Power Quality Improvement in a MicroGrid Integrated Hybrid Renewable Energy Source

Gurusiddappa v g, Dr.S.B Karajgi, EEE Department SDM Collage of Engineering and Technology Dharwad

Abstract—Nowdays air pollution is the dominant issue in the power generation.Due to the usage of fossil fuels for the generation so renewable energy source(RES) has play important role in clean generation of elelctriciy.The hybrid combination of wind/solar systems has proved to be a reliable source to the utility.For extracting maximum power from RES battery are connected to the system due to storage problem and chemical battery issue the RES is directly connected to the microgrid.Maximum power can be generated using MPPT design for the RES source using P&O method .Due to non-linear load connected to micro grid the hormonics can enter into source side so for that shunt active power filter is used to eliminate hormonics and maintain dc link voltage constant so here RES is integrated with micro grid using shunt active power filter as duilitry fuction.

Index Terms— microgrid; renewable source; solar and wind hybrid system; non-linear load; shunt active power filter; MPPT P&O method; D-Q method contro strategy;

1. INTRODUCTION

Since growth in technology the electricity demand is also increasing. Urbanization and industrialization have changed the lifestyle of human society and the need for electrical energy has enhanced significantly. And increasing in the pollution due to usage of fossil fuels, the RES will mitigate this problem.

Solar and wind system is more reliable compare to other system.The problems associated with the usage of chemical batteries like chemical pollution, high initial cost etc have provoked researchers to connect RES to the microgrid. The common disadvantage of both wind and solar power plants are as these generate unreliable power. In order to overcome this problem a new technique is implemented i.e maximum power point tracking algorithm which is applicable to both wind and solar plants. The maximum power can be extracted by MPPT design using P&O method for RES system.

There are many issues while interconnecting to the microgrid like stability issue,protection issue,reliability issue and power quality issue.these issues can be over come by growth in the electronics devices.The power quality issue is over come by shunt active power filter. In order to avoid the extra cost of hardware equipment the authors in paper [1] have added the additional functionality of shunt active power filter to the RES interfacing inverter

- *Gurusiddappa Ganiger Author name is currently pursuing masters degree program in electric power engineering in University, Country, PH-01123456789. E-mail: author_name@mail.com*
- *Co-Author name is currently pursuing masters degree program in electric power engineering in University, Country, PH-01123456789. E-mail: author_name@mail.com*

(*This information is optional; change it according to your need.*)

2. MODLING OF WIND TURBINE

The wind turbine converts wind energy into mechanical energy.this mechanical energy is converted into electrical energy using permanent magnet synchronous machine.for extracting maximum wind power wind speed, pitch angle and generator torque are the control parameter [2]

$$Pm = 0.5\rho ACpV^3$$

$$T=P_m/\omega$$

P_m=mechanical output (W)
C_p=power co-efficient
A=turbine swept area ($m^{2)}$
ρ=air density ($kg/m^{3)}$
V=wind speed m/s)
T=turbine torque(N-m)

0.59 is the theoretical maximum power coefficient value [3]

3. MODLING OF PV ARRAY

In Photovoltaic (PV) system, solar cell is the basic component. PV array is nothing but solar cells are connected in series or parallel for gaining required current, voltage and high power. Each Solar cell is similar to a diode with a p-n junction formed by semiconductor material [4]. It produces the currents when light absorbed at the junction, by the photovoltaic effect. It can be seen that a maximum power point exists on each output power characteristic curve. The Figure 2&3 shows the (I-V) and (P-V) characteristics of the PV array at different solar intensities. The equivalent circuit of a solar cell is the current source in parallel with a diode of a forward bias. Load is connected at the output terminals. The current equation of the solar cell is given by

