Design of 230 kV Twin Bundle Double Circuit Overhead Transmission Line

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ABSTRACT

The purpose of this paper is to study and design of 230 kV twin bundle double circuit overhead transmission line. In design consideration, the selection of economic voltage, choice of conductor size, number of insulators, maximum sag of conductor and minimum height of conductor are considered. 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 bundle conductors are used for reducing the reactance on the line, corona losses, radio interference and surge impedance.

KEYWORDS: twin bundle double circuit, overhead transmission line, resistance, inductance and capacitance

1. 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.

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.

2. LITERATURE REVIEW

A Transmission line is a device for the transfer of electric energy. It can transfer the energy over long or short distance at different voltages. The transmission line of very high voltage, such as; 66kV, 132kV, 220kV, 500kV, are part of a national grid. There are two types of transmission lines

1. Overhead transmission line
2. Underground transmission line

2.1. Overhead Transmission Line

In this type of system, long steel towers are erected on the surface or earth and with the help of cross arms and insulators. The naked wires are turned overhead at a height that not less than 10 meter from the ground. The invention of the strain insulator was a critical factor in allowing higher voltage to be used. Transmission level voltages are usually considered to be 110 kV and about. Lower voltage such as; 66kV and 33kV are usually considered sub-transmission voltages but are occasionally used on long line with light load. Voltages less than 33kV are usually used for distribution. Voltages above 230 kV are considered extra high voltage and require different design compared to equipment used as lower voltages. Overhead transmission lines are un-insulated wire, so design of these lines required minimum clearances to be observed to maintain safety. During adverse weather condition of high wind and low temperature, overhead conductor can exhibit wind induced oscillations with can encroach on their design clearances. Depending on the frequency and amplitude of oscillation, the motion can be termed gallop or flutter. The first consideration in the design of an overhead line is, of course, its electrical
properties. The mechanical factor influencing the design must be considered, the material chosen for the conductor must also be strong enough to withstand the forces to which it is subject as must also be the supports. The tension in the conductor should be adjusted so that it is well within the breaking load of the material, this will mean in practice that an appreciable amount of sag must be allowed for; i.e., the high of the conductor at points between the support will be lower than its high at the point of support, and adequate clearance for earthed objects must be obtained throughout the length of the conductor in all circumstances.

3. DESIGN THEORY OF TRANSMISSION LINE

The supply power and the line length will be given, the most economic voltage can be determined by the following equation.

\[ V = 5.5 \times \frac{L_t + \frac{P \times 10^3}{1.6 \cos \theta \times N_c \times 150}}{1.6} \]

Where,

- \( N_c \) = No. of circuit
- \( L_t \) = Total Line Length
- \( P \) = Transmitted Power
- \( V \) = Economic Voltage

In resistance calculation the following formula should be used to consider the skin effect, \( R_{ac} = K R_{dc} (3.5) \)

Where \( K \) is a function of \( X \)

\[ X = 0.63598 \sqrt{\frac{f \mu}{R_{dc}}} \]

where,

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

When the conductors of a three-phase line are not equilaterally spaced. The line to neutral capacitance is

\[ C = \frac{2a}{GMR_c} \text{F/m to neutral} \]

where, \( GMR_c = \sqrt{r_a \times r_b \times r_c} \)

\[ r = \text{radius of the conductor} \]
\[ k = 8.85 \times 10^{-12} \text{F/m} \]

and capacitive reactance is

\[ X_c = \frac{1}{2\pi f C} \text{\Omega} \]

For a three-phase line, the charging current is found by multiplying the voltage to neutral by the capacitive susceptance to neutral. The phasor charging current in phase 1 is

\[ I_a = j \omega C_s V_a \text{A/mile} \]

The average inductance per-phase can be expressed by the following equation,

\[ L = 2 \times 10^{-7} \ln \left( \frac{GMD}{GMR_L} \right) \text{mH/km} \]

To find the GMD between each phase group,

\[ D_{AB} = \sqrt[3]{D_{ab} D_{bc} D_{ac}} \]
\[ D_{BC} = \sqrt[3]{D_{bc} D_{bc} D_{bc}} \]
\[ D_{CA} = \sqrt[3]{D_{ac} D_{ac} D_{ac}} \]

To find Geometric Mean Distance can be expressed as

\[ GMD = D_{eq} \sqrt[3]{D_{AB} D_{BC} D_{CA}} \]

