LOCALLY FABRICATED UNINTERUPTED POWER SUPPLY (UPS) FOR SYSTEM COMPATIBILITY

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Abstract:
Uninterrupted power supply is an electrical device that provides emergency power to a load when the input power source, typically the utility mains fails or whenever the line voltage varies outside normal limits. Obviously, uninterrupted power supply (UPS) is an indispensable power unit in every size of establishment. Its features such as noiseless working condition, availability of storage elements, numerous system compatibility, etc. have not in any way marred its acceptance. This device is really dominating computer establishments in most developing countries. It has also been found useful in many other applications in big industries, homes offices, industries and religious centers and places of worship for continuous sustainability of energy supplied to electronic gadgets. The stages of the design were divided into sections. The UPS was switched ON, the bulb started to glow, and the UPS worked properly. The components of the UPS such as MOSFET transistor, relay, inverter, transformer and change over circuit were working properly and efficiently.

***Keywords**: UPS, Inverter, Oscillating, Switching, Change-Over, Loww-Battery*

Introduction

The secret of continuous power supply after shutting down of electricity from the national grid is the uninterruptible power supply. It is commonly referred to as UPS, this devices is a cleaver threefold package-a set of battery, an inverter that transforms the low-voltage direct current of the batteries into the standard alternating current equivalent to your wall outlet, and a battery charger that assures that reserve power storage system (the batteries) with interfaces to match it to utility power and your computer system (Abrishamifar et al., 2012; Botteron and Pinheiro, 2007; Chiang et al., 2000; Dauda et al., 2013; Niroomand and Karshenas 2010). A UPS differs from an auxiliary emergency power system or stand-by generator in that it will provide instantaneous or near-instantaneous protection from input power interruptions by means of one or more attached batteries and associated electronic circuitry for low power users, and or by means of diesel generators and flywheels for high power users (Abrishamifar et al., 2012; Botteron and Pinheiro, 2007; Chiang et al., 2000; Dauda et al., 2013; Niroomand and Karshenas 2010). While not limited to protecting any particular type of equipment, a 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 and/or data loss (Abrishamifar et al., 2012; Botteron and Pinheiro, 2007; Chiang et al., 2000; Dauda et al., 2013; Niroomand and Karshenas 2010). UPS units range in size from units designed to protect a single computer without a video monitor (around 200 VA rating) to large units powering entire data centers, buildings, or even cities. The UPS is designed to protect against changes, specifically a temporary loss of electrical supply (Abrishamifar et al., 2012; Botteron and Pinheiro, 2007; Chiang et al., 2000; Dauda et al., 2013; Niroomand and Karshenas 2010). This paper focuses on conversion of AC to DC and from DC to AC power inverters, which aim at efficiently transforming a DC power source to a high voltage AC source, similar to power that would be available at an electrical wall outlet. Inverters are used for many applications, as in situations where low voltage DC sources such as batteries, solar panels or fuel cell must be converting electrical power from a car battery to run a laptop, TV or cell phone (Abrishamifar et al., 2012; Botteron and Pinheiro, 2007; Chiang et al., 2000; Dauda et al., 2013; Niroomand and Karshenas 2010). It has been observed that light goes OFF in Nigeria without notice and one can be very busy either at home or in the office using the power supplied from main source before it goes OFF, instead of keeping whatever activities at the moment waiting for light from main source, with the help of uninterrupted power supply the work could continue. This UPS provides the efficiency in the use of power appliance by ensuring continuous availability of power supply in the absence of the main source (Abrishamifar et al., 2012; Botteron and Pinheiro, 2007; Chiang et al., 2000; Dauda et al., 2013; Niroomand and Karshenas 2010).

