Application Note

Micro-ohmmeter as power source for Dynamic Resistance Measurement (DRM)

The contact system of most HV circuit breakers consists of main and arcing contacts. One of the methods to assess the condition of arcing contacts is to inject high direct current (DC) through the circuit breaker contacts and measure the voltage drop during the breaker operation - a process called Dynamic Resistance Measurement (DRM). Lead batteries were used as a power source to produce pure DC current. Transportation and other technical reasons prevented wide use of lead and other rechargeable batteries for DRM testing. As an alternative, a micro-ohmmeter (the RMO device) can be used as a direct current source. RMO micro-ohmmeter is a portable, lightweight and easy to use device. At the same time it acts as a very powerful true DC ripple-free current source which is an efficient add-on component for DRM measurement execution. As a part of the same measurement set, the DV Power circuit breaker analyzer (CAT device series) records the voltage drop, current, contact motion during the breaker operation.

Connection procedure for this type of measurement is as follows:

1. Connect RMO's current and sense cables to a circuit breaker.
2. Connect current cables to corresponding current outputs on the RMO device
3. Connect sense cables to the analog channel 1 on the CAT device
4. Use Coil control cable to connect the CAT with the CB's control circuit

NOTE
The voltage sense inputs on the RMO Instrument should be short-circuited. If not, it will display the "VOLTAGE SENSE" error message.

Connection scheme is presented below (Figure 1):

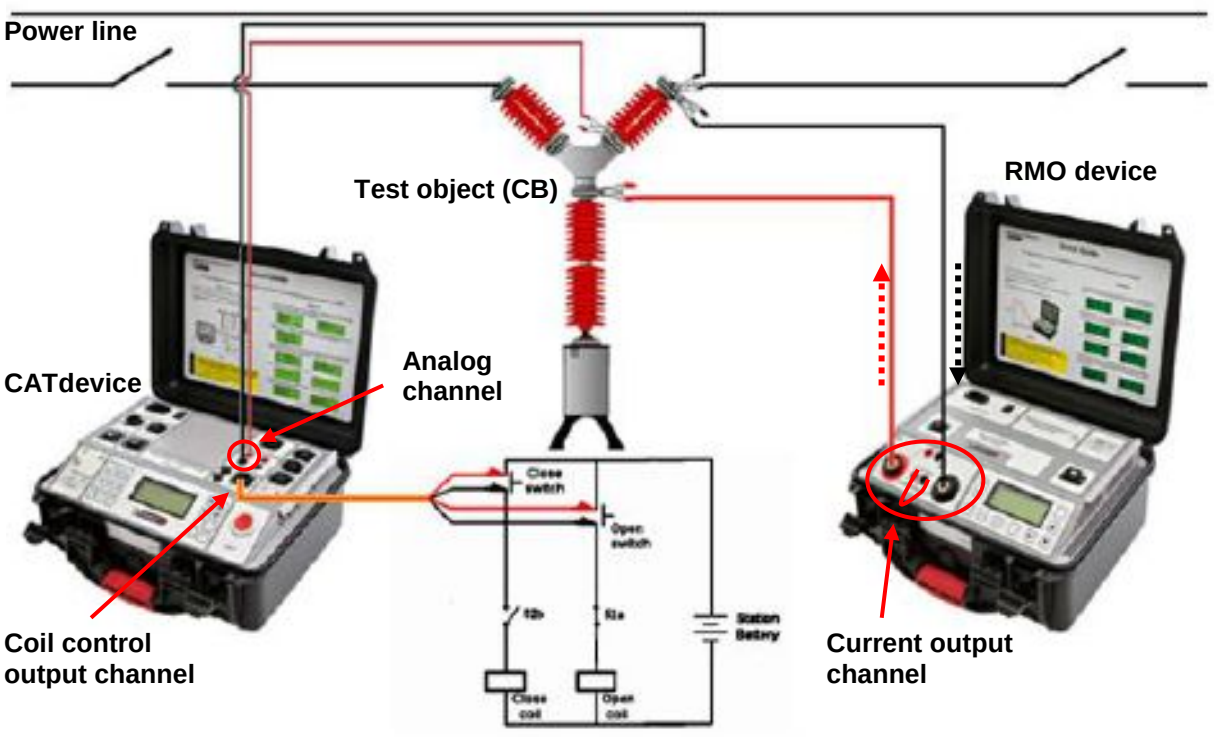

Figure 1 – *RMO device used as power source for DRM*

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The measurement procedure is described below:

1. Set the test current and test duration (e.g. 300 A, 30 s) in the RMO's **CONTIN** mode
2. Press ***ENTER*** to change to the **Ready** state.
3. Set the measurement parameters for **OPEN** test on the CAT device
4. Press ***Start test*** button on the CAT to change to the **Ready** state
5. Press ***START*** on the RMO device to start **CONTIN** test
6. Press ***START*** on the CAT device to start **OPEN** test

NOTE
After the CB opens, the RMO will display "OPEN CONNECTION" error. Press STOP button on the RMO to cancel it.

