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Comparative Analysis for Power Quality Improvement using Optimization Techniques

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ABSTRACT: power quality is one of the major concerns in the present scenario. Harmonics in the system is the key factor for power quality. In this paper the harmonic study for IEEE 30 system is considered and THD (Total Harmonic Distortion) of that system calculated. To reduce the THD, DPFC is employed. For the basic test system harmonic analysis is done and DVR based PI control strategy used to reduce the THD of the system. At first self tuned PI controller is used to reduce harmonics of the system. To improve the quality of the power furthermore optimization techniques used to reduce THD of the system. In this paper, different optimization techniques viz, particle swarm optimization (PSO) and bacterial foraging (BF) optimization are discussed. The resulting values are presented and comparative analysis is given for PI, PSO optimized PI control and Bacterial foraging optimized PI control.

KEYWORDS: Power quality, Harmonics, Distributed Power Flow Controller (DPFC), Dynamic Voltage Restorer (DVR), Bacterial Foraging, and Particle swarm Optimization (PSO).

I.INTRODUCTION

Quality of power is the most concerned area where the system sensitive to the deviations. The presence of harmonics, voltage and frequency variations is the some of the factors which affects the quality of the power [1] [6]. Harmonics in a system is nothing but integral multiples of fundamental component of sinusoidal waveform. Because of these harmonics with the fundamental waveform, the waveform becomes non sinusoidal and distorted. Harmonics in a system is calculated by THD (Total Harmonic Distortion) factor. These harmonics can be reduced by using different scheme controllers of which are discussed in this paper. For Harmonic analysis IEEE 30 bus system is considered.

II.IEEE 30 BUS SYSTEM

The 30 bus system which is shown in fig-1 is consisting of 6 generators and 21 loads. Before doing harmonic analysis on the system, at first it important to know the all bus parameters like bus voltages, phase angle, real power and reactive power at each bus of the balanced system. For calculating those values, Newton Raphson method is used[2].

After employ a converter into it, the bus voltages of the system are changes because of the harmonics injected by the converter. To calculate the bus voltages and THD at each bus after considering harmonics, harmonic analysis is done and those results are presented. The converter which is used in this is of 5000 kw & 0.85 pf at bus 21[2]. The Harmonic voltage waveforms at busses 10 and 22 are presented in fig-5 and fig-6.

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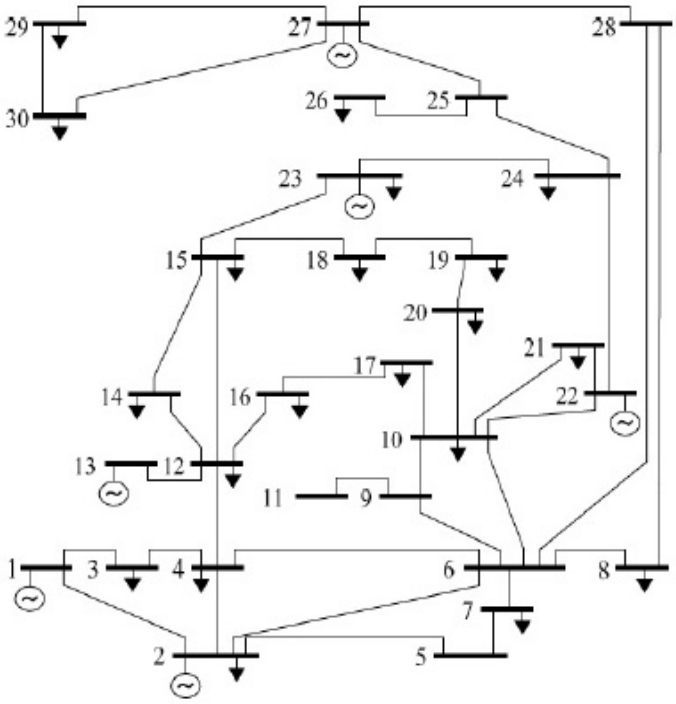

Fig-1: Single line diagram of IEEE 30 bus system

To reduce these harmonics, in this paper DPFC and DVR based pi and optimized PI control strategies are proposed.

