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Three Phase Faults Analysis of Power System

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Three Phase Faults Analysis of Power System

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Abstract- The demand of electrical power is increasing day by day for households, agricultural, commercial, industry sectors etc. This paper is developed in order to maintain that electrical power required by these sectors, as in an electrical system, due to line to ground (L-G), line to line fault (L-L), three lines (LLL) various fault occurs. In this paper it has been discussed how to overcome this problem and for this a system is built, which has an auto reclosing mechanism of disconnecting the supply to avoid large scale damage to the control gears, load or manpower in the grid sub-stations. In this way a tripping mechanism is made in order to curb temporary and permanent faults.

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I. Introduction

Current flows through all components of the electrical power system during normal operating conditions. There are various methods through which one can analyze any power system by calculating the system voltages & currents under normal & abnormal scenarios. Due to some unforeseen circumstances, faults could happen because of natural events or accidents like lightning strike, line to ground faults etc.

Three phase fault analysis and its protection mechanism main function is to ensure safety of equipments and maintain power system stability at high speed.

In order to protect the equipments of power system from faults, knowledge about system faults, their detection, and safe isolation of the faulted area is needed.

There are various types of fault. Some of them are Transient and Permanent Faults.

The occurrence of transient faults accounts to 70-90%. In overhead power lines, most of the faults are transient in nature. In a system comprising of various components like transformers, relays, Momentary tree contact, bird or other animal contact, Lightning Strike, Conductor Clashing or Insulator Flashover, Swinging wires and temporary contact can be the cause of transient faults. Thus, by de- energizing the line for short time transient faults can be cleared. Service to the line can be recreated by instant auto reclosing.[2][3]

The occurrence of Semi Permanent or Permanent faults abides to 10-30%. A semi-permanent fault can be effectuated when a small branch of tree falls on line. In such case of permanent fault, the fault can't be cleared by an instantaneous de-energizing of the line and subsequent auto reclosing. If there is a compeered time-delayed trip then system would let the branch to be burned away without any harm to the existing system. On an overhead line, a broken wire or conductor making a phase open, or a broken pole making the phases to short are the example of common and most often occurring permanent fault. Faults on underground cables are also the example of permanent fault. Most of the faults can be successfully cleared by using the appropriate tripping and auto reclosing mechanism. Proper tripping can de- energize the line for enough time period to pass the fault source and to de-energize the fault arc, then the system automatically recloses the line to maintain the power supply. Thus, auto reclosing mechanism can substantially decrease the outage time because of faults and gives a significant level of service consistency to the consumer and reliability of power system.

In the present scenario of power systems, automatic reclosing system has a very wide area where it can be applied.[2][3]

II. Types of Faults

a) Symmetric and Asymmetric Faults [3]

-Symmetric /Balanced Faults

These are very severe faults and occur infrequently in the power systems. These are of two types namely three lines to ground (L-L-L-G) and three lines (L-L-L). The occurrence of these faults is merely 2-5% in power systems.

- Asymmetric Faults/Unbalanced

These are very common as they occur way more time than symmetric faults and are less severe than former faults. These mainly constitutes of line to ground which is the most common fault (65-70%) , line to line (5-10%) and double line to ground (15-20%) faults.

In line to ground fault, a conductor makes contact with earth or ground. A line to line fault occurs when two conductors make contacts with each other mainly while swinging of lines due to winds. When two conductors make contact with ground then it a double line to ground faults.

b) Type of Faults on a Three Phase System [3]

A. L-to-G Fault (Line to Ground)
B. L-to-L Fault (Line to Line)
C. L-to-L-to-G Fault (Two lines to Ground)

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D. 3Line Fault (Three Phase)
E. 3L-to-G Fault (Three Phase to Ground)

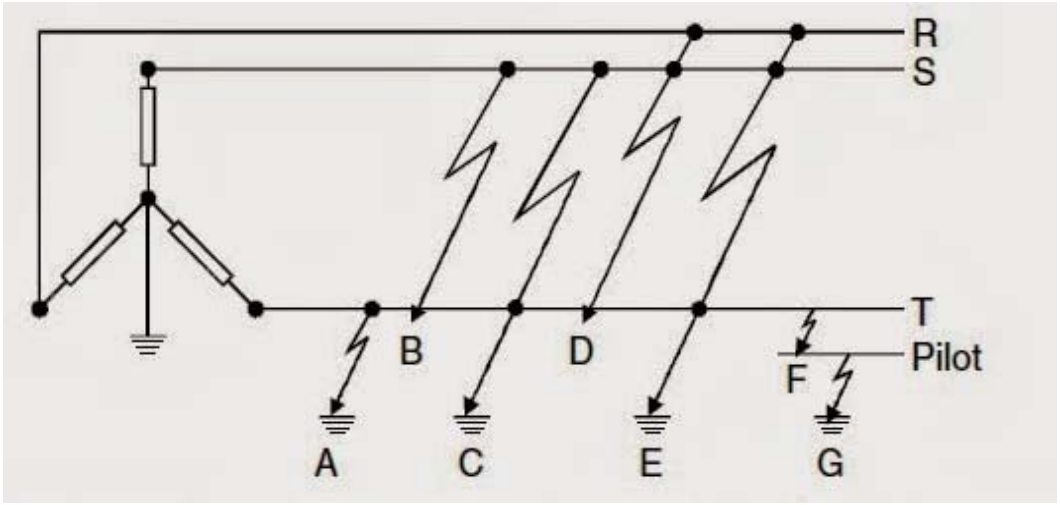


Figure 1 : Three Phase Faults [3]

III. Block Diagram

In figure 2, the basic arrangement of the implemented project can be found.

