Useful Tools for Substation Commissioning

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Abstract

Substation Commissioning comprises a wide variety of secondary testing. Typical tasks are testing of

- Cabinet and panel wiring (terminal by terminal)
- Protection functions (Line, Generator, Transformer)
- Measurement functions
- Annunciations in the station and at remote control locations
- Interface to control system
- Logic switching operations
- Phase sequence
- Current and voltage transformers (polarity, burden)
- and many more

Since its introduction to the market the secondary test set CMC 256 has proven its suitability for these typical commissioning jobs. The feedback received can be summarized in the sentence:

"What really matters to commissioning engineers is a combination of indispensable features in one single piece of test equipment"

- lightweight and rugged hardware
- flexible and easy to use software for testing protection-, control-, and measurement functions
- generation of voltages, currents and binary signals (sufficient number of channels !)
- integrated measurement and analysis functions (analogue and binary)
- software that supports the engineer in preparing, performing and documenting the testing jobs
- protocol testing capabilities especially IEC 60870-5-103 (VDEW protocol)

It is widely accepted that the use of the latest testing technology can help engineers cope with the increasing challenges of their job: It ensures safe and reliable operation of power system equipment by comprehensive testing of all technical functions prior to the regular operation in the shortest possible time

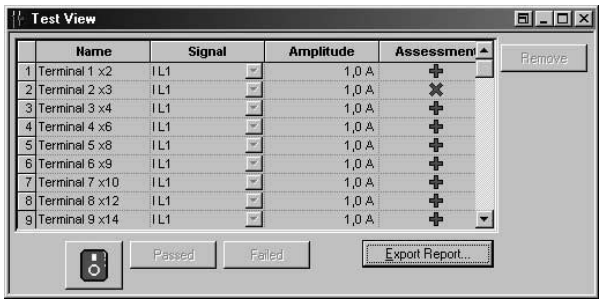
OMICRON's latest software release Test Universe 2.0 contains new test software and improved components. The completion of TU 2.0 with superior testing functionality pursues the goal of responding to the commissioning engineer's needs to a greater extent.

Picture 1: OMICRON commissioning engineers at work in a 30 kV cell

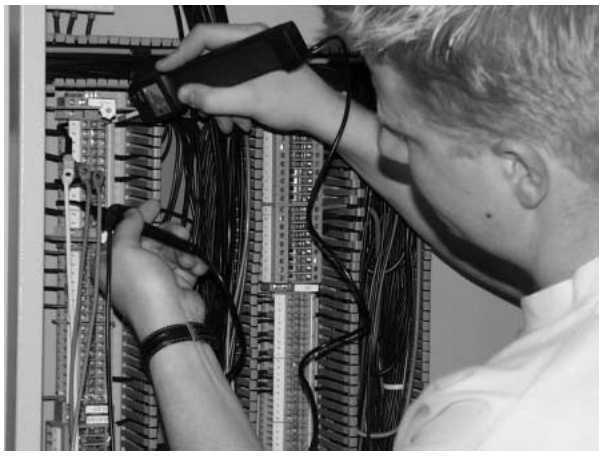
Example 1: Checking the polarity of CT's / VT's

Connecting the devices with the correct polarity is an essential precondition for proper functioning of the facilities of a station. Accordingly, checking of the correct wiring is a time consuming job and takes a considerable part of the commissioning engineer's attention.

A known method for checking the correct polarity of the connected voltage and current transformers is establishing a telephone connection between the secondary transformer terminals and the terminals of the secondary circuit in the relay room. Since the telephones are powered by a battery, any wrong polarity results in an interruption of the link, correct polarity enables the telephone connection. The disadvantage of this method is the need for two people to perform the test. With the probe CPOL and the new software tool Polarity Checker a single person can do this testing job easily. A CMC test set simply injects a signal at the supply line. This signal can be sensed at various points of the secondary circuit. A green LED is displayed in the case of correct polarity, a red where the polarity is wrong



