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IMPLEMENTATION OF OVERVOLTAGE PROTECTION SCHEME FOR INDUCTION MOTOR

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Abstract – *Induction motors are widely used nowadays with applications ranging from residential, commercial and industrial like washing machines, blenders, drilling machines, pumps, compressors, paper mills, textile mills etc. It could be assumed that properly planned, dimensioned, designed, installed, operated and maintained motor systems and drives should not break down, in reality however these conditions are hardly ever ideal. Motor breakdowns can be attributed due to motor undervoltage, overvoltage and electrical faults. These breakdowns in motor operations result in huge losses both in time and money. Hence it becomes necessary to select proper protection systems to prevent damage to motors, so as to preserve the lifetime of motors, ensuring operation continuity, preventing motors from stopping abruptly and enabling restart in the best conditions. This project is designed to detect overvoltage conditions, so that under these conditions damage to motors can be prevented.*

Key Words: **Astable multivibrator, Decade counter, Overvoltage, Time delay, Comparators, 555 Timer, Relay, Induction motor.**

1. INTRODUCTION

The operators of electrical drive systems are under continual pressure to reduce maintenance costs and prevent unscheduled down times, which result in lost production and financial income. Most of the surveys of failure in electrical rotating machines indicate that in general, failures are dominated by bearing and stator winding failures with rotor winding problems being less frequent. Thus motor protection is an essential function for ensuring the continuity of machine operation. So, overvoltage protectors are the arrangements implemented in order to avoid operation of motors in abnormal conditions which could result in negative events such as: overheating, premature ageing, destruction of electrical windings, damage to coupling or gear box. This project helps us to detect overvoltage conditions by continuously comparing the DC sampled voltage which we get at the output of diode D1 with the reference voltage set by potentiometer VR3 and in case of overvoltage conditions the output of the comparator A3 is high, after this with the help of integrator network, Zener diode, SCR and transistors we are able to de-energize the relay thus disconnecting the load from the supply mains. We have used ICs to perform the overvoltage protection instead of circuit breakers or microcontroller. In case of overvoltage condition we prevent the connection of the motor or disconnection of the motor, as an increased voltage could not ensure a correct operation of the motor.

2. OVERVOLTAGE PROTECTION SCHEME FOR INDUCTION MOTOR

The overvoltage protection of induction motor works by comparing DC sampled voltage with the reference voltage, so if overvoltage condition occurs the DC sampled voltage is more than the reference voltage, so further operations are performed by the circuit in order to de-energize the relay thus disconnecting load from mains supply. The main components of the overvoltage protection are NE555 timer, decade counter 4017, quad comparator LM339, quad NOR gate CD4001, current transformer, relay, transistors BC547 and SL100 and a few other components. In normal operating conditions while switching on the mains supply and the 12V DC supply, NOR gate N2 of CD 4001 IC is wired as a NOT (inverter) gate for making an initial reset pulse circuit with RC network formed by R12 and C6. This reset circuit is essential to reset decade counter CD 4017 on initial power on, so that output Q0 of decade counter becomes high and switches on T2. This in turn energizes relay RL1 to provide AC power to the load. In order to achieve overvoltage protection for induction motor, the amount of load current to the motorized electrical gadget is sensed by the coil of 50 Hz, 5A current transformer in the form of AC voltage. Sampled AC voltage in CT coil is proportional to the load current of the electrical gadget. This 50 Hz AC voltage across the coil is rectified and filtered to get corresponding DC sample voltage which is compared with the VR3 reference voltage. If overvoltage condition occurs then this output is high which is further applied to reverse-biased Zener diode through an integrator network to provide the required time delay, then SCR is fired, when the anode potential of the SCR decreases it turns off transistor T4, due to which transistor T3 turns on which decreases the bias of transistor T2 due to which the relay is de-energised and thus the load gets disconnected from the mains supply and hence the damages to the induction motor has been prevented.

3. CIRCUIT DESIGN OF OVERVOLTAGE PROTECTION SCHEME FOR INDUCTION MOTOR

The circuit basically consists of four ICs namely NE555 as IC1, 4017 as IC2, LM339 as IC3 and CD4001 as IC4, transistors, relay, current transformer, resistors, capacitors, SCR, Zener diode and other components.

