Application Note

Megger Tools in PV Applications

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Photovoltaic (PV) systems are a rapidly growing segment of the electrical industry. Arrays are being installed in a variety of locations and electrical contractors need tools that will meet the needs for testing and maintenance activities.

Arrays located in North America are commonly designed and installed with voltages up to 1,000 Vdc on rooftop arrays and 1,500 Vdc on ground-mounted arrays. In addition, many systems are interconnecting with the utility at distribution and transmission voltage levels.

To meet the increasing needs of technicians for PV applications, Megger has a suite of tools perfect for solar technicians to use in all phases of the installation, operations and maintenance of PV arrays. These tools are used in the field at all stages of installation, operation and maintenance.

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Performance Verification

To properly verify the performance of a PV array, multiple tests must be run and the corresponding data points collected. The combination of the Megger DCM1500S digital clamp meter and the PVM210 irradiance sensor, technicians can measure the pertinent values and record the data for verification.

PVM210 Irradiance Sensor

The DCM1500S is the newest addition to the Megger line of electrical testing equipment. This tool allows technicians to safely and effectively measure up to 2,000 Vdc and 1,500 Vac and amperages up to 1,500 A on both ac and dc circuits. The DCM1500S meets the IEC61010 requirements for CAT III 1,000 V and CAT IV 600 V applications. In addition, the DCM1500S comes standard with a temperature probe that technicians can use to measure the operating temperature of the modules.

The voltage output of PV modules is dependent on temperature. PV modules have an inverse relationship with temperature, meaning as the temperature increases, the modules' voltage decreases. The temperature probe on the DCM1500S allows technicians to measure and record the operating temperature of the PV modules so they can then use this information to calculate the expected output voltage of the array. Then, by using the dc voltage measurement feature, technicians can measure the actual voltage to compare to the expected. The exact calculation methods are not covered in this app note, but you can find additional resources on the Megger website and additional resources at the end of this paper.

To complete the dc power measurement, the Megger PVM210 irradiance sensor can be used in conjunction with the amperage feature of the DCM1500S. The amount of current produced by a PV module is dependent on the intensity of the sunlight, or irradiance, striking the array. The PVM210 can quickly be placed in the same plane of the array to measure and display the irradiance. The meter should be placed at the same tilt and orientation as the array, generally done by placing the bottom of the meter on the module's frame. This will allow the meter to

display the same irradiance as the modules and provide the technician with the most accurate data.

The current produced by a PV module is directly proportional to the irradiance. The standard test conditions for the irradiance for PV modules is 1,000 W/m2. Therefore, to determine the expected amperage output from a PV module, divide the irradiance recorded by 1,000 to determine the expected percentage of the module's maximum power current, Imp, as reported on the spec sheet. For example, in the image shown, the PVM210 shows 845 W/m2 striking the array. Therefore, the amount of current actually produced at that time would be 845/1000 or 0.845 or 84.5% of what the spec sheet reports.

DCM1500S Digital Clamp Meter

The amperage-reading capabilities of the DCM1500S can be used to validate the actual current values from the expected values. The ability for the DCM1500S to measure both ac and dc current values up to 1,500 A with its clamp meter means it can be used at all points in nearly every array from an individual module, the output of combiner boxes, inverters and ac panelboards.

To complete the verification process, technicians will need to collect the operating voltage and current values from the output of the inverter(s). These values, along with the correction factors such as the inverter's efficiency, voltage drop for dc conductors and the soiling factor of the array, will allow technicians and engineers to validate the output of the array based on the actual environmental conditions recorded.

Additional DCM1500S features such as the MC4 quick-connect meter adapters, the non-contact voltage detection and bluetooth recording capabilities provide field technicians with the ability to quickly, accurately and safely collect the data points required during the performance-verification process. The optional PV test lead kit also provides a convenient adapter from the DCM1500S probe input to older MC3 style quick connects for older PV array testing.