Picture 2: Polarity Checker: an entry in the list for each tested terminal



Picture 3: CPOL: probe for checking the polarity

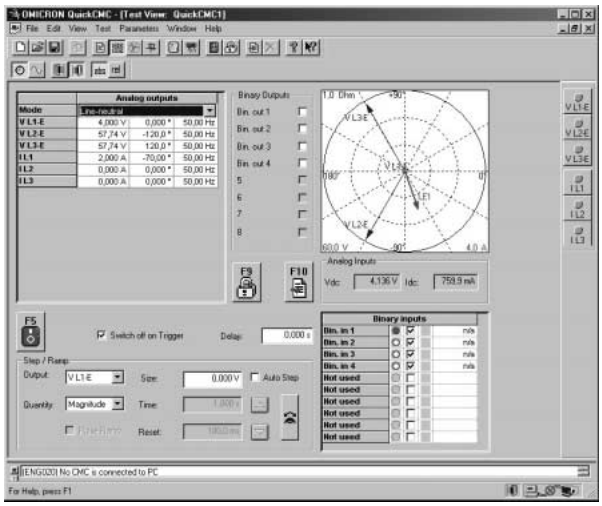
Remark: With a CMC 256 (single phase up to 75 A output current) as an alternative the current can also be injected into the primary side of a current transformer. With this the correct polarity of the primary side can be tested together with the secondary side in one procedure.

Example 2: Burden measurement of a CT

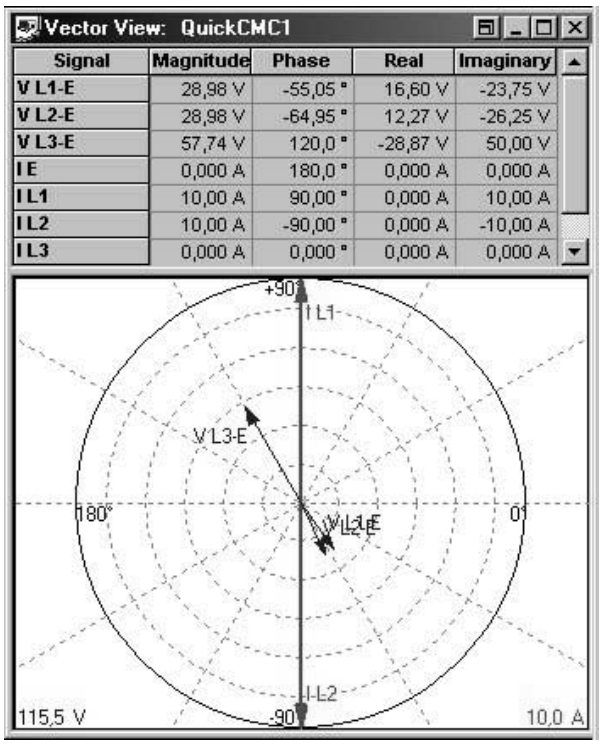
A CMC test set can also easily be used for burden measurements of secondary circuits. At the injection point at the ends of the leads towards the transformer nominal current is injected.

First it is checked to ensure there is no overload condition (Circuit open), then the voltage is measured at the injection point by means of a simple multimeter. In case of In = 1A the calculation is particularly simple, the read value in V corresponds to the burden in VA. (typical value is about 1 - 2 VA if numerical devices are used in the secondary circuit.

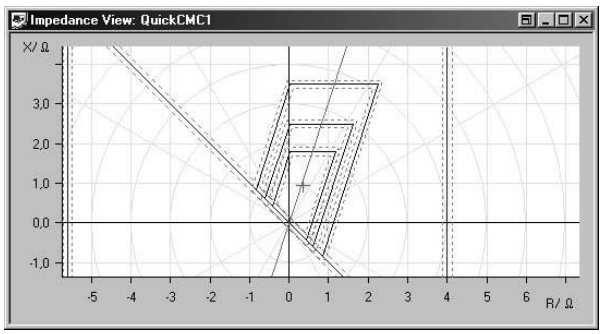
The software module QuickCMC is used for generating the currents (or voltages for burden measurements of voltage circuits). QuickCMC provides a simple interface for utilization of the CMC hardware for many other manual tests. The module has been functionally extended in software version 2.0. As a core component it contains the so called fault calculator. The fault calculator provides a number of recalculations from one quantity to another, for instance impedances (in Ω or % of line length) into voltages and currents. Also calculations from power or symmetrical components into voltage and currents (the natural system) are supported. The test quantities are displayed as vectors in a vector diagram or dots in the impedance plane. Thus for instance distance relays can be tested in a simple manner by direct input of the fault quantity.