Background Study/Design Concept

There are lots of electronic laboratory measuring devices used to measure parameters in the locally design of uninterrupted power supply. These devices are described in details below. Among these devices is *Electronic Workbench*. The electronic work bench is a simulation software which runs on almost any windows platform and can be used to design and simulate a circuitry to see if there are errors in the design layout. In this tool, a signal source can be attached to the input and when switched ON, the output waveform can be viewed on an oscilloscope plot on the screen of the computer. It is very essential tool for designing and test-running circuitry before the main construction process can start. It is also a known fact that when a workable design has been accomplished, 70% of the job is said to be done (Abrishamifar et al., 2012; Botteron and Pinheiro, 2007; Chiang et al., 2000; Dauda et al., 2013; Niroomand and Karshenas 2010). Another device is *Galvanometer* and early scientists experimenting on electricity and magnetism noticed that an electric current produces a magnetic field. This discovery was probably an accident, but it got the curiosity of scientist. When a magnetic compass is placed near a wire carrying a direct electric current, the compass does not point toward magnetic north, the needle is displaced. The extent of the error depends on how close the compass is brought to the wire, and also on how much current the wire is carrying. Scientific experimenters are like children. They first observed, the scientist tried different arrangements to see how much the compass needle could be displaced, and how small a current could be detected. An attempt was made to obtain the greatest possible current-detecting sensitivity. Wrapping the wire in a coil around resulted in a device that would indicate a tiny electric current. This effect is known as galvanism, and the meter so devised was called a galvanometer (Abrishamifar et al., 2012; Botteron and Pinheiro, 2007; Chiang et al., 2000; Dauda et al., 2013; Niroomand and Karshenas 2010). Another one is *Voltmeter*. Current is a flow of charge carriers. Voltage, or electromotive force (EMF), or potential difference, is the "pressure" that makes a current possible. Given a circuit whose resistance is constant, the current that will flow in the circuit is directly proportional to the voltage placed across it. Early electrical experimenters recognized that an ammeter could be used to measure voltage, since an ammeter is a form of constant resistance circuit. If you connect an ammeter directly across a source of voltage in a battery, the meter needle will deflect. In fact, a millimeter needle will probably be "pinned" if you do this with it, and a micrometer might well be wreaked by the force of the needle striking the pain at the top of the scale. For this reason, one should never connect millimeter or micro ammeters directly across voltage sources. An ammeter, perhaps with a range of 0 A to 10 A, might not deflect to full scale if it is placed across a battery, but it is still a bad idea to do this, because it will rapidly drain the battery. Some batteries, such as automotive lead-acid cells, explode under these conditions. This is because all ammeters have low internal resistance. They are designed that way deliberately. They are meant to be connected in series with other parts of a circuit, not right across the power supply. But if one places a large resistor in scribes with an ammeter, and then connect the ammeter across a battery or other types of power supply, you no longer have a short circuit. The ammeter will give an indication that is directly proportional to the voltage of the supply. The smaller the full-scale reading of the ammeter, the larger the resistance to get a meaningful indication from the meter. Using a micro ammeter and a large value of resistor in series, a voltmeter can be devised that will draw only a little current from the source. It is always good when a voltmeter has a high internal resistance. The reason for this is that you don't want the meter to draw much current from the power source. This current should go, as much as possible, towards working whatever circuit is hooked up to the supply, and not into just getting a reading of the voltage. Also, one might not want, or need, to have the voltmeter constantly connected in the circuit. One does not want the behavior of the circuit to be affected the instant you connect the voltmeter to the supply. The less current a voltmeter draws, the less it will affect the behavior of anything that is working from the power supply (Abrishamifar et al., 2012; Botteron and Pinheiro, 2007; Chiang et al., 2000; Dauda et al., 2013; Niroomand and Karshenas 2010).

