IMPLEMENTATION OF FIVE LEVEL INVERTER CONSIDERING PV SYSTEM USING MPPT TECHNIQUE

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ABSTRACT
This paper exposes a single phase five level inverter for PV scheme with a new pulse width modulation control scheme. The inverter capability is used to five steps of producing voltages (V_{dc}/2, V_{dc}, 0, -V_{dc}/2,-V_{dc}) from the input voltage. Maximum Power Point Tracking (MPPT) was implemented in Photovoltaic’s system along Fuzzy controller. The excepted scheme was proved over simulation along with carryout in a model.

Keywords: photovoltaic (PV) system, MPPT, multilevel inverter, fuzzy logic controller, pulse width modulation (PWM), total harmonic distortion (THD).

I. INTRODUCTION
Energy is essential information in the process of monetary, civil along with technical and improvement. Energy utilization is growing appropriate rapidly, Fossil fuels supply will be depleted in few hundred years and energy crisis problem will be created in the world. Therefore renewable energy resources are essential to develop for energy requirements. Inexhaustible energy generation schemes, particular kind of system is photovoltaic. Similarly a scheme reproduces electric power from modifying sunlight into electric power [1].

2. PHOTOVOLTAIC CELL
2.1 PV modeling
A Photo Electric arrange in the collection of varying photovoltaic cells in series and parallel network.

\[
I = I_{SC} - I_d = I_{SC} - I_0 \left( e^{QV_{d}/KT} - 1 \right)
\]

Where,
- \( I_d \) = Reverse saturation current of the diode,
- \( I_{SC} \) = short circuit current,
- \( I \) = photovoltaic cell current,
- \( V \) = PV cell voltage,
- \( Q \) = Electron charge,
- \( V_d \) = Voltage across the diode,
- \( K \) = Boltzmann constant (1.38*10^{-19}J/K),
- \( T \) = Junction Temperature in Kelvin (K)

Solar photovoltaic systems can be dispatched energy to loads over multilevel inverter. A single phase five level converter is mostly used for domestic and small power applications in the ranges that are 10KW [2].

Figure-1. Block diagram of PV system with hybrid converter.

In Series network are in charge being developing the voltage of the section when the parallel network is in charge of raising the current in the supply. Usually a Photovoltaic cell is assembled with the use of a current source as well as an inverted diode joined in parallel into it. It has an individual series and parallel resistance. Series resistance is exactly towards check smart way of the movement of electrons from n to p junction and parallel resistance is through the effluent current [6]. In this circuit we examine a current source (I) additionally a diode and series resistance (R_s). The output current from the photovoltaic array is

\[
I_s = I_{SC} - I_0 \left( e^{QV_{d}/KT} - 1 \right)
\]

(1)

\[
I_d = I_0 \left( e^{QV_{d}/KT} - 1 \right)
\]

(2)

Figure-2. Schematic diagram of photovoltaic cell.

\[
I = I_{SC} - I_0 \left( e^{QV_{d}/KT} - 1 \right)
\]

(3)

Figure-3. V-1 Characteristics of solar panel.
Figure-4. P-V characteristics curve of photovoltaic cell.

The point indicates the best power point at which the output power is high in photo voltaic cell

3. MAXIMUM POWER POINT TRACKING (MPPT)

MPPT implies Maximum Power Point Tracking. MPPT is a power electronic system consisting of a DC chopper (DC-DC converter) to have variable DC from a fixed DC. With control circuitry which controls the output voltage (DC) by controlling duty cycle of DC-DC converter. MPPT stabilizes the voltage for proper operation of load or charging of battery bank irrespective of weather conditions and temperature. MPPT is the interconnection between PV array and electrical load. Load may be battery bank, direct DC load or transmitted to the grid.

It is especially adequate during low light level conditions. These computations result into an output that brings maximum current at the prescribed voltage at each period in time. Low light level situations it will satisfy for the low light level meanwhile detect the current point at which the solar cell gives its optimum power output.

4. MPPT FUZZY LOGIC BASED CONTROLLER

MPPT Fuzzy Logic Controller was constructed and simulated using the Fuzzy Logic Simulink Toolbox represented in figure.

Figure-5. General diagram of fuzzy controller MPPT MATLAB.

Fuzzy logic is simple and robust than conventional PI controller. It is the suitable replacement for the conventional controller. The fuzzy logic controller is consisting of fuzzification, inference & defuzzification. The voltage and change in voltage of the proposed system is taken as an input and duty cycle for the buck converter is considered as an output. Fuzzy rule base is formed as shown in Table-1. Where row represents voltage and column represents change in voltage [5].

The rule base consists of seven membership function for both input and output. Totally forty nine rules formed to get the better duty cycle with variations in the input. Here fuzzy linguistic variable can be expanded as follows.

- NB is Negative Big
- NM is Negative Medium
- NS is Negative Small
- Z is Zero
- PS is Positive Small
- PM is Positive Medium
- PB is Positive Big

The rule formation of fuzzy controller is given in Table-1.

