Design and Fabrication of Solar Cum Battery Powerd Inverter for Stand Alone and Distributed Power Generation Applications

Suhas P. Walde[1] Dr. D. R. Tutakane[2] Prof. Priyanka Deshmukh[3]
[1]Student [2]Professor [3]Head of Dept.
[1,2,3]Department of Electrical Engineering
[1,2,3]Wainganga College of Engineering and Management, Dongargaon, Nagpur, India

Abstract — A hybrid solar inverter is a device that combines the functionalities of a solar inverter and a battery inverter into a single unit. Its main function is to manage the flow of electricity between solar panels, batteries, and the electrical grid in a hybrid solar power system. A simple, reasonably priced converter which feeds solar generated power to an AC grid with battery backup. A push-pull inverter topology with a centre-tap step-up transformer and a push pull configuration of MOSFETs is proposed. For synchronizing with ac grid a RC series connected resistance and capacitor combination is connected across the ac supply to obtain variable leading phase angle control which controls the power feed back to the ac grid from solar inverter in ice-landing mode of operation of inverter. Solar DC energy is converted into quasi square AC power using a single phase quasi square wave three level inverter and a step-up centre-tap transformer. The output voltage and phase angle of the inverter connected to the AC bus are kept under control through duty ratio control and phase angle control, respectively.

Keywords: AC Voltage, DC Voltage, Renewable Energy, PV Panel, Grid Connect, Inverter

I. Introduction

Sun energy is abundantly available and coal energy is depleting fast at every level we are trying to utilize the electrical solar energy. Making use of it in various ways we are directly using it, we are converting into the heat and many other things. In this Project the Battery is charged continuously with Solar Panel or panels. The ratings of the Solar panel and battery are so chosen that a charge controller stage can be avoided to improve the efficiency of the solar charging system. A simple push-pull inverter using 2/4/6 MOSFETS IRF 150 have been fabricated initially to test the performance of the system for 150 W,230 V Quasi Square Wave Inverter to minimize the harmonics using 9V-0-9V/240V, 50 Hz, Centre tap transformer is connected as shown in Fig. 1. Two 1800 phase shifted gate pulses are generated and fed to the two MOSFETs are alternately are provided from our control circuits shown in Fig.2 The reason behind selecting the 9V-0-9V AC at the low voltage side of a step-up transformer is because the fundamental component of RMS square wave 12 Volts 50 Hz AC is approximately 9 V 50 Hz. AC the Gate pulses with 100% duty ratio are shown in Fig. 3 The practical gate pulse controller have been fabricated using IC 555, IC 324 and IC 4017 to generate controllable variable Gate pulses with variable pulse width as shown in Fig.4. These pulses are generated either independently or in synchronized mode depending upon whether we wish to operate in stand-alone or grid connected mode. In Standalone mode Power is available even in absence of solar power due to energy stored during day time. In synchronized mode the power can be fed back to grid to minimize electric bills by using net metering. The Solar Power to be feedback to grid is be controlled by controlling phase shift and pulse width of the gate pulses from control circuit. Prototype working model is developed and tested.

II. Methodology

Proposed three level solar inverter feeds 50 Hz ac power to the AC low voltage bus of 230 volts AC. A simple push-pull inverter using 4 MOSFET'S IRFZ44N in parallel in each push pull inverter limb have been fabricated A 150 W, 230V Quasi

