Important Induction Motor Circuit Formulas PDF

Formulas
Examples
with Units

List of 28
Important Induction Motor Circuit Formulas

1) Armature Current given Power in Induction Motor Formula

Evaluate Formula

Formula

$$I_a = \frac{P_{out}}{V_a}$$

Example with Units

$$3.7004\,\text{A} = \frac{41\,\text{W}}{11.08\,\text{V}}$$

2) Breakdown Slip of Induction Motor Formula

Evaluate Formula

Formula

$$s = \frac{R}{X}$$

Example with Units

$$0.19 = \frac{14.25\,\Omega}{75\,\Omega}$$

3) Field Current using Load Current in Induction Motor Formula

Evaluate Formula

Formula

$$I_f = I_a - I_L$$

Example with Units

$$0.75\,\text{A} = 3.7\,\text{A} - 2.95\,\text{A}$$

4) Force by Linear Induction Motor Formula

Evaluate Formula

Formula

$$F = \frac{P_{in}}{V_s}$$

Example with Units

$$0.2963\,\text{N} = \frac{40\,\text{W}}{135\,\text{m/s}}$$

5) Frequency given Number of Poles in Induction Motor Formula

Evaluate Formula

Formula

$$f = \frac{n \cdot N_s}{120}$$

Example with Units

$$54.6637\,\text{Hz} = \frac{4 \cdot 15660\,\text{rev/min}}{120}$$

6) Gross Mechanical Power in Induction Motor Formula

Evaluate Formula

Formula

$$P_m = (1 - s) \cdot P_{in}$$

Example with Units

$$32.4\,\text{W} = (1 - 0.19) \cdot 40\,\text{W}$$

7) Induced EMF given Linear Synchronous Speed Formula

Evaluate Formula

Formula

$$E_i = V_s \cdot B \cdot l$$

Example with Units

$$4.8654\,\text{V} = 135\,\text{m/s} \cdot 0.68\,\text{T} \cdot 53\,\text{mm}$$

8) Induced Voltage given Power Formula

Evaluate Formula

Formula

$$V_a = \frac{P_{out}}{I_a}$$

Example with Units

$$11.0811\,\text{V} = \frac{41\,\text{W}}{3.7\,\text{A}}$$

9) Linear Synchronous Speed Formula

Evaluate Formula

Formula

$$V_s = 2 \cdot w \cdot f_{line}$$

Example with Units

$$135\,\text{m/s} = 2 \cdot 150\,\text{mm} \cdot 450\,\text{Hz}$$

10) Load Current in Induction Motor Formula

Evaluate Formula

Formula

$$I_L = I_a - I_f$$

Example with Units

$$2.95\,\text{A} = 3.7\,\text{A} - 0.75\,\text{A}$$

11) Maximum Running Torque Formula

Evaluate Formula

Formula

$$\tau_{run} = \frac{3 \cdot E^2}{4 \cdot \pi \cdot N_s \cdot X}$$

Example with Units

$$0.1815\,\text{N*m} = \frac{3 \cdot 305.8\,\text{V}^2}{4 \cdot 3.1416 \cdot 15660\,\text{rev/min} \cdot 75\,\Omega}$$

12) Motor Speed given Efficiency in Induction Motor Formula

Evaluate Formula

Formula

$$N_m = \eta \cdot N_s$$

Example with Units

$$14094\,\text{rev/min} = 0.90 \cdot 15660\,\text{rev/min}$$

13) Pitch Factor in Induction Motor Formula

Evaluate Formula

Formula

$$K_p = \cos\left(\frac{\theta}{2}\right)$$

Example with Units

$$0.7071 = \cos\left(\frac{90°}{2}\right)$$

14) Power Converted in Induction Motor Formula

Evaluate Formula

Formula

$$P_{conv} = P_{ag} - P_{r(cu)}$$

Example with Units

$$10.45\,\text{W} = 12\,\text{W} - 1.55\,\text{W}$$

15) Reactance given Slip at Maximum Torque Formula

Evaluate Formula

Formula

$$X = \frac{R}{s}$$

Example with Units

$$75\,\Omega = \frac{14.25\,\Omega}{0.19}$$

16) Resistance given Slip at Maximum Torque Formula

Evaluate Formula

Formula

$$R = s \cdot X$$

Example with Units

$$14.25\,\Omega = 0.19 \cdot 75\,\Omega$$

17) Rotor Copper Loss given Input Rotor Power Formula

Evaluate Formula

Formula

$$P_{r(cu)} = s \cdot P_{in(r)}$$

Example with Units

$$1.482\,W = 0.19 \cdot 7.8\,W$$

18) Rotor Copper Loss in Induction Motor Formula

Evaluate Formula

Formula

$$P_{r(cu)} = 3 \cdot I_r^2 \cdot R_r$$

Example with Units

$$1.5595\,W = 3 \cdot 0.285\,A^2 \cdot 6.4\,\Omega$$

19) Rotor Current in Induction Motor Formula

Evaluate Formula

Formula

$$I_r = \frac{s \cdot E_i}{\sqrt{R_{r(ph)}^2 + \left(s \cdot X_{r(ph)}\right)^2}}$$

Example with Units

$$0.2186\,A = \frac{0.19 \cdot 67.3\,V}{\sqrt{56\,\Omega^2 + \left(0.19 \cdot 89\,\Omega\right)^2}}$$

