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# Calculation of Right of Way Considering Electric Field, Audible Noise and Radio Interference

**Amit F. Pagi**[1]

[1]*Electrical Engineering Department, SSEC*
*Bhavnagar, India*

*Abstract* — ***A strip of land required for transmission line to construct and maintain is known as right of way of transmission line. Right of way of transmission line is calculated by considering electric field, audible noise and radio interference. Electric field and corona effect both are considered for the evaluation of right of way. Considering these parameters for calculation provides the idea of effect of electric field and corona to surrounding atmosphere.***

***Keywords-Transmission line, electric field, audible noise, radio interference, right of way.***

## I. INTRODUCTION

With increasing the demand of power utilization, bulk amount power to be transferred. Power transmission is done on high voltage to minimize the transmission losses. High transmission has several problems i.e. electric and magnetic field effect on nearby humans, animals and plants. For the corridor passed through the forest then vegetation control of nearby trees is needed. Due to corona effect on high voltage audible noises is generated which become nuisance for nearby people. Radio interference deteriorates the quality of radio signals. Hence communication problem arises. Right of way with its safety region is denoted below.[1]

W= 2WR + WT

Where WR is width of safety region,

WT is width of tower

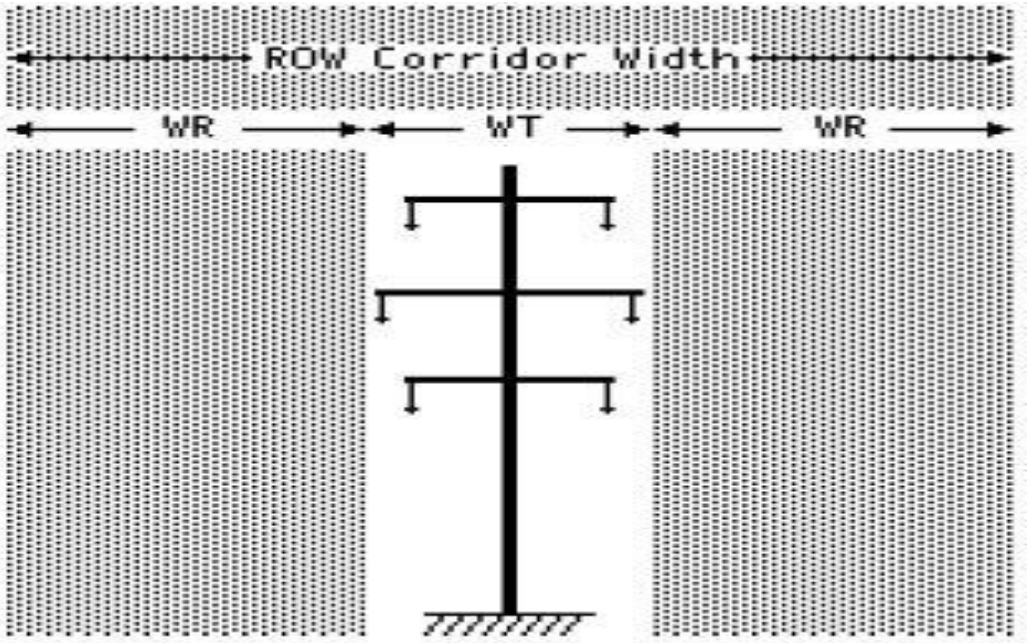


***Fig. 1 Right of way with safety region***[1]

Therefore it is necessary to calculate the corridor for the transmission line beyond that corridor these affect is lesser than predetermined level. Safety limit of these parameter are shown in table.

