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Microcontroller Based Three Phase Fault Analysis for Temporary and 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 remain 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 project is designed to understand about the basic operation of the relay and what are all the advanced techniques that are being used by the people to ensure the safe operation of the electrical appliance. The circuit will isolate the load from the supply if any power fluctuation occurred. The major advantage of the project is, it not only save the appliance but it will also show the type of the fault that has been occurred in the system so that it will be easy for the operator to solve the problem easily. It will also check whether the fault is a permanent or a temporary fault. If the fault is temporary fault then the supply will be restored after a predefined time of 5-10 seconds otherwise a permanent trip signal is given to the relays.***

Key Words: *Three phase fault, tripping mechanism, microcontroller, and ADC.*

1. 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 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 the90% range) at higher, sub transmi00ssion and transmission immediate tripping of one or more circuit breakers to 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. Auto reclosing 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, auto reclosing 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 effects on system stability (particularly at transmission levels). The features are as follows.[1]

1. Isolate the load when there is increase in the load current
2. Types of fault that it can sense: low voltage, high voltage, high current
3. If the load is isolated because of low voltage it will be switched on automatically when the voltage get stabilized
4. Indication of type of fault that has been occurred on a 16x2 dot matrix lcd
5. Can change the current setting easily

This is built by using a Atmega-8 microcontroller. Different sections of the project are designed on separate pcb so that the project can be demonstrated easily. The demonstration of the project is very simple as by opening any one phase wire, which is nothing but a low voltage can be viewed on the display. By working on this project one can understand how to measure the rms value of the sine wave by using an ADC. The voltage and current magnitudes are stepped down by using a PT and CT. from there the output is connected to peak detector circuit which will give the output dc voltage of magnitude equal to the maximum value of the sine wave. From there the output is given to an ADC which is interfaced to the microcontroller .the controller will operate a relay if it finds any abrupt change in the output of the peak detector section, so that the load is separated form the supply. All the required dc voltages are designed in the circuit itself by using the voltage regulator ic's.

. Power cable fault location techniques are used in power system for accurate pinpointing of the fault positions.

The benefits of accurate location of fault are:
1. Fast repair to restore back the power system.
2. Improve the system availability and performance.
3. Reduce operating cost and save the time required by the crew searching in bad weather, noisy area and tough terrains.[2]

2. MATERIALS AND METHODS

The project uses one step-down transformer for handling the entire circuit under low voltage conditions of 12V only to test the 3 phase fault analysis. The primaries of one transformer are connected to a 3 phase supply in star configuration, while the secondary of the same is also connected in star configuration. The output of the transformer are rectified and filtered and are given to 3 relay coils. 12 fault switches, each one is connected across the relay coil, meant to create a fault condition either at star i.e. LL Fault and 3L fault. LED'S are connected at their output to indicate their status. The Microcontroller is used which converts the analog value of the voltage to digital one which is displayed on 16x2 LCD screen. If the fault is created by means of any fault switches the digital value shown on the LCD screen will fluctuate abnormally giving the fault location. If the fault is cleared within the specific time period then it will be temporary fault if it is not then there will be a permanent trip.

This relay is meant for disconnecting the load to indicate fault conditions.

2.1 Analog to Digital Converter

An analog-to-digital converter is a device that converts a continuous physical quantity (usually voltage) to a digital number that represents the quantity's amplitude.

An ADC is defined by its bandwidth (the range of frequencies it can measure) and its signal to noise ratio (how accurately it can measure a signal relative to the noise it introduces). The actual bandwidth of an ADC is characterized primarily by its sampling rate. The dynamic range of an ADC is influenced by many factors, including the resolution, linearity, and accuracy and jitter (small timing errors that introduce additional noise).