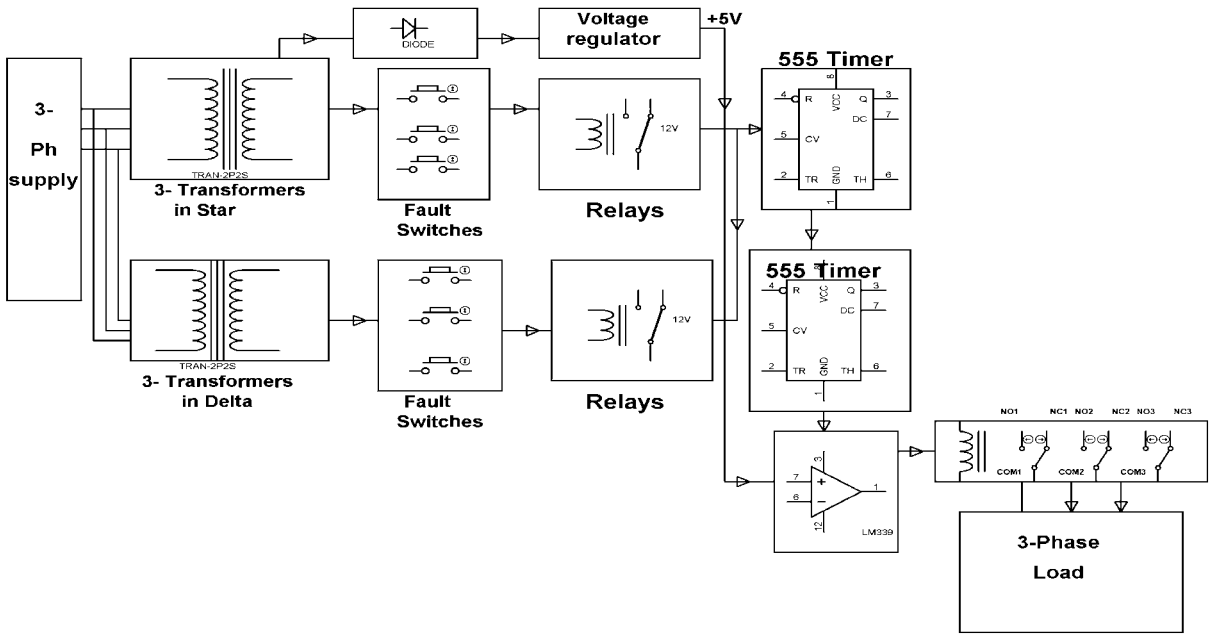


Figure 2 : Block Diagram Arrangement of the Project [1]

a) Components Used

The components required to establish the project, major of them are Power Transformers (Step Down), Voltage Regulator, Relays and 555 Timer, LM 358.[4]

i. *Power Transformers*

This is a equipment which is used to convert electricity from one alternating current (AC) voltage to another alternating current (AC) voltage with less loss of power. There are two types of transformers:-

-Step-up transformers that increase voltage.

-Step-down transformers that decrease voltage.

The ratio of number of turns in the primary & secondary windings determines that a transformer is step up or step down. If primary side windings are less than that of secondary sides then they are known as

step up transformers. Vice versa they are step down transformers.

Figure 3 : 220v/12v Transformer

In this project transformers of (220v/12v) are used in groups of three each in which one group makes a star-star connection and the other group makes a star-delta connection.

ii. *Voltage Regulator (LM 7805)*

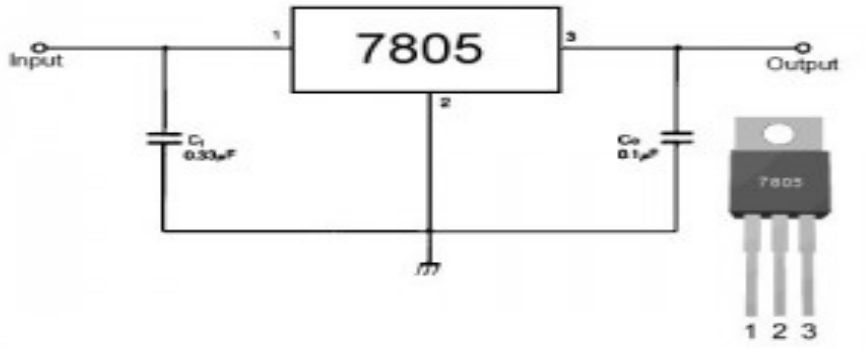


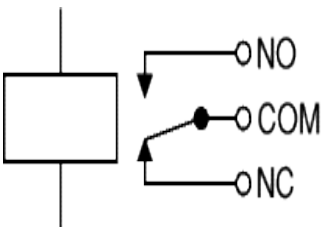
Figure 4 : Voltage Regulator

The LM78XX/LM78XXA is a series of three-terminal positive regulators are available in the TO-220/D-PAK package. It provides several fixed output voltages that helps in a wide range of applications. It helps in maintaining the constant voltage in the circuit as voltage from the voltage source is not constant. It retains thermal shutdown, internal current limiting and safe area protection so it makes them inextinguishable. Heat sinking is a major factor as it help them give over 1A output current and can provide a constant voltage of +5 volts. [1][2][3].

