Novel FLC Based DPFC to Improve the Grid Connected Device Power Quality

[1]Voruganti.Bharath Kumar, [2]SK.Syed Hussain, [3]K.Gopala Krishna, [4]B.Lingam

[1,2.3,4]Assistant Professor in Department of Electrical and Electronics Engineering

[1,] St.Martin's Engineering College, Secunderabad, Telangana, India.

[2-4]KG Reddy College of Engineering and Technology, Chilkur,Moinabad, Telangana, India.

[1]vorugantieee@gmail.com, [2]syedhussain3899@gmail.com, [3]gopalakrishna.korivi@gmail.com,
[4]lingam224@gmail.com

Abstract— In this paper we propose a novel digital controller like FLC based DPFC to improve the power quality and harmonics reduction capability. Generally power quality problems like voltage Dip, swells and harmonics these issues are affecting the system stability. The DPFC device is similar to UPFC but eliminating DC-interface. But always DC bus is used for exchanging the real powers between back to back converters of UPFC but in our proposed method that function is achieved by using 3rd harmonic content in the system. The performance of the system is conduct in MATLAB/simulink environment.

Keywords- Fuzzy logic controller (FLC), sag, swells, harmonics, Distributed Power Flow Controller (DPFC).

1. INTRODUCTION

Electricity has been used in our day to day life in many ways. Due to changing needs of customers with respect to comforts, convenience and flexibility. Electrical energy has become a fundamental necessity for society and socio-economic development. DPFC performs automatic monitoring, protecting and controlling of various equipment's in distribution systems with the use of intelligent electronic devices such as to enhance the power quality greater extent and improves stability of the PS network also. "This paper proposes a multi-agent-based architecture for optimal energy management in smart homes. Four optimization strategies – comfort, cost, green (energy-efficient) and smart (demand side management)- are proposed and explained. The strategies are expected to provide savings (energy and costs), flexibility and control to homeowners in their energy use, and to support utility companies in the management of the electricity network". The use of electricity is increasing as the population of the world is increasing [1].

It powers everyday life devices (example: computer, televisions, and telephones) as well as it powers commercial buildings, industries, internet etc. Hence the demand for electric power is increasing at a high rate particularly at urban areas [2].

Electricity is the most versatile and easily controlled form of energy. At the point of use it is practically loss-free and essentially non-polluting. At the point of generation, it can be produced clean with entirely renewable methods, such as wind, water and sunlight. It is weightless, easier to transport and distribute and it represents the most efficient way of consuming energy. Electricity is created in power plants using various forms of energy. Electricity is generated at power plants by electromechanical generators, primarily driven by heat engines fuelled by combustion or nuclear fission but also by other means such as the kinetic energy of flowing water and wind other energy sources include solar photovoltaics and geothermal power. Distribution network is one of the main parts of the system as it connected directly to the load centre [3]. In general, it is the electrical system between the substation fed by the transmission system and the consumer end.

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Any type of distribution network must be used to transmit electrical power from an alternating current (AC) or Direct current (DC) source to the position where it is to be used. The method of distributing power from where it is produced to where it is used can be very simple. To shift electrical power from the plants to factories, homes and commercial buildings, more complex power distribution systems are used. Generally, a distribution network consists of substations, primary feeder, transformer, distributor and service mains [4]. "Basically, we can say that part of power system we distribute electric power for local use is known as Distribution Network". Energy generation in the distribution levels provide benefits for both the users and the electric provider as generation in distribution network can reduce the transmission losses, as well as cost for power generation [5]-[6]. "It is the final stage in the delivery of electric power. It carries electricity from the transmission system to individual consumers. Distribution substations connect to the transmission system and lower the transmission voltage to medium voltage ranging between 2KV and 35KV with the use of transformers. Primary distribution lines carry this medium voltage power to distribution transformers located near the customer's premises. Distribution transformers again lower the voltage to the utilisation voltage used by lightning, industrial equipment or household appliances. Often several customers are supplied from one transformer through secondary distribution lines. Commercial and residential customers are connected to the secondary distribution lines through service drops".

This PQ issues are investigated earlier in the literature, those are series voltage controllers [3], shunt voltage controllers [4], Hybrid active power filters [5] and integrated series-shunt controllers familiar to known as UPFC [6]. Generally these FACTS controllers are reactive power compensation controllers inserts fault magnitude voltage or current at CPI.

The next sections of this article is organized as configuration of DPFC with PS network in section-II, Conventional PI control scheme and proposed fuzzy method in section –III, simulation discussion in section-IV and concluded in section –V.

2. SYSTEM CONFIGURATION

The configuration of DPFC is shown in fig.I. It mainly contains one shunt voltage control-ler and n number of series voltage controllers. Series voltage controllers are inject volt-age, active power in the transmission lines whereas shunt voltage controllers inserts cur-rent in the transmission line, compensate reactive power and act as power factor correction device. Where High pass filters are eliminate the lower order harmonics and im-proves the power quality.
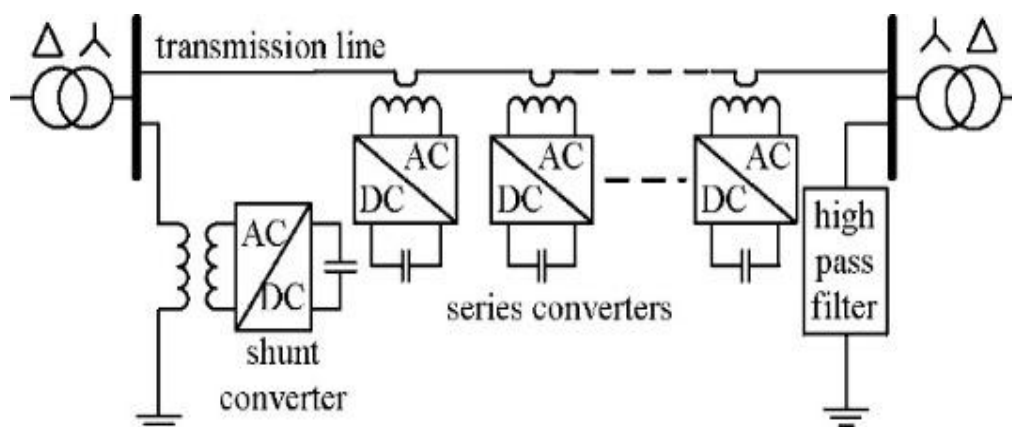

Figure I   Configuration of DPFC.

