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Microcontroller Based Protection Relay for Agricultural Motor

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ABSTRACT:- Induction motors are widely used in agriculture sector as water pumps. This project emphasizes on the protection of induction motor at phase loss and phase imbalance fault condition. In these conditions if the motor functions for a longer time there is high possibility for the damage of motor windings, whereas tripping the motor every time a fault arises is not a good solution as the work gets delayed or pending. A stand- alone, microcontroller-based digital relay is designed and implemented, using ATMEGA328p microcontroller. the faults in the motor are identified and the motor is tripped until the fault is cleared. Additional information such as getting the track of how many times the motor has tripped, reasons for tripping, etc can also be obtained.

KEYWORDS: - phase loss, phase imbalance, digital relay.

I. INTRODUCTION

Induction motor faults are of high maintenance cost and a unwanted down time in the process plant. The prime objective of maintenance is to keep machinery in good operating condition that prevents failure and production loss [1]. Motor condition monitoring can be done with different methodologies as mentioned in IEEE 1434 [97] which are vibration signature analysis, current signature analysis, etc along with the use of appropriate sensors, different signal conditioning and analyzing instruments [2]. There are a number of faults in induction motors, the most common faults among them are mentioned below:

- Phase Imbalance
- Phase loss
- Under or over voltage
- Reverse phase sequence
- Earth fault
- Inter-turn short-circuit fault
- Crawling.

This paper focuses only on first two faults, As the remaining are industrial level faults. The conventional alternative is the use of a capacitor for converting two phase supply to three phase supply but this method of converting injects several harmonics into the supply and it also reduces the lifetime of the motor windings [5]. The two phase to three phase converter using capacitor has following disadvantages:

1. Unbalanced loading.
2. Produce harmonics.

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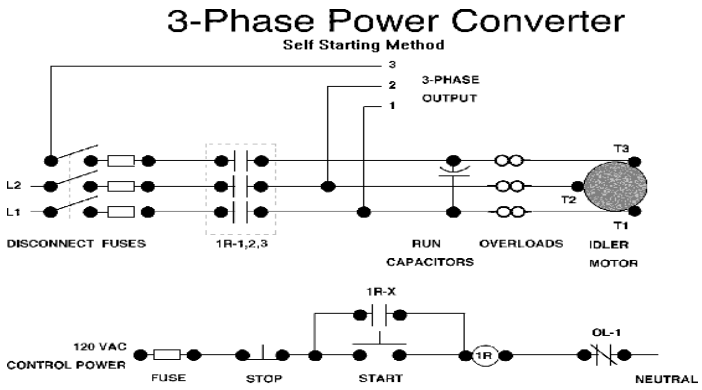
Figure 1. Three phase power converter



To overcome the above problem in the agricultural sector the proposed system uses continuous monitoring of the supply and protecting the motor during the fault conditions.

II. METHODLOGY

The current and voltage values are taken from the supply line with the help of current transducer and voltage transducer respectively and they are given to the measuring unit. From the measuring unit the calibrated values are given to micro controller. The micro controller monitors the values to identify the existence of faults, based on the execution of instruction it gives the command to the relays.

