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Improving The Power Quality Of Ac Transmission System Using UPFC With Fuzzy Control

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ABSTRACT

Power quality is one of the major concerns in the power system. The power quality problem occurred due to a non-linear load in the distribution network and its severe impact on sensitive loads. To overcome this problem, the new series, parallel FACTS device use. The Interline Power Flow Controller (IPFC) is a VSC based Flexible AC Transmission System (FACTS) controller for series compensation with the unique capability of power flow management among the multiple transmission lines in the transmission system. Due to disturbance, the electromechanical oscillations will present in the transmission system and these oscillations should damp out using IPFC. The performance of the considered IEEE 14 bus system is analyzed in terms of oscillations using IPFC. The conventional Proportional Integral controller with Interline Power Flow Controller (IPFC) is used to damp oscillations. In this work, we will be applying the fuzzy PI controller in combination with the Unified Power Flow Controller (UPFC) for better performance and to improve the overall THD of the existing PI IPFC system. An IEEE 14 bus system is modeled in MATLAB/SIMULINK software. Initially, the basic transmission line system model is simulated. After that connect IPFC as well as UPFC controller one by one is simulated in MATLAB and check the output waveform. Finally, apply a fuzzy logic controller for better performance of the transmission line oscillation.This analysis is carried out using MATLAB/Simulink

Keywords-- Flexible AC Transmission System (FACTS), Interline Power Flow Controller (IPFC), Unified Power Flow Controller (UPFC), fuzzy PI controller , MATLAB/SIMULINK.

1.INTRODUCTION

Modern power systems are highly complex and are designed as such to fulfill the growing demands of power with better power quality. High technology nowadays is being used for controlling power flow. Due to this, power quality is improved. Modern technology and new constructions of transmission lines are also needed for improving power system security, profitability, and reliability. Voltage collapse occurs when power systems are heavily loaded, faulted, or have reactive power shortages. Voltage collapse is system instability and it occurs due to many power system components. Reactive power imbalance occurs when the system is faulted, heavily loaded and voltage fluctuation is there.The investigates the performance of series-series. (Interline Power Flow Controller) and series-shunt (Unified Power Flow Controller) FACTS controllers by compensating real and reactive power flow. For analysis, the IEEE14 Bus system is used.

Shunt compensation is used in all high voltage, EHV systems to supply reactive power and improve voltage profile. Series compensation is used to increase transmission line capacity, system stability, etc.

1.1.Benefits for FACTS Controllers

Secure loading of transmission lines nearer to their thermal limits.

- Increased dynamic and transient grid stability.
- It allows more active power in present lines by reducing reactive power flow in the line.
- Access to lower production cost.
- Environmental benefits.
- Upgrade of transmission lines.
- Reduce RP flows, thus allowing the lines to carry more active power.
- Loop flow control.
- Power System Stability Improvement Using FACTS Devices.

2. FACTS CONTROLLERS CAN BE DIVIDED INTO FOUR CATEGORIES

- Shunt controller-SVC and STATCOM,
- Series controller-TCSC, SSSC, and TCPAR
- Series-series-IPFC
- Series-shunt- UPFC

2.1.Series Controllers

Series Controllers consist of capacitors or reactors which introduce voltage in series with the line.

- Static Synchronous Series Compensator (SSSC)
- Thyristor Controlled Series Capacitor (TCSC)
- Thyristor switched series capacitor (TSSC)
- Thyristor-switched series reactor (TSSR)
- Thyristor-controlled series reactor (TCSR)

2.2.Shunt Controllers

Shunt controllers consist of variable impedance devices like capacitors or reactors which introduce current in series with the line.

