# Design Of Undervoltage Protection System For Induction Motor

**Nitish Roat[1], Dr. M.K. Bhaskar[2], Chandan Pathak[3], Rakesh Kumar[4], Prachi Bundela[5], Monika Meena[6]**

[1, 3, 4, 5, 6] Dept of Electrical Engineering

[2]Professor, Dept of Electrical Engineering

[1, 2, 3, 4, 5, 6] MBM Engineering College, Jodhpur, Rajasthan, India

***Abstract-*** *Induction motors are the most commonly used motors in many applications due to which it becomes necessary that a reliable and safe operation is performed. But due to different motor breakdown conditions like motor undervoltage, overvoltage and electrical faults reliable operation is not achieved. Thus different protection systems have been introduced. Working on the same lines, we have designed a protection system to detect undervoltage conditions, so that under these conditions damage to motors can be prevented.*

***Keywords***- Decade Counter, Induction motor, NE555 timer, Piezo buzzer, Undervoltage

## I. INTRODUCTION

Induction motors are being widely used nowadays it becomes necessary to take into account its protection systems in order to reduce downtimes, prevent damages to induction motor. One such protection system we have designed is the undervoltage protection system for induction motor. Unlike others we achieve this protection system by using just ICs and few other components and not by using microcontrollers, circuit breakers etc. This protection system works by comparing DC sampled voltage with a reference voltage in order to determine if the undervoltage condition is taking place or not. If this DC sample voltage is less than reference voltage then undervoltage condition is occurring and thus relay is de-energized through electrical network process.

## II. OVERVIEW OF THE PROTECTION SYSTEM

In this protection system we have used four different ICs namely NE555 timer IC, Decade counter CD4017 IC, Quad voltage comparator LM339 IC, Quad 2-input NOR gate CD4001 IC. In normal voltage conditions while switching on the mains supply and the 12V DC supply, gate N2 of CD4001 IC is wired as a NOT (inverter) gate for making an initial reset pulse circuit with RC network. This reset circuit is essential to reset counter IC2 on initial power on, so that output Q0 of decade counter 4017 becomes high and switches on T2, due to which relay is energized to provide AC power to the load. The undervoltage protection system for induction motor works by comparing DC sampled voltage with the reference voltage, so if undervoltage condition occurs the DC sampled voltage is less than the reference voltage, so further operations are performed by the circuit in order to de-energize the relay thus disconnecting load from supply mains. This happens as follows as DC sample voltage is less than reference voltage output of A1 at pin 2 of LM339 IC become low and output of NOR gate N1 at pin 3 of CD 4001 IC becomes high. Inverted output at pin 10 of NOR gate N3 becomes low. Reset pin 15 of CD 4017 IC becomes low due to which the counter progresses and once Q4 becomes high and drives transistor T1, the piezo buzzer is switched on.

## III. UNDER VOLTAGE PROTECTION SYSTEM CIRCUIT DESIGN

The system basically consists of different IC's, relay, current transformer, piezo buzzer, transistors and other components.

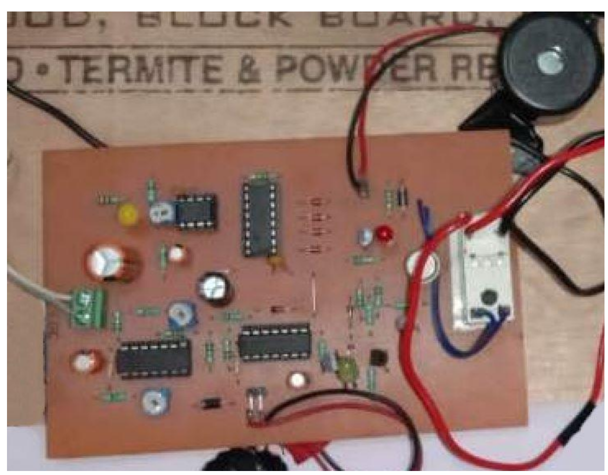


Fig.1 Circuit Design

### 3.1. Induction Motor

An induction motor works on transforming action. The stator works as the primary while the rotor works as the secondary. It is also called asynchronous motor. A rotating field is set up in the stator when a 3-phase supply is given. The stationary rotor cuts the revolving field and due to electromagnetic induction an emf is induced in the rotor conductor. As the rotor conductor is short circuited current flows thorough them. It becomes a current carrying conductor in magnetic field and starts rotating.

Fig.3 Induction Motor

### 3.2. NE555 Timer

NE555 Timer IC consists of 2 comparators, a flip-flop, a voltage divider, a discharge transistor and an output stage. The voltage divider consists of three identical 5kΩ resistors which create two reference voltages at 1/3 and 2/3 of the supplied voltage, which can range from 5 to 15 V. Next are the two comparators. Using the three pins, Trigger, Threshold and Control, we can control the output of the two comparators which are then fed to the R and S inputs of the flip-flop. The flip-flop will output 1 when R is 0 and S is 1, and vice versa, it will output 0 when R is 1 and S is 0. The Q-bar output of the flip-flop goes to the output stage or the output drivers which can either source or sink a current of 200mA to the load.