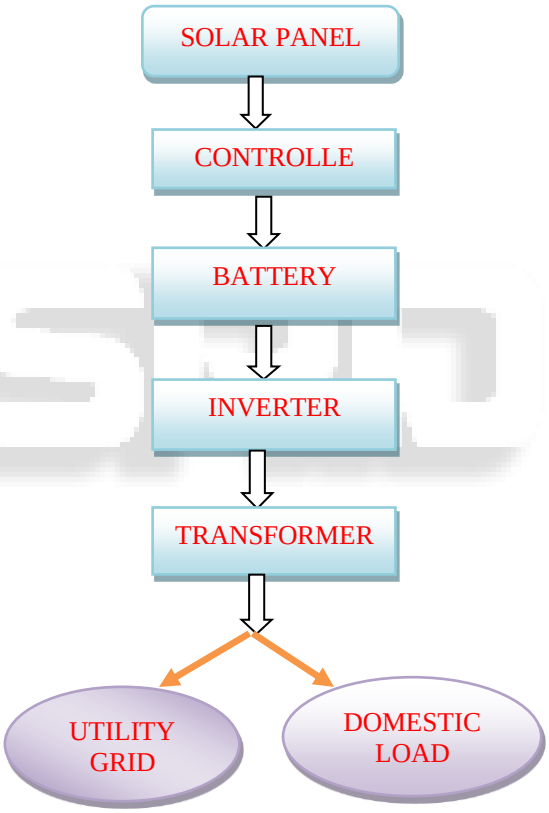


Fig. 1: Block Diagram Proposed Grid Connected Solar Inverter

Square wave Inverter to minimize the harmonies using 9V-0-9V/230V, 50 Hz. centre tap transformer are connected as shown in Fig 2. Two 180 phase shifted gate pulses are generated and fed to the Eight MOSFETs are alternately are provided from our control circuits shown in Fig. 7. The practical gate pulse controller has been fabricated using IC 555, IC 324 and IC 4017 to generate controllable variable Gate pulses with variable pulse width as shown in Fig. 6. These pulses are generated either independently or in synchronized mode depending upon whether we wish to operate in stand-alone or grid connected mode. The Solar Power to be feedback to grid is controllable by R-C phase shift circuit by varying the value of resistance and power factor is controlled by pulse width of the gate pulses from

control circuit. Prototype working model is and tested successfully is shown in Fig. 6 and Fig. 7. High frequency 25 kHz, Buck-boost converter is employed to charge the Battery bank under different solar intensity and load power and load conditions operating under MPPT Duty ratio of the buck boost is controllable from 16 Volts to 20volts. Output voltage Buck boost converter is controlled using Duty ratio control.

A. Power Circuit

A simple push-pull inverter using 4/6/8 MOSFETS IRFZ44N has been fabricated. Initially to test the performance of the system for 150 W, 230V Quasi Square wave Inverter to minimize the harmonics using 9V-0- 9V/230V, 50 Hz, centre tap transformer is connected as shown in Fig. 3. Two synchronized AC pulse using RC phase shift limb connected across the supply is used to obtain two 180 phase shifted gate pulses which are generated using zero crossing detector circuit across resistance of the RC branch and fed to the four-parallel connected MOSFETs bank of push pull inverter.

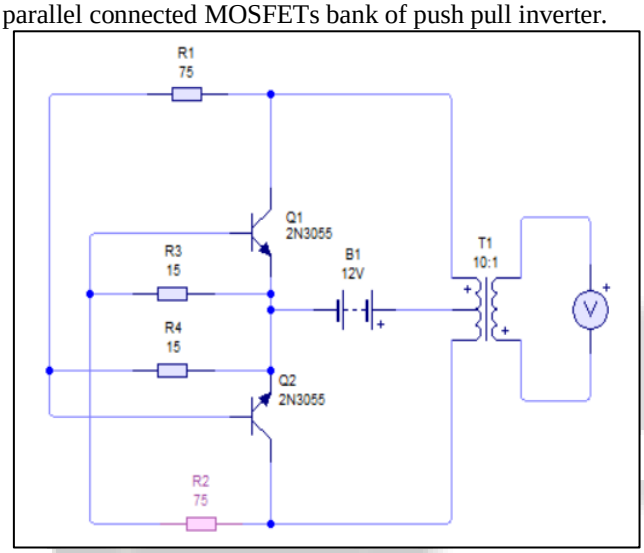


Fig. 2: Power Circuit inverter

Synchronized phase shifted gate pulses are generated and fed to the two MOSFET banks (four MOSFETs connect parallel) are alternately are switched on and off. Generated solar DC power is feedback to grid by controlling the leading phase shift angle of inverter by controlling pulse width and phase shift of the gate pulses by using control circuit working test modal is created and tested successfully.

