

Effective and Safe Testing of GIS Switchgear

Determination of switching times on medium and high voltage Gas Insulated Switchgear

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To fully assess the functionality of medium and high voltage circuit breakers, various mechanical and electrical parameters must be tested. Gas-insulated switchgear (GIS) in particular poses unique and special challenges, including the connection of the test equipment. In today's world, where testing is increasingly performed in a non-invasive manner, test systems must offer a certain flexibility and a wide range of testing solutions in order to get proper results in a timely manner.

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

Normally, the breaker operating time and the contact resistances are measured on medium-voltage breakers. In addition, corresponding travel curves are also recorded in order to obtain conclusions about the state of the entire mechanism. For Contact time, the connection of the measurement leads is made directly to the main contacts or to easily accessible points such as busbars.

In gas-insulated medium-voltage installations, there are hardly any possibilities for attaching the measurement leads to the main contacts of the circuit-breakers. The connection could possibly be made via reserve panels, or other components. If the installation is currently under construction and initial commissioning tests are to be carried out, there are usually ways of performing the tests in the conventional way. That is, testing is performed before the gas is in place, and, the enclosure is closed, so the main contacts are still accessible. However when the system is in operation, and, tests are to be carried out, the costs and benefits of are disproportionate. To perform a conventional test, one must completely isolate the breaker, and, must remove the gas. This can take multiple days. The conventional measuring method in gas-insulated medium-voltage switchgear

is simply uneconomical. KoCoS offers a measuring method using the ACTAS switchgear test systems and external sensors which enables this type of system to be tested at a reasonable cost. As the system does not need to be isolated, the measurement procedure is even less time consuming than testing a non-gas-insulated medium-voltage switchgear using the conventional measurement procedures. The VDS (Voltage Detection System) installed in the systems is used to measure the switching times. These are capacitive measuring points for voltage indicators or integrated capacitive voltage indicators according to VDE 0682-415 or IEC 61243-5. If no voltage transformers are installed, these measuring points are the only and safe way to establish a connection to the main contacts of the circuit breakers.

The capacitive measuring points can be connected directly to the analog measuring inputs of the ACTAS test system provided for this purpose without interposing additional measuring components. The capacitive measuring points are used to measure the three-phase sine wave of the voltages. If the circuit breaker is switched via the control room, the voltage drop is displayed on the ACTAS test system. However, in order to be able to determine a switching time, current clamps are used and attached to the open and close coils. External trigger signals that can be set in the test system can be used to initiate the recording of the measured values and the corresponding evaluation. External triggers can be set in ACTAS to any signals, regardless of whether they are individual binary or analog signals or signal groups. The evaluation of the switching time in ACTAS is fully automatic; there is no need to set a cursor to manually evaluate the switching times and enter values manually (see figure 1).

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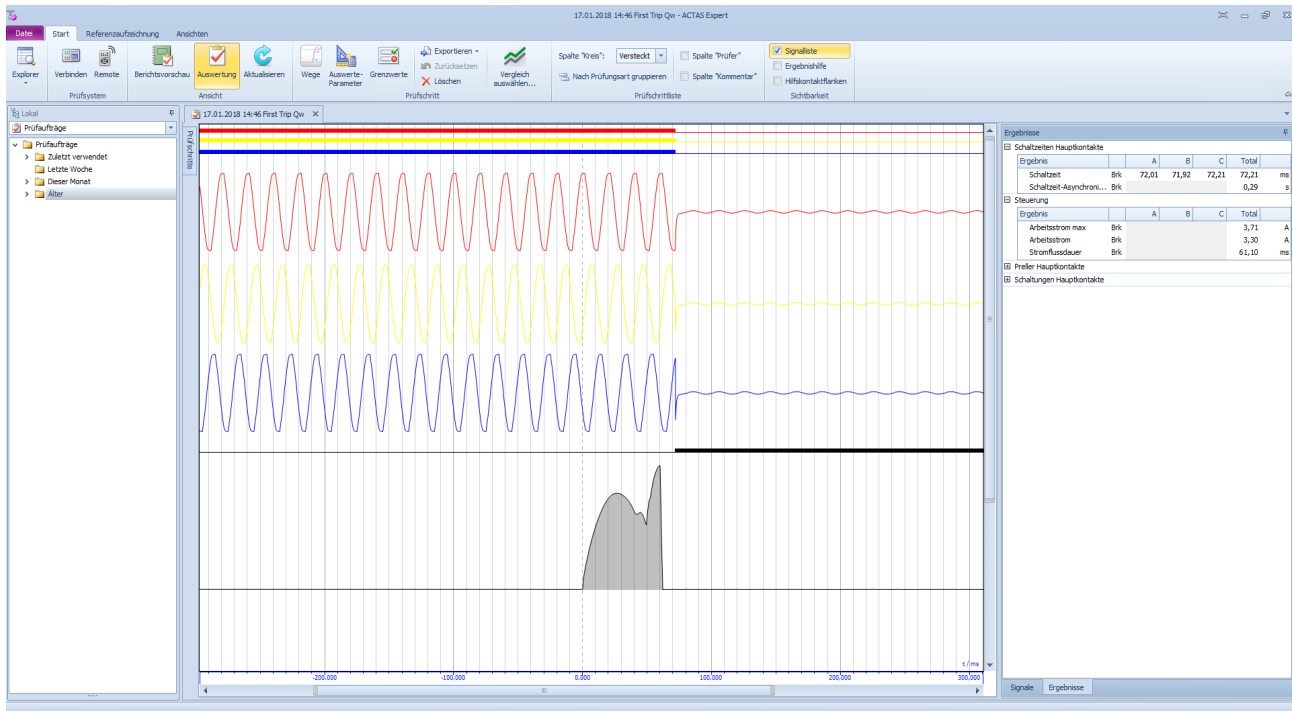


