

## Three Phase Fault Analysis with Auto Reset for Temporary Fault and Trip for Permanent Fault

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### Abstract

This paper to develop an automatic tripping mechanism for the three phase supply system. The project output resets automatically after a brief interruption in the event temporary fault while it remains in tripped condition in case of permanent fault. The electrical substation which supply the power to the consumers, have failures due to some faults which can be temporary or permanent. These faults lead to substantial damage to the power system equipment. In India it is common, The faults might be LG (Line to Ground), LL (Line to Line), 3L (Three lines) in the supply systems and these faults in three phase supply system can affect the power system. To overcome this problem a system is built, which can sense these faults and automatically disconnects the supply to avoid large scale damage to the control gears in the grid sub-stations. This system is built using three single phase transformers which are wired in star input and star output, and 3 transformers are connected in delta connections, having input 220 volt and output at 12 volt. This concept low voltage testing of fault conditions is followed as it is not advisable to create on mains line. 555 timers are used for handling short duration and long duration fault conditions. A set of switches are used to create the LL, LG and 3L fault in low voltage side, for activating the tripping mechanism. Short duration fault returns the supply to the load immediately called as temporary trip while long duration shall result in permanent trip. The concept in the future can be extended to developing a mechanism to send message to the authorities via SMS by interfacing a GSM modem.

**Keywords**—555 Timer, Voltage regulator (LM7805), Relays, Comparator, Transformer (230 V– 12V AC)

### I. Introduction

Various studies have shown that anywhere from 70%, to as high as 90%, of faults on most overhead lines are transient. A transient fault, such as an insulator flashover, is a fault which is cleared by the immediate tripping of one or more circuit breakers to isolate the fault, and which does not recur when the line is re-energized. Faults tend to be less transient (near the 80% range) at lower, distribution voltages and more transient (near the 90% range) at higher, sub transmission and transmission voltages.

Lightning is the most common cause of transient faults, partially resulting from insulator flashover from the high transient voltages induced by the lightning. Other possible causes are swinging wires and temporary contact with foreign objects. Thus, transient faults can be cleared by momentarily de-energizing the line, in order to allow the fault to clear. Autoreclosing can then restore service to the line.

The remaining 10 - 30% of faults are semi-permanent or permanent in nature. A small branch falling onto the line can cause a semi-permanent fault. In this case, however, an immediate de-energizing of the line and subsequent auto reclosing does not clear the fault. Instead, a coordinated time-delayed trip would allow the branch to be burned away without damage to the system. Semi-permanent faults of this type are likely to be most prevalent in highly wooded

areas and can be substantially controlled by aggressive line clearance programs.

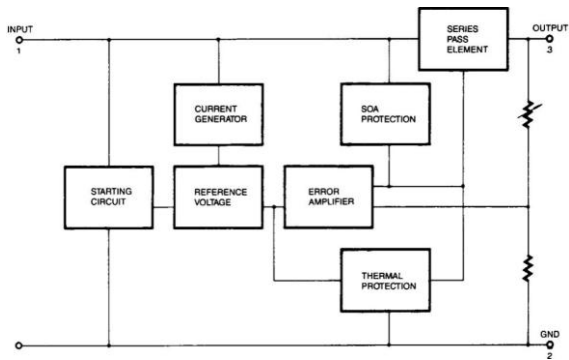
Permanent faults are those that will not clear upon tripping and reclosing. An example of a permanent fault on an overhead line is a broken wire causing a phase to open, or a broken pole causing the phases to short together. Faults on underground cables should be considered permanent. Cable faults should be cleared without auto reclosing and the damaged cable repaired before service is restored. There may be exceptions to this, as in the case of circuits composed of both underground cables and overhead lines.

