International Journal of Research Publication and Reviews

Journal homepage: www.ijrpr.com ISSN 2582-7421

Detection of faults in HVAC Transmission Lines using Wavelet Analysis and Arduino

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ABSTRACT

As The Electric Power System is divided into several divisions, one of which is the transmission system, which transports electricity from producing stations and substations to customers through transmission lines. Lighting, wind damage, trees falling over transmission lines, automobiles or aero planes colliding with transmission towers or poles, birds shorting wires, or vandalism produce faults. This research investigated the causes and consequences of faults in overhead transmission lines such as LG (Line to Ground), LL (Line to Line), and 3L (Three lines) in supply systems. These faults can cause significant damage to electrical system equipment. Wavelet analysis is used to detect and categorize transmission line faults, using the discrete approximation coefficient of the dyadic wavelet transform with distinct wavelets as an indicator. Fault signals are generated using MATLAB/Simulation to analyze the current waveform during a failure.

Key Words: Wavelet Analysis, Transmission, Dyadic Wavelet Transform, faults

I. INTRODUCTION

As we can see in our surroundings, a fault in the transmission line is prevalent during the rainy season, and it is extremely dangerous for us. Because the electrical power system is expanding in size and complexity in all sectors such as generation, transmission, distribution, and distribution, a defect occurs in this complex network, resulting in various economic losses and reduced electrical system dependability. We take care to address this error as quickly as possible; failing to do so may result in total blackout or grid breakdown.

In general, 70% to 90% of faults on overhead wires are caused by lightning strikes, storms, and flashovers, which are extremely dangerous to society. There are many different forms of faults in transmission lines, such as line to line faults and line to ground faults. Faults cause power outages and damage to electrical equipment. We exhibit a prototype model of 3p fault detection here, and we create the fault line using switches. We know that the impedance of a line grows with its length. So we employ resistance combinations in the sense that for each phase, a new set of resistance is used, and for each phase, one relay is used to isolate the load at the time of the fault, which gives the precise duration of the fault that occurs on the line.

Furthermore, in the proposed method, the main objective is to reduce the human efforts by presenting the idea to make the design more reliable and effective in identifying faults and quickly react to the faults in order to reduce the damage which occurs due to them. Also, it ensures high stability and reliability of the power system. It mainly helps in the economic growth of the country.

II. ASSOCIATED HARDWARE COMPONENTS DETAILS

A. Arduino Uno:

The Arduino Duemilanove is a microcontroller board that uses the ATmega328P chip. It is part of the Arduino family of open-source electronics platforms, which are meant to make interactive projects simple for enthusiasts, artists, and engineers.

The board contains 14 digital input/output pins, 6 analogue inputs, a quartz crystal with a frequency of 16 MHz, a USB connection, a power port, and an ICSP header. The digital pins can be used to operate LEDs, motors, and other electrical components and can be set as inputs or outputs. Sensors and other analogue devices can be read via the analogue inputs.

The USB connection or the power jack can be used to power the board. The board gets electricity from the USB connector when powered.

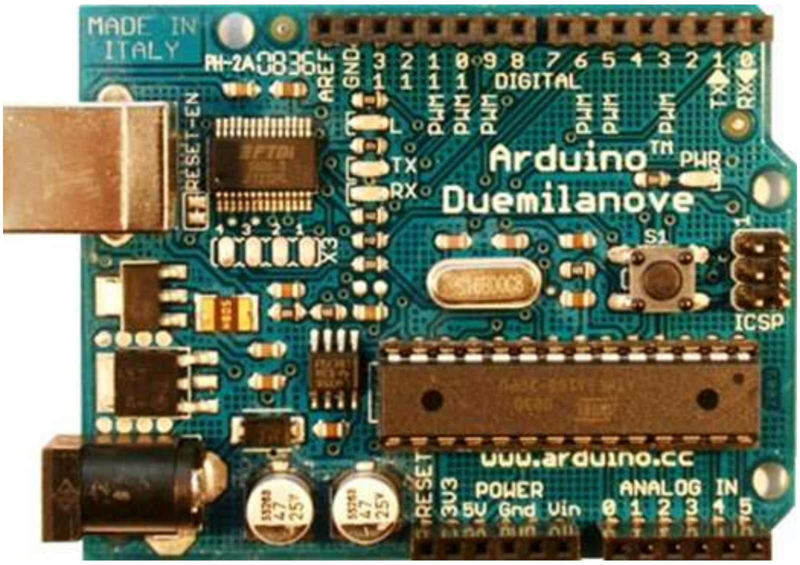

Figure 1. Arduino Duemilanove used in this method

When powered through USB, the board gets power from the computer, and when powered via power jack, it can accept a voltage range of 7-12V.The Duemilanove includes a bootloader that allows it to be programmed over USB using the Arduino Integrated Development Environment (IDE). The integrated development environment (IDE) is a software programme that allows users to write and upload code to the board. The board also has a reset button for restarting the software running on the microcontroller.

