UPGRADATION OF EHVAC LINES BY COMPOSITE AC-DC TRANSMISSION

Major Project Report

Submitted in partial fulfillment of the requirements for the degree of

MASTER OF TECHONLOGY

IN

ELECTRICAL ENGINEERING

(Electrical Power System)

By

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NIRMA UNIVERSITY
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Undertaking Originality Of The Work

I, **Pratik Ashok Desai**, Roll . No.**12MEEE07** , give undertaking that the Major Project entitled **Upgradation Of EHVAC Lines By Composite AC-DC Transmission** submitted by me, towards the partial fulfillment of the requirements for the degree of Master of Technology in Electrical (Electrical Power System) of Nirma University, Ahmedabad, is the original work carried out by me and I give assurance that no attempt of plagiarism has been made. I understand that in the event of any similarity found subsequently with any published work or any dissertation work elsewhere; it will result in severe disciplinary action.

Signature of Student

Date: ——————

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Certificate

This is to certify that the Major Project Report entitled **Upgradation Of EHVAC Lines By Composite AC-DC Transmission** submitted by **Mr.Pratik Ashok Desai(12MEEE07)** towards the partial fulfillment of the requirements for **Master of Technology (Electrical Engineering)** in the field of **Electrical Power System** of **Nirma University** is the record of work carried out by him/her under our supervision and guidance. The work submitted has in our opinion reached a level required for being accepted for examination. The results embodied in this major project work to the best of our knowledge have not been submitted to any other University or Institution for award of any degree or diploma.

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Acknowledgement

With immense pleasure, I would like to present this report on the dissertation work related to " Upgradation of Existing EHVAC line by Composite AC-DC Transmission". I am very thankful to all those who helped me for the successful completion of the dissertation and for providing valuable guidance throughout the project work. It is a pleasant aspect that I have now the opportunity to express my gratitude towards them.

I offer my sincere and heartfelt gratitude to Asst. Prof. Shanker Godwal (Assistant Professor, Electrical Engineering Department, IT, NU) for his valuable guidance, motivation and encouragement. My M.Tech dissertation work would not have been possible without his constant support and helpful discussions. His constant support and constructive criticism has been invaluable assets for my project work. He has shown keen interest in this dissertation work right from beginning and has been a great motivating factor in outlining the flow of my work.

I would also like to thank Dr. S.C.Vora, PG co-ordinator of EPS, Electrical for allowing me to carry out my project work in this very institute . I am thankful to Nirma University for providing all kind of required resources.

My sincere thanks and gratitude to Dr. P.N Tekani, Head, Electrical Engineering Department, Institute of Technology, Nirma University, Ahmedabad for his continual kind words of encouragement and motivation throughout the Dissertation work.

I hereby take the opportunity to express my deep sense of gratitude to my respected institute guide Asst. Prof. Shanker Godwal (Assistant Professor, Electrical Engineering Department, IT, NU) for his valuable and precious guidance as well as active support during the project.

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Abstract

In this present time of populated cities, it is difficult to carry out new layout of transmission line as it not economical as per environment and right of way, even though the demands of loads increase. Also, power transfer is less than to its fullest as the conductors cannot be loaded to its thermal loadability due to transient stability and temperature factor. So, this project shares us an idea of increasing power transfer by superimposing DC current on the AC current in the conductors to its thermal limits. DC power flow is very much independent to transient instability. A bipolar AC circuit line will be used as composite AC-DC power transmission which will help in to have good stability and eliminating oscillations. All previous structures and equipments of the original line will remain as it is.

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Nomenclature

P_{ac} .... AC Power

P_{dc} .... DC Power

X_d .... Reactance of DC Reactor

I_{ac} .... AC Current

I_{dc} .... DC Current

V_{dro} .... Maximum Rectifier DC Voltage

V_{dio} .... Maximum Inverter DC Voltage

R_{cr} .... Rectifier Commutating Resistance

R_{ci} .... Inverter Commutating Resistance

α .... Firing angle of Rectifier

γ .... Firing angle of Inverter

E_S .... Sending End Voltage

I_S .... Sending End Current

E_R .... Receiving End Voltage

I_R .... Receiving End Current

E_s .... Sending End Voltage

I_s .... Sending End Current

V_{dr} .... Rectifier DC Voltage

V_{di} .... Inverter DC Voltage

P_{dr} .... Rectifier DC Power

P_{di} .... Inverter DC Power

Q_{dr} .... Rectifier DC Reactive Power

Q_{di} .... Inverter DC Reactive Power

P_L .... Transmission Line Loss

V_d .... DC Voltage

V_a .... AC Voltage

I_a .... AC Current

I_d .... DC Current

I_{th} .... Thermal Current Limit

δ .... Power Angle

μ_r .... Commutation angle of Rectifier

μ_i .... Commutation angle of Inverter

Chapter 1

Introduction

In present time of populated cities, it is difficult to have new construction of transmission line as it creates congestion as per environment and right of way. The load demand is showing a steady graph but when mapped it indicates unequal progress. Power sometimes remains insufficient at the remote location. These areas are mostly determined by the regulatory policies, environmental availability and cost of energy. Power when transmitted through lines have certain or another limits. It can be due to stability considerations or any physical parameters. The transmission lines cannot be loaded to their thermal limit to keep intact from transient instability because of these limits.

Transmission lines have to consider two points about thermal limits[1]:

a. The mechanical robustness of the aluminium conductors will be lost if it is directly in contact with extreme temperature and this may also lead to annealing.

b. The distance of the conductor from the ground reduces and sagging increases because of the expansion of conductors at high temperatures.

The maximum temperature that an aluminium annealed conductor can bear is 127^{o}C and without annealing is 150^{o}C. The critical temperature at which a conductor starts melting or wears off is 75^{o}C. If temperatures cross these limits, conductors will be bound to melt and eventually break.There are other points which may be responsible for restricted power enhancement in a transmission system. Transient stability is one of the factor which aids in temperature increment in conductors because of switching surges or lightening surges. AC lines cannot be provided with fast control which suggests that flow of power in the line has to be kept much lower than the peak value, under stability limits. This margin has to be sustained even under contingency conditions

Dynamic reactive power control plays an important role in sustaining required voltage profile under fluctuating conditions of loads and transient instability. The more increase in the load levels, higher will be reactive power consumption in the reactance of line.

For having complete advantage of the transmission lines, flexible ac transmission system (FACTS) components are being used to load the lines to its fullest. FACTS devices like state VAR system (SVS), controlled series capacitor (CSC), static phase shifter (SPS) and controlling braking resistors are very useful in controlling stability and remove damping oscillation.

The actual objective of this project is to observe that it is possible to have 65% more power transfer through the lines by superimposing DC supply on AC supply rather than using only AC lines. In current transmission lines, (EHV) AC lines are not allowed to be loaded to their full thermal limits so as to keep it intact against transient instability. With the help of the proposed idea in this project, the thermal loadability of the conductors can be increased to its limit. Both the AC and DC current will flow through the conductors.

