Logo

Single-Phase Transformer Short Circuit Test Procedure

Document Number: RD-EE-001

Note: Because the test procedures I have written are the property of my employers, I wrote this procedure for the fictional company “Logo” to provide a sample of my work. All text and graphics are my own.

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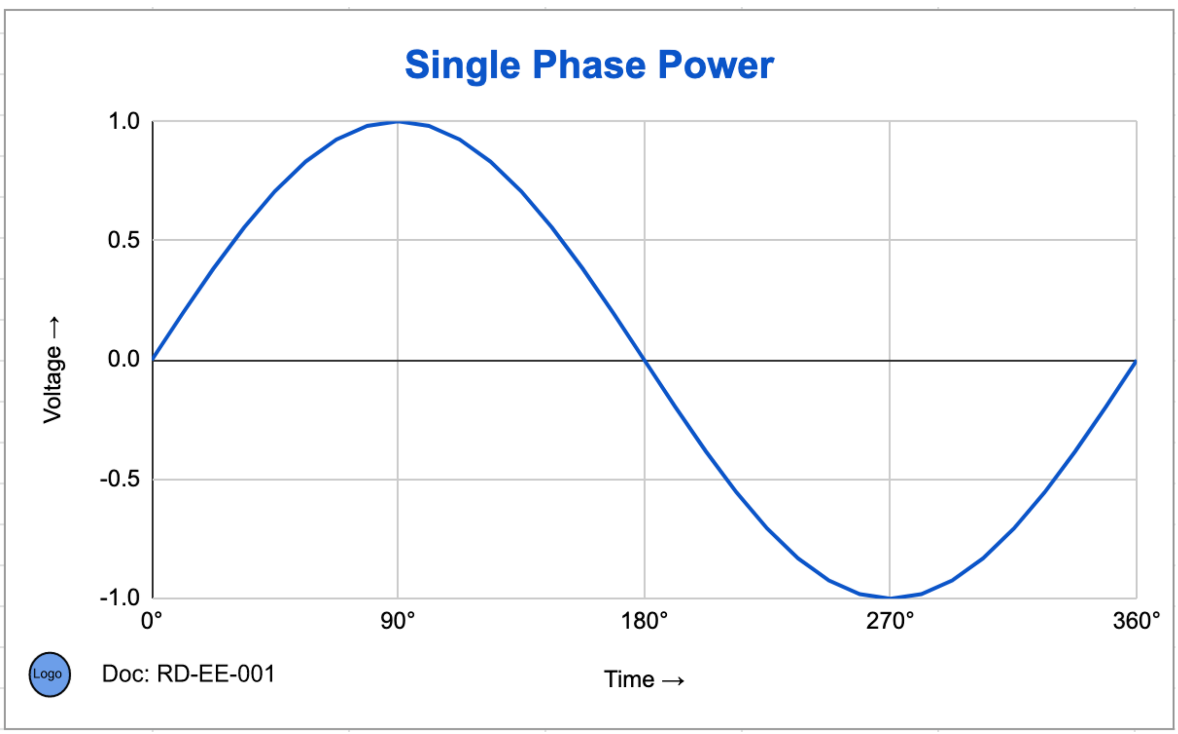
1. Purpose

The Single-Phase Transformer Short Circuit Test is performed to find the equivalent reactance and resistance of the transformer. The series reactance is used to calculate the transformer impedance, while the series resistance value is used to calculate the transformer's full load copper loss. When the short circuit test is performed in conjunction with a Single-Phase Transformer Open Circuit Test (see Logo test procedure RD-EE-002), the copper loss value can then be used to calculate the transformer's efficiency.

This test may be performed to establish parameters of a new Logo Inc. transformer design, to test the quality of alternative materials under consideration for use in the transformer, or to validate transformers or materials manufactured by suppliers.

2. Definitions

Ammeter - An instrument for measuring current in a circuit.
Single-phase power - Single-phase power is the distribution of an alternating current (AC) electricity with two wires: phase(power) and neutral. The power takes the form of a sine wave. The chart in Figure A shows how the voltage rises and falls over time, resulting in peaks and valleys. Single-phase power is used in applications with lower electricity requirements, such as residential homes.



