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Impact of IPFC on Distance Protection of Multiline Transmission System

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ABSTRACT- Due to the development of Power Electronic devices, various FACTS devices such as STATCOM, SSSC, UPFC and IPFC are now installed in transmission line so as to improve the stability, voltage control and power flow control.Distance Relays are the unique devices which are used to protect the transmission line from various shunt faults. The reach of the distance relay is independent of the types of fault when compared to the over current protection.When a FACTS device, say, IPFC is incorporated in order to enhance the power flow control, voltage control, etc., on existing transmission line, it will result in significant change in impedance. This in turn will lead to mal operation of distance relay, as the Distance Relays are sensitive to apparent impedance seen by the relay and zones.This paper analyses the impacts of IPFC in apparent impedance seen by the Distance relay for various shunt faults.

KEYWORDS: IPFC, Distance Relay, Multiline system, Reach of the relay, FACTS, Power system protection

I.INTRODUCTION

FACTS devices are being incorporated in the transmission lines in order to control the power flow and to ensure stable operation of the system. Various FACTS devices such as SVC, TCSC, STATCOM, UPFC are used in practice. Regarding the multiline system, the best suited FACTS device for power flow control is IPFC.On the other hand the adoptability of these devices with the conventional relaying system should be ensured. The optimal setting for the relay operation to coordinate with the FACTS devices are discussed [2] to overcome the undesired effects of their operation together. More specifically the effect of UPFC [4], STATCOM [5] SSSC [6] are discussed.

II. STUDY OF IPFC AND RELAY MODEL

A.STUDY OF IPFC

The IPFC scheme provides, together with independently controllable reactive series compensation of each individual line, a capability to directly transfer real power between the compensated lines. This capability makes it possible to equalize both real and reactive power flow between the lines; transfer power demand from overloaded to under loaded lines; compensate against resistive line voltage drops and the corresponding reactive power demand; increase the effectiveness of the overall compensating system for dynamic disturbances. In other words, the IPFC can potentially provide a highly effective scheme for power transmission management at a multi-line substation.

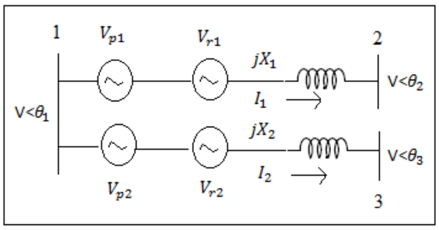

Figure.1 Basic two inverter IPFC

$$I = |I_1| < \left(\frac{\delta_1}{2} - \phi_1\right), I_2 = |I_2| \left(\frac{\delta_2}{2} - \phi_2\right) (1)$$

For the system shown in figure 1, the received power and the injected reactive power at the receiving end of the prime line can be expressed as:

$$P_1 = P_{10} + \frac{VV_{p1}}{X_1} sin\left(\frac{\delta_1}{2} - \phi_1\right) + \frac{VV_{r1}}{X_1} cos\left(\frac{\delta_2}{2} - \phi_1\right) \quad (2)$$

$$Q_1 = Q_{10} + \frac{VV_{p1}}{X_1} cos\left(\frac{\delta_1}{2} - \phi_1\right) + \frac{VV_{r1}}{X_1} sin\left(\frac{\delta_2}{2} - \phi_1\right) \quad (3)$$

Where,

$\delta_1 = \theta_1 - \theta_2, sin\phi_1 = \frac{V_{p1}}{2V sin\frac{\delta}{2}}$(4)

P_{10}andQ_{10} are the real power and reactive power in the line 1 (at the receiving end) when both Vp1 and Vr1 are zero. These are expressed as:

$P_{10} = \frac{V^2 sin\delta_1}{X_1}, Q_{10} = \frac{V^2}{X_1}(1 - cos\delta_1)$(5)

Similar equations also apply to the support line 2 except that $V_{p1}$is not independent. It is related to V_{p2} by the equation.

$$V_{p1}I_1 + V_{p2}I_2 = 0 \quad (6)$$

The above equation shows that V_{p2} is negative if V_{p1} is positive. With the resistance emulation, we have

$V_{p1} = -R_1 I_1, \quad V_{p2} = -R_2 I_2$(7)

Substitute equation (6) in equation (7), we get the constraint involving R_1 and R_2 as

$R_1 I_1^2 = -R_2 I_2^2$(8)

The constraint equation (4) and (6) can limit the utility of IPFC.

