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Power Quality Improvement by using D-STATCOM with Fuzzy logic Controller in Combination with Wind Energy Based System

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ABSTRACT: Importance with renewable systems such as solar Photovoltaic (PV) Cells, wind Energy systems have improved extensively throughout the earlier period decade. To get the uncontaminated energy, the hybrid renewable systems power generation is use. Customers have a preference quality of power since supplier. The power quality can be considered by factor such as voltage distortions of (sags, swells, transient, harmonic distortion and power factor. etc). To acquire the power quality dissimilar techniques are used. In diesel power generator systems the harmonic distortions in the transmission line will be amplified. By implement the harmonics compensation technique in with Fuzzy logic Controller is used for harmonics reduction. The numerous dissimilar aspect of the Photovoltaic system as well as the usually address technological capacity is on rising a range of Photovoltaic system models included with the maximum power-point tracking (MPPT) purpose. MPPT control is attained through intellectual controller. The Intellectual controller is controlled by optimal utilization control method. Solar PV Cells, wind Energy systems, diesel engine systems and an intellectual controller are use in conventional method. The MPPT control methods have a group of constraints, so PQ theory with hysteresis loss current control algorithm is to defeat this difficulty. In this paper, voltage source inverter with Fuzzy logic Controller (PWM-VSI) is coupled connecting diesel generator plus load which compensate the harmonics in the AC side grid. Performance of the harmonics compensation method by using voltage source inverter with Fuzzy logic Controller (PWM-VSI) in the hybrid distribution system is used to achieve the voltage immovability.

KEYWORDS: Total Harmonic Distortion (THD), hybrid renewable systems, Diesel Generator, D-STATCOM, maximum power-point tracking (MPPT), D-STATCOM (PWM-VSI), hysteresis current controller (HCC), , Wind Energy System (WGS). Introduction

I. INTRODUCTION

The rising consciousness for ecological protection and the rising power demand have develop into general position to utilities. This common amplifies in necessity for energy can generate most important challenge for the power distribution systems. Now, employ contain alert on the decrease of Free from environment of energy. The aspiration to search for substitute of renewable energy systems has lead toward the general growth of distributed generation systems (DGs) [1-3]. The DGs way integrate lesser generators through a capability initial beginning 15KW -20MW inside a DGs which extent diagonally a power system provide electric power toward the customers, consequently falling requires the novel structure otherwise improvement the limited distribution lines beside with scheme power quality improvement. However the combination of wind energy systems[4-7] keen on accessible power system impress technological challenge in the Electrical power system as well as require growth of convention power equipment's for electrical Voltage regulation[8-9], constancy and power quality issues. The power quality improvement is an important customer-centric determine which is enormously impacted by the procedure of several system. This manuscript investigate the function of DSTATCOM at load end in a pastoral DGs working through Wind Energy systems as well as supply remote balanced /unbalanced loads. The wind energy systems, grid DGs as well as DSTATCOM strategy in synchronism is verified during simulation in Matlab-Simulink below dissimilar working circumstances. The performance of grid distribution scheme in conditions of voltage. Power quality issues are frequent in the majority of profitable, engineering and effectiveness networks. Normal phenomenon, such as lightning is the large amount common reason of power quality issues. Switching phenomenon resultant in oscillatory transients system in the electrical supplying, for instance while capacitors are switch, in addition add considerably toward power quality turbulence. Also, the relation of elevated power in non-linear loads contributes to the generation of voltage and current harmonic machinery. Connecting the unlike voltage turbulence that can be created, the large amount important and dangerous power quality issues are voltage sags payable toward the elevated efficient sufferers that can be generate. sags can expedition electrical drive otherwise extra susceptible apparatus, most important to

expensive disruption of manufacture [6]. designed for all these reason, from the customer side, power quality problems will grow to be an more and more significant feature to believe in arrange to convince high-quality efficiency. On the additional offer, for the electrical supply manufacturing, the power quality deliver will be one of the distinctive features for ensure consumer reliability in this very spirited as well as deregulated marketplace [7]. To lecture to the requirements of energy clients annoying to recover efficiency during the decrease of power quality connected procedure stoppage as well as energy supplier annoying to exploit working earnings while maintenance clients contented through contribute quality, inventive equipment provide the explanation to money-making power quality improvement solution [8]. Conversely, with the different power quality explanation available, the evident query for a customer otherwise efficacy opposite an exacting power quality issue is which apparatus provide the improved details [9].