The ATmega328P microcontroller chip includes 32KB of flash memory for storing user code, 2KB of SRAM for storing variables, and 1KB of EEPROM for storing data that must be preserved even when power is turned off. Other functions of the chip include timers, interrupts, and communication interfaces such as UART, SPI, and I2C.

Overall, the Arduino Duemilanove is a powerful and adaptable microcontroller board that is simple to use and perfect for a variety of projects ranging from basic LED blinkers to complicated robotics and automation systems. Because of its open-source nature and active user community, it is a popular choice for amateurs, students, and professionals alike.

B. Transformer

A 12V step-down transformer is a type of electrical transformer used to drop the voltage level from a higher voltage input to a lower voltage output, in this instance from a higher voltage AC power source to a 12V output.

The transformer is made up of two wire coils wrapped around a common magnetic core. When the primary coil, which is connected to the input voltage source, is activated, it creates a magnetic field in the core. This magnetic field causes a voltage to be induced in the secondary coil, which is coupled to the load and gives the output voltage.

The transformer is built so that the ratio of turns in the main coil to turns in the secondary coil is such that the output voltage is less than the input voltage. The ratio of a 12V step-down transformer is normally such that the output voltage is 12V RMS.

The transformer is commonly housed in a metal or plastic enclosure, which protects the user from the high voltage input and keeps the user from coming into touch with the transformer's active components.

Figure 2. Stepdown Transformer used in this method

The maximum current that a step-down transformer can handle is a significant factor when utilizing it. The current capacity of a transformer is governed by the size of the wire used in the coils and the core's ability to manage magnetic flux. The transformer might overheat and fail if the load attached to it consumes more current than the transformer's rating. As a result, it is critical to make sure the load connected to the transformer does not exceed its rated current capacity.

C. Relay Driver

A relay driver is an electrical circuit or device that regulates how a relay operates. Relays are frequently used to manage high power or high voltage circuits using low power control signals generated by microcontrollers or other electronic devices. A relay driver amplifies the control signal to activate the relay coil and guarantees that the relay operates reliably on and off.

Figure 3. Relay driver IC ULN 20003

Relay driver integrated circuit. A relay driver IC is an electro-magnetic switch that will be utilized if we wish to use a low voltage circuit to turn on and off a light bulb that is linked to a 220V power source. The ULN2003A is a seven-npn Darlington transistor array with a 500 mA, 50 V output.

D. Flame Sensor

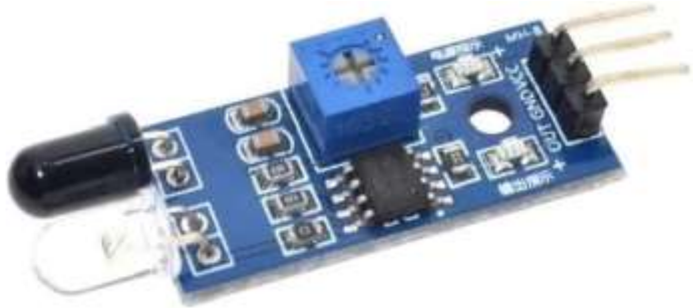

Figure 4. IR Sensor

A flame-sensor is a type of detector that is intended to detect and respond to the existence of a fire or flame. The reaction to flame detection might be affected by its fitting. It has an alarm, a natural gas line, propane, and a fire suppression system. This sensor is commonly found in industrial boilers. The major purpose of this is to verify whether the boiler is operational. Because of the mechanism used to detect the flame, the reaction time of these sensors is faster and more precise than that of a heat/smoke detector.