B. *STUDY OF RELAY*

Table 1. Operation Logic for Relay

Fault	Current at Relay Location I_R	Voltage at Relay Location V_R	Compare $\lvert V_R\rvert$: $\lvert I_R\rvert\lvert Z_{set}\rvert$	Desired response of Relay
F_3External	I_{R3}	V_{R3}	$\lvert V_{R3}\rvert > \lvert I_{R3}\rvert\lvert Z_{set}\rvert$	Restrain
F_2Reach Point	I_{R2}	V_{R2}	$\lvert V_{R2}\rvert = \lvert I_{R2}\rvert\lvert Z_{set}\rvert$	Verge of Operation
F_1 Internal	I_{R1}	V_{R1}	$\lvert V_{R1}\rvert < \lvert I_{R1}\rvert\lvert Z_{set}\rvert$	Trip

The relayhas tocompute the impedanceas seen fromitslocationandcompareitwithsetvaluetotakethetrip decision.Becauseofthesimpleseries model ofthe faulted line, the line impedanceisdirectlyproportionalto the distance of fault .Hencethe name*distancerelay.*Sucharelayiscalled*under-impedancerelay.*Inpractice, however,the word*under is*dropped andthe relay is simplycalled*impedance* relay.Itis possibletosynthesizeseveral morecomplicated distinct relay. Todistinguishthisrelay from theotherdistance relays, it is called as simple *Impedance relay.*The positive sequencecomponent is the only component which is presentduringall faults. Thus, it would be prudentto measure positive sequence impedance between the relay location and the fault soas to cater for everyfault.

C. IMPEDANCE ANALYSIS FOR VARIOUS FAULTS

Phase Faults

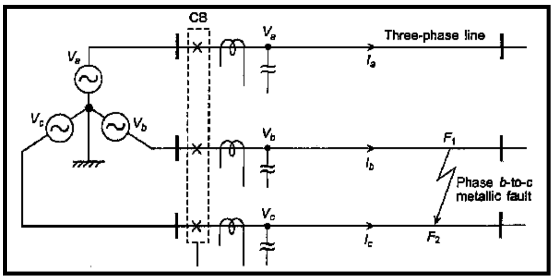

Figure 2.B-C Phase Fault

Writing KVLaround the loopinFigure 2

$$V_{a1} - I_{a1}Z_1 + I_{a2}Z_1 - V_{a2} = 0 \quad (9)$$

$V_{a1} - V_{a2} = (I_{a1} - I_{a2})Z_1$ (10)

$\frac{V_{a1} - V_{a2}}{I_{a1} - I_{a2}} = Z_1$(11)

Since

$V_a = V_{a0} + V_{a1} + V_{a2}$(12)

$V_b = V_{a0} + a^2 V_{a1} + aV_{a2}$(13)

$V_c = V_{a0} + aV_{a1} + a^2 V_{a2}$ (14)

From which

$$V_b - V_c = (a^2 - a) V_{a1} + (a - a^2)V_{a2}$$

$$= (a^2 - a) V_{a1} - (a^2 - a) V_{a2}$$

$$= (V_{a1} - V_{a2}) \quad (15)$$

Therefore

$$V_{a1} - V_{a2} = \frac{V_b - V_c}{a^2 - a} \quad (16)$$

$$I_{a1} - I_{a2} = \frac{I_b - I_c}{a^2 - a} \quad (17)$$

Therefore

$$\frac{V_{a1} - V_{a2}}{I_{a1} - I_{a2}} = \frac{V_b - V_c}{I_b - I_c} = Z_1 \quad (18)$$

Thus, adistance measuringunit with voltageof $V_b - V_c = V_{bc}$ and currentof $I_b - I_c$willmeasure positive sequence impedanceup to fault point Z_1in caseofphase *b-to-c* faults. Similarly,two more units with inputsofV_{ab},$I_a - I_b$andV_{ca}, $I_c - I_a$tocater forphase *a to b, b to c* andphase *c to a*faults. The distancemeasuringunits which cater for phase*a-b*,*b-c*and *c-a* faults are called*phase faultunits*.

