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BUSITEMA UNIVERSITY

FACULTY OF ENGINEERING

DEPARTMENT OF ELECTRICAL ENGINEERING

FINAL YEAR PROJECT REPORT

2023/2024

**DESIGN AND DEVELOPMENT OF AN OVERHEAD TRANSMISSION LINE FAULT
DETECTION SYSTEM INTEGRATED WITH A GSM MODULE.**

BY:

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BU/UP/2020/1240

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**Final Year Project Report Submitted to the Department of Electrical Engineering in
Partial Fulfillment of the requirements for the Award of Bachelor of Science in Electrical
Engineering Degree.**

JUNE 2024

DECLARATION

I, WANJA BRIAN, Registration Number BU/UP/2020/1240, under the supervision and guidance of the University supervisors, declare that this report is my own work, and that the information gathered and used has not been used to obtain any academic award in any other learning institution, with the exception of extracts and summaries for which the original references are stated here.

Signature:

Date: ..3rd/07/2024....

APPROVAL

This is to certify that WANJA BRIAN created this report and submitted it for scrutiny. With my permission as a university supervisor, it is now ready for submission to the Department of Electrical Engineering.

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Signature:

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Date:

.....24/06/2024.....

DEDICATION

I dedicate this report to the special people in my life who, with or without my knowledge, have made substantial sacrifices to assist me get here. I am especially grateful to my beloved dear ones, Mr. and Ms. Maiki and Mr. and Ms. Muhwezi, for their words of support and push for persistence. My colleagues and supervisors have never left my side and are incredibly special. May God definitely bless them.

ACKNOWLEDGMENT

First and foremost, I'd like to thank the Almighty God for allowing me to reach this point in my academic career despite various obstacles.

Second, I'd like to thank our supervisors, Dr. Mirondo Godfrey and Mr. Rwendeire Andrew, for their ongoing supervision, support, and advice, which has resulted in the prompt submission of this study report.

I'd want to thank my coworkers for their persistent encouragement when I felt like giving up.

Finally, I'd like to thank my parents and guardians, who have always been financially supportive and never disappointed me.

ABSTRACT

The goal of this project is to create an improved fault detection system that will increase the efficiency and dependability of Uganda's power transmission networks. With the help of this project, frequent power outages and fault management inefficiencies will be lessened. A system that can identify issues with overhead transmission lines and report the findings via GSM technology will be made possible. The system uses sensors, microcontrollers, and GSM modules to monitor transmission lines for defects such as line breaks, short circuits, and grounding difficulties. Fault detection units are strategically located along transmission lines to continuously monitor electrical parameters and environmental conditions. When a malfunction is identified, an embedded microprocessor processes the data and activates the GSM module, sending an SMS alert to the maintenance crew. This warning contains detailed information about the fault's location and nature, allowing for timely and targeted maintenance interventions.

The project includes hardware and software development. The hardware design comprises selecting and integrating sensors, microcontrollers, and GSM modules that are appropriate for Uganda's ambient conditions. On the software side, essential components include programming the microcontroller for fast data processing and fault detection, as well as establishing the GSM module's connection protocol.

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LIST OF ACRONYMS

AC	Alternating current
BTN	Button
DC	Direct Current
FPI	Fault Passage Indicator
GSM	Global System for Mobile Communication
L-G	Line to Ground
L-L	Line to Line
LCD	Liquid Crystal Display
RF	Radio Frequency
SIM	Subscriber Identity Module
SMS	Short Message Service

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CHAPTER ONE: INTRODUCTION

1.1.BACKGROUND

For the previous number of years now, power supply networks are developing continuously and their reliability getting more significant than ever. The complexity of the whole network comprises a number of components that can fail and interrupt the power supply to the end user. For most of the worldwide low voltage and medium voltage distribution lines, overhead cables have been used for many decades, however they are being influenced frequently by heavy rains, storm, and pollution causing electric faults. Faults in overhead lines can be classified into open circuit fault, over voltage faults, under voltage faults

1.2 PROBLEM STATEMENT

The overhead lines are exposed in air, they become susceptible to physical damages caused by wind or birds which turn into electrical faults. On other hand the end user may lead to the faults for example over loading or poor connections. Theses faults may cause the overhead line to burn, burn the fuse and the fuse dropout links leading to massive damage if not earlier detected.

In order to tackle the above problem, we designed a system that can detect a fault and send a message to the service line for the fault to be easily solved hence reducing massive damages. The

message will entail the type of fault and the coordinate of that place as predetermined by the service provider.

1.3 OBJECTIVES

1.3.1 General Objective

To design and develop an overhead transmission line fault detection system with GSM for communication alerts.

1.3.2 Specific Objectives

- To study and understand the hardware components of the overhead transmission fault detection system.
- To develop the software algorithm for the overhead fault detection system.
- To integrate the GSM into the fault detection system to enable SMS alerts.
- To test and validate the proper functionality of the system.

1.4 RESEARCH QUESTIONS

- What are the key components required to design an overhead transmission fault detection system?
- What software algorithm is required for the overhead transmission fault detection system to detect faults?
- How can a GSM be integrated into the fault detection system to enhance communication?
- How accurate and reliable is the fault detection system in detecting faults and sending alerts?

1.5 PROJECT SIGNIFICANCE

Fault detection in overhead transmission lines is critical for ensuring the dependability and safety of power systems. Quick defect detection reduces downtime, avoiding massive power outages and lowering economic losses. It also reduces safety risks such as electrocution and fires by quickly isolating afflicted areas. Early detection enables proactive repair, which increases infrastructure lifespan and lowers maintenance costs. Furthermore, it aids in grid stability by preventing voltage swings and potential cascade failures. Analyzing fault data provides insights for improving system resilience and meeting regulatory requirements. This project will either be a standalone or set to

coordinate with other protection systems so as to ensure a high degree of reliability by monitoring efficient protection of all zones of the overhead lines. It will be able to initiate the required action to discriminate between the load and fault conditions very quickly as well as warning about possible faults so as to ensure early maintenance and minimize disruptions to the overall network operation.

