;**
- **to protect photovoltaic system equipment and conductors against overcurrent and overvoltage conditions.**

Photovoltaic systems

Photovoltaic systems (stand-alone, grid-connected) are systems which use solar cells to convert light into electricity. A photovoltaic system consists of multiple components, including cells, mechanical and electrical connections and mountings and means of regulating and/or modifying the electrical output. Grid-connected systems are connected to a large independent grid (typically the public electricity grid) and feed power into the grid. The feeding of electricity into the grid requires the transformation of DC into AC by a special, grid-controlled, inverter. In kW-sized installations the DC side system voltage is as high as permitted (typically 1000 V except US residential 600 V) to limit ohmic losses.

Inverters for photovoltaic systems

On the AC side, these inverters must supply electricity in sinusoidal form, synchronized to the grid frequency, limit feed in voltage to no higher than the grid voltage including disconnecting from the grid if the grid voltage is turned off. On the DC side, the power output of a module varies as a function of the voltage in a way that power generation can be optimized by varying the system voltage to find the maximum power point. Most inverters therefore incorporate maximum power point tracking. For safety reasons a circuit breaker is provided both on the AC and DC side to enable maintenance. The AC output usually goes through an electricity meter into the public grid.

Regulations

Like other electrical equipment photovoltaic systems must function correctly in the electromagnetic environment and they may not be influenced by strong interference emissions. Grid-connected inverters may affect the normal operation of the network and other devices connected to it and therefore need not comply with certain standards and regulations. For photovoltaic inverters so far no device-specific standard exists regarding limiting conducted radiofrequency interference (150 kHz to 30 MHz). As grid-connected photovoltaic systems are often constructed on buildings, it is favorable to apply the limits of the European EMC standard EN 61000-6-3. This standard applies to all electrical equipment used in residential areas including residential areas where no special equipment standard exists. The EN 61000-6-3 contains recent mandatory limits for the direct-current side. Almost equivalent is the application of the standard EN 55014 for electrical household appliances, which contains limits regarding conducted radio frequency interference for other lines such as the power supply lines (in the case of a photovoltaic system the direct-current lines). Since photovoltaic systems (such as household appliances) are often operating in residential buildings, the application of these standards is highly suggested in order to reduce unwanted electromagnetic interference from and towards the photovoltaic system and to extend the overall photovoltaic system lifetime.

Electromagnetic interference

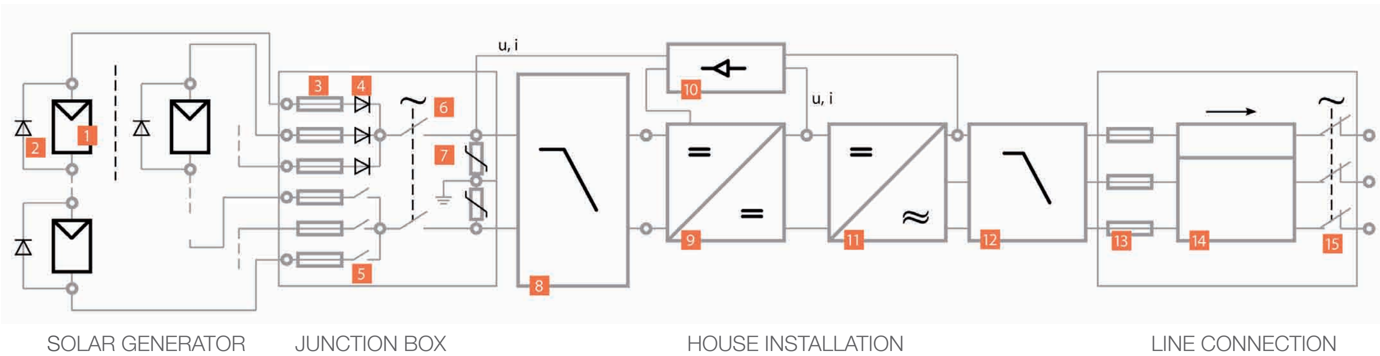
Any digital electronic equipment produces at least some noise. Nearly all electronical equipment now used in photovoltaic systems is digital. However, the most common problem components in photovoltaic systems are inverters. To achieve the highest efficiency possible, inverter power circuits today transition from off to on in an extremely short time (microseconds). Internally, within the inverter, even sine wave models use square waves at various points. Square waves are a composite of a sine wave, plus all odd harmonics (odd integer multiples) of the original sine wave frequency. These harmonics along the whole frequency spectrum cause unwanted interference to be introduced in the photovoltaic system power or control or DC lines or other nearby electronic systems.