Ground Faults

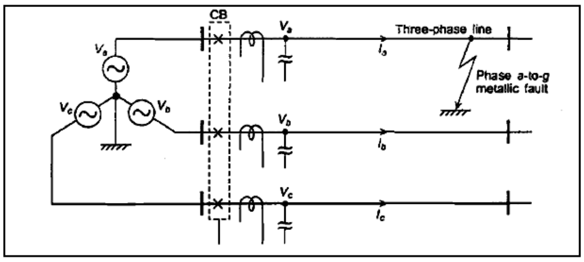

Figure 3.Equivalent circuit for Ground fault

ApplyingKVL aroundtheloopformedbytheseriesconnection ofthethree sequencenetworks,

$$V_{a0} + V_{a1} + V_{a2} = I_{a1}Z_1 + I_{a2}Z_1 + I_{a0}Z_0 \quad (19)$$

However,noting that$V_a = V_{a0} + V_{a1} + V_{a2}$ and adding and subtracting $I_{a0}Z_1$ onthe right-handside,

$$V_a = I_{a1}Z_1 + I_{a2}Z_1 + Z_1 - I_{a0}Z_1 + I_{a0}Z_0 \quad (20)$$

$$= (I_{a1} + I_{a2} + I_{a0})Z_1 + (Z_0 - Z_1)I_{a0}$$

$$= I_aZ_1 + (Z_0 - Z_1)I_{a0}$$

(Or)

$$V_a = \left(I_a + \frac{Z_0 - Z_1}{Z_1} I_{a0}\right) Z_1 \quad (21)$$

Also,

$$I_{a0} = \frac{I_a + I_b + I_c}{3}$$

Let $I_a + I_b + I_c = I_{res}$ (22)

Therefore$I_{a0} = \frac{I_{res}}{3}$

Where,I_{res} is the Residualcurrent

Hence

$$V_a = \left(I_a + \frac{Z_0 - Z_1}{3Z_1} I_{res}\right) Z_1 \quad (23)$$

Finally, the desired impedance as the ratio of

$$Z_1 = \frac{V_a}{I_a + \frac{Z_0 - Z_1}{3Z_1} I_{res}} \quad (24)$$

IntheaboveequationZ_1appearsonbothsidesandtheexpressionappearsabitmixed up. However,in actual practice there is adefinite relationship between $Z_0$and Z_1.For three phase transmission lines Z_0is2.5to3timesZ_1. The exactrelationshipdepends upon thegeometry of the phase conductors and the placementofearthconductors. Assume that$Z_0 = 3Z_1$then the aboveequationsimplifies to:

$$Z_1 = \frac{V_a}{I_a + \frac{2}{3} I_{res}} \quad (25)$$

$$Z_1 = \frac{V_a}{I_a + K\, I_{res}} \quad (26)$$

Where$K = \frac{Z_0 - Z_1}{3Z_1}$

Thus, thephasecurrenthastobecompensatedwithafractionofthe residual currentI_{res} the factor ‘K’ is known as*theresidual current compensationfactor*or*zero-sequence current compensator factor.*Therefore, three numbers ofdistance measuring unitswith inputs of $[V_a, (I_a + KI_{res})]$,$[V_b, (I_b + KI_{res})]$, $[V_c, (I_c + KI_{res})]$, willbe needed for catering toallthe three single line to ground faults. These unitswill becalled*ground faultunits.*

D. THREE-STEPPEDDISTANCE PROTECTION

Thefirst stepofdistance protection is,therefore,set toreach up to80to90%of theline section. In this zone the relay should operate instantaneously and there is no intentionaltimedelay. Thesecondstep isrequiredinorder to provide primaryprotectiontothe remaining 20% to10%ofthe line, which isleft outofthefirst step. In addition, it isset tocoverupto 50%ofthe nextlinesection.

Operatingtime of step II=Operatingtime of step I +Selective time interval.

Where, Selectivetimeinterval =CB operatingtime +Relayover-traveltime

When therearemorethan oneadjoining lines, thesecondstep shouldextend upto 50% into the shortest adjoining line.The third step is provided with an intensionto givefull back-up to the adjoining line section. It covers the line section under consideration,100%ofthenext linesectionand reaches furtherintothe system. The motivationbehind the extended reach ofthis step istogivefullback-uptothenext linesection inspiteofthemaximum under-reachofthethird step.