***Table no. 1 Safety limits of electric field, audible noise and radio interference***

| Parameter | Safety limits | |
|---|---|---|
| Electric field | 5 kV/m[2][3] (Public exposure) | 10 kV/m[2][3] (Occupation exposure) |
| Audible noise | 52.5 dB[4] | |
| Radio interference | 40 dB at 1 MHz[4] | |

## II. CALCULATION OF ELECTRIC FIELD, AUDIBLE NOISE AND RADIO INTERFERENCE

### 2.1 Calculation of electric field

Calculation of electric field is based on image conductor method. For the calculation of electric field charge of conductor is required. Hence transmission line voltage is converted into charge by following relation.[4]

$$[Q/2\pi e_0] = [P]^{-1}[V] = [M][V]$$

Where

$$P_{ii} = \ln(2H/r_{eq}) \text{ and } P_{ij} = \ln(I_{ij}/A_{ij})$$

Here it is electric field is found at $D_i$ distance from the conductor. If the charge on conductor is $q_i$ then

$$E_c = (q_i/2\pi e_0)(1/D_i)$$

Horizontal and vertical component of electric field are as follows.

$$E_{hi} = (q_i/2\pi e_0)\big(x - x_i\big)/[1/{D_i}^2 - 1/(D_i')^2]$$

$$E_{vi} = (q_i/2\pi e_0)\,[(y - y_i)/{D_i}^2 - (y + y_i)\,/{D_i}'^2]$$

Total electric field

$$E = \sqrt{(E_{hi}^2 + E_{vi}^2)}$$

Due to phase difference, total electric field is[4]

$$E_{vn} = V(K_{v1}^2 + K_{v2}^2 + K_{v3}^2 - K_{v1}K_{v2} - K_{v2}K_{v3} - K_{v3}K_{v1})^{1/2}$$

Where $K_{v1} = K_1.M_{11} + K_2.M_{21} + K_3.M_{31}$

$K_{v2} = K_1.M_{12} + K_2.M_{22} + K_3.M_{32}$

$K_{v3} = K_1.M_{13} + K_2.M_{23} + K_3.M_{32}$

And $K_i = \ (y - y_i)/{D_i}^2 - (y + y_i)\,/{D_i}^2]$

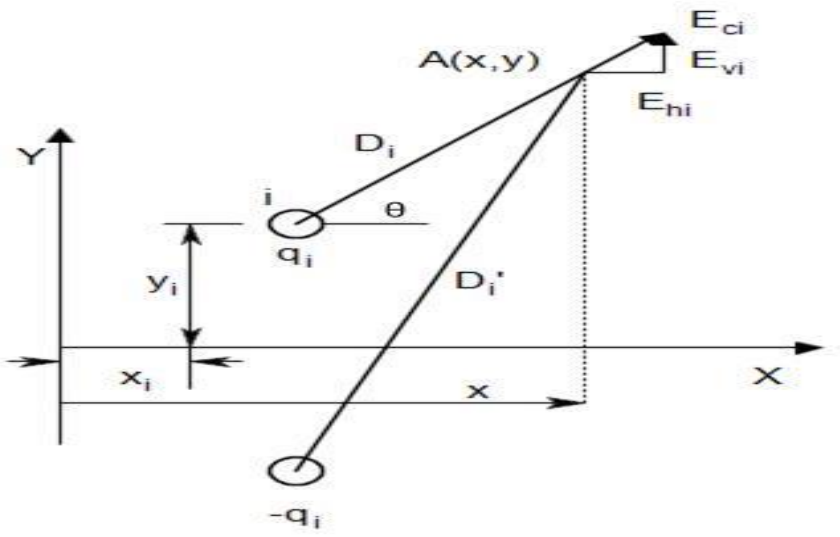


***Fig. 2 Calculation of electric field by image conductor method***

A safety limit of electric field is given in table no.1. Electric field has several hazardous effects on human health as well as plant life. High intensity of electric field causes the risk of damaging DNA, risk of cancer, risk of miscarriage etc.[5] Delta configuration has lesser electric field intensity compare to horizontal configuration.[6]

### 2.2 Calculation of audible noise

In high voltage transmission line, a humming noise is produced due to ionization of air. This noise becomes nuisance for human. This audible noise is calculated by following equation. Following figure indicates the situation of three conductors and a point where quantity is to be measured.