1.1 Literature Survey

The list of literature that has been studied thoroughly is given below

a. **Power System Stability and Control by P.S.Kundur [1].** This book gave an idea of understanding the control scheme of rectifier and inverter. Even, it also discusses about the stability concepts required for the project.

b. **HVDC Power Transmission System by K.R.Padiyar [2].** This book gave complete understanding about HVDC from zero to infinite level. The pros and cons are understood from it.

c. **AC and/or DC substantial power upgrading of existing OHTL corridors by Clerici A, Valtorta G and Paris L [3].** This paper was referred so as to know the advantage and the problems that is faced in existing OHTL AC lines.

d. **Power Upgrading of Transmission Line by Combining AC-DC Transmission by H. Rahman and B.H.Khan [4].** From this paper, the significant idea of loading a line to the thermal loadability of the conductor with the help of superimposing DC current with AC current in a bipolar AC circuit transmission line with the help of converters is taken.

e. **Enhanced power transfer by simultaneous transmission of AC-DC: a new facts concept by H. Rahman and B.H. Khan [5].** This paper gives us the idea that even though DC current flows through the transformer, how zig-zag connection can help in avoiding saturation.

f. **Direct Current Transmission by Edwards Wilson Kimbark [6].** The operation of converters has been explained here in a detailed way which helps in building up basic concepts.The rectification and inversion modes of operation and the hinderance like commutation overlap has been discussed thoroughly. The control of the link is shown in much better way, clearing doubts regarding HVDC control.

g. **Possibility of Power Tapping from Composite AC-DC Transmission by H.Rahaman and B.H.Khan [7].** This paper was referred for the study of having power tapping possibility in composite AC-DC transmission line.

h. **FACTS: Flexible A.C. transmission system by N.G.Hingorani [8].** This book was used to know the basics of FACTS devices.

Chapter 2

Transmission Lines And Reality

2.1 EHVDC Lines

Ever since people came in contact with electricity, the first commercial electrical system they are familiar with is Direct Current (DC) systems. The main drawback of this system is that it is economical to transmit DC power over long transmission lines. This gave rise to extra high voltage AC system. But with the production of valves with high voltages, HVDC transmission system came into existence. The first of this kind having 100kV, 20MW DC link was laid out in the year 1954, between Swedish mainland and the island of Gotland. At present times considering major facts such as environmental factors and control, HVDC transmission systems have been opted for the following reasons [2]:

a. It is beneficial as per environment.

b. It gives the cheapest solution, i.e. economical.

c. Possibility to install asynchronous ties.

d. Fine control on the flow of power.

e. Very smooth to have good power stability, power quality, compensation.

The problems that are associated with EHVDC transmission lines are:

a. **Cost of converters:-**

   At both ends of DC link, a rectifier and an inverter is required. The installation cost of such converters is quite high. AC link has less problem as it requires only transformers.

b. **Reactive power requirement:-**

   It always requires reactive power for rectification or for inversion and also for compensation sometimes.

c. **Generation of harmonics:-**

   Use of rectifier and inverter give rise to higher order harmonics which causes disturbances in the supply.

d. **Difficulty of circuit breaking:-**

   DC current breaking is not possible due to absence of natural zero crossing.

e. **High power generation difficult:-**

   Due to the problems associated with commutation in D.C. machines, voltage and speed are limited which leads to inadequate amount of power.

f. **Absence of overload capacity:-**

   Converters are of fixed rating. It cannot be overloaded as transformers.

2.2 EHVAC Lines

The industrial growth mainly depends on the energy availability and requires energy particularly electrical energy for its development. The source of power that mainly includes the natural resources have been used to a larger extent and thus sources of energy other like Solar, Wind and Biogas etc. are required to meet the demand for the increased speed in consumption. The increasing demand has led to the increase in generation and transmission facilities. Thus high voltages are required for transmission. It has been taking a prominent role in extra-long-distance transmission as development of DC system has been carried out since 1950.

The problems associated with EHVAC lines are[3]:

a. Series Capacitor are used to increase loading in lines. This gives rise to Current Density.

b. Bundle conductors increases skin effect and corona.

c. Lesser the size of the conductor , more will be the voltage gradient at the surface of the conductor leading to corona.

d. Audible Noise, Radio Interference, Corona Energy Loss, Carrier Interference, and TV Interference.

e. AC lines have to struggle with high electrostatic fields underneath.

f. Air gap insulation are more effected by switching surges as compared to lightning surges or any other disturbances.

g. Rise in Short-Circuit currents and chances of occurrence of conditions like Ferroresonance.

h. Use of FACTS devices and series capacitors may also results in SSR conditions and high short circuit current.

i. As per the switching surge over voltages, the insulation co-ordination has to be increased.

Chapter 3

Idea Of Composite AC-DC Transmission

The basic power transfer equation is given by

$$P = (V_1 V_2 sin\delta)/X \tag{3.1}$$

Where,

V1 = Sending end voltage.

V2 = Receiving end voltage.

δ = Rotor angle.

X = Reactance.

If we want to increase the power transfer capacity with respect to this equation, it can be increased by

a. Increasing the value of V_1.

b. Increasing the value of I.

c. Decreasing the value of X.

If we increase the value of , there may be chances of losing stability of the system beyond the critical value (approx.80^o). After this it may happen the system becomes unstable. If reactance of the system is to be reduced, the value of inductance has to be reduced by adding series capacitor. But series capacitor has its own disadvantages like problem of SSR.It is not also feasible to increase the sending end voltage, as the receiving end requires more power and not more voltage. If we consider to increase power by physical changes in the system, it depends upon the conditions at that time and also the cost of such changes would high.

The insight scenario asks us to look into the conventional theory of power transmission and practices, depending upon unique ideas and facts that allows complete implementation of existing transmission facilities with intact system requirements and its security. In order to obtain this level, composite AC-DC transmission is one of the best solution which permits the conductors to have flow of DC current enveloping AC current. The flow of AC and DC current will not interfere each other, and also the DC power flow does not introduce any effect of transient instability. Composite ACDC power transmission was first experimented by using a mono-polar (single) circuit ac transmission.

In this first idea, single circuit dc transmission having ground as path of return was used but there were some limits as ground as a return path was used. Also, voltage pertaining to every conductor w.r.t. ground increases as DC voltage is induced which tends to increase the number of discs in every insulator string to cope up the increased voltage. In this project, the viable knowledge regarding remodelling of a bipolar(double circuit) ac line to composite ACDC transmission irrespective to the change of the existing conductors, structures of towers, and strings of insulators has been shown. In this method, the DC power flow is end-to end double circuit transmission system. The uniqueness of this method is that the power transfer improvement is obtained irrespective of any changes in the original EHV AC line.The main objective of this project is to obtain the advantage of bipolar ACDC transmission and to load the line to the fullest of its thermal loadability.

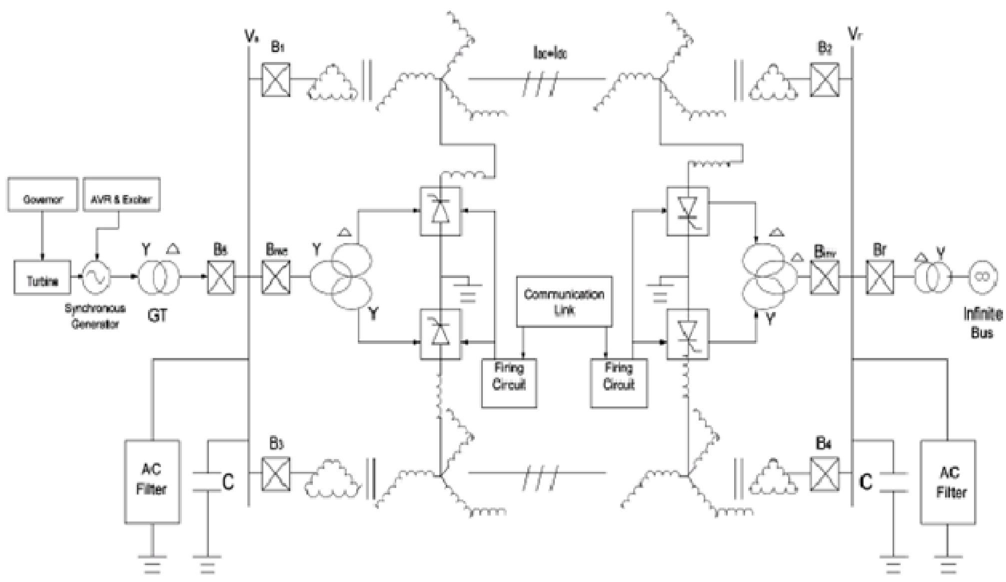

Figure 3.1: Schematic diagram of composite AC-DC transmission [4]

