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APF BASED POWER QUALITY IMPROVEMENT ON MICRO GRID USING ARTIFICIAL INTELLIGENT NETWORK

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ABSTRACT

This paper deals with the injection of wind power into electrical micro grid (MG) application. More alternating energies are compromised and Power quality enhancement has influenced by MG units. But the improper power generation of wind turbine has affects the sensitive load operation due to dip voltage, current harmonics, and interruption as well as real and reactive power variations. The proposed shunt active filter with Artificial Intelligent (AI) technique has produces the effective solution for this problem. Therefore; this paper proposes novel techniques to develop the power quality enhancement in micro grid critical load application.Artificial Intelligent(AI) network includes FUZZY logic, neural networks and genetic algorithm. Shunt active filter is enhanced the performance of MG unit and power quality has realized by fuzzy logic rules in varies load conditions. In addition, the performance of fuzzy logic controller is compared with the conventional proportional integral controller performances. Finally, the proposed concept is developed in MATLAB/Simulink environment.

Keywords: active power filter, artificial intelligent network, fuzzy logic, wind turbine.

INTRODUCTION

MG is a very small integrating distributed generator for power generation to loads, which may supports and controls both grid-connected and islanded modes. The power generation of MG unit has able to produces low output voltage (tens of kilowatts) to different networks, sometimes the MG units has provides combination of power and heat to load [1-2]. If it may run in island mode, to supplying power to load with the connection of grid. The power scheduling system is seriously affected by power quality problems, such as current harmonics, voltage dipping, frequency and fluctuations are occurred caused by power fluctuation. Because voltage variation is depending the reactive power, and frequency is depending the real power of the system [3-4]. Filter and dc storage unit connected compensating equipments are only the solution for these issues in order to enhancing power quality. Generally the voltage can be controlling by using dc source fed power electronic converters [5-6].

Sensitive loads and renewable source through load connected micro grid system should be affected by unbalanced voltage conditions; because the considering MG unit could construed by wind turbine based improper power generating units. As per the standard IEC 61400-12: Wind Turbine performance may conclude and the wind turbine power generation is measured in IEC 61400-21. As well as IEEE standard 519 recommended the harmonics elimination is important factor for power quality improvement and maintained at fault conditions. Therefore, the unbalance voltage flow compensation can be done by shunt active power filter [7]. Which has superior filtering performance, and its compensation is not for specific order harmonic, size and weight are very compact, compared with traditional passive filter. Additionally, the APF have more voltage regulation capability and flexibility. In such a case, DC- and AC micro grids are proposed for different kinds of applications, considering AC sources are interconnected with DC micro grid through power converters. Design and implementation of APF could be suffered by convention control techniques. Since the proposed system is require more comprehensive information about the power system and needs large computing time for on-line parameter identification.

Artificial Intelligence (AI) network could provide effective tools to resolve many power system issues and that could be more effective. Artificial Intelligent (AI) network includes fuzzy logic, neural network, genetic algorithm, hybrid artificial intelligent techniques and expert system [10]. The proposes of a new shunt active filter configuration with fuzzy logic based feedback controller capable to compensating major power quality problems associated with voltage dips, current harmonics and maintaining a prescribed level of supply voltage at the sensitive load condition. This control scheme is preferred two control loops, which is called feed forward loop, combination of probabilistic and fuzzy set theory [11].

In this paper, power quality is enhanced by MG units with the help of APF circuit. The proposed circuit is controlled by FUZZY logic controller, wind turbine model is influenced by the power fluctuations and responds of APF is analyzed and controlled by AI (Artificial Intelligent). In addition to that, the APF is also used to protect the sensitive linear load. The simulation results show the effectiveness of the voltage regulation and its performance investigation of both control techniques.

System configuration

Wind Turbine power generating unit: wind turbine based power generating system is highly influences the power quality. A wind turbine operates by extracting kinetic energy from the wind passing through

its rotor. The power developed by a wind turbine is given by,

$$P = 1/2C_P v V_w^3 A \quad (1)$$

For effective power generation, Permanent magnet synchronous generator is more popular over the induction machine in wind turbine applications, because of the increased power to volume ratio, high reliability, decreasing cost of magnets, increased efficiency and no need of external excitation, smaller in size and easy to control. Also, it having an efficient and a reliable control is very important to have a better understanding of the system. Thus the operation and its influence on power system depend on the structure of the adjoining power network. IEC 61400-3-7 is Assessment of emission limit for fluctuating load [8-9]. Energy storage is mainly aimed at balancing system power and improving power quality of the load. The basic classification of wind power generators are shown in Figure-1(a) and (b).

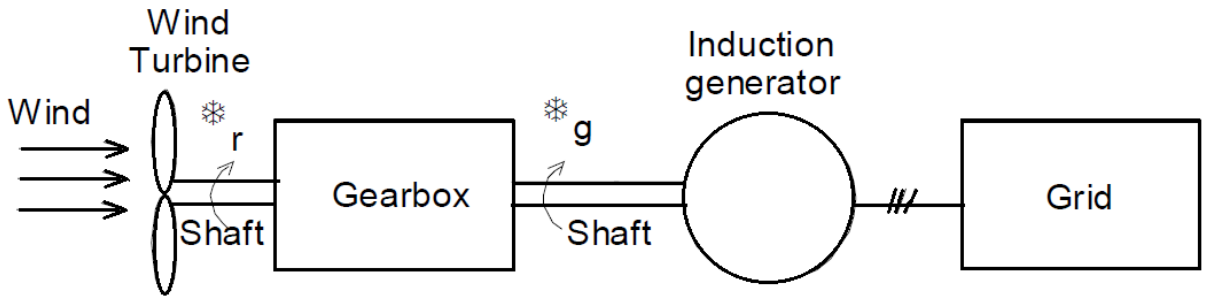

Figure-1(a). Wind turbine with induction generator.

