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# Control Strategies for Microgrid of 7.5kw Hybrid System

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***Abstract*— So as to meet the constantly increasing demand of energy, grid-connected microgrid based on distributed energy will be the surest way to improve the power system in the near future. The implementation of microgrid systems brings enormous benefits to electricity suppliers and end users. The microgrid is usually connected to the main grid, that is when it works in grid connected mode and when the main grid does not supply electricity to users, the microgrid works in island mode and provides power, independent of the main grid. This article presents the control strategies for a hybrid microgrid with a capacity of 7.5 KW with 1.5 kW powered by wind and 6 kW by solar, installed at an engineering college in Maharashtra state. A detailed overview of PQ control strategy and droop control strategy related to microgrid operating modes is provided. This paper also addresses issues of microgrids such as island mode, stability, and unbalanced voltage to supply efficient power quality. P-Q control strategy equilibrates real and reactive power controlling the voltage and droop control is a prominent strategy for controlling actual power in power systems without internal communication. The microgrid can provide voltage and frequency support, improve power quality, and achieve stable and efficient output. Following this strategy the simulation of PQ control is concluded and the results are seen as required for the system i.e. 415V and 18A. Mathematical modelling of P-Q control and droop control is presented and is compared with the simulation result and are observed to be approximately equal.***

***Index Terms*— microgrid, PQ Control, Droop**

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## I. INTRODUCTION

Small power networks known as microgrids link users to electricity sources. Several connected and distributed power generation resources, such as solar cells, wind turbines, or fuel-burning generators, can be found in a microgrid. Large batteries, electric vehicles, hardware, and software for managing and distributing electricity are all needed to store it. End users like homes, businesses, and buildings use it. Microgrids are able to maintain electricity during blackouts and can run independently or be connected to a bigger grid. Moreover, microgrids often need to include a control method to decide how resources are distributed over longer time periods of time and to quickly maintain actual and reactive power balance when the system is isolated. Additionally, the control system must understand how and when to connect to and disconnect from the network. A microgrid power system is a compact power distribution network created to serve little towns with electricity. Throughout the past ten years, microgrid technologies have grown in popularity during the R&D stage. An important benefit of a microgrid is its capacity to run autonomously during disruptions or outages of the electrical system. There are two modes of operation for micro grids: island mode and connected grid mode. When operating in island mode, the microgrid is cut off from the main grid and manages disruptions on its own while maintaining a high level of service without endangering the integrity of the transmission network. The micro-grid is connected to the larger grid in grid- connected mode, enabling two-way power flow.

**Fig. 1**. Solar-wind hybrid microgrid of 7.5KW Capacity.

A microgrid typically comes in two varieties:

1. Alternating Current - Microgrid
2. Direct Current - Microgrid

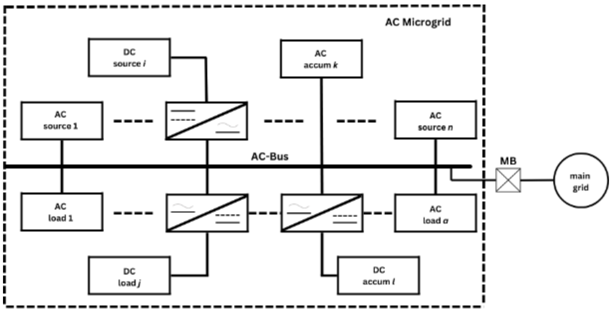


**Fig. 2.** Alternating Current - Microgrid

From fig 2 it depicts a typical alternating current microgrid (AC-MG). In this situation, the MG is made of of an AC power source and an inverter. Connect an alternating current load to the MG, if necessary, via a power converter. Adding extra power electronics, It is possible to connect not just an AC source but also a DC supply and a DC load to the AC-MG via the interface, but this may increase power loss. The AC-mode MG's of operation is determined by the condition of the main circuit breaker (MB) that connects the AC-MG to the AC bus and the main network. As a result, the AC-MG can run from the main grid in either grid-connected (MB deactivated) or islanded mode (MB enabled). In grid-connected mode, the AC-MG power supply does not need to manage voltage magnitude or frequency because the electrical grid controls these factors. In stand-alone mode, on the other hand, the DG of MG must regulate the magnitude and frequency of the voltage, taking into account both steady-state and transient operation.

