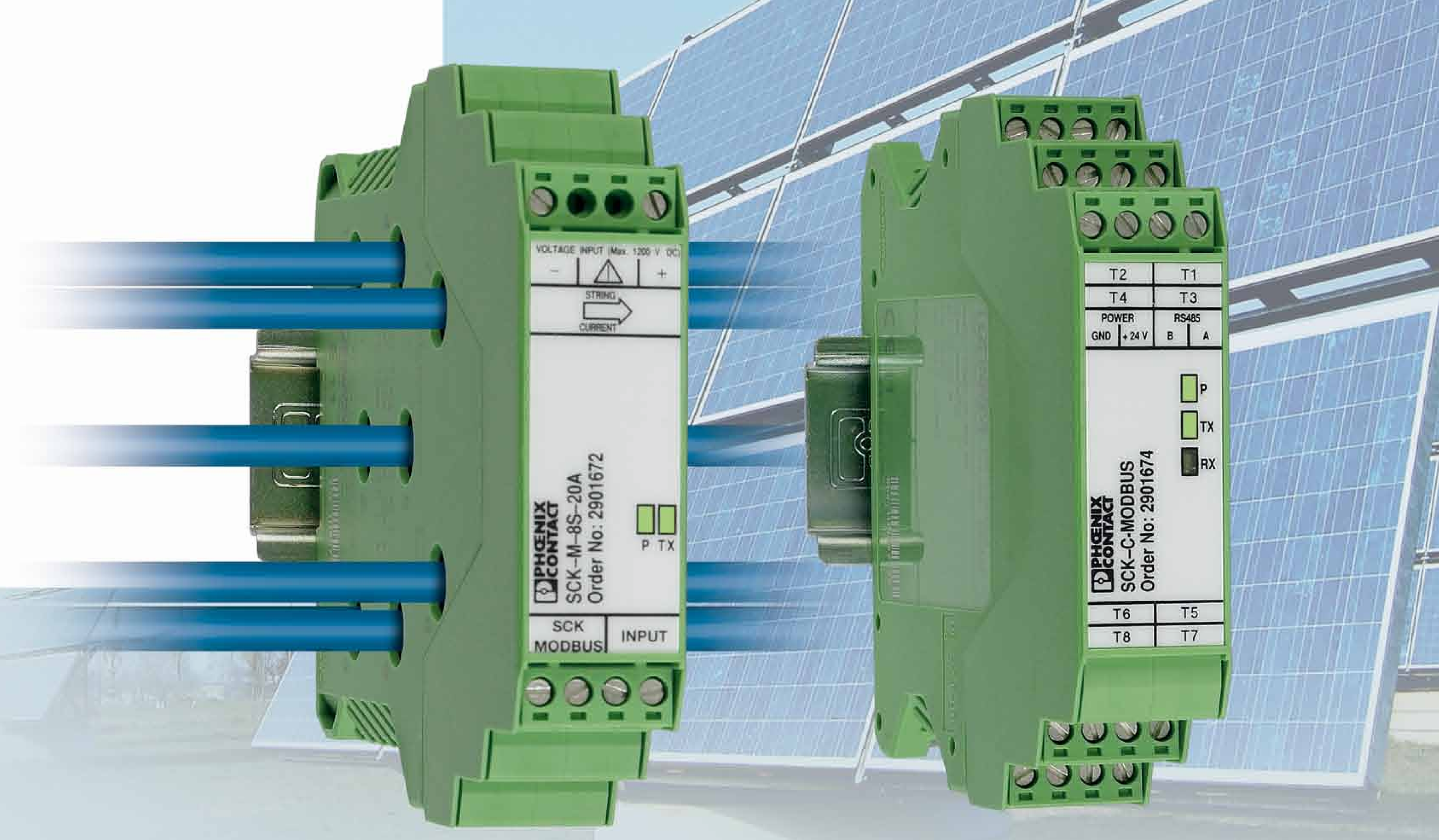
String current monitoring in practice – a progress report



Lotte Ehlers, Andreas Senger
PHOENIX CONTACT Electronics GmbH
Dringenauer Straße 30
D-31812 Bad Pyrmont, Germany

Tel.: + 49 5281 9-463337
Fax: + 49 5281 9-463399
lehlers@phoenixcontact.com
www.phoenixcontact.com

1. Introduction – progress report from a 2 MWp PV power station in Murcia, Spain

In recent years, photovoltaic installations have been further extended to take the form of systems on the roofs of buildings and ground installations, with increased MWp power. Generally, systems of this size are not continuously monitored by the operator. Errors and reductions in power are therefore often not promptly detected.

