



POWER QUALITY ANALYSIS OF LONG TERM EVENTS USING A CONTINUOUS POWER QUALITY RECORDER

There are cases in which the consequences of the events should be traced or followed up on a long time before and/or after the events. These include but not limited to the well known events such as **voltage dips**, **voltage swells**, frequency variation and power swings.

This article include 2 scenarios:

1. When a long time of observation before and event is needed When a long time observation after an event is needed
2. When a long time observation after an event is needed

Each scenario is backed up with few examples.

LONG TERM POST EVENT INVESTIGATION

This example is based on a case in France where Elspec supplied 10 Equalizer systems for 10 wind farms. Upon completion of commissioning the wind farm, a failure in the SWM (a part of the Equalizer) was reported on a weekly basis. It should be noted that in more than 1000 wind turbines where the Equalizer has been installed, such phenomena of repetitive failure has not been seen.

In order to trace the source of the failure, The Elspec Black Box (EG4K) was installed on each of the turbines. A few days following installation, the problem was identified as a result of a disconnection of the turbine transformer. During this time, a high spike on the voltage was created, causing a breakthrough of thyristor isolation in the SWM. The failure was discovered later when the turbine was re-energized by switching on the transformer and during the built-in test which is carried out automatically following power up. The problem was solved easily by providing a pre-signal to the Equalizer controller where the controller entered standby mode a few seconds before disconnection from the transformer.

The following is a laboratory equivalent test which presents directly the above case.

Figure 1 shows the exact timing of the transformer disconnection and the voltage spike which was developed. 20 min later, the transformer disconnected and the BIT (Built in test) was carried out by the Equalizer.