Picture 4: QuickCMC with fault calculator Main View



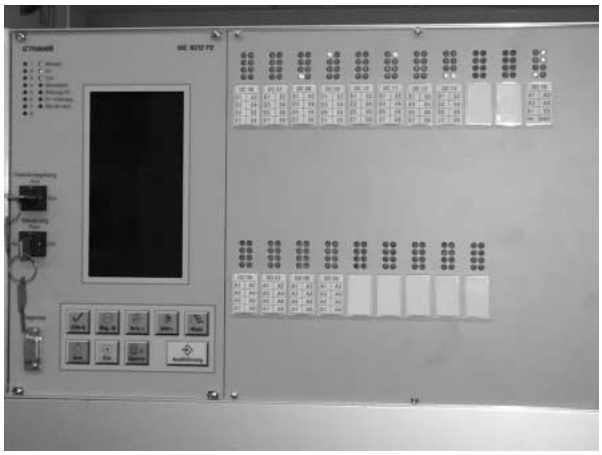
Picture 5: QuickCMC Vector View



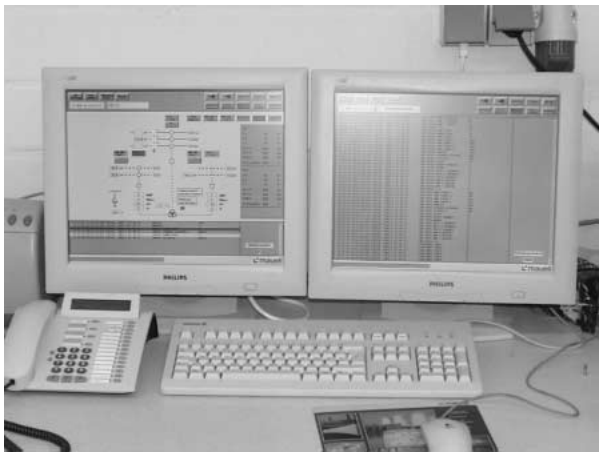
Picture 6: QuickCMC Impedance View

Example 3: Checking the annunciations in a station

An essential part of commissioning a substation is checking the signal annunciations locally (on the front panel of a relay or a field unit) and at remote locations (local and remote substation control systems)



Picture 7: Field unit with LED's and display

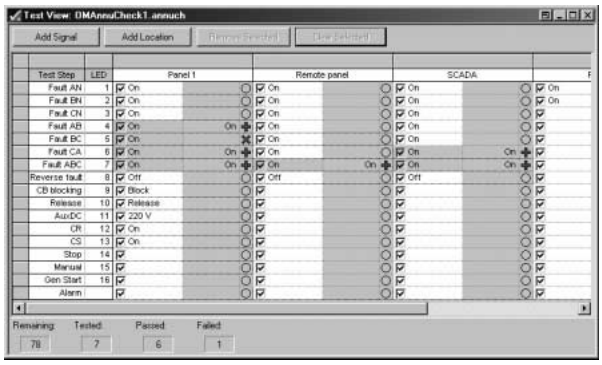


Picture 8: Local substation control system with the message list on the right screen

It is important to perform this test in a well structured way that finally results in a lucid and comprehensive test report. Reason: in larger facilities the number of required test steps (= section in a signal/location matrix) may easily total several hundred. Sometimes things simply get forgotten without careful preparation of a test. The meaning of "signal" in this context is: specific current or/and voltage values injected into a protection relay. The stimulated relay generates annunciations that are transmitted to various locations via binary outputs or via fiber optic. Locations may be the relay LED's, a local field unit or indication panel or the display of a local or superior substation control system. Events that result in an annunciation are not only generated by a classical protection relay. Example: a Buchholz relay that is not directly connected to the SCADA system but via the transformer differential protection.

