5th International Conference on Emerging Trends in Engineering, Technology, Science and Management
Institution of Electronics and Telecommunication Engineers, Ganganagar, Bengaluru, Karnataka, India (ICETETSM-17)
20th August 2017, www.conferenceworld.in ISBN: 978-93-86171-60-3

UPGRADATION OF AN EXISTING HVAC SYSTEM IN TO A HYBRID AC/DC HIGH POWER TRANSSMISSION SYSTEM USING VARIOUS NEW TECHNIQUES

Neelmani Saroj[1], Dr. Upendra Prasad[2]

[12]*Department of Electrical Engineering, B.I.T. Sindri, (India)*

With the designation of fastest growing economy our country INDIA is on the fast trajectory of development but to keep the momentum of growth high availability of uninterrupted power supply is must. With the increase in industries and dens city's even a well forecasted power system is not capable to meet the increasing demand of electric power and high power transmission is a matter of outmost urgency.

It is difficult to load existing long extra high voltage (EHV) ac lines to their thermal limits as a sufficient margin is kept against transient instability. However we can install new transmission line to meet demand but there are huge difficulties in installation of new transmission lines like right of way (ROW) problems, land acquisition and cost.

So instead of installing new lines the existing AC lines are modified to simultaneous AC-DC lines to increase their power transfer capability close to their thermal limits. This thesis presents the method to convert an existing double circuit EHVAC line into a composite AC-DC transmission line. To extend the capability of power transmission and take full advantages of both HVAC and 10
fewer facilities change and lower cost.

I. MOTIVATION

Following advantage is to be expected from the proposed hybrid system

1. It will be possible to load these lines close to their thermal limits.
2. Cost saving in comparison with a new HVAC transmission line or HVDC transmission line alone
3. The advantage of parallel ac-dc transmission for improvement of transient stability and dynamic stability and damp out oscillations has been established
4. With hybrid system we can work on a increased transmission angle up to 80 degree which is not possible in HVAC
5. Higher power angle allow us to transmit more power as sending power is directly proportional to sin(power angle)
6. Less transmission loss
7. Better fault clearing and smart control on power transmission

II. METHODOLOGY

For obtaining most suitable and efficient method of converting a existing HVAC system in to a hybrid AC/DC transmission system, following detailed performance comparison is to be done on the various delicate and imp component of the HVDC and HVAC system

III. CONVERTER

Power electronics converters have more accurate controllability and much faster dynamics, thus enhancing the system stability during power transients and fault condition. Also it is used as rectifier and inverter. To implement it, three types of HVDC architectures can be adopted: LCC, VSC and MMC. Generally, LCC has the advantage of much higher power rating and lower cost which is more suitable for bulk power application, while it needs almost 50% reactive power compensation and strong grid support in case of commutation failure of SCR as well as bulk volume. In contrast, VSC has independent switching capability with both active and reactive power controllability and less space occupation but more cost. To have a fair comparison here for high power long line transmission application, specific needs should be considered.

1. **INJECTION TRANSFORMER:–**As here we want to inject Dc current in to ac system there is a threat of saturation of transformers as we know that transformers got saturated when interconnected with DC. To avoid this problem we want to investigate performance of zig zag transformer as DC injector in main AC system. The saturation of transformer due to flow of dc current can be avoided by using zigzag connected winding at both ends. The windings of zigzag transformer are differentially connected. The fluxes produced by the dc current flowing through each winding of the core of a zigzag transformer have equal magnitude and opposite in direction and hence cancel each other so that the net dc flux becomes zero. Thus, the saturation of the core due to dc current is removed.

2. **SERIES REACTOR:-A** series reactor Xd is used to reduce ripples in dc current. It also reduces the rate of rise of fault current thus allowing sufficient time for the circuit breakers to operate. The triplen harmonics and zero sequence components of currents are also greatly suppressed by the presence of series reactor.

3. **BEST COMBINATION OF AC AND DC:-**We have various method to transmit power in HVAC method and HVDC. IN HVAC we may have single circuit line, double circuit line similarly we have in HVDC monopolar and bipolar dc transmission .while focusing on composite transmission system we will investigate witch possible combination is most suitable an economic. With the help of MATLAB based simulation model we will compare above combinations.

4. **FAULT ANALYSIS:-**As we are using modern power electronics convertors we have a smart control on line and hence while faulty condition we can easily handle the condition. We will investigate the fault clearing capacity of new composite system using MATLAB simulation.

5. **TRANSSMISSION ANGLE:-**AS we have smart control on the system and fault can be cleared much faster hybrid system allow us to vary transmission angle beyond up to 80° which is generally not possible for a pure ac line. Sending end power, receiving end power and transmission losses of both the systems are found out and percentage power upgradation is calculated. Simulation is carried out using MATLAB/SIMULINK model

III. EQUATIONS

We know that total power transfer through a dual circuit HVAC line is equal to-

$$P=3*V^2*\sin\delta 1/Xac$$

Here, Xac is reactance of double circuit line and δ1 is the power angle.