E. Relay

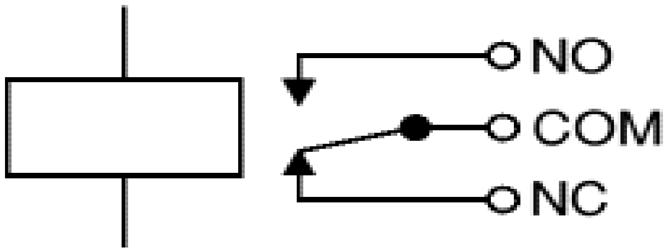

Figure 5. Relay

- A relay is an electrical switch that opens or closes a series of contacts using an electromagnet. As an electric current is transmitted via the relay's coil, a magnetic field is created that attracts a movable armature, which shuts or opens the contacts. Relays are frequently used to manage high power or high voltage circuits using low power control signals generated by microcontrollers or other electronic devices. The relay's switch connections are usually labeled COM, NC and NO:

- COM = Common, always connect to this; it is the moving part of the switch.
- NC = Normally Closed, COM is connected to this when the relay coil is off.
- NO = Normally Open, COM is connected to this when the relay coil is on

F. 16×2 LCD (Liquid Crystal Display) Module with I2C:

The 162 LCD got named as it contains 2 rows with 16 columns. The other possible combination is 82, 102, and 61, and so on. However, the most used one is 162 type LCD which is used in the proposed model. The information exchange between slaves and master takes place by I2C inter-integrated protocol. The other advantage of using I2C is that the number of required connections in the circuit can be minimized. The number of connections is to be done is 12, if you use standard LCD type whereas if I2C is used, only four connections are enough.

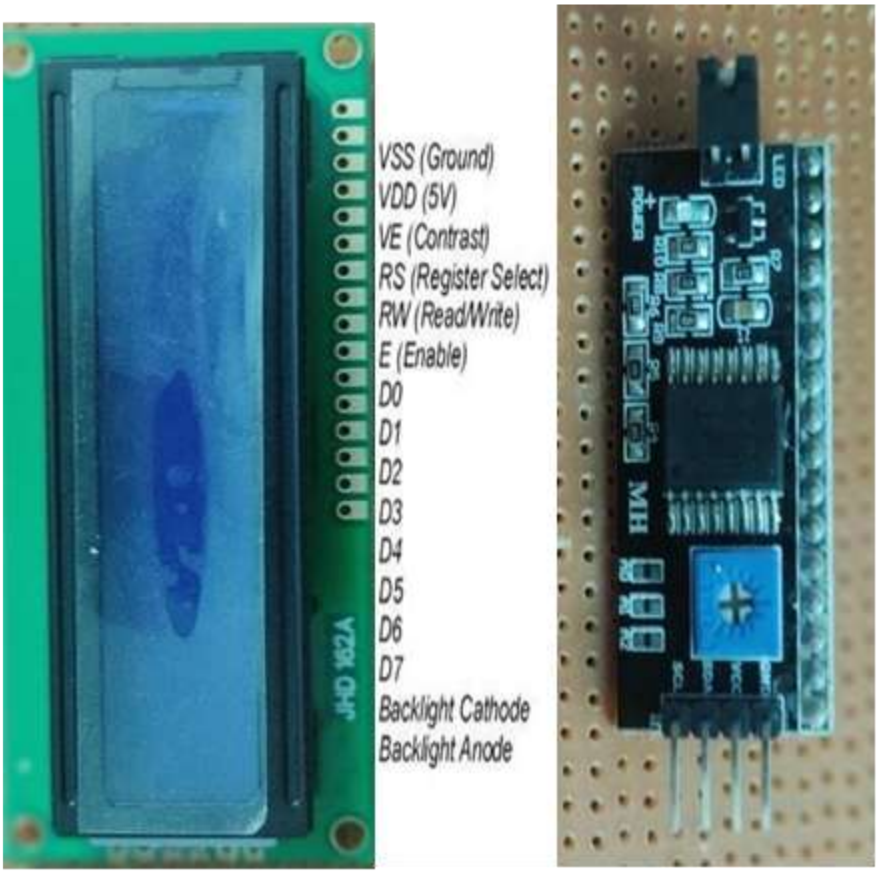

Figure 6. Pin configuration of 16X2 LCD with I2

III. METHODOLOGY

This technique main goal is to investigate the efficiency and working of the present fault detection and classification system. So, keeping all the issues in mind a prototype model is designed to handle customer problems utilizing Arduino. This prototype approach is quite good for detecting type faults and resolving them in real time. It locates the perfect distance of the fault in less time. Prevent future transmission line problems. Given the amount of time and money saved, the project's long-term effects are enormous. The project we have conducted can be utilized as a reference or as a foundation for developing a protective plan to be deployed in other higher-level transmission lines. In addition, the existing system may be configured to function remotely with traditional SCADA or other communication services like as GSM.