Transformer - A transformer is a device used to increase or decrease voltage by means of electromagnetic coils. The transformer winding that carries higher voltage is referred to as the high side, while the winding with lower voltage is the low side.
Variable Autotransformer - An instrument used to vary voltage by means of a dial. Often referred to by the trade name Variac.
Voltmeter- An instrument for measuring voltage in a circuit.
Wattmeter - An instrument for measuring power in a circuit. It features terminals labeled M,C,L, and V, where M is the supply side of the current coil, C is the supply side of the voltage coil, L is the load side of the current coil, and V is the load side of the voltage coil.

3. Equipment

3.1. Voltmeter
3.2. Ammeter
3.3. Wattmeter
3.4. Variable autotransformer
3.5. Connector cables

4. Test Setup

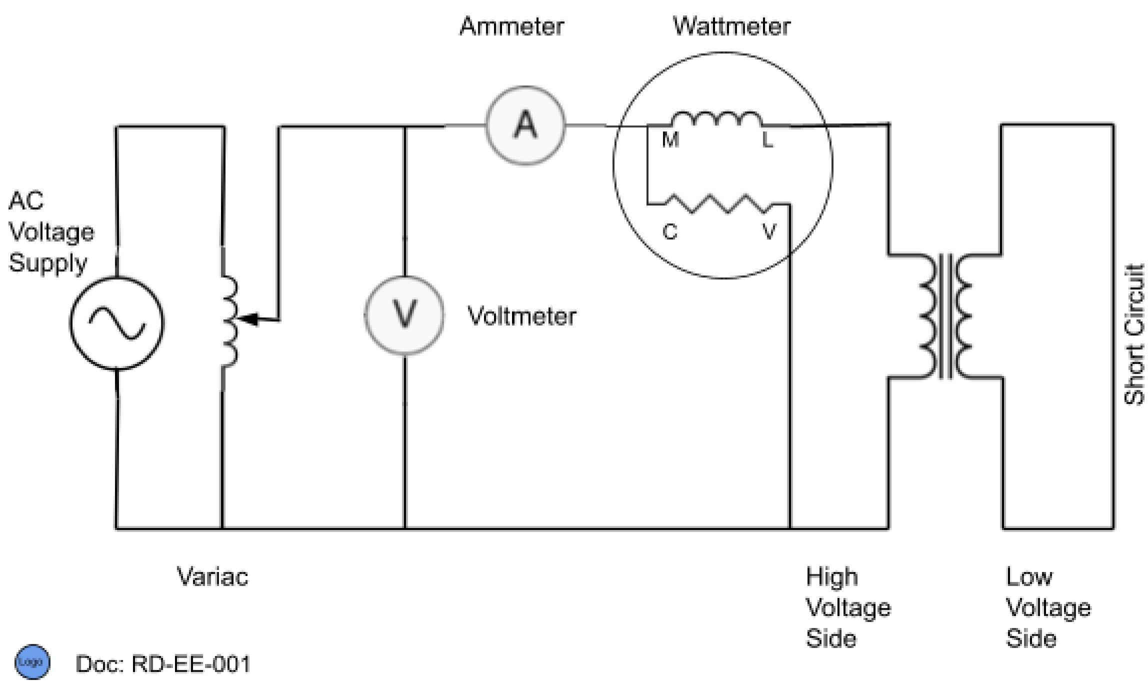


Figure A - Short Circuit Test Wiring Diagram

As outlined below, use connector cables to connect the variable autotransformer, ammeter, voltmeter and wattmeter to the high voltage side of the test transformer, then short circuit the low voltage side. Please refer to the wiring diagram in Figure A. To minimize resistance, connector cables should be short, a larger gauge than the transformer leads, and connections should be tight.

4.1. Connect the variable autotransformer to the AC power supply.
4.2. Connect the positive terminal of the variable autotransformer to the positive terminal of the ammeter.
4.3. Connect the positive terminal of the voltmeter to the positive terminal of the ammeter.
4.4. Connect the negative terminal of the ammeter to the M terminal of the wattmeter.
4.5. Use a connector wire to short circuit the M and C terminals of the wattmeter.
4.6. Connect the L terminal of the wattmeter to the high voltage winding of the transformer.
4.7. Connect the other side of the high voltage winding to the V terminal of the wattmeter.
4.8. Connect the wattmeter V terminal to the negative terminal of the voltmeter.
4.9. Connect the negative terminal of the voltmeter to the negative terminal of the variable autotransformer.
4.10. Short circuit the low side. Use a connector wire to connect the two terminals of the low voltage side of the transformer.
4.11. Note the calibration date of all test equipment on the test sheet.

