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Simulation of Merged AC and DC System for Power Upgradation

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ABSTRACT:Due to increasing power demand there are huge requirements for construction of new transmission lines. But ROW (Right of Way) problems are there for the erection of transmission lines. So instead of erecting newlines 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 simultaneous AC-DC transmission line.Double circuit line is compared with AC DC line Sending end power, receiving end power and transmission losses of both the systems are found out. Simulation is carried out using MATLAB/SIMULINK.

KEYWORDS: HVDC, EHVAC,Matlab/ Simulink

I.INTRODUCTION

The need of power system is to generate power from sending end to the load center of the system, as we know that the load demand has been increasing vigorously specially in the developing countries of the different parts of the world, therefore to meet this load demand we have to develop the power system accordingly and have to find the new ways to meet the demand and provide the power with good power quality. Now a days, the supply of power i.e. reliability of the power is much needed part of the daily lives, with this the quality of power has to be maintained simultaneously[3]. To meet this aspect of the system we have to develop over power system in order to provide reliable power of good quality and maintain the quality which is required for the optimal working of equipment used in our daily lives. Since, to meet all the aspects we are talking about here, we have to develop the power system too, which is now-a-days getting more complex than before. Now a days, to improve the stability of the system and to provide economic dispatch there are many new technologies coming up, as we all know to transmit power from one country to another as well as inside the country also EHV lines are used which cannot be loaded to their maximum thermal limits, Which when loaded causes voltage instability[2]. To solve this problem there are many new methods like FACTS(Flexible AC transmission system) and HVDC which are being used in the different parts of the world

II.EXISTING TRANSMISSION SYSTEMS

HVDC: HVDC i.e. High Voltage Direct Current transmission systems uses DC power for the transmission of extra high voltage long distance transmission. DC was used earlier for the low voltage applications but after the introduction of new DC valves high voltage transmission is also possible now. It is cheaper and more reliable than AC transmission when compared for long distance transmission. But, in case of short distance transmission system AC systems are only preferred till now because of the extra equipment which are added in the DC transmission system increase the cost of the power system. Rectifiers and inverters are needed in this system to convert AC into DC in the sending end and again from DC to AC at the receiving end of the power system. This small conversion and elements used for it may increase the cost of the power system for the short distance transmission of the power. But, in long distance transmission it becomes cheaper as compared to AC transmission system. Since, less no. of conductors are used in it and also the circuits are better and cheaper for DC systems. In HVDC links the power flow of the system can be controlled without considering the phase angle between source and the load, so there is much possibility that it can provide better stability against the disturbances which occurs due to the sudden and rapid fluctuations in thepower. HVDC links are also used to transfer the power between two incompatible networks by allowing transfer of power between two grids which are running on different frequencies such as 50 Hz and 60 Hz[5]. This particular property of the HVDC system helps in improving the stability and economy of each grid which is connected to each other through this HVDC link. As, said above in the paragraph the low voltage transmission for long distance in DC system is inefficient thus, AC systems are used there but again because of the use of DC valves this particular problem is solved in the DC systems and now it can be used for both high voltage as well as low voltage power supply in the system..

HVAC: HVAC transmission system is being used from very early times of the electrical power. As we know that there are many different industries and domestic areas too which needs the electric power. In order to cope up with the increasing demand of the era high voltage supply became the necessity for setting up the equilibrium between demand and the supply part. But as we all know, HVAC transmission lines cannot be loaded to their thermal limits, it will not cope up with the supply and instability occurs in the voltage. There are certain disadvantages of this system or can be said as the problems which encounters while using the HVAC system for the transmission of electrical power they are as follows [4] :