Squirrel cage, and wound rotor methods are two basic classifications of induction machine. Both schemes were considered for much power generation applications. It has more merits and allows flexibility when the wind speed is fluctuating, but the major disadvantage is the need for excitation of the magnetic field via the supply terminals.

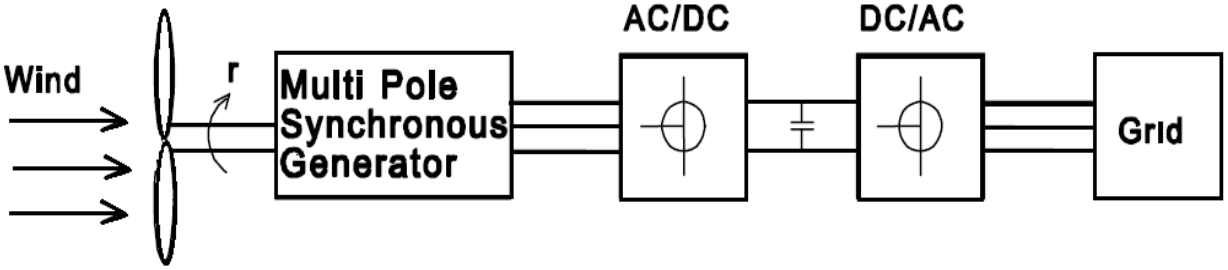

Figure-1(b). Synchronous generator based wind generator.

The dynamic equation is given in equation (2)

$$T_w - T_{em} = J_w \frac{d\omega_w}{dt} + f_w \omega_w \quad (2)$$

where, T_w - wind turbine mechanical torque

T_{em} - PMSG electromagnetic torque

J_w And f_w - total wind turbine inertia and viscous friction coefficient.

The self-excitation property and variable speed conditions are very important factor for choosing PMSG [14]. Additionally, this has removes the requirement of special starting and synchronising equipment for the PMSG. The system should operate at any power angle, without losing synchronism.

ACTIVE POWER FILTER

APF is a new type of VSC based filter, which is used to reduces the harmonics in AC -MG inverted exports can improves the power quality [16-17]. The parallel voltage source converter is interfaced with MG unit; the basic configuration of APF is shown in Figure-2. The considered circuit has offers current harmonics detections and reactive current. The converter has generates a compensating current to the opposite phase. The ultimate aim of APF is to maintain the sinusoidal nominal voltage at sensitive load condition, eliminates current harmonics, correction of power factor and balancing the PCC supply voltage. APF should inject the energy with the help of projected control technique [18]. The fuzzy logic using AI control is that varying switching frequency which will generate a band of significant side harmonics in the region of the switching frequency.

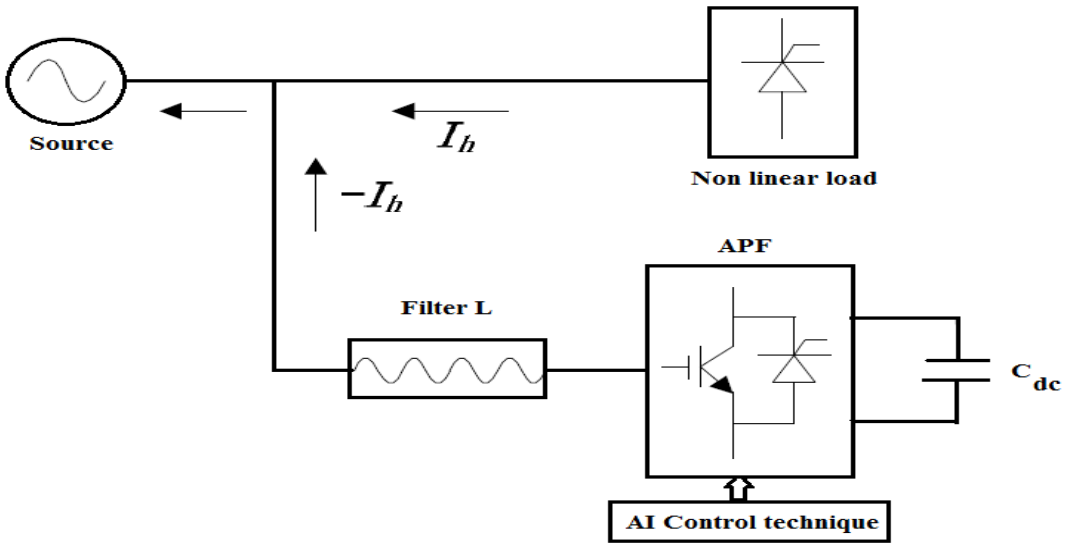

Figure-2. Working principle of APF.

