Application Note

Dynamic Resistance Measurement - DVtest

Introduction

Power transformers are critical, capital-intensive assets for utilities as well as for industry. Regular maintenance is crucial part of extending their life span, since it can help diagnose faults while they are still in their early stages.

Failures can appear on all transformer parts. However, since the OLTCs (On Load Tap Changer) are the only moving parts of transformers, the OLTC failures are the most frequent. Analysis of available statistical data has shown that more than 40% of all transformer failures are caused by the OLTC. This fact makes regular analysis and maintenance of the OLTC one of the most important parts of transformer maintenance.

Analysis of the OLTC condition used to be a complicated and expensive process. Since the OLTCs are placed inside the transformer tank, it was necessary to disconnect the power transformer from the network, open it and remove the transformer oil. Once these actions have been performed, it was necessary to visually check mechanical condition of the OLTC. This procedure was difficult and time-consuming, and the results were not always reliable.

New methods of the OLTC testing and analysis were developed in order to improve this procedure. Among the currently available methods of the OLTC analysis, the DRM (Dynamic Resistance Measurement) has shown very good results. The measurements are performed quickly and easily, while results can be thoroughly analysed.

Dynamic Resistance Measurement and OLTC Analysis

There is a big amount of variety among the OLTCs in today's market. They differ in the number of tap positions, number and type of transition resistors, methods of switching, etc. Up to very recently, only the static behavior of the contact resistances has been taken into consideration in maintenance testing and diagnostics of power transformers. The DVtest (DRM) method can successfully diagnose and analyze the state of all OLTC types.

The DVtest is actually the measurement of the test current change during the transition. The current represent the change of the resistance in the circuit during the change of the tap position. The current is an inverse to the total resistance of the circuit (winding resistance + OLTC contacts resistance). The results are obtained using the RMO-T or TWA series devices together with DV-Win PC software. The connection of the test equipment to the test object for the DVtest is shown in the Figure 1.

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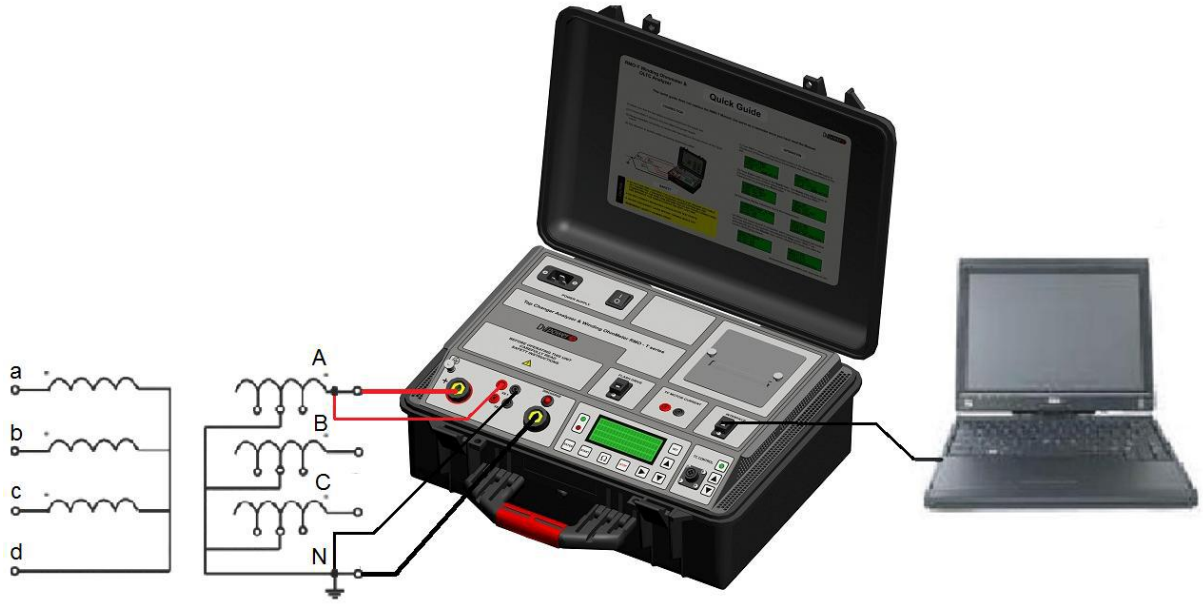

Figure 1. Connection to the test object

An example of an OLTC in the figure below. It consists of the tap selector part and the diverter switch part. This OLTC type has two transition resistors in the diverter. Switching problems of the diverter switch can be detected by analyzing several key features of the DVtest graph which is shown on the Figure 2 for a simple transition.