1.Losses due to skin effect

2. In this system group of conductors are used which are bundled.

3. There are Corona problems occurring in the system resulting in audible noise.

4. Under the conductor lines, there is a high volume of electrostatic field.

5. There are switching over voltages in AC systems which causes more problems than lightning over voltages.

III.SIMULTANEOUS AC DC SYSTEM

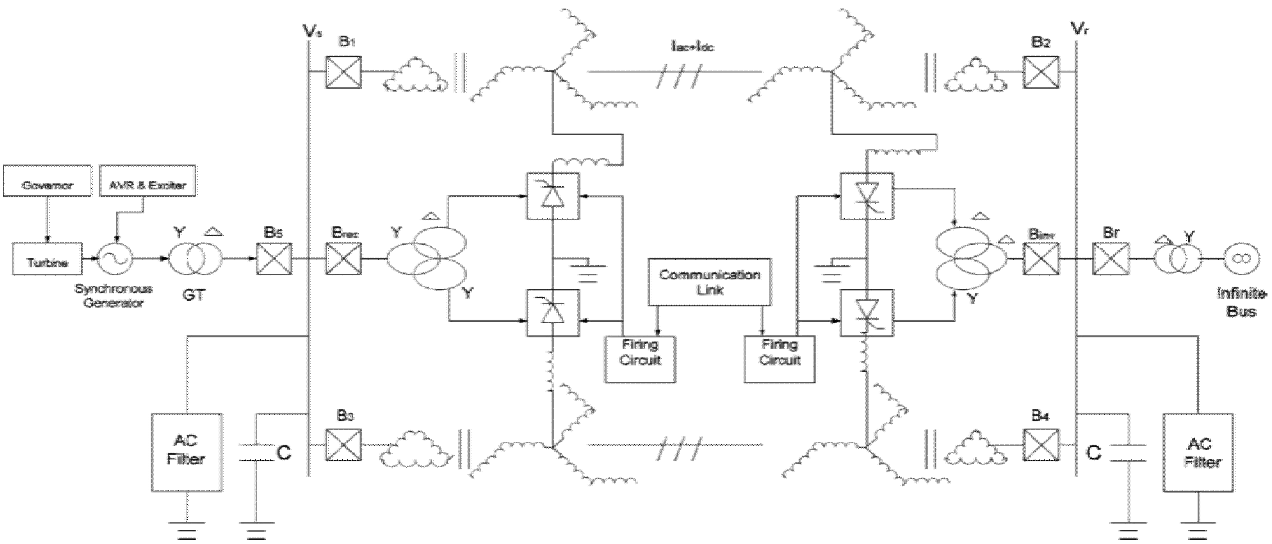

Fig1. Basic scheme of AC DC Simulation

The dc power is obtained through line commutated 12-pulse rectifier bridge used in conventional HVDC and injected to the neutral point of the zigzag connected secondary of sending end transformer and is reconverted to ac again by the conventional line commutated 12-pulse bridge inverter at the receiving end. The inverter bridge is again connected to the neutral of zig-zag connected winding of the receiving end transformer Fig. 1 depicts the basic scheme for simultaneous ac–dc power flow through a double circuit ac transmission line. The double circuit ac transmission line carriers both three-phase ac and dc power. Each conductor of each line carries one third of the total dc current along with ac current. Resistance being equal in all the three phases of secondary winding of zig-zag transformer as well as the three conductors of the line, the dc current is equally divided among all the three phases. The three conductors of the second line provide return path for the dc current. Zig-zag connected winding is used at both ends to avoid saturation of transformer due to dc current. Two fluxes produced by the dc current Id/3 flowing through each of a winding in each limb of the core of a zig-zag transformer are equal in magnitude and opposite in direction. So the net dc flux at any instant of time becomes zero in each limb of the core. Thus, the dc saturation of the core is avoided. A high value of reactor Xd is used to reduce harmonics in dc current. In the absence of zero sequence and third harmonics

