New PCS Task Force
Evaluate the need for an OLTC Diagnostic Field Testing Guide

Chair: Marcos Ferreira   Vice Chair: Raka Levi
Secretary: Tauhid Ansari, 48 members

Literature

TASK: RESEARCH AVAILABLE KNOWLEDGE
DRM

Test Instrument Manufacturers
### AC Leakage Reactance

- **f**: 45-65Hz

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Range</th>
<th>Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Range</td>
<td>5-250V</td>
<td>0.25%</td>
</tr>
<tr>
<td>Range</td>
<td>0.1-700Ω</td>
<td>1% of reading ±10mΩ</td>
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<tr>
<td>Range</td>
<td>10μA-20A</td>
<td>0.25%</td>
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<tr>
<td>Range</td>
<td>0.01μW-3.6kW</td>
<td>0.5%</td>
</tr>
<tr>
<td>Range</td>
<td>1mH-10H</td>
<td>0.5% ±10μH</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
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<th>Range</th>
<th>Accuracy</th>
</tr>
</thead>
</table>

### DC Winding Resistance

- **Range**: 35A 0.5%
- **Range**: 5mV-175V 0.5%
- **Range**: 0.5mΩ-10Ω 0.5% ± 0.05 mΩ

### Test Capabilities

- Power Factor/Tan Delta
- Variable Frequency Power Factor/Tan Delta
- Demagnetization Feature
- 3 Phase Turns Ratio
- 10 kV Turns Ratio
- Leakage Reactance 1Ø and 3Ø equivalent
- 3 Phase Winding DC Resistance
- 3 Phase 10kV (Single Phase) Exciting Current and Loss

### Future Enhancements

- OLTC Dynamic Resistance Measurement (DRM)
- External Reference
- Capacitor Bank
- Primary Injection
- μΩ Meter

Specifications are subject to change without notice.
Winding resistance

The TRAX winding resistance instrument is designed specifically to measure the resistance of all types of inductive circuits. With high output current and high compliance voltage (100 A with up to 50 V true DC voltage), it effectively tests high and low-voltage windings on all power transformers. Thanks to dual measurement inputs, two windings can be measured at the same time (simultaneous winding magnetization). TRAX has multiple built-in safety features to protect the end-user, the test object and the unit itself, including auto-discharge in the event of input power loss.

The TSX switchbox accessory provides functionality to automatically test all transformer windings and taps with just one single connection. All windings are connected at one time. This minimizes the time otherwise needed for reconnection and improves safety by reducing the number of trips up and down the ladder.

Demagnetization

Often, when a transformer trips off-line, or after applying DC test signals in, for example, a winding resistance test, the transformer core remains magnetized. As this can cause issues for further tests, international standards and guides recommend demagnetization before doing excitation current and SFRA measurements.

It is also recommended to perform demagnetization before the transformer is taken into service, thus avoiding unnecessary high in-rush currents.

TRAX provides fully-automatic demagnetization of the transformer core. The method, which adapts a demagnetization cycle unique for the specific transformer design and size, minimizes the time needed for demagnetization.

Tap-changer testing

For testing transformers with load tap-changers, TRAX has two binary outputs for operating the tap-changer. TRAX measures the winding resistance per tap and also verifies the continuity (make-before-break) of the tap-changer during the switching operation.

TRAX also makes it possible to measure the dynamic characteristics of a load tap changer. This unique, patent-pending DRM (dynamic resistance measurement) method can simultaneously measure contact switching times and the resistance value of the diverter resistors.

Turns ratio

The TRAX instrument for turns ratio measurements easily and accurately verifies the vector configuration and measures the turns ratio as well as the phase deviation of various transformers. This ensures that the winding and tap-changer connections are correct and will detect open-circuits and shorted winding sections or turns.

TRAX' turns ratio app determines the transformer turns-ratio as defined by international standards.
- Test currents 5 mA – 60 A DC
- On-load tap changer dynamic resistance measurement
- Three resistance measurement channels
- Rapid automatic demagnetization
- Tap changer motor current monitoring channel
- Automatic discharge circuit
- Built-in tap changer control unit
- Detailed analysis of test results using DV-Win software
- USB flash drive feature

The Tap Changer Analyzer & Winding Ohmanner RMO60TD instrument is designed for winding resistance measurement of inductive objects, and for a tap changer analysis. The RMO60TD instrument is based on the state of the art technology, using the most advanced switch mode technology available today. The RMO60TD instrument is accurate (0.1%), powerful (up to 60 A) and lightweight. It generates a true DC ripple free current with automatically regulated measurement and discharging circuit.