Overvoltage

As open-field systems, photovoltaic systems must be protected particularly against overvoltages caused by lightning strikes. In general we distinguish between the DC side with solar panels for power generation and the AC side behind the inverter for grid supply. With central inverters overvoltage protection is included in the DC circuit; with remote inverters it is in the AC circuit. The DC side, with its special current source characteristics (high DC voltages in the individual strings as well as possible power generation and thus permanent electric arcs after overvoltage), requires protection to allow reliable system operation and to avoid fire hazards. Overvoltage protection guarantees high photovoltaic system availability.

Countermeasures, services and solutions

The following components, measures and services can be used in order to protect photovoltaic equipment and conductors against overcurrent and overvoltage conditions and to reduce unwanted electromagnetic interference from and towards PV equipment:



1 Solar module
2 Bypass diode
3 String overcurrent protection
4 Shottky diode
5 String disconnector
6 DC main switch
7 Overvoltage protection
8 DC filter
9 DC/DC converter
10 Control and regulation
11 DC/AC converter
12 AC filter
13 AC fuse left
14 Generation meter
15 AC main switch

Fig 1: Exemplary block diagram for a grid-connected solar system

As industry standards are shifting and 1000 VDC protection is becoming more common, SCHURTER continues to develop fuses and fuseholders that meet this requirement at both high and low amperages. The quick-acting ASO line fuses (10 × 38 mm) **3**| are UL-recognized. They are designed for DC applications of up to 1000 VDC and are capable of safely breaking nominal currents of up to 30 A, making them perfectly suitable for short circuit protection in the individual lines of PV systems. The FSO matching touch-proof fuseholder **3**| is designed for DIN rail assembly and therefore perfectly suitable for use in junction boxes.

Fig. 2: ASO solarfuse and FSO fuseholder for PV systems

Varistors possess characteristics that divert transient currents away from sensitive components. The connection between the solar generator and the transformer/inverter stage inside a building is governed by the VDE 0185 lightning protection standard which specifies that all power and data lines must be protected against power surges. SCHURTER provides suitable surge protection AVTS, AVTP, AVTT **7**| components.

The DC filter FMER SOL **8**| reduces electromagnetic interference towards the solar panel to a minimum, thereby considerably increasing installation life span and safety. The type FMER SOL filters are suitable for voltages up to 1200 VDC at nominal currents of between 25 A and 1500 A, i.e. for small off-grid systems as well as for power plants of up to 500 kVA.

Fig. 3: FMER SOL filters are designed for rated currents from 25 A to 1500 A at 55°C ambient temperature, and voltages up to 1200 VDC.

Circuits must be protected with fuse-links **11**| against short circuit if separate electronic modules are used, e.g. the parallel switched outputs of inverters are protected with fuses of the type SHT 6.3 × 32 mm.
Protection against short circuits and harmful residual currents in electric appliances must be ensured during maintenance as well. For such purposes, SCHURTER offers various fuse-mounting designs FUL, FEC, FUA, FUP, OGD, OGD-SMD featuring open and shock fuseholders **9**|**10**|**11**| with built-in touch protection and various IP ratings.

Linear chokes **10**| such as DLF are used for smoothing out output voltage fluctuations in step-up/-down transformers, while current-compensated chokes such as DKFP are used for attenuating electromagnetic interference in auxiliary power supplies.