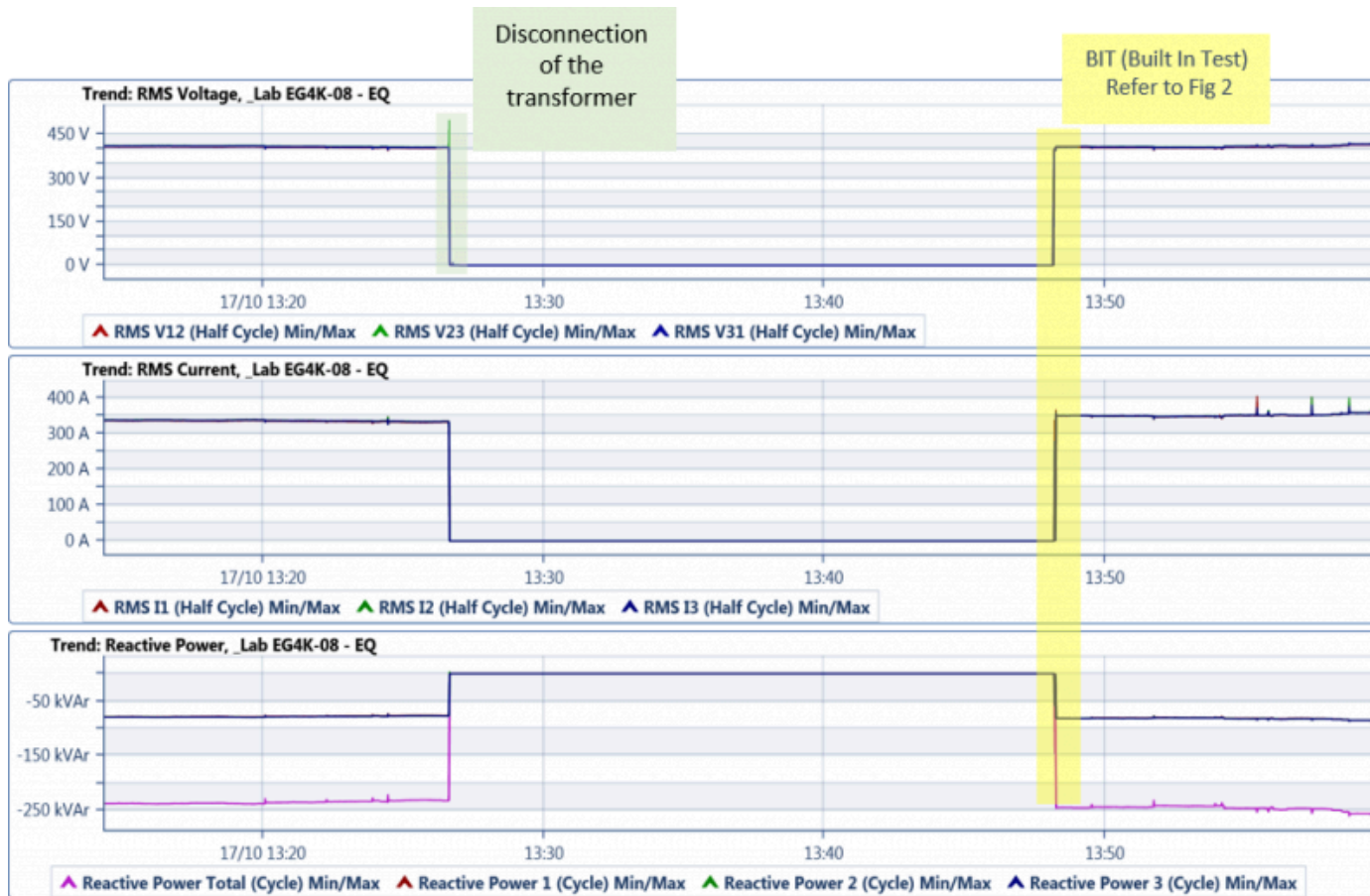


Figure 1: Long time observation on a failure event

Figure 2 shows the BIT (Built in test) in further details. Ten (10) groups were tested, with the first group tested at 60 KVAR and groups 2 through 10 tested at 120 KVAR each. All groups were functioning well excluding group 9, where 1 phase was disconnected and the KVAR was reduced substantially. Upon completion of the test, the equalizer system resumed normal operation where two functional groups were connected and group 9 was disabled (until it could be repaired).

