SAFE AND RELIABLE

New method for grounded contact resistance measurements on high-voltage GIS circuit breakers

Gas-insulated switchgear (GIS) has been used widely in the last few decades and it is still growing in popularity within medium-voltage and high-voltage grids due to its compact layout and high reliability. Its reliability is so high because all components of the switchgear are embedded into a metal enclosure filled with an insulating medium, usually SF_6-gas. This enclosure prevents the current-carrying parts from being worn out by environmental effects. The disadvantage of this encapsulated design is the difficult accessibility to the current-carrying primary path for performing condition assessment measurements.

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However, despite its reliable design, condition assessment of GIS is becoming more and more important as the average age of existing GIS systems move toward the end of their life expectancy. To overcome this accessibility limitation, isolating grounding switches are incorporated into the GIS design for maintenance purposes.

Contact resistance measurement

One of the most common non-invasive circuit breaker condition assessment methods is the static contact resistance measurement. It induces a high current into the current-carrying parts of the GIS and at the same time the voltage drop is measured. By applying this so-called four-wire measurement method, a highly precise resistance value can be measured. This value can then be evaluated to determine the deterioration of the primary path of a GIS. The path consists of the grounding switch, the primary current conductor with its joints, and the circuit breaker contacts.

Staying safe during maintenance work

Due to their compact design, the phenomenon of induced voltages is well known in GIS environments. Therefore, it is mandatory during measurements to have all conducting parts which are accessible by test personnel permanently grounded. This includes the isolating grounding switches which are commonly used for applying non-invasive condition assessment methods to the inner parts of a GIS.

Contact resistance measurement on GIS

Applying a four-wire contact resistance measurement via the grounding switches causes the test current to flow via two paths. One path is through the inner parts of the GIS and the other path is through the enclosure enclosure. Without knowing the exact current flowing through the inner parts, the inner resistance R_{Inner} cannot be calculated accurately. ▸


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Grounded contact resistance measurement (GCR) method

In order to solve this issue, PTM 4.60 comes with a new technique for CIBANO 500, the grounded contact resistance (GCR) measurement method. It measures the resistance once during the open state of the circuit breaker and once during the closed state, allowing the inner resistance to be calculated.

$$R_{Inner} = \frac{1}{\frac{1}{R_{Total}} - \frac{1}{R_{Ground}}}$$

Resistance of the inner parts

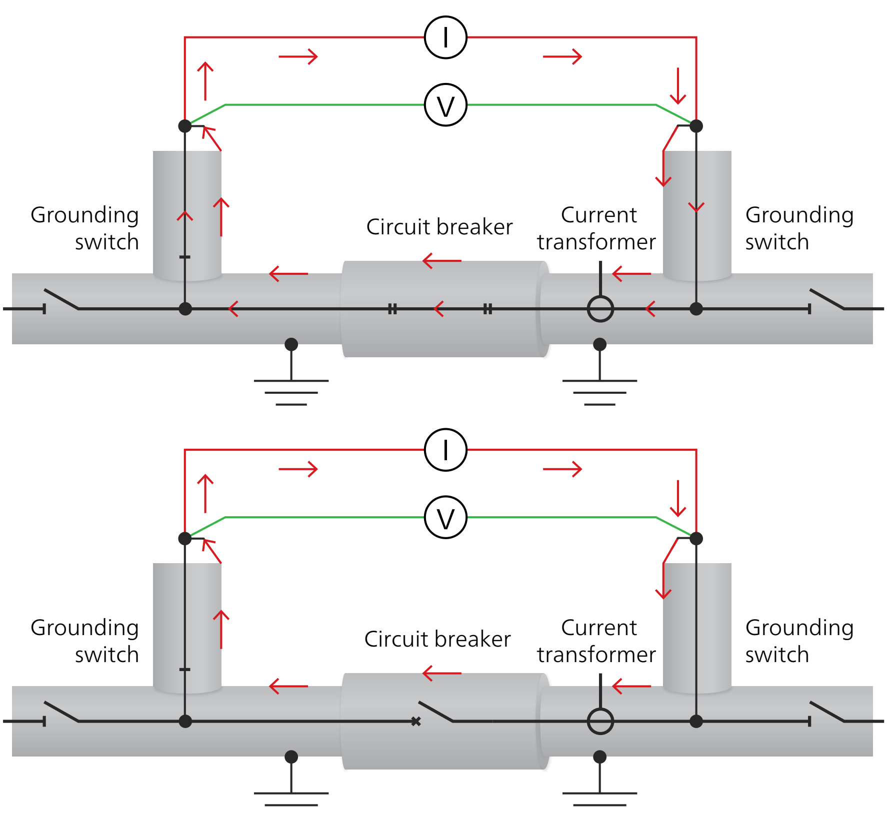
The resistance of the inner parts (R_{Inner}) of a GIS consists of the resistance of the main contacts, the grounding switch contacts, and the conductor.

Ground loop resistance

The ground loop resistance (R_{Ground}) is basically the resistance of the housing of the GIS. It is measured with a four-wire micro ohm measurement on the grounding switches which are located on both sides of the circuit breaker. During this measurement the breaker is open.

Total measured resistance

On a GIS that is grounded on both sides, the total measured resistance (R_{Total}) is a parallel circuit of the ground loop resistance (R_{Ground}) and the resistance of the inner parts (R_{Inner}). The resistance is measured via a four-wire micro ohm measurement on the grounding switches which are located on both sides of the circuit breaker. The breaker is closed during this measurement.



Contact resistance measurement with breaker closed (top) and with breaker open (bottom)

How reliable are the results?

Simulations and field tests in real substation environments have been performed to demonstrate the sensitivity and accuracy of CIBANO 500's new GCR method. They have shown that in GIS where each phase has its own enclosure, an abnormal resistance value of a faulty phase can be detected. However, in a GIS with all three phases in one enclosure, the GCR method cannot identify a bad contact in any of the three phases.

The verification of the GCR method also shows that there is a lower level of accuracy if CTs are in the main measuring path. In order to solve this issue the DC test current must be applied anywhere from a few seconds to a few minutes. This means the CTs are in a state of saturation and no longer affect the measurement results. After each GCR measurement it is recommended that CTs are "cleaned" by applying a demagnetization algorithm. This will ensure that no residual magnetism in the CTs will affect the further operation of the GIS's protection system. CIBANO 500 offers a demagnetization function for the CTs via the primary path and CT Analyzer a demagnetization via the secondary path.

This new feature, combined with the already established CSM method for timing measurements on a GIS that is grounded on both sides allows users to accurately measure timing and contact resistance safely for the first time.