

# Development Of Required Power Point Tracking Algorithm For Standalone Solar Photovoltaic Inverter

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**Abstract:** This work aims to design and develop a single-phase stand-alone solar inverter embedded with a novel Required Power Point Tracking algorithm (RPPT), whereas other work reports solar inverter using Maximum power point tracking (MPPT) algorithm. RPPT algorithm can be applied to grid tie / off grid inverter and also utilize the energy from the PV (Photo Voltaic) panel even in the presence and absence of the grid power. How the work is design using a single phase prototype model was developed to demonstrate the functionality of the proposed RPPT algorithm. Why we need to demonstrate this model because it uses two microcontrollers in which one will generate two-phase PWM switching signal and the other microcontroller for executing the RPPT and load shedding algorithm. This prototype is also uses the sub modules such as H-Bridge driver, single phase inverter step-up transformer and load driver relay module. The RPPT algorithm will continuously monitor the instantaneous power produced by PV module, and optimal power will be selected to deliver it to the load using load shedding algorithm. In the proposed design of stand-alone solar Pv inverter is shown in four level load, shedding algorithm was used to distribute the power to the load. The prototype model was tested with maximum load of 50W. The simulation and experimentation work was carried out and yields the desired performance. We observed that the RPPT algorithm works satisfactorily and the load shedding algorithm was optimally coordinating with the PRRT algorithm. The performance analysis of the proposed system provides better results as compared to the existing system.

**Keywords:** MPPT algorithm, RPPT algorithm, standalone PV inverter, off grid inverter, load shedding algorithm.

## I. INTRODUCTION

Renewable energy plays a significant role in our daily life to meet our energy requirements [1]. India being a tropical country currently focuses on solar energy for large scale power generation to power all industries and homes in the coming years [2].

**Revised Manuscript Received on 30 March 2019.**

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Presently grid tied and off grid inverters are available with separate functionality. Among this grid tied inverters gain more advantages over off grid inverters due to its higher energy conversion efficiency on comparing with off grid inverter, and the energy cannot be harvested in the absence of grid power. Hence the power produced by the PV module becomes unusable. A Stand-alone off grid inverter requires a battery to store the harvested energy, which in turn increases the investment cost and requires periodic maintenance. When the grid power is available, the solar inverter uses MPPT algorithm and switches to on-grid mode and thereby satisfies the on-grid inverter functionality (by exporting surplus power to the grid). In the event of grid failure, this solar inverter switches to off-grid mode, which isolates itself from the grid and provides ac output power for domestic loads. The micro grid-tied solar inverter also contributes significantly to energy production. Energy cannot be harvested in the case of grid power failure; hence the energy harvested by the PV module is unutilized. Therefore the optimization of the PV system is required [3]. The stand-alone PV inverter along with storage batteries has been used commonly, to power the required electrical appliances [4]. Investment and maintenance cost of such system is high for which implemented using MPPT power control algorithm. Which track the required power based on varying load conditions [5], [6] This is concerned about the increase in the efficiency of the PV inverter system by optimization of the power produced [7], Pulse Width Modulation (PWM) signals is used to control the power that has to be delivered based on the load requirement, thereby limiting the current [8]. In most of the previous works PV solar system uses Maximum Power Point Tracking (MPPT) algorithm. A novel RPPT algorithm has to be developed to track the required power depending upon the amount of load power required, which eliminates the necessity of battery and making the system standalone, cost-effective and eco-friendly. The paper is organized as follows. In section II the design of standalone solar PV inverter compatible to RPPT algorithm was discussed. The simulation and experimentation results under various test conditions were discussed in section III, followed by the concluding remarks.