1.6 SCOPE

1.6.1 Technical scope.

The scope of this project included the design and development of an overhead fault detection system that detects and displays the fault and sends a message having location details and the type of the fault, including the hardware and software components. The project was tested and validated.

1.6.2 Geographical scope

This is to be implemented in Uganda.

1.6.3 Time scope.

The design and implementation took three months.

1.7. CONCEPTUAL FRAME WORK

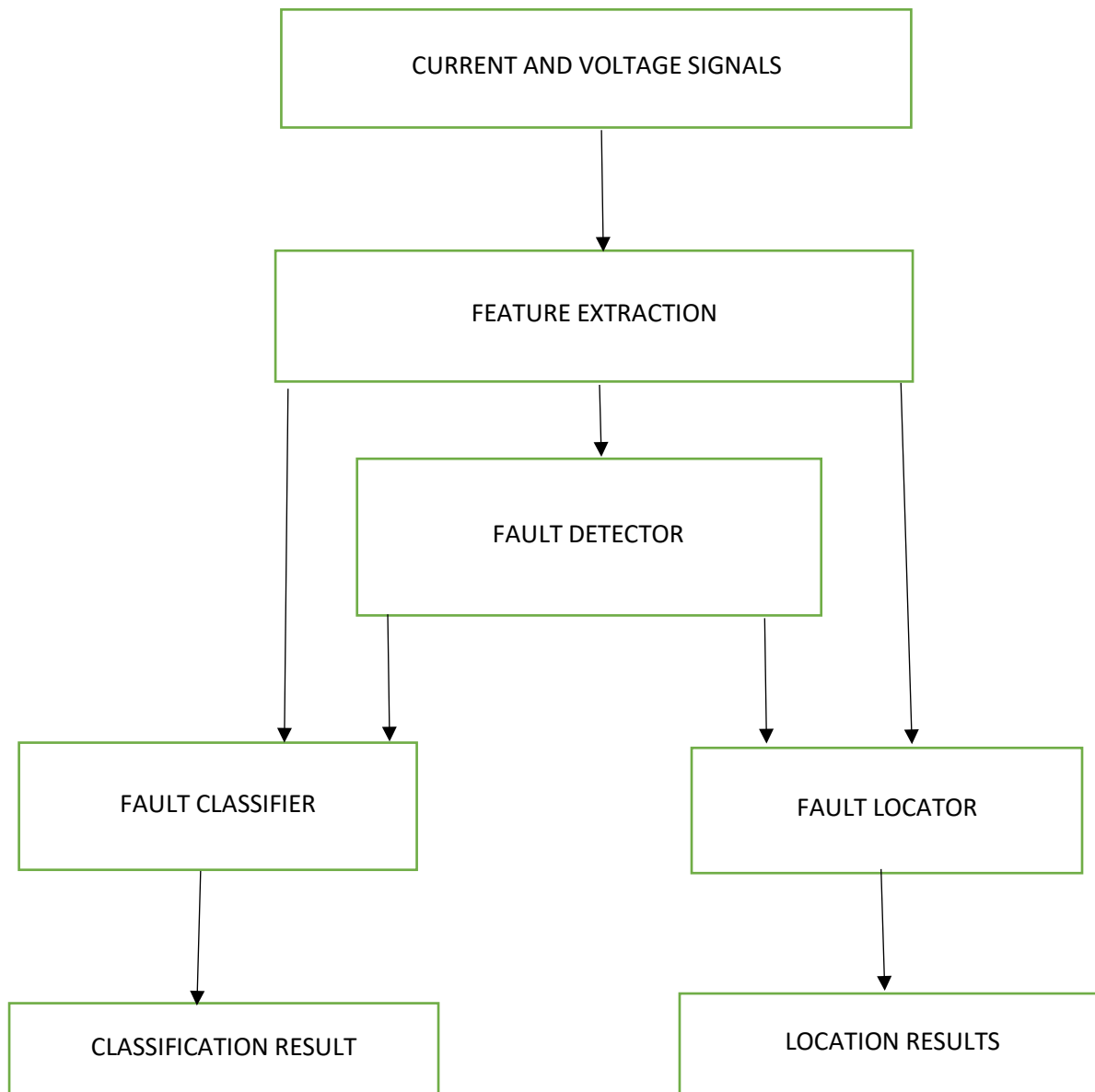


Figure 1 conceptual frame

CHAPTER TWO: LITERATURE REVIEW

2.1. Theoretical review

In overhead line Fault Passage Indicator (FPI) is a device used in electrical power distribution systems to detect and locate faults on power lines. When a fault occurs, such as a short circuit or a power outage, the FPI detects the resulting change in current and transmits a signal to a central control system. It works by detecting changes in the current flowing through a power line. When a fault occurs on the line, such as a short circuit, ground faults, load interruptions or an overcurrent, the current level changes. The FPI detects this change in current and triggers a signal that indicates a fault has occurred [1]. One of the draw backs of a fault passage indicator is that its unable to detect switch-onto-faults.

An overview of impedance- based fault location techniques in electrical power transmission network. The impedance-based method uses phasor voltages and currents captured by fault recorders and known system parameters of the line to calculate the fault location. Fault location techniques reviewed include the variance-based sensitivity method, the one ended impedance method such as Takagi method, Modified Takagi method, Erikson method, the two-ended impedance-based method (synchronized and unsynchronized) two-ended method and unsymmetrical current-only two-ended method. The results show that the simple reactance technique is the simplest of all the impedance - based fault location techniques. The fault resistance and the load current make the technique to deteriorate in accuracy. The Takagi method was developed to correct these lapses because of its robustness to load and sensitivity. [2]. The fault resistance and the load current make the technique to deteriorate in accuracy.

