Effective switchgear testing
Determining operating times using external sensors

Christian Studen M.Sc., Product Manager, KoCoS Messtechnik AG, Korbach, Germany

Various mechanical and electrical parameters must be tested in order to fully assess the functionality of medium- and high-voltage breakers. Gas-insulated switchgear in particular present the tester with special challenges, one of these being the connection of the test equipment. There is also a growing demand worldwide for solutions for "first trip tests". ACTAS switchgear test systems use external sensors in conjunction with external trigger signals to provide a flexible way of carrying out tests of this type.

The great advantage of connecting the measurement technology to the circuit-breaker in this way is that the switchgear does not have to be disconnected. The prerequisite is, of course, that the measured quantities can be accessed safely. The coil currents are recorded using current clamps, while the main contact times are determined using capacitive voltage taps or current clamps. This provides a quick way of making "first trip" measurements and determining operating times on gas-insulated medium-voltage switchgear and GIS installations which are earthed on both sides, to mention just two possibilities.

Testing circuit breakers "online"

As a component part of the power supply system, a circuit breaker functions primarily as a pure conductor within the network and the only requirement it initially has to fulfil is that its transfer resistance be as low as possible. And this situation often persists for years at a time. As long as no fault occurs, there is no need for the circuit breaker to operate. This is very much in the interests of the network operator, but it poses a considerable challenge to the technology of the breaker because as soon as a fault occurs, the breaker has to interrupt a high fault current within a few milliseconds in accordance with its specifications. This is not always achieved, one of the reasons for this often being inadequate maintenance, and it can be that during the course of the first switching operation the circuit breaker does not open within the time specified by the manufacturer. One of the causes for this is friction which is created by deposits such as hardened grease or by environmental influences.

The problem is usually solved by the first switching operation, as this loosens indurations and deposits. If this is not the case and the problem persists over a number of switching operations, it can lead to serious damage to the breaker itself and to the power network too, of course. This makes it all the more important to service and test switchgear in accordance with the specified cycles. By measuring the operating times, conclusions can be drawn as to the state of the contact system, and the first trip is, of course, particularly significant. With conventional (offline) measuring methods, however, the breaker is disconnected and earthed before the test and this requires that an initial switching operation be carried out before the measuring equipment is connected. This makes it impossible to draw conclusions about the behaviour of the breaker during the first trip. This is just one of the reasons why the demand for testing circuit-breakers "online", i.e. without disconnecting them beforehand, is increasing worldwide. Another reason is that operating and maintenance budgets are constantly shrinking. In addition, the demands placed on modern testing technology are increasing, using it flexibly and in a way that saves time is a must nowadays. KoCoS Messtechnik AG meets these requirements with its ACTAS switchgear test systems.

