International Journal on Emerging Technologies 10(3): 281-285(2019)

ISSN No. (Print) : 0975-8364
ISSN No. (Online) : 2249-3255

Effective Power Quality of Grid Connected WECS Employing FLC Controllers

Shivaji Bhukya[1] and S. Prakash[2]
[1]Ph.D. Scholar, Department of EEE, Biher,Chennai, India.
[2]Professor, Department of EEE, Biher, Chennai, India.

(Corresponding author: Shivaji Bhukya)
(Received 16 July 2019, Revised 17 September 2019 Accepted 03 October 2019)
(Published by Research Trend, Website: www.researchtrend.net)

ABSTRACT: In this paper we expose the mitigation of harmonic power quality concerns employing Shunt active power filter (APF) for the power system network with singly-excited induction generator (SEIG) interface single-phase load, SEIG feeding with multi phase load, SEIG feeding with linear load and SEIG fed with non linear load. In almost all WECS, wind turbine is employed as a prime mover to drive the induction generator. The major problem in this article focused is when SEIG feeding to the single phase load or multi phase load are reactive power and production of harmonics due to presence of non linear load. The main disadvantage of IG is the amount of reactive power it absorbs from the grid. Non-linear loads composed power electronics converters, it can generate harmonics in the network it can suppressed greater count by employing APF. Fuzzy PI control scheme is employed to control the switching operation of APF. This control scheme is helpful to achieve useful output power from the WECS. The proposed methodology simulated in MATLAB/SIMLINK software and analyzed results in detail.

Keywords: Wind Energy Conversation System (WECS), Non linear loads, and Fuzzy controllers.

I. INTRODUCTION

For rapid growing of population providing electricity to the society is biggest challenge in front of electrical engineering. Electricity is act as a backbone to run any industry, so implementation of generations growing very fast in every ware. Power generations are broadly available in two ways, Conventional Energy Sources (CES) and non conventional energy sources (NCES). CES are hydro and thermal. In thermal power generation raw material used is fossil fuel (coal) may be completes next two decades. For hydro Power plants main source water and it is available in Seasonally so power generation not done throughout the year. This two power generations inject various fuel gases into the environment and pollute the atmosphere. These problems are much extent overcome by using NCES. NCES are greener and eco friendly nature, like solar, wind and geo thermal. Power generated throughout the year. It doesn't develop any fuel gases to generate the power. Since a decade a rapid growth is their in WECS because of its significant features [1-4].
The next sections of article is summarized as follows architecture of grid associated WECS in section-II, Proposed fuzzy control algorithm in section-III, simulation results in section-IV and concluded in section-V.

II. ARCHITECTURE OF GRID ASSOCIATED WECS

The block diagram of grid associated WECS is exposed in Fig. 1 (a) and configuration of load in Fig.1 (b).
Main object of this paper is provides pure power to load irrespective of its load (D.C or A.C). Loads are available in two type linear load and non linear load. When power feeds to the non linear loads it creates harmonics in to the power system network, fault conditions, sudden insert or removal of load also create disturbance in the power system network very severe extent. If duration this instable issues are many that may leads to damage the load. So every electrical engineer have responsible to provide quality power to the load i.e. customer. The block diagram configuration of load, combination of linear and non linear load is shown in below Fig. 2.

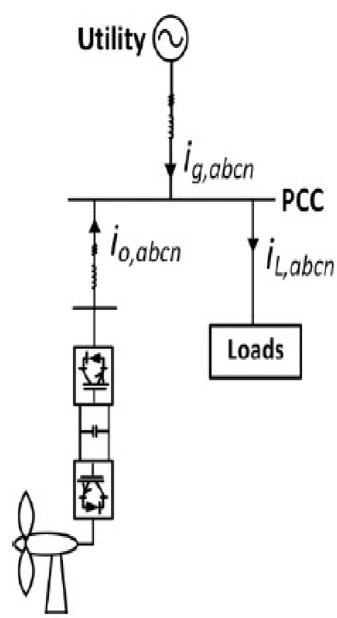

Fig. 1. Schematic diagram of Grid connected WECS.