II. DSTATCOM DEVICE

A D-STATCOM is a restricted reactive power origin, which contain a voltage source Converters a DC link capacitor linked during shunt, capable of produce as well as enchanting reactive power. The operational principles of DSTATCOM are support taking place the exact association of the instantly revolving synchronous compensator.

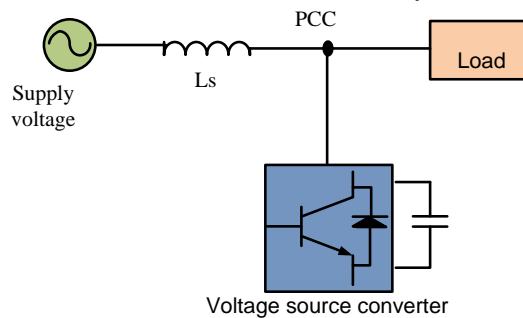


Figure.1. Block diagram of D-STATCOM

The AC incurable of the Voltage Source Converter are coupled toward the point of Common Coupling during an inductance, which could be a filter inductance or the leakage inductance of the couple transformer, as revealed in the Figure. 1. The DC side of the voltage source converter is associated to a DC side capacitor, which bring the ripple current of the voltage source converter as well as is the key reactive energy storage space component. This capacitor can be stimulating by a battery supply, or can be re-energized by the converter itself. If the output voltage of the Voltage Source Converter is equivalent near the AC lethal voltage, no reactive power is delivering toward the system. If the output voltage is larger than the AC lethal voltage, the DSTATCOM is in the capacitive method of procedure and vice versa. The amount of power flow of reactive is relative to the dissimilarity in the two voltages. For a DSTATCOM utilize in favor of voltage regulation at the point of Common Coupling, the reparation should be such that the supply side currents be supposed to lead the deliver voltages; while, for power factor improvement, the supply current should be in phase with the supply voltages. The control approaches calculated in this manuscript are functional through a vision to learning the concert of a D-STATCOM for power factor correction as well as harmonic reduction technique.

III. PROPOSED FUZZY-LOGIC CONTROLLER FOR WIND-ENERGY SYSTEM

The below arrangement having a wind energy system as a renewable systems linked toward the dc-link voltage of a grid interfacing converter is as shown in the Figure.2. The voltage source converter (VSC) interface the wind energy source to the grid also distributes the generate power.

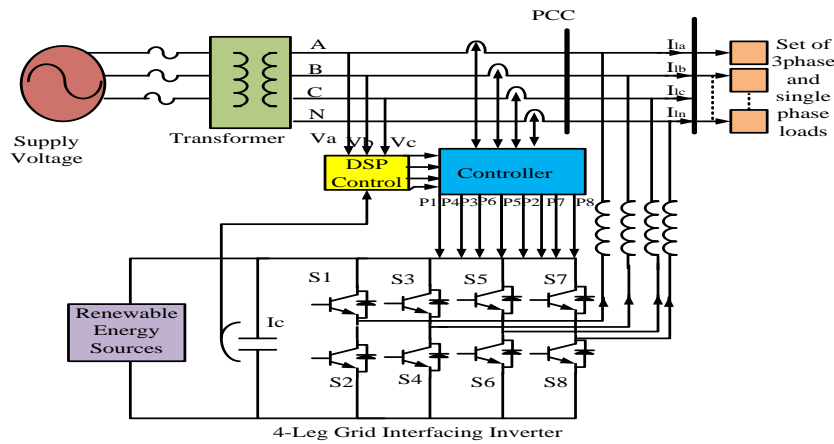


Fig.2. Proposed DTATCOM of renewable based Wind Energy distribution system.

