Smart Overload Fault Trip System For Domestic Application Using Gsm Communication Module

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ABSTRACT

Occurrence of Electrical faults such as overload and short circuit fault is hazardous to electrical devices. Developing an overload fault trip system helps to minimize the chances of damage to electrical devices. This paper explores the concept of overload as an electrical fault with a system designed to shut down supply immediately the current flowing through is high enough to cause damage. The system determines the current flowing in the circuit through a current sensor and compares it to a preset current value. This work discusses a prototype protective system suitable for handling Overload and Short Circuit fault current arising from public power supply with an SMS feedback and warning sign notifications. It further develops an LCD programme to display the current reading and status of the device. The description of various components used in designing and construction of this prototype protective system, and how they are connected are presented. Finally the system is practically implemented and the results obtained verify the essence of the design.

KEYWORDS: *Audrino uno microcontroller, GSM modem, overload system, short message service.*

INTRODUCTION

A Smart Overload Fault Trip System using short message service (sms) notification feedback is a work aimed at protecting electrical system from overload conditions. Various appliances fail due to many reasons, and overload is one of major causes of electrical device failure. In this work, this failure can be overcome with the use of the arduino microcontroller to implement an ultra fast shutdown of electrical load, when the specified current limit is exceeded. A set time of 30 seconds is set after shutdown of electrical load has occurred, after which the load is restored again. The system is programmed to restore load at most three times for a consistent fault, before SMS notification is sent to the user.

PROBLEM STATEMENT

Electrical components make up the devices we use in our day to day activities. When these devices are used within the specified ratings, they last longer and their chances of failure are reduced. Although electrical faults such as Overload and short circuit causes early failures of electrical components.

Overloading of electric circuit describe the fact that the current circulating in the circuit operates more than the capacity of the rated components in the circuit. The resistance of these components produces heat. The latter has a direct relationship with double the current passing the circuit. With this over load, the components get overheated due to presence of high current, thereby leading to the damage of these components. Just like over load fault condition, short circuit also causes flow of large current that can lead to damage of electrical components but at zero voltage.

Therefore there is need to improve the life span of electrical components by protecting them from these electrical faults. This work seeks to design a microcontroller based system that intelligently monitor faults and respond adequately towards preventing the effects of these faults on electrical components and also sends SMS notification to the house owner providing information about the fault occurrence. Therefore the work is aimed at designing and implementing a system that uses a microcontroller and other peripheral devices to intelligently monitor fault and use SMS notification to adequately report the occurrence of the fault.

REVIEW OF RELATED WORKS.

Several types of devices have been used to protect domestic appliances and power systems when faults occur. These devices are either used for isolation in the circuit or for over current protection. Examples of such devices includes fusible links (fuses), miniature circuit breaker, semiconductor switches etc.

Circuit breakers were first developed to interrupt short circuit current, subsequently this technique evolved to satisfy the requirement for selective tripping during fault conditions. A fuse which is an electrical device and consists of a piece of conducting material that carries the current during normal circuit conditions can melt during over current. The piece of conducting material generally referred to as a fuse element or a fuse link has a low melting point so that it does not achieve excess heat when normal current flows. During an over-current, the fuse link attains a very high temperature, thus melting itself. Fuses

usually contain either one element or many elements depending on their breaking capacity. Silver and copper are the most preferred materials that are used in most of the modern fuse links. Fuses are generally classified into three types namely high voltage, low voltage and miniature. High voltage fuses are for voltage applications above 1000V and low voltage fuses are for voltage applications below 1000V. Miniature fuses are based on their physical dimensions.

A form of circuit protection was described by Thomas Edison (Wright and Newbury, 2004). He later patented a fuse in which the wire element was enclosed in a glass envelope. In any event of overload or accidental short circuit, the wire element melts due to overheat from high current.

The cartridge fuse was developed and patented. It consists of fusible copper conductor with thin foil or small diameter wires, enclosed in a glass tube. This glass tube is partially or wholly filled with fine semiconductor material or poor conducting material. In the last decade of 19th century, fuses represented the only available protective scheme for electrical devices (Wright and Newbury, 2004). Fuses are commonly used for lower power applications such as consumer electronics because of their generally low cost. Fuses are not acceptable in many applications as it must be physically replaced when it trips (Wiener and Witham, 1997).

