SMART ULTRA FAST ACTING ELECTROINC CIRCUIT BREAKER

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Abstract - *The smart ultra fast electronic circuit breaker is designed to work as an over current protection device. Conventional circuit breakers like miniature circuit breaker or a fuse is good at breaking the circuit when a short circuit fault occurs. But when an overload fault occurs, the tripping time is slow and depends on the percentage of overload. However, for sensitive loads it is very important to activate the tripping mechanism at the shortest possible time, preferably instantaneously. This project senses the current passing through a series element and the corresponding voltage drop is rectified to dc. This voltage is converted into a digital value and compared against a preset value by a microcontroller to generate an output that drives a relay to trip the load. The unit is extremely fast and overcomes the drawback of the conventional circuit breakers. It uses a PIC Microcontroller. The breaker will automatically reclose if it is a temporary fault and will alert the consumer via SMS if the fault is due to overloading. Furthermore, the breaker can be remotely closed by sending an SMS.*

*Key Words***: Circuit breaker, Relay, Overcurrent, GPS module,**

1.INTRODUCTION

Over-current protection devices are used to protect electrical systems from faults. The commonly used over-current protection devices are the fuse and the miniature circuit breaker.

The fuse is a small piece of wire which melts when a sufficiently large current passes through it. The miniature circuit breaker uses two mechanisms to protect systems against over-current. An electromagnetic plunger trips and breaks the current when a large current flows through the circuit, such as in the case of a short circuit fault. A bimetallic strip is used to break the circuit, when the current is small such as when an overload fault occurs. In this case, the bimetallic strip of the miniature circuit breaker begins to heat and the contacts separate eventually, thus breaking the circuit. The fuse and the miniature circuit breaker are perfect for protecting electrical circuits against short circuit faults. However, the fuse needs to be replaced after every fault. When an overload fault occurs, the tripping time is slow for

the above mentioned systems as the tripping time is dependent on the percentage of overload.

Modern industries and appliances use very complex and sensitive electronic components. These systems are very sensitive and could easily burn out if over-current occurs. Thus modern day systems demand extremely fast tripping speed and high reliability as well as sensitivity. An electronic circuit breaker can meet these demands of the modern industry. The current passing through a circuit can be sensed and given to a microcontroller. The microcontroller will continuously check the value of this current against a preset current to ensure that the the current passing through the circuit is not above the rated value. If the current ever rises above the rated value, the microcontroller activates the tripping mechanism which will break the circuit. Since the microcontroller operates at 20 MHz, the operation is almost instantaneous.

The microcontroller can be programmed to operate as desired for different loads such as giving a time delay during the starting of a motor. The electronic circuit breaker can be reclosed either manually or remotely. A GSM module is integrated with the circuit breaker to allow the users to remotely close the breaker. Furthermore, it can be programmed to send messages to the users to alert them of fault conditions. The Smart Ultra fast acting electronic circuit breaker has numerous advantages compared to conventional over-current protection devices such as the fuse or miniature circuit breaker. Though it is more expensive, it makes up for it by its high operating speed and reliability.

2. EXPLANATION

The basic working of the smart ultra fast acting electronic circuit breaker can be explained with the help of a block diagram. The block diagram shows how the different parts are connected to the microcontroller and the basic logic behind it.

2.1 Block Diagram

The block diagram of the smart ultra fast acting electronic circuit breaker is shown in figure 1. A microcontroller is one of the main components used here. The current transformers acts as the sensor. A GSM module is used to send and receive

messages. The LCD displays the current status of the breaker and a battery pack is provided to ensure that the circuit breaker remains in operation even if the power supply is lost.

The current transformer senses the current passing through the main circuit and steps it down to a smaller value. The current in the main circuit can be sensed by taking the voltage drop across a resistor or by using an opto-coupler. But the current transformer is preferred as it is easy to use, avoids unnecessary energy losses and provides isolation. The current transformer will take the current in the main circuit and step it down to a very small value. This current is converted into voltage by passing it over a series resistor. This voltage is rectified and filtered and then given to the microcontroller
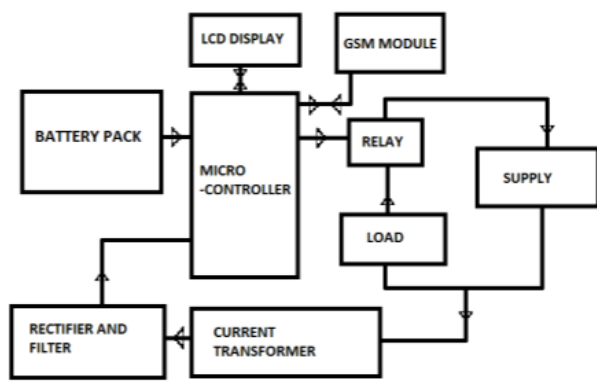

