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Uninterruptible Power Supply Using Solar Rechargeable Battery

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Abstract: Problem statement: A 600 watts Uninterruptible Power Supply (UPS) that consists of an inverter operated with solar rechargeable battery has been constructed and characterized. **Approach:** An inverter of high switching frequency and high power handling, a sensor, an oscillator and other electronic devices were employed in the circuitry. Performance tests involved measurements of supply currents and voltages from the battery to the inverter and the inverter output currents and voltages under varying applied load conditions and various power ratings of 12 volts feed battery. **Results:** Results showed that a threshold battery capacity of 12 volts 62 A/H is required to sustain a steady voltage output of 220-240 volts for hours depending on the external load. Internal control switching and rectifier systems also allow the use of mains supply when available. **Conclusion:** The system provides a standby power source to overcome disruption of work in progress due to power failure.

Key words: Inverter, UPS, oscillator, voltages, switching frequency

INTRODUCTION

Uninterruptible Power Supply is critical to many sectors of the economy such as operation of units in hospitals, banking operations, information technology systems, etc. and generally, a constant power supply is cardinal to rapid economic growth and sustainable development. In developing countries in particular, where power failure is a regular feature, there is great need for improved UPS systems. A power supply system that incorporates a renewable source of energy as contained in this work provides a viable option to overcome the problem of disruption of work in progress due to power failure.

The main components to all forms of Uninterruptible Power Supply systems include maintenance-free lead-acid battery bank, switchgears, inverters and source of energy (Kusko, 1989). The UPS constructed in this work is configured to operate fully in automatic mode with provision for recharging the backup battery from solar energy. Internal switching control incorporating MOSFETs (McKenzie, 2001) and rectifier systems also allow automatic use of the mains supply when available, for operating the load and recharging the battery. In this study, functions of the main components along with their efficiencies and reliabilities are discussed and the results of performance tests of the constructed UPS are presented.

MATERIALS AND METHODS

Inverters: An inverter is an electronic device that takes a direct current (dc) input and produces an alternating current (ac) output. The efficiency of an inverter is highly dependent on the switching device, topology and switching frequency. A standard topology was employed in this work due entirely to its high power handling capabilities. The switching frequency of the design used was 1.858 K Hz This combination of high power and high switching frequency makes the choice of transformer critical for the attainment of the desired goal.

Inverter switch and its operation: The working principle of an inverter is depicted in Fig. 1a (McKenzie, 2001). When switch S_1 is closed the dc source voltage is applied across T_1 and T_3 of the transformer primary. After a certain period of time S_1 is cut off and S_2 closes, now applying the voltage source to T_2 and T_3. In Fig. 1b (McKenzie, 2001) the switches are replaced by FET semiconductor switches which are used because of their high speed switching capability. During the first positive half cycle, transistor T_1 is switched into conduction causing the dc source voltage of 12 volts to be applied across T_1 and T_3 while transistor T_2 is cut off. In the next negative half cycle transistor T_2 is switched into conduction with the source voltage now across T_2 and T_3 while T_1 is cut off.

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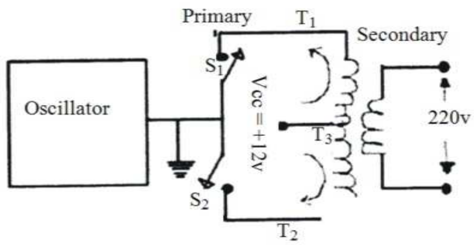
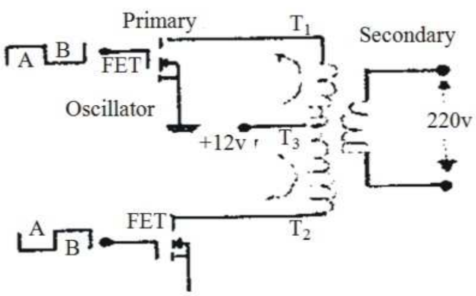