Developmental changes brought to lime light the miniature circuit breaker (MCB). MCB is an automatic, electrically operated switching device designed to automatically protect an electric circuit from overload and short currents. Its response time is within milliseconds. Miniature Circuit Breakers are electromechanical devices which protect an electrical circuit from an over current. The over current, in an electrical circuit, may result from short circuit, overload or faulty design. An MCB is a better alternative to a Fuse since it does not require replacement once an overload is detected. Unlike fuse, an MCB can be easily reset and thus offers improved operational safety and greater convenience without incurring large operating cost.

An MCB embodies complete enclosure in a molded non conducting substance. This provides strong and insulated metallic housing. The system which handles the switching is made up of the fixed and a moving contact whereby the relevant wires are connected respectively to reflect the wires coming inwards and going outwards. The conductive parts are composed of electrolytic copper or silver alloy depending on the rating of the circuit breaker. Under normal work circumstance, the MCB functions as a switch (man alone) to make the circuit ON or OFF. Under over load or in a short circuit mode, the MCB is triggered into action automatically to disallow current from flowing to the load. The indication of this action is seen in the manner in which control is achieved automatically. This action of the MCB can be determined in a two form automatic operation; they include the magnetic tripping and thermal tripping.

Circuit breakers are not just applied for domestic home use alone; they find application in transmission and distribution network. They are capable of interrupting short circuit currents that appear during abnormal condition in the transmission and distribution networks. During this condition, circuit breakers operate in coordination with relays which sense a fault in the circuit and notify the circuit breakers. On receiving a trip signal from the protective relays, the circuit breaker operates in order to interrupt the fault current. Circuit breakers can be categorized in different forms depending on; the voltage level, location, external design and interrupting media. The voltage criterion specifies the circuit breakers that are designed based on their voltage application, these include; low voltage, medium voltage, high voltage and extra high voltage circuit breakers.

The MCB combines thermal and magnetic trips into a single reusable unit capable of switching off loads when there's short circuit. MCBs find more application in local control switches. They are also used to isolate switches in order to prevent faults and protect devices/equipment from issues related to overload.

In the event of short circuit or overload, it is possible to achieve high safety level, greater system availability, and improved power quality of the system with the use of solid state circuit breakers. Solid state circuit breakers (SSCBs) have been developed to reduce the limiting factor of the system to a lower level. The SSCB is made as a circuit breaker which has solid state devices connected in the circuit. This will help to protect the components of the system during abnormal operating condition (Meyer et al., 2004). The SSCB is advancement in technology which can be used to perform various functions. It further offers several benefits which include limiting the fault current for different voltage and current levels, replacing broken module with a spare one in situations where there is a problem with one of the modules in the SSCB. SSCB offers a higher reliability than MCB and it can switch in a range of micro seconds, contrary to millisecond response associated with mechanical circuit breaker (Kreigel, 2016).

Three different semiconductor device scan be used in the design of SSCBs, namely: Insulated Gate Bipolar Transistor (IGBT), Gate Commutated turn-off Thyristor (GCT), Gate-Turn-Off Thyristor (GTO). The switching losses of these devices can be considered as a minor issue in the application of the SSCB.

Although the overload fault trip system using GSM module finds application in divers' area not necessarily for domestic use (Kunel J and Siddthra R 2017, Okonijie K et al 2017, Trupti S et al 2016,

Mungase P and Joshi R 2016). The smart trip system deploys major components such as the arduino microcontroller, power supply unit, current sensor, GSM modem and a Relay. Time required for circuit breaker to trip depends on the magnitude of the fault current. In this work, a microprocessor controlled based circuit breaker device was used to prevent persistent faults within a system of device. The microprocessor via the ACS712 current sensor can be used to regularly monitor the system for instant increase in current and further check to open or close circuit within the system. Sudden and excessive surge has the tendency to cause smart circuit breakers to open while gradual and minor increases are ignored. The smart circuit breaker closes contact only when the fault is removed. The smart breaker incorporates the use of SIM900 GSM Modem to send SMS notifications about un-cleared or persistent fault conditions.

this current is exceeded the circuit quickly trips of the load from the supply line.

In the second section of the design, the notification feedback was configured using a GSM modem interfaced to an arduino microcontroller as a channel for wirelessly sending fault notification to the house owner reporting fault situation. This will be done using short message service (SMS) protocol.