The GMR of two-bundle conductor can be expressed as,

\[ D_b = \sqrt{D_c \times d} \]

where,

- \( d \) = bundle spacing, \( D_s = \text{GMR of each sub conductor} \)

4. DESIGN CALCULATION OF TRANSMISSION LINES

Design Calculation

Line Information Data,

- Total Line Length, \( L = 77.16 \text{ miles (124.18 km)} \)
- Transmission Power, \( P = 280 \text{ MW} \)
- Power Factor, \( p.f = 0.9 \)
- No. of circuit, \( N_c = 2 \text{ circuits} \)
- Phase Spacing = 6 m

Economic Voltage Selection,

\[ V_{eco} = 5.5 \times \frac{L_t + \frac{P \times 10^3}{1.6 \cos \theta \times N_c \times 150}}{1.6} \]

Target Withstand Voltage = \( \max \text{ System Voltage (kV)} \times 1.2 \)

Economic Size of Conductor,

\[ C = 0.013 \times \frac{a \times p}{q} \]

\[ a = \text{percent annual expense to the construction cost of conductor} \]
\[ p = \text{price of conductor (kyat/kg)} \]
\[ q = \text{cost of electricity (kyat/kwh)} \]

Load Current, \( I = \frac{\mu \cdot p}{\sqrt{3} v x p \cdot f \cdot N_c \cdot N_b} \)

Consideration for Choice of Two Bundle Conductor by Corona Voltage,

\[ V_c = \sqrt{\frac{1}{2} \cdot m \cdot m \cdot \delta^2 \cdot 48.8 \cdot \frac{\mu \cdot f}{S \cdot \sqrt{n}} \cdot \left( 1 - \frac{0.301}{\sqrt{r}} \cdot \log \left( \frac{1}{\sqrt{r}} \right) \right) \cdot \frac{1}{\left( \frac{1}{\left( \frac{1}{x} \right)} \right)} \]

Line Constant Calculation

A. Resistance
B. Inductance
C. Capacitance, \( C \)
D. Parallel Admittance
E. For Station1-to Station-2 Transmission Line

Line Load Ability Calculation

\[ P = \frac{V \cdot V \cdot \sin \delta}{X_L} \]
Surge Impedance Loading

\[ Z_0 = \sqrt{X_L X_C} \]

Mechanical Design Calculation

Critical Span

\[ W_b = \sqrt{\left(\frac{W_f^2}{2} + W^2\right)} \]

Maximum Sag of Conductor

\[ K = \frac{T_b}{S} - \frac{W_x E}{247_o} L^2 \]

\[ M = \frac{W_x E}{24 S^2} L^2 \]

\[ M = \left(\frac{T}{S}\right) \left(\frac{T}{S} - K + A\omega E\right) \]

Maximum Sag of Conductor for Equal Level

The fundamental equations for sag calculation are as follow;

\[ \text{Maximum sag of conductor, } D = \frac{W L^2}{8T} \]

where,

- \( L \) = actual standard span
- \( D \) = sag at span L (ft)
- \( T \) = tension at span L (ft)
- \( W \) = weight of conductor (lb)
- \( S \) = cross sectional area of conductor (sq-in)
- \( A \) = temperature coefficient of linear expansion (°F)
- \( t \) = temperature different (°F)
- \( E \) = Young’s modulus (lb/ft²)
- \( T_0 \) = maximum working tension of conductor (lb)
- \( W_x \) = loading, the high temperature loading \( W_h \) for the span (l) more than the critical span and low temperature loading \( W_1 \) for less than the critical span.

Design Data Sheet of the 230 kV Twin Bundle Double Circuit Overhead Transmission Line

5. CONCLUSIONS

Mostly, all of the possible aspects are at most considered in this paper for the design of a new high–voltage, 230 kV twin bundle double circuit overhead transmission line, 280 MW hydropower generation. In this paper, to design 230 kV high–voltage the environmental impact of AC transmission line should be considered and calculated. In this paper, these effects are not considered and calculated. These effects can damage human resources and radio wave, etc. By considering these effects, designing of 230 kV twin bundle double circuit overhead AC transmission line will be perfect.
design. So for future study, these effects should be considered for high-voltage AC transmission line. Other designers will quickly build up personal experience and improved design procedures to suit local circumstances.

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7. REFERENCES