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# Design and Analysis of 500 kV Extra-High-Voltage AC Transmission Line

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**Abstract:** From economical point of view, transmission line system is very important in the electricity supply system. The choice of the line voltage is important to do the design of power transmission line. The electrical transfer of energy from one place to another over long distance with standard regulations is one of the major problems in the field of electrical power engineering. The parameters of overhead transmission line are resistance, inductance and capacitance. The purpose of this thesis is to study, analyze and design of Extra-High-Voltage transmission line with the comprehensive electrical and environmental engineering considerations. It is very important to do design works for each and every Extra-High-Voltage transmission line, to consider all possible plans and changes in the future power system. In design consideration, selection of economic voltage, choice of conductor size, numbers of conductor are considered. Estimating all possible environmental impacts from transmission lines such as conductor surface gradient, radio interference, audible noise and random noise are also described in detail.

**Keywords:** Transmission Line System, Electricity Supply System, Economic Voltage, Conductors, Environmental Impacts.

## I. INTRODUCTION

The electrical transfer of energy from one place to another over long distances with standard regulations is one of the major problems in the field of electrical power engineering. A transmission line is that part of an electrical power system whose function is the transfer of electrical energy from the station where it is generated to a substation where it is distributed. A transmission line may also serve to transfer the energy between two stations of the same system. In order to transmit heavy power efficiently for any considerable distance, comparatively high voltage is required. So, economic choice of voltage should be considered for any power transmission line. The selection of size of the conductor is also important in order to carry the amount of enough current that flows on the line due to the transfer of power. Moreover, the amount of power losses and voltage drop on the line should be in an acceptable range as in the standard regulations. In transmission system, there are two kinds of transmission line, namely overhead lines and underground cables. Overhead line transmission system is cheaper than underground cable system. But maintenance cost for overhead line is higher than that of the underground cables.

The economics of AC power transmission have always forced the planning engineering to transmit as much power as possible through a given transmission line. Today, however, additional constraints should be considered much larger than in the past. In the past, it is only necessary to consider thermal limit for short distance lines with low voltage level and stability limit for medium distance line with medium voltage level and stability limit for long distance line with High-Voltage, Extra-High-Voltage and Ultra-High-Voltage levels. According to the experiences, knowledge and advanced socio-economic situations, the concept of insulation coordination and electrical environmental assessments are mainly influenced for the design of High-Voltage, Extra-High- Voltage and Ultra-High-Voltage transmission lines. According to the International Electrical and Electronic Engineering (IEEE) Standard (1313-1993), for purposes of insulation coordination, maximum system voltages above 1 kV are divided into four voltage classes [4].

Medium Voltage (MV) ->1kV and ≤72.5kV
High Voltage (HV) ->72.5kV and ≤242kV
Extra-High Voltage (EHV) ->242kV and <1000kV
Ultra-High Voltage (UHV) -≥1000kV

## II. TYPES OF CONDUCTOR

In the early days of transmission of electric power conductor were usually copper but aluminum conductors have completely replaced copper because of the much lower cost and lighter weight of aluminum conductor compared with a copper conductor of the same resistance. The fact that an aluminum conductor has a large diameter than a copper conductor of the same resistance is also an advantage. With a larger diameter the line of electric flux originating on the conductor will be farther apart at the conductor surface for the same voltage. Different types of aluminum conductors are as follows;

AAC ; all-aluminum conductors
AAAC; all-aluminum-alloy conductors
ACSR ; aluminum conductor steel-reinforced
ACAR; aluminum conductor alloy-reinforced

ACSR (aluminum conductor steel-reinforced) is the most wildly used conductor material, having particular application at high voltage. It is made up of galvanized steel core one or more strands, and one or more outer layers of aluminum wire. The conductivity is taken to be that of the aluminum alone, and the strength to be 85 percent of the sum of the steel wire plus 95 percent of the sum of the aluminum wires. In H.V lines, the increased diameter of the conductor helps to raise the corona inception level with consequent reduction in power losses and radio interferences [2].