The traveling wave method utilizes high frequency electromagnetic impulses generated by sudden change in voltage and current caused by a fault. These waves propagate away from the fault in both directions and travel along transmission lines until eventually attenuating. The traveling wave method uses the time stamp of the arrival of these waves to busses with appropriate fault locators along with line characteristics to calculate the distance to fault. The two main traveling wave fault location algorithms include the single-ended method and the double-ended method [3]. Though traveling wave propagation along transmission lines can be affected by system parameters and

network configuration [4] and traveling wave methods can be difficult to use to locate faults near busses and faults with 'near-zero' fault inception angles [5].

Distributed Device Based Methods, type of knowledge-based technique is distributed devicebased methods for locating fault [6]. Presents a mathematical approach that locates faults based on installed voltage sensors' information and the network's topological structure. The relation of the voltage sensors with sections was formulated as a matrix. The other matrix was constructed based on the topological relation between sections and nodes in an electric network. Through some matrix operations, all faulted sections could be found.

The hybrid methods that locate faults based on more than one algorithm to achieve a more accurate estimation of the faulted section. [7] proposed a hybrid method that computed the fault distance using measurements available at the substation. They used post-fault values of current or voltage to reduce the multiple estimation problems induced by the existence of multiple fault points in the network. To identify the actual fault location, a fault diagnosis procedure was applied to rank the list of multiple potential fault locations. By doing a circuit simulation, the operation of a particular combination of protective devices and the load change pattern during different fault scenarios could be obtained. Then by matching the fault situation to these scenarios, the actual faulted section could be determined.

Power needs to be transmitted from the power station to the load centers located far away [8]. So, the possibility of fault in the transmission lines is considerable. Here, comes the use of signal processing in the digital distance protection. Fourier transform and wavelet transforms are used for locating faults. Simulation is done with MATLAB/SIMULINK. Simulation result shows that wavelet method is more robust tool to locate the faults in the transmission lines. Further it is showed that both wavelet transform and Fourier transform methods can be used to find the characteristics of disrupt signals irrespective of the noise levels present. Noise in overhead transmission line signals, such as electromagnetic interference or environmental disturbances, can degrade the accuracy and reliability of defect detection with wavelet transforms.

In [9], wireless sensor network is used for detecting and locating the failure in the power line. In this paper, the power transmission line is divided by wireless sensor networks. Periodically, it

measures the energy difference and deviation any is informed to the concerned officials. This proposed system is especially used for detecting asymmetrical faults. Wireless sensor network face constraints such as power, space, and processing power, which can limit the longevity of sensor nodes

In [10], Artificial Neural Network is used for power failure detection. But neural network requires training and the training may not be fully done. In [11], Support Vector Machine (SVM) is used for training data. In [12], surveys of most papers concerned with power transmission failure are surveyed. From the above survey it is inferred that the most of the proposed methods are using GSM-SMS as the communication medium. Along with this, the interruption caused by the nature in sensing the required information by the sensor is not dealt with. Also, artificial intelligence technique used requires training data which is difficult to get the actual data, also the output of the system solely depends on the training set.

2.2. TYPES OF FAULTS

In power system two broadly classification of faults is;

- Symmetrical faults
- Unsymmetrical faults

2.2.1. SYMMETRICAL FAULTS

A three-phase fault is called a symmetrical type of fault. In a three-phase fault, all the three phases are short circuited. There may be two situations –all the three phases may be short circuited to the ground or they may be short circuited without involving the ground. A three-phase short circuit is generally treated as a standard fault to determine the system fault level.

2.2.2. UNSYMMETRICAL FAULT

Single phase to ground, two-phase to ground, phase to phase short circuits, single phase open circuit and two-phase open circuit are Unsymmetrical types of faults.

Single phase to ground (L-G) faults

A short circuit between any one of the phase conductors and earth is called a single phase to ground fault. It may be due to the failure of the insulation between a phase conductor and the earth, or due to a phase conductor breaking and falling to the ground.

Two-phase to ground (2L-G) fault

A short circuit between any two phases and earth is called a double line to ground or a two phase to ground fault.

Phase to phase (L-L) fault

A short circuit between any two phases is called a line to line or phase to phase fault.

Open circuited phases

This type of fault is caused by a break in the path, such faults occur when one or more phase conductors break or a cable joint or a joint on the overhead lines fails, such situation may also arise when circuit breakers or isolators open but fail to close one or more phases. Due to the opening of one or two phases, unbalanced currents flow in the system, thereby heating rotating machines.

Protective schemes must be provided to deal with such abnormal situations.

CHAPTER THREE: MATERIALS AND METHODOLOGY

3.1 MATERIALS

The materials required for building this system include;

- Current sensors. □ Voltage sensor.
- A GSM module
- Micro controller.
- LCD display
- Connecting wires
- Relay

3.2 METHODOLOGY

In this chapter we have documented on how we achieved our specific objectives, techniques we employed and the tools that we used to develop the prototype of this overhead fault detection system.

This involved designing the hardware and software components of the system, assembling the components, testing and validating its accuracy and reliability.

3.2.1. SYSTEM STUDY AND ANALYSIS

These are steps, approaches, strategies, techniques, tools we used to execute this project right from the beginning up to presentation of results. Specifically, we followed specific steps, approaches, strategies, techniques and tools in order to execute/accomplish the specific objectives.

3.2.1.1. Document review

This involved searching related literatures on the research topic that we were undertaking and this guided us on what to do so as to make improvements on existing systems. It was a very key aspect of system study. Reviewing some of the documents coming from newspaper articles, journals, books provided a lot of information on the different kinds of system.

3.2.1.2. Documentaries and Videos

Most of the different systems that are written in our literature review have videos, tutorials and documentaries, and this was of great importance in helping us have a broader idea on those systems.

3.2.1.3. Consultation

Several consultations from our project supervisors and other lecturers provided technical support. Also discussing this project with our fellow colleagues gave us a broader understanding of what is required of us.

3.2.1.4. Internet

The internet is a source of relevant information and data, literature about existing systems such as those mentioned in the literature review. The information obtained from such documentation was necessary for the identification and analysis of the requirements needed to accomplish the system.