III.DPFC CONTROL

Distributed power flow controller (DPFC) is nothing but it's a combination of static synchronous compensator (STATCOM) and a static synchronous series compensator (SSSC) without DC link capacitor. It can say that DPFC is a UPFC without dc link capacitor. UPFC is converted into DPFC when DC link capacitor taken out and distribute the series converter [3] [4]. DPFC is shown in fig-2

DPFC is more reliable compare to UPFC because in case of UPFC if fault in one converter is occurred it will be Go to second converter though the DC link capacitor. Another advantage of DPFC is the cost of DPFC less compare to the UPFC [5].

Within the DPFC, the transmission line presents a common connection between the AC ports of the shunt and the series converters. Therefore, it is possible to exchange active power through the AC ports. By using this DPFC in the harmonic 30 bus system, it can observe that reduction of harmonic content. Those results are results are shown in fig-7 and fig-8

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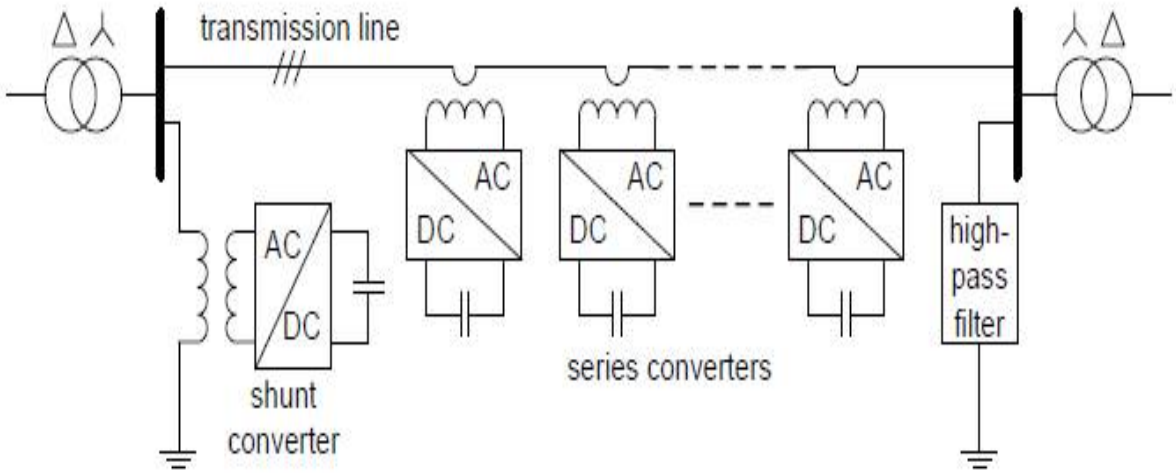

Fig- 2: DPFC configurations

IV. DVR WITH PI CONTROL

DVR is series connected device which injects voltage dynamically into the system to reduce the harmonics in the system. It is one of the effective FACT devices to improve the quality of the power. Generally it is installed in between distributed system and critical load feeder. DVR is also used for mitigating voltage sag and swells in the system [6].

In this paper, a basic subsystem which has two feeder system and three winding transformer considered. In these two feeders one of the feeders is uncompensated and other one is compensated by dynamic voltage restorer [7]. The basic test system is in fig-3

