Design And Testing of Low Cost Solar Inverter

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Abstract- *In recent years, the interest in solar energy has risen due to surging oil prices and environmental concern. In today's climate of growing energy needs and increasing environmental concern, alternatives to the use of non-renewable and polluting fossil fuels have to be investigated. One such alternative is solar energy. Solar energy is quite simply the energy produced directly by the sun and collected elsewhere, normally the Earth. The sun creates its energy through a thermonuclear process that converts about 650,000,0001tons of hydrogen to helium every second.*

A solar inverter, or converter or PV inverter, converts the variable direct current direct current (DC) output of a photovoltaic(PV) solar panel into a utility frequency alternating current (AC) that can be fed into a commercial electrical grid or used by a local, off-grid electrical network. It is a critical balance of system (BOS)–component in a photovoltaic system, allowing the use of ordinary AC-powered equipment. Solar power inverters have special functions adapted for use with photovoltaic arrays, including maximum power point tracking and anti-islanding protection.

Keywords- Grid connection, Maximum Power point tracking, PCB, Buck converter, Boost converter, Half bridge inverter.

I. INTRODUCTION

The world is facing its great energy crisis. The reason behind energy crisis is localized shortage, wars and market manipulations. Electricity is produced from Non-renewable and Renewable energy resources. Most non-renewable enery resources are fossil fuels, petroleum, coal and natural gas.

Renewable energy is energy that produces from renewable energy resources. According to today’s scenario total installed capacity of power station in India is 3,30,860.58 MW.

About 18.37% consumption of total energy is comes from renewable energy resources and that is 60.98 GW without including large hydro power plant generation. If we include large hydro power plant electricity generation then standalone generation from large hydro power plant is 44.41 GW and contribution of hydro power plant is 13.6% of the total power generation capacity.

Contribution of solar energy in India is 20GW according to February 2018 survey and this solar energy used from produce electricity from sunlight energy. Total installed capacity of wind power is 32.72GW mainly spread across the south, west and north region, 10% of all energy from traditional biomass, mainly used for heating, and 13.5% from hydroelectricity. New renewable (small hydro, modern biomass, solar, geothermal, and bio-fuels) account for another 3% and are growing rapidly. At the national level, at least 30 nations around the world already have renewable energy contributing more than 20% of energy supply. National renewable energy markets are projected to continue to grow strongly in the coming decade and beyond. Wind power. Nuclear energy is not much preferable because of its harmful radiation effect on the mankind. After some of ten years conventional sources will not sufficient enough to fulfill the requirements of the mankind. So some of the electrical power should be generated by non-conventional energy sources like solar, wind .With the continuously reducing the cost of PV power generation and the further intensification of energy crisis, PV power generation technology obtains more and more application.

Conventionally, there are two ways in which electrical power is transmitted. Direct current (DC) comes from a source of constant voltage and is suited to short-range or device level transmission. Alternating current (AC) power consists of a sinusoidal voltage source in which a continuously changing voltage (and current) can be used to employ magnetic components. Long distance electrical transmission favors AC power, since the voltage can be boosted easily with the use of transformers.

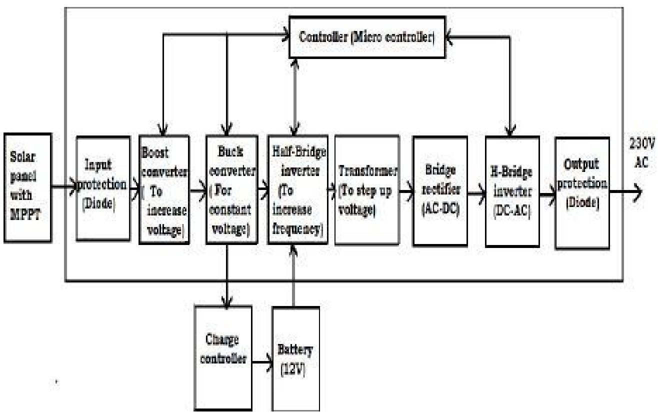

Figure 1.1 Block diagram of the overall topology of the inverter system

II. SOLAR INVERTER PARTs

There are few sections of the solar inverter they are:

1. The solar panel
2. Rechargeable battery
3. The inverter.

2.1 SOLAR PANEL

A solar panel (also solar module, photovoltaic module or photovoltaic panel) is a packaged, connected assembly of solar cells, also known as photovoltaic cells. The solar panel can be used as a component of a larger photovoltaic system to generate and supply electricity in commercial and residential applications

Figure 2.1 Solar Panel

2.2 RECHARGABLE BATTERY

The battery used in this project is a rechargeable sealed lead sulphate battery rating 12V 4.5AH. This type of battery is excellent for rechargeable purpose

A rechargeable battery or storage battery is a group of one or more electrochemical cells. They are known as secondary cells because their electrochemical reactions are electrically reversible. Rechargeable batteries come in many different shapes and sizes, ranging anything from a button cell to megawatt systems connected to stabilize an electrical distributionnetwork. Several different combinations of chemicals are commonly used, including: lead– acid, nickel cadmium (NiCd), nickel metal hydride (NiMH),lithium ion (Li-ion), and lithium ion polymer (Li-ion polymer).

Figure 2.2 Rechargable Battery

2.3 INVERTER

Since normal dc can’t be used in most applications due to which there is a requirement that somehow the dc is changed to ac for this the inverter is used which converts the dc to ac of suitable range for use in house hold appliances.

In this project the dc from the sealed rechargeable battery of 6V is fed to the inverter which then converts it to ac of 140V – 220V this makes it possible to recharge normal mobile chargers. An inverter is an electrical device that converts direct current (DC) to alternating current (AC).

III. DESIGN PROCEDURE

3.1 Design Procedure

The initial idea for the project consisted of an MPPT input stage followed by a single boost converter, which would bring a nominally 12 V solar panel up to the necessary 230 V DC. Using two boost converters in tandem was briefly considered but eventually discarded as excessively difficult to control and inelegant. 12 V nominal input voltage was not feasible since, at 300 W, this corresponds to a current of almost 42 A. Not only would this converter have heavy losses but it would be very difficult to test with available laboratory equipment. Thus, it was decided that the input voltage would be 12V, 24V, 48V, 36V nominally.

3.2 MPPT Stage Design

The concept of maximum power point tracking is best illustrated. MPPT is designed with AT89S52 MCU. Solar panel output is interfaced to Microcontroller through ADC. The controller continuously checks the voltage level of the panel and operates the stepper motor to attain maximum voltage. An LDR is used to sense the day / night

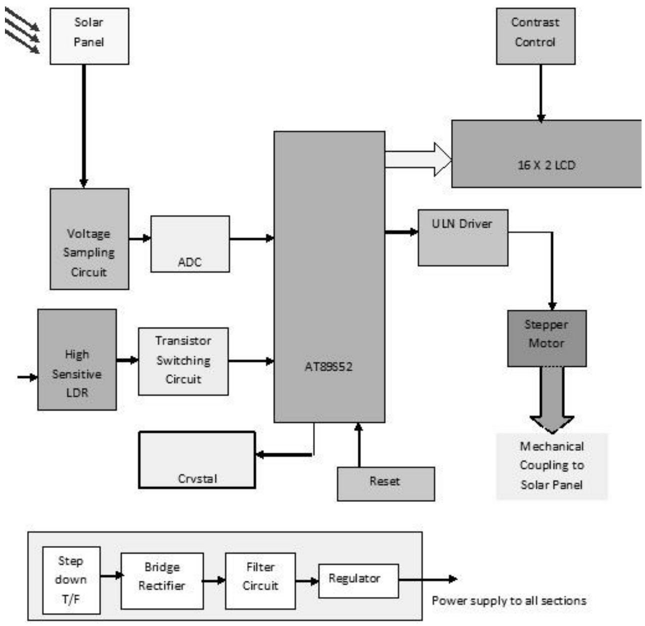

Figure 3.1 Block diagram of MPPT explanation

condition, to disable the tracking in night condition. The stepper motor is driven by a ULN driver. Figure 3.2 shows the block diagram for the process of MPPT design.

