Microcontroller-based System for Voltage Monitoring, Protection and Recovery using Proteus VSM Software

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ABSTRACT
To protect electric and electronic device against voltage drop, overshoot, and fluctuation of the main supply, a microcontroller-based circuit is designed. The circuit will keep monitoring the power supply and ensure the main voltage connected to the board feeding the controlled devices connected if it measures within a required voltage range (RVR). If the voltage falls below or above the RVR then the main supply would be disconnected from the feeding board. The circuit then will keep monitoring the voltage and reconnect it to the feeding board once its amplitude falls back stable in the required voltage range. The design was simulated successfully using Proteus software.

Keywords
Microcontroller, Proteus, Monitoring, Protection, Recovery,

1. INTRODUCTION
All countries suffer from grid voltage instability at above or under voltage standards that cause home or office electric appliances damage, like computers, refrigerators, TV sets, or other equipment[1]. This paper aims for the design of an embedded system using a microcontroller to monitor the amplitude of the main voltage and interrupts the supply when it increases or decreases from a programmed range. Furthermore, the system will enable the recovery of the supply if already disconnected, when the voltage assumes again the required range. The microcontroller is a specialized microprocessor that houses much of the support circuitry onboard, such as ROM, RAM, serial communications ports, ADC, etc [2]. Microcontrollers have become the heart of the new technologies that are being introduced daily. A microcontroller is mainly a single chip microprocessor suited for control and automation of machines and processes. Today, microcontrollers are used in many disciplines of life for carrying out automated tasks in a more accurate manner [3-4]. The block diagram of the microcontroller system is shown in Fig 1.

Microcontroller essentially consists of Central Processing Unit (CPU), timers and counters, interrupts, memory, input/output ports, analog to digital converters (ADC) on a single chip [5]. With this single chip integrated circuit design of the microcontroller the size of control board is reduced and power consumption is low [6].

This paper presents the design and simulation of the microcontroller based system for voltage monitoring, protection, and recovery using PIC877A microcontroller simulated on Proteus VSM Software.

2. PROTEUS VSM SOFTWARE
Proteus software is from British Labcenter Electronics Company. It is widely used globally. Besides the function other EDA tools have, like principle layout, PCB automatic or artificial wiring and the SPICE simulation, its revolution feature is circuit simulation’s interactive [7].

Proteus Virtual System Modeling (VSM) combines mixed mode SPICE circuit simulation, animated components and microprocessor models to facilitate co-simulation of complete microcontroller based designs. For the first time ever, it is possible to develop and test such designs before a physical prototype is constructed [8].

Proteus simulation environment includes ISIS and ARES. In the ISIS environment, electronic circuit can be directly simulated in the stage of schematic. It also provides virtual machines, simulation of the input signal which makes a convenient simulation. ARES is mainly used for PCB (Printed Circuit Board-PCB) design. The device library provides schematic device and its package. It can design printed circuit board in this environment [9].
3. DEVELOPMENT TOOLS and EXPERIMENTAL RESULTS

3.1 System Design

System is constructed and implemented as shown in Fig 2.

![Block diagram of voltage controller](image)

The main component is PIC16F877A MCU that senses the received voltage and compares it with reference value fed from MCU (PORTC). AC voltage source (220V) is applied to 9V step-down transformer that transforms the 220 volt to 9 volt, then apply it to 8 bits ADC to convert to 8 bits digital; this 8 bits binary word is compared with 8 bits reference value coming from PORTC of PIC 16F877A MCU. If the 8 bits generated from ADC is greater than the 8 bits representing maximum-voltage reference, that means the voltage is greater than 230 volt, and must be disconnected. If the 8 bits from ADC is less than the 8 bits low-voltage reference, that means the voltage is less than 215 volts, and must be disconnected. If the 8 bits that come from ADC is equal to the 8bits which come from MCUs PORTC, that means the voltage is in normal range and one minute delay must be applied to insure the stability of voltage within the required range. After one minute in which the voltage remains in range, the voltage source will be connected to device. The warning message block is constructed of three, LEDs. Red LED which indicates high voltage, yellow LED indicates low voltage, and green LED indicating normal voltage. The relay will respond to the proper signal from the microcontroller to switch the voltage supply on and off. Input reference RVR block indicates users can adjust reference voltage to any range. External battery is necessary for microcontroller operating in case of supply voltage source interruption. Digital comparator CD4063BMS is responsible for comparing sensed voltage with reference. The transistor 2N1893 is to sense the output decision signal that comes from MCU, and trigger the relay to connect or disconnect the AC voltage.

