



# Power System Stability Formulas

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

# Power System Stability 2

1) Accelerating Torque of Generator under Power System Stability

fx 
$$T_{
m a} = T_{
m m} - T_{
m e}$$

Open Calculator

32N\*m = 44N\*m - 12N\*m

2) Active Power by Infinite Bus

$$ext{P}_{ ext{inf}} = rac{{{{\left( { ext{V}} 
ight)}^2}}}{{\sqrt {{{\left( { ext{R}} 
ight)}^2} + {{\left( {{ ext{X}_{ ext{s}}}} 
ight)}^2}}} - rac{{{{\left( { ext{V}} 
ight)}^2}}{{{{\left( { ext{R}} 
ight)}^2} + {{\left( {{ ext{X}_{ ext{s}}}} 
ight)}^2}}}$$

Open Calculator

$$= \frac{(11\mathrm{V})^2}{\sqrt{{(2.1\Omega)}^2 + {(57\Omega)}^2}} - \frac{(11\mathrm{V})^2}{{(2.1\Omega)}^2 + {(57\Omega)}^2}$$

3) Angular Displacement of Machine under Power System Stability

fx 
$$\left[\delta_{
m a} = heta_{
m m} - \omega_{
m s} \cdot t
ight]$$

Open Calculator

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



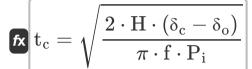
#### 4) Clearing Angle

$$\delta_{
m c} = rac{\pi \cdot {
m f} \cdot {
m P_i}}{2 \cdot {
m H}} \cdot ({
m t_c})^2 + \delta_{
m o}$$

Open Calculator 🗗

$$\pi \cdot 56$$
Hz  $\cdot 200$ 

## 5) Clearing Time



Open Calculator 🗗

$$\mathbf{ex} \left[ 0.36991 \mathrm{s} = \sqrt{\frac{2 \cdot 39 \mathrm{kg \cdot m^2 \cdot (61.9 rad - 10°)}}{\pi \cdot 56 \mathrm{Hz} \cdot 200 \mathrm{W}}} \right]$$

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

$$S = V_p \cdot I_p$$

Open Calculator 🗗

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

## 7) Critical Clearing Angle under Power System Stability

$$\delta_{
m cc} = a \cos igg( \cos (\delta_{
m max}) + igg( rac{{
m P_i}}{{
m P_{max}}} igg) \cdot (\delta_{
m max} - \delta_{
m o}) igg)$$

$$\boxed{ 47.58211^\circ = a \cos \biggl( \cos(60^\circ) + \biggl( \frac{200 \mathrm{W}}{1000 \mathrm{W}} \biggr) \cdot (60^\circ - 10^\circ) \biggr) }$$





## 8) Critical Clearing Time under Power System Stability

 $\mathbf{f}$   $\mathbf{t}_{cc} = \sqrt{rac{2 \cdot H \cdot (\delta_{cc} - \delta_{o})}{\pi \cdot f \cdot P_{max}}}$ 

Open Calculator

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

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

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

Open Calculator

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

## 10) Inertia Constant of Machine

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

Open Calculator

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

## 11) Kinetic Energy of Rotor

 $extbf{KE} = \left(rac{1}{2}
ight) \cdot ext{J} \cdot \omega_{
m s}^2 \cdot 10^{-6}$ 

Open Calculator 🗗

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







# 12) Lossless Power Delivered in Synchronous Machine 🗗

 $\mathbf{f} \mathbf{x} | \mathbf{P}_{l} = \mathbf{P}_{\max} \cdot \sin(\delta)$ 

Open Calculator 2

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

## 13) Maximum Steady State Power Transfer 🗗

 $extbf{P}_{e, ext{max}} = rac{ ext{modulus}(E_g) \cdot ext{modulus}(V)}{ ext{modulus}(V)}$ 

Open Calculator

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

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

 $X_s$ 

 $M_{
m i} = J \cdot \left(rac{2}{
m P}
ight)^2 \cdot \omega_{
m r} \cdot 10^{-6}$ 

Open Calculator

 $oxed{ex} 0.000726 ext{kg} \cdot ext{m}^2 = 6.0 ext{kg} \cdot ext{m}^2 \cdot \left(rac{2}{2}
ight)^2 \cdot 121 ext{m/s} \cdot 10^{-6}$ 