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or its multiple harmonic voltages, under normal operating conditions, the ac current flow through each transmission line will be restricted between the zigzag connected windings and the three conductors of the transmission line. Even the presence of these components of voltages may only be able to produce negligible current through the ground due to high value of Xd. Assuming the usual constant current control of rectifier and constant extinction angle control of inverter, 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. The second transmission line carries the return dc current, and each conductor of the line carries Id/3 along with the ac current per phase. And are the maximum values of rectifier and inverter side dc voltages and are parameters per phase of each line. Rcr, Rci are commutating resistances, and, α, γ are firing and extinction angles of rectifier and inverter, respectively. Neglecting the resistive drops in the line conductors and transformer windings due to dc current, expressions for ac voltage and current

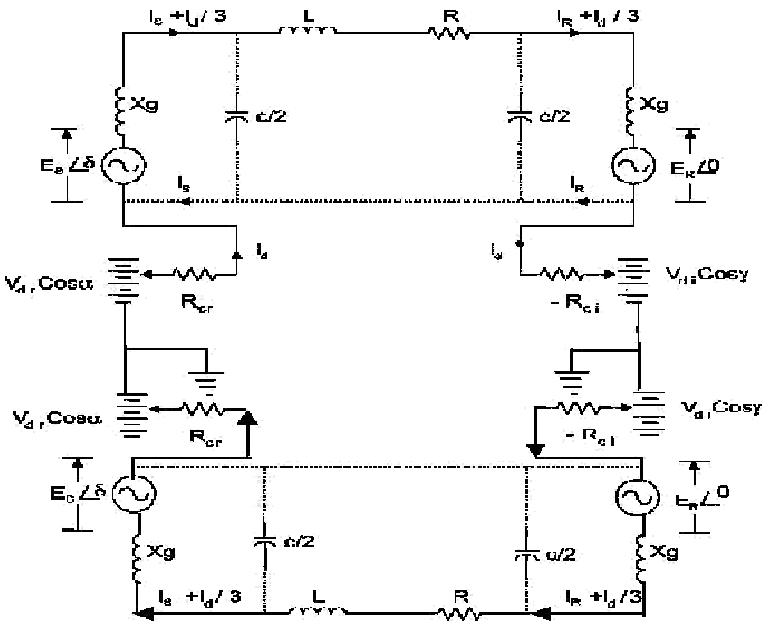

Fig2:Equivalent circuit diagram

Sending end voltage and current in terms of A,B,C, D parameters are,

$E_s = A * E_R + B * I_R$ (1)

$I_S = C * E_R + D * I_R$ (2)

$P_S + jQ_S = \frac{-E_S * E_R E_R^*}{B^*} + D * E_S^2$ (3)

$P_R + jQ_R = \frac{(E_S * E_R)}{B^*} - A * E_R^2 / B^*$ (4)

Active powers of converters are,

$P_{dr} = V_{dr} * I_d$ (5)

$P_{di} = V_{di} * I_d$ (6)

Reactive powers of converters are,

$Q_{dr} = P_{dr} * \tan\theta_r$ (7)

$Q_{di} = P_{di} * \tan\theta_i$ (8)

$\cos\theta_r = [\cos\alpha + \cos(\alpha + \mu_r)] / 2$ (9)

$\cos\theta_i = [\cos\Upsilon + \cos(\Upsilon + \mu_i)] / 2$ (10)

Total active and reactive powers at the two ends are

$P_{st} = P_s + P_{dr}$ (11)

$P_{rt} = P_R + P_{di}$ (12)

$Q_{st} = Q_s + Q_{dr}$ (13)

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$Q_{rt} = Q_R + Q_{di}$ (14)

Transmission loss for each line is

$P_{LOSS} = (P_S + P_{dr}) - (P_R + P_{di})$ (15)

$I_{rms} = \sqrt{{I_a}^2 + (\frac{I_d}{3})^2}$ (16)

Power loss,

$P_L \approx 3 * I^2 * R$ (17)

Total power in line,

$P'_{total} = 2 * M * SIL$ (18)

