Important Transformer Circuit Formulas PDF

Formulas
Examples
with Units

List of 35
Important Transformer Circuit Formulas

1) Efficiency of Transformer Formula

Evaluate Formula

Formula

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

Example with Units

$$0.8889 = \frac{120\,\text{kW}}{135\,\text{kW}}$$

2) EMF Induced in Primary Winding Formula

Evaluate Formula

Formula

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

Example with Units

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

3) EMF Induced in Secondary Winding Formula

Evaluate Formula

Formula

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

Example with Units

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

4) Equivalent Impedance of Transformer from Primary Side Formula

Evaluate Formula

Formula

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

Example with Units

$$36.003\,\Omega = \sqrt{35.97\,\Omega^2 + 1.54\,\Omega^2}$$

5) Equivalent Impedance of Transformer from Secondary Side Formula

Evaluate Formula

Formula

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

Example with Units

$$51.838\,\Omega = \sqrt{51.79\,\Omega^2 + 2.23\,\Omega^2}$$

6) Equivalent Reactance of Transformer from Primary Side Formula

Evaluate Formula

Formula

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

Example with Units

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

7) Equivalent Reactance of Transformer from Secondary Side Formula

Evaluate Formula

Formula

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

Example with Units

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

8) Equivalent Resistance from Primary Side Formula

Evaluate Formula

Formula

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

Example with Units

$$35.9661\,\Omega = 17.98\,\Omega + \frac{25.90\,\Omega}{1.2^2}$$

9) Equivalent Resistance from Secondary Side Formula

Evaluate Formula

Formula

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

Example with Units

$$51.7912\,\Omega = 25.90\,\Omega + 17.98\,\Omega \cdot 1.2^2$$

10) Frequency given EMF Induced in Primary Winding Formula

Evaluate Formula

Formula

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

Example with Units

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

11) Frequency given EMF Induced in Secondary Winding Formula

Evaluate Formula

Formula

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

Example with Units

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

12) Impedance of Primary Winding Formula

Evaluate Formula

Formula

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

Example with Units

$$18.0015\,\Omega = \sqrt{17.98\,\Omega^2 + 0.88\,\Omega^2}$$

13) Impedance of Secondary Winding Formula

Evaluate Formula

Formula

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

Example with Units

$$25.9174\,\Omega = \sqrt{25.90\,\Omega^2 + 0.95\,\Omega^2}$$

14) P.U. Primary Resistance Drop Formula

Evaluate Formula

Formula

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

Example with Units

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

15) Primary Current given Voltage Transformation Ratio Formula

Evaluate Formula

Formula

$$I_1 = I_2 \cdot K$$

Example with Units

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

16) Primary Leakage Reactance Formula

Evaluate Formula

Formula

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

Example with Units

$$0.8889\,\Omega = \frac{1.28\,\Omega}{1.2^2}$$

17) Primary Voltage given Voltage Transformation Ratio Formula

Evaluate Formula

Formula

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

Example with Units

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

18) Primary Winding Resistance Formula

Evaluate Formula

Formula

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

Example with Units

$$17.9792\,\Omega = \frac{25.89\,\Omega}{1.2^2}$$

19) Reactance of Primary Winding in Secondary Formula

Evaluate Formula

Formula

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

Example with Units

$$1.2672\,\Omega = 0.88\,\Omega \cdot 1.2^2$$

20) Reactance of Secondary Winding in Primary Formula

Evaluate Formula

Formula

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

Example with Units

$$0.6597\,\Omega = \frac{0.95\,\Omega}{1.2^2}$$

21) Resistance of Primary Winding in Secondary Formula

Evaluate Formula

Formula

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

Example with Units

$$25.8912\,\Omega = 17.98\,\Omega \cdot 1.2^2$$

22) Resistance of Secondary Winding in Primary Formula

Evaluate Formula

Formula

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

Example with Units

$$17.9861\,\Omega = \frac{25.90\,\Omega}{1.2^2}$$

23) Secondary Current given Voltage Transformation Ratio Formula

Evaluate Formula

Formula

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

Example with Units

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

24) Secondary Leakage Reactance Formula

Evaluate Formula

Formula

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

Example with Units

$$0.9524\,\Omega = \frac{10\,\text{V}}{10.5\,\text{A}}$$

25) Secondary Voltage given Voltage Transformation Ratio Formula

Evaluate Formula

Formula

$$V_2 = V_1 \cdot K$$

Example with Units

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

26) Secondary Winding Resistance Formula

Evaluate Formula

Formula

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

Example with Units

$$25.9056\,\Omega = 17.99\,\Omega \cdot 1.2^2$$

27) Terminal Voltage during No Load Formula

Evaluate Formula

Formula

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

Example with Units

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

28) Transformation Ratio given Primary and Secondary Current Formula

Evaluate Formula

Formula

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

Example with Units

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

29) Transformation Ratio given Primary and Secondary Number of Turns Formula

Evaluate Formula

Formula

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

Example

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

30) Transformation Ratio given Primary and Secondary Voltage Formula

Evaluate Formula

Formula

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

Example with Units

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

31) Transformation Ratio given Primary Leakage Reactance Formula

Evaluate Formula

Formula

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

Example with Units

$$1.206 = \sqrt{\frac{1.28\,\Omega}{0.88\,\Omega}}$$

32) Transformation Ratio given Secondary Leakage Reactance Formula

Evaluate Formula

Formula

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

Example with Units

$$1.1997 = \sqrt{\frac{0.95\,\Omega}{0.66\,\Omega}}$$

33) Voltage Regulation at Lagging PF Formula

Evaluate Formula

Formula

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

Example with Units

$$83.4716 = \left(\frac{10.5\,\text{A} \cdot 25.90\,\Omega \cdot \cos\left(30°\right) + 10.5\,\text{A} \cdot 0.93\,\Omega \cdot \sin\left(30°\right)}{288\,\text{V}}\right) \cdot 100$$

34) Voltage Regulation at Leading PF Formula

Evaluate Formula

Formula

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

Example with Units

$$80.0809 = \left(\frac{10.5\,\text{A} \cdot 25.90\,\Omega \cdot \cos\left(30°\right) - 10.5\,\text{A} \cdot 0.93\,\Omega \cdot \sin\left(30°\right)}{288\,\text{V}}\right) \cdot 100$$

35) Voltage Regulation at Unity PF Formula

Evaluate Formula

Formula

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

Example with Units

$$81.7763 = \left(\frac{10.5\,\text{A} \cdot 25.90\,\Omega \cdot \cos\left(30°\right)}{288\,\text{V}}\right) \cdot 100$$

Variables used in list of Transformer Circuit Formulas above

- **%** 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)*

Constants, Functions, Measurements used in list of Transformer Circuit Formulas above

- Functions: **cos**, cos(Angle)
  Cosine of an angle is the ratio of the side adjacent to the angle to the hypotenuse of the triangle.
- Functions: **sin**, sin(Angle)
  Sine is a trigonometric function that describes the ratio of the length of the opposite side of a right triangle to the length of the hypotenuse.
- Functions: **sqrt**, sqrt(Number)
  A square root function is a function that takes a non-negative number as an input and returns the square root of the given input number.
- 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

- 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)*

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