To keep sufficient margin against transient instability, δ1 is kept low generally about 30° to 40°.

Now, the total power transfer through a hybrid AC-DC composite high voltage transmission line, Total Power = AC Power + DC Power i.e.

PT= 3*V^2*sinδ1/Xac + 2*Vdc*Idc

Here in this case, the power angle δ can be enhanced to a very high value due to fast controllability and modulation of the DC power.

Hence,

Percentage Power Upgradation = (PT-P)*100/PT

IV. PURPOSED SIMULATION MODEL

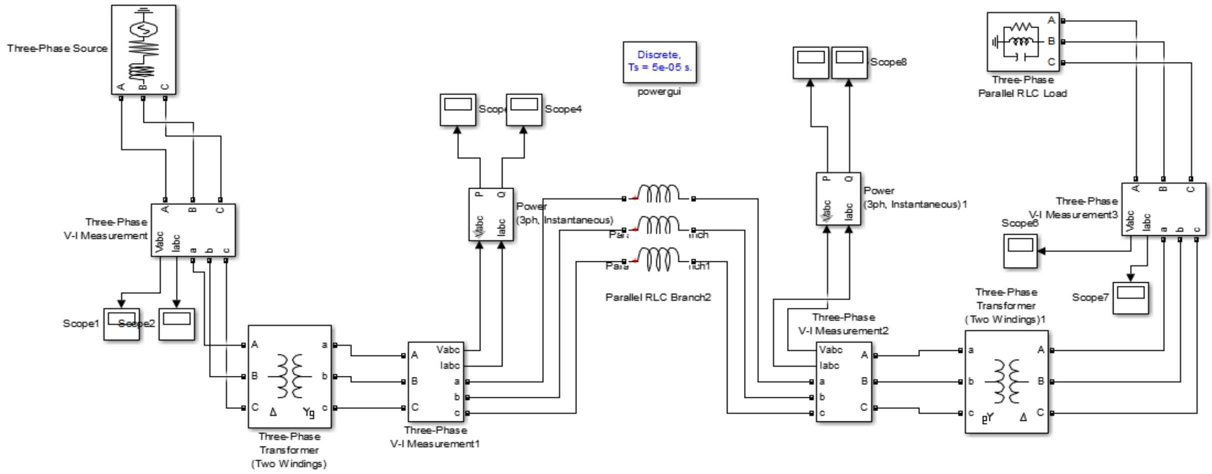


Figure:- SIMULATION model for HVAC Transmission Line

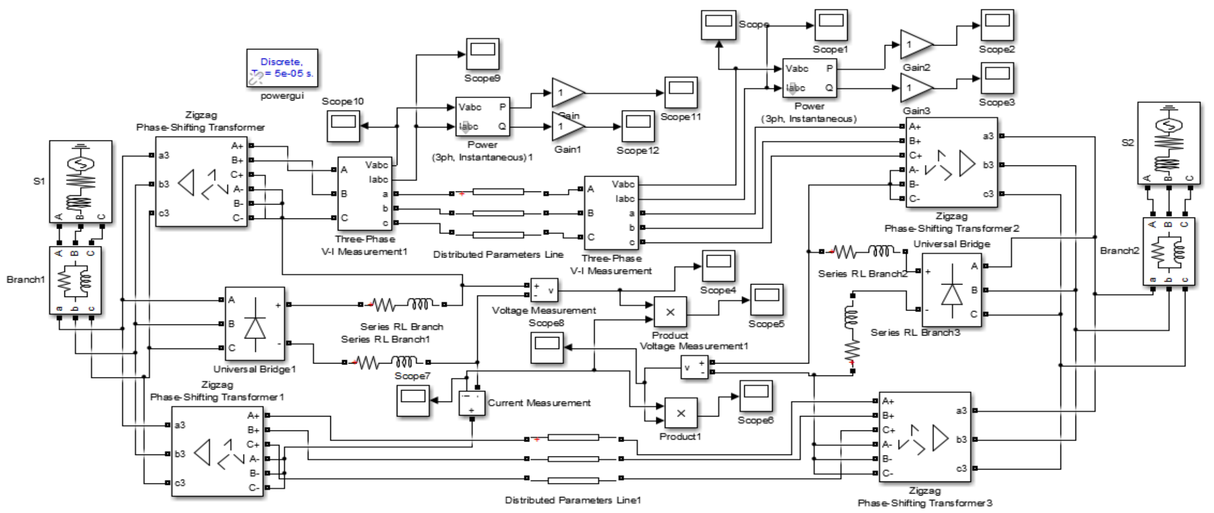
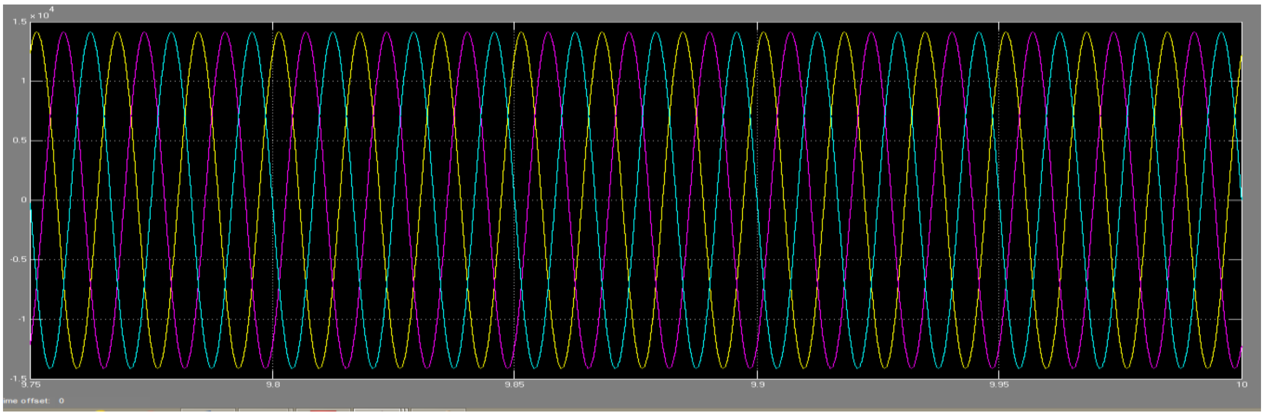