Although auto reclosing success rates vary from one company to another, it is clear that the majority of faults can be successfully cleared by the proper use of tripping and auto reclosing. This de-energizes the line long enough for the fault source to pass and the fault arc to de-energize, then automatically recloses the line to restore service. Thus, autoreclosing can significantly reduce the outage time due to faults and provide a higher level of service continuity to the customer. Furthermore, successful high-speed reclosing auto reclosing, on transmission circuits can be a major factor when attempting to maintain system stability. For those faults that are permanent, auto reclosing will reclose the circuit into a fault that has not been cleared, which

may have adverse affects on system stability (particularly at transmission levels).

### II. VOLTAGE REGULATOR

The LM78XX/LM78XXA series of three-terminal positive regulators are available in the TO-220/D-PAK package and with several fixed output voltages, making them useful in a Wide range of applications. Each type employs internal current limiting, thermal shutdown and safe operating area protection, making it essentially indestructible. If adequate heat sinking is provided, they can deliver over 1A output Current. Although designed primarily as fixed voltage regulators, these devices can be used



with external components to obtain adjustable voltages and currents.

Fig1 (a) Block diagram of voltage regulator

Parameter	Symbol	Value	Unit
Input Voltage (for $V_O = 5V$ to $18V$ )	$V_i$	35	V
(for $V_O = 24V$ )	$V_i$	40	V
Thermal Resistance Junction-Cases ( $T_O=220$ )	$R_{\theta JC}$	5	$^{\circ}C/W$
Thermal Resistance Junction-Air ( $T_O=220$ )	$R_{\theta JA}$	65	$^{\circ}C/W$
Operating Temperature Range (KA78XX/A/R)	$T_{OPR}$	$0 \sim +125$	$^{\circ}C$
Storage Temperature Range	$T_{STG}$	$-65 \sim +150$	$^{\circ}C$

Fig1 (b) Absolute Maximum Ratings

It has some features:

- Output Current up to 1A.
- Output Voltages of 5, 6, 8, 9, 10, 12, 15, 18, 24V.
- Thermal Overload Protection.
- Short Circuit Protection.
- Output Transistor Safe Operating Area Protection.

