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CHAPTER 6

DEVELOPMENT OF A THREE PHASE ISOLATOR WITH SURGE PROTECTOR FOR A THREE PHASE ELECTRIC WATER PUMPING MACHINE

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Abstract

This paper presents the development of a protective device for valuable electrical equipment which is worth considering when setting up industries. One of such possible needs is the protection of electrical equipment from the damaging effect of extremely high or low voltage source or faults from mains supply. For the purpose of this research, a three phase isolator is designed to effectively power three phase electric water pumping machine for irrigation purposes and water supply to towns and cities for life sustainability. The incorporation of this device in the input supply circuit to an electric water pumping machine has been found to be of great advantage in ensuring proper functionality of the machine which guarantees constant water supply for sustaining livelihood.

Keywords: Three Phase Supply, Isolator, Surge, Comparator, Electric Pumping Machine, Step Transformer.

Introduction

Supply of water to towns and cities comes in a network called water reticulation systems. Water reticulation systems are water distribution networks through which water is collected and then treated before the distribution to the consumers. Water is delivered to its destination with the use of pressure and the energy created by that pressure. Since the topographies of the earth surfaces are not the same, there is always a need to enhance the pressure in the water pipes for efficient conveyance of water to the different consumers at their different locations, whether at low or high lands, mountains or valleys, for their various uses (drinking, washing, irrigation and the likes). To do this, an electric pumping machine is usually employed to insert the driving pressure into the pipe networks. These pumps come in two types, namely; the single and three phase-powered electric pumps. The use of single phase electric pump is limited to domestic applications in residential buildings and other private uses. Three phase electric pumping machines are used for town water supply and for large scale farm irrigation purposes.

Water is life so they say. It is in view of this, that this design seeks to find a lasting solution to a problem peculiar with three phase electric water pumping machines. One of such possible needs is the protection of electrical equipment from the damaging effect of extremely high or low voltage source or faults from mains supply.

Methodology

Specific circuit stages in the design

Comparator Circuit

The d.c supply is applied into the circuit from the rectifier with shunted 1,000μF capacitor into the comparator stage with two voltage dividers as shown below.

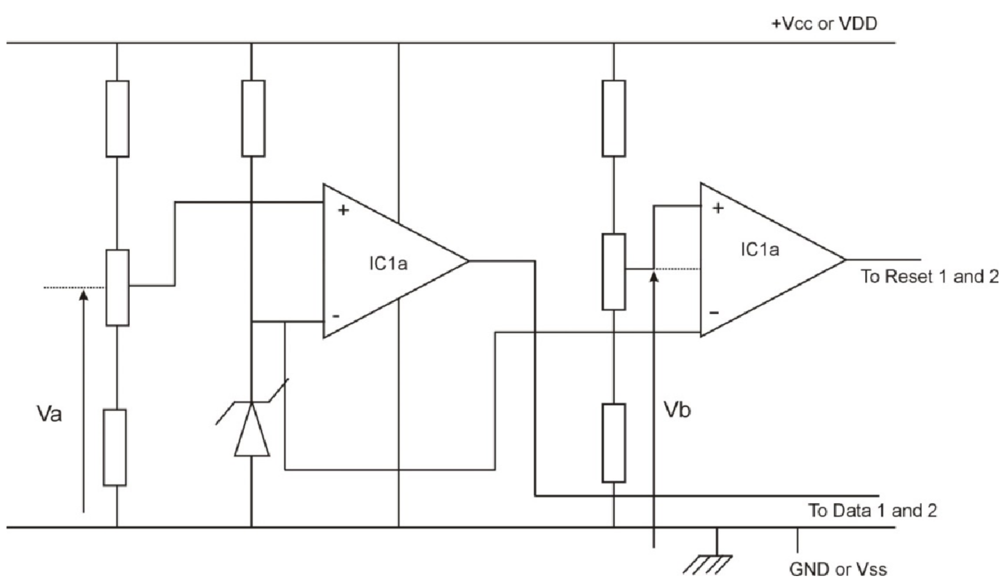

Fig. 1.0 Comparator Circuit

Condition for closing of electromagnetic relay,

At normal voltage; $V_b < V_a > V_z$

Condition for closing of electromagnetic relay,

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At normal voltage; $V_b < V_a > V_z$

The diagram below illustrates the wiring of the dual ‘D’ flip-flops with the transistors stages and LED indicators.