III. WORKING OF CONTROL CIRCUIT

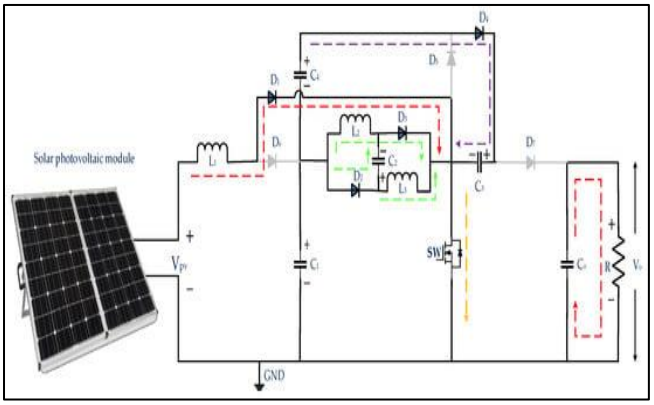


Fig. 3: Power Flow Control

Fig. 3 Line synchronize pulse Generation circuit for power flow control Vao is in phase with 230-volt AC grid. Vbo is leading Vab whose phase angle is controllable by varying the resistance Rbo. The power feed to the grid there for be controllable by Ruo. For obtaining leading, line synchronized square wave control pulses opamp I is employed.

For off grid applications a100 Hz oscillator is used in a stable multi vibrator mode. For grid connected system a series resistance capacitance RC limb is connected across the AC side of the control circuit and an ac voltage across resistance R is used to generate the phase shifted synchronized square pulses. This Square wave clock pulse at pin 3 are fed to dived by two digital divider using IC 4017. The Control circuit of solar power inverter with stand-alone mode. These pulses are fed to the base of two pulses amplifier through pulse amplifier using transistor BC547.Two zero crossing square pluses and derived from AC voltage available across resistor (R), Show in fig.4. The leading phase angle, there by power flow is controllable by varying the value of resistor (R), with is connected with fix capacitor (C) and the RC limb is connected across AC source voltage. This tow zero crossing square pulse are feed to derived circuit using lower power npn transistor for trigging MOSFATE push pull inverter available high voltage side of the step-up transformer is connected across the single phase 230V 50 Hz. Ac grid Fig. 4. Supply voltage signal "v, and controllable leading voltage, signal "v" scale v. 5v/div, 1-10ms/div.

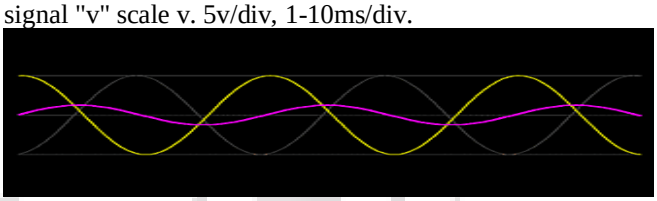


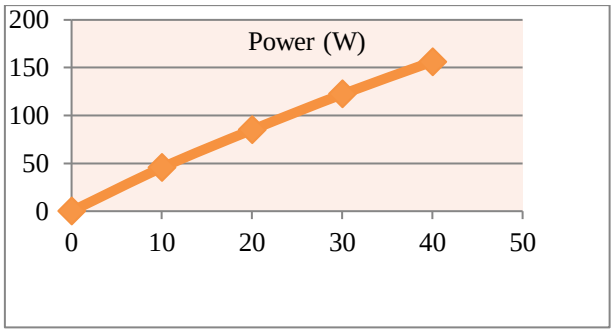
Fig. 4:

The power flow controlled from solar power inverter will be feed to the grid in a controlled manner depending on available of the AC solar power, will be feed to the grid by varying the phase shift between source and inverter voltage. The complimentary output from output from driver circuit using transistor are fed to two Power MOSFET banks MOSFET banks are connected to the power circuit in push pull configuration. The ac voltage output across low voltage winding of centre tap transformers fed to the low voltage grid using step up transformer whose high voltage winding terminals are connected to the AC grid. This way the low voltage AC from push pull inverter is set up to 230-volt AC

