Important Synchronous Motor Circuit Formulas PDF

Formulas
Examples
with Units

List of 31
Important Synchronous Motor Circuit Formulas

1) 3 Phase Input Power of Synchronous Motor Formula

Evaluate Formula

Formula

$$P_{in(3\Phi)} = \sqrt{3} \cdot V_L \cdot I_L \cdot \cos\left(\Phi_s\right)$$

Example with Units

$$1584\,\text{W} = \sqrt{3} \cdot 192\,\text{V} \cdot 5.5\,\text{A} \cdot \cos\left(30°\right)$$

2) 3 Phase Mechanical Power of Synchronous Motor Formula

Evaluate Formula

Formula

$$P_{me(3\Phi)} = P_{in(3\Phi)} - 3 \cdot I_a^{\,2} \cdot R_a$$

Example with Units

$$1056.2505\,\text{W} = 1584\,\text{W} - 3 \cdot 3.70\,\text{A}^{\,2} \cdot 12.85\,\Omega$$

3) Angular Slot Pitch in Synchronous Motor Formula

Evaluate Formula

Formula

$$Y = \frac{P \cdot 180}{n_s \cdot 2}$$

Example with Units

$$162.8406° = \frac{3 \cdot 180}{95 \cdot 2}$$

4) Armature Current of Synchronous Motor given 3 Phase Mechanical Power Formula

Evaluate Formula

Formula

$$I_a = \sqrt{\frac{P_{in(3\Phi)} - P_{me(3\Phi)}}{3 \cdot R_a}}$$

Example with Units

$$3.7\,\text{A} = \sqrt{\frac{1584\,\text{W} - 1056.2505\,\text{W}}{3 \cdot 12.85\,\Omega}}$$

5) Armature Current of Synchronous Motor given Input Power Formula

Evaluate Formula

Formula

$$I_a = \frac{P_{in}}{\cos\left(\Phi_s\right) \cdot V}$$

Example with Units

$$3.6999\,\text{A} = \frac{769\,\text{W}}{\cos\left(30°\right) \cdot 240\,\text{V}}$$

6) Armature Current of Synchronous Motor given Mechanical Power Formula

Evaluate Formula

Formula

$$I_a = \sqrt{\frac{P_{in} - P_m}{R_a}}$$

Example with Units

$$3.7009\,\text{A} = \sqrt{\frac{769\,\text{W} - 593\,\text{W}}{12.85\,\Omega}}$$

7) Armature Resistance of Synchronous Motor given 3 Phase Mechanical Power Formula

Evaluate Formula

Formula

$$R_a = \frac{P_{in(3\Phi)} - P_{me(3\Phi)}}{3 \cdot I_a^2}$$

Example with Units

$$12.85\,\Omega = \frac{1584\,W - 1056.2505\,W}{3 \cdot 3.70\,A^2}$$

8) Armature Resistance of Synchronous Motor given Input Power Formula

Evaluate Formula

Formula

$$R_a = \frac{P_{in} - P_m}{I_a^2}$$

Example with Units

$$12.8561\,\Omega = \frac{769\,W - 593\,W}{3.70\,A^2}$$

9) Armature Winding Constant of Synchronous Motor Formula

Evaluate Formula

Formula

$$K_a = \frac{E_b}{\Phi \cdot N_s}$$

Example with Units

$$0.6148 = \frac{180\,V}{0.12\,Wb \cdot 23300\,rev/min}$$

10) Back EMF of Synchronous Motor using Mechanical Power Formula

Evaluate Formula

Formula

$$E_b = \frac{P_m}{I_a \cdot \cos\left(\alpha - \Phi_s\right)}$$

Example with Units

$$179.8755\,V = \frac{593\,W}{3.70\,A \cdot \cos\left(57° - 30°\right)}$$

11) Distribution Factor in Synchronous Motor Formula

Evaluate Formula

Formula

$$K_d = \frac{\sin\left(\frac{n_s \cdot Y}{2}\right)}{n_s \cdot \sin\left(\frac{Y}{2}\right)}$$

Example with Units

$$0.0013 = \frac{\sin\left(\frac{95 \cdot 162.8°}{2}\right)}{95 \cdot \sin\left(\frac{162.8°}{2}\right)}$$

12) Input Power of Synchronous Motor Formula

Evaluate Formula

Formula

$$P_{in} = I_a \cdot V \cdot \cos\left(\Phi_s\right)$$

Example with Units

$$769.0306\,W = 3.70\,A \cdot 240\,V \cdot \cos\left(30°\right)$$

13) Load Current of Synchronous Motor given 3 Phase Mechanical Power Formula

Evaluate Formula

Formula

$$I_L = \frac{P_{me(3\Phi)} + 3 \cdot I_a^2 \cdot R_a}{\sqrt{3} \cdot V_L \cdot \cos\left(\Phi_s\right)}$$