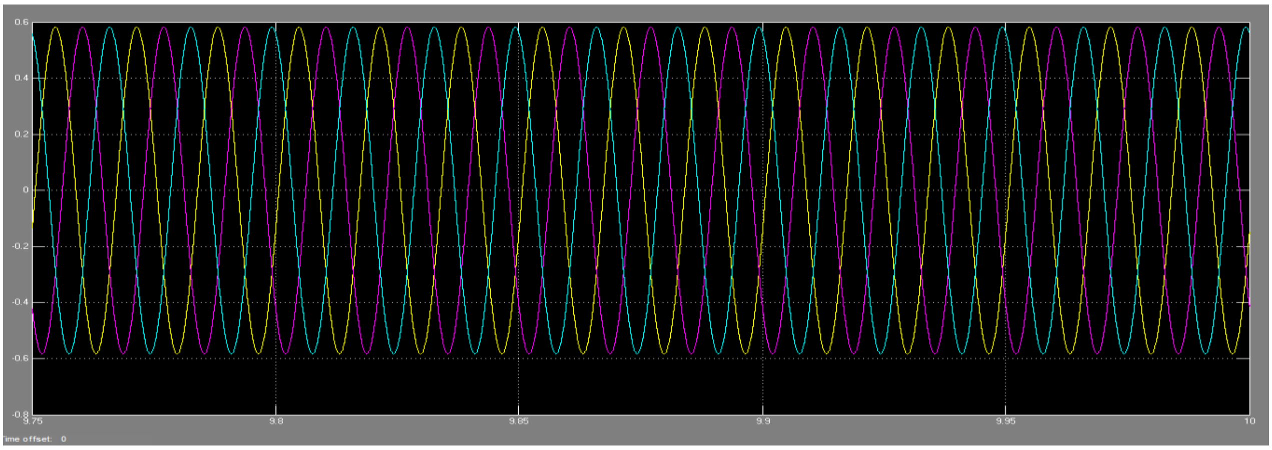
Figure2:- SIMULATION model for composite HVAC-HVDC Transmission Line