(a)



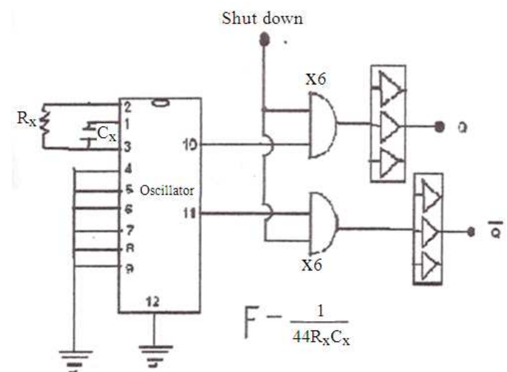
(b)

Fig. 1: (a) Working principles of inverter (b) FET switching

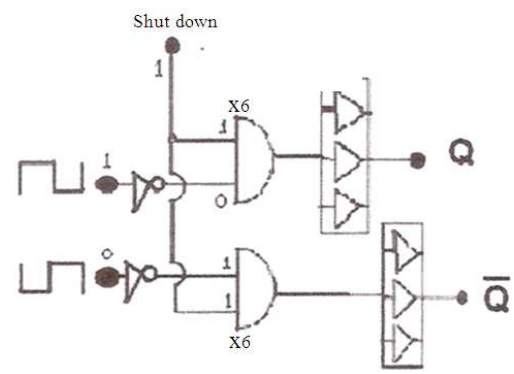
With this cumulative switching, alternating EMF is induced across the primary of the transformer which induces an ac voltage across the secondary (Theraja and Theraja, 2009).

Sensor: The sensor is comprised of an opto-isolator which gives an output whenever there is mains utility supply and vice versa. This switch is used to drive series of transistor and inverter gates in order to enhance their switched voltage capability. Its function is as follows. If there is utility supply the transistor is switched on by the opto-isolator circuit and this causes a delay circuit to be activated. The circuit will then delay for approximately 3 sec, after which it goes high. This change of state shuts down the isolator thereby stopping the inverter which was before now, 'ON'. The delay further switches the output from the inverter to the utility without much flicker.

Oscillator: The oscillator is built around components which are configured as a free running astable multi-vibrator whose frequency is dependent on the values of C_x and R_x alone as shown in Fig. 2a (McKenzie, 2001). This oscillator generates outputs that are complementary, that is $\bar{Q}$ and Q. These outputs are used to drive the push-pull output stage of the inverter forming the two parallel powered MOSFETs each per/channel.



(a)



(b)

Fig 2: (a) Astable multi-vibrator (b) Astable multi-vibrator LOGIC switching

Since the oscillator output signals are complementary, both FETs (channels) will not be in conduction simultaneously. The output of the oscillator is gated to an "and" gate as in Fig. 2b which further buffers the signal and also provides a shut down facility whenever there is utility supply (McKenzie, 2001).

Other components: Other components employed in the construction of the inverter include opto-isolator consisting of a light emitting and a light sensitive devices (William, 1991), delay and change over circuit which is built around Lm 358 op-amp which acts as comparator monitoring the voltage at its two points "non-inverting and inverting" (McKenzie, 2001). Also, snubber circuits for controlling switching stresses, solar cell unit comprising of solar power and solar current booster (John, 2005) used for generating electricity from the sun by induction and radiation. Transistors, rectifiers and relays were also employed. The composite circuit of the inverter is shown in Fig. 3. The change over circuit is included in Fig. 4.

