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Performance Evaluation of A Modified Sine Wave Single Phase Inverter

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ABSTRACT
Solar energy the ultimate and future source of energy, getting its importance day by day and will become the prime source of energy for humankind in the near future. Solar power inverters in grid power supply for solar lighting system is used in rural homes of Indian villages. The power supply system comprises of solar (PV) array, PWM converter incorporating PWM control strategy and energy storage battery devices. The model of the system has been designed for its operation of a prototype solar power converter. Varieties of inverters are available in the market in that square wave inverter is cheaper. But it has poor efficiency and used only for resistive load. The sine wave inverters which are available in the market are costlier. Modified sine wave inverter is similar to a sine wave inverter but its output wave is not as smooth as that of sine wave and the modified sine wave inverter is good for all loads. The modified sine wave inverter is analyzed by using different PWM generating IC's like CD4047 and SG3525 and with different designed transformer to reduce the cost and size of the inverter to improve the efficiency.

Key words: *PWM, CD4047, SG3525, Inverter transformer.*

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I. INTRODUCTION

The three major parts in an inverter are inverter oscillator, power transistor and transformer. Today most of the inverter industries using SG3525, because this IC chip has fixed frequency pulse width modulation voltage regulator control circuit, with different output for single ended or push-pull application. The SG3525 is an electrical inverter or switching regulator on a single chip with all the functions necessary for the production of a regulating power supply. Moreover it can be used as control element for high power inverter. For the implementation of this project CD4047 is used, which has the following features and specifications. High voltage type (20v rating) and low power consumption which makes the circuit to consume less power. The CD4047 introduce less error in a circuit, because the special cmos oscillator configuration and one external resistor and capacitor are required for monostable (one-shot) or a-stable (free-running) operation. It is more flexible and gives the true and complemented buffered outputs. The monostable multivibrator feature of CD4047 gives positive or negative edge trigger output. Pulse width independent of trigger pulse duration and long pulse widths possible using small RC components by means of external counter provision. The fast recovery time essentially independent of pulse width and pulse width accuracy maintained at duty cycles approaching 100%. The astable multivibrator is free-running or getable, operating modes approaching 50% duty cycle oscillator output is available and having good astable frequency stability.

II. METHODOLOGY

The combination of PWM controller, driver circuit and output circuit are known as inverter, block diagram is shown in Fig. 1. Using a sinusoidal frequency as control voltage for pulse width modulation circuit, it is likely to generate a high power waveform whose average voltage vary with the sine wave, which is suitable for driving ac loads.

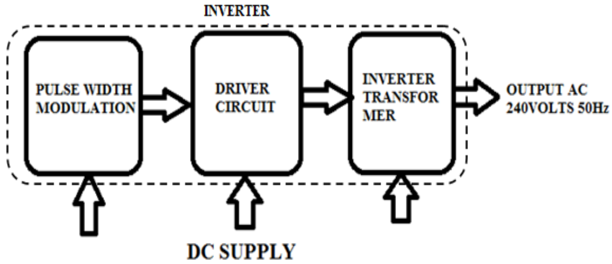

Fig.1. Block diagram of inverter

PWM signal is generated by CD4047. CD4047 has two outputs (available at pins 10 and 11), which are complementary to each other. These square wave pulses are pre amplified by TIP31 transistors, which acts as a driver circuit for the MOSFET'S. This amplified signal is used to switch IRFZ44N transistors to drive the inverter transformer. The 240 volts ac is available at the secondary side of inverter transformer.

III. IMPLEMENTATION AND TESTING.

PWM Generation: An oscillator stage is the simplest part in an inverter circuit. It's basically an astable multi-vibrator configuration, which can be implemented in different ways like NAND gates, NOR gates, devices with built-in oscillators (IC 4060, IC LM567, CD4047 or just 555 IC), can be used. Here CD4047 is used as astable mode of operation. Which will produces two complimentary signals at pin 10 and 11 with 50% duty cycle and the time difference between these signals is 0.01seconds, which are of square in nature. Here it is wired in astable mode. It works by charging a capacitor (C2) through a resistor (RV1) as in every astable multi-vibrators. Variable resistor (RV1) is provided for adjusting the output frequency to exact 50Hz. The time period of the oscillation is given by the equation (1).

$$T = 4.40*R*C\ldots\ldots\ldots\ldots(1)$$

MOSFET Bank and Driver stage: The N-channel enhancement mode standard level field-effect power transistor in a plastic envelope. It is having very low on-state resistance and has integral zener diode giving ESD protection up to 2kV. It is intended to use in switched mode resistance power supplies and general purpose switching applications. The drain source voltage of IRFZ44N is 55volt, drain current is 49Amps and total power dissipation is 110watts. The complimentary signals have voltage magnitude of 2-2.5V, but to trigger the MOSFET IRFZ44N 3-3.5V of voltage is required. It is obtained by employing TIP31 transistor as a voltage amplifier. The 4 MOSFET are connected in series and then connected in parallel with another 4 MOSFET (which are also connected in series). The gate resistance is calculated by using equation (2).