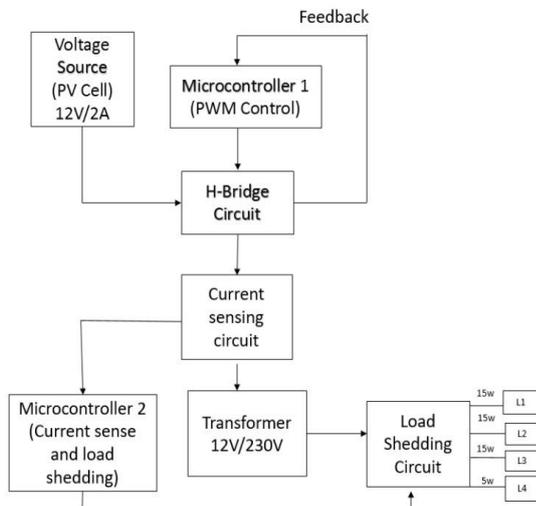
## II. METHODOLOGY

### 2.1. Design of standalone solar PV inverter

The proposed block diagram of stand-alone solar PV inverter is shown in Figure 1.

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It consists of two microcontrollers, one for generating 2 phases PWM signal output, whose pulse width is controlled by the feedback obtained from the load current sensor and the instantaneous PV power. The other microcontroller is used to implement the RPPT algorithm and load shedding algorithm. This will send the feedback control signal to vary the pulse width of PWM Controller.



**Fig.1. Block diagram of a single phase Standalone Solar PV Inverter.**

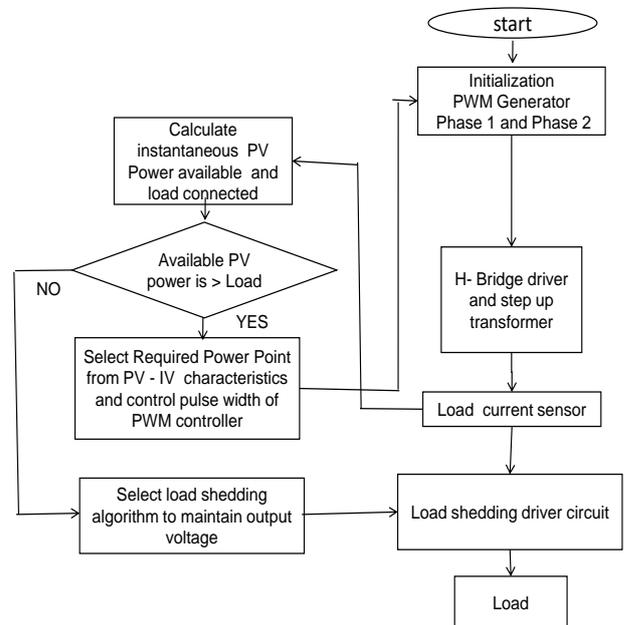
Controlled DC power source is used to emulate the PV-IV characteristics for experimentation. CMOS H-Bridge is used to drive the inverter transformer. The control input to the H-bridge circuit is a PWM signal generated by the PWM microcontroller 1. The output of the H-bridge is then fed as input to an inverter transformer, which in turn steps up the input voltage given to it. This stepped-up output is given to the load shedding circuit, to which different user loads are connected. The functionality of this circuit is to enhance or cut down load based on the PV power generated, i.e., the output voltage of the PV module and the load power requirement. This is implemented by measuring the amount of current through the H-bridge circuit with the use of current sensing circuit, thereby calculating the amount of current needed for the user load to operate on.

The microcontroller 2 plays the primary role as controlling optimal power delivery accomplished to the user load. This is done by controlling each load connected to the load shedding relay circuit, which will turn switches the user load ON or OFF depending on the PV power available. If the instantaneous power is found to be lesser than the load power requirement, the duty cycle of the PWM signal is dynamically varied and provides a feedback to the microcontroller 1, which acts to control the PWM signal width accordingly in turn it satisfies the load power requirement. If the instantaneous power is found to be greater than the load power requirement, the duty cycle of the PWM signal is decreased accordingly there by it satisfies the load power requirement.