### III. SCHEMATIC DIAGRAM

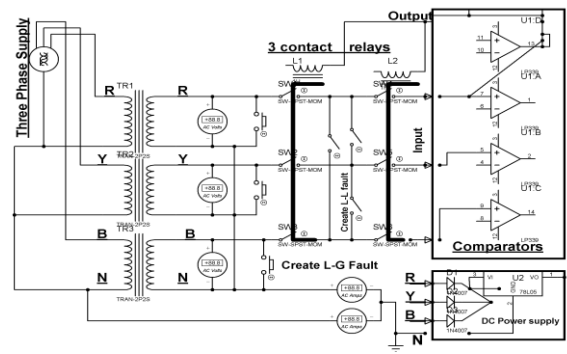


Fig2 (a) Block diagram

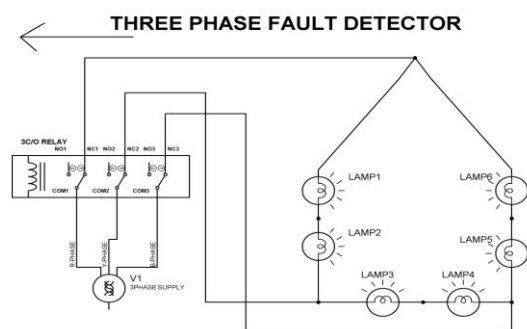


Fig2 (b) Proposed schematic diagram

#### Working principle:

The project uses 6numbers step-down transformers for handling the entire circuit under low voltage conditions of 12v only to test the 3 phase fault analysis. The primaries of 3 transformers are connected to a 3 phase supply in star configuration, while the secondary of the same is also connected in star configuration. The other set of 3 transformers with its primary connected in star to 3 phase have their secondary's connected in delta configuration. The outputs of all the 6 transformers are rectified and filtered individually and are given to 6 relay coils. 6 push buttons, one each connected across the relay coil is meant to create a fault condition either at star i.e. LL Fault or 3L Fault. The NC contacts of all the relays are made parallel while all the common points are grounded. The parallel connected point of NC are given to pin2 through a resistor R5 to a 555 timer i.e. wired in monostable mode. The output of the same timer is connected to the reset pin 4 of another 555 timer wired in astable mode. LED'S are connected at their output to indicate their status. The output of the U3 555 timer from pin3 is given to an Op-amp LM358 through wire 11 and d12 to the non inverting input pin3, while the inverting input is kept at a fixed voltage by a potential divider RV2. The voltage at pin2 coming from the potential divider is so held that it is higher than the pin3 of the Op-amp used as a comparator so that pin1 develops zero logic that fails to operate the relay through the driver transistor Q1.

This relay Q1 is '3CO' relay i.e. is meant for disconnecting the load to indicate fault conditions.

#### Operating procedure:

While the board is powered from a 3phase supply all the 6 relay coils get DC voltage and their common point disconnects from the NC and moves on to the NO points there by providing logic high at pin2 of 555 timer U1 i.e. that is kept on monostable mode. While any push button across the relay is pressed it disconnects that relay and in the process in common contacts moves to the NC position to provide a logic low at trigger pin of 555 timer to develop an output that brings the U3 555 timer which is used in astable mode for its reset pin to high such that the astable operation takes place at its output which is also indicated by flashing D11 LED.

If the fault is off temporary in nature i.e. if the push button pressed is released immediately the U1 monostable disables U3 the output of which goes to zero in the event of any push button kept pressed for a longer duration the monostable output provides a longer duration active situation for U3 the astable timer the output of which charges capacitor C13 through R11 such that the output of the comparator goes high that drives the relay to switch off three phase load.

The output of Op-amp remains high indefinitely through a positive feedback provided for its pin1 to pin3 through a forward biased diode and a resistor in series. This results in the relay permanently switched on to disconnect the load connected at its NC contacts permanently off. In order to maintain the flow of DC supply the star connected secondary set DC'S are paralleled through D8, D9 & D10 for uninterrupted supply to the circuit voltage of 12v DC and 5v DC derived out of voltage regulator IC 7805.

### IV. HARDWARE TESTING

#### 1. Conductivity Test:

In electronics, a continuity test is the checking of an electric circuit to see if current flows (that it is in fact a complete circuit). A continuity test is performed by placing a small voltage (wired in series with an LED or noise-producing component such as a piezoelectric speaker) across the chosen path. If electron flow is inhibited by broken conductors, damaged components, or excessive resistance, the circuit is "open".

Devices that can be used to perform continuity tests include multi meters which measure current and specialized continuity testers which are cheaper, more basic devices, generally with a simple light bulb that lights up when current flows.

An important application is the continuity test of a bundle of wires so as to find the two ends belonging to a particular one of these wires; there will be a negligible resistance between the "right" ends, and only between the "right" ends.

This test is the performed just after the hardware soldering and configuration has been

completed. This test aims at finding any electrical open paths in the circuit after the soldering. Many a times, the electrical continuity in the circuit is lost due to improper soldering, wrong and rough handling of the PCB, improper usage of the soldering iron, component failures and presence of bugs in the circuit diagram. We use a multi meter to perform this test. We keep the multi meter in buzzer mode and connect the ground terminal of the multi meter to the ground. We connect both the terminals across the path that needs to be checked. If there is continuation then you will hear the beep sound.

#### 2. Power ON Test:

This test is performed to check whether the voltage at different terminals is according to the requirement or not. We take a multi meter and put it in voltage mode. Remember that this test is performed without ICs. Firstly, if we are using a transformer we check the output of the transformer; whether we get the required 12V AC voltage (depends on the transformer used in for the circuit). If we use a battery then we check if the battery is fully charged or not according to the specified voltage of the battery by using multimeter.