Where,

M - Multiplying factor whose magnitude decreases with decrease in length of line. We can get value of M from loadability curve

Allowing I_a to be $I_{threshold}$

$I_{th}=[I_a^2+(I_d/3)^2]^{1/2}$

The total power transfer through the composite line

$P'_{total}=P_{ac}+P_{dc}=3V_a^2 Sin^{\delta}2/X+2V_dI_d$ (20)

ac current per phase per circuit of the double circuit line

$I_a=V(Sin^{\delta}/2)/X$ (21)

The dc current

$I_d=3\sqrt{Ith^{*2} - Ia^{*2}}$ (22)

Also,

$Vmax=\sqrt{2Vph}$ = $Vd+\sqrt{2}V_a$ (23)

$V_{LL}=\sqrt{6}V_a$ (24)

$Vd=Vph/\sqrt{2}$ (25)

$Va=Vph/2$ (26)

Where,

Vph –Phase voltage

V_{LL}- is the line to line voltage

Va-effective AC and DC voltage

V.COMPUTED RESULTS OF THE PROPOSED SCHEME

400 KV, 50Hz, 450km Double circuit line (∂=30)

Z=0.03252+j0.33086Ω/km/ph/ckt

=0.332454 ∠84.38y=j3.33797*10^-6 ∠90

Ith=1.8KA/ckt

SIL=511MW/ckt

M=1.1

X=74.4435 Ω/ph

V_{ph}=per phase rms voltage of original AC line

V_a= per phase rms voltage of composite AC DC line

V_d=Dc voltage superimposed on V_{ph}

V_{ph}230KV-Per phase voltage of ac line

$V_{ph}=V_{LL}/\sqrt{3}=400/\sqrt{3}=230.94$

DC superimpose on $V_{ph} \rightarrow V_d=V_{ph}/\sqrt{2}=230.94/\sqrt{2}=163.299$ A

Per phase rms voltage of composite AC-DC line $V_a=V_{ph}/2$ =230.94/2 =115.47KV B

X=74.4435Ω/ph

$P'_{total}=3V^2_{ph} Sin^{\delta}/X$ [Power transfer through circuit before conversion]

$P_{AC} = 3*(230.94)^2*sin30/74.4435$ =1074.63MW C

P_{AC} = 1074.63MW D

The total Power transfer through Composite line

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$P_{total} = P_{ac} + P_{dc}$

$= 3V^2_a Sin^{\delta}/X + 2V_d{*}I_d$

To calculate I_d first calculate I_a

$I_a = (V{*}(Sin^{\delta}/2))/X$

$=(230.94{*}(Sin30))/74.4435$

$I_a = 3{*}\sqrt{Ith^{*2} - Ia^{*2}}$

$=3{*}\sqrt{1.8^2 - 0.7755^2}$

$=3{*}\sqrt{2.63852}$

$=3{*}1.6243$

$I_d = 4.8730KA$ E

$P'_{total} = P_{ac} + P_{dc}$

$=3V^2_a Sin^{\delta}/X + 2V_d{*}I_d$

$=3{*}(115.47)^2{*}sin30/77.4435 + 2{*}163.299{*}4.873$

$=258.252+1591.51$

$P_{ac}+P_{dc} = 1849.76MW$ F

Compairing D with F

%Diff =((1849.76-1074.63)/1074.63)*100

=0.721299*100

$(P_{ac}+P_{dc})$=72.1299% (Increase in Power transfer capacity)

VI. CONCLUSION

The feasibility to convert ac transmission line to a composite ac–dc line has been demonstrated. For the particular system studied, there is substantial increase (about 72.12%) in the load ability of the line. The line is loaded to its thermal limit with the superimposed dc current. The dc power flow does not impose any stability problem. The advantage of parallel ac–dc transmission is obtained. Dc current regulator may modulate ac power flow. There is no need for any modification in the size of conductors, insulator strings, and towers structure of the original line.

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