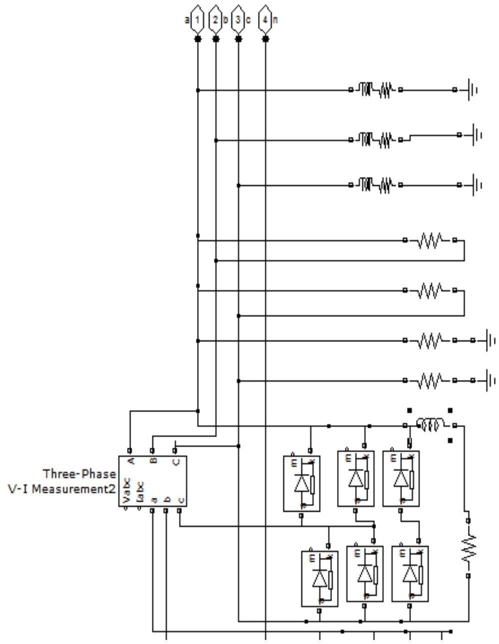

Fig. 2. Configuration of loads represents in MATLAB.

A. Modeling of Wind generator

In paper consider SECIG to produce electrical power from wind that mathematical modeling is described below. The equivalent circuit of IG in d-q axis represented as below Fig. 3 & 4.

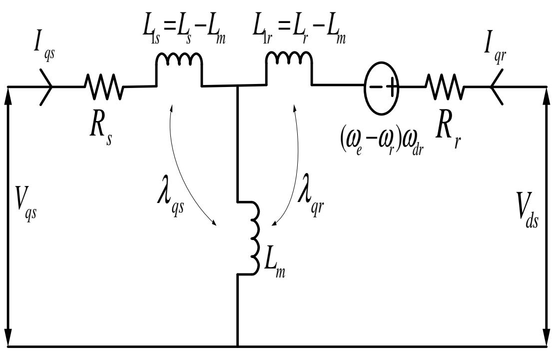

Fig. 3. Equivalent circuit of IG (q-axis).

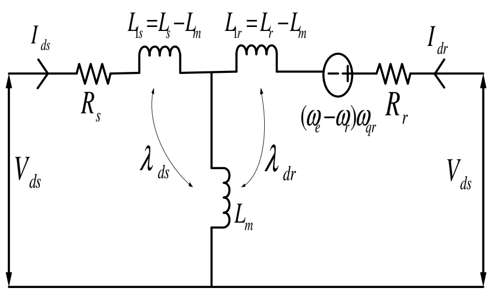

Fig. 4. Equivalent circuit of IG (d-axis).

The stator circuit equations are given by

$$V_s^{\;r} = R_s i_s^{\;r} + \frac{d\lambda_s}{dt} + J\omega_k \lambda_s^{\;r} \quad (1)$$

$$V_r^{\;r} = R_r i_r^{\;r} + \frac{d\lambda_r}{dt} + J(\omega_k - \omega_r)\lambda_r^{\;r} \quad (2)$$

where,

$v_s^{\;r}, v_r^{\;r}$= Stator and rotor voltage space vectors,

$\lambda_s,^r \lambda_s^{\;r}$=Stator and voltage flux linkage space vectors,

$i_s^{\;r}, i_r^{\;r}$= Stator and rotor current space vectors and

ω_r= Rotor angular speed.