CONTROL OF APF

The Artificial Intelligence (AI) technique is an effective controlling tool to solving many power system issues and that they could be more flexible when it can be connected properly together with traditional mathematical approaches. The proposed Artificial Intelligence control technique is generally classified as expert system control, fuzzy-logic control, neural network control and genetic algorithm. Fuzzy-logic controller is applied for obtained effective voltage regulation and fast transient response. Since infinite number of membership functions are allowable in fuzzy set. The degree of each membership elements are indicated by a number between 0 and 1.

Fuzzy logic controller is a rule based nonlinear system. Moreover, fuzzy logic rules do not required a controlled plant models, and not sensitive to system parameter variations. By using fuzzy logic, the human experience can be used in designing the controller.

Generally, the fuzzy logic controller has constructed by two real time inputs and measured at every sample time, named as error and rate of error. One output named actuating signal for each phase. The input signals are fuzzified and represented in fuzzy set notations as membership functions are processed as per Figure-3(a).

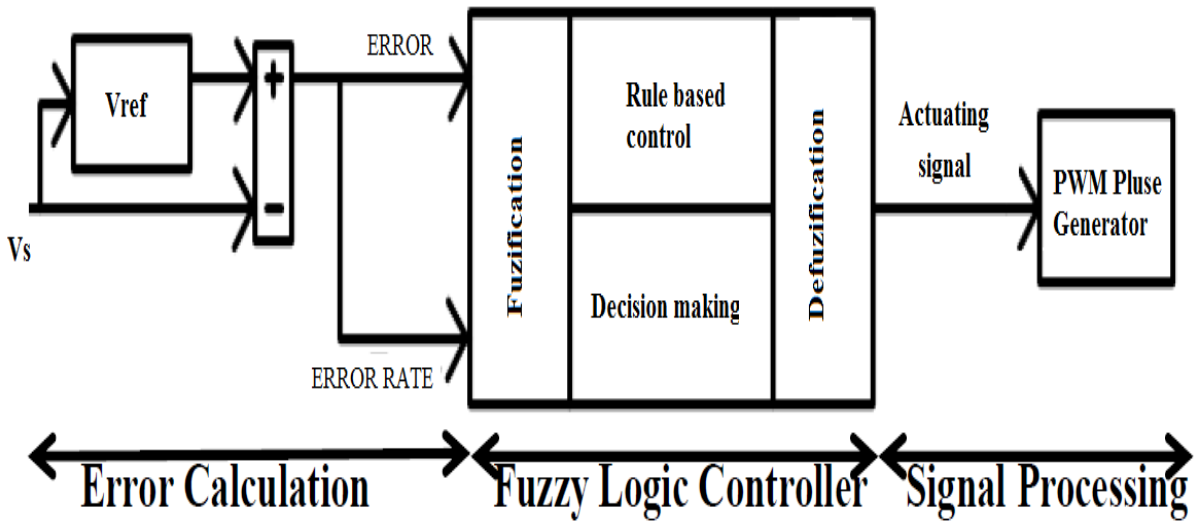

Figure-3(a). Basic process of fuzzy logic.

The membership function for the input (*error*) is drawn as per the Figure-3(b). The interval input of the membership function is set at (-1 to 1).

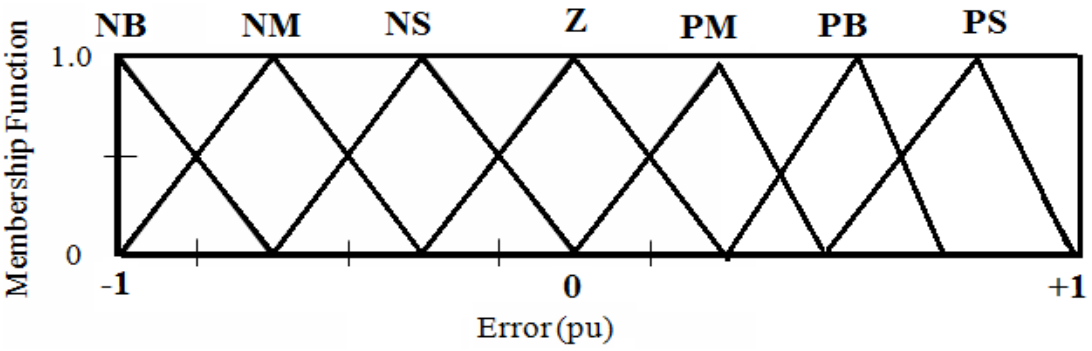

Figure-3(b). Membership function.

Fuzzy process can be realized by Mamdani inference scheme. It has been used because it can obtain the relationship between their input and output functions.

Table-1. Fuzzy logic rules.

Ce\e	NB	NM	NS	Z	PS	PM	PB
NB	NB	NB	NB	NM	NM	NS	Z
NM	NB	NB	NM	NM	NS	Z	PS
NS	NB	NM	NM	NS	Z	PS	PM
Z	NM	NM	NS	Z	PS	PM	PM
PS	NM	NS	Z	PS	PM	PM	PB
PM	NS	Z	PS	PM	PM	PB	PB
PB	Z	PS	PM	PM	PB	PB	PB

Considering inputs error and rate of error are defined by seven different linguistic variables such as negative big (NB), negative medium (NM), negative small (NS), zero (ZE), positive small (PS), positive medium (PM) and positive big (PB) characterized by triangular membership functions. These functions have been chosen to satisfy the output requirements of the fuzzy controller. The output functions are derived as the table: 1. There are 49 rules fuzzy controller.