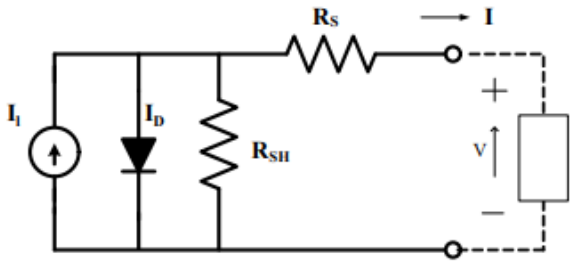

Fig. 1 Equivalent circuit for PV cell

$$I = Iph - I_D - Ish$$

$$I = Iph - Io\,[\exp(q V_D / nKT)] - (V_D / R_{SH})$$

I=output current
I_{ph}=photo voltaic current
Io=saturation current
q=charge of electron
V_D=diod voltage
K=boltzmann constant
T=temperature in K
n=diod ideality factor
Ish=current through R_{SH}

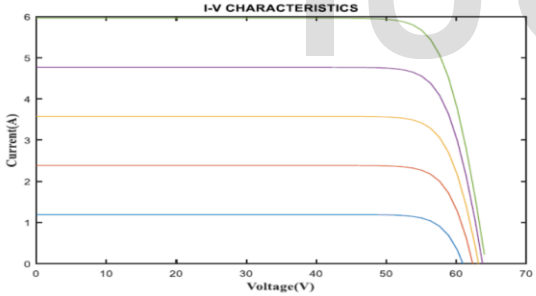

Fig .2 I-V Characteristics of PV array

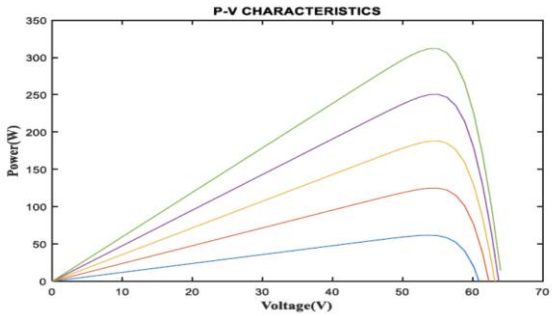

fig .3 P-V Characteristics of PV array

4. MPPT DESIGN

Define Perturb-and-observe (P&O) method is dominantly used in practical PV systems for the MPPT control due to its simple implementation, high reliability, and tracking efficiency.Fig 4 shows the flow chart of the P&O method [5]. The present power P (k) is calculated with the present values of PV voltage V (k) and current I (k), and is compared with the previous power P (k-1). If the power increases [6], keep the next voltage change in the same direction as the previous change.

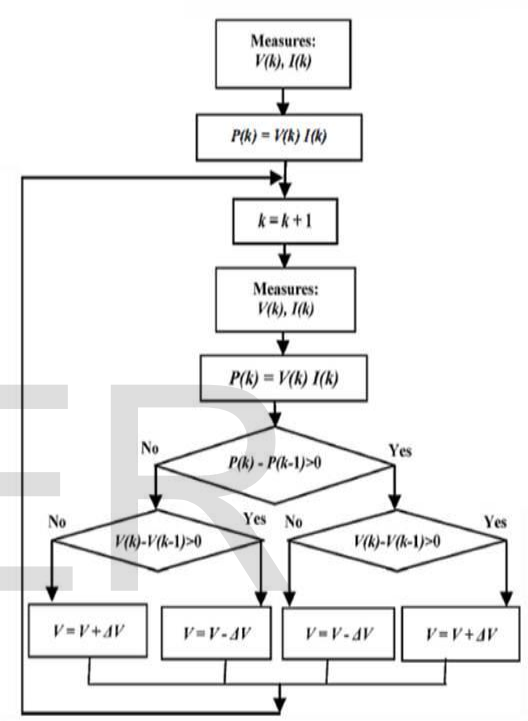

Fig4; flow chart for MPPT algorithm

5. SOLAR AND WIND HYBRID SYSTEM INTEGRATION WITH MICROGRID

DC power generated by the solar system and this power is unregulated DC so it can be regulated by DC-DC boost converter with MMPT design.WTG produces the AC power this AC power is rectified by uncontrolled rectifier in first stage then DC link voltage maintained constant using boost converter.Shunt active power filter is used to interface with the microgrid PI controller based voltage feed back is used to manitaine DC voltage constant [7].