$$\lambda_s^{\;r} = L_s i_s^{\;r} + L_m i_r^{\;r} \quad (3)$$

$$\lambda_s^{\;r} = L_m i_s^{\;r} + L_r i_r^{\;r} \quad (4)$$

where,

L_s = Stator inductance

L_r = Rotor inductance

L_m = Mutual inductance

$$\frac{d\lambda^r{}_s}{dt} = v_s^{\;r} - \frac{R_s}{K}(L_r\lambda_r^{\;r} - L_m\lambda_r^{\;r}) - J\omega_k\lambda_s^{\;r} \quad (5)$$

$$\frac{d\lambda^r{}_r}{dt} = v_r^{\;r} - \frac{R_r}{K}(L_s\lambda_r^{\;r} - L_m\lambda_s^{\;r}) - J(\omega_k - \omega_r)\lambda_r^{\;r} \quad (6)$$

where,

K =.$L_s L_r - L^2{}_m$

The torque expression is given by,

$$T_e = \frac{3}{2}\frac{p}{2}\frac{L_m}{L_s}(\lambda_s^{\;r} i_r^{\;*r}) \quad (7)$$

III. PROPOSED METHOD

To operate voltage source inverters (switch pattern) for both machine side and grid side controllers like sliding mode controller, cascade controllers, field oriented control [5], Individual pitch control [6], Vector control [7-8], Adaptive neural networks [9]. To implement these controller methods requires a lot of process knowledge design PI controllers. It much depends on the proportional gain (K_P) value. Still the research is going on this era because in numerous cases intend of PID controllers are inadequately tuned, so as a result a few controllers are too destructive and some controllers are giving not acceptable response. In present decade modern control theory, fuzzy controller is more dominant because super feature self auto tuned. The complete control scheme block diagram of machine side and grid side is shown in Figs. 5 and 6.

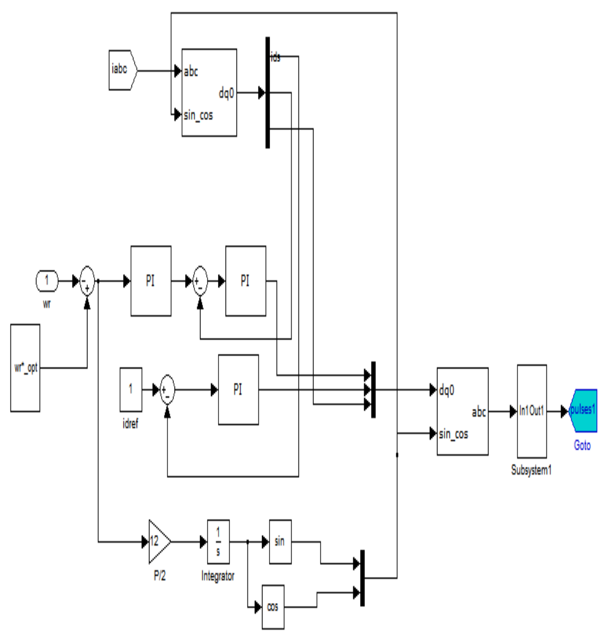

Fig. 5. Configuration of machine side control scheme represents in MATLAB.

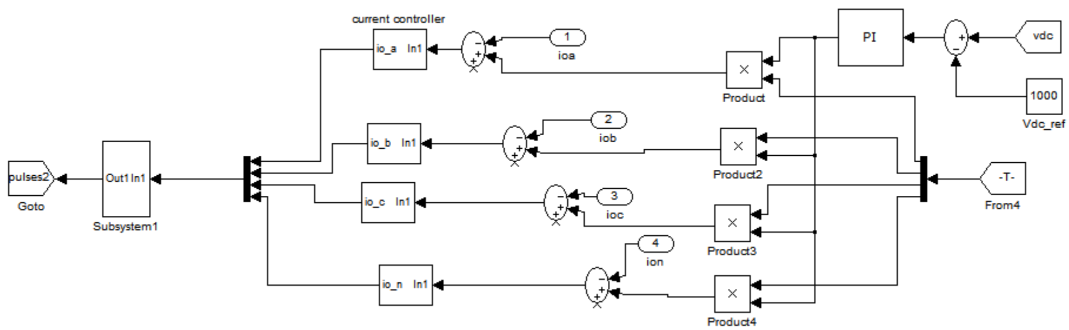

Fig. 6. Configuration of grid-side control scheme represents in MATLAB.