- Static Synchronous compensator (STATCOM)
- Static VAR Compensator (SVC)
  - ➢ Thyristor Controlled Reactor (TCR)
  - ➢ Thyristor Switched Reactor (TSR)
  - ➢ Thyristor Switched Capacitor (TSC)
  - ➢ Mechanically Switched Capacitor (MSC)
  - ➢ Harmonic Filter

2.3.Series-Series-IPFC

It is a combination of series controllers or a unified controller. The objective of introducing this controller is to address the problem of compensating several transmission lines connected at a substation The Interline Power Flow Controller (IPFC) provides, in addition to the facility for independently controllable reactive (series) compensation of each line, a capability to directly transfer or exchange real power between the compensated lines.Simplified Schematic of Two-Converter IPFC Mode shown in fig.1.

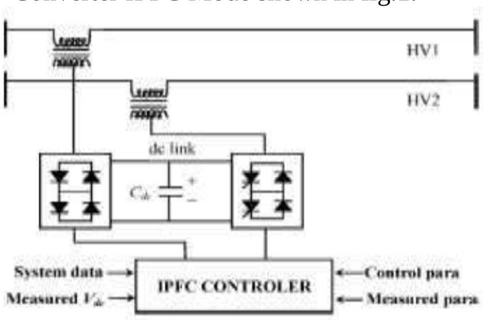

Fig.1. Simplified Schematic of Two-Converter IPFC Mode.

2.4.Series-Parallel-UPFC

Unified Power Flow Controller (UPFC) is the most versatile device designed based on the concept of a combined series-shunt FACTS Controller. It can simultaneously control all the transmission parameters affecting the power flow of a transmission line i.e. voltage, line impedance, and phase angle. The simplified schematic unified power flow controller is shown in fig.2.

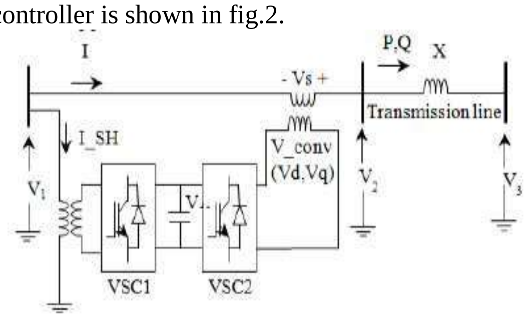

Fig.2. Simplified SchematicUnified Power Flow Controller

3.DIFFERENT STAGES OF OPERATION

Based on the literature view we analyze the whole system in different stages which are as follows:

3.1. Stage-I

IEEE 14 bus system considered for analysis is shown in Fig.3.MATLAB simulation model ofIEEE 14 Bus Power Network This system includes five T-G units with IEEE type-1 exciters14 buses, three transformers, and twenty AC transmission lines. This system has 11 loads totaling. Bus 1 is selected as a slack bus. The generator G1 is considered as reference. The three synchronous compensators are considered as generators to meet the demand of real power by loads. The generators are modeled with both P and Q limits as standard PV buses, loads are considered as constant PQ loads. The output waveform of the IEEE 14 bus power network is shown in fig.4.