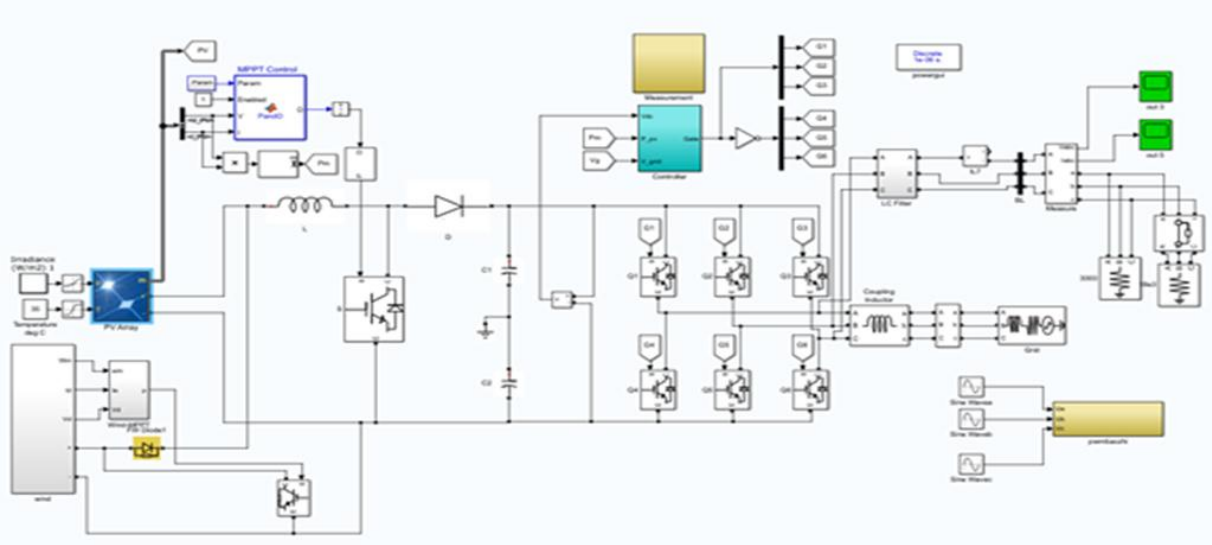

Fig. 5 solar wind hybrid system

6. SHUNT ACTIVE POWER FILTER

Non-linear laods are connected at the point of common coupling the source voltage get distorted and these loads will inject the current harmonics to the microgrid so other load connected to microgrid will be get damaged. Due to current harmonics the losses in the system is increases.So shunt active filter (Fig. 6) is used as duality fuction one is interfacing and onther one act as filter for load harmonics [8].

There are three steps following for shunt active filter operation. first one is to generate reference current using suitable control strategy.Second one is comparing reference current with actual current output to generate switching pulses.These switching pulses are used by inverter to synthesize the reference current at last stage of the shunt active power filter.

The generation of reference current needs the extaction of load current harmonics.These load harmonics can be extacted by the I_d-I_q method control statagy as shown in fig.7 which is more simple and give good results in distorted voltage condition. For satisfactory operation DC-link voltage kept constant using PI controller.Three phase load current are sensed and converted to d-q frame.A PLL is used to synthesizing the circuit with grid voltage.I_d is the active current and I_q is reactive current.Harmonic components are found out by calculating fundamental component of I_d and I_q using lowpass filter.This harmonic current component is multiflied by -1 as these currents cancels the harmonic present in the system.controlled DC link voltage is added with d-axix component to generate reference current .this reference current is transformed back to the abc frame and given to current controller.

Hysteresis current controller is used to compare the reference current and actual current and pulses are given to the inverter.

