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Development of a Unique Electric Power Source Change-Over Notification Device

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Abstract

A unique electric power source change-over notification device has been developed in response to the problem of unreliable power supply enabling possible uninterrupted power supply to sensitive electronic facilities. The device uses PIC16F628A microcontroller to monitor the system power changeover, a voltage sensor to detect the flow of electricity into the system, the buzzer outputs the warning sound to alert while the Global System for Mobile communication (GSM) module sends alert from Short Message Service (SMS) during power changeover. A 12Volts 7.2Amps power source serves as the emergency power supply for the circuit. The system has a response time of 44 seconds for activation of the buzzer and 69 seconds for the GSM module. The developed device has been evaluated to be capable of serving as add-on to electronic devices with zero tolerance to power failure; as required by sensitive electronic devices like medical, research and manufacturing facilities.

Keywords: Buzzer; Change-over; GSM Module; Microcontroller; Power-Sensitive Device

Introduction

Achieving an effective, efficient and reliable electric power supply has been a major challenge in most developing countries. There have been several approaches towards providing a reliable electric power such as nuclear power stations, hydro-power stations, solar panels, fuel cells and other renewable energy sources (Dennis, 2015). In locations where electricity is unstable, measures have been taken to provide alternative emergency power supply to support the main power source. The change-over from the main power source to the emergency power supply is known to be accompanied with challenges like power surge, voltage drop and other undesirable effects (Jonathan, 2007). Many electronic devices have been developed in order to tackle the problems of power change-over, which includes Uninterrupted Power Supply (UPS) units, power stabilizer, circuit breakers, fuse and their circuits (Mooley, 2006).

The importance of stable power supply has been highlighted (Camero and Gomez, 2017). The quest for stable power supply could be better appreciated when electronic devices such as life support machines in the medical field, analytical laboratory and industrial machines are considered. Such sophisticated facilities are not only to be protected against damage from incessant power outage but stability requirements are also important for their optimal performance (Okokpujie *et al,* 2017). Most alternative emergency power supply systems rely on fuel-powered generating sets. Monitoring their fuel consumption and duration of operation is very important to replenishing the fuel. It is therefore necessary to have an alert system indicating a change-over source to the facility for proper monitoring of the fuel level. Also, where the alternative emergency power is an inverter, it is necessary to have adequate monitoring to avoid excessive battery drain (Grueneich, 2015).

Power failure notification systems are needed for unstable power situations as well as for real-time interventions, even at distances from the facilities. It immediately notifies the user whether or not power is in mains. Power failure may be caused by different factors but the notification system informs when power is off or returned to the mains. For instance in an electronic incubator for hatching of eggs, a constant temperature regime is required throughout the period of incubation to hatching of the chicks. This is because fluctuations in temperature would amount to malformations or eventual death of the chicks, resulting in financial losses. Even with alternative emergency power sources, there is the need to monitor the duration of intervention to avoid failure of the power supply. This has suggested a pressing need for a prompting device for any power change-over caused by electric power failure (Haidar *et al,* 2014).

In this work, a unique electric power source change-over notification device is developed to address the fluctuations in power source for efficient operations of power sensitive electronic facilities.

Materials and Methods

The block diagram for the development of the unique electric power source change-over is as shown in Figures 1a and 1b. The developed device uses Short Message Service (SMS), a common economical and convenient service through the Global System for Mobile Communication (GSM) network, to deliver message on either "Power Off" or "Power Restored" (Makhijani *et al,* 2015). Remote data communication and monitoring is supported by SMS due to its bi-directional data transfer and its stable performance (Oancea, 2011).