The elimination of common dc link capacitor of UPFC is treats as DPFC. DPFC generally employed in distribution side it is more economical and reliable. The active power exchange with DPFC controller is shown in figure II.
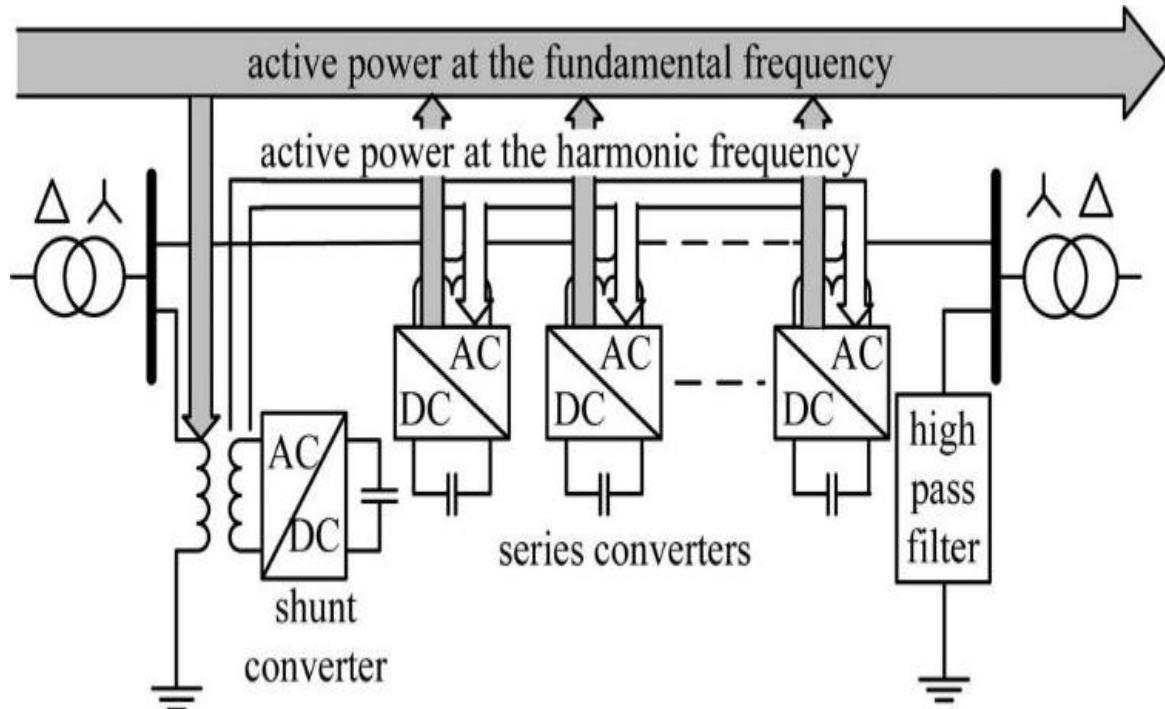

Figure II   Real power exchange between DPFC

3.   CONTROL SCHEME

3.1 Fuzzy based VSI Controller Design:

Fuzzy based VSI controller implementation is similar to the fuzzy MPPT algorithm. In this error is treats as set of fuzzy rules. These fuzzy sets are provides PI control parameters by selecting rules, shape of membership and de-fuzzification. The fuzzy rules set mentioned in Table-1. The fuzzy logic rationale contrasts with both idea and substance from conventional multi-valve legitime frame works such as "(NB) negative big, (NS) negative small, (Z) zero, (PB) positive big and (PS) positive small".

Table 1 Fuzzy Rule Set

		Error (E)				
		NB	NS	Z	PS	PB
Change in Error (ΔE)	NB	NB	NB	NS	NS	Z
	NS	NB	NS	NS	Z	PS
	Z	NS	NS	Z	PS	PS
	PS	NS	Z	PS	PS	PB
	PB	Z	PS	PS	PB	PB