**A. Line constants**

The transmission line is an electric circuit which has four constants, that is resistance R, inductance L, capacitance C and leakage admittance y and it is necessary to fully understand these line constants so as to calculate its electrical characteristics.

**B. Resistance**

The resistance of transmission line conductors is the most important cause of power loss in a transmission line. The term resistance, unless specifically qualified, means effective resistance. The effective resistance of a conductor is

$$R = \frac{\text{power loss in conductor}}{|I|^2} \quad \textbf{(1)}$$

Where the power is in watt and I is the rms current in the conductor in amperes. The effective resistance is equal to dc resistance of the conductor only if the distribution of current throughout the conductor is uniform. Direct current resistance is given by the formula.

$$R_0 = \frac{\rho l}{A}\,\Omega \quad \textbf{(2)}$$

Where, $\rho$ = resistivity of conductor ($2.83\times10^{-8}\ \Omega$ m)
l = length
A = cross-sectional area

The resistance of a conductor at any temperature is

$$\frac{R_2}{R_1} = \frac{T+t_2}{T+t_1} \quad \textbf{(3)}$$

$R_1$ and $R_2$ are the resistance of conductor at temperature $T_1$ and $T_2$. $T_1$ and $T_2$ are conductor temperature in degrees Celsius.

$T_0$ = constant varying with conductor material
= 234.5 for annealed copper
= 241 for hard-drawn copper
= 228 for hard-drawn Aluminum

**1. Skin effect**

Uniform distribution of the current throughout the cross section of a conductor exists only for direct current. As the frequency of alternating current increase, the non-uniformly of distribution become more pronounced. An increase in frequency causes non-uniform current density. This phenomenon is called skin effect. In resistance calculation the following formula should be used to consider the skin effect,

$$R_{ac} = K\,R_{dc} \quad \textbf{(4)}$$

where, K is a function of X.

$$X = 0.63598\sqrt{\frac{\mu f}{R_{dc}}} \quad \textbf{(5)}$$

f = system frequency in Hz
$\mu$= permeability = 1.0 for non-magnetic material
$R_{dc}$ = dc resistance in $\Omega$/mile

**TABLE 1:** SKIN EFFECT

| X | K | X | K | X | K |
|---|---|---|---|---|---|
| 0.0 | 1.0 | 1.0 | 1.00519 | 2.0 | 1.07816 |
| 0.1 | 1.0 | 1.1 | 1.00758 | 2.1 | 1.09375 |
| 0.2 | 1.00001 | 1.2 | 1.01071 | 2.2 | 1.11126 |
| 0.3 | 1.00004 | 1.3 | 1.01470 | 2.3 | 1.13069 |
| 0.4 | 1.00013 | 1.4 | 1.01969 | 2.4 | 1.15207 |
| 0.5 | 1.00032 | 1.5 | 1.02582 | 2.5 | 1.17538 |
| 0.6 | 1.00067 | 1.6 | 1.02332 | 2.6 | 1.20056 |
| 0.7 | 1.00124 | 1.7 | 1.04205 | 2.7 | 1.22752 |
| 0.8 | 1.00212 | 1.8 | 1.0524 | 2.8 | 1.2562 |
| 0.9 | 1.00340 | 1.9 | 1.0644 | 2.9 | 1.28644 |

Source; [1]

**C. Inductance and inductive reactance**

When the conductors of three-phase line are not spaced equilaterally, the problem of finding the inductance becomes more difficult. Then the flux linkages and inductance of each phase results in an unbalanced circuit. Balance of the three phase can be restored by exchanging the position of conductors at regular intervals along the line so that each conductor occupies the original position of every other conductor over an equal distance .Such an exchange of conductor position is called 'transposition' [1]. The inductance per phase in bundle is,

$$L = 2\times10^{-7} \ln \frac{D_{eq}}{D_S^b} \quad \textbf{(6)}$$

For 4-strand bundle, $D_S^b = 1.09\sqrt[4]{D_S \times d^3}$ **(7)**

$D_{eq}$ = equivalent GMD
$D_s$ = GMR of the conductor
d = Spacing of bundle conductor