Defuzzification is the converting process of the controller outputs in linguistic labels, this has represents fuzzy set to real control signals [10]. Signal Processing is the outputs of fuzzy program and generates the controlling signals for switching pulses of the PWM inverter by comparing with a conventional pulse generation methods. Thus the effective fuzzy logic scheme is implemented for the APF control process.

The block diagram of the controller is shown in Figure-4. The load sides current have been extracted in each phase using fundamental active and reactive power considered as per the reference source current(I^*S_a, I^*S_b, I^*S_c). The load side currents are named (i_{La}, i_{Lb}, i_{Lc}) and the PCC voltages (v_{Sa}, v_{Sb}, v_{Sc}). The averages of the respective weights are W_p and $W_q$at the each sample time.

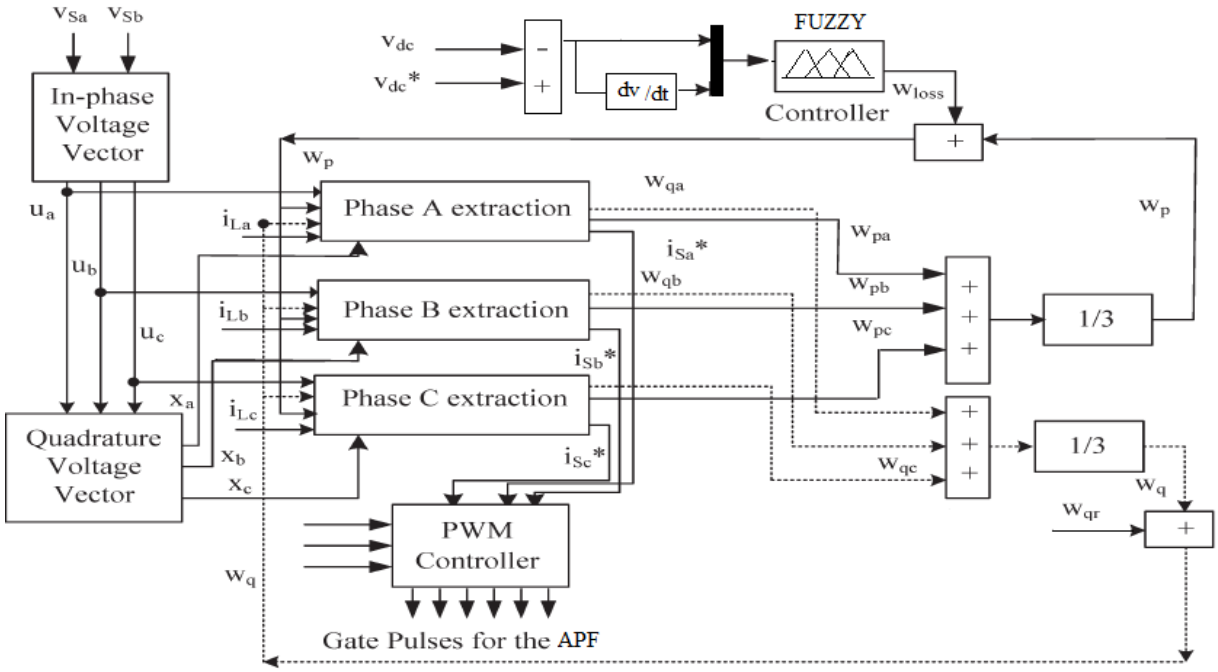

Figure-4. Schematic controller diagram.

$$v_S = V_1 Sin\omega t \sum_{n-2}^{\alpha} V_n Sin\omega t(n\omega t + \theta_n);$$

$$i_L = I_1 Sin\omega t \sum_{n-2}^{\alpha} I_n Sin\omega t(n\omega t + \theta_n)$$

$$I_1 = I_P + I_q$$

Where;

V_n,$I_n$are the peaks of the fundamental and harmonic components of the voltage and current,

$I_p$and I_q-active and reactive power components of the load current.

$$\omega_p = (\omega_{pa} + \omega_{pb} + \omega_{pc})/3;$$

$$\omega_q = (\omega_{qa} + \omega_{qb} + \omega_{qc})/3$$

ω_p , ω_q are corresponding average weight of the active and reactive components of the load;

The fuzzy logic rules are used to controlling the DC link voltage and ac terminal voltage. A self-supporting DC link is realized by proposed fuzzy network. The reference values (v^*_{dc}) of the dc link voltages of APF, and the controller estimates losses of the source side, hence this is added with w_p. The reference source currents in the each phases are control by the three-leg APF. Thus the reference source currents are compared, and the error is used to generate the gating signals for the power electronic semi conducting switches.

SIMULATION ANALYSIS

The proposed APF device is verified under different cases using MATLAB/Simulink software. To evaluate the capability of wind turbine power generation for microgrid to improve the power quality and reliability of the microgrid connected distribution network. The integration of wind induction generator is the responsible total wind farm. Due to their rated power, it will be connected directly to the load. There are three modes of operations carried out in this simulation. The test should analyses the voltage fluctuation and regulations at sensitive load condition as well as low rated power flow condition. The corresponding fuzzy controller is used to reduce the harmonics and improves the fast transient operation due to maintaining good power factor correction in system. The required simulation parameters of the system are list in Table-2.

Table-2. Simulation parameter for overall circuit.