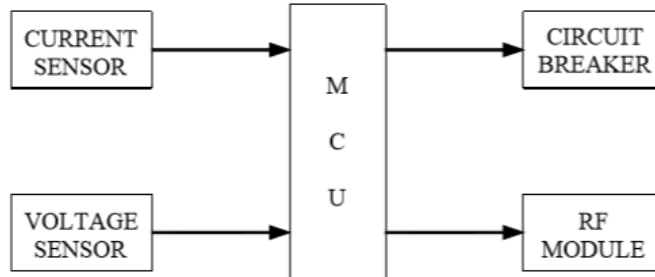
3.2.2. SYSTEM CONSTRUCTION

The system is used to detect fault and send a SMS alert using the GSM network once the fault is detected with its location. The microcontroller which serves as the heart of the entire system enables access to real time state of the system. It receives the perceived parameter during power transmission, detect breach in short circuit limit set by comparing the current sensed with the preset limit. If the current sensed is more than the pre-set current short circuit limit, the microcontroller sends a signal for the relay to trip off the system, else the system remains connected. When the relay trips of the system, an SMS alert is sent to the utility mobile phone via the GSM network. The GSM module and liquid crystal display (LCD) module are also connected to the microcontroller. The LCD module displays the parameters being monitored in the system, they include; the temperature, frequency of the supply, voltage, current the power consumed by the load in the system.

There are two systems, one at the line and the other in the service room as represented in the block diagram below;

3.2.2.1. SYSTEM BLOCK DIAGRAM

LINE MONITOR SYSTEM



CENTRAL CONTROL SYSTEM

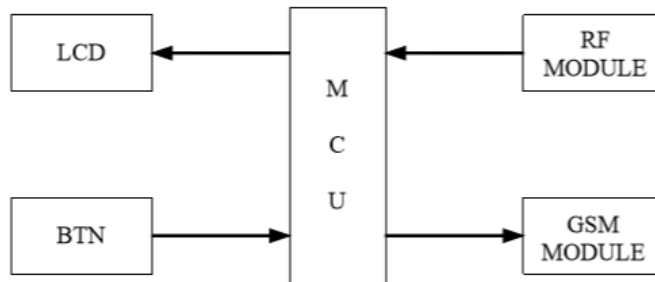


Figure 2 Block diagram

The Arduino is programmed using the C language.

3.2.2.2. The communication system

The GSM modem is a wireless modem that works with a GSM wireless network. Unlike the dialup modem, the GSM modem sends and receives data through waves. It requires a SIM card from a wireless network carrier to function. Whenever the set threshold is bridged, the system sends an instant message to the utility mobile phone, stating the existing fault using the GSM modem.

Operation of the GSM

GSM Modems are controlled by the microcontroller using the AT commands. However, the GSM modem supports a fixed and extended set of AT commands. Defined in the GSM standards are these extended set of AT commands which enables the following functions;

- Send SMS messages.
- Reading, writing and searching phone contacts.
- Monitor signal strength.
- Read, write and delete SMS messages

3.2.2.3. The switching device relay

The relay acts as an electrical disconnection to isolate the entire system on the occurrence of fault. It shut down or de-energizes other electrical equipment in the system, which will then allow work to be carried out further down the line. As an electrical device for automatic control, it is actuated by variation in the conditions of the electrical circuit.



Figure 3 relay [13]

3.2.2.4. The sensing unit

The sensing unit consists of the voltage sensing, the current sensing, as it helps to acquire electrical parameter and make the respective signals available for the micro controller to process.

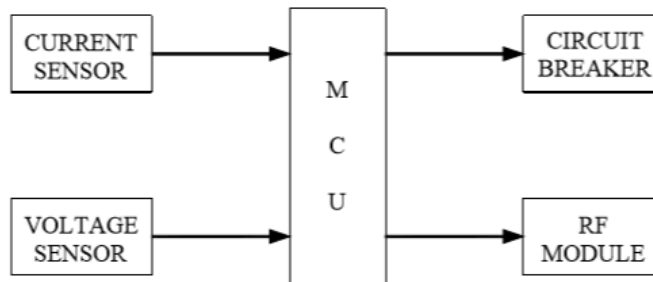
CHAPTER FOUR: SYSTEM DESIGN.

4.0. Introduction

System design is the most crucial and important part of the project as it requires an individual to come up with the blueprint (in this case a block diagram and the circuit diagram) upon which the prototype of the system is to be developed.

Block Diagram

LINE MONITOR SYSTEM



CENTRAL CONTROL SYSTEM

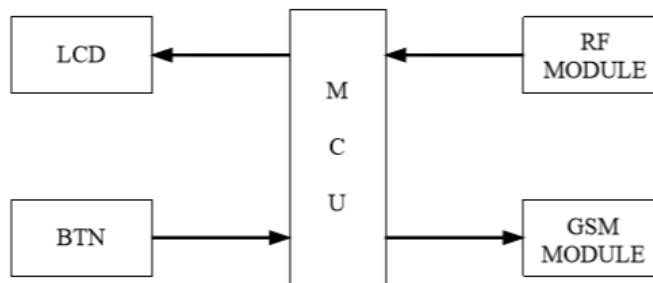


Figure 4 Block diagram

Line monitor system

The line monitor block has the current sensor, voltage sensor, circuit breaker, RF module all of are connected to the microcontroller. The microcontroller section is basically the brain of the system. Here in this block, there is an Arduino board that carries an ATmega328P microcontroller that has been given a set of instructions that give the system commands on how to relate different components within the system.

The voltage sensor measures, calculates, and determines the voltage supply. This sensor can detect the AC or DC voltage level. This sensor's input can be a voltage, and its output can be switches, analog voltage signals, current signals, audio signals, and so on. The current sensor measures the current of the line. The circuit breaker is used for breaking while the RF module is used for communication with the central control system.

