Grid-connected Pv System For Pid Controller Using Matlab

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Abstract

This paper presents a single-phase five-level photo-voltaic (PV) inverter topology for grid-connected system. The photo-voltaic arrays are connected to fivelevel inverter. By implementing maximum power point tracking algorithm are producing more power from PV array. The DC power from the PV array is applied to PWM inverter, which is controlled by PID controller. The output of inverter is AC supply, it's connected to grid. A digital proportional–integral– derivative current control algorithm is implemented in MATLAB version7.5. For dynamic performance of the grid current will be almost sinusoidal. The total harmonic distortion produce by inverter will be less.

Keywords: Photovoltaic array, PID current controller, PWM multilevel inverter and MATLAB 7.5.

I. Introduction

In recent year, the demand for renewable energy is more because of shortage of fossil fuels. The renewable energy source is long effective life, maintenance free and do not create pollution. The solar energy is most effective power generation compare other renewable energy sources. The solar energy is directly converted to electric energy. The photo-voltaic energy conversion technology is the most useful way of harnessing solar photovoltaic cells. The photo-voltaic cells are generating DC electricity without involvement of any mechanical generators. The electrical energy output from solar PV cells depends upon the intensity of sunlight incident on conversion efficiency and temperature of operation. Energy conversion devices are used to convert sunlight to electricity by the use of the photo-voltaic effect. The maximum power point tracking algorithm is implemented to maximum energy obtained for PV arrays.

The PV array output power is applied to multilevel inverter. The inverter is used to conversion of DC to AC voltage. The cascaded H-bridge inverter is one of the common methods; it's used proposed inverter topology. The modulation and control strategies have been developed sinusoidal PWM. A five-level PWM inverter output voltage can be represented in the following five levels: zero, +1/2Vdc, +Vdc, -1/2Vdc, and -Vdc. This inverter topology uses two reference signals, instead of one reference signal, to generate PWM signals for the switches. Both the reference signals Vref1 and Vref2 are identical to each other, except for an offset value equivalent to the amplitude of the carrier signal Vcarrier. Because the inverter is used in a PV system, a proportional–integral–derivative (PID) current control scheme isemployed to keep the output current sinusoidal and to have high dynamic performance under rapidly changing atmospheric conditions and to maintain the power factor at near unity.

Simulation results are presented to validate the proposed inverter configuration. The inverter offer lower total harmonics distortion (THD) and quality of power.

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II. Photovoltaic Model

Solar cell is basically a p-n junction fabricated in a thin wafer or layer of semiconductor. The electromagnetic radiation of solar energy can be directly converted electricity through photovoltaic effect. Being exposed to the sunlight, photons with energy greater then the band-gap energy of the semiconductor are absorbed and create some electron-hole pairs proportional to the incident irradiation. Under the influence of the internal electric fields of the p-n junction, these carriers are swept apart and create a photocurrent which is directly proportional to solar insolation. PV system naturally exhibits a nonlinear I-V and P-V characteristics which vary with the radiant intensity and cell temperature.

Since a typical PV cell produces less than 2W at 0.5V approximately, the cells must be connected in series-parallel configuration on a module to produce enough high power. A PV array is a group of several PV modules which are electrically connected in series and parallel circuits to generate the required current and voltage. The equivalent circuit for the solar module arranged in NP parallel and NS series is shown in Figure1. The equivalent circuit for the solar module and maximum power point algorithm is implemented to MATLAB. The equivalent circuit is described on the following equation

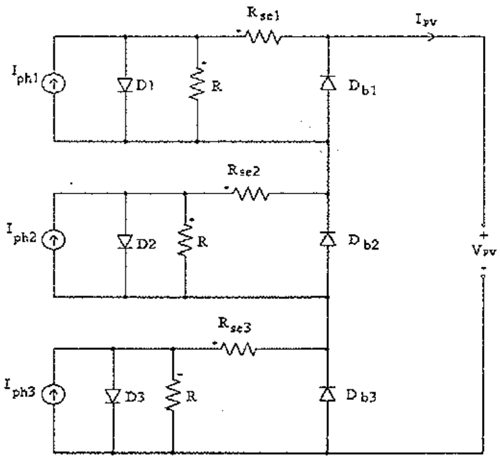

Figure1. Series Connected PV Array with bypass diodes

III. Proposed Inverter Topology

The proposed inverter topology is consists of PV array, five-level H-bridge inverter, grid system as shown in figure2. The PV array is generated dc supply through solar energy. The DC supply is applied to five-level inverter through dc bus capacitor. The five-level inverter is used to conversion of DC to AC voltage. The ac voltage is connected to utility feeder through filtering inductor. The injected current must be sinusoidal with low harmonic distortion. The load is considered as resistive and inductive load.

