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ACTIVE AND REACTIVE POWER DECOUPLING USING CURRENT-VOLTAGE CONTROLLER AND DROOP METHOD IN THE INVERTER CONNECTED TO ISLANDING MICROGRID

Manisha Kumari Meena[1], Rahul Sharma[2]

[1,2]*Department of Electrical Engineering,National Institute Of Technology Kurukshetra (India)*

ABSTRACT

Microgrid are used at low voltage level. Low voltage level microgrid transmission line have low inductance and high resistance. Due to the high resistance coupling occur in the system and voltage and current are unbalance in the system so that error produced. Therefore, harmonics produce and system become unstable. To reduce the effect of line resistance droop controller are used. After connecting droop system stability improved and harmonics reduced. To overcome the problem occur by voltage and current, PI controller are used. Dynamic response also improved by PI controller. Experimental result gives correct waveform of voltage, current, active and reactive power.

I. INTRODUCTION

A microgrid is a localized grouping of electricity generation, energy storage, and loads that normally operates connected to a traditional centralized grid. This single point of common coupling with the microgrid can be disconnected. The microgrid can then function autonomously. Generation and loads in a microgrid are usually interconnected at low voltage and it can operate in DC, AC or the combination of both. According to the recent developments in renewable energy systems, storage systems, and the nature of newly emerging loads, there have been some researches for comparing the efficiency and performance of AC and DC microgrid. From the point of view of the grid operator, a connected microgrid can be controlled as if it were one entity[1].

Microgrid generation resources can include stationary batteries, fuel cells, solar, wind, or other energy sources. The multiple dispersed generation sources having their own advantages and disadvantages. Wind DG source have voltage sag and harmonics because continuously changing nature of air. Diesel engine and gas turbine DGs have lesser power quality because of varying supply[2]. Photovoltaic system also have limitations such as, having high starting cost and less efficient but it gives better performance and has pollute free as compare to other DGs. So, the photovoltaic system is used as DG source in this paper.

To improve power quality, many control schemes has been proposed like, Proper power flow regulation using vector control principle has been proposed in [3]. Dual Vector Current control uses two VCC's for positive and negative sequence components along with DC link voltage control in [4]. Synchronous PI current control has also been proposed which convert the three phase grid voltages to synchronously rotating (*dq*) frame for proper decoupling in [5]. The grid currents become DC variables and thus no steady state-state error adjustment is required. A method for active and reactive power control has been mentioned in [6]. It control scheme to maintain the DC link voltage constant by a Voltage Control Loop. However, the transient conditions has not been taken into account. Harmonics suppression techniques have also been proposed with the help of filters in [3] which are not considered the effects of filters on the control loop. Above discussed control schemes have so many problems. To improve the power quality and mitigate the aforesaid problems, this paper proposes frequency and voltage virtual droop control method. In this control scheme, voltage or frequency are controlled by the control of active and reactive power using droop method. This method improves the system stability and dynamic responses in transient as well as steady state conditions. DG system is connected to grid by taking grid impedance into account. In microgrid transmission line always behave as a high resistance low inductance line. So to suppress the adverse effect of high resistance on control loop and dynamic response, droop method with PI controller scheme is proposed. This Improve dynamic performance of system under different operating conditions [7].

This paper is divided in 4 sections, proposed control method is discussed in section 2, section 2 is divided into 2 parts (1-droop method, 2- voltage and current control design), and results are discussed and shown in section 3 to validate the proposed control scheme in different conditions. Lastly, Section 4 is concluded the outcome of the work and improvement in power quality using the proposed control scheme in DG system

II. PROPOSED METHOD

2.1. Droop method

The power flow into a line written as[8]:

