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A Prototype of Distribution System to Detect & Locate the Fault Using IoT

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Abstract: The proposed methodology was to detect and locate faults in the distribution system by using IoT. A microcontroller-based technology is being used to identify faults in each zone of the system which is connected by a resistive load. This prototype consists of different types of sensors that will automatically detect the short circuit faults and monitor different parameters like current, voltage, power, power factor and temperature during unbalanced conditions. IoT is used to communicate data to remote monitoring devices and make the system intelligent during faulty conditions.

Index Terms **- Faults, Detection, Location, Parameters and IoT.**

I. INTRODUCTION

Intelligent technology and integration play an important role in the advancement of the power system. Electrical demand for home, commercial, and industrial loads is increasing day by day. In addition, the administration of electric power distribution systems is increasing fastly. Electricity has now reached every distant part of the country. As a result, we now have a complicated network of power systems. The distribution lines are used to transmit this energy to the various consumers. These lines have various divisions, at the same time possibility of fault taking place in a different zone. Electrical equipment such as transformers, generators, and transmission lines are all damaged by these faults. For the uninterrupted electricity supply, we want to prevent those faults as plenty as possible. Consequently, we must identify faults as quickly as feasible. Microprocessors and microcontroller-based architectures for this fault detection are rapidly evolving.

Distribution line fault detection is a very new concept in power system fault detection, and it is still in its infancy. This is just a part of a larger grid. The device is designed to locate transmission line faults so that the user may quickly comprehend the current state of the distribution line. The true objective is to constantly display the distribution line status and so protect the distribution line fault due to the constraints of LG, LLG, and LLLG fault. If any of these things happen, a user can quickly fix it. A power system isn't static; it varies throughout operation (such as when generators and transmission lines are turned on and off) and planning of the addition of generators and transmission lines. As a result, fault research should be conducted on a regular basis with the assistance of engineers. Electrical system defects can be caused by a variety of factors, including insulation failure, flashover, physical damage, or human error. These faults could be symmetrical in nature, affecting all three phases, or asymmetrical in nature, affecting only one or two phases. Faults can also be caused by a short circuit to earth or between two conductors, or by damaged conductors in any of the phases.

In India, the power sector is rapidly expanding. Peak Consumption is expected to be around 203.01 GW in 2020-21 (up to 31.10.2021), with an installed capacity of 390.79 GW, with a generation mix of Coal 201.9 GW (51.9%), Lignite 6.62 GW (1.7%), Gas 24.9 GW (6.4%), Diesel 0.51 GW (0.1%), Hydro 46.51 GW (12.0%), Wind, Solar & Other RE 103.05 MW (26.4%), Nuclear 6.8 (1.7 percent). 390.79 GW Total Installed Capacity (Fossil Fuel & Non-Fossil Fuel) (100 per cent).

India's natural energy resources are unevenly dispersed and concentrated in a few areas. In the north-eastern region, the Himalayan foothills supply hydro resources (NER). Coal reserves exist in Jharkhand, Odisha, West Bengal, Chhattisgarh, and parts of Madhya Pradesh, whereas lignite reserves exist in Tamil Nadu and Gujarat. In addition, a large number of power stations generated from natural gas and renewable energy sources such as solar and wind have been established around the country.[7]

Power Grid Corporation of India Limited (POWER GRID), a Central Transmission Utilities (CTU), is in charge of planning an interstate transmission infrastructure (ISTS). State Transmission Utilities (STU) (especially State Transco/ SEBs) are in charge of the growth of the Intra State Transmission System.

A fault is an aberrant flow of electric current in an electrical power system. For instance, a short circuit occurs when current flows around the typical load. When a circuit is disrupted by a failure, an open-circuit fault develops.[5] In a three-phase system, a fault can damage one or more phases, as well as ground, which is only present between phases.[4],[5] A "ground fault" or "earth fault" is a fault in the ground that allows current to flow into the earth. Asymmetrical fault, transient fault, over and under-voltage, under and over current, and power factor reduction are all examples of faults that might occur in our distribution line.[5] Equipment errors, weather circumstances, and human errors are the main causes of faults, and the impacts of faults include decreased efficiency, equipment losses, and disruption of interconnected active circuits.[13] Thus, protective devices are required. Protective devices in power systems detect faults and operate circuit breakers and other devices to prevent service interruptions to a minimum.[4]

Symmetrical faults, are very severe faults and occur infrequently in the power system. In this fault, both the pre-fault and post-fault systems are balanced, therefore also known as a balanced system.[13] These are basically of two types line to line to ground (L-L-G) and line to line to ground (L-L-L-G). Symmetrical faults occur for only 2-5 per cent of system failures.[13] If these faults occur, the system remains balanced but results in severe damage to the electrical power system apparatus.[13]

Unsymmetrical faults are quite common faults. They are not harmful as symmetrical faults. These faults have a balanced pre-fault system but an unbalanced post fault system, therefore also known as an unbalanced system. In brief types of unsymmetrical faults are discussed. First is Line to Line (LL) fault, this is a common type of fault. When a short circuit takes place either due to ionization of air or insulation break down, lines come into physical contact. The second short circuit fault is Line to Ground (LG) fault, it is the most frequent fault accounting for 65-70 per cent of fault. In this fault short circuit takes place between line and ground.[13] The main causes are lightning or storm damage. And last is the Double Line to Ground (LLG) fault, during storms, two lines come into contact with the ground.[7]