Parameters	Values
DC link capacitor value [mF]	700
Filter Inductor (L) [mH]	16.7
Filter Capacitor (C) [µF]	20
Switching Frequency (HZ)	50
Load (Ω&mH)	R =100

The basic internal structure of wind form with distribution line is shown in Figure-5; corresponding wind power generator through load connected wave form of three phase voltage and current are shown in Figure-6. at the time of (time 0 to 0.1 sec).

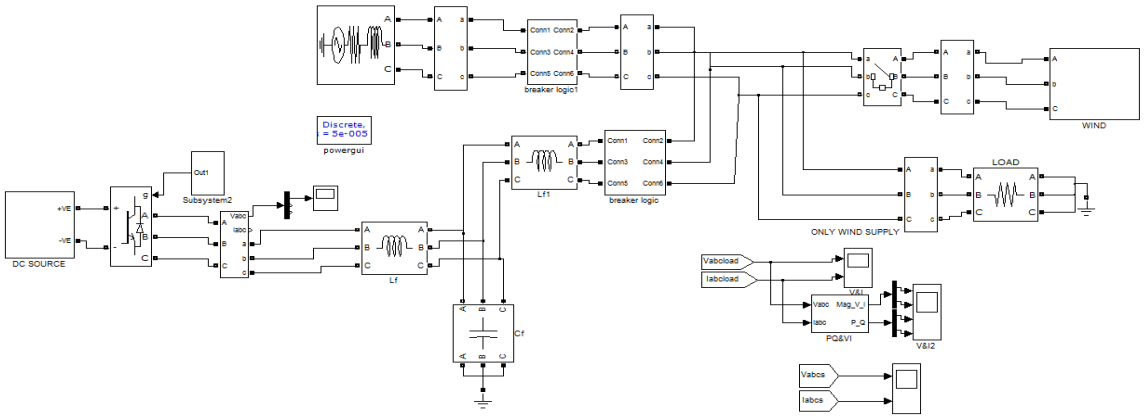

Figure-5. Wind generator with sensitive load condition (T= 0 to 0.1 sec).

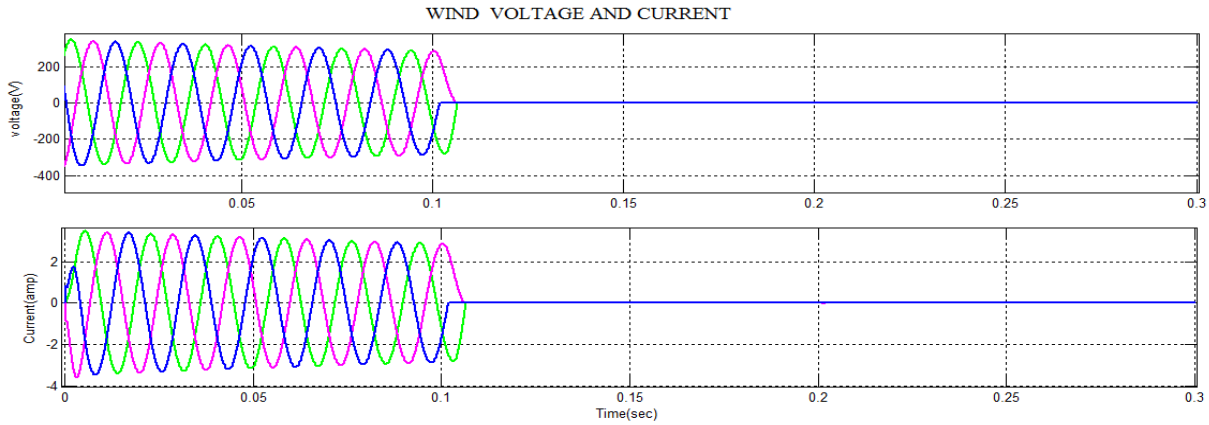

Figure-6. Voltage and current waveform (T= 0 to 0.1 sec).

The three-phase AC voltage and current are allowable into load side, the active power and reactive power of load can be calculated and the measured voltage; current waveforms are shown in Figures 7 and 8.

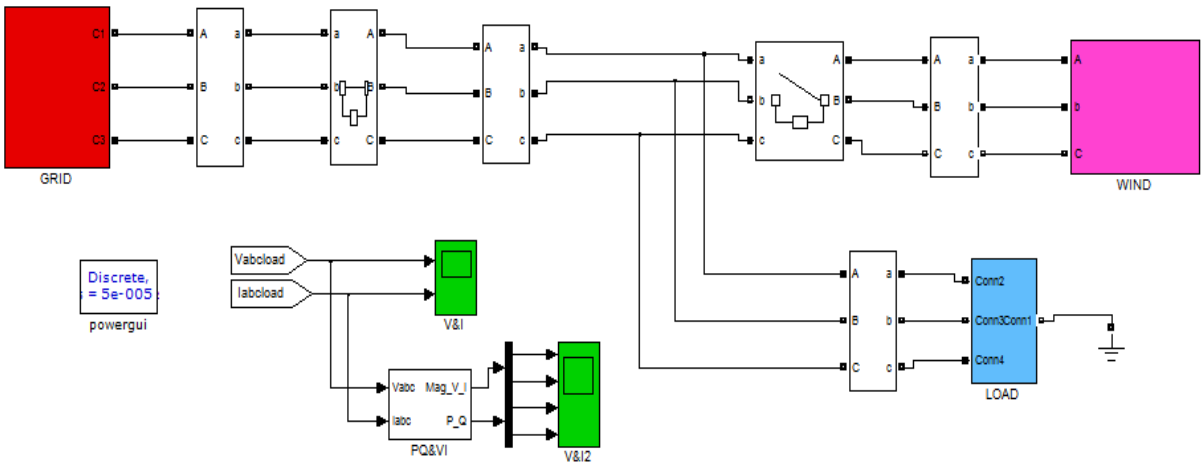

Figure-7. GRID to load condition(T=0.2 to 0.3).

