

## Power upgrading of Transmission Line by converting EHVAC into EHVDC

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### Abstract

The increased demand for power transfer in combination with environmental and economic issues which set constraints to building new lines, force the implementation of new technologies into the existing system in order to improve its power capability. The fast development of power electronics based on new and powerful semiconductor devices has led to innovative technologies, such as HVDC, which can be applied to transmission and distribution systems. - Long extra high voltage (EHV) ac lines cannot be loaded to their thermal limits in order to keep sufficient margin against transient instability. With the scheme proposed in this paper, it is possible to load line conductors to their full current capacity. This paper gives the feasibility of converting a double circuit EHVAC line into EHV DC. Experimental studies are carried out for the determination of increase in percentage power. No alterations of conductors, insulator strings, and towers of the original line are needed. Each HVAC circuit uses 3 conductors but HVDC uses only 2, so the two circuits (6 conductors) that are often used for HVAC transmission may be converted into three HVDC circuits , each with 2 conductors. This change can increase transmission capacity of a double-circuit HVAC line by a factor of 3 or more.

### KEYWORDS

*EHVDC representation of EHVAC line, Alternating current, Direct current calculations.*

## 1. Introduction

HVDC transmission has been in use for more than 50 years. It has proved to be a reliable and valuable transmission media for electrical energy and has a number of technical advantages compared with HVAC transmission. Nonetheless, a comprehensive HVDC/HVAC system planning approach is not commonly found within utilities, and therefore full advantage is not being taken of the HVDC technology. This paper presents the Experimental study for the determination of increase in percentage power. Each HVAC circuit uses 3 conductors but HVDC uses only 2, so the two circuits (6 conductors) that are often used for HVAC transmission may be converted into three HVDC circuits , each with 2 conductors. This change can increase transmission capacity of a double-circuit HVAC line by a factor of 3 or more.

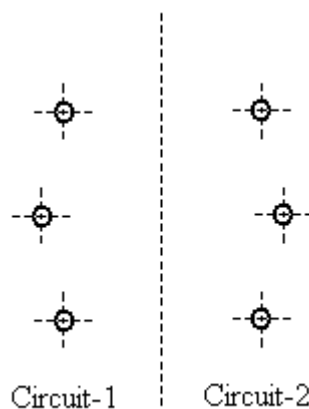
## 2. Advantages of EHVDC over EHVAC

The efficiency of the system will improve to great extent because HVDC transmission has 30-50% less transmission loss than comparable alternating current overhead lines. For lengths of

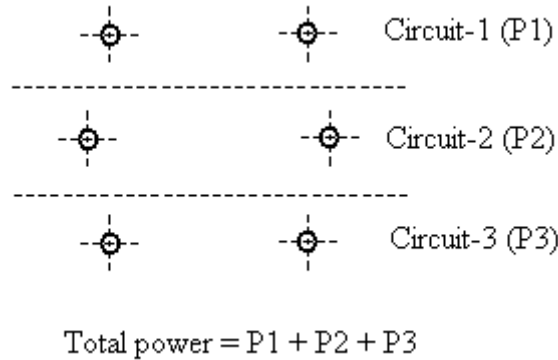
600 KM or more, overhead lines using HVDC technology are more cost-effective than AC technology. The power loss in a HVDC transmission line can be 50% to 70% of that in an equivalent HVAC transmission line. Thus for large distances an HVDC solution have lower loss. In HVDC system number of transmission lines required is less as compared to HVAC. No need of intermediate substation for compensation in HVDC lines. EHVAC lines needs intermediate substations at an interval of 300 Km for compensation. HVDC gives transient stability does not pose any limit. Line can be loaded upto thermal limit of lines and valves. The permissible loading of an EHV-AC lines is limited by transient stability limit and line reactance to almost one third of thermal rating of conductors. No such limit exists in case of HVDC lines. conductors are utilized fully. Long EHVAC lines are loaded to less than 0.8 Pn (surge impedance loading). No such condition is imposed on HVDC line. Long EHVAC lines have varying voltage along the line due to absorption of reactive power. This voltage fluctuates with load. Such a problem does not arise in HVDC lines. Power flow through HVDC line can be controlled more rapidly and accurately than that of EHVAC . HVDC power flow can be increased at a rate of 30 MW per minute. This is not possible with EHVAC line. For the same power transfer and same distance, the corona losses and radio interference of DC system is less than that of AC system. DC system requires insulation level is lower than corresponding ac insulation. HVDC transmission line does not have series reactance and shunt reactance. Hence voltage regulation problems and stability problems, transmission losses etc. due to the flow of reactive power flow are absent in HVDC transmission systems. Transmission losses are low. Skin effect is absent in dc system. Charging currents are absent in dc system. The phase to phase clearance, phase to ground clearance required is smaller for dc transmission as compared to equivalent ac transmission. HVDC transmission can utilize earth return and therefore does not need a double circuit. EHV AC always needs a double circuit. In HVDC system bipolar line may be operated in a monopolar mode by earth as a return path when the other pole develops a permanent fault.