III. TEST SYSTEM – ANALYSIS AND SYSTEM DESCRIPTION

Single circuit, 400 kV, horizontal configuration, line is considered for the simulation. The system consists of two transmission lines and resembles the multiline system with IPFC configuration. In this figure, the IPFC is connected between the prime and the test transmission lines. The IPFC structure is realized by connecting two Static Synchronous Series Compensators in both the lines and adjoining them at the common dc link. The performance of relays for different fault types, fault locations, and fault resistances is analyzed to show the impact of VSC-based IPFC on distance protection of the multiline system. Faults are realized at 300th km in the test line with the per-unit distance from the relay location. In this sense, it has a value between 0.5 and 1.0 for faults between and in the sample system.For the calculation of apparent impedance seen by the relay, symmetrical components are used. The system taken here has the fault to the right of IPFC in order to show the significant effect of IPFC.

The parameters for the system considered are given below.

Fundamental frequency = 50 Hz

Source-1

Positive sequence Impedance = 1.7431+19.4i Ω

Zero sequence Impedance =2.6147+4.8862i Ω

MVA Rating = 2000 MVA

Source-2

Positive sequence Impedance = 0.8716+9.71i Ω

Zero sequence Impedance = 1.3074+2.4430i Ω

MVA Rating = 2000 MVA

Transmission Line Data

Configuration = Horizontal

Number of sub conductor = 2 No's.

Height of the conductor from ground = 15 meter

Phase to Phase distance = 11 meter

Diameter of the conductor = 3.18 cm

Bundle space = 45.72 cm

Length = 450 km

Positive sequence Impedance:

$$Z_1 = 0.2546 + 0.312789i\Omega/Km$$

Zero sequence Impedance:

$$Z_0 = 0.3864 + 0.47974i\Omega/Km$$

The following faults are considered for the analysis.

(i)Phase to Ground fault

(ii)Phase to phase fault

At the relay point, positive sequence voltage can be expressed as

$$V_G^{(1)} = I_{G1}^{(1)}\left(0.5Z_L^{(1)}\right) + \left(I_{G1}^{(1)} + I_{Sh}^{(1)}\right) X \left((x - 0.5)Z_L^{(1)}\right) + V_{Se1}^{(1)} + R_f I_f^{(1)} (27)$$

The positive sequence mutual impedance of the line is negligible compare to zero sequence impedance then the above equation can be written as follows

$$\mathrm{V}_{\mathrm{G}}^{(0)} = \mathrm{I}_{\mathrm{G}1}^{(0)}\left(0.5\left(\mathrm{Z}_{\mathrm{L}}^{(0)} - \mathrm{Z}_{\mathrm{m}}^{(0)}\right)\right) + \left(\mathrm{I}_{\mathrm{G}1}^{(0)} + \mathrm{I}_{\mathrm{Sh}}^{(0)}\right)\mathrm{X}\left((\mathrm{x} - 0.5\mathrm{ZL0}-\mathrm{Zm0}+\mathrm{VSe10}+\mathrm{RfIf0} \qquad (28)$$

For the single phase faults, following equation can be used

$$\mathrm{V}_{\mathrm{G}}^{(1)} + \mathrm{V}_{\mathrm{G}}^{(2)} + \mathrm{V}_{\mathrm{G}}^{(0)} = \mathrm{V}_{\mathrm{G}}(29)$$

$$\mathrm{I}_{\mathrm{G}}^{(1)} + \mathrm{I}_{\mathrm{G}}^{(2)} + \mathrm{I}_{\mathrm{G}}^{(0)} = \mathrm{I}_{\mathrm{G}} \qquad (30)$$

Considering the equation (27) and (28),

$$\mathrm{V}_{\mathrm{G}} = \mathrm{I}_{\mathrm{G}}\left(\mathrm{x}\mathrm{Z}_{\mathrm{L}}^{(1)}\right) + \mathrm{I}_{\mathrm{G}1}^{(0)}\left[\mathrm{x}\left(\mathrm{Z}_{\mathrm{L}}^{(0)} - \mathrm{Z}_{\mathrm{L}}^{(1)} - \mathrm{Z}_{\mathrm{m}}^{(0)}\right)\right] + \mathrm{I}_{\mathrm{Sh}}(\mathrm{x} - 0.5)\mathrm{Z}_{\mathrm{L}}^{(1)}(31)$$