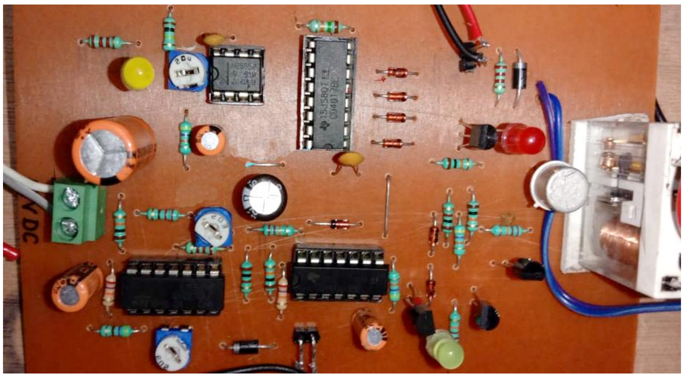

Fig -1: Circuit Design

3.1 Induction Motor

Induction motor also known as an asynchronous motor. In an induction motor, the electric current in the rotor needed to produce torque is obtained via electromagnetic induction from the rotating magnetic field of the stator winding. The rotor of an induction motor can be a squirrel cage rotor or wound type rotor.

Fig -2: Induction Motor

3.1 CD 4017 IC Decade Counter

The CD4017 is a CMOS Decade counter IC. CD4017 is used for low range counting applications. It can count from 0 to 10 (the decade counter) and its outputs are decoded. CD4017 is as 'Johnson 10 stage decade counter'. It has 16 pins.

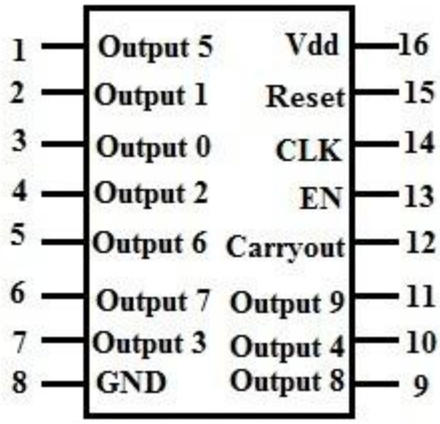

Fig -3: CD4017 IC

3.2 NE555 Timer

The NE555 Timer provides clock pulses. It can be operated in three different modes namely monostable mode, bistable mode and astable multivibrator mode to provide a variety of applications such as one-shot or delay timers, pulse generation, LED and lamp flashers, alarms and tone generation, logic clocks, frequency division etc.

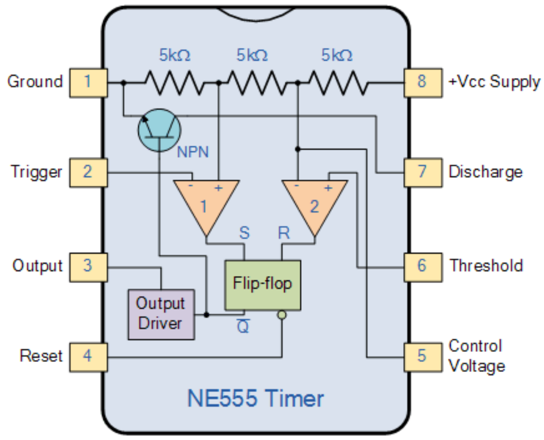

Fig -4: NE555 Timer IC

The 555 Timers name comes from the fact that there are three 5kΩ resistors connected together internally producing a voltage divider network between the supply voltage at pin 8 and ground at pin 1. An astable circuit has no stable state i.e. the output continually switches state between high and low without any intervention from the user, called a 'square' wave, hence the name "astable". A monostable mode produces one pulse of set length in response to a trigger input such as a push button. The output of the circuit stays in the low state until there is a trigger input, hence the name "monostable" i.e. one stable state. A bistable mode (or Schmitt trigger) has two stable states, high and low. Note that all the different modes represent a different type of circuit that has a particular output.

3.3 LM339 Quad Voltage Comparator

LM339 is a voltage comparator IC. The device consists of four independent voltage comparators that are designed to operate from a single power supply. LM339 is a 14-pin device.

