



Power Transformer Testing

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PDH: 3

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Transformers may be tested using AC or DC voltage. AC voltage is preferable to DC voltage for transformer testing because AC voltage simulates the internal stress that the transformers face during operating conditions. The following tests are routinely conducted in the field on the transformer:

- Excitation current test
- Insulating fluid dielectric tests
- Insulation PF test
- Insulation Resistance test
- TTR test
- Polarity test
- AC or DC hi-pot test
- Induced potential test
- Frequency response analyzer
- Dissolved gas analysis tests
- DC winding resistance
- Transformer core ground test
- Polarization recovery voltage test

AC Hi-Pot Test

The AC hi-pot test is used to assess transformer windings condition. Hi-pot test is suggested for all voltages, particularly those above 34.5 kV. For transformer routine maintenance testing, the test voltage should not surpass 65% of factory test voltage. Nevertheless, the hi-pot test for routine maintenance is typically not applied to transformers because of the possibility of damage to the winding insulation. Hi-pot test is typically used for acceptance testing or after transformer repair testing. The AC HV test value should not surpass 75% of the factory test value. When AC hi-pot tests are used for routine maintenance, the power transformer can be examined at rated voltage for 3 min instead of testing at 65% of factory test voltage. The AC hi-pot test values for voltages up to 69 kV are presented in Table 1.

Table 1. AC dielectric test for acceptance and routine maintenance for liquid-filled power transformers

Transformer winding voltage (kV)	Factory test AC voltage (kV)	Acceptance field test AC voltage, 75% (kV)	Maintenance periodic test, 65% (kV)
1.20	10	7.50	6.50
2.40	15	11.20	9.75
4.80	19	14.25	12.35
8.70	26	19.50	16.90
15.00	34	25.50	22.10
18	40	30.00	26.00
25.00	50	37.50	32.50
34.50	70	52.50	45.50
46.00	95	71.25	61.75
69.00	140	105.00	91.00

TTR Test

During TTR test voltage is applied to one transformer winding. Also, voltage on another winding on the same core is detected. In the case of a low voltage hand-crank powered TTR, 8 V AC is applied to the tested, low-voltage transformer winding and a reference transformer in the TTR set. The HV transformer windings and the TTR reference transformer are connected through null detecting equipment. After polarity has been made at 8 V, when the null reading is zero, the dial readings show the ratio of the tested transformer.

In the case of an electronic TTR test set, a voltage (usually 80 V AC) is applied to the tested transformer HV winding. The voltage detected on the low-voltage winding is measured and the voltage ratio between high and low windings is determined. Voltage ratio is proportionally equal to turns ratio.

The TTR test gives the following:

- It checks the turns ratio and polarity of single- and three-phase power transformers, one phase at a time.
- It verifies nameplate ratio, polarity, and vectors.
- It checks polarity and the ratio (but not voltage rating) of transformers without markings. Tests consider all transformer no-load tap positions. Tests consider all load taps on load, tap changer (LTC) transformers if connected for voltage ratio control. On LTC transformers connected for phase angle control, ratio and polarity are completed only in neutral positions. If checked on load taps, measurements may be taken for reference for future comparison, but will deviate from nameplate ratings. LTC taps may be checked by using low three-phase voltage and reading volts and the phase angle for each.
- Find issues in power transformer windings, such as open-circuit and short-circuits of turn-to-turn sensitivity. The standard deviation as described in IEEE C57.12.00-2006, suggests that results should be within 0.5% of nameplate markings, with rated voltage applied to one winding. The TTR with accuracy of 0.1% is accepted as sufficiently accurate.

The following steps are used for completing the TTR test:

- Transformer is isolated and tagged and leads disconnected
- Check transformer nameplate

- Check the polarities and vectors (phasors)
- Determine ratios for each no-load and load tap position

The test connections are presented in Figure 1 a through c. In the case of an electronic TTR, a unity ratio check is also done, but null and zero checks are not mandatory.