Fig. 1 shows the schematic diagram of composite AC-DC transmission through a bipolar (double circuit) ac transmission.A 12-pulse rectifier is used for conversion of AC power into DC power at the sending end. DC current is injected at the neutral connection of the sending end transformer whose secondary is having zig-zag connection and the 12-pulse conventional inverter is used to convert the DC current back into AC current from the neutral of the receiving end transformer having zig-zag secondary connection. The bipolar ac transmission line will contain together, three-phase AC including DC power ($P_{ac}+P_{dc}$). All conductors of each circuit will have 1/3 of the total DC current in addition to AC current.DC current will be divided equally in all the phases as resistances of the zig-zag secondaries of the transformers and all the conductors are equal in magnitude.The other circuit of the bipolar will act as a ground return for the system. The purpose of using Zig-Zag connection in secondary though it is not used widely nowadays is due to presence of DC component there are chances of transformer saturation [5].So to avoid this, zig-zag is used. 2 fluxes are produced in the inner and outer coil of the winding which are having equal magnitude but opposite in direction. This leads to zero resultant DC flux at any instant of time in each limb of the core. Thus, the DC saturation of the transformer core is avoided. A high value of reactor X_d is used to reduce harmonics in DC current.

The ac current flow in transmission line will be kept inbetween the zigzag secondaries and the conductors in absence of harmonics and other components. There will be very negligible current flowing through ground due to large value of X_d even in presence of such components.

Chapter 4

Equivalent Circuit Of The Proposed Scheme

The equivalent circuit of the proposed idea under normal operating steady state condition is given in Fig. 2. Here, it is assumed that the rectifier has CC control and inverter has CEA control.The ground return path of the scheme is shown with the help of dotted line. The task of this circuit is to carry the dc return current I_d, and every conductor carries $I_d/3$ along with the ac current per phase.

V_{dro} and V_{dio} are the maximum values of rectifier and inverter side dc voltages and are equal to $(3\sqrt{2}/\Pi)$ times converter ac input line-to-line voltage.Resistance R,Inductance L, and Capacitance C are the line parameters per phase of each line. R_{cr}, R_{ci} are commutating resistances of rectifier and inverter respectively, and so are α, γ are firing and extinction angles of both.

If the resistances which drops in the conductors line and winding of the transformer due to the existence of dc current are neglected, expressions for ac voltage and current, and for P active power and Q reactive power as per A, B, C, and D parameters of each line may be written as:

$$E_S = A_{ER} + B_{IR} \tag{4.1}$$

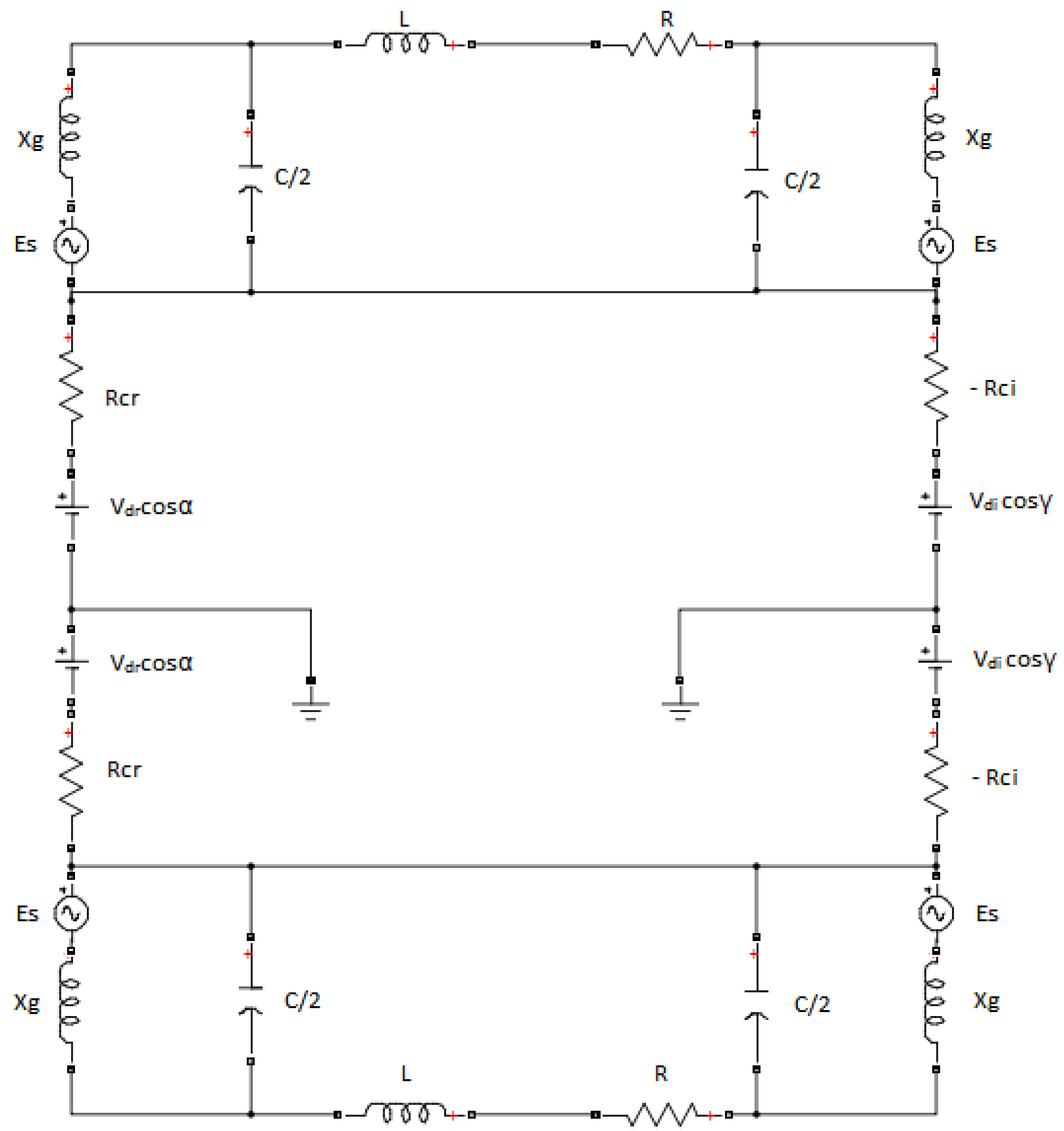

Figure 4.1: Equivalent Circuit of Composite AC-DC transmission

$$I_S = C_{ER} + D_{IR} \tag{4.2}$$

$$P_S + jQ_S = -E_S.E_R^*/B^* + D^*E_R^2/B^* \tag{4.3}$$

$$P_R + jQ_R = -E_S^*.E_R/B^* - A^*E_R^2/B^* \tag{4.4}$$

The dc power Pdr and Pdi of each rectifier and inverter may be depicted as below after considering ac resistance drop negligible

$$P_{dr} = V_{dr}I_d \tag{4.5}$$

$$P_{di} = V_{di}I_d \tag{4.6}$$

Reactive powers required by the converters are[6]:

$$Q_{dr} = P_{dr}\tan\theta_r \tag{4.7}$$

$$Q_{di} = P_{di}\tan\theta_i \tag{4.8}$$

$$\cos\theta_r = [\cos\alpha + \cos(\alpha + \mu_r)]/2 \tag{4.9}$$

$$\cos\theta_i = [\cos\alpha + \cos(\alpha + \mu_i)]/2 \tag{4.10}$$

μ_r and μ_i are commutation angles of inverter and rectifier, respectively, and total active and reactive powers at the two ends are $P_{ac} + P_{dc}$.

