DESIGN ANALYSIS AND REALIZATION OF MICROCONTROLLER BASED OVER CURRENT RELAY WITH IDMT CHARACTERISTICS: A PROTEUS SIMULATION

HARSH DHIMAN

Department of Electrical Engineering, The M. S. University, Vadodara, INDIA, Email: hsdhiman1098@gmail.com

ABSTRACT

The paper presents a PROTEUS model of Micro controller based Over current and Differential Relay. The relay can be used to sense faults in transmission line based on analog to digital conversion of the 3-phase current and simultaneously issuing a trip signal if the actual line current is greater than set reference value. The proposed model can also be implemented as Differential relay, which often find their application in transformers protection. The model uses various analog devices for conversion purposes and displays the current values as sensed by the micro controller.

Keywords – ADC, Differential Relay, Embedded C Programming, I to V converter, PIC Microcontroller.

1. INTRODUCTION

Power System protection is an important aspect of design of power system. As far as faults in power system are concerned, majority of faults are line-ground faults and detecting such faults and removing them can be easily done with the help of numerical relay. Nowadays a spurt is seen usage of Numerical relays over conventional Electromechanical relays, with an added advantage of low cost and improved flexibility. The model uses current transformer to sense the AC line current and converts it into DC using a precision rectifier. The sensed current is then fed to the Analog to Digital port of microcontroller via I to V converter. The signal so obtained is compared with reference value stored in EEPROM of microcontroller. Subsequently the relay signal can be issued to the circuit breaker if the sensed value exceeds set reference. The model presented here can also be used as a Differential relay in case of transformer protection.

2. METHODOLOGY

An "Over Current Relay" is a type of protective relay which operates when the load current exceeds a preset value. In a typical application the over current relay is used for over current protection, connected to a current transformer and calibrated to operate at or above a specific current level. This model will attempt to design and fabricate over current protection relay using PIC micro controller. The PIC micro controller will cause the circuit breaker to trip when the current from load current reaches the setting value in the PIC micro controller. In order to design it, first the load current need to measure in order to monitor it using current sensor including testing the fault (over current) and when such condition arise, it will isolate in the shortest time possible without harming the any other electrical devices

The Basic idea of this model is to compare the value of the current as sensed by the ADC of the microcontroller and compare it with set reference value. To perform such comparison, the program can be written in Embedded C language and can be loaded in microcontroller. Here we have taken PIC as the microcontroller with inbuilt Analog to Digital Converter (ADC). In order to sense the current, first the AC value of current is converted into DC using a +precision rectifier and then fed to I to V converter. Since the analog port of microcontroller senses on DC value, we have to perform this conversion. After the conversion has been done the signal is now sent to ADC port of PIC microcontroller, where the signal after analog to digital conversion is compared with reference value of current set in amperes. If this sensed value is greater than reference , one of the ports of microcontroller is made HIGH, and the relay driver starts operating thus tripping the circuit breaker and disconnecting the apparatus from rest of the power system. To realize such operation we have taken ULN2003 as relay driver. For testing and simulation purpose we have taken a simple incandescent bulb as a device to be protected. The entire model was simulated in PROTEUS and satisfactory results were obtained. In order to change the value of incoming AC current, a rheostat is connected in series to test for different values of line current. The programming is done in mikroC, a popular compiler for PIC microcontrollers. Similarly the model can be setup for a differential protection scheme of transformers. Here the two currents let say I_1 and I_2 from the two ends of the apparatus can be taken, converted into DC and then fed to the ADC channels of PIC microcontroller.

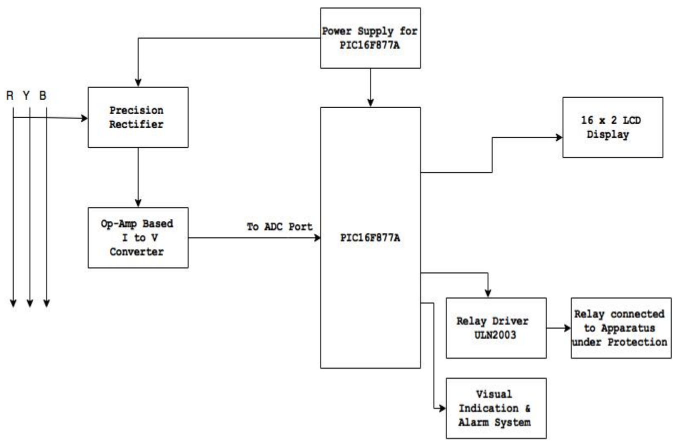

Figure 1: Block diagram of the simulation circuit using microcontroller relay

2.1 WORKING PRINCIPLE OF THE BLOCKS

2.1.1. Power Supply

The power supply uses a step down transformer to step down the input mains voltage to a voltage level suitable for the electronics within the device. A centre tapped transformer, with two diodes for full wave rectification is used to convert the ac voltage to a pulsating dc voltage followed by a filter, comprising of a capacitor to filter out (smooth) the pulsation

2.1.2. Load

Load may be industrial type or residential type or both the type connected to the power transformer, which varies continuously with time.

