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Transformer Circuit Formulas

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List of 35 Transformer Circuit Formulas

Transformer Circuit

1) Efficiency of Transformer

Open Calculator

fx $$\eta = \frac{P_{out}}{P_{in}}$$

ex $$0.888889 = \frac{120\text{kW}}{135\text{kW}}$$

2) EMF Induced in Primary Winding

Open Calculator

fx $$E_1 = 4.44 \cdot N_1 \cdot f \cdot A_{core} \cdot B_{max}$$

ex $$13.32\text{V} = 4.44 \cdot 20 \cdot 500\text{Hz} \cdot 2500\text{cm}^2 \cdot 0.0012\text{T}$$

3) EMF Induced in Secondary Winding

Open Calculator

fx $$E_2 = 4.44 \cdot N_2 \cdot f \cdot A_{core} \cdot B_{max}$$

ex $$15.984\text{V} = 4.44 \cdot 24 \cdot 500\text{Hz} \cdot 2500\text{cm}^2 \cdot 0.0012\text{T}$$

4) Equivalent Impedance of Transformer from Primary Side

Open Calculator

fx $$Z_{01} = \sqrt{R_{01}^2 + X_{01}^2}$$

ex $$36.00295\Omega = \sqrt{(35.97\Omega)^2 + (1.54\Omega)^2}$$

5) Equivalent Impedance of Transformer from Secondary Side

Open Calculator

fx $$Z_{02} = \sqrt{R_{02}^2 + X_{02}^2}$$

ex $$51.83799\Omega = \sqrt{(51.79\Omega)^2 + (2.23\Omega)^2}$$

6) Equivalent Reactance of Transformer from Primary Side

Open Calculator

fx $$X_{01} = X_{L1} + X'_2$$

ex $$1.54\Omega = 0.88\Omega + 0.66\Omega$$

7) Equivalent Reactance of Transformer from Secondary Side

Open Calculator

fx $$X_{02} = X_{L2} + X'_1$$

ex $$2.23\Omega = 0.95\Omega + 1.28\Omega$$

8) Equivalent Resistance from Primary Side

Open Calculator

fx $$R_{01} = R_1 + \frac{R_2}{K^2}$$

ex $$35.96611\Omega = 17.98\Omega + \frac{25.90\Omega}{(1.2)^2}$$

9) Equivalent Resistance from Secondary Side

Open Calculator

fx $$R_{02} = R_2 + R_1 \cdot K^2$$

ex $$51.7912\Omega = 25.90\Omega + 17.98\Omega \cdot (1.2)^2$$

10) Frequency given EMF Induced in Primary Winding

Open Calculator

fx $$f = \frac{E_1}{4.44 \cdot N_1 \cdot A_{core} \cdot B_{max}}$$

ex $$495.4955\text{Hz} = \frac{13.2\text{V}}{4.44 \cdot 20 \cdot 2500\text{cm}^2 \cdot 0.0012\text{T}}$$

11) Frequency given EMF Induced in Secondary Winding

Open Calculator

fx $$f = \frac{E_2}{4.44 \cdot N_2 \cdot A_{core} \cdot B_{max}}$$

ex $$495.4955\text{Hz} = \frac{15.84\text{V}}{4.44 \cdot 24 \cdot 2500\text{cm}^2 \cdot 0.0012\text{T}}$$