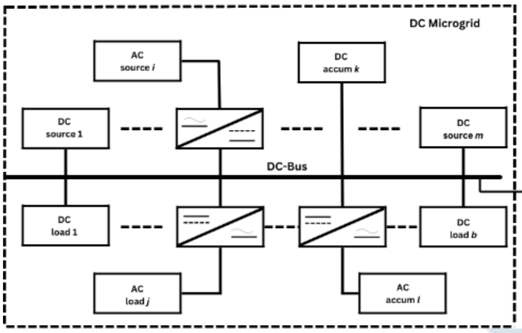


**Fig. 3.** DC Microgrid

From fig 3 depicts a typical direct current microgrid system (DC-MG). In this example, the DC load and generator units are linked to the MG via a power cable. If necessary, use a converter. Because of the decreasing cost of solar panels, DC-MG is becoming increasingly popular. In addition, an extra power electronics interface in the DC-MG can be used to connect AC loads and AC sources. Hybrid MGs are made up of DC and AC sub-MGs, as well as a network interface that links or disconnects the utility from the rest of the system. For bidirectional power exchange between AC-DC microgrids, one or more interconnected converters (ICC) are employed.

## II. CONTROL STRATEGIES

A microgrid should also include a control strategy to maintain active and reactive power balance on an instantaneous basis when the system is isolated, and to determine how resources are distributed over longer periods. The control system should also recognize when and how to connect/disconnect from the network and follow different control strategies.

I. PQ Control Strategy.
II. Droop Control Strategy.
III. V/F Control Strategy.
IV. Current Control Strategy.

This article introduces PQ control strategy and droop control strategy.

### A. PQ Control Strategy

PQ method is a typical control that is employed in microgrid systems. PQ injects active and reactive power to regulate the inverter's output voltage. PQ control prevents the microgrid controller from altering the microgrid output parameters in response to voltage or frequency variations at the terminals, which depend on a reference frequency signal to function.

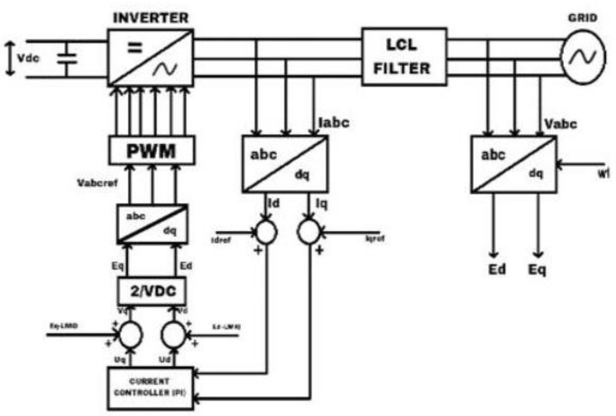
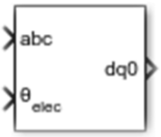


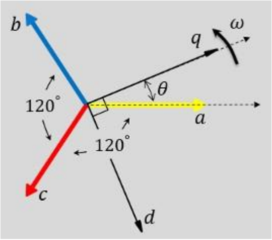
**Fig.4.** Block diagram of PQ control strategy Mathematical Modelling.



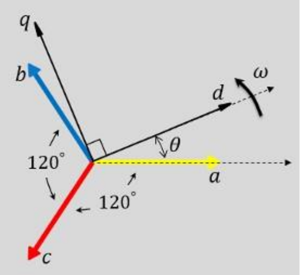
The Park Transform block transforms a three-phase system's time domain components from the abc reference frame to the rotating reference frame's forward, quadrature, and null components. The block can keep the forces active and reactive by using the system forces in the ABC repository by implementing an invariant version of Park's transformation. The zero the is equivalent of zero when you have a balanced system. The block can be configured to align the axis a from a three phase system at time t=0 with the axis d or q from a rotary reference frame. The stator winding's magnetic axis' abc direction data and rotational reference frame dq0 are depicted in the image.

Where:

- At first, the axis a and q are lined up.



- At first, the axis a and d are lined up.



The two situations mentioned above, the angle $\theta = \omega t$, where as the:

- For the alignment of the axis q , the angle between the axes a and q, and for the alignment of axis d, it is the angle between the a and d axes.
- The d-q reference frame's rotational speed is given by the ω
- begin with the initial alignment the time t is in sec.