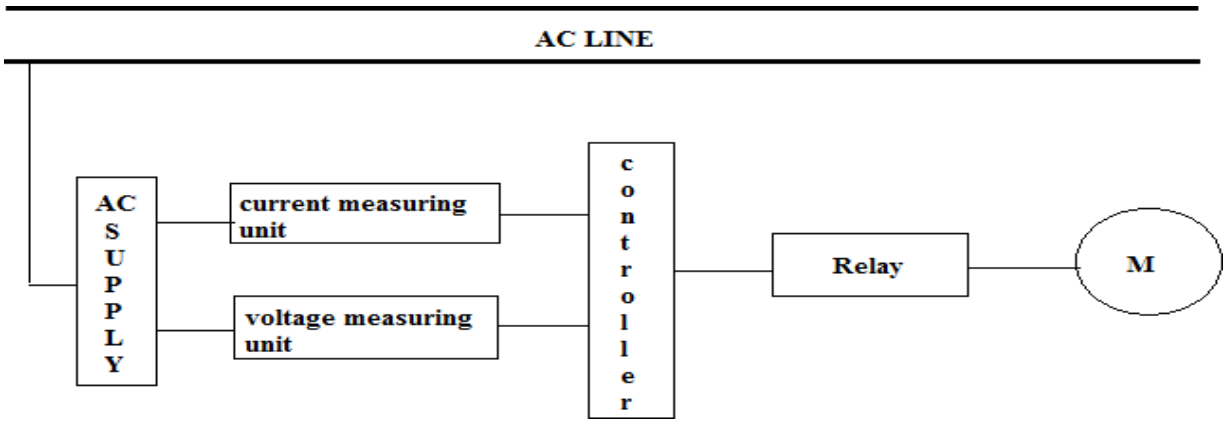


Figure 2. Methodology

In this way the proposed system controls the motor from fault condition. The methodology of our project is explained in block diagram as shown in Figure 2.

III. PROPOSED SYSTEM

The block diagram representation of the proposed system is shown in the figure. CT and PT are used to sense the current and voltage of the supply and the values are given to analog to digital converter. The

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The microcontroller compares the actual value with set value based on that the microcontroller gives instruction to the relay for turn on and turn off operation.

A. POWER SUPPLY

This power supply circuit is designed to get regulated output DC voltage. 7812 IC is used to give the constant +12V supply. 7912 is used to give the constant 12V supply. Bridge rectifiers using diodes is used for