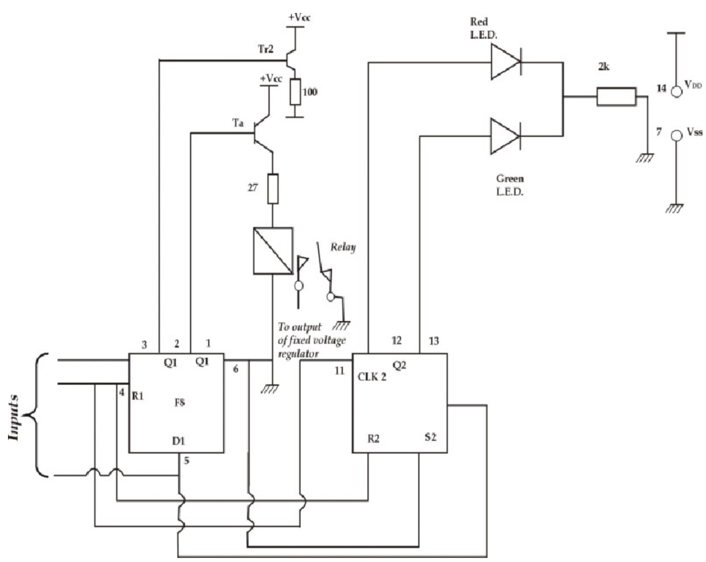

Fig 2.0 Diagram of connection of the dual ‘D’ flip-flop to transistors and L.E.D indicators.

Table 1: Truth Table for ‘D’ flip-flop

Set 1 & 2	Reset 1 & 2	CLK 1 & 2	Data 1 & 2	Q1	Short Q1	Q2	Short Q2
0	1		0	0	0	0	1
0	0		1	0	1	1	0

State 1 occurs when the voltage is very high low i.e.

Very high $V_b > V_a > V_z$ or $V_b < V_a < V_z$

State 2 occurs when the voltage is at normal voltage level

$V_b < V_a > V_z$

So that, at the state1, there is no output on pin 1 and pin 13 of the IC2 which means that there is output at pin 12 (N.B: pins 2 and pin 12 are complement of pins 1 and 13), hence red LED is on, i.e. it gives out red light and green LED is off. Similarly in state 2, there is output on pin 1 and 13, which means that there is no output at the pin 2 and pin 12, hence red LED light is off and green LED is on, i.e. it gives out green light and consequently leads to closing of electromagnetic relay as the clock pulse is failing (or   ). This takes place in the other two remaining phases.

The diagram below illustrates the connection of the relays of each phase to the NAND gate.