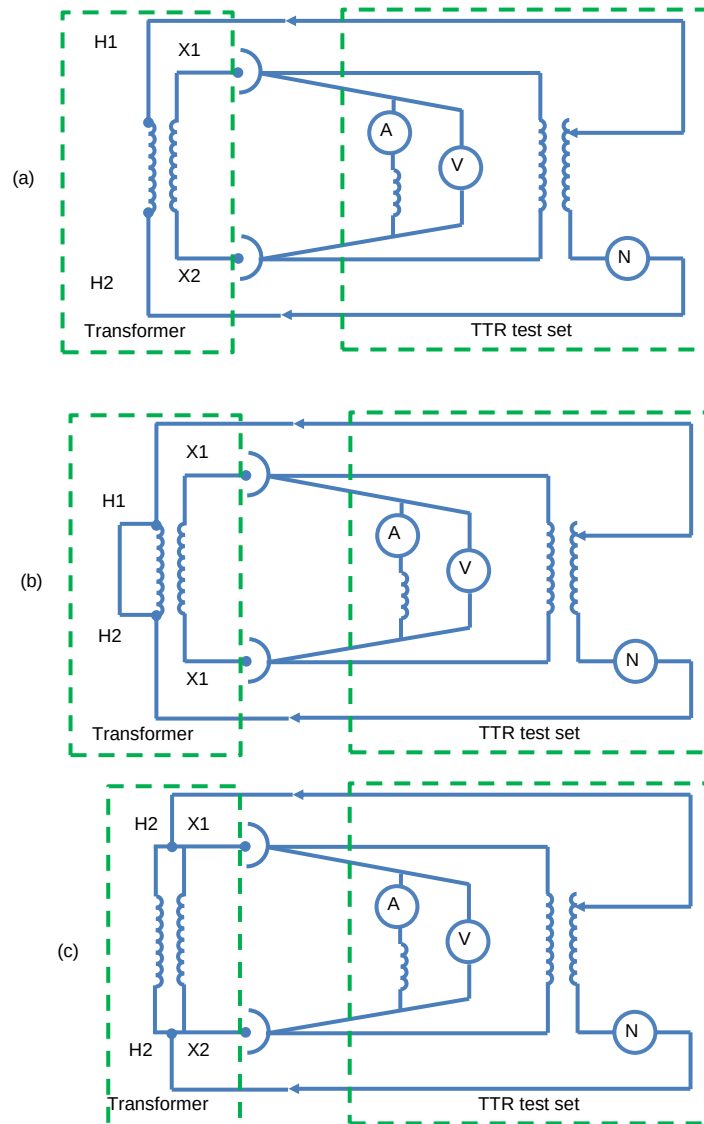


Figure 1. TTR test set connections; (b) test connection for null verification for TTR and (c) test connections for zero verification for TTR

Alternative Test for TTR

In case a TTR test set cannot be used, fast and rough test can be completed to verify the continuity and phase identification of transformer windings. The test consists of the following. The equipment required for this test is a 100 W lamp with socket and an extension cord for connection to a 120 V 60 Hz power supply, with which three test procedures are completed.

Test 1: Connect the 120 V, 60 Hz power through the lamp to the transformer primary, terminals as presented in Figure 2 (a). Leave the transformer secondary winding open. The lamp will burn dimly.

Test 2: Keep connections as presented in test 1, but now short the secondary winding. The lamp should burn with great brilliance. If the lamp still burns with somewhat less than full brilliance, check for issues in the transformer winding. Connections for this test are presented in Figure 2 (b).

Test 3: This test is similar to tests 1 and 2, but as applied to a three phase transformer for phase identification and phase continuity check. Complete tests 1 and 2 for each winding of a three-phase transformer individually with the remaining windings kept open. The test connection arrangement is shown in Figure 2 (c).



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