The RMO60TD instrument can perform a simple, quick and reliable transformer on-load tap changer condition
<table>
<thead>
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<th>No.</th>
<th>Type</th>
<th>Description</th>
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<th>With TD 5000</th>
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<td>Vector Group</td>
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<td>Static and dynamic resistance of Tap Changer contacts</td>
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The document is subject to change
Literature search

Papers, research,
Doctoral thesis
Doctoral Thesis

- OLTC Diagnosis on High Voltage Power Transformers using Dynamic Resistance Measurements
- Author: Jur Erbrink,
- Technische Universiteit Delft, Holland
- Faculty Electrical Engineering, Mathematics and Computer Science
- Department High Voltage Technology and Management
- 28. March 2011
- ISBN 9789461690425
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• On Load Tap Changer Dynamic Resistance Measurement, By Raka Levi, Alex Cincar, Keith Bensley, published in Australia at TechCon 2010

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• Reproducibility of Dynamic Resistance Measurement Results of On-Load Tap Changers – Effect of Test Parameters; J.J. Erbrink1*, E. Gulski1, J.J. Smit1, R. Leich2, P.P. Seitz3 and B. Quak3 1 Delft University of Technology, Delft, the Netherlands 2 Liandon, Alkmaar, the Netherlands 3 Seitz Instruments AG, Niederohrdorf, Switzerland - Japan 2010

• Condition Assessment of OLTC using static and dynamic resistance tests; Brendan Diggin, ESBI, presented at the AMforum FORUM Dublin 2010
2011-2017

- **Optimised Tool for the Measurement of Winding Resistances on Power Transformers**, Marc Müller, Haefely Test AG, Basel, Switzerland, ISH 2011 Leibniz University Hannover
- **TDA: Tap-changer Dual Assessment**, Eric Back, PG&E, Marcos Ferreira, Reinhausen Manufacturing, Dave Hanson, TJ|H2b, Edis Osmanbasic, DV Power, TechCon USA Chicago 2012
- **Results from Experiences of Performing Dynamic Resistance Measurements on Resistance and Reactance LTC Types**, Kellie Robinson Bonneville Power Administration, Steve Larson, Snohomish County Public Utility District, Marcos Ferreira, Reinhausen Manufacturing Inc. Doble Conference Boston 2012
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- On-load Tap Changer Testing – **Dynamic Recording**, NETA World Journal
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Big manufacturers
and recognized names in our industry
By doing this, the current drop when the transition resistors are connected can be seen. The operation time for the OLTC is also possible to measure. The reason for this is that the impedance causes slow reactions in current change during measurement and high impedances make the interpretation of the resulting curves difficult and endanger the value of the measurement.

When performing a measurement the current shall be as high as possible. But measurement below 10A is a grey zone. According to reports in the topic of DRM the measurement current should not exceed 10% of the rated current of the transformer current of the regulating side or at close at possible without magnetize the core.

**Benefits using a DRM instrument**

Before the transformer is shipped a fingerprint is taken. The finger print of the transformer are the test protocols. Nothing is made on the tap changer.

Last time the tap changer is tested is at the tap changer factory.

By performing a DRM mesurement in the transformer factory and at site and than compare the result its possible to see if something has happened with the tapchanger during the transport. This can be made on all type of tapchangers (vaccum and oil types)

However its is important that the measurement is made by the same brand of DRM instrument. The instrument can than be used to control the operation times at the maintenance stops. Also here its important that the same brand of instrument is used. Otherwise the results can be hard to interpret.

For the oil type tap changer using the flag cycle type, also the contact wear can be controlled.
TAPSCAN® DRM
DYNAMIC RESISTANCE MEASUREMENT FOR ASSESSING TAP-CHANGERS
Resistência dinâmica
A-N 1->13
The circuit that results provides the DRM records is connected on the primary side while the secondary side of the transformer is short circuited. The resistance value measured at the primary side is influenced by the secondary resistance [5]. Therefore, the value of the secondary resistance should be known. Directly after switching on the current on the primary side the measured resistance equals:

\[ R_{tot} = \frac{U_o}{I_o(0)} - N^2R_2 \]

After the current, has stabilized, the resistance equals:

\[ R_{tot} = \frac{U_o}{I_o(\infty)} \]

\[ R_2 = \frac{1}{N^2}\left(\frac{U_o}{I_o(0)} - R_{tot}\right) \]

Once the secondary resistance is derived, the known resistor can be used to derive the total resistance \( R_{tot} \). The
UTILITIES

• Specifying to transformer manufacturers a benchmark test with all new units delivered
(s) Dynamic resistance measurement.

