Case Study

Advantages of using High Resolution, Continuous PQ Recorder/Analyzer in Solar Farms

Overview

As there are more and more Wind Turbine and Photo Voltaic manufacturers for energy producing farms worldwide, there is a growing need for continuous PQ monitoring at the Point of Common Coupling (PCC). Monitoring PQ has technical, economical and legal implications.

Electrical parameters fluctuates continuously and depend on many factors such as wind and sun. Installing Continuous, high resolution recording and monitoring devices in PCC location enables the utility and/or the farm operators to ensure compliance with the grid requirements.

Experience shows us that many PQ events that are within the permitted range, can still be a source of problem to the energy producers and consumers which many times are a source for PQ investigation and thorough post event analysis.

The ideal way for analyzing the above abnormalities is the use of a Class-A PQA capable of continuously recording & retaining all network parameters for a long period of time at a high resolution, including waveform. This kind of PQA should enable the investigation and presentation of all electrical parameters based on the applicable industry standards. This PQA should serve as a "Black-Box" used in airplanes. It will record all data as mentioned above without the need of setting up triggers or thresholds.

In the following slides one can see few examples of data recorded by a continuous high resolution PQA recorder at a PCC location in Photovoltaic Farms. These measurements show anomalies that are still within the standards but thank to the specific Elspec PQA capabilities, these occurrences can be observed and analyzed

Example 1: Transformer taps changing

This example can be motivated by showing the RMS voltage changes, the change of THD and voltage waveform in the two different time zones below. (Illustration 1 & 2)

Illustration 1: RMS voltage change. Voltage THD distortion and Voltage Waveform during 1850 cycles.

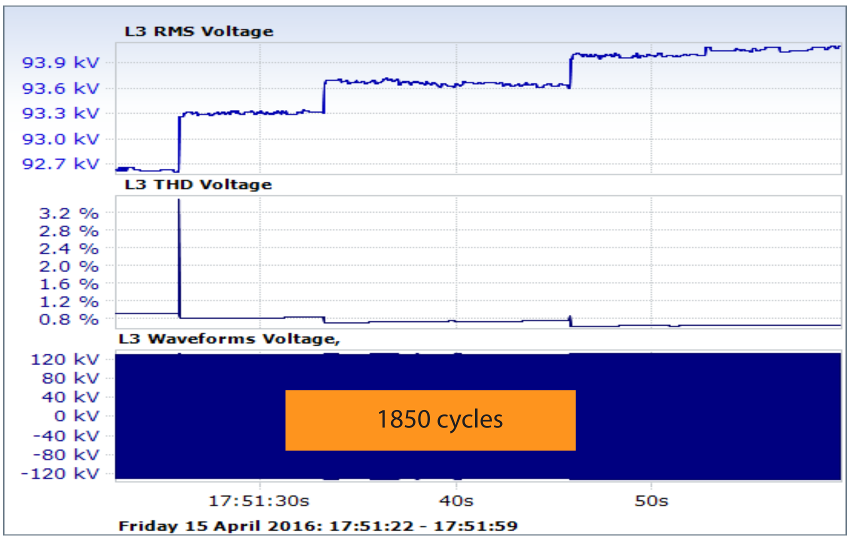
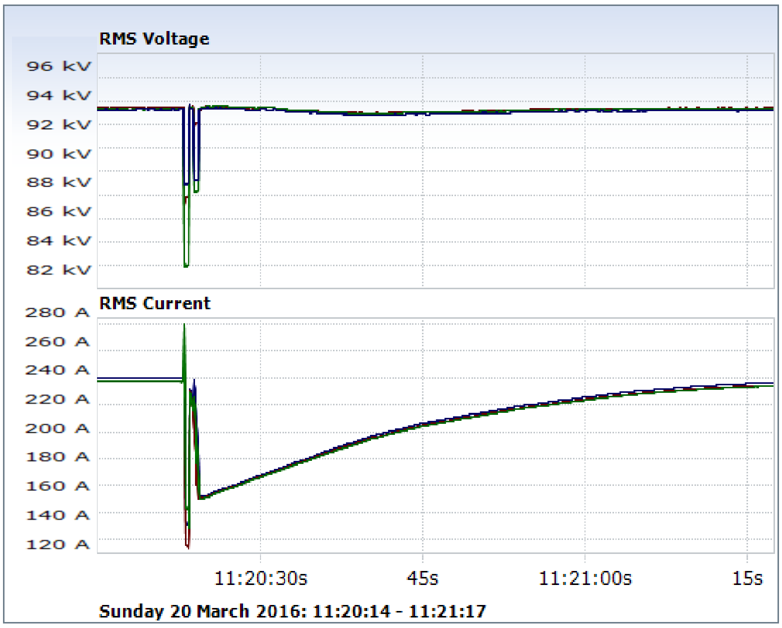


