DEVELOPMENT OF ON-LINE SINGLE PHASE UNINTERRUPTIBLE POWER SUPPLY (UPS) FOR LOW POWER APPLICATION

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Uninterruptible Power Supply (UPS) is an electrical apparatus that provides emergency power to a load when the input power source (from main utility) fails to deliver electric power. The purpose of this paper is to show development of an on-line mode single phase UPS that suitable for 240 V (AC), 50 Hz type of electrical appliances, especially for personal computers or low power electrical appliances. The advantage of the on-line mode of UPS is there is no transfer time during the transition from normal to back-up modes. The design consists of battery charger/ rectifier module, inverter module and battery. One of the important components used is IC NE555 and the function is to generate pulses and control the frequency of inverter. Proteus 7.1 SP2 software is used to simulate the designed circuits. The UPS is developed with output specification, 240 V (AC), 50 Hz. The developed UPS has been tested on a personal computer and successfully provides backup power up to 400 W for about 15 minutes. Therefore, the developed UPS is able to provide temporary backup electric power for critical electrical appliances when outage condition occurs.

Keywords: Uninterruptible Power Supply, Inverter, Rectifier, Single Phase UPS, On-line mode UPS.

1. INTRODUCTION

Electrical power is one of the sources of energy that is important in daily life. However, the power disturbances always can be happened which can caused by faults on the distribution system, the operation of nearby equipment, lightning strikes, normal utility operations, or any other causes [1]. The resulting disturbances such as electrical noise, voltage spikes, sags, swells, and complete outages can exceed the electrical tolerances designed for the electrical equipment in use [2]. This sudden problem will cause big problems to the user. For instance, user of the sensitive loads like computer will deal with the problem such as missing the precious documents due to the sudden blackout.

In order to eliminate or reduce the loss of important data or control, it may be necessary to provide a level of power protection as needs. An Uninterruptible Power Supply (UPS) is the perfect answer. These devices are designed to provide continuous power to a load, even with an interruption or loss of utility supply power. While not limited to safeguarding any particular type of equipments, the UPS is typically used to protect computers, data centers, telecommunication equipment or other electrical equipment where an unexpected power disruption could cause injuries, fatalities, serious business disruption or data loss [3-5].

A line-interactive UPS has been proposed by [4] and Improved Single-Phase Line-Interactive UPS by [5] have been discussed. These types of UPSs offer the

characteristics of an inverter-preferred UPS. This is based on the combination of two full-bridge voltage source inverters (VSI) converters: one in series with the input and the other in parallel with the load [4]. An inverter-preferred UPS, also known as an online double-conversion UPS, supplies the load through the inverter during either abnormal or normal input power conditions. A rectifier charges the battery, floating on the dc link, and also powers the inverter. A static bypass switch may connect the input line to the load, bypassing the inverter during overload or inverter failure. This UPS is composed of the pulse width modulation (PWM) rectifier, providing a regulated output voltage regardless of input power conditions. This topology is usually the most costly.

[6-7] discussed about standby UPS by considering the application of a simple six SCR Bridge, the inverter of the UPS. However, the topology of the passive standby UPS itself has disadvantages, including a limited load voltage regulation capability, no ability to reduce the source voltage harmonics, and a long switching time, resulting in a system that can not accept certain sensitive loads. Therefore, the development of on-line UPS is expected to overcome all these deficiencies.

On-line UPS systems consist of a converter as a rectifier/charger, a battery set, an inverter, and a static bypass switch as shown in Figure 1. The rectifier/charger continuously supplies the DC bus. Its power rating is required to meet 100% of the power demanded by the load as well as the power demanded for charging the battery bank.

The batteries are rated in order to supply power during the back up time. The duration of this time varies in different applications. The inverter is rated at 100% of the load power since it must supplies the load during the normal mode of operation as well as during the back up time. It is connected in series with the load; hence, there is no transfer time associated with the transition from normal mode to stored energy mode [8].