IV. RESULTS

Sr.no	Phase Angle of Inverter w.r.t Grid Voltage (degree)	Power Fed to 1 ph ACGrid (Watts)
1	10(leading)	45.5
2	20(leading)	85
3	30(leading)	122.2
4	30(leading)	156.3
5	40(leading)	183

Table 1: Phase Angle Vs Solar Inverter Output Power



Phase Angle Leading w.r.t. AC Line

Fig. 5**:** Phase Angle Vs Inverter Output Power

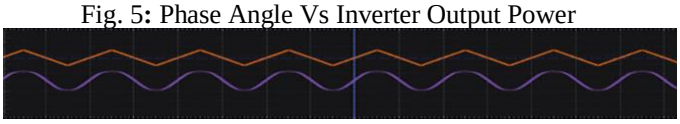


Fig. 6: Triangular Carrier wave scale, voltage, 200 m V/div; time, 10ms/div

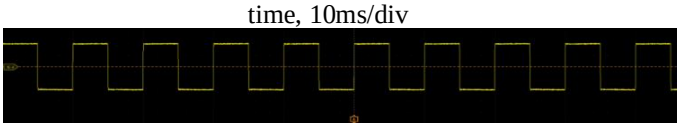


Fig. 7: Square wave, scale, voltage, 500m V/div; time, 20ms /di

With the help of IC555 using , at pin no.2 of IC555 triangular wave of 100Hz is generated which is used for PWM, shown in fig 6. Around 1 uF value of capacitor at pin no.3 generated Square wave clock pulse of 100 Hz.

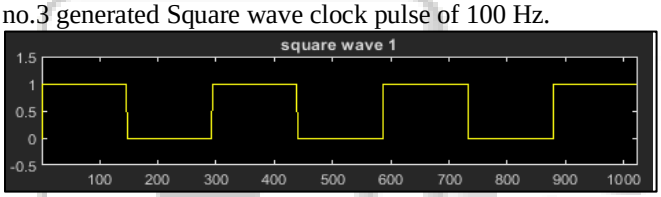


Fig. 8: Complementary Gate Pulses For Maximum inverter Voltage For Square wave output, scale voltage, 500mV /div; time 5ms/ div

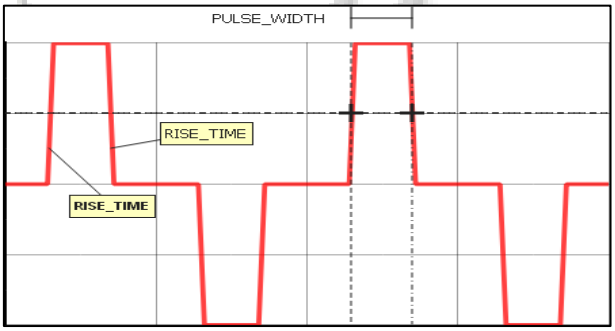


Fig. 9: Low voltage side, inverter voltage AC 50Hz wave from, 40% duty ratio quasi square wave, voltage scale, 5v/ div: time 10ms/div

V. Conclusion

The increase in output power fed from solar hybrid inverter to the grid as the inverter phase angle becomes leading. The phase angle is variable from 0-90 degrees using variable resistance of R-C series branch with upper terminal of the capacitor connected to the ac source available from transformer and bottom terminal of their resistance is connected at other terminal of AC supply available across low voltage side of the 230V to 9V transfer. From the experimental results it is concluded that the power fed to grid using 3 level inverter increases as the leading phase shift angle between ac grid voltage and inverter ac voltage is increased from 0 to 90 degrees. The maximum power fed to the grid is found near 90 degrees leading with respect to ac grid voltage. In absence of grid power, the solar power can be utilized using independent 100 Hz square wave oscillator to obtain 50 Hz quasi square wave output 230 volts Ac supply. This can be used to drive domestic electrical utilities. The proposed hybrid inverter has therefore the specialty that it can feed to the ac grid during availability as well as non-availability of ac grid supply.

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