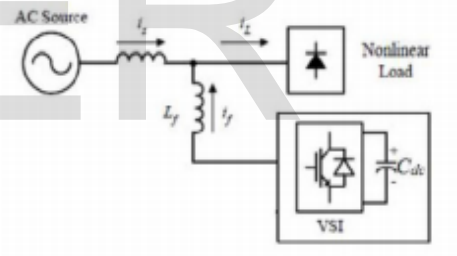

Fig. 6 Shunt active power filter

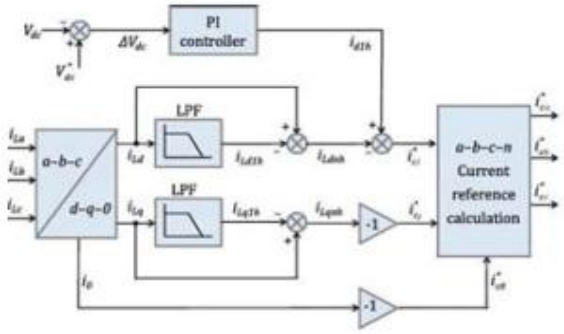

Fig. 7 I_d-I_q control stratagy

TABLE 1
Solar parameter

Parameter	values
Irradiation	1000 w/m^2
Temperature	35^{0}C
open circuit voltage	64.6V
short circuit current	6.14A
max voltage	54.7 V
max current	5.76 A
max power	315.07 W

TABLE 2
Wind parameter

Parameter	values
Pitch angle	0 degree
Nominal mechanical out-put power	8.5Kw
Air density	0.55kg/m2
Wind speed	12m/s
Cut in speed	5m/s
Cut out speed	25m/s

TABLE 3
System parameter

Parameter	values
Supply voltage	400V 50HZ
Source parameter	0.01e-3H 0.1Ω
Load parameter	10kw 50var
DC link capacitance	3e-3F
Reference DC link voltage	700V
Filter parameter	5e-3H 0.1 Ω

7. REULTS

The system described in the fig. 5. Three phase unbalanced load connected to microgrid. Wind and solar hybrid system is also integrated to microgrid using three leg inverter.MPPT is designed for the system to extract maximum power from RES system.Shunt active power filter is used to compansate the load harmonic entering into source side by suppling reactive power. Source current and voltage are sinusoidal. DC link voltage maintained constant.