Transmission loss for each line is:

$$P_L = (P_S + P_{dr})(P_R + P_{di}) \tag{4.11}$$

I_a being the RMS AC current per conductor at any point of the line, the total RMS current per conductor becomes:

$$I = [I_a^2 + (I_d/3)^2]^{1/2} \tag{4.12}$$

Power loss for each line

$$P_L \approx 3I^2R \tag{4.13}$$

The resultant current in any conductor is having offset from zero. The gate signals to each SCRs are stopped and that to the bypass SCRs are injected for protection of rectifier and inverter whenever fault is there.Hence, the current in any conductor is having zero offset.The line having faults are separated with the help of circuit breakers CBs. CBs installed at both ends of line cut off the current at natural current zeroes, and no DC CB is required.Now, permitting the resultant current in the conductor equal to its thermal limit (I_{th}).

Now, allowing the net current through the conductor equal to its thermal limit (I_{th}):

$$I = [I_a^2 + (I_d/3)^2]^{1/2} \tag{4.14}$$

Let V_{ph} be per-phase RMS voltage of existing AC line. Let V_a be the per-phase voltage of AC part of composite AC-DC line with DC V_d voltage superimposed on it.The peak voltage in both cases should be equal:

$$V_{max} = \sqrt{2}V_{ph} = V_d + \sqrt{2}V_a \tag{4.15}$$

Electric field produced by any conductor bears a dc element superimpose on it a sinusoidal varying ac element. However, the instantaneous electric field polarity changes to + or - two times in a cycle if ($V_d/V_a < \sqrt{2}$) is covered.Therefore, higher distance required for insulator discs in HVDC lines is not necessary.

Each conductor is to be insulated for V_{max} , but the line-to-line voltage has no dc component and $V_{LLmax} = \sqrt{6}V_a$.Therefore, it is ac voltage which decides the separation distance between two conductors.

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

$$V_d = V_{ph}/\sqrt{2} \tag{4.16}$$

$$V_a = V_{ph}/2 \tag{4.17}$$

The total power transfer through the double circuit line before conversion is as follows:

$$P_{total} \approx 3V_{ph}^2 sin\delta_1/X \tag{4.18}$$

Where X is the transfer reactance per phase of the bipolar circuit line, and 1 is the power angle between the sending end and receiving end voltages. To keep sufficient stability margin,$\delta 1$ is generally kept low for long lines and seldom exceeds 30^o.With the increasing length of line, the load ability of the line is decreased. An approximate value of $\delta 1$ may be computed from the load ability curve by knowing the values of surge impedance loading (SIL) and transfer reactance X of the line.

$$P_{total} = 2.M.SIL \tag{4.19}$$

Where M is the multiplying factor and its value will have decrement with the line length. The value of M can be obtained from the loadability curve.

The total power transfer through the composite line:

$$P_{total} = P_{ac} + P_{dc} = 3V_a^2 sin\delta 2/X + 2V_d I_d \tag{4.20}$$

The power angle $\delta 2$ between the ac voltages at the two ends of the composite line may be increased to a high value due to fast controllability of dc component of power. For a constant value of total power, P_{ac} may be modulated by fast control of the current controller of dc power converters.

Approximate value of ac current per phase per circuit of the double circuit line may be computed as:

$$I_a = V(sin\delta/2)/X \tag{4.21}$$

The rectifier DC current order is adjusted online as:

$$I_d = 3\sqrt{(I_{th}^{*2}) - (I_a^{*2})} \tag{4.22}$$

Basic observation and analysis shows that methods which are normally used in HVDC/AC system may be implemented for the intent of the protective scheme and instrumentation designs to be availed in the simultaneous line of AC-DC transmission.The gate signals to each SCRs are stopped and that to the bypass SCRs are injected for protection of rectifier and inverter whenever fault is there. CBs are then activated at both ends to keep system intact from faulty one. To protect the system from voltage surges, surge diverter is used which placed between neutral connection of zig-zag secondary and ground.

Chapter 5

Description Of The System Model

Here the system has been presented in the form of model called Bergeron. The main point is that it is having LC distributed parameter travelling wave line model along with resistance in lump.It is somewise similar of having a numbers of π sections continuously, but the resistance will be lumped (1/2 in the middle of the line, 1/4 at each end). Like π sections, the Bergeron model perfectly shows the fundamental frequency only. It also indicates the impedances at other frequencies, except that the losses remains same. This model is most useful for studies where the fundamental frequency load flow is of importance.

Two six pulse universal bridge are used in designing rectifier and inverter. The rectifier is having constant current control and inverter is having constant excitation control strategy along with voltage dependent current order limiter.They are connected to the system buses with help of 3-winding transformers. Each and every thyristor is provided a RC snubber circuit. To remove harmonics from the system, AC passive filters are designed for 11th and 13th harmonics at each end of the buses. Reactive power necessity for rectifier and inverter is fulfilled by these filters.

For the control scheme of the converters, HVDC control block has been used. A master control has been designed to start and stop the scheme in case the current increases more than the thermal current limit.

Length of the line	450 km
Sending End Voltage	500 kV
Receiving End Voltage	345 kV
Transformer MVA Rating (Sending)	1200 MVA
Transformer MVA Rating (Receiving)	2750 MVA
Conductor	Moose (twin conductor)
Impedance Z	0.00687+j0.3864 Ω/km/ph/ckt
Admittance Y	j6.547e^{-}6 S/km/ph/ckt
Current Carrying Capacity of Conductor	0.970 kA
Reactance	74.4435 Ω/ph
Multiplying Factor M	1.1
Thermal Current	1.94 kA

Parameters that are being used are described in the above table.

Chapter 6

Computations And Simulation

6.1 Simulation Model

Considering the above noted values from table, we get the following results,

Surge Impedance Loading (SIL) = 514.4 MW/ckt.

From equation 4.15, 4.16 and 4.17, we get $V_a = 122$ kV and $V_d = 172.5$ kV.

Therefore, the computed results of power would be as follows:

Here, power angle $\delta = 30^o$ and $\delta = 45^o$ has been considered.

When this proposed method is implemented in MATLAB modelling, we get the following results.

Here,$V_a = 153.8$ kV and $V_d = 217.5$ kV.

6.2 Results Obtained

From the tables one can observe that there is no much difference in values of ac current or the total power that is obtained. Even the difference can be further reduced, by controlling the dc current.

If we observe the total ac/dc current waveform, we can see that due to the introduction of dc current, the waveforms are not pure sinusoidal by nature. It is having some distortion which is being controlled by passive filters.