A. Photovoltaic solar cells

PV cell is an energy translation tool, which is use to change the solar energy addicted to an electrical energy as well as the quantity of electrical power formed depends ahead solar Photovoltaic cell irradiation as well as temperature.

B. Voltage Source Controlled Interfacing Inverter

A voltage source current converter is a power electronic device which is linked in move with the scheme. The meaning of this inverter is to exchange the dc voltage into a three phase ac voltage. If the inverter output voltage is better than the vacant scheme voltage then the inverter perform in capacitive method. The switch machine use in this voltage source converter is an IGBT.

C. Control method for Grid connected Inverter as Shunt APF (Active power filter)

The turn ON as well as turn OFF instant of the inverter switch be supposed to be such that the load along with the associated renewable systems might be appear as an impartial load to the scheme. For this kind of power, we require observing the production of dc link capacitor incessantly as well as are contrast through the suggestion voltage V_{dc}^* . The variation among the indication and definite voltages determination leave during a voltage manager, whose final production give a dynamic current module $1m$. By multiply this hit the highest point significance ($1m$) through three element sine vectors (U_a , U_b and U_c) which are in period through the three source voltages will produce the position current (I_a^* , I_b^* and I_c^*). The orientation grid current (I_n^*) is locate toward zero creature the instant addition of disinterested grid currents. The synchronize approach (9) obtain since phase locked loop (PLL) [1] is use to produce agreement vector pattern as

$$U_a = \sin \theta \tag{1}$$

$$U_b = \sin(\theta - \frac{2\pi}{3}) \tag{2}$$

$$U_c = \sin(\theta + \frac{2\pi}{3}) \tag{3}$$

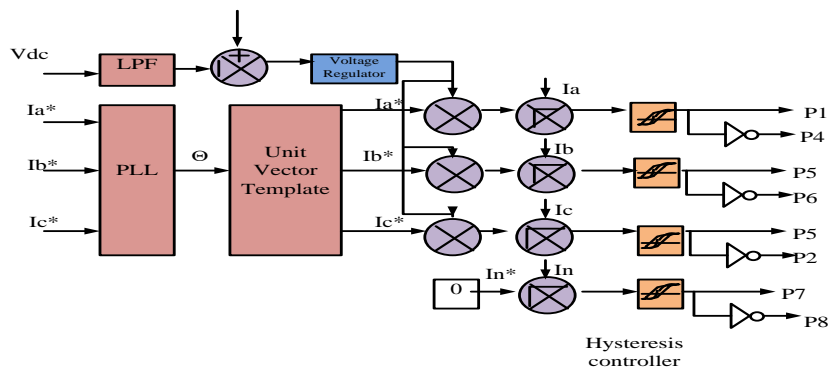


Fig.3. Circuit Diagram of Grid Connected Control System.

The reference grid currents of the three phase system is given as

$$I_a^* = I_m * U_a \tag{4}$$

$$I_b^* = I_m * U_b \tag{5}$$

$$I_c^* = I_m * U_c \tag{6}$$

The neutral current is taken as

$$I_c^* = 0 \tag{7}$$

The reference grid currents (I_a^* , I_b^* and I_c^*) are compared with actual grid currents (I_a , I_b and I_c) to compute the current error as

$$I_{aerr} = I_a^* - I_a \tag{8}$$

$$I_{berr} = I_b^* - I_b \tag{9}$$

$$I_{cerr} = I_c^* - I_c \tag{10}$$

D. Hysteresis Current Control method

In this effort, the hysteresis current control process is use to manage the process of the Voltage Source converter. The gate manage indications in favor of the grid connected inverter to operate as an active filter for compensate existing harmonics is specified by hysteresis current manage signal. A fault indication I_{aerr} is use to manage the switch in a voltage source Converter. The variation among the preferred current I_a' as well as the current individual inject by the inverter IA is in use as fault. If the faults exceed the higher boundary of the group, the higher control of the inverter is twisted OFF as well as the subordinate control is twisted ON, which imply to the current start lessening. If the mistake cross the lesser boundary of the group, the subordinate button of the inverter is twisted OFF and the higher switch is twisted ON, which imply that the current start growing as well as get support addicted to the group. The higher and highest values of the error signal are e_{min} and e_{max} correspondingly. The variety of the error signal is $e_{max} - e_{min}$ straight control the quantity of ripple contented in the current amount produced from Voltage source converter.

