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To find Optimal Place of Series Compensation and SVS for an Extra High Voltage Transmission System

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***Abstract*– Now a days, system security and reliability are main concern with the increasing demand of electricity and interconnections of Extra High Voltage (EHV) systems. Progressively complex system was formed due to surges in environmental and economic pressures. Power-frequency over-voltages and attaining the maximum power transfer limit over a long transmission lines are two main concerns of EHV system. It is verified that more power can be transferred by reducing transmission distance with the help of series& shunt compensations. Due to practical and economical reasons, the compensating elements are located at few points along the line instead of being distributed over the entire line. Location, circuit schematic of series capacitor is the deciding factors for maximum power transfer capability, Voltage control conditions and efficiency of power transmission of the compensated transmission system.**

***Keywords* - Efficiency, Series Compensation, SVS, Max P_R, MATLAB**

I. Introduction

Enormous electric power was transmitted across the transmission lines, for this it is crucial to study some aspects to bound the measurement of electrical transmission capacity. Thermal effect on the conductors, stability problem, and voltage drop are few of the aspects. By building of new transmission lines, restriction build by these aspects can be overwhelmed. For long transmission lines, this method is very luxurious. To avoid this, we can use series economic compensation restrictions. Transmission line compensation states that power transfer capability was surged by doing amendment in the electrical quality of the transmission line. For revoke the reactance part of line, series capacitor is used in case of series compensation. Consequence of this was enhanced system stability which is demonstrated by surge in power transfer capability of line at specified level of power transfer. Natural load is surged effectively & transmission angle is reduced.

There is lot of remunerations of series compensation, but one disquiet in the execution of series compensation in real-world system is their effect on line breakers because of high level of Transient Recovery Voltage (TRV) and Rate of Rise of Recovery Voltage (RRRV). In anomalous circumstances, i.e., short-circuit faults, tie-line between grids of opposite phase, breakers are opened.

II. Mathematical Modelling

Maximum Receiving End Power

$$P_R = \frac{|V_S||V_R|}{|B_0|}\cos(\beta-\delta) - \frac{|A_0||V_R|^2}{B_0}\cos(\beta-\alpha)$$

Where $A_0 = |A_0|\angle\alpha,\ \ B_0 = |B_0|\angle\beta$

P_R will be maximum at $\delta = \beta$
Such that

$$P_R = \frac{|V_S||V_R|}{|B_0|} - \frac{|A_0||V_R|^2}{|B_0|}\cos(\beta-\alpha)$$

Neglecting α as in real situation α is minute.

$$P_R = \frac{|V_S||V_R|}{|B_0|} - \frac{|A_0||V_R|}{|B_0|}\cos\beta$$

Substituting $|V_S| = K|V_R|$

$$P_R = \frac{|V_R|^2}{|B_0|}(K - |A_0|\cos\beta)$$

The optimal gain of series capacitive reactance X_C(opt) is calculated by:

$$\frac{dP_{R(max)}}{dX_C} = 0$$

Compensation Efficiency

The proportion of net reduction in transfer reactance to the series capacitive reactance (XC) used is known as compensation efficiency η_C. Therefore, the effective series capacitive reactance X'_C (as compared to the actual value of X_C) is specified by:

$X'_C = \eta_C X_C$

Therefore,

$$\eta_c = \frac{Net\ reduction\ in\ transfer\ reactance}{Series\ capacitive\ reactance\ used}$$

General formulas for compensation efficiency is obtained for each shunt & series compensation location

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III. CASE STUDY (MATLAB ANALYSIS AND PLOTS)

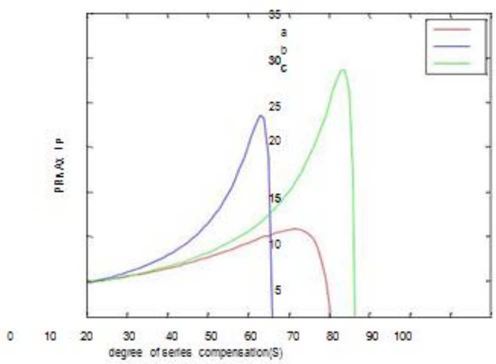
A 500 kV, 300 km long transmission line has been considered for analysis for different locations of series and shunt compensation. The analysis and plots have been carried out in MATLAB.

Case 1

Series compensation scheme located at the sending end of the transmission line without SVS.

