# Important Power System Stability Formulas PDF

**Formulas**
**Examples**
**with Units**

**List of 20**
**Important Power System Stability Formulas**

## 1) Accelerating Torque of Generator under Power System Stability Formula

Evaluate Formula

Formula

$$T_a = T_m - T_e$$

Example with Units

$$32\,\text{N*m} = 44\,\text{N*m} - 12\,\text{N*m}$$

## 2) Active Power by Infinite Bus Formula

Evaluate Formula

Formula

$$P_{inf} = \frac{(V)^2}{\sqrt{(R)^2 + (X_s)^2}} - \frac{(V)^2}{(R)^2 + (X_s)^2}$$

Example with Units

$$2.0842\,\text{W} = \frac{(11\,\text{V})^2}{\sqrt{(2.1\,\Omega)^2 + (57\,\Omega)^2}} - \frac{(11\,\text{V})^2}{(2.1\,\Omega)^2 + (57\,\Omega)^2}$$

## 3) Angular Displacement of Machine under Power System Stability Formula

Evaluate Formula

Formula

$$\delta_a = \theta_m - \omega_s \cdot t$$

Example with Units

$$20.2\,\text{rad} = 109\,\text{rad} - 8.0\,\text{m/s} \cdot 11.1\,\text{s}$$

## 4) Clearing Angle Formula

Evaluate Formula

Formula

$$\delta_c = \frac{\pi \cdot f \cdot P_i}{2 \cdot H} \cdot \left(t_c\right)^2 + \delta_o$$

Example with Units

$$61.9302\,\text{rad} = \frac{3.1416 \cdot 56\,\text{Hz} \cdot 200\,\text{W}}{2 \cdot 39\,\text{kg·m²}} \cdot \left(0.37\,\text{s}\right)^2 + 10°$$

## 5) Clearing Time Formula

Evaluate Formula

Formula

$$t_c = \sqrt{\frac{2 \cdot H \cdot \left(\delta_c - \delta_o\right)}{\pi \cdot f \cdot P_i}}$$

Example with Units

$$0.3699\,\text{s} = \sqrt{\frac{2 \cdot 39\,\text{kg·m²} \cdot \left(61.9\,\text{rad} - 10°\right)}{3.1416 \cdot 56\,\text{Hz} \cdot 200\,\text{W}}}$$

## 6) Complex Power of Generator under Power Angle Curve Formula

Evaluate Formula

Formula

$$S = V_p \cdot I_p$$

Example with Units

$$1282.42\,\text{VA} = 74\,\text{V} \cdot 17.33\,\text{A}$$

## 7) Critical Clearing Angle under Power System Stability Formula

Evaluate Formula

Formula

$$\delta_{cc} = acos\left(\cos\left(\delta_{max}\right) + \left(\frac{P_i}{P_{max}}\right) \cdot \left(\delta_{max} - \delta_o\right)\right)$$

Example with Units

$$47.5821° = acos\left(\cos\left(60°\right) + \left(\frac{200\,\text{W}}{1000\,\text{W}}\right) \cdot \left(60° - 10°\right)\right)$$

## 8) Critical Clearing Time under Power System Stability Formula

Evaluate Formula

Formula

$$t_{cc} = \sqrt{\frac{2 \cdot H \cdot \left(\delta_{cc} - \delta_o\right)}{\pi \cdot f \cdot P_{max}}}$$

Example with Units

$$0.017\,\text{s} = \sqrt{\frac{2 \cdot 39\,\text{kg·m²} \cdot \left(47.5° - 10°\right)}{3.1416 \cdot 56\,\text{Hz} \cdot 1000\,\text{W}}}$$

## 9) Damped Frequency of Oscillation in Power System Stability Formula

Evaluate Formula

Formula

$$\omega_{df} = \omega_{fn} \cdot \sqrt{1 - \left(\xi\right)^2}$$

Example with Units

$$8.9549\,\text{Hz} = 9\,\text{Hz} \cdot \sqrt{1 - \left(0.1\right)^2}$$

## 10) Inertia Constant of Machine Formula

Evaluate Formula

Formula

$$M = \frac{G \cdot H}{180 \cdot fs}$$

Example with Units

$$0.0591 = \frac{15 \cdot 39\,\text{kg·m²}}{180 \cdot 55\,\text{Hz}}$$

## 11) Kinetic Energy of Rotor Formula

Evaluate Formula

Formula

$$KE = \left(\frac{1}{2}\right) \cdot J \cdot \omega_s^{\,2} \cdot 10^{-6}$$

Example with Units

$$0.0002\,\text{J} = \left(\frac{1}{2}\right) \cdot 6.0\,\text{kg·m²} \cdot 8.0\,\text{m/s}^{\,2} \cdot 10^{-6}$$