Illustration 4 : High Voltage and current change in photovoltaic system – one minute observation



In this illustration:

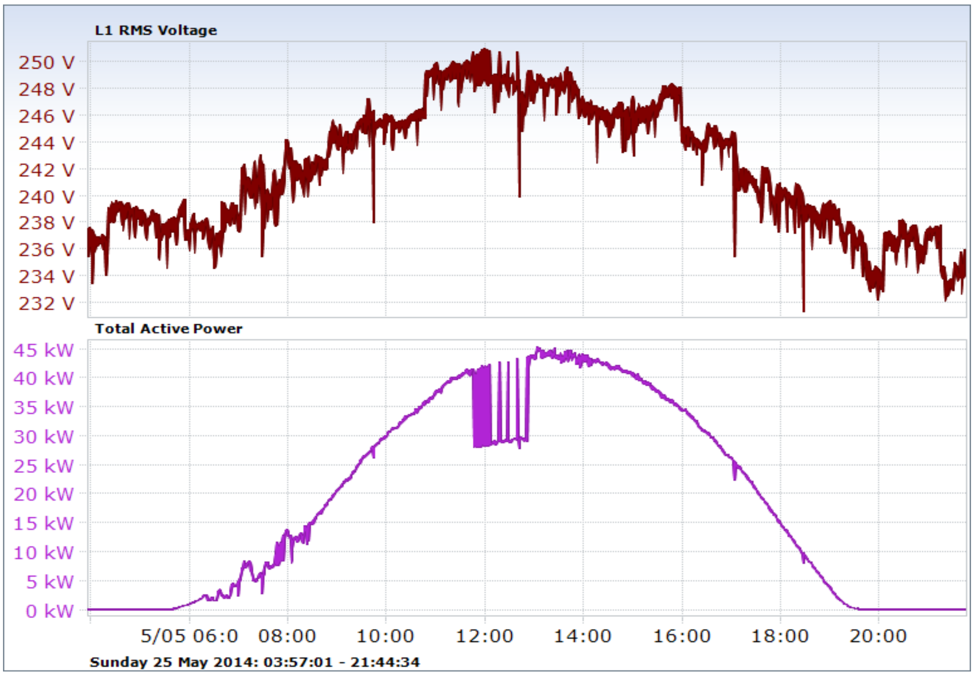
- After the first voltage drop, the current attempted to restore it's value to 240A per Phase but the second consequent voltage drop caused it to drop again to 150A, resulting in gradual restoration to 240A that lasted 53 seconds
- All Other available PQAs that do not have continuous high resolution recording are registering average values of 10/15 minutes as long as the values are within the standards. In these kinds of PQSs, only the event of the first voltage drop would have been recorded as it exceeded the 90% drop threshold. The second voltage drop would not have been recorded as it falls within the standards.

Conclusion: Using PQA with continuous high resolution recording is the only way to analyze the network's response to changes that occurred until the network stabilized again.

Example 3: Voltage changes as a result of problems in the photovoltaic system

This example illustrates the effect of the generated power (KW) on the voltage level in a 50KW photovoltaic system connected to a LV network. Daily fluctuations of power and voltage are shown in Illustration - 5. It can be observed that from 11:45 until 12:50 there are many fluctuations of power. In order to better understand the changes, we zoomed in to 5 minutes range as can be seen in illustration 6