The inductive reactance,

$$X_L = 2\,\pi\,f\,L \quad \text{Ohm/km} \quad \textbf{(8)}$$

**TABLE 2:** SELF-GMD OR GMR OF STRANDED CONDUCTORS

| | |
|---|---|
| Solid round conductor | 0.779 R |
| Full stranding: | |
| 7-strands | 0.726 R |
| 19-strands | 0.758 R |
| 37-strands | 0.768R |
| 61-strands | 0.772R |
| 91-strands | 0.774 R |
| 127-strands | 0.776 R |
| Hollow stranded conductors and ASCR (neglecting steel strands): | |
| 30-strands (two-layers) | 0.826 R |
| 26-strands (two-layers) | 0.809 R |
| 54-strands (two-layers) | 0.810 R |

Source; [5]

**D. Capacitance and capacitive reactance**

Capacitance to neural is the ratio of the change on a conductor to the voltage between that conductor and neutral.

$$C = \frac{2\pi k}{\ln\left(\frac{D_{eq}}{D_{sc}^b}\right)} \quad \text{F/m} \quad \textbf{(9)}$$

for 4-strand bundle, $D_{sc}^b = 1.09\sqrt[4]{rd^3}$ **(10)**

$D_{eq}$ = equivalent GMD
r = radius of conductor
d = Spacing of bundle conductor

$k = 8.85\times10^{-12}$ F/m

The capacitive reactance, $X_c = \frac{1}{2\pi f C_n}$ Ohm km **(11)**

**E. Surge impedance**

In transmission system, characteristic impedance is called surge impedance. It is usually reserved for the special case of a losses line. If a line is lossless, its resistance and conductance are zero and the characteristic impedance reduces as,

$$Z_0 = \sqrt{X_L X_C} \text{ (Ohms)} \quad \textbf{(12)}$$

where, $X_L$= series inductance per unit length of the line
$X_C$= shunt capacitance per unit length of the line

These $X_L$ and $X_C$ are the basic parameter of the transmission line [3]. In transmission system, characteristic impedance is called surge impedance. It is usually reserved for the special case of a losses line. If a line is lossless, its resistance and conductance are zero and the characteristic impedance reduces as,

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**E. Surge impedance loading (SIL)**

Surge Impedance Loading (SIL) of a line is the power delivered by a line to a purely resistive load equal to its surge impedance. Under this condition the sending-end and receiving-end voltages are equal in magnitude but different in phase position. Surge impedance loading in itself is not a measure of maximum power that can be delivered over line.

$$SIL(3\phi) = (kV_{LL})^2/Z_0 \quad \text{(MW)} \quad \textbf{(13)}$$

where, $kV_{LL}$ = line to line voltage (kV, rms)
$Z_0$ = Surge impedance of the line (ohms) [3]

## III. DESIGN CONSTRUCTION FOR 500KV EHV AC TRANSMISSION LINE

**A. Selection of transmission line voltage**

It is very important to select proper voltage level for a transmission line because that will lead to many consequences in operation of power system and if there is an incorrect decision by a designer or decision marker, it is very difficult and costly to solve the problems in future. Generally the supply power and the line length will be given; the most economic voltage can be determined by the following equation.

$$V = 5.5\sqrt{L + \frac{\text{Load in KVA}}{150}}\ \text{kV} \qquad \textbf{(14)}$$

where, L = Line length in mile (263 miles)

### B. Economic size of conductor

Kelvin's Law may be represented by the following formula in case of aluminum conductor.

$$C = 0.013\sqrt{\frac{ap}{q}}\ \ (\text{Ampere/mm}^2) \qquad \textbf{(15)}$$

where,

C = most economical density of current (Ampere/mm$^2$)

a = percent annual expense to the construction cost of conductor (18.4%)

p = price of conductor (kyat/kg) (2500 kyat/kg)

q = cost of electricity (kyat/kWh) (35 kyat/kWh)

The current I is work out as follows:

$$I = \frac{\mu P}{\sqrt{3} V pf}\ \text{Ampere} \qquad \textbf{(16)}$$

where, µ = utility factor being (0.6 )

pf = power factor being 0.85

V = line voltage (kV) (500 kV)

