CALCULATION OF ELECTRIC FIELDS ELECFLD.MCD

Work Order Account ....:
Client ....:
Project ....:
Feature ....:Compute and Plot Electric Field
Item ....:
By/Date ....:Paul Dorvel 7/19/10
Checked/Date ....:
Approved/Date ....:

Validation : SCE Fields 2D program set up for same circuit configuration, loading, phasing and other values, computes E within 0.3%. This small error is likely due to time sampling and calculation point differences. 7-19-10

PROBLEM STATEMENT

Compute and plot electric fields from a transmission line based on EPRI Red Book Chapter 8 Methods pp330-332. Also compute space potential especially for evaluating ADSS placement in the HV space. See Step 7.

Step 1 - SET Origin to 1,1 for convenience

$ORIGIN := 1$

Step 2 - DEFINE constants

$\varepsilon := 8.854 \cdot 10^{-12} \cdot \frac{farad}{m}$ permittivity of free space

Replaced by built in permittivity constant.

$f := 60 \cdot Hz$ system frequency in Hz

$\omega := 2\pi \cdot f$ convert to radians

$\omega = 376.991\, s^{-1}$

$a := e^{j \cdot 120 \cdot deg}$ $a = -0.5 + 0.866j$

$\phi := 120$ phase angle

Deleted and specified in input matrix DA

Step 3 - INPUT Line Characteristics

Step 3.1 INPUT Line Data

$V := 230 \cdot kV$ $\qquad V_{lg} := \frac{V}{\sqrt{3}}$

$b\_max := 60 \qquad a := 1 .. 3 \qquad b := 1, 2 .. b\_max \qquad t_b := b \cdot ms$

$$VMXX_b := \begin{bmatrix} V_{lg} \cdot \left(\cos\left(\omega \cdot t_b + \phi \cdot deg\right) + j \cdot \sin\left(\omega \cdot t_b + \phi \cdot deg\right)\right) \\ V_{lg} \cdot \left(\cos\left(\omega \cdot t_b\right) + j \cdot \sin\left(\omega \cdot t_b\right)\right) \\ V_{lg} \cdot \left(\cos\left(\omega \cdot t_b - \phi \cdot deg\right) + j \cdot \sin\left(\omega \cdot t_b - \phi \cdot deg\right)\right) \\ 0 \\ 0 \end{bmatrix}$$

Voltage now specified per wire in input matrix

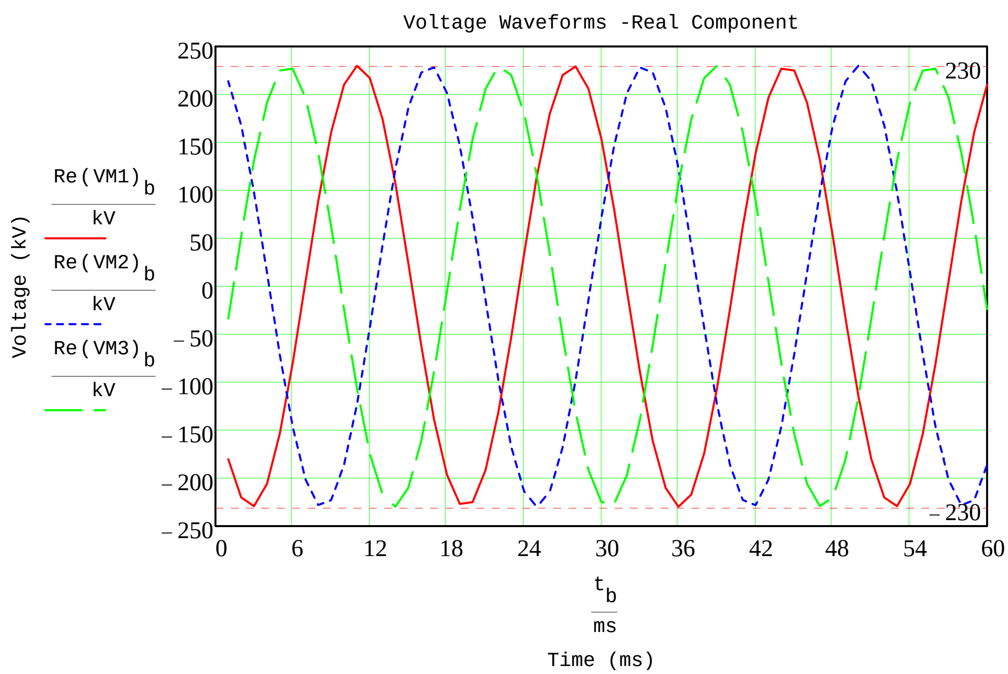
Use line-ground voltage.

$$VMXX_2 = \begin{pmatrix} -127.123 + 38.381j \\ 96.8 + 90.901j \\ 30.323 - 129.282j \\ 0 \\ 0 \end{pmatrix} \cdot kV \qquad VMXX_{50} = \begin{pmatrix} -66.395 + 115j \\ 132.791 \\ -66.395 - 115j \\ 0 \\ 0 \end{pmatrix} \cdot kV$$

$$VM1_b := V \cdot \left(\cos\left(\omega \cdot t_b + \phi \cdot deg\right) + j \cdot \sin\left(\omega \cdot t_b + \phi \cdot deg\right)\right)$$

$$VM2_b := V \cdot \left(\cos\left(\omega \cdot t_b\right) + j \cdot \sin\left(\omega \cdot t_b\right)\right)$$

$$VM3_b := V \cdot \left(\cos\left(\omega \cdot t_b - \phi \cdot deg\right) + j \cdot \sin\left(\omega \cdot t_b - \phi \cdot deg\right)\right)$$



Step 3.1 - Wire Spatial Coordinates. Adjust C for additional wires. There is no practical limit to the number of wires. Note improvement is to make a larger array C with spatial dimensions, associated voltages, phase shifts if any,diameters etc.

$$C := \begin{pmatrix} -16 & 35 \\ 0 & 35 \\ 16 & 35 \\ -10 & 45 \\ 10 & 45 \end{pmatrix} \cdot ft$$

Shieldwire 1
Shieldwire 2

Phase 1
Phase 2
Phase 3

Wire coordinates now specified in input matrix, allowing for multiple lines and wires.