SWITCHGEAR TESTING

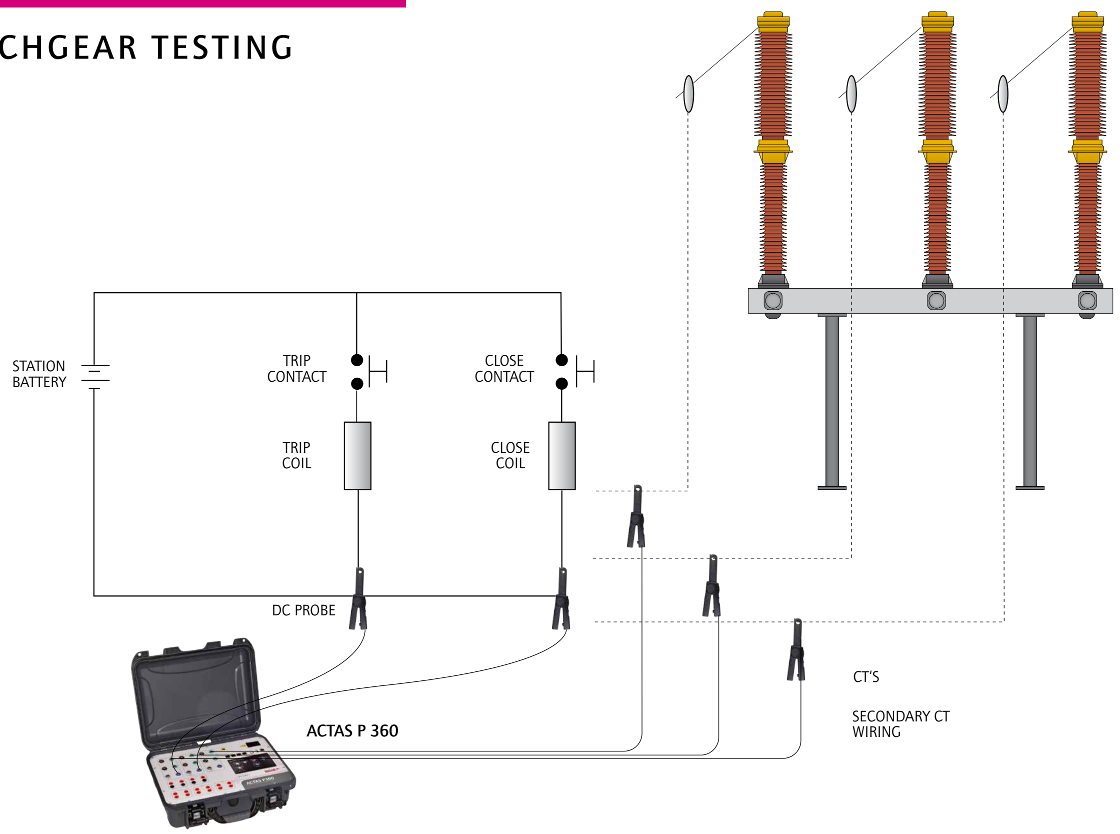

Figure 1: Connection scheme of a first trip measurement with ACTAS P360 and AC/DC current clamps. The sensors are connected to the secondary side of the current transformers and to the release coils.

With ACTAS, circuit breakers can be tested both online and offline using a variety of methods. Tests carried out during or after maintenance work on the breaker to assess the condition of the interrupter unit, for example, are usually carried out offline, i.e. after the breaker has been disconnected and earthed. Dynamic measurement methods offer a multitude of ways to carry out a detailed analysis without having to open the main contact chambers. Current sources or ohm meters are used to assess the characteristics of resistance, current and voltage drop. Offline tests, however, are usually expensive and require a lot of time and personnel.

Advantages of the first trip measurement method

As an online test, using the first-trip measurement method with ACTAS has some advantages over offline testing. From an economic point of view, the amount of time that can be saved is particularly relevant, as the disconnection and isolation of the breaker from other equipment is completely eliminated. In addition, there are also savings with regard to maintenance costs and resources if no defects are detected during the online measurement as this may make it unnecessary to carry out a test in offline mode.

The advantages of the first trip measurement method:

- No need to disconnect the circuit breaker
- No need to disconnect control circuits
- Savings in measurement time and resources
- Breaker sticking/delay can be detected during the first switching operation
- It may be possible to do without a complex offline test
- Tests are possible under real conditions
- No long downtimes for the components to be tested

Using ACTAS, first trip measurements can be performed on three phases. For connection to secondary current transformers, up to nine external analog sensors, such as non-contact DC or AC clamps, can be connected to the test system simultaneously and recorded. Up to three direct voltage measurement channels are available for voltage transformers. The measuring equipment and sensors are mounted while the breaker is in operation. Usually AC/DC current clamps are used which are mounted on the secondary side of the current transformers and on the operating coils. The operating times can be evaluated via the signals recorded accordingly and the characteristic of the coil current can give an indication of the status of the components of the switchgear.