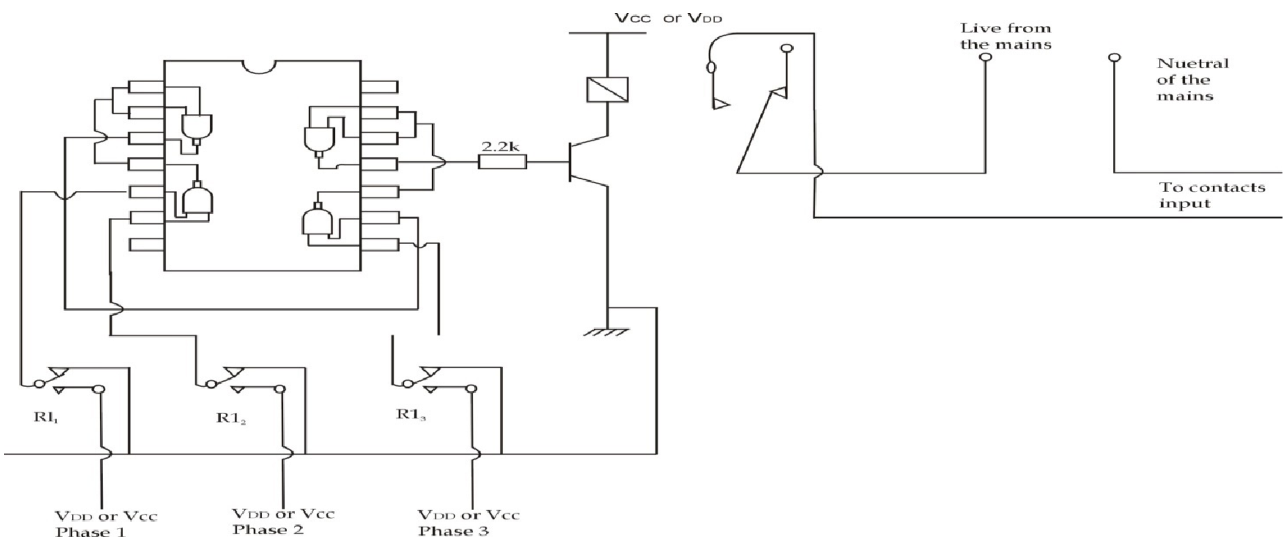

Fig. 3 Diagram of connection of the dual ‘D’ flip-flop to transistors and L.E.D indicators.

A four 2 input NAND gate wired to form 3 input AND gate is employed because it is cheap and versatile. If not for the cost, a 3 input AND gate could as well be used.

All the poles on each electromagnetic relay will go to Vcc i.e. positive supply rail when the voltage on each phase is at normal voltage level (i.e. at safe voltage for load, 200-230 Vac). At this point, the contractor closes.

Conversely, if there is either low or high or power outage in one phase the contactor opens.

The clock pulse Generator

The Clock pulse is generated from NE555 wired in astable (free running) mode as shown below,

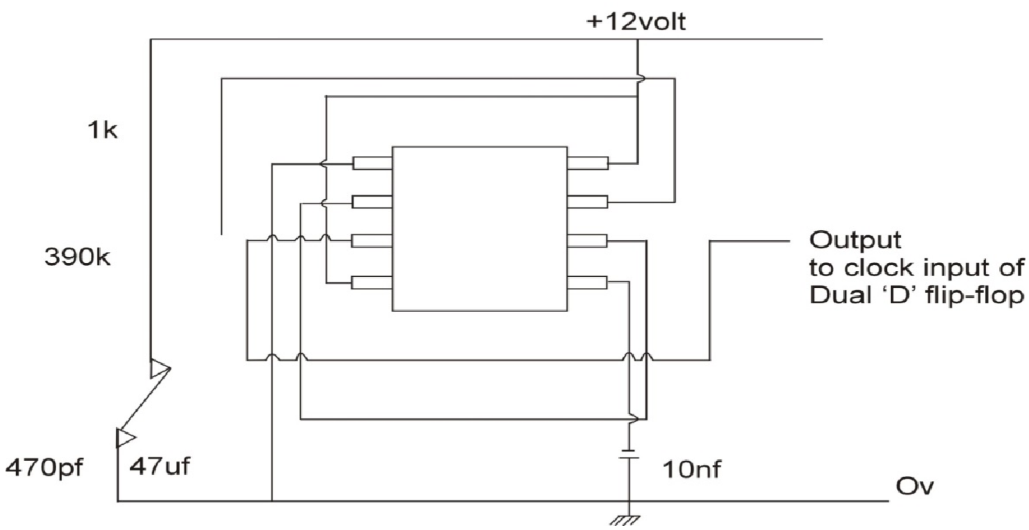

Fig. 4 Clock pulse Generator

The timer has been designed to work in two switching modes of 2 seconds and 5 minutes. Two seconds has been chosen for industrial electric motors that need quick take off (as in this design for electric pumping machine) and 5 minutes for phase air-conditioner or 3-phase cold room where stability of supply needs to be ensured before they are switched on.