Fig. 4: DKFP current-compensated choke

Pulse transformers **10**| such as ISR are used for reliably controlling power transistors and for converting measured values, galvanically isolated, from the power circuit to signals in the control circuit, in order to enable the control circuit to derive from the power circuit the necessary parameters for controlling the solar inverter.

The DC voltage generated by PV systems is converted to standardized AC line voltage using frequency inverters or solar inverters which reassemble the maximum solar energy supplied at the correct line frequency (50 or 60 Hz) and amplitude (250 or 380 VAC). The conversion process, however, causes interference which makes it more difficult to comply with the line quality as specified by the law. This is where SCHURTER individual components or entire AC filters FMAC ECO, FMAD, FMBC NEO, FMBD NEO **12**| prove remedial. For off-grid systems, sinusoidal filters are also suitable.

Fig. 5: FMBB NEO filter for one phase systems are characterized by a high symmetrical and asymmetrical attenuation.

EMC measurement services, individual solutions

SCHURTER will perform all necessary preliminary tests concerning immunity and interference in the photovoltaic system or equipment. Our EMC competence center is equipped with all the measurement tools necessary and an EMC chamber for measuring line-bound interference.

Fig. 6: ESD immunity testing

References

List of DIN standards regarding photovoltaic (PV):

EN 61000-6-3	Electromagnetic compatibility – Part 6-3 Emission standard for residential, commercial and light-industrial environments
EN 55014	Electromagnetic compatibility – Requirements for household appliances, electric tools and similar apparatus
DIN VDE 0126-21	Photovoltaics in building technology and telecom
DIN EN 60904-1	Photovoltaic devices – Part 1: Measurement of photovoltaic current/voltage (IEC 60904-1)
DIN EN 60904-3	Photovoltaic devices – Part 3: Measurement for terrestrial photovoltaic (PV) devices with reference on the spectral distribution (IEC 60904-3)
DIN EN 60904-10	Photovoltaic devices – Part 10: Methods of linearity (IEC 60904)
DIN EN 61727	Photovoltaic systems – Properties of the network interface (IEC 61727)

Links

www.schurterinc.com/solartech
www.schurterinc.com/products
www.schurterinc.com/product_news

Contact

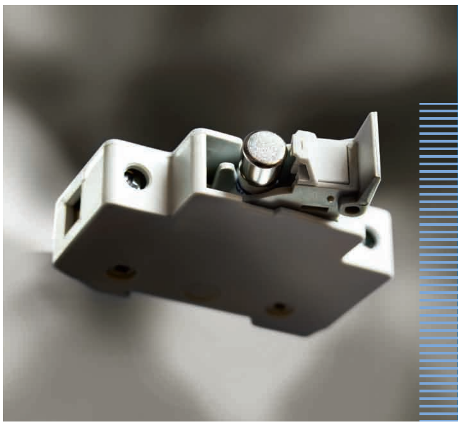
Please do not hesitate to contact us if you have any questions or if you would like to perform preliminary tests concerning immunity and interference of your photovoltaic system or equipment.

SCHURTER INC
447 Aviation Blvd
Santa Rosa, CA 95403
USA
info@schurterinc.com
www.schurterinc.com

About SCHURTER

SCHURTER is an internationally leading innovator and manufacturer of fuses, connectors, circuit breakers, input systems and EMC products as well as a PCB-assembly service provider for the electronics industry.

Customers are manufacturers of computers and peripheral equipment, appliances/instruments, telecommunication equipment, operator panels, medical technology, industry automations, renewable energy, aerospace, hobby, household and gardening equipment.



ASO, the high-performance fuse for PV systems, together with FSO, a touch-safe fuseholder

The ASO fuse protects PV modules, conductors and similar DC applications from the potentially devastating effects of a low short circuit current in systems upwards of 1000 VDC.

0165.0585 / 09.11_us