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# Transformer Design Formulas

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# List of 19 Transformer Design Formulas

## Transformer Design

### 1) Area of Core given EMF Induced in Primary Winding

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

[Open Calculator !\[\]\(a870788d6ed9b8fd294b7654a8c8526b\_img.jpg\)](#)

$$ex \quad 2477.477\text{cm}^2 = \frac{13.2\text{V}}{4.44 \cdot 500\text{Hz} \cdot 20 \cdot 0.0012\text{T}}$$

### 2) Area of Core given EMF Induced in Secondary Winding

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

[Open Calculator !\[\]\(c50c8b7b2cc2cf9ff925edec0ee94c0d\_img.jpg\)](#)

$$ex \quad 2477.477\text{cm}^2 = \frac{15.84\text{V}}{4.44 \cdot 500\text{Hz} \cdot 24 \cdot 0.0012\text{T}}$$

### 3) Eddy Current Loss

$$fx \quad P_e = K_e \cdot B_{\text{max}}^2 \cdot f^2 \cdot w^2 \cdot V_{\text{core}}$$

[Open Calculator !\[\]\(f60b7a900783ac3fd531bfd9c111be6d\_img.jpg\)](#)

$$ex \quad 0.401063\text{W} = 0.98\text{S/m} \cdot (0.0012\text{T})^2 \cdot (500\text{Hz})^2 \cdot (0.7\text{m})^2 \cdot 2.32\text{m}^3$$

### 4) EMF Induced in Primary Winding given Input Voltage

$$fx \quad E_1 = V_1 - I_1 \cdot Z_1$$

[Open Calculator !\[\]\(83bbbd261710c59db0214aa27b2edc0d\_img.jpg\)](#)

$$ex \quad 13.2\text{V} = 240\text{V} - 12.6\text{A} \cdot 18\Omega$$




5) Hysteresis Loss 

$$fx \quad P_h = K_h \cdot f \cdot (B_{max}^x) \cdot V_{core}$$

[Open Calculator !\[\]\(cbe80b694ebd74fcfe136a095b608235\_img.jpg\)](#)

$$ex \quad 0.052424W = 2.13J/m^3 \cdot 500Hz \cdot (0.0012T^{1.6}) \cdot 2.32m^3$$

6) Maximum Core Flux 

$$fx \quad \Phi_{max} = B_{max} \cdot A_{core}$$

[Open Calculator !\[\]\(3e2231b1ad3ca8da8658228c00dd08e0\_img.jpg\)](#)


$$ex \quad 0.3mWb = 0.0012T \cdot 2500cm^2$$

7) Maximum Flux in Core using Primary Winding 

$$fx \quad \Phi_{max} = \frac{E_1}{4.44 \cdot f \cdot N_1}$$

[Open Calculator !\[\]\(0d5ec72f61334709c3fc9450209b754f\_img.jpg\)](#)

$$ex \quad 0.297297mWb = \frac{13.2V}{4.44 \cdot 500Hz \cdot 20}$$

8) Maximum Flux in Core using Secondary Winding 

$$fx \quad \Phi_{max} = \frac{E_2}{4.44 \cdot f \cdot N_2}$$

[Open Calculator !\[\]\(b64b40baaee5acddc1eab8538ba84754\_img.jpg\)](#)

$$ex \quad 0.297297mWb = \frac{15.84V}{4.44 \cdot 500Hz \cdot 24}$$



## 9) Number of Turns in Primary Winding

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

[Open Calculator !\[\]\(e78f798d4ea5c530c9db49e7d26e6b95\_img.jpg\)](#)

$$\text{ex } 20 = \frac{13.2\text{V}}{4.44 \cdot 500\text{Hz} \cdot 2500\text{cm}^2 \cdot 0.0012\text{T}}$$

## 10) Number of Turns in Secondary Winding

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

[Open Calculator !\[\]\(05be7c7a8995decd503647c99211f7c2\_img.jpg\)](#)

$$\text{ex } 24 = \frac{15.84\text{V}}{4.44 \cdot 500\text{Hz} \cdot 2500\text{cm}^2 \cdot 0.0012\text{T}}$$

## 11) Percentage All Day Efficiency of Transformer

$$\text{fx } \% \eta_{\text{all day}} = \left( \frac{E_{\text{out}}}{E_{\text{in}}} \right) \cdot 100$$

[Open Calculator !\[\]\(fe3aebe81acea8d45108cd2768939da7\_img.jpg\)](#)

$$\text{ex } 89.28571 = \left( \frac{31.25\text{kW} \cdot \text{h}}{35\text{kW} \cdot \text{h}} \right) \cdot 100$$

## 12) Percentage Regulation of Transformer

$$\text{fx } \% = \left( \frac{V_{\text{no-load}} - V_{\text{full-load}}}{V_{\text{no-load}}} \right) \cdot 100$$

[Open Calculator !\[\]\(899d8b7697d64725bf017d3296cfcf1b\_img.jpg\)](#)

$$\text{ex } 81.15585 = \left( \frac{288.1\text{V} - 54.29\text{V}}{288.1\text{V}} \right) \cdot 100$$