## 12) Lossless Power Delivered in Synchronous Machine Formula

Evaluate Formula

Formula

$$P_l = P_{max} \cdot \sin\left(\delta\right)$$

Example with Units

$$707.1068\,\text{W} = 1000\,\text{W} \cdot \sin\left(45°\right)$$

## 13) Maximum Steady State Power Transfer Formula

Evaluate Formula

Formula

$$P_{e,max} = \frac{\text{mod}\,\underline{us}\left(E_g\right) \cdot \text{mod}\,\underline{us}\left(V\right)}{X_s}$$

Example with Units

$$30.8772\,\text{V} = \frac{\text{mod}\,\underline{us}\left(160\,\text{V}\right) \cdot \text{mod}\,\underline{us}\left(11\,\text{V}\right)}{57\,\Omega}$$

## 14) Moment of Inertia of Machine under Power System Stability Formula

Evaluate Formula

Formula

$$M_i = J \cdot \left(\frac{2}{P}\right)^2 \cdot \omega_r \cdot 10^{-6}$$

Example with Units

$$0.0007\,\text{kg·m²} = 6.0\,\text{kg·m²} \cdot \left(\frac{2}{2}\right)^2 \cdot 121\,\text{m/s} \cdot 10^{-6}$$

## 15) Output Power of Generator under Power System Stability Formula

Evaluate Formula

Formula

$$P_g = \frac{E_g \cdot V_t \cdot \sin\left(\zeta_{op}\right)}{x_d}$$

Example with Units

$$0.096\,\text{W} = \frac{160\,\text{V} \cdot 3\,\text{V} \cdot \sin\left(90°\right)}{5000\,\text{AT/Wb}}$$

## 16) Real Power of Generator under Power Angle Curve Formula

Evaluate Formula

Formula

$$P_e = \frac{\text{mod}\,\underline{us}\left(E_g\right) \cdot \text{mod}\,\underline{us}\left(V\right)}{X_s} \cdot \sin\left(\delta\right)$$

Example with Units

$$21.8335\,\text{W} = \frac{\text{mod}\,\underline{us}\left(160\,\text{V}\right) \cdot \text{mod}\,\underline{us}\left(11\,\text{V}\right)}{57\,\Omega} \cdot \sin\left(45°\right)$$

## 17) Rotor Acceleration Formula

Evaluate Formula

Formula

$$P_a = P_i - P_{ep}$$

Example with Units

$$100.1\,\text{W} = 200\,\text{W} - 99.9\,\text{W}$$

## 18) Speed of Synchronous Machine Formula

Evaluate Formula

Formula

$$\omega_{es} = \left(\frac{P}{2}\right) \cdot \omega_r$$

Example with Units

$$121\,\text{m/s} = \left(\frac{2}{2}\right) \cdot 121\,\text{m/s}$$

## 19) Synchronous Power of Power Angle Curve Formula

Evaluate Formula

Formula

$$P_{syn} = \frac{\text{mod}\ \underline{us}\left(E_g\right) \cdot \text{mod}\ \underline{us}\left(V\right)}{X_s} \cdot \cos\left(\delta\right)$$

Example with Units

$$21.8335\,\text{W} = \frac{\text{mod}\ \underline{us}\left(160\,\text{V}\right) \cdot \text{mod}\ \underline{us}\left(11\,\text{V}\right)}{57\,\Omega} \cdot \cos\left(45°\right)$$

## 20) Time Constant in Power System Stability Formula

Evaluate Formula

Formula

$$T = \frac{2 \cdot H}{\pi \cdot \omega_{df} \cdot D}$$

Example with Units

$$0.111\,\text{s} = \frac{2 \cdot 39\,\text{kg·m}^2}{3.1416 \cdot 8.95\,\text{Hz} \cdot 25\,\text{Ns/m}}$$