The main advantage of on-line UPS is very wide tolerance to the input voltage variation. In addition, there is no transfer time during the transition from normal to stored energy modes. It is also possible to regulate or change the output frequency [9].
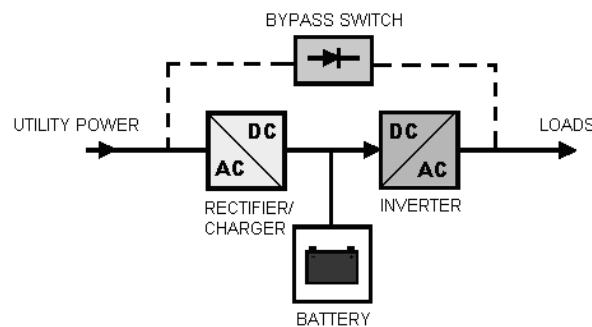

Figure 1: On-line UPS Block Diagram

The objectives of this paper is to show the development of online mode single phase UPS that able to supply temporary electric power to the personal computer or other low power electrical appliances during sudden outage condition. The output specifications of the UPS are 240 V (AC), 50 Hz and 400 W.

2. DESIGN CONSIDERATION

2.1 Rectifier/Charger Circuit

A bridge rectifier is used as a battery charger as shown in Figure 2 has been considered. The rectifier/charger circuit is in normal condition when the green and red LEDs are light up as shown in Figure 3. In the case of power failure, the green LED is OFF and the red LED is switch ON to indicate that the system is now in backup mode.
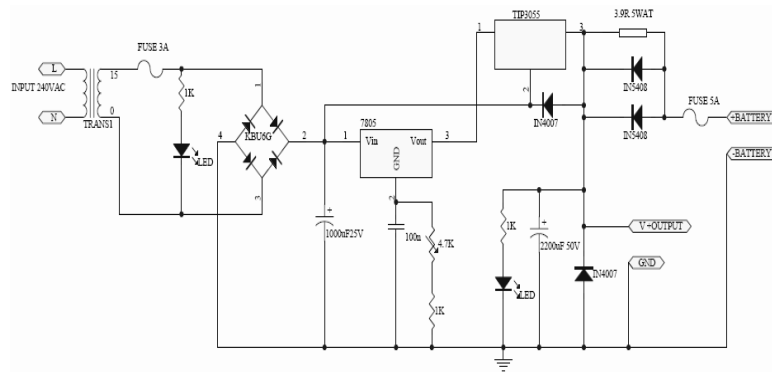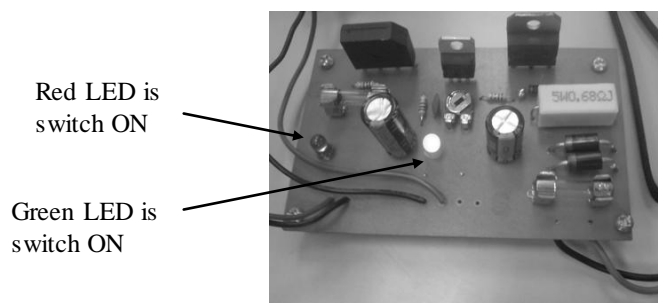