Figure 1: Evaluation of a measurement on a gas-insulated medium-voltage system via VDS. The sine wave shows the voltage measured by the VDS. Above it, the resulting binary signals of the main contacts are displayed, below it the coil current. The measurement was triggered by an external trigger signal on the coil current.

For connecting external sensors, the ACTAS P360 test system offers a total of nine sensor connection sockets to which current clamps, pressure, and displacement sensors can be connected. The dual function of the sensor connections means that analog, digital, or incremental sensors can be connected to the same sockets. This makes it possible to simultaneously record and analyze the coil current for open and close coils as well as the currents of the drives installed in gas-insulated medium-voltage systems, such as disconnectors and ground switches. Only the test system and the corresponding current clamps are required for this, no other components are needed. The evaluation or calculation of results is also performed automatically, and tabulated, rather than using cursors.

Determination of switching times for gas-insulated high-voltage switchgear with ground on both sides

GIS high-voltage switchgears are located at many nodes in our voltage network, such as three-phase or single-phase encapsulated switchgear panels. High-voltage switchgears consist of several components and can be designed differently depending on the required function. They contain components such as current transformers, disconnectors, ground switches, circuit breakers, etc. Compared to air insulated switchgear (AIS), they offer a number of advantages, including smaller space

requirement, higher personnel safety, a longer service life, and higher reliability. Disadvantages compared to AIS are evident in terms of maintenance, as individual components are very difficult to access. Measurements, such as those of circuit-breaker operating times and resistance of the circuit-breaker interrupter units, are rather difficult to carry out, since the basic requirement is that in high-voltage installations, all the parts being worked on must be grounded. In outdoor switchgear systems (AIS), measurement with ground on both sides is generally not a major problem, simply because the typical ground resistance is much higher than the main contact resistance (see figure 2). KoCoS uses „Dynamic Timing“ to combine the ACTAS switchgear test system with PROMET resistance meters.

The standards DIN VDE0105-100 and EN50110-1 clearly state that a GIS system must be measured with ground on both sides. The problem, which is particularly relevant for GIS, is the very low ground resistance resulting from the encapsulation of the entire switchgear in a metal housing. It often can be that the ground and housing resistance is lower than the main contact resistance. This makes it difficult to carry out a condition assessment of the switchgear using standard measuring equipment (see figure 3).

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The following measurements are compared to evaluate the different measuring methods:

- Conventional measurement with one side grounded
- Dynamic Timing method with one side grounded
- GIS timing procedure with grounding on both sides for single-phase and three-phase encapsulated GIS

Conventional measurement with one side grounded

In conventional measurement, the main contact inputs of ACTAS are used to check when the switch is in the ON or OFF position. This method is generally used for medium-voltage breakers or breakers without an arcing contact. Conventional measurements show that the circuit breaker has an operating time of approximately 50 ms for closing and approximately 25 ms for opening (see figure 4).

Dynamic Timing with one side grounded

For circuit-breakers with an arcing contact, the Dynamic Timing method is used with ground on one side. Measurements are performed with a combination of the ACTAS switchgear test system and the PROMET resistance meter. Both systems can also be used as „Stand Alone“ test systems, on their own. It is possible to control the resistance measuring devices via ACTAS. In

this case, PROMET acts as the main contact measuring lead for the Dynamic Timing method. The current driven in this process and the voltage drop measured back at the interrupter unit of a circuit breaker allow a very detailed status evaluation of the interrupter unit.

With the dynamic timing method (see figures 5 and 6), the results compare almost exactly to those of a conventional switching time measurement (see figure 4). The great advantage of this method over conventional measurement is a more detailed evaluation of the state of the breaker based on the results. With the Dynamic Timing method, the individual areas of the contact path can be displayed very well. Via additionally connected travel signals, the length of the arcing contact can be measured without having to open the switching chamber.

