Transformer Equivalent Circuit from Open- and Short-Circuit Tests

Transformer equivalent-circuit parameters, percentage impedance and full-load copper loss from open-circuit and short-circuit test readings.

Method: Chapman; Electric Machinery Fundamentals; ...

Input parameters

Unit system: SI

Parameter	Value	Unit
Open-circuit test voltage (rated, LV side)	415.00	V
Open-circuit current	15.000	A
Open-circuit power (3 phases)	2,200.0	W
Short-circuit test voltage (line, HV side)	550.00	V
Short-circuit current	52.500	A
Short-circuit power (3 phases)	10,500	W
Rated HV line voltage	11.000	kV
Rated power	1,000.0	kVA

Calculated results

Parameter	Value	Unit
Core-loss resistance per phase (LV, star)	78.284	Ω
Magnetising reactance per phase (LV, star)	16.317	Ω
Equivalent resistance per phase (HV, star)	1.2698	Ω
Equivalent reactance per phase (HV, star)	5.9136	Ω
Percentage impedance	4.9987	%
Full-load copper loss	10.495	kW

Notes for this case

• Three-phase transformer: line voltages and three-phase powers are converted to star-equivalent per-phase values (V/√3, P/3); a single-phase test entered here would be wrong by √3 and 3. If the short-circuit test was not at rated current, copper loss scales with current squared (done here via R_eq).

Formula and method

$$V_0 = \frac{V_{oc}}{\sqrt{3}},\ P_0 = \frac{P_{oc}}{3},\ \cos\phi_0 = \frac{P_0}{V_0 I_{oc}},\quad R_c = \frac{V_0^2}{P_0},\ X_m = \frac{V_0}{I_{oc}\sin\phi_0}$$

$$Z_{eq} = \frac{V_{sc}/\sqrt{3}}{I_{sc}},\ R_{eq} = \frac{P_{sc}/3}{I_{sc}^2},\ X_{eq} = \sqrt{Z_{eq}^2 - R_{eq}^2},\quad z = \frac{Z_{eq} S}{V_{HV}^2},\ P_{cu} = 3 I_r^2 R_{eq},\ I_r = \frac{S}{\sqrt{3}\,V_{HV}}$$

Variables

V_{oc}	Open-circuit test voltage (rated, LV side)	V
I_{oc}	Open-circuit current	A
P_{oc}	Open-circuit power (3 phases)	W
V_{sc}	Short-circuit test voltage (line, HV side)	V
I_{sc}	Short-circuit current	A
P_{sc}	Short-circuit power (3 phases)	W

V_{HV}	Rated HV line voltage	V
S	Rated power	VA
R_c	Core-loss resistance per phase (LV, star)	Ω
X_m	Magnetising reactance per phase (LV, star)	Ω
R_{eq}	Equivalent resistance per phase (HV, star)	Ω
X_{eq}	Equivalent reactance per phase (HV, star)	Ω
$\mathcal{Z}$	Percentage impedance	-
P_{cu}	Full-load copper loss	W
V_0, P_0	Open-circuit voltage and power per phase	V, W
ϕ_0	No-load power-factor angle	rad
Z_{eq}	Equivalent impedance per phase (HV, star)	Ω
I_r	Rated HV line current	A

Method and standards

Per-phase test analysis.

Assumptions and limits

- Three-phase transformer only: voltages are line values and powers the three-phase totals. For a single-phase transformer do not use this page: enter its readings in R_c = V²/P, X_m = V/(I sin φ₀), Z_eq = V/I, R_eq = P/I² directly, otherwise the results are off by √3 and 3.
- Star equivalent; balanced test.

References

• Chapman
• Electric Machinery Fundamentals
• 5th ed. (McGraw-Hill, 2012)
• ch. 2 (transformer tests and equivalent circuit)

Report details

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Results are for engineering estimation. Verify critical designs against the referenced standards and your own data.

This calculator online

https://calc.firecad.com/electrical/transformers/transformer-oc-sc-test

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Reopens the calculator with the inputs of this report.