POWER UPGRADING OF TRANSMISSION BY SIMULTANEOUS AC-DC TRANSMISSION

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ABSTRACT:

Due to restrictions imposed on new transmission lines because of right-of-way cost, environmental and regulatory concerns. There is a need to enhance the power transfer capability of the existing lines without major changes. This paper gives the feasibility of enhanced power transfer by simultaneous ac-dc transmission through the same line. According to the characteristics of long extra high voltage (EHV) ac lines cannot be loaded to their thermal limits in order to keep sufficient margin against transient instability. With scheme proposed in this paper, it is possible to load this line very close to their thermal limits. The conductors are allowed to carry usual ac along with dc superimposed on it. The added dc power flow does not cause any transient instability. This paper gives of converting a double circuit ac line into composite ac-dc power transmission line to get advantages of parallel ac-dc transmission to improve stability and damping out oscillation. Simulation and experimental studies are carried out for the coordinated control as well as independent control of ac and dc power transmissions. No alterations of conductors, insulator strings and towers of the original lines are needed. Substantial gain in load ab ility of the line is obtained. This thesis presents the method to convert an existing double circuit EHVAC line into simultaneous ac-dc transmission line simulation is carried out using MATLAB SIMULINK.

Keywords : *EHVAC transmission, HVDC transmission, simultaneous ac-dc transmission, MATLAB SIMULINK*

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1. INTRODUCTION

In recent year, to transfer electrical power with high efficiency for long distance, construction of the new transmissions are necessary. The power is often available is not close to the growing load centers but at remote locations. These locations are determined by environmental acceptability, cost of available energy and regulatory policies. To transfer this available energy through existing long (EHV)ac lines to load centers has a certain upper limit due to stability consideration. Hence these ac lines are not loaded to their thermal limit to keep sufficient margin against transient stability. To avoid this problem of transient instability the conversion of a double circuit ac lines to composite ac-dc lines without altering the original line conductors, towers and insulator strings has been presented. In this proposed scheme the dc power flow is point-to-point bipolar transmission system suggested the conversion of ac line to dc line for power upgrading of long ac line. The main advantages of simultaneous ac-dc power transmission is to load the line close to its thermal limit without losing transient stability.

2. LITERATURE SURVEY

This paper presents the power upgrading of transmission line by simultaneous ac-dc transmission. In simultaneous ac-dc power transmission, the conductors are allowed to carry superimposed dc current along with ac current. Ac and dc power flows independently and the added dc power flow does not cause any transient stability. The authors, H. Rahman and B.H. Khan have earlier shown that EHV ac line may be loaded to a very high level by using it for simultaneous ac-dc power transmission as reported in reference .In this proposal, we have used Double circuit transmission line and then conversion of double circuit ac line into composite ac-dc line without altering equipments.

3. EXISTING TRANSMISSION ISSUES

3.1 High Voltage DC Transmission::

1. Costly Terminal Equipment: Converters which are used in HVDC are more expensive than the conventional ac equipment.
2. More Maintenance of Line Insulator: Maintenance of insulators in HVDC transmission line is more.
3. Voltage Transformation: It is not easier in case of dc and hence it has to be accomplished on the ac side of the system.

3.2 High Voltage AC Transmission:

1. Increased Current Density because of increase in line loading by using series capacitors.
2. Use of bundled conductors.
3. High surface voltage gradient on conductors.
4. Corona problems: Audible Noise, Radio Interference, Corona Energy Loss, Carrier Interference, and TV Interference.
5. Increased Short-Circuit currents and possibility of Ferro resonance conditions.