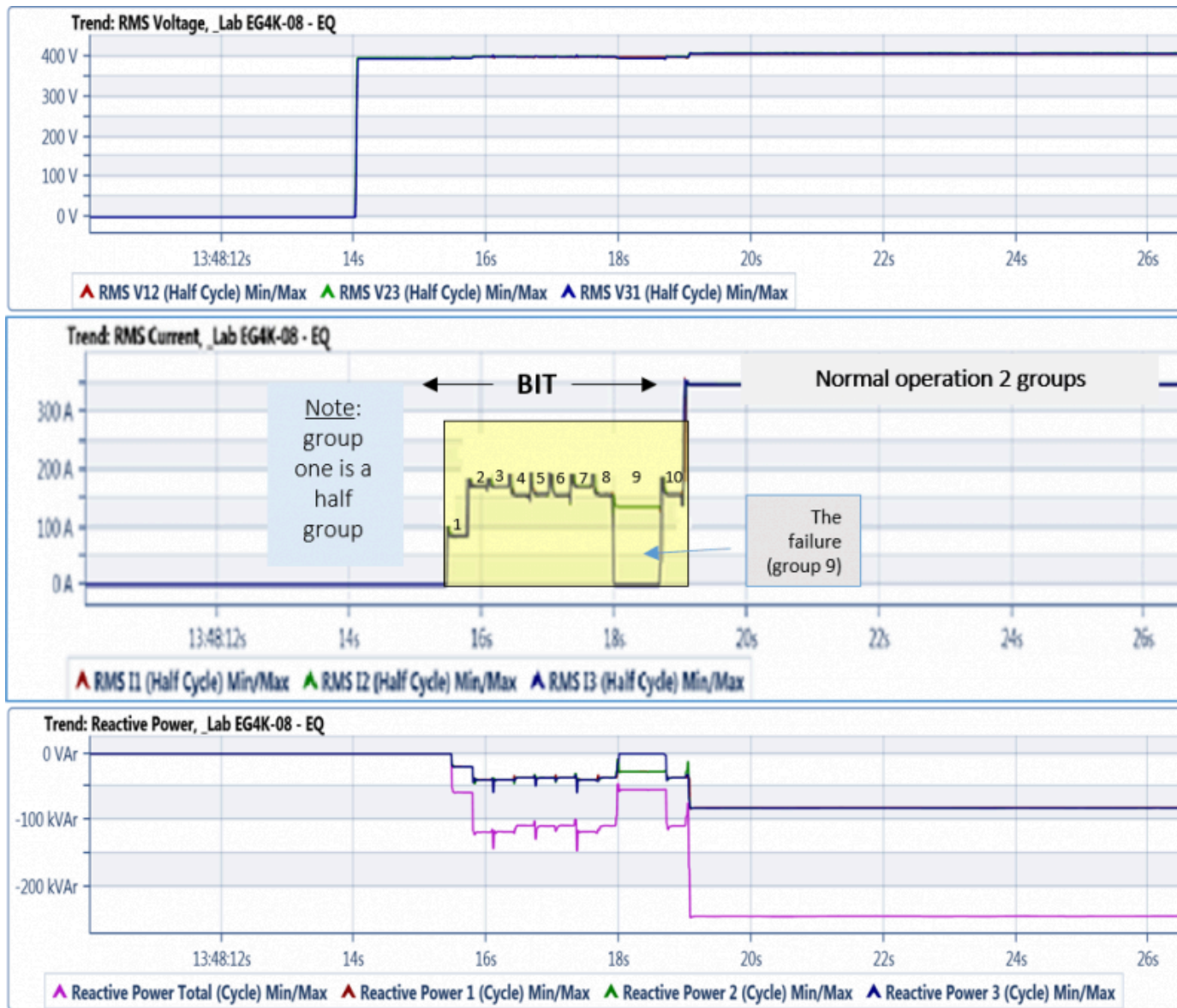


Figure 2: Zoom in on the BIT (Built in test)

In Figure 3 the status of group 9 was reported for the first time as a failure on the failure screen with the exact timing.



Figure 3: Controller fault screen

LONG TERM PRE-EVENT INVESTIGATION

An event which may elapse a few cycles can cause a sever interruption due to loss of power. This is due to the fact that there are certain tools and devices that require a long period of time to resume normal operation; this include a large motors supported by auxiliary devices, and many more. The continuous recording enables follow up on the process of resuming normal operation and evaluation

and proof of possible damage caused due to the event (a **sag** in this specific case). Few examples of losses of power due to **short sags** are presented below:

POWER LOSS IN PHOTO-VOLTAIC FARM

In the example below, the voltage dropped from 93KV to 86KV – approximately 7%. A traditional **power quality analyzers** with set-up voltage threshold of $\pm 10\%$ did not record the event. In addition the duration of the power loss event was approximately 60 seconds, which was high above the duration of the recorder.

The continuous measurements recorded the event and its full duration, and provided the exact information about the loss of power (60 sec).