The system design involves both hardware and software sections. The hardware was implemented using modular design method while the software was implemented using embedded C language. System firmware application was developed using arduino integrated development

environment v1.0.6.The operation of the intelligent overload trip system is illustrated in the block diagram shown in figure1 below.

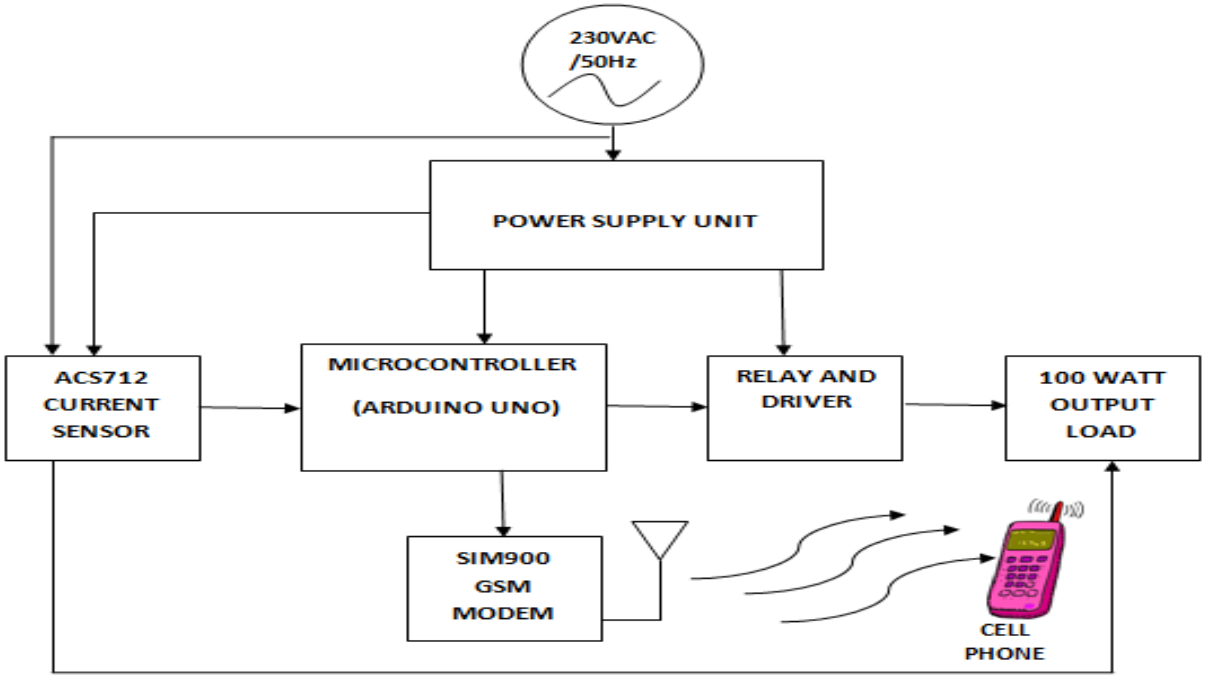

Figure1: Block diagram of a Smart overload fault trip system with SMS Notification

DESIGN METHODOLOGY AND ANALYSIS

The design is made up of two sections:

- The over load fault protection scheme.
- Fault notification feed back through short message service.

The overload protection scheme uses an ACS712 current sensor for monitoring overall load current. The sensor has a current sense range up to 20amperes. The sensor is configured to continuously monitor the running current of a 100watts load. A preset current of 0.43A will be used as an overload condition. Once