Figure 2: Rectifier/Charger Circuit

Red LED is switch ON

Green LED is switch ON

Figure 3: Rectifier/Charger circuit when the presence of power supply

2.2 Inverter Circuit

Inverter circuit for this system consists of a step-uptransformer, an IC NE555 to generate pulses, power transistors for switching, and a relay for by-passed switch as shown in Figure 4. The ON condition of the inverter is represented by the light up of a green LED as shown in Figure 5.
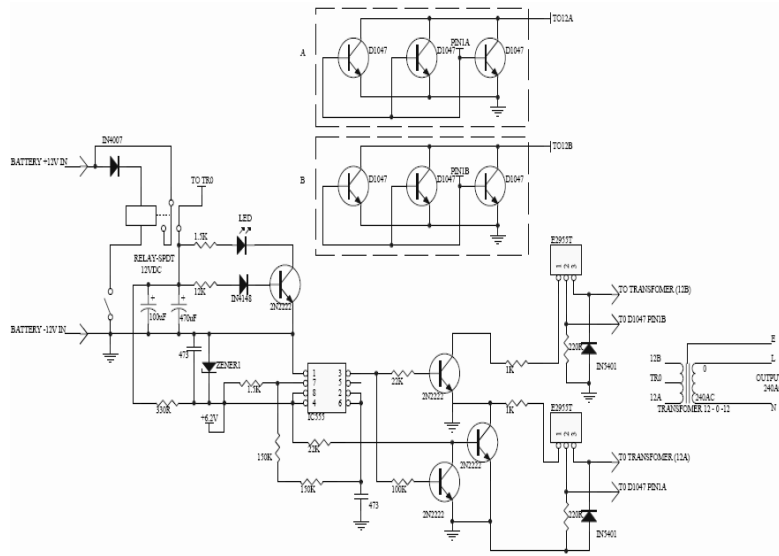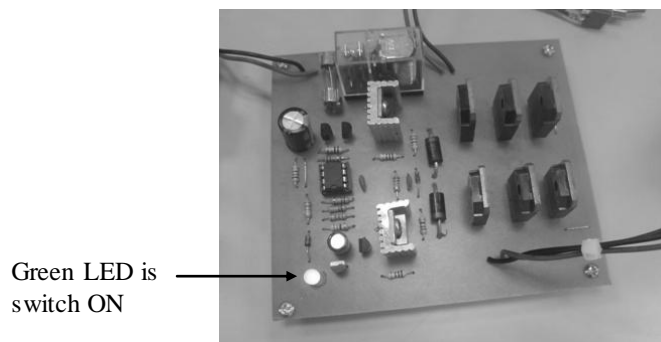

Figure 4: Inverter Circuit

Green LED is switch ON

Figure 5: Inverter circuit in ON condition

3. RESULT

3.1 Simulation Result

Figure 7 shows the circuit of rectifier that simulated on Proteus 7.1 SP2 software. The output of the rectifier circuit is about 15 V (DC).
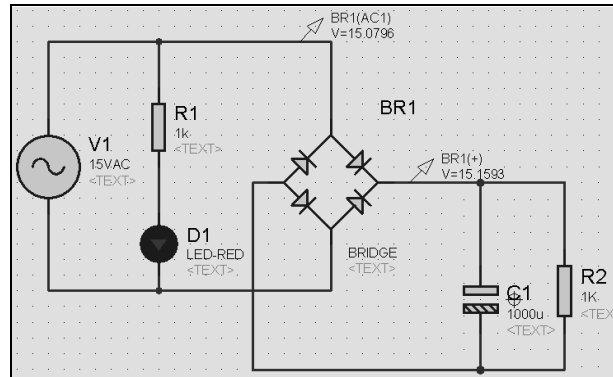

Figure 7: The rectifier circuit

The charger circuit is shown in Figure 8. The input voltage is fed from the output of the rectifier circuit which is 15 V (DC). The voltage regulator L7805CV is used to regulate voltage from 15 V to 12.6 V to charge the battery.
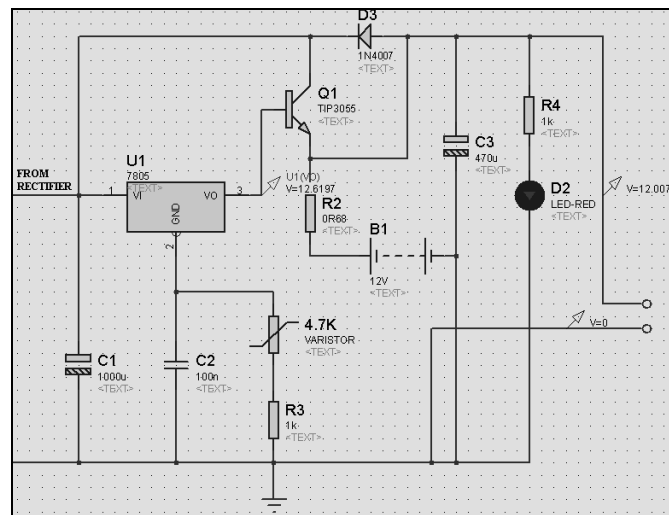