### 13) Primary Winding Resistance given Impedance of Primary Winding

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

[Open Calculator !\[\]\(e2376d476d06eb31946dc01a69a4403a\_img.jpg\)](#)

$$ex \quad 17.97848\Omega = \sqrt{(18\Omega)^2 - (0.88\Omega)^2}$$

### 14) Secondary Winding Resistance given Impedance of Secondary Winding

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

[Open Calculator !\[\]\(0b5e7e25e8775f7e7e80906ada4f0021\_img.jpg\)](#)

$$ex \quad 25.90258\Omega = \sqrt{(25.92\Omega)^2 - (0.95\Omega)^2}$$

### 15) Self-Induced EMF in Primary Side

$$fx \quad E_{self(1)} = X_{L1} \cdot I_1$$

[Open Calculator !\[\]\(bd3b31712ad9bab5a241210fa6925cdd\_img.jpg\)](#)

$$ex \quad 11.088V = 0.88\Omega \cdot 12.6A$$

### 16) Self-Induced EMF in Secondary Side

$$fx \quad E_2 = X_{L2} \cdot I_2$$

[Open Calculator !\[\]\(7bc43b319a082987e20f7bf78f4bab80\_img.jpg\)](#)

$$ex \quad 9.975V = 0.95\Omega \cdot 10.5A$$



## 17) Stacking Factor of Transformer

$$fx \quad S_f = \frac{A_{net}}{A_{gross}}$$

[Open Calculator !\[\]\(d3fb9f94af8b26d1c844efa9a98805b0\_img.jpg\)](#)

$$ex \quad 0.833333 = \frac{1000\text{cm}^2}{1200\text{cm}^2}$$

## 18) Transformer Iron loss

$$fx \quad P_{iron} = P_e + P_h$$

[Open Calculator !\[\]\(e1d6102fe77919492c04879c8450f1f5\_img.jpg\)](#)

$$ex \quad 0.45\text{W} = 0.4\text{W} + 0.05\text{W}$$

## 19) Utilisation Factor of Transformer Core

$$fx \quad UF = \frac{A_{net}}{A_{total}}$$

[Open Calculator !\[\]\(ab4e2b3fc7e7887b7a72f548aa6f5e60\_img.jpg\)](#)

$$ex \quad 0.322581 = \frac{1000\text{cm}^2}{3100\text{cm}^2}$$



## Variables Used

- % Percentage Regulation of Transformer
- $\% \eta_{\text{all day}}$  All Day Efficiency
- $A_{\text{core}}$  Area of Core (Square Centimeter)
- $A_{\text{gross}}$  Gross Cross Sectional Area (Square Centimeter)
- $A_{\text{net}}$  Net Cross Sectional Area (Square Centimeter)
- $A_{\text{total}}$  Total Cross Sectional Area (Square Centimeter)
- $B_{\text{max}}$  Maximum Flux Density (Tesla)
- $E_1$  EMF Induced in Primary (Volt)
- $E_2$  EMF Induced in Secondary (Volt)
- $E_{\text{in}}$  Input Energy (Kilowatt-Hour)
- $E_{\text{out}}$  Output Energy (Kilowatt-Hour)
- $E_{\text{self}(1)}$  Self Induced EMF in Primary (Volt)
- $f$  Supply Frequency (Hertz)
- $I_1$  Primary Current (Ampere)
- $I_2$  Secondary Current (Ampere)
- $K_e$  Eddy Current Coefficient (Siemens per Meter)
- $K_h$  Hysteresis Constant (Joule per Cubic Meter)
- $N_1$  Number of Turns in Primary
- $N_2$  Number of Turns in Secondary
- $P_e$  Eddy Current Loss (Watt)
- $P_h$  Hysteresis Loss (Watt)















- **P<sub>iron</sub>** Iron Losses (Watt)
- **R<sub>1</sub>** Resistance of Primary (Ohm)
- **R<sub>2</sub>** Resistance of Secondary (Ohm)
- **S<sub>f</sub>** Stacking Factor of Transformer
- **UF** Utilisation Factor of Transformer Core
- **V<sub>1</sub>** Primary Voltage (Volt)
- **V<sub>core</sub>** Volume of Core (Cubic Meter)
- **V<sub>full-load</sub>** Full Load Terminal Voltage (Volt)
- **V<sub>no-load</sub>** No Load Terminal Voltage (Volt)
- **w** Lamination Thickness (Meter)
- **x** Steinmetz Coefficient
- **X<sub>L1</sub>** Primary Leakage Reactance (Ohm)
- **X<sub>L2</sub>** Secondary Leakage Reactance (Ohm)
- **Z<sub>1</sub>** Impedance of Primary (Ohm)
- **Z<sub>2</sub>** Impedance of Secondary (Ohm)
- **Φ<sub>max</sub>** Maximum Core Flux (Milliweber)





# Constants, Functions, Measurements used

- **Function:** **sqrt**, sqrt(Number)  
*Square root function*
- **Measurement:** **Length** in Meter (m)  
*Length Unit Conversion* 
- **Measurement:** **Electric Current** in Ampere (A)  
*Electric Current Unit Conversion* 
- **Measurement:** **Volume** in Cubic Meter (m<sup>3</sup>)  
*Volume Unit Conversion* 
- **Measurement:** **Area** in Square Centimeter (cm<sup>2</sup>)  
*Area Unit Conversion* 
- **Measurement:** **Energy** in Kilowatt-Hour (kW\*h)  
*Energy Unit Conversion* 
- **Measurement:** **Power** in Watt (W)  
*Power Unit Conversion* 
- **Measurement:** **Frequency** in Hertz (Hz)  
*Frequency Unit Conversion* 
- **Measurement:** **Magnetic Flux** in Milliweber (mWb)  
*Magnetic Flux Unit Conversion* 
- **Measurement:** **Electric Resistance** in Ohm ( $\Omega$ )  
*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* 
- **Measurement:** **Electric Conductivity** in Siemens per Meter (S/m)  
*Electric Conductivity Unit Conversion* 



- **Measurement: Energy Density** in Joule per Cubic Meter ( $\text{J/m}^3$ )  
*Energy Density 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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