The actual value of voltage across (Vdcact) CPI point is contrast with reference DC voltage (Vdc) that error is optimized with fuzzification then error is rectified send to the system after de-fuzzification. The control strategy of operate VSC with fuzzy-PI controller is shown in below fig.III.
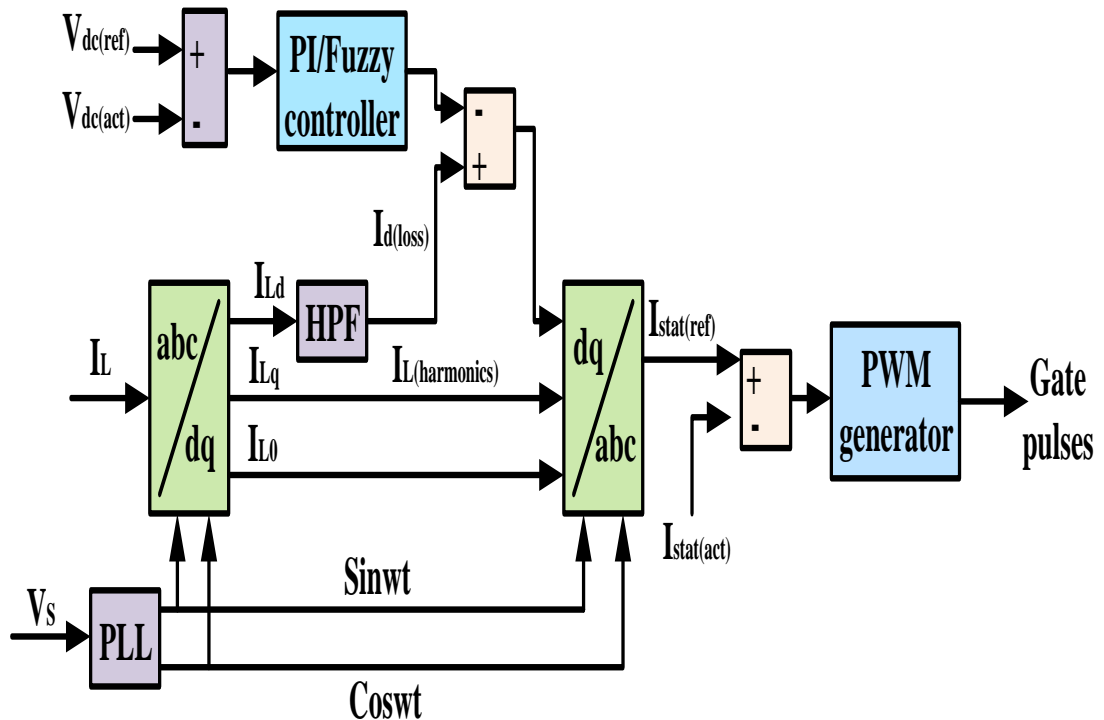

Figure III   Control strategy of Fuzzy-PI based VS

4.   SIMULATION RESULTS

In this proposed paper simulation results are discussed for different conditions as mentioned below.

1. Without DPFC
2. DPFC with PI controller
3. DPFC with FLC controller.

a.   Case 1: Without DPFC:

In this condition we are design our source grid is interfaced with nonlinear load. Due to the load we get the power quality issues like sag, swell and harmonics. From below waveforms we can easily says like time 0.5 sec the load voltage get the sag and same time load current get the swell and after 1sec the system is getting stable. The MATLAB model of PS network without DPFC controller is shown in fig.IV.
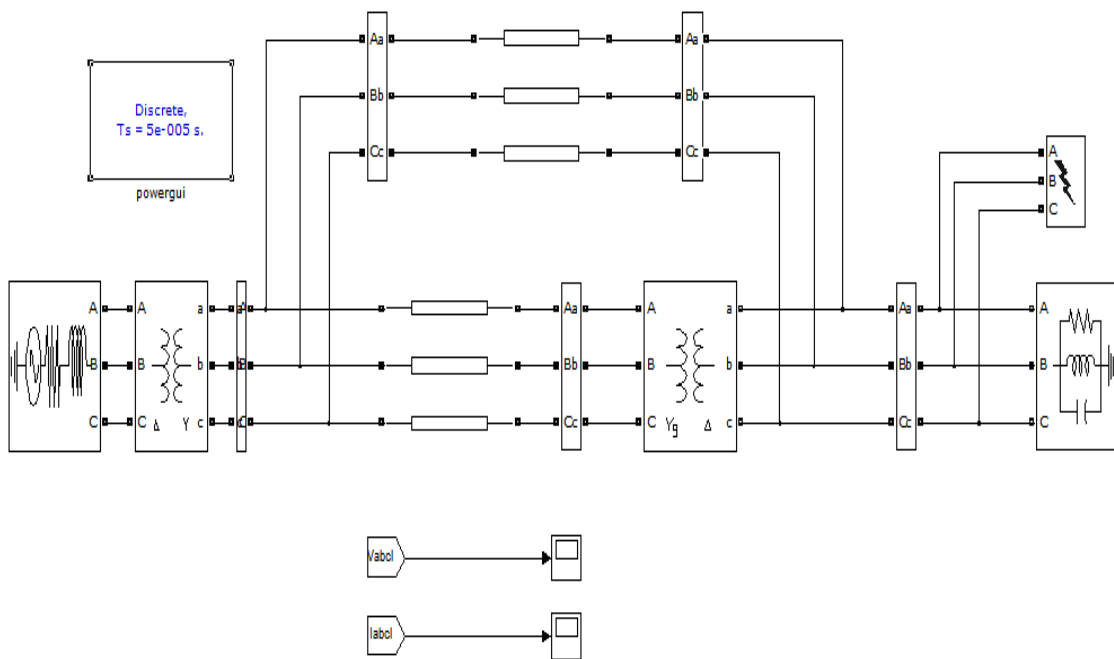
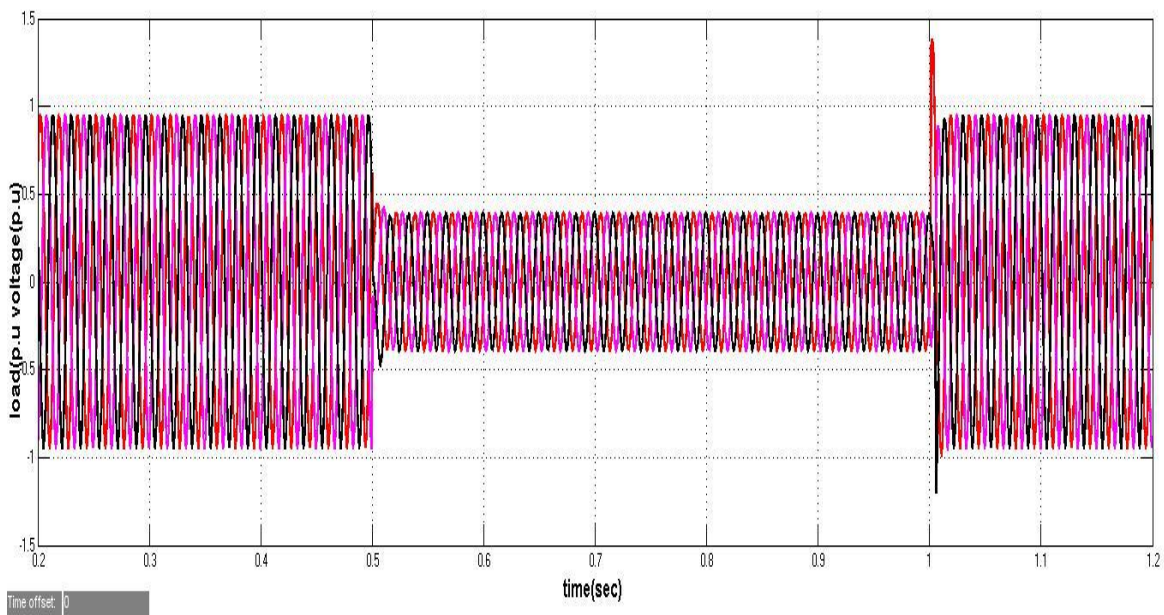**Figure IV   without DPFC Simlink Diagram**
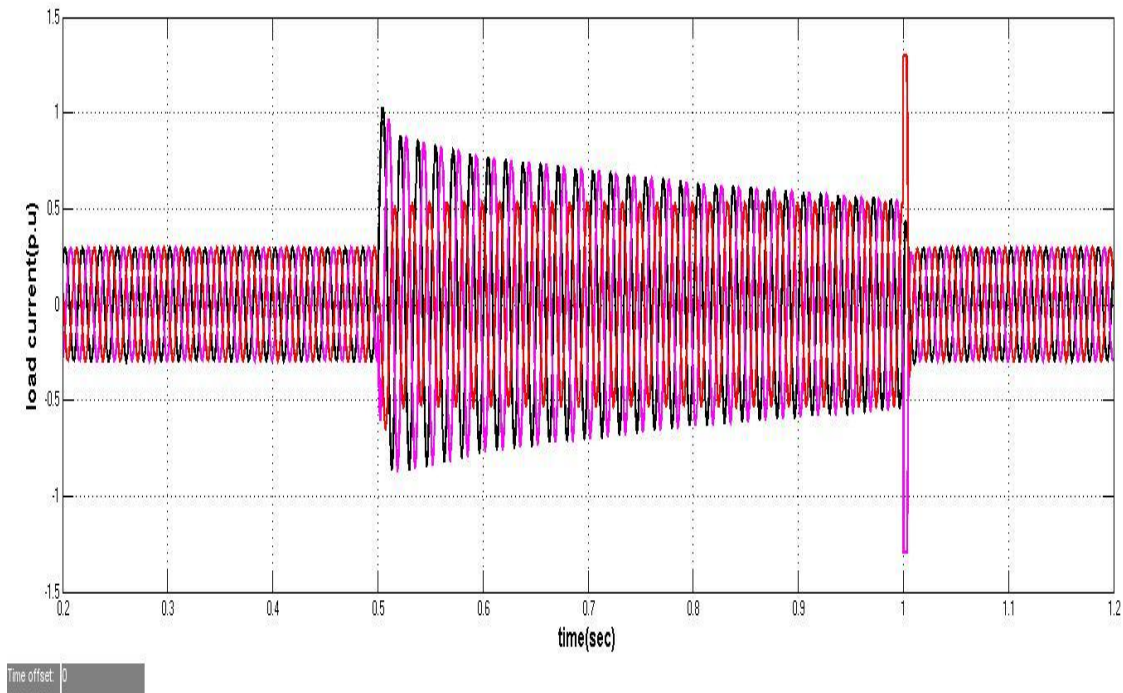

Figure V   Load voltage without DPFC (sag)