5. Procedure

With the low voltage side of the transformer short circuited, the maximum rated current is applied to the high voltage side of the transformer. Current, voltage, and power measurements are taken and used to calculate the circuit characteristics.

5.1. To apply the rated current to the transformer, switch on the variable autotransformer and slowly increase its voltage. Watch the current reading on the ammeter until the maximum rated current for the circuit is flowing.
5.2. Record the ammeter (current), voltmeter (voltage), and wattmeter (power) readings on the test sheet. These values will be denoted as I_{SC}, V_{SC}, and W_{SC}, respectively.
5.3. Perform calculations.

6. Calculations

Use the recorded current, voltage, and power values, I_{SC}, V_{SC}, and $W_{SC,}$ to find equivalent copper loss, resistance, impedance, and reactance.

On the transformer's high voltage side, the equivalent circuit of the short circuit test is as shown in Figure C.

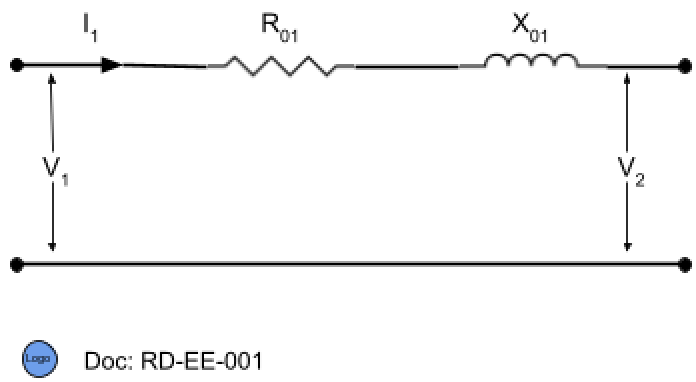


Figure C - Single Phase Transformer Short Circuit Test Equivalent Circuit

6.1. The equivalent copper loss of the transformer is equal to the recorded power value, W_{SC}. The circuit power is represented by the equation: $W_{SC}= I_{SC}^2R_{01}$.

6.2. Find the equivalent resistance, R_{01}, using the equation:
$R_{01}= \frac{W_{SC}}{I_{SC}^2}$

6.3. Find the equivalent impedance, Z_{01}, using the equation:
$Z_{01}= \frac{V_{SC}}{I_{SC}}$

6.4. Find the equivalent reactance, X_{01}, using the equation:
$X_{01}= \sqrt{Z_{01}^2 - R_{01}^2}$

6.5. Find the power factor, cosϕ, using the equation:
$\cos\phi= \frac{R_{01}}{Z_{01}}$

6.6. Find the output power, $Power_{out}$, using the equation:
$Power_{out}= V_{SC}I_{SC}\cos\phi$

6.7. Find the power loss, $Power_{loss}$, using the equation:
$Power_{loss}= W_{SC}+W_{O}$

Where W_{SC} is the transformer copper loss (see step 6.1) and W_O is the iron loss, which can be found with the Single-Phase Transformer Open Circuit Test (see Logo test procedure RD-EE-002).

6.8. Efficiency $\eta = \frac{Power_{out}}{Power_{in}}$. However, $Power_{in} = Power_{out} + Power_{loss}$, so we can find the transformer efficiency, η, using the equation:

$$\eta = \frac{Power_{out}}{Power_{out}+Power_{loss}}$$

7. Pass/Fail Criteria

7.1. If testing for validation purposes, the single-phase transformer passes the short circuit test if the measured impedance, Z_{01}, is within 3% of the nameplate value.

7.2. If testing for transformer efficiency, efficiency (η) must be greater than 95%.

7.3. This test may also be performed for informational purposes only, to determine the electrical parameters for a new design, for example.

8. Revision

Revision	Date	Description	Name
00	12/1/2022	Procedure Published	Lorraine Rivera-Newberry