Preliminaries Comparison Based on Performance of 400KV and 750KV Double Circuit Transmission Line

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***Abstract*— In this paper, A Comparison based on Standard Transmission Line Voltages is evaluated. An Overhead Double circuit Transmission Line of 400KV and 750KV has been compared based on average values of Line Parameters. Both Lines are taken as 400Km Long. The main focus of this paper is on Power handling capacity and line losses. A precise values of different parameters such as, No. of Towers required, average height of Tower, Phase spacing of Conductor, Bundle conductor spacing, and X/R ratio are also calculated. Calculation of Line and ground parameters, depending on properties of Bundle conductor has been implemented in MATLAB. An Important point based on mechanical consideration in Line performance is also highlighted.**

Keywords*— Transmission Line; Line Parameters; Double circuit; Bundle conductor; Tower.

I. INTRODUCTION

Due to day by day increment in requirement of electrical energy, two types of transportation are greatly affected. The first one is natural gas or oil transportation by roadway or by railways and the second one is the bulk power transportation. For transmission line, as the bulk power transmission is not feasible by overhead transmission lines, varying lower voltage ratings (kV rating below 400 kV). Now a days, there are requirement for using 400kV or more just like having four way or six ways roads used for transportation. Thus EHVAC and HVDC transmission line plays a very important role in bulk power transmission. To fulfil these ever increasing bulk power consumptions, many developing and developed countries are using EHVAC, UHVAC and HVDC transmission systems [1-2].

The limitations of HVDC are in maintenance, conversion, control, switching, availability and terminal investment. The required static inverters are very expensive and have limited overload capacity. At smaller transmission distances the losses in the static inverters are bigger as compared to an AC transmission line. The cost of the inverters required at terminals may not be offset by reductions in line construction cost and lower line loss. In contrast to AC systems realizing multiterminal systems are complex. Controlling of power flow in a multiterminal DC system requires good communication between all the terminals and power flow must be actively regulated by the inverter control system. The application of multi-terminal lines are not inherently used in today's world. Thus HVDC is less reliable and has lower availability than AC systems, mainly due to the extra conversion equipment. Single pole systems are still having the availability of about 98.5%, and.with much unscheduled down time due to fault. Fault redundant bipole systems provide high availability for 50% of the link capacity, but availability of the full capacity is about 97%.High voltage DC circuit breakers are challenging to build because some mechanism must be included in the circuit breaker to force current signal to zero, otherwise arcing and contact wear would be too great to allow reliable switching. Operating a HVDC scheme requires many spare parts to be kept, often exclusively for one system as HVDC systems are less standardized than AC systems and technology changes faster.

According to inter regional transmission capacity for 11^{th} five year plan (2007-2012), the total power of new inter regional link that must be added by National Power Grid of India is foreseen to be 20700 MW.In North Eastern Region (NER) from Biswanath Chariyali to North Region (NR) Agra, A 4000MW, HVDC Bipole system of +- 600kV is to be installed. From North Eastern Region (NER) of Bongaigon to Eastern Region (ER) Silliguri 400kV D/C is 1000MW are still under initial stage. In Eastern Region (ER) to North Region (NR) total capacity is 3500MW (i.e Barh to balia 400 kV D/C (Quad Moose) is 1200MW and Sasaram to Fatehpur 765 kV is 2300MW) are under developing stages.In ER to Western Region (WR) total capacity is 5700MW (i.e Rourkela – Raipur 400kV, D/C is 1400MW, North Karanpura - Sipat 765kV is 2300MW, Hirma – Sipat 400kV, D/C, 1000MW and Hirma – Raipur 400kV D/C is 1000MW). In NR to WR total capacity is 5500MW (i.e Agra-Gwalior 765kV is1200MW, Agra-Gwalior 765kV, S/C, line-2 2300MW, Kankroli - Zerda 400kV, D/C, 1000MW and RAPP-Nagda 400kV, D/C, 1000MW). In Western Region (WR) from Parli to South Region (SR) Raichur the total power is of1000MW. Thus the installation need study and comparison between two different ratings towers.

