

The missing link

Photovoltaic installations need connectors that can stand up to the challenge. By **Frank Rosenkranz**.



As fossil fuels become more scarce and expensive, the eyes of the world are turning to renewable energy. Carbon free technologies, such as photovoltaic (PV) power installations, are booming.

This translates into tougher requirements for components: low efficiency or panel failure might be a nuisance with domestic installations, but these are unacceptable when it comes to large scale power generation.

However, PV technology is still developing and thin film PV panels offer an attractive way of converting solar energy into electricity. The downside of thin film panels is a lower level of efficiency when compared to crystalline silicon

panels. While thin film panels range from 6 to 12% efficiency, most crystalline panels yield an average of 15% efficiency. As a result, it is important to prevent any deterioration in efficiency during operation. This was the starting point for Tyco Electronics' second generation PV interconnection system.

Pioneering solar panel installations were often equipped with connector and cable solutions taken from other field applications. While this offered a practical solution, the specific operating conditions of PV installations presented a unique set of challenges.

Solar connectors are exposed to harsh environmental influences and, over an expected

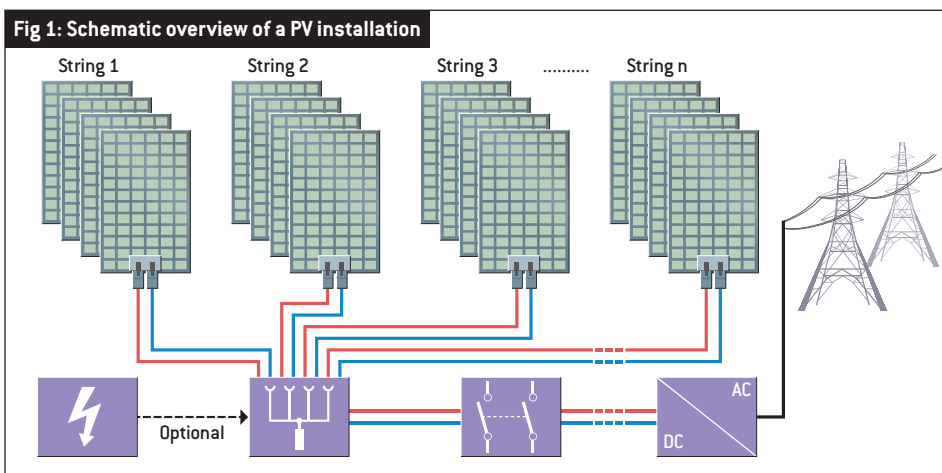
panel lifetime of at least 25 years, they must withstand extremes of temperature. Such wide temperature changes cause relative movement between the connector pin and socket, which results in fretting corrosion. If the connector pins are made from tin – as is sometimes the case – the development of an oxide layer increases contact resistance – impacting panel efficiency and often resulting in panel failure.

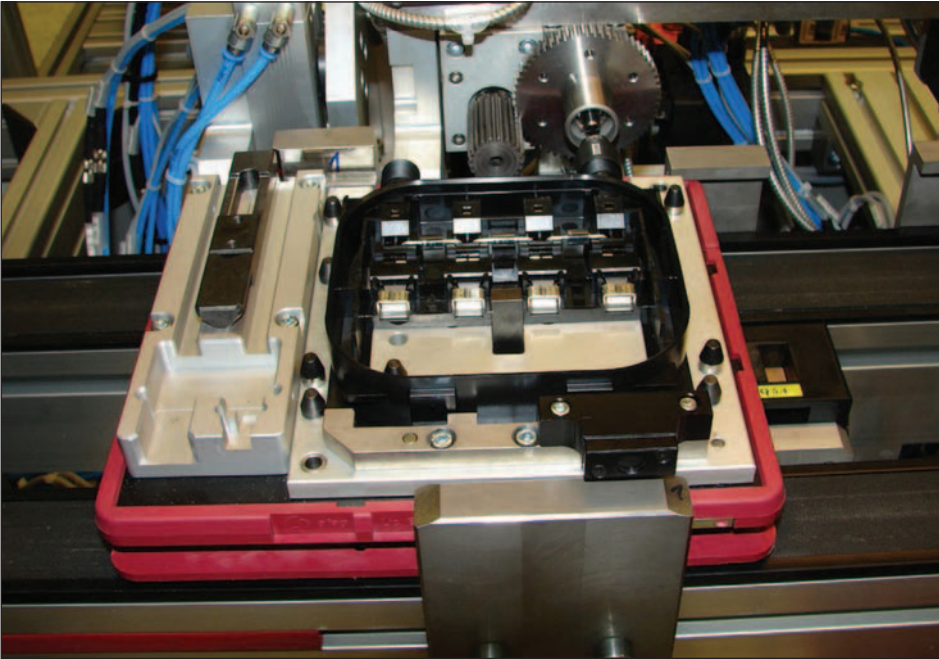
In fact, the requirements of solar panel interconnection are so specific that Tyco's PV R&D staff initially drew a blank when they searched the corporation's product database looking for a suitable solution. The closest product was a single pole automotive connector. Unfortunately, this connector was designed for 0.75 mm² wire, used a cable with single insulation and was designed for low current levels. By contrast, PV panels require a cable of up to 6 mm² and double insulation in order to cope with currents of up to 25A.