Central control system

The central control block has a microcontroller, GSM, LCD, BTN, RF module. The LCD is used for displaying the information from microcontroller. GSM module then sends the message alerts to the concerned parties in case of faults. The BTN is used to switch on the system. The RF module is use to transmit or/and receive signals between the two systems.

Circuit diagram

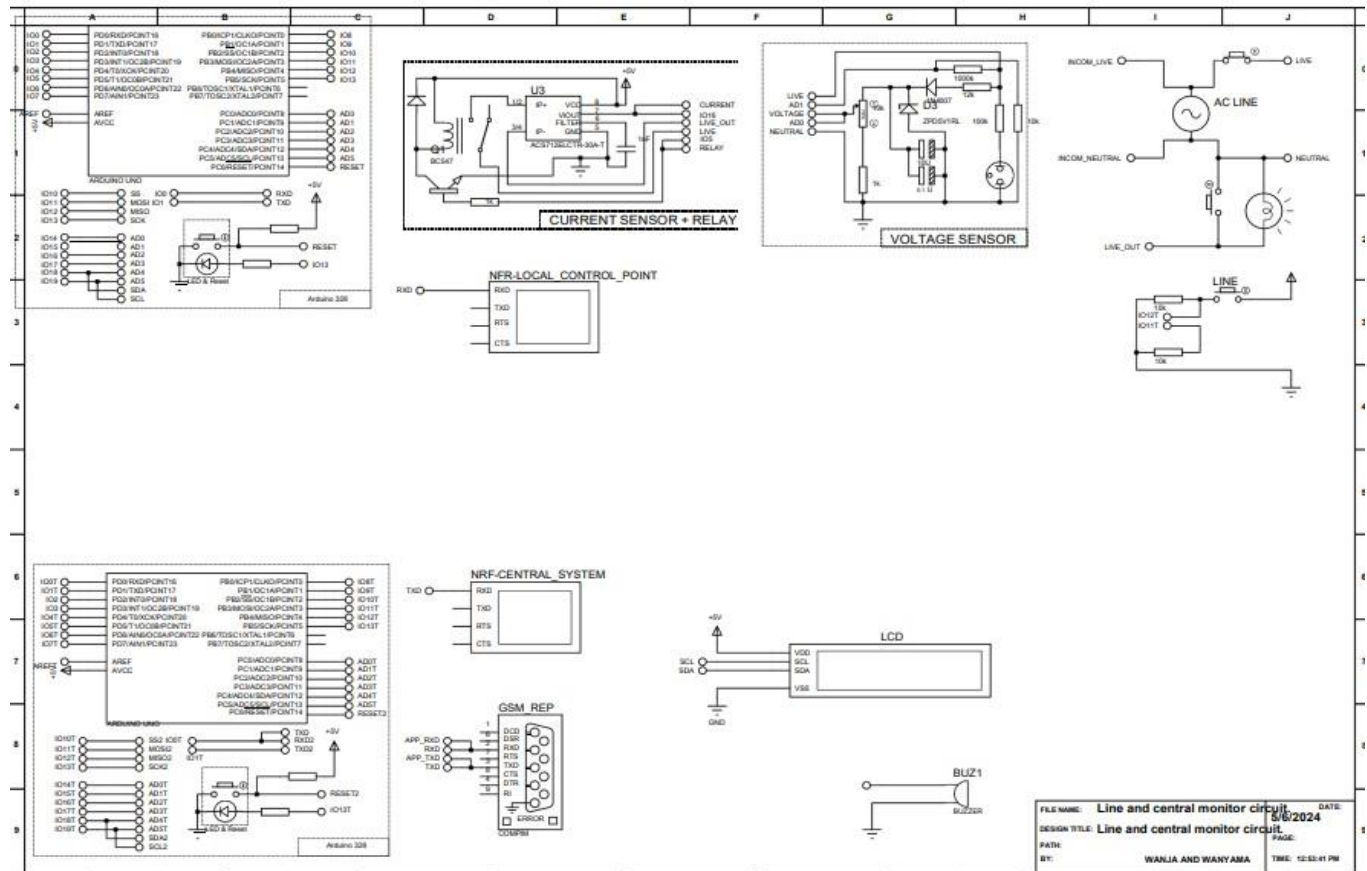


Figure 5 Circuit diagram

According to the schematic diagram above, our system includes the following essential components: a 240V power supply, two microcontrollers, an RF module, a relay, a GSM module, an LCD screen, a voltage sensor, a current sensor, a power supply, a voltage regulator, and others. The 240V power supply is directly linked to the current sensor, voltage sensor, relay, and power supply, as illustrated. The power supply unit steps down the 240V to 12V, which is then delivered to the voltage regulator, which delivers 3.3V and 5V to the RF module and microcontroller,

respectively. The RF module is used to communicate with the central monitoring system, which includes an LCD screen, a GSM module, and an RF module all connected to the microcontroller. For the case of the line monitor system the current and relay are connected to pins IO16 and IO5, the voltage sensor is connected to pins AD1 and AD0 of the microcontroller.

For the case of the central monitor system, the LCD screen is connected to the ground, 5V VCC supply, SCL and SDA pins of the microcontroller, RF to TXD, GSM to RXD and TXD pins as indicated on the schematic diagram