An ADC may also provide an isolated measurement such as an electronic device that converts an input analog voltage or current to a digital number proportional to the magnitude of the voltage or current. The digital output may use different coding schemes. Typically the digital output will be a two's complement binary number that is proportional to the input.

$$ADC\ value = \frac{Analog\ Value}{Reference\ Value} \times Resolution$$

2.2 Resolution

The resolution of the converter indicates the number of discrete values it can produce over the range of analog values. The values are usually stored electronically in binary form, so the resolution is usually expressed in bits. In consequence, the number of digital values available, is assumed to be a power of two. For example, an ADC with a resolution of 8 bits can encode an analog input to one in 256 different levels. The values can represent the ranges from 0 to 255.

Resolution can also be defined electrically, and expressed in volts. The minimum change in voltage required to guarantee a change in the output code level is called the least significant bit (LSB) voltage. The resolution Q of the ADC is equal to the LSB voltage. The voltage resolution of an ADC is equal to its overall voltage measurement range divided by the number of digital value.

$$Q = \frac{E_{FSR}}{2^M},$$

Where M is the ADC's resolution in bits and EFSR is the full scale voltage range.
Normally, the number of voltage intervals is given by

$$N = 2^M,$$

Where, M is the ADC's resolution in bits.

2.3 Calculations

ADC value = $\frac{Analog\ voltage}{Reference\ voltage} \times$ Resolution
Resolution is of 10 bit
Normally, the number of voltage intervals is given by

$$N = 2^M,$$

Where, M is the ADC's resolution in bits.
So M = 10,
Therefore, N = 2^{10} = 1024 [(0-1023) Range]
N1- normal condition, N2- Fault location 1(F-1), N3- Fault location 2 (F-2), N4- Fault location 3 (F-3), N5- Fault location 4 (F-4).

ADC value at N1 = $\frac{3.5V}{4V} \times 1023 = 716$ (NORMAL CONDITION)
ADC value at N2 = $\frac{3V}{5V} \times 1023 = 613$ (Fault location – F1)
ADC value at N3 = $\frac{2.5V}{5V} \times 1023 = 511$ (Fault location – F2)
ADC value at N4 = $\frac{2V}{5V} \times 1023 = 409$ (Fault location – F3)
ADC value at N5 = $\frac{1.5V}{5V} \times 1023 = 306$ (Fault location – F4)

2.4 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.

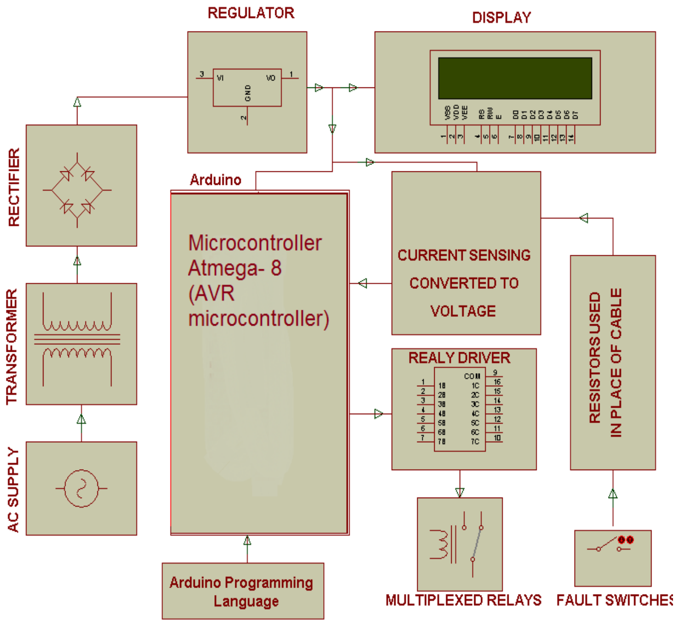

Fig.1. Block diagram of microcontroller used fault analysis for temporary and permanent fault