In Figure 4, LM 7805 has 3 pins denoted by 1-Input, 2-Ground and 3-Output.

iii. *Relays*

It is a device (electrically operated switch) which helps in protecting a system from severe damages by detecting and isolating faults on transmission and distributions lines by opening and closing of circuit breakers.



5.1

5.2

Figure 5

Here figure 5.1 shows the relay contacts. There are three terminal of the relay, one is common for the supply and the other two are normally open (NO) and normally close (NC).

iv. *Integrated Circuit (ICs)*

An integrated circuit is a semiconductor chip on which thousands of resistor and capacitors are fabricated in order to function in particular way. They can be transistor, microprocessors, timer, counter, amplifier etc. ICs used here are:-

a. *555 Timer IC*

It is an integrated circuit, simple 8 pin Dual in Line package for timers, pulse generation and oscillator applications which can be used as Monostable and Astable Mode or as Timer IC. Its supply voltage is 3v to 15volt [3]

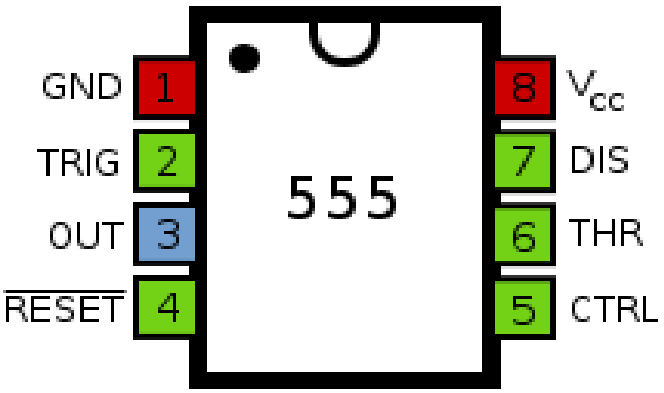


Figure 6 : 555 Timer

Pin	Name
1	GND
2	TRIG
3	OUT
4	RESET
5	CTRL
6	THR
7	DIS
8	V+, VCC

b. *LM 358 IC*

The LM358 series consists of two independent, high gain; internally frequency compensated operational amplifiers which were designed specifically to operate from a single power supply over a wide range of voltages. In this project, a potential divider is connected to its triggered input (Pin 2) and the output of 555 Timer is connected to the non inverting input (pin 3). It is acting like a comparator whose output is connected to 3 CO relay in order to drive it.

There are two cases:-

- If the inverting terminal input is greater than the non-inverting terminal input then the output of the comparator will be logic low (i.e. ground)
- If the inverting terminal input is less than non inverting input then the output of the comparator will be logic high and will drive the 3 CO Relay.

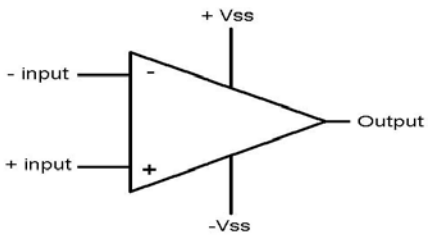
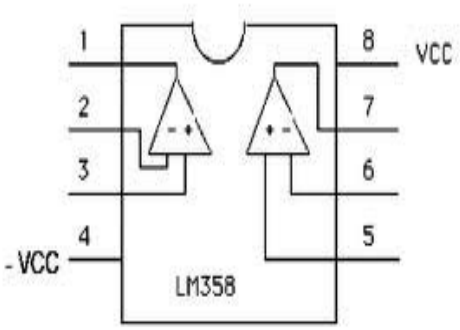


Figure 7 : LM 358

PIN CONNECTIONS

1 - Output 1
2 - Inverting input 1
3 - Non-inverting input 1
4 – VCC-
5 - Non-inverting input 2
6 - Inverting input 2
7 - Output 2
8 _ VCC+



b) Quantities of components used

Main components used	Quantity
Power Transformers (12v,500mA	6
Voltage Regulator	1
Relays (12v)	6
3C/O Relay	1
555 Timer	2
Operational Amplifier (LM 358)	1
Transistor (Bc547)	6
2 pin push buttons	6
LEDs	10
Diodes (IN 4007)	15

c) Voltage at IC Pins

Integrated Chips (IC)	Pin (No.)	Voltages at pins without IC (Voltage)	Voltages at pin with IC (Voltage)
555 Timer	5	0	11
(Monostable Mode)	6	16	0
	7	16	0
555 Timer	1	5	0
(Astable Mode)	6	5	0
	7	5	0
LM 358 (Operational Amplifier)	3	0	3