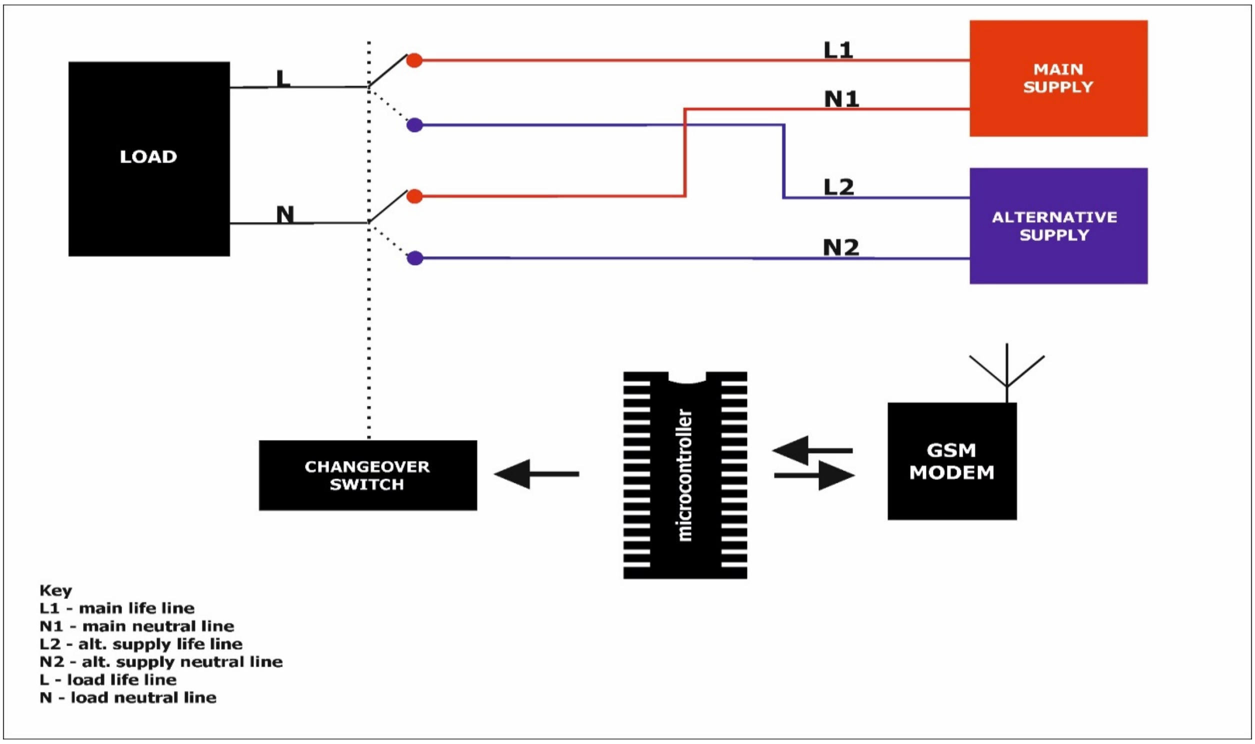

Figure 1a: Connection of the Main and Alternative Power Supplies to the Changeover Switch

