Commissioning – Testing of current and voltage transformers

Current and voltage transformers are vital components in an overall protection technology system. It is therefore important that the transformer is not just seen as a one-off piece of equipment, but is always tested as part of the complete system.

Commissioning is an opportune time to demonstrate the proper functioning of current and voltage transformers. The only problem is that there is increasingly less and less time in which to do this. We therefore need to consider how the transformers and the protection system can be adequately tested within a reasonable timeframe. This paper should be viewed as a proposal for how a test plan for commissioning or refurbishing a protection system might look.

Who decides what has to be tested and how?

To ensure consistency in testing quality and comparability, the scope of the test and how it is to be carried out should be laid down by the plant operator in a policy document and monitored accordingly. If the plant operator does not already have such a policy, then the guidelines provided by the Forum Netztechnik Netzbetrieb (FNN) can be a useful starting point.
These guidelines, which date from 2009, cover the use of protection systems in electrical networks and contain recommendations concerning how transformers can be tested during commissioning:

- Comparison of the data on the rating plate with the required values
- Insulation test to demonstrate that the insulation values of the individual cores to ground and each other are being maintained
- Checking the wiring and ratio of the individual current transformer cores, ideally by a primary injection test of the transformer
- Checking the winding direction in cases where examination of the factory test report provided by the transformer manufacturer is not possible
- Measurement of the operating burden
- Measurement of the internal burden, if unknown.

This testing proposal for current transformers and their circuits complies with the recommendations of the FNN. These are recognized as state-of-the-art, so in the event of a fault provide the tester with a certain degree of legal security.

Proposed test sequence for a current transformer

The information on the rating plate is important as it is used in all test reports to identify the test object. Incorrectly installed transformers can be readily identified by comparing the data on the rating plate with the circuit diagrams or plant drawings. This is also a good moment to compare the installation orientation of the current transformer (direction P1 and P2) with the single-phase wiring diagram. If a current transformer with multiple primary ratios needs to be tested, the configuration should also be checked before carrying out any measurements.

As a further important step, it is recommended injecting asymmetric current values, for example, 100 mA, 200 mA, 300 mA, using a protection test set (**Figure 1**) in order to ensure that the wiring from the transformer terminal box to the protection device is correct. The values can be checked on the display or by using a current probe on the device.

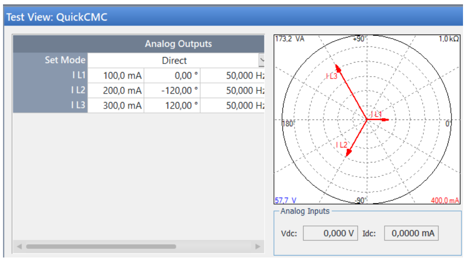


Fig. 1: Asymmetric injection with the QuickCMC

The insulation measurement is carried out as described in the FNN recommendations. The insulation resistance is measured using an insulation tester at 1000 VDC for a maximum of 10 seconds per core or line. The insulation of the cores is measured against ground (the secondary grounding on the transformer cores has to be removed in order to do this) and all the cores are measured against each other. In addition, the secondary wiring should also be measured to check that its insulation resistance is adequate. An insulation resistance value of above 100 MΩ can be considered good. The cores and the cables can become charged following the measurement, so should be grounded briefly. Checking the transformation ratio, the winding direction, operating burden, and internal burden can be carried out through a primary injection (for example, using OMICRON's CPC 100) as well as a secondary injection.

The test involving a secondary injection (for example, CT Analyzer from OMICRON) is carried out in two stages. Firstly, a measurement is taken on the burden side of the secondary circuit (**Figure 2**).

Fig. 2: Connection diagram for measurement of operating burden

In the second stage, the transformer side of the secondary circuit has to be rewired (**Figure 3**).

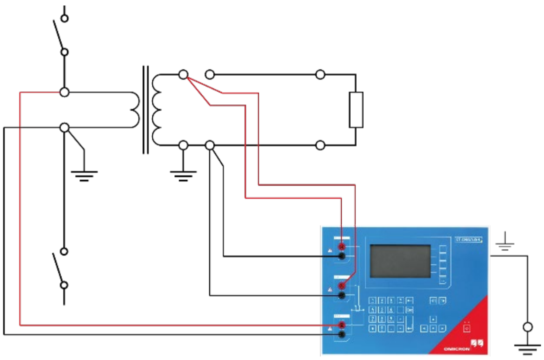
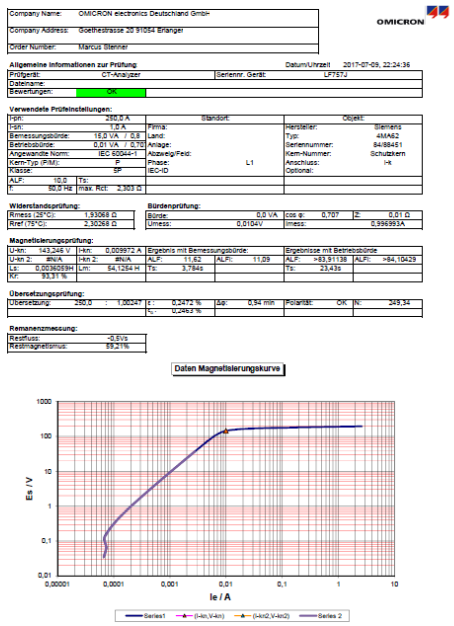


Fig. 3: Connection diagram for transformer measurement

Using the CT Analyzer can reduce the testing time to around 5 minutes per core. A further advantage of using the CT Analyzer to carry out this test is automatic evaluation in the test report, assuming that all the required data from the rating plate are entered in the test template of the CT Analyzer.