Figure 8: The charger circuit

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The IC555 timer is used in the inverter circuit to generate pulses as shown in Figure 9. While, Figure 10 shows duty-cycle of the IC555 timer output.
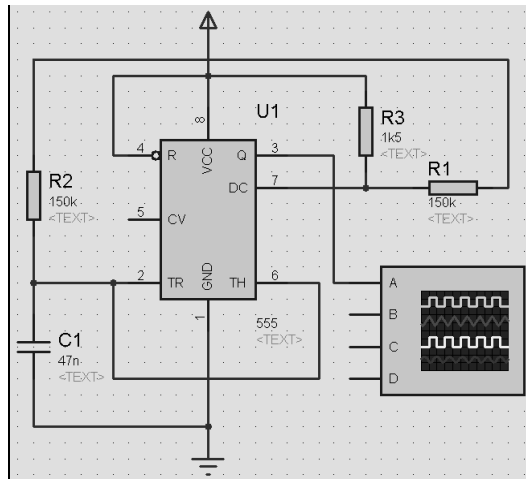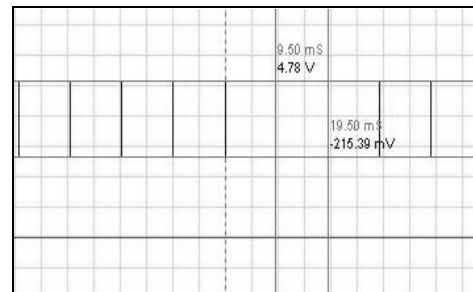

Figure 9: IC555 connection

Figure 10: duty-cycle

3.3 Hardware Result

Figure 11 shows the measured output from rectifier, 15 V (DC). The measured output shows the agreement with simulation result. The measured output result from IC NE555 of pulses is shown in Figure 12. The time (period) of the IC NE555 is measured as 20 ms and equal to 50 Hz with amplitude 18 V.
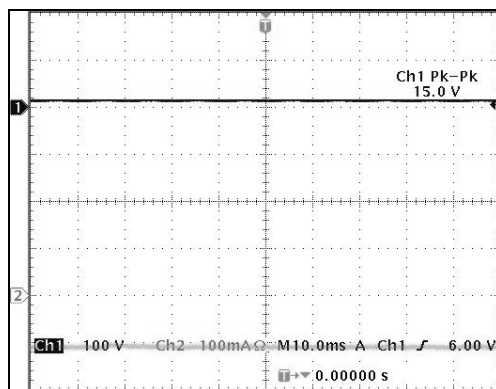

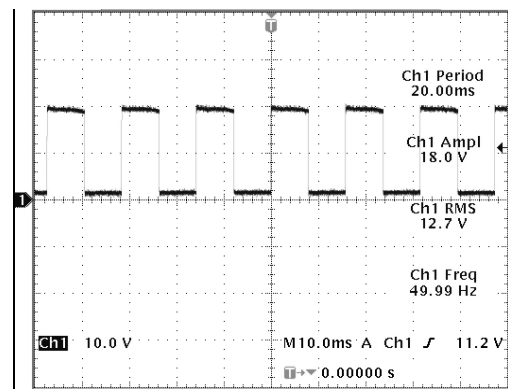Figure 11: The rectifier output

Figure 12: The generated pulses

The generated pulses have been amplified through connection of the six transistors D1047. The amplified waveform is shown in Figure 13(a) whereby peak to peak

voltage is 326 V, 50 Hz. The measured output signal before step-up transformer is 180 V peak to peak, 50 Hz and shown in Figure 13(b).

