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Research paper

Transformer less 1Φ Inverter for Grid-Connected PV Systems with an Optimized Control

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Abstract

This paper investigates the transformerless single-phase inverter incorporates with the photovoltaic system along with the support of grid voltage. Solar Energy is a Non-Conventional Energy source which is mandatory for power generation due to their immeasurable parade and green pleasant nature. One-cycle control (OCC), Ruggedness and consistency which makes the interfacing with the grid easily. For grid interfacing, the inverter circuit does not need phase locked loop facility and are gradually being working for such solicitations. The strategy of the OCC inverter of one stage for solar PV applications is supported by means of a Sinusoidal Pulse Width Modulation to enhance inverter enactment at both low and high insolation levels. These factors allows the plan of a MPPT along P&O controller that pointedly progresses inverter playacting. Though, the OCC-based structures testified previous sensing of the grid voltage which slightly equalizers the strength of its characteristics, In order to dazed the restriction of prior researches, an One Cycle Control based grid-connected one-stage PV system is suggested. The sustainability of the suggested scheme is inveterate by performance simulation justification.

Keywords: *Photovoltaic module, Maximum-power-point tracking, One-cycle control, PWM.*

1. Introduction

Non-Conventional energy sources, a perceptible growing of minor photovoltaic, power plants coupled to low-voltage distribution networks is estimated in the imminent. A one-cycle control (OCC) technique is applied to single-stage inverter, it has been obtainable, and those are investigated from the past few years. The theoretical investigations of an existing inverter, described in, is not in-detail. Thus, it does not permit suitable enactment both in positions of injected current quality into the grid and power extracted from the photovoltaic array. Wherein an important enhancement of the theoretical model has been suggested for the further enhancement of the photovoltaic power extracted model and to decrease the distortion in the single phase grid injected current. Results obtained from the simulation have established that the variable sets aiding one-cycle controller operation can be boosted to get closely maximum power at peak average power. Additionally it as highlight the inverter proposed maximum power at maximum power point tracking algorithm [1]. The tracking parameter value is analog circuits is implementing the OCC are fixed. The specific irradiation level power is maximum because of PV array is tracking position is maximum. So different atmospheric condition a reliable decrease in efficiency of PV. To avoid such a limit, [4] suggested the knowledge of corresponding digital MPPT controller with analog OCC circuitry, have presented. Naturally benevolent tools like photo voltaic based systems are progressively used for electrical power producing in the situation of climate change, global warming, and fast crumple of petroleum derivatives. There is a wide gap between the available electricity production and the demand in the world, especially in the emerging countries. They have equalized this demand by utilising the non-conventional energy sources such as PV.

The global policy makers across the world, providing significant encouragements even to singular customers to install single solar PV panel and sell the additional power to the Government sector.

The cost effective grid connected inverter and its consistency which inhibits low maintenance has become interfacing to grid. An illustrative grid-connected PV inverter system has many power stages [1]. The first stage phase is generally to draw maximum power from the solar array fed to DC–DC converter by adjusting MPPT and also to increase the DC voltage level. The DC output obtained from this stage is then converted to AC by inverter and feed to the grid. The solar array output is being controlled by the inverter to feed to the grid which is attained ultimately by modulating the DC voltage.

The single stage inverter ensures the cost effectiveness, compactness and trustworthiness of the PV system[2]–[5]. Pulse width modulation is one of the greatestand frequentlyused controlling method three / single phase inverters in industries since 1970's[5]-[15].

The consistency of a hard switched mode functioning PV system has been showing two stage systems, which are 1) MPPT algorithm extracts maximum solar array 2) grid maintaining power quality from the solar array.

Hence, the regulator control arrangement of inverter fed grid systems normallycontains of two control current loops. First current control loop to regulate and injecting the currentto the grid while satisfying approved power factor and THD, while a MPPT algorithm incorporated with the current-control loop. A PLL for connecting with a touching grid is always a problematic scheme like harmonic distortions and frequency variation is existing in the line voltages. Also, the PLL consumes significant DSP used for its operation. For simplifying the control circuit for the inverter connected with the grid in a PV system, structures based on one-cycle control is being suggested [3].

In addition current-control loop system behaviour fast dynamic response, a PV system connected with the grid can function at a maximum-power point is described in [3]. The performance in the process of tracking maximum power from the solar array is very sensitive to the set of proposal design parameters. Hence, MPPT is operation is not assured because of the variations in the control system parameters values due to ageing, and changes in operating conditions.