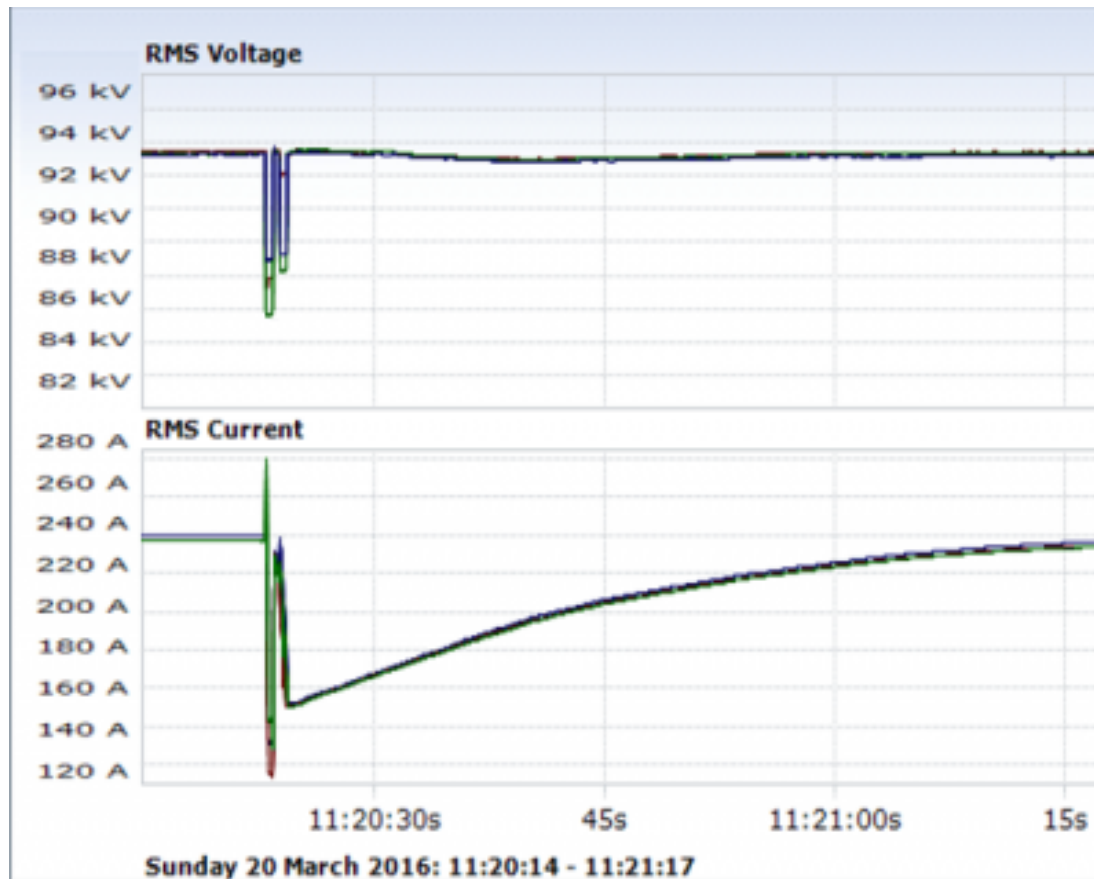


Figure 1: Loss of power event

POWER LOSS AT CONGO DRC, COPPER MINE

In this example, the voltage was dropped at a copper mine in the Democratic Republic of Congo.

The average power of the plant was almost 16 MW. The event started as a short **voltage dip** of approximately 100 msec and then gradually, the voltage dropped within approximately 60 seconds to almost 0. The plant was able to recover after only an hour.

The continuous high resolution measurements allowed us to analyze in detail how the event developed during a relatively long time of 60 seconds until the power crashed completely.

Figure 2 below provides a general view of the first 60 seconds of the event and Figure 3 is a zoom-in of the **voltage dip**.