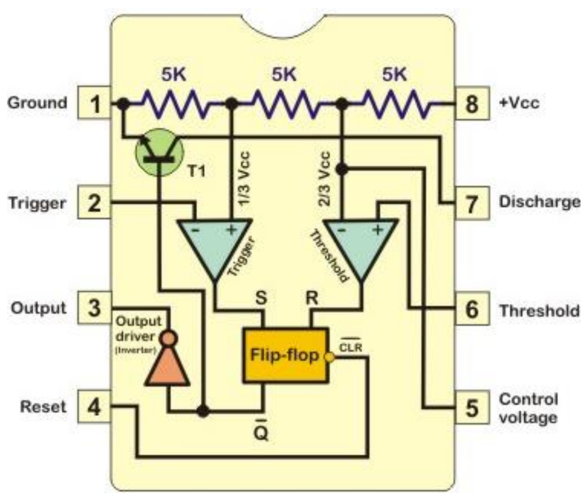


Fig.4 NE555 Timer IC

### 3.3. CD 4017 IC Decade Counter

CD 4017 IC is used for counting applications, it has the capability to turn on 10 outputs sequentially in a pre-defined time and reset the count or hold it when required. It can operate on wide supply voltage ranging from 3 V to 15 V, typically +5 V, has a maximum clock frequency of 5.5 MHz.

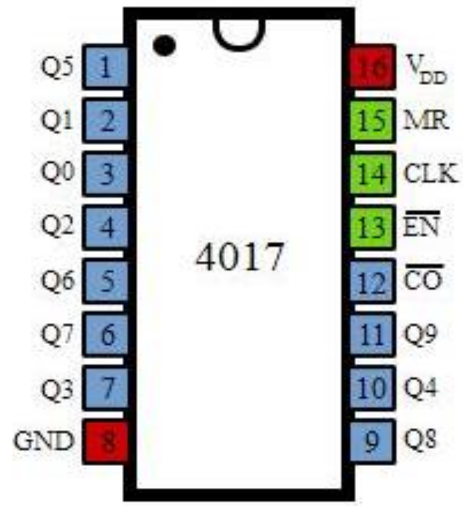


Fig.5 CD 4017 IC

### 3.4. LM339 Quad Voltage Comparator

LM339 consist of four independent voltage comparators designed to operate from single power supply over a wide voltage range.

Features:

1. Input Offset Voltage: 2 mV
2. Min Supply Voltage: 2 V
3. Max Operating Temperature: $70^{0}$ C
4. Max Supply Voltage: 36 V
5. Output Current: 18 mA
6. Max Input Current: 250 Na

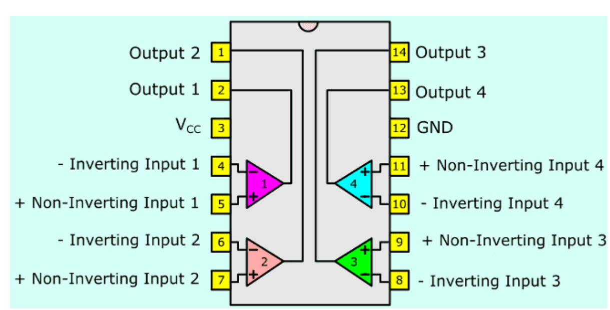


Fig.6 LM339 IC

### 3.5. CD 4001 Quad 2-Input NOR Gate

CD 4001 consists of four independent 2-input NOR gates. It has a wide operating voltage range. It is a low power CMOS IC.

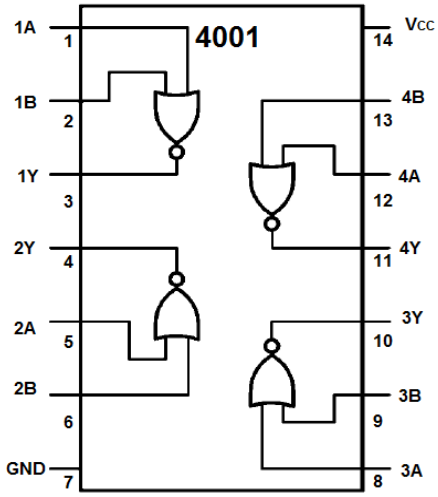


Fig.7 CD 4001 IC

**3.6. Current Transformer**

A current transformer (CT) is used to measure the current of another circuit. A CT is designed to produce an alternating current in its secondary winding that is proportional to the current that it is measuring in its primary. Thus the current transformer reduces a high current to a lower value and therefore provides a safe way of monitoring electrical current.

Fig.8 Current Transformer

**3.7. Relay**

Relays are switches that open and close circuits electromechanically or electromagnetically. Relays control one electrical circuit by opening and closing contacts in another circuit. When the relay is not energized and if a relay contact is normally open (NO), then there is an open contact and if a relay contact is normally closed (NC), then there is a closed contact. In either case, applying electrical current to the contacts will change their state i.e. NO changes to NC and NC changes to NO.