Evaluating the results of the current transformer test

The evaluation involves comparing the measured values with those specified in the corresponding standard. The tester should look at the results and carry out a cross-check on a similar core from a different phase or bay. Measuring the magnetization characteristic is a simple way of demonstrating that the core assignment is correct.



Company Name:	OMICRON electronics Deutschland GmbH
Company Address:	Goethestrasse 20 91054 Erlanger
Order Number:	Marcus Stenner

Allgemeine Informationen zur Prüfung Datum/Uhrzeit 2017-07-09, 22:24:36

Prüfgerät:	CT-Analyzer	Seriennr. Gerät:	LF757J
Dateiname:			
Bewertungen:	OK		

Verwendete Prüfeinstellungen:

I-pn:	250,0 A	Standort:		Objekt:	
I-sn:	1,0 A	Firma:		Hersteller:	Siemens
Bemessungsbürde:	15,0 VA / 0,8	Land:		Typ:	4MA62
Betriebsbürde:	0,01 VA / 0,70	Anlage:		Seriennummer:	84/88451
Angewandte Norm:	IEC 60044-1	Abzweig/Feld:		Kern-Nummer:	Schutzkern
Kern-Typ (P/M):	P	Phase:	L1	Anschluss:	I-k
Klasse:	5P	IEC-ID		Optional:	
ALF: 10,0	Ts:				
f: 50,0 Hz	max. Rct: 2,303 Ω				

Widerstandsprüfung:

Rmess (25°C):	1,93068 Ω
Rref (75°C):	2,30268 Ω

Bürdenprüfung:

Bürde:	0,0 VA	cos φ:	0,707	Z:	0,01 Ω
Umess:	0,0104V	Imess:	0,996993A		

Magnetisierungsprüfung:

U-kn: 143,246 V	I-kn: 0,009972 A	Ergebnis mit Bemessungsbürde:		Ergebnisse mit Betriebsbürde	
U-kn 2: #N/A	I-kn 2: #N/A	ALF: 11,62	ALFI: 11,09	ALF: >83,91138	ALFI: >84,10429
Ls: 0,0036059H	Lm: 54,1254 H	Ts: 3,784s		Ts: 23,43s	
Kr: 93,31 %					

Übersetzungsprüfung:

Übersetzung: 250,0 : 1,00247	ε : 0,2472 %	Δφ: 0,94 min	Polarität: OK	N: 249,34
	ε_c : 0,2463 %			

Remanenzmessung:

Restfluss:	-0,5Vs
Restmagnetismus:	59,21%

Daten Magnetisierungskurve

Fig. 4: Example of a test report

Fig. 5: Measuring configuration of the CT analyzer in the field

After the test – final checks

After completing the test, all the grounds must be reconnected and the electrical circuits closed again. To check this, another primary injection at about 50% of the nominal current should be carried out and the display referred to in order to monitor the measured values for every installed device. Using a polarity checker and injecting a square-wave signal, with the same measuring configuration and primary injection, it's then a simple matter to locate any wiring faults as far as the protection device is concerned. In contrast to the old, conventional battery method, the advantage of using a square-wave signal is that it prevents saturation of the current transformer.

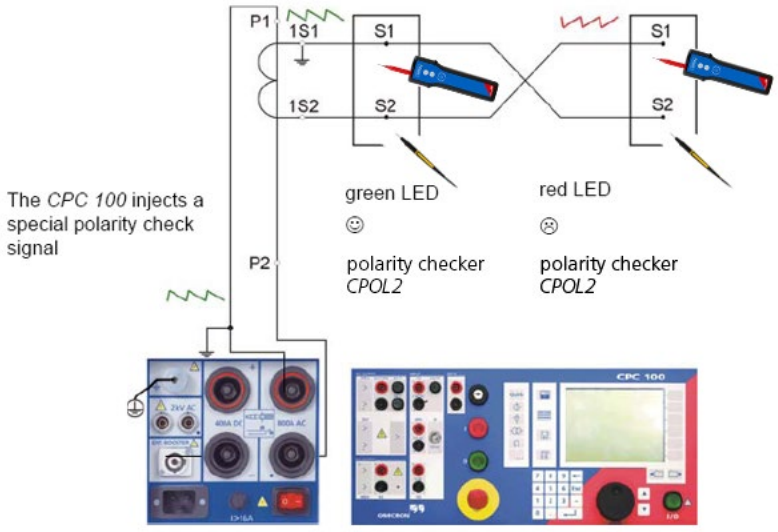


Fig. 6: Wiring testing with the CPOL2

The automatically generated test report simplifies the evaluation and documentation of the test and saves a huge amount of time.