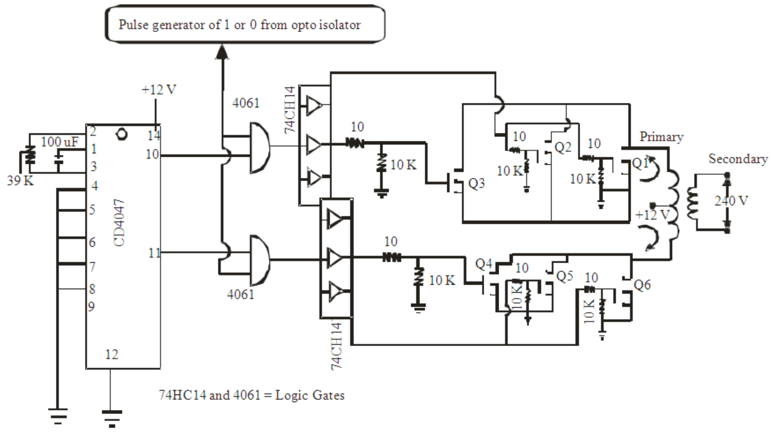


Fig. 3: 600 Watts inverter circuit

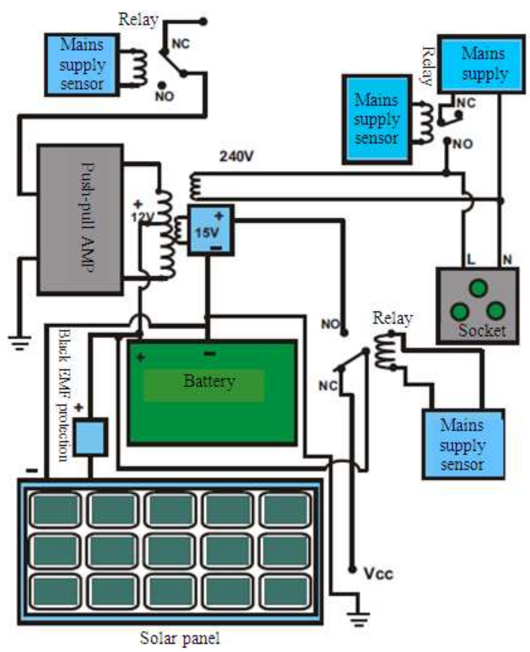


Fig. 4: Change over circuit diagram

RESULTS AND DISCUSSION

Results of the performance test of the constructed UPS are displayed in Fig. 5-10 for the cases of 12 volts feed batteries of 55, 62 and 75 amp h^{-1}.

Following the construction, the inverter was tested, first to determine the functionality of the various component circuit modules which were found to function accurately. The inverter was further tested for performance using three sealed batteries, 12 volts 55 amp h^{-1}, 12 volts 62 amp h^{-1} and 12 volts 75 amp h^{-1} as storage media. As shown in Fig. 5b, c and 6b, c the 12 volts 55 amp h^{-1} battery sustained 60 watts load for 50 min and the100 watts load for 45 min only.

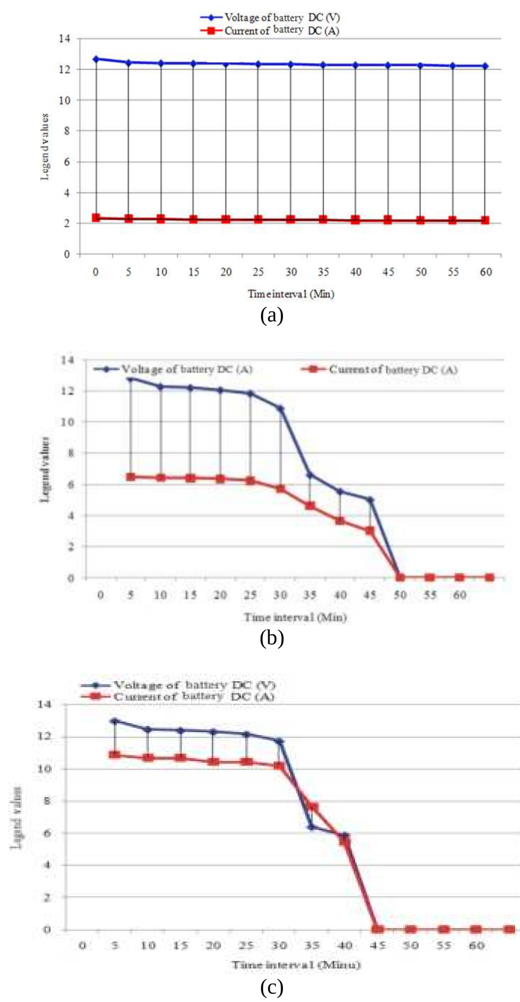
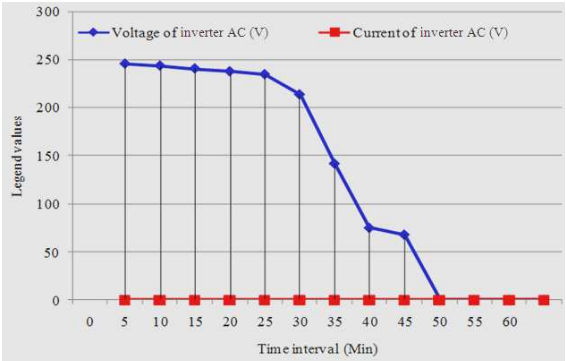