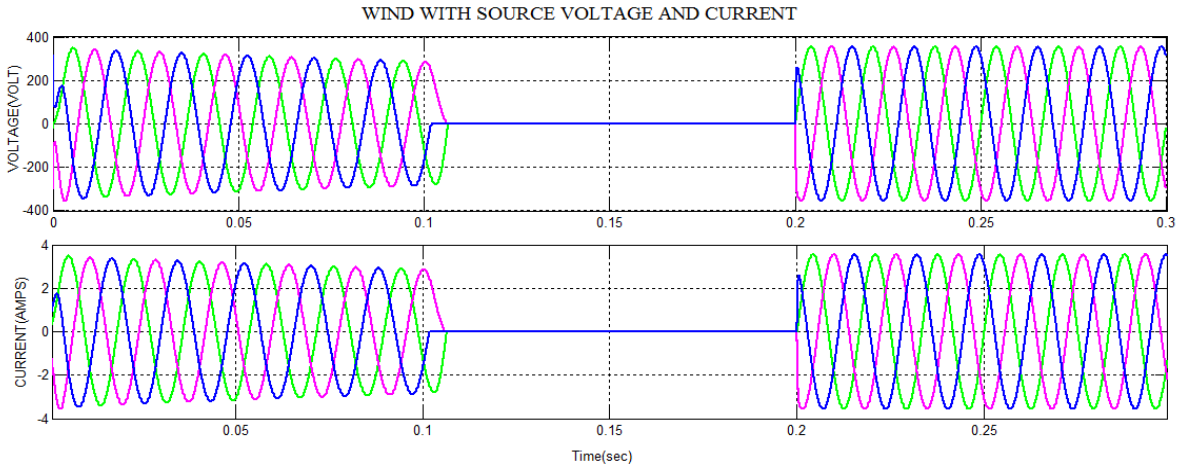

Figure-8. Micro grid voltage and current at discontinuous condition.

The Active power filter is connected to the micro grid using shunt configuration, design is used for filtering the ripple and hormonics in the PCC voltage. Figure-9 shows VSC configuration of APF is designed by dc link capacitor connected inverter arrangement with LC filters. The proposed controller is generates PWM pulses for inverting the DC storage voltage and regulating the three phase bus voltage. The inverted voltage is shown in Figure-10; and the Figure-11 show the three AC voltages and current waveform at time of 0.1 to 0.2.

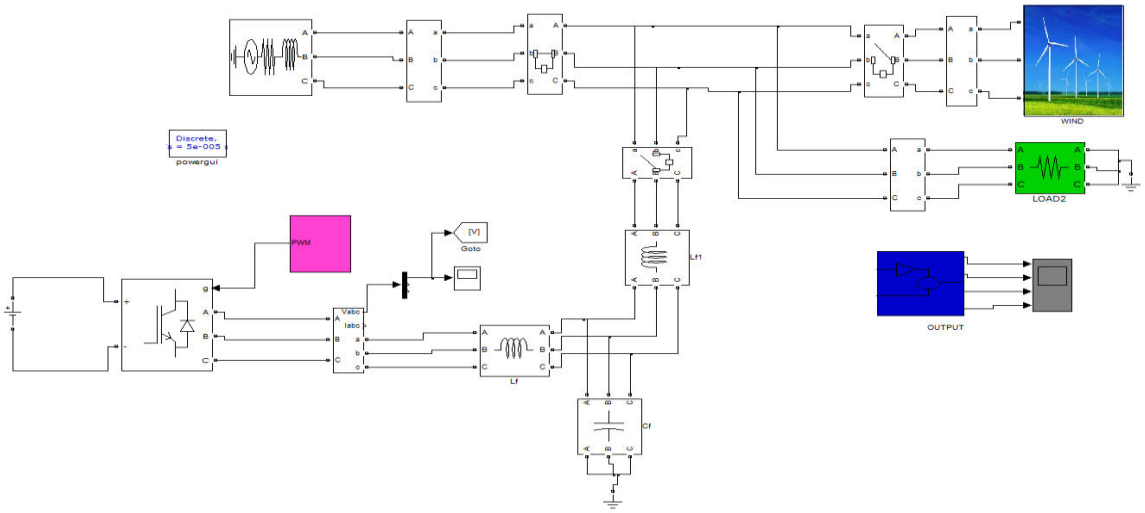

Figure-9. APF with micro grid circuit.