$rows(C) = 5$ $NC := rows(C)$

Step 3.3 - Define wire electrical values for computation of impedances

Step 3.3.1 - Subconductor Bundle Radius

$NSC := 1$ Number of subconductors per phase bundle

If Nsc >1 then input non-zero value RADb below

$S := 0$ Input Subconductor spacing in feet

$$RAD_b := \frac{S}{2 \cdot \sin\left(\frac{\pi}{NSC}\right)} \qquad RAD_b = 0$$

$RAD_b := 0$ Subconductor bundle radius (in feet)

$RAD_b := if(NSC = 1, 0, RAD_b)$

$RAD_b = 0$ for use below

Step 3.4 - Enter shieldwire diameter in inches, compute GMR. Note if no shieldwire enter 0 for diameter. Combine in single array above.

$DIA_{sw} := 0.5in$ in inches

Diameters now specified per wire in input matrix..

Step 3.5 - Enter diameter in inches for sing[...] Combine in single array above.

$DIA_{ph} := 0.927 \cdot in$ in inches

Step 3.6 - Develop Maxwell Potential Coefficients, [P]

$i := 1 .. rows(C)$ $j := 1 .. rows(C)$

$$P_{i,j} := if\left[i = j, \frac{\ln\left(4 \cdot \frac{C_{i,2}}{DIA_{ph}}\right)}{2 \cdot \pi \cdot \varepsilon}, \frac{\ln\left[\sqrt{\frac{\left(C_{i,1} - C_{j,1}\right)^2 + \left(C_{i,2} + C_{j,2}\right)^2}{\left(C_{i,1} - C_{j,1}\right)^2 + \left(C_{i,2} - C_{j,2}\right)^2}}\right]}{2 \cdot \pi \cdot \varepsilon}\right]$$

Same. Input from input matrix columns

$$P = \begin{pmatrix} 83.797 & 16.769 & 9.803 & 21.54 & 12.344 \\ 16.769 & 83.797 & 16.769 & 19.442 & 19.442 \\ 9.803 & 16.769 & 83.797 & 12.344 & 21.54 \\ 21.54 & 19.442 & 12.344 & 86.604 & 17.069 \\ 12.344 & 19.442 & 21.54 & 17.069 & 86.604 \end{pmatrix} \cdot \frac{mile}{\mu F}$$

$$P^{-1} = \begin{pmatrix} 13145 & -1708 & -596 & -2639 & -822 \\ -1708 & 13536 & -1708 & -1980 & -1980 \\ -596 & -1708 & 13145 & -822 & -2639 \\ -2639 & -1980 & -822 & 13070 & -1551 \\ -822 & -1980 & -2639 & -1551 & 13070 \end{pmatrix} \cdot \frac{pF}{mile}$$

Processing OK.

Step 3.8 - Calculate Q from [Q]= [P]$^{-1}$*[V]

Compute Charge Density on Conductors as a function of V and wire coordinates only. Time dependency related to b.

$QM_b := P^{-1} VMXX_b$

Eliminate array subscript a by separating QM into charges on each wire due to all wires. Compute real and imaginary components of Q.

$QM1_b := \left(QM_b\right)_1$

$QM1R_b := Re\left[\left(QM_b\right)_1\right]$

$QM1I_b := Im\left[\left(QM_b\right)_1\right]$

$QM2_b := \left(QM_b\right)_2$

$QM2R_b := Re\left[\left(QM_b\right)_2\right]$

$QM2I_b := Im\left[\left(QM_b\right)_2\right]$

$QM3_b := \left(QM_b\right)_3$

$QM3R_b := Re\left[\left(QM_b\right)_3\right]$

$QM3I_b := Im\left[\left(QM_b\right)_3\right]$

$QM4_b := \left(QM_b\right)_4$

$QM4R_b := Re\left[\left(QM_b\right)_4\right]$

$QM4I_b := Im\left[\left(QM_b\right)_4\right]$

$QM5_b := \left(QM_b\right)_5$

$QM5R_b := Re\left[\left(QM_b\right)_5\right]$

$QM5I_b := Im\left[\left(QM_b\right)_5\right]$

Major change in this step. Time varying charge on wire 1 $((QM)_b)_1$ converted to single valued vector of (b). But there is one per wire. New document goal is to eliminate this brute force step to allow for more automatic population of QM and subsequent variables based on nested array manipulation

Step 3.9- Establish Measuring Points for Calculation of Electric Field

$N := 100$ — Number of Points

$ROW_L := -100 \cdot ft \qquad ROW_R := 100 \cdot ft$ — Establish ROW limits + and -. ROW_R is marker

$CL := 0 \cdot ft$ — Establish CL position- Marker only

X_k used to plot E values.

$\Delta X := 2 \cdot ft$ — Distance interval between points

$k := 1 .. N$ — Index k

$X_k := (k \cdot \Delta X + ROW_L)$ — Distance across right of way

$X_k := if(X_k = 0, 1 \cdot ft, X_k)$ — Eliminate possibility of X=0 discontinuity

$ym := 1 \cdot m$ — Measuring height for electric field

Step 3.10 COMPUTE the X-component of El Field for each wire, measuring point and time point defined by b. Compute separate terms EX1, EX2 and EX3 to eliminate i subscript.