GIS Timing with grounding on both sides

For testing GIS systems grounded on both sides, the Dynamic Timing method cannot be used in the same manner as used with AIS testing grounded on both sides. It is not possible to measure the correct switching time of the circuit breaker integrated in the GIS. The above-mentioned components installed in GIS, such as current transformers, cause measurement delays.

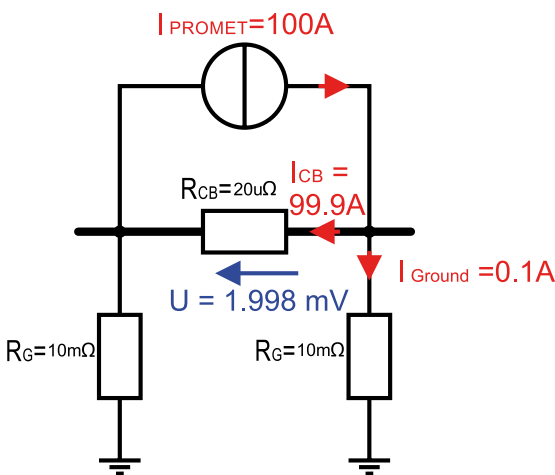


Figure 2 - Air Insulated Switchgear with both sides grounded - typical values

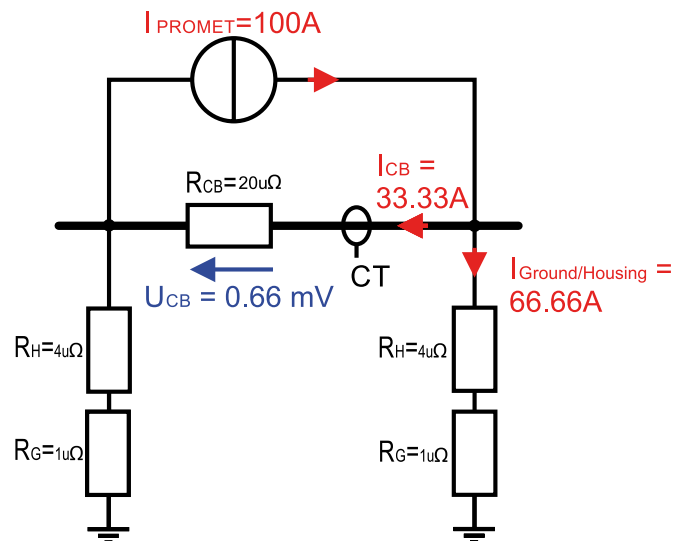


Figure 3 - Gas Insulated Switchgear with both sides grounded - typical values

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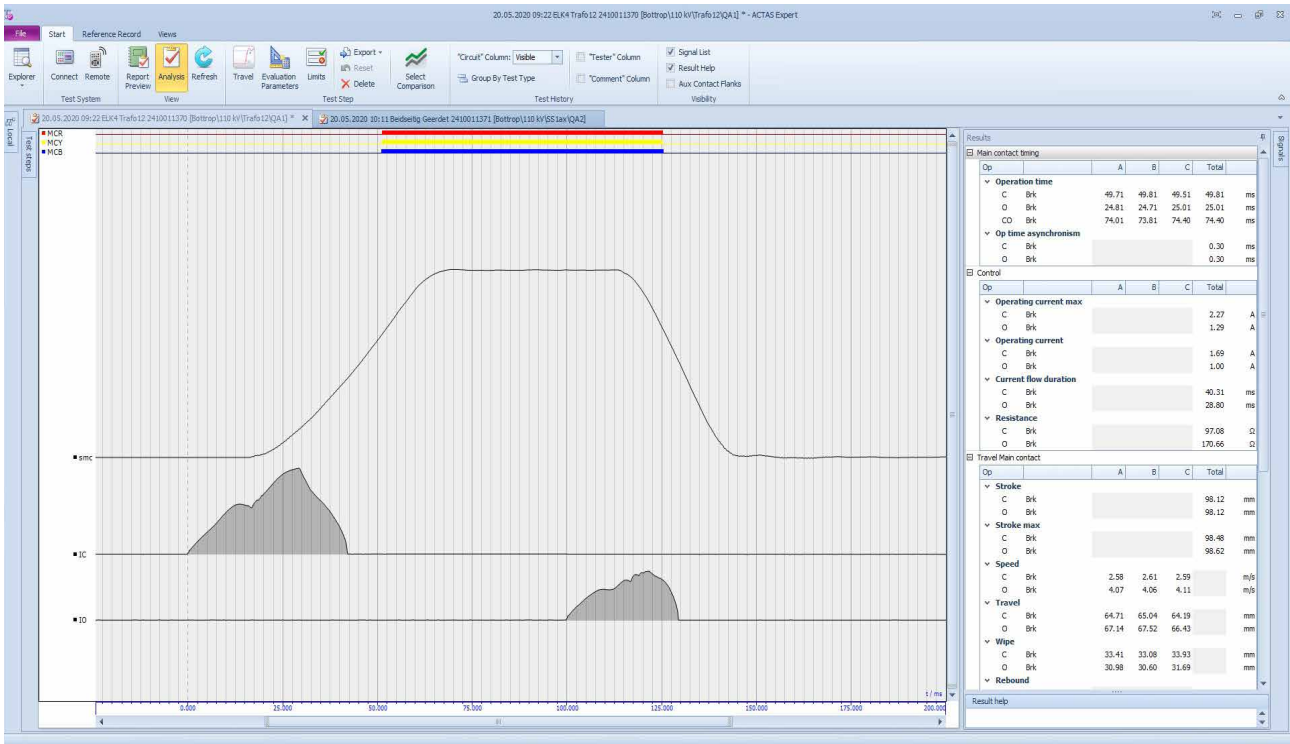