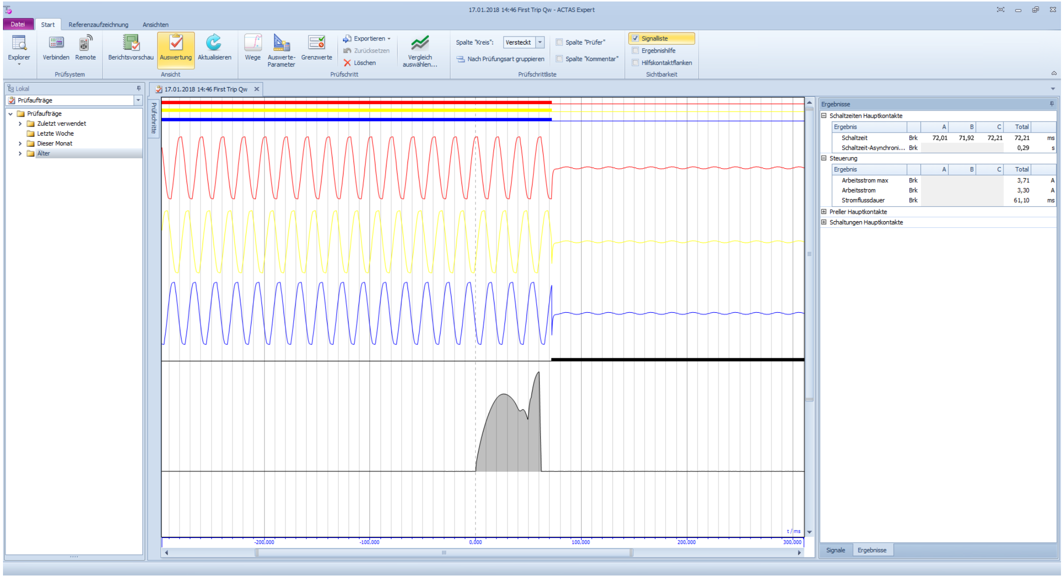

Figure 2: Evaluation of a first trip measurement with ACTAS P260. The sine characteristic shows the measured currents in the secondary transformers. The resulting binary signals of the main contacts are displayed above. The measurement was triggered by an external trigger signal on the coil current.

In addition to the main contact times, which are determined via the secondary current of the current transformers, coil currents can also be recorded. According to IEC 62271-100, the operating times determined are composed of the time to contact separation and the arcing time. Due to the large number of analog measurement inputs, ACTAS also offers the possibility of recording values such as auxiliary contact times. It is also possible to record travel signals, but measurements may only be made via a monitoring system or via encoders integrated in the breaker to avoid having to handle unprotected drives.

Further advantages of online testing result from the fact that no control circuits and no terminal strips located in the cabinet have to be disconnected. This avoids errors caused by changes to the wiring when connecting the measuring equipment. It may even be possible to detect wiring problems which may exist in the system, as the circuit breaker is tested under real conditions with the first trip method.

By contrast, when tests are evaluated, it does not matter whether they were performed online or offline. By superimposing the results of new tests on old test results, a comparison can always be made by laying the signal characteristics over each other and comparing them. The coil current and coil voltage characteristics can be compared in this way to determine whether the release coils are sticking or delayed or whether the supply voltage is faulty.

Passive determination of operating times for gas-insulated medium-voltage switchgear

The time to contact separation and the contact resistances are measured on medium-voltage breakers as a rule. However, in some cases appropriate travel characteristics are also recorded in order give an indication of the state of the whole breaker. The connection of the operating time measuring leads is made directly to the main contacts in this case or at easily accessible points such as busbars.

With gas-insulated medium-voltage switchgear, however, there are hardly any ways of attaching the operating time measuring leads to the main contacts of the circuit breakers. The connection could be made, if at all, via reserve panels or other components. If the system is currently under construction and the first tests are to be carried out, there are usually ways and means of carrying out the measurements in the conventional way. However, if the plant is in operation and revision measurements are be carried out, the cost-benefit ratio is very unsatisfactory. Planning and execution take a lot of time, making the conventional measuring method quite simply uneconomical for gas-insulated medium-voltage switchgear.