Fig. 5: Input current and voltage using 12 volts 55 A/H battery with (a) no load (b) 60 watts load and (c) 100 watts load



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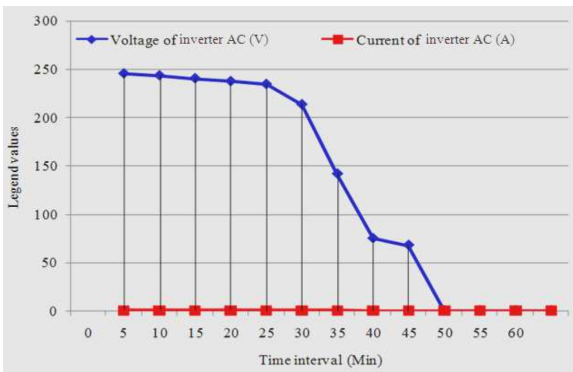

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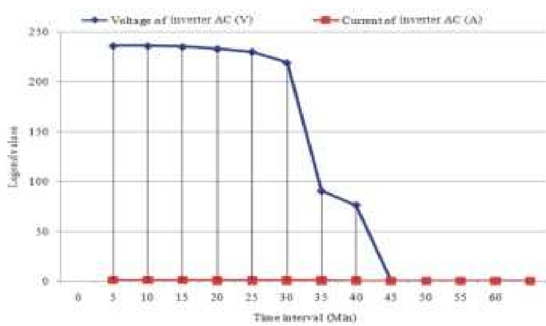
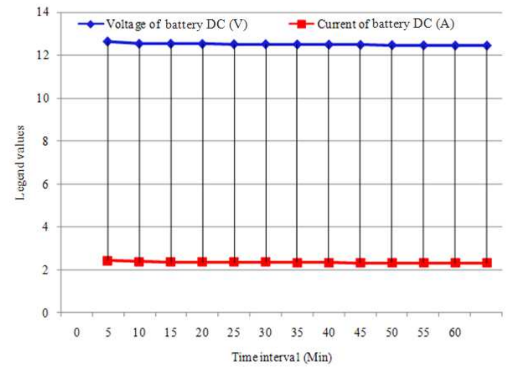


(c)

Fig. 6: Output current and voltage using 12 volts 55A/H battery with (a) no load (b) 60 watts load and (c) 100 watts load



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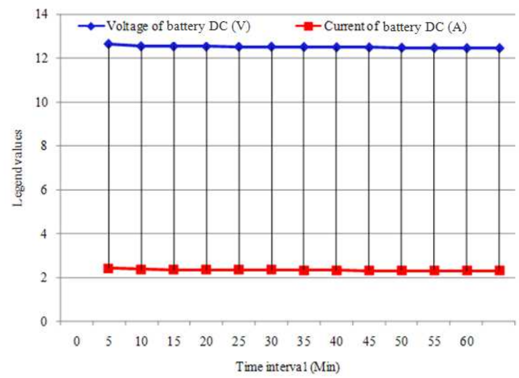