The steady state voltage limits according to central electrical authority that may be used in India are given according to following table I.

TABLE I. VOLTAGE LIMITS

Voltages (KV) in R.M.S				
	Nominal Rating		Emergency Rating	
Nominal	Maximum	Minimum	Maximum	Minimum
66	72.5	60	72.5	59
110	123	99	123	97
132	145	122	145	119
220	245	198	245	194
230	245	207	245	202
275	300	261	300	255
345	362	324	362	317
400	420	380	420	372
500	525	470	525	460
750	765	705	765	693
765	800	728	800	713

II. EHVAC TRANSMISSION LINE

A. Line Parameters

A detail calculation of line parameters has been done. For getting the estimation of how much power a double circuit line at a given voltage can handle, it is mandatory to know the value of positive sequence line inductance and its reactance at power frequency. The line loss caused by I2R heating of a conductor is more important for conservation of energy. Therefore, in order to lower the i2r heating losses we need not require to lower the current I that may be transmitted but we can lower the conductor resistance R using bundled conductors comprising of several sub conductors in parallel. We will utilizes this average value of line parameter for given tower configuration as shown in table a for preliminary data estimation.

B. Power Handling Capacity

As we know by neglecting the line resistance the power which is to be transmitted depends upon the magnitude of voltage at sending end Vs and receiving end voltage Vr, the phase difference 'del' and the last parameter i.e. total positive sequence reactance 'x' per phase.

Therefore,

$$P = VsVrSin\delta / Lx \qquad (1)$$

Where,

P= Power in MW;

Vs and *Vr* are voltages in kV (line-line);

L= length of line in km.

The power handling capacity for a double circuit is usually given by

$$P = V^2 Sin\delta / Lx \qquad (2)$$

And the power loss in a six phase transmission line can be given as

$$Ploss = 6I^2 rL = V^2 Sin^2 \delta . r / Lx^2 \qquad (3)$$

The comparison based on system parameters between 400Kv and 750Kv, 400Km long transmission line is shown in table II.

TABLE II. SYSTEM PARAMETERS COMPARISON

System Parameters	400KV	750KV
Average height (m)	49	77.5
Phase spacing (m)	12	16.8
Conductor	ACSR Moose, Twin Bundle 2*31.77mm	ACSR Moose, Quad Bundle 4*30mm
Bundle spacing (m)	0.4572	0.4572
Bundle diameter (m)	0.4889	0.5172
r (ohm/ Km)	0.03177	0.0136
x (ohm/Km)	0.327	0.272
x/r	10.292	20
No. of circuits required	5	2
Current/circuit (KA)	1.76	3.97
Resistance for 400 Km (ohm)	12.7	5.44
Total Power loss (MW)	590	308

C. Long Transmission Line

In modern world, civilization depends heavily on the consumption of electrical energy for industrial, commercial, agricultural, domestic and other purposes. As we know, electrical power is generated in large by thermal, hydro, nuclear power station. The energy transfer from these generating stations to distant distribution networks is done via mean of transmission line. Now a day's modern electrical power system is in the form of a large interconnected network with constant frequency in the grid. All the generating stations, transmission and distribution systems are interconnected by means of 3 phase AC system operating synchronously at the common single frequency. (In India 50 Hz and USA 60 Hz). The basic function of a transmission system is to transfer electrical power from one location to another location or from one network to another network which is connected in the grid or outside the grid.

Transmission system is necessary for bulk power transfer from generating station up to the main transmission line (network). As the thumb rule, higher the power rating higher is the requirements of transmission voltage. Longer the lines, higher are the required transmission voltage. This will give lesser current, lesser I^2 R line losses, higher power transferability. In the ending-end substation, the voltages are stepping up and then transmitted. At the receiving end the voltage may be appropriately stepped down by using power transformer.