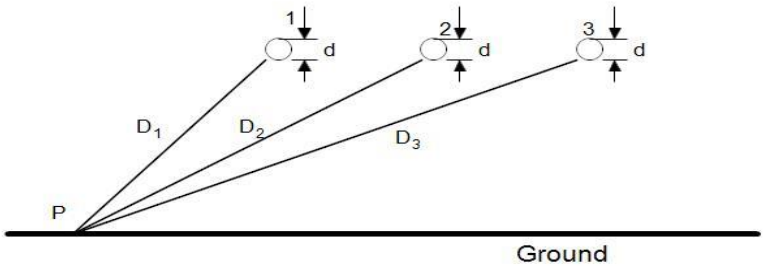


***Fig. 3 Configuration for calculation of audible noise and radio interference***

Audible noise is calculated by[4]

For $N < 3$

$$AN(i) = 120 \log_{10} E_{am}(i) + 55 \log_{10} d - 11.4 \log_{10} D(i) - 115.4\ dB$$

For $N \geq 3$

$$AN(i) = 120 \log_{10} E_{am}(i) + 55 \log_{10} d - 11.4 \log_{10} D(i) + 26.4 \log_{10} N - 128.4\ dB$$

Here $E_{am}$ is surface voltage gradient of conductor, d is a diameter of sub-conductor, D is an aerial distance and N is number of sub-conductor.

Total AN is obtained by following equation[4]

$$AN = 10 \log_{10} \sum_{i=1}^{3} 10^{0.1AN(i)}\ \text{dB}$$

Here, it is considered for 3 conductor configuration. Safety limits of AN is given in table no.1

### 2.3 Calculation of radio interference

Radio interference is produced due to corona which affects the performance of communication. It creates noise in communication network. Hence the quality of signal is reduced. RI affects amplitude modulation (AM) technique. It affects when the AM is in the range of 0.5 to 1.5 MHz.

Calculation of RI is found by following equation.[4]

$$RI_i(dB) = 3.5 g_m + 6d - 33 \log_{10}(D_i/20) - 30$$

Here $g_m$ is maximum conductor surface voltage gradient; d is a diameter, D is an aerial distance. A safety limit of RI is given in table no.1.

## III. RESULT AND DISCUSSION

For calculation purpose, a horizontal configuration is taken. In this configuration, conductor height from the ground is H m, separation between phases is S m, number of sun-conductor is denoted by N, bundle spacing is denoted by B, and d indicated the diameter of conductor. Below figure gives the brief idea about the configuration.

Data utilized for the calculation of electric field, audible noise and radio interference is as follows. [4]

Line voltage=735 kV,

Height of conductor a from ground = 20 m

Height of conductor b from ground = 20 m

Height of conductor c from ground = 20 m

Separation between conductor a and b = 14 m

Separation between conductor b and c = 14 m

Separation between conductor c and a = 28 m

Number of sub-conductor = 4

Conductor diameter = 0.01525 m

Bundle spacing = 0.4572 m

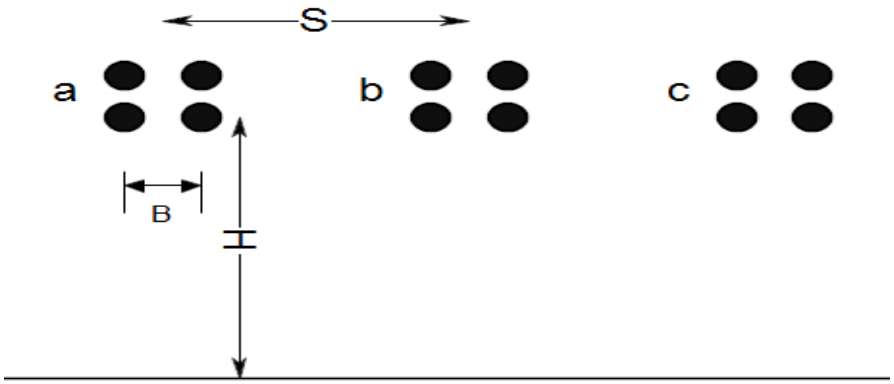


***Fig. 4 Horizontal line configuration***

Electric field is measured at 2 meter above from the ground level whereas audible noise and radio interference is measured at ground level. Result obtained by using above data is shown below.

