



Megger[®]

**Pinpointing concealed
problems inside a resistive-
type OLTC before physical
inspection**

CASE STUDY

True dynamic resistance
measurement

Pinpointing concealed problems inside a resistive-type OLTC before physical inspection – Application of True DRM

Background:

- The following experience centered on a seventeen-position resistive-type On-load Tap Changer (OLTC) that is installed on the HV side of a three-phase YNd1, 25 MVA, 132/11.5 kV transformer. This load tap-changing transformer is operated by Electric Power Transmission Network in the City of Karbala, Iraq.
- A systematic procedure of off-line testing techniques, including Dynamic Resistance Measurement (DRM), identified internal damage of the OLTC. After repair, a verification testing protocol assured the OLTC's successful restoration to a normal and safe operating condition, as evidenced by the DRM graphical and numerical response.

Summary:

- The maintenance team at the Electric Power Transmission Network in the City of Karbala performed routine electrical tests on the transformer including: winding resistance measurements (WRM), transformer turns ratio (TTR), short circuit impedance (SCI), excitation current, and line-frequency power factor (a.k.a. dissipation factor or tan delta).
- The maintenance team's TRAX instrument afforded the opportunity to complete advanced testing also, including: magnetic balance, Frequency Response of Stray Losses (FRSL) and OLTC Dynamic Resistance Measurement (DRM) tests.
- Only the DRM test results clearly flagged a deficiency in Phase B of the OLTC, which was not observed in static measurements. Static measurements are those that are performed while the OLTC (and DETC) is stationary at each of a number of selected tap positions. Examples of tests that provide static tap changer measurements include excitation current, TTR, WRM, and sweep frequency response analysis (SFRA).

- Dynamic tap changer measurements, such as provided by a DRM test, are critical to assess a resistive-type OLTC's bridging or 'transition' components, which only appear in a test circuit during the OLTC's transition from one tap position to the next. A resistive-type OLTC does not use its bridging state as a viable tap service arrangement/position, so these components never appear in the test circuit of a static measurement.

Test results:

- In this case, the DC WRM on all tap positions (a series of static measurements, Figure 1) shows a very small variation (around 0.2 %) between the three phases and for all taps. This is well within the generally agreed, maximum allowable variation of 2 – 3 %.

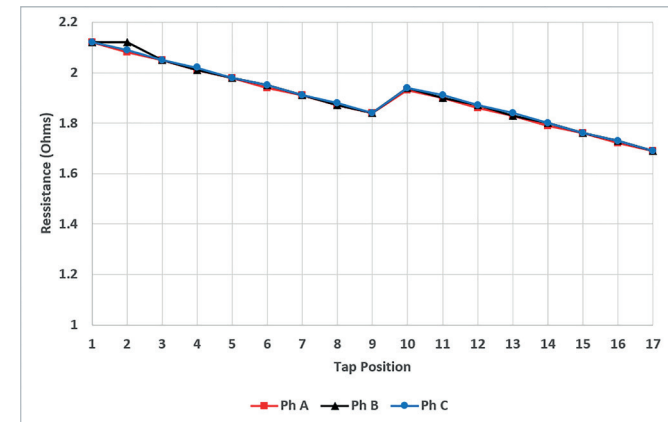


Figure 1: WRM results for all 17 taps and all three phases

- Looking at the TTR measured values (Figure 2), it was observed that all phases and all taps have a measured ratio well within the generally agreed acceptance value of 0.5 %.

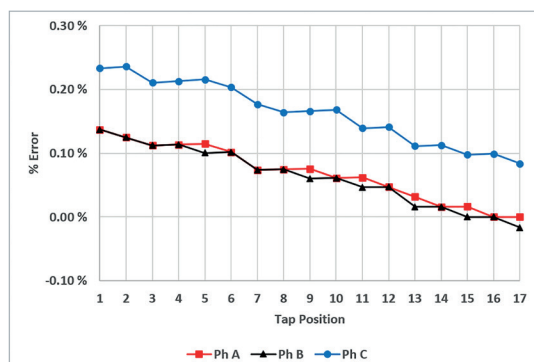


Figure 2: TTR results (% error all 3 phases and all tap positions)

- The Line-Frequency (LF) power factor (PF), or dissipation factor (DF), and NB DFR (narrowband dielectric frequency response) test results (Figure 3) were acceptable. No notable insulation degradation was indicated.

