GOSSEN METRAWATT

Safety through Competence

Mains Interference
Plagues Solar Parks Too

Technical Article on Power Quality

GOSSEN METRAWATT's monitoring system doesn't miss a single fault.

The Tauberland Solar Park in Wertheim, Germany, went online in 2010. Equipment completed during the East and West construction phases generates a total of roughly 22 MWp (peak) and is currently supplying the equivalent of 9000 households with electrical power. With a planned power rating of 72 MWp after the final construction phase, the solar park is not only one of Europe's largest photovoltaic systems, it's also one of the most modern and effective of its type (see figure 1).

Figure 1: Tauberland Solar Park – Aerial View

Converting sunlight into electrical energy at Tauberland should result in reduced CO2 emissions amounting to 5600 tons per year. This quantity corresponds to the annual emissions generated by a medium sized, coal-fired power plant. The system covers an area of 850,000 square meters (more than 9 million square feet), and includes roughly 180,000 modules from various manufacturers (see figure 2).

Figure 2: Tauberland Solar Park – Photovoltaic Panels

Figure 3: Tauberland Solar Park – 110/20-kV Transformer

Approximately 4000 kilometers (2500 miles) of communication lines and power cables are laid throughout the system, connecting modules and individual stations with one another.

A 110/20 kilovolt transformer feeds power to the high-voltage grid which belongs to operating company EnBW. The transformer has a rating of 40 MVA and replaced a provisional solution in 2010. Current planning specifies that a total of two transformers will be used to feed power to the grid after completion of the final construction phase (figure 3).

Project costs amounted to roughly € 100 million and have been financed by government organizations as well as private investors.
Feeding power to the grid from the West construction phase is handled by four inverters with a total power rating of 8 MW. (Figure 4).

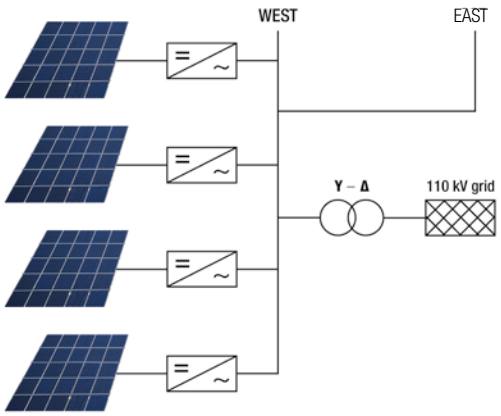

Figure 4: Tauberland Solar Park Schematic Plant Diagram

The inverters are equipped with relays for voltage monitoring. If the limit value of ± 10% is violated, the relay is tripped and disconnects the inverters from the grid.
The year 2011 was distinguished by high monetary yield, but was also characterized by numerous inverter failures.

Especially on days with variable cloudiness, shutdowns occurred sporadically and randomly at all four units of construction phase West. It took up to 5 minutes before the inverters went back to work. The system was at a standstill during this time and the operating company suffered profit losses. The financial damage amounted to about € 400,000 per year.

Two independent authorities were commissioned to perform measurements in order to pinpoint the causes of the shutdowns. Amongst other instruments, the HBS-Box, a portable power disturbance analyzer manufactured by HBS Steuerungstechnik, together with primary components including GOSSEN METRAWATT's MAVOSYS 10 and MAVOWATT 70 power disturbance analyzers (see figure 5a, b) were used for analysis purposes.

Figure 5a: Power Disturbance Analyzer Mavowatt 70

Figure 5b: Power Disturbance Analyzer Mavosys 10

After conducting a series of measurements at the medium and low-voltage levels, the experts discovered the cause: the inverters were influencing each other reciprocally. Inverter operation was causing mains pollution. Above all the 15th and 25th harmonics were very pronounced.

Total harmonic distortion was 4.4%, which is considered a fairly high value nowadays (figure 6). With the help of the above mentioned power disturbance analyzers, it was determined that a resonant circuit occurred for which impedance reached its maximum at roughly 1000 Hz (resonant frequency) due to transformer inductance and cable capacitance. As a result of feeding harmonic current to the grid, there was a very high level of 20th harmonics.