### 3. Conversion of EHVAC line into EHVDC

#### 3.1. Representation of EHVAC Double circuit Transmission Line



### 3.2 Representation of same transmission line as EHVDC



From above diagram it is clear that the same transmission line can be represented as EHVDC by using three circuits and total power can be transmitted will equals to the sum of power transmitted by the three circuits.

### 3.3 Calculation of Power

#### 3.3.1 EHVAC

The loadability of a Moose, ACSR, non bundle conductor, 400kv, 50hz, 450km double circuit ac line has been computed.

The parameter of the line are :

$$z = 0.03252 + j0.33086 \text{ ohm/km/circuit.}$$

$$y = j3.33797 \times 10^{-6} \text{ s/km/circuit.}$$

$$\text{Transfer reactance } X = 74.4435 \text{ ohm/ph.}$$

$$\text{Surge impedance loading SIL} = 511.22 \text{ MW/circuit.}$$

$$\text{The total power transfer through the double circuit line is : } P_{\text{total}} = 3V_{\text{ph}}^2 \sin\delta / X \quad (1)$$

$$\text{Approximate value of AC current per phase per circuit of the double circuit line may be computed as : } I_{\text{ph}} = V_{\text{ph}}(\sin\delta) / X \quad (2)$$

Here X is the transfer reactance per phase of the double circuit line and  $\delta$  is the power angle between the voltages at the two ends. To keep sufficiently margin,  $\delta$  is generally kept low for long lines and its value seldom exceeds  $30^\circ$ .

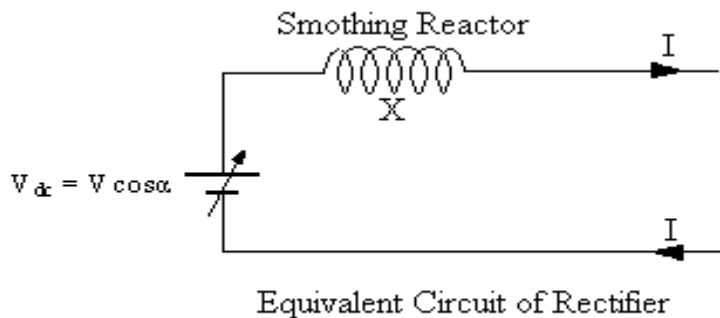
Using equations 1 and 2 the computed power and conductor current at receiving end are :

$$P_{\text{ac total}} = 1077 \text{ MW ; (at } \delta=30^\circ)$$

$I_{ph/circuit} = 0.803 \text{ KA}$  .

### 3.3.2 EHVDC (conventional double circuit EHVAC line converted into EHVDC)

Same transmission line can be represented by three DC circuits (having two conductors per circuit). To achieve smooth DC output voltage a large smoothing reactor is connected in series with the convertor as shown in equivalent circuit of rectifier.



Parameter of 400kv, 450KM line are :

$R = 0.03252 \Omega/\text{KM}/\text{conductor}$

Total resistance of two conductors line =  $0.03252 * 450 * 2 = 29.26\Omega/\text{circuit}$

$X = 100 \Omega$  (Reactance of smoothing Reactor) /circuit

$z = 29.26 + j100 \text{ ohm}/\text{circuit}$

$\alpha = 18^\circ$  (Delay angle)

$V_{dc} = V \cos \alpha$

$P = V_{dc}^2 / z$

Total power transfer through three circuits of line  $P_{dc \text{ total}} = 3(V_{dc}^2 / z)$  (3)

Approximate value of DC current per circuit may be computed as  $I = V_{dc} / z$  (4)

Using equations 3 and 4 the computed power and conductor current at receiving end are :

**$P_{dc \text{ total}} = 4332 \text{ MW}$  ; (at  $\alpha=18^\circ$ )**

**$I_{\text{per circuit}} = 3.8 \text{ KA}$  .**

It has been observed from computation that there is a substantial up-gradation of power transfer capacity of the line by EHVDC power transmission as compared to EHVAC transmission.

Power Upgradation = (Power transfer by dc line – Power transfer by ac line)/Power transfer by ac line

$$\% \text{ Power Upgradation} = [(P_{dc} - P_{ac})/P_{ac}] \times 100 = \mathbf{302.2\%}$$

#### **4. Conclusion**

The merits of EHVDC over EHVAC have been demonstrated. For the particular system studied, there is substantial increase in the loadability of the line. The line is loaded to its thermal limit with dc current. No modification is required in the size of conductors, insulator strings and towers structure of the original line.

#### **5. Future scope**

In this paper, it is shown that by converting EHVAC line into EHVDC, we can improve the transmission capacity of the line by the factor of 3 or more without altering the physical equipment. This work can be extended for analyzing the losses on this type of transmission. This work is done on double circuit AC transmission lines but it can be extended to other types of transmission methods.

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