Repair and maintenance of solar power systems

Automatic shutdown of individual modules

Solar systems use a simple, manageable technology that home owners and businesses can use to contribute to CO2 reduction. The fact that there is great interest in solar energy can be seen in the steadily growing number of solar installation companies. Their staff must have technical knowledge if the solar power systems are to function reliably.

Technicians face a variety of challenges when they are called on to repair damage to a solar power system.

Large energy parks are normally equipped with a comprehensive monitoring system. In addition, these parks employ specialists of operations management. The situation is different for the countless small systems installed on the roofs of private houses and the medium-sized commercial systems on the roofs of businesses and warehouses. Technical amateurs are responsible for a number of these systems. Businesses at least have electro-technical personnel on their facility management staff that can operate and maintain their own systems. Concluding a maintenance contract is another common practice. However, after start-up, there is usually no professional to look after solar systems. But if the owner notices a drop in power generation and repairs are therefore to be carried out, or if renovation is undertaken near the system, those performing the work should be conscious of the fact that they are dealing with an electrical system with high voltages and currents.

System voltages of up to several hundred volts

Solar roof systems commonly use string inverters. When many solar modules are connected in series to form a string, a system voltage of up to several hundred volts can build up (Figure 1). The central element in the solution is the inverter, which is often mounted in the house near the home connection. The DC lines normally run from the roof through the house or along the house into the basement. Because it carries the full system voltage, the cable

should be laid in fireproof channels for reasons of safety. Solar systems thus designed are intended for a service life of more than 20 years, which is achievable without additional measures if installation is flawless.

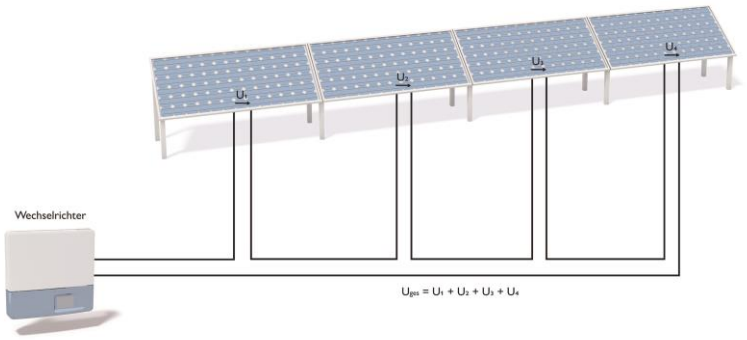

Figure 1 - Diagram of a typical solar power system: The serial linking of the solar modules means a build-up of system voltage to several hundred volts.

If installation is performed correctly, normal operation of such systems poses no danger. To test and ensure long-term safety, maintenance measures prove to be a good idea. Private houses in particular tend to undergo renovation work, such as the development of the attic, during the lifespan of a solar power system. There are also many conceivable adjustments to commercially used buildings that require technically correct handling of the voltage-carrying solar power system lines. If systems are damaged or soiled, direct contact with them becomes unavoidable. Published studies on typical damage to solar power systems show that the most common affects cabling and contacts (Figure 2). This damage must be repaired; otherwise, in addition to lower power generation, the danger of fire or shock will remain. Renovation, cleaning, repair, or maintenance: to protect amateurs and professionals alike, the operator of the solar power system must consider the resultant danger.

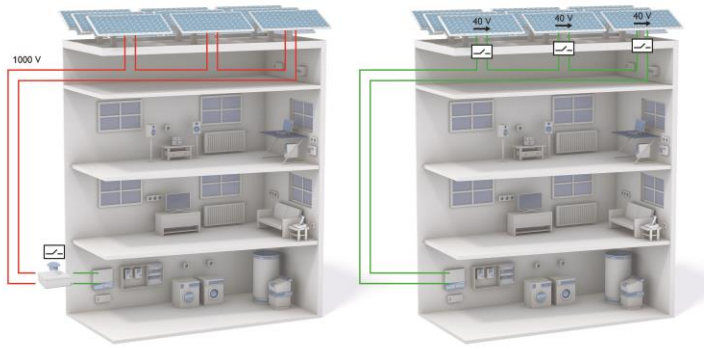

Figure 2 - The most common sources of error in solar power systems are cabling and contacts, although repairs must be performed quickly and safely for fire safety reasons; the risk priority number (RPN) illustrates the rank of the risks considered.

Disconnecting has so far been complicated and expensive

If, for example, cabling repairs are necessary, the normal safety measures for dealing with electrical systems must be carried out (Figure 3). The five well-known safety rules are in effect: Disconnect, secure against reconnection, determine that there is no voltage, ground and short-circuit, and isolate from any neighbouring components that are electrically live.

Disconnecting a solar power system is usually done through the inverter. This removes all AC voltage from and de-energizes the system. The DC voltage is also interrupted so that no current is flowing. But DC current cannot be turned off as long as the sun is shining on the solar modules. This means that there is still voltage between the switching apparatus and the generator (Figure 4, left). This is because even a little sunlight generates high voltages. Short-circuiting the string centrally at the inverter is not a good solution. If there were a cable break, the technician would be subjected to the full power of the string if he touched the two exposed cable ends. For the described system layout, completely covering the generator, completely disconnecting the individual modules from the string, or conducting repairs at night are the only safe methods of work. But such measures are complicated and expensive.