The network must be so reliable that it can carry sensitive data to and from the transmission grid, just like the current state of the transmission line and control information.[8] The real-time load monitoring and fault detection system is described in this study it will automatically detect and notify the authorities of a specific location of a fault.[14] This results in the reduction of the fault clearing time. It's a prototype model that uses a microcontroller to determine parameters like voltage, current, power factor, and temperature using various sensors. On the LCD, the zone and fault types are displayed and send data to communicating devices using IoT. The status of the equipment is displayed via LEDs.

II. Problem Identification

First, to handle electric load growth and for reliability purposes, there is a growing need for more electricity nowadays. Both electrically and technologically, the area's substations are approaching their maximum capacity. This puts them at risk of being overloaded, which could result in power outages and damage to other system components. Distribution systems need to be built so one outage will not cause the overloading of another distribution line. If two failures occur, the system must be designed to prevent cascading outages. A new substation and transmission lines will reduce the loading on the existing substations, ensure greater electric reliability and will improve regional stability for the power grid. The power grid is a network of interconnected transmission lines that is frequently referred to as the power grid.[12] If any interruption occurred in these lines the whole power supply system will be affected. Substations receive transmission lines and transformers scale down the power to lower voltages. From there, distribution lines deliver power to individual electric users. An interconnected network of transmission and distribution lines is used to construct electrical power delivery systems. That way if there is a problem with one section of an electric line, then every section will be affected.

Our power distribution lines make up a significant part of our power system and are primarily exposed to the surroundings. As a result, there's a good chance it'll develop a fault. Many power companies rely on circuit indicators for fault detection, despite the fact that fault indicators have made detecting many types of defects much easier. Technical crews and patrol teams, on the other hand, must physically travel along the lines and cover a large distance to locate the fault. It elongates the repair process and raises the restoration cost. Real-time load monitoring is necessary, as well as identification of the different types of faults and their parameters, as well as further differentiation. Sensor-based wireless power distribution monitoring can help with these challenges. Many sensors, like current sensors and temperature sensors, are widely and cheaply available on the market by using interfacing devices like IoT. The equipment can interface with each other and give us the desired output.

III. Methodology

The circuit description and operation of this prototype have been detailed in this section. A 230V, 50 Hz ac supply is used to power the circuit. It is constituted of a step-down transformer that converts 230V to 12V and then an LED. A full-wave rectifier with two diodes rectifies the signal, which is then filtered by a capacitor coupled to a voltage regulator. ATMEGA328 is a 32Kbytes, 2Kbytes SRAM, 23 general-purpose I/O lines, and In-System Programmable Flash with Read-While-Write capabilities.[14] It primarily has two types of pins: Analog pins ranging from A0 to A5 and digital supporting pins ranging from 1 to 13. A 16MHz crystal oscillator is attached to pins 9 and 10 to provide clock pulses to the microcontroller. We have two microcontrollers in this prototype, namely M1 and M2. The RESET button pair is connected to the six resistors that represent the distinct transmission lines of the two zones, Zone 1 and Zone 2, and their connections to the microcontroller are referred to as. R, Y, and B wirings are connected to ports PB1, PB2, and PB3, respectively, in Zone 1. R, Y, and B wirings are connected to ports PB4, PB5, and PB6, respectively, in Zone 2. These two zones are interconnected in M2, the secondary supply is delivered to M2 from the rectified output of the transformer, and the LCD is connected from PIN1 to PIN12. To display the zone and faults that occur in the distribution line, we use an LCD connected from pin D4 to D7 in M1. To deliver data to remote communicating devices, the Esp8266 Wi-Fi Module is wired to M1 pin D8. The microcontroller also has a relay driver that controls the relays and displays the status of the relays through LEDs. The voltage regulator and three current sensors are coupled to the analog pins, which are then connected to the resistive loads depicted by incandescent 100W lights.

Under normal circumstances, the power distribution line receives a 230V ac supply. There are three sorts of faults that can occur when a manual fault is applied to a line: line to ground fault, double line to ground fault, and line to line to line to ground fault. The location of the problem is then displayed (zone 1 or zone 2). This transmission line is connected to the microcontroller, which interprets the incoming inputs and displays the instant current and power factor of the relevant phases on the LCD. IoT is used to communicate data to remote monitoring devices and make the system intelligent during faulty conditions. The loads are represented by bulbs, which glow in normal conditions and turn off when a fault occurs on that line. The ACS712 Current Sensor uses an indirect sensing approach to calculate the current.[14] A voltage proportional to the observed magnetic field is generated by the hall sensor, which is used to monitor the current.[14] The three pins are ground, supply, and output. The power factor is calculated using the cosine of the phase angle, which is determined by the phase difference between voltage and current. Because of the existence of harmonics, the power factor value degrades.