$$P + jQ = S = V_S[(Vs - Vabc\ )/Z]^*$$

$$= V_S(V_S - V_{abc}\, e^{j\delta}/Z\, e^{j\delta} \quad (1)$$

$$= V_S^2\, e^{j\delta} - V_S V_{abc} e^{j(\delta+\theta)} \quad (2)$$

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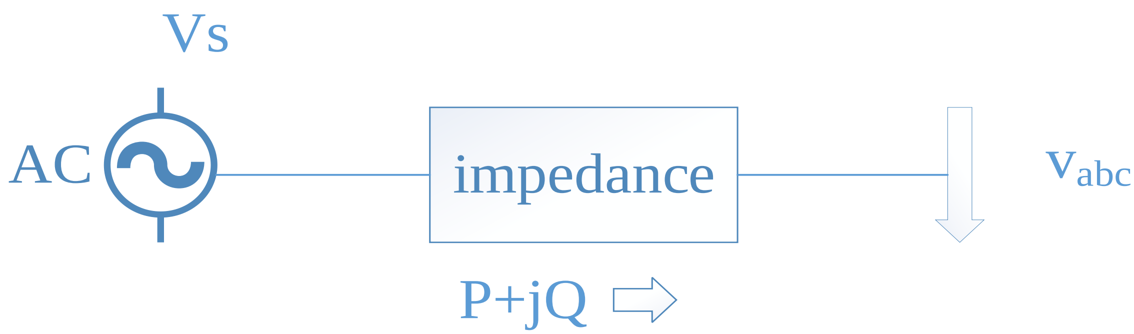

Fig. 1 equivalent circuit of grid connected microgrid

Active and reactive power flow in the line can be written as [9]:

$$P = V_S^2 \cos\theta / Z - V_S V_{abc} \cos(\theta + \delta)/Z \quad (3)$$

$$Q = \frac{V_S^2 \sin\theta}{Z} - V_S V_{abc} \cos(\theta + \delta)/Z \quad (4)$$

with $Ze^{j\theta}$=R+Jx so equation (2) and (3) can be written as

P=$V_S[R(V_S - V_{abc}\cos\delta) + XV_{abc}\sin\delta]/(R^2 + X^2)$

Q=$V_S[R(-V_{abc}\sin\delta) + X(V_S - V_{abc}\cos\delta)]/(R^2 + X^2)$

For overhead lines X>>R, so R can be neglected. Power angle δ is small, then sin$\delta = \delta$ and cos$\delta = 1$

$$\delta \cong XP/V_s V_{abc} \quad (5)$$

$$V_s - V_{abc} \cong XQ/V_s \quad (6)$$

For X>>R, small power angle and small voltage difference in equation shows that the angle δ can be control by regulating active power and voltage can be control by regulating reactive power. Control of frequency dynamically controls the power angle thus the real power flow[10].

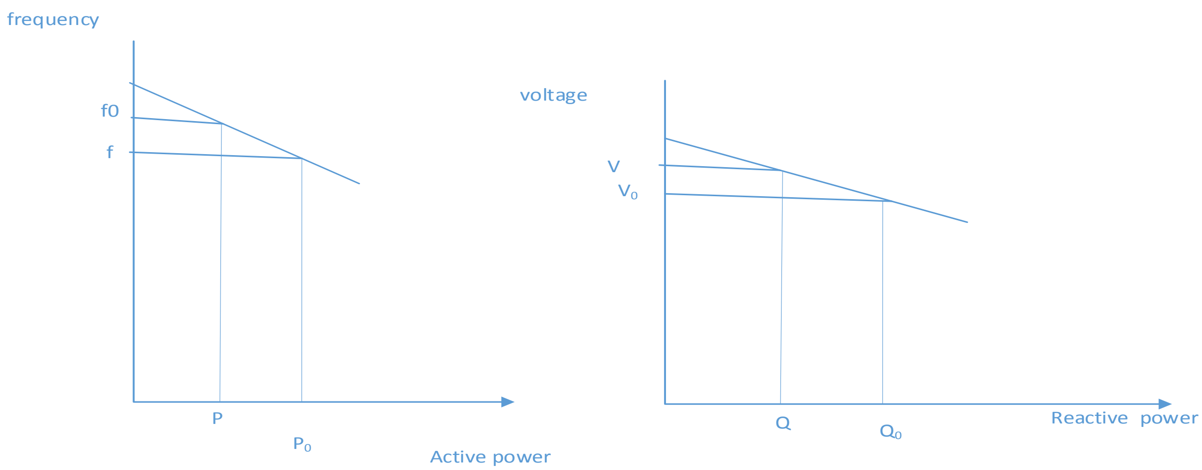

Fig. 2 droop voltage and droop frequency characteristic

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2.2. Voltage and Current Control Design

The reference voltage, frequency and amplitude will be controlled by the droop functions, generated in abc and transformed to $\alpha\beta$ coordinates. The $\alpha\beta$ coordinates are obtained by using the well-known Clarke transformation. Current and voltage are also transform from abc to $\alpha\beta$ [11].