In this configuration PI controller tuning parameters are obtained employing set of fuzzy rules. Those fuzzy rules are tabulate in below Table 1.

Table. 1: Set of Fuzzy Rules.

ee / e	**NB**	**NM**	**NS**	**ZR**	**PS**	**PM**	**PB**
NB	NB	NB	NB	NB	NM	NS	ZE
NM	NB	NB	NB	NM	NS	ZE	PS
NS	NB	NM	NS	NS	ZE	PS	PM
ZR	NB	NM	NS	ZE	PS	PM	PB
PS	NM	NS	ZE	PS	PS	PM	PB
PM	NS	ZE	PS	PM	PM	PB	PB
PB	ZE	PS	PM	PB	PB	PB	PB

IV. SIMULATION RESULTS

The block diagram of grid connected WECS with linear and non linear load is shown in below Fig. 7.

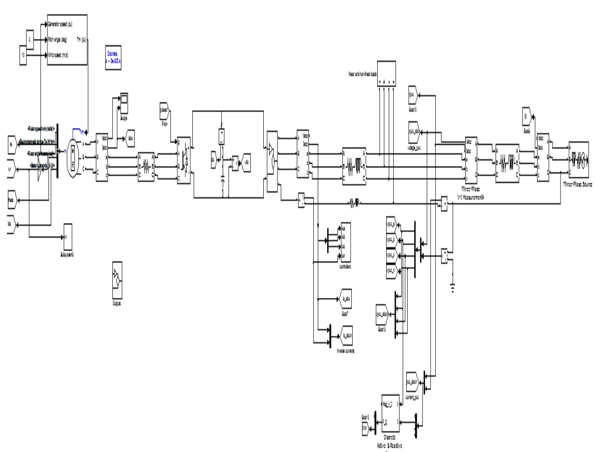

Fig. 7. Block diagram of grid associated WECS system.

The Simulation results of voltage measurement at PCC, load current, PCC current, Current at PCC, output DC Voltage, rotor speed, and inverter currents are shown in from Figs. 8-17 respectively.

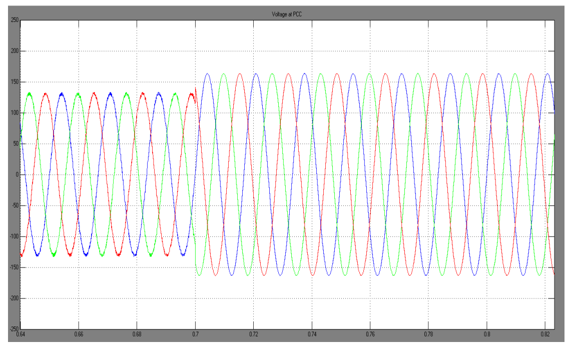

Fig. 8. Voltage measurement at PCC.

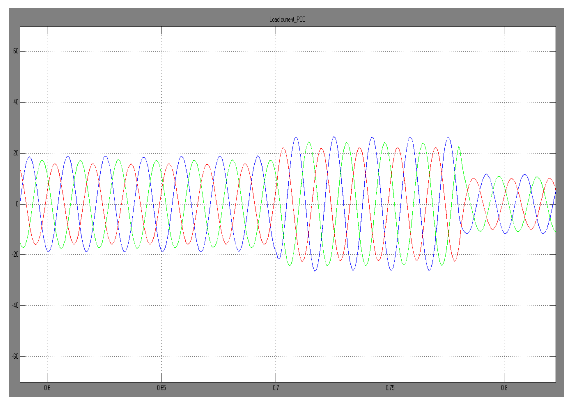

Fig. 9. Load current.