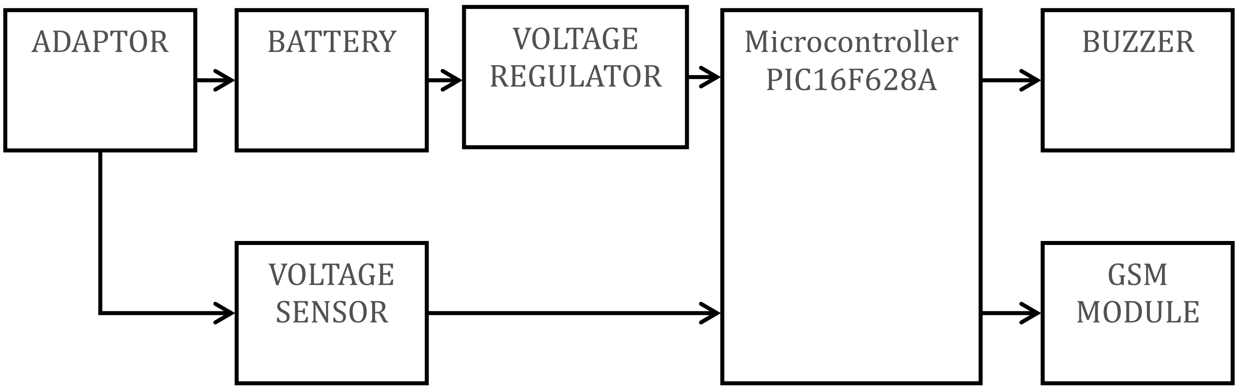

Figure 1b: Block Diagram of the Electric Power Source Change-Over Notification Device.

Power failure alert system for electricity plug-in mains is achieved by the following technique:

- Transmission Control Protocol/Internet Control Protocol (TCP/IP) as an alert system for "power ON state" in the mains.
- GSM Module for alert notification "power ON state" in the mains.
- Sound Alarm Alert for electricity plug-in mains.
- Alert system using Bluetooth notification with sound "power ON state" in the mains.

The remote alert is restricted by distance depending on the method used in the system. In this work, multiple methods system for the remote alert was employed for both power outages and restorations phases in order to have effective notification. The GSM based SMS notification system was combined with a sound alarm system for notification when power switches from the main supply to the emergency power source.

The Power Supply Unit

The circuit was powered from a 12 Volts supply since each component required a voltage of either 12 Volts or 5 Volts to operate. An adapter of 12Volts 2.5Amps was used to power the system from the main supply and a battery of 12Volts 7.5Amps acted as the alternative emergency power source, with the adapter charging the battery when the system is switched on. The capacitor, C1 was used to stabilize the current flowing into the circuit while the diode, D1 prevented the reverse flow of current from the battery when the main power source is not available. The circuit design is presented in Figure 2 and the coupling of the power supply unit is as illustrated by Ewald and Mohammad (2015). The LM7805 voltage regulator, with outlet labeled VDD, was used to reduce the power flowing through it to 5Volts 1Amp while the capacitor, C2 stabilized the current flowing from the 7805 voltage regulator. The TIP41 transistor amplified the current from the voltage regulator to about 2Amps. The diode, D6 prevented reverse flow of current from the TIP41 transistor. The capacitors C5 and C6 stabilized the current flowing from the amplifier.