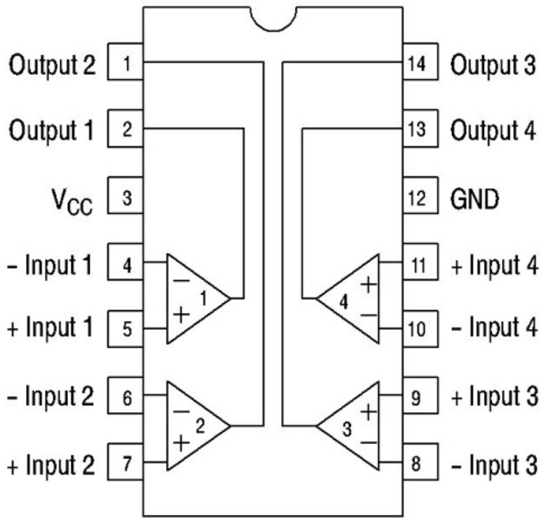

Fig -5: LM339 IC

The LM339 is specifically designed to operate with a single-polarity power supply over a wide range of voltages.

3.4 CD 4001 Quad 2-Input NOR Gate

The CD4001 quad gate is a monolithic complementary MOS (CMOS) integrated circuit constructed with N- and P-channel enhancement mode transistors.

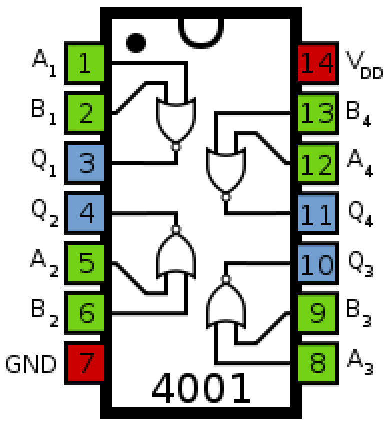

Fig -6: CD 4001 IC

This IC consists of four independent 2-input NOR gates. The action of each gate is such that its output goes to the low state if one or both inputs are in high state, while it goes to high state if both the inputs are in low state. The CD4001 can be operated from any D.C power supply in the range 3 V to 18 V.

3.5 Relay

Relay is a switch which controls (open and close) circuits electromagnetically. The relay makes or breaks contact with the help of a signal in order to switch it ON or OFF. It is mainly used to control high powered circuit using a low power signal.
A relay is said to switch one or more poles. Each pole has contacts that can be thrown in mainly three ways. They are

1. Normally Open Contact (NO): NO contact is also called a make contact. It closes the circuit when the relay is activated. It disconnects the circuit when the relay is inactive.
2. Normally Closed Contact (NC): NC contact is also called a break contact. This is opposite to the NO contact. When the relay is activated, the circuit disconnects. When the relay is deactivated, the circuit connects.
3. Change-Over (CO)/ Double-Throw (DT) Contacts: This type of contacts is used to control two types of circuits. They are used to control a NO contact and a NC contact with a common terminal.

Applications of Relays:
1. Control a high-voltage circuit with a low-voltage signal, e.g. in some types of modems or audio amplifiers.
2. Control a high-current circuit with a low-voltage signal.

Fig -7: Relay

3.6 Current Transformer (CT)

A current transformer is an instrument transformer used for the transformation of current from a higher value to a lower value.

Types of current transformer
1. Wound Type
2. Bar-Type
3. Toroidal Type

Fig -8: Current Transformer

3.7 BC547 Transistor

The BC547 transistor is an NPN transistor. It is widely used transistor and can be used in most general purpose applications like in variety of electronic circuits in switching small load on very low input voltage and current, in amplification of small audio and other signals, sensor circuits, audio preamp circuits, audio amplifier stages, transistor darlington pairs, radio frequency circuits etc.

Features and Specifications
1. Maximum Current: 100mA
2. Maximum Power: 500mW
3. Max Voltage: 45V
4. Frequency Transition: 300MHz

