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Auto-Reset Mechanism with GSM Assisted Feature for Temporary Fault and Permanent Fault Trip Conditions in Power System

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Abstract: The auto-reclose relay is a critical relay that is used to re-energize a line after it has been tripped by the main protection relay due to a fault. A three-phase power system that distributes power to industrial and home consumers might experience many breakdowns. These failures are caused by a variety of defects that can be either transient or permanent. The power system could be seriously harmed because of these faults. This might disturb the power supply and bring numerous industries connected to the system to a stop. This technology can resolve the problem by automatically sensing the fault and disconnecting the system from the power supply, preventing large-scale damage to the system's equipment. The system automatically distinguishes between a temporary interruption and a permanent fault and cuts the supply for a short or lengthy period of time as needed. The constructed model contains several limits to make the modeling process easier, and the findings suggest that MATLAB Simulink software can be used to simulate the scheme for the project. If the tripping occurs, the Global System for Mobile Communication (GSM) system will send an SMS to the operators of the power system. If the system detects a fault, it will cause the system to trip or interrupt and send an SMS to the operators.

Keywords: Auto-Reclose Relay, Temporary Fault, Permanent Fault, GSM

1. Introduction

Accidental power outages are a huge source of concern for power providers all over the world. "Unfortunately, power outages will continue to occur, and the faults cannot be fully prevented" [1]. Disturbances such as natural disasters or anomalies in the power system are common causes of faults. "Power quality covers a wide range of issues that affect utilities and consumers" [2]. Some faults that usually occur in the systems are line-to-line faults, line-to-ground faults, and double line-to-ground faults [3]. However, the impact can be reduced if the power system is equipped with an appropriate protection scheme.

The proposed project, an auto-reset mechanism with GSM assisted feature for temporary fault and permanent fault trip conditions in power system, is a protection scheme that can help to reduce the percentage of fault that occurred in a power system and enhance the protection of equipment in the

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power system. Furthermore, the auto-reclose mechanism will be studied and implemented in this project as it is an important aspect to be considered for this project to work. However, the auto-reclose security scheme is difficult to grasp, and only a few power system software packages provide an auto-reclose model for power system analysis, and these packages are expensive [4].

2. Method

This study will be divided into two (2) parts which are the auto-reclose for temporary fault and tripping for permanent fault protection scheme, and the GSM module for a fault monitoring system. In the first part, the circuit design and configuration of the protection will be discussed along with its operation and parameters based on the simulation done in MATLAB software. In the second part, the fault monitoring system will be explained based on the simulation done in Proteus software.

2.1 The auto-reclose for temporary fault and tripping for permanent fault protection scheme

A protection scheme is a complex and difficult scheme to be modeled using the software. It's difficult to obtain research software that includes built-in protective relay models. Special protection relay models are typically found in software used by the electrical power industry, and the costs of buying them are extremely costly. There are currently no protection relay models or toolboxes available in the MATLAB or Simulink packages. The most important parameters of an auto-reclose scheme are dead time, reclaim time, and single or multi-shot. These parameters are influenced by the type of protection, type of switchgear, possible stability problems, and effects on the various types of consumer loads. Furthermore, the system stability is a determining factor on whether high-speed auto-reclose is attempted or not, and whether the transmission system is weak or strong has an impact on the problems that occur. This includes concerns about reclosing too slowly and the risk of the system being unbalanced if the system is reclosed back onto a faulted line. Multi-trip recloses attempts may be possible in cases where reclosing onto a faulted line has no impact on the system's stability. In this instance, the repair of the line is more important for the consumers' load continuity.

2.1.1 Circuit design and configuration

Figure 1 shows a double infeed 132 kV transmission line. The transmission line is simulated for single phase-to-ground, two phase-to-ground, and three phase-to-ground, and the fault occurred 80 km from the substation.