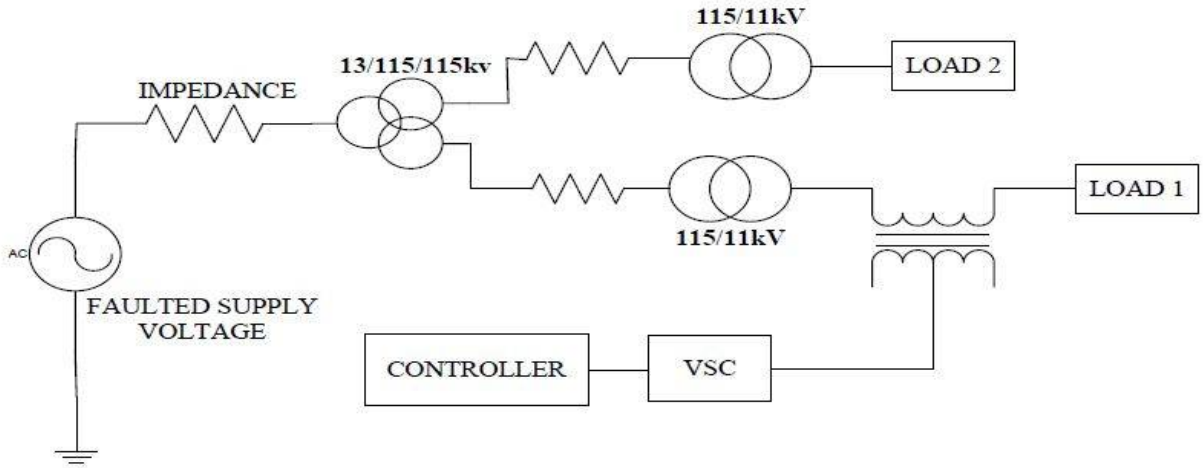

Fig-3: Single line diagram of basic test system.

The controller used here is PI self tuned controller which is in fig-4. It is a negative feedback controller. Depending on the error produced, the response can be adjusted by constants k_p and k_i. K_i is called proportional gain constant which is depends on the magnitude of the error. Ki is called integral constant which is depends on the both the magnitude and

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time duration of the error. By adjusting these gain values we reduce system harmonics. PI controller is shown below fig-4 and the results obtained by the implementing the DVR with PI control is shown in fig-9

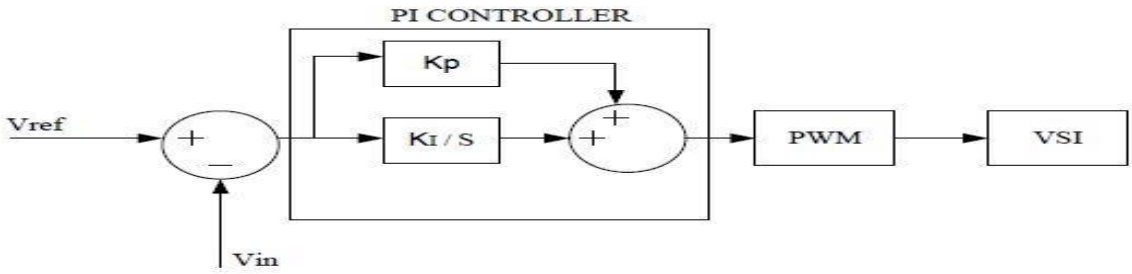

Fig-4: PI controller

V. DVR WITH OPTIMIZED PI VALUES

To apply optimization techniques to control parameters, first find objective function of the system. To minimize this objective function with control parameters, optimization techniques are used [8]. Here bacterial foraging and particle swarm optimization techniques are used.

Bacterial foraging optimization is based on the research of foraging behaviour of the E.colli bacteria. Particle swarm optimization technique is based on the research of swarm behaviour of such as birds finding food by flocking [9] [10]. Based on the algorithms of each optimization techniques, the optimized values of control parameters k_p and k_i are obtained and those are submitted in the PI control mechanism and results are noted. The results are noted in fig-10.