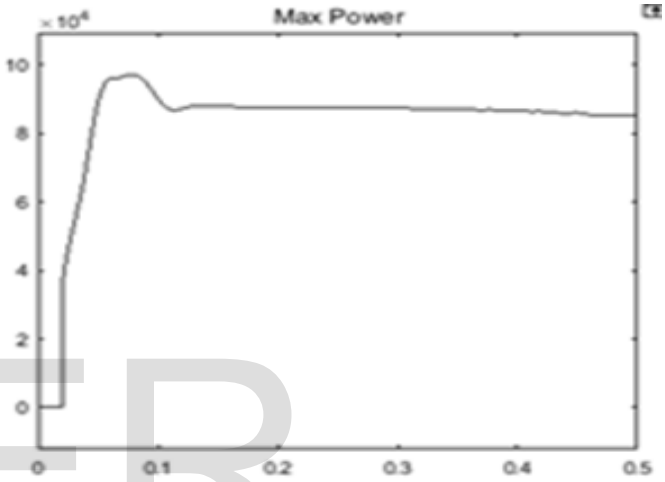

Fig.8 Max power by MPPT Design

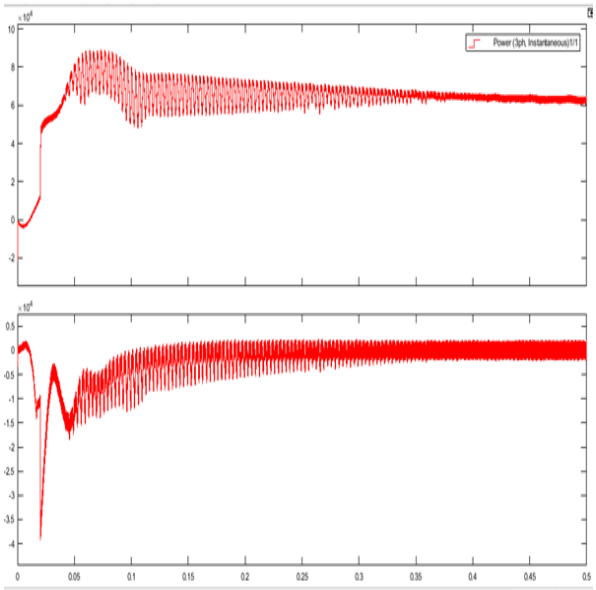

Fig.9 Output of the inverter

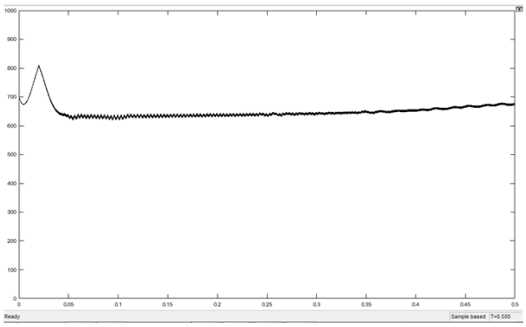

Fig.10 DC link voltage

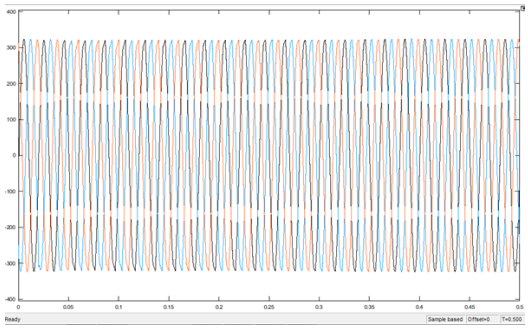

Fig.13 Load voltage

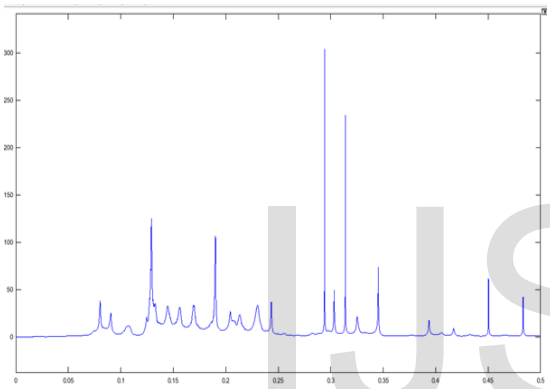

Fig.11 THD before compensation

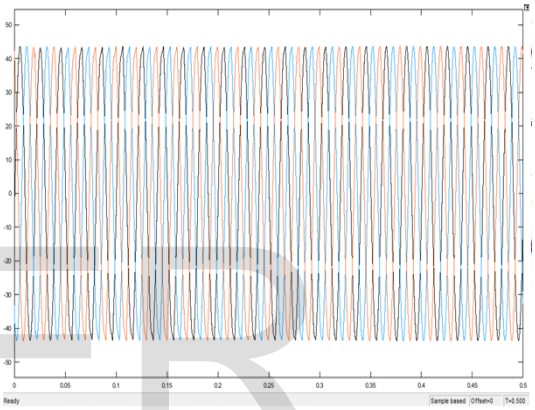

Fig.14 Load current

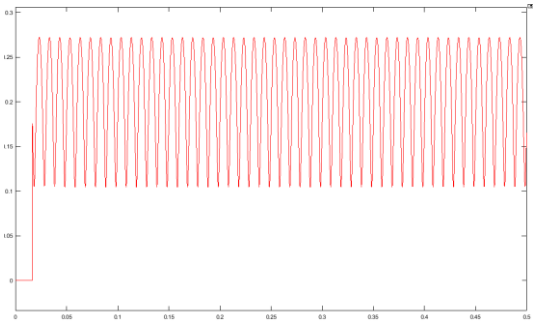

Fig.12 THD after compensation

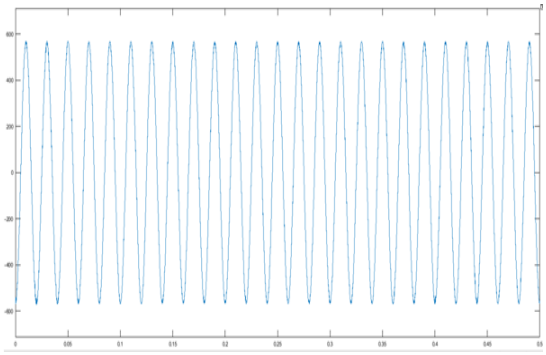

Fig.14 Source voltage

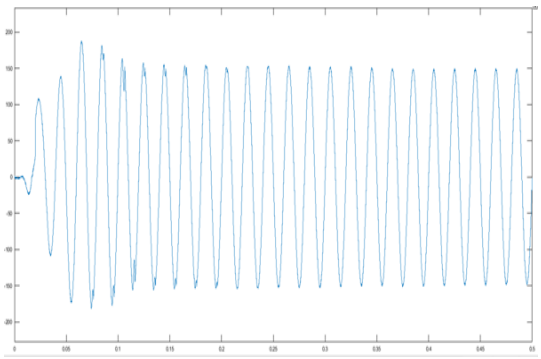

Fig.14 Source current

8. CONCLUSION

The integration of RES to the microgrid and coordination control schemes are proposed in this paper.The Extraction of maximum power can be achieved by P&O MPPT method is also proposed in this paper.The whole system is simulated in matlab/simulink.The solar and wind system is intigrated to microgrid through VSI using DC shunted grid connected scheme.I_d-I_q control strategy add the shunt active power filter functionality to the interfacing inverter.Simulation results shows that the microgrid can operate stably in grid operated mode.Source current THD is reduced to <5%, which is acceptable current harmonics as per IEEE standard 519 for power quality.

REFERENCES

[1] M Singh, V Khadkikar, A Chandra and R K Varma "Grid Interconnection of Renewable Energy Source at the distribution level and power quality improvement features", IEEE Transactions on Power delivery, Vol 26,Issue 1,PP 307- 315,2011.