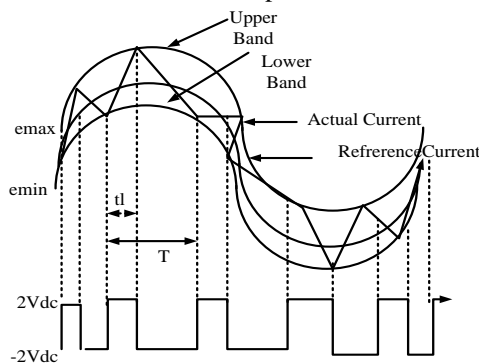


Fig.4. Hysteresis Current Control Techniques

Hysteresis group PWM arrange is essentially an immediate reaction current control technique of PWM, wherever the definite current incessantly tracks the control current surrounded by a hysteresis group. A position sine wave current signal is compare with the genuine phase current wave. When the current exceed a arranged hysteresis band, the higher switch in the inverter bridge is twisted off as well as the lesser control is twisted on, and the current start to decompose. As the current irritated the lesser group limit, the lesser switch is twisted off as well as the higher switch is twisted on. The authentic existing is forced to path the sine position inside the hysteresis group by reverse as well as outswitching of the upper and lower switches. The inverter then fundamentally becomes a current basis with peak-to-peak current flow, which is prohibited inside the hysteresis group, which makes the basis current to be sinusoidal wave form.

E. Fuzzy Logic Control method

i) Fuzzy System

A fuzzy system is a scheme of variables that are connected using fuzzy control logic. A fuzzy controller use defines policy to manage a fuzzy scheme base on the current value of input variables. Fuzzy scheme consists of three main parts: linguistic variables, membership functions and rules.

ii) Linguistic Variables and Terms

Linguistic variables stand for, in terms, the input variables as well as output variables of the scheme to be restricted. Linguistic variables typically include an odd integer of linguistic conditions, with central point linguistic expression as well as symmetric linguistic conditions at every one excessive. Each linguistic variable has a variety of estimated standards. The linguistic variables existing temperature as well as preferred temperature apiece strength contain the linguistic expressions cold, moderate, along with hot. The linguistic inconsistent heater location may contain the linguistic expressions off, low, and high.

iii) Membership Functions

Membership utility is arithmetic function equivalent to linguistic expressions. Membership utilities represent the amount of connection of linguistic variables inside their linguistic expressions. The amount of connection is incessant among 0 along with, wherever 0 is equivalent to 0% association and 1 is equal to 100% membership. There are further than a few category of membership purpose accessible, specifically, triangular outline, trapezoidal outline, perpendicular column outline, wave outline, as well as bell outline association function. The a variety of membership function are shown in Fig .5.

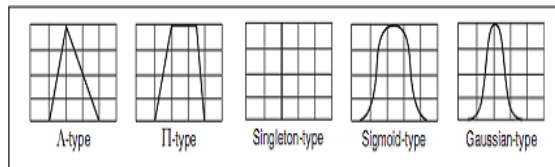


Fig.5: various membership functions

iv) Fuzzy control Inputs as well as Output

For instance in conditions of temperature there are two inputs as well as base on the grouping of these inputs, the output is obtained. Each of these inputs has seven subsets.

