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Harmonics analysis of active and Reactive Power Droop Control in Cascaded type Microgrid

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Abstract: *In this report a space vector PWM technique-controlled series connected distribution generation units are controlled with stable power sharing. In cascaded-type micro grid, the synchronization and power balance of distributed generators become two new issues that need to be addressed urgently. To that end, an f-P/Q droop control is proposed in this letter, and its stability is analyzed as well. This proposed droop control is capable to achieve power balance under both resistive-inductive and resistive-capacitive loads autonomously. Compared with the inverse power factor droop control, an obvious advantage consists in extending the scope of application. Finally, the feasibility of the proposed method is verified by simulation results. The method will ensure in accurate power sharing even if the communication is interrupted. If the load changes while the communication is interrupted, the accuracy of power sharing is reduced but the proposed method is better than the conventional droop control method. In addition, the accuracy of power sharing base on the proposed method is not affected by the time delay in the communication channel and local loads at the output of the inverters. The control model has been simulated in Matlab with two or three inverters are connected in series. A comparative analysis is carried out with THDs of the output voltage with SPWM and SVPWM techniques. The active powers are also compared with improvement in the ripple of the power.*

Keywords: *Cascaded-type microgrid, droop control, power balance, SPWM and SVPWM.*

1. Introduction

Micro grid provides an efficient method for securely integrating dispersed energy resources that may be used in both grid-connected and insular modes. By its configuration, the microgrid may be split into two categories: parallel as well as cascaded. The former was thoroughly examined. The droop control is being used extensively to achieve parallel type microgrid power sharing as well as extended to additional applications that include a storage system's state-of-charge (SOC) balancing, a cost-effective distribution system for distributed generators (DGs) and a PWM system drive system for droop control. Furthermore, the cascaded microgrid type is a novel one just introduced. [1]
Initially, the cascaded converter is used on multilayer inverters and first expanded to microgrid applications for greater voltage and better usage. The cascaded form is extremely useful in particular for PV grid linked application and battery management. The power balance of all modules is important in an islanded cascaded-type microgrid. In order to establish power balance, a reverse drop control is suggested, which may also be utilised in the DC microgrid. For the AC microgrid, a novel inverse power factor drop control is suggested for power balancing. The technique is nevertheless only relevant in instances of resistive-inductive loads by a researcher. But this technique is utilised for inductive resistive loads as well as capacitive resistive loads. [2]
This study offers an F-P/Q droop control in the cascaded-type microgrid in order to overcome constraints. Frequency synchronisation and the power sharing across all DGs under resistive as well as resistive loads may be accomplished autonomously. The stability of the system suggested is theoretically shown.

2. Cascaded-Type Microgrid

MICROGRID provides an efficient solution for the reliable integration of dispersed power resources in gridrelated and insular modes. Through its configuration, the microgrid may be divided into two main categories: parallel and cascaded type. Originally, the cascaded converter is used on multilayer inverters and first expanded to microgrid applications for greater voltage and better usage. The cascaded form is extremely useful in particular for PV grid linked application and battery management. The power balance of all modules is important in an islanded cascaded-type microgrid. In order to establish power balance, a reverse drop control is suggested, which may also be utilised in the DC microgrid. For the AC microgrid, a novel inverse power factor drop control is suggested for power balancing. However, this technique applies exclusively to resistive-inductive load situations.[6]

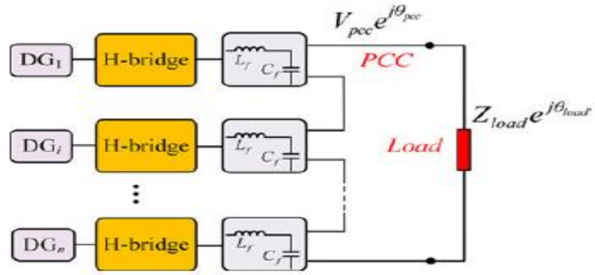


Figure 1 Structure of islanded cascaded-type microgrid

This letter offers an f-P/Q droop control method in the cascaded type microgrid to solve the constraint. Frequency synchronisation and the power sharing across all DGs under resistive and resistive loads may be accomplished autonomously. The stability of the system suggested is theoretically shown. [7]

3. Droop Controller Method

It is autonomous approach for controlling the frequency and voltage amplitude of the generator connected to micro grid. It takes the advantages that real power controls frequency and that the reactive power controls the voltage. The power sharing can be done by the droop control method by using the real power controller and reactive power controller. [8].

