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# Power System Stability Formulas

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# List of 20 Power System Stability Formulas

## Power System Stability

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

Open Calculator

fx $$T_a = T_m - T_e$$

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

### 2) Active Power by Infinite Bus

Open Calculator

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

ex $$2.084176\text{W} = \frac{(11\text{V})^2}{\sqrt{(2.1\Omega)^2 + (57\Omega)^2}} - \frac{(11\text{V})^2}{(2.1\Omega)^2 + (57\Omega)^2}$$

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

Open Calculator

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

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

## 4) Clearing Angle

Open Calculator

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

ex $$61.93019\text{rad} = \frac{\pi \cdot 56\text{Hz} \cdot 200\text{W}}{2 \cdot 39\text{kg·m}^2} \cdot (0.37\text{s})^2 + 10^\circ$$

## 5) Clearing Time

Open Calculator

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

ex $$0.36991\text{s} = \sqrt{\frac{2 \cdot 39\text{kg·m}^2 \cdot (61.9\text{rad} - 10^\circ)}{\pi \cdot 56\text{Hz} \cdot 200\text{W}}}$$

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

Open Calculator

fx $$S = V_p \cdot I_p$$

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

## 7) Critical Clearing Angle under Power System Stability

Open Calculator

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

ex $$47.58211^\circ = a\cos\left(\cos(60^\circ) + \left(\frac{200\text{W}}{1000\text{W}}\right) \cdot (60^\circ - 10^\circ)\right)$$

## 8) Critical Clearing Time under Power System Stability

Open Calculator

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

ex $$0.017035s = \sqrt{\frac{2 \cdot 39kg \cdot m^2 \cdot (47.5^\circ - 10^\circ)}{\pi \cdot 56Hz \cdot 1000W}}$$

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

Open Calculator

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

ex $$8.954887Hz = 9Hz \cdot \sqrt{1 - (0.1)^2}$$

## 10) Inertia Constant of Machine

Open Calculator

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

ex $$0.059091 = \frac{15 \cdot 39kg \cdot m^2}{180 \cdot 55Hz}$$

## 11) Kinetic Energy of Rotor

Open Calculator

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

ex $$0.000192J = \left(\frac{1}{2}\right) \cdot 6.0kg \cdot m^2 \cdot (8.0m/s)^2 \cdot 10^{-6}$$

## 12) Lossless Power Delivered in Synchronous Machine

Open Calculator

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

ex $$707.1068\text{W} = 1000\text{W} \cdot \sin(45^\circ)$$

## 13) Maximum Steady State Power Transfer

Open Calculator

fx $$P_{e,max} = \frac{\text{modulus}(E_g) \cdot \text{modulus}(V)}{X_s}$$

ex $$30.87719\text{V} = \frac{\text{modulus}(160\text{V}) \cdot \text{modulus}(11\text{V})}{57\Omega}$$

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

Open Calculator

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

ex $$0.000726\text{kg·m}^2 = 6.0\text{kg·m}^2 \cdot \left(\frac{2}{2}\right)^2 \cdot 121\text{m/s} \cdot 10^{-6}$$

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

Open Calculator

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

ex $$0.096\text{W} = \frac{160\text{V} \cdot 3\text{V} \cdot \sin(90^\circ)}{5000\text{AT/Wb}}$$

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

Open Calculator

fx $$P_e = \frac{\text{modulus}(E_g) \cdot \text{modulus}(V)}{X_s} \cdot \sin(\delta)$$

ex $$21.83347\text{W} = \frac{\text{modulus}(160\text{V}) \cdot \text{modulus}(11\text{V})}{57\Omega} \cdot \sin(45^\circ)$$

## 17) Rotor Acceleration

Open Calculator

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

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

## 18) Speed of Synchronous Machine

Open Calculator

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

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

## 19) Synchronous Power of Power Angle Curve

Open Calculator

fx $$P_{syn} = \frac{\text{modulus}(E_g) \cdot \text{modulus}(V)}{X_s} \cdot \cos(\delta)$$

ex $$21.83347\text{W} = \frac{\text{modulus}(160\text{V}) \cdot \text{modulus}(11\text{V})}{57\Omega} \cdot \cos(45^\circ)$$

## 20) Time Constant in Power System Stability

Open Calculator

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

ex $$0.110964\text{s} = \frac{2 \cdot 39\text{kg·m}^2}{\pi \cdot 8.95\text{Hz} \cdot 25\text{Ns/m}}$$

# Variables Used

- **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)*
- $T_m$ 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)*

# Constants, Functions, Measurements used

- Constant: **pi**, 3.14159265358979323846264338327950288
  *Archimedes' constant*
- Function: **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.*
- Function: **cos**, cos(Angle)
  *Cosine of an angle is the ratio of the side adjacent to the angle to the hypotenuse of the triangle.*
- Function: **modulus**, modulus
  *Modulus of a number is the remainder when that number is divided by another number.*
- Function: **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.*
- Function: **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*
- 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*

## Check other formula lists

- Overhead AC Supply Formulas
- Overhead DC Supply Formulas
- Power System Stability Formulas
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