The error in voltage ($\Delta v = v_{ref} - v_{act}$) has been computed by analyzing the actual voltage along the
reference voltage. The voltage error and the change in voltage error are the inputs of fuzzy controller and the output is the suitable change in PWM signal. The formation of fuzzy controller is shown in Figure-6.

Figure-6. Fuzzy logic controller.

5. PROPOSED MULTILEVEL INVERTER METHODOLOGY

Multilevel inverter is able to satisfy specifications using very high switches, but increase switching losses due to very high switches, disturbance (or) noise, Electromagnetic interference (EMI) to another equipment. Developing its output waveform, cut down its harmonic levels, reduces switches and smaller filter capacity is used.

To obtain a quality output voltage waveforms (or) output current waveforms with minimum amount of ripple content, it’s desire high switching frequency additionally various PWM techniques. In this system switching losses are less than the three level inverters, lower filter capacity, less EMI, less total harmonic distortion (THD) complete of which make them compact and economically satisfied.

Different methods for many level inverters have been presented past years. Typical types of many level inverters are Diode clamped, Flying Capacitors, and cascaded multilevel inverter. This paper development of altered H-bridge single phase multilevel inverter has two diode enclosed bidirectional switches along with PWM mode. The methodology was enforced to PV system with MPPT and fuzzy logic controller.

The required five level of output voltages were developed as follows.

Maximal positive output (Vdc): S1 is towards joined the load positive fatal through Vdc and S4 is towards joined the load negative fatal through ground. Entire another controlled switch is absent. The voltage activated through the load fatal is Vdc. Figure-8(a) view the current direction that are operating on the indicated point.

Figure-8(a). Mode 1.

Half of the positive output (Vdc/2): The bidirectional switch S5 is towards joined the load positive fatal through Vdc and S4 is towards joined the load negative fatal through ground. Entire another controlled switch is absent. The voltage activated through the load fatal is Vdc/2 Figure-8(b) Views the current direction that are operating on the indicated point.

Figure-8(b). Mode 2.

Zero output: The indicated level can be formed by two switching sequences. Switches S1 and S2 are upon (or) S3 and S4 are upon and all another controlled switch is absent. The fatal ab is short circuit and the voltage activated to the load fatal is zero. Figure-8(c) views the current direction that are operating on the indicated point.

Figure-8(c). Mode 3.
Half of the negative output (-V_{dc}/2): The switch S_3 is towards joined the load positive fatal through V_{dc} and the bidirectional switch S_5 is towards joined the load negative fatal through ground. Entire another controlled switch is absent. The voltage activated through the load terminals is -V_{dc}/2 Figure-8(d) views the current direction that are operating on the indicated point.

Maximal negative output (-V_{dc}): S_3 is towards joined the load positive fatal through V_{dc} and S_2 is towards joined the load negative fatal through ground. Entire another controlled switch is absent. The voltage activated through the load fatal is -V_{dc} Figure-8(e) views the current direction that are operating on the indicated point.

### 6. SIMULATION CIRCUIT AND RESULTS

The simulation circuit for expected single-phase five-level inverter topography is shown in Figure-16. Simulations were implemented by using MATLAB SIMULINK and it also helps to verify the PWM switching action. The converter (DC to AC) accepts a full-bridge structure including an ancillary circuit. PV arrays are joined through the converter (DC to AC) via a DC–DC boost converter.

### Table 1: Switching table for 5-level inverter

<table>
<thead>
<tr>
<th>Modes</th>
<th>S1</th>
<th>S2</th>
<th>S3</th>
<th>S4</th>
<th>S5</th>
<th>Voltage Levels</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mode 1</td>
<td>ON</td>
<td>OFF</td>
<td>OFF</td>
<td>ON</td>
<td>OFF</td>
<td>V_{dc}</td>
</tr>
<tr>
<td>Mode 2</td>
<td>OFF</td>
<td>OFF</td>
<td>OFF</td>
<td>ON</td>
<td>ON</td>
<td>V_{dc}/2</td>
</tr>
<tr>
<td>Mode 3</td>
<td>OFF</td>
<td>ON</td>
<td>OFF</td>
<td>ON</td>
<td>OFF</td>
<td>Zero</td>
</tr>
<tr>
<td>Mode 4</td>
<td>OFF</td>
<td>OFF</td>
<td>ON</td>
<td>OFF</td>
<td>ON</td>
<td>-V_{dc}/2</td>
</tr>
<tr>
<td>Mode 5</td>
<td>OFF</td>
<td>ON</td>
<td>ON</td>
<td>OFF</td>
<td>OFF</td>
<td>-V_{dc}</td>
</tr>
</tbody>
</table>
7. PROTEUS MODEL OF IBC WITH MULTILEVEL INVERTER

Figure-19. Development of Five level inverter in proteus software.
inverter is fewer related with that in the three level inverter in simulation results.

REFERENCES