12) Impedance of Primary Winding

Open Calculator

fx $$Z_1 = \sqrt{R_1^2 + X_{L1}^2}$$

ex $$18.00152\Omega = \sqrt{(17.98\Omega)^2 + (0.88\Omega)^2}$$

13) Impedance of Secondary Winding

Open Calculator

fx $$Z_2 = \sqrt{R_2^2 + X_{L2}^2}$$

ex $$25.91742\Omega = \sqrt{(25.90\Omega)^2 + (0.95\Omega)^2}$$

14) P.U. Primary Resistance Drop

Open Calculator

$$R_{pu} = \frac{I_1 \cdot R_{01}}{E_1}$$

$$34.335 = \frac{12.6\text{A} \cdot 35.97\Omega}{13.2\text{V}}$$

15) Primary Current given Voltage Transformation Ratio

Open Calculator

$$I_1 = I_2 \cdot K$$

$$12.6\text{A} = 10.5\text{A} \cdot 1.2$$

16) Primary Leakage Reactance

Open Calculator

$$X_{L1} = \frac{X'_1}{K^2}$$

$$0.888889\Omega = \frac{1.28\Omega}{(1.2)^2}$$

17) Primary Voltage given Voltage Transformation Ratio

Open Calculator

$$V_1 = \frac{V_2}{K}$$

$$240\text{V} = \frac{288\text{V}}{1.2}$$

18) Primary Winding Resistance

Open Calculator

$$R_1 = \frac{R'_1}{K^2}$$

$$17.97917\Omega = \frac{25.89\Omega}{(1.2)^2}$$

19) Reactance of Primary Winding in Secondary

Open Calculator

$$X'_1 = X_{L1} \cdot K^2$$

$$1.2672\Omega = 0.88\Omega \cdot (1.2)^2$$

20) Reactance of Secondary Winding in Primary

Open Calculator

$$X'_2 = \frac{X_{L2}}{K^2}$$

$$0.659722\Omega = \frac{0.95\Omega}{(1.2)^2}$$

21) Resistance of Primary Winding in Secondary

Open Calculator

$$R'_1 = R_1 \cdot K^2$$

$$25.8912\Omega = 17.98\Omega \cdot (1.2)^2$$

22) Resistance of Secondary Winding in Primary

Open Calculator

fx $$R'_2 = \frac{R_2}{K^2}$$

ex $$17.98611\Omega = \frac{25.90\Omega}{(1.2)^2}$$

23) Secondary Current given Voltage Transformation Ratio

Open Calculator

fx $$I_2 = \frac{I_1}{K}$$

ex $$10.5\text{A} = \frac{12.6\text{A}}{1.2}$$

24) Secondary Leakage Reactance

Open Calculator

fx $$X_{L2} = \frac{E_{self(2)}}{I_2}$$

ex $$0.952381\Omega = \frac{10\text{V}}{10.5\text{A}}$$

25) Secondary Voltage given Voltage Transformation Ratio

Open Calculator

fx $$V_2 = V_1 \cdot K$$

ex $$288\text{V} = 240\text{V} \cdot 1.2$$

26) Secondary Winding Resistance

Open Calculator

$$R_2 = R'_2 \cdot K^2$$

$$25.9056\Omega = 17.99\Omega \cdot (1.2)^2$$

27) Terminal Voltage during No Load

Open Calculator

$$V_{\text{no-load}} = \frac{V_1 \cdot N_2}{N_1}$$

$$288V = \frac{240V \cdot 24}{20}$$

28) Transformation Ratio given Primary and Secondary Current

Open Calculator

$$K = \frac{I_1}{I_2}$$

$$1.2 = \frac{12.6A}{10.5A}$$

29) Transformation Ratio given Primary and Secondary Number of Turns

Open Calculator

$$K = \frac{N_2}{N_1}$$

$$1.2 = \frac{24}{20}$$

30) Transformation Ratio given Primary and Secondary Voltage

Open Calculator

fx $$K = \frac{V_2}{V_1}$$

ex $$1.2 = \frac{288\text{V}}{240\text{V}}$$

31) Transformation Ratio given Primary Leakage Reactance

Open Calculator

fx $$K = \sqrt{\frac{X'_1}{X_{L1}}}$$

ex $$1.206045 = \sqrt{\frac{1.28\Omega}{0.88\Omega}}$$

32) Transformation Ratio given Secondary Leakage Reactance

Open Calculator

fx $$K = \sqrt{\frac{X_{L2}}{X'_2}}$$

ex $$1.199747 = \sqrt{\frac{0.95\Omega}{0.66\Omega}}$$

33) Voltage Regulation at Lagging PF

fx

Open Calculator

$$\% = \left(\frac{I_2 \cdot R_2 \cdot \cos(\varphi_2) + I_2 \cdot X_2 \cdot \sin(\varphi_2)}{V_2} \right) \cdot 100$$

ex

$$83.47157 = \left(\frac{10.5\text{A} \cdot 25.90\Omega \cdot \cos(30°) + 10.5\text{A} \cdot 0.93\Omega \cdot \sin(30°)}{288\text{V}} \right) \cdot 100$$