4. SIMULTANEOUS AC-DC TRANSMISSION SYSTEM

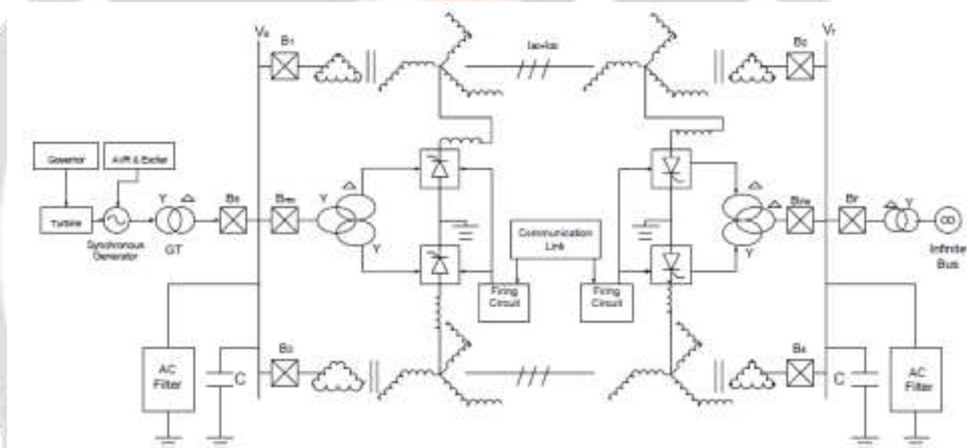


Figure 1 Basic scheme for simultaneous ac-dc transmission

Figure 1 shows the basic scheme for simultaneous ac-dc power through a double circuit ac transmission line. The dc power is obtained through line commutated six-pulse rectifier bridge using PWM technique used in conventional HVDC and injected to the neutral point of zig-zig connected secondary of sending end transformer and is reconverted to ac again by the conventional line commutated six-pulse bridge inverter using PWM technique at the receiving end. The inverter bridge is again connected to the neutral of zig-zig connected winding of the receiving end of transformer. The double circuit ac line carries both three phase ac and dc power. Each conductor of each line carries one-third of total dc current along with ac current. Three conductors of the second line provide return path for dc current. Zig-zig connected winding is used at the both ends to avoid saturation of transformer due to dc current.

5. METHODOLOGY

Assuming the usual constant current control of rectifier and constant extinction angle control of inverter as mentioned later, the equivalent circuit of the scheme under normal steady-state operating condition is given in Fig. 2. The dotted lines in the figure show the path of ac return current only. R_{cr} and R_{ci} are commutating resistances, and, α, γ are firing and extinction angles of rectifier and inverter, respectively. It is based on a Distributed LC parameter travelling wave line model, with lumped résistance. Its represents the L and C elements of PI sectioning a distributed manner.The feasibility of the conversion of the AC Line to Composite AC-DC Line is considered.

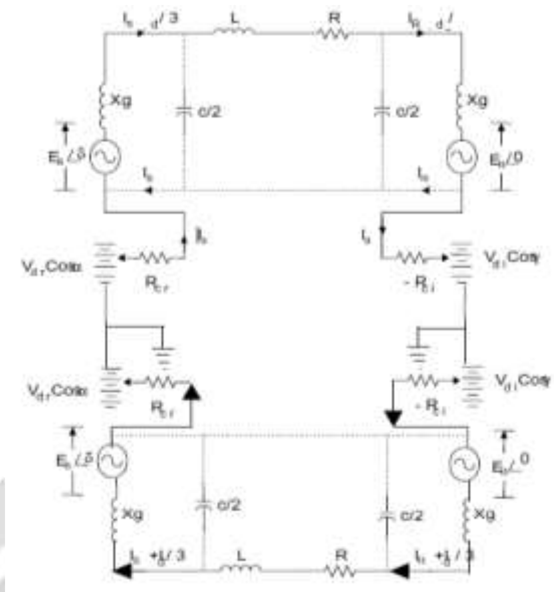


Figure 2 Equivalent circuit diagram of simultaneous ac-dc transmission

Consider data:

- Synchronous Machine:

Power = 2750 MVA, Voltage = 24KV, Frequency = 50Hz

- Transmission line Parameters:

Phase = 3-Φ, Voltage = 400KV, Length (l) =450Km

Z=0.3324∠84.38 Ω/Km/ph/ckt, $Y = 3.3379 * 10^{-6}$∠90 S/Km/ph/ckt, I_{th}=1.8KA/ckt