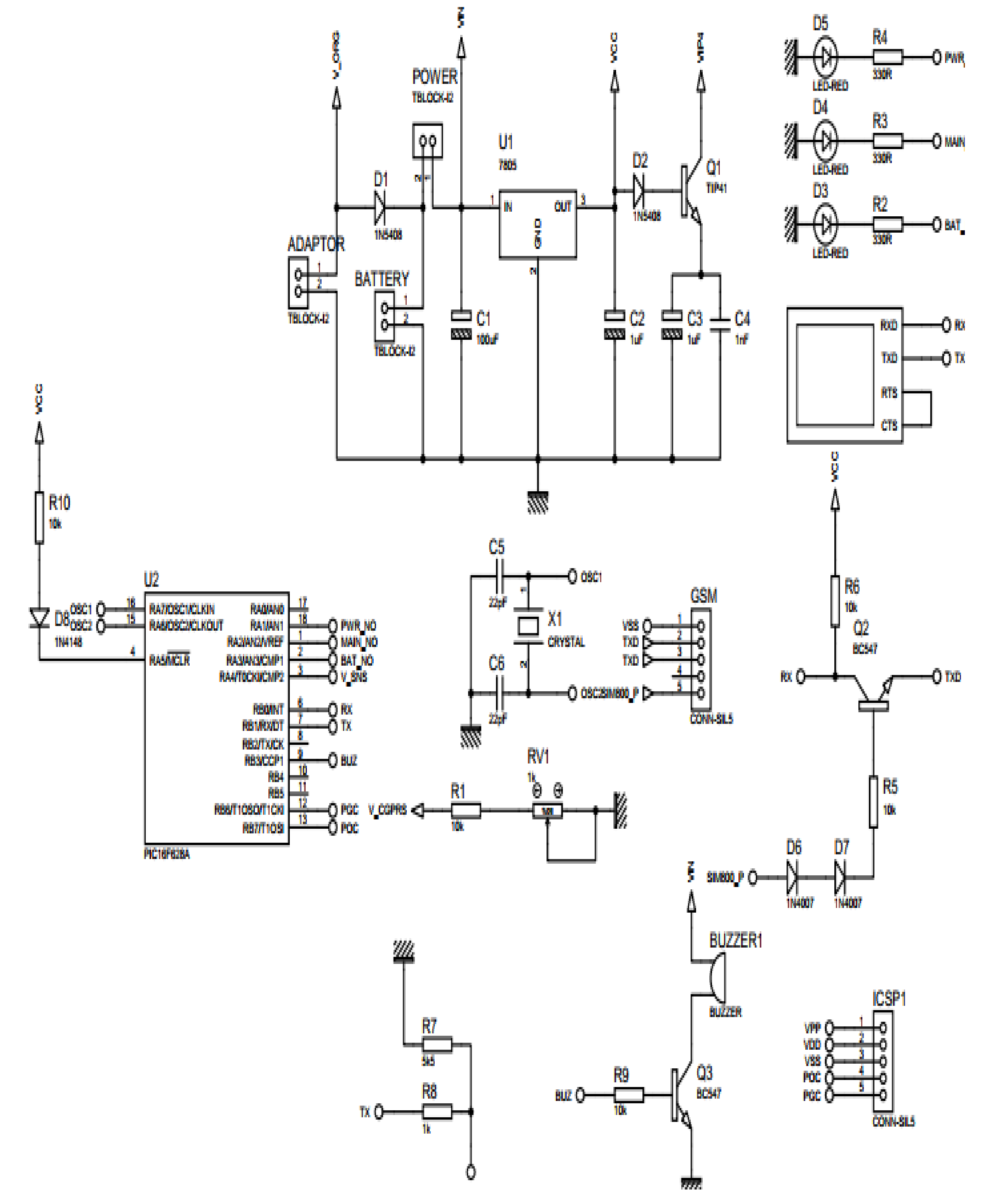

Figure 2: Circuit Diagram of the Unique Electric Power Source Change-Over Monitoring Device

The Voltage Sensing Unit

The voltage divider sensing circuit operated such that when there was no voltage across V_CHRG, there was no voltage across V_SNS. The information was read by the microcontroller that there was no voltage in the adapter. When power was restored to V_CHRG, there was voltage across V_SNS, thereby sending information to the microcontroller of the availability of voltage (Figure 2).

Microcontroller Unit

A microcontroller functions as a type of microprocessor furnished in a single integrated circuit and needs a minimum of support chips. Its principal nature is self-sufficiency and low cost; and this informed its use in this work. A microcontroller usually includes a central processor, input and output ports, memory for program and data storage, an internal clock, and one or more peripheral devices such as timers, counters, analog-to-digital converters, serial communication facilities, and watchdog circuits. The microcontroller PIC16F628A was used in this work. It supported the data up to 8-bits. It had 224 bytes Random Access Memory (RAM) for data with 128 bytes of Electrically Erasable Programmable Read Only Memory (EEPROM) which can store data even after the electric power has been removed from the microcontroller (Tchawou *et al*, 2019). It was a high performance, fully static, Complementary Metal Oxide Semiconductor (CMOS) microcontroller. It had low voltage programming, low speed Clock mode and 4MHz internal oscillator. It was ideal for analog/integrated level applications in automotive, industrial appliances and consumer applications. The 18-pin Flash-based PIC16F628A microcontroller was used to control the buzzer and also transmitted the information to the GSM module.