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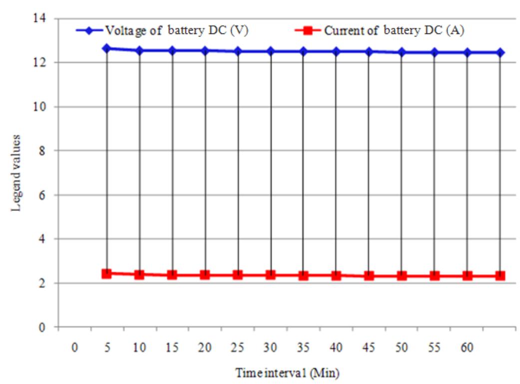

(c)

Fig.7: Input current and voltage using 12 volts 62A/H battery with (a) no load (b) 60watts load and (c) 100 watts load

Figure 7b and c and 8b and c show that 12 volts 62 amp h^{-1} battery sustained both 60 watts and 100 watts loads for more than 1 h with input voltage to the inverter remaining steady at 12 volts and the inverter output voltage steady between 220-240 volts. Similar results of steady input voltage of 12 volts and output voltage of 220-240 volts exceeding 1 h were obtained for the same loads using 12 volts 75 amp h^{-1} battery as shown in Fig. 9b and c and 10b and c.

Figure 5a-10a also show that for all the three feed battery capacities the input and output voltages remained steady at no load indicating the reliability of the inverter. The Fig. 5-10 also show that relatively large current is drawn by the inverter when load is connected to the output.

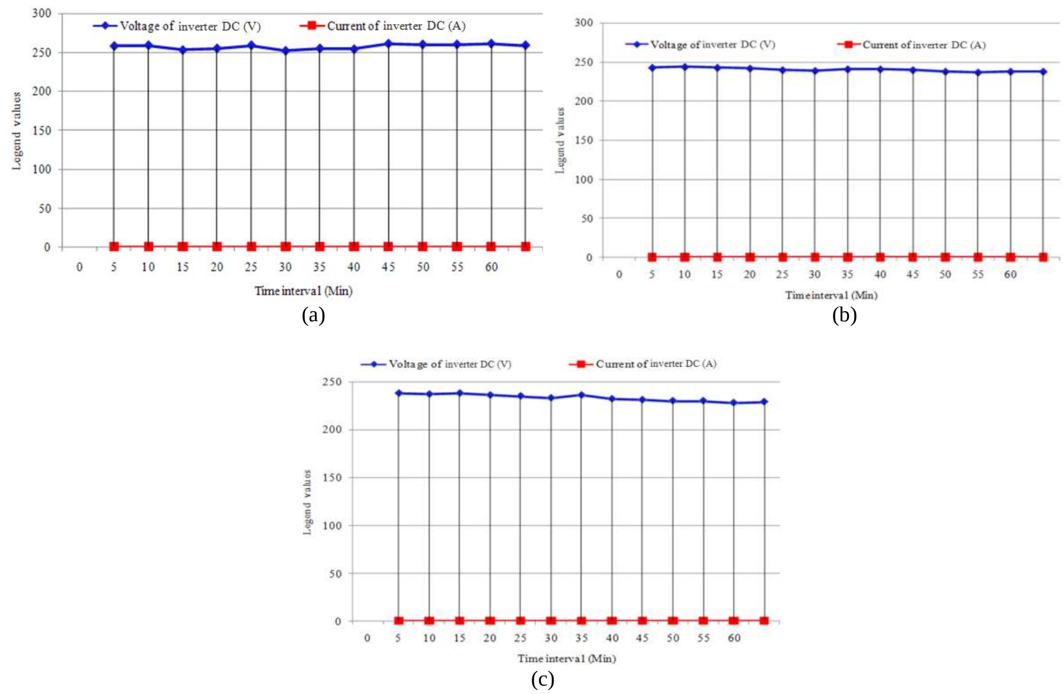

Fig. 8: Output current and voltage using 12 volts 62A/H battery with (a) no load (b) 60 watts load and (c) 100 watts load