- X=74.4435 Ω/ph
- Sending End Voltage (Rms) =230.94KV
- Sending End Current = $I_s = \frac{550*10^6}{3*230.94}$ = 0.793KA
- Surge impedance = $Z_c = \sqrt{\frac{z}{y}} = \sqrt{\frac{0.3324\angle 84.38}{3.3379*10^{-6}\angle 90}}$ =315.29∠-2.81
- Determination of ABCD parameters: A, B, C and D parameters of each line are computed as follows:

A=0.999∟0.0109, B=7.778∟16.776ohm, C =$7.804*10^{-5}$∟22.39mho, D=0.999∟0.0109

Sending end voltage and current are written as:

$$\begin{matrix} Es \\ Is \end{matrix} = \begin{bmatrix} A & B \\ C & D \end{bmatrix} \begin{matrix} Er \\ Ir \end{matrix}$$

$$\begin{matrix} Er \\ Ir \end{matrix} = Inv\begin{bmatrix} A & B \\ C & D \end{bmatrix} \begin{matrix} Es \\ Is \end{matrix}$$

Therefore the SE and RE Voltage and Currents are calculated:

Es =230.94∟0 KV & Is =0.793∟0 KA

Er =224.7∟-0.445 KV &Ir =0.8125∟0.58 KA

Active and Reactive Power in terms of ABCD parameters are:

$Ps+jQs = \frac{-EsEr^*}{B^*} + \frac{D^*Es^2}{B^*}$ = Ps =189.7363MW Qs=3.013MVAR

$Pr+jQr = \frac{ErEs^*}{B^*} - \frac{A^*Er^2}{B^*}$= Pr=185.209MW Qr=-0.5172MVAR

Allowing maximum permissible voltage offset such that the composite voltage wave just touches zero in every cycle:

$V_d = V_{ph}/\sqrt{2}$=163.299 KV

And the rms value of voltage of composite AC-DC line is given by_

$V_a = V_{ph}/2$= 115.47 KV

We know that reactance per phase of double circuit line is X=74.4435Ω/ph. Let δ1 is the power angle between the voltage at the two ends (to keep sufficient stability margin.δ1 is generally kept low for long lines and seldom exceeds 30˚). And δ2 is the power angle between the AC voltages at the two ends of the composite line.

Total power transferred through the double circuit line before conversion is as follows:

Consider the Power Angle δ1=30, δ2=30

$$Pac = \frac{3\,v_{ph}{}^{2} sin\delta1}{X} = 1074.6394 MW$$

But AC current/ph/ckt of double circuit line may be computed as

$$I_{\alpha} = \frac{vsin\,{}^{\delta}/_{2}}{X} = 0.7755 \text{ KA}$$

But the dc current $Id = 3\sqrt{Ith^2 - I\alpha^2}$ = 4.873 KA

Total power transferred through the composite line is:

$$Ptotal=.Pac+Pdc= \frac{3\,v_{\alpha}{}^{2}\,sin\delta1}{X} + 2VdId$$

Pac+dc = 1860.16 MW

6. SIMULINK MODELS AND THEIR RESULTS

6.1 SIMPLE DOUBLE CIRCUIT HVAC LINE

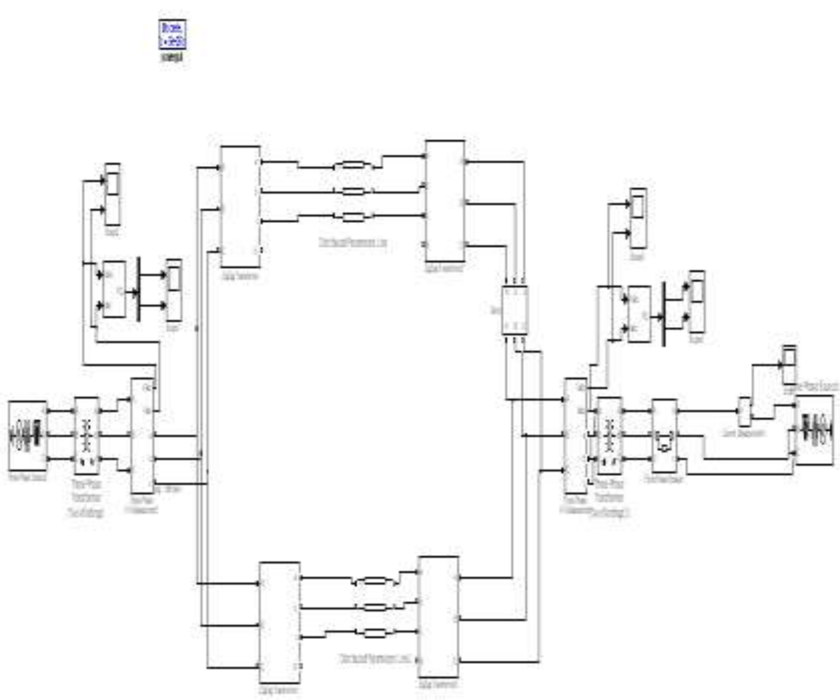


Figure 3. Simple double circuit hvac line

6.2. BLOCK DIAGRAM FOR HVAC TRANSMISSION SYSTEM