VI. RESULTS AND DISCUSSION

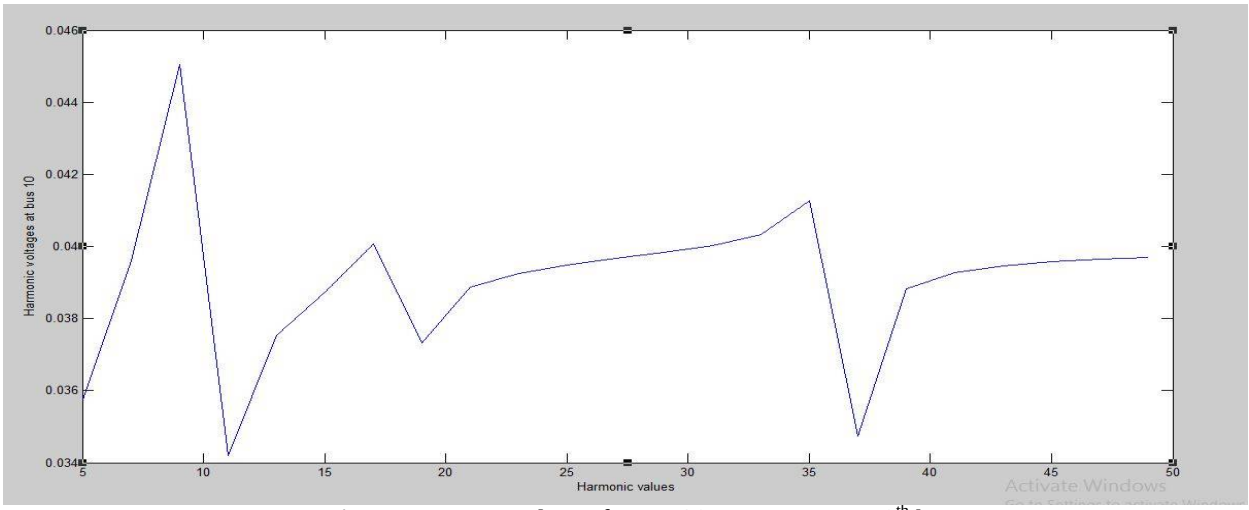

Fig-5: Harmonic values of IEEE 30 Bus system at 10th bus

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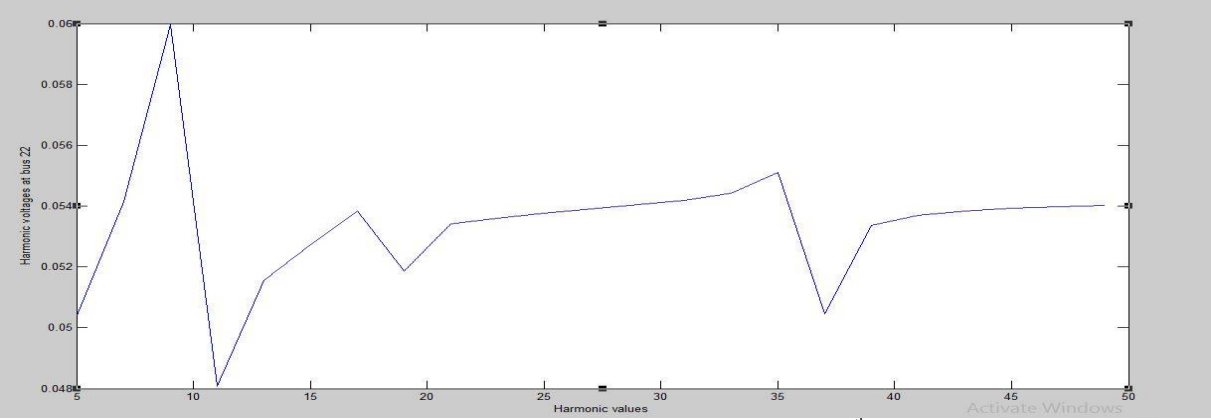

Fig-6: Harmonic values of IEEE 30 bus system at 22th Bus

In IEEE 30 bus system we add a converter at bus 21 where harmonics are injects into the system. Because of these harmonics the voltages at busses 10 and 22 are changes because these are directly connected to the bus 21. So the Harmonic analysis at 10 and 22 are shown in above figures.