IV. THREE PHASE TRANSMISSION LINE FAULT DETECTION

Working Principle of proposed fault detection method:

A Three Phase Line Fault Detection is a device that offers visible and remote detection of abnormal conditions in an electrical power distribution system. While patrolling for this issue, indicator lamps on the RYB phase can identify it. In recent years, impedance relays or distance relays have been used to detect and clear the fault; however, this system takes a long time to calculate the distance using the impedance and the pre-fault current relay, and until the system reaches the fault location and repairs the faulty phase, the system is in an OFF state, and the supply to the consumers is unreliable.

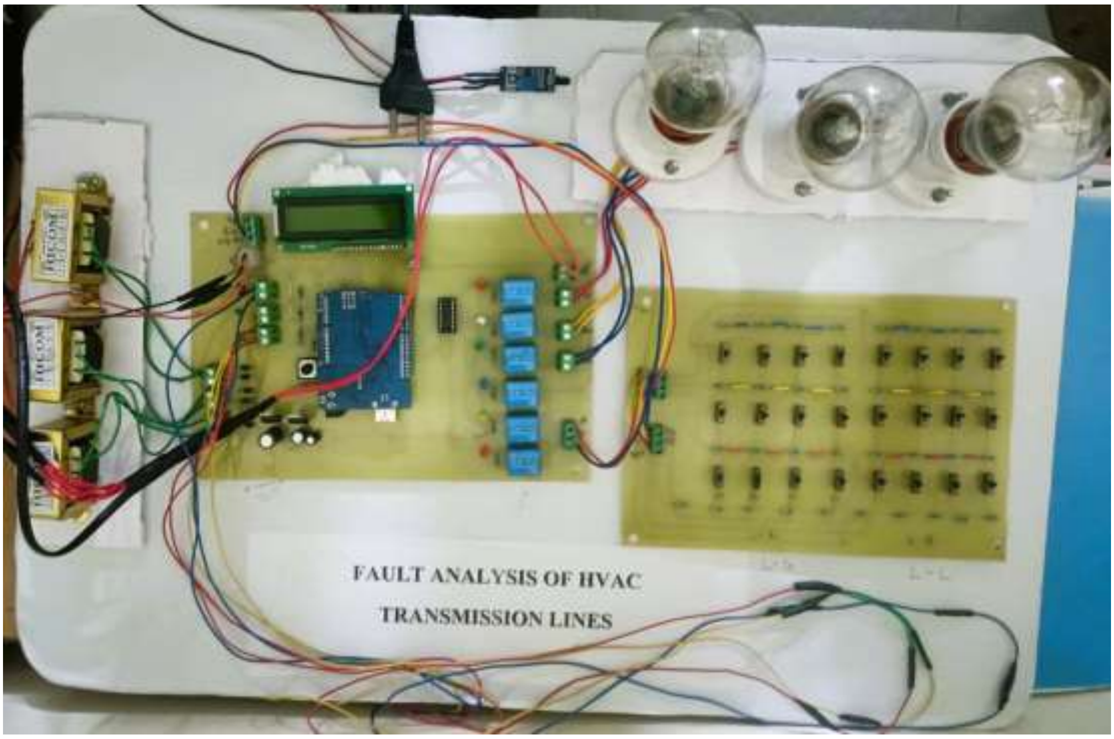

Figure 7. The designed Working Model of Fault Analysis of HVAC Transmission Lines

Faults are caused by a failure of insulation between phase conductors, between earth and phase conductors, or both. Three phases to earth, phase to phase, single phase to earth, two phases to earth, and phase to phase are all conceivable short circuit fault circumstances. The fault in a single line to ground fault occurs between any of the three lines and the ground. A fault develops between any two of the three lines and the ground in a double line to ground fault. A line-to-line fault happens when a fault occurs between any two lines. When a fault occurs, the voltage abruptly changes. If not adjusted in a timely manner, this voltage shift may cause catastrophic harm to the system. Programs placed into the Arduino UNO kit to identify underground cable failures. When a problem occurs in subterranean wires, we can locate it using an Arduino controller kit. The defects are displayed in kilometers on the LCD display. In this project, we manually created faults. The resistance value is proportional to the length of the cable. In this case, opposition is the project's driving force. If there is a divergence in the resistance, the voltage value will vary; this is referred to as a FAULT.