V. RESULTS

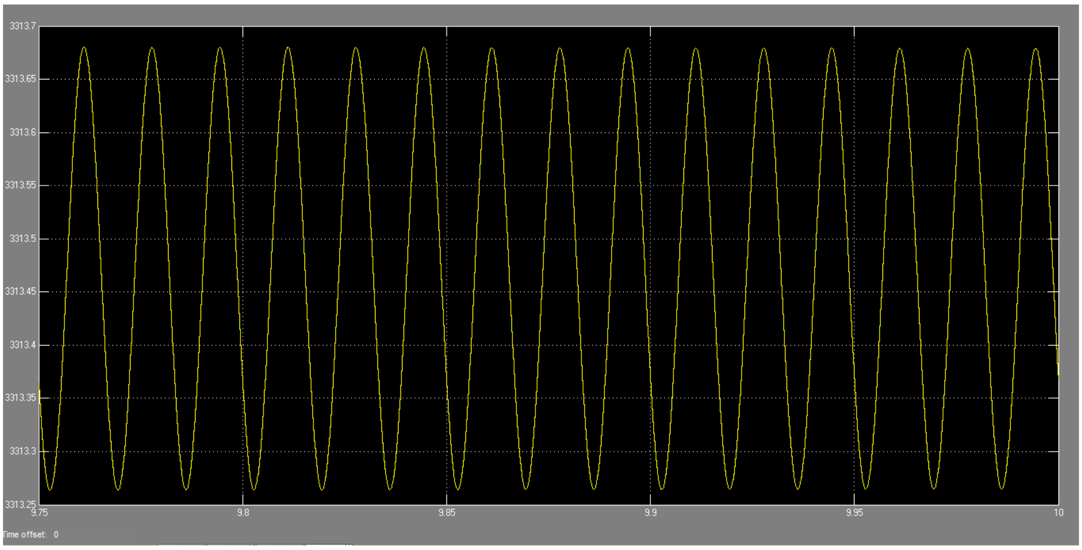
1. For simple HVAC Transmission Line



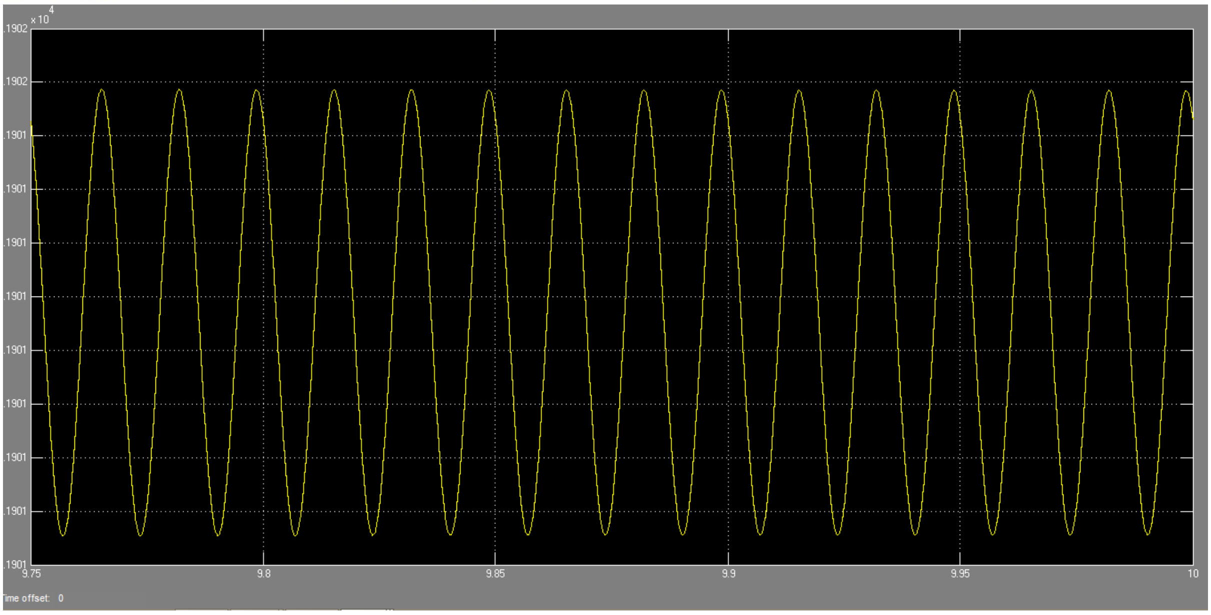
Sending End Voltage



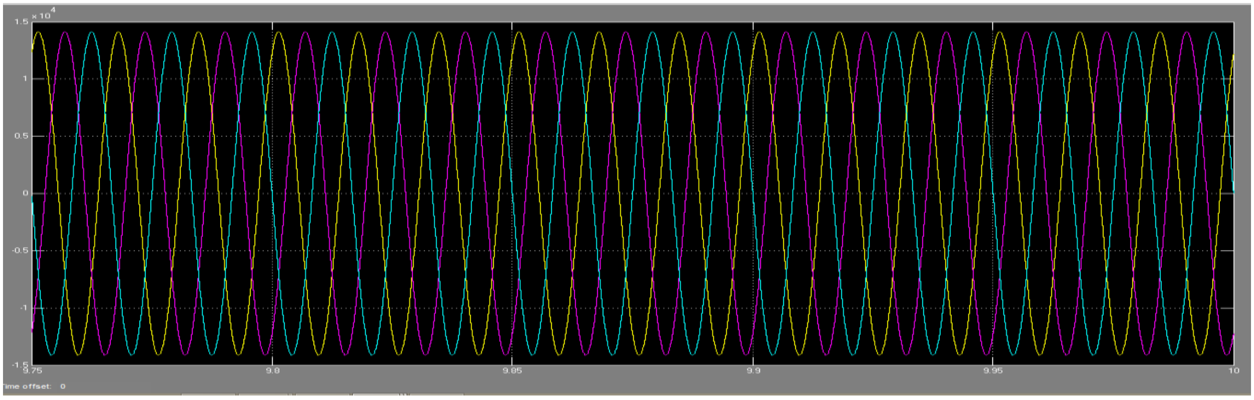