Tan Delta - Power Transformer							
Designation	f (Hz)	U	I	C	%PF at 38 °C	ITC2 Corr. Factor	Corr. %PF to 20°C
CHG + CHL	50.00	9.999 kV	31.56 mA	10.05 nF	0.204	1.202	0.246
CHG	50.00	9.999 kV	18.39 mA	5.856 nF	0.226	1.202	0.271
CHL	50.00	9.999 kV	13.17 mA	4.192 nF	0.183	1.202	0.220
CLG + CLH	50.00	5.011 kV	128.4 mA	81.57 nF	0.222	1.202	0.267
CLG	50.00	5.008 kV	121.8 mA	77.39 nF	0.227	1.202	0.273
CLH	50.00	4.998 kV	6.578 mA	4.189 nF	0.178	1.202	0.214

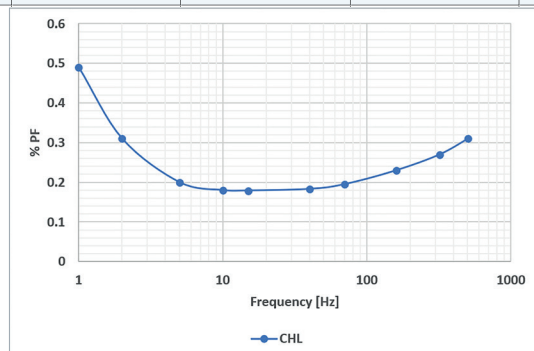


Figure 3: LF PF/DF results and NB DFR plot (1 – 505 Hz)

- Advanced OLTC testing was carried out with the Dynamic Resistance Measurement application in the TRAX SW. During the transition from one tap position to the next, the current drops and that is represented by the 'ripple', which expresses the maximum amount that the DC current decreases as a percentage of the test current. The ripple is normally plotted for all phases and taps as presented in Figure 4.

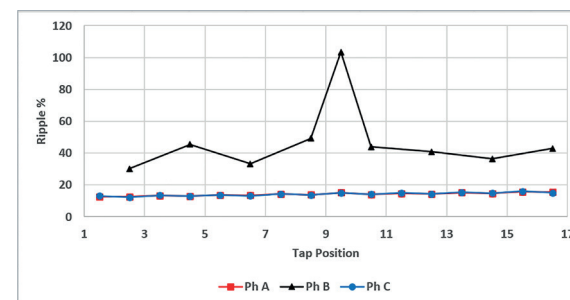


Figure 4: Ripple for each tap transition for all 3 phases

- From Figure 4 the following is observed:
 - The ripples of phases A and C practically overlap each other.
 - The ripple is higher for Phase B and varies much more than the ripples in phases A and C do, the latter which lend to nearly flat lines.
- The ripple graph from phase B may be different compared to the graphs of phase A and/or C due to different induction.
- In this case, the difference in ripples between phases combined with the variance of ripples within Phase B indicate a problem for Phase B.
- DRM analysis provides even more insight than comes from measuring the ripple alone. In a 'true' DRM test, the transition resistors' values are determined with great precision. Figure 5 shows the dynamic resistance for transition 12-13 for Phase C and Figure 6 shows the DRM for transition 13-12 for phase B. Notice the difference in scales on the y-axis (in ohms) of both graphs.

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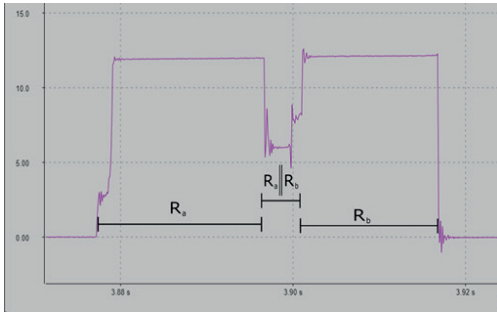