Using an Arduino board, the project will determine the line to line and line to ground faults. When a fault arises for whatever reason, the repairing procedure for that specific cable is challenging since the exact position of the cable defect is unknown.

The project employs the common notion of Ohms law, which states that when a low DC voltage is supplied at the feeder end via a series resistor (Cable lines), current varies depending on the position of the fault in the cable. If there is a short circuit (Line to Ground), the voltage across the series resistors changes, which is then passed to the Arduino board's inbuilt ADC to provide exact digital data for display in kilometers.

It is built with a series of resistors that indicate cable length in kilometers, and faults are generated by a set of switches at each known kilometer to ensure accuracy. The fault occurring at a specific distance and phase are shown on an LCD interfaced to the Arduino board. The goal of this project is to use an Arduino board to calculate the distance in kilometers from the base station to the line to ground line to the line fault. We utilized a flame sensor in this case. When a flame is detected, the project cuts off power to the load.

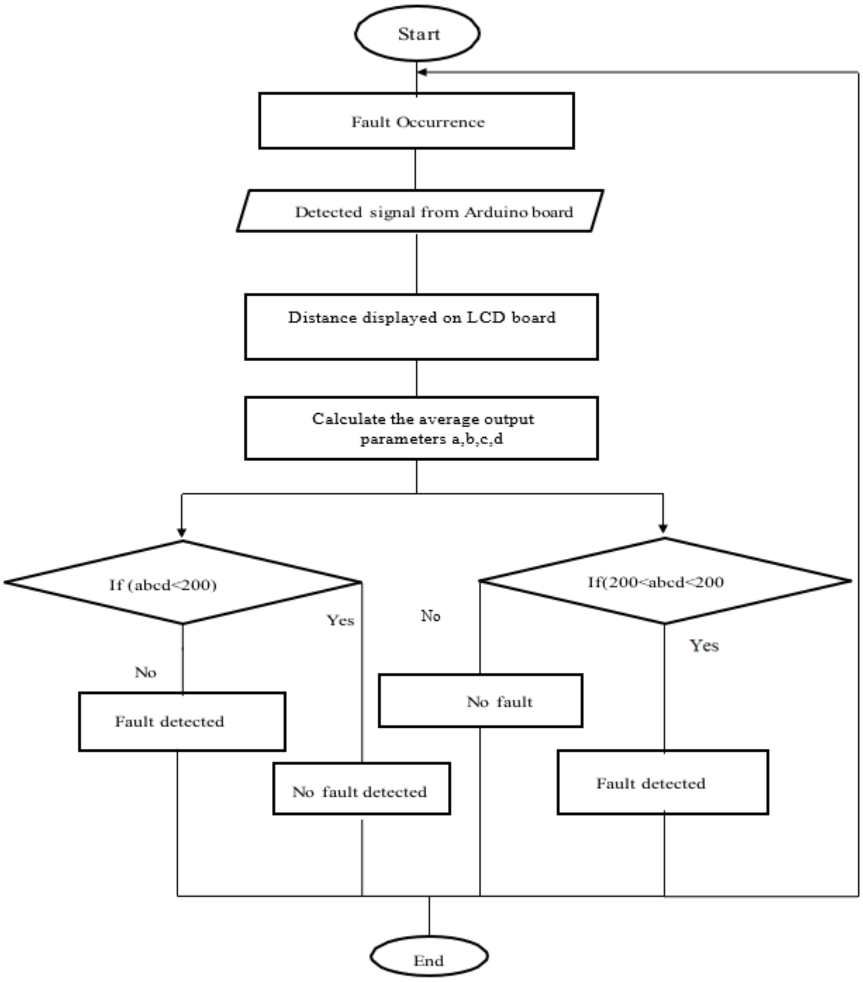

Figure 8. Fault detection System Flow Chart

The working model is based on Wavelet Transform Method. Based on this method it is simulated in MATLAB. The below is the simulation diagram of the proposed model where we create faults manually.