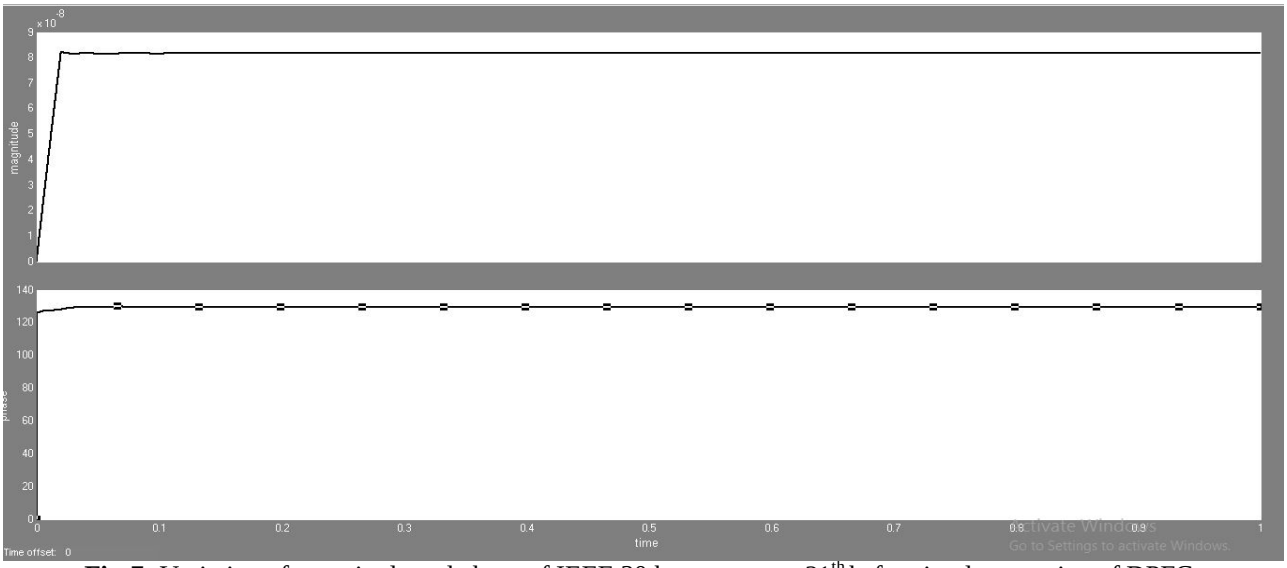

Fig-7: Variation of magnitude and phase of IEEE 30 bus system at 21th before implementation of DPFC

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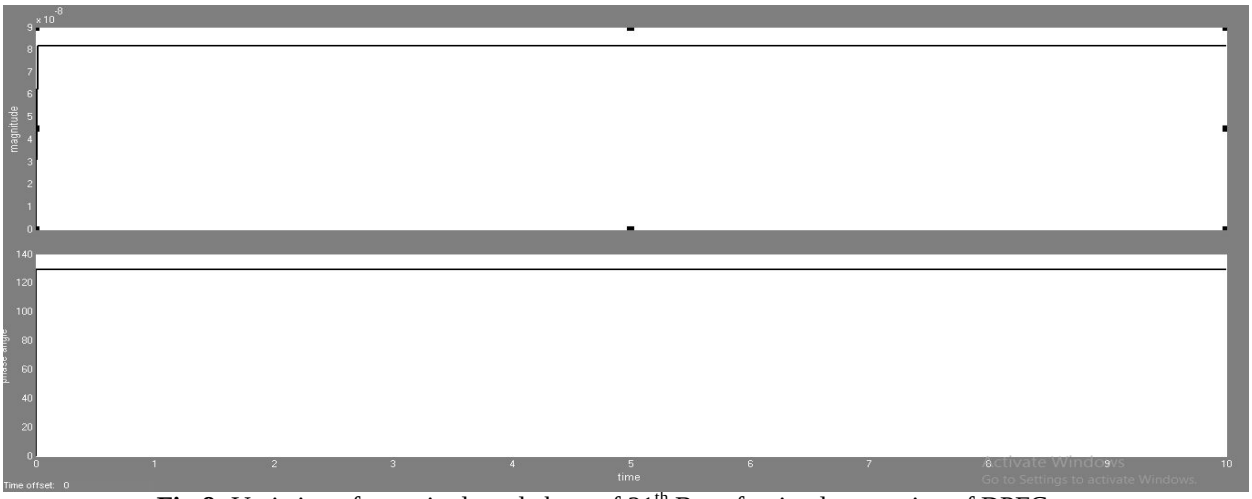

Fig-8: Variation of magnitude and phase of 21th Bus after implementation of DPFC

From the above figures it can be said that before implementation of DPFC, it taking some damping in the system but after implementation of the DPFC the damping in the system is reduced.

