VOLTAGE-FREQUENCY AND REAL / REACTIVE POWER CONTROL OF PHOTOVOLTAIC SYSTEM

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Abstract
A control scheme for photovoltaic (PV) system using maximum power point tracking is presented in this paper. Also, real and reactive power control for the system is discussed. Frequency and voltage support is provided by this system on the load side. These control strategies illustrate the efficient synchronization among inverter voltage/frequency, real/reactive power control and maximum power point tracking control.

Key Words : Real and reactive power control, maximum power point tracking, voltage and frequency control, photovoltaic, battery storage.

1 INTRODUCTION
The common power electronic resources used in a power system are PV array, fuel Cell or turbines. The micro source controllers are used in the inter connection of these resources and storage devices. The synchronization amongst these resources is done through a
central controller. The load is connected to the grid through circuit breakers.

The recent researchers interest in this area is the voltage-frequency and real / reactive power control of inverter power to improve the system performance\(^1\). Voltage-frequency or real / reactive power control for a photovoltaic system with maximum power point tracking is not handled in the past publications. Earlier publications in this area lack the voltage-frequency control of energy storage element.

The maximum power point tracking algorithm for dual axis solar tracking system is dealt in\(^2\). Voltage-frequency or real / reactive power control is used at the inverter side\(^3\), maximum power point tracking control technique is used at the photovoltaic side. In\(^4,5\), fuzzy logic technique based machine modeling is presented.

In this paper, the models of PV, battery, inverter and converter are discussed. The control algorithm for maximum power point tracking of PV unit is proposed. The synchronization between each of these control techniques is the originality of this paper. The output of inverter is maintained at desired voltage level by controlling the inverters input voltage.

\section{2 \textbf{CONTROL OF SOLAR GENERATORS}}

The one diode\(^6\) based solar PV model, real / reactive power control algorithm and maximum power point tracking control integrated with voltage control for PV unit are presented in this section. The results for simulation are also discussed.
Figure 1 shows the PV model configuration with real / reactive power control. Single stage pattern is used in this system. Kaki-moto et al\(^7\) developed a control algorithms for the same.

A coupling inductor \(L_c\) is used to connect the PV structure across grid. This arrangement is used to suppress current ripples from the solar system output.

The solar photovoltaic model with double stage configuration for P-V control is shown in Figure 2.
Figure 2: P-V Control of Integrated PV system

The rest of the model is shown as an infinite voltage source with an impedance of $R + jX_L$. A capacitor is used as a DC link and connected between the PV source and inverter. The real source is the photovoltaic unit and the reactive source is the capacitor bank. By proper current control scheme applied to the inverter, the required amount of power is drawn from the system.
3 POWER CONTROL METHOD

The block diagram of power control system is shown in Figure 3. In (1), \(v_i(t)\) represents the input voltage and \(v_o(t)\) represents the output voltage.

\[
v_i(t) = -2v_i(t) \cos(\omega t) \quad (1)
\]

\[
v_o(t) = -2v_o(t) \cos(\omega t + \alpha) \quad (2)
\]

These factors are applicable in both steady state and transient state, since they are all time variant.

4 MAXIMUM POWER POINT TRACKING AND BATTERY INTEGRATED VOLTAGE CONTROL METHODS

Only 30% of the input light energy is transformed into useful electrical output in a normal solar system without a controller. Maximum power point tracking scheme improves the efficiency of the photovoltaic system by increasing the percentage of solar rays irradiant on the panels. Two stages of control are implemented, maximum
power point tracking and inverter voltage control for management of battery power.

It works on the principle of matching impedance at load and source. The converter is adjusted suitably to achieve impedance matching and hence maximum power.

![Proposed System Configuration with maximum power point tracking](image)

**Figure 4:** Proposed System Configuration with maximum power point tracking

![Flowchart for P&O algorithm](image)

**Figure 5:** Flowchart for P&O algorithm. D is the step of the perturbation
The proposed system with maximum power point tracking and integrated voltage control methods is shown in Figure.4. Most of these methods are based on the P&O method. This algorithm is simple to implement. It is an iterative method. Figure.5 shows the flowchart for this. The photovoltaic systems voltage is disturbed by a small increment and the resulting change is measured. If it is a positive change, the voltage with the applied disturbance is to be along the direction of increment. If it is a negative change, the obtained operating point is shifted away from the former set position. The direction of increment and the operating voltage are to be in exactly opposite directions. The voltage is reduced and moved to point B. For the increase in irradiance level there is a subsequent increase in power in the positive direction. Hence, operating point to moves from position B to C. In this way, raise in heat rays shifts the maximum power from position to position. This process continues in an iterative manner until the increase in irradiance stops.

5 RESULTS AND DISCUSSION

The fuzzy logic based voltage and frequency control is exposed in Figure.6. Figure.7 shows the fuzzy controller for v / f control and power control. The solar panels output voltage is shown in Figure.8. The input voltage of inverter is shown in Figure.9. The output voltage and current waveforms of the inverter are shown in Figure.10. The real and reactive powers of load and inverter are depicted in Figures 11 and 12 respectively. Figure.13 depicts the load voltage.

Figure 6: Voltage-frequency control using Fuzzy logic
Figure 7: Voltage-frequency and real / reactive power Control using Fuzzy controller for 3 phase loads

Figure 8: PV panel voltage
Figure 9: Input voltage to the inverter

Figure 10: Output voltage and current of Inverter
Figure 11: Real and Reactive power of Load

Figure 12: Real and Reactive power of Inverter
6 CONCLUSION

Real and reactive power control based photovoltaic system is presented in this paper. The results are presented for the simulated system. The steady state and transient behavior of the PV system is also presented. It is shown that the real and reactive power control is advantageous in maintaining the voltage stability and power flow control in power systems.

A voltage-frequency control algorithm for a maximum power point tracking controlled photovoltaic system is presented. The method of maximum power point tracking control is integrated with the real / reactive power control algorithm to support critical loads. From the obtained results, the effectiveness of this control technique is clearly observed.

References