Sometimes, it is desirable to have an ammeter (*Amp meter*) that will allow for a wide range of current measurements. The full-scale deflection of a meter assembly cannot easily be changed, since this would mean changing the number of coil turns and/or the strength of the magnet. But all ammeters have a certain amount of internal resistance. If a resistor, having the same internal resistance as the meter, is connected in parallel with the meter, the resistor will take half the current. Then take twice the current through the assembly to deflect the meter to full scale, as compared with the meter alone. By choosing a resistor of just the right value, the full-scale deflection of an ammeter can be increased by a factor of 10, or 100, or ever 1000. This resistor must be capable of carrying the current without burning up. It might have to take practically all of the current flowing through the assembly, leaving the meter to carry only 1/10,or 1/100 of the current. This is called a shunt resistance or meter shunt. Meter shunts are frequently used when it is necessary to measure very large currents, such as hundreds of amperes. They allow micro ammeters or millimeter to be used in a versatile millimeter, with many current ranges (Abrishamifar et al., 2012; Botteron and Pinheiro, 2007; Chiang et al., 2000; Dauda et al., 2013; Niroomand and Karshenas 2010). *Wattmeter*, the measurement of electrical power requires that voltage and current both be measured simultaneously. Remember that power is the product of the voltage and current. That is, watts (P) equals volts (E) times amperes (I), written as p= EL In fact, watts are sometimes called volt-amperes in a dc circuit. You might think that you can just connect a voltmeter in parallel with a circuit, thereby getting a reading of the voltage across it, and also hook up an ammeter in series to get a reading of the current through the circuit, and then multiply volts by amperes to get watts consumed by the circuit In fact, for practically all dc circuits, this is an excellent way to measure power. Wattmeter an electric iron might consume 500 W, or a current of 500/12 = 41.67 A. and a large heating unit might gobble up 500 W, requiring a current of 1000/ 117 = 8.55 A. this might blow a fuse or breaker, since these devices are often rated for only 15 A. One might have probably had an experience where one hooked up too many appliances to a single circuit, blowing the fuse or breaker. The reason was that the appliances, combined, drew too much current for the house wiring to safely handle, and the fuse or breaker, detecting the excess current, opened the circuit (Abrishamifar et al., 2012; Botteron and Pinheiro, 2007; Chiang et al., 2000; Dauda et al., 2013; Niroomand and Karshenas 2010). In the electronics laboratory, a common piece of test equipment is the millimeter, in which different kinds of meters are combined into a single unit. The *volt-ohm-millimeter* (VOM) is the most often used. As its name implies, it combines voltage, resistance and current measuring capabilities. You should not have too much trouble envisioning how a single millimeter can be used for measuring voltage, current and resistance. The preceding discussions for measurements of these quantities have all included method in which a current meter can be used to measure the intended quantity. Commercially available *MultiMate's* have certain limits in the values they can measure. The maximum voltage is around 1000 V; larger voltages require special leads and heavily insulated wires, as well as other safety precautions. The maximum current that a common VOM can measure is about 1 A. the maximum resistance is on the order of several mega ohms or tens of mega ohms. The lower limit of resistance indication is about an ohm's.