Example with Units

$$5.5\,A = \frac{1056.2505\,W + 3 \cdot 3.70\,A^2 \cdot 12.85\,\Omega}{\sqrt{3} \cdot 192\,V \cdot \cos\left(30°\right)}$$

14) Load Current of Synchronous Motor using 3 Phase Input Power Formula

Evaluate Formula

Formula

$$I_L = \frac{P_{in(3\Phi)}}{\sqrt{3} \cdot V_L \cdot \cos\left(\Phi_s\right)}$$

Example with Units

$$5.5\,\text{A} = \frac{1584\,\text{W}}{\sqrt{3} \cdot 192\,\text{V} \cdot \cos\left(30°\right)}$$

15) Load Voltage of Synchronous Motor given 3 Phase Mechanical Power Formula

Evaluate Formula

Formula

$$V_L = \frac{P_{me(3\Phi)} + 3 \cdot {I_a}^2 \cdot R_a}{\sqrt{3} \cdot I_L \cdot \cos\left(\Phi_s\right)}$$

Example with Units

$$192\,\text{V} = \frac{1056.2505\,\text{W} + 3 \cdot 3.70\,\text{A}^2 \cdot 12.85\,\Omega}{\sqrt{3} \cdot 5.5\,\text{A} \cdot \cos\left(30°\right)}$$

16) Load Voltage of Synchronous Motor using 3 Phase Input Power Formula

Evaluate Formula

Formula

$$V_L = \frac{P_{in(3\Phi)}}{\sqrt{3} \cdot I_L \cdot \cos\left(\Phi_s\right)}$$

Example with Units

$$192\,\text{V} = \frac{1584\,\text{W}}{\sqrt{3} \cdot 5.5\,\text{A} \cdot \cos\left(30°\right)}$$

17) Magnetic Flux of Synchronous Motor given Back EMF Formula

Evaluate Formula

Formula

$$\Phi = \frac{E_b}{K_a \cdot N_s}$$

Example with Units

$$0.1209\,\text{Wb} = \frac{180\,\text{V}}{0.61 \cdot 23300\,\text{rev/min}}$$

18) Mechanical Power of Synchronous Motor Formula

Evaluate Formula

Formula

$$P_m = E_b \cdot I_a \cdot \cos\left(\alpha - \Phi_s\right)$$

Example with Units

$$593.4103\,\text{W} = 180\,\text{V} \cdot 3.70\,\text{A} \cdot \cos\left(57° - 30°\right)$$

19) Mechanical Power of Synchronous Motor given Gross Torque Formula

Evaluate Formula

Formula

$$P_m = \tau_g \cdot N_s$$

Example with Units

$$592.9128\,\text{W} = 0.243\,\text{N*m} \cdot 23300\,\text{rev/min}$$

20) Mechanical Power of Synchronous Motor given Input Power Formula

Evaluate Formula

Formula

$$P_m = P_{in} - {I_a}^2 \cdot R_a$$

Example with Units

$$593.0835\,\text{W} = 769\,\text{W} - 3.70\,\text{A}^2 \cdot 12.85\,\Omega$$

21) Number of Poles given Synchronous Speed in Synchronous Motor Formula

Evaluate Formula

Formula

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

Example with Units

$$3 = \frac{61\,\text{Hz} \cdot 120}{23300\,\text{rev/min}}$$

22) Output Power for Synchronous Motor Formula

Evaluate Formula

Formula

$$P_{out} = I_a^2 \cdot R_a$$

Example with Units

$$175.9165\,\text{W} = 3.70\,\text{A}^2 \cdot 12.85\,\Omega$$

23) Phase Angle between Voltage and Armature Current given Input Power Formula

Evaluate Formula

Formula

$$\Phi_s = acos\left(\frac{P_{in}}{V \cdot I_a}\right)$$

Example with Units

$$30.0039° = acos\left(\frac{769\,\text{W}}{240\,\text{V} \cdot 3.70\,\text{A}}\right)$$

24) Power Factor of Synchronous Motor given 3 Phase Mechanical Power Formula

Evaluate Formula

Formula

$$Cos\Phi = \frac{P_{me(3\Phi)} + 3 \cdot I_a^2 \cdot R_a}{\sqrt{3} \cdot V_L \cdot I_L}$$

Example with Units

$$0.866 = \frac{1056.2505\,\text{W} + 3 \cdot 3.70\,\text{A}^2 \cdot 12.85\,\Omega}{\sqrt{3} \cdot 192\,\text{V} \cdot 5.5\,\text{A}}$$