This is similar major step. New program seeks to create an EX $_{i,b,k}$ allowing for an arbitrary large number of wires. Below individual equations are set up for each wire.

$$\ldots_{b,k} \ldots \frac{\ldots}{2 \cdot \pi \cdot \varepsilon} \ldots \left[\frac{\ldots}{\left[(C_{1,1} - X_k)^2 + (C_{1,2} - ym)^2\right]} - \frac{\ldots}{\left[(C_{1,1} - X_k)^2 + (C_{1,2} + ym)^2\right]} \right]$$

$$EX2_{b,k} := \frac{(QM2_b) \cdot \left[X_k - (C_{2,1})\right]}{2 \cdot \pi \cdot \varepsilon} \cdot \left[\frac{1}{\left[(C_{2,1} - X_k)^2 + (C_{2,2} - ym)^2\right]} - \frac{1}{\left[(C_{2,1} - X_k)^2 + (C_{2,2} + ym)^2\right]} \right]$$

$$EX3_{b,k} := \frac{(QM3_b) \cdot \left[X_k - (C_{3,1})\right]}{2 \cdot \pi \cdot \varepsilon} \cdot \left[\frac{1}{\left[(C_{3,1} - X_k)^2 + (C_{3,2} - ym)^2\right]} - \frac{1}{\left[(C_{3,1} - X_k)^2 + (C_{3,2} + ym)^2\right]} \right]$$

$$EX4_{b,k} := \frac{(QM4_b) \cdot \left[X_k - (C_{4,1})\right]}{2 \cdot \pi \cdot \varepsilon} \cdot \left[\frac{1}{\left[(C_{4,1} - X_k)^2 + (C_{4,2} - ym)^2\right]} - \frac{1}{\left[(C_{4,1} - X_k)^2 + (C_{4,2} + ym)^2\right]} \right]$$

$$EX5_{b,k} := \frac{(QM5_b) \cdot \left[X_k - (C_{5,1})\right]}{2 \cdot \pi \cdot \varepsilon} \cdot \left[\frac{1}{\left[(C_{5,1} - X_k)^2 + (C_{5,2} - ym)^2\right]} - \frac{1}{\left[(C_{5,1} - X_k)^2 + (C_{5,2} + ym)^2\right]} \right]$$

Step 3.11 COMPUTE the Y-component of E Field for each wire and point. Follow similar procedure as in 3.10 above.

See comment on previous page.

$$EY1_{b,k} := \frac{QM1_b}{(2\cdot\pi\cdot\varepsilon)}\cdot\left[\frac{(ym - C_{1,2})}{\left[(C_{1,1} - X_k)^2 + (C_{1,2} - ym)^2\right]} - \frac{(ym + C_{1,2})}{\left[(C_{1,1} - X_k)^2 + (C_{1,2} + ym)^2\right]}\right]$$

$$EY2_{b,k} := \frac{QM2_b}{(2\cdot\pi\cdot\varepsilon)}\cdot\left[\frac{(ym - C_{2,2})}{\left[(C_{2,1} - X_k)^2 + (C_{2,2} - ym)^2\right]} - \frac{(ym + C_{2,2})}{\left[(C_{2,1} - X_k)^2 + (C_{2,2} + ym)^2\right]}\right]$$

$$EY3_{b,k} := \frac{QM3_b}{(2\cdot\pi\cdot\varepsilon)}\cdot\left[\frac{(ym - C_{3,2})}{\left[(C_{3,1} - X_k)^2 + (C_{3,2} - ym)^2\right]} - \frac{(ym + C_{3,2})}{\left[(C_{3,1} - X_k)^2 + (C_{3,2} + ym)^2\right]}\right]$$

$$EY4_{b,k} := \frac{QM4_b}{(2\cdot\pi\cdot\varepsilon)}\cdot\left[\frac{(ym - C_{4,2})}{\left[(C_{4,1} - X_k)^2 + (C_{4,2} - ym)^2\right]} - \frac{(ym + C_{4,2})}{\left[(C_{4,1} - X_k)^2 + (C_{4,2} + ym)^2\right]}\right]$$

$$EY5_{b,k} := \frac{QM5_b}{(2\cdot\pi\cdot\varepsilon)}\cdot\left[\frac{(ym - C_{5,2})}{\left[(C_{5,1} - X_k)^2 + (C_{5,2} - ym)^2\right]} - \frac{(ym + C_{5,2})}{\left[(C_{5,1} - X_k)^2 + (C_{5,2} + ym)^2\right]}\right]$$

In new program this is a sum over i of the H and V contributions at each point (b,k).

Step 4.0 COMPUTE Total X, Y components of E Field at each point "k" due to all conductors. Field and components are time varying with index "b" and space varying with index "k"

$$EXT_{b,k} := \left(EX1_{b,k} + EX2_{b,k} + EX3_{b,k} + EX4_{b,k} + EX5_{b,k}\right)$$

$$EYT_{b,k} := \left(EY1_{b,k} + EY2_{b,k} + EY3_{b,k} + EY4_{b,k} + EY5_{b,k}\right)$$

Step 5.0 EXPRESS total E Field Phasor at each point "k" as complex value. Note that the voltage, charge and E Field are time varying at each point, tracked with index "b".