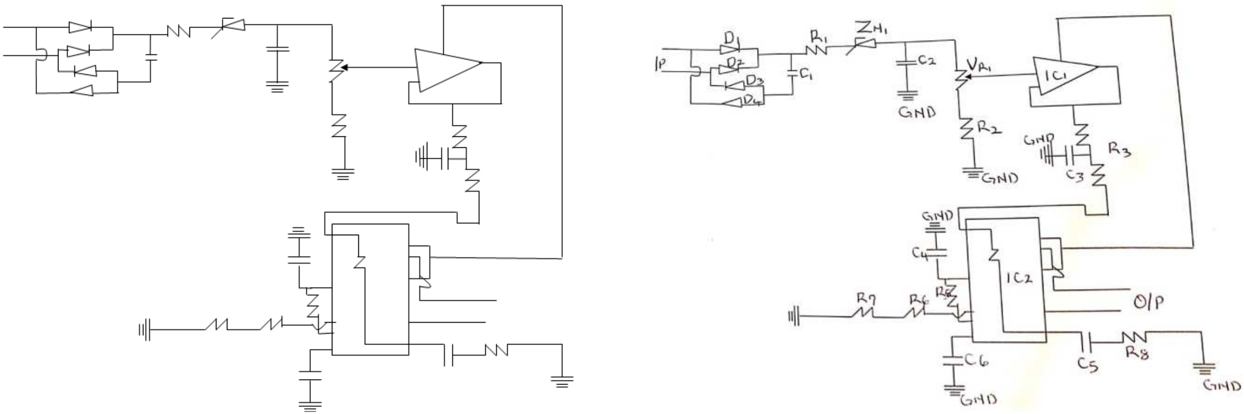

Figure 1: The oscillator circuit

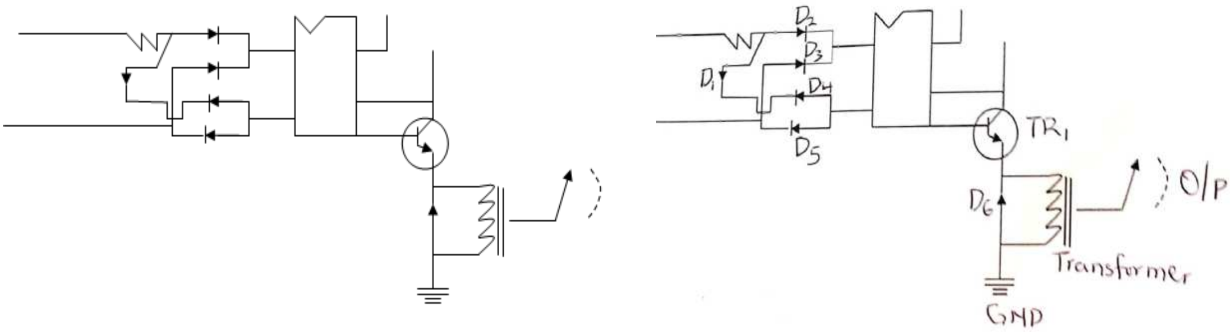

Figure 2: The changeover circuit of the UPS

Design and Construction/Results and Discussion

The design and construction stages were grouped into five sections and these are discussed below

Oscillator Section

The IC SG3524 is used in the oscillation section of this UPS. This IC is used to generate the $50H_z$ frequency required to generate AC supply by the inverter. To start this process, battery supply is given to the pin-15 of the SG324 through on/off switch which passes through the normally close contact of the relay. Pin-8 is connected to the negative terminal of the battery. A voltage regulator LM7008 is connected across the battery through two capacitors connected in parallel and grounded as shown in the circuit (Fig. 1). This regulates the 12V supply from the battery. Pin-5 and 7 of the IC are the oscillation section pins. The frequency produced by the IC depends on the value of the capacitor and resistor connected at these pins. The two capacitors (each 0.1µF) are connected to pin-7. These capacitors decide the 50Hz frequency output by the IC. Pin-5 is timing resistance pin. The resistance at this pin keeps the oscillator frequency constant. Preset variable resistor is connected to ground from pin-6 of the IC, this preset is used so that the value of the output frequency can be adjusted to a constant 50Hz. A fixed resistor of a known value is connected in series with the variable resistor to deliver a given frequency as shown by the relation:

$$F=1.30/RT*CT \quad (1)$$

where F is the frequency in KHz, RT is the total resistance at pin-6 and CT is the total capacitance at pin-7. Therefore to obtain a frequency of 50Hz, given CI +C2 =CT, CT=0.1+0.1=0.2, making RT subject formula, therefore we have:

$$RT=1.31/0.01=131K \quad (2)$$

Therefore RT must be varied at 131k to obtain a frequency of 50Hz. In this design, a resistor of 100K and a variable resistor of 20 K were fixed. Signal generated at the oscillator section of the IC reaches the flip-flop section of the IC. This section converted the incoming signal into signal with changing polarity. This signal with changing polarity means that when the first signal is positive the second would be negative and when the first signal goes negative the second would be positive. Therefore to achieve a frequency of 50Hz this process most repeat 50 times per second at a regular interval (i.e. an alternating signal with 50Hz, frequency is generated inside the flip-flop section of the IC). This 50Hz frequency alternating signal has an output at pin-11 and 14 of the IC. The alternating signal may also be known as the MOS drive signal. This MOS drive signal at pin-11 and 14 are between

3-4V. Voltage at these pins should be same, because any variation in the voltage at these pins could damage the MOSFET at the output.