In order to avoid these restriction multi objective optimization using for finding control parameter which is extracts power from the insolation range [4]. In order to discourse the above problem, a modified P&O technique for tracking the maximum-power point is functional to an OCC-based structure so that the system activates at MPOP. The MPPT controller requires to sense grid current, PV current, grid voltage, dc-link voltage to realize the MPPT process. The grid voltage detection decreases the strength of the OCC-based approach because of the THD present in the grid voltage and it would disturb performance of grid. Moreover, system is more complexity because of more sensors is presents, and also reduces the system reliability. In order to over the aforementioned limitations, OCC-based PV system is projected in this paper.

The recommended structure estimates grid voltage from the inverter output voltage. The switching operation of inverter and the filters associated with the output DC voltage decides the necessary elements of the inverter. The knowledge of estimating the grid currents, grid voltage and the switching function, has been essential in case of 3Φ converters. While, theoretically, the techniqueobtainable is parallel to the aforesaidoutlines, the recommended method is different section are given below. First one the implementation of the inverter and estimate the output-voltage and has been recognized by connecting simple analogue circuits.

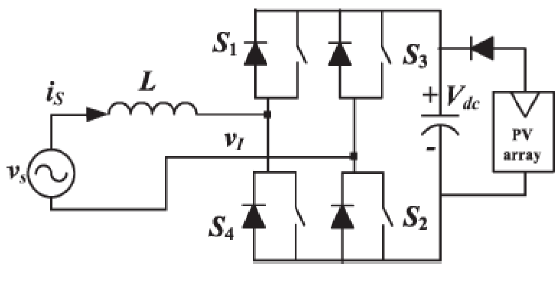

Fig1: Φ grid-connected PV system(single stage).

The evaluation of the proposed scheme purely depends on the output voltage of the inverter and the estimating voltage in the grid.

The value of the filter inductor of this structure is depends up on the grid current. So the inductor value affects the process of those structures. Only two sensors has been used as compared to OCC and MPPT blocks. The existing scheme is difficult. Further, the proposed scheme requires only two sensors while comparing with MPPT and OCC.

The analogue controller has been used to realize this scheme. The principle of this scheme is discoursed in detail in Segment II. The problems pertaining to the understanding of the MPPT is offered in Segment III. Complete simulation educations are approved out to validate the efficiency of the proposed structure, while the feasibility of the structure has been established by performance investigational studies on a prototype established for the purpose.

2. PV System Inverter

A grid-connected PV and Voltage source inverter connected as shown in Fig1. The output voltage of the single phase inverter are controlled to produce desired voltage to the source. By adjusting the phase and magnitude of the inverter through a correct PWM approach. The output power derived from the solar array which is connected to the grid can be measured for maintaining a low THD and to keep the power factor nearing to unity. The inverter, be exact with the OCC-based regulator method as simple OCC-based arrangements display. Operation instability happens when the operation of converter is in inverting mode.

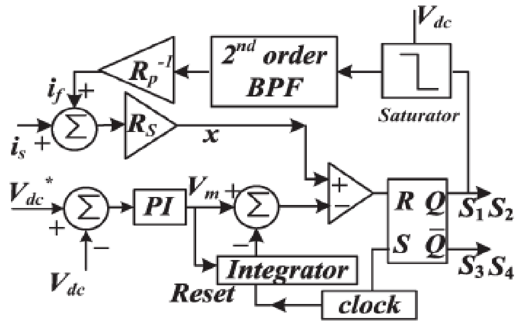

Fig. 2: Control block diagram of the proposed voltage-sensorless scheme.

The actual grid voltage is derived by multiplying the gain constant with the measured grid voltage. This actual current added with fictitious by the inverter. Then add two signal use to generate gate signal to drives inverter with help of OCC core controller. The proposed control structure not measuring grid voltage in this paper. Thefictional current compulsory to avoid the instability problem in inverter associated with OCC. It produces the fictional current essential by multiplication of a constant gain with the output voltage of the inverter. The block diagram for explaining the control of the suggested structure is as shown in Fig 2. The voltage of DC capacitor is identified and equated with the set value that is reference value and the generated error signal produced will be fed to a PI Controller regulator to produce a Vm signal. The readjustment enabled integrator helping to create fixed frequency saw tooth waveform and its peak voltage will be 2 Vm. The reset of the integrator can be activated based on the signal Ts. And the frequency of the clock Fs has been used to fix the saw tooth waveform and fundamental frequency. The integrator Ti can be set Ts time constant clarified. A proportional signal set by the fictitious current signal of the inverter output voltage (if = VI1/Rp) is added a source current and correctly signal scaled to achieve the modulating signal x, where

$$x = is+if= is+\frac{V_{I1}}{R_P}$$

In order to find VI1 and hence if, inverter gate pulses are helped to complete a saturator. By filtering, the proportionalsignal to VI1 can be found. The harmonic band of the saturator inverter output has: 1) a necessary frequency 50 Hz; 2) higher frequency modules; and 3) DC component and multiples of switching frequency signal. Therefore, a suitable filter preferably band pass filter is essential to recover the important component of the required signal and filter the unwanted higher order harmonic components. A second-order filter having a central fundamental frequency component is equal to the frequency (50 Hz) is charity for the determination. The basic diagram of the second-order filter is displayed in Fig 4. The amplitude modulating signal is multiplied by a gain source resistance Rs and is then equated with the saw tooth waveform signal to produce the gate pulse of inverters.