Figure 4: Conventional measurement of a single-phase encapsulated GIS, earthed at one end, with ACTAS P360, CO switching sequence

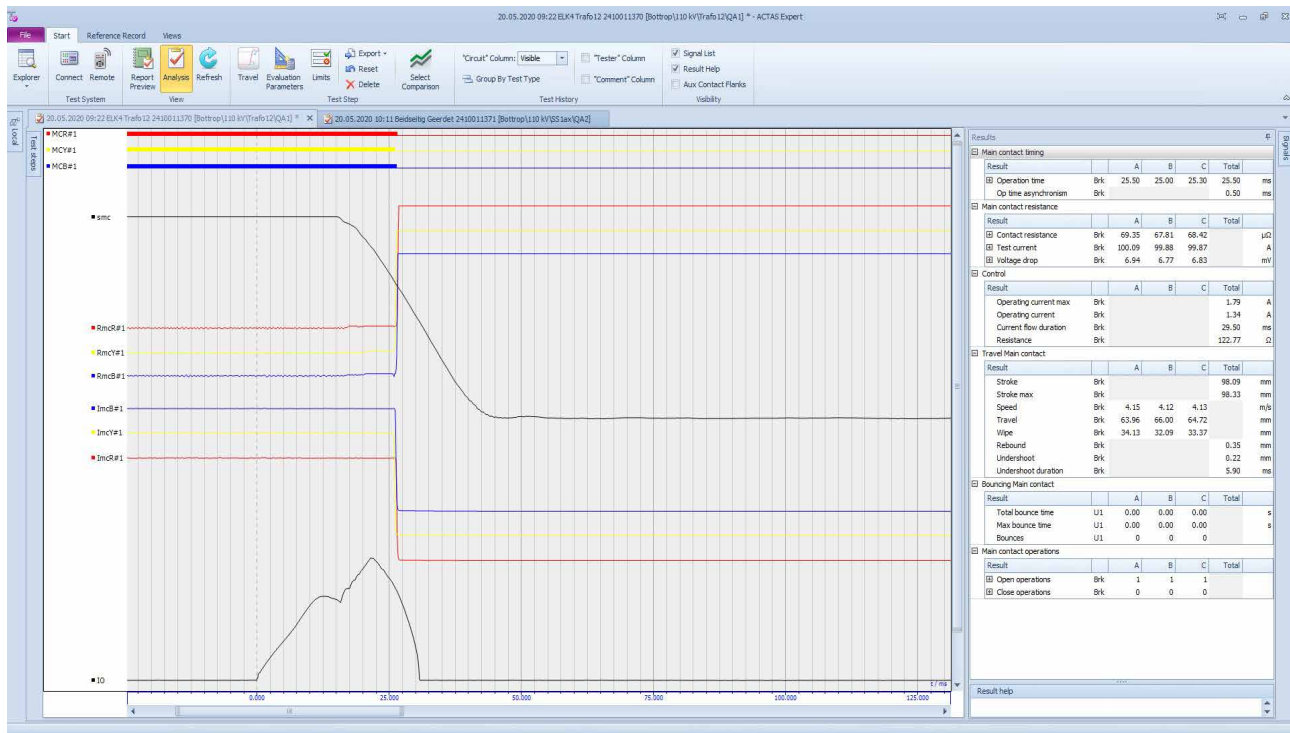


Figure 5: Dynamic timing measurement of a single-phase encapsulated GIS, grounded at one end, with ACTAS P360 and 3 PROMET L100, O switching sequence