Driver/Switching Section
The MOS drive signal from the pin-11 and 14 of the IC are given to the base of the transistor T1 and T2. This resulted in the MOS drive signal getting separated into two different channels. Transistor T1 and T2 amplify the 50Hz MOS drive signal at their base to a sufficient level and output them from the emitter while the collector are grounded. 50Hz signal from the emitter of T1 is given to the gate of each MOSFET in the MOSFET channel, through resistance RA4-2K. Each MOSFET gate receives the 50Hz signal through a resistor (RA6-RA9). And also 50Hz signal from the emitter of T2 is given to the gate of each MOSFT in the second MOSFET channel, through resistance RA19-2K. Each MOSFET gate receives the 50Hz signal through a resistor (RA14 –RA17). When the first MOSFET was on, the current flows through the first half of the inverter transformer bifilar winding. When the second MOSFET channel turns ON, the current flows through the second half of the inverter transformer winding. The switching on/off of the MOSFET channels will start an alternating current in the bifilar winding of inverter transformer. AC current in the bifilar winding will induce an AC current of 50Hz, in the 220 and 240v tapings of the transformer. The AC voltage output from the transformer is connected to the normally close of the relay to the output socket. The 50Hz alternating MOS drive signal reaches each MOSFET channel separately which result in the MOSFET channels being alternating on and off (i.e. when the first channel is ON the second channel will be OFF, and when the second channel is ON, the first will be OFF). This on/off switching is repeated 50 times per second. The drain (D) of all the MOSFETs of one channel is connected together and one end of the inverter transformers bifilar winding is connected to this connection. Likewise the drain of the MOSFET of the second channel is also connected together and the other end of the inverter transformers bifilar winding is connected to this connection. The position terminal of the battery is connected to the center tapping of the bifilar winding which result in the positive supply reaching drain of each MOSFET transistor through each end of the bifilar winding. Source (S) terminal of each MOSFET is connected to the negative terminal of the battery through a shunt of low value resistance. Because polarity of the 50Hz MOS drive signal at pin-11 and 14 are different, at a time only one channel from the output channel remains ON, the other channel stays OFF.

Changeover Section
The changeover section is used to Switch on the inverter when the AC mains supply switches off and Switch off the inverter when the AC mains supply returns. When the UPS receives AC mains supply, it stops drawing the battery supply, and the AC mains supply at the UPS input is directly sent to the UPS output socket. The change over circuit adopted for this design is very simple. It consists of 12V step down transformer and can be divided into two states i.e when there is Power supply from AC source the inverter would be switch off and when there is no supply it goes back and switches the inverter. This process happens like this, when there is AC supply, the oscillator which is connected to the output of the normally close of the relay connects the oscillator with power sources and the switching process starts. But when power supply comes back on, a 12V signal is sent to the coil of the relay through the diodes D1 and D2. The common of transformer is connected to the negative terminal of a 220uf capacitor and the positive terminal is connected to the cathode of D1. The coil energizes in the process and contacts the normally open relay thereby connected the load to the AC supply. During this process a 12V signal is sent to the shutdown pin of the IC CB4047 to shut down the inverter and hence stop its switching process and this is shown by the circuit in Fig. 2.

Low Battery Cut-Off Section
When the battery becomes discharged i.e. the battery voltage falls below a set voltage level, the UPS should switch off because if it continues to draw current from a discharges battery (Fig. 3), the battery will get damaged. Therefore to switch off the UPS in low-battery condition, a low battery cut circuit is put to use. This circuit is made of pin-2,3 and 4 of an IC2 (LM7008). Pin-4 of the IC2 is given a 5V reference voltage goes below a set point, pin-2 of the IC2 outputs a low-battery signal. This low battery signal is used to drive T15 and SCR T10 (XL08), and sends a shutdown signal at the shutdown pin-10 of PWM controller IC(CB4047). When the PWM controller IC2 receives low-battery shutdown, signal at its pin-16, its oscillation section stops the operation and the UPS will automatically shutdown