2.1.3. PIC Microcontroller

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. 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.

2.1.4. Precision Rectifier

Precision Rectifier: Often called as super diode, the precision rectifier is used in order to convert the alternating value of line current into dc value. Also a three phase rectifier can be used, but due to high output current and harmonic content former is preferred. The precision rectifier is made up of Op-Amp in conjugation with diode and resistors.

2.1.5. I to V Converter

I to V converter is an Op-Amp based analog circuit that converts a current entity in to a voltage one. The Op-Amp based I to V converter can be used in both inverting and non-inverting mode depending on the application.

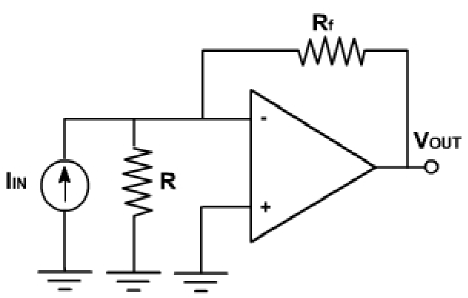

Fig 2: I to V Converter

2.1.6. Relay Driver

The relay driver circuit is used to drive the relays, here we have used ULN2003 IC which is a Darlington pair capable of 500mA and up to 50V which are also compatible with TTL and 5V CMOS logic. Here the relay driver is connected via Port D of PIC16F877A. One of the pins of PORT D has been configured to drive the relay when the sensed current exceeds the set reference. Thus the relay gets activated when the set port of the microcontroller is digital high.

2.1.7. Relay

A relay is an electrically operated switch. Current flowing through the coil of the relay creates a magnetic field which attracts a lever and changes the switch contacts. The coil current can be on or off so relays have two switch positions and they are double throw (changeover) switches.

2.1.8. LCD Display

The LCD Display is used to display the supply voltage and it will change as the load will be changed and displays on to the LCD display. So, the operator in the substation can see the readings and take necessary actions when abnormal condition occurs.

2.1.9. Relay connected to Apparatus under protection

The signal from the relay driver is used to drive the relay when the current value exceeds the set reference. Here in PROTEUS simulation we have taken an incandescent light bulb as the device to be protected and the simulation results were observed.

2.2 COMPONENTS USED AND THEIR VALUES

- AC Current source : 5A
- Diode 1N4007
- Op-Amp 741 for I to V Converter
- 1K Potentiometer for varying analog input
- PIC16F877A as a microcontroller unit (MCU)
- 4MHz crystal
- 10µF ceramic capacitor for interfacing with crystal
- 2x16 LCD Display
- ULN2003 as a Relay Driver IC
- Light bulb as a apparatus under protection
- 12V Relay Coil
- Red and Green LED's for indicating status of relay tripping state.
- 1K Potentiometer for adjusting LCD brightness

2.3 IMPLEMENTING INVERSE DEFINITE MINIMUM TIME CHARACTERISTICS (IDMT)

In order to plot the IDMT characteristics for Overcurrent relay, the full load current of the transmission line must be known. Let the full load current of the transmission line be 250A and taking into consideration 125% overload capacity of the transmission line the thermal rating of the transmission line comes out to be 312.5A.

Citation: 10.2348/ijset09151146
ISSN (O): 2348-4098
ISSN (P): 2395-4752

Now in order to calculate the plug setting for thermal overload on the line
OL Plug Setting = Overload Current/CT ratio.

OL plug setting = 312.5/500 = 0.625 A

Plug Setting Multiplier for (I >) = OL Plug Setting*CT Secondary current = 0.625*0.5 = 0.3125A

PSM= Max Fault Current / (PS * CT ratio)

Let the max fault current be 10kA

PSM= 10000/ (0.3125*500) = 64

Thus calculating operating time for IDMT curve we get,

Operating time, t= (80*TMS)/ (PSM^2-1) seconds for extremely inverse characteristics

T= 80*0.125/ (64*64-1) = 0.002442 seconds

Actual operating time = Relay operating time + CB Time = 0.502442

Thus the Extremely Inverse characteristics of the over current relay have been implemented and the LCD shows the operating time of the relay itself in seconds as shown in the figure below.