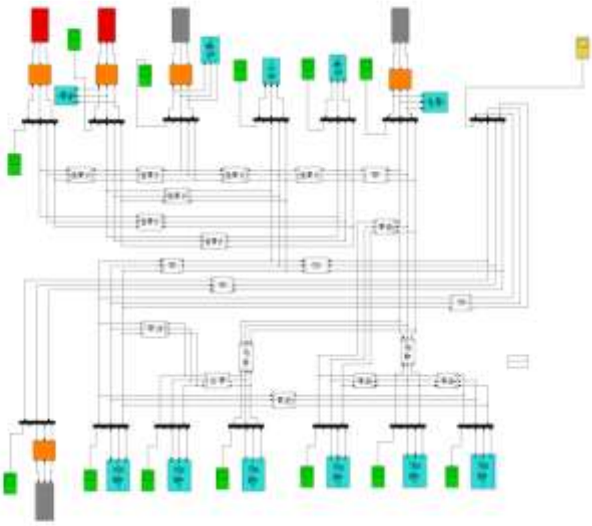

Fig.3. MATLAB simulation model ofIEEE 14 Bus Power Network

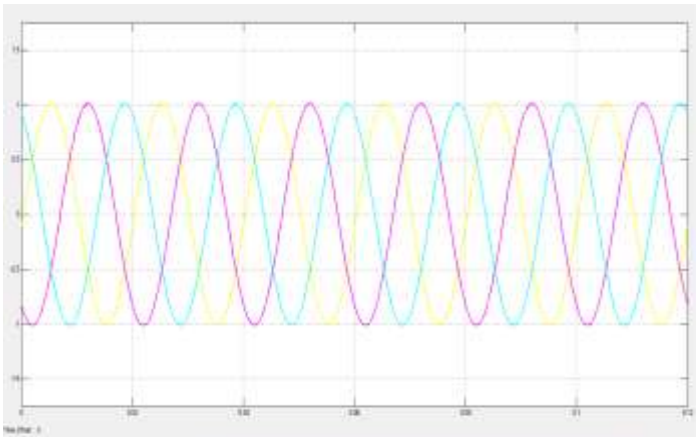

Fig.4. The output waveformofIEEE 14 Bus Power Network

3.2.Stage-II

In this stage apply the IPFC controller on IEEE 14 bus system but while connecting IPFC on all 14 bus system separately then system become so large and MATLAB not run all system at a time because of that converting the system in the coding format in MATLAB and check the result is in the form of the matrix using Newton Raphson Load flow analysis which is as follows –

Newton Raphson Load flow Analysis

Bus No	V pu	Angle Degree	Injection MW	Injection MVar	Generation MW	Generation Mvar	Load MW	Load MVar
1	1.0600	0.0000	131.113	82.461	131.113	82.461	0.000	0.000
2	1.0000	-2.0170	20.000	-94.106	40.000	-84.106	20.000	10.000
3	0.9924	-4.8851	-45.000	-15.000	-0.000	0.000	45.000	15.000
4	0.9931	-3.8913	59.773	0.400	99.773	5.400	40.000	5.000
5	0.9781	-5.4217	-60.000	-10.000	-0.000	0.000	60.000	10.000
6	0.9892	-5.2581	-45.753	-8.521	-45.753	-8.521	0.000	0.000
7	0.9946	-5.3248	-54.020	5.607	-54.020	5.607	0.000	0.000
Total			6.113	-39.159	171.113	0.841	165.000	40.000

Line FLow and Losses

From Bus	To Bus	P MW	Q MVar	From Bus	To Bus	P MW	Q MVar	Line Loss MW	Line Loss MVar
1	2	88.089	77.731	2	1	-85.633	-70.361	2.457	7.370
1	3	43.024	17.089	3	1	-41.498	-12.512	1.526	4.578
2	3	26.297	-3.876	3	2	-25.873	5.148	0.424	1.272
2	7	29.867	-6.049	7	2	-29.310	7.721	0.557	1.672
2	5	49.468	3.180	5	2	-48.486	-0.231	0.983	2.949
3	6	22.371	3.198	6	3	-22.319	-3.043	0.052	0.156
4	5	11.629	2.459	5	4	-11.514	-2.115	0.115	0.344
4	6	-22.280	-5.552	6	4	22.319	5.000	0.039	-0.552
4	7	-29.349	3.025	7	4	29.310	-3.764	-0.039	-0.739
Total Loss						6.113	17.048		

Fig.5. The output of IPFC in matrix form using MATLAB

pcon1 =45.7527
pcon2 = 54.0202
qcon1 = 8.5209

it =19
VS1 =0.0470
VS2 =0.0546
Ts1 = -1.8467
Ts2 = -1.5603
Ts1_in_degrees = -105.8083
Ts2_in_degrees =-89.3992
maxerror = 6.0911e-06

FACTS devices can effectively minimize the overall generating cost without active power generation dispatching. In case an IPFC is incorporated to control the active and reactive power flows in a chosen transmission line, the effectiveness varies with the location of the IPFC series VSC without the branch power flow constraints.