The faults that occur most frequently are:

- Wiring faults (phases swapped)
- Multiple grounding of the electrical circuits
- Insulation faults due to incorrectly laid cables (cutting into the individual cores)
- Overloading of the protection circuits
- Incorrect installation orientation of the current transformer or individual transformer cores
- Connection of measuring instruments to protection transformer cores and vice versa

Preview – new types of transformer

The emergence of non-conventional transformers, also referred to as optical transformers, the acquisition of measured values from conventional transformers using merging units, and the distribution of digital measured values across process buses, has led to a transformation in the way current transformers are tested. Many of the aforementioned tests can no longer be carried out.

Current transformers can only be tested by way of a primary injection, as the transformers only output digital values (sampled values) and not analog secondary values. The CPC 100 enables the primary current to be output and the sampled value stream to be read directly via the Ethernet interface in the test set. This facilitates the measurement of the transformation ratio, the polarity and the angular error of the optical transformer.

Figure 7 illustrates a test with the CPC 100 in which the test current is driven by conventional and non-conventional transformers. To check that the sampled values on the process bus were configured correctly, we recorded and compared the sampled value streams of both transformers on the DANEO 400. This revealed that the resulting signal waveforms of the non-conventional and conventional transformers were the same both in level and phase. By contrast, differences are evident when we examine the harmonic components.

Fig. 7: Test with the CPC 100 in which the test current is driven by a conventional and a non-conventional transformer

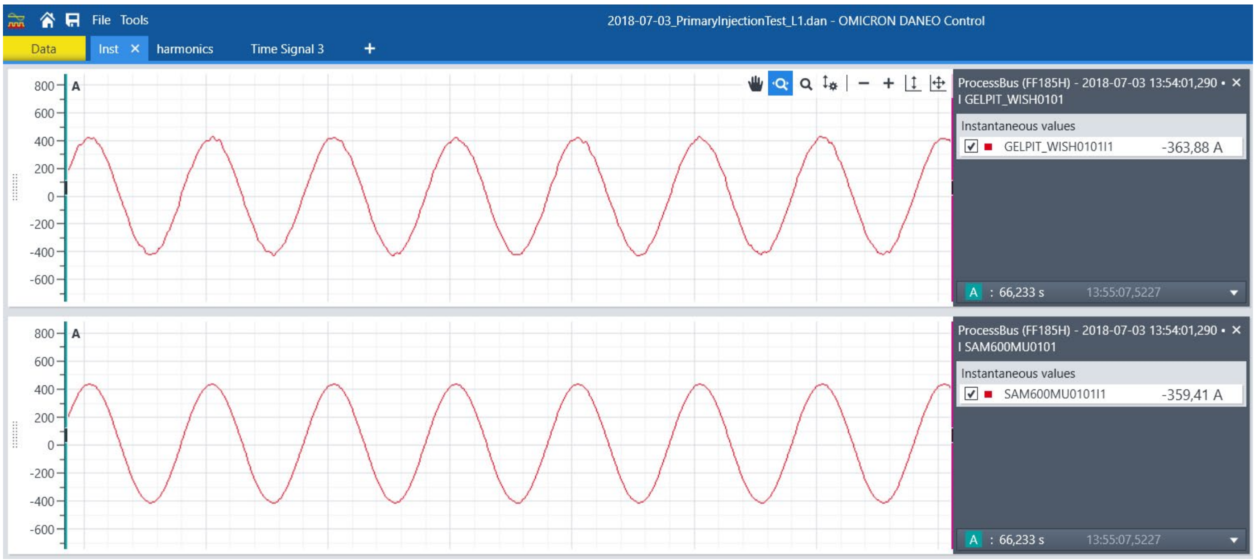


Fig. 8: Signal plot comparison using OMICRON's DANEO 400

SUMMARY

The test plan described above shows that a consistent test quality and level of documentation can be achieved without consuming too much time during the test. The overheads involved in collating the final documentation can also be reduced using the preformatted test report.

This test plan is put forward as a recommendation and as an invitation to discuss alternative proposals. Should you have any questions, comments or suggestions for improvement, we would be delighted to discuss them with you.

About the author

Marcus Stenner served an apprenticeship as a power plant technician at Miele. Completing his apprenticeship in 1999, he then went on to study energy technology at the Bielefeld University of Applied Sciences. He finished his studies there in 2004, and has since worked at OMICRON, where he was initially responsible for the commissioning and testing of switchgear. After digressing for a while into product training, he took over as head of the Measuring, Testing, Commissioning and Customer Test Support team in 2010.
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