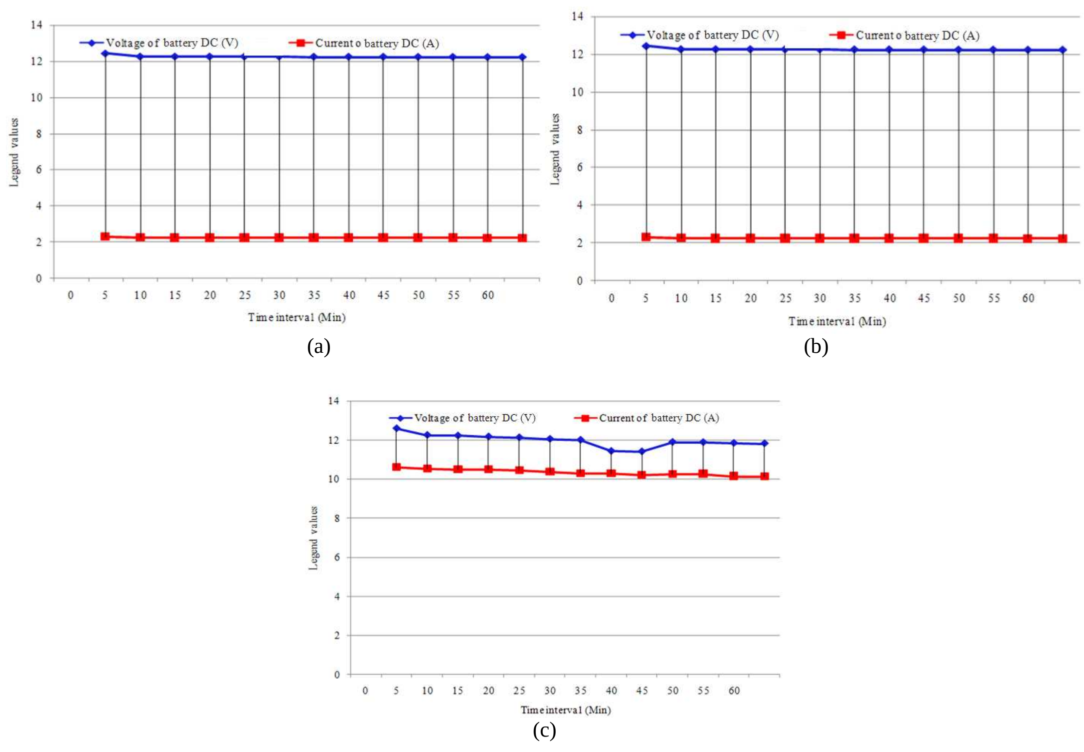

Fig. 9: Input current and voltage using 12 volts 75A/H battery with (a) no load (b) 60watts load and (c) 100 watts load

