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Design of auto adjusted DC-DC-AC PV grid-inverter suitable for universal application

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Abstract:

In photovoltaic (PV) distributed generation system, the knee point is how to capture the energy generated by PV array and optimal conversion for achieve maximum productivity of the system. In this paper, re configurable high step up dc to dc converter and re configurable dc to ac inverter suitable for local utility interconnection is presented. Proposed dc to DC to AC hardware is tested under the conditions of different loads with variable standards also at different solar power input. The power fluctuation in the input or output is sensed with WCS 2705 hall sensor, and it's fed to ultra-low power MSP 430 powerful microcontroller, 200 kHz sampling error signal is reconfigured according to memory setting. Thus, enhanced generated power absorb, optimized loss and higher stability are implemented. Specific real time 2 kilowatt hardware of the proposed feature full controller based dc to dc to ac inverter is presented. The real time hardware implementation results justify the stability and feasibility of the universal load analysis and the proposed hardware topology. Experimental Verification of a Module Integrated Isolated Coupled Inductor based DC-DC Boost Converter fed Micro-inverter.

Keywords: Photovoltaic (PV), MSP Controller, Hall Sensor, SPWM Inverter, DC to AC converter.

I. INTRODUCTION

Among all existing green power sources, photo voltaic systems (PVs) are currently being widely implemented in all sectors and have a profitable prospect. However, for the reason that mounted PV capability are not uniformly disbursed, Owing to the power fluctuation and unpredictability of PV electricity output, serious issues may also rise up, together with poor voltage regulation [1][2].

Many milestone studies have been completed to solve those problems by way of managing PV energy output. For example, it's proposed in [3] [4] [5] that energy fluctuation of PVs be decreased by using directly curbing their electricity output and putting in controllable loads to expend the excess power at this technique can bring about decrease revenue loss than putting in strength storage systems.

Decentralized control methods, such as fixed voltage maximum power point tracking (MPPT) and frequency droop control ([4] [6] [7]) require local and pre-defined information's. Therefore, they are robust and save the cost of controllers.

However, as the features, protection techniques of PV based DGs increased, it becomes difficult to coordinate all the DGs to serve a common purpose. In comparison, a distributed control scheme, which only requires local communication network and information exchange, can enjoy the advantage of economic efficiency and robustness.

In this proposed work, a high step up dc to dc converter and adjustable frequency inverter modified deign is presented with the following features.

1) It works with the low power high speed controller and it has closed loop control technique.

2) The dc to dc converter designed with high gain value and the single phase DC to AC inverter designed suitable for different frequency load.

3) Solar power charge controller operates with more than 94% efficiency and inverter operates with low switching stress.

4) The distributed high efficiency power generation system had capable to interconnect with micro grid.

The remaining part of work is organized as follows. A brief review of high step up DC to DC converter and DC to AC inverter with suitable diagrams is presented in Section II .The MATLAB Simulink design of proposed work, results output waveform and components values specifications is presented in Section III. The IV section contains newly developed hardware setup of the proposed model demonstrates its effectiveness with their circuit, components value and result. And conclusions are finalized in Section V.

II. PROPOSED DC-DC-AC DESIGN

The proposed architecture consists of a PV charge controller with a P&O control algorithm, single phase SPWM inverter, MSP centralized controller. In the following divisions, details on the above defined tittles are to be elaborated.

A. Solar Interconnected With High Step Up Dc To Dc Converter

The voltage should be stepped up to sufficient level at which the DC/DC conversion can be performed to DC/AC load voltage requirements. Overall performance of the distributed PV system is affected by the efficiency of high step-up DC/DC converters. This circuit is focused on high efficiency high gain step-up DC/DC converters. Proposed DC/DC converters can be achieved by decreasing duty ratio of MOSFET and reducing potential stress on switches. This new design is 10A Maximum Power Point Tracking (MPPT, P&O) solar charge controller created for PV panel inputs corresponding to 12V and 24V panels. The design is targeted for high output voltage solar dc to dc converter solutions and is capable of operating with 12V/24V panels and up to 2A, 320V output current& voltage. Designed with universal use in mind, it can easily be adapted to a different voltage input and output voltage system by changing position of selector switch. The Solar MPPT Charge Controller was designed with real time parameter considerations. The circuit has an operating efficiency of above 94% at full load in a 24V system. For 12V systems the efficiency is above 96% and includes losses in the reverse battery protection MOSFETs.

B. Single Phase SPWM Inverter

SPWM generating technique is commonly used in commercial inverter system. Various control parameter like compliment pulse, dead band gap, varying frequency cycle can be implemented in MSP controller by setting of pre-defined registers. High speed of controller is obtained by the proposed PLL programming. Whenever the voltage level of the sinusoidal waveform is higher than the triangular waveform, a logic ‘1’ signal is generated. Otherwise, it is logic ‘0’. As a result, the controller produces SPWM gating signals to turn the switching devices on and off accordingly.

Consequently, the inverter produces output voltage waveform resemble to the SPWM waveform. Then, the output voltages pass through the filter to removes higher harmonics from the waveform and make the waveform nearly sinusoidal.

