Important FACTS Devices Formulas PDF

Formulas
Examples
with Units

List of 21
Important FACTS Devices Formulas

1) AC Transmission Line Analysis Formulas

1.1) Effective Conductance of Load Formula

Evaluate Formula

Formula

$$G_{eff} = \frac{P_{re}}{V_n^2}$$

Example with Units

$$1.0783\,\text{S} = \frac{440\,\text{W}}{20.2\,\text{V}^2}$$

1.2) Electrical Length of Line Formula

Evaluate Formula

Formula

$$\theta = \beta' \cdot L$$

Example with Units

$$20.6265^\circ = 1.2 \cdot 0.3\,\text{m}$$

1.3) Phase Constant of Compensated Line Formula

Evaluate Formula

Formula

$$\beta' = \beta \cdot \sqrt{\left(1 - K_{se}\right) \cdot \left(1 - k_{sh}\right)}$$

Example

$$1.2969 = 2.9 \cdot \sqrt{\left(1 - 0.6\right) \cdot \left(1 - 0.5\right)}$$

1.4) Source Current in Ideal Compensator Formula

Evaluate Formula

Formula

$$I_s = I_L - I_{com}$$

Example with Units

$$32\,\text{A} = 42\,\text{A} - 10.0\,\text{A}$$

1.5) Thevenin's Voltage of Line Formula

Evaluate Formula

Formula

$$V_{th} = \frac{V_s}{\cos\left(\theta\right)}$$

Example with Units

$$57.4656\,\text{V} = \frac{54\,\text{V}}{\cos\left(20^\circ\right)}$$

1.6) Velocity Propagation in Lossless Line Formula

Evaluate Formula

Formula

$$V_p = \frac{1}{\sqrt{l \cdot c}}$$

Example with Units

$$0.5661\,\text{m/s} = \frac{1}{\sqrt{2.4\,\text{H} \cdot 1.3\,\text{F}}}$$

1.7) Wavelength Propagation in Lossless Line Formula

Evaluate Formula

Formula

$$\lambda = \frac{V_p}{f}$$

Example with Units

$$0.0112\,\text{m} = \frac{0.56\,\text{m/s}}{50\,\text{Hz}}$$

2) Static Synchronous Compensator(STATCOM) Formulas

2.1) Positive Sequence Voltage of STATCOM Formula

Evaluate Formula

Formula

$$V_{po} = \Delta V_{ref} + X_{droop} \cdot I_{r(max)}$$

Example with Units

$$85.25\,\text{V} = 15.25\,\text{V} + 10\,\Omega \cdot 7\,\text{A}$$

2.2) RMS Error Vector in Load Distribution under STATCOM Formula

Evaluate Formula

Formula

$$E_{rms} = \sqrt{\left(\frac{1}{T}\right) \cdot \int\left(\left(\varepsilon_1\right)^2 + \left(\varepsilon_2\right)^2 + \left(\varepsilon_3\right)^2 \cdot x, x, 0, T\right)}$$

Example with Units

$$4.1821 = \sqrt{\left(\frac{1}{2\,\text{s}}\right) \cdot \int\left(\left(2.6\right)^2 + \left(2.8\right)^2 + \left(1.7\right)^2 \cdot x, x, 0, 2\,\text{s}\right)}$$