### 2.2. Required Power Point Tracking Algorithm

RPPT algorithm is employed for standalone solar photovoltaic (PV) systems to optimize power extraction under various atmospheric conditions without using storage battery. RPPT algorithm will track the required power for the load and

the available output power from the solar PV module. The execution flow of RPPT algorithm is shown in Figure 2. The primary role of RPPT algorithm is to match the output power of the PV panel with the load requirement under varying atmospheric conditions. RPPT algorithm is developed to accomplish the need of off-grid applications. The RPPT circuitry will initialize the PWM control circuit for the specified frequency of operation and its operation is similar to the Stand-alone inverter circuit to which the load is connected. In the next stage, the output power from the solar PV module is calculated. Hence calculated power is subjected to a condition check on whether it is greater than the load power requirement. If the condition is satisfied, the RPPT algorithm will select the required voltage point from the PV-IV characteristics of the typical PV module data stored in memory as look up table in microcontroller 2. When the maximum power delivered by PV module is less than the load requirement, then the RPPT algorithm will initiate to disconnect the load assigned with less priority among the connected loads.



**Fig. 2. Execution flow of Required Power Point Tracking (RPPT) Algorithm**

## III. RESULTS AND DISCUSSION

### 3.1 Implementation in Proteus Environment

The schematic of Standalone solar PV inverter implemented in Proteus environment is shown in the Figure 3 in which RPPT algorithm was embedded in ATMEGA328PWM microcontroller.

In the proposed circuit, the PWM output is generated by microcontroller 1; H- bridge driver circuit is constructed using IRF540 discrete N-channel MOSFET. A step up inverter transformer of 12 V / 230 V is used in the system. The PV voltage source is emulated using power from a variable power supply source, whose voltage can be varied from 13V to 18V for characterization.



Microcontroller 1 will generate 2 phase 180° phase shift PWM signal whose duty cycle can be controlled from 25% to 99% supplies constant amplitude of 5V. This signal is available at pins 9 and 10, that is fed as driving current to the H-Bridge circuit to drive ac load.

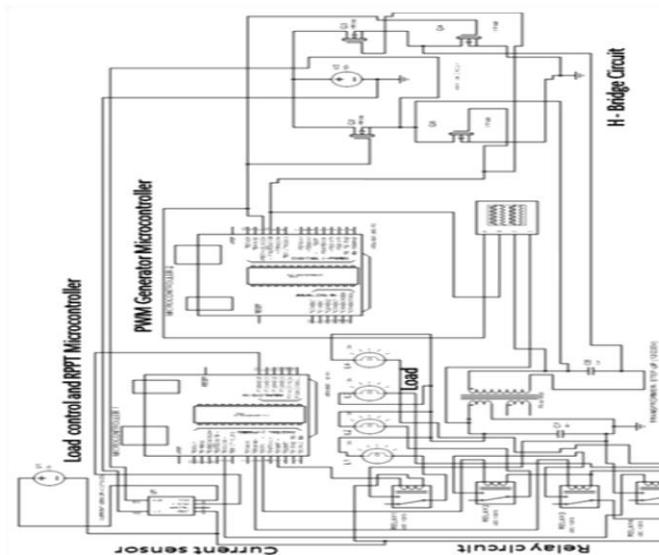


Fig. 3. Circuit schematic of Prototype model

The current sensor module ACS 712 is used to measure the leg current of H-Bridge. The current sensor output signal is fed to Microcontroller 2 to calculate the instantaneous value of load current. The feedback from the current sensor is used to select the required power to be drawn from the PV module. The ac voltage of 230V/50 Hz is available at the output of inverter transformer is fed to the load using four channel load shedding relay module. Simulation output of PWM signal and output of the inverter is shown in Figure. 4.

3.2 Prototype Implementation of Standalone Inverter using RPPT algorithm

A prototype model was developed to implement RPPT and load shedding algorithm. The typical solar PV voltage is will vary from 14V to 17V which is emulated from the controlled dc voltage source. Prototype model was developed to handle 50W maximum power and RPPT algorithm was embedded tested for various input PV voltage and load conditions.