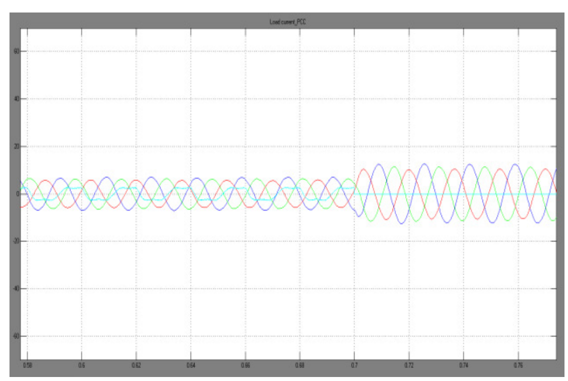

Fig. 10. PCC current.

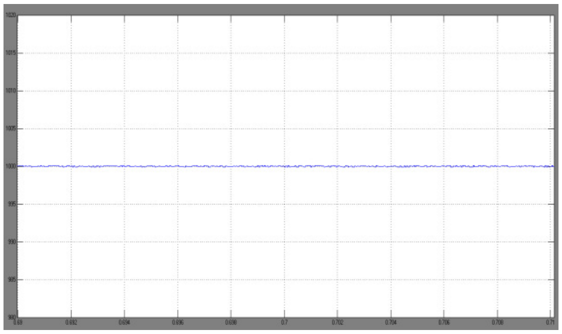

Fig. 11. DC voltage.

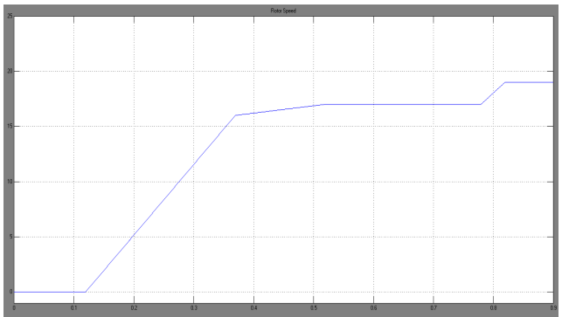

Fig. 12. Rotor speed.

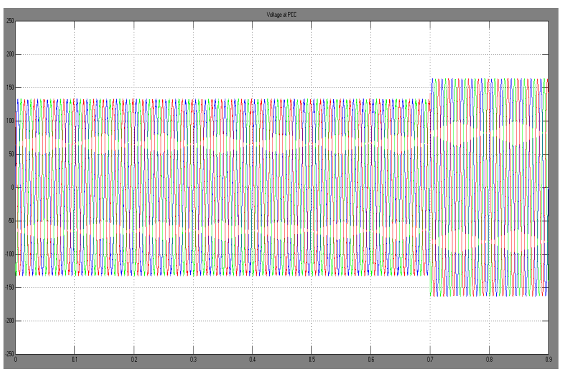

Fig. 13. Voltage measurement at PCC.

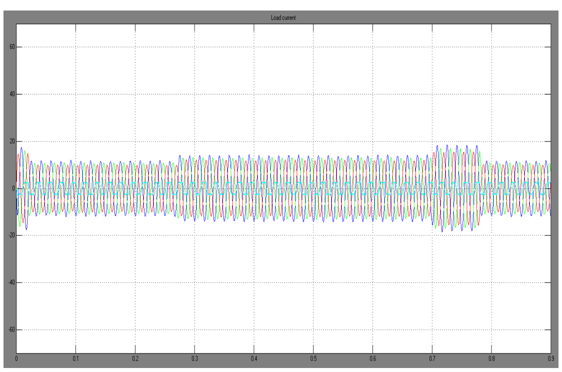

Fig. 14. Load current.