20) Rotor Efficiency in Induction Motor Formula

Evaluate Formula

Formula

$$\eta = \frac{N_m}{N_s}$$

Example with Units

$$0.9163 = \frac{14350\,\text{rev/min}}{15660\,\text{rev/min}}$$

21) Rotor Frequency given Supply Frequency Formula

Evaluate Formula

Formula

$$f_r = s \cdot f$$

Example with Units

$$10.374\,Hz = 0.19 \cdot 54.6\,Hz$$

22) Rotor Input Power in Induction Motor Formula

Evaluate Formula

Formula

$$P_{in(r)} = P_{in} - P_{sl}$$

Example with Units

$$7.8\,W = 40\,W - 32.2\,W$$

23) Slip given Efficiency in Induction Motor Formula

Evaluate Formula

Formula

$$s = 1 - \eta$$

Example

$$0.1 = 1 - 0.90$$

24) Starting Torque of Induction Motor Formula

Evaluate Formula

Formula

$$\tau = \frac{3 \cdot E^2 \cdot R}{2 \cdot \pi \cdot N_s \cdot \left(R^2 + X^2 \right)}$$

Example with Units

$$0.0666\,\text{N*m} = \frac{3 \cdot 305.8\,\text{V}^2 \cdot 14.25\,\Omega}{2 \cdot 3.1416 \cdot 15660\,\text{rev/min} \cdot \left(14.25\,\Omega^2 + 75\,\Omega^2 \right)}$$

25) Stator Copper Loss in Induction Motor Formula

Evaluate Formula

Formula

$$P_{s(cu)} = 3 \cdot I_s^2 \cdot R_s$$

Example with Units

$$13.9804\,\text{W} = 3 \cdot 0.85\,\text{A}^2 \cdot 6.45\,\Omega$$

26) Synchronous Speed in Induction Motor Formula

Evaluate Formula

Formula

$$N_s = \frac{120 \cdot f}{n}$$

Example with Units

$$15641.7478\,\text{rev/min} = \frac{120 \cdot 54.6\,\text{Hz}}{4}$$

27) Synchronous Speed of Induction Motor given Efficiency Formula

Evaluate Formula

Formula

$$N_s = \frac{N_m}{\eta}$$

Example with Units

$$15944.4444\,\text{rev/min} = \frac{14350\,\text{rev/min}}{0.90}$$

28) Torque of Induction Motor under Running Condition Formula

Evaluate Formula

Formula

$$\tau = \frac{3 \cdot s \cdot E^2 \cdot R}{2 \cdot \pi \cdot N_s \cdot \left(R^2 + \left(X^2 \cdot s \right) \right)}$$

Example with Units

$$0.058\,\text{N*m} = \frac{3 \cdot 0.19 \cdot 305.8\,\text{V}^2 \cdot 14.25\,\Omega}{2 \cdot 3.1416 \cdot 15660\,\text{rev/min} \cdot \left(14.25\,\Omega^2 + \left(75\,\Omega^2 \cdot 0.19 \right) \right)}$$

Variables used in list of Induction Motor Circuit Formulas above

- **B** Magnetic Flux Density *(Tesla)*
- **E** EMF *(Volt)*
- E_i Induced EMF *(Volt)*
- **f** Frequency *(Hertz)*
- **F** Force *(Newton)*
- f_{line} Line Frequency *(Hertz)*
- f_r Rotor Frequency *(Hertz)*
- I_a Armature Current *(Ampere)*
- I_f Field Current *(Ampere)*
- I_L Load Current *(Ampere)*
- I_r Rotor Current *(Ampere)*
- I_s Stator Current *(Ampere)*
- K_p Pitch Factor
- **l** Length of Conductor *(Millimeter)*
- **n** Number of Poles
- N_m Motor Speed *(Revolution per Minute)*
- N_s Synchronous Speed *(Revolution per Minute)*
- P_{ag} Air Gap Power *(Watt)*
- P_{conv} Converted Power *(Watt)*
- P_{in} Input Power *(Watt)*
- $P_{in(r)}$ Rotor Input Power *(Watt)*
- P_m Mechanical Power *(Watt)*
- P_{out} Output Power *(Watt)*
- $P_{r(cu)}$ Rotor Copper Loss *(Watt)*
- $P_{s(cu)}$ Stator Copper Loss *(Watt)*
- P_{sl} Stator Losses *(Watt)*
- **R** Resistance *(Ohm)*
- R_r Rotor Resistance *(Ohm)*
- $R_{r(ph)}$ Rotor Resistance per Phase *(Ohm)*
- R_s Stator Resistance *(Ohm)*
- **s** Slip

Constants, Functions, Measurements used in list of Induction Motor Circuit Formulas above

- constant(s): **pi**, 3.14159265358979323846264338327950288 *Archimedes' constant*
- 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: **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 Millimeter (mm) *Length Unit Conversion*
- Measurement: **Electric Current** in Ampere (A) *Electric Current Unit Conversion*
- Measurement: **Speed** in Meter per Second (m/s) *Speed Unit Conversion*
- Measurement: **Power** in Watt (W) *Power Unit Conversion*
- Measurement: **Force** in Newton (N) *Force 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*
- Measurement: **Angular Velocity** in Revolution per Minute (rev/min) *Angular Velocity Unit Conversion*
- Measurement: **Torque** in Newton Meter (N*m) *Torque Unit Conversion*

- V_a Armature Voltage *(Volt)*
- V_s Linear Synchronous Speed *(Meter per Second)*
- **w** Pole Pitch Width *(Millimeter)*
- **X** Reactance *(Ohm)*
- $X_{r(ph)}$ Rotor Reactance per Phase *(Ohm)*
- **η** Efficiency
- **θ** Short Pitched Angle *(Degree)*
- **τ** Torque *(Newton Meter)*
- τ_{run} Running Torque *(Newton Meter)*

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