Sending End Current



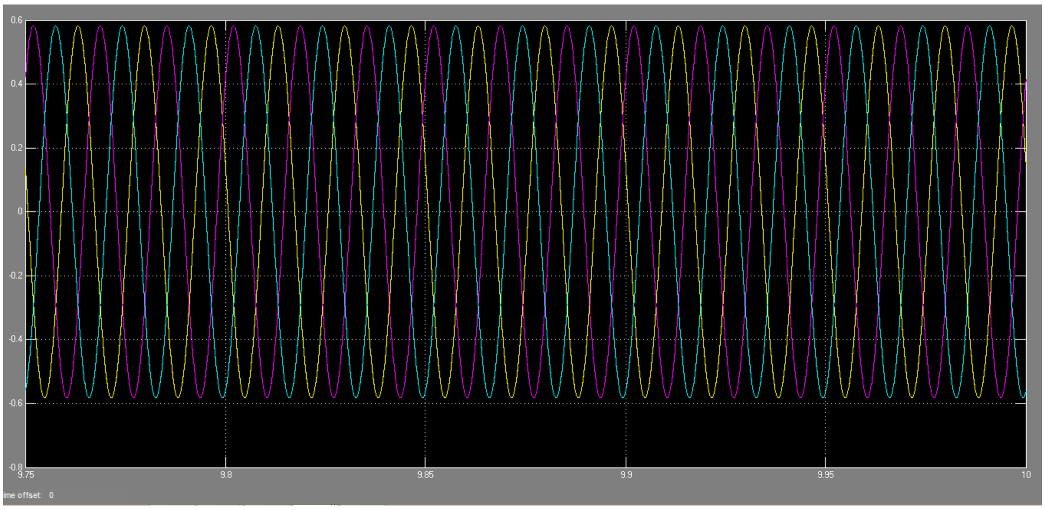
Steady State Sending End Active Power



Steady State Sending End Reactive Power

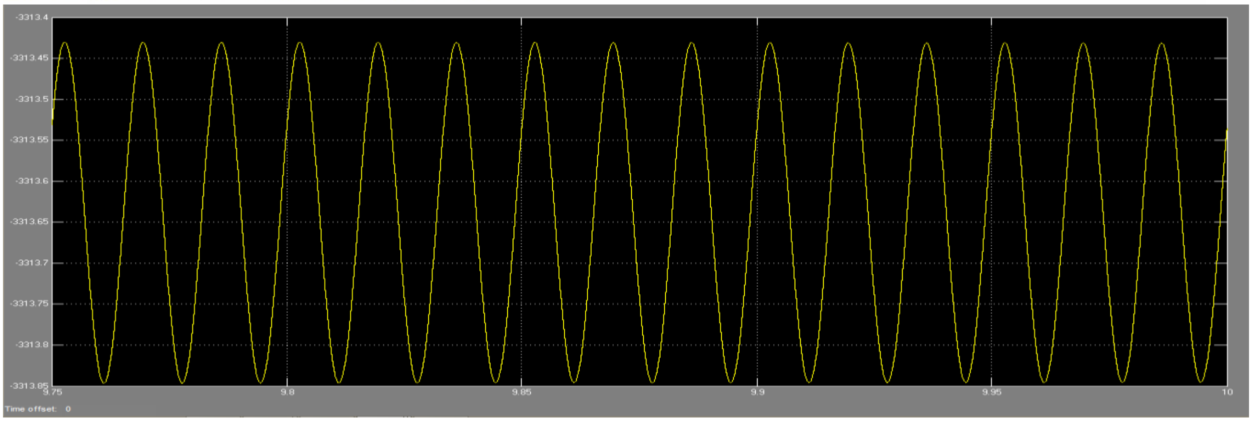


