REACTIVE POWER COMPENSATION USING SERIES PULSE VOLTAGE COMPENSATION FOR LCC HVDC

#1N. SANDEEP KUMAR, M.Tech Student,  
#2P. ASHOK, Assistant Professor,  
Dept of EEE,  
MOTHER THERESSA COLLEGE OF ENGINEERING & TECHNOLOGY, PEDDAPALLI, TS, INDIA.

ABSTRACT: This Project Presents new control scheme (PI controller Based) Reactive Power compensation using Series Pulse Voltage Compensation for LCC HVDC at Offshore Wind Power work explains the concept of reactive power compensation for line commutated HVDC system by the use of PI control based series voltage injection strategy. The CIGRE benchmark model and the series compensated model have been simulated in MATLAB/Simulink. The simulation results suggest that the suggested compensating strategy gives encouraging results. The reactive power compensation is significant and also as small value of capacitance is used in this control strategy, it results in significant reduction in the size and cost of converter terminal.

I. INTRODUCTION

In the present scenario, we know the available sources of electricity generation are not sufficient enough to supply its growing demand. Also in the coming years, the power engineers will have to depend on renewable energy sources for satisfying the increasing demand. The renewable energy sources include solar, wind, tidal etc. Among these sources use of wind has gained much attention and support in the recent year. Power generation by wind at onshore sites is visible at countries like U.S.A., China, and India. Wind energy is sometimes called another form of solar energy and has a wide scope in the near future. The scarcity of land, better wind condition, opposition to the visual and noise pollution is forcing the installation of offshore sites for wind power generation. As the distance to shore is increasing HVDC transmission is becoming more attractive compared to AC transmission that requires intermediate reactive power compensation and also suffers from stability issues. The available HVDC technologies are the line commutated converter based HVDC (LCC HVDC) and the voltage sourced converter based HVDC (VSC HVDC). The classic LCC HVDC maintains constant current and has the following advantage over the VSC HVDC, that is, high power capability, has lower station losses, uses semiconductors that are highly reliable and mature. Though it possess disadvantages like the incapability of black start (B. Singh et al, 2009), problems related to reactive power and harmonics that make the size of the converter terminal high thereby increasing the cost. The reactive power compensation is done using series or shunt compensation. Till date there have been many compensating devices introduced. The shunt and series compensating devices such as STATCOM, SSSC, TCSC, MERS (B. Singh et al, 2009, L. Gyugyi et al, 1997). Static compensator (STATCOM) is a leading shunt device and static synchronous series compensator (SSSC) is a leading series reactive power compensating device. But have the disadvantage of high switching loss due to high switching frequency. Thyristor controlled series compensator (TCSC), magnetic energy recovery switches (MERS) and gate commutated series capacitor (GCSC) are few other series compensating devices which have the advantage of exclusion of injection transformer and lower switching losses (E. H. Watanabe et al, 2004, E. H. Watanabe et al, 2008, J. A.Wiik et al, 2009). These are transformer-less voltage injection topologies with the associated benefit of compactness. In this paper the CIGRE benchmark model is used to study the reactive power for HVDC system and then compared with series voltage injection strategy using proportional integral controller, utilised to compensate the reactive power problem at the converter terminal of the HVDC technology employed for offshore wind power. This reactive power compensation strategy injects series voltage in short duration pulses. These pulses are generated by the use of proportional and integral controller. The series pulse voltage injection is used here to demonstrate the reactive power compensation. Conventional CIGRE HVDC benchmark model

Fig. 1. Schematic arrangement of the LCC HVDC test setup based on the CIGRE benchmark values.
II. PROPOSED COMPENSATOR WITH PI CONTROL

The matrix impedance contained \( S \) and \( \mathbf{D} \) in \( \mathbf{T} \) is such that the short out proportion (SCR) is 2.5, demonstrative of an exceptionally frail network. The aggregate capacitance in the shunt latent channel is 273 F. Also, the aggregate inductance is 450 mH. The objective of responsive pay is to decrease or wipe out the receptive power, and to enhance the consonant substance in currents. The subscript speaks to the concerned branch (for the branch with the - associated transformer and for the branch with the - joined transformer); though rep-disdains the concerned stage (, or ). Unless generally men-tioned, little letters allude to the prompt amount. The capital letters speak to normal estimations of dynamic and receptive power on the air conditioner side, and dcc - connection power, voltages, and currents. The rms estimations of currents and voltages on the air conditioner side are additionally rep-disliked by capital letters.