25) Power Factor of Synchronous Motor given Input Power Formula

Evaluate Formula

Formula

$$Cos\Phi = \frac{P_{in}}{V \cdot I_a}$$

Example with Units

$$0.866 = \frac{769\,\text{W}}{240\,\text{V} \cdot 3.70\,\text{A}}$$

26) Power Factor of Synchronous Motor using 3 Phase Input Power Formula

Evaluate Formula

Formula

$$Cos\Phi = \frac{P_{in(3\Phi)}}{\sqrt{3} \cdot V_L \cdot I_L}$$

Example with Units

$$0.866 = \frac{1584\,\text{W}}{\sqrt{3} \cdot 192\,\text{V} \cdot 5.5\,\text{A}}$$

27) Pull Out Torque in Synchronous Motor Formula

Evaluate Formula

Formula

$$\tau = \frac{3 \cdot V_\Phi \cdot E_a}{9.55 \cdot N_m \cdot X_s}$$

Example with Units

$$0.0346\,\text{N*m} = \frac{3 \cdot 28.75\,\text{V} \cdot 25.55\,\text{V}}{9.55 \cdot 13560\,\text{rev/min} \cdot 4.7\,\Omega}$$

28) Synchronous Speed of Synchronous Motor Formula

Evaluate Formula

Formula

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

Example with Units

$$23300.2837\,\text{rev/min} = \frac{120 \cdot 61\,\text{Hz}}{3}$$

29) Synchronous Speed of Synchronous Motor given Mechanical Power Formula

Evaluate Formula

Formula

$$N_s = \frac{P_m}{\tau_g}$$

Example with Units

$$23303.4275\,\text{rev/min} = \frac{593\,\text{W}}{0.243\,\text{N*m}}$$

30) Torque Induced in Synchronous Motor Formula

Evaluate Formula

Formula

$$\tau = \frac{3 \cdot V_\Phi \cdot E_a \cdot \sin(\delta)}{9.55 \cdot N_m \cdot X_s}$$

Example with Units

$$0.0334\,\text{N*m} = \frac{3 \cdot 28.75\,\text{V} \cdot 25.55\,\text{V} \cdot \sin(75°)}{9.55 \cdot 13560\,\text{rev/min} \cdot 4.7\,\Omega}$$

31) Voltage of Synchronous Motor given Input Power Formula

Evaluate Formula

Formula

$$V = \frac{P_{in}}{I_a \cdot \cos(\Phi_s)}$$

Example with Units

$$239.9905\,\text{V} = \frac{769\,\text{W}}{3.70\,\text{A} \cdot \cos(30°)}$$

Variables used in list of Synchronous Motor Circuit Formulas above

- **CosΦ** Power Factor
- E_a Internal Generated Voltage *(Volt)*
- E_b Back EMF *(Volt)*
- **f** Frequency *(Hertz)*
- I_a Armature Current *(Ampere)*
- I_L Load Current *(Ampere)*
- K_a Armature Winding Constant
- K_d Distribution Factor
- N_m Motor Speed *(Revolution per Minute)*
- n_s Number of Slots
- N_s Synchronous Speed *(Revolution per Minute)*
- **P** Number of Poles
- P_{in} Input Power *(Watt)*
- $P_{in(3\Phi)}$ Three Phase Input Power *(Watt)*
- P_m Mechanical Power *(Watt)*
- $P_{me(3\Phi)}$ Three Phase Mechanical Power *(Watt)*
- P_{out} Output Power *(Watt)*
- R_a Armature Resistance *(Ohm)*
- **V** Voltage *(Volt)*
- V_L Load Voltage *(Volt)*
- V_Φ Terminal Voltage *(Volt)*
- X_s Synchronous Reactance *(Ohm)*
- **Y** Angular Slot Pitch *(Degree)*
- **α** Load Angle *(Degree)*
- **δ** Torque Angle *(Degree)*
- **τ** Torque *(Newton Meter)*
- τ_g Gross Torque *(Newton Meter)*
- **Φ** Magnetic Flux *(Weber)*
- Φ_s Phase Difference *(Degree)*

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

- Functions: **acos**, acos(Number)
  The inverse cosine function, is the inverse function of the cosine function. It is the function that takes a ratio as an input and returns the angle whose cosine is equal to that ratio.
- 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: **sin**, sin(Angle)
  Sine is a trigonometric function that describes the ratio of the length of the opposite side of a right triangle to the length of the hypotenuse.
- 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: **Electric Current** in Ampere (A)
  Electric Current Unit Conversion
- Measurement: **Power** in Watt (W)
  Power Unit Conversion
- Measurement: **Angle** in Degree (°)
  Angle Unit Conversion
- Measurement: **Frequency** in Hertz (Hz)
  Frequency Unit Conversion
- Measurement: **Magnetic Flux** in Weber (Wb)
  Magnetic Flux Unit Conversion
- Measurement: **Electric Resistance** in Ohm (Ω)
  Electric Resistance 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

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