3) Static Synchronous Series Compensator(SSSC) Formulas

3.1) Degree of Series Compensation Formula

Evaluate Formula

Formula

$$K_{se} = \frac{X_c}{Z_n \cdot \theta}$$

Example with Units

$$0.6303 = \frac{1.32\,\Omega}{6\,\Omega \cdot 20^\circ}$$

3.2) Electrical Resonance Frequency for Series Capacitor Compensation Formula

Evaluate Formula

Formula

$$f_{r(se)} = f_{op} \cdot \sqrt{1 - K_{se}}$$

Example with Units

$$37.9473\,\text{Hz} = 60.0\,\text{Hz} \cdot \sqrt{1 - 0.6}$$

3.3) Power Flow in SSSC Formula

Evaluate Formula

Formula

$$P_{sssc} = P_{max} + \frac{V_{se} \cdot I_{sh}}{4}$$

Example with Units

$$1565\,\text{W} = 300\,\text{W} + \frac{220\,\text{V} \cdot 23\,\text{A}}{4}$$

3.4) Resonance Frequency for Shunt Capacitor Compensation Formula

Evaluate Formula

Formula

$$f_{r(sh)} = f_{op} \cdot \sqrt{\frac{1}{1 - k_{sh}}}$$

Example with Units

$$84.8528\,\text{Hz} = 60.0\,\text{Hz} \cdot \sqrt{\frac{1}{1 - 0.5}}$$

3.5) Series Reactance of Capacitors Formula

Evaluate Formula

Formula

$$X_c = X \cdot \left(1 - K_{se}\right)$$

Example with Units

$$1.32\,\Omega = 3.3\,\Omega \cdot \left(1 - 0.6\right)$$

4) Static Var Compensator(SVC) Formulas

4.1) Steady State Change of SVC Voltage Formula

Evaluate Formula

Formula

$$\Delta V_{svc} = \frac{K_N}{K_N + K_g} \cdot \Delta V_{ref}$$

Example with Units

$$7.5374\,\text{V} = \frac{8.6}{8.6 + 8.8} \cdot 15.25\,\text{V}$$

4.2) Total Harmonic Distortion Factor Formula

Evaluate Formula

Formula

$$THD = \frac{1}{V_{in}} \cdot \sqrt{\sum\left(x, 2, N_h, V_n^{\,2}\right)}$$

Example with Units

$$8.5335 = \frac{1}{4.1\,\text{V}} \cdot \sqrt{\sum\left(x, 2, 4, 20.2\,\text{V}^{\,2}\right)}$$

4.3) Voltage Distortion Factor in Single Tuned Filter Formula

Evaluate Formula

Formula

$$D_n = \frac{V_n}{V_{in}}$$

Example with Units

$$4.9268 = \frac{20.2\,\text{V}}{4.1\,\text{V}}$$

5) Thyristor Controlled Series Capacitor(TCSC) Formulas

5.1) Capacitive Reactance of TCSC Formula

Evaluate Formula

Formula

$$X_{tcsc} = \frac{X_C}{1 - \frac{X_C}{X_{tcr}}}$$

Example with Units

$$4.3113\,\text{F} = \frac{3.5\,\Omega}{1 - \frac{3.5\,\Omega}{18.6\,\Omega}}$$

5.2) Effective Reactance of GCSC Formula

Evaluate Formula

Formula

$$X_{gcsc} = \frac{X_C}{\pi} \cdot \left(\delta_{ha} - \sin\left(\delta_{ha}\right)\right)$$

Example with Units

$$419.9998\,\Omega = \frac{3.5\,\Omega}{3.1416} \cdot \left(60\,\text{cyc} - \sin\left(60\,\text{cyc}\right)\right)$$

