SINGLE PHASE INVERTER WITH WIDE INPUT VOLTAGE RANGE FOR SOLAR APPLICATION

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Abstract - *Solar energy is considered as fastest growing renewable energy source after wind energy for electricity generation. Solar energy is a free, clean abundant sun energy considered as inexhaustible source for electricity generation. Solar photovoltaic system is characterised with variable output power due to its operation dependency on solar irradiance and cell temperature. To maximize the energy generation potential of solar PV, research effort is focused on solar cell manufacturing technology to increase its generation efficiency and exploring advancement in power electronic devices for small and large scale deployment. Presented in this project is a single phase inverter with no transformer for solar PV application. A closed loop DC-DC boost converter that accepts wide input DC voltage from 12 V to 48 V to produce constant 48 V DC voltage is modelled in Matlab/Simulink. An H-bridge 2-level inverter was used to convert the DC voltage to chopped AC voltage which was then filtered to give pure sinusoidal AC of 48V peak. The output voltage of the inverter has a very low total harmonic distortion of less than 1 % which makes the system suitable for local AC load.*

***Key Words*: DC-DC converter,H-Bridge Inverter, Unipolar PWM, Photovoltaic system**

1. INTRODUCTION

In order to meet the rising global energy demand from sustainable environmental friendly sources, various renewable energy are now given adequate attention. Renewable energy comes from energy sources that naturally regenerate over a short period of time. Some are derived from the sun like thermal and photoelectric and other from natural movements of the environment like the wind, rain fall, and geothermal energy. In the nearest feature, solar and wind energy are expected to contribute more than 30 % of renewable energy within the power industries. Solar energy is presently the fastest growing renewable energy source after wind energy for electricity generation. In a span of five years, the world solar PV electricity generation increased from below 10 GW in 2007 to over 100 GW operating capacity in year 2012. Research efforts towards maximizing solar energy advantage are now focused on how to increase efficiency of solar cells via manufacturing technologies and to explore the advancement in power electronic devices to be able to adapt the solar PV generation for small and large scale power system application.

The link between solar energy generator and the loads is an efficient power converter that delivers the generated energy. Power converters are used to improve the power quality of solar photovoltaic system because of associated intermittency and continuous variation. The generated power from solar PV are DC component and mostly at different level from the load demand, so there is a need for voltage regulation and conversion to AC component for AC loads application. Presented in this paper is a design and simulation of single phase inverter with wide input voltage range which is suitable for variable solar photovoltaic source. Supply voltage from the solar panel is first regulated and boosted to high DC voltage which is then subsequently converted to AC voltage for AC load supply. After filtering, the output voltage of the inverter shows that the system is suitable for local AC load and grid connection has a very low total harmonic distortion of less than 1 %.

1.1 Block Diagram

The block diagram of Fig. 1 shows the configuration of the single phase inverter comprising of a DC-DC boost converter and H bridge inverter. The supply voltage from the solar PV panel is subjected to variability due to the effect of environmental parameters such as temperature and solar irradiance that affects it output power.

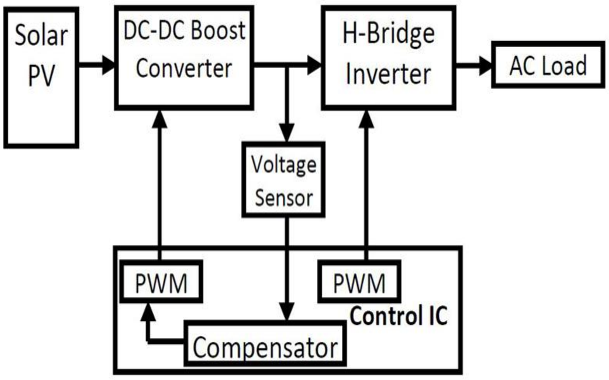

Fig1 -: Block Diagram

The DC-DC converter is used to regulate the supply voltage from the solar PV. The regulated voltage is then boosted to 48 V DC voltage in order to eliminate the need for transformer in the system. An H bridge inverter was used to convert the DC voltage to chopped AC the 48 V peak voltage which gives a 34 V RMS voltage after filtering. The chopped AC voltage containing both carrier and modulating frequency was filtered using passive LC low pass filter allowing only voltage at fundamental frequency of 50 Hz at the output.

