Dynamic Resistance Measurement method applying high DC current

Adnan Secic, Project Leader, DV Power Sweden
Budo Milovic, Application Engineer, DV Power Sweden

ABSTRACT

A dynamic resistance measurement (DRM) of circuit breakers using a micro ohm meter as a power source capable of generating few hundred amperes is presented. Having high current through the breaker contacts and simultaneous monitoring the voltage drop across the main contact during the operation of the breaker was reported first in 1993 [1-2]. The DRM test requires a circuit breaker analyzer with a high resolution measurement [3]. From the resulting resistance plot the point of change from main contacts to arcing contacts can be detected. The resistance curve, as a function of a contact travel can be used to reveal potential problems related to the arcing contact condition [4]. In the case where motion is also measured, the actual length of the arcing contacts can be calculated.
This paper explains the benefit of injecting the current as high as possible, but not less than 100A, to provide a reliable voltage drop reading, thus allowing exact detection of the arcing contact performance.

INTRODUCTION

The design of modern high-voltage puffer-type SF6 gas circuit breakers is based on the switching of two parallel contact sets. First, the low-resistance silver-plated contacts, or the main contacts, are specifically designed to carry the load current without any excessive temperature rise. The second, tungsten-copper arcing contacts operate at breaker opening following the main contact part. The electrical arc starts after the separation of the arcing contacts. The tungsten-copper material is designed to carry the arc until it is cleared at the next zero–crossing.

The overall contact system of circuit breakers consists of two distinct contact elements:

- *Contacts with primary role to conduct currents when breaker is in closed position*
- *Arcing contacts designed to be first to touch and last to part; any electrical arc formed during breaker operation will appear on the arcing contacts.*

We would like to present a new dynamic-contact resistance measurement method that can be used as a tool to diagnose the condition of these arcing contacts. The method has been validated by field tests performed on SF6 gas circuit breakers [5-6]. The new method is based on the breaker contact resistance measurement during an opening operation at rated contact speed. After reviewing the characteristics of the dynamic resistance curve and the measuring system and parameters, the paper deals with relevant values that can be extracted from the resistance curve for detecting contact anomalies, wear, and/or misalignment. Finally, case studies are presented and test results are discussed.

MEASUREMENT TECHNIQUES

Battery as a power source for DRM test

Regular 12 V car-batteries can be used as source for current injection. Analog channel (range 1 V) at CAT64 test instrument was used for voltage drop measurement across breaker terminals. It is recommended to perform trip free test without battery to check if everything is connected properly and breaker will operate trip free.

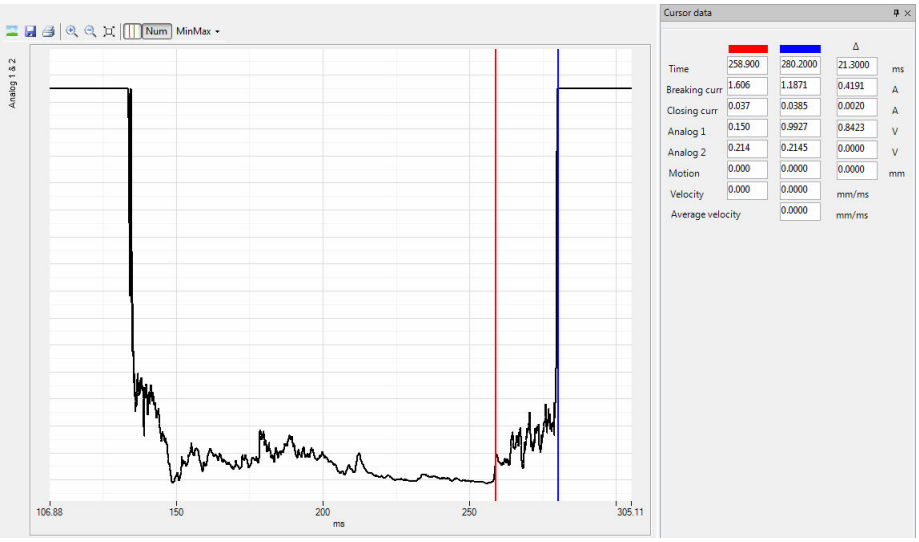

Figure 1: 145 kV SF6 circuit breaker

Car battery was used as power source for high current injection. Voltage drop was measured across breaking elements during trip-free operations.

Disadvantages of this solution are weight, possibility of accidental battery short circuiting as well as contact connection. The use of lead acid or other rechargeable batteries as a source presents technical problems that will prevent their use as a practical source.

DRM at low contact speed

There is an alternative method which uses slow motion of circuit breaker when DC current is injected. Such slow motion method results do not represent a real situation because there are no breakers which will operate with such low speed. Specifically contact system will not behave as when breaker is operated at normal velocity. Additional disadvantage is that this method is intrusive for some breaker mechanisms, since an adjustment to the operating mechanism is required. There is a potential risk of damaging the operating mechanism when restoring it back in service.