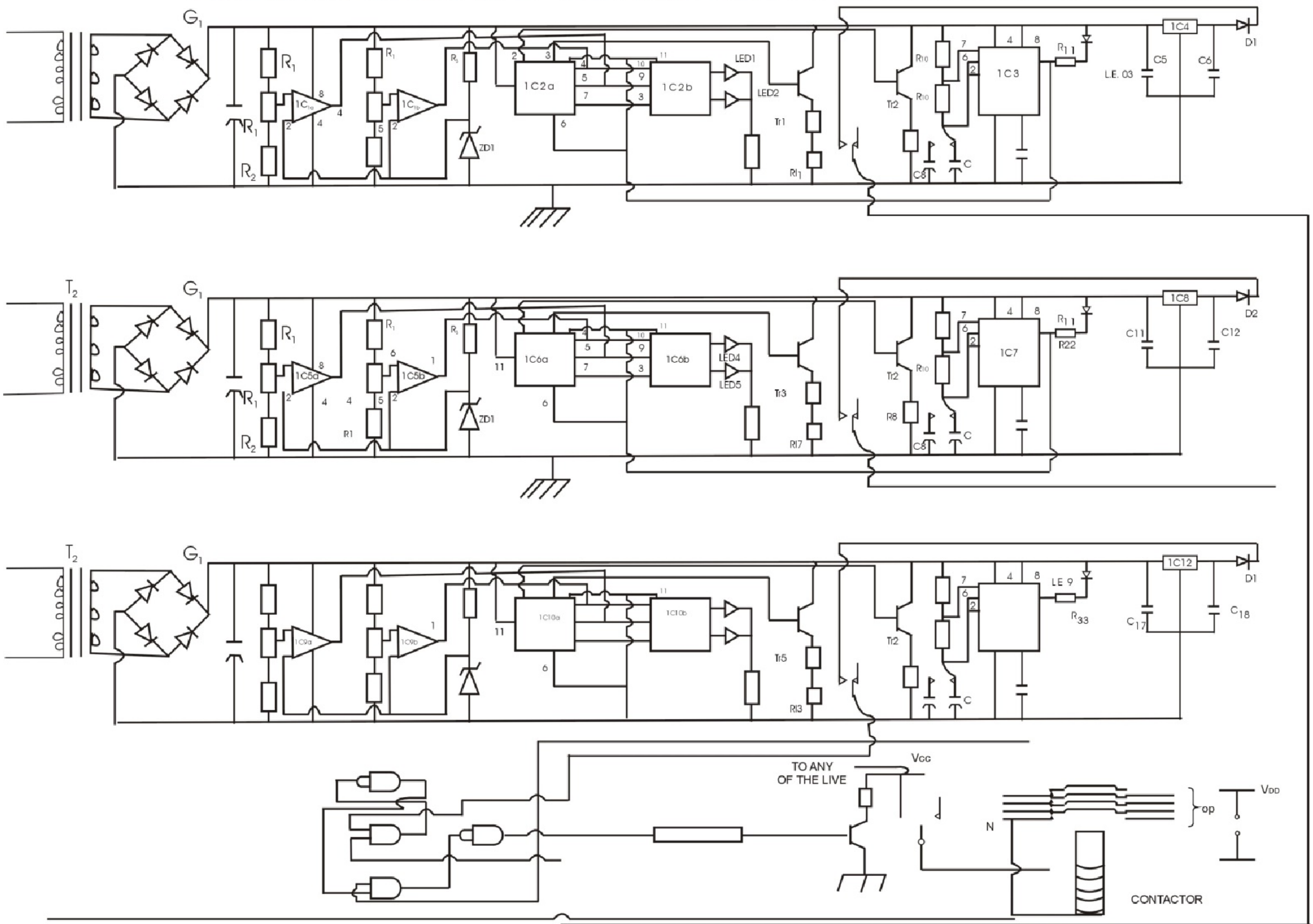

Fig. 5 Schematic diagram of a 3-phase isolator with surge projector

Circuit Operation and Setting

The diagram below is the overall functional block diagram of the three phase isolator with surge protector.