The test shall be performed by the application of the continuous DC current or DC voltage to the winding with tap changer while the other winding short-circuited. The transient test current fluctuations shall be recorded during the tap changer switching process. The response shall be recorded with an oscilloscope, transient recorder or a specialized instrument. The oscillograms of maximum to minimum tap and each tap transition shall be reported.

For the winding with tap changer connected in star connection. Simultaneous three phase test shall be performed and the test current flowed through each phase shall be 1 A or more while the other winding short-circuited.

For the winding with tap changer connected in delta connection. Single phase test shall be performed and the test current flowed through phase under test shall be 1 A or more. For this case the applied current shall be 1.5 time of requirement test current.

For items (f), (g), (h) and (i) the test shall be performed at all taps.
Vibro-Acoustic
Instrument manufacturers

- ZENSOL
- MR
- DV POWER
Literature search

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• "Diagnostics vibro-acoustiques pour disjoncteurs à haute tension" – PPT presentation - January 2009 – Hydro Quebec - Michel Landry

ON-LINE TAP CHANGER DIAGNOSIS BASED ON ACOUSTIC TECHNIQUE

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ABSTRACT

In this paper, a reliable acoustic measuring system for online condition monitoring of on-load tap changer is described. Vibration signals during the tap-change process are detected by a sound emission sensor coupled to an amplifier. The measured signature is analysed in order to determine the tap-change characteristic time. The sequence of tap-change process in the diverter switch is studied to understand the operation of the investigated tap changer. The studies were done in different tapping positions during off-load condition. The investigations took place during normal operation and under failure conditions of the tap changer, in order to verify the performance of the acoustic method.

KEYWORDS

On-load tap changer diagnosis, Acoustic measuring, Vibration signals.

INTRODUCTION

On-Load Tap Changers (OLTCs) are parts of the voltage regulating system in an electrical transmission network. They are connected to the transformer and are responsible for maintaining the voltage level under variable loading conditions. By changing a tapping on the winding, the OLTC enables the turns ratio of the transformer to vary and thus the level of output voltage. An OLTC has two main components: a selector switch and a diverter switch. A

ACOUSTIC MONITORING METHOD

Acoustic diagnosis has been successfully applied in many industrial applications, mainly in aeronautics and manufacturing. In the field of electrical equipment, it has been applied in monitoring of circuit breakers by numerous investigators [2], [3]. For application of the acoustic diagnosis in tap changers, a record of vibration signals emitted during the tap-change should include information about transition time and bouncing characteristics of arcing contacts in the diverter switch [4].

EXPERIENCE FROM LABORATORY TEST

The studies of the acoustic method were conducted during no-load situation on a tap changer mounted in the laboratory for experimental purposes as shown in Fig. 1a. It is a diverter-switch type, series voltage up to 220 KV, current intensity from 400 to 1000 A. During the investigations, it was manually operated from tap 1 to tap 19. The acoustic sensor was fixed onto the top cover of the
TAPSCAN® VAM

VIBROACOUSTIC MEASUREMENTS FOR ASSESSING TAP CHANGERS.

TRANSFORMER CONTROL
ZENSOL

Strongly built Strongly backed

TAP-4
On-Load Tap Changer (OLTC)
Your OLTC Diagnosis Guide

This booklet’s goal is to present you a complete diagnostic solution for on line tap changers. This solution, developed by Zensol in 2009, is in continuous evolution.

Zensol is the leader in the application of the vibro-acoustic method to tap changers (OLTCs). Our instruments

You will find, in this booklet, details about our OLTC Analyzer, the TAP-4, an instrument developed in cooperation with Hydro-Québec and commercialized since 2009. The OTM-X, on the market since 2014, will be introduced after that. It is the only standalone vibroacoustic event recorder for on line tap changers on the market.
- On-load tap changer dynamic resistance measurement
- Three resistance measurement channels
- Four temperature measurement channels
- Automatic resistance/temperature measurement for the Heat Run test
- Rapid automatic demagnetization
- Vibration measurement
- Tap changer motor current monitoring channel
- Automatic discharge circuit
- Built-in tap changer control unit
- Detailed analysis of test results using DV-Win software
If IEEE does not provide guide?

- Variety of products
- Variety of methods
- Different parameters
- Different filters

- Customers need a GUIDE!
- Guide that would help standardize the procedures
Where?

- Let’s have it in the PCS
- **Performance Characteristics Subcommittee**

- C57.149 SFRA Guide is under PCS

- What is the difference?
Do not involve DGA

• C57-139 IEEE guide for DGA in OLTC 2015