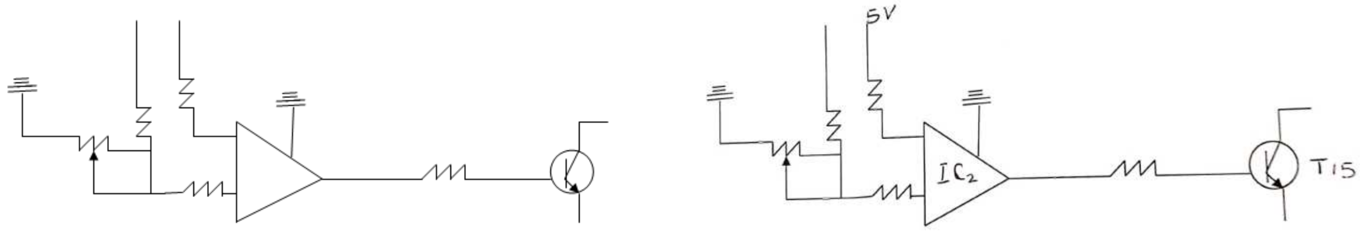

Figure 3: Low battery cut off

Resistors
Fixed and variable resistors were used in this design to help fine-tune the output of the oscillator to a constant 50Hz frequency.

Test and Analysis
Before UPS was assembled, it was tested properly; its various presets were tested properly. When testing a UPS, one should test its inverter section (the section which operates on battery supply) first. Next is the charging section (section which operates on AC main supply). Requirement for testing inverter section: A fully charged battery to the inverter was connected. A current meter or ampere meter was required to check the load current and charging current. For this, connect a 50 Amp Meter in series between the positive terminal of inverter. Connect a 0 - 300V AC voltmeter parallel to the inverter output socket. To check the AC supply frequency of inverter output, connect a frequency meter parallel to the output socket.

Conclusion (Testing)

In conclusion, to test and set the inverter section, the procedural steps is hereby outlined: Remove the battery wires from the section. Outer ends of 12-0-12 winding of inverter charger transformer are connected to the heat sink. Remove these connections from the heat sink. Now, if the battery is reconnected, MOSFET drains will not receive any battery supply. Reconnect the battery. Remove the 3- pin MOSFET drive connector between the mains PCB and the MOSFET PCB. Do not connect the inverters mains supply from reaching the inverter. Without AC mains supply, 240V/220V transformer will not produce the 220V AC supply. Without 220V AC supply, 12V. Regulated DC supply was not produced and the charging circuit will not operate. Switch on the inverter switch. 12V supply from battery will reach pin -15 of IC (CB4047). If the oscillator section is operating, pin -11 and 14 should have equal MOS drive voltage. To check the MOS drive voltage, set the millimeters at 10V AC range, and check the voltage between pin 11 of IC2 ground. Multimeter should show a voltage between 4 V to 5 V. Voltage at pin 11 and 14 should be equal. If these voltages were OK then reconnect the 3-pin connector between the mains PCB and the MOSFET. Make sure that the voltage at pin- 11 and 14 of 1C2 (CB4047) should be equal. If there is difference in the voltage on these pins, or if the MOS drive voltage is missing, then there is some fault in the circuit. If the MOS drive voltage is OK at pin – 11 and 14 of 1C2 then check the MOSFET transistor gates for MOS drive voltage. If the MOS drive voltage is missing from all the MOSFET gates, then check that the 3- pin connector joining the output plate with MOS drive signal. If the MOS drive signal is missing from one of the MOSFET gate then check the 22E resistance at the gate. If the MOS drive signal is missing from all the MOSFETs in one channel, then check the transistors and other components in that channel. When proper MOS drive signal is available at the gate of all the MOSFET transistors of both channels, switch off the inverter. Remove the battery connection. Reconnect the end points of 12-0-12 inverter cum-charger transformer to the heat sinks, i.e. to the MOSFET drain. Keeping the inverter on/off switch in off position connect the battery to the inverter. Connect the voltmeter and frequency meter to the inverter output. Connect two 500W/ 250 V bulbs to the UPS output socket. Switch on the UPS. If the bulb starts to glow, the UPS is working properly. All the components of the UPS MOSFET transistor, relay, inverter transformer, changeover circuit, etc. are working properly and efficiently. If the bulb does not glow than check the inverter transformer for 220V AC supply.240V tapping of inverter transformer is connected to the N/O-2 terminal of relay. Check the AC supply by keeping the Multimeter in 250V AC range (Abrishamifar et al., 2012; Botteron and Pinheiro, 2007; Chiang et al., 2000; Dauda et al., 2013; Niroomand and Karshenas 2010).

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