EE431 Fall 2008

Report Due Oct. 21 2008

Transmission Line Design Project – Assignment 2

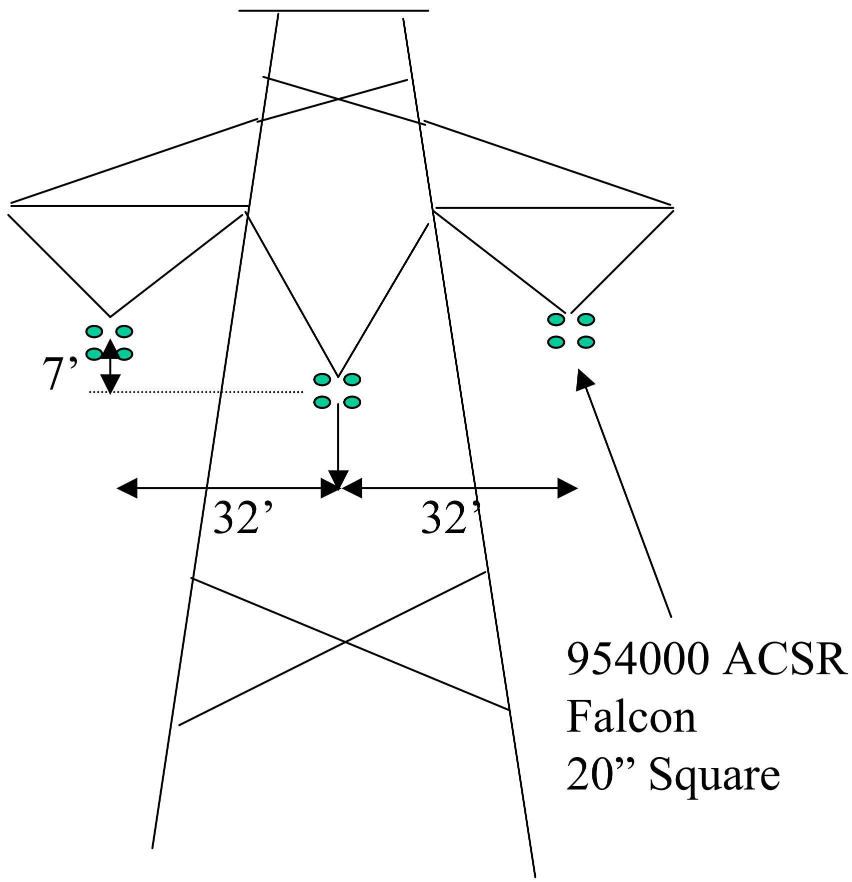
Extend your design tool to:

1. Perform a full-load and no load analysis and display
    a. At Full load: Sending end voltage, Sending end complex power, F
       Power Loss and Reactive power Loss
    b. At No load (Assuming a sending end voltage equal to that in Part
       Receiving end voltage, Sending end complex power, Real Power
       Reactive power Loss
    c. Voltage Regulation
    d. Loadability at nominal voltage for δ=35 deg

Use data from homework problems and verify your tool via hand calculations.

What to turn in:

500 KV



For the 200 mile long line shown

- Find z and y
- Calculate ABCD parameters based on long line model
- The receiving end load is 600 MW at 0.95 power factor lag
    - Calculate Voltage regulation
    - Power loss at full load
    - Sending end power at full load and no load
    - Loadability for δ=35 deg

Step 1 Conductor Parameters

Conductor Resistance $R := 0.0684 \quad \frac{ohm}{mi}$

GMR $r' := 0.052$ ft

Bundle spacing $d := 20$ in $d := \frac{20}{12}$ $d = 1.667$ ft

Phase Distances

$D12 := \sqrt{32^2 + 7^2}$ $D12 = 32.757$ ft $D23 := D1\!:$ ft $D13 := 64$ ft

Step 2 Line Resistance Per Phase

$R := \frac{R}{4}$ $R = 0.017 \quad \frac{ohm}{mi}$

Step 3 Bundle GMR

$$DsL := \sqrt[4]{r' \cdot d \cdot d \cdot \sqrt{2}\, d}$$

$DsL = 0.764$ ft

Step 2 GMD

$$Deq := \sqrt[3]{D12 \cdot D23 \cdot D13} \quad ft$$

$Deq = 40.951$

Step 5 impedance

In ohm/mi at 60 Hz

$X := 0.1213 \cdot \ln\left(\frac{Deq}{DsL}\right)$ $X = 0.483 \quad \frac{ohm}{mi}$ per phase

Impedance $z := R + i \cdot X$ $z = 0.017 + 0.483i$ $\frac{\Omega}{mi}$

Capacitance

Outer diameter $od := 1.545$ "

Radius (not GMR) $r := \frac{od}{24}$ feet

$Dsc := \sqrt[4]{r \cdot d \cdot d \cdot \sqrt{2}\, d}$ $Dsc = 0.806$ ft

Capacitance

$C := 2 \cdot \pi \cdot 8.854 \cdot \frac{10^{-12}}{\ln\left(\frac{Deq}{Dsc}\right)}$ $C = 1.416 \times 10^{-11}$ $\frac{F}{m}$