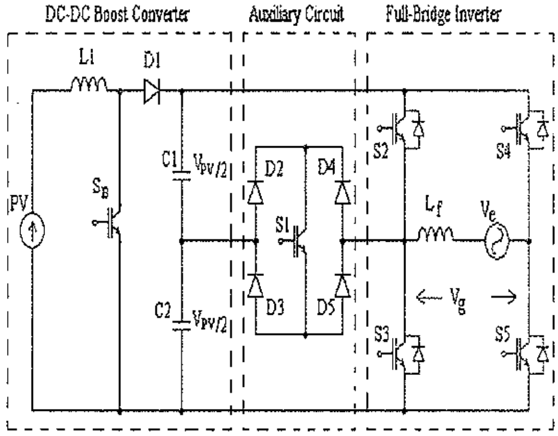

Figure 2 : Proposed inverter topology

IV. Modulation Technique And Operation Of Proposed Inverter

A sinusoidal PWM is used, it is one of the most efficient method. Two reference signals Vref1 and Vref2 and triangular carrier signal Vcarrier were used to generate the PWM switching signals. The modulation index Ma is maintained between 0 to1. The output voltage produced by comparison of the two reference signals and the carrier signals can be expressed as fourier series coefficient,

$$V_o(\theta)=A_o+\sum_{n=1}^{\infty}(A_n\cos n\theta+B_n\sin n\theta) \quad (2)$$

n-even number, so $A_o=0$, $B_n=0$

$$V_o(\theta)=\sum_{n=1,3..}^{\infty}(A_n\cos n\theta) \quad (3)$$

$$A_n=4V_{pv}/n\pi\sum_{m=1}^{p}[(-1)^{m}\sin(n\alpha_m)] \quad (4)$$

where, m is a pulse number, ± is the phase angle displacement.

In this work, two reference modulation techniques is incorporated into the sinusoidal PWM technique to produce PWM switching signals for full-bridge inverter switches and auxiliary switch. Switching pattern for the single-phase five-level inverter is shown in figure3.

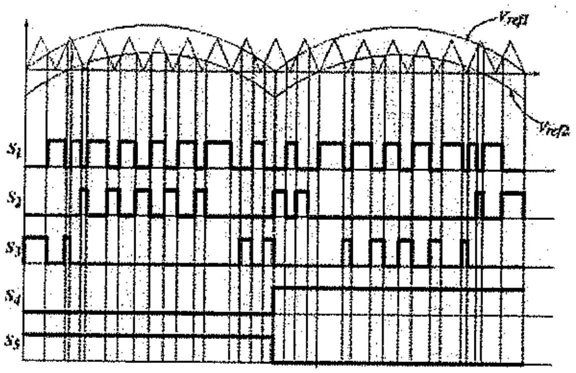

Figure 3 : Switching pattern for the single-phase five level inverter

The proposed inverter is generate five- level output voltage i.e. 0, +Vpv/2, +Vpv, -Vpv/2, and -Vpv. The auxiliary circuit is consists of four diodes and switch S1, it is generate half level of PV supply voltage i.e. +Vpv/2, -Vpv/2. The five-level inverter output voltage Vinv is shown in figure4. Table I illustrates the level of Vinv during S1-S5 switch ON and OFF. The ideal five-level inverter output voltage is shown in figure4.

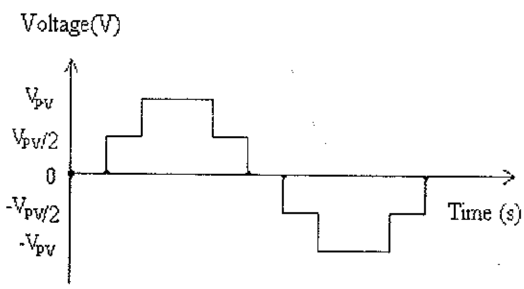

Figure 4 : Ideal five-level inverter output voltage Vinv

TABLE I
INVERTER OUTPUT VOLTAGE DURING S1"S5 SWITCH ON AND OFF

S_1	S_2	S_3	S_4	S_5	V_{inv}
ON	OFF	OFF	OFF	ON	$+V_{pv}/2$
OFF	ON	OFF	OFF	ON	$+V_{pv}$
OFF	OFF or (ON)	OFF or (ON)	ON or (OFF)	ON or (OFF)	0
ON	OFF	OFF	ON	OFF	$-V_{pv}/2$
OFF	OFF	ON	ON	OFF	$-V_{pv}/2$