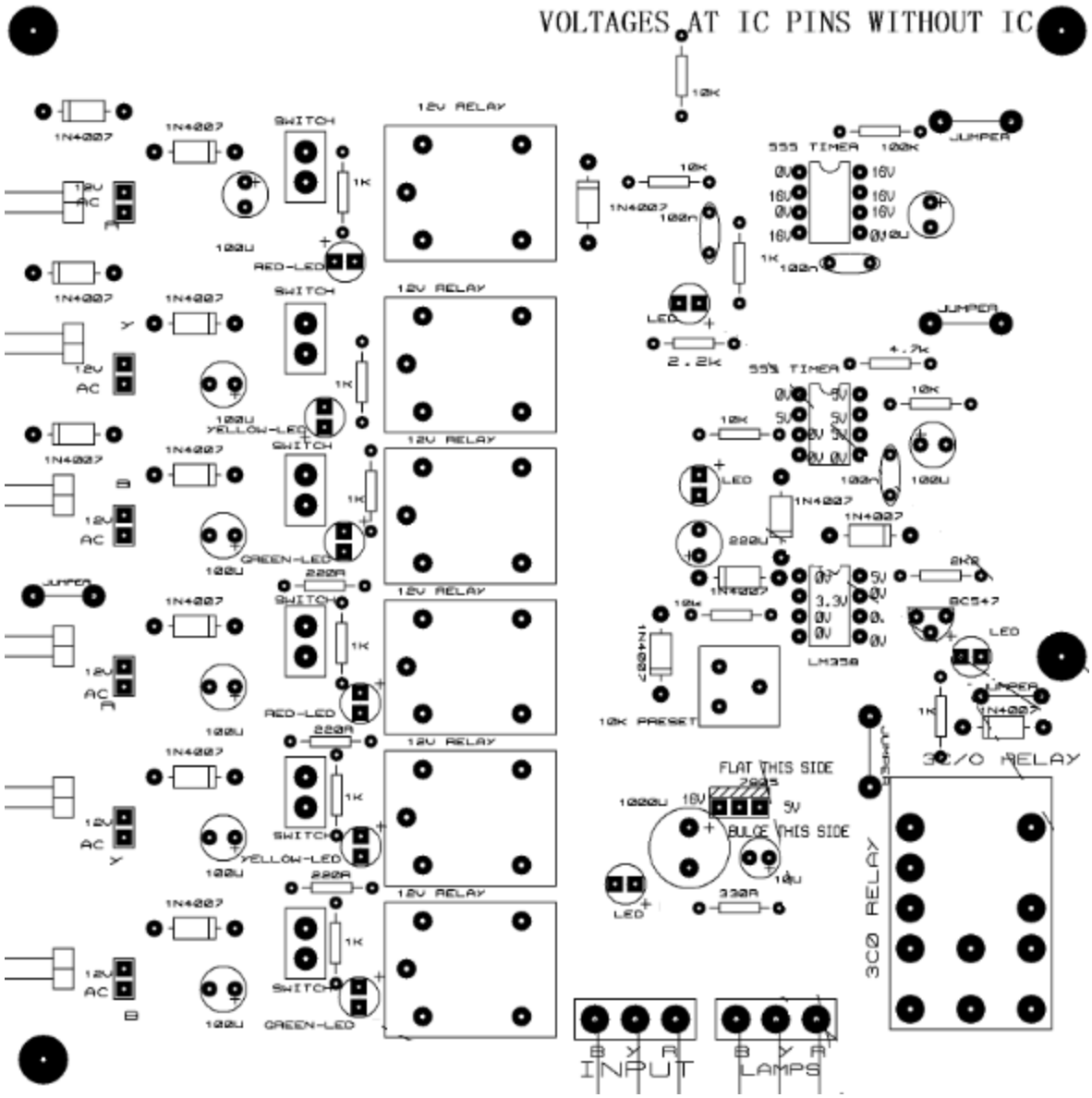


Figure 8 : Voltages at IC Pins without IC (PCB)