Fig -1: Block Diagram

The microcontroller cannot take more than 5 volts. Therefore the value given to the microcontroller is regulated to be less than 5 volts. The microcontroller continuously compares the input with a preset value which is programmed in it. If at any moment the input becomes greater than the preset value, the microcontroller sends a signal which immediately trips the relay thereby interrupting the supply. The microcontroller sends a message to the user via the GSM module to alert the user of the fault. The fault can be cleared and the breaker can be reset either manually or by sending a message to the breaker.

2.2 Software

The software programmed in the microcontroller is a vital part of the working of the circuit breaker. The limit which determines when the relay should trip and reclose is specified in the program. Furthermore, the time lag which allows harmless overloads are also specified in the program. Essentially, for the smart ultra fast acting circuit breaker to work effectively, the programming has to be efficient. The basic working of the software can be explained with the help of a flow chart.
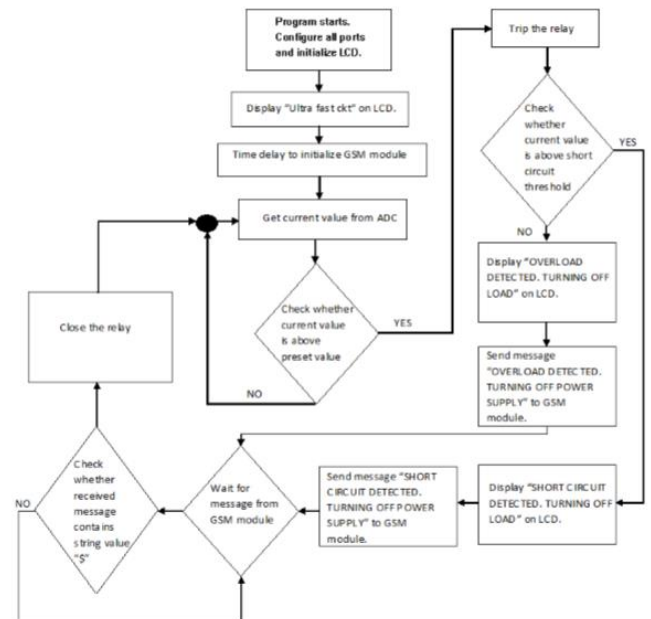

Fig -2: Program flow chart
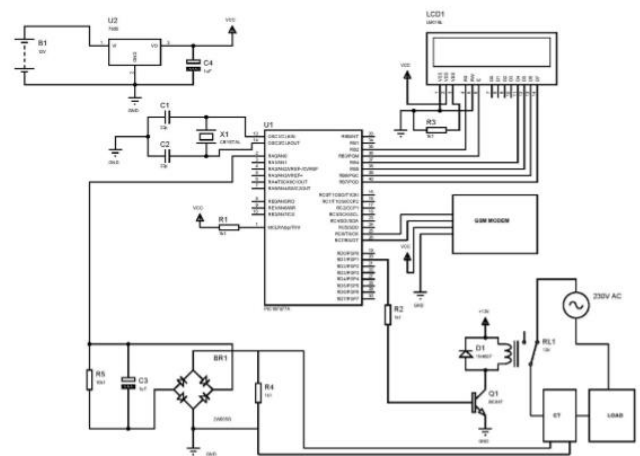
3. CIRUCIT DIAGRAM AND OPERATION

Fig -3: Circuit Diagram

The PIC16877A is a central part of the circuit. The GSM module is connected to pin 25 and 26 of the PIC microcontroller to send and receive messages. The supply and ground pins of the GSM module are connected to the main supply and neutral. A current transformer is connected in the main circuit. This current transformer senses the current passing through the main circuit and steps it down to a smaller value. This current is passed through a resistor and the corresponding voltage drop is taken. This voltage is rectified using a bridge rectifier and the output is filtered. This dc voltage is given to the pin 2 of the PIC microcontroller. This dc voltage is configured to be less than 5V as the PIC microcontroller cannot have an input greater than 5V. An external clock circuit is connected to pins 13 and

14 of the microcontroller. An LCD is used to display the status of the circuit breaker. Pins 35-40 are connected of the microcontroller are connected to the LCD. The normally open terminals of a relay are connected in series with the main circuit. Pin 20 of the PIC microcontroller is connected to the base of a transistor. This transistor is used to drive the relay. A battery pack is provided to the system to keep the PIC microcontroller in operation in the event of a power failure.