5.3) TCR Current Formula

Evaluate Formula

Formula

$$I_{tcr} = B_{tcr} \cdot \sigma_{tcr} \cdot V_{tcr}$$

Example with Units

$$0.9299\,\text{A} = 1.6\,\text{S} \cdot 9° \cdot 3.7\,\text{V}$$

5.4) Voltage of Thyristor Controlled Series Capacitor Formula

Evaluate Formula

Formula

$$V_{tcsc} = I_{line} \cdot X_{line} - V_{dl}$$

Example with Units

$$6.022\,\text{V} = 3.4\,\text{A} \cdot 2.33\,\Omega - 1.9\,\text{V}$$

Variables used in list of FACTS Devices Formulas above

- B_{tcr} TCR Susceptance in SVC *(Siemens)*
- **c** Series Capacitance in the Line *(Farad)*
- D_n Voltage Distortion Factor in Single Tuned Filter
- E_{rms} RMS Error Vector
- **f** Lossless Line Frequency *(Hertz)*
- f_{op} Operating System Frequency *(Hertz)*
- $f_{r(se)}$ Resonance Frequency of Series Capacitor *(Hertz)*
- $f_{r(sh)}$ Resonance Frequency of Shunt Capacitor *(Hertz)*
- G_{eff} Effective Conductance in Load *(Siemens)*
- I_{com} Compensator Current *(Ampere)*
- I_L Load Current in Ideal Compensator *(Ampere)*
- I_{line} Line Current in TCSC *(Ampere)*
- $I_{r(max)}$ Maximum Inductive Reactive Current *(Ampere)*
- I_s Source Current in Ideal Compensator *(Ampere)*
- I_{sh} Shunt Current of UPFC *(Ampere)*
- I_{tcr} TCR Current in SVC *(Ampere)*
- K_g SVC Gain
- K_N SVC Static Gain
- K_{se} Degree in Series Compensation
- k_{sh} Degree in Shunt Compensation
- **l** Series Inductance in Line *(Henry)*
- **L** Line Length *(Meter)*
- N_h Highest Order Harmonic
- P_{max} Maximum Power in UPFC *(Watt)*
- P_{re} Real Power of Load *(Watt)*
- P_{sssc} Power Flow in SSSC *(Watt)*
- **T** Time Elapsed in PWM Current Controller *(Second)*
- **THD** Total Harmonic Distortion Factor

Constants, Functions, Measurements used in list of FACTS Devices 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: **int**, int(expr, arg, from, to) *The definite integral can be used to calculate net signed area, which is the area above the x -axis minus the area below the x -axis.*
- 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.*
- Functions: **sum**, sum(i, from, to, expr) *Summation or sigma (∑) notation is a method used to write out a long sum in a concise way.*
- Measurement: **Length** in Meter (m) *Length Unit Conversion*
- 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: **Power** in Watt (W) *Power Unit Conversion*
- Measurement: **Angle** in Degree (°), Cycle (cyc) *Angle Unit Conversion*
- Measurement: **Frequency** in Hertz (Hz) *Frequency Unit Conversion*
- Measurement: **Capacitance** in Farad (F) *Capacitance Unit Conversion*
- Measurement: **Electric Resistance** in Ohm (Ω) *Electric Resistance Unit Conversion*

- V_{dl} Voltage Drop Across Line in TCSC *(Volt)*
- V_{in} Input Voltage in SVC *(Volt)*
- V_{n} RMS Voltage in SVC *(Volt)*
- V_{p} Velocity Propagation in Lossless Line *(Meter per Second)*
- V_{po} Positive Sequence Voltage in STATCOM *(Volt)*
- V_{s} Sending End Voltage *(Volt)*
- V_{se} Series Voltage of UPFC *(Volt)*
- V_{tcr} TCR Voltage in SVC *(Volt)*
- V_{tcsc} TCSC Voltage *(Volt)*
- V_{th} Thevenin's Voltage of Line *(Volt)*
- X Line Reactance *(Ohm)*
- X_{c} Series Reactance in Capacitor *(Ohm)*
- X_{C} Capacitive Reactive *(Ohm)*
- X_{droop} Droop Reactance in STATCOM *(Ohm)*
- X_{gcsc} Effective Reactance in GCSC *(Ohm)*
- X_{line} Line Reactance in TCSC *(Ohm)*
- X_{tcr} TCR Reactance *(Ohm)*
- X_{tcsc} Capacitive Reactive in TCSC *(Farad)*
- Z_{n} Natural Impedance in Line *(Ohm)*
- β Phase Constant in Uncompensated Line
- β' Phase Constant in Compensated Line
- δ_{ha} Hold off Angle in GCSC *(Cycle)*
- ΔV_{ref} SVC Reference Voltage *(Volt)*
- ΔV_{svc} Steady State Change in SVC Voltage *(Volt)*
- ε_{1} Error Vector in Line 1
- ε_{2} Error Vector in Line 2
- ε_{3} Error Vector in Line 3
- θ Electrical Length of Line *(Degree)*
- λ Wavelength Propagation in Lossless Line *(Meter)*
- σ_{tcr} Conducting Angle in TCR *(Degree)*

- Measurement: **Inductance** in Henry (H)
  Inductance Unit Conversion
- Measurement: **Wavelength** in Meter (m)
  Wavelength Unit Conversion
- Measurement: **Electric Potential** in Volt (V)
  Electric Potential Unit Conversion
- Measurement: **Transconductance** in Siemens (S)
  Transconductance Unit Conversion

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