I 1: Temperature Error (INPUT-1)

I 2: Temperature Error Rate (INPUT-2)

O1 : Fuzzy output to Heating rod or Pump (output)

e) Subsets For Inputs And Output

I 1(Temperature Error): Positive Big, Positive Medium, Positive Small, Zero, Negative Small, Negative Medium, Negative Big

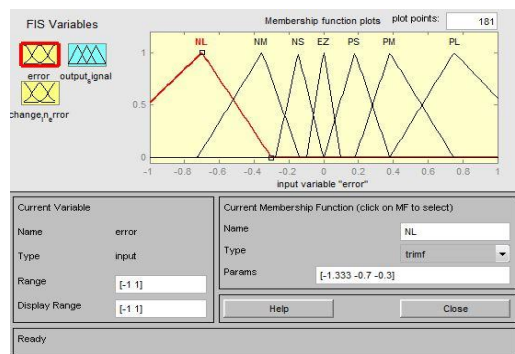


Fig.6: membership function for error

I 2 (Temperature Error Rate): Positive Big, PositiveMedium, Positive Small, Zero, Negative Small, NegativeMedium, Negative Big

Figure 7 displays the Edit Variable dialog box with all membership functions for the Error rate input variable.

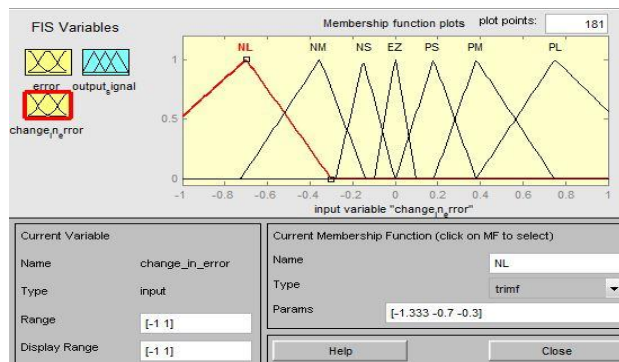


Fig.7: membership function for error rate

Output: Positive Big, Positive Medium, Positive Small, Zero, Negative Small, Negative Medium, Negative Big.

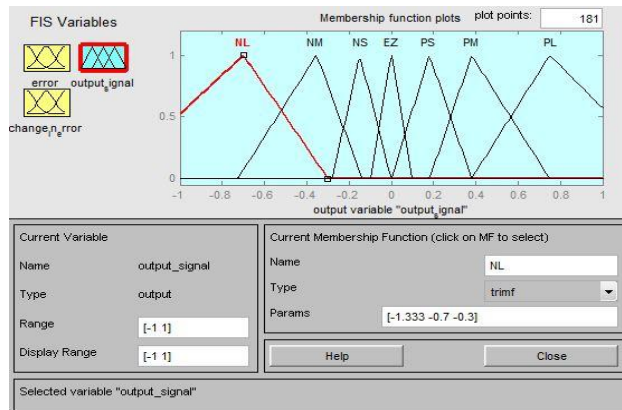


Fig.8: membership function for fuzzy output

Table 1: rule base table

Error Rate	PB	PM	PS	ZO	NS	NM	NB
Error							
PB	PB	PB	PB	PB	PM	PM	PS
PM	PB	PB	PB	PB	PB	PM	PS
PS	PB	PB	PB	PB	PM	PS	NM
ZO	PB	PM	PM	PM	PS	ZO	NS
NS	PM	PS	ZO	NS	NM	NB	NB
NM	PM	ZO	NS	NM	NB	NB	NB
NB	ZO	NS	NM	NB	NB	NB	NB

IV. WIND ENERGY SYSTEM

Wind energy systems are plentiful approximately in any division of the earth. Its survival in environment cause by not smooth heat lying on the exterior of the ground as well as the earth’s revolution earnings that the wind possessions will constantly be accessible. The predictable traditions of generate electrical energy with nonrenewable resources such as coal, natural gas, oil, etc., contain huge impact on the surroundings as it contribute enormous quantity of carbon dioxide to the earth’s environment which in twist will reason the hotness of the earth’s outside to amplify, identified as the green house consequence. Consequently, with the advance in knowledge, conduct of generate electrical energy using RES such as the wind Systems are urbanized. These days, the expenditure of wind electrical energy that is linked to the grid is as economical as the price of generates electrical energy with coal as well as oil. Thus, the growing reputation of green electrical energy resources the insist of electrical energy created by non RES is in addition greater than before consequently.