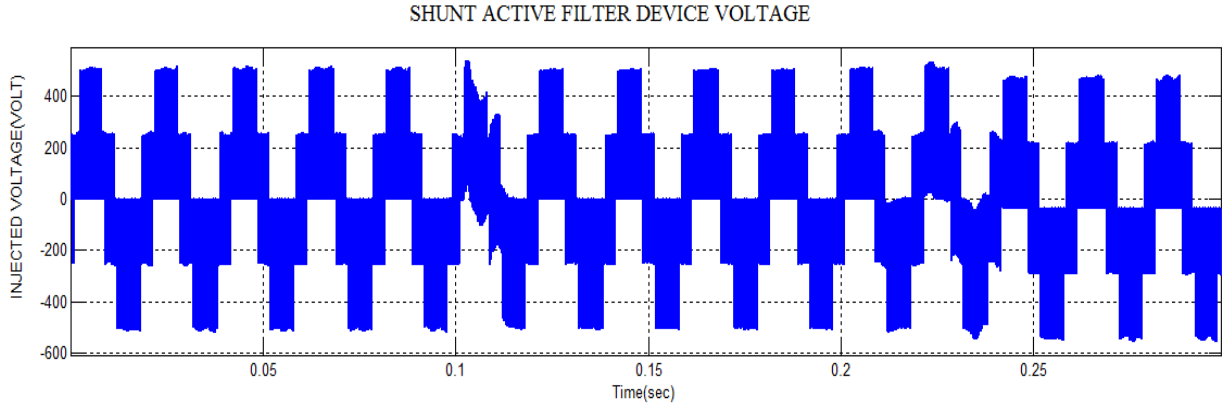

Figure-10. APF injected voltage.

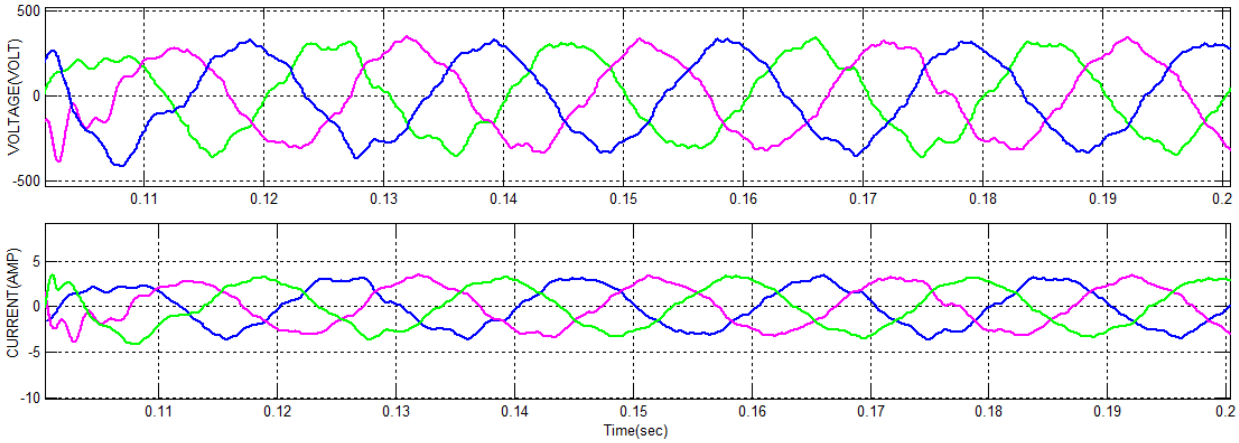

Figure-11. Three phase filter voltage and current.

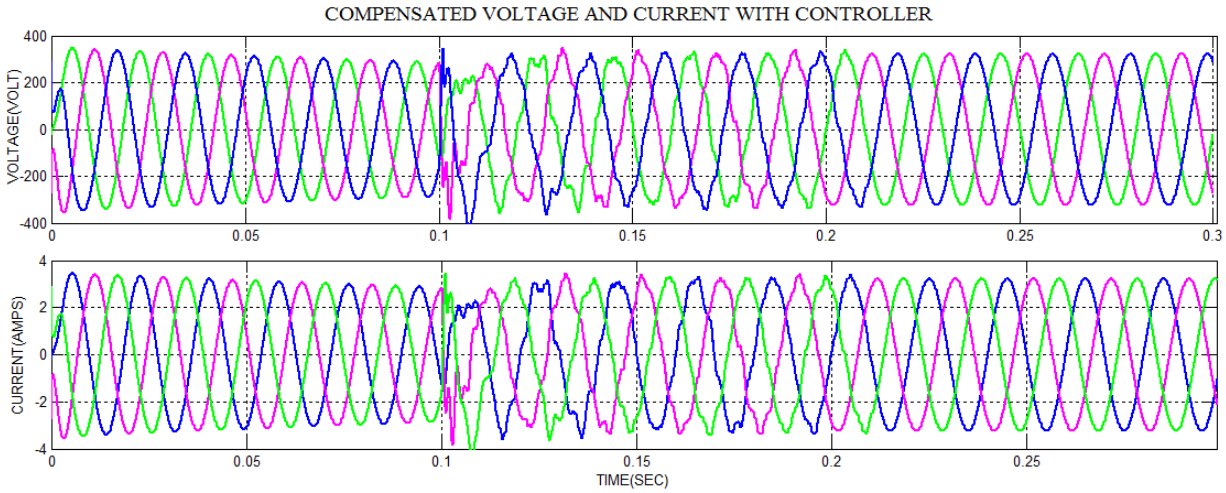

Figure-12. Micro-Grid voltage and current waveform.