The final measured output signal is in AC square wave and provides 673 V peak to peak and frequency is about 50 Hz, Figure 13(c). Therefore, the final output signal in rms is about 238 V (AC, rms). However, this type of waveform is not suitable for powering devices with high inductive or capacitive loads, like electric motors and surge suppression devices. This type of waveform is hard on the DC power supplies in computers, and should not be used to power that device except for power backup for few minutes that needed to perform a proper shutdown of the computer.
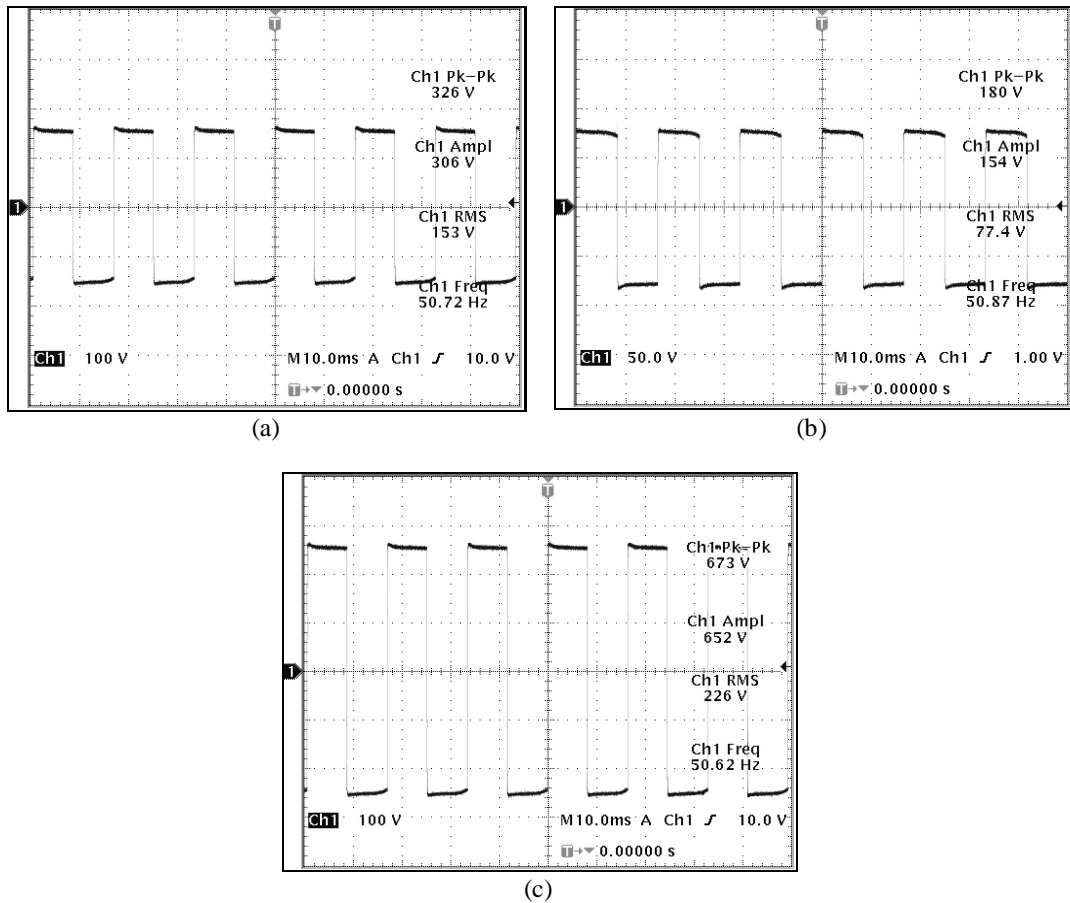

(a)   (b)

(c)

Figure 13: (a) The amplified signal, (b) The output of inverter circuit before step-up transformer, (c) The final output of the project

4. CONCLUSION

The objective to develop 400 W with 240 V (AC, rms), 50 Hz single phase Uninterruptible Power Supply (UPS) that provide the uninterrupted power for about 15 minutes has been presented. Unfortunately, the project only generated AC square wave output and the output waveform can be improved by considering appropriate filter circuit. However, the system is able to give temporary power for low power of electrical appliances (up to 400 W).

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