Figure 5: DRM Curve for transition 12-13 Phase C

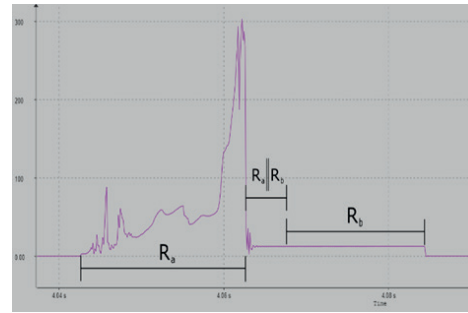


Figure 6: DRM Curve for transition 13-12 Phase B

- Figure 5 is a typical transition DRM response for a 2-resistor switch that has been in service for some time. Resistance values and transition times for both resistors are similar.
- Figure 6 shows something that is far from normal, wherein the apparent resistance goes all the way up to 300 Ω . After 20 ms, the resistance drops to a stable 12 Ω , indicating that the second transition resistor has made contact.
- The DRM test results lead to a much more specific conclusion (than that rendered by the ripple test results alone). The diverter switch operates in both directions; therefore, the fault sometimes comes at the second transition resistance and not at the first one.
- The DRM analysis identifies a problem/deficiency with one of the transition resistors of phase B.



Figure 7: Resistive Type OLTC as removed for inspection



Figure 8: Broken contact for the wire connecting the transition resistors to the transition arcing contact in Phase B

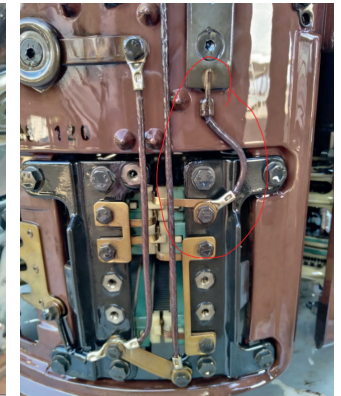


Figure 9: Connection between transition resistors to the transition arcing contact in Phase A (for comparison)

Actions taken:

- Based on the DRM analysis, the owner decided to inspect the OLTC thoroughly. After cleaning the OLTC, a loose connector was found (Figure 7).
- The broken contact (Figure 8) was welded back in place (Figure 9) and the OLTC was reinstalled.
- A verification test was performed to verify the OLTC condition after repair. Figure 10 shows the ripple for each transition for all three phases. Now things look normal.

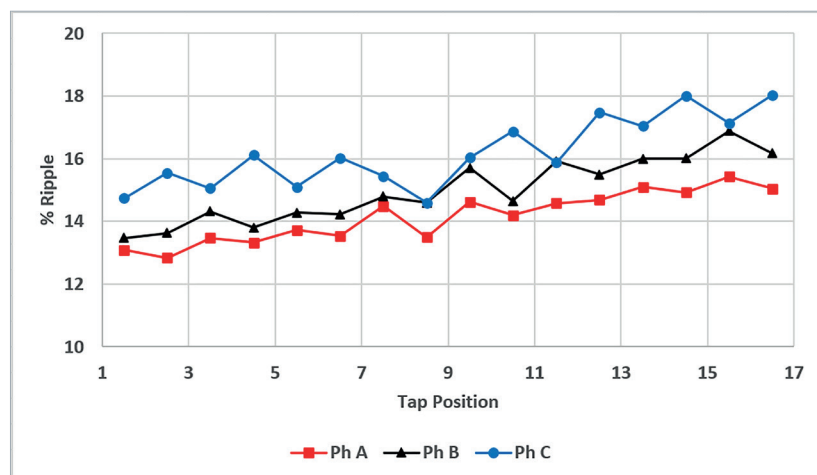


Figure 10: Ripple for each transition after repair

The true DRM test results obtained on the transition 13-12 for Phase B after repair can be seen in Figure 11. Repairs were successful and the Electric power transmission network in Karbala confidently and safely returned this transformer back to service.