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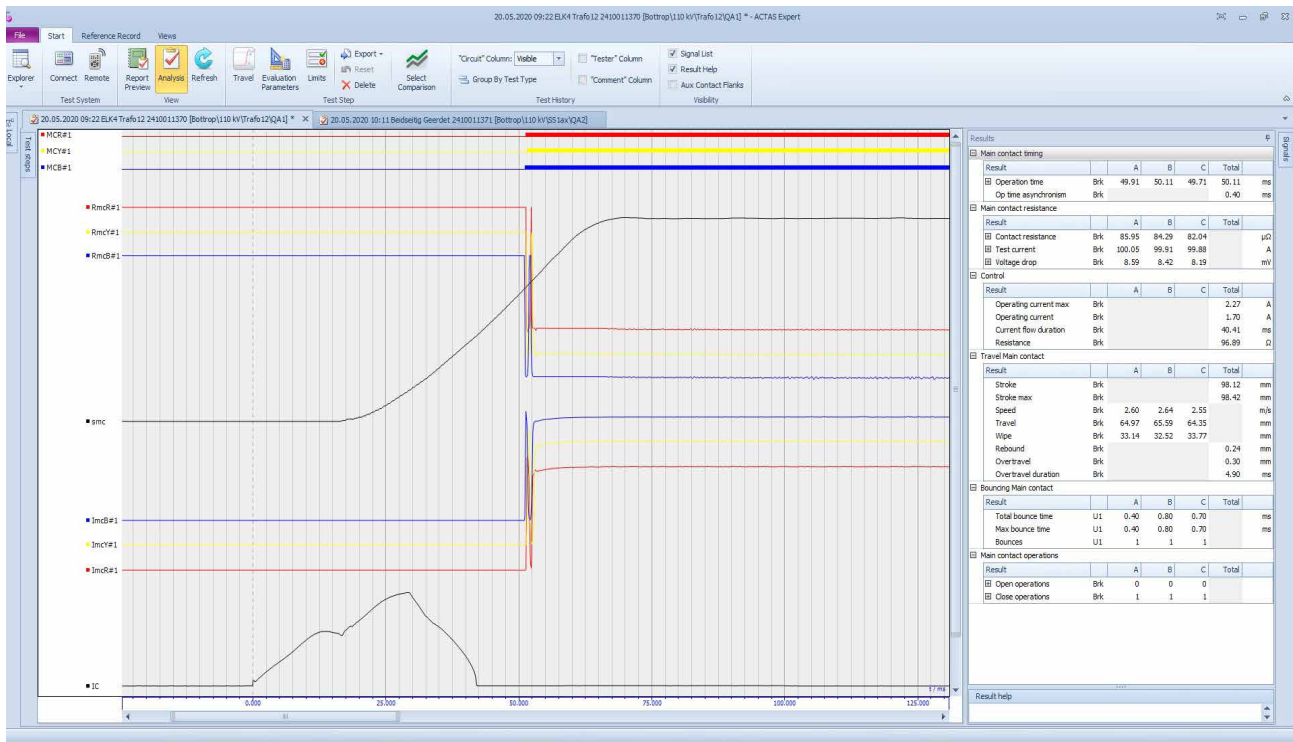


Figure 6: Dynamic timing measurement of a single-phase encapsulated GIS, grounded at one end, with ACTAS P360 and 3 PROMET L100, C switching sequence

Depending on the switching sequence, the result will contain correspondingly faster switching times when tripping or slower switching times when closing. KoCoS uses the GIS Timing method to measure correct switching times. For this measuring method, the GIS must have at least one insulated ground lead to the outside. Again, PROMET resistance meters are used and the resistance measuring devices are controlled by ACTAS (see figure 7). The resistance measuring devices are only used as current sources and not as actual measuring instruments. In order to obtain measured values, in addition to the resistance meters and ACTAS, current sensors specifically developed for KoCoS are used. They are flexible Rogowski coils which can be attached to the insulated ground. The current curves measured during the switching operation on the insulated ground can be used to determine the switching times for opening and closing during the various switching sequences of the circuit-breaker. This method has a great safety advantage and still offers the possibility of evaluating the GIS systems by means of measurement results and correspondingly recorded measurement signals.

Single-phase encapsulated GIS with grounding on both sides

To measure single-phase encapsulated GIS systems, it is possible to combine various PROMET resistance meters and ACTAS test systems. The PROMET models differ mainly in their design and the level of current output; the PROMET L100 and PROMET SE are battery-powered devices with a current output of 100 A and 200 A respectively. In a single-phase encapsulated GIS, it is recommended that three of these devices be connected in parallel to the insulated ground and to the housing. It is better if the switchgear has one on both sides of the insulated earth. When using PROMET R300 or R600 with a current output of up to 600 A, three devices should again be connected in parallel to the insulated earth of the GIS. When comparing the switching times of the GIS timing measurement with those of the conventional and dynamic timing measurement, it is quickly recognizable that the switching times are the same, except for a few decimal places (see figure 8). When comparing the Dynamic Timing and GIS Timing measurement methods, it becomes clear that it is also possible to measure the length of the arching contact,

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for example, when measuring with Rogowski coils (see figure 9). Just like the Dynamic Timing method, the measuring method has advantages over conventional method; not only in terms of safety, but also in terms of the possibilities for detailed analysis.