3. EXPERIMENTAL RESULT

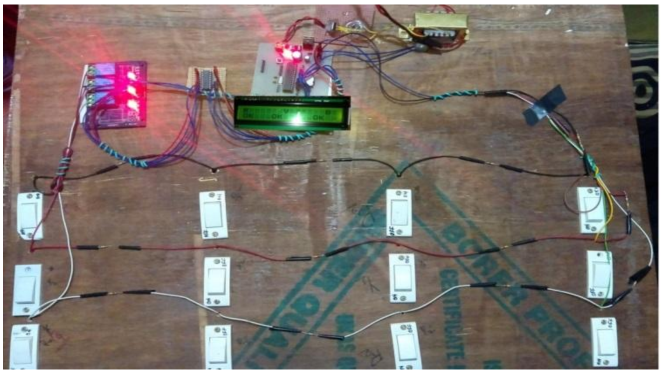

Fig.2. Experimental set up and testing under normal condition

- In this case all the three lines are working properly or we can say normally stable without any fault.

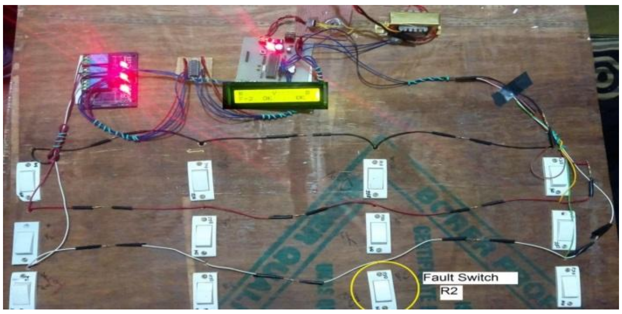

Fig.3. Experimental set up and testing under line to ground fault condition

- In the circuit the fault is created at R2 and if the fault is temporary i.e, for few seconds the mechanism will clear the fault automatically and if it is permanent i.e, for greater time period then relay will trip the line permanently and the fault location will displayed on the screen

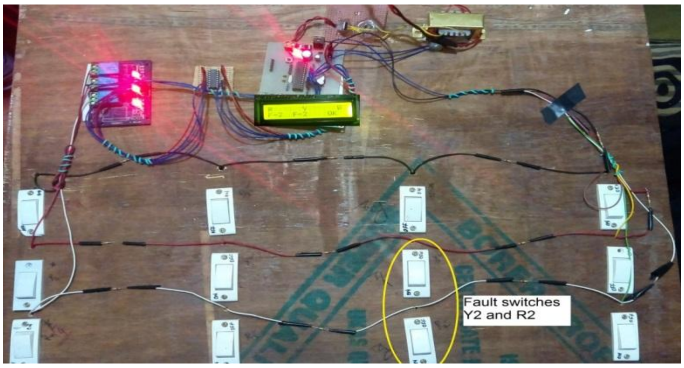

Fig.4. Experimental set up and testing under line to line fault condition

- As shown in fig. the fault is created in lines R and Y phase and since the fault is permanent the relay will trip both the lines and the mechanism will show the fault location on the LCD screen.

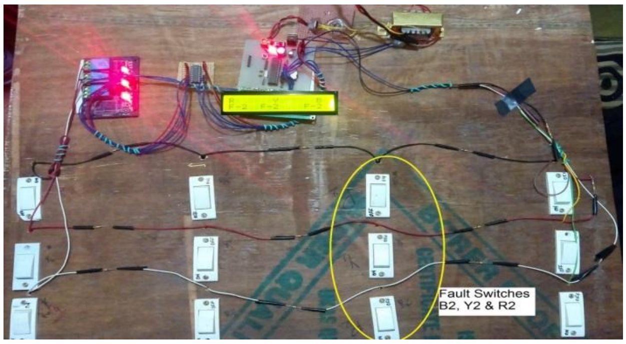

Fig.5. Experimental set up and testing under line to line to line fault condition

- As shown in fig. 5 all the three phases are faulted and since it is a permanent fault the relay will all the three loads of the line or phases permanently and the fault location will be displayed on the screen.

4. CONCLUSIONS

This paper is designed successfully with on single phase transformer 230V to 12V of output for develop and automatic tripping mechanism using microcontroller for the three phase supply system while temporary fault and permanent fault occurs. The concept of 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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