$Re\_EXT_{b,k} := Re(EXT_{b,k})$ $Im\_EXT_{b,k} := Im(EXT_{b,k})$

$EXT_{b,k} := Re\_EXT_{b,k} + j \cdot Im\_EXT_{b,k}$

$Re\_EYT_{b,k} := Re(EYT_{b,k})$ $Im\_EYT_{b,k} := Im(EYT_{b,k})$

$EYT_{b,k} := Re\_EYT_{b,k} + j \cdot Im\_EYT_{b,k}$

Step 6.0 COMPUTE MAXIMUM Values at each spatial point "k" based on Appendix 8.1 of Deno

Step 6.1 SUMMARIZE EQUATIONS REQUIRED FOR ANALYSIS

Horizontal field component (X)

$$H_{b,k} := \sqrt{\left(Re\_EXT_{b,k}\right)^2 + \left(Im\_EXT_{b,k}\right)^2}$$

Same.

Vertical field component (Y)

$$V_{b,k} := \sqrt{\left(Re\_EYT_{b,k}\right)^2 + \left(Im\_EYT_{b,k}\right)^2}$$

Phase angle for X component

$$\theta_{b,k} := \operatorname{atan}\left(\frac{Im\_EXT_{b,k}}{Re\_EXT_{b,k}}\right)$$

Phase angle for Y component

$$\phi_{b,k} := \operatorname{atan}\left(\frac{Im\_EYT_{b,k}}{Re\_EYT_{b,k}}\right)$$

Basic equation for magnitude of E field

$$E^2 = H^2\cdot\cos(\omega\cdot t + \theta)^2 + V^2\cdot\cos(\omega\cdot t + \phi)^2$$

$\frac{d}{dt}E^2$ **is set equal to 0 to find times t at which field vector and components are extremes.**

Solution to this is given below which is also set = 0

$$\tan(2\cdot\omega\cdot t) + \frac{\left(H^2\cdot\sin(2\cdot\theta) + V^2\cdot\sin(2\cdot\phi)\right)}{\left(H^2\cdot\cos(2\cdot\theta) + V^2\cdot\cos(2\cdot\phi)\right)}$$

Step 6.2 COMPUTE ω*t at which the fields are a maximum and minimum value on the field ellipse.

Explicit solution for ω*t is given below. The result is one possibility for an extreme value of H, min or max. There are four values of ω*t that satisfy the equation, corresponding to each of four quadrant points ont the field ellipse.

Compute the first value of ω*t and corresponding time t.

Same.

$$\omega t1_{b,k} := \frac{1}{2}\operatorname{atan}\left[\frac{-\left[\left(H_{b,k}\right)^2\cdot\sin\left(2\cdot\theta_{b,k}\right) + \left(V_{b,k}\right)^2\cdot\sin\left(2\cdot\phi_{b,k}\right)\right]}{\left(H_{b,k}\right)^2\cdot\cos\left(2\cdot\theta_{b,k}\right) + \left(V_{b,k}\right)^2\cdot\cos\left(2\cdot\phi_{b,k}\right)}\right] \qquad t1_{b,k} := \frac{\omega t1_{b,k}}{\omega}$$

And the other angles and times are defined as follows.

$$\omega t2_{b,k} := \omega t1_{b,k} + \frac{\pi}{2} \qquad t2_{b,k} := \frac{\omega t2_{b,k}}{\omega}$$

$$\omega t3_{b,k} := \omega t1_{b,k} + \pi \qquad t3_{b,k} := \frac{\omega t3_{b,k}}{\omega}$$

$$\omega t4_{b,k} := \omega t1_{b,k} + \frac{3\pi}{2} \qquad t4_{b,k} := \frac{\omega t4_{b,k}}{\omega}$$

Step 6.3 COMPUTE Maximum and Minimum values of total E Field as it traces the field ellipse at each point k at a time point b.

Substitute values of t found above and define four separate ω*t values

Same.

$$E\_MAG\_Axis1_{b,k} := \sqrt{\left(H_{b,k}\right)^2 \cdot \cos\left(\omega \cdot t1_{b,k} + \theta_{b,k}\right)^2 + \left(V_{b,k}\right)^2 \cdot \cos\left(\omega \cdot t1_{b,k} + \phi_{b,k}\right)^2}$$

$$E\_MAG\_Axis2_{b,k} := \sqrt{\left(H_{b,k}\right)^2 \cdot \cos\left(\omega \cdot t2_{b,k} + \theta_{b,k}\right)^2 + \left(V_{b,k}\right)^2 \cdot \cos\left(\omega \cdot t2_{b,k} + \phi_{b,k}\right)^2}$$

$$E\_MAG\_Axis3_{b,k} := \sqrt{\left(H_{b,k}\right)^2 \cdot \cos\left(\omega \cdot t3_{b,k} + \theta_{b,k}\right)^2 + \left(V_{b,k}\right)^2 \cdot \cos\left(\omega \cdot t3_{b,k} + \phi_{b,k}\right)^2}$$

$$E\_MAG\_Axis4_{b,k} := \sqrt{\left(H_{b,k}\right)^2 \cdot \cos\left(\omega \cdot t4_{b,k} + \theta_{b,k}\right)^2 + \left(V_{b,k}\right)^2 \cdot \cos\left(\omega \cdot t4_{b,k} + \phi_{b,k}\right)^2}$$

Note that ω*t 1 and 3 are the minimum pair while ω*t 2 and 4 are maximum pair. This relationship may not always hold but there will be two similar pairs. But values for 1 and 2 [or any consecutive pair] will contain a minimum and a maximum.

Select maximum value of extremes 1 and 2 below for each b,k combination

Same

$$E\_MAX_{b,k} := \max\left(E\_MAG\_Axis1_{b,k}, E\_MAG\_Axis2_{b,k}\right)$$

Next select the maximum value at each position k by selecting the maximum value while varying b, the time interval. This program eliminates the time index b.