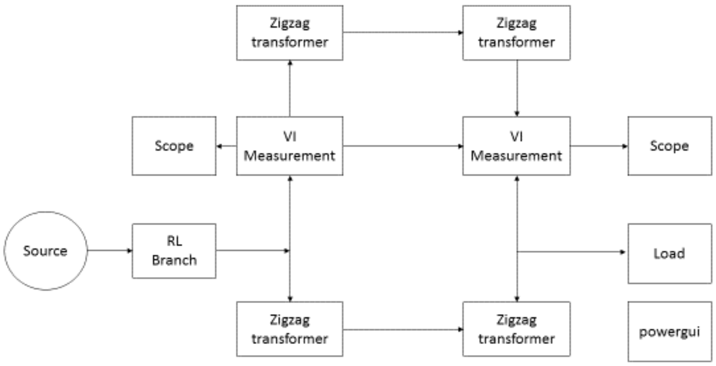


Figure 4 . Block diagram for hvac transmission system

6.3. SIMULATION RESULT OF HVAC MODEL

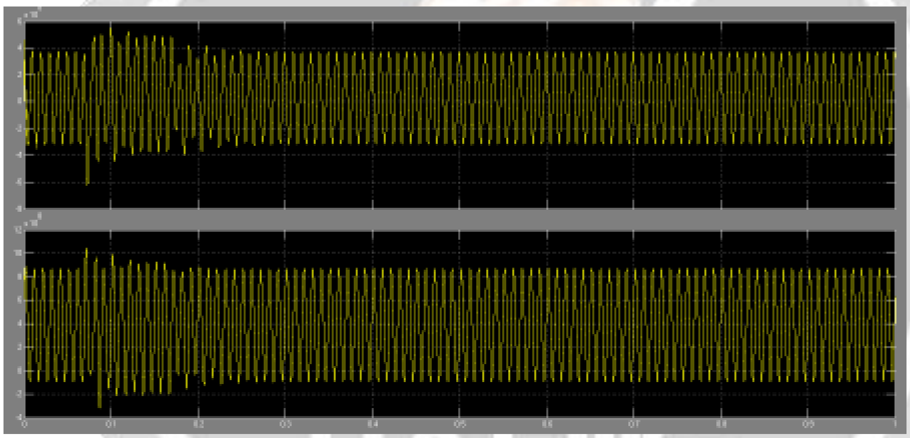


Figure 5 Input Active and Reactive Power Waveforms

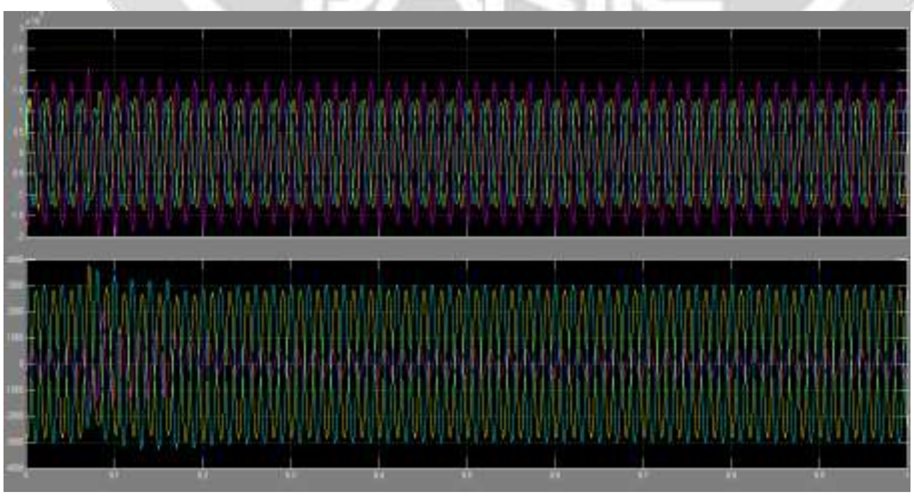


