Application Note

Using CONTINuous Mode for Contact Resistance Measurement

All DV Power micro ohmmeters (RMO series) have the following two basic test modes:

- SINGLE
- CONTINuous

Single mode is a standard mode for contact resistance measurement. The RMO instrument generates a filtered (true) DC current in the shape of an automatically regulated current ramp virtually eliminating magnetic transients. The measurement is done in a period of 1 s, after the set current is reached.

Below is an illustration of a single test ramp for the 200 A current

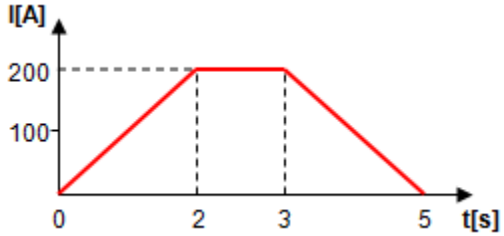

Figure 1 - *SINGLE test ramp*

However, besides the SINGLE test, in some cases some additional measurements are needed for obtaining the accurate and reliable information about the contact resistance of the circuit breaker. For this reason, RMO devices have additional CONTIN mode which enables continuous DC current generating in predefined period of time.

The Fig. 2 illustrates the test ramp in the CONTIN mode for the 200 A current

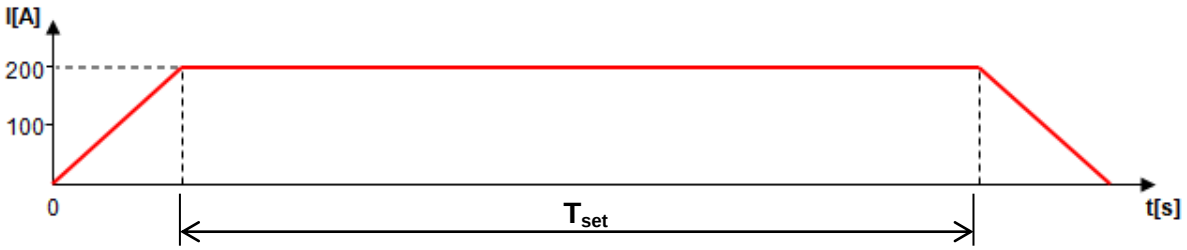

Figure 2 - *CONTIN test ramp*

The maximal T_{set} that can be selected in case of 200 A is 150 s (2.5 min). During the test, a new result is shown on the display at each second and the last result is saved in the internal memory. User can also choose which result to save by pressing the button **Ω**.

When using DV-Win software, all results are saved in the excel worksheet table. The user can set the sampling time for each test (e.g. for 20 s test, device will save 20 results if the sample time is 1s and 5 results if sample time is 4s).

Postal address
IBEKO Power AB
Box 1346
181 25 Lidingö
Sweden

Delivery address
IBEKO Power AB
Stockholmsvägen 18
181 50 Lidingö
Sweden

Contact
phone: +46 8 731 76 99
fax: +46 8 731 77 99
sales@dv-power.com

When is Recommended to Use CONTINUOUS Mode?

The resistance of circuit breakers is a very good indicator of circuit breaker's condition. The resistance value outside of specifications or some expected range can be an indicator of:

- damaged contacts
- contact force lower then specified
- polluted isolation medium
- malfunction – breaker is not in fully closed position.

In order to assess the condition of the circuit breaker and to find a cause of increased resistance value, some additional checking is needed. One of them is to disassemble the breaking chamber and to visually check the condition of the main contacts, which is very complicated and time consuming procedure.

NOTE
It is recommended to use the CONTIN test when results obtained in the SINGLE test are out of specifications, or out of some expected range, or suspicious in any other way.

Generating a high DC current in a longer period of time enables the following benefits:

a) Avoidance of "decreased contact surface" phenomena.