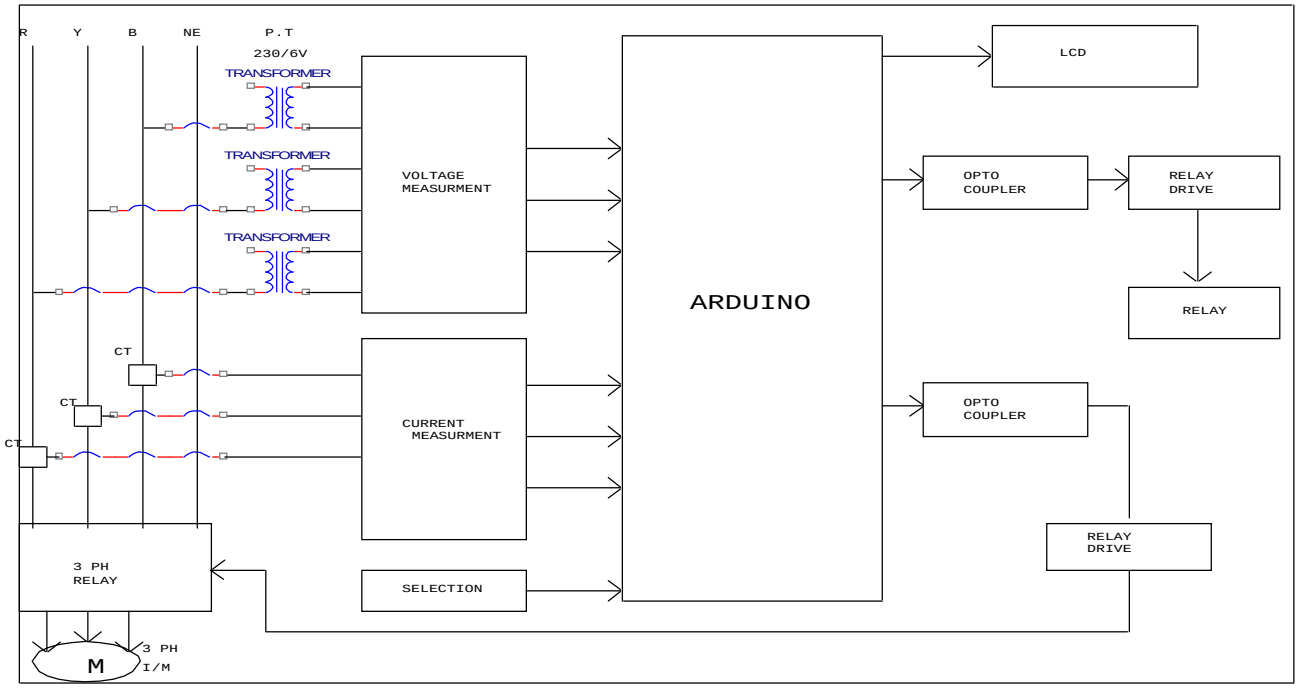

Figure 3. Proposed System

values which are obtain from the transducers are analog. The values are given to the Arduino ATMEGA328P. rectifying purposes. The power supply section is for supplying power to the entire circuit.

B. VOLTAGE MEASUREMENT

In this, voltage protection circuit is used to sense the voltage in between the phase and neutral in 3 Phase 4 Wire system. feed back to the summing point and clamping the op amp output to –0.6V this clamped output swing aids in minimizing response time, because it prevents amplifier saturation. Output from this inverting rectifier is added to the original input

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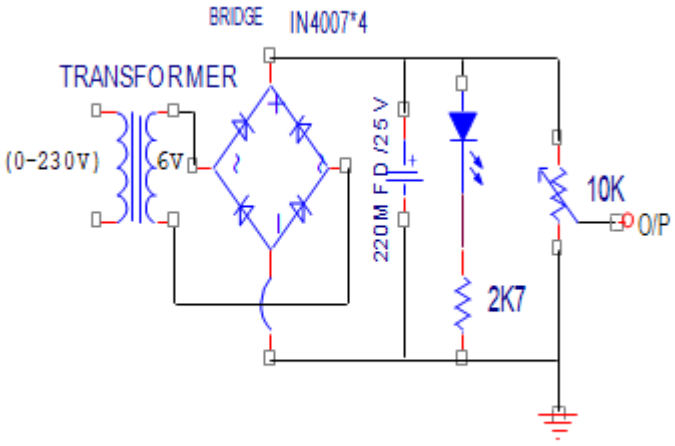

Figure 4. Circuit diagram of Voltage measurement unit

signal in next stage op amp (summing mixture), with the signal amplitude and phase relations. Negative attenuations of Ein results in no output at E1, due to the rectification. Ein feeds A2 through 200KΩ resistance, and E1 feeds A2 through a 100KΩ resistor. The net effect of this scaling is that, for equal amplitude of Ein and E1, E1 provide twice as much current from the running point. This fact is used as the negative alteration of E1 produces twice the input current of that could by the positive alteration of Ein. The output from the summing amplifier is given to the inverting amplifier with Figure 4. Circuit diagram of Voltage measurement unit Here 230V supply given to the input of the primary winding of the potential transformer. The unity gain.

$$V_{output} = \frac{r_f}{r_1} x V_{in} \quad \text{- (1)}$$

potential transformer is step - down the voltage in (+6) – 0 – (-6) V.

The stepped down AC voltage is rectified and filtered by using of this full wave rectifier and filtering circuits. This smooth DC low voltage applied across the variable resistor 10KΩ which is used to provide the variable DC milli voltage. This voltage is fed to the comparator.

C. CURRENT MEASUREMENT

This circuit around the first half formed as a half wave rectifier. That produces an inverted half wave replica of the input signal. For negative input signal at R1 output is positive. Forward biasing D1 and closing the negative feedback through R2.

R_F = feed back resistance = 20 K R_I = Input resistance = 20 K

D. OPTO COUPLER WITH RELAY DRIVER

Opto coupler not only separates the high voltage input side and the microcontroller but also prevents damage to the microcontroller due to the line voltage transistor. It also reduces the effects of electrical noise common in industrial

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environments, which cause erratic operation of the microcontroller.

