Important Transformer Design Formulas PDF

Formulas
Examples
with Units

List of 19
Important Transformer Design Formulas

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

Evaluate Formula

Formula

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

Example with Units

$$2477.4775\,\text{cm}^2 = \frac{13.2\,\text{V}}{4.44 \cdot 500\,\text{Hz} \cdot 20 \cdot 0.0012\,\text{T}}$$

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

Evaluate Formula

Formula

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

Example with Units

$$2477.4775\,\text{cm}^2 = \frac{15.84\,\text{V}}{4.44 \cdot 500\,\text{Hz} \cdot 24 \cdot 0.0012\,\text{T}}$$

3) Eddy Current Loss Formula

Evaluate Formula

Formula

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

Example with Units

$$0.4011\,\text{W} = 0.98\,\text{S/m} \cdot 0.0012\,\text{T}^{\,2} \cdot 500\,\text{Hz}^{\,2} \cdot 0.7\,\text{m}^{\,2} \cdot 2.32\,\text{m}^3$$

4) EMF Induced in Primary Winding given Input Voltage Formula

Evaluate Formula

Formula

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

Example with Units

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

5) Hysteresis Loss Formula

Evaluate Formula

Formula

$$P_h = K_h \cdot f \cdot \left(B_{max}^{\,x}\right) \cdot V_{core}$$

Example with Units

$$0.0524\,\text{W} = 2.13\,\text{J/m}^3 \cdot 500\,\text{Hz} \cdot \left(0.0012\,\text{T}^{\,1.6}\right) \cdot 2.32\,\text{m}^3$$

6) Maximum Core Flux Formula

Evaluate Formula

Formula

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

Example with Units

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

7) Maximum Flux in Core using Primary Winding Formula

Evaluate Formula

Formula

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

Example with Units

$$0.2973\,\text{mWb} = \frac{13.2\,\text{V}}{4.44 \cdot 500\,\text{Hz} \cdot 20}$$

8) Maximum Flux in Core using Secondary Winding Formula

Evaluate Formula

Formula

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

Example with Units

$$0.2973\,\text{mWb} = \frac{15.84\,\text{V}}{4.44 \cdot 500\,\text{Hz} \cdot 24}$$

9) Number of Turns in Primary Winding Formula

Evaluate Formula

Formula

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

Example with Units

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

10) Number of Turns in Secondary Winding Formula

Evaluate Formula

Formula

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

Example with Units

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

11) Percentage All Day Efficiency of Transformer Formula

Evaluate Formula

Formula

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

Example with Units

$$89.2857 = \left(\frac{31.25\,\text{kW*h}}{35\,\text{kW*h}}\right) \cdot 100$$

12) Percentage Regulation of Transformer Formula

Evaluate Formula

Formula

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

Example with Units

$$81.1558 = \left(\frac{288.1\,\text{V} - 54.29\,\text{V}}{288.1\,\text{V}}\right) \cdot 100$$

13) Primary Winding Resistance given Impedance of Primary Winding Formula

Evaluate Formula

Formula

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

Example with Units

$$17.9785\,\Omega = \sqrt{{18\,\Omega}^2 - {0.88\,\Omega}^2}$$

14) Secondary Winding Resistance given Impedance of Secondary Winding Formula

Evaluate Formula

Formula

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

Example with Units

$$25.9026\,\Omega = \sqrt{25.92\,\Omega^2 - 0.95\,\Omega^2}$$

15) Self-Induced EMF in Primary Side Formula

Evaluate Formula

Formula

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

Example with Units

$$11.088\,V = 0.88\,\Omega \cdot 12.6\,A$$

16) Self-Induced EMF in Secondary Side Formula

Evaluate Formula

Formula

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

Example with Units

$$9.975\,V = 0.95\,\Omega \cdot 10.5\,A$$

17) Stacking Factor of Transformer Formula

Evaluate Formula

Formula

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

Example with Units

$$0.8333 = \frac{1000\,cm^2}{1200\,cm^2}$$

18) Transformer Iron loss Formula

Evaluate Formula

Formula

$$P_{iron} = P_e + P_h$$

Example with Units

$$0.45\,W = 0.4\,W + 0.05\,W$$

19) Utilisation Factor of Transformer Core Formula

Evaluate Formula

Formula

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

Example with Units

$$0.3226 = \frac{1000\,cm^2}{3100\,cm^2}$$

Variables used in list of Transformer Design Formulas above

- **%** Percentage Regulation of Transformer
- **$\%\eta_{all\ day}$** All Day Efficiency
- **A_{core}** Area of Core *(Square Centimeter)*
- **A_{gross}** Gross Cross Sectional Area *(Square Centimeter)*
- **A_{net}** Net Cross Sectional Area *(Square Centimeter)*
- **A_{total}** Total Cross Sectional Area *(Square Centimeter)*
- **B_{max}** Maximum Flux Density *(Tesla)*
- **E_1** EMF Induced in Primary *(Volt)*
- **E_2** EMF Induced in Secondary *(Volt)*
- **E_{in}** Input Energy *(Kilowatt-Hour)*
- **E_{out}** Output Energy *(Kilowatt-Hour)*
- **$E_{self(1)}$** 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_{iron}** Iron Losses *(Watt)*
- **R_1** Resistance of Primary *(Ohm)*
- **R_2** Resistance of Secondary *(Ohm)*
- **S_f** Stacking Factor of Transformer
- **UF** Utilisation Factor of Transformer Core
- **V_1** Primary Voltage *(Volt)*
- **V_{core}** Volume of Core *(Cubic Meter)*
- **$V_{full\text{-}load}$** Full Load Terminal Voltage *(Volt)*

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

- 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: **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

- $V_{no\text{-}load}$ No Load Terminal Voltage *(Volt)*
- **w** Lamination Thickness *(Meter)*
- **x** Steinmetz Coefficient
- X_{L1} Primary Leakage Reactance *(Ohm)*
- X_{L2} Secondary Leakage Reactance *(Ohm)*
- Z_1 Impedance of Primary *(Ohm)*
- Z_2 Impedance of Secondary *(Ohm)*
- Φ_{max} Maximum Core Flux *(Milliweber)*

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