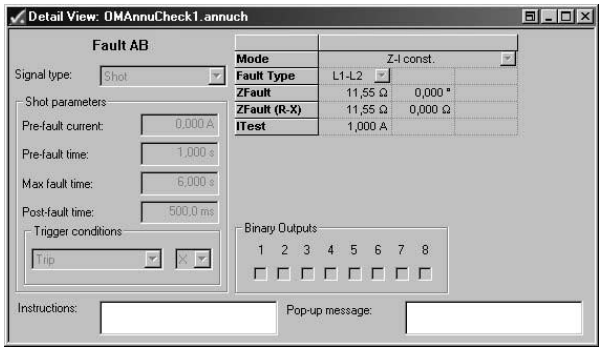
A new software module Annunciation Checker will be available in TU 2.0 that supports the commissioning engineer when checking if messages are displayed correctly at a certain location.

This new module differs substantially from the other test modules of the OMICRON Test Universe. Firstly a test within Annunciation Checker can be extended while a test runs. When preparing complex tests there must be room for on-site decisions. Secondly this module offers the possibility to perform the test in any desired order (location by location or signal by signal). Test steps can be repeated at any time without the need to reset the already obtained test results.



Picture 9: Annunciation Checker: matrix structure of main view

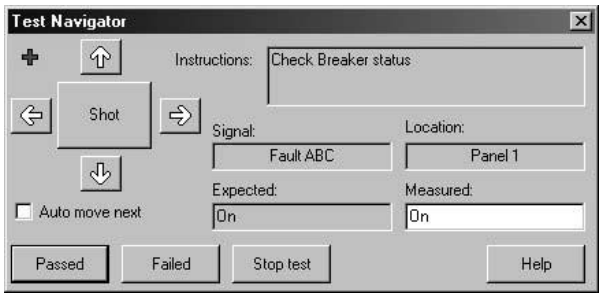
The image above shows the main view of the module. Signal entries can be made in the left column top side down. From left to right (first row, column 2-n) the locations are apparent. A signal may initialize a message at one or several locations. Signals are defined in the Detail View.



Picture 10: Annunciation Checker: Detail View

The Annunciation Checker's Detail View includes the Fault Calculator. Signals can be output as shots or steady state. For a shot it is possible to define a basic trigger condition. For each signal instructions to the test engineer can be defined that are displayed at run time. Often certain actions by the test person are required during the testing procedure. The instructions guide the test engineer through the testing procedure.

After starting the test the Test navigator pops up. The user manoeuvres through the signal/location matrix by means of the Test Navigator. He injects the appropriate test quantities and assesses the displayed messages at the corresponding location. A phone or radio connection allows the communication to remote locations.

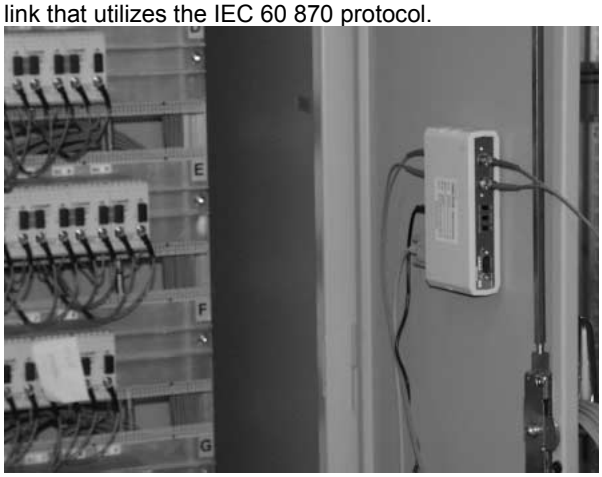


Picture 11: Annunciation Checker: detail view

A critical issue very often is the testing of the data transfer to the SCADA system. If the transmission fails it is essential to track the signal path. Checking the transmission of data via a standard protocol is not feasible anymore with conventional methods. Especially at the interface protection/control system disputes arise. In many cases responsibilities for protection and system control are separated which can make the whole issue complicated. In the following Example 4 another useful tool is introduced that shows how data transfer problems can be investigated.