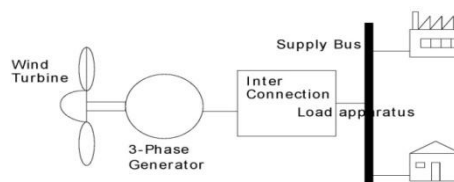


Fig.9. wind energy system Structure.

The main apparatus of a representative wind energy transfer scheme contain a wind turbine, generator, as well as interconnection tools as well as manage scheme, as shown in Figure 5. Wind turbines can be classified into the perpendicular alignment kind as well as the parallel federation type. Most present wind turbines utilize a flat axis pattern through two or three blades, working either down-wind or up-wind. A wind turbine can be calculated for a steady speed otherwise changeable speed process generator is joined toward the rotor of a wind turbine straight, offer high consistency, little maintenance, as well as probably small cost for convinced turbines , power electronic converters to offer a present frequency as well as present voltage power to their load.

V. MATLAB/SIMULINK RESULTS

The model of the proposed system effort IS through by MATLAB software. The scheme in different load circumstances is shown in figures

A. *Balanced Nonlinear Load*

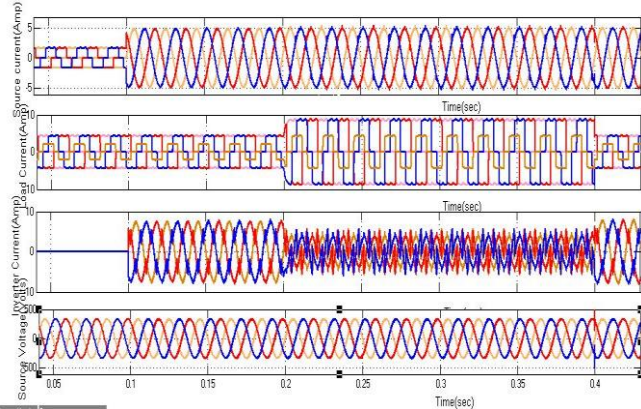


Fig.10. Simulation Waveforms of Balanced Non-linear Load systems

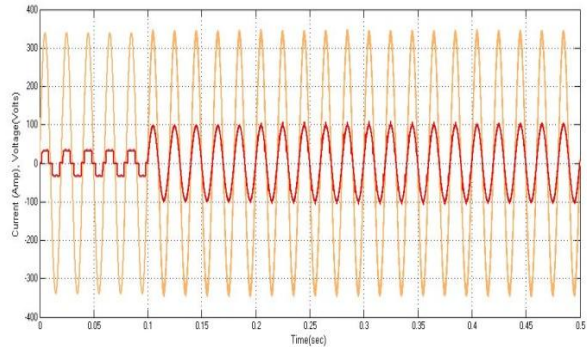


Fig.11. Simulation Waveforms of source voltage and current.

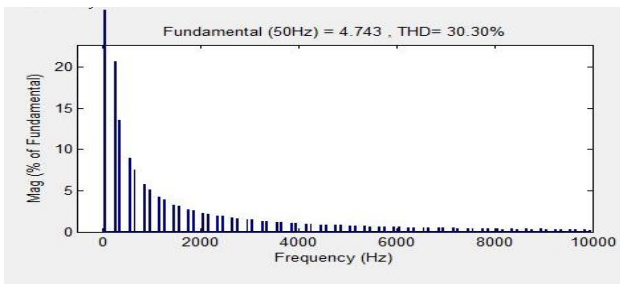


Fig.12. THD of source current before compensation.