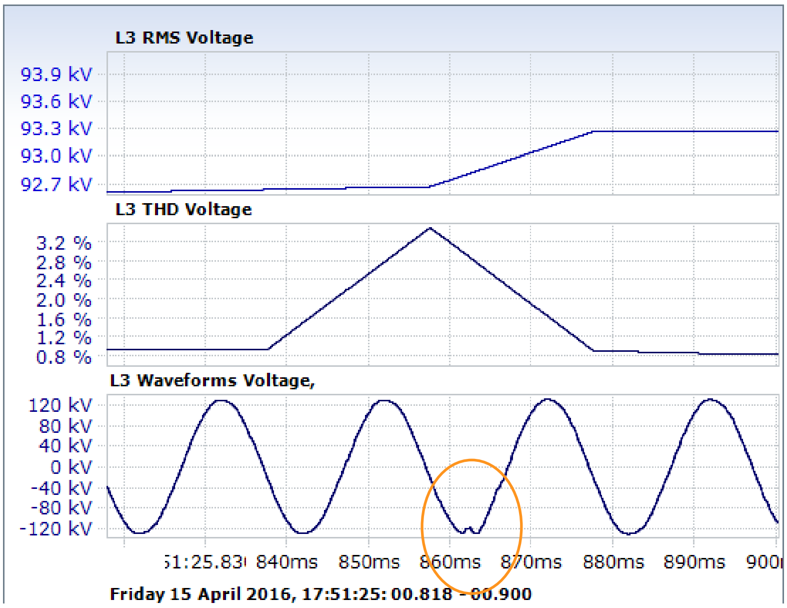
Illustration 5 : daily changes of power and voltage in a 50KW photovoltaic system



In Illustration 1:

there are 3 voltage raises following tap changing in the transformer.In the first tap change, the transformer stayed for 7 seconds and in the second tap change the transformer remained for 12 seconds.

Illustration 2 : Voltage RMS, THD & waveform changes in a 4 cycle's window



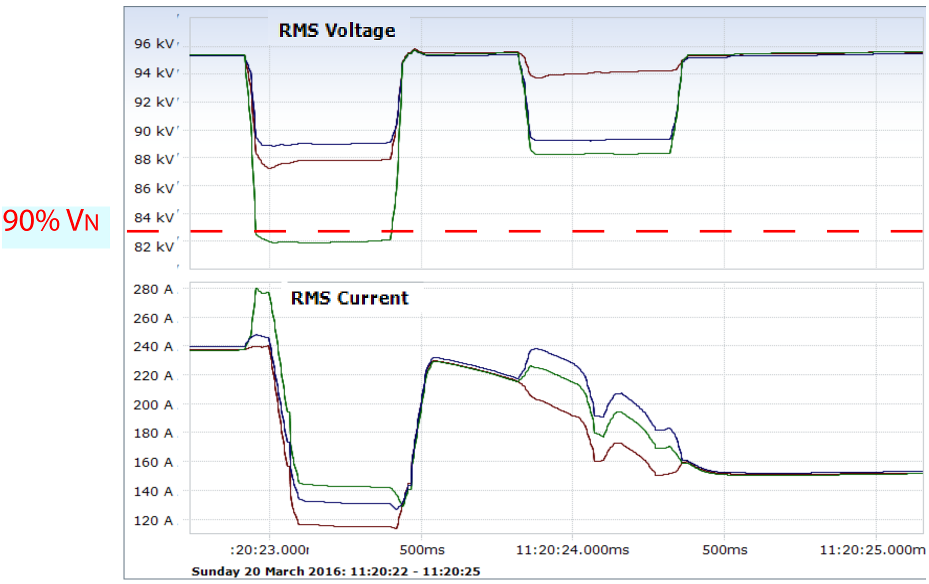
- We have zoomed into 4 cycles during the tap change from Stage 1 to stage 2.
- The distortion in phase 3 waveform can indicate a potential problem in the tap changer.

Conclusion:The above distortion is within the PQ standards range and therefore would not have been recorded by any other PQ analyzer that do not have continuous high resolution recording and retention of waveform such as the G4 Blackbox by Elspec. Using any other PQA will not facilitate the investigation and the follow up of such events.

Example 1: Consequent voltage drops

This example can be illustrated by recording 3 phase high voltages and currents of a photovoltaic system. In these measurements one can see two consequent voltage drops in two different time zones (Illustration - 3 & illustration - 4). The values in the graph are RMS values based on a cycle by cycle basis.