Common causes of errors or output reductions in PV systems include, for example:

- Damage to modules or cabling
- Contamination and shadowing
- Loss of power from the PV modules (e.g., ageing)
- Theft

Undetected errors reduce the current yield and thereby also the return for the system operator. Effective system maintenance and monitoring keeps running costs low and ensures that maximum yield is achieved.

The progress report from a 2 MWp PV power station in Murcia, Spain, sheds light on the following aspects:

- Common output reductions in a large PV power station
- Representation of output reduction via string current monitoring
- Response time and type to different errors
- Increased monitoring functions using a suitable monitoring concept

2 MWp system in Murcia, Spain

2. Measuring technology and structure – the SOLARCHECK PV string monitoring solution

String current measurement:

The current generated by a solar module is directly related to the total insolation. An insolation sensor in the vicinity of a PV module provides an indication of the expected current yield in relation to the error-related deviation. Contact-related errors are also noticeable as altered currents.

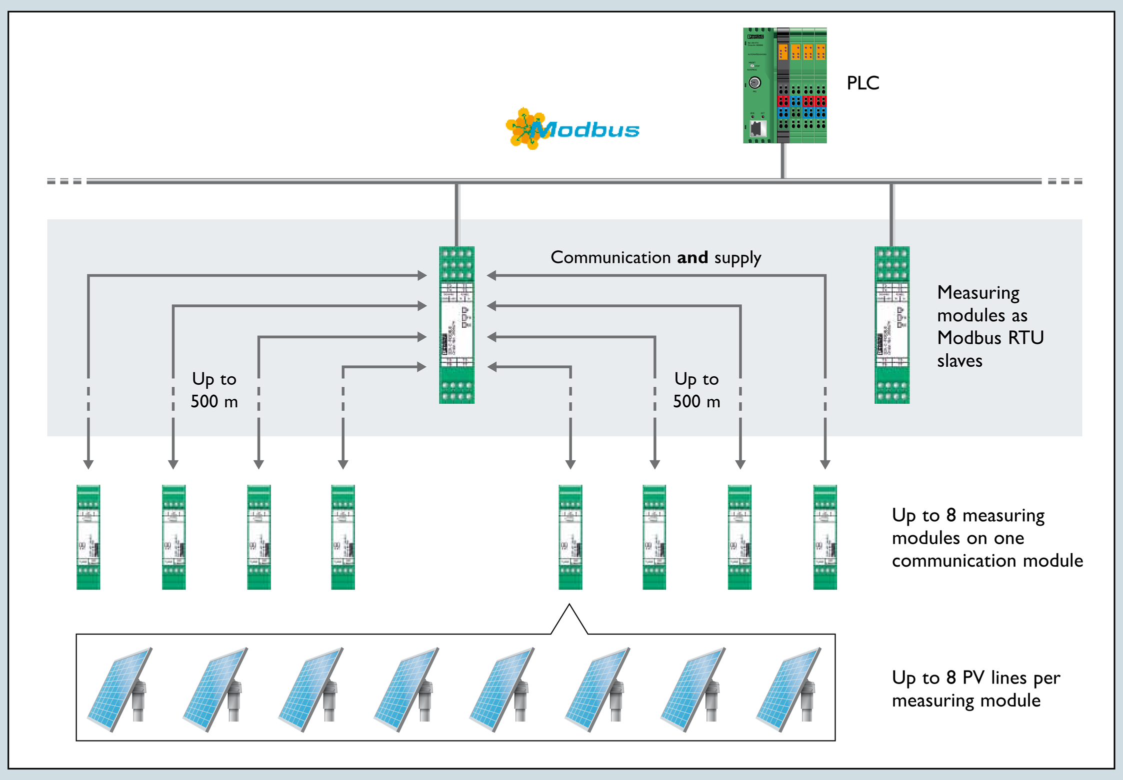
The modular structure enables reliable coverage of large distances and clear assignment of data to the appropriate strings.