Three-phase encapsulated GIS with grounding both sides

For the measurement of three-phase encapsulated GIS systems, it is also possible to combine various resistance measuring devices with an ACTAS test system. The only difference to single-phase encapsulated GIS switchgear is that only one PROMET R300 or R600 is required. The test current is divided in parallel between the 3 switch chambers and the housing of the GIS switchgear. Due to the higher current output of 300 or 600 A, a current level is reached in the breaker units, which enables a switching time determination by Rogowski coils. It is recommended that the PROMET current cables be attached to pole B, as this is the most even way of distributing the current. However, a certain unevenness remains, which is indicated in the recorded measurement data by a larger deflection of the evaluation signal at

pole B (see figure 10). Of course, it is also possible to use 3 X PROMET L100 to apply enough current.

Measuring method for GIS without an insulated ground

For GIS without an insulated ground, it is possible to carry out a measurement using the first trip measurement method. For this purpose KoCoS offers the First Trip Test Monitor, which not only records the first opening of the switch but also allows other switching sequences to be determined. For the First Trip method, current clamps are connected to the secondary side of the current transformers of the circuit breaker. The corresponding switching time can be measured via the measured sine wave of the current over each phase depending on the switching sequence. In order to determine the zero point of the switching time, the coil currents are also measured using current clamps. The ACTAS System then can be triggered on the coil current value accordingly. For this purpose, external triggers can be set in the test system, both for binary signals and their flank as well as for analog signals with an adjustable threshold value which must be exceeded or fallen below depending on the operation.

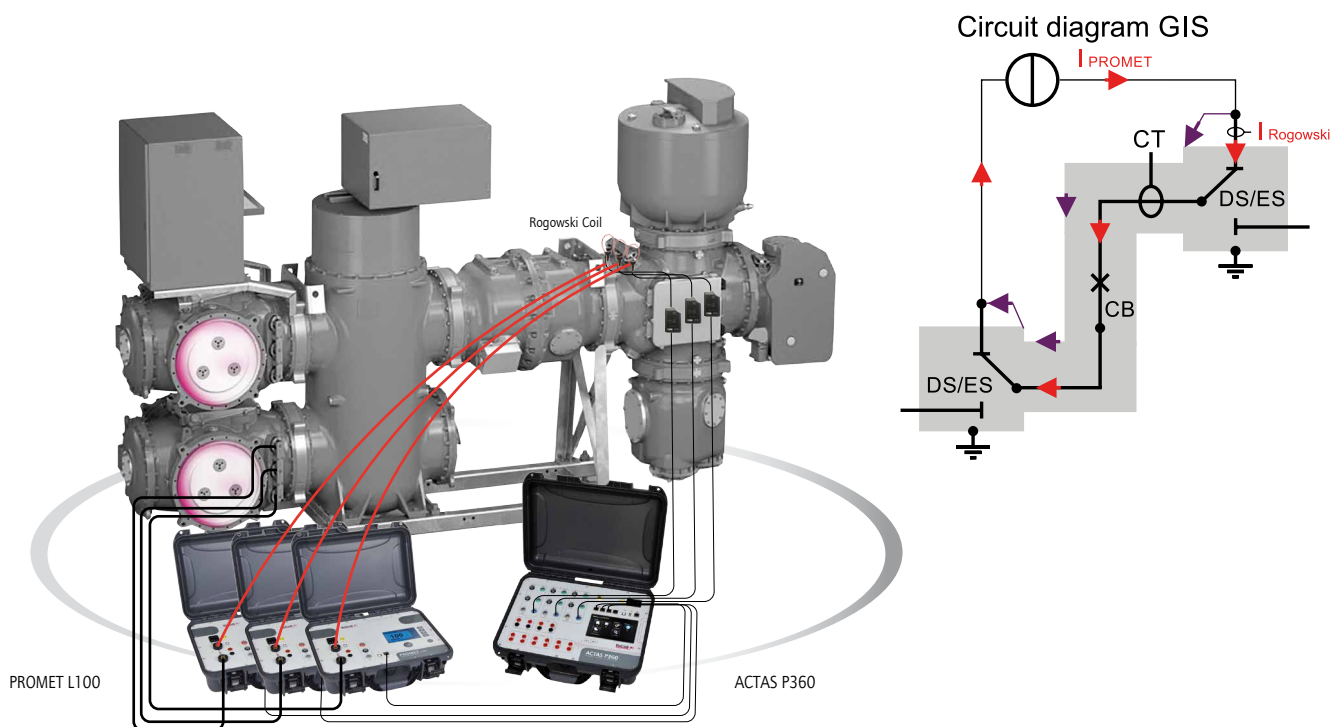


Figure 7: schematic and equipment view of Measurement at three-phase encapsulated GIS with ACTAS P360, 3 X PROMET L100 and Rogowski coils at the insulated ground