P = Maximum Power (kW) (790 MW)

The most economic size of conductor=A=I/C (mm$^2$) **(17)**

### C. Choice of conductor by corona voltage

The corona critical voltage of bundle conductor is expressed as.

$$V_C = \sqrt{3}\, m_0 m_1 \delta^{\frac{3}{2}} \times 48.8 \times \frac{nr}{1 - \frac{2(n-1)}{S}\sin\frac{\pi}{n}} \times \left(1 + \frac{0.301}{\sqrt{rd}}\right)\log\frac{D}{r^{\frac{1}{n}} S^{\frac{(n-1)}{n}}} \qquad \textbf{(18)}$$

Where, n is the number of components of the bundle conductor and S is the geometric mean value of the space between the components and given by the following expression.

$$S = \sqrt[n-1]{S_{12} S_{13} S_{14}} \qquad \textbf{(19)}$$

Where,

$V_C$= disruptive critical voltage in kV (line to line)

$m_0$= factor of irregularly of conductor surface being 0.8

$m_1$= factor of weather being 1 in fair weather and 0.8 in rainy weather

δ = factor of air density being 1.0

D = spacing of conductor (cm) (1310 cm)

d = Diameter of conductor (2.589 cm)

n = number of bundle conductor (4)

### D. Contamination design for porcelain insulator

The target withstand voltage for contamination design can be calculated with the following Equation,

$$\text{Targets withstand voltage} = \frac{\text{maximum voltage (KV)}}{\sqrt{3}} \times 1.2 \qquad \textbf{(20)}$$

The design withstand voltage of each insulator discs is proportional to the number of insulator strings. Table shows the design withstand voltage of a porcelain insulator discs according to the Equivalent Salt Deposit Density (ESDD) level.

**TABLE 3:** CONTAMINATION DESIGN WITHSTAND VOLTAGE (KV/DISC) FOR PORCELAIN SUSPENSION INSULATOR

| Kind of insulator | Size of insulator (mm) | | | ESDD (mg/cm$^2$) | | | |
|---|---|---|---|---|---|---|---|
| | Diameter | Connection distance | Leakage distance | 0.03 | 0.06 | 0.12 | 0.25 |
| Susp-insulator | 280 | 170 | 370 | 13 | 11.2 | 9.7 | 8.3 |
| Susp-insulator | 320 | 195 | 460 | 15 | 12.9 | 11.2 | 9.6 |

Source; [6]

### E. Environmental impacts

Environmental impacts from transmission lines are conductor surface gradient, radio interference, audible noise and random noise.

### 1. Conductor surface gradients

Generally, the gradient is not uniform around the periphery of a conductor but has points of defined minimum and maximum. In bundled conductors, the individual sub-conductors may have values of maximum gradient which differ from each other. For a bundle of two or more sub-conductors of individual sub-conductors, the highest value among the gradient s of individual sub-conductors is defined as the maximum bundle gradient. The calculation steps for gradient are as follows:

1. Determine values of capacitance per unit length of line C, in farads/meter.
2. Determine average charge density on one conductor of the phase bundle.

$$Q = CV/N \text{ (kC, rms/meter)} \quad \textbf{(21)}$$

where, C = Capacitance (F/meter)
  a. V = line-to-ground voltage (kV,rms)
  b. N = Number of bundle conductor per phase
3. Find the average conductor gradient

$$E_{AV} = Q/(2\pi\varepsilon_0 r) \text{ (kV,rms/cm)} \quad \textbf{(22)}$$

where, Q = Average charge density (kC,rms/meter)
$\varepsilon_0 = (1/36\pi)\times 10^{-9}$ (F/meter)
r = conductor radius (cm)

4. Find the bundle diameter,

$$D = S/[\sin \Pi/N] \quad \textbf{(23)}$$

Where, S = bundle spacing (cm)
N = Number of bundle conductor per phase
5. Determine the maximum value of E around the conductor periphery

$$E_{MAX} = E_{AV}\,[1+(d/D)\,(N-1)] \text{ (kV,rms/cm)} \quad \textbf{(24)}$$

Where, $E_{AV}$=Average conductor gradient (kV,rms/cm)
D = Bundle diameter (cm)
d = sub-conductor diameter (cm)

6. For the horizontal case, the gradient calculated in step 5 is for the outer phase, for the middle phase, multiply by a factor of 1.08. For the delta case, the gradient calculated in step 5 is within the accuracy limit for all phase.