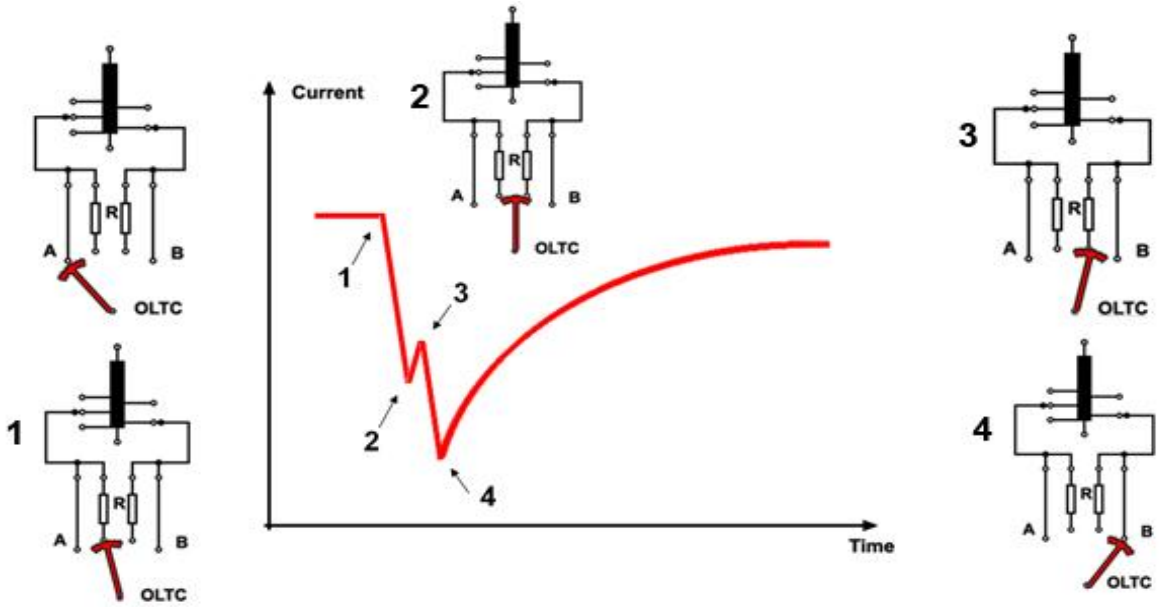

Figure 2. Dynamic behavior of the diverter switch.

During the DVtest, the instrument continuously records current while positions of the OLTC are changed. The measurement is performed very quickly. It is not necessary to discharge the transformer

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and then to charge it again for each tap change. Once the transformer is charged, the operator changes the tap positions and the instrument will record the transitions.

Advantage of any test method is simplicity and user-friendliness. The DVtest provides these advantages, by creating a graph where problems are easily recognized.

Three important parameters can be observed on the DVtest graph:

- Current ripple
- Transition time
- Shape of the graph

Current Ripple

The current ripple is the test current change (in percentage points) during the transition. This depends on the construction of the transformer/OLTC and there is no strictly defined value for comparison or pass/fail criteria. During the results analysis, this value is compared to the value of the next transition, the results of one phase with the other two phases and complete results are compared with the results obtained from previous test.

Transition Time

The transition time is the time necessary for the change of the OLTC position. It also depends on the construction of the tap changer and it usually takes between 30 and 50 milliseconds for resistive type OLTC.

Shape of the Graph

The graph obtained by DV-Win can have different shapes for different types of tap changers. It can be affected by the number and size of resistors used during the change of tap positions, tap changer mechanism, contact construction and condition, etc

One can easily observe and diagnose bad contacts by zooming the graph, like in the Figure 3, where before- and after-repair results are compared.