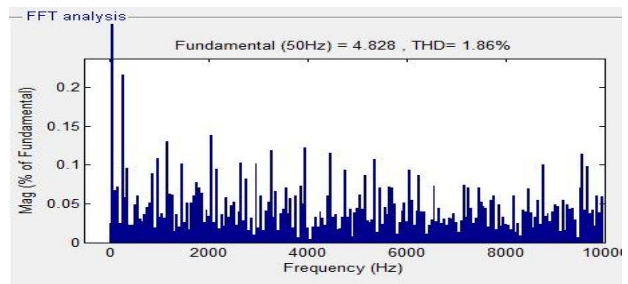


Fig.13. THD of source current after compensation.

The Figure.10 shows the simulation results of Balanced condition Non-linear Load systems starting 0 to 0.1 sec the Simulation Waveforms are (a) Source current, (b) Load current, (c) Inverter current and (d) source voltage is non-sinusoidal suitable toward reasonable non-linear loads. When the inverter is twisted ON by 0.1 sec it determination start compensate the non-sinusoidal current addicted to sinusoidal. The FFT investigation also observed. The source current of balanced Non-linear load before compensation is 30.30%. The source current of balanced Non-linear load after compensation is 1.86%.

B. *Proposed system with Unbalanced Non-linear Load*

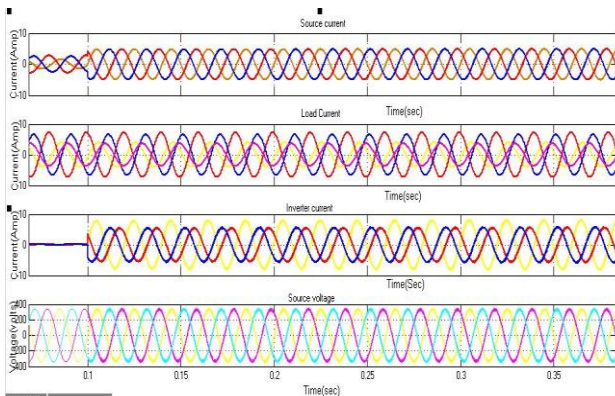


Fig.15. Simulation results of unbalanced Non-linear Load

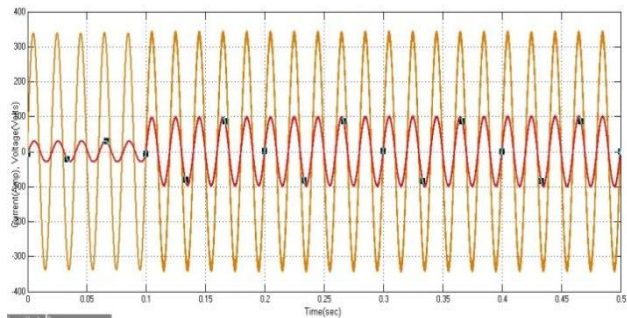


Fig.16. source voltage and current

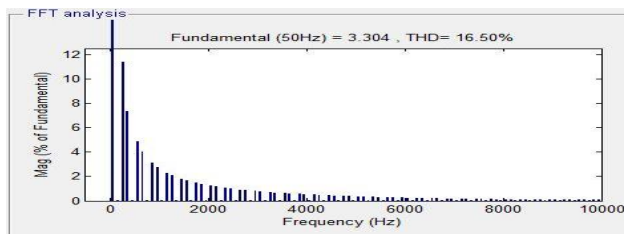


Fig.17. THD of source current before compensation

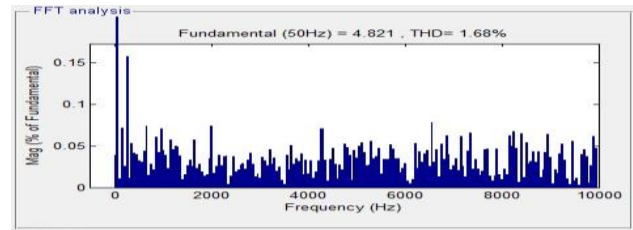


Fig.18. THD of source current after compensation

The Figure.15 shows the simulation results of unbalanced Non-linear load system starting 0 to 0.1 sec and the simulation waveforms are (a) Source current, (b) Load current, (c) Inverter current and (d) source voltage is non-sinusoidal suitable toward reasonable non-linear loads. When the inverter is twisted ON by 0.1 sec it determination start compensate the non-sinusoidal current addicted to sinusoidal. The FFT investigation also observed. The source current of unbalanced non-linear load before compensation is 16.50% The source current of unbalanced non-linear load after compensation is 1.68%