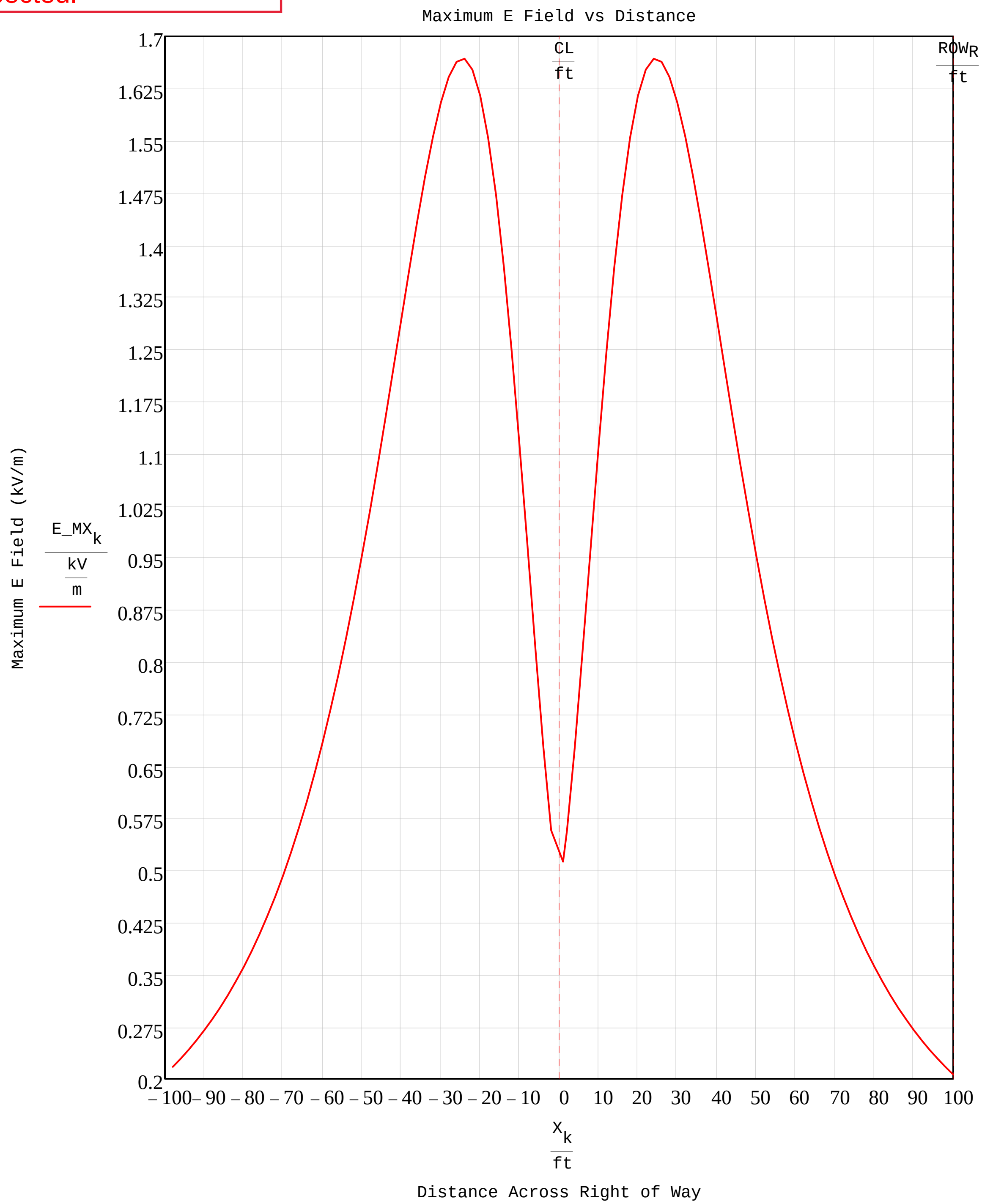
```
E_MX_k := | A_k ← 0
          | for  b ∈ 0, 1 .. (b_max − 1)
          |     | b ← b + 1
          |     | A_k ← E_MAX_b,k  if E_MAX_b,k > A_k
          |     | A_k  otherwise
          | A_k
```

Same

Step 6.3A PLOT Maximum values of total E Field as it traces the field ellipse at each point X ft.

MX := max(E_MX) MX = $1.668 \cdot \frac{kV}{m}$ U := match(MX, E_MX) = $\begin{pmatrix} 38 \\ 62 \end{pmatrix}$ Peak4 := $X_{(U_1)} = -24 \cdot ft$ Peak5 := $X_{(U_2)} = 24 \cdot ft$

Plot is OK and as expected.



