



# **Transformer Design Formulas**

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## **List of 19 Transformer Design Formulas**

## Transformer Design 🗷

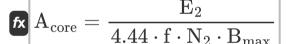
1) Area of Core given EMF Induced in Primary Winding



$$\mathbf{K} \mathbf{A}_{\mathrm{core}} = rac{\mathrm{E}_1}{4.44 \cdot \mathrm{f} \cdot \mathrm{N}_1 \cdot \mathrm{B}_{\mathrm{max}}}$$

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

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



 $ext{ex} \ 2477.477 ext{cm}^2 = rac{15.84 ext{V}}{4.44 \cdot 500 ext{Hz} \cdot 24 \cdot 0.0012 ext{T}}$ 

### 3) Eddy Current Loss

 $\mathbf{F}_{\mathrm{e}} = \mathrm{K}_{\mathrm{e}} \cdot \mathrm{B}_{\mathrm{max}}^2 \cdot \mathrm{f}^2 \cdot \mathrm{w}^2 \cdot \mathrm{V}_{\mathrm{core}}$ 

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

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



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



### 5) Hysteresis Loss

 $\mathbf{F}_{h} = K_{h} \cdot f \cdot (B_{max}^{x}) \cdot V_{core}$ 

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 $\texttt{ex} \ 0.052424 W = 2.13 J/m^{_3} \cdot 500 Hz \cdot \left(0.0012 T^{1.6}\right) \cdot 2.32 m^{_3}$ 

## 6) Maximum Core Flux

fx  $\Phi_{
m max} = {
m B}_{
m max} \cdot {
m A}_{
m core}$ 

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 $0.3 \mathrm{mWb} = 0.0012 \mathrm{T} \cdot 2500 \mathrm{cm}^{2}$ 

### 7) Maximum Flux in Core using Primary Winding

 $\Phi_{
m max} = rac{{
m E}_1}{4.44\cdot{
m f}\cdot{
m N}_1}$ 

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

## 8) Maximum Flux in Core using Secondary Winding

fx  $\Phi_{
m max} = rac{{
m E}_2}{4.44\cdot{
m f}\cdot{
m N}_2}$ 

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## 9) Number of Turns in Primary Winding

 $N_1 = rac{\mathrm{E}_1}{4.44\cdot\mathrm{f}\cdot\mathrm{A}_{\mathrm{core}}\cdot\mathrm{B}_{\mathrm{max}}}$ 

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 $20 = rac{13.2 ext{V}}{4.44 \cdot 500 ext{Hz} \cdot 2500 ext{cm}^2 \cdot 0.0012 ext{T}}$ 

## 10) Number of Turns in Secondary Winding

 $N_2 = rac{\mathrm{E}_2}{4.44\cdot\mathrm{f}\cdot\mathrm{A}_\mathrm{core}\cdot\mathrm{B}_\mathrm{max}}$ 

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

# 11) Percentage All Day Efficiency of Transformer 🗗

 $\left. \mathcal{H} 
ight| \% \eta_{
m all \, day} = \left( rac{E_{
m out}}{E_{
m in}} 
ight) \cdot 100 \, .$  $89.28571 = \left(\frac{31.25 \text{kW*h}}{35 \text{kW*h}}\right) \cdot 100$ 

# 12) Percentage Regulation of Transformer 🗗

 $\% = \left(rac{
m V_{no-load} - V_{full-load}}{
m V_{no-load}}
ight) \cdot 100$ 

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



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



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

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Open Calculator

 $oxed{ex} \left[ 17.97848\Omega = \sqrt{\left(18\Omega
ight)^2 - \left(0.88\Omega
ight)^2} 
ight]$ 

# 14) Secondary Winding Resistance given Impedance of Secondary Winding

 $\left| \mathbf{R}_2 = \sqrt{\mathbf{Z}_2^2 - \mathbf{X}_{\mathrm{L2}}^2} 
ight|$ 

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

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

fx  $\mathrm{E}_{\mathrm{self}(1)} = \mathrm{X}_{\mathrm{L}1} \cdot \mathrm{I}_1$ 

 $\texttt{ex} \ 11.088 \texttt{V} = 0.88 \Omega \cdot 12.6 \texttt{A}$ 

16) Self-Induced EMF in Secondary Side

## fx $\mathrm{E}_2 = \mathrm{X}_{\mathrm{L}2} \cdot \mathrm{I}_2$

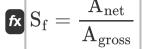
 $\mathbf{ex} \ 9.975 \mathrm{V} = 0.95 \Omega \cdot 10.5 \mathrm{A}$ 

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### 17) Stacking Factor of Transformer



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 $oxed{ex} 0.833333 = rac{1000 {
m cm}^2}{1200 {
m cm}^2}$ 

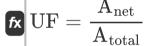
### 18) Transformer Iron loss

fx  $P_{iron} = P_e + P_h$ 

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 $\mathbf{ex} \ 0.45 \mathrm{W} = 0.4 \mathrm{W} + 0.05 \mathrm{W}$ 

### 19) Utilisation Factor of Transformer Core



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 $= \frac{1000 \mathrm{cm^2}}{3100 \mathrm{cm^2}}$ 



#### Variables Used

- % Percentage Regulation of Transformer
- %η<sub>all day</sub> All Day Efficiency
- Acore Area of Core (Square Centimeter)
- Agross Gross Cross Sectional Area (Square Centimeter)
- Anet Net Cross Sectional Area (Square Centimeter)
- Atotal Total Cross Sectional Area (Square Centimeter)
- B<sub>max</sub> Maximum Flux Density (*Tesla*)
- **E**<sub>1</sub> EMF Induced in Primary (Volt)
- E<sub>2</sub> EMF Induced in Secondary (Volt)
- **E**<sub>in</sub> Input Energy (Kilowatt-Hour)
- Eout Output Energy (Kilowatt-Hour)
- E<sub>self(1)</sub> Self Induced EMF in Primary (Volt)
- **f** Supply Frequency (Hertz)
- I<sub>1</sub> Primary Current (Ampere)
- **l**<sub>2</sub> Secondary Current (Ampere)
- Ke Eddy Current Coefficient (Siemens per Meter)
- K<sub>h</sub> Hysteresis Constant (Joule per Cubic Meter)
- N<sub>1</sub> Number of Turns in Primary
- N<sub>2</sub> Number of Turns in Secondary
- Pe Eddy Current Loss (Watt)
- Ph Hysteresis Loss (Watt)





- Piron 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>I 2</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 (m³)
   Volume Unit Conversion
- Measurement: Area in Square Centimeter (cm²)
   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 (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
- Measurement: Electric Conductivity in Siemens per Meter (S/m)
   Electric Conductivity Unit Conversion





• Measurement: Energy Density in Joule per Cubic Meter (J/m³)

Energy Density Unit Conversion





#### **Check other formula lists**

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

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