A. L-G FAULT

Using symmetrical components the apparent impedance for the single line to ground fault can be represented as follows:

$$\mathrm{Z}_{\mathrm{R}1} = \frac{\mathrm{V}_{\mathrm{G}}}{\mathrm{I}_{\mathrm{G}1} + \left(\frac{\mathrm{Z}_{\mathrm{L}}^{(0)} - \mathrm{Z}_{\mathrm{L}}^{(1)}}{\mathrm{Z}_{\mathrm{L}}^{(1)}}\right)\mathrm{I}_{\mathrm{G}1}^{(0)}} = \frac{\mathrm{V}_{\mathrm{G}}}{\mathrm{I}_{\mathrm{R}1}}(32)$$

Using equations (28) & (31)

$$\mathrm{Z}_{\mathrm{R}1} = \mathrm{x}\mathrm{Z}_{\mathrm{L}}^{(1)} - \mathrm{x}\mathrm{Z}_{\mathrm{m}}^{(0)}\frac{\mathrm{I}_{\mathrm{G}1}^{(0)}}{\mathrm{I}_{\mathrm{R}1}} + \frac{\mathrm{I}_{\mathrm{Sh}}}{\mathrm{I}_{\mathrm{R}1}}(\mathrm{x} - 0.5)\mathrm{Z}_{\mathrm{L}}^{(1)} + \frac{\mathrm{I}_{\mathrm{Sh}}^{(0)}}{\mathrm{I}_{\mathrm{R}1}}(\mathrm{x} - 0.5)\left(\mathrm{Z}_{\mathrm{L}}^{(0)} - \mathrm{Z}_{\mathrm{L}}^{(1)} - \mathrm{Z}_{\mathrm{m}}^{(0)}\right) + \frac{\mathrm{V}_{\mathrm{Se}\,1}}{\mathrm{I}_{\mathrm{R}1}} + \mathrm{R}_{\mathrm{f}}\frac{\mathrm{I}_{\mathrm{f}}}{\mathrm{I}_{\mathrm{R}1}}(33)$$

As seen from the above equation it can be said that there is a change in impedance due to the voltage injected in series and / or reactive power injected / absorbed.

B. L – L FAULT

The apparent impedance seen at relay for phase to phase (A-B) is as follows

$$\mathrm{Z}_{\mathrm{R}1(\mathrm{A}-\mathrm{B})} = \frac{\mathrm{V}_{\mathrm{A}} - \mathrm{V}_{\mathrm{B}}}{\mathrm{I}_{\mathrm{A}} - \mathrm{I}_{\mathrm{B}}} = \frac{\mathrm{V}_{\mathrm{relay}}}{\mathrm{I}_{\mathrm{relay}}} = \frac{\mathrm{V}_{\mathrm{G}}^{(1)} - \mathrm{a}\mathrm{V}_{\mathrm{G}}^{(2)}}{\mathrm{I}_{\mathrm{G}1}^{(1)} - \mathrm{a}\mathrm{I}_{\mathrm{G}1}^{(2)}}\ (34)$$

Using equation (27),

$$\mathrm{V}_{\mathrm{G}}^{(1)} - \mathrm{a}\mathrm{V}_{\mathrm{G}}^{(2)} = \mathrm{x}\mathrm{Z}_{\mathrm{L}}^{(1)}\left(\mathrm{I}_{\mathrm{G}1}^{(1)} - \mathrm{a}\mathrm{I}_{\mathrm{G}1}^{(2)}\right) + \left(\mathrm{I}_{\mathrm{Sh}}^{(1)} - \mathrm{a}\mathrm{I}_{\mathrm{Sh}}^{(2)}\right)(\mathrm{x} - 0.5)\mathrm{Z}_{\mathrm{L}}^{(1)} + \mathrm{V}_{\mathrm{Se}\,1}^{(1)} - \mathrm{a} + \left(\mathrm{I}_{\mathrm{Sh}}^{(1)} - \mathrm{a}\mathrm{I}_{\mathrm{Sh}}^{(2)}\right)\mathrm{R}_{\mathrm{f}}(35)$$