The new measuring method with external sensors makes it possible to test this type of system with a reasonable amount of effort. It is even less time-consuming than testing a non-gas-insulated medium-voltage switchgear with conventional measuring methods, as the system does not have to be disconnected. The VDS (Voltage Detection System) installed in the systems is used to measure the operating times. These are capacitive measurement points for voltage indicators or integrated capacitive voltage indicators to VDE 0682-415 or IEC 61243-5. If no voltage transformers are installed, these measurement points are the only way and the safe way to establish a connection to the main contacts of the circuit breakers.

These capacitive measurement points can be connected directly to the analog measurement inputs of the ACTAS test system provided for this purpose without further intermediate measuring components. The capacitive measuring points are used to measure the three-phase sine wave of the voltages, as it were. If the circuit breaker is connected via the control room, the voltage break is displayed on the ACTAS test system. However, in order to be able to determine an operating time, current clamps are used and are attached to the opening and closing coils. The procedure with this method is similar to the procedure for a first trip measurement. External trigger signals which can be set in the test system can be used to trigger the recording of the measurement values and an appropriate evaluation. In ACTAS, external triggers can be set on any signal, regardless of whether they are individual binary or analog signals or signal groups. The evaluation of the operating time is fully automatic in ACTAS. It is not necessary to set a cursor to manually evaluate and enter the operating times.

For the connection of external sensors, the ACTAS P360 test system offers a total of nine sensor connection sockets to which current clamps as well as pressure and travel sensors can be connected. Due to the dual functionality of the sensor connection sockets, analog and also digital or incremental sensors can be connected to the same sockets. This makes it possible to simultaneously record and analyse the coil current for the closing and opening coil as well as the currents of the drives installed in gas-insulated medium-voltage switchgear, such as disconnectors and earthing switches. Only the test system with the appropriate current clamps is required for this purpose, other components are not needed. The evaluation and calculation of results is also carried out automatically, this being another unique selling point for ACTAS in comparison with other test systems.

Determination of operating times for GIS with earthing on both sides

In high-voltage systems, there is a basic requirement that any parts on which work is being carried out must be earthed. However, DIN VDE0105-100 and EN50110-1 introduce another difficulty, especially for GIS systems, namely that a circuit breaker must be earthed on both sides in the substation for testing purposes. With outdoor switchgear, measurement with earthing on both sides is generally not a major problem and the solution provided by KoCoS is "Dynamic Timing" and the combination of the ACTAS switchgear test system with the PROMET ohm meter. Both systems

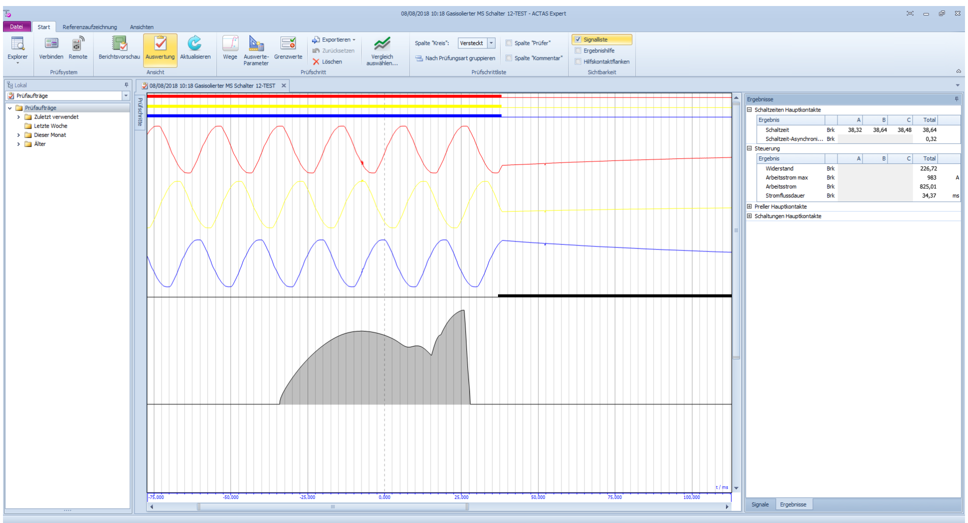

Figure 3: Evaluation of a measurement on a gas-insulated medium-voltage switchgear via VDS. The sine characteristic shows the voltage measured via the VDS. The resulting binary signals of the main contacts are displayed above. The measurement was triggered by an external trigger signal on the coil current.