Table I: Computed Results

Power Angle δ	30^o	45^o
AC Power (MW) $P_{ac} = 3V_a^2 sin\delta/X$	300	423.97
AC Current (kA) $I_a = V(sin\delta/2)/X$	0.4241	0.6271
DC Current (kA) $I_d = 3\sqrt{{I_{th}}^2 - {I_a}^2}$	5.247	5.061
DC Power (MW) $P_{dc} = 2V_d \times I_d$	1810.22	1746.045
Total Power(MW) $P_{total} = P_{ac} + P_{dc}$	2110.2	2170

Table II: Simulated Results

Power Angle δ	30^o	45^o
AC Power (MW) $P_{ac} = 3V_a^2 sin\delta/X$	476.63	674
AC Current (kA) $I_a = V(sin\delta/2)/X$	0.5347	0.791
DC Current (kA) $I_d = 3\sqrt{{I_{th}}^2 - {I_a}^2}$	5.156	4.851
DC Power (MW) $P_{dc} = 2V_d \times I_d$	2242.86	2110.2
Total Power(MW) $P_{total} = P_{ac} + P_{dc}$	2719.49	2784.2

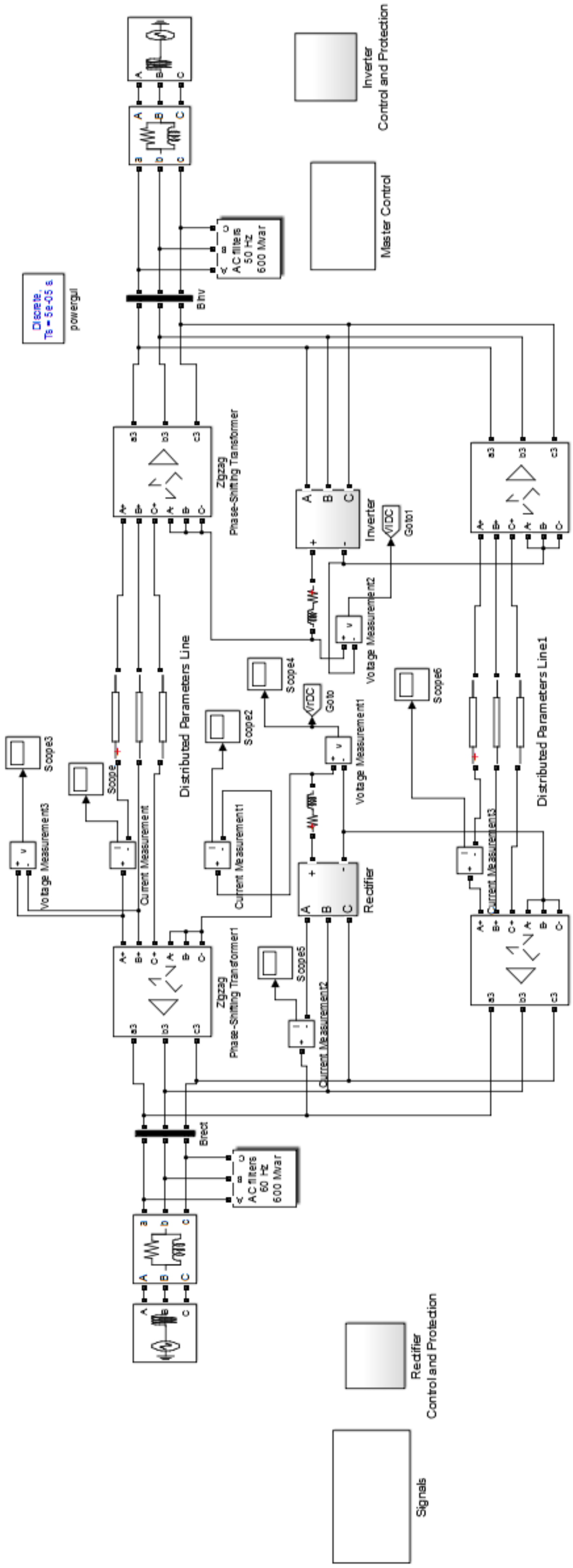

Figure 6.1: Simulation model of AC-DC Transmission

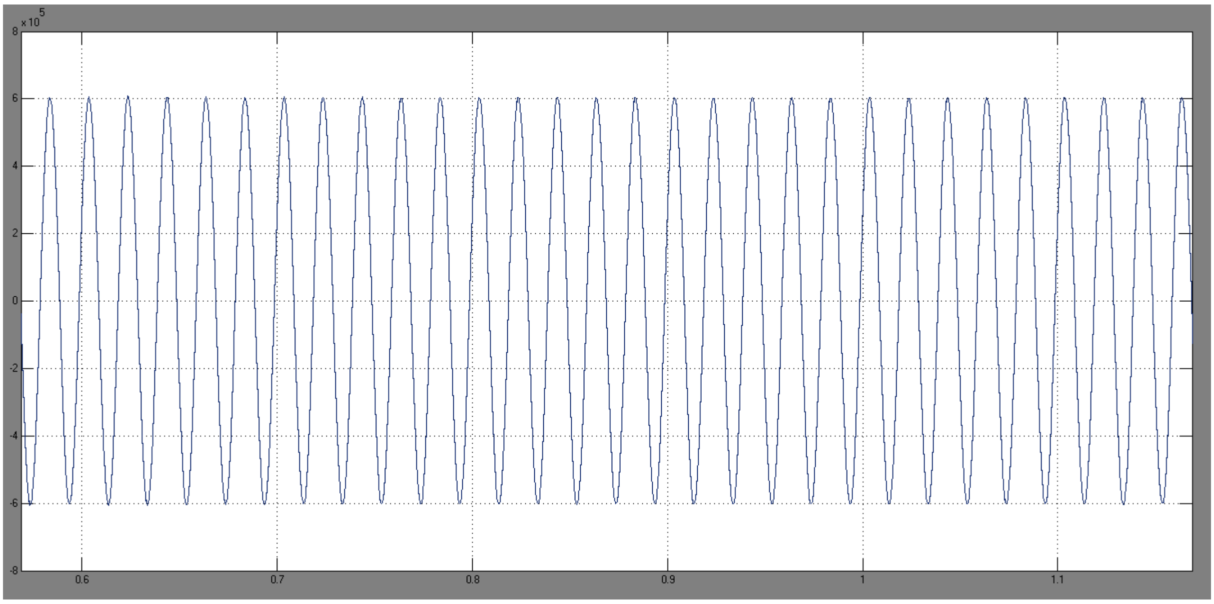

Figure 6.2: Sending End Voltage

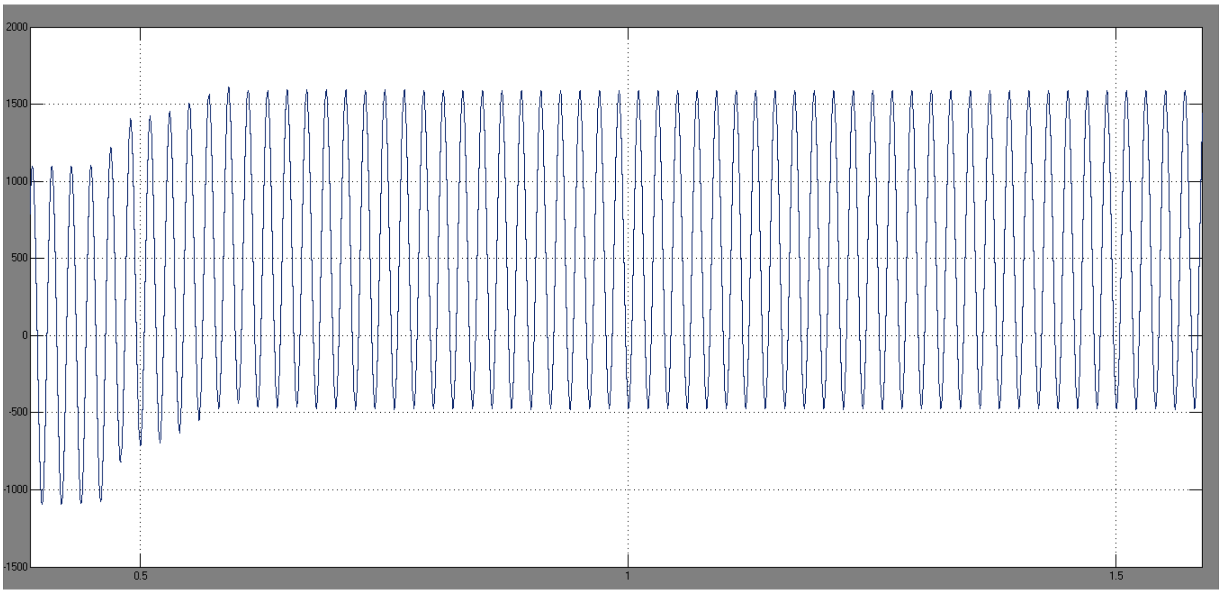