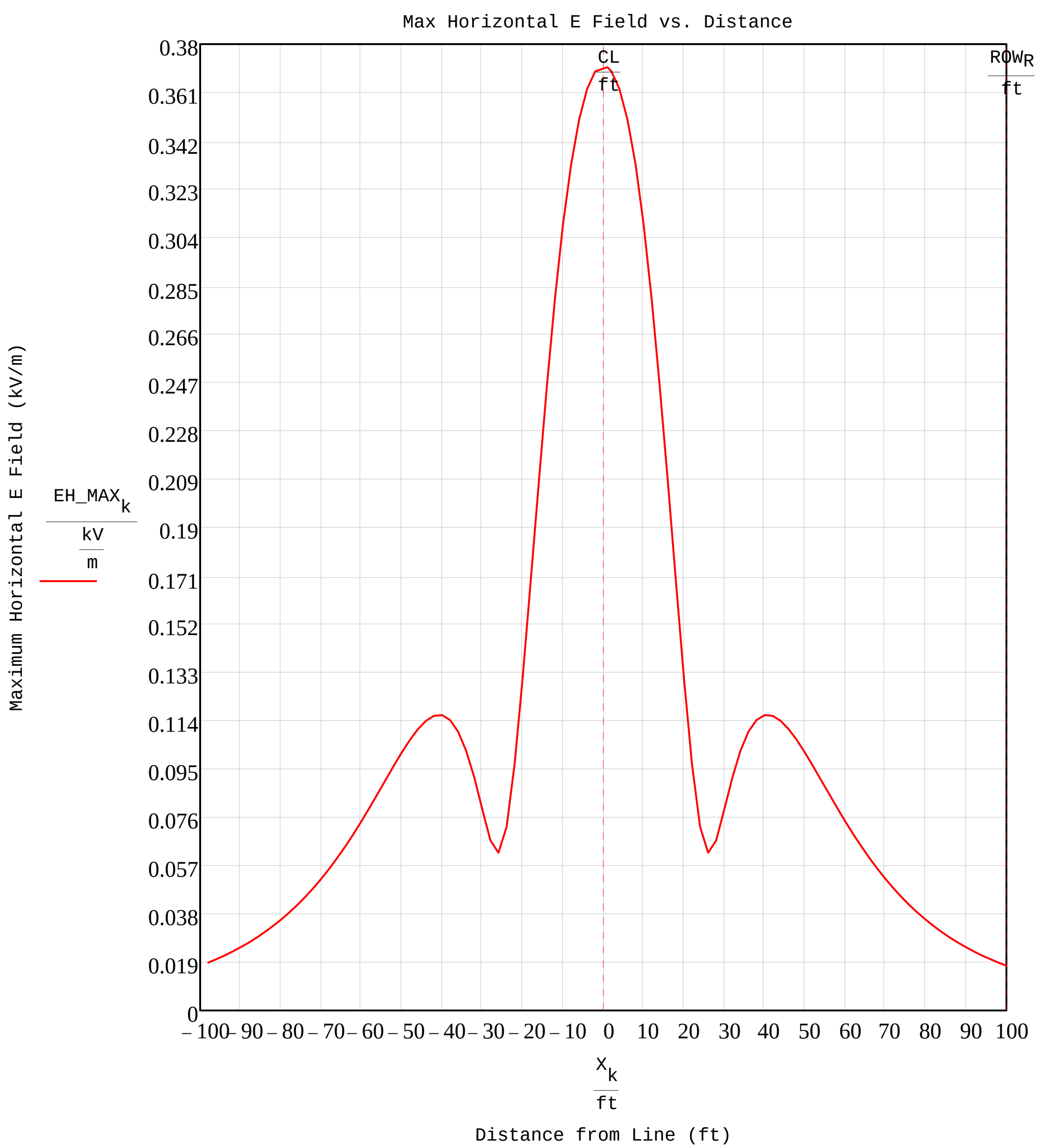
Step 6.4 COMPUTE and PLOT Separate Maximum Horizontal (X) Component

$$H_{b,k} := \sqrt{\left(Re\_EXT_{b,k}\right)^2 + \left(Im\_EXT_{b,k}\right)^2}$$

```
EH_MAX_k := | HMAX_k ← 0
            | for  b ∈ 0, 1 .. (b_max − 1)
            |     | b ← b + 1
            |     | HMAX_k ← H_b,k   if  H_b,k > HMAX_k
            |     | HMAX_k   otherwise
            | HMAX_k
```

Plots OK and as expected.

$HX := \max(EH\_MAX)$ $HX = 0.371 \cdot \frac{kV}{m}$ $M := \text{match}(HX, EH\_MAX) = (50)$ $Peak3 := \left(X_{M_1}\right) = 1 \cdot ft$



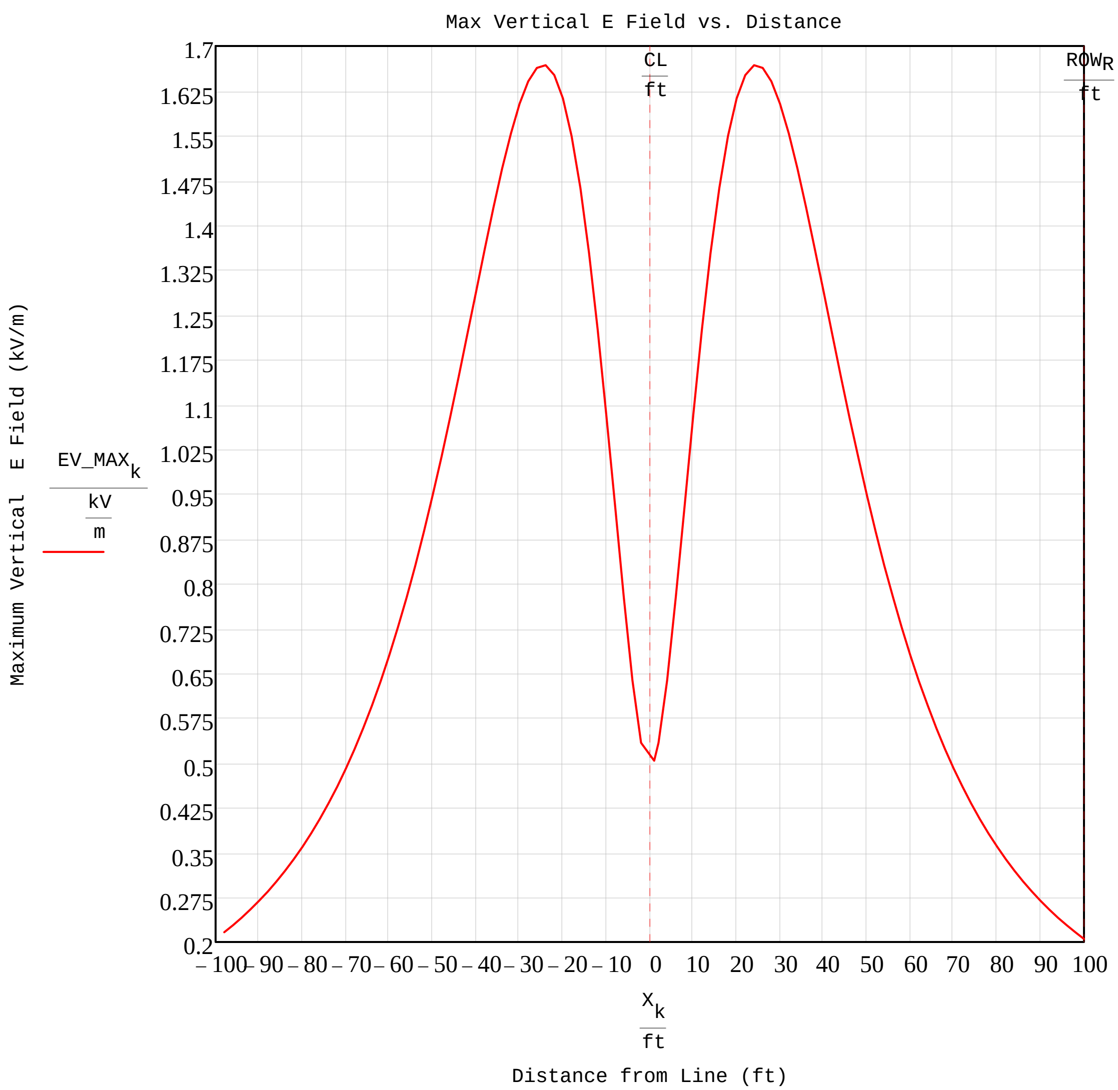
Step 6.5 COMPUTE and PLOT Separate Maximum Vertical (Y) Field Component

