

Megger Application Guide

Tap Changer Testing

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1 Introduction

This application note describes tap changer testing in general and details on how to use the capabilities in MTO210, 300 and 330 for tap changer measurements. It is not replacing the MTO user manuals where general operation of the instrument and connection schemes for various transformers is described.

2 Transformer tap changers

The power transformer is an integral and expensive part of all electric power networks at all levels from generation and transmission down to distribution. The on load tap changer is the only moving part connected to the transformer windings. The importance of its reliability cannot be over emphasised. Taking a transformer off the system to investigate an internal problem with a tap changer is an expensive exercise; therefore it is in every utility's interest to carry out condition assessments of their tap changers to help detect developing faults at an early stage

The tap changer allow ratio to be increased or decreased by fractions of a percent. Any of the ratio changes involve a mechanical movement of a contact from one position to another. It is this contact that needs to be checked by way of its resistance. The contact may go bad for a number of reasons.

1. Misaligned when manufactured causing insufficient surface contact. Full load current overheats contact surface causing it to burn.
2. Current passing through contact exceeds full load rating.
3. Tap changing operation not "Make before break" creating internal arcing of contact surface.

Tap changers are divided into two types; On-load (OLTC) and Off-load/de-energized (DECT). The OLTC allows selection of ratio change while the transformer is in service. This means that the ratio of a transformer can be changed while power (current) is still passing through it. Figure 1 depicts a typical resistive type OLTC with tap selector and diverter switch.

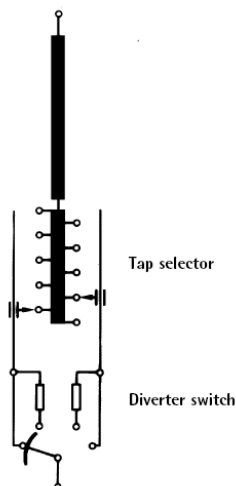


Fig 1. Typical on-load tap changer (diverter switch - tap selector principle)

The resistors in the diverter switch are typically a few ohms. Total operation time of an LTC is between 3 and 10 sec pending design. Actual contact switching time for a resistive tap-changer is

usually in the order of 30-70 ms and the transition resistors are loaded for about half that time or more.

Reactance type LTCs uses a preventive auto transformer instead of the two resistors in the standard diverter switch which means that the additional resistance in the diverter device is very low. Switching time in reactive tap-changers are significantly longer, in the order of seconds.

The second type of tap changer is the Off-load/de-energized (DECT). This is not as common as LTC because in order to change taps, the transformer has to be taken out of service or at least disconnected from the load. On distribution transformer this type of switch may also be used to change nameplate voltage and/or configuration.

3 Methods for tap changer testing

3.1 Winding resistance measurements (static)

Winding resistance measurements (WRM) are normally performed for every tap the same way as WRM for individual windings. The test instrument is continuously injecting test current and the resistances for each tap are measured sequentially as the tap changer is stepped through its positions. Results are typically presented as a graph or table with resistance values for each tap. Resistance changes between taps should be consistent with only small deviations between different tap position changes.

3.2 Dynamic measurements

There are several methods developed for testing tap changers but common for all are that a current is injected in the tap changer, either in one phase or all phases, and during the operation of the tap changer, the current and/or the voltage is measured as a function of time. Test current vary from about 0.1 A to standard test current for winding resistance measurements, typically 1% of rated current for the transformer winding. The test may be performed at the same time as measuring winding resistance or as a separate test.

Standard methods are;

- Discontinuity detection
- Dynamic current measurement ("ripple")
- Dynamic resistance measurement

3.2.1 Discontinuity detection

This method should detect if there is a break-before-make condition in the tap changer by monitoring current change. The measurement is typically performed at the same time as winding resistance measurements and the instrument detects if the contact switching is continuous or if there is an interruption in the current path.

Open contact detection can be made by current change detection, detecting dI/dt changes or detecting voltage change on the opposite side of the transformer i.e. if the tap changer is on the HV side, the detection is performed by measuring voltage transients on the corresponding LV winding.

Methods for contact timing based on current change detection are principally pending test current. If the test is performed at a current level where the inductance is high, the inductance in the transformer winding smoothes the current change. If the test is performed at a current level at or

above saturation level, the inductance is low and current level change will be higher and with longer duration.

3.2.2 Dynamic current measurement

Dynamic current measurement is in a way similar to discontinuity testing but in addition to just detecting discontinuity, the actual test current is measured and the result is presented as a percentage ripple value or more detailed in a current-time diagram. The intention is to give a value that describes the conditions during operation and provide contact timing.

Dynamic current measurements are also pending test current and inductance of the circuit in the same way as detecting discontinuity with current change detection. A method to reduce transformer inductance when performing dynamic measurements is to short-circuit the not tested corresponding LV (or HV) windings. This action is principally “replacing” the inductance of the winding with the short-circuit impedance. Inductance is greatly reduced and contact timing can be measured with higher accuracy.

3.2.3 Dynamic resistance measurement

Dynamic resistance measurement (DRM) is a standard method for circuit-breaker testing and can also be applied on tap changer contacts. A relatively small and constant test current is injected through the tap changer and the voltage over the test circuit is measured with sufficient resolution to create a resistance versus time diagram for the LTC contact operation. Interruptions are easily recognized and irregularities in the diverter resistor values can be measured.

DRM testing is usually combined with short-circuiting corresponding winding to reduce influence of inductance.

