IJIREEICE

ISSN (Online) 2321 – 2004
ISSN (Print) 2321 – 5526

INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH IN ELECTRICAL, ELECTRONICS, INSTRUMENTATION AND CONTROL ENGINEERING
Vol. 4, Issue 3, March 2016

Automatic Voltage Balancing System for Industrial Applications

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Abstract: This paper presents the design and construction of a low cost under and over voltage protective device, which was fabricated using a microcontroller, transistor, IC and other discrete components. A microcontroller PIC16F877 is at the heart of the device which performs the major control of the device. The device is simple and of low cost. It can withstand loads up to **5 ampere** and the required set voltage range for the device to allow supply to the connected load at the output varies from **170 – 270 Volts**. This device can be used directly as standalone equipment between the mains supply and the load, or it may be inserted between an existing automatic/manual stabilizer and the load. The over/under voltage cut-off with time delay provides over/under-voltage protection, and protection against transients. The over/under voltage cut-off with ON-Time delay provides various types of protection 1) Over-voltage protection 2) Under-voltage protection 3) Protection against transients 4) Protection to load from frequency turning ON & OFF by providing time delay.

Keywords: Microcontroller, over voltage, under voltage, protection.

I. INTRODUCTION

Voltage irregularities are one of the greatest power quality issues facing industry and home today and often times, is responsible for damaging valuable electrical equipment. Electrical Power System protection is required for protection of both user and the system equipment from fault, hence electrical appliances are not allowed to operate without any protective device installed. Power System fault is defined as undesirable condition that occurs in the power system, and the undesirable conditions are short circuit, current leakage, ground short, over current, under and over voltage. The ability of protection system is demanded not only for economic reason but for expert and reliable service. Technically speaking, an over/under voltage condition is reached when the voltage exceeds/lags the nominal voltage within a fraction of seconds. Short duration voltage events can also occur such as transients (both impulsive and oscillatory), sags/dips and swells. Short duration intermittent supply failures can last anywhere from 0.5 cycles up to 1 minute and can be caused by a number of occurrences such as supply system faults, equipment failures, or malfunctions in control equipment. Under-voltage might result into brownout, distortion or permanent damage while overvoltage in the form of spikes and surges could cause distortion, burn-out, meltdown, and fire, electro-pulsing and permanent damage. Owing to the incessant damages done by fluctuations in the power supply, there is dire need to address the problem through other alternatives, which give birth to design and construction of an equipment to protect the connected loads against under and over voltage supply. Under and over voltage protection is needed between supply terminal and the appliances (connected loads).

II. MATERIALS AND METHODS

The main purpose of the device is to isolate the load from over voltage and under voltage conditions by controlling the relay tripping coil using a PIC micro controller. The microcontroller will compare the supply voltage with the desired pre-set voltage and will operate the tripping coil in the relay if the input voltage falls below or above the pre-set range of values. The under voltage and the over voltage protective device is shown in block diagram in Figure 1.

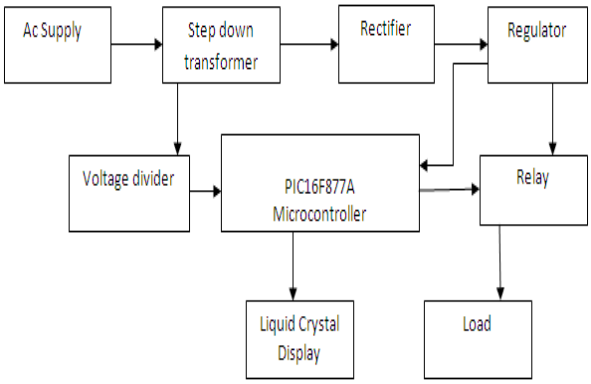

Figure 1: Functional Block Diagram of the Under and Over Voltage Protective Device.

III. EXPLANATION OF EACH BLOCK

(1) AC Input: An AC power supply typically takes the voltage from a main supply and lowers to the desired voltage. The input supply from the public utility where the device will be energized which connects the load to the supply when the supply is within 170V – 270V range.

(2) Step-down transformer: Usually, DC voltages are required to operate various electronic equipment and these voltages are 5V, 9V or 12V. But these voltages cannot be obtained directly. Thus the AC input available at the mains supply i.e., 230V is to be brought down to the required voltage level. This is done by a transformer. Thus, a step

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down transformer is employed to decrease the voltage to a required level.