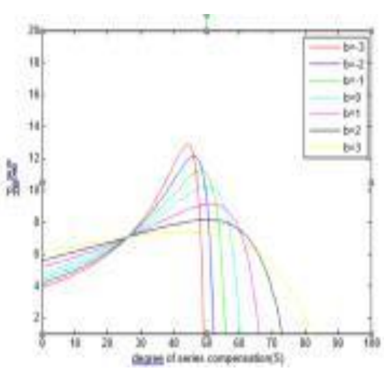
PLOT (PR_max_puvs S)

Plot of maximum receiving end power in pu against degree of series compensation for a series compensated transmission line of length 300 km without SVS.



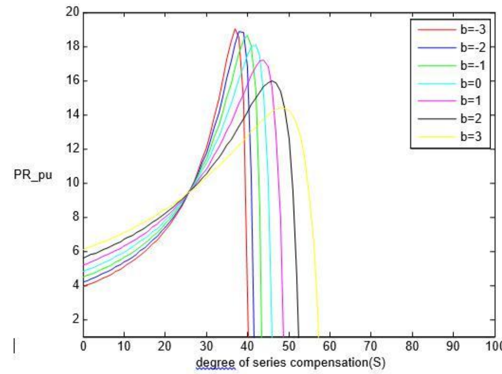
Case 2

Plot of maximum receiving end power in pu against degree of series compensation for a compensated transmission line of length 300 km with series compensation at the sending end and SVS at midpoint Scheme with series compensation located at the sending end and SVS at the midpoint.



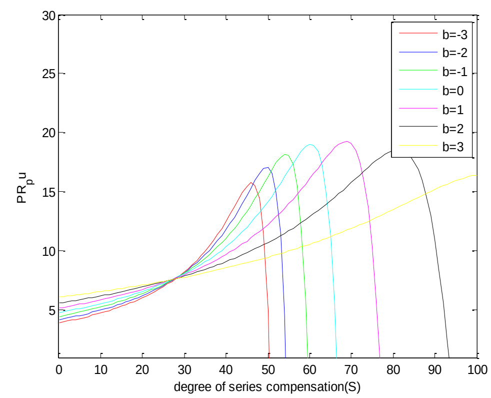
Case 3

Plot of degree of series compensation and SVS located at the midpoint of the transmission line.



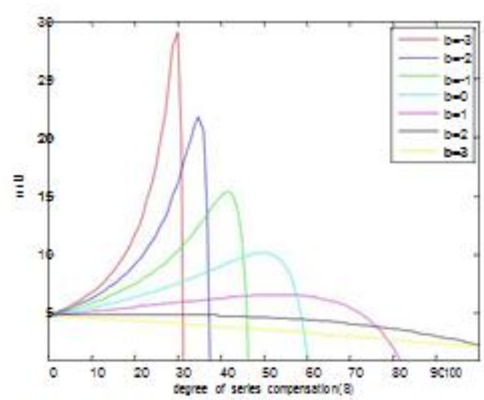
Case 4

Plot of maximum receiving end power in pu against degree of series compensation for a compensated transmission line of length 300 km with series compensation at the receiving end and SVS at the midpoint.



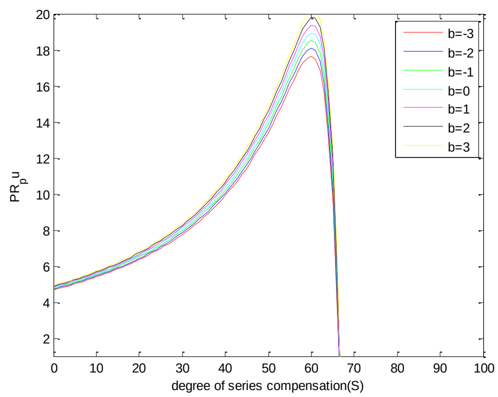
Case 5

Plot degree of series compensation and SVS located at the sending end of the transmission line.



Case 6

Plot degree of series compensation and SVS located at the receiving end of the transmission line.



IV. CONCLUSION

Judgement of maximum power transfer PR(max) is established for the 500kv, 300 km long EHVtransmission line. Comprehensive equation for Capacitive reactance & PR max in form of A,B,C,D constants are established for series compensated line.. The comprehensive equation for ideal value of series compensation has been established & ideal value is established for various cases of series compensation. For obtaining the optimal location of series & shunt compensation, norms of PR (max) & compensation efficiency is used. Maximum PR(max) &ηc is obtained by the research on SVS & (Case 3) center position of series compensation

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