Connection to the Murcia application:

- 64 measuring modules for 512 strings
- 16 strings per stringbox (2 measuring modules per stringbox)
- 1 communication module for every 2 measuring modules in each stringbox

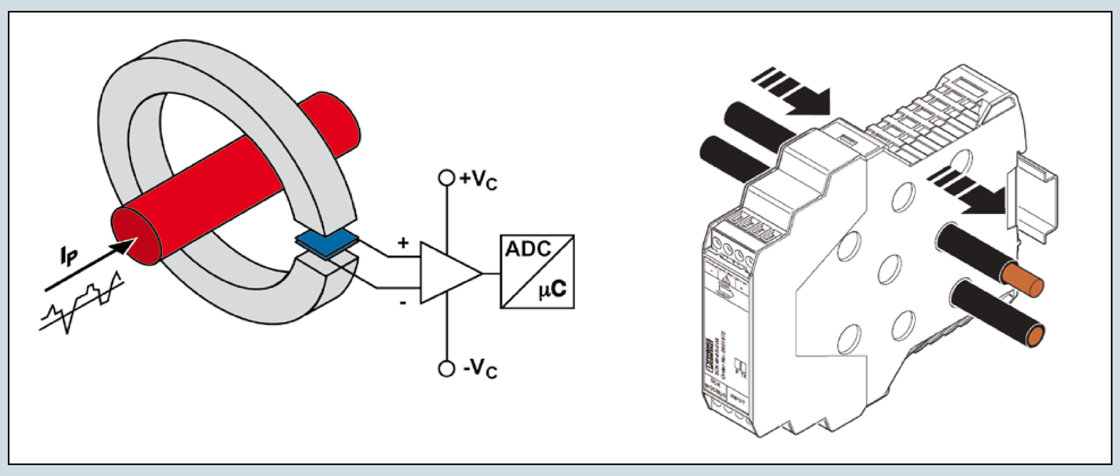
Measuring technology:

- 8 measuring channels per measuring module, according to the Hall sensor principle
- The string cabling is routed through the measuring channel, measuring is contact-free.



Solarcheck networking concept

- Each measuring channel is surrounded by a magnetic core. This absorbs the magnetic field generated, through which the current from the string cabling flows.
- The Hall sensor, positioned vertically in a gap in the magnetic core, generates a corresponding current signal according to the strength and direction of this magnetic field. This signal is thereby in proportion to the string current and is used for evaluation purposes.

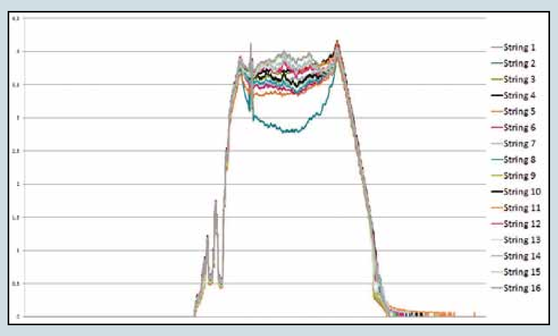


Current measurement principle using a Hall sensor

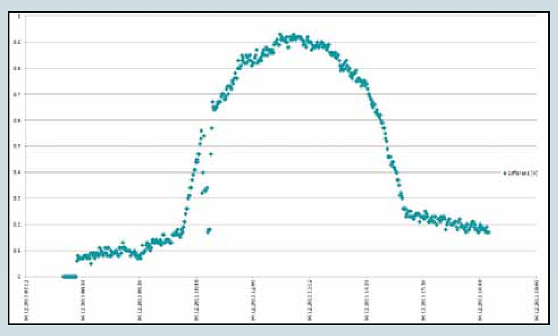
3. Error characteristics and how to respond – detected by the permanent string current monitoring

1. Errors which have a minimal effect on operation.

Example: individual strings with reduced power



Significantly reduced power from string 2

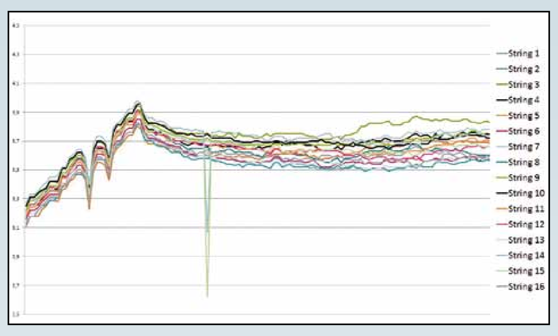


Difference in currents between string 2 and 4

Impact of the errors: The system continues to operate, minor financial losses

Response: 72 hours at the most, usually within 48 hours

Conclusion: without a monitoring system, such errors are very hard to detect, as they do not cause an alarm to sound based on the system connection and the alarm thresholds on the inverter.