Receiving End Voltage

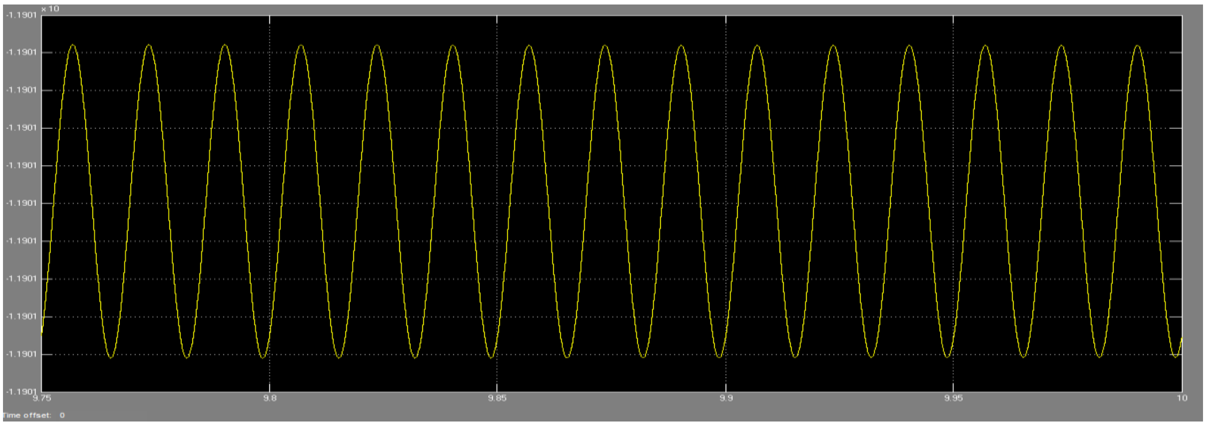


Receiving End Current

 ISBN: 978-93-86171-60-3

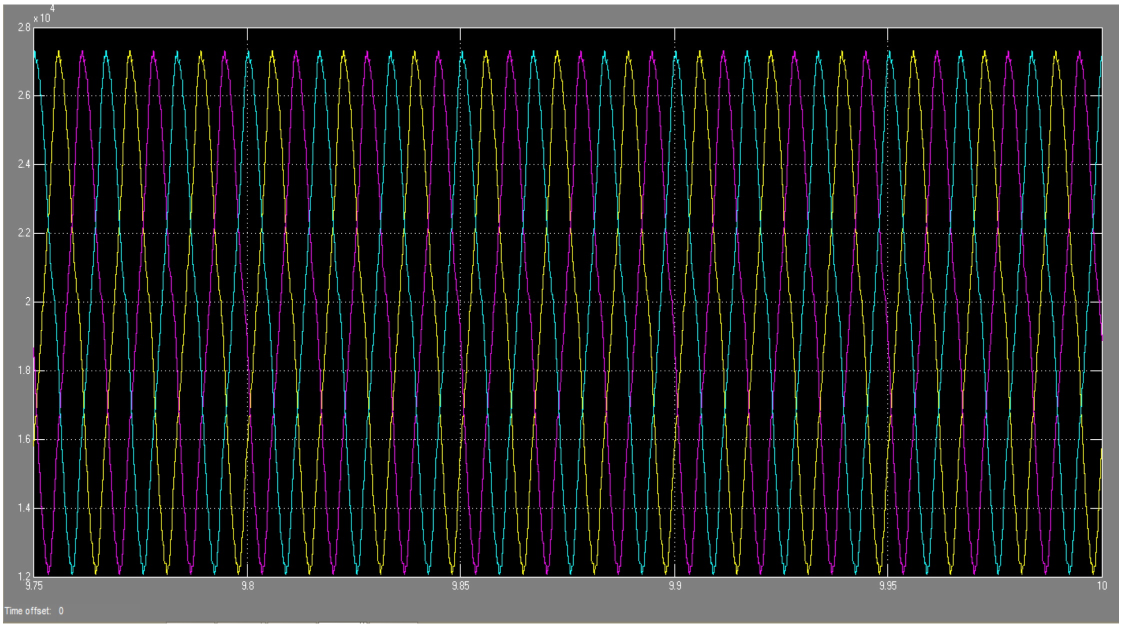


Steady State Receiving End Active Power