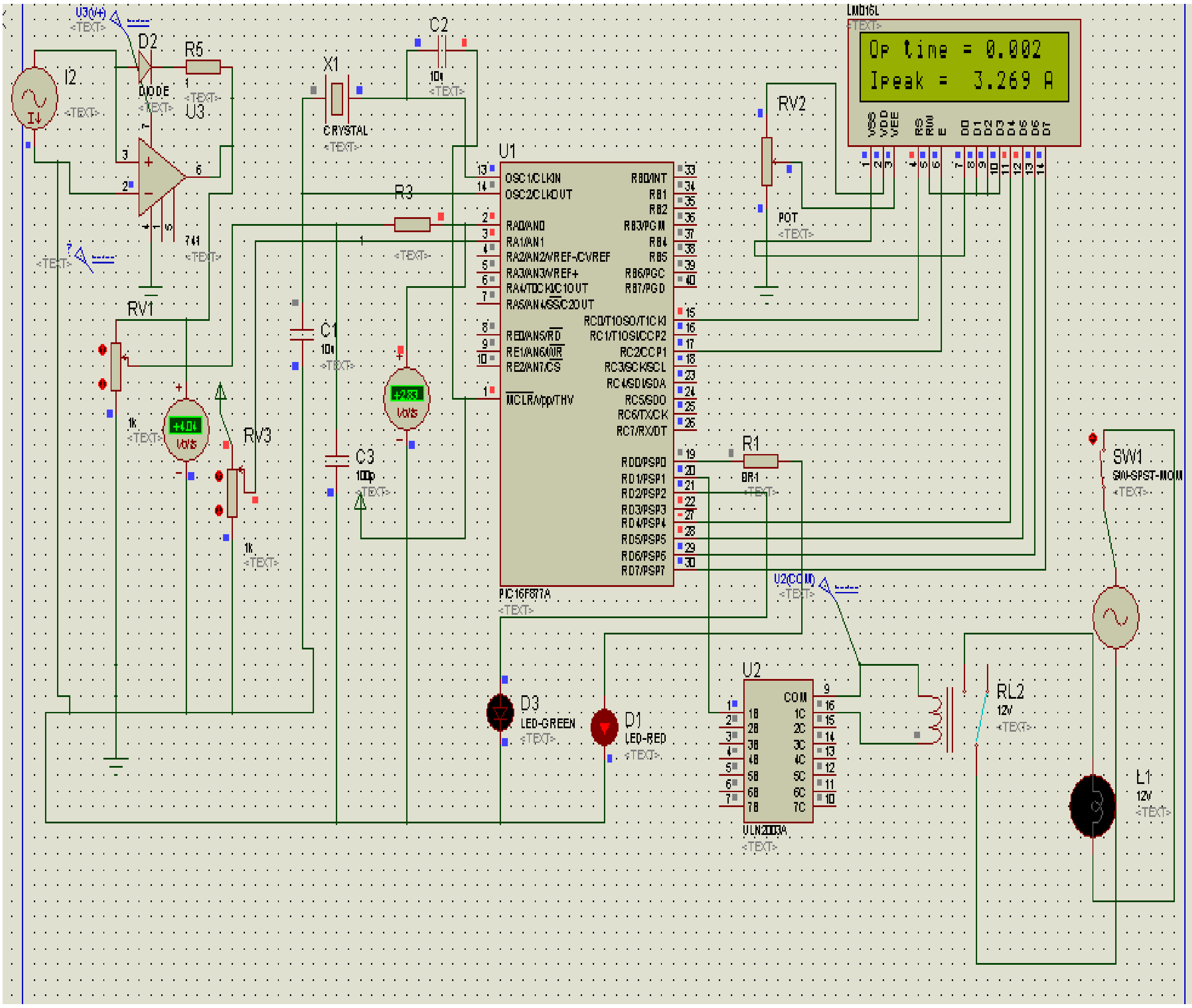

Figure 3: Proteus schematic showing the operating time and the current at the time of tripping

