

6.1.2 Ratio/polarity/phase

6.1.2.1 General

The turns ratio of a transformer is the ratio of the number of turns in a higher voltage winding to that in a lower voltage winding. The voltage ratio of a transformer is the ratio of the rms terminal voltage of a higher voltage winding to the rms terminal voltage of a lower voltage winding under specified conditions of load. ~~For all practical purposes, when the a single phase transformer is on open circuit, its voltage and turns ratios may be considered equal.~~

Sentence eliminated per web meeting 15 Sept 09

The polarity of a transformer is determined by the internal connections and is indicated by the nameplate markings. Polarity is of interest if the transformer is to be connected in a parallel manner with one or more other transformers.

Results of the polarity and transformation ratio tests are absolute, and may be compared with the manufacturer's nameplate specifications.

Transformer winding ratios, polarity, and phase connections should be checked before energizing the transformer for the first time on site. The ratio in particular is checked during regular (e.g., annual) inspections and it is recommended that it also be checked before returning the transformer to service if the unit has been subjected to a through-fault.

Proposed addition:

If the transformer has taps for changing voltage ratio, the turns ratio should be determined for all taps. This means all taps of the de-energized tap changer (DETC) and all taps of the load tap changer (LTC). It is considered best practice to perform the final (DETC) test in the "As Left" position. It is considered best practice to perform the turns ratio test after a DETC change.

Following sections removed to Appendix

6.1.2.2 Measurement of transformer polarity

6.1.2.2.1 Measurement of transformer polarity by inductive kick

6.1.2.2.2 Measurement of transformer polarity by alternating voltage

6.1.2.2.3 Polarity of polyphase transformers

Proposed replacement below 6.1.2.3

~~6.1.2.3 Transformer turns ratio test set~~

6.1.2.2 Measurement of Ratio / Polarity / Phase

There are a number of **modern** commercial transformer turns ratio test sets available from manufacturers serving the power industry. These instruments, when operated in accordance with the manufacturer's instructions, provide convenient and accurate readings of : ~~ratio and polarity of power transformers.~~

Ratio

Polarity verification

Phase angle

~~Excitation current~~

Test meter excitation current

Name agreed at web meeting 15 Sept 09

Proposed addition:

The principle of operation is to apply a reduced voltage to the HV terminals and produce a voltage at the LV terminals. The two voltages are accurately measured and used to calculate and display the transformer ratio.

A continuous testing mode facilitates measurements on multi-tap windings and quickly measures, displays and records the ratio and excitation current for each tap. Communication ports are helpful in automation of testing and recording of test data.

~~If the transformer has load taps, the turns ratio should be determined for all of these taps with the tap changer for de-energized operation in one specific position such as the nominal or the maximum turns position. In addition, with the load tap changer (LTC) in the neutral position, the turns ratio should be determined for all positions of the tap changer for de-energized operation.~~

This statement appears in 6.1.2.1 General (above)

~~If a commercial test set is not available, then transformation ratio may be measured and interpreted using the procedures in 6.1.2.3.1 and 6.1.2.3.2. This is covered in 6.1.2.3 below~~

Following sections removed to Appendix

6.1.2.3.1 Voltmeter method

6.1.2.3.2 Ratio measurement using a capacitance and power factor bridge

Proposed replacement:

6.1.2.3 Other methods for measurement of transformer ratio / polarity / phase

If a commercial test set is not available, transformer ratio can be measured using the Voltmeter method or the Capacitance and Power Factor bridge method.

Also polarity can be verified using the Inductive Kick method or the Alternating Voltage test method.

These other methods are described in Appendix 6.1.2

6.1.2.4 Interpretation of the transformer ratio test (this needs to be revised see Comments below)

The turns ratio tolerance should be within 0.5% of the nameplate specifications for all windings. For three-phase, Y-connected windings, this tolerance applies to the phase-to-neutral voltage. If the phase-to-neutral voltage is not explicitly indicated on the nameplate, then the rated phase-to-neutral voltage should be calculated by dividing the phase-to-phase voltage by $\sqrt{3}$.

From time to time it may be observed that the measured ratios of the outer phases of a three-phase transformer will be slightly different. Unless the differences are >0.5% there is no cause for rejection of this transformer.

Infrequently, it will be found that the ratio will be different from that specified on the transformer nameplate. This condition may occur when a very large transformer is equipped with a low-voltage winding having a relatively small number of turns. In this case, the turns ratio should be expressed to the nearest complete turn. This error is one of resolution, since the number of turns may be less than 200 turns (200 turns being required to provide 0.5% resolution). For further information see IEEE Std C57.12.00-1993.

It should also be noted that transformers with load taps in the low-voltage winding, may not have an equal

number of turns between taps due to the overall low number of turns in the low-voltage winding. In such cases, the voltage variation with tap changer operation will not be uniform. All three phases should have the same measured ratio, although it may not be in exact agreement with the nameplate.

Comments on Interpretation of results

This Section needs to be revised. The existing wording appears to be written around the limitations of measurement equipment in years past i.e. resolution.

This section needs the contributions and experience of all members of the Working Group.

There is much that can be added here to assist the person using this Field Guide.

Attached are contributions to date as of 15 September 2009.