### 3.1 Electric field

Plot of electric field versus distance from center line is shown below. Electric field shown in graph is 2 m above from the ground level. Electric field under the outer conductor is highest compare to other places. There is dip in electric field plot under the central conductor. As distance increase from the center line electric field reduce gradually. From figure it observed that at the 42 m distance from the center line electric field is less than 2 kV/m which is a safety limit of electric field. Hence right of way of transmission line is 42 m is only electric field is considered.

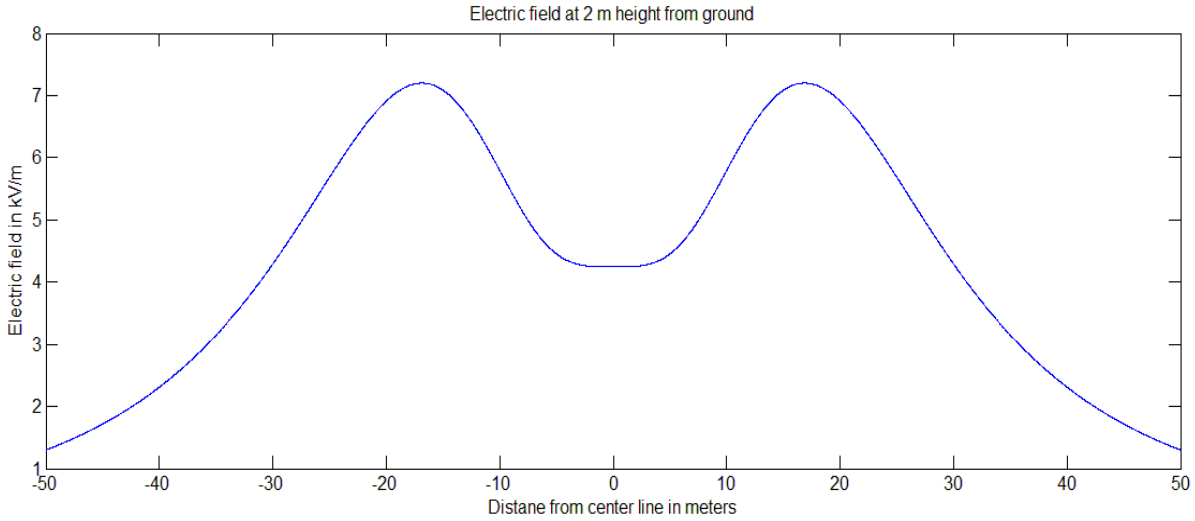


***Fig. 5 Electric field profile at 2 m height from ground***

### 3.2 Audible Noise

Plot of audible noise versus distance from center line is shown below. It is observed that audible noise is highest under the central conductor. Audible noise is decrease with increase in distance from the center line. Audible noise lies in safety region beyond 39 m from the center line. Hence right of way is 39 m, if only audible noise is considered.