Illustration 3 : Voltage and Current changes in a photovoltaic farm recorded in HV during 3 seconds window

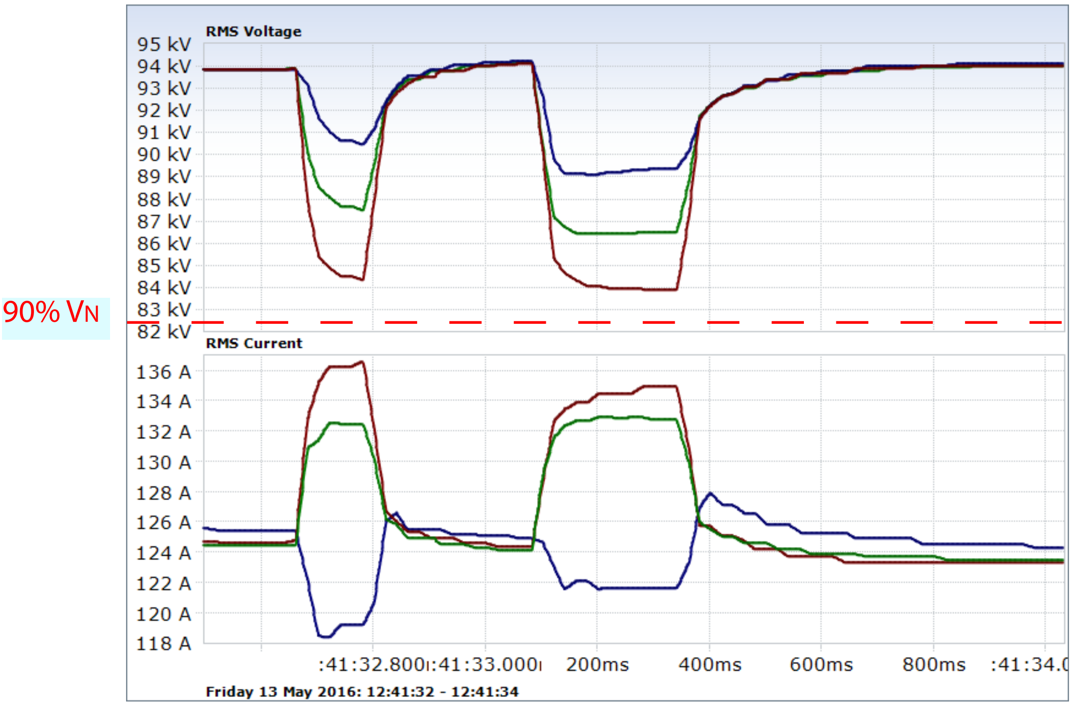


In this illustration:

- There are two consecutive 3 phase voltage drops (420 ms apart), each one for approximately 520ms.
- Only one phase exceeded more than 90% drop from the nominal voltage (reaching 52KV)
- During the first drop, the current also dropped by some 50% and returned to almost the same as it was before this drop.
- The second voltage drop did not exceed the 90% drop level; however IT SHOWS that during this period the current changed and continue dropping although the voltage drop did not exceed the permitted level.

Example 4: Photovoltaic system reaction to HV voltage drops that are within the standard.

Illustration 7: Registration of HV and current in a photovoltaic system during two voltage drops