But IPFC fails to give any impressive performance beyond this point. If the rating of the capacitor is increased then the cost of the equipment is also increased. So, after comparing the performances of series-series(IPFC) and series-shunt(UPFC) FACTS devices it can be concluded that desirable performance is obtained with the addition of UPFC(series-shunt) to the system for a capacitor value of 250µF.

3.3.Stage-III

In this stage, connect the UPFC controller on IEEE 14 bus system which is shown in fig.6.MATLAB simulation model of UPFC and their output waveform result is shown in fig.8. The output of UPFC and fig.7 shows the output of UPFC in continuous working mode.

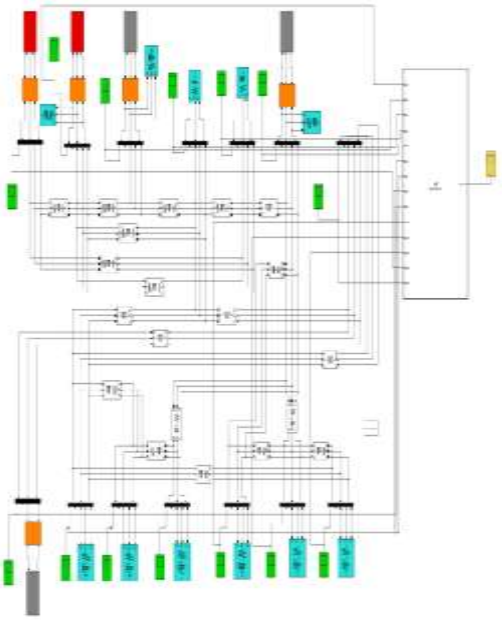

Fig.6. .MATLAB simulation model of UPFC

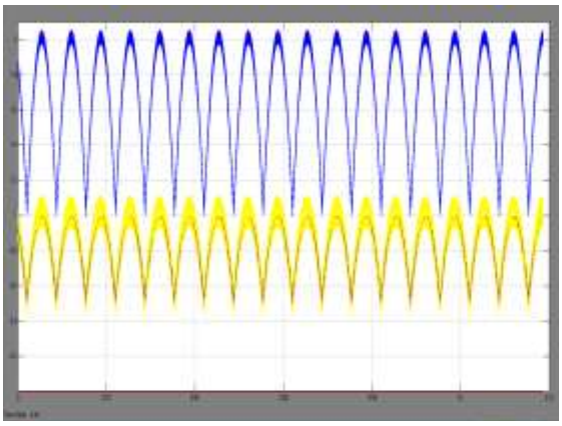

Fig.7. The output waveform of UPFC in a continuous working model.

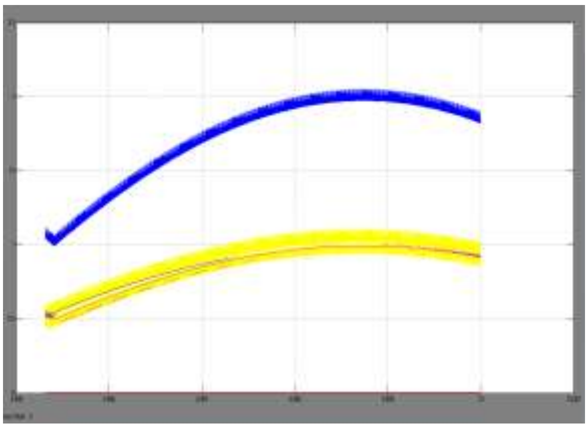

Fig.8. The output waveform of UPFC

A comparison study between the applications of the unified power flow controller (UPFC) and the interline power flow controller (IPFC) in optimal power flow (OPF) control. The performance of the UPFC and the IPFC is compared from the viewpoint of the total active power losses.