Then we apply this voltage to the power supply circuit. Note that we do this test without ICs because if there is any excessive voltage, this may lead to damaging the ICs. If a circuit consists of voltage regulator then we check for the input to the voltage regulator (like 7805, 7809, 7815, 7915 etc) i.e., are we getting an input of 12V and a required output depending on the regulator used in the circuit. EX: if we are using 7805 we get output of 5V and if using 7809 we get 9V at output pin and so on.

This output from the voltage regulator is given to the power supply pin of specific ICs. Hence we check for the voltage level at those pins whether we are getting required voltage. Similarly, we check for the other terminals for the required voltage. In this way we can assure that the voltage at all the terminals is as per the requirement.

### V. TESTING AND RESULTS



fig 8.1. Practical Circuit of Linear load

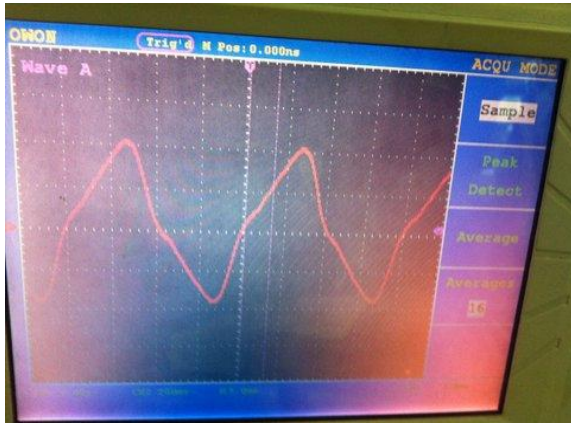


Fig.8.2. Input voltage of Linear load

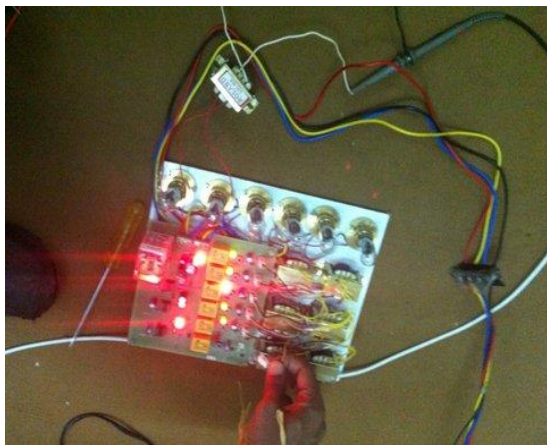


Fig.8.3. Practical Circuit of Non linear load

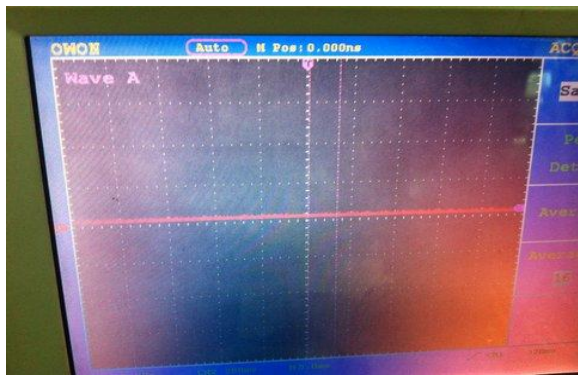


Fig.8.4. Input Voltage of Non linear load

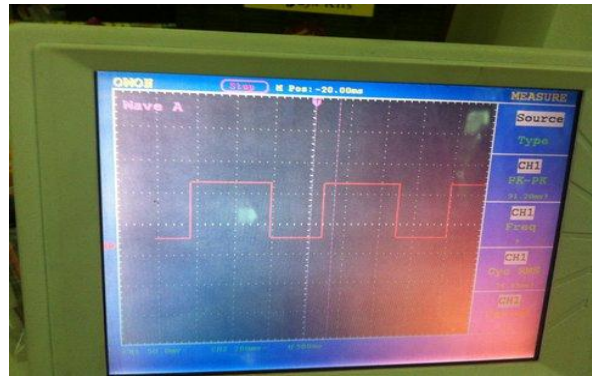


Fig.8.5. Output voltage of the 12v dc supply (monostable)