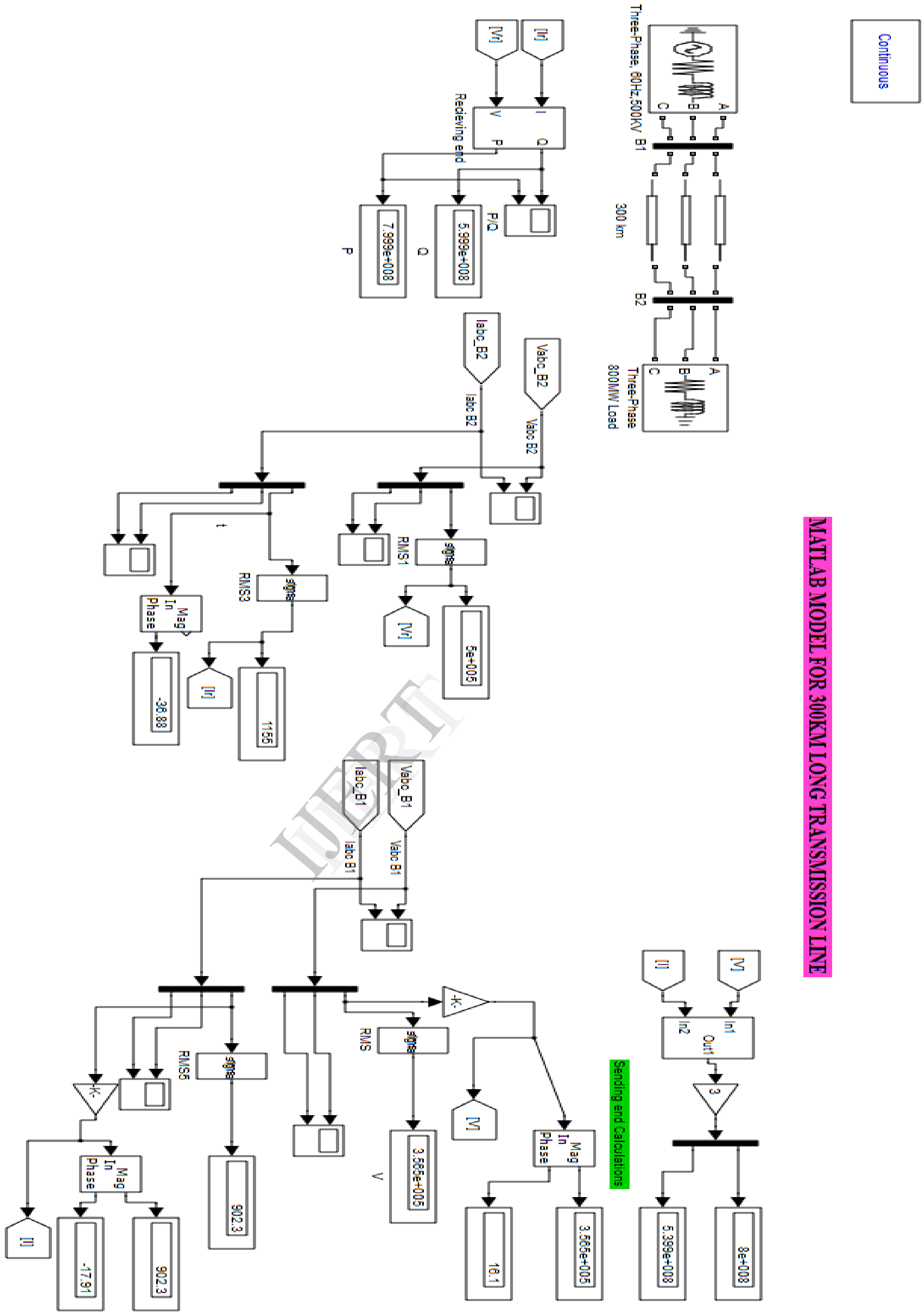

Figure 1. Matlab model for 300Km Long 400kV D/C Line.