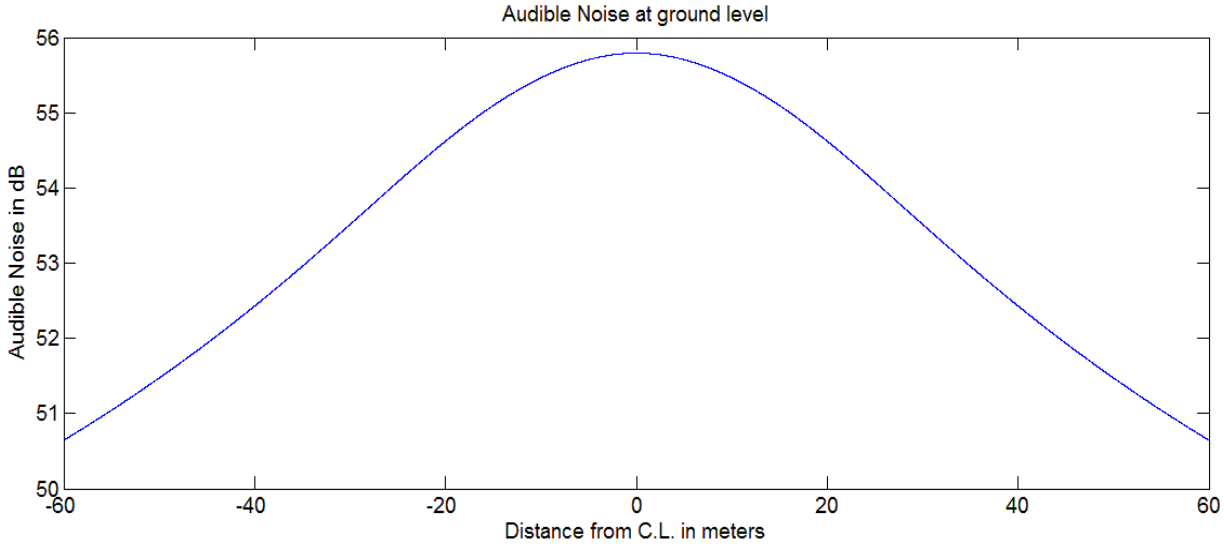


***Fig. 6 Audible noise profile at ground level***

### 3.3 Radio interference

Plot of radio interference versus distance from center line is shown below. RI is observed highest under the central conductor. Intensity of RI is decrease with increase the distance from the center line. At 1 MHz, the maximum permissible limit of RI is 40 dB. RI value less that its limit is beyond 38 m. Hence right of way is 38 m is only RI is considered.

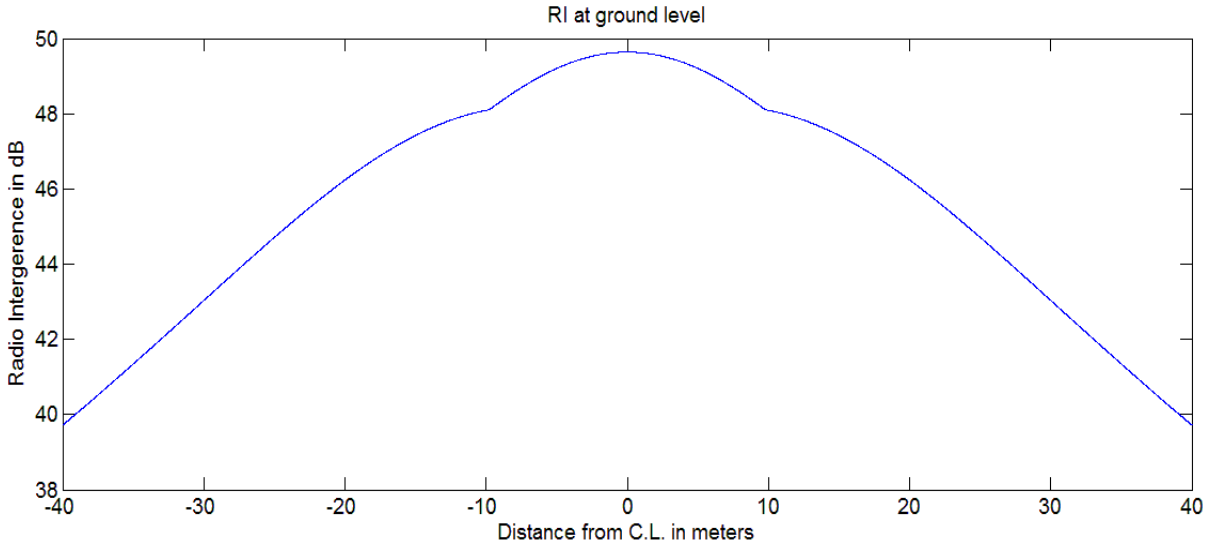


***Fig. 7 Radio interference profile at ground level***

Separate right of way by considering only electric field, audible noise and radio interference is 42 m, 39 m and 38 m respectively. If all three parameter are considered then transmission line right of way becomes 42 m.

## IV. CONCLUSION

In this paper calculated right of way considered the effect of electric field, audible noise and radio interference. Hence beyond the right of way of transmission line three parameters i.e. electric field, audible noise and radio interference intensity below the safety limits.

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