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

 $ext{P}_{ ext{g}} = rac{ ext{E}_{ ext{g}} \cdot ext{V}_{ ext{t}} \cdot ext{sin}ig( \zeta_{ ext{op}} ig)}{ ext{Y}_{ ext{t}}}$ 

Open Calculator

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





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

 $ext{P}_{e} = rac{ ext{modulus}(E_g) \cdot ext{modulus}(V)}{ ext{X}} \cdot ext{sin}(\delta)$ 

Open Calculator 🗗

## 17) Rotor Acceleration

fx  $P_{
m a}=P_{
m i}-P_{
m ep}$ 

Open Calculator

= 100.1 W = 200 W - 99.9 W

## 18) Speed of Synchronous Machine

 $\left|\omega_{
m es} = \left(rac{
m P}{2}
ight)\cdot\omega_{
m r}
ight|$ 

Open Calculator 🗗

## 19) Synchronous Power of Power Angle Curve

 $\mathbf{P}_{ ext{syn}} = rac{ ext{modulus}(\mathrm{E_g}) \cdot ext{modulus}(\mathrm{V})}{\mathrm{X_s}} \cdot \cos(\delta)$ 

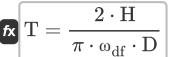
Open Calculator 🗗

 $extbf{ex} 21.83347 ext{W} = rac{ ext{modulus}(160 ext{V}) \cdot ext{modulus}(11 ext{V})}{57 \Omega} \cdot ext{cos}(45\degree)$ 



#### 20) Time Constant in Power System Stability





Open Calculator

$$oxed{ex} 0.110964 ext{s} = rac{2 \cdot 39 ext{kg} \cdot ext{m}^2}{\pi \cdot 8.95 ext{Hz} \cdot 25 ext{Ns/m}}$$



#### Variables Used

- D Damping Coefficient (Newton Second per Meter)
- **E**<sub>g</sub> 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<sub>D</sub> Phasor Current (Ampere)
- J Rotor Moment of Inertia (Kilogram Square Meter)
- KE Kinetic Energy of Rotor (Joule)
- M Inertia Constant of Machine
- Mi Moment of Inertia (Kilogram Square Meter)
- P Number of Machine Poles
- Pa Accelerating Power (Watt)
- Pe Real Power (Watt)
- P<sub>e,max</sub> Maximum Steady State Power Transfer (Volt)
- Pep Electromagnetic Power (Watt)
- P<sub>q</sub> Output Power of Generator (Watt)
- P<sub>i</sub> Input Power (Watt)
- Pinf Active Power of Infinite Bus (Watt)
- P<sub>I</sub> Lossless Power Delivered (Watt)
- Pmax Maximum Power (Watt)
- P<sub>svn</sub> Synchronous Power (Watt)





- R Resistance (Ohm)
- S Complex Power (Volt Ampere)
- t Time of Angular Displacement (Second)
- **T** Time Constant (Second)
- **T**<sub>a</sub> Accelerating Torque (Newton Meter)
- t<sub>c</sub> Clearing Time (Second)
- t<sub>cc</sub> Critical Clearing Time (Second)
- Te Electrical Torque (Newton Meter)
- T<sub>m</sub> Mechanical Torque (Newton Meter)
- **V** Voltage of Infinite Bus (Volt)
- V<sub>D</sub> Phasor Voltage (Volt)
- V<sub>t</sub> Terminal Voltage (Volt)
- X<sub>d</sub> Magnetic Reluctance (Ampere-Turn per Weber)
- X<sub>s</sub> Synchronous Reactance (Ohm)
- δ Electrical Power Angle (Degree)
- δ<sub>a</sub> Angular Displacement of Machine (Radian)
- δ<sub>c</sub> Clearing Angle (Radian)
- δ<sub>CC</sub> Critical Clearing Angle (Degree)
- δ<sub>max</sub> Maximum Clearing Angle (Degree)
- δ<sub>0</sub> Initial Power Angle (Degree)
- ζ<sub>op</sub> Power Angle (Degree)
- θ<sub>m</sub> Angular Displacement of Rotor (Radian)
- ξ Oscillation Constant
- ω<sub>df</sub> Damping Frequency of Oscillation (Hertz)



- ω<sub>es</sub> Speed of Synchronous Machine (Meter per Second)
- ω<sub>fn</sub> Natural Frequency of Oscillation (Hertz)
- ω<sub>r</sub> Rotor Speed of Synchronous Machine (Meter per Second)
- ω<sub>s</sub> 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





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