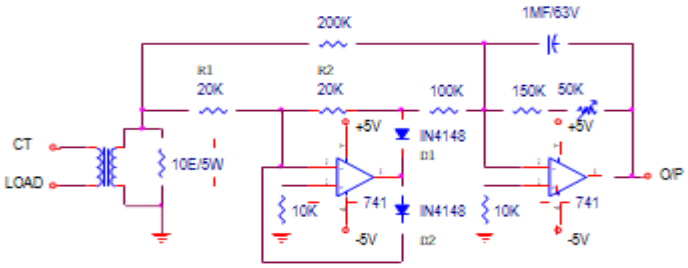

Figure 5. Circuit diagram of Current measurement unit.

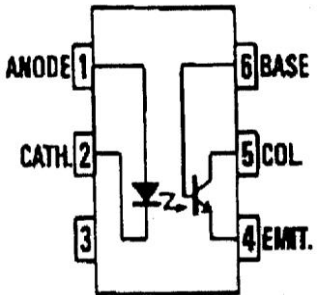

Figure 6. Pin diagram of MCT2E

This produces an inverted gain of almost exactly one, since R1 and R2 are closely matched for positive input signals, the amplifier output is negative and D1 is off D2 is on in this case, applying

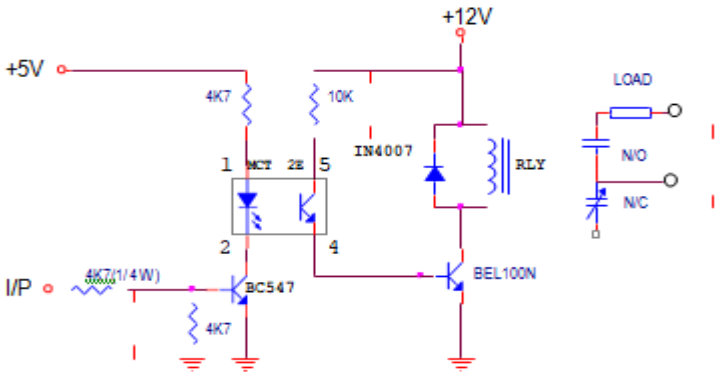

Figure 7. Circuit diagram of Opto coupler with relay driver

E. OPTO COUPLER WITH RELAY DRIVER

The opto coupler with relay driver is shown in the figure. It isolates the high voltage circuitry with the low voltage circuit in order to avoid damage to the microcontroller and other smaller rating components.

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to the current measuring unit and voltage measuring unit. The measuring unit will measure the current and voltage availability in the supply side and the values are given to the microcontroller.

ABSOLUTE MAXIMUM RATINGS

- Output voltage: 55V.0
- Input voltage: –0.3V to 30V.
- Continuous Collector current: 500mA.
- Continuous Base current: 25mA
- Operating free air temperature range: 0^{o}C to $+70^{o}$C
- Storage temperature range: $–65^{o}$C to $+150^{o}$C.

E. ATMEG328p MICROCONTROLLER

The board used is Arduino Uno which is a microcontroller board based on the ATmega328p. It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz crystal oscillator, a USB connection, a power jack, an ICSP header, and a reset button. The number of pins used in the project are mentioned below

Input pins

1. 5 analog pins
2. 2 digital pins

Output ports

1. 10 digital pins

F. HARDWARE IMPLEMENTATION

The hardware connection is shown in figure 8. The transformer will step down the phase voltages and currents. The step downed current and voltage are given

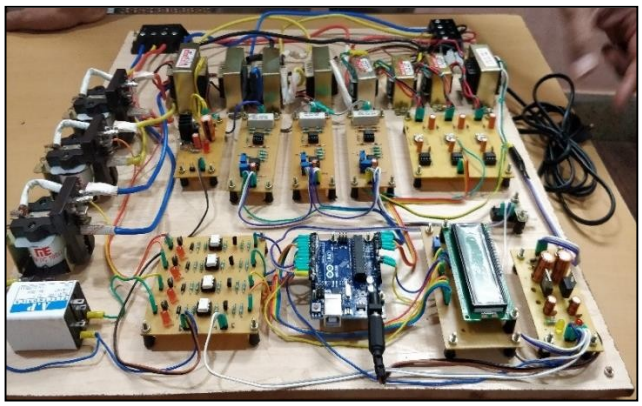

Figure 8: Hardware

The voltage measuring unit and current measuring unit hardware connection are shown the figure 9. These current and values help the controller to identify the fault conditions.