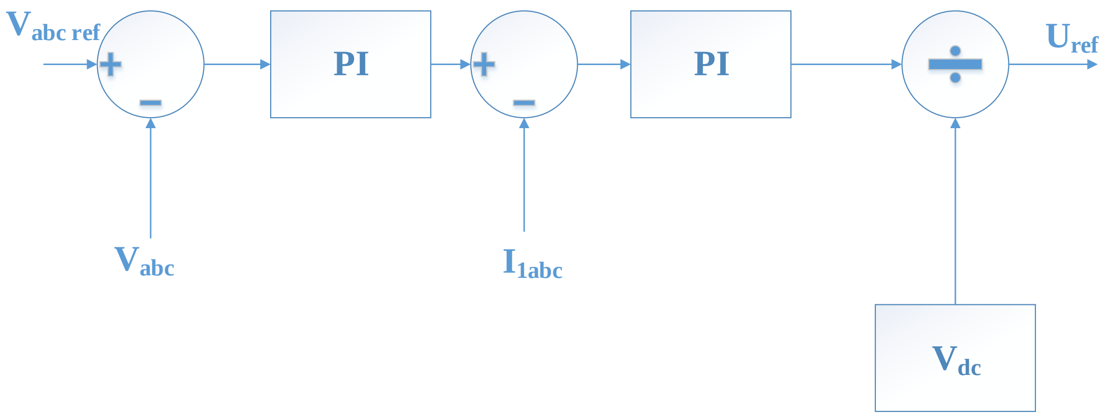

Fig. 3 Block diagram of voltage and current control design

Fig. 4 shows the power stage of VSI consisting of a tree phase pulse width modulation (pwm) inverter and LCL filter. This LCL filter may exhibit a critically unstable response when trying to control output current with inverter voltage. The term proportional + resonant (PR) are used to tuned at fundamental frequency,5th, 7th and 11th harmonics. Not only current control loop but also voltage control loop includes current harmonic tracking in order to supply nonlinear currents to nonlinear loads.

The voltage and current controller are based on PR structure used to archive zero steady state error. Based on the abs to $\alpha\beta$ coordinate transformation principal, a three phase system can be modeled in two independent single phase system.

$i_{2abc}(s) = V_{abc\ ref}(s)G_{inv}(s) - V_{abc}(s)/Z_{sys}(s)$

$G_v(s) = k_{pv} + 2k_r w_c s/(s^2 + 2w_c s + w_n^2)$

$G_c(s) = k_{pi}$

Where $k_{pv} and\ k_{pi}$ are the proportional coefficients. $G_v and\ G_c$ are the voltage and current controller. w_n is the frequency of the system[12].

III. RESULT

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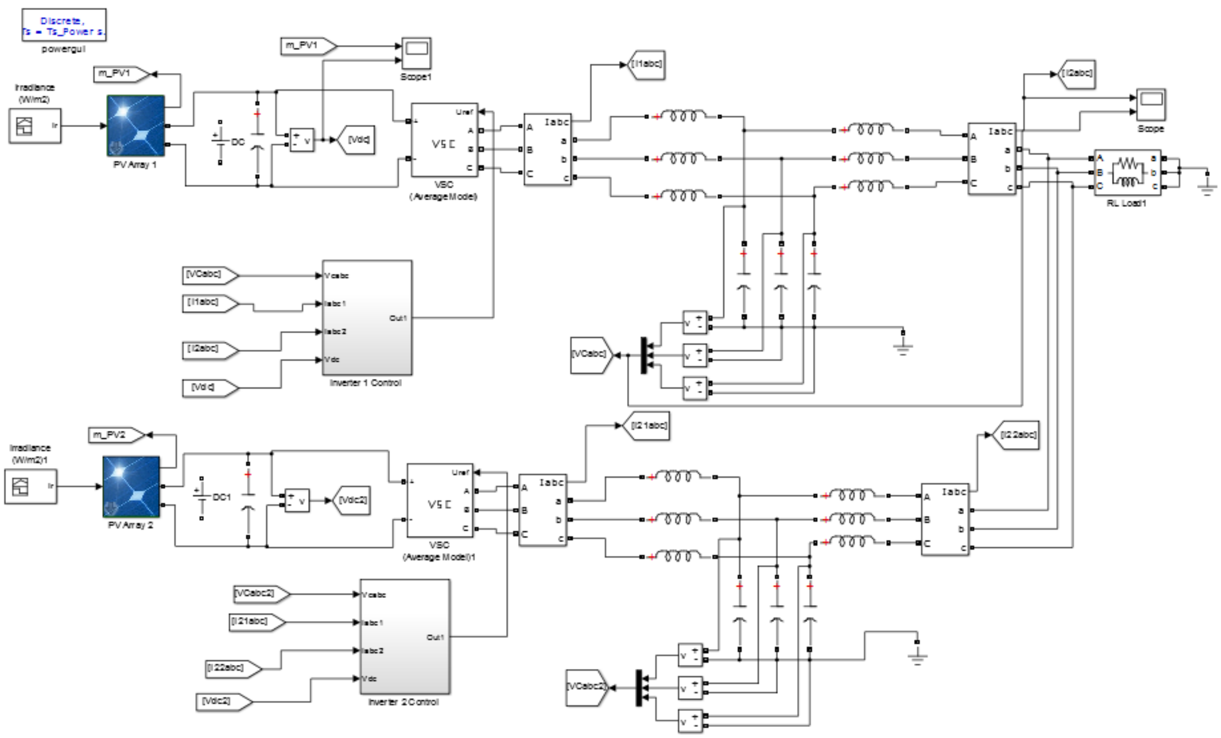