At each rising edge of the pulse clock signal, S3 and S4 are switched ON which leads to the boost in source current Is. And saw tooth signal is equal to the modulating signal waveform, switched OFF S3 and S4 and S1 and S2 are switched ON, hence Is decrease. The rising edge and falling edge slopes of Is are given by (vs+ Vdc)/L and (vs − Vdc)/L, correspondingly, where vs is efficacy voltage, and L is the magnitude of the boost inductor, Vdc is the DC capacitor voltage.

The switching pulses are generating after comparing the modulating signal x along with saw tooth waveform. When modulating signal is less than the saw tooth waveform, S3 and S4 are switched ON, and the inverter output voltage is −Vdc. When modulating signal is greater than the sawtooth waveform, we have to turn ON the switches S1 and S2 and the inverter output voltage is +Vdc.

3. P&O Methodology

The P&O technique is the most popular techniques to get the maximum power by using maximum-power point tracking. Enactment of MPPT by P&O technique is commonly completed by using discrete analogue, digital signal processor and microcomputer, but digital circuitry also used for application. The controller involves of an analogue multiplier, free-running clock, a sample and hold circuit, a toggle switch, an integrator. The P&O maximum power tracking controller algorithm obtains the signal Vmf from the OCC controller signal of is displayed Fig 2.

The output amplitude Vdc∗ of the P&O control algorithm sets by the dc voltage reference by the OCC which is shown in Fig 2. An integrator coupled with the output signal of the T flip-flop produces the reference control voltage Vdc∗ . The time period of the P&O algorithm cycle is absolute by a free clock running which sets sampling time instants for the Sample and Hold circuit used toggle flip-flop. In order to appreciate the working operation of the MPPT Dependent on the output voltage of the toggle flip-flop, Vdc∗ use to set either a rising edge or a falling edge slope. The OCC control algorithm set rate of change in Vdc∗ is smaller. An analogue multiplier perform low bandwidth, is the ratio of Vm and Vdc. The signal Vm/Vdc used to sample of time period.

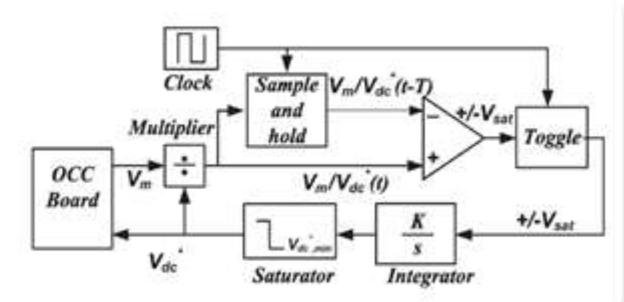

Fig. 3: The MPPT realization block diagram.

Sample and hold circuits value stored by the compares to current and Vm/Vdc. A comparator (positive) signal suggests that in the current signal, inverter output cane be decreased because of a comparator (negative). Along with the current signal output, power in the P&O will also be indicated in the Output.

4. Simulation Results

For measuring the performance of the proposed OCC voltage-sensorless grid-connected inverter system, comprehensive simulation trainings are supported out on MATLAB [5]-[15]. For quantitatively displaying, the scheme which is proposed have no difficulty of current variability while operation of working in the inverting mode of grid connected system, this model displayed in fig 1is simulated. As source current and the grid inverter voltage are nearly 180 degree out of phase, the structure is delivering power to the grid at nearly unity power factor. Performance of the simulated result, it can be incidental that the energetic response of the offered OCC based voltage system is having good stabilitybehaviour in current controllable and fast, is measured during the operation of inverting mode.

The inverter parameters for the simulation as follows:

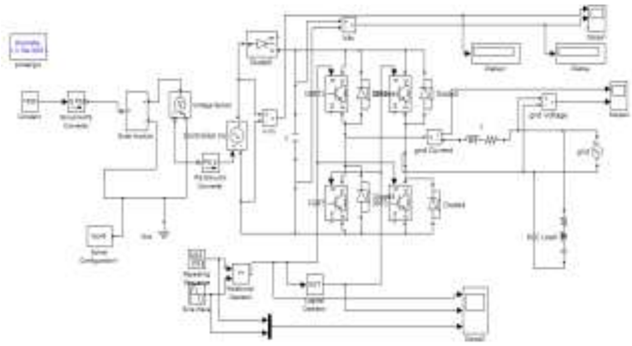

Fig. 4: Simulink model for grid connected inverter.