Figure 6 Input Voltage and Current Waveforms

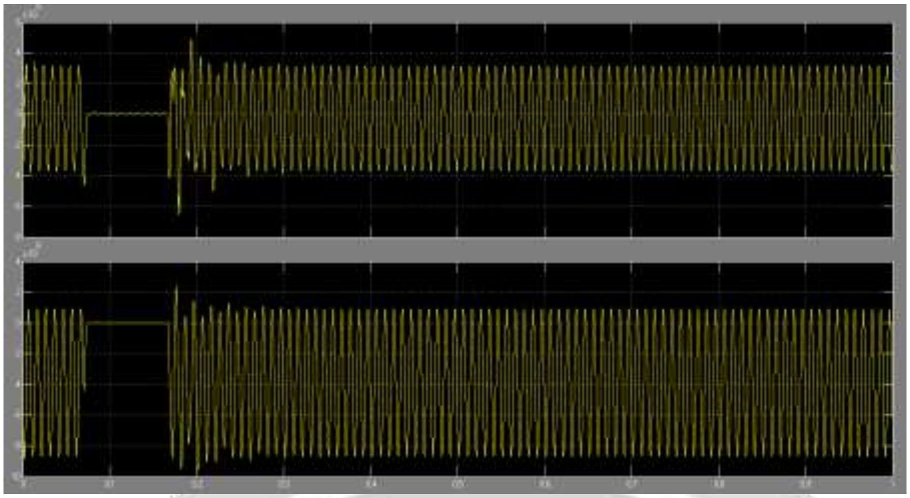


Figure 7 Output Active and Reactive Power Waveforms

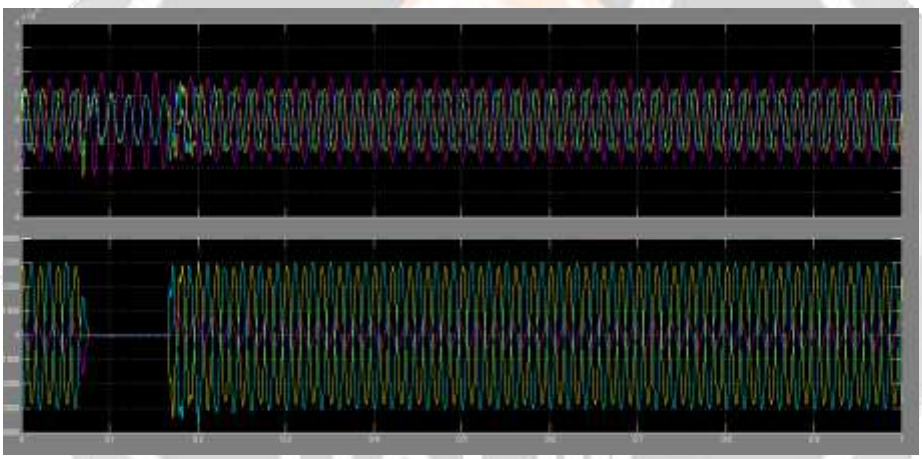
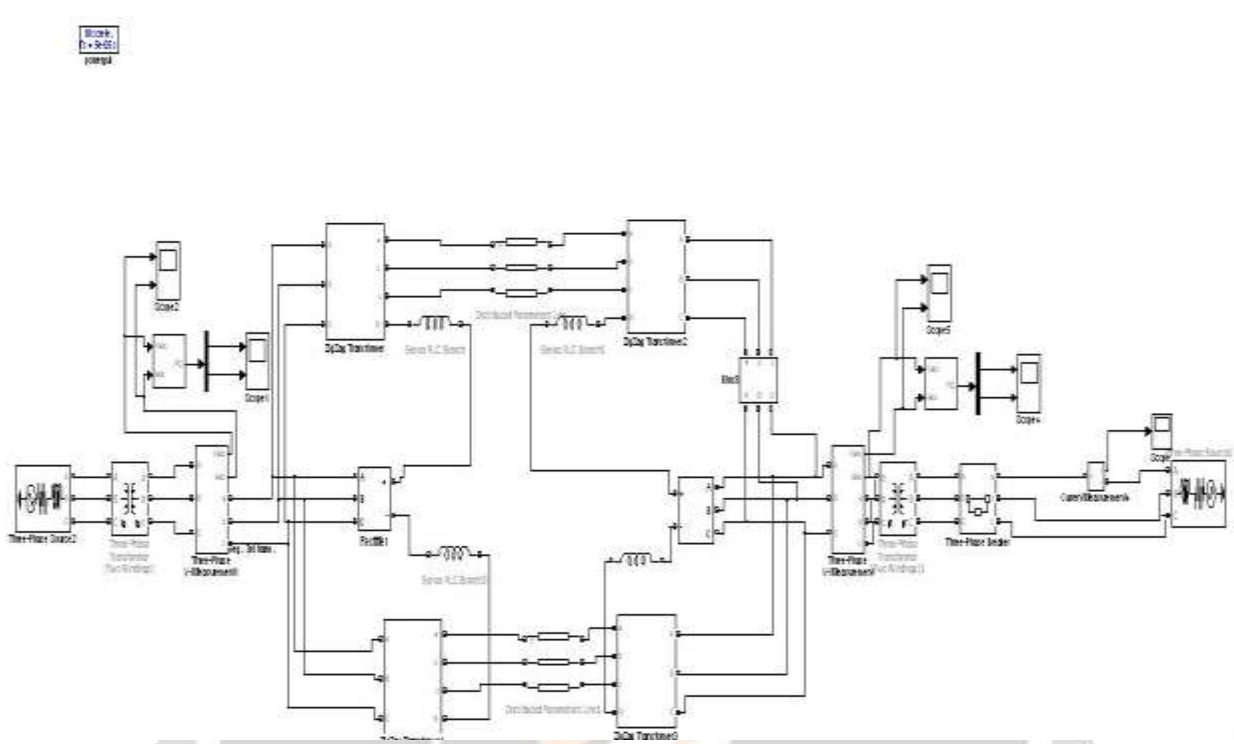
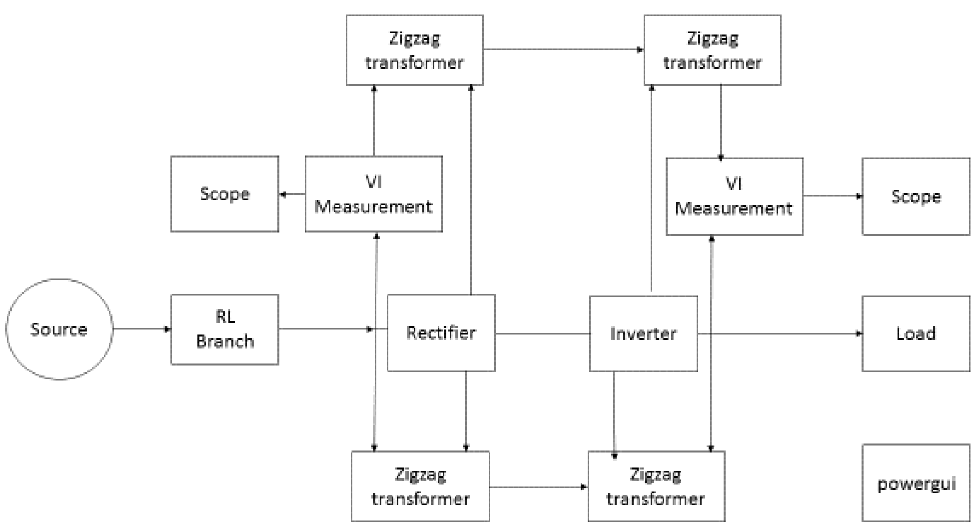