R=gate voltage/minimum gate current......(2)

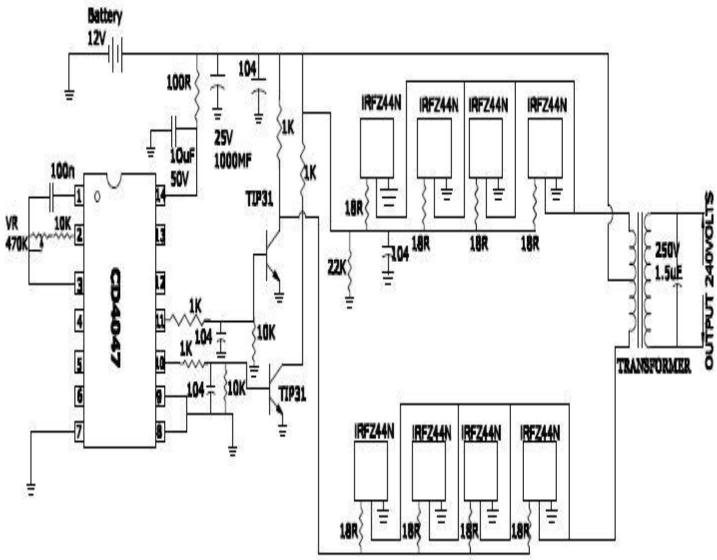

Fig.2. Inverter circuit.

Inverter Transformer: The inverter transformer is selected as per the required load. Here the 600VA centre tapped transformer is used, where the transformer can be loaded up to 600watts and it can also withstand up to 800watts. The rating of the transformer shown in Fig 2 has Primary 12-0-12 V, 50Amps and Secondary 230V.

The output at the pin 10 &11 of CD4047 has two complimentary square pulses, and these pulses given to the upper and lower side of the center tapped transformer 12-0-12 / 230V transformer. At the secondary side of the transformer AC voltage of 230V is obtained, which is used to power the home appliances. The implemented circuit is tested on lamp load.

IV. RESULTS AND DISCUSSIONS

The experimental setup with resistive load is shown in Fig.3. Here solar panel is connected to the battery through solar charge controller circuit. The battery terminals are connected to the inverter circuit through 2 pin PWM pulse connector to MOSFET bank. The MOSFET bank is connected to centre tap 12-0-12 / 230V transformer for the connection of the load. The calculation of efficiency and voltage regulation of implemented project work are calculated by referring the values obtained during experimentation.

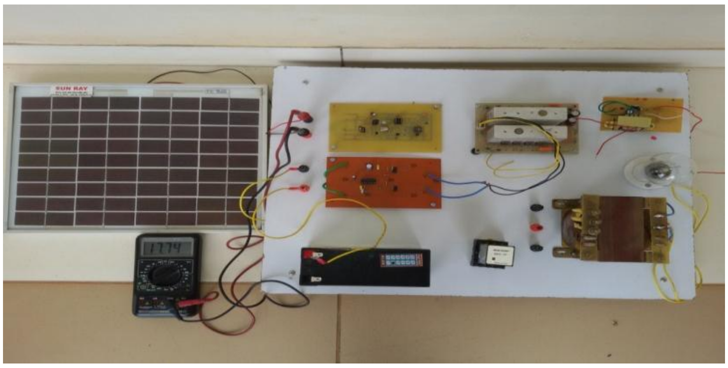

Fig.3. Experimental setup.

Voltage of 330V is obtained at output terminal on no load and 13.08V at battery terminal. When 100W, 230V lamp load is connected to the output terminal, the observed voltage is 240V and the current is 0.5A. At the same time the terminal voltage of the battery is 13.08V and current drawn from the battery is 10.08A. The terminal output voltage waveform of the implemented project work is shown in Fig 4. Nature of waveform is modified sine wave.

The measured input power at the battery terminal is 136.51 Watts and output power is 100 Watts, hence losses of 6.51Watts give efficiency of 73.25%. Voltage regulation for no-load output terminal voltage 330V and full load output terminal voltage 265V is calculated as 19.69 %. The power factor of inverter is calculated. For the output power of 100 watts, 0.5amperes and 265volts the power factor is 0.754. This is close to the standard inverters.

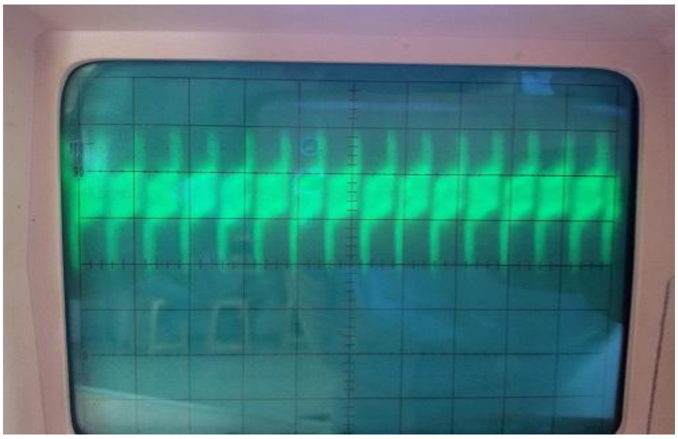

Fig.4.CRO output at resistive load

V. CONCLUSION AND FUTURE SCOPE

In this work discussion is made on different parameters like efficiency, permissible voltage levels, voltage regulation and the harmonics for a lamp load. The open circuit voltage is 330V, which is normally high for the inverters with open loop system. The Efficiency and voltage regulation of the standard inverters and implemented inverter are nearly equal.

In future implemented project can be extending to run the inductive loads. The extension of this project can be done by the following measures. To improve the efficiency of inverter, it is essential to design inverter by adopting the low loss semiconducting devices. The open circuit voltage is normally high in open loop inverter system. It can be minimized or kept constant to a standard 230V by incorporating closed loop inverter system. In the closed loop inverter system the high level languages like C, C++ and embedded C are used for programming of PWM. Voltage regulation which depends on open circuit voltage of an inverter, it can be automatically improved by adopting closed loop inverter system.

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