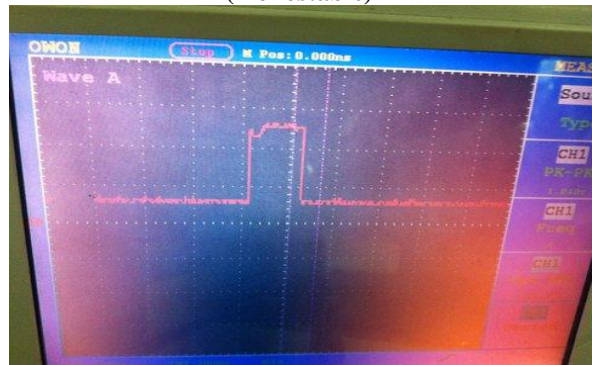


Fig.8.6. Output voltage of the 12v dc supply (astable)

**CALCULATIONS IN THERIOTICALLY:**

For L-G:

$$P_{base} = 500 \text{ mva}, \quad v_{base} = 230$$

$$I_{base} = \frac{P_{base}}{V_{base} \cdot \sqrt{3}} = \frac{500}{230 \cdot \sqrt{3}} = 1.255 \text{ kA}$$

$$Z_{base} = \frac{V_{base}}{I_{base} \cdot \sqrt{3}} = \frac{230}{1.255 \cdot \sqrt{3}} = 5.52 \Omega$$

$$Z_{pu \text{ source}} = \frac{Z_{actual}}{Z_{base}} = \frac{6}{5.52} = 1.08 \Omega$$

$$Z_{pu - Transformer} = \text{base} \frac{\text{mva}}{\text{transformer mva}} \cdot z\%/100$$

$$= \frac{500}{500} \cdot \frac{6}{100} = 0.06 \Omega$$

$$\text{Fault mva} = \frac{\text{Basemva}}{z_{pu \text{ source}}} = \frac{12}{1.08} = 11 \text{ mva}$$

$$\text{Line to neutral voltage on the secondary of the transformer} = \frac{12}{\sqrt{3}} = 6.92 \text{ v}$$

$$\text{Fault kA} = \frac{\text{Fault mva}}{3 \cdot V_{L-N}} = \frac{11}{\sqrt{3} \cdot 6.92} = 0.917 \text{ A}$$

For L-L:

$$\text{Base mva} = \frac{10000}{1000} = 1 \text{ mva}$$

$$mva \text{ value} = \frac{1mva}{Z_{pu}} = \frac{1mva}{0.06} = 16.66A$$

Use the admittance method to calculate fault current

$$\frac{1}{\text{Utility mva}} + \frac{1}{\text{Transformer}} = \frac{1}{mva}$$

$$\frac{1}{500} + \frac{1}{16.66} = \frac{1}{mva}$$

$$0.002 + 0.06 = \frac{1}{mva}$$

$$mva = \frac{1}{0.002 + 0.06}$$

$$mva = 16.129A$$

$$\text{Fault current at } 230v = \frac{16.129}{1.66 * 0.23} = 4A$$

$$\text{Fault current at } 12v = \frac{16.129}{1.66 * 0.12} = 8A$$

## VI. CONCLUSION

This project is designed in the form of Hardware for three single phase transformers 230v to 12V of output for to develop an *automatic* tripping mechanism for the *three phase* supply system while temporary fault and permanent fault occurs. Here we used 555 timer with relay for the fault is temporary or permanent.

Short duration fault returns the supply to the load immediately called as temporary trip while long duration shall result in permanent trip. The concept in the future can be extended to developing a mechanism to send message to the authorities via SMS by interfacing a GSM modem.

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