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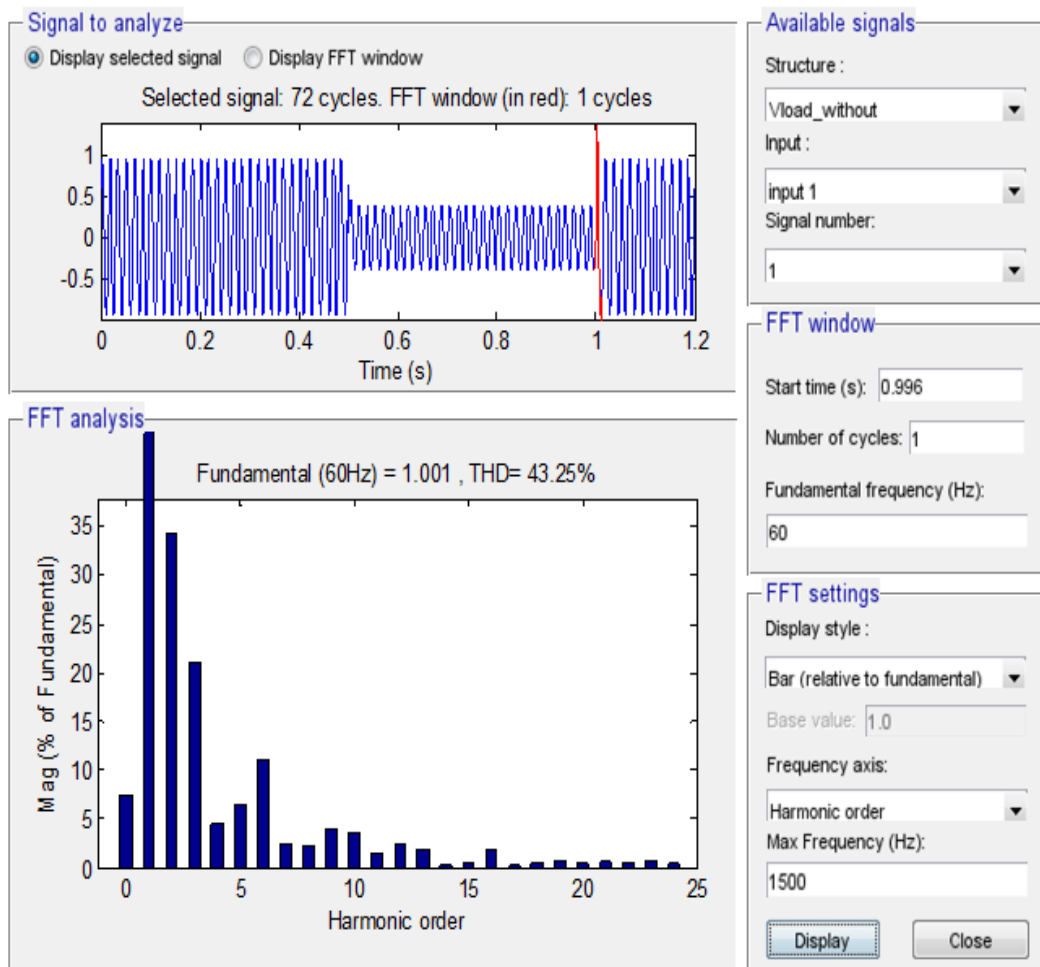**Figure VI   Load Current without DPFC (swell)**

Figure VII   THD Plot

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b. *Case 2: Conventional method with PI controller:*

The MATLAB model of PS network with DOFC and PI controller is shown in figure.9. In this condition we are design the PI controller based DPFC to enhance the system performance. From the below figures we exposed like after 0.5 sec voltage sag is compensated by injecting the equal and opposite voltage into the system through series controller of DPFC. By using conventional controller we compensate the sag, swell and harmonics. From figure.11 of representing we get the %THD 0.69 only but in case of without DPFC we get around 43.25%.
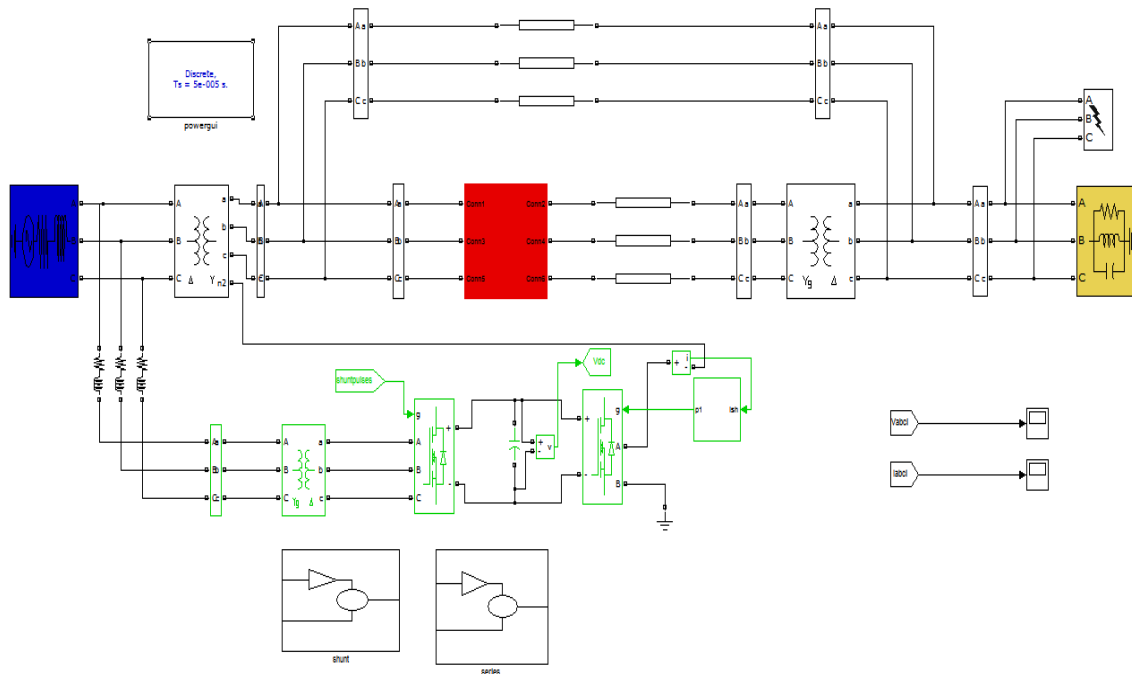
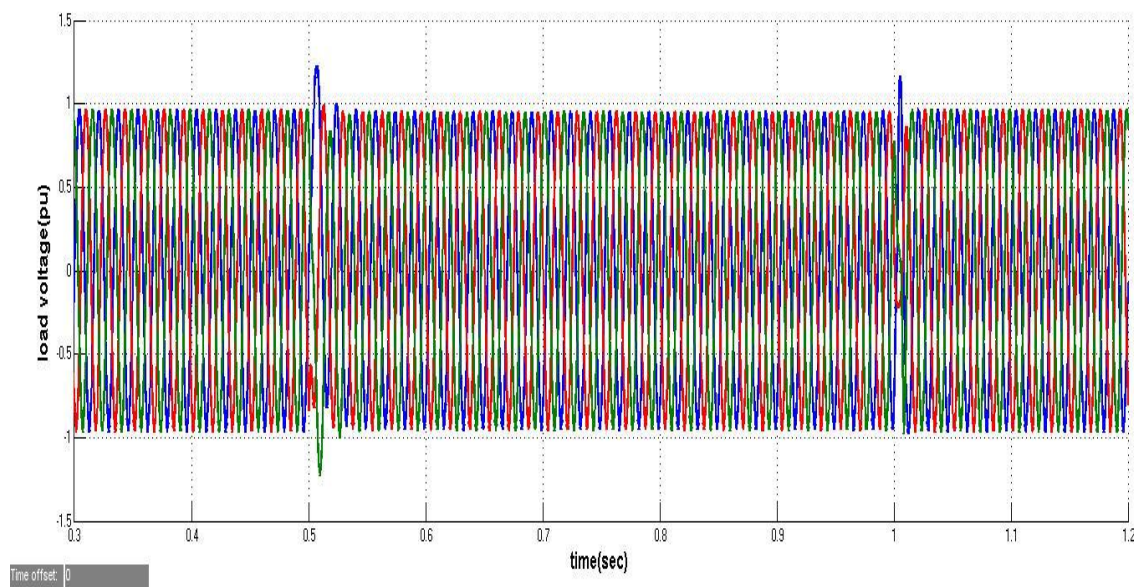**Figure VIII   Simlink Diagram of DPFC with Conventional PI Controller**