Fig.9 Relay

**3.8. Piezo Buzzer**

At the heart of a piezo-type buzzer is the piezoelectric element. The piezoelectric element is composed of a piezoelectric ceramic and a metal plate held together with adhesive. Both sides of the piezoelectric ceramic plate contain an electrode for electrical conduction. Exposure to mechanical strain will cause the material to develop an electric field, and vice versa.

Characteristics

1. Wide operating voltages: 3~250 V
2. Lower current consumption
3. Larger footprint
4. Higher sound pressure level

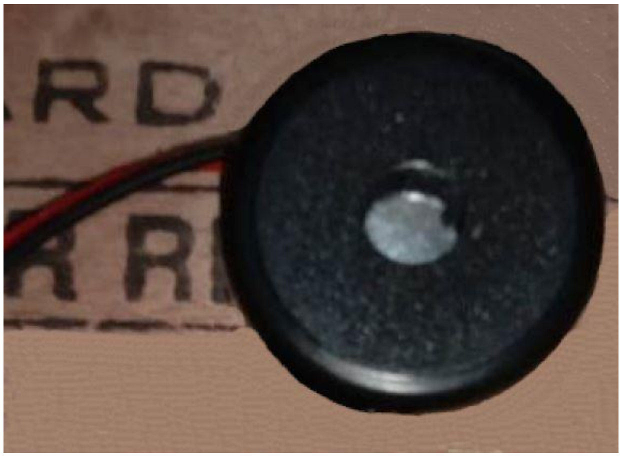

Fig.10 Piezo Buzzer

**3.9. BC547 Transistor**

BC547 can be used commonly for amplifiers and switches. It has three terminals namely collector terminal, base terminal and emitter terminal respectively. This transistor is usually used for amplification and switching purposes. Its maximum current gain is around 800. BC547 is biased in such a way that it is partially on for all the applied inputs, for the amplification purpose. The input signal is amplified at the base and then transferred to the emitter.


Fig.11 BC547 Transistor

### 3.10. SL100 Transistor

SL 100 is a three layer NPN device within the working range, the collector current $I_C$ is a function of the base current $I_B$, a change in the base current giving a corresponding amplified change in the collector current for a given collector emitter voltage $V_{CE}$. . A protruding edge in the transistor case indicates the emitter. The base is nearest to the emitter while collector lies at the other extreme of the casing. Features of this transistor include high ruggedness, simple drive requirements, high safe operating area etc.

Fig.12 SL100 Transistor

## IV. WORKING

This undervoltage protection system for induction motor consists of four ICs namely NE555 as IC1, 4017 as IC2, LM339 as IC3 and CD4001 as IC4 and other components. The amount of load current flowing through the induction motor is sensed by the primary of the CT in the form of AC voltage. Sampled AC voltage in the secondary of CT coil is proportional to the load current of the induction motor.

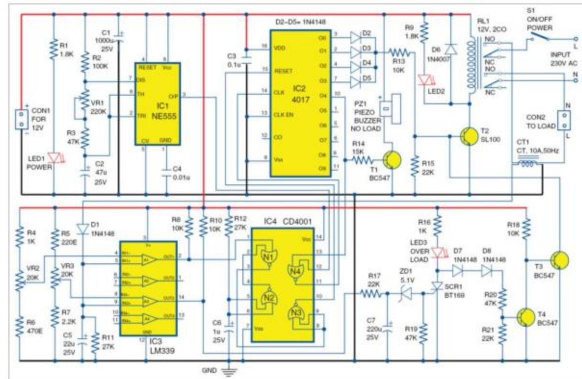


Fig.13 Circuit Diagram

In undervoltage condition, the protection system works as follows, DC sample voltage from the rectifier D1 at pin 5 is less than the reference voltage at pin 4 from the potmeter VR2. Output of comparator A1 at pin 2 of IC3 become low and output of NOR gate N1 at pin 3 of IC4 become high. Inverted output at pin 10 of NOR gate N3 becomes low. This allows the counter to progress through Q1, Q2, Q3 and Q4. Here Q0 to Q3 are ORed and used to drive transistor T2, so that T2 conducts till counter output reaches Q4. This is done to establish sufficient time delay before cutting off the supply to the load. This delay can be adjusted by changing the frequency of astable multivibrator IC1 by adjusting the value of potentiometer VR1. Once Q4 becomes high and drives T1, the piezo buzzer (PZ1) is switched on. The high Q4 is fed to input pin 13 of NOR gate N4, which blocks the clock pulses of IC2 at pin 14. Due to which functioning of counter IC2, logical circuits and comparators freezes till next switching off and on of AC supply using switch S1.

## V. CONCLUCSION

We have designed an undervoltage protection system for induction motor using various IC's like NE555 as IC1, CD 4017 as IC2, LM339 as IC3, CD4001 as IC4, relay, current transformer, piezo buzzer, transistors and various other components.

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