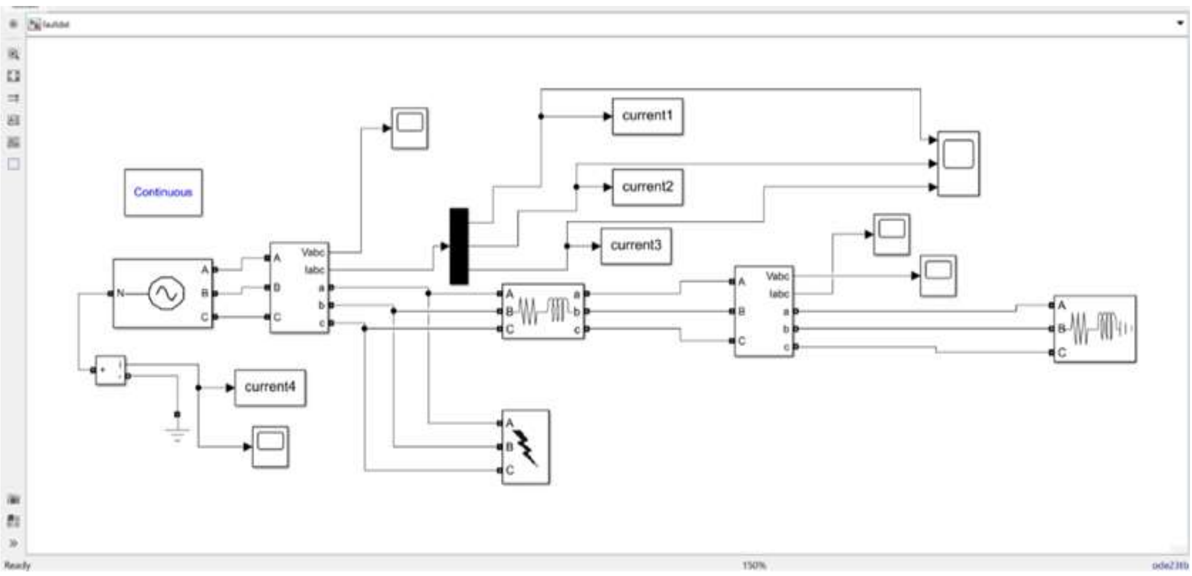

Figure 9. Simulation Diagram

V. FAULT DETECTION SYSTEMSYSTEM SCHEMATIC DIAGRAM

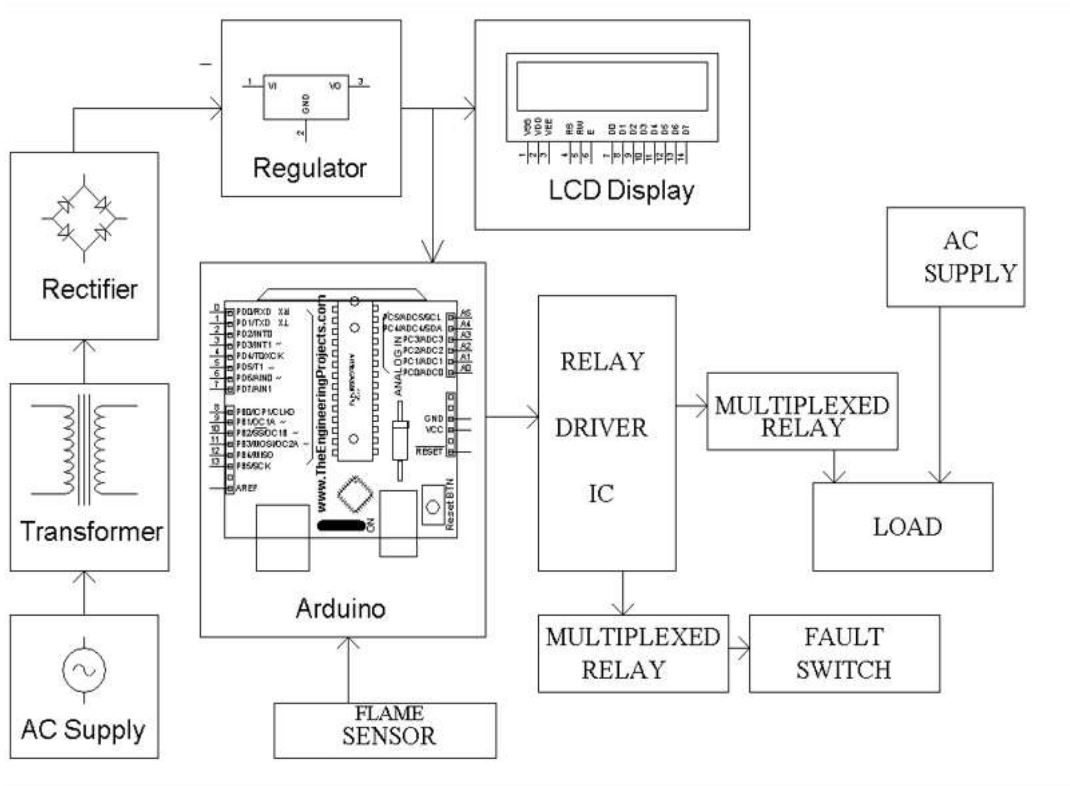

Figure 10. Fault Detection System Schematic Diagram

VI. RESULTS AND DISCUSSION:

The primary investigation of this work is to ensure the efficiency of the fault detection system gets improved. A novel method for detecting, classifying, and locating transmission line problems is proposed. WT was utilized to extract data from three-phase current waveforms and identify problem information from high frequency characteristics. Finally, the three-phase fault detection system employing the wavelet transform approach provides a dependable and effective means of detecting transmission line defects. The wavelet transform approach extracts fault-related characteristics from current signals and correctly classifies fault kinds. This approach offers several benefits, including excellent accuracy, quick processing speed, and minimal computing complexity. As a result, implementing a wavelet transform-based fault detection system can increase the power system's dependability and safety. The value of M, N, P, and Q in each fault and non-fault condition. When the faults creating in the simulation then the simulation gives the detailed coefficients (m, n, p, and q) values. Based on the q Values the faults are classified.