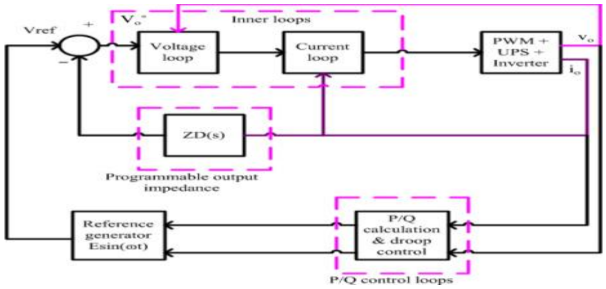


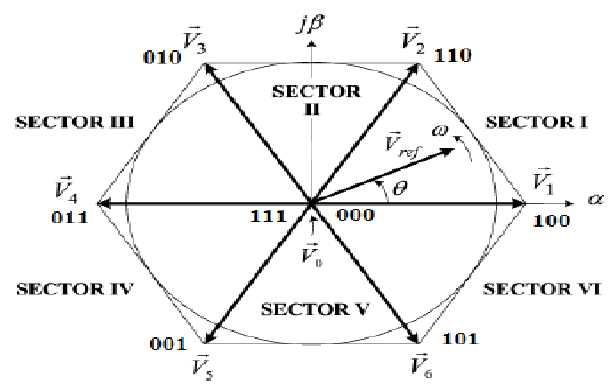
Figure 2 Droop Controller Technique

The total harmonic distortion (THD) at the point of common coupling are minimized for the stand-alone and system relating the problem on reactive power sharing. The capacitive virtual impedance loop is used to control the voltage harmonics which occurs at PCC. In grid connected mode, the current control loop is applied to flow the active and reactive power for the power grid and frequency operation. In autonomous mode, power converters are used for operation in three sub-moles like convection droop mode, PCS mode and synchronization mode. The (Vg\Vdc) droop control which provides the dc link voltage at inverter output to maintain the power in micro grid. P-Vg droop control maintains the voltage limiting the constant power band. The hierarchical control consist voltage droop control and impedance control loop for VSI based MG system .These maintaining the phase angle and voltage reference of real power and reactive power. Virtual inductor is used for inverter output of power electronic devices connect to DG system which disconnect the coupling between real and reactive power. An enhanced droop control based on virtual impedance for controlling the frequency to minimize the reactive power load, unbalanced power load and distorted harmonic power load issues.[9]

4. Methodology

Space Vector Modulation

The idea of space vector is developed from the induction machine rotating magnetic field. Three phase volumes are converted into two phase volumes. Active and zero vectors may be represented correspondingly by active and zero space vectors. Typical two-level VSI space vector architecture is given in the figure. The six V1 to V6 vectors form a symmetrical hexagon of identical sections (1 to 6). Each sector is divided into 60 degrees. [10]
From Figure, Vref is the reference voltage vector which used to control the magnitude and frequency of fundamental voltage



Figurer 3 schema of space vector for two-level VSI

4.1 Role of SVPWM in Micro Grid

Technology evolution, environmental concerns associated with central electric power plants and deregulation of the electric utility industry are providing the opportunity for renewable energy resources to become very important in order to satisfy the on – site customer expanding power demand. From the utility point of view, application of distributed energy sources can potentially reduce the demand for distribution and transmission facilities. Clearly, distributed generating placed near loads will decrease transmittal and distribution circuit flows with two major effects: loss reduction and possible network assets replacement. [11-13]
Micrograms may assist the network in times of stress by reducing congestion and supporting fault recovery. The development of microgrids may help to emission reductions and climate change mitigation. This is because technologies for distributed generating units are available and are presently being developed based on renewable sources and micro sources with high emissions.

4.2 Advantages of SVPWM

Space vector PWM is considered a better technique of PWM implementation owing to its associated advantages mentioned below:
Better fundamental output voltage.
Improved harmonic spectrum.
· Easier implementation in Digital Signal Processor and Microcontrollers.
Conventional techniques involve look up tables for achieving this optimum switching sequence.

5. Simulation Results and Discussion

The simulation test results are presented in this section to show the effectiveness of the proposed SVPWM controller. Offline digital time-domain simulations were carried out in MATLAB/SIMULINK and experimental tests were conducted to verify the results of the simulations. And with the help of FFT analysis, SPWM Controller and SVPWM Controller are compared.

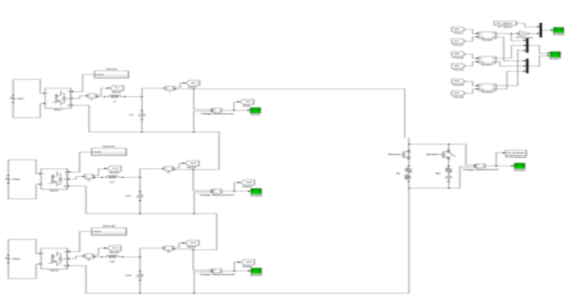


Figure 4 Proposed test systems with three modules in series

The above is the proposed three-inverter module connected in series for output voltage generation. The below is the controller with sinusoidal PMW technique.