During an opening operation, sudden resistance change coincides with the separation of the main contacts and the separation of the arcing contacts. The resistance change would result in a sudden change of the voltage drop measured across the breaking element.

During each opening and closing operation, a fraction of the arcing contact material burns away.
It is known that the temperature at the centre of the arc is around 25,000 °C. This temperature is four times higher than the temperature on the surface of the sun. There is no material which can withstand such a high temperature. One of the consequences of material loss at the arcing contacts is that the time difference between separation of the main contacts and the separation of arcing contacts is shorter. This time difference is called the contact overlapping time, see the Figure 2.

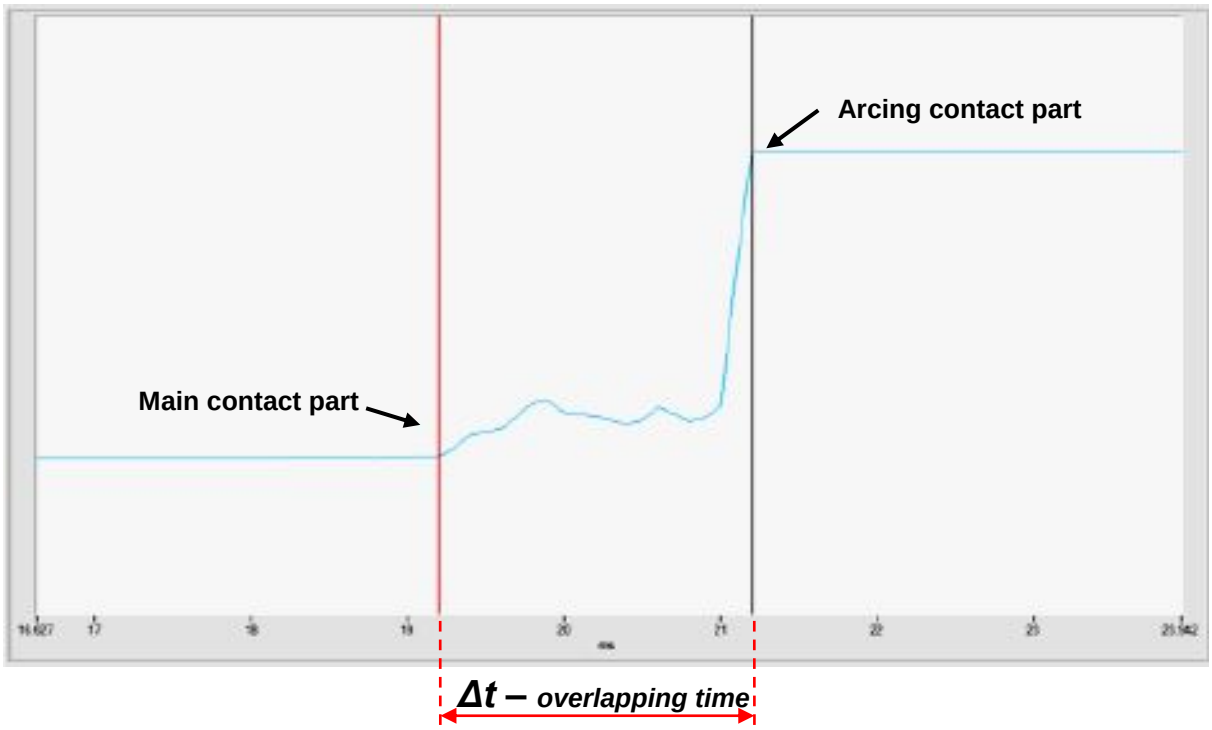

Figure 2 – *Overlapping time*

When the motion is measured, the difference between the moment of main and arcing contacts parting can be presented in distance units, for example millimetre. (Figure 3)

NOTE
Either analog or a digital transducer can be connected to the CAT transducer input channels.