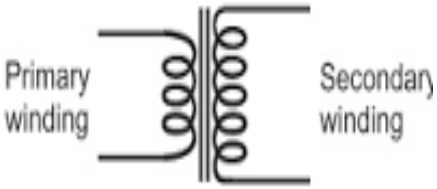
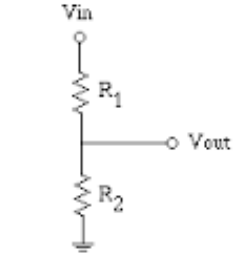


Figure2: Step down Transformer

(3) Rectifier: The output from the transformer is fed to the rectifier. It converts A.C. into pulsating D.C. The rectifier may be a half wave or a full wave rectifier. In this project, a bridge rectifier is used because of its merits like good stability and full wave rectification.

(4) Voltage regulator: As the name itself implies, it regulates the input applied to it. A voltage regulator is an electrical regulator designed to automatically maintain a constant voltage level. In this project, power supply of 5V and 12V are required. In order to obtain these voltage levels, 7805 and 7812 voltage regulators are to be used. The first number 78 represents positive supply and the numbers 05, 12 represent the required output voltage levels.

(5) Voltage divider circuit: A voltage divider is a simple circuit which turns a large voltage into a smaller one. Using just two series resistors of resistances 1 kilohm respectively and an input voltage, output voltage can be obtained that is a fraction of the input.



$$V_{out} = \frac{R_2}{R_1 + R_2} V_{in}$$

Figure3: Voltage divider

(6) PIC 16F877A Micro-Controller: The PIC16F877A microcontroller performs the major functions of decision and control. The input voltage monitor is connected to the microcontroller which provides a sample of the input supply voltage to the microcontroller for comparison with the programmed set values in the microcontroller.

Figure4: PIC microcontroller

The PIC16F877A microcontroller was used in the design in order to reduce the complexity of the design and to ensure an easy interface with a liquid crystal display.

(7) Relay Driver: This is an NPN transistor that controls and supplies current through the coil of the relay that connects the mains supply to the load. The relay is a single pole relay which, upon being activated by the PIC via the transistor, makes under normal mains supply voltage and brakes under abnormal mains supply voltage

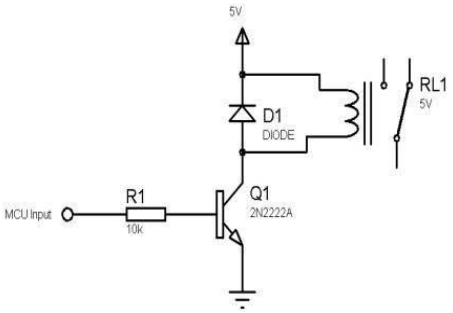


Figure5: Relay Driver

(8) Liquid Crystal Display (LCD): This displays the supply voltage as well as some information at „switch on" or when the supply voltage is out of range of the desired pre-set range of values.

Figure6:2 x 16 LCD display

IV. EXPLANATION OF THE CIRCUIT DIAGRAM

The circuit diagram of the developed device is shown in Figure 6. The circuit was designed, and its functionality was simulated using Proteus Software. Input to circuit is 230voltage.Potential transformer step downs 230 volt AC voltage in 12 volt AC. After that bridge rectifier converts step down AC into pulsating dc voltage based on the peak value rectifier output is 15volts.filter capacitor is used to get a clear pulsating DC output without any distortion Voltage regulators are used to regulate the voltage. Regulator 7805 is used for microcontroller to give 5volts; similarly regulator 7812 is given for relay to act at 12volts respectively. Crystal oscillator 4 MHz are used to convert the electrical energy and mechanical energy between the crystal in the resonant mode of operation in order to provide stable and accurate single frequency oscillation. Transformer output is fed to the voltage divider circuit which inturn gives analog input to microcontroller. Voltage divider further divides the voltage into two parts.
If the voltage is between 170-270, the transistor goes to conduction state relay energizes hence the motor runs and the LCD displays as normal voltage. If the voltage is below 170 or above 270, the transistor goes to cutoff state and relay de-energizes and hence the motor ceases and the LCD displays as under/over voltage.