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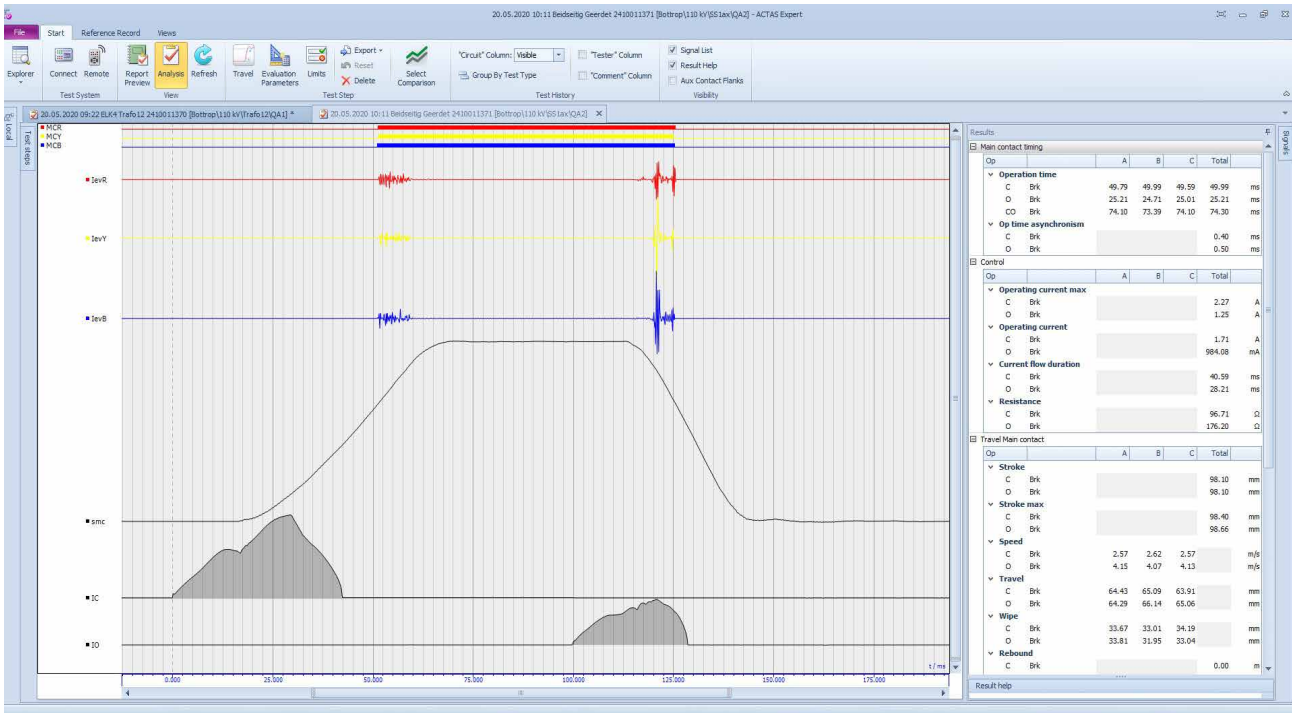


Figure 8: Single-phase encapsulated GIS, grounded on both sides, with ACTAS P360 and 3 PROMET L100, CO switching sequence