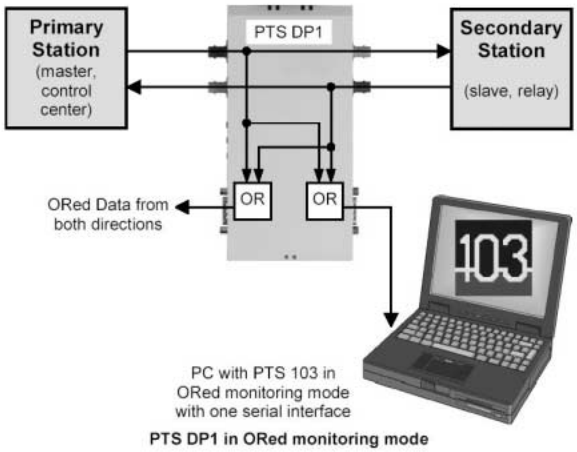
Example 4: Testing the data flow from a relay to the sub station control system

Due to the introduction of the VDEW protocol there is an increasing need for testing the communication link between an IED (intelligent electrical device) and the SCADA system master unit. With PTS DP1 along with the software PTS 103 commissioning engineers can easily get access to the data traffic of a communication link that utilizes the IEC 60 870 protocol.



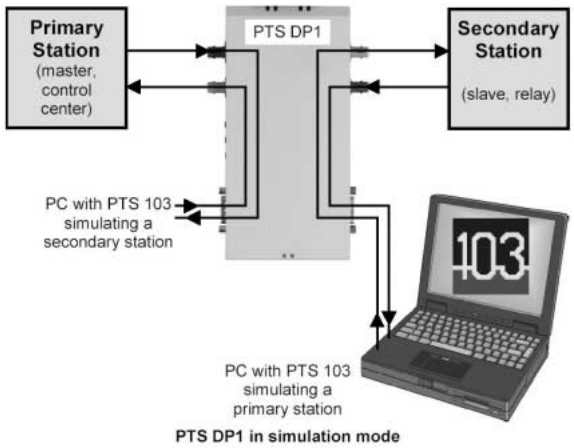
Picture 12: Fibre optic distribution cabinet with PTS DP1 in half duplex monitoring mode

In case a certain message is not displayed properly by the SCADA system clarification is needed whether the message has been released by the IED or not. The PTS DP1 solves this problem. It is simply inserted into the optical link from the IED to the SCADA system master unit. If the master unit works properly the sent commands and request can be displayed as well as the response of the IED. For this purpose PTS works in the so called monitoring mode.



Picture 13: Monitoring with only one COM port

If either the master unit or the IED is unavailable some meaningful testing can still be made utilizing the simulation mode. With this mode a protection engineer for instance can independently check whether the relay sends the right data to the master. The master in this mode is simulated by the PC.

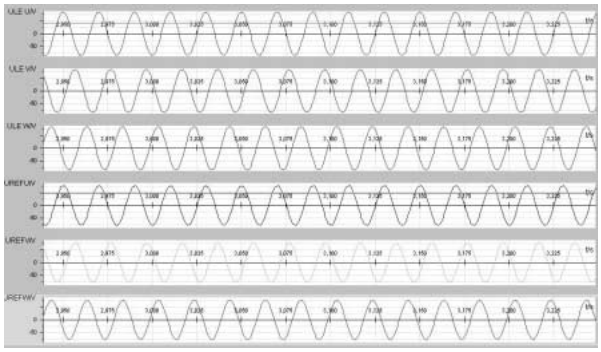


Picture 14: PTS in simulation mode

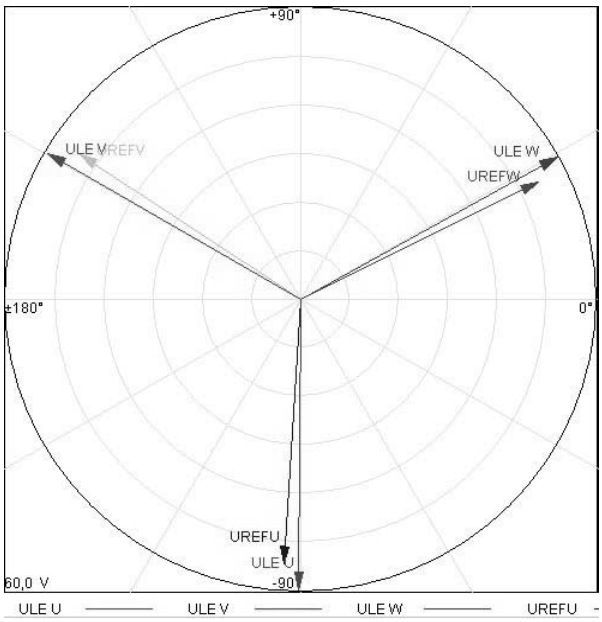
Example 5: Recording of events

In many cases the quality of a process is just as good as its documentation. This especially applies to commissioning jobs. Therefore it makes much sense to make records when putting station equipment into operation. Sometimes it might be necessary, perhaps in a legal context to have accurate records of critical