UPFC and the IPFC are powerful tools for power flow regulation, by which the transfer capability of the transmission line can be increased significantly. Combined with the generating bus voltage adjustment, the OPF incorporating either The capacity of the UPFC is usually significantly larger than that of the IPFC to achieve a similar.

3.4.Stage-IV

In this stage, now we add the Fuzzy logic controller using MATLAB which is shown in fig.9. for improving the system oscillation of the transmission line while connecting the UPFC controller in it and check the performance of the IEEE 14 bus power network. Fig.10. and Fig.11. shows the input and output waveform of the fuzzy logic controller respectively.

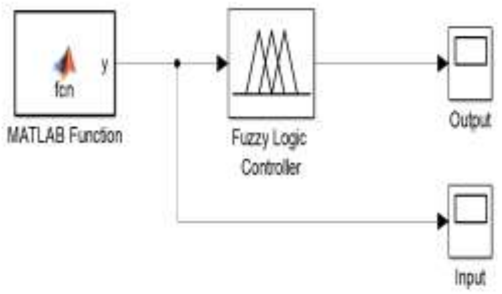

Fig.9. Fuzzy logic controller using MATLAB

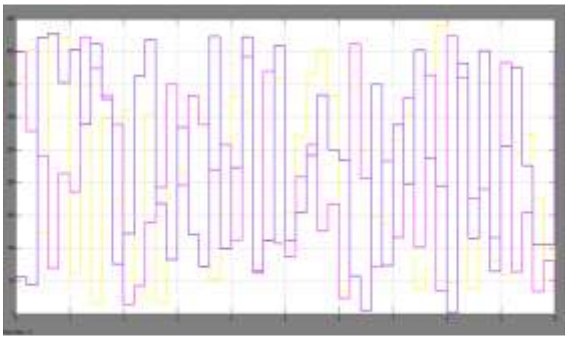

Fig.10. The input waveform of the fuzzy logic controller

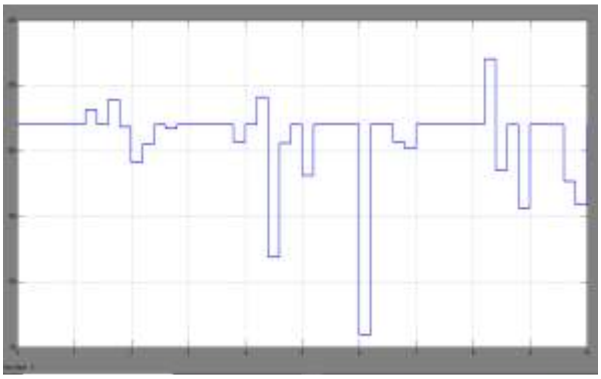

Fig.11.The output waveform of the fuzzy logic controller

From the input and output waveform of the fuzzy logic controller, it is clear that the fuzzy logic controller divides the all set valve in different level and choice the best value from it and give them the more accurate result. In this technique, the Fuzzy Logic controller performance is also compared to a PI controller. It's been observed that the Fuzzy Logic controller gives a better response PMSM drive as compared to the PI controller.

The fuzzy logic speed controller based closed-loop vector control of The powerPMSM drive system has been proposed. The fuzzy logic speed controller was used in the speed loop, and it helped to improve the system performance.

4.CONCLUSION

From the analysis of all 4 stages, it is concluded from the first stage represent the response of the IEEE 14 bus power network output. After that 2 and 3 stages, it is clear that both IPFC and UPFC are balanced the real and reactive power respectively as well as the converters' losses are neglected. There is a considerable improvement in real and reactive power with a change in capacitance value. But increased capacitor rating means an increase in the cost of the equipment. So, we can conclude that UPFC gives better performance (power profile) when compared to IPFC for a given operating condition with much low value of capacitance.

After that from next 4 stages conclude that when we analyze the performance of PI controller there are some disadvantages like time delay, response time is more but when we use FUZZY-PI then these all drawbacks are neglected because Fuzzy-PI updates its parameter on each control cycle on a different range and give the quick response.

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