IV. DESIGN VERIFICATION: TESTING AND ANALYSIS

The following section will summarize the results and data gathered during testing of each power stage individually. For power converters, the figures of merit are the input/output characteristics

4.1 Boost Converter Testing: Results and Analysis

Testing of the boost converter was a straight-forward process. Various input voltages and loads were applied and measurements were taken for input voltage, current, and power as well as output voltage, current, power.

The solar panel was modeled by using a Magna Power supply capable of a DC input voltage of 0-400V and providing a current up to 27A. The load was a CFL load capable of handling 3- 1 5V/0-6A with a peak maximum power of 150W. The input voltage was varied for typical solar panel output voltages of 12V, 24V, 36V, and 48V. The output voltage was taken at 2 points: the minimal output voltage of 1 9V and maximum voltage of 23V, due to limitation of the electronic load. Another limitation of the testing was the output power, which was limited to 150W by a single electronic load. The results displayed in graphical form in Figures 5.1 & Figure 5.2

Figure 5.1 show the input/output voltage relationships as well as the associated duty ratio for each of the operating conditions; the duty ratio represents the control signal via a feedback loop that was provided by the control board.

Figures 5.2 display power output characteristics. For the operating range, the boost converter exhibited and efficiency between 95-85%

4.2 Buck Converter Testing: Results and Analysis

Buck converter testing was carried out in a similar manner to the testing of the boost converter. The same power supply was utilized as well as the CFL load; the same output power limitation of 75W was present.

The input voltage was varied between 1 9V and 23V, while varying the load as well. The output voltage was held at 12V and associated input/output voltage levels and power measurements were taken.

Figure 5.3 displays the output characteristics as well as the input in graphical manner. This plot shows the variation of the output voltage on the input voltage as well as the associated duty ratio necessary to achieve proper operation.

Figure 5.4 displays the power characteristics of the buck converter. The plot shows the variation of efficiency with respect to Vin and Pin; the achieved efficiency results fall in the range between 99-81%.

4.3 Half-Bridge Testing: Results and Analysis

In order to test the half-bridge circuit, a constant 12Vdc input needed to be supplied over the range of minimum and maximum load. The output waveform was monitored with an oscilloscope to ensure the proper 12Vp-p square wave signal was present.

While using discrete power resistors is certainly feasible, in order to apply a 300W load, a power resistor of 0.33 8. is necessary with that particular power rating.

Figure 5.5 displays a graph of the resulting output and power characteristics of the half-bridge inverter. However, once a power of approximately 130W was reached, the efficiency was significantly affected. At this power and voltage level, the current going into the load would be approximately 1 0A. Due to safety reasons, the half-bridge inverter could only be tested up to this operation point. The oscilloscope plots that show the relevant half-bridge signals;

this is shown in Figure 5.6 under a variety of operating conditions. The oscilloscope signals are: Ch. 1 is the output waveform, Ch.2 is the switching signal, Ch.3 is the Vds on the high side switch, and Ch.4 is the output current.

V. RESULTS

5A. Simulation results of each circuit:

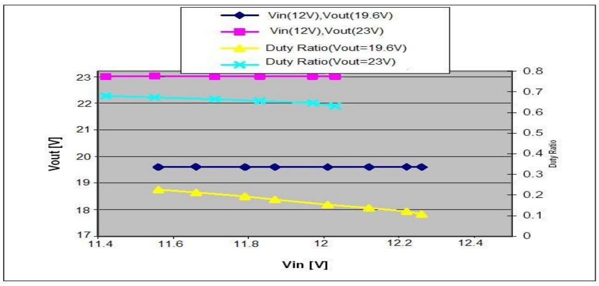

Figure 5.1 Boost Output Characteristics Vin=12V, Vout=19.6V & Vout=23V

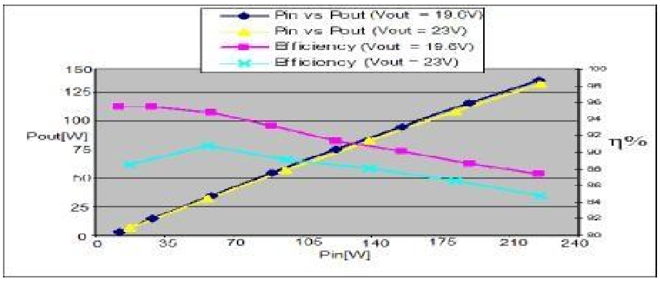

Figure 5.2 Boost Power Characteristics Vin=12V, Vout=19.6V & Vout=23V

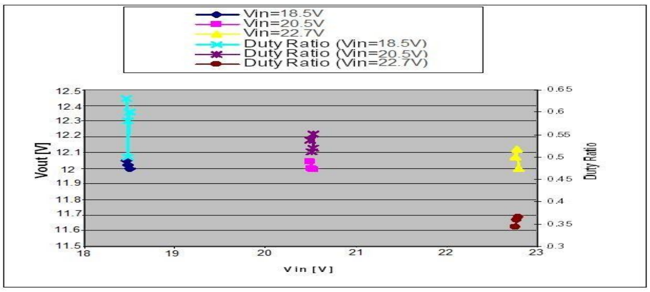

Figure 5.3 Buck Output Characteristic

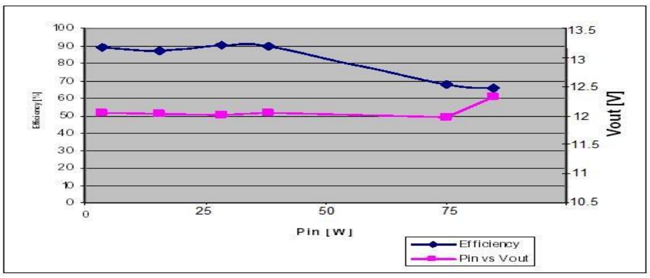

Figure 5.4 Buck Power Characteristic

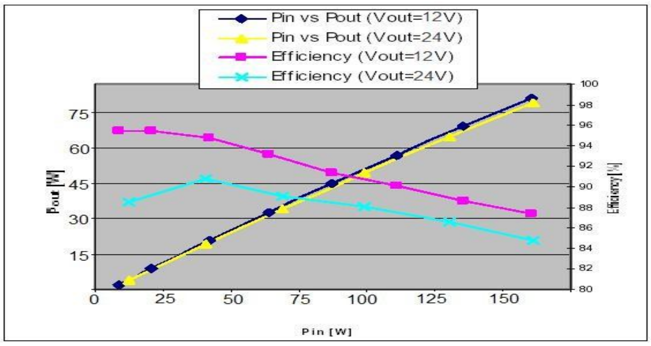

Figure 5.5 Half Bridge Performance

VI. CONCLUSION

Photovoltaic power production is gaining more significance as a renewable energy source due to its many advantages. These advantages include everlasting pollution free energy production scheme, ease of maintenance, and direct sunbeam to electricity conversion. However the high cost of PV installations still forms an obstacle for this technology. Moreover the PV panel output power fluctuates as the weather conditions, such as the insolation level, and cell temperature.

Although the project was never fully integrated, the disparate elements showed promise. The boost converter met the specifications up to 150W, while the buck converter did so up to about 75W. The half-bridge was unable to be tested using conventional methods and available equipment above 25W, but showed excellent performance up to that point. The h-bridge, although unable to provide high power levels, displayed the proper PWM output at bus voltages up to 230V. Among the stages, there was consistently an issue with inductive voltage spikes. This accounted for many of the performance limitations seen. Another issue involved the printed circuit boards. The PCBs used were not rated for the operating currents required and haphazard external routing schemes had to be devised. Even if the devices were capable of handling the aforementioned inductive spikes, it is unlikely that the PCBs could handle power levels as high as 300W

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