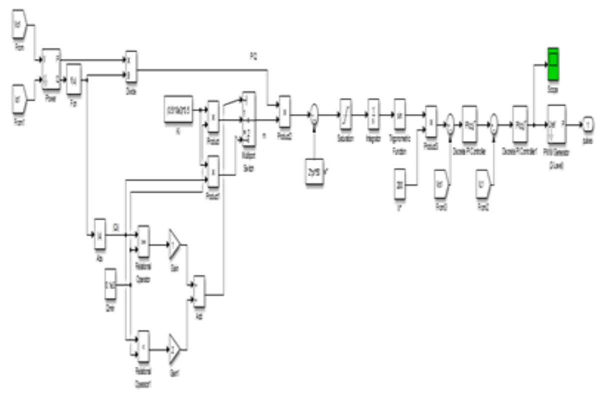


Figure 5 Proposed PQ droop controller with SVPWM technique

The above is the controller updated with Space vector PWM technique replacing conventional Spwm technique.

The THDs of the output voltages are analyzed using FFT analysis for both the controllers.

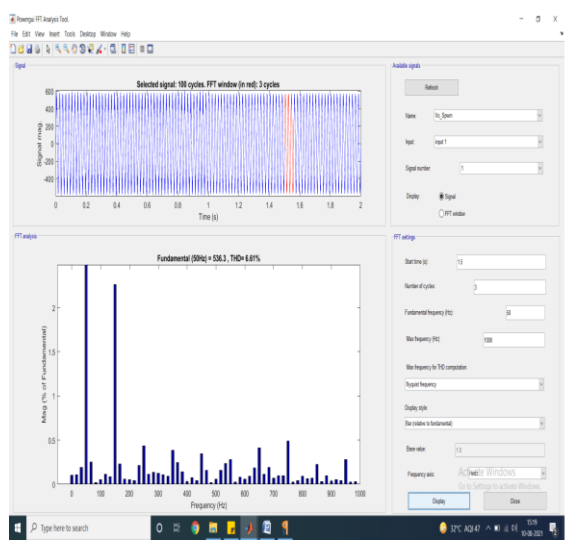


Figure 6 THD of output voltage with SPWM technique

The above is the FFT analysis of the output voltage at the load when the three series connected modules is operated with SPWM technique which is recorded at 6.61%. Later by updating the SPWM with SVPWM the harmonics of the load voltage is gradually decreased to very low value of 0.4% which can be seen below.

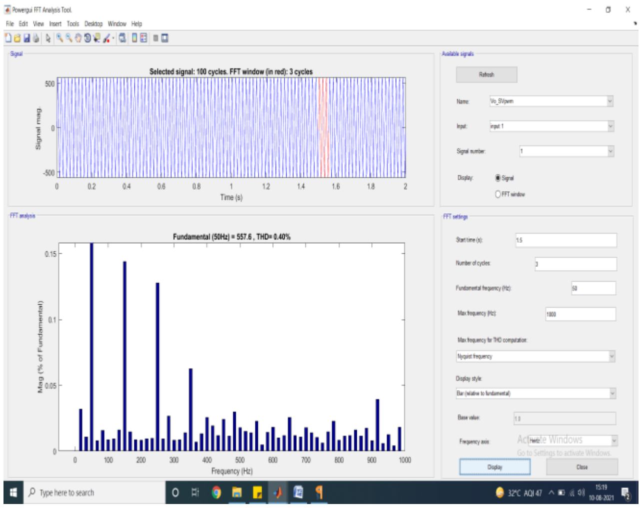


Figure 7 THD of output voltage with SVPWM technique

6. Conclusion

As per the above results the SVPWM technique module has fewer ripples in active power and lower THD in the output voltage. It realizes accurate real-power and reactive-power balance under both resistive-inductive and resistive-capacitive loads autonomously. Meanwhile, it is convenient to regulate the ac bus voltage. The method will ensure in accurate power sharing even if the communication is interrupted. If the load changes while the communication is interrupted, the accuracy of power sharing is reduced but the proposed method is better than the conventional droop control method. In addition, the accuracy of power sharing base on the proposed method is not affected by the time delay in the communication channel and local loads. The THD of the output voltage with SPWm is 6.61% and with SV pwm is 0.4% which is better and very less.

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