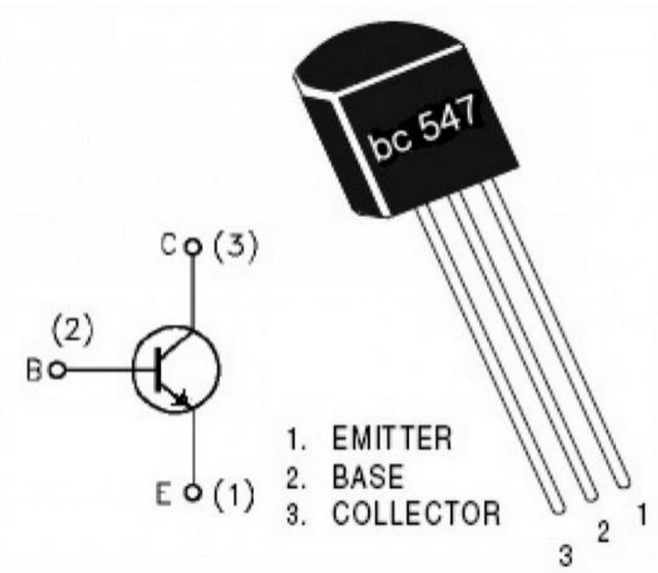

Fig -9: BC547 Transistor

3.8 SL100 Transistor

SL100 is a general purpose low power transistor. It can be used for the various applications like switching circuits, amplifying circuits etc. Applications of SL100 transistor include general switching, amplification and sound reproduction, radio transmission and signal processing. The SL100 transistor has 3 terminals namely a collector, a base and an emitter. 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 and Specifications
1. Collector-Emitter voltage: 50 V
2. Collector-Base voltage: 60 V
3. Emitter-Base voltage: 5.0 V
4. 0.5 A of Collector Current

Fig -10: SL100 Transistor

3.9 Miscellaneous

Other than the above mentioned components this project includes components like 5.1V Zener Diode as ZD1, SCR1, signal diodes 1N4148, rectifier diode 1N4007, LEDs, 2-pin terminal connectors, Resistors, Potentiometer, Electrolytic and Ceramic capacitors.

4. WORKING

This protection system for induction motor consists of four ICs namely NE555 as IC1, 4017 as IC2, LM339 as IC3 and CD4001 as IC4, transistors, relay, current transformer 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. This 50Hz AC voltage across the coil is rectified and filtered to get corresponding DC sample voltage at the output of diode D1 1N4148.

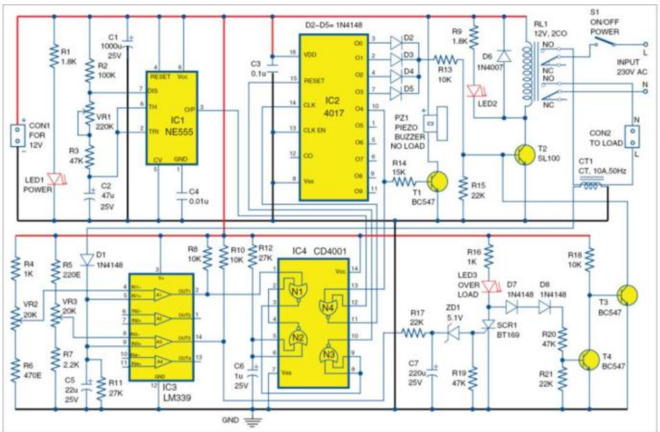

Fig -11: Circuit Diagram

Clock signal is provided to decade counter 4017 (IC2) from the 555 timer running in astable multivibrator mode through NOR gate N4. Other input of N4 is fed from Q4 output of IC2. If Q4 of IC2 is low, clock signal enters counter IC2. In normal operating conditions of the induction motor, Q4 of IC2 will be in low state. Q0 output of IC2 will be high if reset pin 15 of IC2 is in high state. If reset pin 15 of IC2 is in low state, then it allows the counter to count, thus each output from Q0 through Q3 will change the state from low to high sequentially. All four outputs (Q0 to Q3) are logically ORed and used to drive transistor T2 SL100 and energize relay RL1.

There are two basic modes of operation,

1. In normal-voltage condition output at pin 2 of IC3 is high and output at pin 14 is low (after initial reset time delay). NOR gate N1 output at pin 3 of IC4 is low and NOR gate N3 output at pin 10 is high. This high condition keeps IC2 in reset state. Q0 is high and counter IC2 does not progress. High Q0 is used to switch on T2 and energize RL1. This connects AC mains power to the load through relay contacts. In this condition, T3 is cut off and maintains base bias of T2 as high.

2. In over-voltage condition, DC sample voltage from rectifier at pin 9 of IC3 goes more than the voltage across VR3 and output at pin 14 changes from low to high. This high level is applied across reverse-biased Zener Diode ZD1 though an integrator formed by resistors R10, R17 and capacitor C7. This integrator network and Zener diode provide sufficient time delay to fire SCR1 though its gate. This time delay is necessary in order to avoid unwanted tripping off the load by initial in-rush current to inductive load or occurrence of any brief overvoltage condition. Due to prolonged overvoltage condition, anode potential of SCR goes less than one volt. This small anode voltage is not sufficient to forward bias diodes D7 and D8, which in turn cut off T4 due to which T3 switch on, and its collector potential comes down to ground potential. This in turn pulls down base bias of T2, leading it to cut off. This leads to de-energizing RL1 and withdrawal of mains supply to load. LED3 initially dim glows brightly once the SCR1 is fired indicating the registered status of overvoltage condition till next restart.
From the below figure we can conclude that an increase in motor amperes may either indicate either an undervoltage or overvoltage condition.