Source: - http://www.edgefxkits.com/

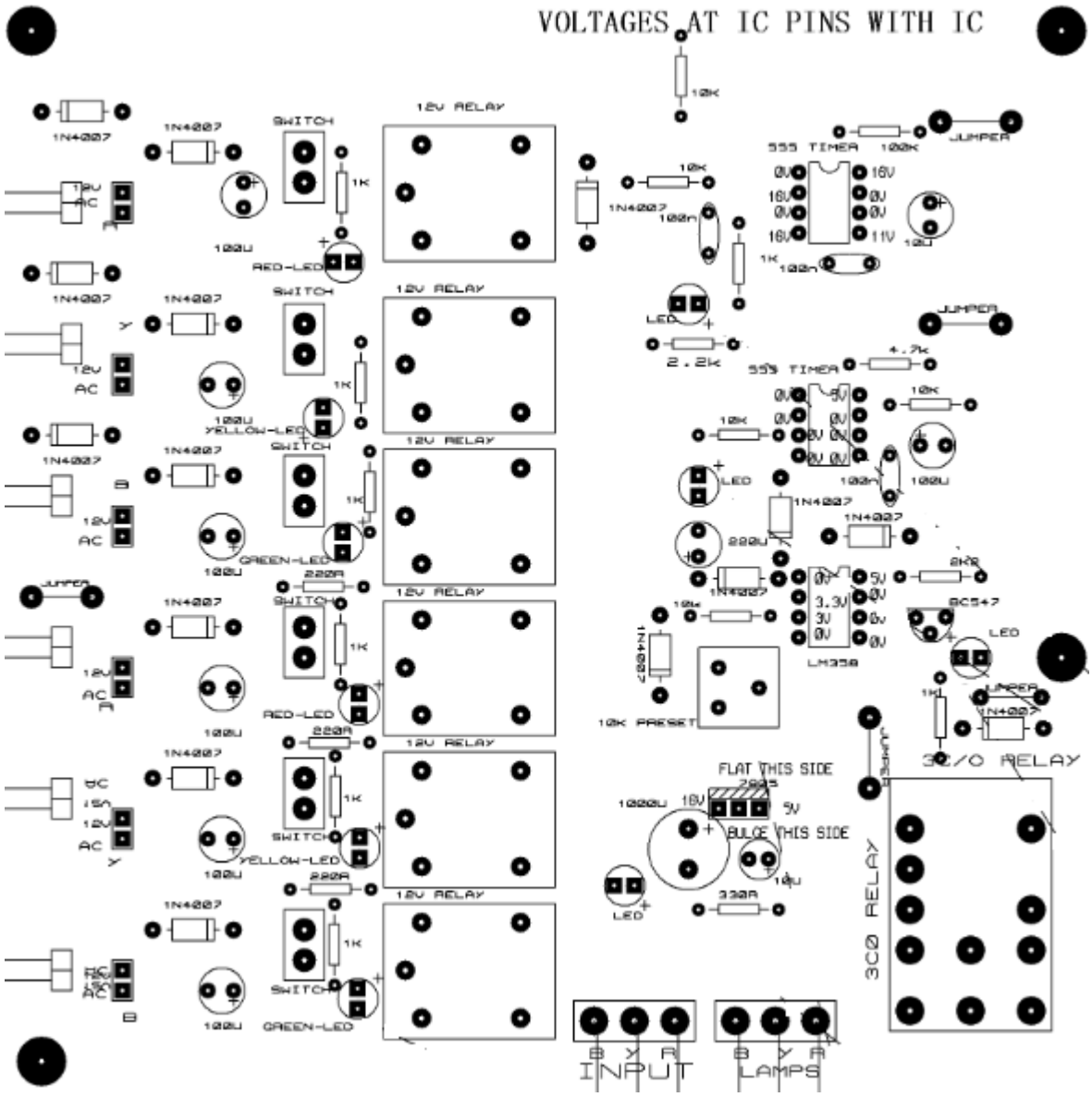


Figure 9 : Voltages at IC Pins with IC (PCB)