## Variables used in list of Power System Stability Formulas above

- **D** Damping Coefficient *(Newton Second per Meter)*
- $E_g$ EMF of Generator *(Volt)*
- **f** Frequency *(Hertz)*
- **fs** Synchronous Frequency *(Hertz)*
- **G** Three Phase MVA Rating of Machine
- **H** Constant of Inertia *(Kilogram Square Meter)*
- $I_p$ Phasor Current *(Ampere)*
- **J** Rotor Moment of Inertia *(Kilogram Square Meter)*
- **KE** Kinetic Energy of Rotor *(Joule)*
- **M** Inertia Constant of Machine
- $M_i$ Moment of Inertia *(Kilogram Square Meter)*
- **P** Number of Machine Poles
- $P_a$ Accelerating Power *(Watt)*
- $P_e$ Real Power *(Watt)*
- $P_{e,max}$ Maximum Steady State Power Transfer *(Volt)*
- $P_{ep}$ Electromagnetic Power *(Watt)*
- $P_g$ Output Power of Generator *(Watt)*
- $P_i$ Input Power *(Watt)*
- $P_{inf}$ Active Power of Infinite Bus *(Watt)*
- $P_l$ Lossless Power Delivered *(Watt)*
- $P_{max}$ Maximum Power *(Watt)*
- $P_{syn}$ Synchronous Power *(Watt)*
- **R** Resistance *(Ohm)*
- **S** Complex Power *(Volt Ampere)*
- **t** Time of Angular Displacement *(Second)*
- **T** Time Constant *(Second)*
- $T_a$ Accelerating Torque *(Newton Meter)*
- $t_c$ Clearing Time *(Second)*
- $t_{cc}$ Critical Clearing Time *(Second)*
- $T_e$ Electrical Torque *(Newton Meter)*

## Constants, Functions, Measurements used in list of Power System Stability Formulas above

- constant(s): **pi**, 3.14159265358979323846264338327950288 *Archimedes' constant*
- 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: **modulus**, modulus *Modulus of a number is the remainder when that number is divided by another number.*
- 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: **Time** in Second (s) *Time Unit Conversion*
- Measurement: **Electric Current** in Ampere (A) *Electric Current Unit Conversion*
- Measurement: **Speed** in Meter per Second (m/s) *Speed Unit Conversion*
- Measurement: **Energy** in Joule (J) *Energy Unit Conversion*
- Measurement: **Power** in Watt (W), Volt Ampere (VA) *Power Unit Conversion*
- Measurement: **Angle** in Radian (rad), Degree (°) *Angle Unit Conversion*
- Measurement: **Frequency** in Hertz (Hz) *Frequency Unit Conversion*
- Measurement: **Electric Resistance** in Ohm (Ω) *Electric Resistance Unit Conversion*

- $T_m$ Mechanical Torque *(Newton Meter)*
- $V$ Voltage of Infinite Bus *(Volt)*
- $V_p$ Phasor Voltage *(Volt)*
- $V_t$ Terminal Voltage *(Volt)*
- $x_d$ Magnetic Reluctance *(Ampere-Turn per Weber)*
- $X_s$ Synchronous Reactance *(Ohm)*
- $\delta$ Electrical Power Angle *(Degree)*
- $\delta_a$ Angular Displacement of Machine *(Radian)*
- $\delta_c$ Clearing Angle *(Radian)*
- $\delta_{cc}$ Critical Clearing Angle *(Degree)*
- $\delta_{max}$ Maximum Clearing Angle *(Degree)*
- $\delta_o$ Initial Power Angle *(Degree)*
- $\zeta_{op}$ Power Angle *(Degree)*
- $\theta_m$ Angular Displacement of Rotor *(Radian)*
- $\xi$ Oscillation Constant
- $\omega_{df}$ Damping Frequency of Oscillation *(Hertz)*
- $\omega_{es}$ Speed of Synchronous Machine *(Meter per Second)*
- $\omega_{fn}$ Natural Frequency of Oscillation *(Hertz)*
- $\omega_r$ Rotor Speed of Synchronous Machine *(Meter per Second)*
- $\omega_s$ Synchronous Speed *(Meter per Second)*

- Measurement: **Electric Potential** in Volt (V)
  *Electric Potential Unit Conversion*
- Measurement: **Torque** in Newton Meter (N*m)
  *Torque Unit Conversion*
- Measurement: **Moment of Inertia** in Kilogram Square Meter (kg·m²)
  *Moment of Inertia Unit Conversion*
- Measurement: **Damping Coefficient** in Newton Second per Meter (Ns/m)
  *Damping Coefficient Unit Conversion*
- Measurement: **Reluctance** in Ampere-Turn per Weber (AT/Wb)
  *Reluctance Unit Conversion*

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