2.4 CIRCUIT DESCRIPTION

The above diagram shows the Proteus schematic diagram of the Overcurrent relay. The microcontroller chosen was PIC16F877A, having 8 ADC ports. In order to use this as a differential relay for transformer protection the multiple ADC ports of microcontroller can be used. The AC current source of 5A is taken and is fed to the I to V converter, here we have taken noon-inverting mode of Op-Amp. The resistor with a diode in series is connected at the output of Op-Amp. One can also perform rectification of AC current before feeding it to the Op-Amp. A variable resistor is used in order to change the value of the input analog quantity to the ADC port of microcontroller. The A-D conversion takes place and the trip signal is issued accordingly. From the diagram above the relay drive is connected to one of the pins of PORT D of PIC16F877A. The relay coil of 12V is chosen and is connected with the apparatus ie light bulb. The light bulb is energized from a 240V AC voltage source. Also in order to assure that the

Citation: 10.2348/ijset09151146
ISSN (O): 2348-4098
ISSN (P): 2395-4752

relay has tripped, for visual indication LED's are interfaced with PORT D. When the relay trips the red LED glows to show the tripping action, when the system is stable the green led glows. The programming part is done in mikroC, a compiler for PIC microcontrollers. The entire program is written in embedded C language. For using this relay as differential relay, two channels of ADC are used and the percentage bias is set in the program accordingly.

3. SIMULATION RESULTS

The circuit is simulated for normal as well as faulty operation. The pickup value is set to 2.5 A in the program. Using the variable resistor, the analog input to the ADC port of the microcontroller was increased and once the current value exceeds, 2.5A the relay trips the apparatus from rest of the system and as an observation the light bulb stops glowing with a red LED glowing and LCD displaying the value of peak current and status of relay as shown in the figure 5.

Similarly the normal operation of the Overcurrent relay can be realized with the green LED glowing and LCD showing the peak value of line current less than set 2.5A, shown in figure 7.

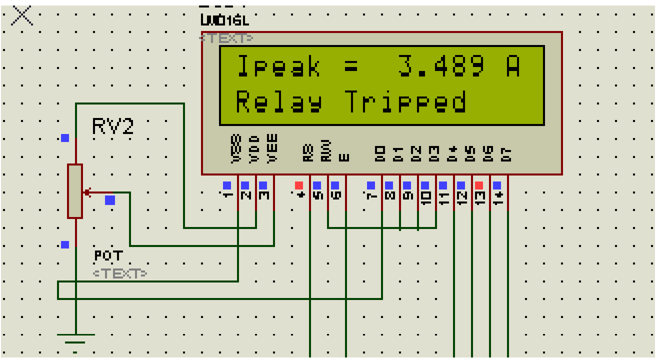

Figure 4: LCD indicating status of relay (tripping state)

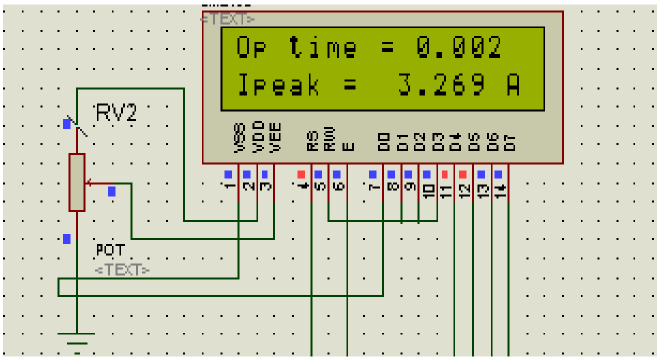

Figure 5: Proteus schematic of Microcontroller based relay showing the tripping status with the current value

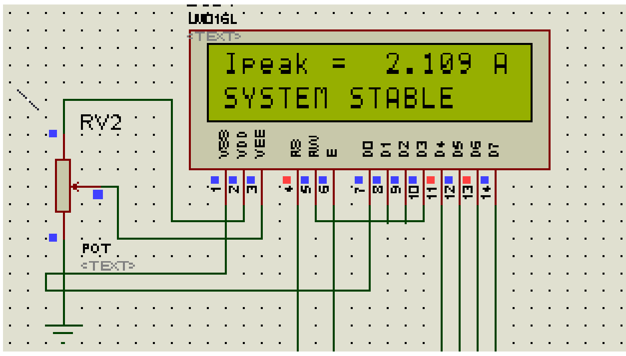

Figure 6: LCD Showing the status of Relay (Normal Operation)