Alarm Circuitry

In the ´´OFF state´´ of the main power source, the microcontroller sent a voltage signal to the base of the transistor Q1. The action of this voltage signal turned the buzzer to a solid state switch (Keith, 2005). Upon application of pressure in form of voltage to the base of the transistor, current flowed through the collector to the emitter, which triggered the buzzer to produce a loud sound. On the other hand, when power was restored, voltage signal was applied to the base of the transistor Q1 and current stopped flowing through the collector to the emitter, switching the buzzer off.

GSM Module

The GSM SIM800L module was used in this work. It was a low-cost cellphone GSM breakout board based on SIM800L module. It supported quad-band GSM/GPRS network, available for GPRS and SMS message data remote transmission (Frenzel, 2016). The board had the desirable feature of compact size and low current consumption. Actually, it was a miniature cellular module. It supported quad band frequency (850/950/1800/1900) MHz. The GSM SIM800L had long range connectivity, making it appropriate for this work. When powered, the two antenna module boots up; searched for cellular network and activated login automatically. It had an on board Light Emitting Diode (LED) display for connection state indication. It displayed fast LED blinking for no network coverage and slow LED blinking when logged in. It required a power supply of about 3.7V and 4.2V for optimal performance.

After the coupling of the electronic components on the circuit board, the device was packaged into a plastic box for compactness and to protect the circuit from corrosion. The packaged device is as shown in Figure 3.

Figure 3: The Packaged Electric Power Source Change-Over Notification Device

Results and Discussion

The performance of the developed Unique Electric Power Source Change-over Monitoring Device was evaluated based on its response time to power failure and effective distance required to contact the user. The device was tested for operation efficiency, response time for both the buzzer and GSM SIM800L module and the sound range for the buzzer. The response time of the buzzer to power failure and restoration in the system is presented in Table 1 while that of the GSM SIM800L module is shown in Table 2. The coverage of the buzzer sound in both closed-room condition and open-air environment at different times of the day is presented in Table 3.

Table 1: Buzzer Response Time to Change in Power Source

Change in Power Source	**Buzzer Response Time (seconds)**			
	1st Test	**2nd Test**	**3rd Test**	**Average**
Main Power Supply to Emergency Source	44.00	45.00	44.00	44.33
Emergency Source to Main Power Source	3.00	2.00	3.00	2.67

Table 2: GSM SIM800L Module Response Time to Change in Power Source

Change in Power Source	**Response Time for GSM Module (seconds)**			
	1st Test	**2nd Test**	**3rd Test**	**Average**
Main Power Supply to Emergency Source	69.00	69.00	68.00	68.67
Emergency Source to Main Power Source	12.00	10.00	11.00	11.00

Table 3: Coverage of Buzzer Sound as a Function of Temperature

Temperatures (ºC)		23	28	25
Coverage of Buzzer Sound (m)	Closed-Room Condition	32	26	29
	Open-Air Condition	86	78	81

The measured parameters for the device were considered to ascertain the reliability of the system under power failure in line with a previous study (Vishnu and Regikumar, 2016). The average response time to power failure was determined to be 44.33 seconds for the buzzer and 68.67 seconds for the GSM SIM800L module. The achieved response time is ideal for prompt alert during power outage. A 40 seconds time delay was deliberately added before effecting the transmission of message alert. This was to accommodate a quick power-restoration scenario where a no unit loss would have been lost by the GSM module. The delay takes care of electric power fluctuations for less than 40 seconds such that the device will not respond to such power fluctuations.

Conclusion

A unique electric power source change-over notification device has been developed and implemented as an add-on to power sensitive devices. This is in response to the unstable nature of power sources in developing countries. The developed device prototype can be further improved to accommodate increase in the number of users using Bluetooth technology. The packaged device can be integrated into a conventional electric socket outlet for easy connectivity to highly sensitive electronic devices.

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