System Flowchart

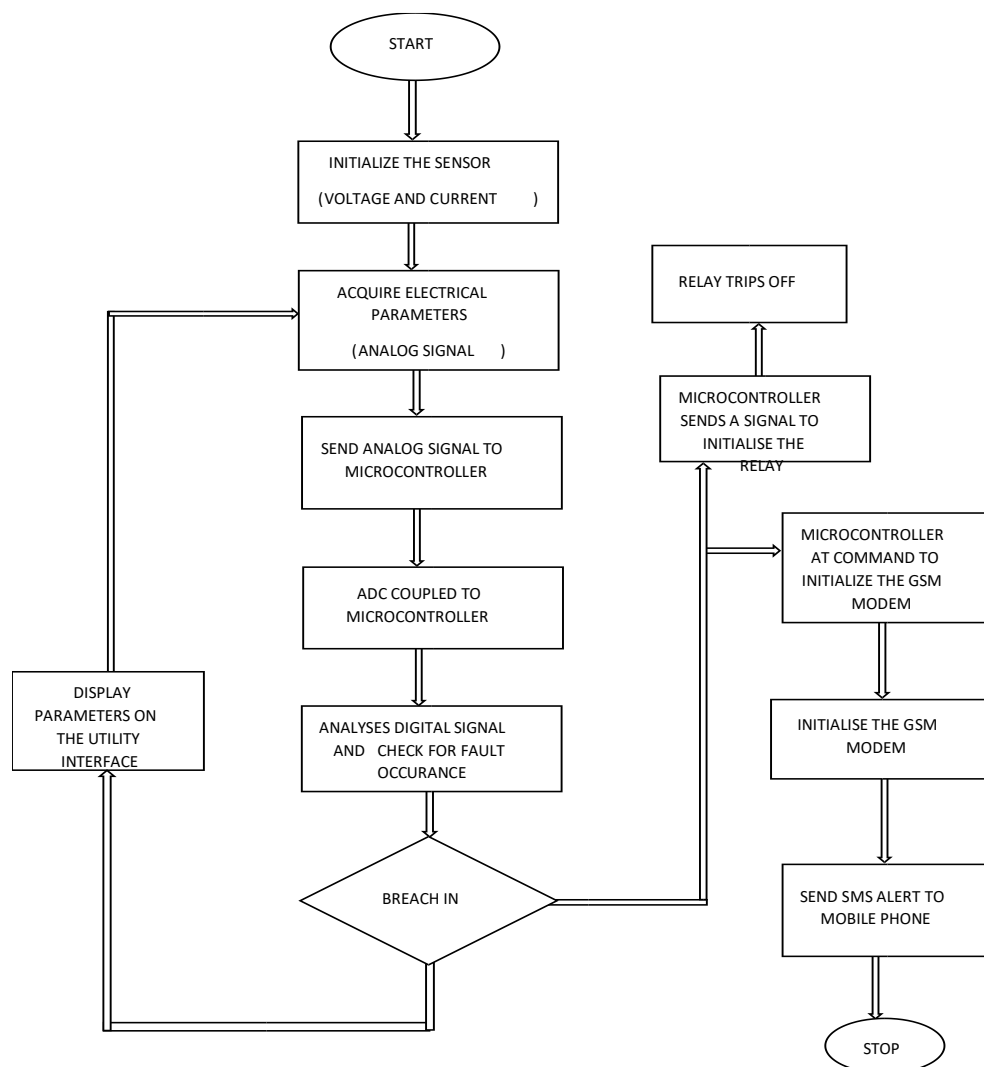


Figure 6 Flow chart

The flow chart below shows how the system is used to detect fault and send a SMS alert using the GSM network once the fault is detected. The microcontroller which serves as the heart of the entire system enables access to real time state of the system. It receives the perceived parameter during power transmission, detect breach in Over voltage, under voltage, overload and short circuit limit set by comparing the voltage and current sensed with the pre-set limit. If the voltage or current sensed is more than the pre-set limits, the microcontroller sends a signal for the relay to trip off the system, else the system remains connected.

When the relay trips off the system, an SMS alert is sent to the utility mobile phone via the GSM network. The GSM module and liquid crystal display (LCD) module are also connected to the PIC microcontroller. The LCD module displays the parameters being monitored in the system, they include; the voltage, current and the status of the line.

Once the fault is attended to, the system restores to normal operation.

CHAPTER FIVE: SYSTEM IMPLEMENTATION AND TESTING

5.1. System testing and Validation

Testing in electronics is an evaluation of the parametric, functional or timing performance of components when electrical power is applied. The reason to have electrical tests was to find out electrical malfunctions or operations outside of the desired electrical limits.

However, on carrying out electrical tests we got to discover that all the components were working within the desired ranges. These tests were also carried out to ensure that requirements of the system were met so as to perform exactly what was expected of the project. Several test equipment was used such as the multimeter, tape measure, and all these tests were carried out in order to try to meet the set requirements in the scope of the project **Component testing**

Digital multimeter

A multimeter is a testing tool that can measure two or more electrical values. It was used to measure voltage (volts), current, resistance (ohms), and to check continuity. We used a multimeter to measure the voltage supplied to various components, and the voltages were all within the required ranges, which will be tabulated below.

Measured voltage during system testing

Table 1: Measured voltages

Component	Voltage
Microcontroller	5V
buzzer	5V
GSM module	5.70
RF module	3.3V
LCD	5V
Power supply	Output 12V
Voltage regulator	3.3V to 5V

Block testing

Block testing is basically running a test to check the functionality of the system's entire block. This allows for rapid troubleshooting to determine which block is not serving its intended purpose. This system consists of two functional blocks: the line monitoring block and the central monitoring block. As a result, we had to do broad tests to determine whether each block was functioning properly.

Line monitor block testing

The line block consisted of a current sensor, voltage sensor, relay and the RF module all of which were connected to the microcontroller (brain of the line block). When these individual components were connected and tests run, all of the modules were functional, for example the voltage and current were measured and the RF module was able to communicate with the central monitoring system for the currents and voltages less than the set values, the relay would not break the line. for the currents and voltages beyond the set values the relay would break the line and this information was sent to the central monitoring system.