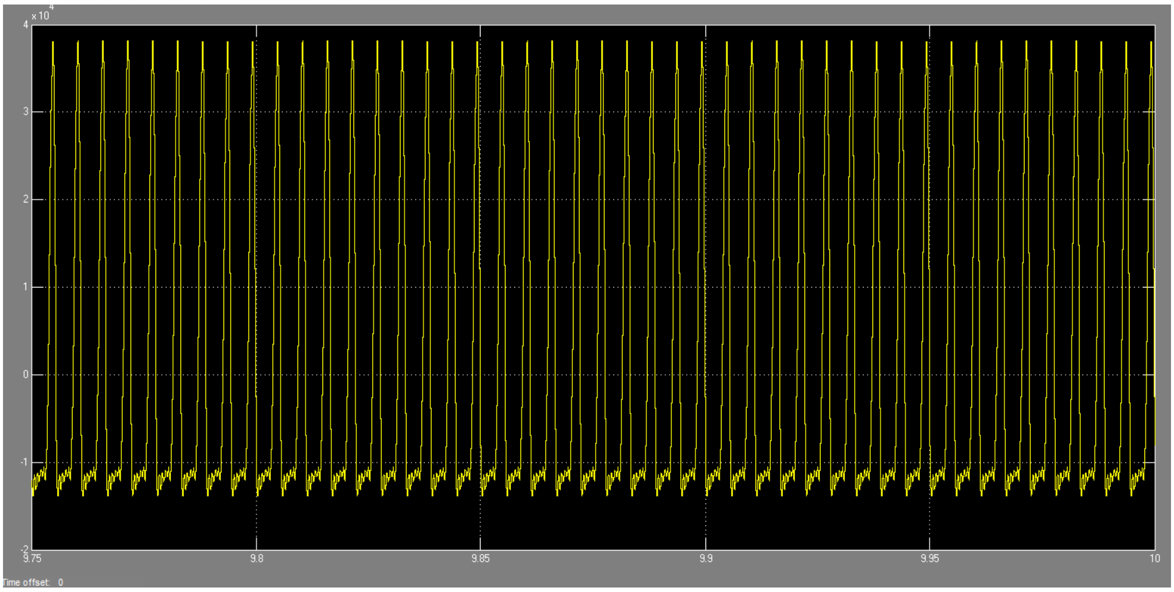


Steady State Receiving End Reactive Power

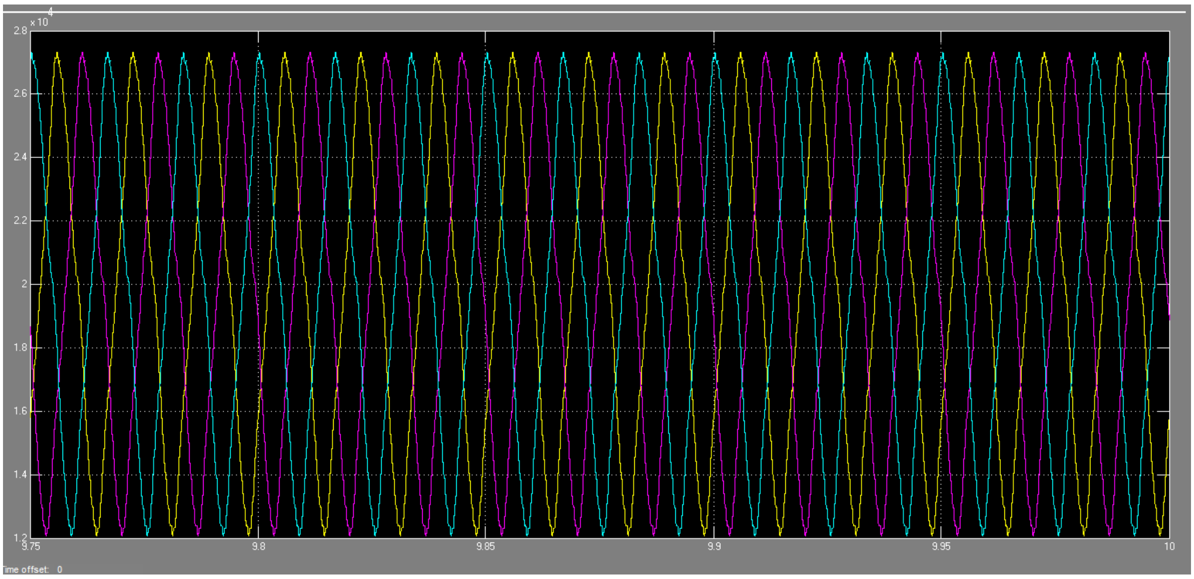
For Composite HVAC-HVDC Transmission Line:-