1.2 DC-DC Converter Design and Simulation

The steady state parameters of the DC-DC boost converter were calculated using the following equations,
The steady state input to output conversion ratio of boost converter is

$$V_{out} = \frac{V_{in}}{1-D}$$

The magnitude of peak-to-peak inductor current ripple ΔI_L is given by,

$$\Delta I_L = \frac{V_{in} D}{f_s L}$$

The output capacitor voltage can be determined based on the desired output voltage ripple ΔV_C,

$$C_{out(\min)} = \frac{I_{out(mac)} D}{f_s \Delta V_{out}}$$

Parameters	Symbols	Values
Input voltage range	V_{in}	20-30 V
Output voltage	V_{out}	100 V
Average output current	I_o	0.8 A
Inductor current ripple	I_o	0.1 A
Output ripple voltage	V_o	1 V
Switching frequency	f_s	25 kHz
Load resistance	R_L	125 Ω
Duty cycle	D	0.75
Inductor	L	7.5 mH
Output capacitor	C	24 µF

1.3 Open loop Simulation of DC- DC Converter

Based on the DC-DC boost converter design parameters presented in Table I, open loop simulation was carried out in Matlab/Simulink environment as shown in Fig. 2.

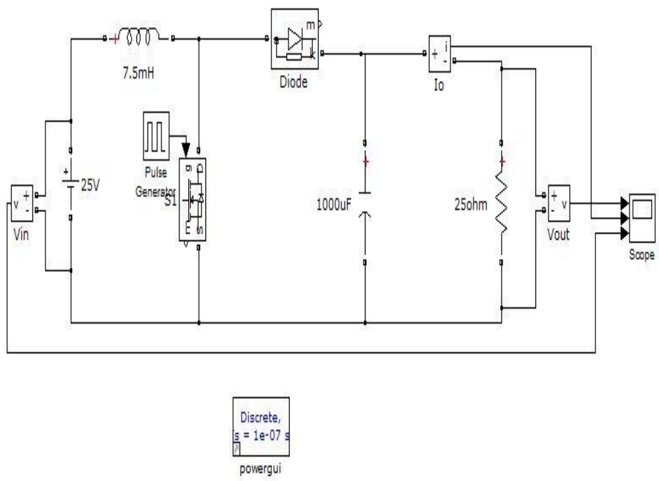

Fig -2: Open loop DC-DC converter

1.4 Inverter Simulation

The main function of the inverter in the solar PV system is to convert the DC voltage from DC-DC boost converter to alternating current (AC). The H-Bridge inverter consisting of four switched MOSFET was employed with two switches per leg as shown in Fig. 3. The switches are turned on and off diagonally with T1, T2 turning on the same time and then T3, T4 in succession.

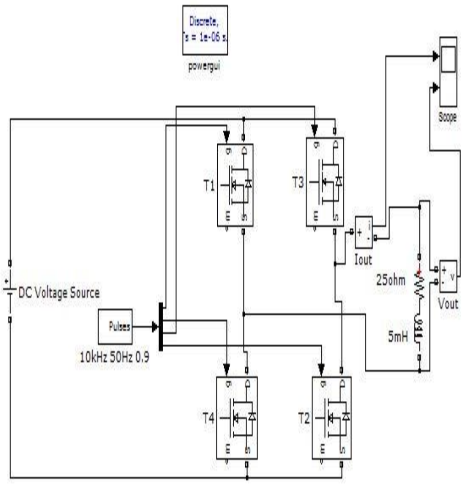

Fig -3: Three phase H-bridge inverter

1.5 DC-DC Converter with Inverter

The complete Simulink model of the single phase inverter is shown in Fig. 4 with DC-DC converter. The variable supply voltage (20V-30V) from the solar PV is regulated and boosted to 100 V by the DC-DC boost converter. Before filtering the inverter transforms the regulated DC voltage to chopped AC voltage of 100 V peak which was then filtered by LC low pass filter to give pure sinusoidal AC output voltage. The inverter output voltage presented in Fig. 6 has root mean square voltage (*rms V*) of 70V with total harmonic distortion (THD) of 0.68 .