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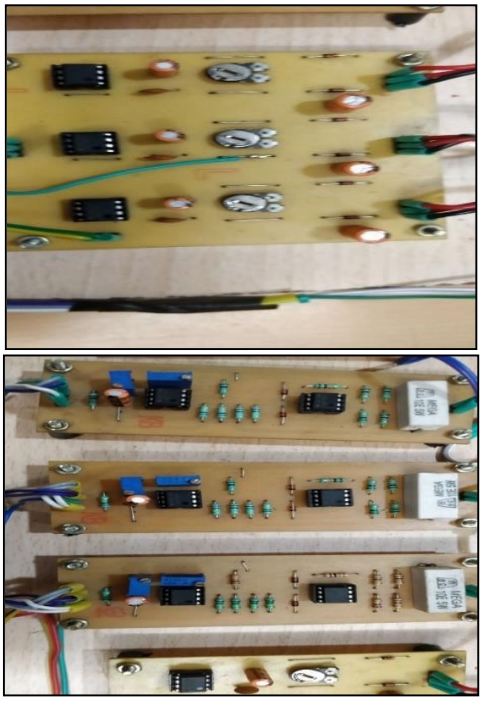

Figure 9: Voltage and Current measuring unit

The microcontroller gets the supply from the pwer supply unit which provides it with the operating voltage of 5V. The microcontroller ATMEGA328P is programmed to identify the faults by taking the current and voltage values obtained by the respective measuring unit and voltage measuring units.

Here the phase loss fault is identified by utilising the phase voltage values and the phase imbalance fault is identified by identifying the imbalance in the current values in the phase currents.

The MCT2E opto coupler is used to provide the operating signals to the relay by taking electrical isolation into care. The main purpose of using this opto coupler is to protect the lower rating components from getting damaged when there is reverse surge from the relay. During the case of reverse surge during the reverse flow of current it will get damage and it protect the microcontroller from the reverse current.

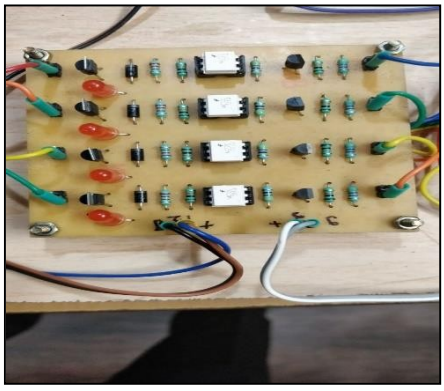

Figure 10: Opto couplers for each relay driver.

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The signals from the optocoupler are provided to the relay driver circuit, which energizes the relay using the power from the power supply unit.

IV. RESULT

For test purpose a balanced 3 phase resistive load is connected with our system and the phase loss fault and phase imbalance are produced using a MCB, the LCD will display the actual value of the supply voltage and current based on that which the microcontroller will process and provide the output. The set value and the actual value of the supply voltage is shown in Figure 11.

In this system the following two conditions are checked and the necessary measures are implemented:

(1) The microcontroller analyses the phase currents drawn by the load, if all the phases draw same current then the system allows the load to operate, whereas if there is a phase imbalance condition then it iterates for set number of times and if imbalance still persists then it is tripped off permanently.

(2) If any one phase of the supply fails the microcontroller detects the fault with the help of voltage of the respective phase. The controller checks for some iterations for the recovery of the lost phase, if the phase is not retrieved even after the set iteration count the relay trips the supply permanently.