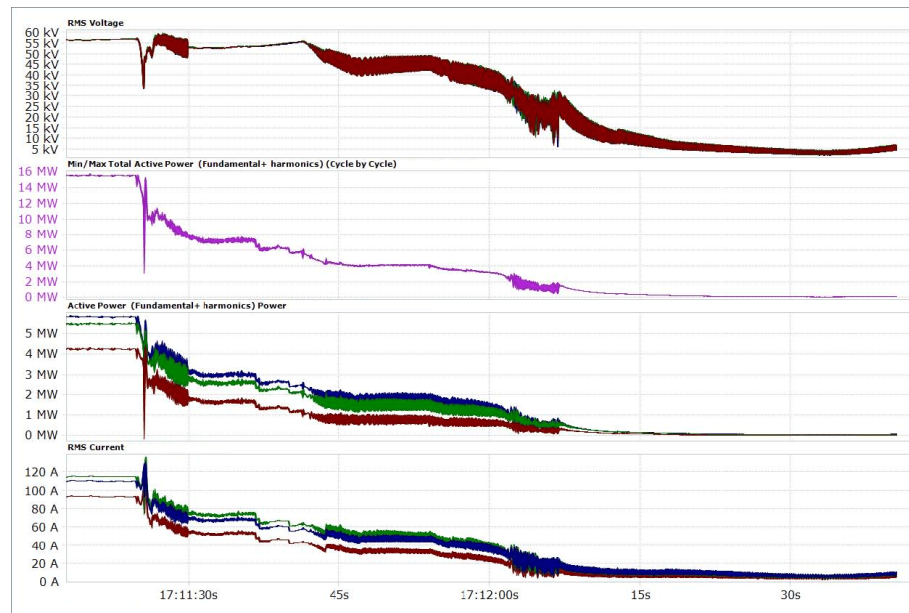


Figure 2: General view of the beginning of the event

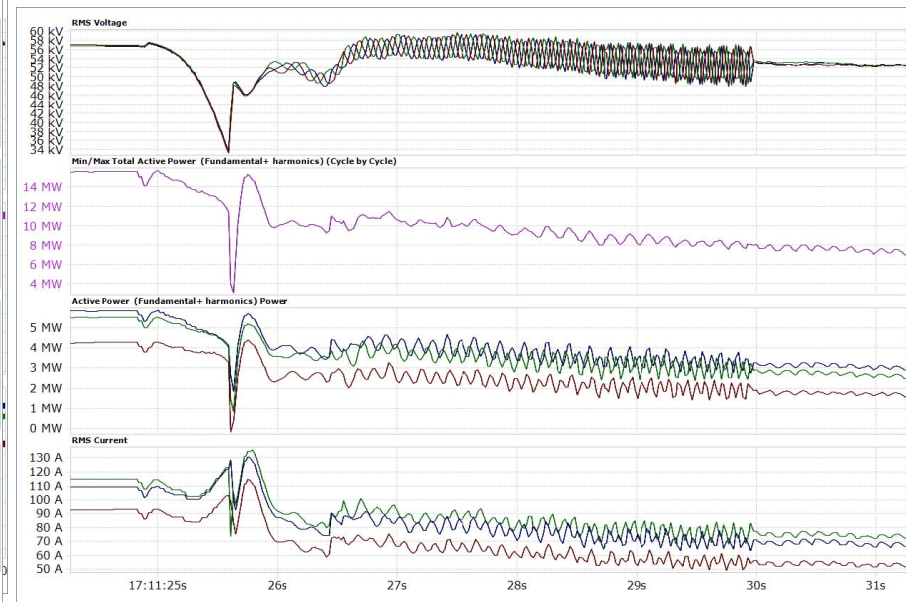


Figure 3: Zoom in the 6 seconds **voltage dip**

VOLTAGE OSCILLATION

In this case, the voltage oscillated within roughly 5 seconds and then increased to high above the nominal rate. The plant lost most of its power for approximately 10 minutes and only recovered within an hour.

The continuous measurement enabled an in-depth investigation of a long time event in which a full hour elapsed (described in Figure 4) as well as an investigation of the oscillation (refer to the zoom in in Figure 5).

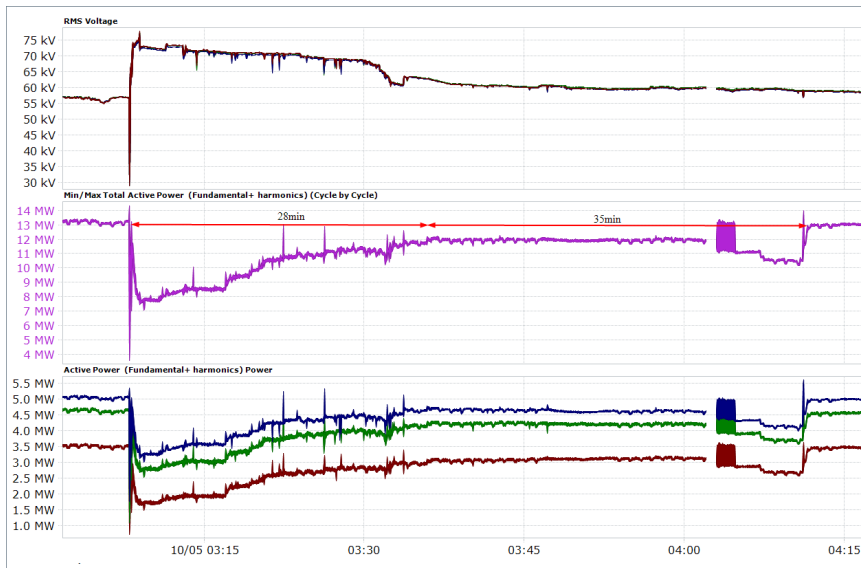


Figure 4: 1 hour continuous recording at 1 cycle resolution

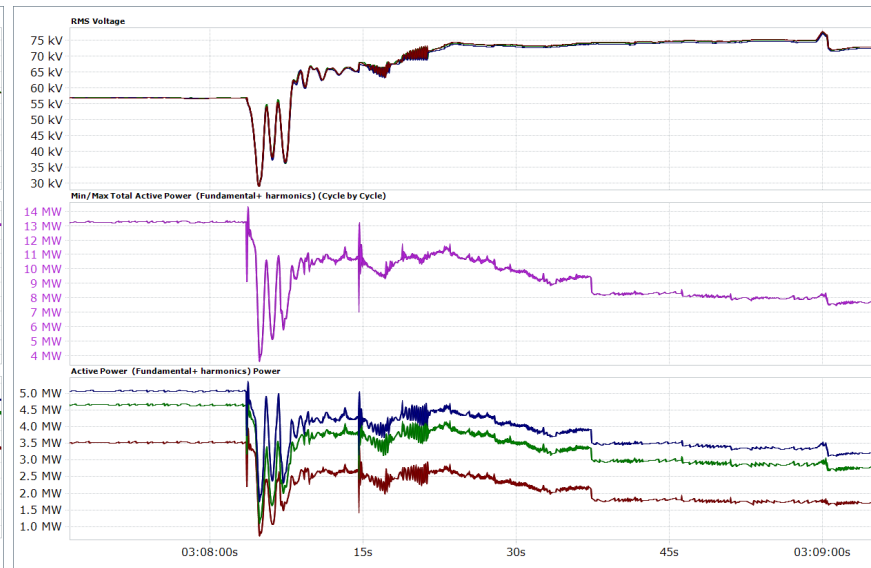


Figure 5: Zoom in on the voltage oscillations during the event



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