can be used stand alone, but it is also possible to control the ohm meters using ACTAS. In this context PROMET functions as a main contact measuring lead, as it were, for the Dynamic Timing method. PROMET SE ohm meters have two current outputs and two voltage feedback channels. Up to 200 A can be provided per current output. The operating time of the breaker can be determined by the current flowing in the interrupter unit or by the measured voltage drop. In addition to the operating time measurement, static and dynamic resistance measurements can be carried out with the same measurement setup. External sensors play an important role here too, as current clamps can be used to carry out the resistance measurement with earthing on both sides.

With GIS switchgear, it is not very easy to determine the operating times with earthing on both sides using this method due to the very low resistance ratio between earth and interrupter unit. Many test methods can only be used if the SF6 gas is extracted and then refilled after the test. In addition, the breaker must be completely disconnected. KoCoS, on the other hand, offers the first-trip method which enables GIS systems to be tested economically.

Another way of determining operating times for a GIS system which is earthed on both sides is a combination of the KoCoS "First Trip" and „Dynamic Timing" measurement methods. Here, the circuit-breaker must have at least one insulated earthing switch connected to the outside. Again, PROMET ohm meters are used which, depending on the model, generate currents of up to 600 A and can be controlled by ACTAS. However, Rogowski coils are used as current sensors in this case because they can be flexibly attached to the insulated earthing switch. The current characteristics measured in the insulated earthing switch during the switching operation can be used to determine the operating times for opening and closing the circuit breaker. This method has a great safety advantage as the GIS system can remain earthed on both sides during the entire duration of the test.

Finally, it should be noted that the use of external sensors enables flexible, effective tests to be carried out on switchgear to meet the economic requirements of today's companies - the prerequisite, of course, is always the safe accessibility of the measurement quantities.

Figure 4: ACTAS switchgear test systems, PROMET ohm meter and accessories for carrying out online and offline tests.

Literature:

[1] Richter, F.: Verfahren zur Durchführung und Bewertung von Schaltgeräteprüfungen
ETZ, issue 15 (2003)

[2] Dreier, J.: Überprüfung und Beurteilung von Motoren und Auslösespulen an Schaltgeräten
Netzpraxis, volume 54 issue 6 (2015)

[3] Studen, C.: Schaltgeräte zeit und kostensparend prüfen
Netzpraxis, issue 9 (2017)

[4] IEC 62271-100
High-voltage switchgear and controlgear – Part 100 2008

[5] DIN VDE0105-100 / EN50110-1
Operation of electrical installations 2013

[6] VDE 0682-415 / IEC 61243-5
Live working - Voltage detectors Voltage detective systems (VDS) 2001

[7] KoCoS MESSTECHNIK AG, Korbach: www.kocos.com

Curriculum Vitae

Christian Studen is Product Manager for Circuit Breaker Test Systems at KoCoS Messtechnik AG in Korbach, Germany. He provides product and application support to distributors and customers throughout the world.

Christian joined KoCoS in May 2013 and spent the first two years on the Service & Support team acquiring knowledge and practical experience in electrical power engineering. After completing an apprenticeship as a power electronics installer with Viessmann in Allendorf, Germany, Christian earned a B.S. in Electrical Engineering at the University of Applied Sciences in Lemgo, Germany. While working towards his M.S. in Mechatronic Systems, he was employed as a research assistant in the power electronics laboratory.

Christian Studen M.Sc., Product Manager,
KoCoS Messtechnik AG, Korbach, Germany

KoCoS A FRIEND OF ENERGY

KoCoS Messtechnik AG
Südring 42
34497 Korbach, Germany
Phone +49 5631 9596-40
info@kocos.com
www.kocos.com