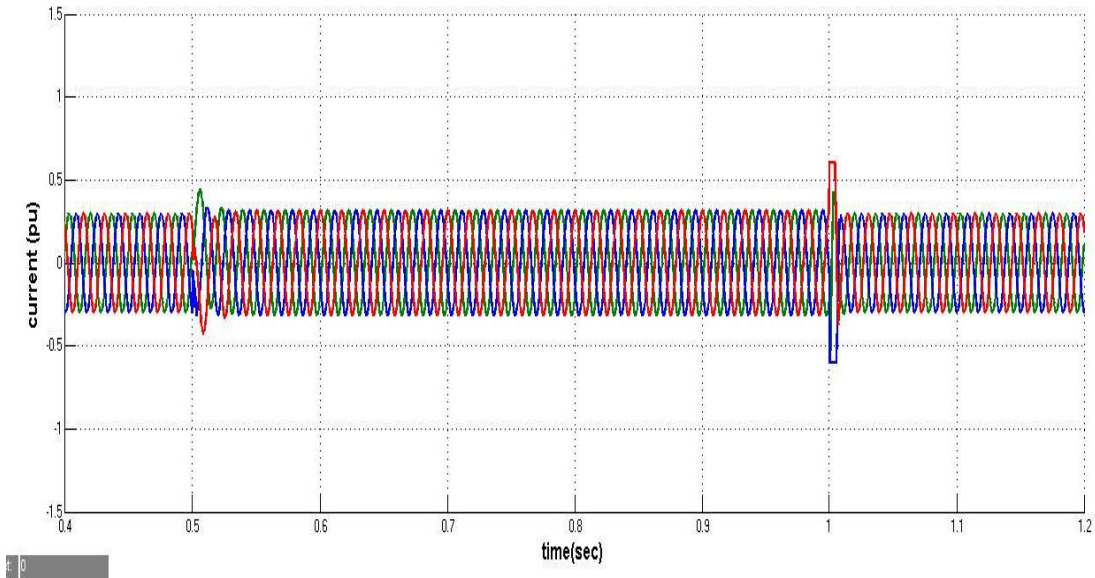**Figure IX   Load Voltage with DPFC PI Controller**

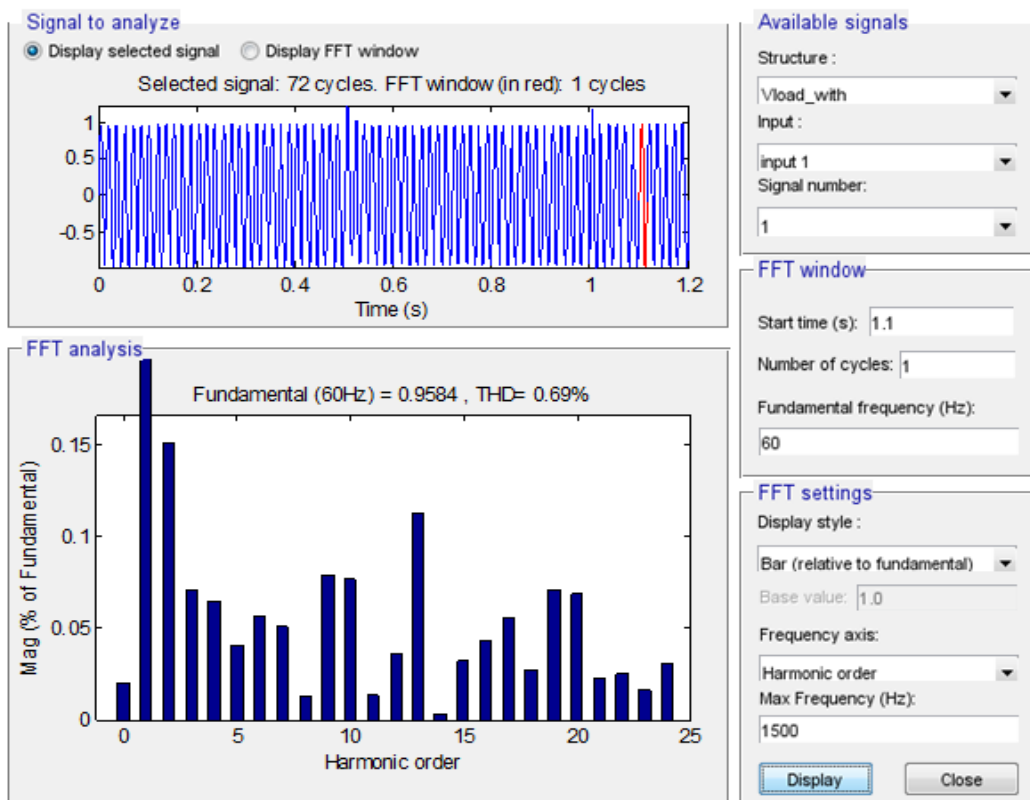**Figure X Load Current with DPFC PI Controller**