Fig.4 Model of grid connected microgrid using droop method in MATLAB

Output voltage, current and output of PV cell waveform of the system using droop method shown below:

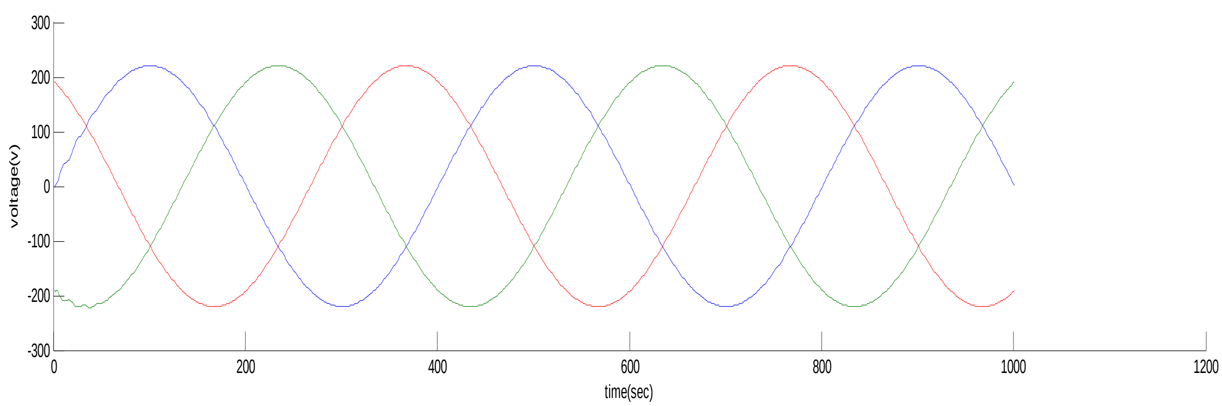

Fig. 5 Output voltage of grid connected microgrid

As shown in fig.5 the voltage wave form are purely sinusoidal. But if are not connect the PI controller then some oscillation are occur in the system.