**2. Audible Noise**

Bonneville Power Administration (BPA) formula is probably the most widely used formula and is described next. The average or the L50 value of AN in rainy weather for any phase of the transmission line is given as:

$$AN_i = 120\log(g) + k\log(n) + 55\log(d) - 11.4\log(R) + AN_0 \quad \textbf{(25)}$$

where, g = average maximum bundle gradient ( kVrms/cm)
n = the number of sub-conductor
d = the sub-conductor diameter (cm)
R = the radial distance from the phase to the point of observation (m)
k =26.4 for n ≥3, and 0 for n <3
$AN_0$= -128.4(In case of n≥3) and
-115.4 (In case of n<3)

$$SPL = 10\log\left[\sum_{i=1}^{3} 10^{\frac{AN_i}{10}}\right] \quad \textbf{(26)}$$

where, SPL = resultant sound pressure, dB (A)
ANi = Noise Level due to phase I, dB (A)

**3. Random Noise**

Random noise for heavy rain,

$$P = 20\log n + 44\log d - 665/E + 22.9(n-1)d/D + 67.9 - 10\log R - 0.02R \quad \textbf{(27)}$$

where n = number of sub-conductors
d = sub-conductor diameter in cm
D = bundle diameter in cm
E = conductor-surface gradient in kV/cm
R = distance from line to measurement point in m
$K_n$ = 7.5 for n=1, 2.6 for n=2, and 0 for n≥ 3

$$P_{total} = 10\log\left[\sum_{i=1}^{3} 10^{\frac{P_i}{10}}\right] \quad \textbf{(28)}$$

Random noise for wet conductor, $P_{wci} = P_i + \Delta A_{wci}$

$$\Delta A_{wc} = 10.4 - 14.2\, E_c/E + [8(n-1)d/D] \quad \textbf{(29)}$$

$$E_c = 24.4/d^{0.24} \quad \textbf{(30)}$$

$E_c$ = correction factor for wet condition

**4. Radio Interference**

The general form of comparative or empirical formula for calculating the corona generated RI from any phase of the transmission line is

$$RI_{fair} = -105.81 + 117.41\log(Ga) + 40.38\log d + 1.54\log N - 10.22\log D - 27.10\log f \quad \textbf{(31)}$$

$$RI_{foul} = -81.89 + 119.56\log(Ga) + 43.57\log d + 3.97\log N - 19.05\log D - 25.07\log f \quad \textbf{(32)}$$

RI = radio interference in dB above 1µV/m
Ga = Average conductor surface gradient of s phases [kV/cm]
d = Diameter of sub-conductor [cm]
N = Number of sub-conductor
D = Radial distance [m]
f = Frequency [MHz]

## IV. DESIGN CALCULATION RESULTS OF 500KV EHV AC TRANSMISSION LINE

Line Data,
Total Line Length = 423 km (263 mile)
Transmitted Power = 790 MW
System Frequency = 50 Hz
Phase Spacing = 13.1 m
Spacing of bundle conductor = 40 cm
Number of bundle conductor = 4
Line configuration = Horizontal

Economic voltage selection,

$$V = 5.5\sqrt{263 + \frac{790\times10^3}{150}}\ \text{kV} = 409\ \text{kV}$$

Economic voltage = 409 kV
So, selected voltage = 500kV

Economic size of conductor, $A = \frac{I}{C}\ (mm^2)$

Most economical density of current,

$$C = 0.013\sqrt{\frac{18.4\times2500}{35}} = 0.47 \approx 0.5 \quad A/mm^2$$

$$\text{Load current, } I = \frac{\mu P}{\sqrt{3}Vpf} = \frac{0.6\times790\times10^3}{\sqrt{3}\times500\times0.85} = 644\ A$$