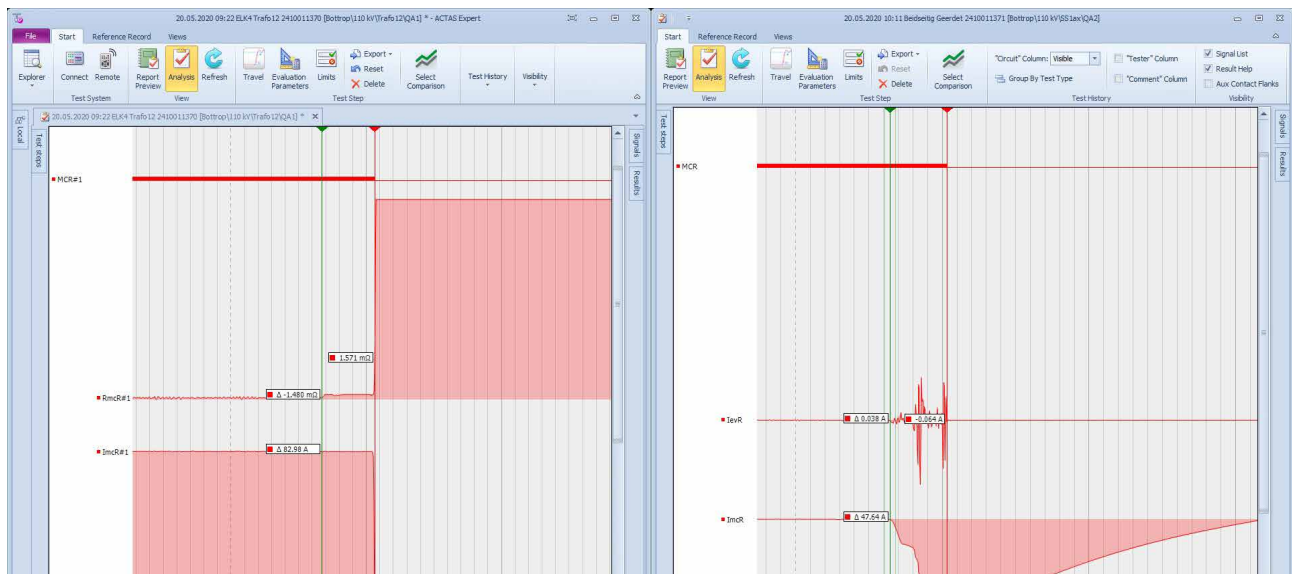


Figure 9: Single-phase encapsulated GIS grounded on both sides, O switching sequence with ACTAS P360 and 3 PROMET L100, pole A in comparison (on the left Dynamic Timing / on the right GIS Timing)

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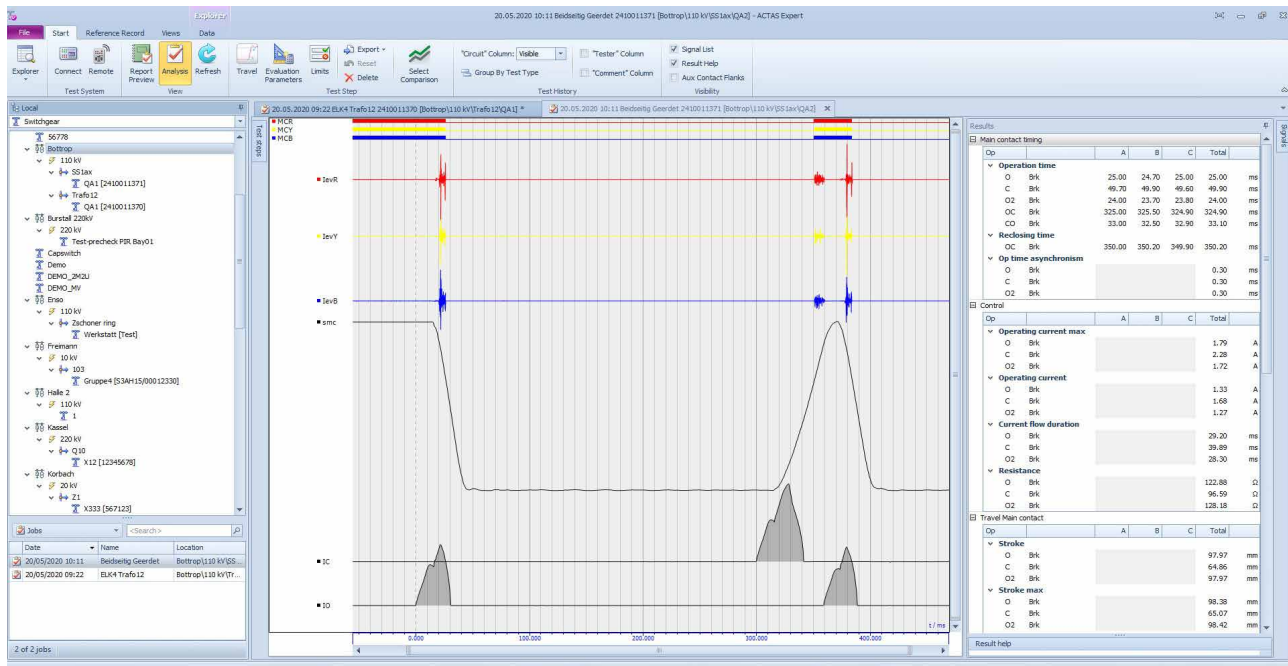


Figure 10: Three-phase encapsulated GIS switchgear, grounded on both sides, OCO switching sequence with ACTAS P360 and PROMET R600

Summary

It must be noted that commercial advertising of both sides grounded is a very vague term. As applied to Air insulated switchgear, it is quite easy to perform this test if the Breaker resistance is much lower than the ground resistance, which is almost always the case. When purchasing test equipment for testing GIS Switchgear, it must be clear that the manufacturer's test equipment must be able to handle the case where the resistance of the breaker is equal or higher than the ground resistance. To do this, the use of Rogowski coils enables flexible, effective tests to be carried out on GIS, which above all guarantees the necessary level of safety, as all components can remain grounded on both sides. This method has great advantages. Not only are the safety aspects of testing improved, so are the economic aspects; tests can be completed to more effectively in a shorter time. It is also required that if contact resistance is measured, that measurement set must be able to measure with both sides grounded as well.

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