Figure 4 - Repair of faulty insulation is simple, but the technician must exercise due caution when working around

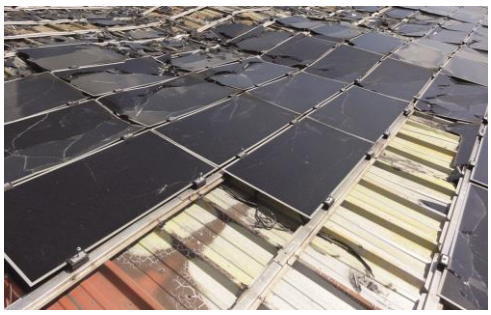

Figure 3 - The voltage conditions during a central system shut-down (left) are different from those during direct shut-down at the solar module (right).

Danger resulting from fire damage is scarcely estimable

In addition to necessary planned maintenance and repair work, there are situations in which people could be unexpectedly forced to deal with a voltage-carrying solar power system – a flood or fire, for example. It has been shown that a house that has caught fire can be saved and does not need to become a controlled burn merely because it has a solar power system. Firefighters are trained to deal with electrical systems. Solar power systems are no exception, so buildings with them are extinguished as a matter of course. Nevertheless, firefighters must take appropriate precautionary measures, such as maintaining a safe distance. What is especially critical in dealing with potentially

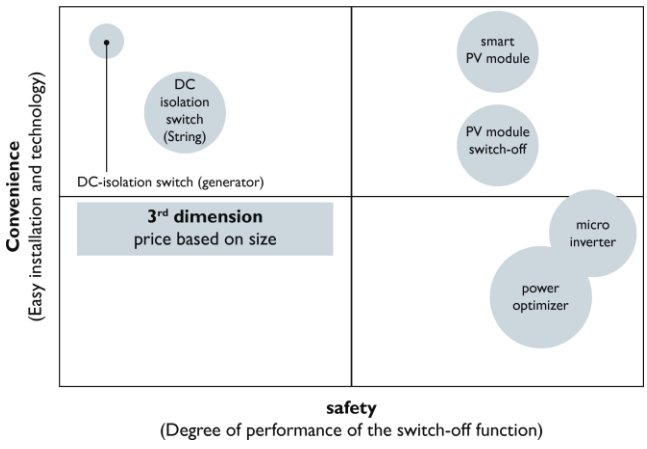

Figure 5 - Because it is not clear what parts of the solar power system are still live, the only alternative is to work on the system at night.

damaged voltage-carrying cables in a house is the rescue of a person. Such an effort is supported by the fireproof installation of the voltage-carrying cable and the clear marking of its route.

A tougher question is how clean-up work on a partially destroyed system can be carried out (Figure 5). The original cable route is usually known, but which parts of the string are still connected and which cables are damaged or even melted together in the cable shafts can scarcely be estimated. A system that has been that badly damaged constitutes a further fire hazard and must therefore be dismantled as quickly as possible. Even if the inverter has been switched off and other switching has been done to the system, the technician is often unfamiliar with the current and voltage conditions and is therefore hardly in a position to calculate the risk. This is especially true when there is still water from extinguishing efforts or weather conditions are poor.

Autonomous recognition of proper function

Figure 6 - The technical implementation methods require different levels of investment and result in different levels of safety.

Various switching mechanisms for solar power systems are currently available and vary in cost and level of safety. Central solutions that are mounted once for each system prove to be the cheapest, but offer the lowest levels of safety. The highest protection can be had from microinverters that generate AC directly at the solar module. They reduce voltage one module at a time to a safe level or switch the modules off individually (Figure 6). Microinverters are primarily suitable for systems that are partially in the shade or those with many modules of varied orientation.

The approach of switching off solar modules directly or placing switching apparatus with each module is an economical one. The switching apparatus should also autonomously be able to detect proper solar power system functioning so as to provide for a high degree of safety in the case of partially damaged systems. If the surroundings are not unambiguously safe, the solar module in question must automatically be shut down. Intentional shut-down of the solar power system for maintenance purposes could then be performed using the normal

inverter switching procedure. The system would then follow the central switching procedure module by module, and the maximum possible voltage would only be that of the individual module, which is at the safe level of about 40 volts (Figure 4, right). At the same time, the solution described produces a safe environment for workers when the connection of the house in question is switched off at the main fuse.

Summary

Inverters automatically react to the absence of the network and shut down. Why should solar modules not do the same thing and thereby make the entire system safe? Such switching apparatus would autonomously ensure a safe environment, allow planned shut-downs for maintenance, and even facilitate initial system installation because high voltages would only be activated when the system has been completely assembled. Phoenix Contact is working on just such a solution.

For further information visit:
www.phoenixcontact.co.uk

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