DOI 10.17148/IJIREEICE.2016.4366

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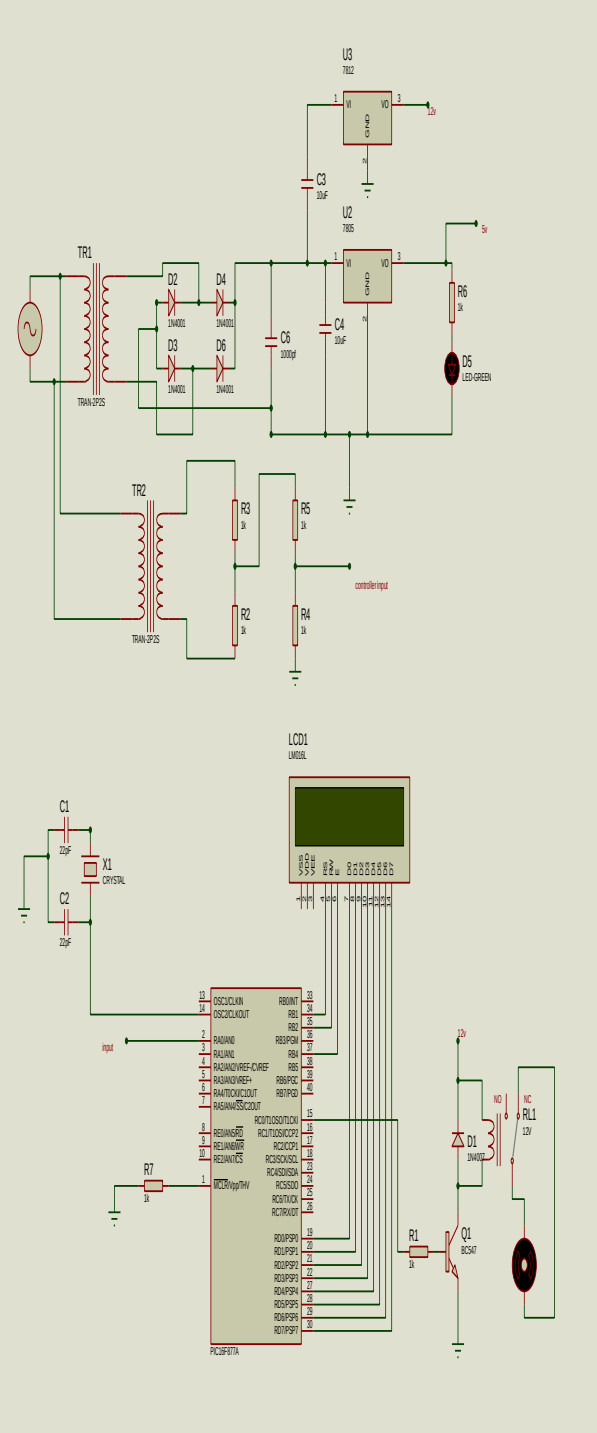

Figure7: Circuit diagram

GRAPHICAL REPRESNTATION OF OVER AND UNDER VOLTAGE

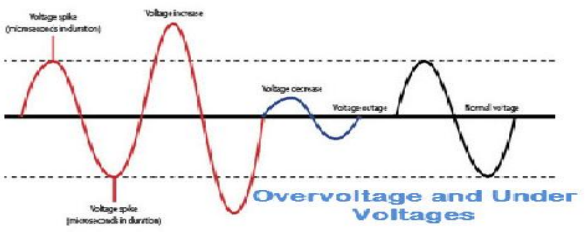

Figure8: Over and under voltage

In this graph over voltages are the voltages that exceed the normal or rated values which cause insulation damage to electrical appliances leading to short circuits. Similarly, under-voltage causes overloading of the equipment leading to lamp flickers and inefficient performance of the equipment. Thus, this article is intended to give under and overvoltage protection circuit schemes with different control structures.

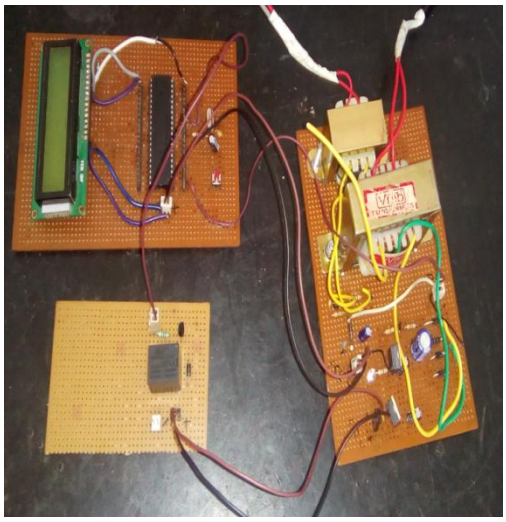

Figure9: Hardware Implementation

V. CONCLUSION

The aim of designing and constructing a low cost micro – controller based under and over voltage protective device was achieved in this work. The device supplies power to the connected load whenever the input supply is within the required pre-set voltage, thereby protecting the output connected loads from un-necessary damages. The device is found to be economical, easier to maintain and repair.
This proposed system will trip the load in the event of the input voltage falling below/above a set value. PIC microcontroller is used for controlling the voltage in which a program is inbuilt. This controls the output if the input voltage to them crosses the range beyond the set voltage. A relay is then operated to cutoff the load for safety reasons. The concept in future can be extended by integrating an alarm, which sounds when voltage fluctuations occur. It can also be interfaced with a GSM modem to convey alert message to the user via SMS to take appropriate action.

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