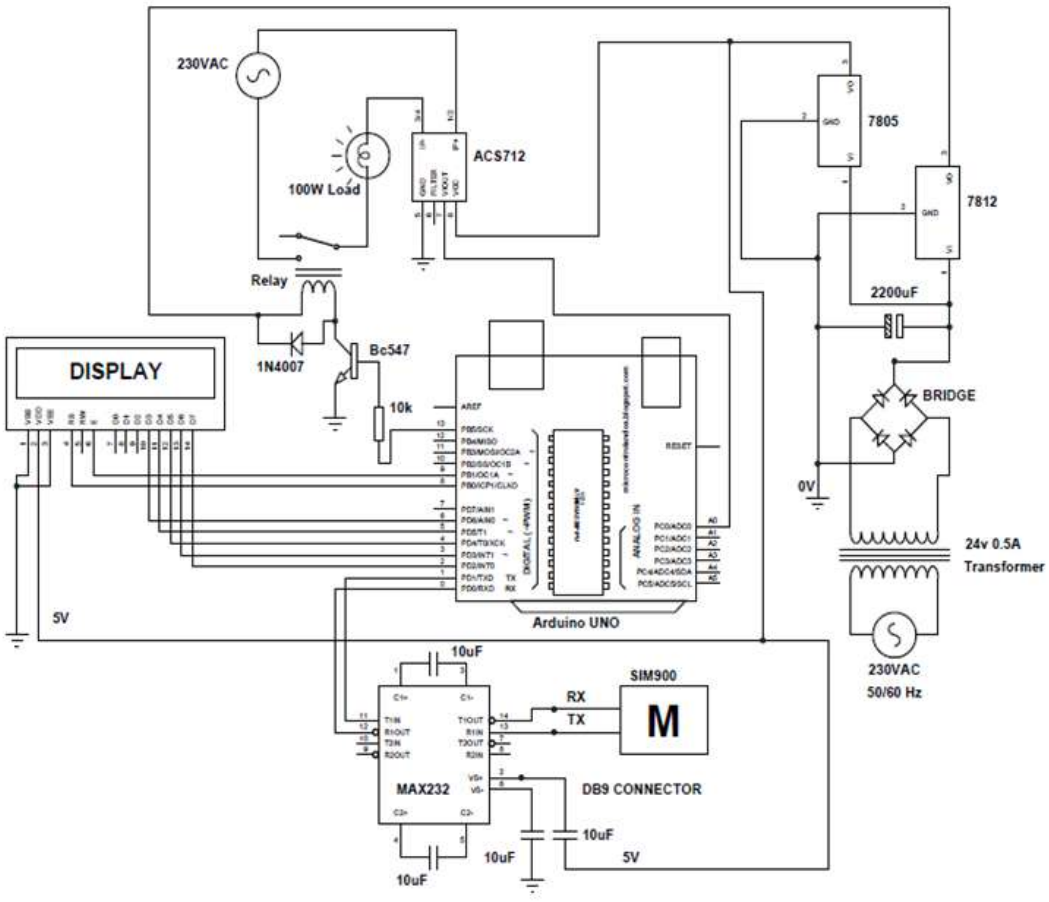

Figure 2; Circuit diagram of smart overload fault trip system

SYSTEM DESIGN

The system design is further categorized into two sections namely; Hardware design; and Software design.

Hardware Design

The entire system is made up three sections, comprising of the input, control and the output sections. The input section comprises of the power supply unit that rectifies and regulates the supply current and voltage respectively, and a current sensor that measures current and transmits it serially to the control unit to initiate action based on the value of current measured. It is the responsibility of the control unit to harness all control actions in respect to what is sent by the input stage. All control action is carried out using arduino microcontroller. The output section is made up of two components which include the display and the load (LAMP). The display (liquid crystal display) will ensure the system is user friendly. This will facilitate the update of the system at any point in time. In this work, the load which is been controlled is represented by the lamp based on the level of the load running current. If beyond a100watt running current, it will be switched off by the microcontroller or remain on if otherwise.

Software Design

The software design comprises of an application firmware programmed with high level language using Arduinov1.0.6 integrated development environment. The firmware relates all units of the system design from the input unit, the control unit and then the output unit. The design software's used for the purpose of this design include the Proteus7.8professional and Arduino Integrated development environment v1.6.12

RESULTS AND DISCUSSIONS

The completed smart overload fault trip device was finally tested and result obtained is thus shown in the table 1 below.