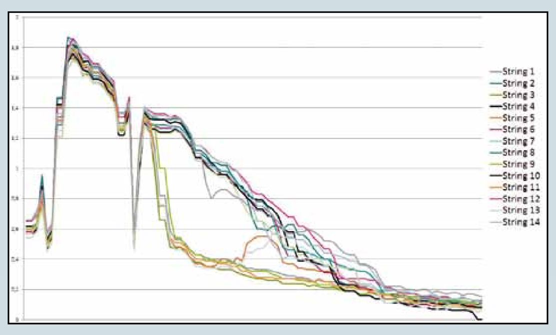
Brief interruption to two strings, the incident can be used for inverter error analysis.

Minor malfunctions and reduced output are only eliminated with moderate expense, e.g., through regular optimized checks using PV string current monitoring.

2. Errors which sometimes affect operation.

Examples:

- Tripped string fuses
- Inverter failures (scale: 10 kW inverter in 1000 kW system)
- Premature switch off of system components due to suboptimal inverter design



Switching off several strings at an early stage

Impact of the errors: the system (partially) continues to operate, minor financial losses

Response: 24 hours at the most, the benefit of immediate action is usually compared with the cost of potential losses.

Conclusion: string fuses that have tripped should not have to be replaced immediately; instead, fuses should be replaced regularly as a part of daily checks.

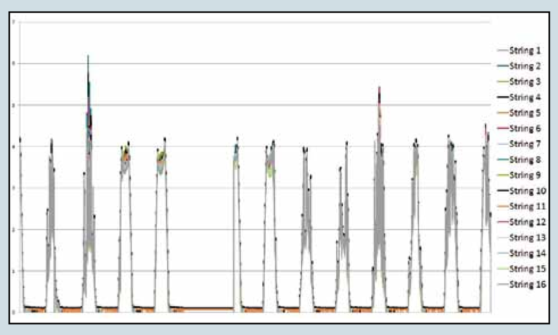
Serious errors, such as inverter failure or numerous tripped fuses are partially also detected by inverters and must be corrected immediately.

Additional PV string current monitoring is highly advantageous for improved analysis of error causes.

3. Errors which result in total failure.

Examples:

- Defective central inverters
- Defective supply / mains failure



Total failure on 12.06.2011

Impact of the errors: system stops operating, maximum financial damage

Response: immediate

Conclusion: even total failure can be detected in various parts of the system, the cause, however, is not always so easy to pinpoint.

PV string current monitoring improves error analysis significantly by:

- The option of displaying previous data with improved granularity, to locate the problem more effectively.
- Differentiated evaluation of currents and voltages to isolate errors, so that targeted and therefore inexpensive repairs can be implemented.

4. Summary

The example case demonstrates that maximum yield is achieved by effective system maintenance and monitoring, and ensuring running costs are kept to a low.

In the case of a PV system of this size, it is both advisable and financially beneficial to monitor the system beyond the specified functions of the inverter. Even actions which have a minor impact on the effectiveness of the system can be clearly detected and promptly rectified.

String current monitoring provides precise information on system behavior during continuous operation, meaning that appropriate maintenance can be performed. If inverter structures or connections are not optimized, these can be detected and rectified.

The operating information provided on the strings significantly improves troubleshooting, causal research, and detecting where failures and reduced output are occurring.

Further data from other systems (not used in detail here):

- Marche, Italy (500 kWp)
- Basilicata, Italy (1.67 MWp)
- Emilia Romagna, Italy (2.9 MWp)
- Avila, Spain (2 MWp)

This data confirms the conclusion reached:

the ability to react faster and improved troubleshooting notably increases system effectiveness. A statement on the monetary aspect or on the reduction of the payback period of a PV power station cannot yet be made at this point in time, but is nevertheless the subject of further investigations.

Expression of thanks

Particular thanks must be expressed to the operator of the system described, Grenergy Renovables, for making the data available and also to Marta Mieres Barcena at Phoenix Contact in Spain for her help with mediation and translation.

With kind support from: Grenergy renovables

PHOENIX CONTACT
INSPIRING INNOVATIONS