***DRM at rated contact speed using micro ohmmeter* as the power source**

Another successfully used strategy was performing the DRM tests at rated opening speed injecting current of at least 100 A. The CAT126D test instrument was used as both power source, and current and voltage drop recorder. Test object was 145 kV SF6 dead tank circuit breaker.

Technical characteristics of a 200 A micro ohm meter used as a power source were: load voltage of up to 7 V, and measuring accuracy of ± (0.1 % reading + 0.1 % full scale).

Linear to rotary converter was used for digital rotary transducer T1, with transfer function: 1 mm at contacts = 2.7904 deg at transducer. Measured static resistance of the CB is 88.9 μΩ and this value shows no damage on the main contacts.

The DRM results obtained at 200 A current indicated the main contacts separation at 19.6 ms. It means that the arcing contact overlapping time is approximately 5.2 ms (that is the expected time) and overlapping length is approximately 20.6 mm*. Resistance value obtained is around 400 μΩ to 1400 μΩ after the main contacts open. This resistance value is common for arcing contacts. First step noticed on the graph at 15 ms is probably due to fact that the main contact resistance increases as the contacts start moving.

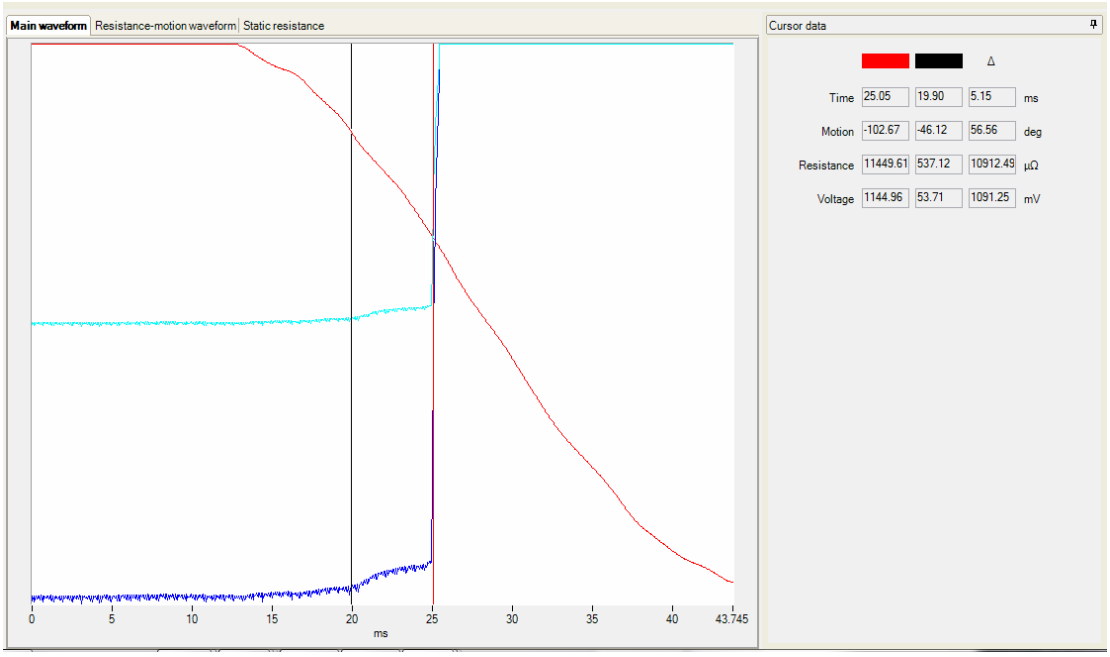

Figure 2: DRM graph at 100A on 145 kV SF6 circuit breaker.

DRM results obtained with 100 A current. It is hard to identify the point of main contact parting. The presumed main contact separation point is indicated based on other measurements.

