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Transformer Circuit Formulas

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List of 35 Transformer Circuit Formulas

Transformer Circuit

1) Efficiency of Transformer

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

[Open Calculator !\[\]\(a870788d6ed9b8fd294b7654a8c8526b_img.jpg\)](#)

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

2) EMF Induced in Primary Winding

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

[Open Calculator !\[\]\(c50c8b7b2cc2cf9ff925edec0ee94c0d_img.jpg\)](#)

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

3) EMF Induced in Secondary Winding

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

[Open Calculator !\[\]\(f60b7a900783ac3fd531bfd9c111be6d_img.jpg\)](#)

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

4) Equivalent Impedance of Transformer from Primary Side

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

[Open Calculator !\[\]\(83bbbd261710c59db0214aa27b2edc0d_img.jpg\)](#)

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



5) Equivalent Impedance of Transformer from Secondary Side 

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

[Open Calculator !\[\]\(cbe80b694ebd74fcfe136a095b608235_img.jpg\)](#)


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

6) Equivalent Reactance of Transformer from Primary Side 

$$fx \quad X_{01} = X_{L1} + X'_{2}$$

[Open Calculator !\[\]\(3e2231b1ad3ca8da8658228c00dd08e0_img.jpg\)](#)


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

7) Equivalent Reactance of Transformer from Secondary Side 

$$fx \quad X_{02} = X_{L2} + X'_{1}$$

[Open Calculator !\[\]\(0d5ec72f61334709c3fc9450209b754f_img.jpg\)](#)


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

8) Equivalent Resistance from Primary Side 

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

[Open Calculator !\[\]\(b64b40baaee5acddc1eab8538ba84754_img.jpg\)](#)

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

9) Equivalent Resistance from Secondary Side 

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

[Open Calculator !\[\]\(aff7c69c44a5e015f18c35867ef3f5c3_img.jpg\)](#)

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




10) Frequency given EMF Induced in Primary Winding 

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

Open Calculator 

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

11) Frequency given EMF Induced in Secondary Winding 

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

Open Calculator 

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

12) Impedance of Primary Winding 

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

Open Calculator 

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

13) Impedance of Secondary Winding 

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

Open Calculator 

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



14) P.U. Primary Resistance Drop 

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

Open Calculator 


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

15) Primary Current given Voltage Transformation Ratio 

$$fx \quad I_1 = I_2 \cdot K$$

Open Calculator 

$$ex \quad 12.6A = 10.5A \cdot 1.2$$

16) Primary Leakage Reactance 

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

Open Calculator 

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


17) Primary Voltage given Voltage Transformation Ratio 

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

Open Calculator 

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




18) Primary Winding Resistance 

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

[Open Calculator !\[\]\(d3fb9f94af8b26d1c844efa9a98805b0_img.jpg\)](#)


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

19) Reactance of Primary Winding in Secondary 

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

[Open Calculator !\[\]\(e1d6102fe77919492c04879c8450f1f5_img.jpg\)](#)


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

20) Reactance of Secondary Winding in Primary 

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

[Open Calculator !\[\]\(ab4e2b3fc7e7887b7a72f548aa6f5e60_img.jpg\)](#)

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

21) Resistance of Primary Winding in Secondary 

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

[Open Calculator !\[\]\(5abce1a84a655b073239ab33e1199487_img.jpg\)](#)

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



22) Resistance of Secondary Winding in Primary

[Open Calculator !\[\]\(feabb98897b440bc8695a03336a6e2df_img.jpg\)](#)

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

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

23) Secondary Current given Voltage Transformation Ratio

[Open Calculator !\[\]\(642aa997563f9a325b310230bb5078b7_img.jpg\)](#)

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

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

24) Secondary Leakage Reactance

[Open Calculator !\[\]\(51514032c8ca341817228f39f1307b05_img.jpg\)](#)

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

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

25) Secondary Voltage given Voltage Transformation Ratio

[Open Calculator !\[\]\(f219cfc00b8db0cd1a81ae1fc9afaf28_img.jpg\)](#)

$$\text{fx } V_2 = V_1 \cdot K$$

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



26) Secondary Winding Resistance 

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

[Open Calculator !\[\]\(6605b201d6f14d9b3bcb8ab5f274d107_img.jpg\)](#)

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

27) Terminal Voltage during No Load 

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

[Open Calculator !\[\]\(e8fb589d58dad1692debababa5e928b6_img.jpg\)](#)


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

28) Transformation Ratio given Primary and Secondary Current 

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

[Open Calculator !\[\]\(4688aadfd656ded00cd6bdfae55089a9_img.jpg\)](#)

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

29) Transformation Ratio given Primary and Secondary Number of Turns 

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

[Open Calculator !\[\]\(4146d17f71dced09c6ad789cacceaa6d_img.jpg\)](#)

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



30) Transformation Ratio given Primary and Secondary Voltage 

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

[Open Calculator !\[\]\(c3d993ca47bfe2a953c700506ce31fa0_img.jpg\)](#)

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

31) Transformation Ratio given Primary Leakage Reactance 

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

[Open Calculator !\[\]\(17413706fd4997a1a4bdf85c6864eee1_img.jpg\)](#)

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


32) Transformation Ratio given Secondary Leakage Reactance 

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

[Open Calculator !\[\]\(4b7a79268f6ba26c1471d4232fffa85a_img.jpg\)](#)

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



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

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

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

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

35) Voltage Regulation at Unity PF 

fx

Open Calculator 

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

ex

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



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)
- $E_{\text{self}(2)}$ 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)
- $V_{\text{no-load}}$ 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 



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