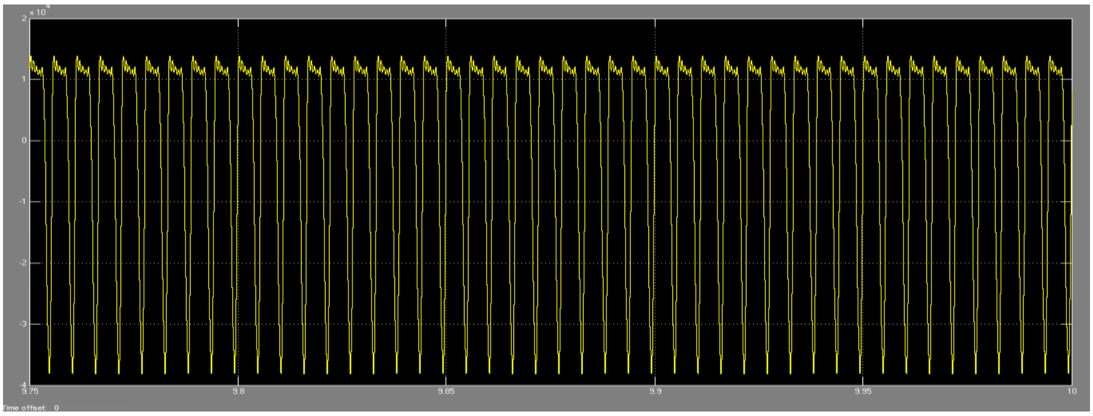
Sending End Voltage



Steady State Sending End Active Power



Steady State Receiving End Voltage



Steady State Receiving End Active Power

VI. CONCLUSION

This paper states the feasibility of hybrid AC/DC transmission scheme aimed at upgradation of existing long AC line. We can see from the above graphical results that power transfer at receiving end due to purposed composite AC/DC transmission line has been increased for same line without changing conductors, tower structure or even insulators. Also as power angle increased up to 70°.Use of power electronics converters allow us to enhance critical clearing angle and critical clearing time for smooth and stable operation of power system.

REFRENCES

[1] R. D. Dunlop, R. Gutman, and P. P. Marchenko, "Analytical development of load ability characteristics for EHV and UHV transmission lines," in *IEEE Transaction on Power Apparatus and Systems*, vol. PAS-98, no.2, pp. 606-617, March 1979.

[2] N. Flourentzou, V. G. Agelidis, and G. D. Demetriades, "VSC-Based HVDC power transmission systems: an overview," in *IEEE Transaction on Power Electronics*, vol. 24, no.3, pp. 592-602, March 2009.

[3] R. Lucas, "AC --small power DC hybrid transmission for improving power system stability," in *Electric Power Systems Research*, 2000, pp. 9-15.

[4] H. Rahman and B. H. Khan, "Enhanced power transfer by simultaneous transmission of ac-dc: A new facts concept," in *Power Electronics, Machines and Drives* (PEMD), April 2004, vol.1, pp.186-191.

[5] K. P. Basu and H. Rahman, "Feasibility study of conversion of double circuit ac transmission line for simultaneous ac-dc power transmission," in *IEEE PEDS*, 2005, pp. 972-976.

[6] Hafizur Rahman and B. H. Khan, "Power upgrading by simultaneous AC–DC power transfer in a double circuit ac line," in *Power India Conference*, 2006.

[7] H. Rahman and B. H. Khan, "Power upgrading of transmission line by combining AC–DC Transmission," in *IEEE Transaction on Power Systems*, vol. 22, no.1, pp. 459-466, February 2007.

[8] K. P. Basu, "Stability enhancement of power system by controlling HVDC power flow through the same ac transmission line" in *IEEE Symposium on Industrial Electronics and Applications* (ISIEA 2009), October 4-6, 2009, pp. 663-668.

[9] H. Rahman and B. H. Khan, "Stability improvement of power system by simultaneous AC–DC power transmission," in *Electric Power Systems Research*, 2008, pp. 756-764.

[10] J. Lundkvist, I. Gutman, and L. Weimers, "Feasibility study for converting 380 kV AC lines to hybrid AC / DC lines," Presented at *EPRI's High-Voltage Direct Current & Flexible AC Transmission Systems Conference*, November 5-6, 2009.

 ISBN: 978-93-86171-60-3

[11] *Cigré Technical Brochure* No. 425, “Increasing capacity of overhead transmission lines-needs and solutions –“, August 2010.

[12] STRI. Jan Lundquist, (Oct. 2011). "Converting AC lines to DC for increased power transfer capacity," [Online]. Available:
http://ec.europa.eu/energy/infrastructure/tent_e/doc/off_shore_wind/2011_annual_report_annex4_en.pdf

[13] M. H. Okba, M. H. Saied, M. Z. Mostafa, and T. M. Abdel- Moneim, "High voltage direct current transmission – a review, Part II – converter technologies," in *IEEE Energy tech*, May, 2012, pp. 1-7.

[14] K. Eriksson, “Operational experience of HVDC light TM,” in *AC-DC Power Transmission*, 2001, pp. 205-210.

[15] S. Norrga, “VSC HVDC-past, present and future,” in *European Conference on Power Electronics and Applications*, 2011.

[16] B. Jacobson, P. Karlsson, G. Asplund, L. Harnefors, and T. Jonsson, “VSC-HVDC transmission with cascaded two-level converters,” in *CIGR´E*, B4-110, 2010.

[17] R. L. Hauth, P. J. Tatro, B. D. Railing, B. K. Johnson, J. R. Johnson, and J. L. Fink, “HVDC power transmission technology assessment report ORNL/Sub/95-SR893/1,” Oak Ridge National Laboratory, April 1997.

[18] J. Green, A. Bowen, L. J. Fingersh, and Y. Wan, "Electrical collection and transmission systems for offshore wind power," in *Offshore technology conference*, 2007.