Source: - http://www.edgefxkits.com/

IV. Simulation

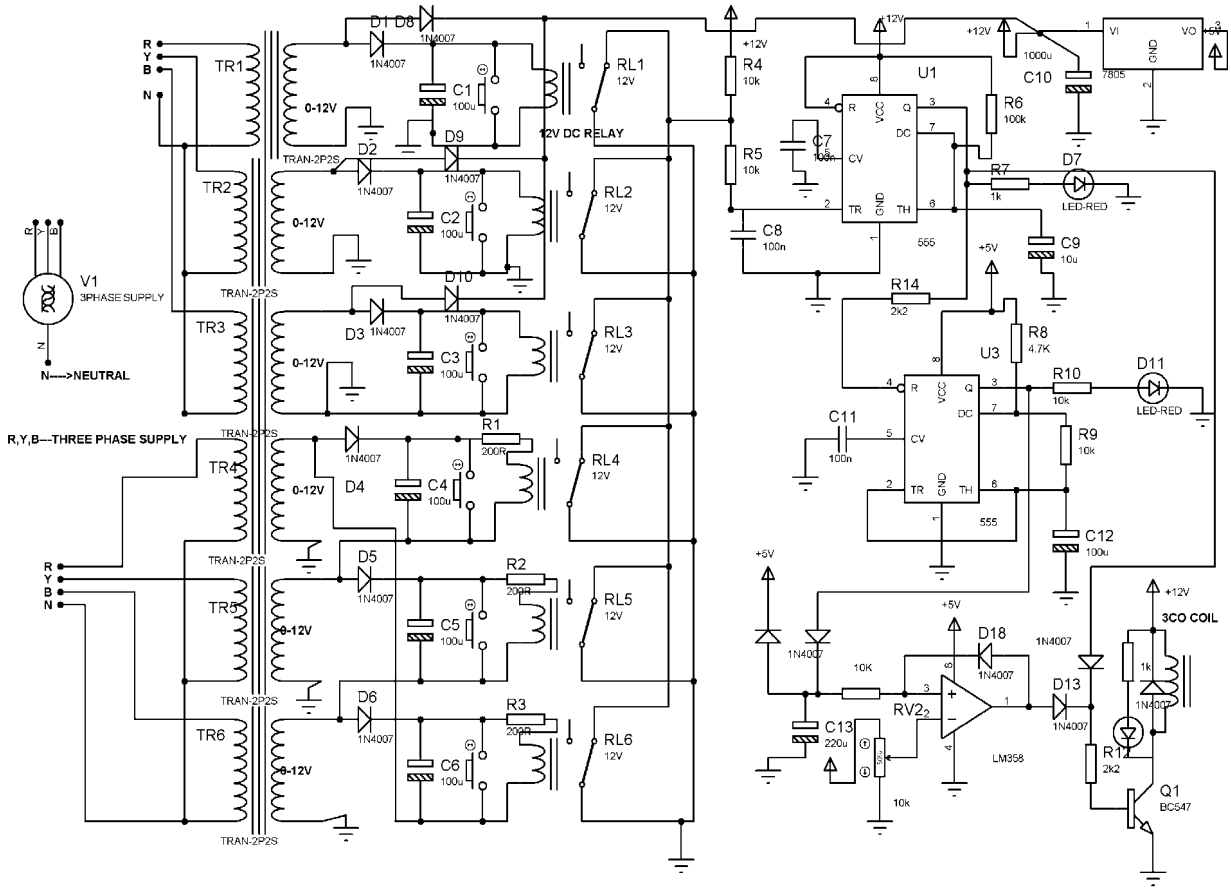


Figure 10 : Circuit Simulation [5]

The initial stage, the circuits have been designed and simulated in PROTEUS. After this all the faults were produced like line to ground (L-G), line to line (L-L), double line to ground (2L-G), 3 line to ground (3L-G). The circuit diagram can be found in Figure 9.

a) Operational Explanation

i. *Working*

Six step down transformers are connected to the board producing 12v to the circuit. These six are divided in group of two each, in which one group is connected in star-star connection and the latter is connected in star-delta connection. All the six transformers are the rectified and filtered individually with the help of rectifying circuit and are then given to corresponding relay coils.

Push buttons are connected to each relay coil to create fault conditions. The Normally Closed (NC) contacts of all the relays are then made parallel while all common points are grounded. The parallel connected point of NC is then linked to Pin 2 of 555 Timer (Monostable Mode) through a resistor R5. The output (Pin 3) of the same timer U1 is connected to Reset (Pin4) of the other 555 timer (Astable Mode). LED is connected at their output each to indicate their status. The output (Pin 1) of 555 Timer (U3) is given to Op-Amp LM 358 through wire 11 and d12 (IN4007) to the Non-Inverting Input (Pin 3) which acts as a comparator. It compares the value of Pin 2 (Inverting Input) and 3 (Non-Inverting Input) of LM358. The voltage of Pin 2 is kept at fixed/constant voltage with the help of a Potential Divider. It is generally kept higher than the Pin3 of Operational Amplifier so that Pin 1 ie Output of LM 358 develops low (Zero Logic) which fails to operate 3 CO relay through the transistor Q1 and the same is used for disconnecting the load used in fault conditions.[1]

ii. *Operational Procedure*

Transformers and Lamp Bulbs are connected along with Three Phase Power Supply (230V). After the board is powered by 3 phase supply, all relay coils get DC voltage and due to this the common points disconnects from NC contacts and moves to the NO contacts. When push buttons are pressed, it disconnects the relay and due to this the common points moves to the NC position to provide a logic low at a trigger pin (Pin 2) and the output (Pin 3) which is linked to reset pin (Pin 4) develops high logic indicated by D11 flashing LED of 555 Timer (u3) which is in Astable Mode.

-If fault is temporary

If any push button is released after a short time, 555 Timer (U1) in Monostable Mode disables U3 due to which the output of U3 goes to zero.

-If fault is permanent

If any push button is pressed for a longer duration, then the output of 555 Timer (U3) present in Monostable Mode provides a longer duration of active situation for 555 Timer (U3), output of the same charges the capacitor C13 through R11. The output (Pin 1) of Operational Amplifier (LM 358), though acting like a comparator gets high which in turn drives the 3 CO relay through transistor Q1 to switch off 3 phase load (lamps in this case).[1]

V. Hardware Implementation

Step 1

First, a circuit is printed on Printed Circuit Board (PCB).