The cable required for a PV application was too big to fit the automotive connector's terminal. Add to that the flat profile of the solar module cable and there was no match available from the company's existing product range. Tyco's engineers decided they needed to design a new product to address these challenges.

Their efforts resulted in the PV specific SOLARLOK interconnection system. Instead of using tin contacts, the IP67 connector range features silver coated contacts: the silver oxide

Fig 1: Schematic overview of a PV installation





that results from fretting corrosion is an electric conductor.

As the complete PV array interconnection system is exposed to harsh environmental conditions, there is little point in optimising single components. If a solar power station's initial efficiency is to be maintained over its lifetime, a consistent high performance interconnection system is needed. This comprises:

- a scalable junction box platform with two to six rails and blocking diodes for serial or parallel



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interconnection of crystalline and thin film PV panels;

- cable couplers (male and female);
- T-branch connectors;
- dc/ac inverter receptacles;
- IEC 60228 Class 5 cable;
- main switch with 60A current carrying capacity and integrated overvoltage protection to separate the complete PV array from the inverter; and
- application tooling.

The system is designed for fast installation during panel production, with set up on site. Features include polarity keyed housings, fully shrouded contacts, reliable high cycle life and 'squeeze to release' connections.

Highly refined crimping technology is an important pillar of long term reliability. Through its global application tooling division, Tyco Electronics provides tools to ensure the formation of cold welded microjunctions during crimping. The contact used in SOLARLOK connectors originates from a proven design for industrial machinery – but has been modified to suit a another complex requirement. While the front of the socket contact has to show sufficient tension, the rear must be soft enough to avoid crack formation during crimping. Tooling and crimp design are closely interdependent areas – ensuring the integrity of crimping joints is at the level of a perfect solder joint, but without the need to X-ray each individual joint.

Thin film PV panel technology poses another specific challenge. Because panel efficiencies are lower, the capital cost must be lower to help ensure an adequate return on investment. But lower capital cost cannot compromise long term reliability. To help ensure reliability over time and under extreme conditions, Tyco has developed special junction boxes for thin film panels.

One key feature of the boxes is the blocking diode between the rails. This crucial safety element addresses a specific property of solar cells – if a cell fails, it will convert from a power supplier to a consumer – effectively draining energy from other cells. This, in turn, heats the malfunctioning cell and the resulting temperature can destroy the panel. The blocking diode prevents this by isolating the malfunctioning panel section.

The importance of attention to technical detail is underpinned by another example. One potential long term problem with PV installations is dampness creeping into gaps in the system. Tyco has developed a reliable technical solution to avoid leak paths between a polyolefin (PO) cable wall and the junction box.

PO is the material of choice for cable walls as it shows high resistance to UV radiation, humidity and ozone. Electron beam cross linking of PO has proven to be the superior technology in this application. However, electron beam cross linked PO will not normally form a bond with the polyphenyloxide (PPO) used for the box housing. To facilitate the use of the two best materials for the application, Tyco has used its plastics engineering knowledge to develop the intellectual property that is key to interlinking PO and PPO and thus establishing a watertight bond between box and cable.

While SOLARLOK connectors have initially been designed for use in PV applications, the fact that they are cost effective, reliable and waterproof will extend their use to other demanding applications.

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