Figure XI THD Plot

c.   Case 3: In this proposed method we are controlling DPFC by FLC controller

The MATLAB model of PS network with DPFC and intelligent fuzzy PI controller is shown in figure.12. By comparing output simulation results compare to conventional PI controller proposed FLC controller works very well. THD also less obtained mentioned in fig.16.
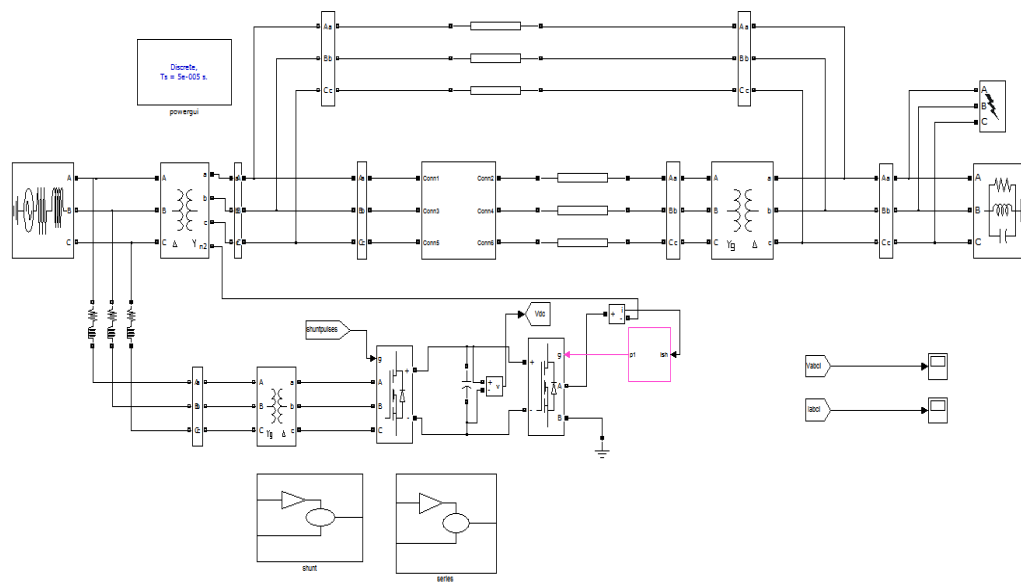
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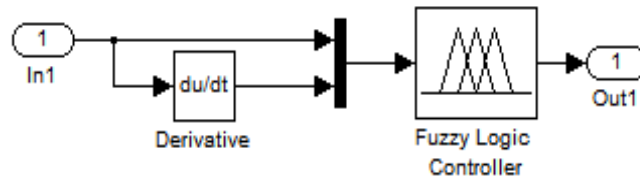**Figure XII   Proposed Method Simlink Diagram**