$$V_{b,k} := \sqrt{\left(Re\_EYT_{b,k}\right)^2 + \left(Im\_EYT_{b,k}\right)^2}$$

```
EV_MAX_k :=  | VMAX_k ← 0
             | for b ∈ 0, 1 .. (b_max − 1)
             |    | b ← b + 1
             |    | VMAX_k ← V_b,k  if V_b,k > VMAX_k
             |    | VMAX_k  otherwise
             | VMAX_k
```

Plots OK and as expected

$VX := max(EV\_MAX)$ $VX = 1.668 \cdot \frac{kV}{m}$ $Z := match(VX, EV\_MAX) = \begin{pmatrix} 38 \\ 62 \end{pmatrix}$ $Peak1 := X_{(Z_1)} = -24 \cdot ft$ $Peak2 := X_{(Z_2)} = 24 \cdot ft$



STEP 7 COMPUTE Space Potential VR from Q values in step 3.8 above

Step 7.1 SET UP Line Voltages

$$VMX := V_{lg} \cdot \begin{bmatrix} e^{j \cdot \frac{2 \cdot \pi}{3}} \\ 1 \\ e^{-\left(j \cdot \frac{2 \cdot \pi}{3}\right)} \\ 0 \\ 0 \end{bmatrix} \qquad VMX = \begin{pmatrix} -66.395 + 115j \\ 132.791 \\ -66.395 - 115j \\ 0 \\ 0 \end{pmatrix} \cdot kV$$

Step 7.2 COMPUTE Line Char

$$QSP := P^{-1} \cdot VMX \qquad QSP = \begin{pmatrix} -6.587 \times 10^{-7} + 9.819j \times 10^{-7} \\ 1.258 \times 10^{-6} \\ -6.587 \times 10^{-7} - 9.819j \times 10^{-7} \\ -2.061 \times 10^{-8} - 1.299j \times 10^{-7} \\ -2.061 \times 10^{-8} + 1.299j \times 10^{-7} \end{pmatrix} C \cdot m^{-1}$$

$$QSP_{REAL} := Re(QSP) = \begin{pmatrix} -6.587 \times 10^{-7} \\ 1.258 \times 10^{-6} \\ -6.587 \times 10^{-7} \\ -2.061 \times 10^{-8} \\ -2.061 \times 10^{-8} \end{pmatrix} C \cdot m^{-1} \qquad QSP_{IMAG} := Im(QSP) = \begin{pmatrix} 9.819 \times 10^{-7} \\ 0 \\ -9.819 \times 10^{-7} \\ -1.299 \times 10^{-7} \\ 1.299 \times 10^{-7} \end{pmatrix} C \cdot m^{-1}$$

Step 7.3 EXPRESS Intermediate dimensional parameters using the same notation as BPA

Set up coordinates for conductors:

$$X2_i := \left(C^{\langle 1 \rangle}\right)_i \qquad Y2_i := \left(C^{\langle 2 \rangle}\right)_i$$

Express real, imaginary and total space potential in terms of x, y

$$VR2(x,y) := \frac{1}{\varepsilon} \cdot \sum_{i=1}^{NC} \left[QSP_{REAL_i} \cdot \left[\ln\left[\frac{\sqrt{\left(X2_i - x \cdot ft\right)^2 + \left(Y2_i - y \cdot ft\right)^2}}{y_m} \right] - \ln\left[\frac{\sqrt{\left(X2_i - x \cdot ft\right)^2 + \left(Y2_i + y \cdot ft\right)^2}}{y_m} \right] \right] \right]$$

$$VI2(x,y) := \frac{1}{\varepsilon} \cdot \sum_{i=1}^{NC} \left[QSP_{IMAG_i} \cdot \left[\ln\left[\frac{\sqrt{\left(X2_i - x \cdot ft\right)^2 + \left(Y2_i - y \cdot ft\right)^2}}{y_m} \right] - \ln\left[\frac{\sqrt{\left(X2_i - x \cdot ft\right)^2 + \left(Y2_i + y \cdot ft\right)^2}}{y_m} \right] \right] \right]$$

$$VT2(x,y) := \frac{\sqrt{VR2(x,y)^2 + VI2(x,y)^2}}{kV}$$

Step 7.4 SET UP boundaries for contour plot of space potential.