Figure 6.3: Total AC-DC Current

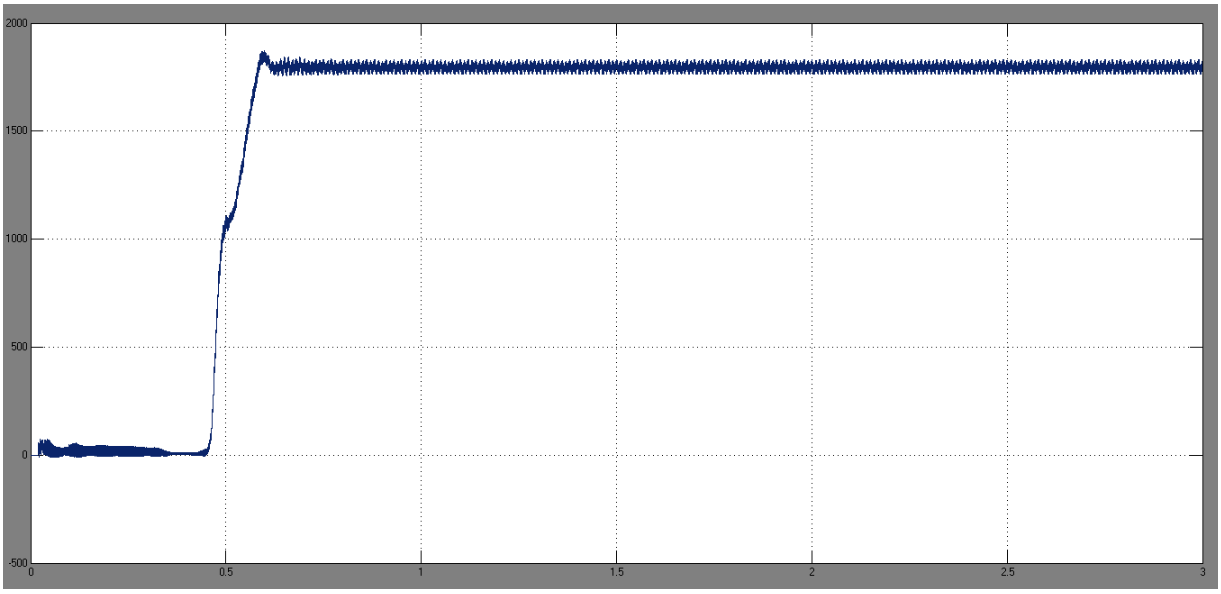

Figure 6.4: Rectifier Current

The current waveform is shifted from zero crossing to 500 which clearly indicates that dc current is injected in transmission line.

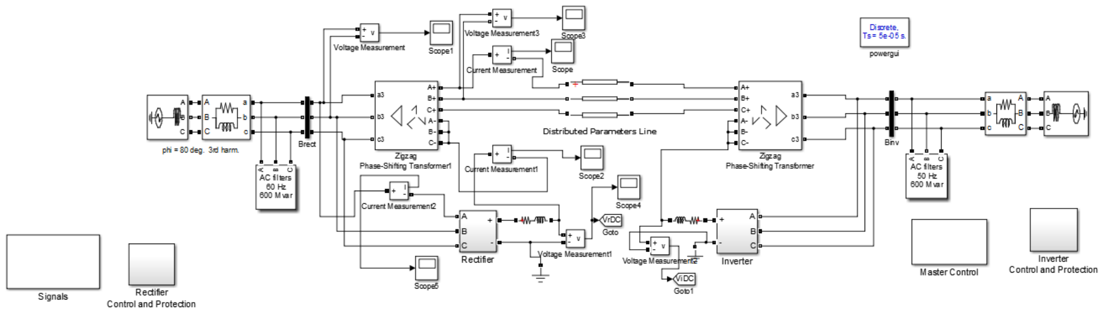

Figure 6.5: Stimulation of Single Circuit

Table III: Simulated Results

Power Angle δ	30^o	45^o
AC Power (MW) $P_{ac} = 3V_a^2 sin\delta/X$	476.63	674
AC Current (kA) $I_a = V(sin\delta/2)/X$	0.5347	0.791
DC Current (kA) $I_d = 3\sqrt{{I_{th}}^2 - {I_a}^2}$	5.156	4.851
DC Power (MW) $P_{dc} = V_d \times I_d$	1121.43	1055.1
Total Power(MW) $P_{total} = P_{ac} + P_{dc}$	1598.06	1729.1

6.3 Single Circuit Transmission

Monopolar (single circuit) transmission scheme is also shown here. As it has only one circuit DC power will be half of as compared to double circuit transmission line. The model and simulated table is shown above:

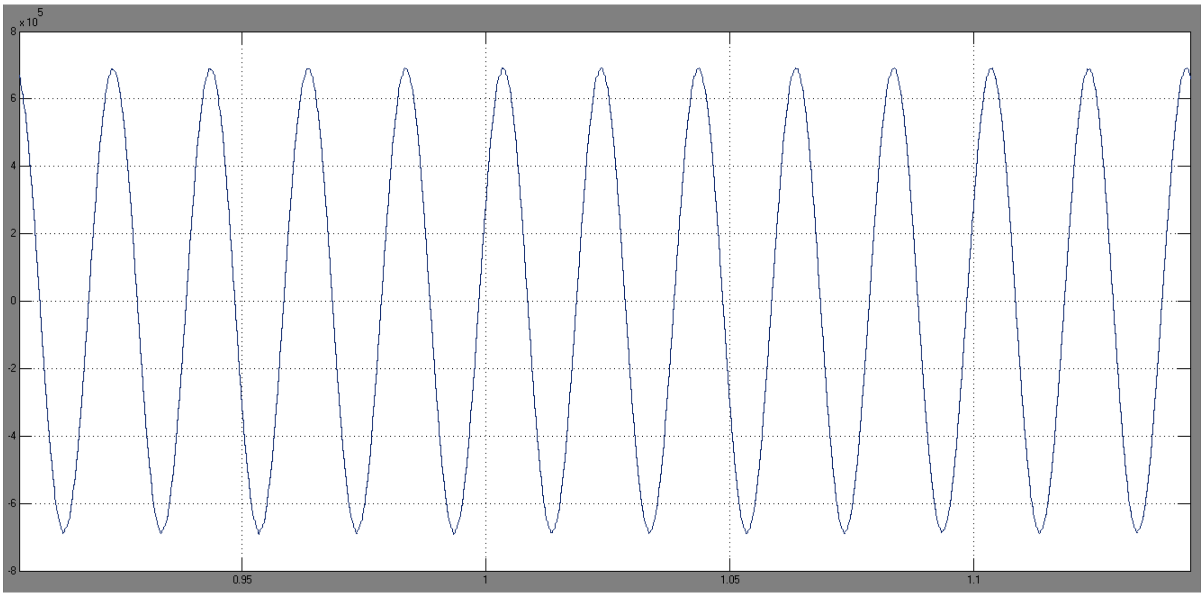

Figure 6.6: Single Circuit Voltage

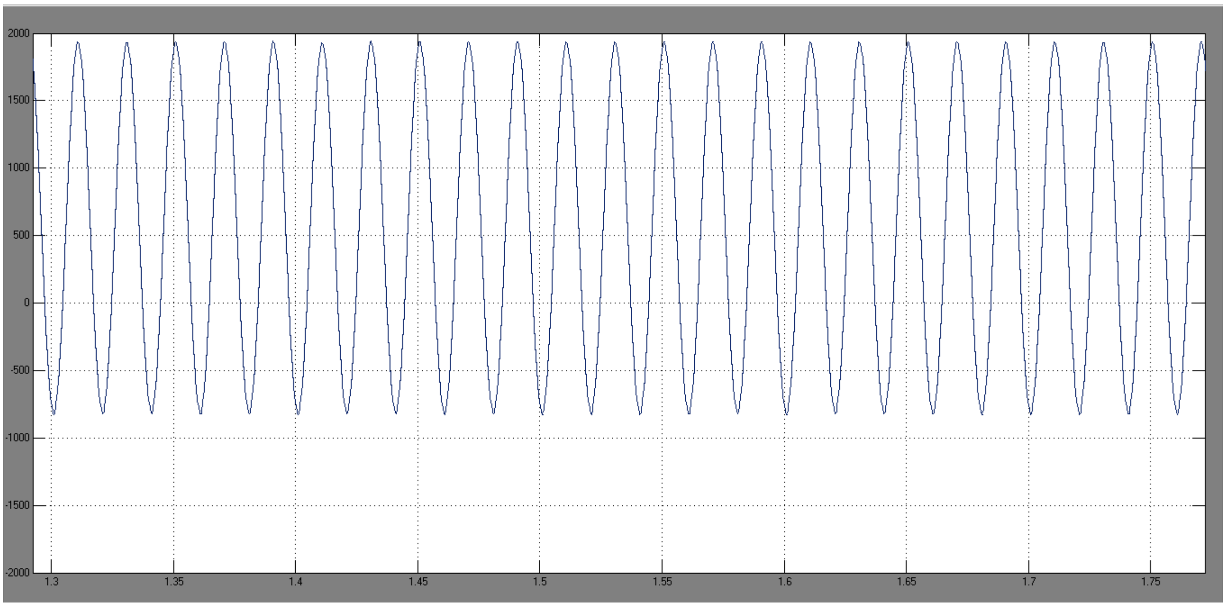

Figure 6.7: Single Circuit Current AC-DC

Chapter 7

Power Tapping Potentiality

Going further in this proposed idea, one thought is also taken in case of having potentiality of power tapping though DC current is superimposed in the line. Here, a conventional plan of tapping of power is taken from the simultaneous AC/DC power transmission line. Here, such stations are considered of drawing up power around ten percent of the total power transfer capability of the composite line. However,further tapping of power can be done with respect to the fact that it will be less than ac power [7].

The prominent points of a tapping stations are: the tap rates which is in pu system should be fixed. The tap must have a very low effect on the stabilities of the system.Any disturbances in the power tapping should shut the whole system.The tap control system has to be strictly local. If these fails, ultimately we have to install a control strategy having may complexity which will raise the hardware expenditure. Small tap stations having a total rating lower than ten percent of the main terminal value have possible applications where meager communities or industries require cost efficient electric power.