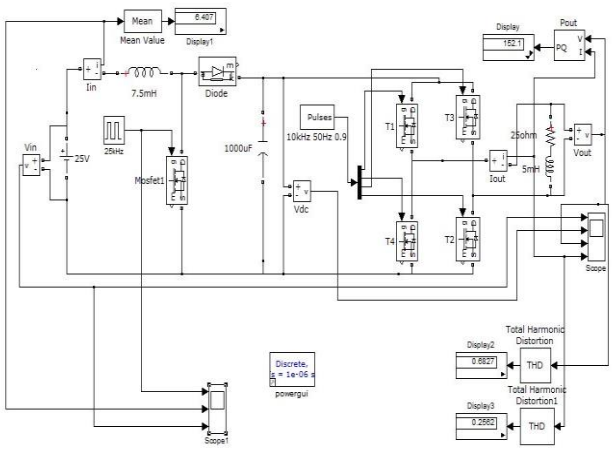

Fig -4: DC-DC Converter with Inverter

2. CIRCUIT DIAGRAM AND WORKING

A PID controller is used for regulating the variable supply voltage from the solar PV panel to a constant voltage. The main function of inverter in the solar PV system is to convert the DC voltage from DC-DC boost converter to alternating current. The H-bridge inverter consisting of four switched MOSFET was employed with two switches per leg. The switches are turned ON and OFF diagonally. The unipolar PWM switching was employed because it exerts less switching stress on the switching device. The inverter output voltage switches between 0 and Vdc making the voltage thus experienced by the switch device the same with the supply voltage unlike bipolar switching strategy that has output voltage swing between Vdc and –Vdc exerting double voltage stress on the switch. The output voltage of the inverter is a chopped AC voltage of 48V peak with component of carrier frequency which was then filtered using a passive LC low pass filter to obtain pure sinusoidal AC output at 50Hz frequency.

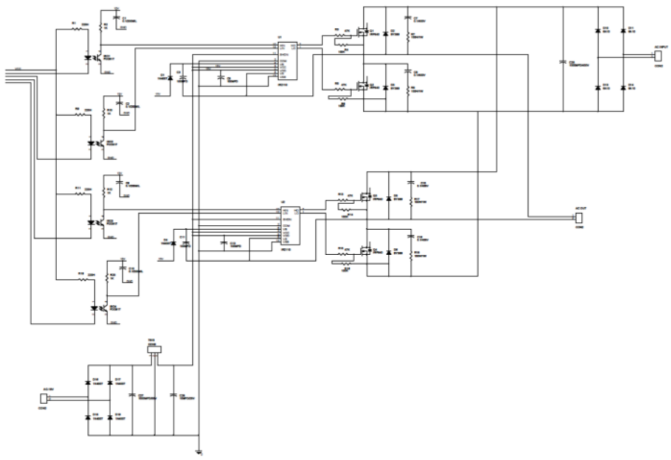

Fig -5: Inverter circuit diagram

3. HARDWARE IMPLEMENTATION AND RESULTS

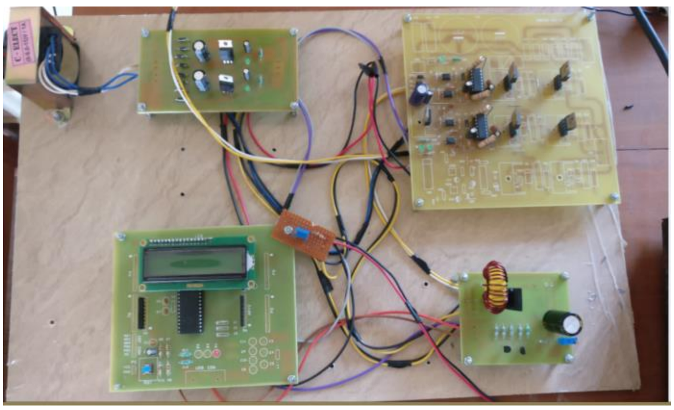

Fig -6: Completed hardware

Variable dc voltage from the solar panel was regulated and boosted using the DC-DC converter. The boosted output of the converter was given to the H-bridge switched inverter to obtain an alternating waveform of 48V peak.

4. CONCLUSIONS

A single phase inverter with DC-DC boost converter for solar PV system with wide input voltage range is designed and modelled in Matlab/Simulink environment and implemented as a hardware in PCB. The simulation result shows that the DC-DC boost converter was able to regulate the variable supply DC input voltage (12V-48V) from the solar PV and maintain it at 48 V DC voltage regardless of supply voltage variations. The inverter stage successfully converts the DC voltage to 48 V peak AC voltage. The inverter output has a very low THD making the system suitable for AC local load supply.
The circuit is implemented as a hardware on a PCB board and the output waveforms are verified on a DSO. The hardware result shows that the DC-DC boost converter was able to boost DC input voltage ranging from 12V to 48V to a 48 V DC voltage. The inverter stage successfully converts the DC voltage to 48 V peak AC voltage. Pure sinusoidal wave was obtained by passing the output through a filter.
This project is a stepping stone to a cheaper and efficient pure sine wave inverter, by using the data collected in this report as well as the schematics and recommendations the product produced here can be improved upon. Simple additions such as circuit protection could greatly improve the performance of this project. The project, in its present condition, does work in the manner the team wished and has met every goal set at the commencement of this venture.

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