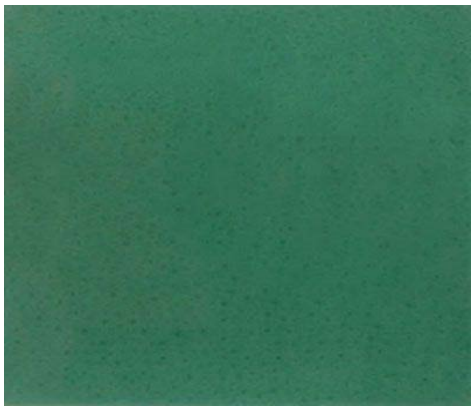


Figure11 : PCB

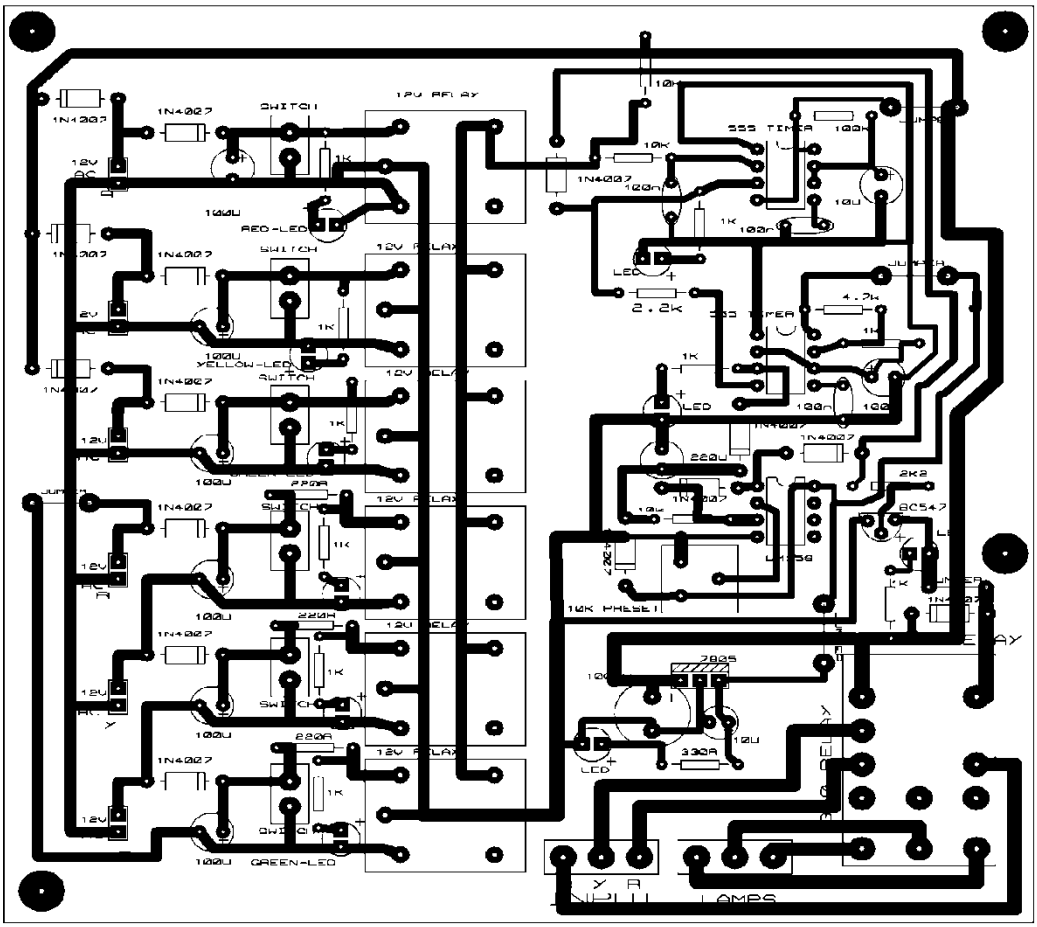


Figure 12 : PCB layout design [5]

All the components are then adjusted and soldered to the board carefully. After this, secondary side of six transformers is connected to the relays of the circuit designed on the PCB in order to produce faults. In the groups of three each, one group is connected in star-star connection and the other group is connected as star-delta connection. After this 6 lamps are connected along with 230 V supply.

Now all the circuit should be fitted on wooden board with help of drilling.