Hence the apparent impedance for Phase to Phase (A-B) is

$$Z_{R1(A-B)} = xZ_L^{(1)} + \frac{\left(I_{Sh}^{(1)} - aI_{Sh}^{(2)}\right)}{I_{relay}}(x - 0.5)Z_L^{(1)} + \frac{V_{Se\,1}^{(1)} - aV_{Se\,2}^{(2)}}{I_{relay}} + \frac{\left(I_f^{(1)} - aI_f^{(2)}\right)}{I_{relay}}R_f(36)$$

Where

$V_G^{(1)}, V_G^{(2)}, V_G^{(0)}$ → Positive, negative and zero sequence voltage.

$I_G^{(1)}, I_G^{(2)}, I_G^{(0)}$ → Positive, negative and zero sequence current.

$Z_G^{(1)}, Z_G^{(1)}, Z_G^{(0)}$ → Positive, negative and zero sequence current.

I_f, R_f → Fault current and Fault resistance

IV. **SIMULATION STUDY FOR CONVENTIONAL DISTANCE RELAY**

A. TEST SYSTEM - OPERATION

Simulations are performed on system compensated by IPFC on 300th km of transmission line which is shown in figure. 5.1. Firing angle of both shunt and series converters are fixed for the sake of simplicity and analyzed the impedance of transmission line seen by the Relay. Where the voltage and current measured at Relay point is digitized at the frequency of 10 kHz & the digitized data were fed to the Fourier series block which converts the time domain data into Phase domain data. The processed data then given to the Relay unit which is designed based on the equation already derived. In order to evaluate the impact of impedance in a single step, constraints are incorporated in simulation.

B. ANALYSIS OF IMPEDANCE FOR L-G FAULT

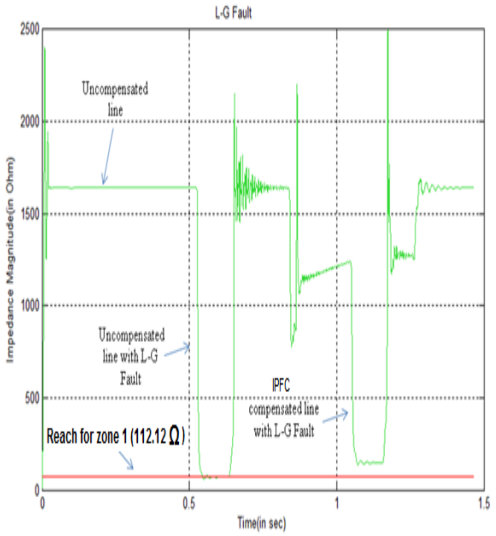

Figure .4Impedance seen by the relay for L – G fault

C. ANALYSIS OF IMPEDANCE FOR L-L FAULT

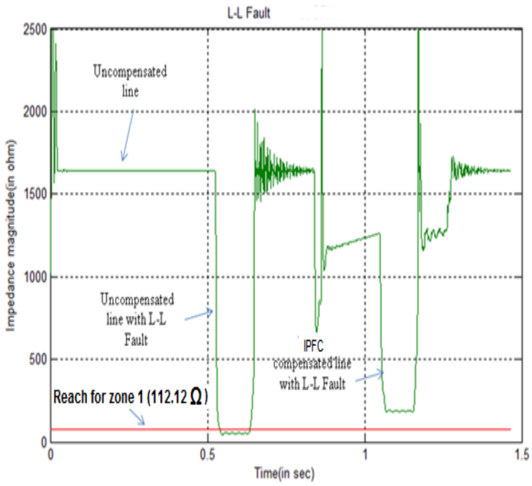

Figure. 5Impedance seen by the relay for L – L fault

Inference:

In figure.4 and figure.5, duration of 0.0s to 0.8s shows the impedance of the system measured at relay location for the uncompensated line.In which from 0.5s to 0.6s, L-G and L-L faults are respectively introduced for the duration of 5 cycles (i.e. 100 ms). In response to the fault the system voltage is reduced and the fault current is increased.From 0.8s to 1.4s IPFC is incorporated where the impedance measured is slightly decreased compared to the impedance of previous uncompensated line with no fault. The amount of reduction in Impedance is subject to the firing angle of VSC's.Once again the same fault is introduced from 1.0s to 1.1s. Now the comparison can be made with the impedance obtained for the uncompensated & IPFC compensated line. Result shows that the impedance with IPFC is large compared to the impedance without IPFC. Hence the impedance falls out of zone1 for the fault within zone1, which indicates the over reach of relay.