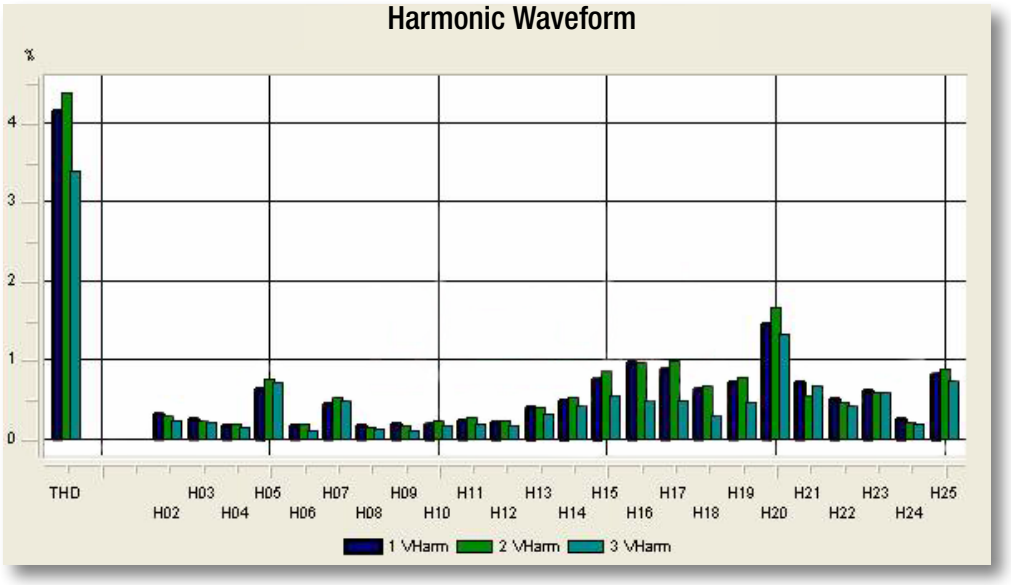

Figure 6: Overall VTHD as Percentage (recorded with HBS-Box and Mavosys 10)

As a result of high current values and high line impedance, the TRMS voltage value for the entire system exceeded the limit threshold, the protective device was tripped and the inverters were disconnected from the grid. After the voltage level had dropped back down to the specified level, the inverters were connected to the grid once again. Depending on weather conditions, the inverters were disconnected from the grid several times a day (see figure 7).

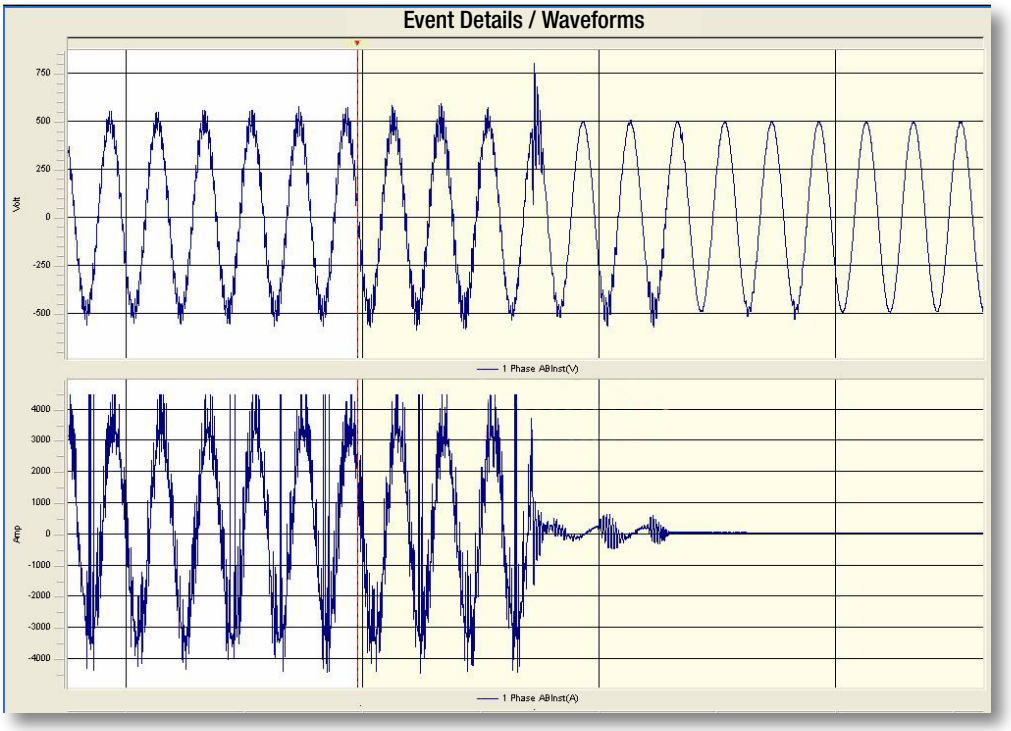

Figure 7: Characteristic Voltage and Current Curves Before and After Shutting Down the Inverters

After the cause of the failures had been determined, Condensator Dominit from Brilon installed a passive harmonic filter with total compensation power of 174 kVAr. The filter is comprised of several damped capacitors with neutral point connection (see figure 8).

Figure 8: Passive Harmonic Filter from Condensator Dominit

These frequency-sensitive resistors in the electrical resonant circuit generate a narrow-band “absorption effect” for the currents of the undesired frequencies and quench them. At the same time, the impedance maximum is attenuated. As a result, harmonic currents fed to the grid are reduced to a minimum and harmonic voltages are kept within “normal” values.

Immediately after placing the filter into operation, voltage quality improved and the TRMS voltage value has remained within the tolerance range since the filter was installed. As predicted, the inverters with filter circuit remain uninterruptedly in operation and fulfill their purpose, namely feeding electrical power generated from solar energy to the grid whenever it’s available.

We wish the operators of the Tauberland Solar Park plenty of sunshine and trouble-free operation.

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