C. Balanced Nonlinear Load with Fuzzy logic controller

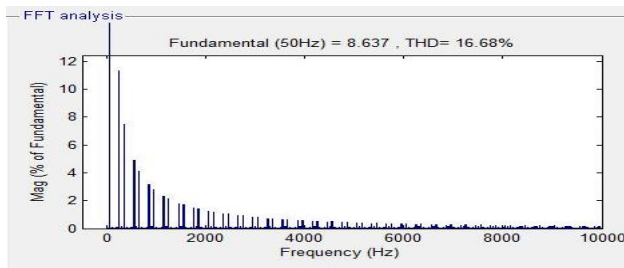


Fig.19. THD of source current before compensation

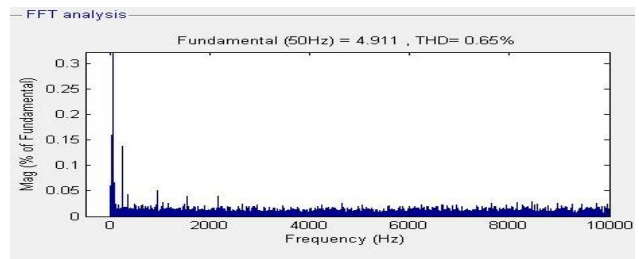


Fig.20. THD of source current after compensation

The Figure.19 and Fig.20 shows the simulation results of balanced Non-linear load system under Fuzzy-Logic controller. The source current of balanced with Fuzzy logic non-linear load before compensation is 16.68%. The source current of balanced with Fuzzy logic non-linear load after compensation is 0.65%.

TABLE.2. comparison of various loads Total Harmonic Distortions (THD) in Percentages of source currents

Type of Loads	Before Compensation	After Compensation
Balanced type of non-liner load	30.80%	1.86%
Unbalanced type of non-liner load	16.50%	1.68%
Balanced type of non-liner load with fuzzy logic controller	16.68%	0.65%

VI. CONCLUSION

In this paper examine the improvement of power quality it requirements a methodical information of nature of the power quality problems more than the exacting position of transmission lines as well as whole thoughtful of FACTS devices as well as controllers. In this proposed with fuzzy logic controller, a rapid and economical efficient D-STATCOM with fuzzy logic controller is planned for dropping the problem of harmonics in industrialized distribution system. Hysteresis loss current control and fuzzy logic controller are the algorithms operate the error indication which is the differentiation among the location voltage as well as definite measured fill voltage to generate the switches of an inverter with a PWM system. The Fuzzy based D-STATCOM handle the circumstances devoid of any difficulty as well as inject the suitable voltage module to accurate speedily any change in the supply voltage present by maintenance the load voltage balanced as well as steady at the supposed significance. The presentation of a shunt active filter is considered with function of grid Connecting inverter in different load circumstances. The power quality issues similar to current harmonics, current unbalance due to unbalanced as well as nonlinear load connected to the PCC is remunerated efficiently by means of shunt active power filter (APF). The Fuzzy logic controller is used to produce the

switch pulse for the industrial drives of grid interfacing converter. The proposed with fuzzy logic controller system is better compare to the further conservative controller method in conditions of energy economy as well as dynamic concerts. The proposed with fuzzy control algorithm based D-STATCOM has the facility for high-quality compensation characteristics. By using this Fuzzy controller with proposed system approach the THD is reduced up to 0.65%.

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