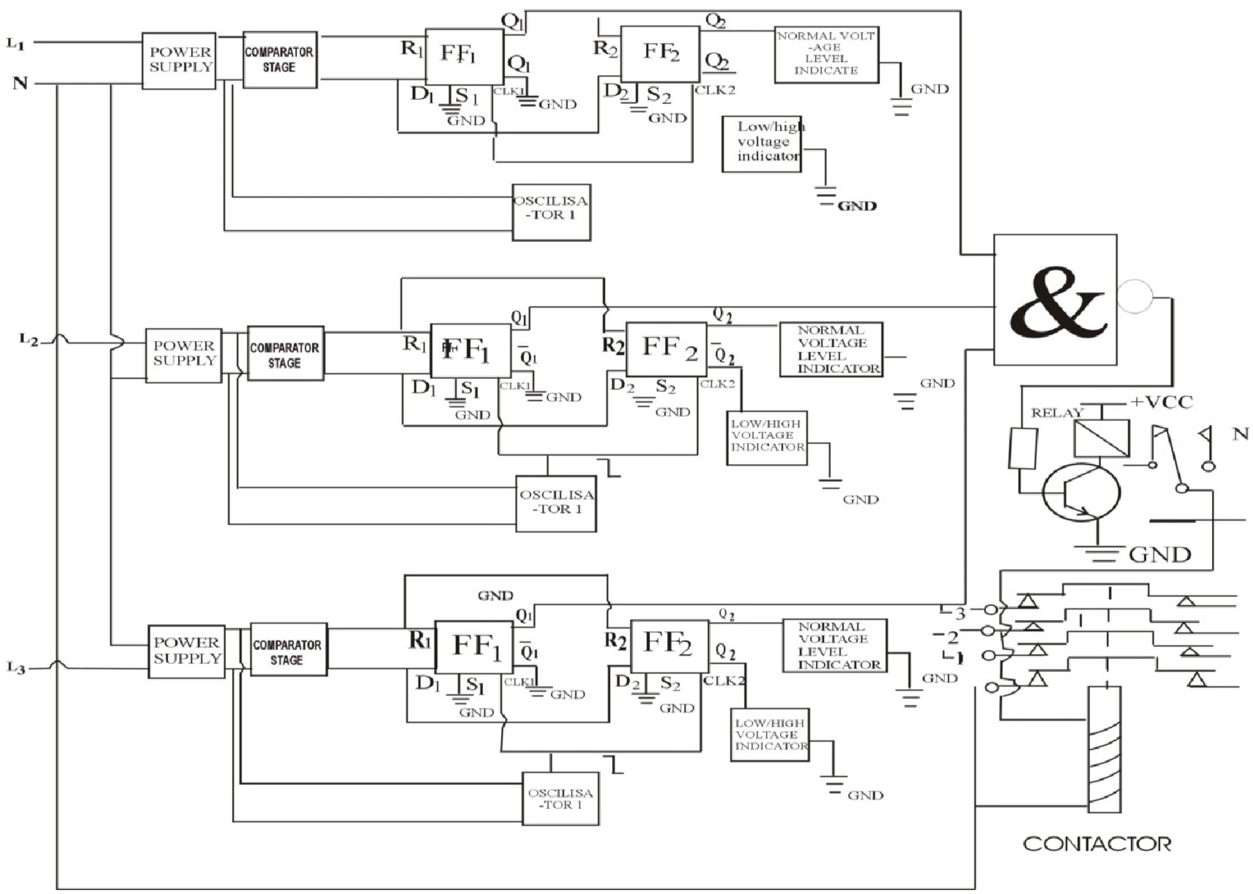

Fig. 6 overall functional block diagram of the three phase isolator with surge protector.

