Boost Converter with MPPT and PWM Inverter for Photovoltaic system

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Abstract—This paper presents boost converter with maximum power point tracking technique for photovoltaic system to extract maximum power from solar panel, and the system is connected with battery storage system, and cascaded with PWM inverter along with an RC low pass passive filter which outputs a stable AC voltage, which is not possible in traditional PV inverter system. The circuit operation principle, control strategy, and characteristics of the system are analysed in detail. Simulation results are shown to verify the theoretical analysis.

Index Terms—pulse width modulation (PWM), maximum power point tracking (MPPT), boost converter, passive filter (RLC), grid.

I. INTRODUCTION

As people are much concerned with the environmental problems and the fossil fuel exhaustion because of the conventional power generation, Renewable energy sources are becoming widely popular, due to which the cost of renewable energy sources are dropping, and new technologies are developed to efficiently utilize renewable energy sources2. Apart from power generation renewable energy sources are used in transportation system also. The photovoltaic solar panel is widely used in many grid connected and stand-alone application. It has several advantages like no noise, no installation area limitation, and no additional maintenance cost but its installation cost is high and low efficiency and also due to non-linear characteristic it requires maximum power point Tracking. There are many different types of MPPT algorithms based on simplicity, time taken, and stability [6]. The DC-DC boost converter can achieve high boost gain, however high gain is restricted be switches used. The PWM inverter with RC low pass passive filter outputs almost sinusoidal output waveform.

The output can be either used for standalone load or can be integrated with power grid. Before connecting the system with power grid the output should synchronized with grid parameters [1].

This paper presents boost converter controlled with MPPT and SPWM inverter with RC low pass passive filter to ensure a sinusoidal output. The benefit of this paper is to give access to a pollution free source of energy.

II. DESIGN AND CONTROL STRATEGY

A. Photovoltaic cell

The electrical equivalent circuit of photovoltaic cell can be expressed in many ways, the simplest circuit is as shown below.

\[ I_L = I_{ph} - I_D \]
Where, \( I_l \) is load current, \( I_{ph} \) is photo current and \( I_d \) is diode current. Voltage and current varies as per solar irradiance and temperature.

**B. Boost converter**

The boost converter is a switching circuit which is used to step-ups DC voltage.

![Fig 3. Boost converter](image)

\[
V_o = \frac{V_s}{1 - D} \tag{2}
\]

The outpour voltage \((v_o)\) depends on input voltage \((v_i)\) and duty cycleratio \((D)\). The values of inductor and capacitor can be calculated by using below equations by choosing a constant switchingfrequency \((f)\), and \((\Delta V_o/V_o)\) output voltage ripple should be suitably selected.

\[
C = \frac{D}{R \left( \frac{\Delta V_o}{V_o} \right) f} \tag{3}
\]

\[
L = \frac{D(1 - D)^2 R}{2f} \tag{4}
\]

**C. Maximum power point tracking (MPPT)**

MPPT works on Maximum power transfer theorem which stats that output power will be maximum if input parameters and output parameters are matched. The principle of working is as voltage and current of PV cell will be varying based on solar parameters the MPPT will be designed in such a way that it finds maximum power point of cell for different voltage and current by estimating power and gives signal to control boost converter to work in maximum efficiency condition. There are different ways of doing so, but perturb and observer method is simplest. The flow chart for perturb and observers as shown below.

![Fig 4. Flow chart of perturb and observers method](image)

**D. PWM Inverter and Filter circuit**

![Fig 5. Single phase Inverter circuit](image)

The single phase full bridge inverter consists of four switches, controlled using PWM signals, the switches can be selected based on power rating of the circuit. The PWM signals are result of two signals merging namely reference signal and carrier signal, the two signal will be of different parameters merged to get desired PWM signal as shown below.

![Diagram](image)
The generated PWM signal is given to $S_1$ and $S_2$, and the same signal is complemented and given to $S_3$ and $S_4$, by doing so we can avoid short circuit caused by improper operation of switches.

The filter used is a passive filter consisting of Resistor and Capacitor. The filter is low pass type, it is made to resonate ($f_0$) close to fundamental frequency that is 4 to 5 times of fundamental frequency and values of resistor and capacitor values are calculated by keeping one constant.

$$f_0 = \frac{1}{2\pi RC} \quad (5)$$

### III. SIMULATION RESULT

The simulation is performed in MATLAB user interface, the circuit is built in matlab and executed, the setup is built using following parameter values as shown in the below table which are designed using above formulas, and the results are shown. FFT analysis is done in matlab to check THD percentage in the output voltage. The THD is 6.5% which is near to standard value that is 5%.

<table>
<thead>
<tr>
<th>Specification details</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum Power $P_o$</td>
<td>100W</td>
</tr>
<tr>
<td>PV cell voltage $V_{PV}$</td>
<td>17v</td>
</tr>
<tr>
<td>Converter output voltage $V_{OC}$</td>
<td>39v</td>
</tr>
<tr>
<td>Switching frequency controller $f$</td>
<td>25Khz</td>
</tr>
<tr>
<td>Converter inductor and capacitor $(L, C)$</td>
<td>$(126\mu F, 40\mu F)$</td>
</tr>
<tr>
<td>Battery $V_{Bat}$</td>
<td>36v</td>
</tr>
<tr>
<td>Filter parameters $(R, C)$</td>
<td>$(170\Omega, 4.7\mu F)$</td>
</tr>
<tr>
<td>Output parameters $(V_p, V_{RMS})$</td>
<td>$(336v, 230v)$</td>
</tr>
</tbody>
</table>

![Simulation circuit diagram](Fig 7. Simulation circuit)
IV. CONCLUSION

This paper presents a photovoltaic system with boost converter controlled by MPPT circuit based on perturb and observer method for better efficiency and stability, single phase full bridge PWM Inverter which performs inversion, by designing passive filter properly we get stable sinusoidal output voltage. The output can be used for stand-alone load or for connecting to grid after synchronising with grid parameters.
REFERENCES