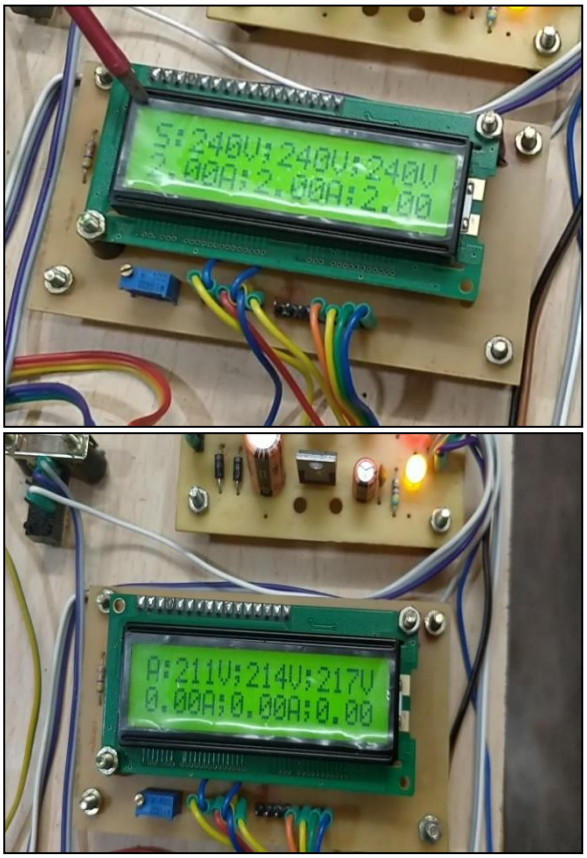

Figure 11: LCD showing preset values by operator and actual values from the supply

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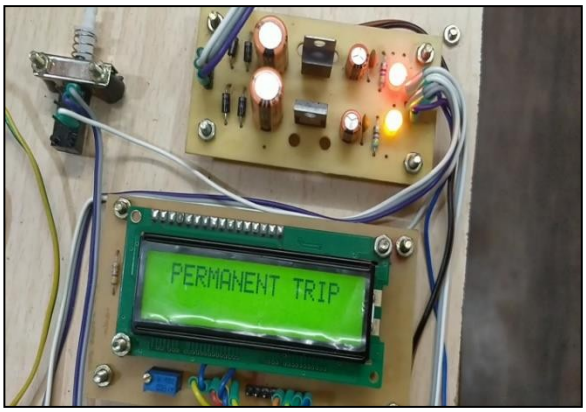

Figure 12: LCD showing the permanent trip during the continuous fault condition

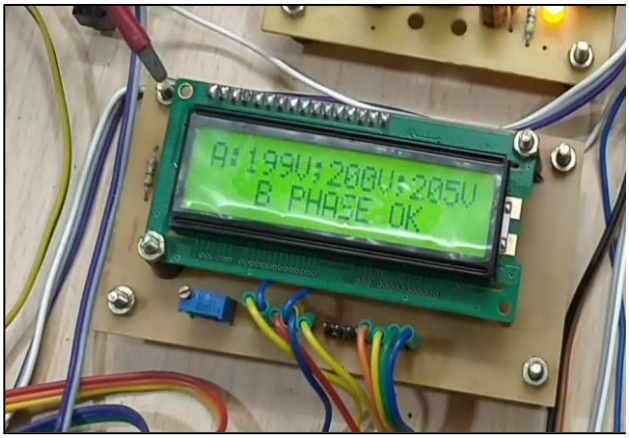

Figure 13: LCD showing the healthy phases in order to detect the unhealthy phase

IV. CONCLUSION

In this way the protective relay reduces cost for rewinding and also the productivity of the motor is improved by implementing continuous monitoring of the fault. The installation part is also quite easy since there are no extra terminals all we need to connect is theinput and the output wires.

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