V. Control System And Algorithm

The proposed inverter is used to gridconnected PV system. So the power is injected to the grid, it is maintain the power factor at near unity. As the irradiance level is inconsistent throughout the day, the amount of electric power generated by the solar modules is always changing with weather conditions. To overcome this problem, maximum power point tracking (MPPT) algorithm is used. The perturb and observe algorithm is used to extract maximum power from the PV modules. The feedback controller used in this application utilizes the PID algorithm. The proposed inverter is the current injected into the grid, grid current Ig is sensed and feed back to a comparator which compares it with the reference current Iref. Iref is obtained by sensing the grid voltage and converting it to reference current and multiplying it with constant m. This is to ensure that Ig is in phase with grid voltage Vg and always at near-unity power factor. All the algorithm are developed in C++ language and its implemented to MATLAB version7.5.

Formula :

The PID algorithm can be expressed in the continuous time domain as,

$$u(t)=K_p e(t)+K_i \int_0^t e(\tau)\, d\tau + K_d \frac{d}{dt} e(t) \quad (5)$$

where, u(t)-control signal, e(t)-error signal, tcontinuous-time-domain time variable, τ - calculus variable of integration, Kpproportional- mode control gain, Ki-integralmode control gain, Kd-derivative-mode control gain.

VI. Simulation Results

The proposed system was performed by using MATLAB. The DC output of the PV array is applied five-level inverter. A fivelevel inverter inverts DC supply to AC supply. The outputs of the inverter are 230V and 50HZ for voltage and frequency respectively. The simulation five-level output as shown in figure5. The grid current is almost a pure sine wave as shown in figure6. The total harmonic distortion can be analyzed in PID current control scheme. The PID current controller was produce low harmonic distortion and sudden step response as shown in figure7. The power factor can be calculated using mathematical calculation. The power factor is near unity.

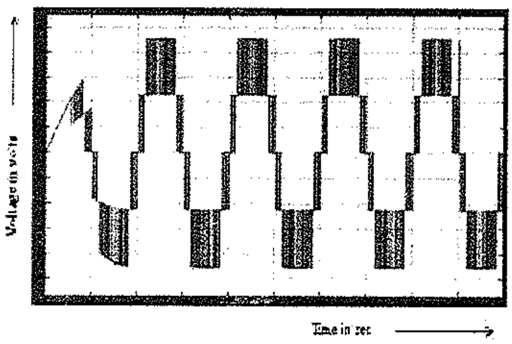

Figure 5 : Proposed inverter output voltage

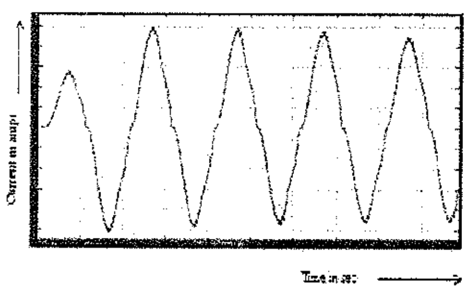

Figure 6 : Grid current

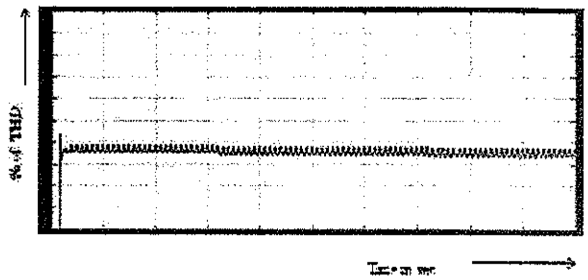

Figure 7 : THD in PID current control scheme

VII. Conclusion

This paper presents a single-phase five-level photo-voltaic (PV) inverter topology for gridconnected application. The photovoltaic models, operation of proposed inverter topology, control system algorithm, modulation technique and simulation results were analyzed. The control system algorithms are developed in C++ language and it's implemented in MATLAB version7.5. The PID current controller was producing low harmonic distortion and sudden step response. The grid current is almost sine wave and the power factor also near unity.

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