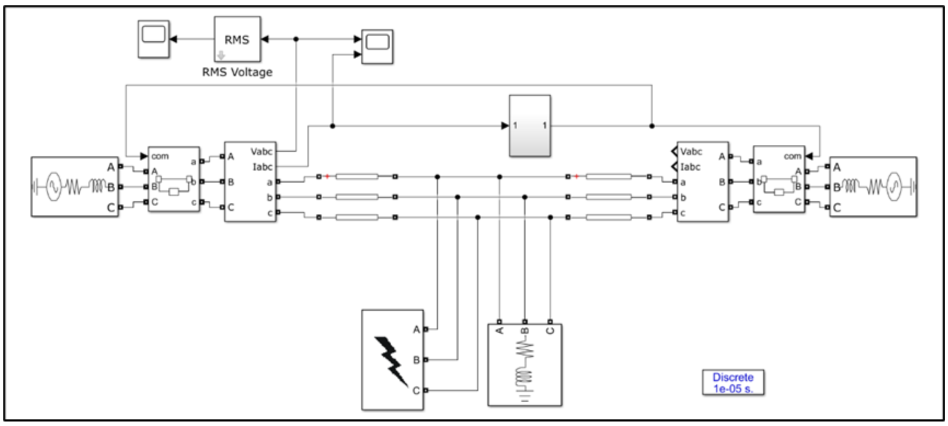

Figure 1: Double infeed 132 kV transmission line

Figure 2 shows the subsystem for an overcurrent relay. The input of the relay is the current and the root means square (RMS) of the current will be measured. The auto-reclose relay is equipped with multiple timers for the on-off delay, and some logic gate for the operation.

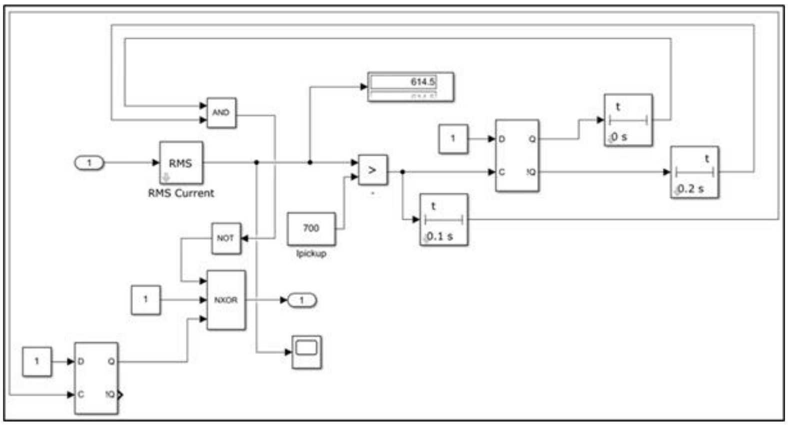

Figure 2: Design of the auto-reclose relay

The pickup current setting will be compared to the RMS value of the fault current. When the fault current exceeds the pickup current, the overcurrent relay is activated, and two signals are sent: one to activate the auto-reclose relay, and another to trip the circuit breaker.

2.1.2 Model parameter settings

Table 1 shows parameter and relay settings used in the model and simulation. The settings are for over-current and auto-reclose relays, and the parameters are for three-phase sources which represent substations, three-phase transmission lines, and load.

Table 1: Parameter and relay settings

Source parameters	**Values**
Phase to phase voltage	132 kV
Frequency	50 Hz
3 phase short circuit level	1000 MVA
X/R ratio	5
Transmission line parameters	**Values**
Positive sequence resistance	0.1622174 Ω/km
Zero sequence resistance	0.4056307 Ω/km
Positive sequence inductance	0.001229668 H/km
Zero sequence inductance	0.00516616 H/km
Line length	160 km
Overcurrent relay setting	**Values**
Rated current	614.5 A
Pick-up current (I_{pickup})	700 A
Auto-reclose relay setting	**Values**
Local dead time	0.20 s
Load parameters	**Values**
Active power	10 kW
Inductive reactive power	10 kVar
Capacitive reactive power	0

Table 2 shows the fault settings for the transient and permanent fault which will be simulated for the model.

The results of the auto-reclose operation are discussed in the next section. However, the results will only show the simulation for three phase-to-ground faults.