D. EVALUATION OF IPFC IMPACT

Table. 2 Impedance values for various shunt faults

Fault Type	**Fault Location (in km)**	**Impedance of uncompensated line (in Ω)**	**Impedance of IPFC compensated line (in Ω)**	**Difference in impedance**
L - G	300	110∠67°	165∠80°	55∠13°
L - L	300	95∠26°	155∠65°	60∠39°
L - L - G	300	70∠42°	120∠75°	50∠33°
L - L - L	300	75∠54°	135∠75°	60∠21°
L - L - L - G	300	102∠54°	150∠85°	48∠31°

For analysis L-L fault falls under Zone 1 is considered which contains positive sequence impedance. Positive sequence Impedance of the line is

$$Z_1 = 0.02546 + 0.312789i\frac{\Omega}{Km}(37)$$

For 80% of line Total line length the Impedance is

$$Z = 0.8\ X\ 450 = 360\ km$$

∴ Impedance for Zone-1 is

$$Z_1 = 0.02546 + 0.312789i\Omega/KmX\ \ 360\ km$$

$$= 9.1656 + 112.16i\Omega$$

$= 112.982\angle 85.3465\ \Omega$ (38)

Hence

$$\left|Z_{zone\ -1\ (or)set}\right| = 113\ \Omega(39)$$

But the fault is introduced at 300th km. Hence impedance for L-L fault from equation (37) is

$$Z_1 = 0.02546 + 0.312789i\Omega/KmX\ \ 300\ km$$

$= 7.638 + 93.86i\Omega(40)$

$= 94.17\angle 85.3465\ \Omega(41)$

$|Z_{calculated}\ | = 94.17\ \Omega(42)$

For uncompensated line (From the Table 2)

$\left|Z_{simulation\ \ (uc)}\right| = 95\ \Omega\ (approx)(43)$

For compensated line (From the Table 2)

$\left|Z_{simulation\ \ (c)}\right| = 155\ \Omega\ (approx)(44)$

So, for the compensated line, comparing equation (42) and (43) calculated values for L-L fault is nearer to the simulation result.

$$94.17\ \Omega \cong 95\ \Omega\ (approx)$$

This impedance is within the Zone-1. Hence,

$$\left|Z_{simulation\ \ (uc)}\right| < \left|Z_{zone\ -1\ (or)set}\right|$$

for the above relation, according to the logic set, the impedance Relay will operate. But when comparing the impedance of IPFC compensated line with uncompensated line huge difference exist. Also the impedance measured for the IPFC compensated line falls beyond the Zone-1according to the simulation result obtained and from equation (42)&(44)

$$\left|Z_{simulation\ \ (uc)}\right| > \left|Z_{zone\ -1\ (or)set}\right|$$

Hence the relay will mal operate due to under reach for the fault.

V. CONCLUSION

A multiline test system of 400 V, 50 Hz is designed. It is compensated by the incorporation a of six pulse VSC based IPFC unit, realized by adjoining two SSSCs at the dc link. Using MATLAB/Simulink conventional distance relay unit is designed and it is fed by the necessary voltage and current measurements in order to calculate the fault impedance. Various shunt faults are fed to the system at its 300th km. The apparent impedance seen by the relay is calculated at conditions of before and after compensation by IPFC. It is concluded that the incorporation of IPFC in the multiline system affects the actual fault impedance that should be seen by the relay. This effect is due to the injection/absorption of real/reactive power by the IPFC on the multiline system. As a consequence the perturbation in the actual fault impedance forces the relay to mal operate and thus the relay under reaches or over reaches.

Thus the undesired effects introduced by the incorporation of IPFC on the distance protection of multiline system isanalyzed.

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