Figure 7 LCD display at central monitoring point

Central monitor block testing

The central block consisted of the LCD, power button, RF module, GSM module all of which were connected to the microcontroller. When these individual components were connected and tests run, all of the modules were functional, for example the message was displayed on the LCD and the person in charge was able to receive the SMS message on their phone showing whatever was

displayed on the screen. This information was sent to the central monitoring block by the line monitoring system

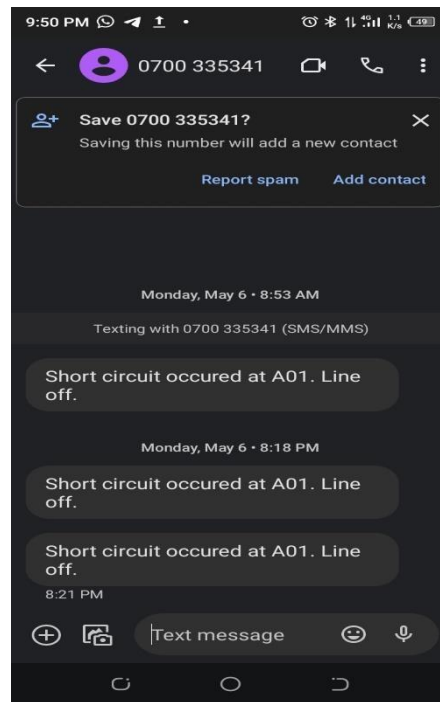


Figure 8 SMS message on phone

Final prototype testing

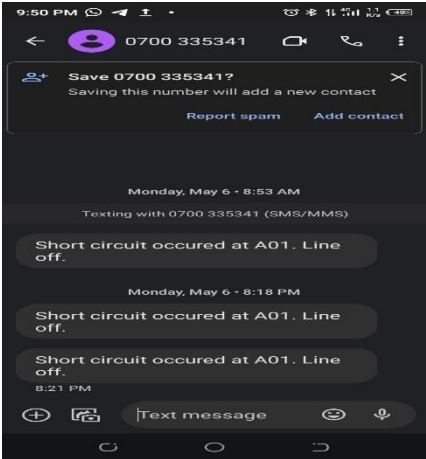
Prototype testing is the practice of evaluating a prototype in a real-world context to confirm design decisions before development begins. The goal was to identify problems and opportunities for improvement early on so that we could make the necessary modifications before beginning development and create a product that satisfies the needs and expectations of our users.

Under prototype testing, we sampled the prototype under two conditions:

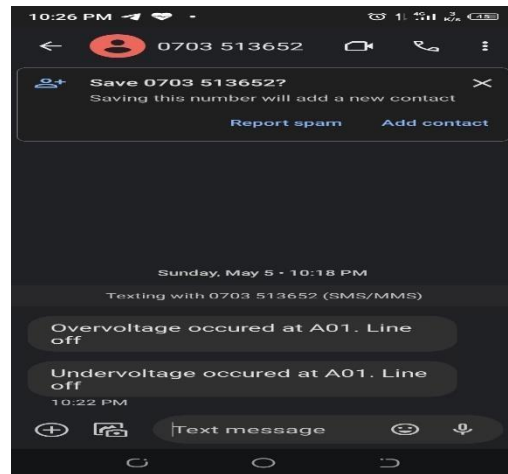
First, we used a laptop which required current less than 10A and the system was on normal progress.

Secondly, we used a coil rated at 2880W. The set value in the code was 10A, thus anything above 10A was considered a problem and referred to as overcurrent, and the RF module in the line monitoring system sent the signals to the central control monitoring system, which then sent a message to the person in charge. The relay was also opened.

Table 2: Prototype testing

Activity	LCD /SMS
When the current is beyond the set value(overcurrent) the message is displayed on the LCD screen in the monitor system and SMS alerts sent to the person in charge meaning there is a fault on the line	 The screenshot shows a text conversation on a dark-themed mobile interface. At the top, the contact is '0700 335341'. A system message asks to 'Save 0700 335341?'. The conversation history shows three incoming messages from the contact, all stating: 'Short circuit occurred at A01. Line off.' The messages are timestamped 'Monday, May 6 - 8:53 AM', 'Monday, May 6 - 8:18 PM', and '8:21 PM'. The bottom of the screen shows a 'Text message' input field with icons for attachments, emojis, and sharing.
When the current is normal, the message is displayed on the LCD screen and no message is sent to the person in charge meaning there is no fault on the line	 The photograph shows a small, rectangular green LCD screen mounted on a green printed circuit board (PCB). The screen displays four lines of white text: 'Current: 25A', 'Voltage: 21423V', 'line A01: ON', and 'No Fault'. The PCB has several gold-colored pins and components visible around the screen.

When the voltage is beyond or below the set value on the line, this message is displayed on the LCD screen in the monitoring system and SMS alerts sent to the person in charge meaning there is a fault on the line



CHAPTER SIX: CHALLENGES, RECOMMENDATION AND CONCLUSION.

CHALLENGES

Variability in Environmental Conditions: Transmission lines are exposed to varying environmental conditions such as weather, temperature, and humidity, which can affect the performance of the fault detection system.

Integration with Existing Infrastructure: The fault detection system must be integrated with existing infrastructure, including the transmission line itself, substations, and control centers. This integration can be challenging due to the complexity of the systems involved

Cost and Economic Considerations: The cost of developing and implementing a fault detection system must be balanced against the potential economic benefits of reducing downtime and maintenance costs. This requires careful consideration of the system's cost-effectiveness

RECOMMENDATIONS

Real-Time Monitoring: The system should be able to detect and respond to errors in real time, allowing for speedy maintenance and reducing downtime.

Integration with Existing Infrastructure: The system should be built to smoothly interact with existing infrastructure, including as the transmission line itself, substations, and control centers.

Cost Effectiveness: The system should be cost-effective, decreasing the economic load on the power system and its users.

CONCLUSION

It was possible to create a fault detection system by communicating via the GSM wireless network. The system designed was capable of detecting transmission faults, hence achieving the project's primary objectives. The fault occurrences were displayed, and the message was conveyed via the GSM network to the utility mobile phone. A bidirectional communication was created when the

system received an instruction from the utility phone to change the contact to which the SMS alert was sent.