Table 2: Fault settings

Fault parameters	Values/Type	
Type of fault	Transient fault	Permanent fault
Fault location from local substations	80 km	80 km
Fault initiation time	0.10 s	0.10 s
Fault disappearance time	0.15 s	N/A
Fault resistance	100 Ω	100 Ω

2.2 GSM module for fault monitoring system

GSM stands for global system for mobile communication and is a mobile communication modem (GSM). In 1970, Bell Laboratories came up with the idea for GSM. It is the world's most used mobile communication system [5]. GSM is an open and digital cellular system that uses 850MHz, 900MHz, 1800MHz, and 1900MHz frequency bands to provide mobile voice and data services. A GSM digitizes and compresses data before sending it along a channel with two separate streams of client data, each in its time slot. The digital system can handle data speeds ranging from 64 kbps to 120 Mbps. In this study, the GSM system will send SMS to the person in charge if the tripping occurs. If the system detects an over-current, it will trip (open circuit) and send an SMS to the operators. Additionally, this system provides users with additional notifications, such as an emergency warning system (LCD).

2.2.1 Circuit design and configuration

Figure 3 shows the design of the GSM module for the fault monitoring system that will be used in this study.

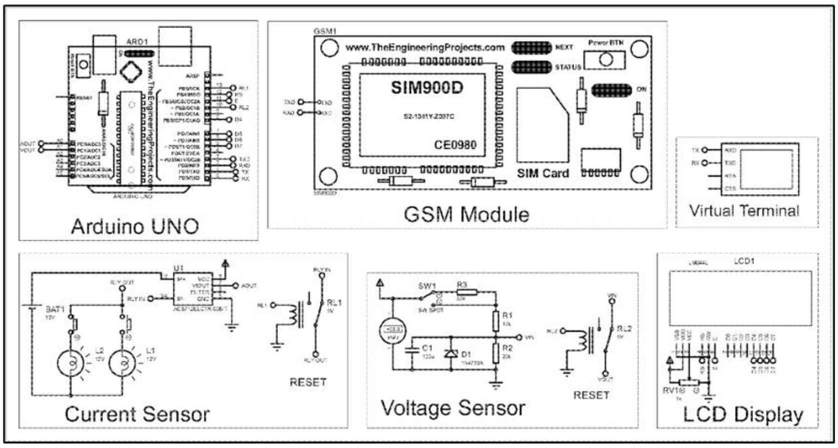

Figure 3: GSM module design for monitoring system

In Figure 3, the monitoring system are consisting of the Arduino UNO as the microcontroller, sensors with reset buttons for both current and voltage, an LCD display to indicate the status of the power system, the GSM module and lastly the virtual terminal to display the message sent via SMS. However, due to the lack of a proper block set in MATLAB Simulink, the monitoring system is simulated in different software, hence, the value of current and voltage used in this system is only a representation for the value in the main system.

2.2.2 Operation

Table 3 shows the value of current and voltage to represent the condition for temporary and permanent fault.

Table 3: Current and voltage representation for temporary and permanent fault

Representative	Fault condition	
	Normal	Over
Current	<1 A	>1 A
Voltage	<10 V	>10 V

In Table 3, the current value of 1 A is equivalent to 700 A, which is the pick-up current of the system, while the voltage value of 10 V is equivalent to 132 kV, which is the phase-to-phase voltage of the system. The monitoring system will determine whether the system experienced a fault in the current or the voltage through the sensors installed in the system. However, the sensor only monitors the fault condition of overcurrent and overvoltage. When the fault occurred, it will send a signal to the microprocessor, Arduino UNO, to trigger the reset buttons of the respective sensors according to the fault occurring in either the voltage or the current. When a temporary fault occurred, the reset buttons will be triggered and then closed again so that the system return to normal operation, while if a permanent fault occurred, the reset buttons will act the same, however, if the buttons are triggered for more than 1 times, then the operator will be notified, and the system will be turned off to prevent further damage.

3. Results and Discussion

The results and discussion section presents data and analysis of the study. The auto-reclose and tripping system with temporary and permanent fault was simulated in a multiple fault condition along with the GSM module for the fault monitoring system.

3.1 Auto-reclose and tripping system with temporary and permanent fault condition (Simulation)

Figure 4 and Figure 5 show waveforms and RMS value of voltage and current for temporary fault conditions respectively, while Figure 6 and Figure 7 depicted permanent fault conditions respectively. A fault was initiated from 0.10 s until 0.15 s for a temporary fault at 80 km from the substation. While for the permanent fault, it is initiated at 0.10 s and continue onwards until the system is tripped.