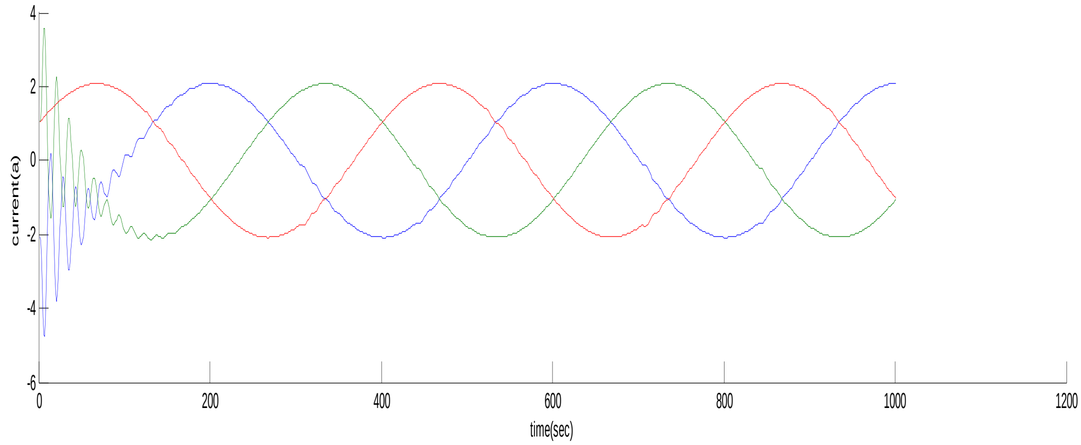

Fig.6 output current of grid connected microgrid

As shown in current waveform some transient occur in the starting which is clearly seen in the waveform.

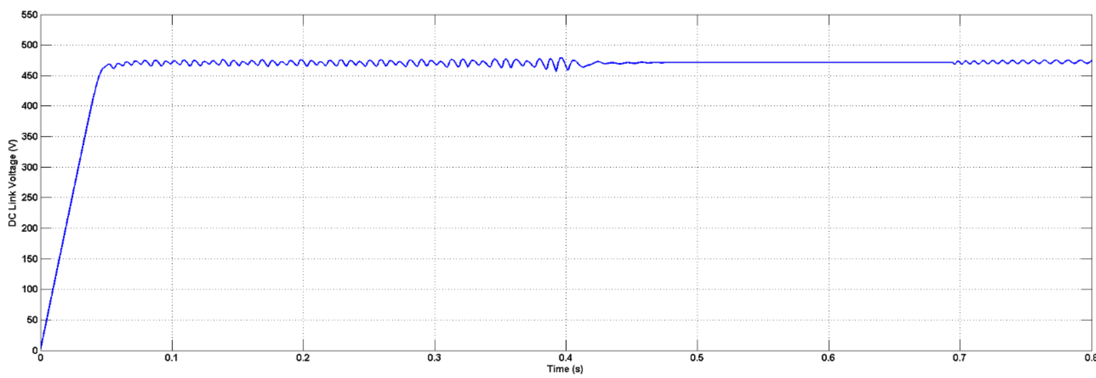

Fig. 7 input of the inverter which is the output of PV cell

In the wave form during some time voltage are fluctuated but after that steady state occur in the system. Again voltage fluctuate when voltage are changed.

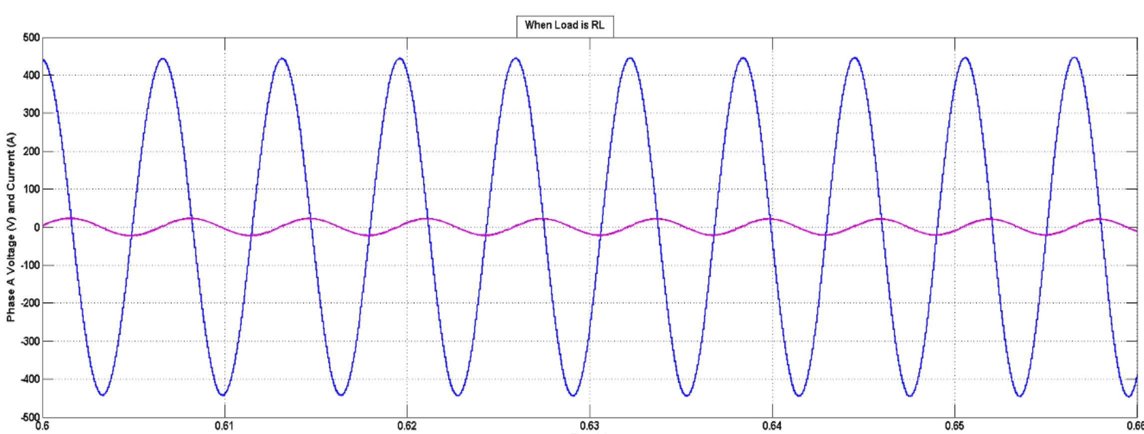

Fig. 8 output of voltage and current for one phase

This wave form represent the voltage and current for single phase. As clearly seen that voltage much larger than current in the waveform.

IV. CONCLUSION

The power quality in a low voltage microgrid can be decreased by designing droop control method with PI controller. The voltage and frequency are control by regulating active and reactive power and error of voltage and current reduce by PI controller Experimental results of a low voltage microgrid consisting of two 6-Kw inverters validate the control design..

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