[2] Gururaj M V,Vinatha U and Jayasankar V N "Interconnection of Wind–Solar hybrid Renewable Energy source to the 3 phase-3 wire distribution system along with power quality improvements at the grid side"

[3] K Pavankumar Reddy* and M. Venu Gopala Rao "Modelling and Simulation of Hybrid Wind Solar Energy System using MPPT"

[4] Chen YM, Liu YC, Hung SC, Cheng CS." Multi-input inverter for grid-connected hybrid PV/wind power system". IEEE Transactions on Power Electronics. 2007 May; 22(3):1070–7.

[5] L. Piegari, R. Rizzo, "Adaptive perturb and observe algorithm for photovoltaic maximum power point tracking," Renewable Power Generation, IET, vol. 4,no. 4, pp. 317-328, July 2010

[6] C. Liu, B. Wu and R. Cheung" advanced algorithm for Mppt control of photovoltaic systems" Canadian Solar Buildings Conference Montreal, August 20-24, 2004 Refereed Paper.

[7] Yaow-Ming Chen. Chung-Sheng Cheng.and Hsu-Chin Wu. "Grid-Connected Hybrid PV/Wind Power Generation System with Improved DC Bus Voltage Regulation Strategy". Proceedings of 21st annual applied power electronics conference and exposition APEC'06, ,pp.1088-1094, 2006

[8] SushreeSangitaPatnaik.,Anupkumar panda, "Real time performance analysis and comparison of various control schemes for particle swarm optimization-based shunt active power filters" , Journal on Electric power & Energy systems, Vol 52, 2013,pp 185-197