![Circuit diagram of the design](image)

The circuit diagram of the design is shown in Fig 3.

3.2 Flowchart of the System

![Flowchart of the system](image)

3.3 Program Code of System

To make it easy to understand, the program code has been sectionized into three parts:
- Sensor code
- Processing code
- Wait cycle code

First, part of code that is responsible of sensing the magnitude of source voltage is illustrated in Fig 5.
As shown in Figure 5, first MOVLW 0XE2 instruction and MOVWF PORTC feed value to a comparator from PORTC of microcontroller as reference to compare with output of ADC (sensed value). If the sensed voltage is greater than 0XE2 that means the voltage is greater than RVR and must be switched off by relay; if the voltage is less than 0XE2 check if the voltage is lower than RVR by comparing the sensed voltage with 0XD0. If the voltage is less than 0XD0 it means that the voltage is less than RVR and must be switched off by relay; otherwise, the voltage is in RVR range and it will not be interrupted.

Second, part of code responsible for control and action is illustrated in Fig 6:

As shown in Fig 6, if the voltage is within RVR, send 0 signal to relay, and 1 signal to green LED. If the voltage is greater than RVR, send 1 signal to relay and 1 signal to red LED; if the voltage is less than RVR send 1 signal to relay, and 1 signal to yellow LED.

Third, part of code subroutine that represents wait cycle (to ensure stability of voltage) is:

To program chip in Proteus, see Figure 8 hex code is downloaded to the PIC 16F877A chip. To download hex code to PIC chip there are four steps:

1. Double click on MCU.
2. Edit component window will appear as shown in Fig 8 click on program file.
3. Choose the hex file from specific directory folder and double click on it.
4. Click ok, now the microcontroller is programmed.
3.5 Simulation And Experimental Results

This part discusses the results of software environment (Proteus simulator). Normal voltage or Required Voltage Range RVR proposed here is in range of 215-230 (i.e. greater than low voltage (215 volt) and less than upper voltage (230 volt).

The result of software part (Proteus environment) is illustrated in Figures 9-11.

As shown in Fig 9, when the voltage is lower than RVR, the blue LED which represents the voltage supply is off, and yellow LED is lighted (indicating voltage is below normal range).

As shown in Fig 10, this shows the voltage within RVR, and the blue LED represents the connected voltage supply. Green LED illustrates that the voltage is normal within RVR.

As shown in Fig 11 when the voltage is higher than RVR, the blue LED representing switched-off voltage supply (being disconnected), and red LED is lighted.

4. CONCLUSION

A microcontroller-circuit is designed to monitor the main voltage supply, and interrupt it if it falls below or above a required voltage range (RVR). If the voltage is disconnected, the microcontroller circuit will keep monitoring the voltage and only reconnect it back if it complies with the RVR and becomes stable. The simulation of the design was successful. The design is suitable for domestic use, given the fluctuations in main voltage supply worldwide, especially during summer and severe weather condition, and subsequent power-cuts. Voltage fluctuation leads to damage of electronic and electrical equipment connected to the main supply.
This simulation used a range of RVR of 215-230 volt as boundary of normal voltage; a keypad is recommended in the design to input the RVR by user. Keypad gives the advantage of picking any voltage range (110 V supply for example). Embedded system technique, which based on microcontroller is intelligent system which in case of use it as voltage monitoring to protect home or office electric appliances will provide more and more of valuable devices so this technique is favorable and useful.

5. REFERENCES