Step 7.4.1 EXTRACT limits of X and Y conductor positions.

$Xmin := Round\left(min\left(C^{\langle 1\rangle}\right), 1\cdot ft\right)$ $Ymin := Round\left(min\left(C^{\langle 2\rangle}\right), 1\cdot ft\right)$ $Xmin = -16\cdot ft$ $Ymin = 35\cdot ft$

$Xmax := Round\left(max\left(C^{\langle 1\rangle}\right), 1\cdot ft\right)$ $Ymax := Round\left(max\left(C^{\langle 2\rangle}\right), 1\cdot ft\right)$ $Xmax = 16\cdot ft$ $Ymax = 45\cdot ft$

Step 7.4.2 SPECIFY deltas to compute bounds of plot from limits above. Note vary these values to expand the plot area.

$\delta X := 10\cdot ft$ $\delta Y := 20\cdot ft$

Step 7.4.3 COMPUTE left, right X and lower,upper Y boundaries for plot. Note that you can also alter the plot area by adding an appropriate multiplication factor in front of δx or δy.

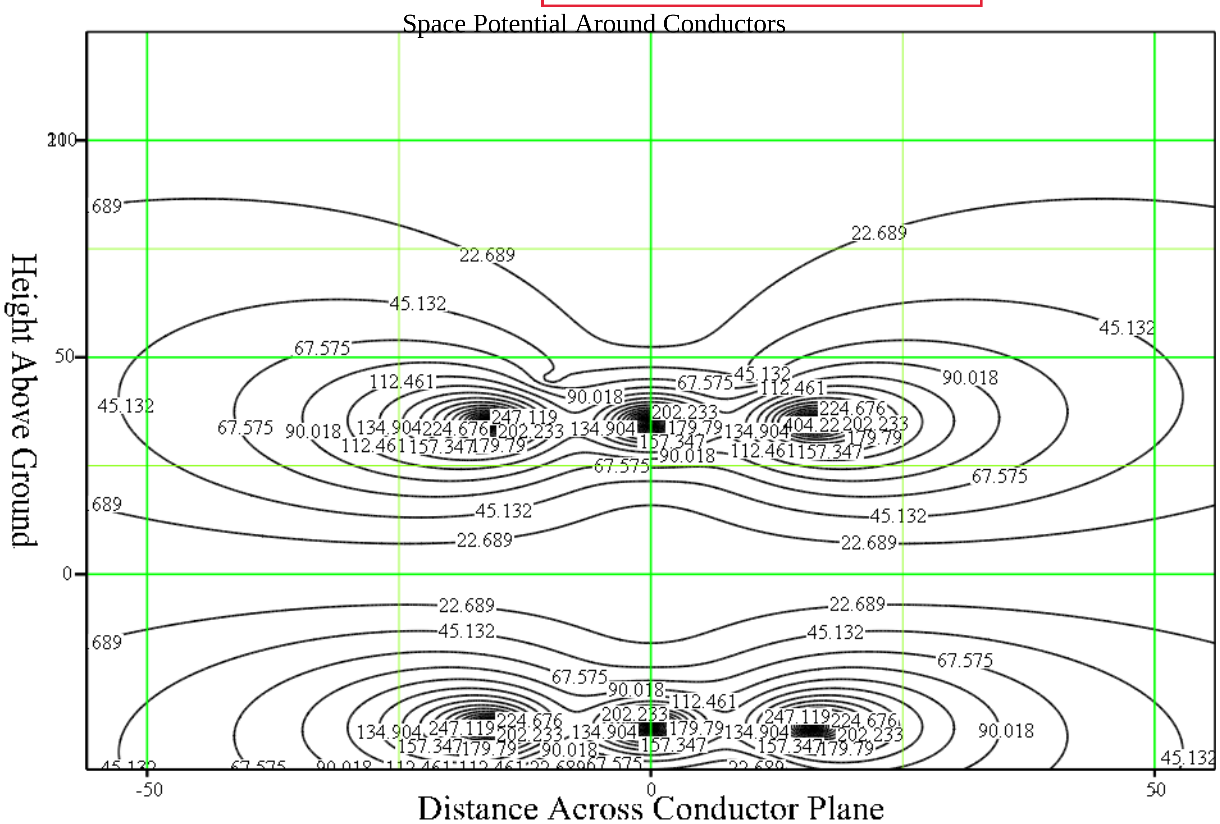
$XL := \frac{Xmin - 4\delta X}{ft}$ $XR := \frac{Xmax + 4\delta X}{ft}$ $YU := \frac{Ymax + 4\delta Y}{ft}$ $YL := \frac{Ymin - 4\delta Y}{ft}$

$XL = -56$ $XR = 56$ $YU = 125$ $YL = -45$

Step 7.5 CREATE Mesh for grid and produce the contour plot. See the description of input for the CreateMesh command below. You can directly vary all the inputs to the right of the function (VTT),i.e replace say XL with a number. The electric potential is often used to pick the most appropriate ADSS jacket and position on the structure.

VTT := CreateMesh(VT2, XL, XR, YL, YU, 200, 200)

Plots OK and as expected. Need to vary plot parameters for best view.



VTT