I = 644 A (for four conductor)

$$I = \frac{644}{4} = 161\ A \text{ (for 1-conductor)}$$

$$A = \frac{I}{C} = \frac{161}{0.5} = 322\ mm^2 \text{ (636 MCM)}$$

Economic cable size = 636 MCM (322 $mm^2$)

Consideration for choice of 636 MCM 4-bundle conductors by corona voltage,

$$V_C = \sqrt{3}\, m_0 m_1 \delta^{\frac{3}{2}} \times 48.8 \times \frac{nr}{1-\frac{2(n-1)}{S}\sin\frac{\pi}{n}} \times (1+\frac{0.301}{\sqrt{rd}})\log\frac{D}{\frac{1}{r^{\frac{1}{n}}S^{\frac{(n-1)}{n}}}}$$

$$S = \sqrt[n-1]{S_{12}S_{13}S_{14}} = \sqrt[4-1]{40\times56.57\times40} = 44.9\ cm$$

$$V_C = \sqrt{3}\times0.8\times1\times1^{\frac{2}{3}}\times48.8\times\frac{4\times1.295}{1-\frac{2(4-1)}{44.9}\sin\frac{\pi}{4}}\times$$

$$(1+\frac{0.301}{\sqrt{1.295\times2.589}})\log\frac{1310}{\frac{1}{r^{\frac{1}{4}}S^{\frac{(4-1)}{4}}}}$$

$V_C$ = 833.28 kV (Line to Line)

Corona critical voltage, $V_C$ = 833.28 kV (Line to Line)

Thus, 636 MCM, ACSR conductor should be chosen to avoid from corona effect.

Number of insulator

$$\text{Target withstands voltage} = \frac{\text{maximum system voltage (kV)}}{\sqrt{3}}\times1.2$$

= 381 kV

Withstand voltage for 210 kN Suspension insulator =13 kV/disc (From Table 3, ESDD = 0.03 $mg/cm^2$)

Thus, Number of insulator discs = 381/13 = 30 discs (for 210 kN insulators)

Withstand voltage for 300kN Suspension insulator=15 kV/disc (From Table 3, ESDD = 0.03 $mg/cm^2$)

Thus, Number of insulator discs = 381/15 = 26 discs (for 300 kN insulators)

Line constant calculations are as follow; Resistance R, At 20˚C, DC resistance,

$$R_0 = \frac{\rho l}{A} = \frac{2.83\times10^{-8}}{322.3\times10^{-6}} = 0.087806\ \Omega/km$$

At 50℃,

$$\frac{R_{dc(50)}}{R_{dc(20)}} = \frac{T+t_2}{T+t_1}$$

$$R_{dc}(50) = 0.087806 \text{ x } \frac{228\times50}{228\times20} = 0.09843\ \Omega/km$$

$R_{dc}(50)$= 0.09843 x 1.6091 = 0.15838 Ω/mile

Skin effect, $R_{ac} = K\, R_{dc}$ where, K is a function of X,

$$X = 0.063598\sqrt{\frac{\mu f}{R_{dc}}} = 0.063598\sqrt{\frac{1\times50}{0.15838}} = 1.13$$

By using linear interpolation from Table 1,

$$K = 1.00758 + \frac{1.01071-1.00758}{0.15835} \text{ x } (1.13 - 1.1) = 1.008519$$