Shunt susceptance

$Bc := 2 \cdot \pi \cdot 8.854 \cdot 10^{-12} \cdot 1609 \cdot \frac{377}{\ln\left(\frac{Deq}{Dsc}\right)}$ $Bc = 8.59 \times 10^{-6}$ $\frac{mho}{mi}$

$y := i \cdot Bc$

Long line

$\gamma := \sqrt{z \cdot y}$ $\qquad Zc := \sqrt{\frac{z}{y}}$ $\qquad \gamma = 3.605 \times 10^{-5} + 2.037i \times 10^{-3}$ $\qquad Zc = 237.155 - 4.197i$

$l := 200$

$A := \cosh(\gamma \cdot l)$ $\qquad B := Zc \cdot \sinh(\gamma \cdot l)$ $\qquad C := \frac{\sinh(\gamma \cdot l)}{Zc}$ $\qquad D := A$

$A = 0.918 + 2.857i \times 10^{-}$[illegible] $B = 3.233 + 93.95i$ $\qquad C = -1.655 \times 10^{-6} + 1.671i \times 10^{-3}$

$B = 3.233 + 93.95i$

Check $\qquad A \cdot D - B \cdot C = 1$

$Y' := \frac{2 \cdot \tanh\left(\gamma \cdot \frac{l}{2}\right)}{Zc}$ $\qquad Z' := Zc \cdot \sinh(\gamma \cdot l)$

$Y' = 8.699 \times 10^{-7} + 1.742i \times 10^{-3}$ $\qquad Z' = 3.233 + 93.95i$

Performance of uncompensated line

Full and no load ABCD matrix

$$ABCDline := \begin{pmatrix} A & B \\ C & D \end{pmatrix} \quad ABCD := ABCDline$$

Full Load Conditions

Line Length $l := 200$

Per phase Receiving end Complex power $SR\phi := \left(\frac{1}{3}\right)\cdot\left(\frac{600000000}{0.95}\right)\cdot e^{i\cdot acos(0.95)}\ VA$

Receiving end l-n voltage $VR := \frac{500000}{\sqrt{3}}\ V$

Receiving end(load) current(Overbar represents complex conjugate)

$$IR := \overline{\left(\frac{SR\phi}{VR}\right)} \qquad |IR| = 729.285 \qquad arg(IR) = -18.195\ deg$$

$$VRfl := \frac{500000}{\sqrt{3}}\ V \qquad IRfl := IR \qquad IR = 692.82 - 22\,A719i$$

$$Vs := A\cdot VRfl + B\cdot IRfl \qquad |Vs| = 2.96\times 10^{5}\ \ l-n \qquad arg(Vs) = 12.723\ deg$$

$$Is := C\cdot VRfl + D\cdot IRfl \qquad |Is| = 693.276 \qquad arg(Is) = 23.393\ deg$$

$$Vrnl := \frac{Vs}{A} \qquad |Vrnl| = 3.223\times 10^{5}\ \ Vl-n$$

$$\sqrt{3}\cdot|Vs| = 5.126\times 10^{5}$$

$$SSfl := 3\cdot Vs\cdot\overline{Is} \qquad SSfl = 6.049\times 10^{8} - 1.14i\times 10^{8}$$ Sending end power

Losses $Sloss := \left(Vs\cdot\overline{Is} - VRfl\cdot\overline{IRfl}\right)\cdot 3 \qquad Sloss = 4.886\times 10^{6} - 3.112i\times 10^{8}$

No load analysis

$$VRnl := \frac{Vs}{A} \qquad |VRnl| = 3.223 \times 10^{5} \qquad \sqrt{3}\cdot|Vrnl| = 5.583 \times 10^{5}$$

$$Isnl := C\cdot VRnl \qquad |Isnl| = 538.586$$

Voltage regulation

$$Reg := \frac{(||VRnl|| - |VRfl|)\cdot(100)}{|VRfl|} \qquad Reg = 11.658 \quad \text{percent}$$

Step 3d Loadability at δ=35 deg Remember, we use rated valuesfor voltages

$$Vs := \frac{50000}{\sqrt{3}} \qquad Vr := \frac{50000}{\sqrt{3}}$$

$$Pmax := \left[|Vs|\cdot\frac{|Vr|\cdot\cos\left(\arg(B) - 90\cdot\frac{3.14}{180}\right)}{|B|} - (|Vr|)^2\cdot \mathrm{Re}\left(\frac{A}{B}\right)\right]\cdot 3 \qquad Pmax = 2.566 \times 10^{7}$$

$$Pmax := \left[|Vs|\cdot\frac{|Vr|\cdot\cos\left(\arg(B) - 35\cdot\frac{3.14}{180}\right)}{|B|} - (|Vr|)^2\cdot \mathrm{Re}\left(\frac{A}{B}\right)\right]\cdot 3 \qquad Pmax = 1.507 \times 10^{7}$$