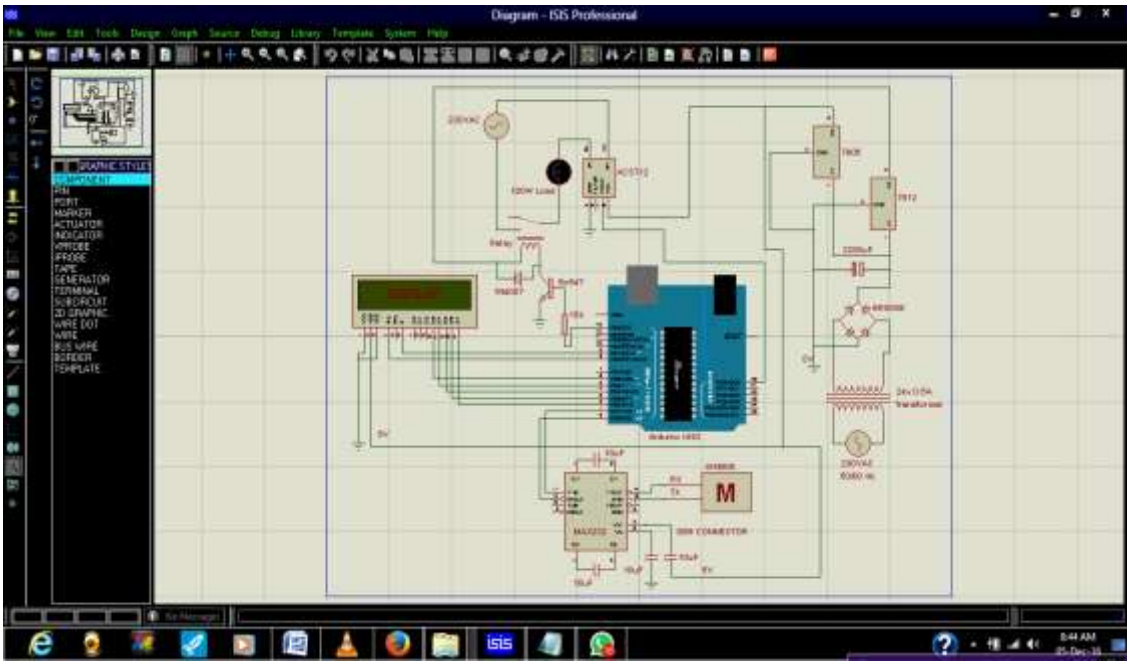

Figure 3; System complete circuit in ISIS professional (Proteus)

Table1: Description of results obtained

Process	Action and description
Power is turn ON in the circuit	Display turns on, and shows a welcome message for 17seconds after which the entire system is powered ON.
Connection of two 100W rated bulb (Overload)	Microcontroller reads input from the sensor to shutdown load through the relay and restores it in 30seconds, if fault has been removed. Otherwise after three trials and the fault is still present, the controller sends overload SMS notification message through the GSM MODEM to an already set phone number in the module.

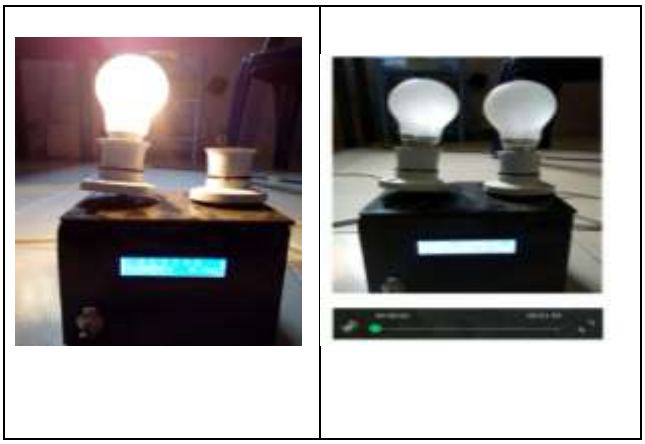

Figure 4 Pictorial presentation of fault trip system

Figure 5: Pictorial Implementation of the system showing overload notification

CONCLUSION

In this work a Smart Overload Fault Trip System that uses a microcontroller and other related components that intelligently monitors overload fault condition and informs the user of the occurrence of this fault via an SMS notification has been successfully designed and implemented. The microcontroller was set to terminate supply to the load if current value in the circuit exceeds 0.43A (which is equivalent to 0.43A x 230V=100W). The supply can be restored after 30 seconds. If the fault current is permanent, the system trips after three trials and the user is adequately notified.

This system will protect electrical appliances from fault conditions arising from public power supply and excess load when much electrical device are in operation. This system is therefore referred to as 'Smart' as it incorporates both automatic regulation of load and feedback control via SMS.

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