1) Rp: 1.5 Ω;
2) RS: 0.16 Ω;
3) series inductor: 2000 µH
4) dc-link capacitor: 2200 µF;
5) switching frequency: 20 kHz;
6) central frequency of BPF: 49.80 Hz.
7) quality factor of BPF (Q): 2.0;

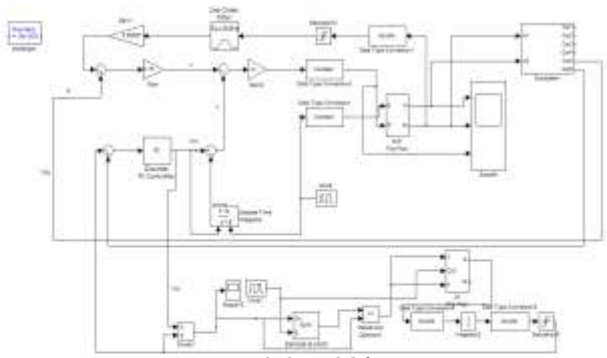

Fig.5: Simulink model for OCC.

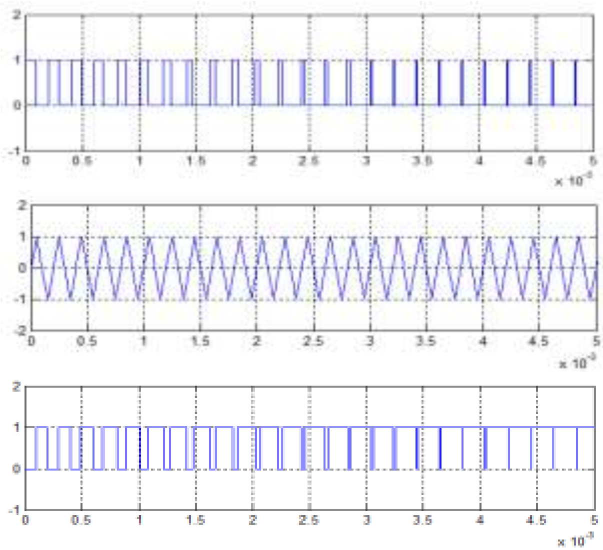

Fig6: Simulated performance of SPWM signal

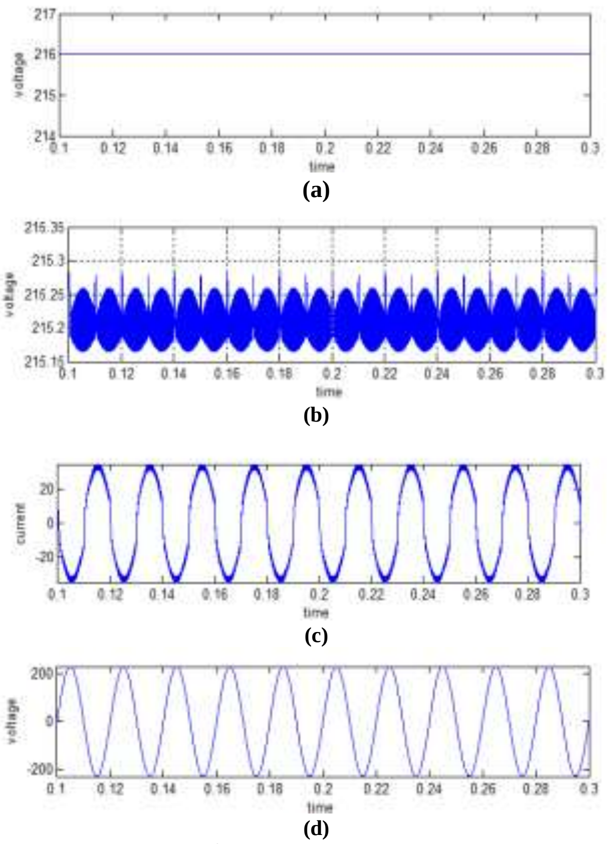

Fig7: Stable operation of the proposed scheme. (a) PV voltage. (b) DC-link voltage (c) Grid current. (d) Grid voltage.

5. Conclusion

In this paper, the best strategy of inverter for PV applications has been completed and it is exact by means of SPWM Techniques. In normal system, sensing to the grid voltage in order to challenge the instability difficulties. But in the recommended method no sensing element for the grid voltage which is one of the main benefit and OCC does not need the package of a PLL for connecting the inverter circuit to the grid and also increase the overall efficiency. If OCC built MPPT Tracker is coupled to this structure which tracks peak to peak power of the PV panel resulting in the increase in the system efficiency.

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