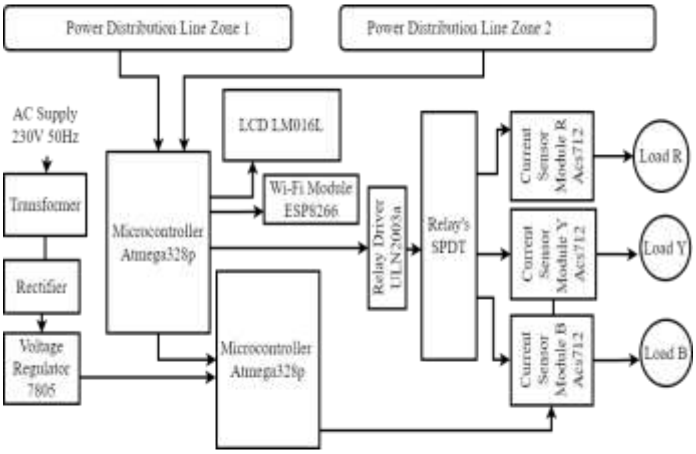

Figure 1. Block Diagram

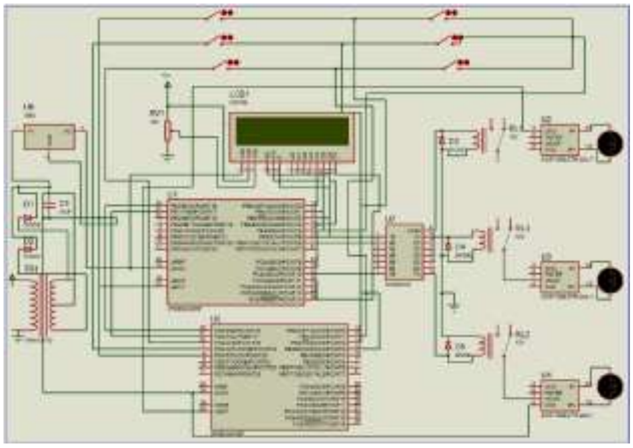

Figure 2. Circuit Diagram

IV. Result Analysis

This prototype model detects the fault and displays the location of the fault on the LCD. All three bulb phases (R, Y, and B) will glow when the system is in good operating order. During the fault, the bulb for that particular phase will be turned off. This, among other things, makes real-time load monitoring easier to detect and displays instantaneous current and power factors. The figure below describes the designed prototype model.

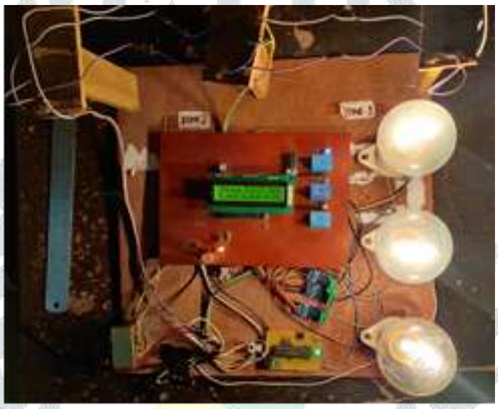

Figure 3. Power Distribution line installed on a laboratory prototype

At the normal operating condition, the values displayed on the LCD are enlisted in Table 1.

Table 1 Results at Normal Conditions

Phase	Parameters		
	Voltage (in Volt)	**Current (In Ampere)**	**Power Factor (cosØ)**
R	230	0.44	0.89
Y	230	0.45	0.90
B	230	0.47	0.88

The microcontroller detects all possible faults that are manually entered, and the fault, as well as its location and parameters, are displayed on the LCD, as shown in Table 2.

Table 2 Results at Fault Conditions

Parameters	Line to Ground (LG)									Double Line to Ground (LLG)			Line to Line to line to Ground (L-L-L-G)		
	Phase R			Phase Y			Phase B								
Phases	R	Y	B	R	Y	B	R	Y	B	R= Y = 0 B	Y= B = 0 R	B= R = 0 Y	R	Y	B
Voltage (In Volt)	0	230	230	230	0	230	230	230	0	230	230	230	0	0	0
Current (In Amper)	0	0.43	0.42	0.44	0	0.45	0.44	0.46	0	0.45	O.45	0.45	0	0	0
Power Factor (cosØ)	0	0.89	0.90	0.87	0	0.87	0.9	0.89	0	0.89	0.88	0.9	0	0	0

V. CONCLUSIONS

A prototype model of power line fault detection and location was built using a microcontroller in this project. Hardware was created to connect the model to an LCD.[1] All potential manual errors are conducted during the testing, and the faults are correctly detected by the microcontroller and displayed on the LCD.[1] IoT is used to communicate data to remote monitoring devices and make the system intelligent during faulty conditions. The created approach aids in determining the location of faults that occur regularly. The current sensor and microcontroller work together to provide continuous current monitoring in a high voltage connection. Finally, it is discovered that if additional research on this system is conducted, a simple, efficient, accurate, and quick technique of power line problem detection and location may be applied in practice, contributing to the new standard IoT based electric power system.[1].

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