The transformation for alignment between axis A and axis Q is implementation utilizing the Park Transform block as

$$\begin{bmatrix} d \\ q \\ 0 \end{bmatrix} = \frac{2}{3}\begin{bmatrix} \sin(\theta) & \sin(\theta-\frac{2\pi}{3}) & \sin(\theta+\frac{2\pi}{3}) \\ \cos(\theta) & \cos(\theta-\frac{2\pi}{3}) & \cos(\theta+\frac{2\pi}{3}) \\ \frac{1}{2} & \frac{1}{2} & \frac{1}{2} \end{bmatrix}\begin{bmatrix} a \\ b \\ c \end{bmatrix},$$

Where:

1. In the abc reference frame, the three phases system is represented as a, b, and c.
2. The Dual-axis system with the rotating the terms of reference frame includes d and q.
3. Within the stationary reference frame, the zero element of the two-axis system is equal to 0.

The block accomplishes the transition by utilising the following equation for the alignment of the axis of phases a to q with constant power:

$$\begin{bmatrix} d \\ q \\ 0 \end{bmatrix} = \sqrt{\frac{2}{3}}\begin{bmatrix} \sin(\theta) & \sin(\theta-\frac{2\pi}{3}) & \sin(\theta+\frac{2\pi}{3}) \\ \cos(\theta) & \cos(\theta-\frac{2\pi}{3}) & \cos(\theta+\frac{2\pi}{3}) \\ \sqrt{\frac{1}{2}} & \sqrt{\frac{1}{2}} & \sqrt{\frac{1}{2}} \end{bmatrix}\begin{bmatrix} a \\ b \\ c \end{bmatrix}.$$

The block implements the transition by utilising the following equation for the alignment of the axis of phases a to d:

$$\begin{bmatrix} d \\ q \\ 0 \end{bmatrix} = \frac{2}{3}\begin{bmatrix} \cos(\theta) & \cos(\theta-\frac{2\pi}{3}) & \cos(\theta+\frac{2\pi}{3}) \\ -\sin(\theta) & -\sin(\theta-\frac{2\pi}{3}) & -\sin(\theta+\frac{2\pi}{3}) \\ \frac{1}{2} & \frac{1}{2} & \frac{1}{2} \end{bmatrix}\begin{bmatrix} a \\ b \\ c \end{bmatrix}.$$

The block implements the transition with Constant power the alignment of the axis of phase a to d is

$$\begin{bmatrix} d \\ q \\ 0 \end{bmatrix} = \sqrt{\frac{2}{3}}\begin{bmatrix} \cos(\theta) & \cos(\theta-\frac{2\pi}{3}) & \cos(\theta+\frac{2\pi}{3}) \\ -\sin(\theta) & -\sin(\theta-\frac{2\pi}{3}) & -\sin(\theta+\frac{2\pi}{3}) \\ \sqrt{\frac{1}{2}} & \sqrt{\frac{1}{2}} & \sqrt{\frac{1}{2}} \end{bmatrix}\begin{bmatrix} a \\ b \\ c \end{bmatrix}.$$

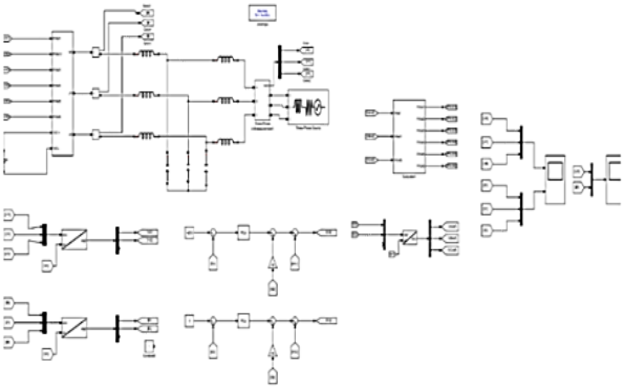


**Fig. 5.** Simulation of PQ control strategy

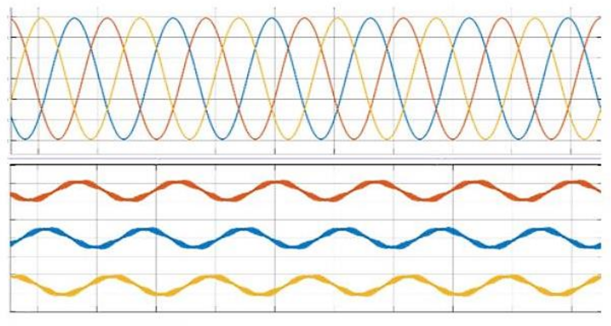


**Fig. 6.** Simulation result of three phase voltage and current w.r.t. time.

The above result of the simulation shows the graph between 3 phase Voltage w.r.t. time. And the result on the lower part shows the graph between 3 phase current w.r.t. Time.