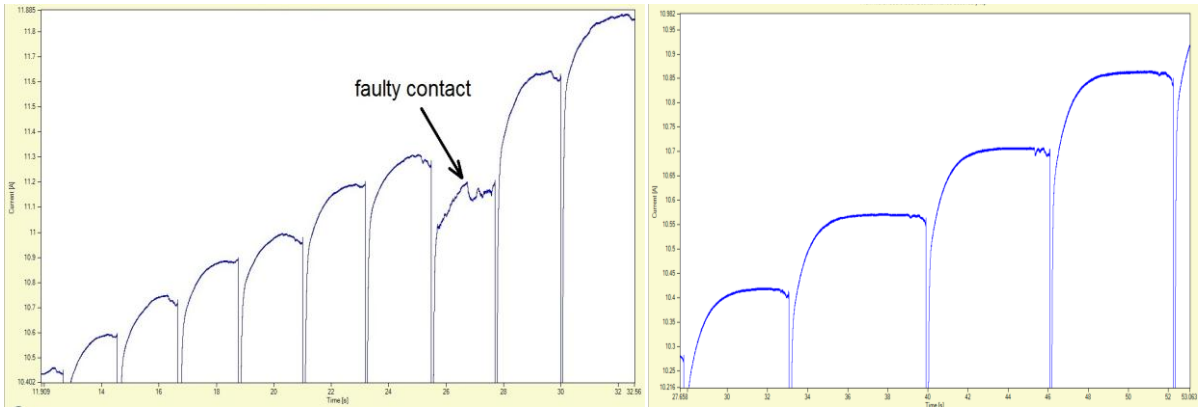

Figure 3. DVtest graph before and after repairs

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In addition to graphical presentation, numerical values are provided for a quick comparison of Ripple, Transition time, and other parameters used for diagnostics at each tap position, as seen in the Table 1.

Table 1. Numerical values of measured parameters at first 10 tap positions

Date and time	Connection	Current [A]	R1(25°C) [mOhm]	R1(75°C) [mOhm]	V1 [mV]	Ripple	Tap position	Transition time [ms]
5/8/2010 13:58	1U - 1V	10.74	291.2437	347.36	3126.641	0	1	0
5/8/2010 13:59	1U - 1V	10.93	285.0616	339.9868	3116.955	8.5	2	46.8
5/8/2010 14:00	1U - 1V	11.15	279.0591	332.8277	3112.185	8.5	3	48.1
5/8/2010 14:00	1U - 1V	11.37	272.5099	325.0166	3097.266	8.4	4	46.8
5/8/2010 14:01	1U - 1V	11.57	266.7406	318.1357	3085.091	8.4	5	45.5
5/8/2010 14:02	1U - 1V	11.78	260.5021	310.6952	3067.431	8.8	6	45.7
5/8/2010 14:02	1U - 1V	11.99	254.1737	303.1474	3046.654	9.5	7	44.4
5/8/2010 14:03	1U - 1V	12.25	246.5858	294.0975	3019.804	10.4	8	50.6
5/8/2010 14:04	1U - 1V	12.25	245.8175	293.1812	3010.838	11.2	9	48.5
5/8/2010 14:04	1U - 1V	12.52	239.5066	285.6543	2997.603	11	10	50.8

Separate control window in DV-Win provides useful tools, like moveable markers on the graph measuring characteristic values, time and amplitude. The values shown on the control window are the time interval between two markers, and current difference between the markers. A typical diagram is shown on the Figure 4. This diagram shows a good condition of the OLTC.