The load L1, L2, L3 are rated as 15W/230V incandescent bulbs respectively, and L4 is rated with 5W/230V (LED bulb) connected through load shedding algorithm. Figure 5 through Figure 8 shows the results of the proto model tested for various input PV voltage and loading shedding conditions.

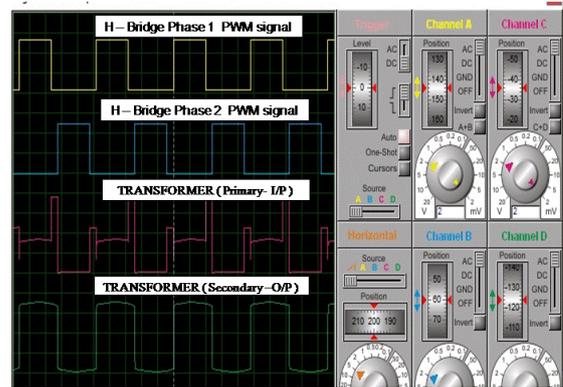


Fig:4. Simulation outputs of 2 phase PWM output, primary and secondary voltages of inverter transformer

3.2.1 Case 1: Peak loading condition

Assumed PV output voltage output is 17 V. In this case the system is connected with a full load capacity in which the loads L1 to L4 are enabled through the load shedding algorithm. Figure 5 shows the leg current of 2.8 for 50W load connected.



Fig: 5. Stand-alone PV inverter connected with full load (50W).

3.2.2 Case 2: Optimal loading for 16V from PV module

Figure 6 depicts the PV voltage emulated for 16V. The RPPT algorithm automatically senses the leg current and PV module voltage and connects load L1 to L3 and disconnects load L4. For this test case this system connects to total of 45W power and the draws 2.8A peak leg current.



Fig: 6. Stand-alone PV inverter connected with optimal load (45W).

## 3.2.3 Case 3: Optimal loading for 15V

### from PV module

Case 3: In this case, PV voltage output is emulated for 15V. The RPPT algorithm evaluates the optimal power as 30W based on the 1.8A leg current. The load shedding algorithm connects the load L1 and L2 and sheds L3 and L4 which is shown in Figure 7.



Fig. 7. Stand-alone PV inverter connected with optimal load (30W).

## 3.2.4 Case 4: Optimal loading for 14V from PV module

Case 4: the worst case scenario is considered here, in which the output voltage of PV module is assumed as 14V. Based on the PV-IV characteristics of the particular module, the optimal power output for that condition was selected as 15W and the peak leg current is 1.1A. The RPPT algorithm enables the load L1 and sheds the load L2 to L4 and the test case is shown in Figure 8.

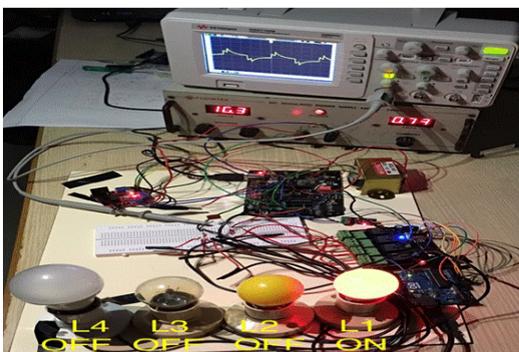


Fig. 8. Stand-alone PV inverter connected with optimal load (15W).

## IV. CONCLUSION

The RPPT algorithm was developed and prototype of single-phase square wave standalone PV inverter was designed and implemented without storage batteries. It was observed that the RPPT algorithm works satisfactorily and the load shedding algorithm was optimally coordinating with the PRRT algorithm. The overall performance analysis of the proposed system is significantly providing the better solution. The functionality of the RPPT and load shedding algorithm was tested for various PV output power and user load conditions and the obtained results was discussed. This technique can be applied to develop a sine wave standalone PV inverter as future work.

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