$R_{ac}$ = 1.008519 x 0.09843= 0.09927 Ω/km

$$\text{For 4-bundle, } R_{ac} = \frac{0.09927}{4} = 0.02482\ \Omega/km$$

Inductance L,

$$D_{eq} = \sqrt[3]{13.1\times13.1\times26.2} = 16.5\ m$$

$D_s$ = 0.826 R (From Table.2, for 30 strands aluminum)

$$D_s = 0.826 \text{ x } \frac{2.589\times10^{-2}}{2} = 0.0107\ m$$

$$\text{For a 4-strand bundle, } D_S^b = 1.09\sqrt[4]{0.0107\times0.4^3} = 0.1763\ m$$

$$L = 2\times10^{-7}\ln\frac{16.5}{0.1763} = 0.9078\ mH/km$$

Inductive reactance,

$X_L$ = 2π x 50 x0.9078 x $10^{-3}$ = 0.2852 Ω/km

Capacitance C, For a 4-strand bundle,

$$r = \frac{2.589\times10^{-2}}{2} = 0.012945\ m$$

$$D_{sc}^b = 1.09\sqrt[4]{1.2945\times10^{-2}\times(0.4)^3} = 0.1849\ m$$

$D_{eq}$ = 16.5 m , k = 8.85 x $10^{-12}$ F/m

$$C_n = \frac{2\pi\times8.85\times10^{-12}}{\ln(\frac{16.5}{0.1849})} = 0.01238\ \mu F/km$$

Capacitive Reactance,

$$X_c = \frac{1}{2\pi f C_n} = 0.2571 \times 10^6\ \Omega\ \text{km}$$

Surge Impedance,

$$Z_0 = \sqrt{X_L X_C} = \sqrt{0.2852 \times 0.2572 \times 10^6} = 270.786\ \Omega$$

Surge impedance loading,

$$SIL_{3\phi} = \frac{(KV_{LL})^2}{Z_0} = \frac{(500)^2}{270.786} = 923.239\text{MW}$$

**TABLE 4:** CALCULATION RESULTS FOR 500 KV EHV AC TRANSMISSION LINE

| | |
|---|---|
| Economic voltage | V = 409 kV |
| Selected voltage | V = 500 kV |
| Economic size of conductor | A = 322 $mm^2$ (636 MCM) |
| Number of conductor | 4 |
| Diameter of conductor | 2.589 cm |
| Corona voltage | $V_C$ = 833.28 kV |
| Number of insulator discs | 30 discs (for 210 kN insulators)<br>26 discs (for 300 kN insulators) |
| Resistance | $R_{ac}$ = 0.02482 Ω/km |
| Inductance | L = 0.9078 mH/km |
| Inductive reactance | $X_L$ = 0.2852 Ω/km |
| Capacitance | C = 0.01238 µF/km |
| Capacitive reactance | $X_C$ = 0.2571 x $10^6$ Ωkm |
| Surge Impedance | $Z_0$ = 270.786 Ω |
| Surge Impedance Loading | 923.239 MW |

**TABLE 5:** CALCULATION RESULTS FOR ELECTRICAL ENVIRONMENTAL EFFECTS OF 500 KV EHV AC TRANSMISSION LINE

| | |
|---|---|
| Maximum bundle gradient | For outer phases,<br>$E_{max}$ = 14.11 kV rms/cm<br>For middle phase,<br>$E_{max}$ = 15.24 kV rms/cm |
| Audible Noise (AN) | $AN_1$ = 34.59 dBA<br>$AN_2$ = 32.48 dBA<br>$AN_3$ = 30.86 dBA |
| Sound pressure level | SPL = 37.68 dBA |
| Random Noise | For heavy rain ------ 45.09 dB above 20µPa<br>For wet conductor ------ 40.16 above 20µPa |
| Radio Interference | $RI_{fair}$ = 44.86 dB µV/m<br>$RI_{foul}$ = 63.02 dB µV/m |

## V. CONCLUSION

In transmission line system, the effects for economical point of view are very important. The choice of the line voltage is important to do the design of power transmission line. Different voltage systems with the same power flow have different carrying current on the line. Higher current tends to produce the higher losses. To reduce the current on the line, the line voltage is to be increased. But the accessories of the line should withstand the higher voltage and which will increase the cost. The size of conductor is generally a very considerable part of the total cost of overhead line. To reduce the power losses in the line, it is necessary to employ conductor of low resistance and therefore large cross sectional area. But the cost of conductor material will increase and small cross sectional area should be used. So utilities should choose the size of conductor by comparing the cost of losses with the cost of conductor material equal the cost of loss is the economical use of the conductor material.

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