Figure XIII   Proposed FLC Controller
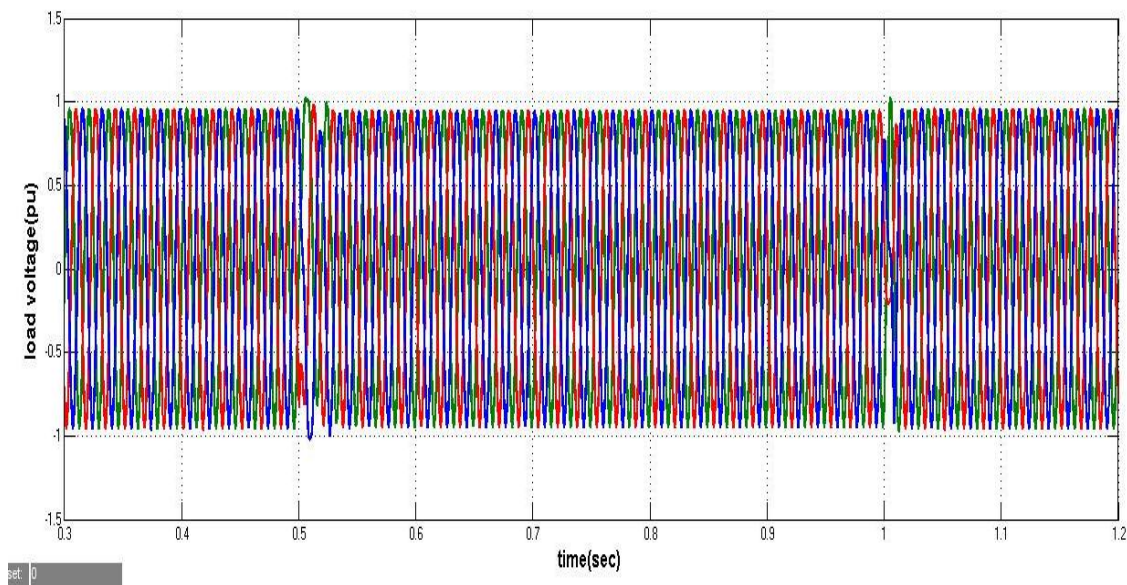

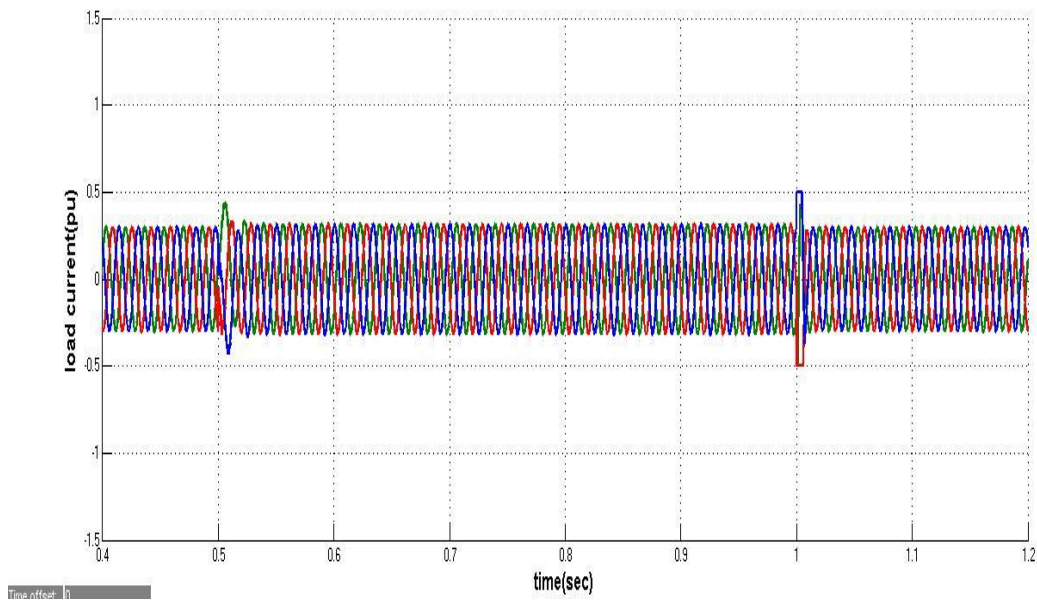**Figure XIV   Load voltage with DPFC - FLC Controller**

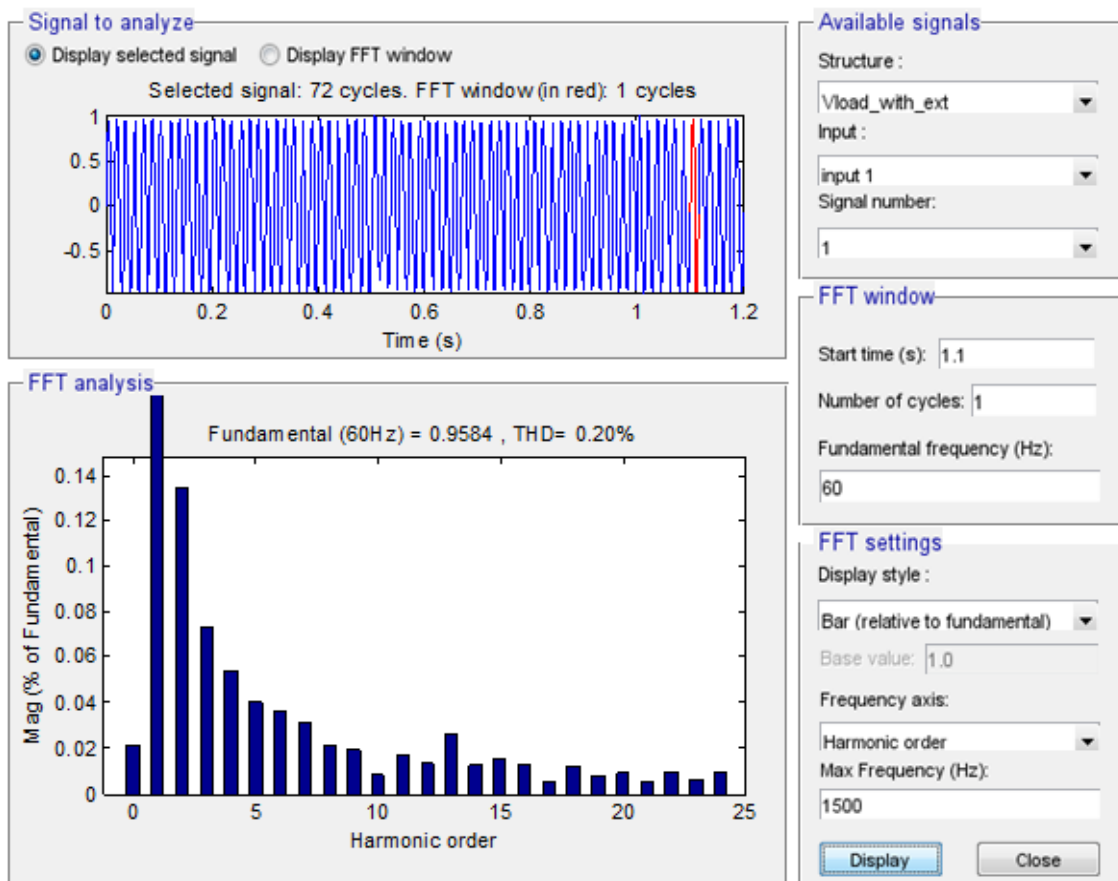**Figure XV   Load Current with DPFC - FLC Controller**

Figure XVI   THD Plot

5. CONCLUSION

In this proposed paper we are utilizing FLC based digital controller to enhance the system performance with DPFC. The non linear load is integrating with grid affect the power quality issues like voltage sag, swell and harmonics. These problems are compensating with DPFC with FLC controller. In this paper we are comparing the conventional PI with DPFC and FLC with DPFC the proposed system is getting better results.

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