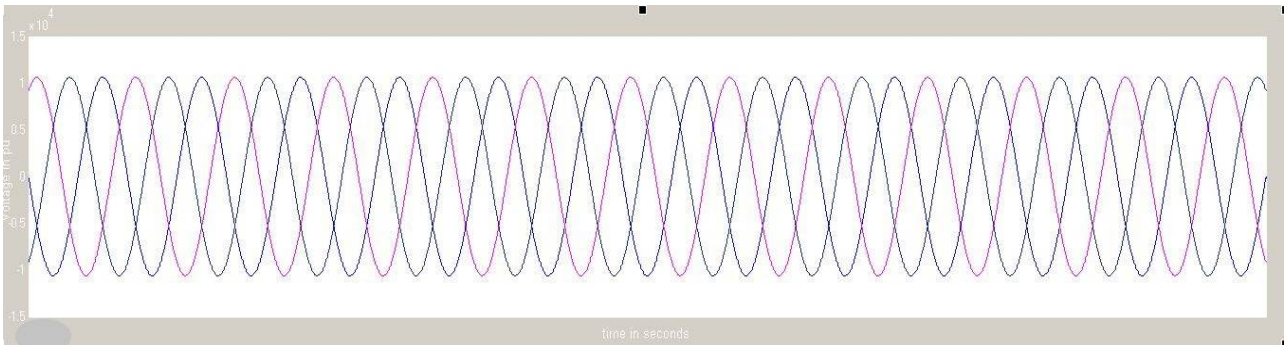

Fig-9: Load voltage waveform of PI control DVR

The above waveform denotes the voltage variation of DVR because of PI control implementation.

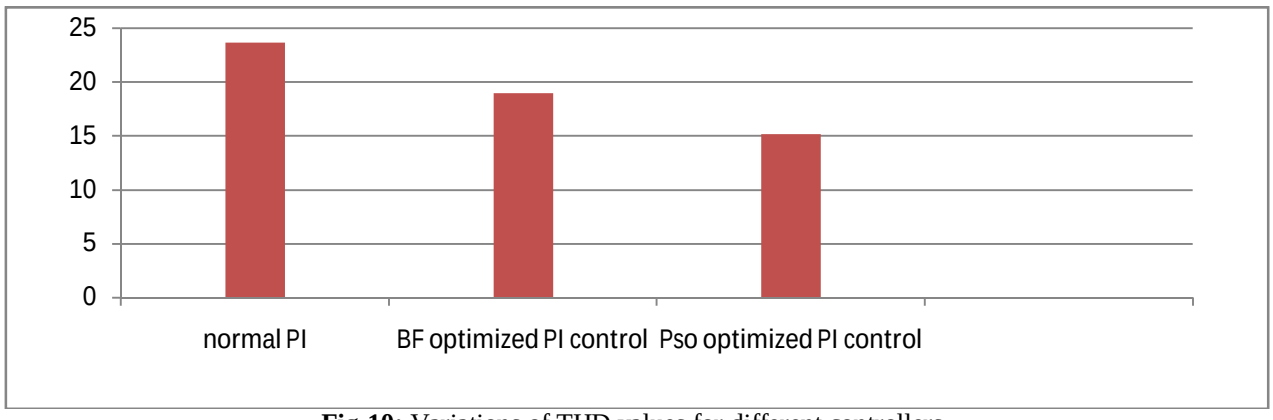

Fig-10: Variations of THD values for different controllers.

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After implementation of normal PI control THD of the system is 23.70% and for optimized PI of bacterial foraging and Particle swarm optimization are 19.01% and 15.20% respectively.

VII. CONCLUSION

From the results it can be concluded that the response of system is improved because of the implementation of DPFC into the system. Oscillations in the system are reduced because of distributed power flow controller. In case of Dynamic voltage regulator (DVR) implementation on basic test system, from the comparative analysis it can suggest that particle swarm optimization is better of remaining control strategies. Total Harmonic Distortion is less compare to remaining. Harmonics can be reduced up to large extend from system by PSO optimized PI control.

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