From the waveform, we can identify the supplied to load power is almost stable through the energy release of wind generation. There is no essential difference between the two modes about the role of APF in the MG's power quality improvement. The filtering performance of APF can be better reflected in discharge mode and injected voltage is generated without help of transformer, so the flow of low or dip voltage in micro grid can be observed and regulated by APF to achieving the desired waveform even though the fault cause a transient in nominal voltage. Figure-12 shows the Micro-Grid voltage, when frequency variation in grid or discontinuous power generation in MG, then regulated to nominal grid frequency.

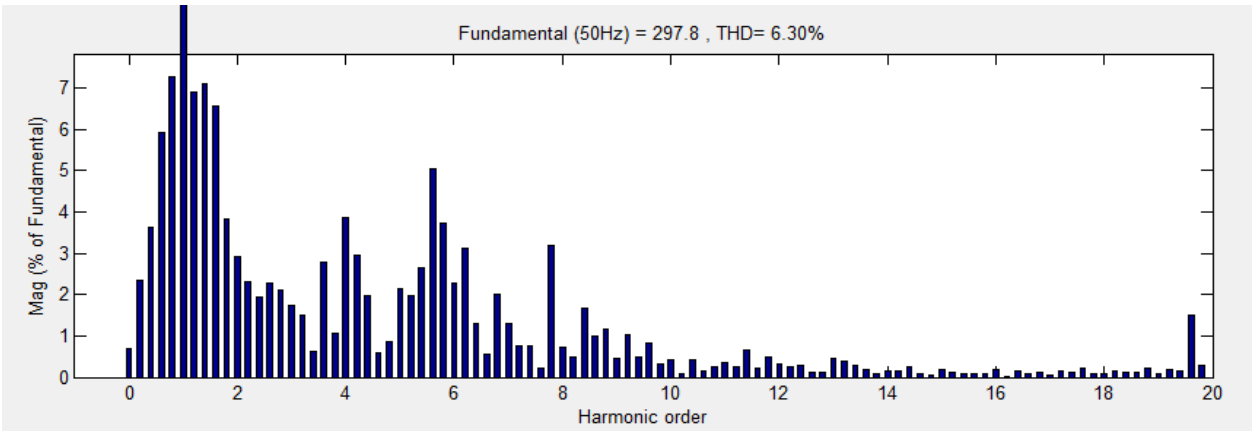

Figure-13. THD analysis using PI controller.

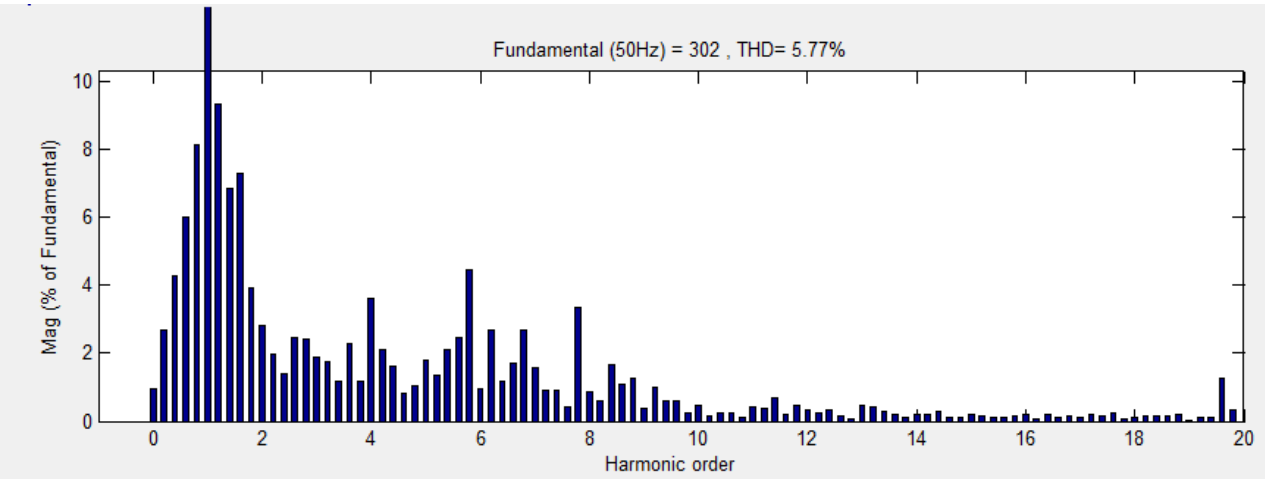

Figure-14. THD analysis using FUZZY controller.

There is no essential difference in between the PI and fuzzy controllers generated voltage and current waveforms of the MG's power quality improvement. But the fuzzy logic control technique is obtained better harmonic elimination by Fast Fourier Transform (FFT) analysis,5.77% and 6.30% are the measured rate of current harmonic distortion for fuzzy and PI controller. Which is shown in Figures 13 and 14.

CONCLUSIONS

In this paper a combined system of APF and wind power generator is presented to enhance the power quality of micro-grid. The circuit performance has been mainly demonstrated for current hormonics elimination along with voltage regulation harmonic elimination, power factor improvement, real and reactive compensation and load balancing. The active power filter is controlled using the fuzzy logic controller. The dc bus voltage of the APF has been regulated to the reference dc bus voltage under discontinuous power generation in wind turbine. Voltage regulation and power factor correction are achieved by APF. Additionally the better THD is obtained by using fuzzy controller, 5.77% THD is measured. It has been found fast transient response, thus in the paper can achieve the purpose of enhancement micro-grid's power quality.

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