Here, two different conditions are presented to validate the total performance of the MSC and the GSC Controllers are during different wind speeds are discussed. In Fig. 15, a test is done to validate the controller when it switches from active power delivery only to active and non active compensation at maximum wind power. From Fig. 15, at *t* = 7 s, the inverter started providing active power as well as non active compensation. The Ig becomes sinusoidal and it is balanced. If it is balanced load neutral current is zero and it is unbalanced neutral is present that is make neutralized by employing four leg inverter.

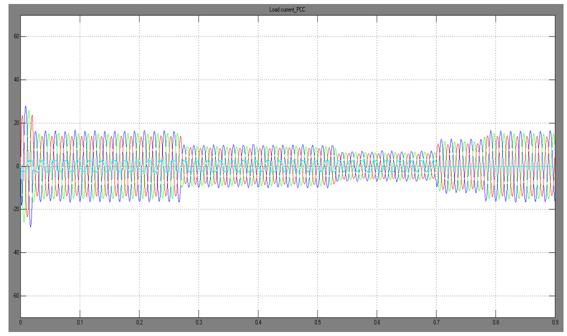

Fig. 15. PCC Current.

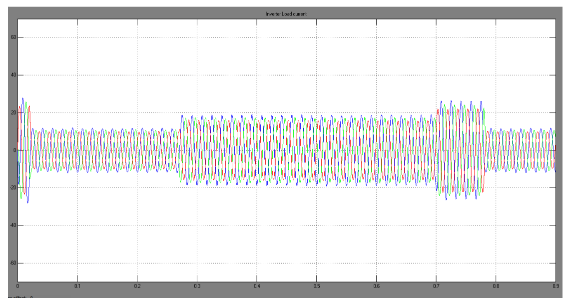

Fig. 16. Inverter Current.

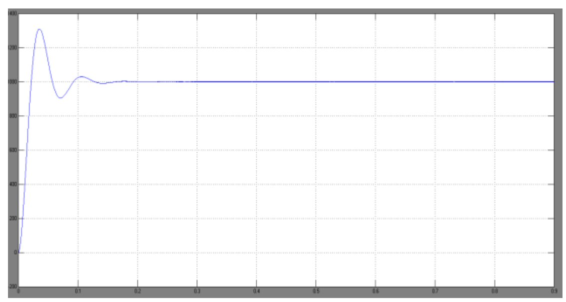

Fig. 17. DC voltage.

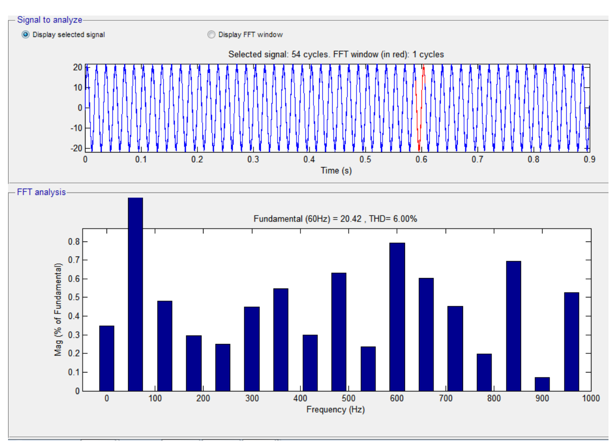

Fig. 18. THD at grid voltage of PI controller.

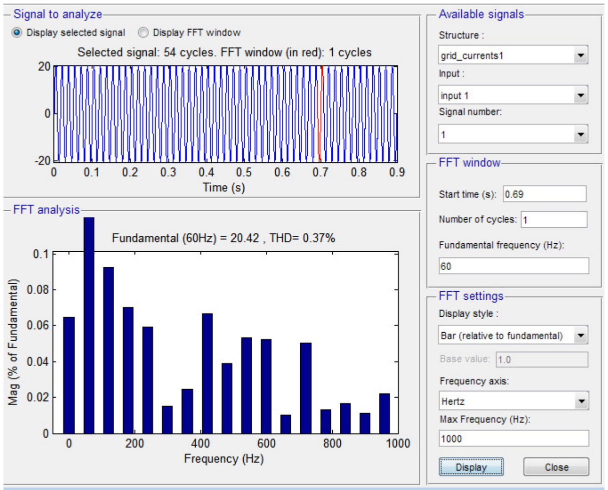

Fig. 19. THD represent of proposed FLC controller.