The DCM1500S also pairs with mobile devices via Bluetooth and the Megger link app. This Feature aids in the data collection process by recording data

DCM1500S Bluetooth Recording

readings continuously or allowing technicians to record individual readings as they move through the system. All of the meter functions can be recorded and downloaded into a CSV file for future reference.

It should be noted that many arrays, especially rooftop arrays, include module-level power electronics (MLPEs) wired directly to PV modules. These power electronics can either be dc-to-dc converters or microinverters. It is important for field technicians to identify the MLPE form and function to accurately account for the voltage and current output as they relate to the performance-verification process.

The full depth of establishing a performance-verification process and the calculations required is beyond the scope of this application note, but we encourage you to visit our website for more information, resources and videos on the use of Megger tools for these PV-specific tasks. In addition, the Sunspec Alliance has produced two guides, Commissioning for PV Performance and PV System Performance Assessment, that can assist in establishing and executing the tests during commissioning and operations.

PV System Maintenance

Operations and maintenance teams need to rely on these same tools as well as others to help troubleshoot problems within the PV arrays.

The thermal camera, TC3231 provides field technicians a good way to identify potential problems within the array itself, or inside any piece of electrical equipment where poor connections may cause poor performance or even be a source of fires. The camera features a temperature range of -20° C to 300° C, making it valuable for discovering hotspots within individual modules, diodes that have failed in module junction boxes and poor electrical connections.

The handheld camera is easy to operate and allows the technician to maintain a safe distance from the components being tested. An integrated SD memory card allows up to 6,000 images to be saved for

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TC3231 Thermal Camera

future evaluation and data recording. The camera can be adjusted for image blending with the thermal readings, time display for data recording and the ability to adjust the emissivity to gain the most accurate readings based on the devices being measured.

The final component of Megger's solar test kit is the MIT2500, a handheld insulation resistance tester. The MIT2500 is a multifunctional instrument, including voltage, resistance and capacitance measurement capabilities. However, its primary function is as an insulation resistance tester which identifies when hazardous ground faults are present due to compromised wires. Insulation resistance testing should be done prior to energizing your array at the commissioning stage as well as during routine maintenance checks to monitor the integrity of your conductors. Not detecting these faults quickly can cause major delays and costly damages with the risk of shock, fires, property damage and more.

The MIT2500 has a wide range of testing voltages from 50 to 2500 V, making it applicable to all PV systems. Tests can be performed on the PV source and output circuits, inverter output circuits and utility interconnection equipment rated less than 25 kV.

A megohmmeter's insulation resistance test measures two components: current leakage **through** the insulation and current leakage **over** the insulation material. The current leaking through the insulation, without the surface leakage, is the true measure of the safety and quality of the conductors and insulation you're testing. The Megger MIT2500 is the only handheld megohmmeter with a guard terminal which eliminates or greatly reduces the effect of surface leakage on the test results. The guard terminal is an important component to help field technicians collect better test data and allows the tool to calculate and remove any surface leakage that occurs during normal testing procedures.

The data-collection feature built into the MIT2500 provides technicians an easier method to collect the test results for further analysis and documentation on the status of the conductors at the time of the test.

MIT2500 Insulation Resistance Tester

Megger has developed numerous resources to assist PV system technicians and electricians with the most up-to-date information on the use of its tools in PV-specific applications. To learn more about all of the tools presented here and additional training resources, please visit us.megger.com/applications/renewable-products.

Resources

Commissioning for PV Performance
sep.yimg.com/ty/cdn/yhst-77580361692593/SunSpec_commissioning_guidelines.pdf

PV System Performance Assessment
sunspec.org/wp-content/uploads/2015/06/SunSpec-PV-System-Performance-Assessment-v2.pdf

Megger Renewables Page
us.megger.com/applications/renewable-products

Mayfield Renewables System Sizing Blog
mayfield.energy/blog/pv-string-size

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