III. PI CONTROLLER

The general block diagram of the PI speed controller is shown in Figure 3.1

The proportional and integral terms is given by:

\[
u(t) = K_p e(t) + K_i \int e(t) dt
\]

Kp and Ki are the tuning knobs, are adjusted to obtain the desired output. The following speed control is used to demonstrate the effect of increase/decrease the gain, Kp and Ki. The result obviously shows with PI controller, we are able to eliminate the steady state error. In summary with small value of Ki (Ki = 0.01), we have smaller percentage of overshoot (about 13.5%) and larger steady state error (about 0.1). As we increase the gain of Ki, we have larger percentage of overshoot (about 38%) and manage to obtain zero steady error and faster response. The output Of the speed controller (torque command) at \( n \)-th instant is expressed as follows:

\[
Te(n) = Te(n-1) + K_p \omega_{re}(n) + K_i \omega_{re}(n)
\]

Where \( Te \) (n) is the torque output of the controller at the \( n \)-th instant, and Kp and Ki the proportional and integral gain constants, respectively.

Control Of Spvc

The SPVC can just infuse as much voltage in a stage as is accessible on its dc-join capacitor. Second, the bigger the arrangement infused voltage, the prior the commutating-voltage traverse will be. The system embraced is to charge the SPVC dc join when the concerned stage is conveying the top current. The release would happen amid compensation of current into the concerned stage. Current commutates into a stage amid the positive and negative half cycles. Thusly, the arrangement ought to be to charge amid the positive half cycle, release amid the substitution in the negative half cycle, charge again amid the negative half cycle, release amid the replacement in the Positive half cycle, and, at long last, charge again amid the posiThe beginning stage of control is delineated in Fig.5.3. Furthermore, are contrasted with half of the reference receptive power. This is done in light of the fact that the two branches are indistinguishable in their responsive power utilization and, accordingly, the SPVCs in the two need to take an equivalent weight. Since the current into the LCC rectifier terminal is trapezoidal, we can expect that the current is steady (equivalent to) amid the interim in which the SPVC dc connection must be charged. The crest of this voltage can be figured utilizing (3) or (4) expecting the starting voltage on the SPVC dc connection is to be zero and \( i_{ijk} \) equal to \( I_d \)

\[
V_{compdc-jk-MT} = I_d(\phi - \beta)/C = I_d\gamma_{charge}/\omega C.
\]

IV. SIMULATION RESULTS

Fig 3 Reactive power control loop

Reverse right away. It ought to be noticed that is in radians. Accepting (the line voltage at the essential side of the converter transformers) as the reference, the heap side line voltage on the YY transformer ( will be in stage with it At the positive-going zero intersection of , stage needs to take negative current from stage after a postponement equivalent to the terminating deferral edge.

Fig 4 Simulation diagram Of proposed system
Simulink/SimPowerSystems was utilized to reproduce two cases. Case I exhibits responsive power control with a changing dynamic power reference and case II demonstrates the capacity of SPVC to take after a changing reactive power reference with settled. Notwithstanding the control circle in Fig. 4, two more control circles have been included. The initially (portrayed in Fig. 5) is for dynamic power control which comparesthe reference dc-join current on the HVDC line with to create the required terminating deferral edge. The second circle (appeared in Fig. 6) is for keeping at an altered worth around 15 , a trade off between least responsive power utilization and quick power control above evaluated power for constrained term. is kept steady through the utilization of generally moderate onload tap changers (OLTCs) on the converter transformers, which change the voltage size after detecting the change into take it back to the reference esteem. SimPowerSystems does not contain OLTC transformer obstructs for time-space reproductions. We have, in this manner, made an option arrangement by making the network voltages behind its impedance utilizing controlled-voltage source squares. The circle in Fig. 6 controls these voltages taking into account the correlation of The recreations begin with the SPVC skirted in both cases. The SPVC is joined at 3 s and shows its ability of taking after . At 6 s, the reference ( or ) is changed,and the execution of the SPVC is shown for the following 3s. The base qualities are 1000 MVA, 500 kV, and 2 kA for plotting Case 1:
The dynamic and responsive powers are plotted in Fig. 5. As the SPVC is associated, drops from an estimation of 0.55 to 0 p.u., as
CONCLUSION

The Proposed model is simulated and the behavior of the rectifier terminal is observed. It is observed that the reactive power consumption is high. The shunt passive filters placed should compensate for the reactive power but they are not sufficient enough to supply the reactive power. The series pulse voltage injection is made the active and reactive power at the rectifier terminal is observed. The waveforms show that the results are encouraging and the reactive power is compensated. Comparing the shunt passive filter and SPVC for reactive power compensation it can also be inferred that the requirement of capacitance is comparatively low which results in reduced size of terminal equipment.

REFERENCES