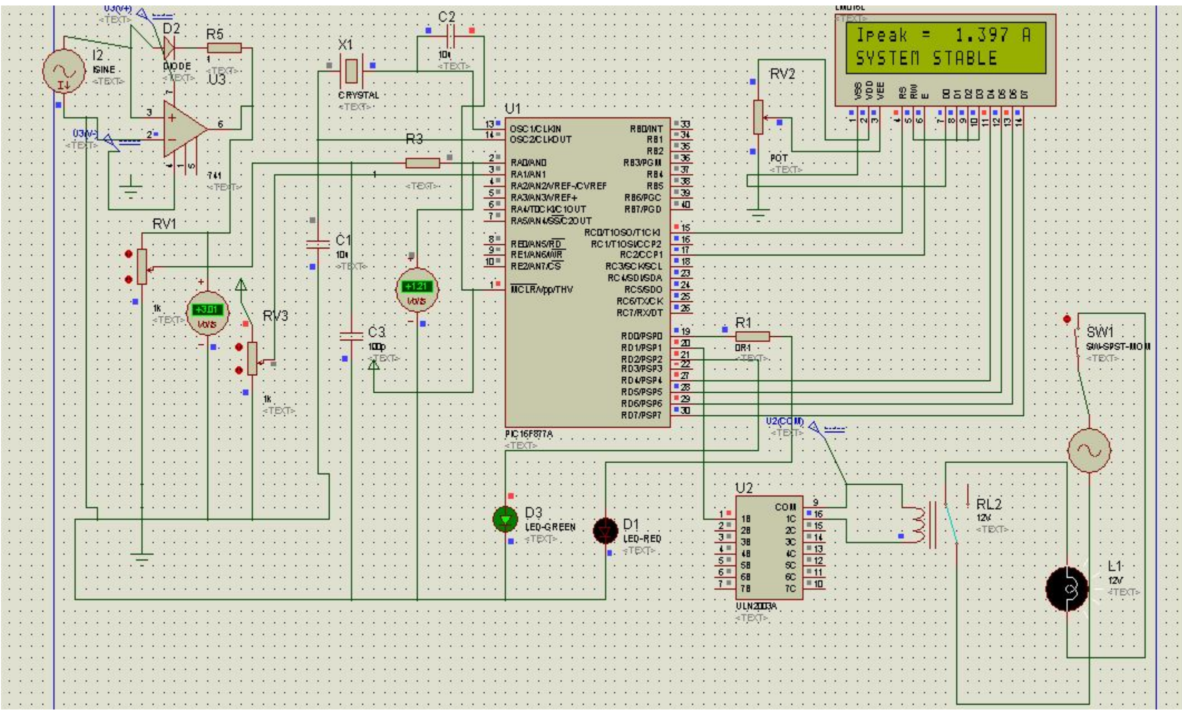

Figure 7: Proteus schematic of Microcontroller based Overcurrent relay showing the Normal Operation

The figure below shows the schematic of the LCD display of the the microcontroller based relay showing the operating time of the relay along with the value of the current at which the trip has occurred.

4. OBSERVATIONS

- As we increase the value of the analog input we see that the current value increases.

- Once the current value exceeds its pickup value, PORT D of the microcontroller turns high and relay starts operating.

- The maximum full load current is taken as 2.5A after reducing it by a current transformer. Once the current reaches its overload capacity the relay trips the apparatus under protection.

- Thus the relay trips as the current value crosses 3.125A, which is 125% of full load current.

5. CONCLUSION

The design and the realization of Microcontroller based Overcurrent and Differential Relay was done in Proteus and the simulation results carried out were found to be satisfactory. The similar approach can also be done more advanced and fast microcontrollers like Digital Signal Processors (DSP's) for both the applications. It is found that this model can also be adopted to sense the current in all the three phases of the transmission line and in case of transformer. Also this model can be used as a frequency relay by sensing the frequency of the operating voltage and can be useful in case of transformer applications where over fluxing and under fluxing are often observed while switching on.

REFERENCES

1. Ponnle A. A, Omojoyegbe M. O.,"Development of a Low Cost Microcontroller Based Under and Over Voltage Protection Device", International Journal of Scientific Engineering and Technology (ISSN : 2277-1581) Volume No.3 Issue No.9, pp : 1225-1229,1 SEPTEMBER ,2014.

2. S. M Bashi, N. Mariun and A. rafa (2007). 'Power Transformer protection using microcontroller based relay', Journal of applied science, 7(12), pp.1602-1607.

3. S. Dharanya, M. Priyanka, R. Rubini and A. Umamakeswari;"Real Time Monitoring and Controlling of Transformers", Journal Of Artificial Intelligence 6(1):33-42 2013.

4. Technical Research Paper ,"Microcontroller based Fault Detector" ,International Journal of Advancements in Research & Technology, Volume 1, Issue 5, October-2012 1 ISSN 2278-7763 .

5. Badri Ram and D N Vishwakarma," Power System Protection and switchgear,"2nd Edition, Tata Mcgraw Hill education Pvt Limited.