Figure 8 Output Voltage and Current Waveforms

6.4. SIMULTANEOUS HVAC-DCSIMULINK MODEL



6.5. BLOCK DIAGRAM FOR SIMULTANEOUS HVAC-DC TRANSMISSION SYSTEM



6.6 SIMULATION RESULT OF HVAC-DC MODEL

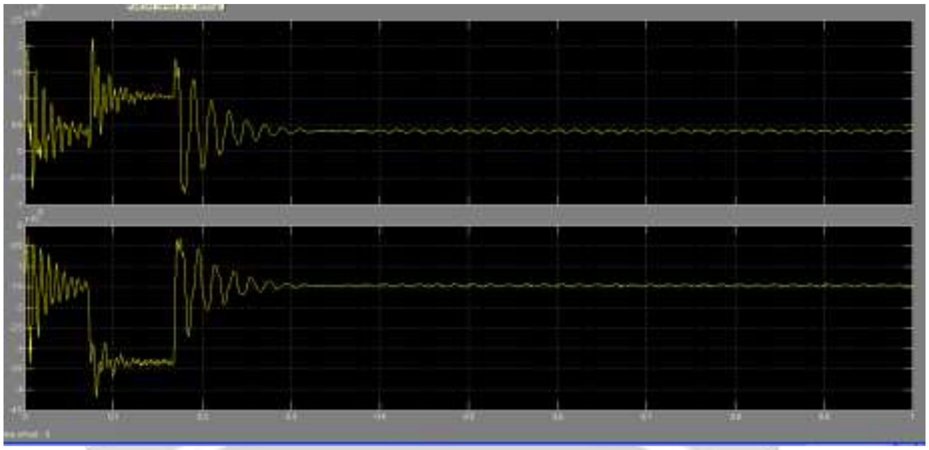


Figure 9 1 Input Active and Reactive Power Waveforms

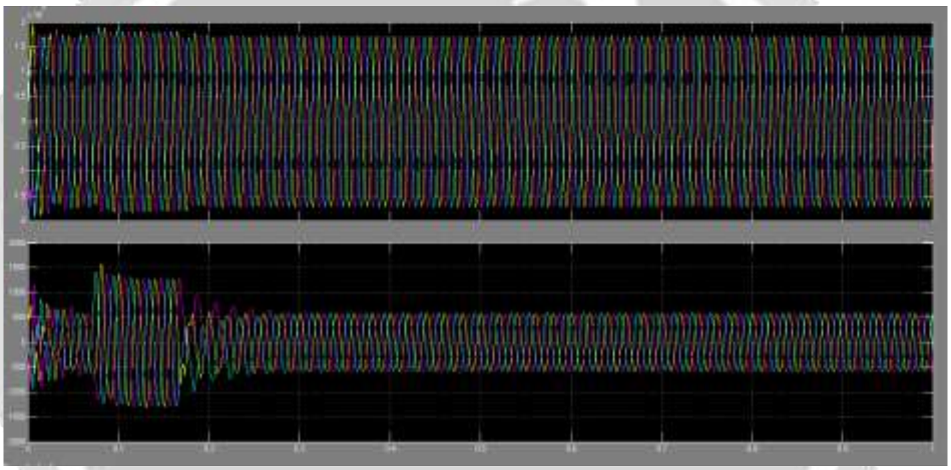


Figure 10 Input Voltage and Current Waveforms

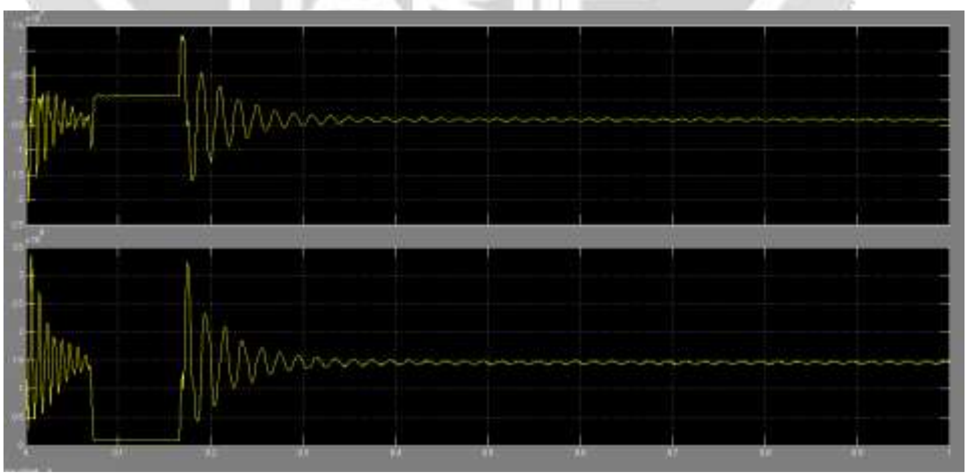


Figure 11 Output Active and Reactive Power Waveforms

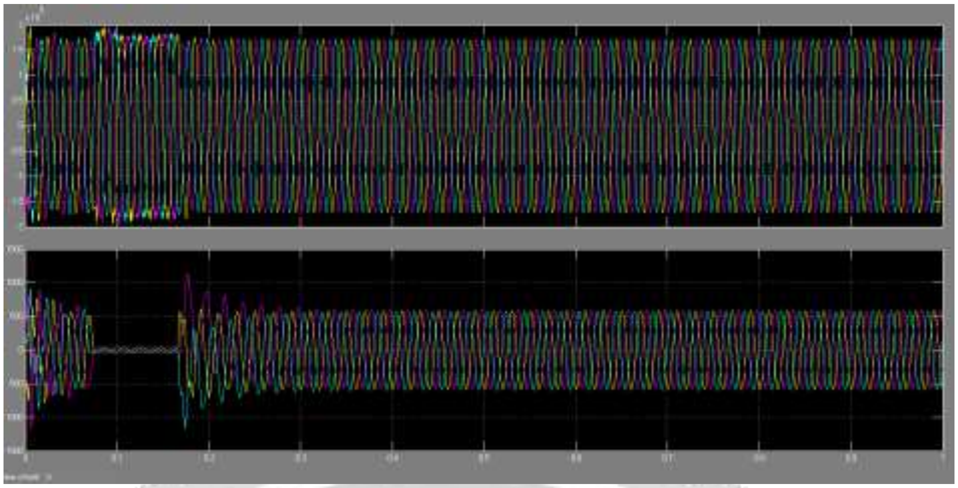


Figure 12 Output Voltage and Current Waveforms

7. CONCLUSION

In this project, it is shown that by injecting DC power in AC power transmission lines, we can improve the transmission capacity of the line by 2 to 4 times without altering the physical equipment. In every transmission line the faults are occurred which interrupts the power supply, to avoid the faulty conditions some protection schemes are used in transmission line. By considering such a drawback in transmission line and with using a solution technique this work can be extended for analyzing the faults effect and different protect schemes suitable to that particular type of transmission. The most important factor is that it is possible to analyze the conditions in simultaneous ac-dc transmission by using UPFC (Unified Power Flow Control) device.

8. FUTURE PROSPECT

In this project, it is shown that by injecting DC power in AC power transmission lines, we can improve the transmission capacity of the line by 2 to 4 times without altering the physical equipment. In every transmission line the faults are occurred which interrupts the power supply, to avoid the faulty conditions some protection schemes are used in transmission line. By considering such a drawback in transmission line and with using a solution technique this work can be extended for analyzing the faults effect and different protect schemes suitable to that particular type of transmission. The most important factor is that it is possible to analyze the conditions in simultaneous ac-dc transmission by using UPFC (Unified Power Flow Control) device.

9. REFERENCE

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