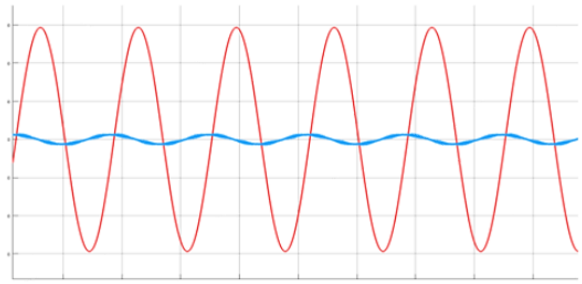


**Fig. 7.** Simulation result of single-phase voltage and current w.r.t. time.

Where, the graph shows Voltage and current w.r.t. time. Voltage is represented by red colored waveform and current by sky blue waveform.

After performing the simulation and mathematical modelling accurate results have been observed.

### B. Droop Control

The DG output voltage's consistent amplitude and frequency are assured by the v/f control. The fundamental idea behind v/f control is to lateralize the slope curve itself. In this control, the frequency remains constant where the voltage varies.

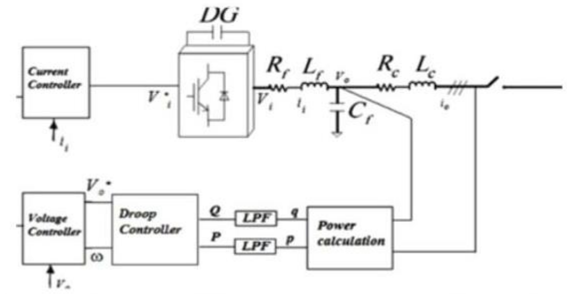


**Fig. 8.** Block diagram of Droop control

Mathematical Modelling for Droop Control: Frequency droop and voltage magnitude v droop d are determined in grid-connected droop control using filtered active power pLPF and reactive power qLPF, as illustrated in the following formula:

$$\omega_{droop} = \omega_0 + m_\omega(p_{LPF} - p_0)$$

$$v_{droop,d} = v_0 + m_v(q_{LPF} - q_0)$$

Normally, ω0 and v0 are set to 1pu, which is their nominal values. Degrees of freedom are provided by p0 and q0, which are both zeroed out in this work. The slope coefficients are mω and mv. Angle θ (abc to dq) of the park transformation is calculated by integrating ωdroop.

In grid-connected hang-up control, the output active power *p and reactive power *q are determined by the filtered frequency and voltage, respectively. As a result, active and reactive powers are isolated rather than frequency or voltage, as in the preceding equation for the grid-forming droplet equation:

$$p^* = p_0 + \frac{1}{m_\omega}(\omega_{LPF} - \omega_0),$$

$$q^* = q_0 + \frac{1}{m_v}(v_{LPF} - v_0),$$

Generally, ω0 and v0 specify the nominal frequency and voltage values respectively and offer a certain amount of freedom, where ωLPF and vLPF are frequency and amplitude of the measured and low-pass filtered voltage. The secondary controller of the microgrid central controller establishes p0 and q0.