Figure 13 : Wooden Board

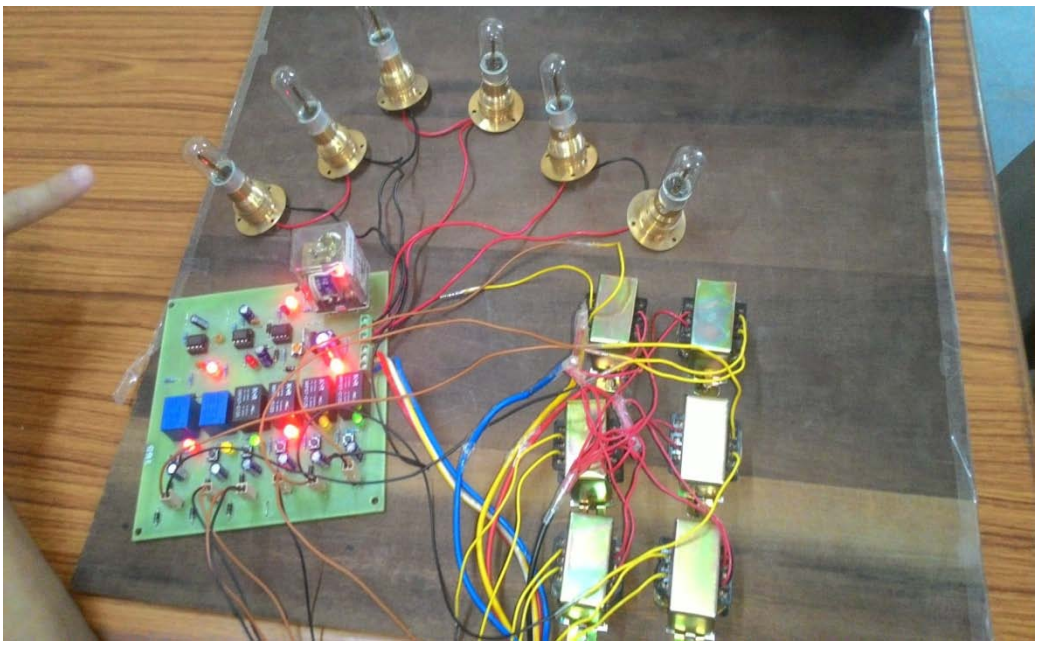


Figure 14 : Implementation of Hardware Model

Step 2 Powering the circuit

Process of starting the circuit-

- Turn the preset fully anti-clockwise and connect six transformers to the board.
- Use variac so that there is no sudden over voltage in the system. Slowly rotate it clockwise so that system starts properly.
- All 6 relay Led, power supply Led and 3 c/o Relay shall be glowing.

- Both LEDs of 555 Timer shall be in off position.
- Turn the preset slowly clockwise so that 3 C/O Relay led goes off.

That completes the setting procedure and the board is ready for use.

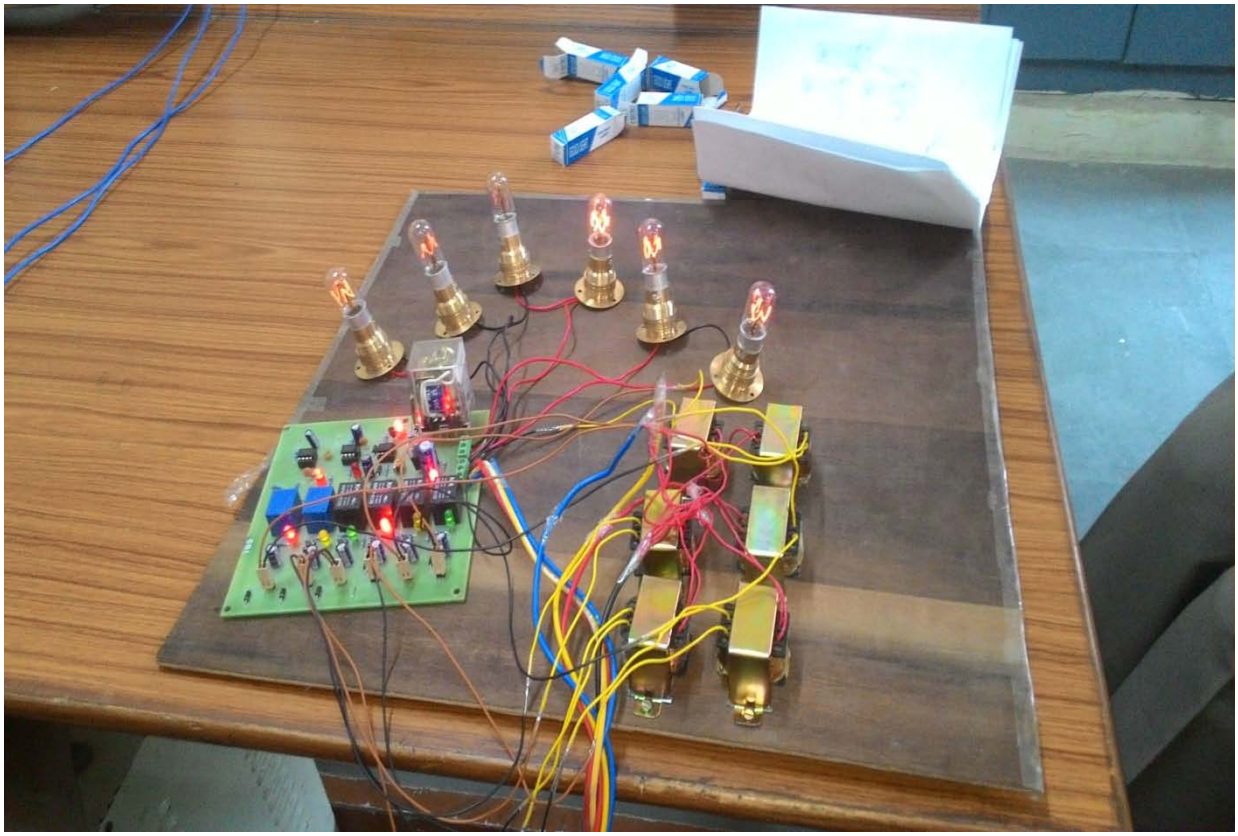


Figure 15 : Powering the circuit

VI. Conclusion

This project is designed to develop an automatic tripping mechanism in case of temporary and permanent faults. A schematic diagram has been developed by Proteus 8.3 software which helps in simulation of different types of faults which in turns helps to build hardware for the project. In this case, two 555 timers are used along with relays in order to determine whether fault is temporary or permanent.[3] Nowadays, a mechanism to send message to the authorities via SMS by interfacing a GSM modem GPRS based network is used for tracking transformers. In future there can be more advancement in Three Phase Fault Analysis System like:-

- GPRS based network is used for tracking transformers.
- A mechanism to send message to the authorities via SMS by interfacing a GSM modem
- Improvements to human machine interface
- Long Distance Data Transmission [4]

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