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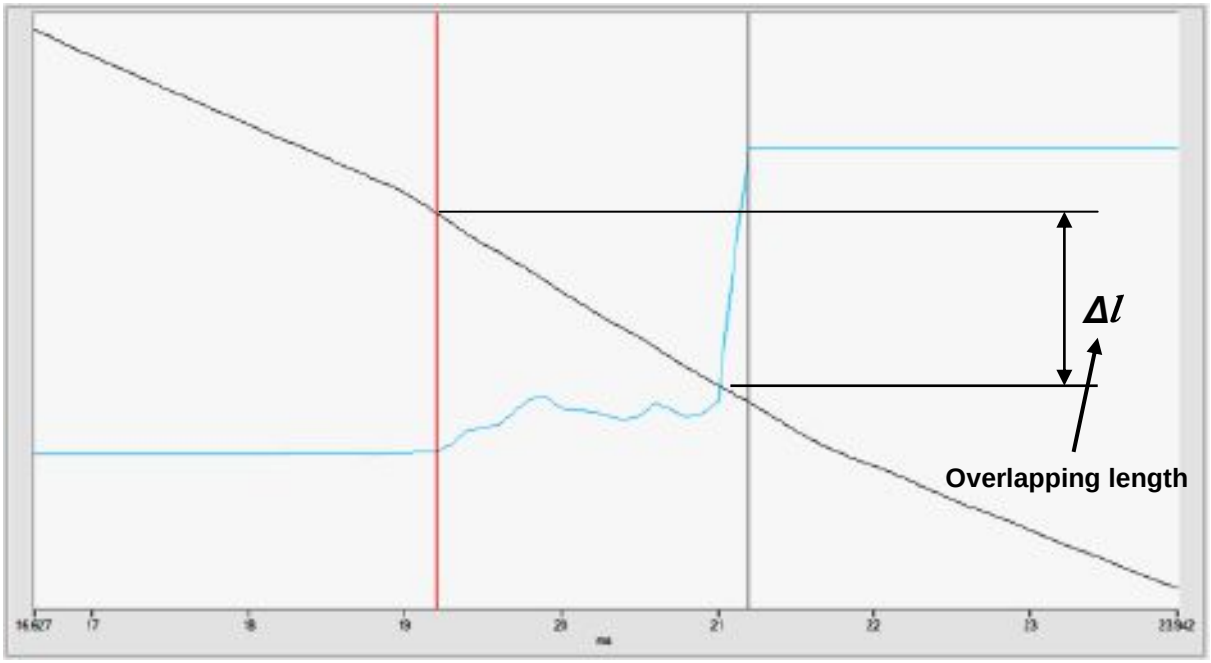

Figure 3 – *Overlapping length shown in millimetres*

Shunt deployment for current recording during DRM

Except for a voltage drop and motion, CAT device can also record a current during a breaker operation.

For this type of measurement a milliohm shunt (R ≤ 5 mOhm) should be connected in a series between the RMO output current cable and the circuit breaker. One additional current connection cable is needed to connect the shunt with a circuit breaker.

Two voltage sense or analog channels cables (analog cables) can be used for recording the test current change (change of the voltage divided by a constant resistance of the shunt). These cables should be connected to the analog channel 2 (set at a 2.5 V range).

The connection diagram is presented in the figure below:

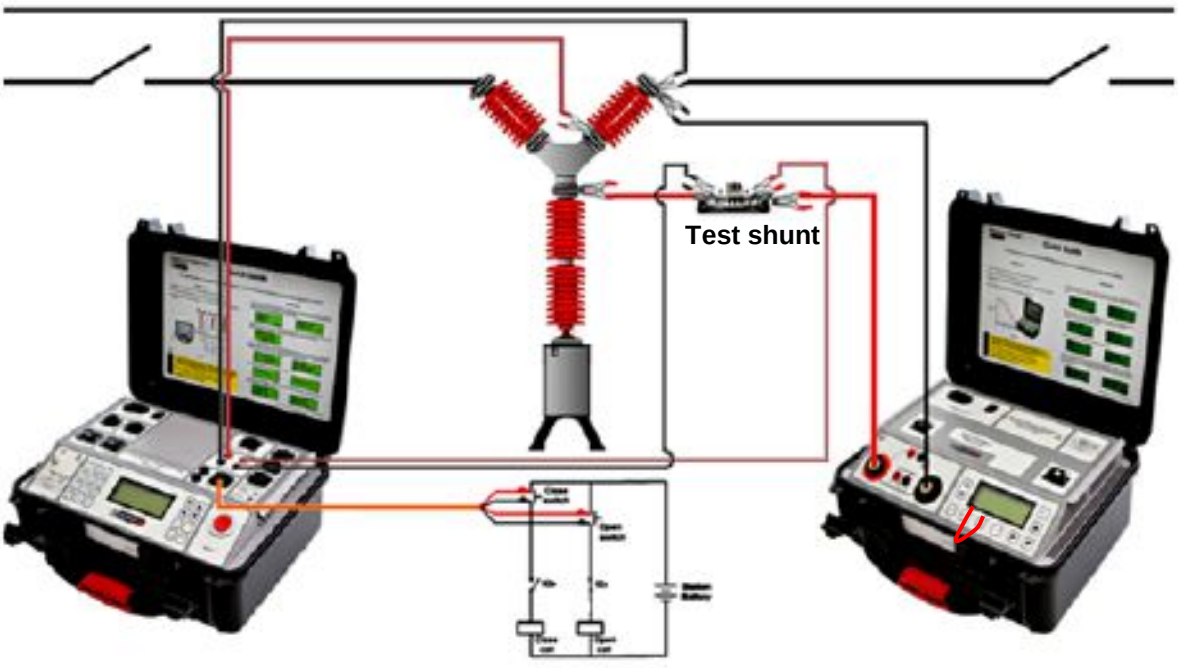

Figure 4 – *Current recording using a test shunt*

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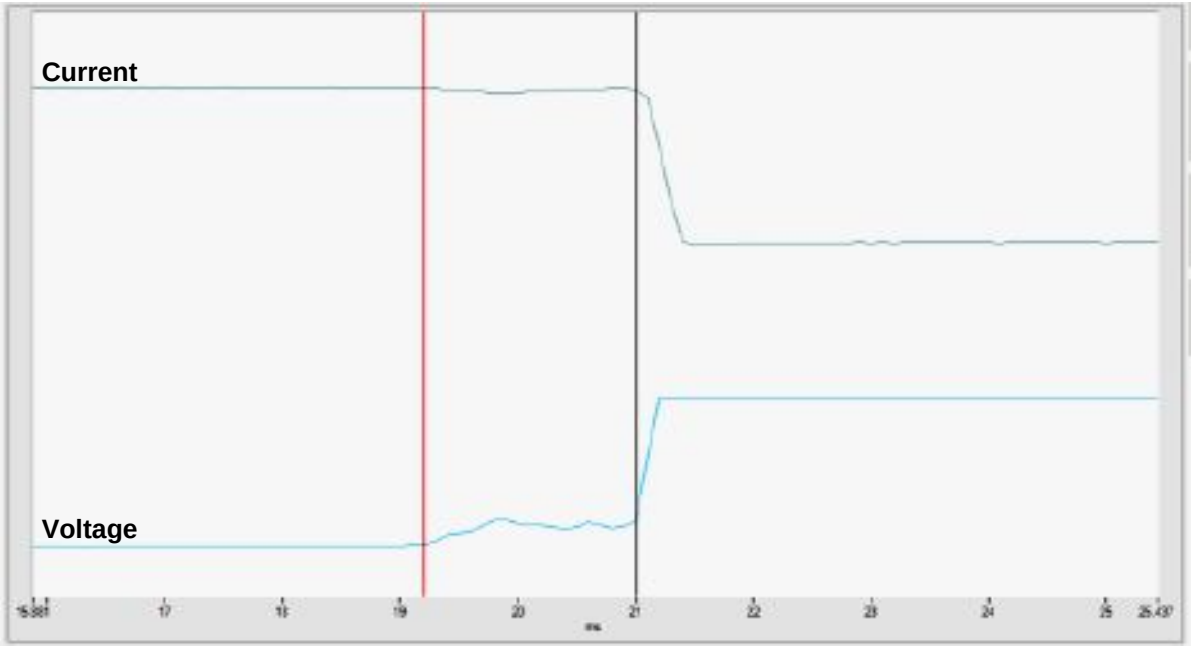

Figure 5 – *Current and voltage drop diagram*

For a period after the main contacts open, a voltage drop and a current are not constant and a calculation does not represent a resistance, but rather an impedance. Industry practice is to name this calculation a "dynamic resistance" when the voltage drop and the current are not constant.

Overlapping length of main and arcing contacts is calculated manually. One cursor should be positioned at the starting point of the main contact part and the second at the ending point of the arcing contact separation.

NOTE
Very important advantage of our CAT device is that DRM measurement can also be performed in "both sides grounded" (BSG) circuit breaker condition.

Dynamic resistance measurement in BSG condition

Testing in conditions when the CB is grounded from both sides provides more safety to the device and the user, since a current paths guides any induced current through the ground.