From Figs. 18 and 19 clearly expose like the proposed controller perfectly enhance the ripple mitigation characteristics.

In case of existing controller we get the % of THD is around 6% and at the same time in case of proposed fuzzy logic controller we get the around 0.37%.

V. CONCLUSION

In this paper investigates the mitigation of harmonic power quality concerns employing APF for the power system network with singly-excited induction generator (SEIG) linked single-phase load, SEIG associated with multi phase load, SEIG interfaced with linear load and SEIG feeding with non linear load. In almost all WECS, wind turbine is employed as a prime mover to drive the induction generator. The major problem in this article focused is when SEIG feeding to the single phase load or multi phase load are reactive power and production of harmonics due to presence of non linear load. Non linear loads are creates harmonics in the system. This power quality issues are mitigated by employing fuzzy logic controlled based APF. By FLC control scheme to operate the APF, MATLAB/SIMLINK results are proving that APF to be operated satisfactorily for single phase non-linear loads connected as harmonic compensator for WECS.

FUTURE SCOPE

Mainly in this proposed method consider Fuzzy logic controller it is very robust in nature and also we have very advanced controllers like ANN and wavelet controllers. If we extend this proposed method by that advance controllers it may enhance the power quality.

REFERENCES

[1]. Global wind report annual market update 2013. [Online]. Available: http://www.gwec.net.

[2]. S. Li, T. A., Haskew, R. P., Swatloski, & Gathings, W. (2012). Optimal and direct-current vector control of direct-driven PMSG wind turbines. *IEEE Trans. Power Electron.*, Vol. *27*, no. 5, pp. 2325–2337.

[3]. Angela, N., Liserre, M., Mastromauro, R. A., & Aquila, A. D. (2013). A survey of control issues in PMSG-based. *IEEE Trans. Ind. Informat.*, Vol. *9*, no. 3, pp. 1211-1221.

[4]. Lagorse, J., Simoes, M. G., & Miraoui, A. (2009). A multiagent fuzzy-logic based energy management of hybrid systems. *IEEE Trans. Ind. Appl.*, Vol. *45*, no. 6, pp. 2123-2129.

[5]. Tan, X., Li, Q., & Wang, H. (2013). Advances and trends of energy storage technology in microgrid. *International Journal Elect. Power Energy System*, Vol. *44*, pp. 179-191.

[6]. Ribeiro, P. F., Johnson, B. K., Crow, M. L., Arsoy, A., & Liu, Y. (2001). Energy storage systems for advanced power applications. *Proc. IEEE*, Vol. *89*, no. 12, pp. 1744-1756.

[7]. Simoes, M. G., Bose, B. K., & Spiegel, R. J. (1997). Fuzzy logic based intelligent control of a variable speed cage machine wind generation system. *IEEE Trans. Power Electron.*, Vol. *12*, no. 1, pp. 87-95.

[8]. Chauhan, A., & Saini, R. P. (2014). A review on integrated renewable energy system based power generation for stand-alone applications: Configurations, storage options, sizing methodologies and control. *Renew. Sustain. Energy Rev.*, Vol. *38*, pp. 99-120.

[9]. Bhende, C. N., Mishra, S., & Malla, S. G. (2011). Permanent magnet synchronous generator-based standalone wind energy supply system. *IEEE Trans. Sustain. Energy*, Vol. *2*, no. 4, pp. 361-373.

How to cite this article: Bhukya, S. and Prakash S. (2019). Effective Power Quality of Grid Connected WECS Employing FLC Controllers. *International Journal on Emerging Technologies*, **10**(3): 281–285.