The contact surface is inversely proportional to resistance:

$$\boldsymbol{R = r \times l = \rho \times \frac{l}{S}}$$

This means a decreased contact surface area directly leads to increased contact resistance. One of the reasons of decreased contact surface can be an insulating layer between the contact surfaces of the sliding contacts caused by a dry lubricant and/or decomposition products. Using the high DC current in a longer period of time (CONTIN test) ensures resistive layers are punctured and disintegrated.

EXAMPLE *- ABB HPL circuit breaker*
Increased contact resistance cannot alone be considered as a reliable indication of deteriorated contacts or connections. Temperature rise tests on an HPL circuit-breaker having increased contact resistance and applying the approach as stated above have revealed that:

- The higher value of contact resistance does not result in increased temperature rise;
- The contact resistance after the test had decreased to a value within the normal range.

The explanation of the phenomenon of increased resistance is a dry lubricant and/or decomposition products build an insulating layer between the contact surfaces of the sliding contacts (puffer cylinder and contact fingers). Because of the fact that the sliding contacts consist of two rings of contact fingers (one in the upper current carrying part and one in the bottom current carrying part), a moderate increase of the contact resistance will cause an unbalance between the currents carried by each individual finger. This may result in that only a few contact fingers are carrying the current, especially when measuring contact resistance with low DC currents.
When the load current is increased, like when performing a temperature rise test, the voltage across the individual contacts will increase until the resistive layer is punctured and disintegrated. It should be noted the local temperature rise of the individual contacts is so moderate that it will neither give any

Postal address
IBEKO Power AB
Box 1346
181 25 Lidingö
Sweden

Delivery address
IBEKO Power AB
Stockholmsvägen 18
181 50 Lidingö
Sweden

Contact
phone: +46 8 731 76 99
fax: +46 8 731 77 99
sales@dv-power.com

noticeable temperature rise of the breaking chamber insulator nor of the terminals. The contact surfaces have been free from burning marks after such a test.
For the circuit-breakers having a load current of less than 400 A, the recommendation is the resistance values of 1,000 μΩ per a breaking unit may be permitted when measuring with 100-400 A DC.
If higher resistance values are detected a check of the contact position should be made to ensure the problem is not related to a mechanical failure.

b) Analysis of the resistance change during the measurement

CONTIN test enables monitoring resistance values change during the test. Having in mind a temperature cannot be significantly increased during the test; the contact resistance during the test should be relatively constant. Any significant resistances changes indicate loose contact and unstable measurement conditions. Because of this, only results which are relatively constant during the test duration can be taken into consideration and analyzed.

EXAMPLE - *Tested CB with rated contact resistance 100 uΩ*

Please observe one example from a real life test case.

Inconsistencies were detected when single mode measurements were applied. After applying three continuous measurements, it was noticed that resistances during the test were changing. Also, the resistances in each subsequent test were getting lower and lower.

Table 1 - *Measurement with continuous current*

Test current	1. measurement	2. measurement	3. measurement
200 A	239 uΩ	200 uΩ	123 uΩ

This was the clear indication that established contact isn't good enough or some pollution insulation layers were built on the contact surface. Because of this, it was decided to re-close the circuit breaker and repeat the measurement in CONTIN mode.

The saved results in three CONTIN test obtained after O-C operation are presented in the table below:

Table 2 – *Results obtained after O-C operation*

Test current	1. measurement	2. measurement	3. measurement
200 A	100.1 uΩ	100 uΩ	100.1 uΩ

These results could be analyzed as a valid reference, because the resistance value didn't vary during the test. Also, the results of thee repeatable tests were consistent and in the expected range.

It was assumed that a thin emulsion layer was built on the contact surface.

Postal address
IBEKO Power AB
Box 1346
181 25 Lidingö
Sweden

Delivery address
IBEKO Power AB
Stockholmsvägen 18
181 50 Lidingö
Sweden

Contact
phone: +46 8 731 76 99
fax: +46 8 731 77 99
sales@dv-power.com