Where L_1, L_2 and L_3 are Live from phase 2 and live 3 from phase 3; Q_1 is input from phase, 1, Q_2 is output from phase 2 and Q_3 is output from phase 3.

How to set for Operation

The circuit is set up as shown above, VRI is set such that the voltage for load is in between 200 volt-230 volt A.C. After that is done, VR2 is done, VR2 is also set for at a voltage higher than the zener diode voltage but not up to voltage on the tap of VR1, all these voltages are measured to the ground. When this done, it can be connected to a variac for verification of the voltage.

Principle of Operation

This unit derives its voltage sensing from the voltage divider R1, VR, R2 and R4, VR2, R5. When the voltage is at safe value, say 200-230 Vac, ICIa gives a positive output at pin 1 which is greater than 7.5 volt and also greater than the reference voltage of the zener diode.

Similarly there is also an output from IC 1b at pin 7 but not up to output voltage at pin 1, it is also greater than reference voltage, the delay input pin 5 and which control the output of the IC2a and IC2b, sets pin 1 (Q1) and pin 13 (Q2) to ‘1’ (high level, hence the relay switch closes up to normally open (n.o) contact of the relay after the end of the of an interval of clock pulse, which is then fed to the input of NAND logic gate. If this condition is satisfied in all the 2 remaining phases, there will be an output from the contactor.

When there is low voltage, all the 2 operational amplifiers outputs’ are lower than the reference voltage, then pin 4 (R1) and pin 10 (R2) control the output of the IC2a and IC2b and reset pin 1 (Q1) and pin 13 (Q2) to ‘O’ (low level), hence the relay contact is released to normally close (n.c.) contact, which means that pin 2 (short Q1) and pin 12 (short Q2) are set to high level.

Similarly, if there is high voltage, all the pin outputs 1C1a and 1C1b are greater than reference voltage from zener diode voltage (7.5 volt), at the moment, reset pins of IC2 control the output. Therefore pin 1 (Q1) and pin 13 (Q_2) are reset, that is they are at ‘O’ (loe level), and so there will be no input into the NAND logic gate, hence, the contractor breaks the mains circuit.

When there is power outage in one phase, there will be no input into the input of the NAND logic gate, consequently there is no output at the output gate of the NAND logic gate, so the contactor breaks the mains circuit.

Problem Encountered

In the design and construction of the 3- phase Isolator with surge protector, the problem of getting a 3-phase supply at the preliminary stage of the design was initially a problem. The idea of feeding the available single phase to the different input arms separately, in form of Red, Yellow and Blue phases seemed to be the only option at the workshop of construction. This we did throughout the construction stage until it was taken out to a nearby factory for final testing.

Conclusion and Recommendation

Apart from Three-phase electric pumping machine, this device can efficiently serve as a protective device for industrial motors like 3-phase pillar drilling machine and lathe machine. When the timer is set to 2 seconds mode it could also serve as a protector to phase central or split air conditioner. This unit is very sensitive to electrical surge, for instance, the lightning which causes sudden voltage increment of phase; it quickly isolates the equipment from the mains source.

This unit can be improved upon by making use of a specially wound transformers for each of the 3 phases, so that it can withstand a high voltage of up to 380 volt ac.

This unit is good only where the alternating current (a.c.) voltage is at constant normal voltage level, hence, to maximize the usage, a 3-phase voltage regulator is used alongside with it.

In conclusion, this unit is highly recommended for all 3-phase powered equipment to prevent them from damage due to extreme cases of the supply mains.

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