The switching frequency of the SPWM signal is 20 kHz and the frequency of reference signal is 50Hz. So for the SPWM switching technique, total 400 PWM signal is generated. For each quarter cycle of If we observe first 100 pulses which are held between 0 to 90 degree angles of reference wave, the duty cycle is increases.

In same manner from 90 to 180 degree, it is decreasing. From 180 to 270, next 100 pulses are in form of decrementing. Once again they are in incrementing form in 270 to 360 degree. This cycle is repeated at 120 degree apart for second phase and for third phase it is situated at 240 degree. As we change the modulation index, the pulse width is changed.

The output is therefore obtained from the digital pins instead of PWM pin. By changing the parameters in the program the duty cycle of the output wave form can be changed. The compliment waveform of the obtained PWM output is obtained by employing the NOT logic in The MSP program.

It is such that when a logical high is obtained on a pin a logical LOW is obtained on the other pin. This output is given to the gate terminals of the IGBTs present in the Inverter Module and the Inverter output is obtained as shown in the fig 9. To get sinusoidal output filter circuit is used as shown below.

C. *MSP Centralized Controller*

This MSP controller presents small size, robust 600-VA DC to DC to AC inverter based on TI's MSP430G2553 controller. The MSP430 controller has features such as ultra-low operating current and ultra-fast. In this system, controller PWM output is used for a boost stage to get 320-V DC from a 12-V PV panel.

In our practical implementation of a high step up DC to DC converter for Photovoltaic system for distributed generation application based on Perturb and Observe Maximum Power Point Tracking (MPPT) method controlled by MSP were designed. The system is controlled by sensing the solar panel parameters (V, I) accordingly controller generating the PWM signal cycle of the high step up converter.

III. HARDWARE IMPLEMENTATION

While designing an inverter can be complex, it does become easier when broken down into its component steps. The following sections detail each component within the project, as well as how each section is constructed and interacts with other blocks to result in the production of a 120V pure sine wave power inverter. With this, the assumption is made that that the high-voltage DC source already exists, whether it is from a transformer or a boost converter. There are many examples of those already on the market, and they are outside the scope this project.

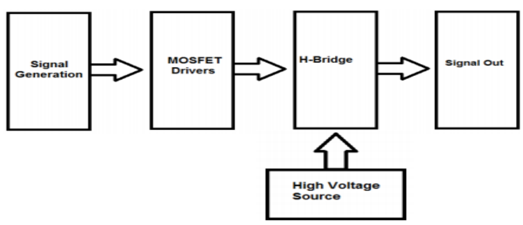

Fig.1.Hardware Block Diagram

The block diagram in this figure shows the three steps we need to generate the output signal. The signal is generated within the MSP430G2553 microcontroller. Then, it is input to the MOSFET drivers to provide a safety catch as well as the ability to keep the MOSFETS active when they are high. Finally, it passes into the MOSFETS of the H-bridge and draws power from the high voltage supply through the filter to generate the appropriate output signal.

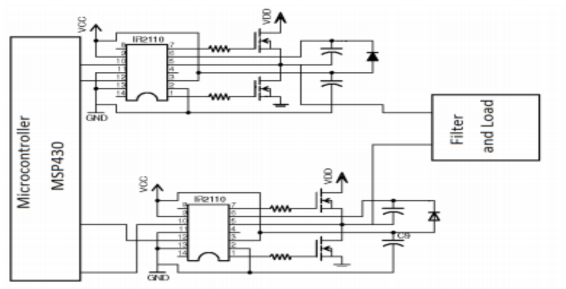

Fig.2.MOSFET Driver Circuit

This was the initial design of the circuit. The first task accomplished was an initial design for the output waveforms for the MSP430. In order to design these, the waveforms were simulated in MATLAB, to predict an accurate output.

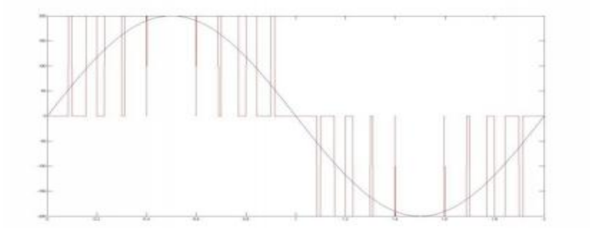

Fig.3.Sinusoidal PWM Signal

This first signal design was generated by integrating the sine wave at each potential switch point for the signal, and then adding a pulse of either positive or negative voltage whenever the integral had increased by more than a pulse's power. The first result of this design was the following microcontroller output:

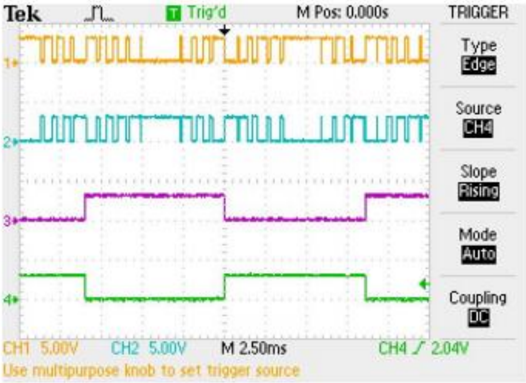

Fig.4.Pulses of inverter signals

The bottom two signals were the 60Hz base signal, while the upper two were the PWM activation. There were two sets of inverted signals to act as controls to both sides of the pillars of the "H"; when one MOSFET was on, the other on that side would be off, and vice versa. Almost immediately, an issue appeared: despite the specs of the MOSFET driver listing 3V as the minimum input voltage and the MSP430 outputting a high of 3.3V, the signals were not triggering the driver successfully. After testing to ensure that the drivers did, in fact, work and that they had been installed correctly, it appeared that there was an intermediate step necessary to amplify the signal to the point where the drivers would receive it.