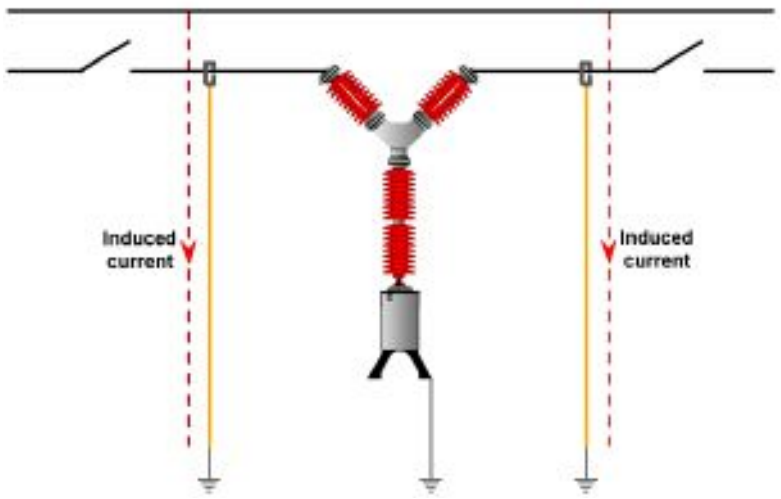

Figure 6 – *Increased safety in "Both sides grounded" condition*

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The voltage drop and the current graphs recorded during the BSG test are presented below (Figure 7) while the resistance and the motion diagrams are in the Figure 6.

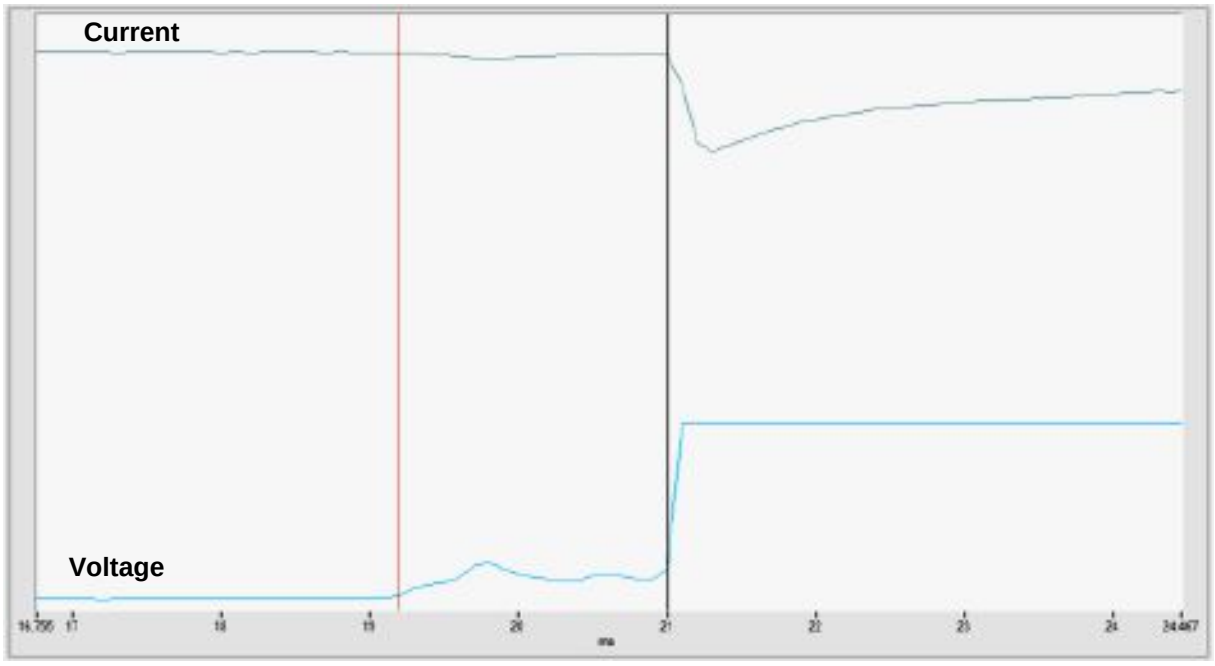

Figure 7 – *Voltage drop and current – both sides of CB grounded*

In this Application Note all the diagrams correspond only to the trip operation. The overlapping time and length are best calculated when the trip operation is performed. For example, closing operation can be used to detect misalignment of arcing and main contacts. Such problems can be also detected during regular timing and motion testing while observing the velocity diagram during the first period of the arcing contact engagement.

Use of a micro-ohmmeter as a power source for the DRM test, shows very good results in detecting the moment of main contact separation, as well as main and arcing contacts' overlapping time and distance.

In case of current injection testing a dead tank circuit breaker with CTs mounted on bushings, demagnetization of the CT is required. The demagnetization option on the RMO-D series micro ohmmeters allows injection of relatively high DC current into the main current circuit of dead tank circuit breakers without concerns for magnetization of current transformers.

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