34) Voltage Regulation at Leading PF

fx

Open Calculator

$$\% = \left(\frac{I_2 \cdot R_2 \cdot \cos(\varphi_2) - I_2 \cdot X_2 \cdot \sin(\varphi_2)}{V_2} \right) \cdot 100$$

ex

$$80.08094 = \left(\frac{10.5\text{A} \cdot 25.90\Omega \cdot \cos(30°) - 10.5\text{A} \cdot 0.93\Omega \cdot \sin(30°)}{288\text{V}} \right) \cdot 100$$

35) Voltage Regulation at Unity PF

Open Calculator

fx

$$\% = \left(\frac{I_2 \cdot R_2 \cdot \cos(\varphi_2)}{V_2} \right) \cdot 100$$

ex

$$81.77625 = \left(\frac{10.5\text{A} \cdot 25.90\Omega \cdot \cos(30°)}{288\text{V}} \right) \cdot 100$$

Variables Used

- **%** Percentage Regulation of Transformer
- A_{core} Area of Core *(Square Centimeter)*
- B_{max} Maximum Flux Density *(Tesla)*
- E_1 EMF Induced in Primary *(Volt)*
- E_2 EMF Induced in Secondary *(Volt)*
- $E_{self(2)}$ Self Induced EMF in Secondary *(Volt)*
- **f** Supply Frequency *(Hertz)*
- I_1 Primary Current *(Ampere)*
- I_2 Secondary Current *(Ampere)*
- **K** Transformation Ratio
- N_1 Number of Turns in Primary
- N_2 Number of Turns in Secondary
- P_{in} Input Power *(Kilowatt)*
- P_{out} Output Power *(Kilowatt)*
- R_{01} Equivalent Resistance from Primary *(Ohm)*
- R_{02} Equivalent Resistance from Secondary *(Ohm)*
- R_1 Resistance of Primary *(Ohm)*
- R'_1 Resistance of Primary in Secondary *(Ohm)*
- R_2 Resistance of Secondary *(Ohm)*
- R'_2 Resistance of Secondary in Primary *(Ohm)*
- R_{pu} P U Primary Resistance drop

- V_1 Primary Voltage *(Volt)*
- V_2 Secondary Voltage *(Volt)*
- $V_{no\text{-}load}$ No Load Terminal Voltage *(Volt)*
- X_{01} Equivalent Reactance from Primary *(Ohm)*
- X_{02} Equivalent Reactance from Secondary *(Ohm)*
- X'_1 Reactance of Primary in Secondary *(Ohm)*
- X_2 Secondary Reactance *(Ohm)*
- X'_2 Reactance of Secondary in Primary *(Ohm)*
- X_{L1} Primary Leakage Reactance *(Ohm)*
- X_{L2} Secondary Leakage Reactance *(Ohm)*
- Z_{01} Equivalent Impedance from Primary *(Ohm)*
- Z_{02} Equivalent Impedance from Secondary *(Ohm)*
- Z_1 Impedance of Primary *(Ohm)*
- Z_2 Impedance of Secondary *(Ohm)*
- η Efficiency
- φ_2 Secondary Power Factor Angle *(Degree)*

Constants, Functions, Measurements used

- Function: **cos**, cos(Angle)
  Trigonometric cosine function
- Function: **sin**, sin(Angle)
  Trigonometric sine function
- Function: **sqrt**, sqrt(Number)
  Square root function
- Measurement: **Electric Current** in Ampere (A)
  Electric Current Unit Conversion
- Measurement: **Area** in Square Centimeter (cm²)
  Area Unit Conversion
- Measurement: **Power** in Kilowatt (kW)
  Power Unit Conversion
- Measurement: **Angle** in Degree (°)
  Angle Unit Conversion
- Measurement: **Frequency** in Hertz (Hz)
  Frequency Unit Conversion
- Measurement: **Electric Resistance** in Ohm (Ω)
  Electric Resistance Unit Conversion
- Measurement: **Magnetic Flux Density** in Tesla (T)
  Magnetic Flux Density Unit Conversion
- Measurement: **Electric Potential** in Volt (V)
  Electric Potential Unit Conversion

Check other formula lists

- **Mechanical Specifications Formulas**
- **Reactance Formulas**
- **Resistance Formulas**
- **Transformation Ratio Formulas**
- **Transformer Circuit Formulas**
- **Transformer Design Formulas**
- **Voltage & EMF Formulas**

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