4 Using MTO for tap changer measurements

The MTO210 and 3xx are designed for LTC testing with the instrument left ON while changing from tap to tap and secondary windings of the transformer NOT short-circuited. This allows the operator to take measurements very quickly without discharging the transformer for every tap. A current change larger than 10% (10% current drop) is detected and may be categorized as by the setting of the instrument.

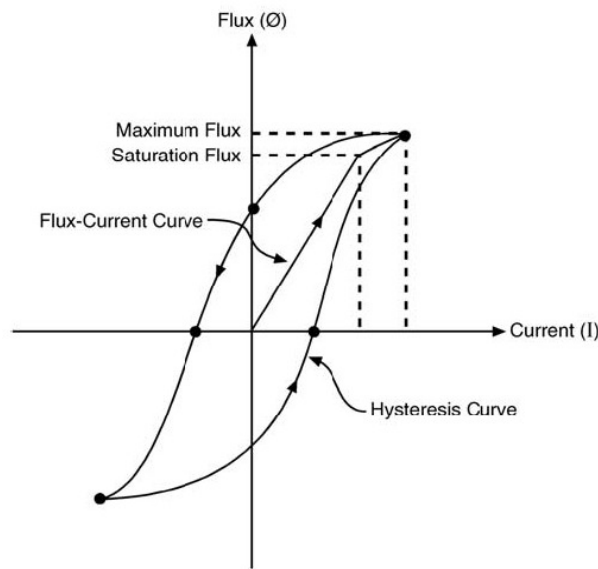
- 0 – OFF (default, > 200 ms detection)
- 1 – > 80 msec detection
- 2 – > 20 msec detection
- 3 – > 5 msec detection

If the tap change causes a current change > 10% lasting shorter than the time setting, the unit will indicate and record the event but not stop the test. If the current change is longer than the setting, the unit will record the event and shut down the test. If the current is completely interrupted in a high inductance circuit, the unit will record the event and shut down the test irrespective of the current change detection setting (also in default/“OFF” setting).

As stated previously, “current change/ripple” is pending test current, contact timing and inductance of the winding. This is important to understand when analyzing test results.

4.1 Influence of transformer inductance

Following diagram describes the principal relationship between magnetic flux and test current



The inductance of the winding is high for low currents when the core is not saturated and becomes very low for currents above the saturation level.

Dynamic current measurements are pending test current level and source impedance of the test set.. If the test is performed at a current where inductance is high, current change is lower compared to testing at currents where the core is saturated (lower inductance).

OLTC testing is typically performed as a winding resistance test but results are taken sequentially and indications of discontinuity are monitored. Test current for HV winding resistance measurements are often around saturation level or higher, where the inductance is low. This way of testing may give “high” current change/ripple even for “good” contacts. For continuity testing during standard WRM/tap, measurements at lower current (higher inductance) should be considered (more similar to normal working conditions of the transformer).

4.2 Guideline for test and analysis

4.2.1 WRM

Measuring the winding resistance for each individual tap is normally quite straightforward. The most common issue is probably that the tester has not waited for a sufficient time for taking measurements after a tap change. Monitor the resistance value closely before storing the value to make sure the resistance value has stabilized!

Fig 2 shows a typical behavior for a transformer/tap-changer in as-new condition

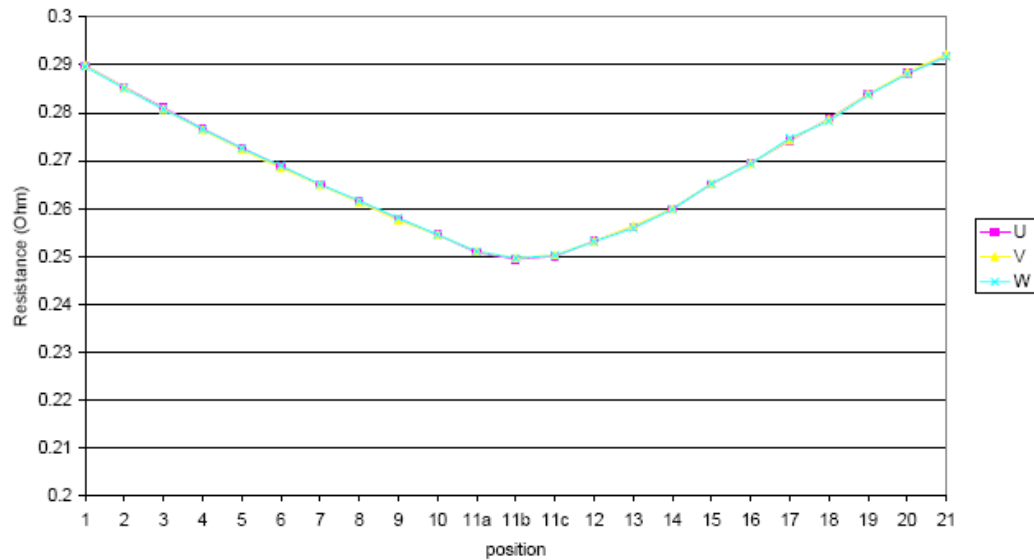


Fig 2. Winding resistance vs tap position for a new transformer

4.2.2 Continuity

During the tap changer winding resistance/tap measurement, continuity can be monitored. Default setting is 0/"OFF" which means that only discontinuity is detected.

If the current change detection time is activated and a current change event is recorded, the following list should be considered:

- Investigate the type of tap-changer tested. Resistor or reactance type?
- If resistor type; what are the values of the resistors compared to the winding resistance?
- Compare test current and rated current for the transformer. If the test current was close to saturating or higher (around 1% of rated current or higher), re-test at lower current/higher inductance (around 0.1% or less) e.g. 0.1 or 1A instead of 10A