events available. Having that in mind, it becomes obvious that it is a good thing to record critical start-up operations of equipment like transformers, generator or motors. CMC 256 along with the software option EnerLyzer provides 10 channels totally for recording of analog and binary signals. The recorded instances subsequently can be displayed by the analysis- and visualization software TransView. Example 1 shows the recording of 6 voltages for checking the phase sequence and making a phase comparison.

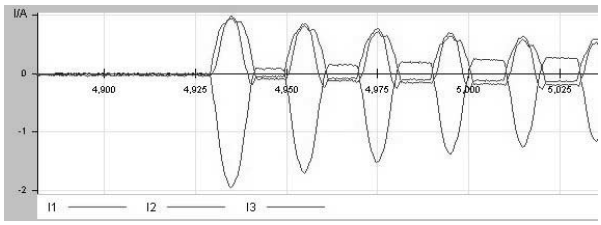


Picture 15: Recorded voltages

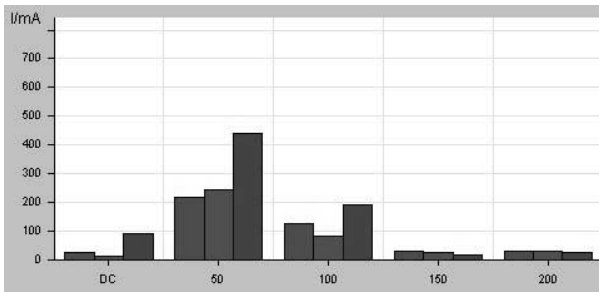


Picture 16: Recorded voltages in vector view show that the rotation sense is the same and the phase shift small

Example 2 shows the starting cycle of a power transformer.



Picture 17: Recorded currents of a transformer at the moment of inrush



Picture 18: Harmonics of a transformer inrush displayed as bar graphs

In recording mode a number of trigger possibilities are available. EnerLyzer for instance can also be used for temporary monitoring and analysis of Power Quality.

EnerLyzer however, can do more than just recording. There are extensive analog measurement functions that can be used for various purposes in the commissioning process. EnerLyzer is a classical trouble-shooting and analysis tool and thus forms an indispensable part of the equipment required by a substation commissioning engineer.

Summary

Commissioning of a substation is a complex and responsible task. In the past the big utilities have had the technical personnel and expertise and thus did the commissioning on their own. As a result of the cost cutting programs of the last 10 years many of the big utilities suffer more and more form lack of qualified engineers and, thus increasingly outsource commissioning jobs. Many new private and mostly smaller commissioning companies have established themselves in the market. These companies work under difficult conditions and face an immense time and cost pressure. The tools available today can facilitate the commissioning engineer's job.

Picture 19: Substation commissioning with CMC 256 at substation RWE Net Luestringen, Germany

Literature

[1] User Manual CMC 256

[2] User Manual PTS DP1

[3] Schutzprüfung mit Einbeziehung des VDEW-Protokolls (IEC 60870-5-103, OMICRON user conference 2003, Christian Enk, Dr. Fred Steinhauser OMICRON electronis

[4] Aufzeichnung der Winkel zwischen zwei 110 kV-Netzen mit EnerLyzer und CMGPS als Planungsgrundlage einer Netzkupplung, OMICRON user conference 2003, Armin Kogler, Vorarlberger Kraftwerke AG (EnerLyzer application)

[5] Practical ARC testing in the 110 kV system of HEW AG, OMICRON user conference 2002, Marcus Bartels, HEW AG (EnerLyzer application)

[6] Synchronization of power station generator and power system – Testing the accuracy of a synchronizing device using special EnerLyzer features, OMICRON user conference 2001, Boris Bastigkeit, OMICRON electronics (EnerLyzer application)