To accomplish this, a pull-up resistor and a BJT were connected to the output of the MSP430G2553 microcontroller, pulling the on signal up to the 12V rail that also powered the MOSFET drivers, resulting in enough signal to pass through the drivers and activate the MOSFETs.

After the various iterations of the circuit and the minor bug fixes that had to be made, the final product looked like this:

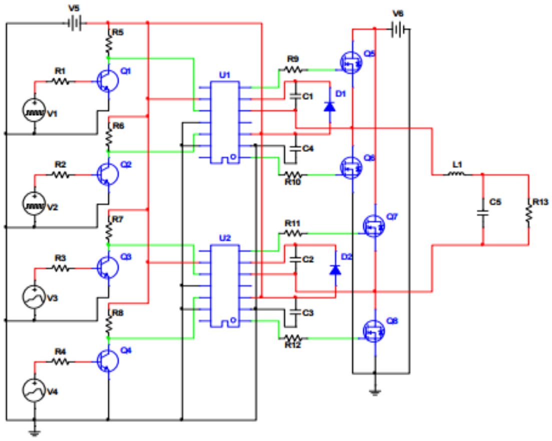

Fig.5.Circuit diagram for Hardware

The first tests performed with this version of the circuit were low voltage tests with varying filters and loads, in order to see how the circuit responded. With no load and filter components at 1 mH and 100 µF, the following output was taken across the open "load".

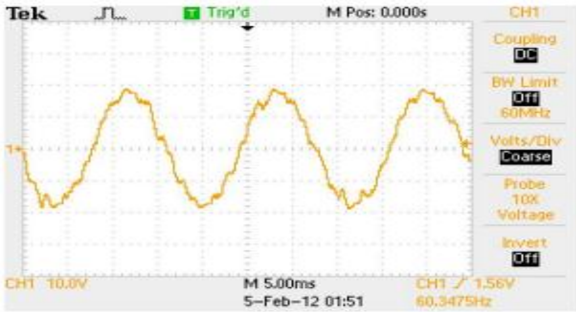

Fig.6.Output Waveform for Inverter with No-load

When a standard 12V, 25W light bulb was used as the load the waveform smoothed to the following:

Fig.7.Output Waveform for Inverter with Filter

This led to a significant voltage drop across the filter due to the very low resistance of the light bulb, as compared to the voltage source in use. The voltage across the H-bridge also dropped when this path was added. Therefore, to calculate the low voltage efficiency of this circuit, the power entering the H Bridge was compared to the power exiting the H-bridge, which resulted in an efficiency of 62.7%. This seemed low; however, as the circuit was tested with higher voltages, the efficiency increased as the static losses became less relevant. When testing the higher voltages, due to the cap on the switching speed, we were unable to find filter components large enough to properly test a filtered high-voltage circuit. However, we did obtain the following output across a 100W, 120V standard light bulb:

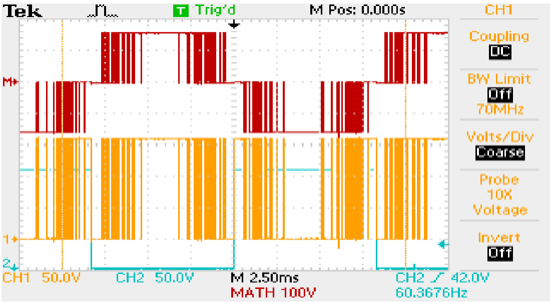

Fig.8.Output Waveform for Inverter with load

When we measured the power loss between the DC source and the load, we obtained a much better efficiency than in the low voltage tests: 82.6%.

IV.CONCLUSION

The goals of this project were to create a working DC-AC sine wave inverter that could efficiently provide a kilowatt of power using 3-level PWM and comparing it to other methods currently on the market. Looking at this goal, we accomplished it, though there is room for improvement. Our inverter had an efficiency of over 80%, a significant improvement over similar 2-level PWM systems. By comparison to the modified sine systems, the harmonics were significantly smaller, allowing for more effective use with delicate circuitry. While we did not test the maximum power provided by this circuit, we are confident that the inverter we built can withstand this power. The parts are all well within specs limits with an additional 30% safety margin, therefore we can safely say that it will provide the necessary power. This project provides a good building block that can be added in to many general-use high-power applications, as well as a base to work off for a self-regulating power supply, especially if the MSP centralized controller controls both the DC/DC converter and the DC/AC inverter.

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