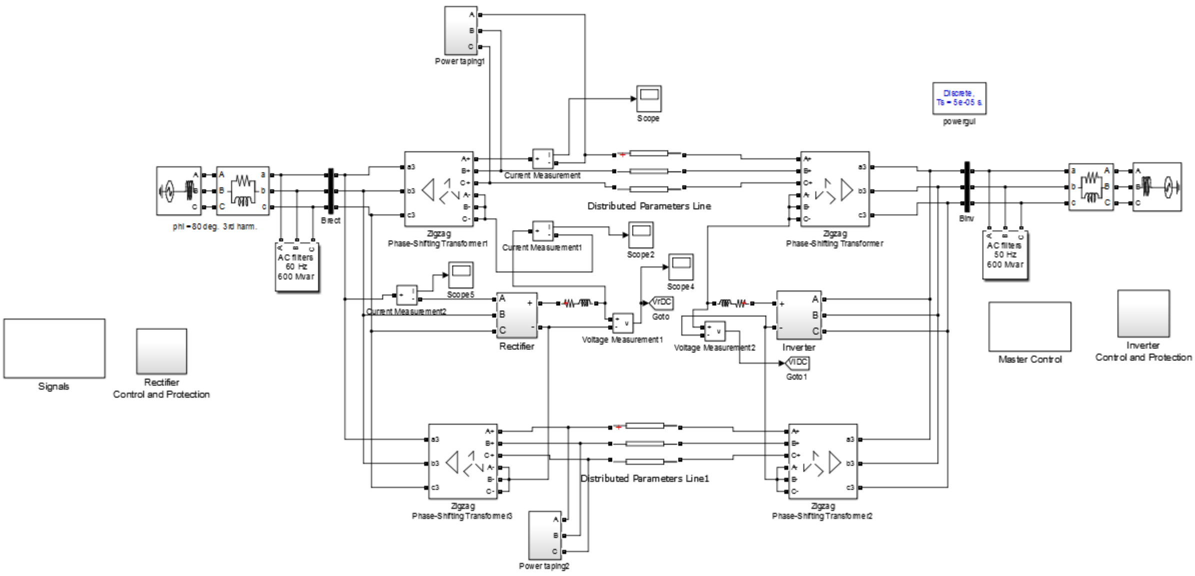

Figure 7.1: Double Circuit with Power Tapping

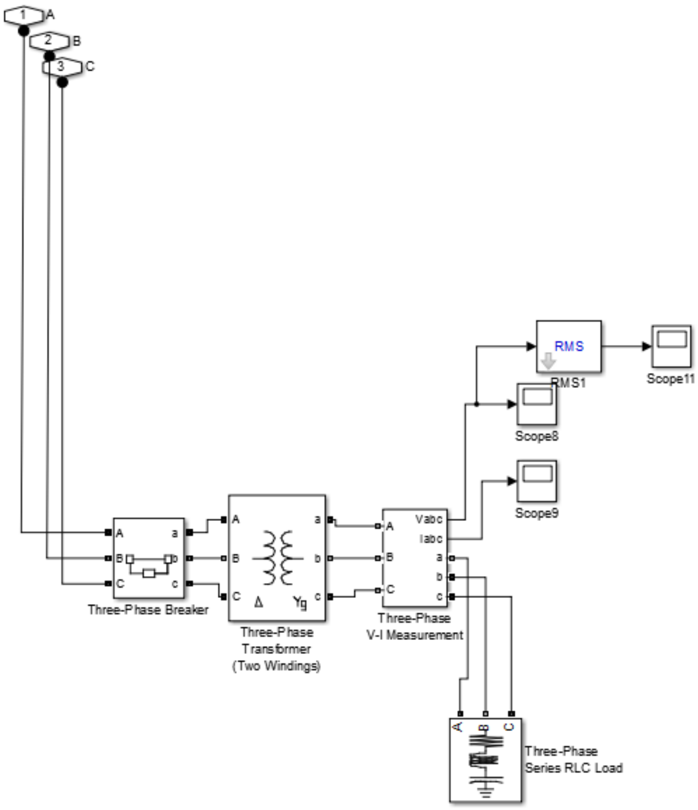

Figure 7.2: Power Tapping Circuit

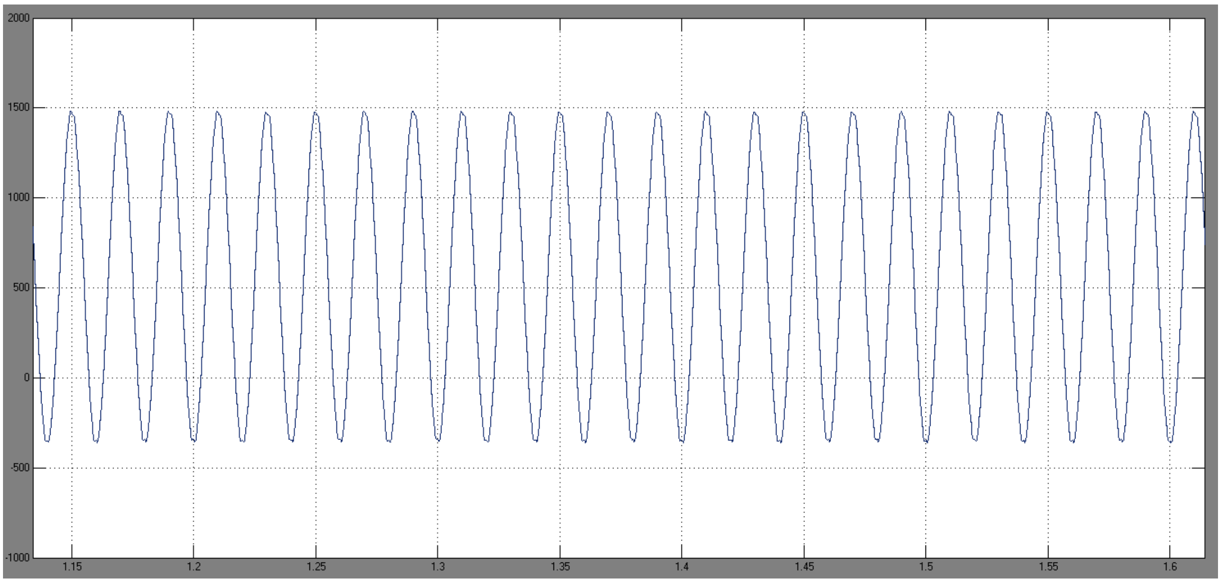

Figure 7.3: Variation in current due to power tapping

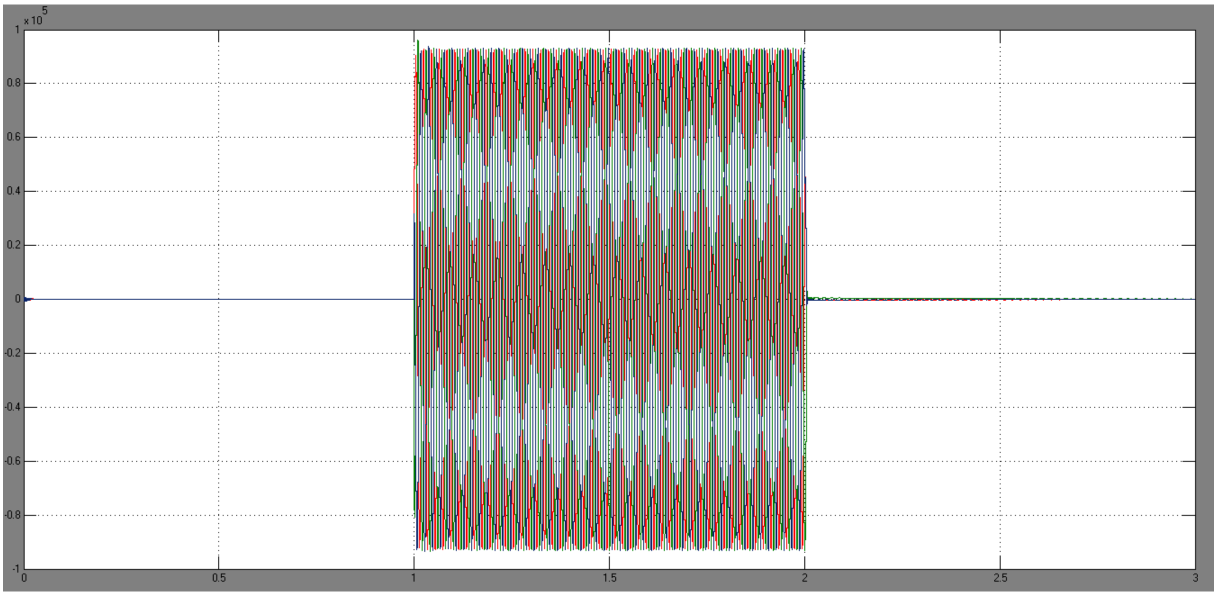

Figure 7.4: Circuit Breaker Operation

Chapter 8

Advantages Of The Proposed Scheme

1. It is not possible to load the AC lines to their full thermal loadability as there should be a safe margin to protect the system from transient instability and moreover the voltage regulation should not exceed the permitted margin. In this condition, composite flow of power has no exertion of extra load on the system stability. Also voltage regulation will remain constant as the resistive drop of dc current is minimum as compared to impedance drop of ac current.

2. Composite AC-DC transmission is to load the line to the fullest of its thermal loadability with the help of injection of dc current in the lines.

3. In the duration of peak load, the need of extra dc power with voltage at lesser than the rated voltage is thought of. Existing line will not have alteration in insulation if V_d is kept in the limit of 5% to 10% of E_{ph}.

4. Insulation level in phase to ground can be reached to a higher level by increasing the no. of discs in the insulator strings of the lines with alteration of cross-arms of tower structures. This will aid in increment of E_{max} proportionally. The power flow increases in the line by use of increased magnitude of V_d. As the

HVDC line if installed separately costs high, the alteration in the AC lines is reasonable.

5. The better stability of the system and removal of oscillations from the system may be achieved with help of DC power control because of the use of fine tuning of firing angle (α) and extinction angle (γ) of the rectifier and inverter. It also helps in regulating VAR needs of the converters which in turn improve the voltage profile at lesser load and it behaves as inductive shunt compensation. Even capacitive VAR is taken into consideration as it is providing the required proportion of inductive VAR for the converter system. [8].

6. As DC power is superimposed along with AC power, the individual and accurate regulation of active power and reactive power which are associated with both AC and DC, may be look at as one of the component of FACTS.

7. This composite system may be utilized in some peculiar requirements of LV and MV distribution system. In case of area where arc furnace is used , 3-ϕ supply cannot be rectified easily using power rectifier as 3-ϕ power is applied along with DC power around the place where there is presence of very high temperature. Here, composite system will have a greater edge. Similarly in aircraft system, 3-ϕ loads are connected to the supply having 400Hz frequency and another line is taken for DC loads. Now, whenever there is usage of higher frequency, the presence of skin effect is there which restrains the maximum benefit of distribution wires. Composite transmission minimizes weight as well as volume of the distributors.

8. Another interesting thing is that when PV solar cells are used to produce DC power, it's transmission through AC lines can be directly given to nearby DC loads. Also DC filter are not demanded in such transmission due to absence of harmonics and disturbances.

Chapter 9

Conclusion

The viability of designing a conventional existing AC transmission line into a composite AC-DC line has been exhibited. For this local system, there is significant increment (about 82.47%) in the line loadabilty. The transmission line is loaded to its thermal limit with the DC current superimposed on AC. The DC component has no impact on the reliability of the system. The preference of bipolar composite AC-DC transmission is obtained. DC current regulator may give balance to AC power flow. No need of alteration in conductors size, insulator strings, and structure of tower of the existing line is required. The maximum magnitude of AC and DC voltage components of the converted composite line are $1/2$ and $1\sqrt{2}$ times the ac voltage before conversion, respectively.

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