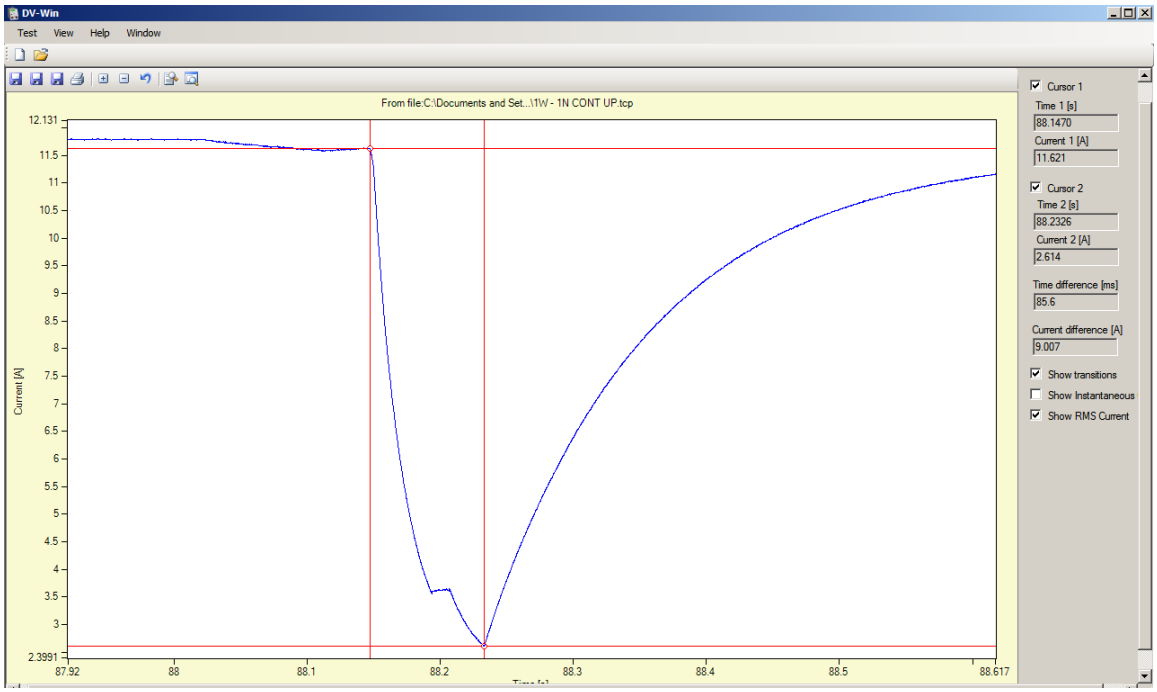

Figure 4. Current change during one good transition

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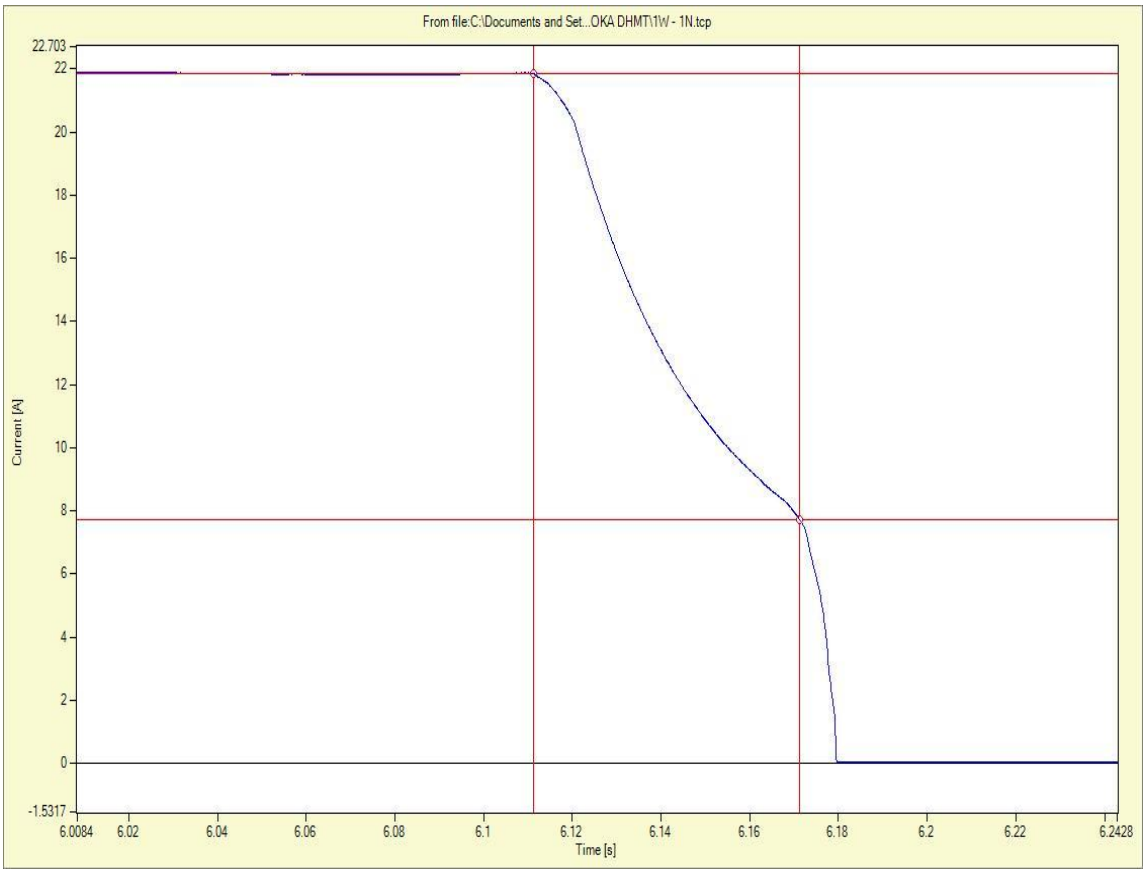

Figure 5. Current interruption during bad (opening) transition

The Figure 5 shows the current value during the transition with a discontinuity. This is an unacceptable operating condition of OLTC diverter. The program produces a warning message to the operator when the discontinuity is detected. If the discontinuity period is longer than two seconds the test is automatically stopped by the device and the inductive energy is safety discharged.

Since different types of OLTCs have different DVtest graphs, it is necessary to compare the results obtained at earlier measurement on the same OLTC. Three major parameters that the user needs to consider are changes in the shape of the graph, current ripple and transition time. If significant differences are apparent between the graphs obtained testing the OLTC and the graphs previously obtained, it is a clear indication of deterioration of tap changer condition.

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