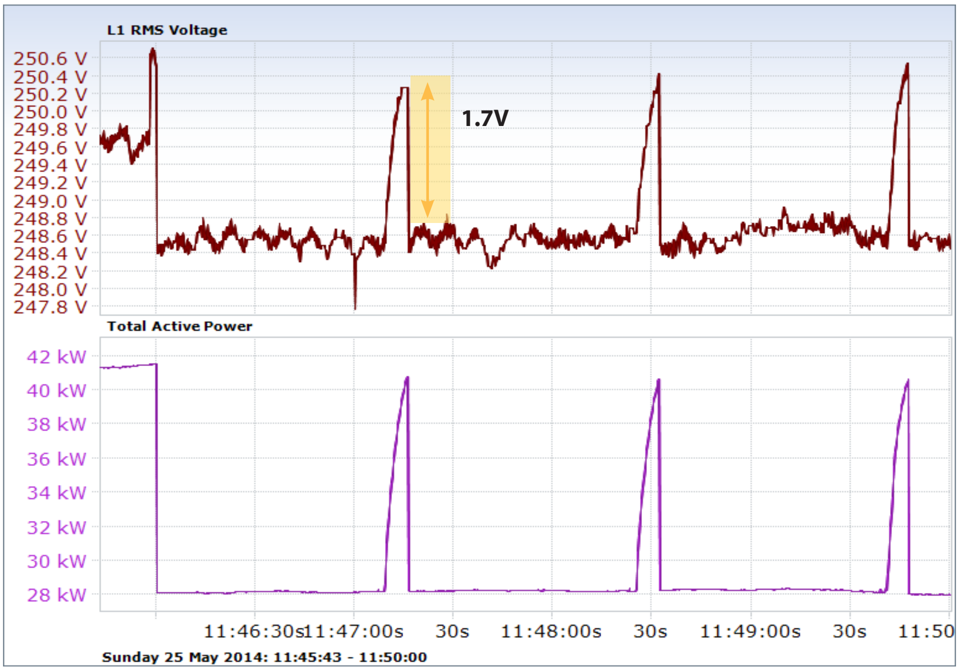


In this illustration:

- The following example shows the reaction of the photovoltaic system to High Voltage drops that are within the standards. These two voltage drops are generated by the utility side and are lasting for 150 ms and 270 ms respectively. In Illustration 8, we see 3 voltages and 3 currents in a 3 seconds window during which the voltage drops occurred.The appropriate system reaction to these short voltage drops can clearly be seen.

Conclusion: Only a continuous high resolution PQ recorder that is not triggered based can demonstrate that the system is working properly since the voltage drops are within the permitted standards and 10/15 minutes average data cannot show the fast system response to the voltage changes

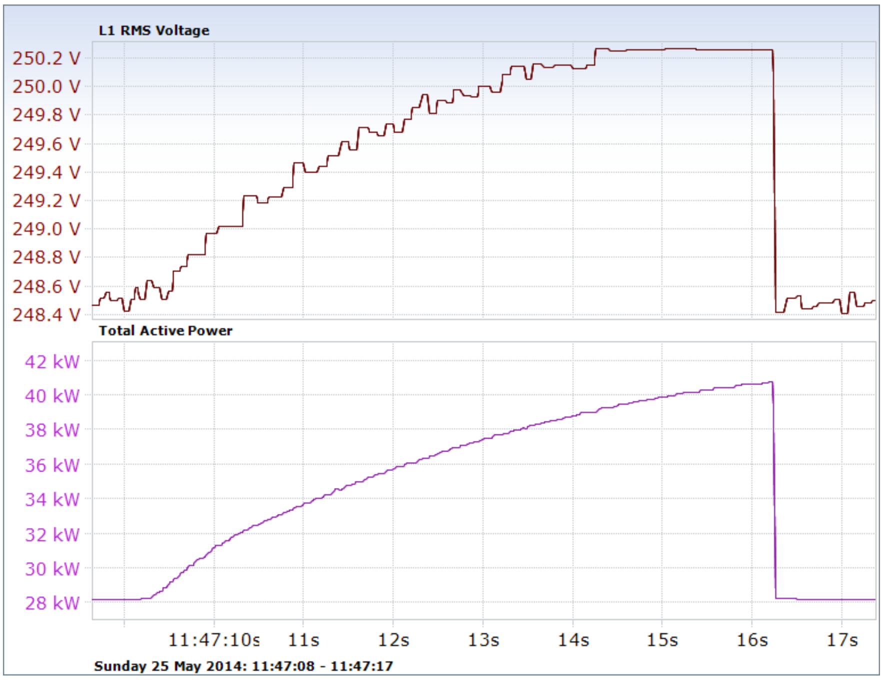
Illustration 6 : Power and Voltage fluctuations in a 50KW photovoltaic system (zoomed in to 5 minutes range from Illustration - 5)



In this illustration:

- When the voltage is ranging between 250,2 V to 250.6V, the converter's power is going down from 41 KW to 28 KW and as a result the voltage is going down by 1.7V. After one minute, the power is going up again and the Voltage is followed suite.When the voltage is reaching up to a 250.2 V again, the power decreases immediately to 28 V.
- In order to better understand the process of these changes; we zoomed in to 9 seconds window as shown in the following Illustration 7.

Illustration 7: Power and Voltage fluctuations in a 50KW photovoltaic system (zoomed in to 9 seconds range from Illustration 6)



In this illustration:

- The shape of voltage and power raise is caused by a malfunctioning of the photovoltaic system that causes unnecessary voltage changes.

Conclusion: Using PQA with continuous high resolution recording is the <u>only way</u> to identify anomalies such as the above, since the voltage values are within the standards and 10/15 minutes average cannot expose this phenomenon.