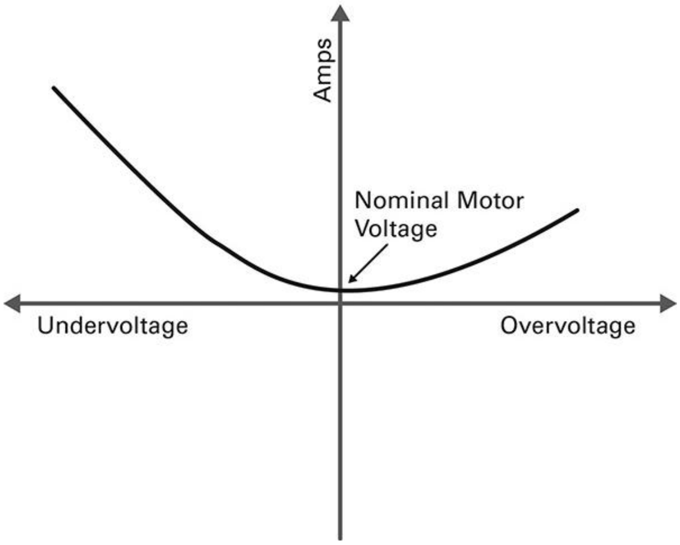

Fig -12: Change in Motor Amps vs. Name Plate Motor Voltage for Induction Motors

5. CONCLUSIONS

In this project, we have designed a circuit for protection of induction motor against overvoltage conditions without using any protective device like circuit breaker, microcontroller etc. Instead we have used various IC's like NE555 as IC1, 4017 as IC2, LM339 as IC3, CD4001 as IC4, transistors, relay, current transformer which perform their respective tasks and help in avoiding operations of motors in abnormal conditions like overvoltage conditions.

6. FUTURE SCOPE

In general more protection schemes can be introduced with the help of simple circuitry for protection of other types of faults occurring in induction motor.

REFERENCES

[1] M. Cunkas, R. Akkaya and A. Ozturk, "Protection of ac motors by means of microcontrollers", 10th Mediterranean Electrotechnical Conference (MEleCon), Vol. III, 2000.

[2] Rupali M. Shivpuje and Mr. Swapnil D. Patil, "Microcontroller based fault detection and protection system for induction motor", International Conference on Intelligent Computing and Control Systems (ICICCS), 2017.

[3] Ravi Waswani, Aakanksha Pawar, Mangesh Deore and Rajankumar Patel, “Induction motor fault detection, protection and speed control using arduino”, International Conference on Innovation in Information, Embedded and Communication Systems (ICIIECS), 2017.

[4] Gagan Garg and Dr. Amrita Sinha, "An improved method for protection of three phase induction motor using microcontroller", International Conference on Power, Control and Embedded Systems (ICPCES), 2014.

[5] Ramazan Bayindir and Ibrahim Sefa, “Novel approach based on microcontroller to online protection of induction motors”, Energy Conversion & Management, Vol. 48, Issue 3, March 2007.

[6] I. Colak, H. Celik, I. Sefa and S. Demirbas, “On line protection systems for induction motors”, Energy Conversion and Management, Vol. 46, Issue 17, October 2005.

[7] T. K. Chatteijee, D. K. Mittra, S. Mahata and S. Kareddy, "A novel solid-state integrated protection system for three phase induction motors", International Conference on Power Systems, 2009.

[8] I. Colak, R. Bayindir, A. Bektas, I. Sefa and G. Bal, "Protection of Induction Motor Using PLC", International Conference on Power Engineering, Energy and Electrical Drives, 2007.

[9] M. Sudha and P. Anbalagan, "A Novel Protecting Method for Induction Motor Against Faults Due to Voltage Unbalance and Single Phasing", 33rd Annual Conference of the IEEE Industrial Electronics Society, 2007.

[10] R.Bayinder, I.Sefia, I.Colak and A. Bektas ,‘Fault detection and protection of induction motors using sensors’, IEEE Trans, Energy Conversion, Vol. 23, Issue 3, Sept 2008.