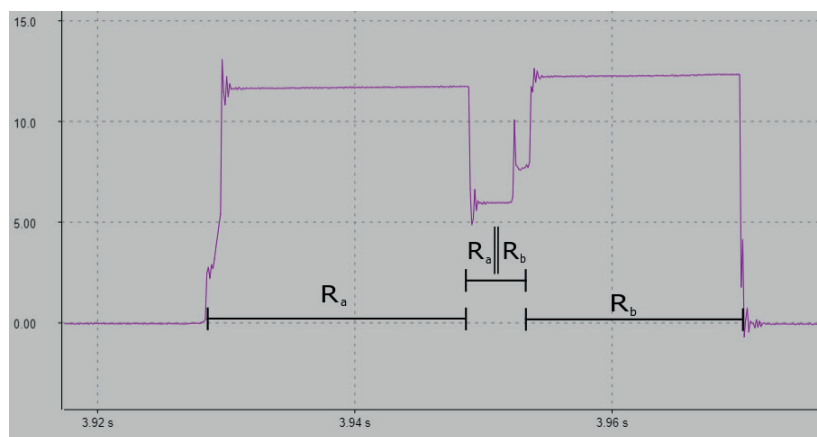
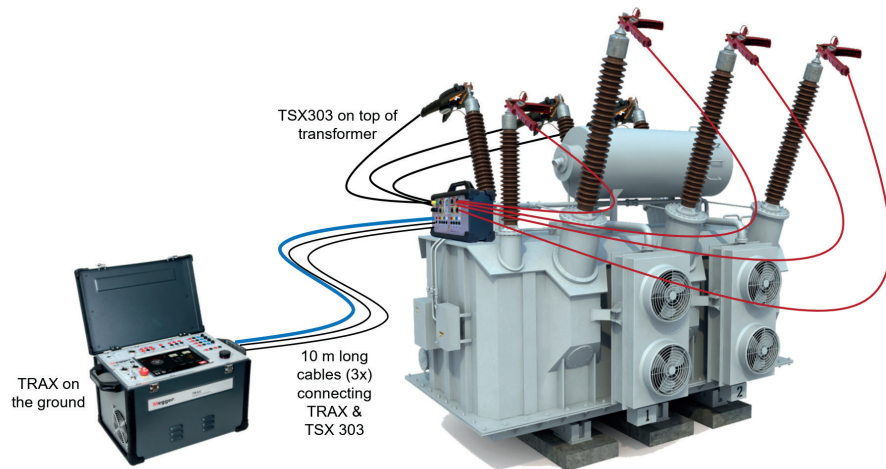


Figure 11: DRM curve for transition 13-12 Phase B after repair.

Conclusions:

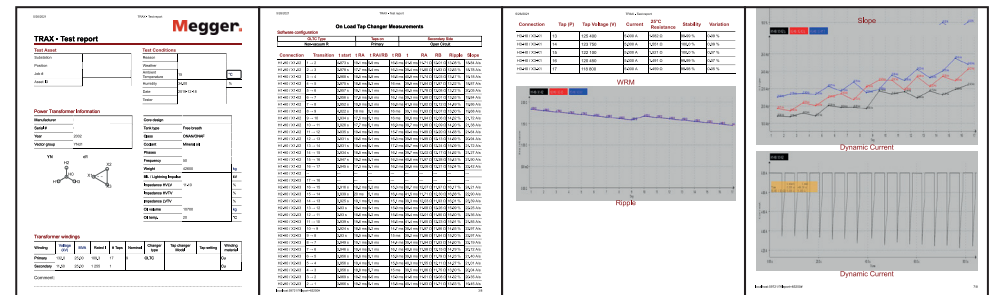
- Routine electrical and dielectric testing on the YNd1 25 MVA transformer did not provide clear indication of mechanical damage in the seventeen-position resistive-type OLTC.
- True DRM allows for identification of faulty components affecting the resistive characteristic of the transition resistors in the OLTC.
- Megger suggests that a make-before-break test is included as part of the static winding resistance test.
- The DRM procedure does not add significant testing time, but it shows great value in identifying defects in transition resistors or their connections to the transition arcing contact.
- The normal WRM test did not indicate any problem, nor did any of the other tests performed, except for the DRM test. DRM testing is useful for power transformer OLTC assessment.

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Product Reference:

TRAX + TSX 303 field set-up

- The transformer and substation multi-function TRAX system offers a wide variety of tests in compliance with IEEE, IEC, CIGRE and NETA suggested testing procedures.
- OLTC testing is part of the Advanced Transformer Testing SW package



Sample pages from a Megger TRAX report

TRAX – Transformer and substation tester

- Multifunctional test set for the entire substation
- Unique and proprietary methods for superior measurement results: Power Factor (DF/tan delta) with individual temperature correction (ITC) capability, 505 to 1 Hz narrowband DFR, OLTC 'true' DRM, and more
- Easy to use through apps with common GUI
- Time savings by use of common lead set and not having to learn discrete test sets
- Cost savings by only buying one instrument
- Continuous release of new functionality and accessories assuring future proofing



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