III. Tower Design

The purpose of Tower is to support the conductors [1]. The material used to build up the tower is usually steel. Figure 1 shows typical pylons in a 400kV route. Figure 1(a) is for Suspension Tower, 1(b) is 25^0 deviation Tower, 1(c) is 90^0 deviation Tower and 1(d) Terminal Tower design.

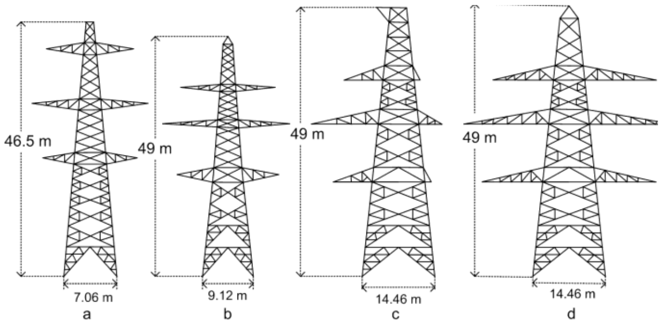

Figure 2. Types of Tower for 400kV D/C Line.

Sag of span also affects the selection of tower. There are standards which defines distances from construction and trees to the conductor. However, it is a difficult situation when the span between the towers is long, tower must be higher. These ensure that the conductor does not touch the ground or not even close to the ground. Thus the height of the towers depends on voltage rating, no. of conductors, sag and weight of the conductor. There are mainly four types of tower that may be used for a 400 kV double circuit transmission line shown ion figure 1. Out of which the suspension tower is the cheapest and mostly used worldwide. The purpose of this tower is to sustain the conductor because they are not affected by external forces. Figure 2 shows a typical 750 kV double circuit transmission tower used in China.

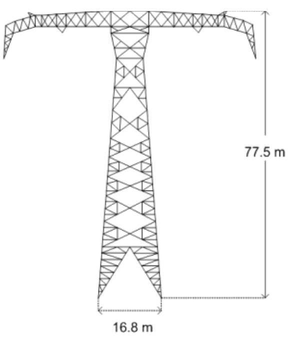

Figure 3. 750kV Tower.

A. *Right of way*

As we know that the line clearing is one of the main task of civil engineering, it includes felling i.e too large trees must be cut down under the circumstance of fault situation that can happen when a tree fault on line. This means that the selected tower must have a defined width of the right of the way [3-4]. The specified right of way of self supporting tower is as shown in figure 4.

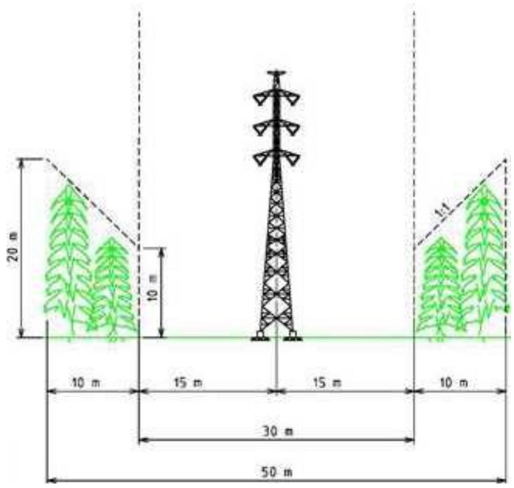

Figure 4. Right of way for Tower design.

IV. Conclusion

Different types of tower structures have been studied for analysis purpose. The double circuit transmission line for 400 kV and 750 kV has been implemented in MATLAB simulation software. In the comparison between 750 kV and 400 kV transmission line on the basis of mechanical structure, amount of steel required (in terms of weight), Right of Way and the total power loss, it was found that for 400 km long transmission system, 750 kV system should be well preferred over 400 kV system. Also, in terms of future aspect 750 kV transmission line would be more suitable for execution purpose over 400 kV system considering bulk amount of power transmission.

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