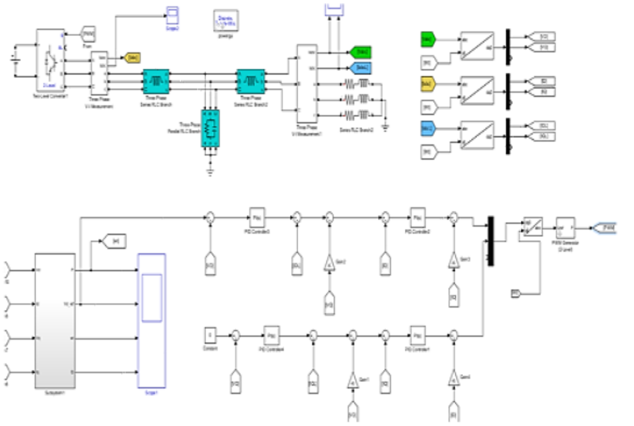


**Fig. 9.** Simulation of Droop control strategy

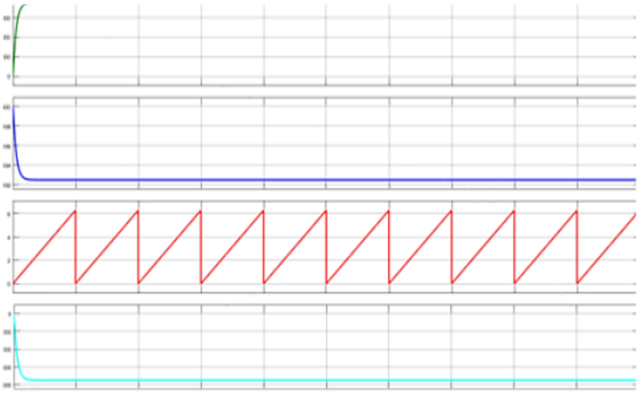


**Fig. 10.** Simulation result of Droop control strategy

- The 1st block of simulation result, represented by the green colored waveform shows graph between Power (in watts) w.r.t. Active power.
- The 2nd block shows the result that is represented by the blue colored waveform showing graph of Voltage (in volts) w.r.t. reference voltage.
- The red colored waveform shows graph between Phase angle w.r.t. Amplitude (Radians).
- The last block shows the simulation result, represented by the sky blue colored waveform showing graph between Power (in watts w.r.t. the Reactive power.

## III. CONCLUSION

People's increasing concern for protection of environment and energy sustainability promotes the incorporation of distributed resources of energy, in which the idea of micro-grid is initiated to enable the incorporation of a huge number of micro- generators, energy storage systems and of charges. As the study demonstrates, most of the initial research efforts have centered on AC micro-grid. However, in view of the improved efficiency brought about by avoiding the power electronics conversion step, DC microgrids and hybrid microgrids have attracted so much of attention and research for the scientific community. This paper will examine in detail the distributed co-operative control system currently uses in this micro-grid topologies. In order to maintain efficient microgrid performance and consumer satisfaction, microgrid control is essential. Various control strategies can be used for microgrid control. This article introduces P-Q control strategy and droop control strategy in detail. The goals of the P- Q control technique are to balance active and reactive power and manage the voltage at the transmitting end. The simulation results of this strategy are observed to be accurate compared to the theoretical values. In droop control, the voltage and frequency vary, and by performing simulations, it can be observed that the power quality is maintained. This article provides a brief description of both strategies.

## REFERENCES

[1] Mushtaq N. Ahmed, Mojgan Hojabri, Ali Mahmood Humada, Hamdan Bin Daniyal, Hatem Fahad frayyeh. “An overview on Microgrid Control strategies,” At International Journal of Engineering and Advanced Technology (IJEAT) ISSN: 2249 – 8958, Volume-4 Issue-5, June 2015.

[2] azel Mohammadi, Behnam Mohammadi- Ivatloo, Gevork B. Gharehpetian, Mohd. Hasan Ali, Wei, Ozan Erdinc and Mohammadamin Shirkhani. “Robust Control Strategies for Microgrids: A Review,” At IEEE Systems Journals.

[3] Enrique Espina, Jacquline Llanos , Claudio Burgos-Mellado, Roberto Cardenas-Dobson, Manuel Martinez-Gomez, and Doris Saiz. “Distributed Control Strategies for Microgrids: An Overview,” Date of publication October 20, 2020.

[4] Min-Rong Chen, Huan Wang, Guo-Qiang Zeng, Yu-Xing Dai, and Da-Qiang Bi. “Optimal P-Q Control of Grid-Connected Inverters in a Microgrid Based on Adaptive Population Extremal Optimization,” Published: 13 August 2018.

[5] Asma Alfergani , Khalid Ateea Alfaitori , Ashraf Khalil, Nagi Buaossa· “Control Strategies in AC Microgrid: A Brief Review,” March 2018.

[6] Shiv prakash Bihari , pradip kumar sadhu , kumari sarita,baseem khan.d. arya , r. k. saket and d. p. kothari “A Comprehensive Review of Microgrid.

[7] Control Mechanism and Impact Assessment for Hybrid Renewable Energy Integration,”

[8] A. Naderipour ,A. Asuhaimi Mohd Zin , M. H. Bin Habi Buddin A. Naderipour ,A. Asuhaimi Mohd Zin , M. H. Bin Habi Buddin. “Control of Compensation Devices by p-q, d- q and Fourier Control Methods to Improve the Power Quality in a Microgrid,” December 2015.

[9] Maen Z. Kreishan and Ahmed F. Zobaa. - "Optimal Allocation and Operation of Droop Controlled Islanded Microgrids: A Review" Published at MDPI (energies) 31 July 2021

[10] Simon Eberlein, Krzysztof Rudion. - " Small- signal stability modelling, sensitivity analysis and optimization of droop controlled inverters in LV microgrids" Published at ScienceDirect 27 July 2020