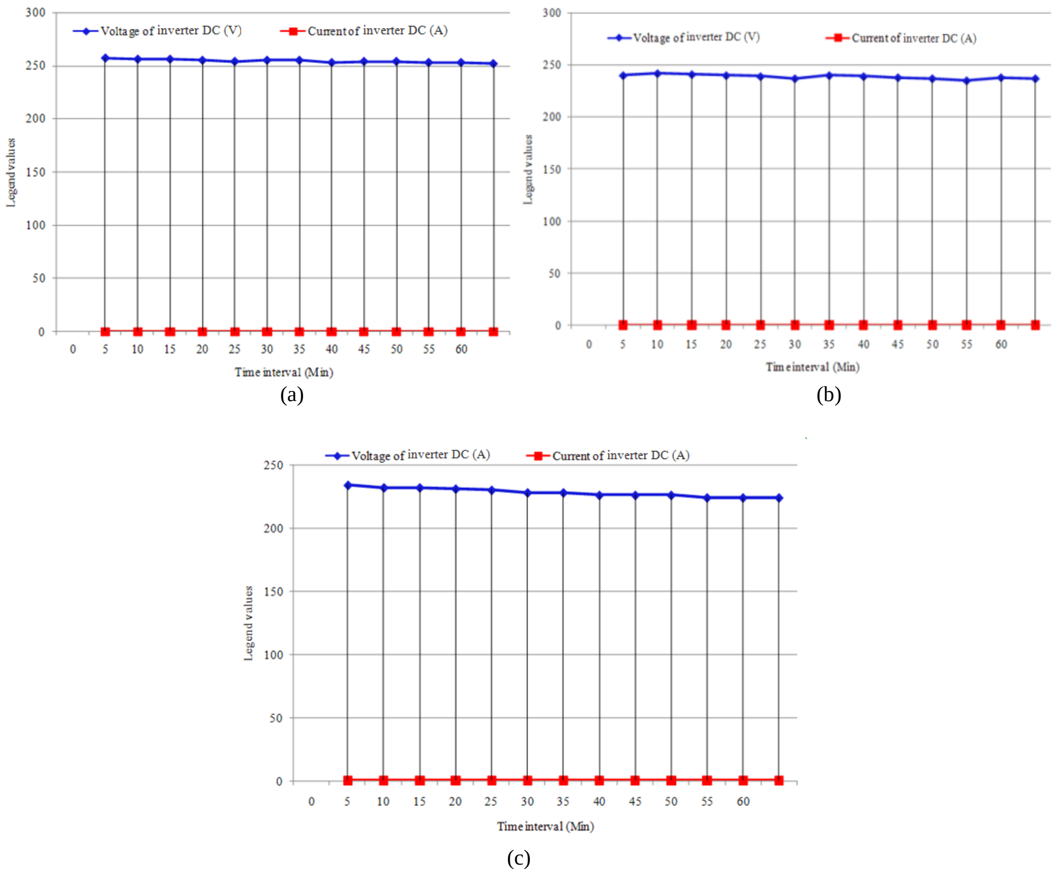

Fig. 10: Output current and voltage using 12 volts 75A/H battery with (a) no load (b) 60 watts load and (c) 100 watts load

CONCLUSION

A dc-ac inverter system that uses solar rechargeable battery has been constructed and tested. It functions efficiently with deep cycle 12 volts battery with capacity rating of 62 A/H and above that can sustain steady output of 220-240 volts to external load for some hours. It requires large diameter cables for input link to the inverter in order to withstand the huge current drawn by the inverter when load is connected to the output. For efficient solar energy conversion, a sealed battery is recommended. MOSFETs of uniform values and power ratings are also used to construct the left and right arms of the input to set up the inverter transformer.

REFERENCES

John, G., 2005. Silicon shortage stalls. Wired News. http://eng.anachorpedia.org/solar_power

Kusko, A., 1989. Emergency/Standby Power Systems. 1st Edn., McGraw-Hill Inc., USA., ISBN: 13: 9780070356894, pp: 239.

McKenzie, S., 2001. Hughes Electrical Technology. 7th Edn., Pearson Education Inc., USA., ISBN: 0582247055, pp: 390.

Theraja, B.L. and A.K. Theraja, 2009. Electrical Technology. 23rd Edn., S. Chand and Company Ltd., USA., ISBN: 10: 8121924375, pp: 919.

William, L.F., 1991. An Introduction To Modern Electronics. 1st Edn., John Wiley and Sons Inc., USA., ISBN: 10: 047762247, pp: 358.