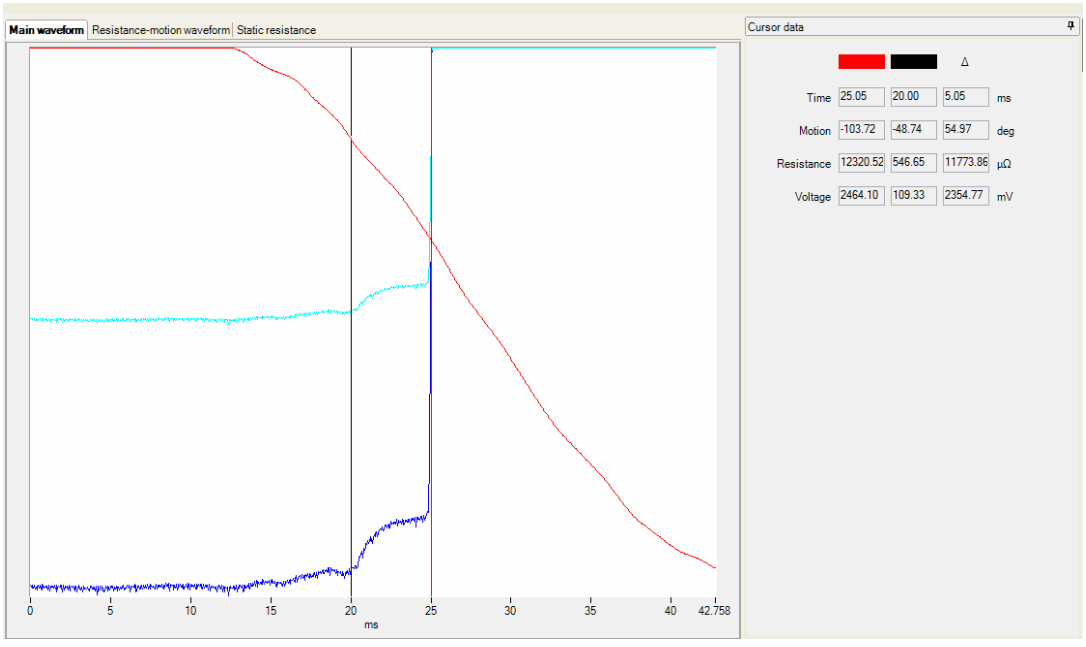

Figure 3: DRM graph at 200A on 145 kV SF6 circuit breaker.

The DRM graph is obtained at 200A. The graph is far smoother and the point of main contact parting can be easily identified.

CONCLUSION

The preventive maintenance on a high voltage (HV) breaker consists of several routine tests. The timing and motion tests are one means used to assess the breaker mechanical condition. When the timing and motion results indicate an abnormality, the DRM test can be an effective way to further diagnose the internal condition of the breaker contacts.

Figure 3 depicts an example of dynamic resistance measurement on high voltage circuit breaker where transition from static resistance value to open contact is shown.

Based on above graphs (***Fig.2*** and ***Fig.3***), it becomes clear that interpreting the DRM curve at 100 A may lead to a wrong diagnostic conclusion, especially for the main contact separation which occurs at approximately 19 ms. As the injected current is increased (100 to 200 A), the graph is far smoother and the main contact separation can be easily identified, as shown in Figure 3.

In view of these results, it would be recommended to apply an injected current of at least 200 A when performing DRM tests at the rated contact speed on 145 kV SF6 circuit breakers.

*Note: *Measured lenght of the arcing contact is approximatly 20,6 mm (57,6 deg), from 19,6 ms to 24,9 ms. Transducer: Emeta, MA306-10-2500-3, Model: #S108-B 2500*

REFERENCES:

[1] F. Salamanca, F. Borras, H. Eggert, and W. Steingräber, “Preventive diagnosis on high-voltage circuit breakers,” in Proc. CIGRE Symp., Berlin, Germany, 1993, pp. 120–02.

[2] M. Ohlen, B. Dueck, and H. Wernli, in Proc. Dynamic Resistance Measurements—A Tool for Circuit Breaker Diagnostics, Stockholm Power Tech Int. Symp. Electric Power Engineering, Sweden, Jun. 18–22, 1995, vol. 6, pp. 108–113.

[3] R. Kumar Tyagi and N. Singh Sodha, “Condition-based maintenance techniques for EHV-class circuit breakers,” presented at the Doble Client Conf., Boston, MA, 2001.

[4] J. Levi, “A SIMPLIFIED METHOD FOR DETERMINING HV CIRCUIT BREAKER CONTACT CONDITION - DYNAMIC RESISTANCE MEASUREMENT presented at the Doble Client Conf., Boston, MA, 2005.

[5] R.Ostojic, J. Levi, “USE OF MICRO OHM METER AS A POWER SOURCE FOR DRM TESTING ON DEAD TANK CIRCUIT BREAKERS, presented at the Doble Client Conf., Boston, MA, 2013.

[6] M. Landry, A. Mercier, G. Ouellet, C. Rajotte, J. Caron, M. Roy, F. Brikci, “A new measurement method of the dynamic contact resistance of HV circuit breakers IEEE PES Transmission and Distribution Conference and Exhibition, Dallas, USA, p. 1002-1009, 21-24 May 2006.

BIOGRAPHY

Adnan Secic is a firmware developer at DV Power, Sweden. As a project leader he is currently responsible for the development of CAT series instruments. Adnan received his Bachelor of Science in Electrical Engineering from University of Sarajevo Bosnia and Herzegovina in 2008 and is currently preparing M. Sc. in EEA (Electronics, Electrotechnics and Automation).

Budo Milovic has been employed at DV Power since 2007, and currently works as technical application engineer for CAT instruments and circuit breaker testing. His field of interest is improvement of the circuit breaker testing equipment. He received his Bachelor of Science in Electrical Engineering from University of East Sarajevo, Bosnia and Herzegovina in 2005.