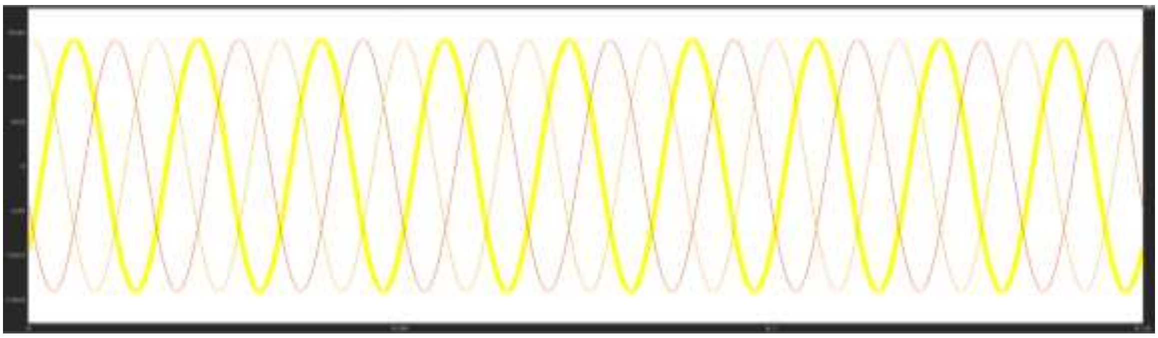

Figure 11. No fault Condition

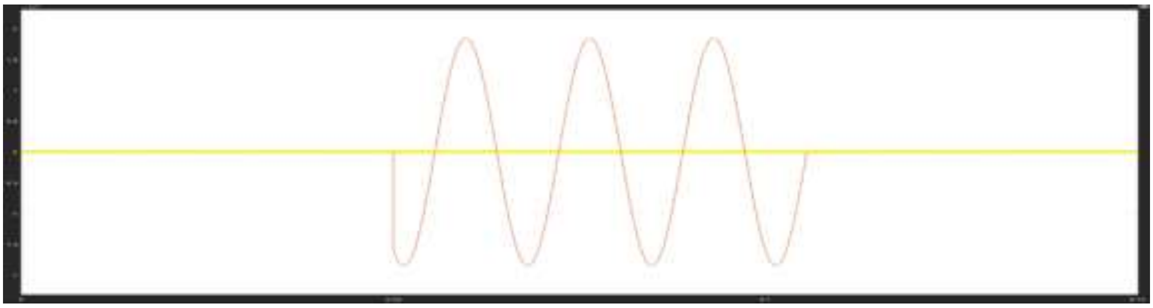

Figure 12. Y phase to Ground fault

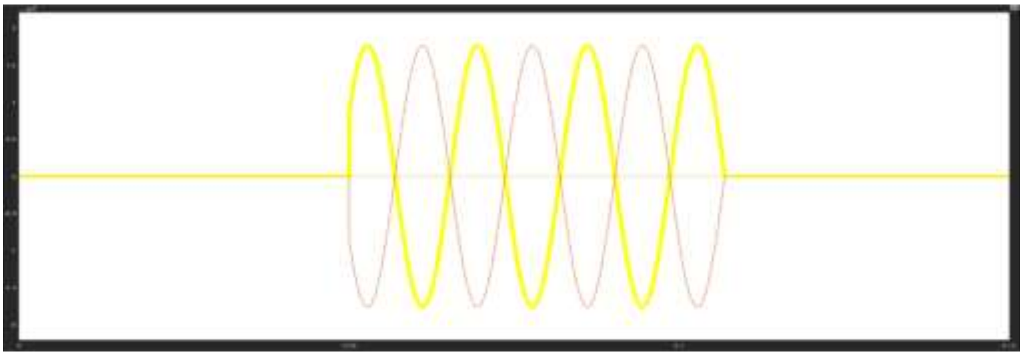

Figure 13. R phase to Y phase fault

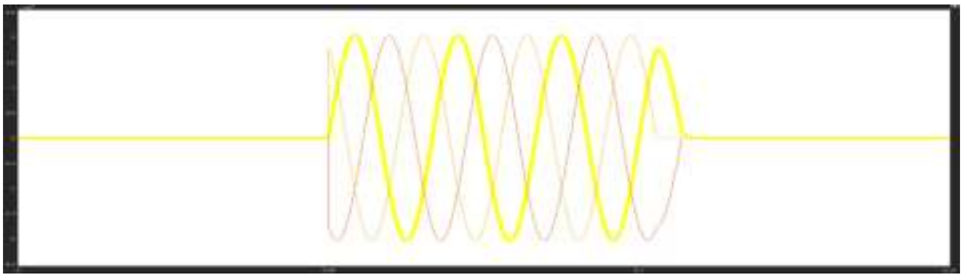

Figure 14. R Phase to Y Phase to Ground Fault

By designing the snubbers more accurately, the whole drive can be made more sophisticated. Also, by using a microcontroller the control circuit becomes simpler and the switching circuitry reduces. The inertia of the motor is not sufficient to overcome the magnetic locking of the motor under the regenerative mode, so the inertia of the motor is to be increased for better running. The simulation results are present here:

Type of Fault	**Max. Coefficient of Phase A Current**	**Max. Coefficient of Phase B Current**	**Max. Coefficient of Phase C Current**	**Max. Coefficient of Ground Current**
Three phase to ground faults	1.6097e+07	4.0725e+07	1.6097e+07	0.005
Three Phase faults	1.6097e+07	4.0725e+07	1.6097e+07	0.0081
Double line to ground faults (AB-G)	1.0796e+07	2.1332e+07	103.9772	7.757e+05
Double line to ground faults (AC-G)	1.9807e+07	103.9772	8.6730e+06	1.9393e+06
Double line to ground faults (BC-G)	103.9784	4.0725e+07	8.1478e+06	9.7619e+05
Line-to-line faults (A-B)	1.0794e+07	2.0363e+07	103.9772	0.0087
Line-to-line faults (A-C)	2.0363e+07	103.9772	8.6153e+06	0.0204
Line-to-line faults (B-C)	103.9784	4.0725e+07	7.3573e+06	0.0100

Single line to ground fault(A-G)	1.3523e+06	103.9772	103.9772	1.6087e+06
Single line to ground fault(B-G)	103.9784	3.7024e+06	134.3960	1.1253e+06
Single line to ground fault(C-G)	103.9784	103.9772	1.4099e+06	3.7023e+06
System without fault	103.9784	103.9772	103.9772	7.1737e-10

VII. CONCLUSION

A satisfactory analysis of the efficiency of a HVAC transmission line fault detection system is completed. Finally, wavelet transform-based fault detection systems have been shown to be successful in identifying many sorts of problems in complex systems. The capacity of wavelet transforms to capture transitory signal behaviour and to divide signals into distinct frequency bands makes it an appropriate tool for fault identification. Moreover, wavelet-based fault detection systems outperform traditional approaches in terms of accuracy and dependability. Nonetheless, selecting a wavelet function and threshold values for fault detection continue to be significant issues in the design and implementation of such systems. Overall, wavelet-based fault detection systems offer a lot of real-world promise in a variety of sectors.

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