When any fault occurs such as an overload or a short circuit, the microcontroller detects it and immediately trips the relay. The status of the breaker is displayed on the LCD and the appropriate message is sent to the user via the GSM module. The supply can then be resumed either manually or remotely. The user can send a preset value such as a dollar sign via SMS to the circuit breaker to restore the supply. The microcontroller on receiving the message checks it for a dollar sign and on finding it, recloses the relay.

4. HARDWARE IMPLEMENTATION

A prototype of the smart ultra fast acting electronic circuit breaker was successfully constructed using following components:

1. PIC microcontroller - PIC16877A
2. GSM module - SIM 900A
3. Current transformer
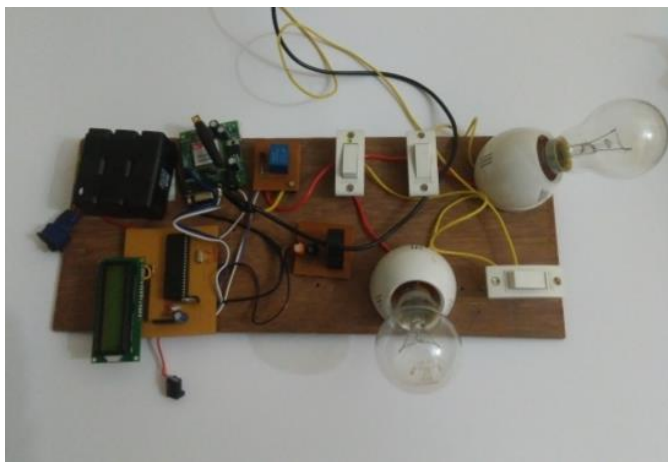4. Relay
5. Liquid crystal display

Fig -4: Smart ultra fast acting electronic circuit breaker
3. CONCLUSIONS

The testing is done under the assumption that one lamp constitutes the rated load of the system. So when the second lamp is turned on, an overloaded condition is detected and the relay trips instantaneously. The LCD showed the overloaded status and an SMS was received stating that the system has been overloaded and that supply has been cut off.

The supply was restored by sending a dollar sign to the system after clearing the fault.

A short circuit condition was simulated with the help of a switch. When the switch was closed, a short circuit fault was created. This was identified by the microcontroller and the corresponding short circuit fault message was received by SMS. The approximate tripping time of the system is 0.002 seconds. The operating time does not vary depending on the fault.

The smart ultra fast acting electronic circuit breaker proposes a new approach to over-current protection. Conventional methods are very good at breaking short circuit currents. But when overloading takes place, it could take a few seconds for the supply to be interrupted. This can be a problem when the present day sensitive loads come into the picture. The smart ultra fast acting electronic circuit breaker has an approximate tripping time of 0.002 seconds. This is almost as close as the operating time of a miniature circuit breaker in the event of a short circuit fault. However, miniature circuit breakers could take up to 2 minutes to interrupt the supply when overloading takes place. The electronic circuit breaker is far superior in this regard as its time of operation does not vary depending on the type of fault. Furthermore, this project can be programmed to react differently to different loads and also perform special operations such as reclosing automatically in the event of an external fault such as a short circuit.

Thus, the smart ultra fast acting electronic circuit breaker can be used to replace conventional over-current protection devices. It is perfect for low voltage applications. For high voltage applications, the relay could be replaced with an IGBT to eliminate the problem of arc extinction. Thus, by using an IGBT instead of a relay, the system can be used for over-current protection in both low voltage applications as well as high voltage application. Furthermore, the GSM module can be used to connect the circuit breaker to the internet for online monitoring and control.

REFERENCES

[1]   H.W. Wolff and T.G.F Atherton, "Miniature circuit-breakers", Journal of the Institution of Electrical Engineers ,Vol. 1, 1955;4:232-234

[2]   Jicheng Yu, Yingying Tang and George G. Karady, "Design of an IGBT based electronic circuit breaker", IEEE North American Power Symposium (NAPS), 2010.

[3]   P.Abirami and Merin Lizbeth George, "Electronic circuit breaker for overload protection", IEEE International Conference on Computation of Power, Energy Information and Communcation (ICCPEIC), 2016

[4]   P. Meckler and W.Ho, "Does an electronic circuit breaker need electrical contacts?", IEEE conference on Eletrical Contacts, 2004