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APPENDIX

Device configurtion

```
/**
 * @file patient_config.h
 * @defgroup home_files
 */
#ifndef DEVICE_CONFIG_H
#define DEVICE_CONFIG_H

/** @brief - When debugging using the serial monitor and nodemcu */
// #define DEVICE_DEBUG
/** @brief - Defines the maximum allowed string length for any given variable in the program */
#define DEVICE_MAX_STR_LEN 25
typedef enum DEVICE_COMMAND
{
    CMD_NONE,
    /** @brief - Command to switch off/on the power line */
    CMD_SWITCH_LINE,
    /** @brief - Command to switch the local server on/off
     * @note - The local server is needed to switch current operator numbers
     */
    CMD_SWITCH_SERVER,
    /** @brief - Command to restore factory settings */
    CMD_DEVICE_RESET
}
DEVICE_COMMAND;
/** @brief - Defines all the different types of errors to expect*/
typedef enum DEVICE_ERROR
{
    /** @brief - No errors so far */
    NO_ERROR,
    /** @brief - Errors to do with the power line being monitored, for example, when a short
    circuit has occured */
    LINE_ERROR,
    /** @brief - Errors to do with the GSM communication, for example, GSM has no network */
    GSM_ERROR,
    /** @brief - Errors to do with file handling, for example, if a file fails to open or can't be
    written */
    FILE_ERROR,
```

```

    /** @brief - Communication errors, for example, failure to connect to ESP-now peer */
    COMM_ERROR
}
DEVICE_ERROR;

/** @brief - Defines all the parameters that the light works with be it volatile or non-volatile parameters*/
typedef struct DEVICE_PARAMS
{
    char server_IP[DEVICE_MAX_STR_LEN];
    char server_name[DEVICE_MAX_STR_LEN];
    char server_password[DEVICE_MAX_STR_LEN];
    char error_message[DEVICE_MAX_STR_LEN];
    char user_number[DEVICE_MAX_STR_LEN];
    /** @brief - holds the current error yet to be cleared */
    DEVICE_ERROR device_error;
    /** @brief - holds the current state of the server */
    bool server_running;
    /** @brief - holds the current value of the last read voltage */
    float line_voltage;
    /** @brief - holds the current value of the last read current */
    float line_current;
    /** @brief - holds the current line error code */
    uint8_t line_fault;
    /** @brief - holds the current count of errors logged */
    uint8_t log_count;
    /** @brief - holds the current value of the last read heart rate */
    bool line_status;
}
DEVICE_PARAMS;
extern DEVICE_PARAMS device_params;
/* ----- Lets prototype all functions ----- */
/// @brief set the current device error
/// @return true if error setting was successful
bool device_setError( DEVICE_ERROR error);
/// @brief This function should be called to in case of any error
/// @param new_error the exact type of error that has occured
/// @note The next state will be determined by the type of error submitted
void device_errorHandler( DEVICE_ERROR new_error);
/// @brief setup the peripherals to be used as primary inpput

```

```

// bool device_inputSetup( void );
// @brief read status commands from the primary input device
// @return the specific commands processed by the input device
// DEVICE_COMMAND device_inputRead(void);
// @brief Checks if the display is available and boots it up
// @return false if the display can not be found
bool device_displayInit( void );
// @brief update the display with the given information
void device_displayUpdate(bool config);

// @brief Display a given error message
// @param error is a pointer the error message string which is to be displayed
// @attention This function does not return, the code will stay in this function until an external
reset occurs
void device_displayError( char *error );
// @brief Reads the device configured states and initialises the device parameters from memory
appropriately
// @note This function will always start the local service depending on the last configured state
bool device_serverInit( void );
// @brief This function will turn on the server
// @retval True if the server starts successfully
bool device_serverStart( void ); // @brief This
will turn off the server // @retval false if the
server has been stopped bool
device_serverStop( void );
// @brief get any inputs coming in from the server side
// @return false if there is no connected client on the server
bool device_serverUpdate( void ); // @brief log every fault
that occurs
// @param info the fault information to be logged
// @return false if logging failed bool
device_serverLogFault(char *info);
// @brief This function saves the current device configurations to memory
// @note This should be called after the intended configurations have been set.
// @retval true if the saving was successfull
bool device_saveConfigurations( void );
// @brief Rstore back the default values/configurations
void device_ResetDefaults( void );
// @brief Initialise the gsm messaging service

```

```

    /// @note This function is blocking until the gsm service is ready
bool device_gsmInit( void );
    /// @brief Send a given message to the current operator
    /// @param res_msg A string containing the message to be sent online.
    bool device_gsmSendSMS(char *res_msg);
    /// @brief Initialize the espnow communication service
/// @return true if communication has been established
bool device_espnowInit( void );
    /// @brief Start the espnow communication    ///
@return true if the communication is active    bool
device_espnowStart( void );    /// @brief Stop the
espnow communication    /// @return false if the
communication is inactive    bool
device_espnowStop( void );
    /// @brief This function takes care of all the espnow business.
    /// @return true if communication is still active
    /// @note This function does not handle local server requests but only espnow communications
bool device_espnowUpdate( void );

#endif

/* ----- END OF FILE ----- */

```

Device input

```

#include "device_config.h"
#include <ClickButton.h>
#define BUTTON D0
ClickButton button(BUTTON, LOW, CLICKBTN_PULLUP);
bool
device_inputSetup( void )
{
    button.debounceTime = 20;
    button.multiclickTime = 250;
    button.longClickTime = 1500;
    return true;
}

DEVICE_COMMAND device_inputRead(void)
{
    button.Update();
    if(button.clicks != 0)

```

```

{
    #ifdef DEVICE_DEBUG
        Serial.print("Button cicked: ");
        Serial.println(button.clicks);
    #endif
    switch(button.clicks)
    {
case -1:
        return CMD_DEVICE_RESET;
        break;
case 1:
        return CMD_SWITCH_SERVER;
break;
        case 2:
            return CMD_SWITCH_LINE;
            break;
    }
}

return CMD_NONE;
}

/* ----- EOF ----- */

```