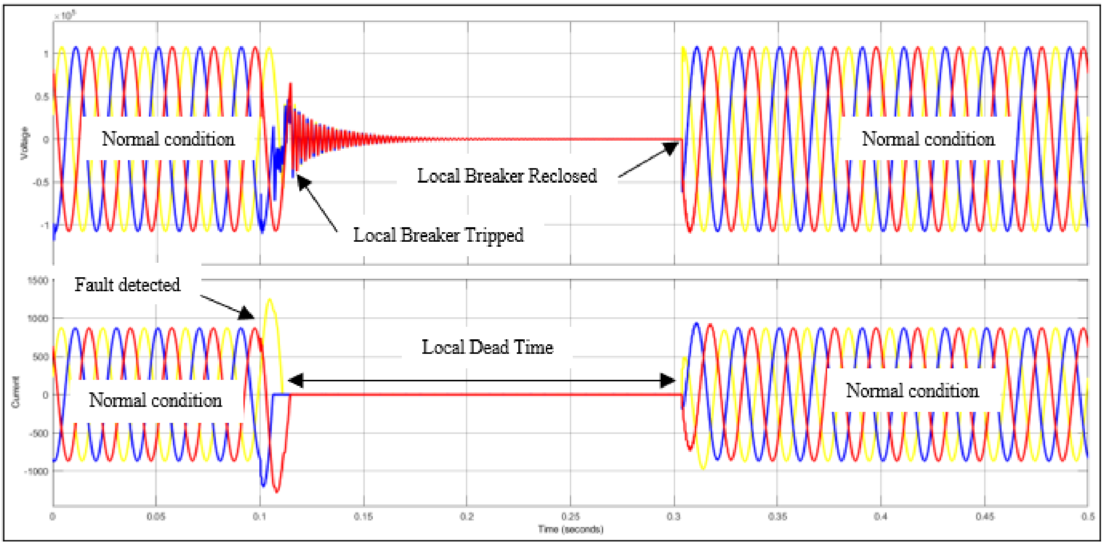

Figure 4: Waveforms for a temporary fault condition

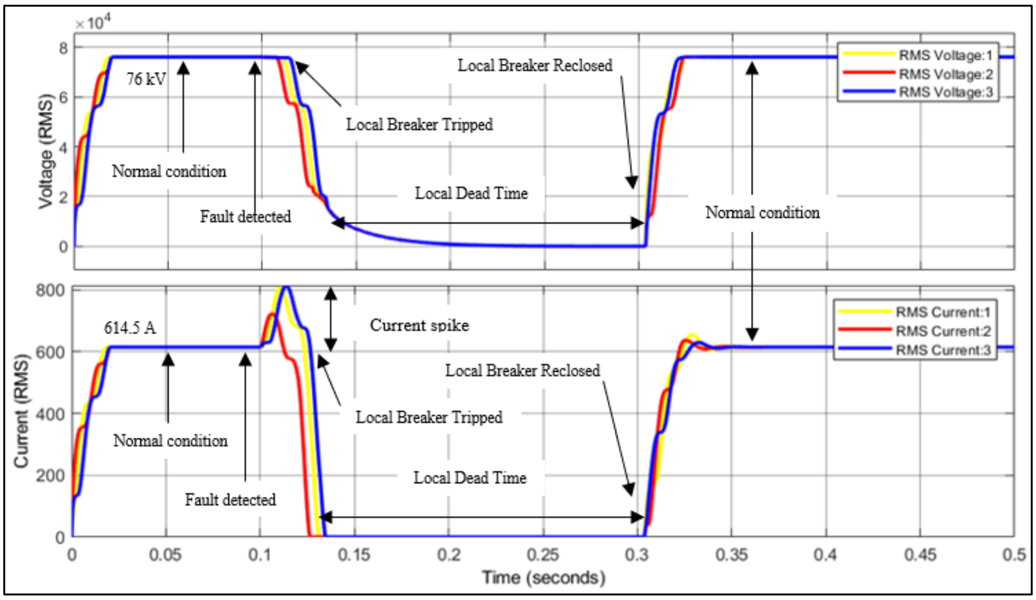

Figure 5: RMS value for a temporary fault condition

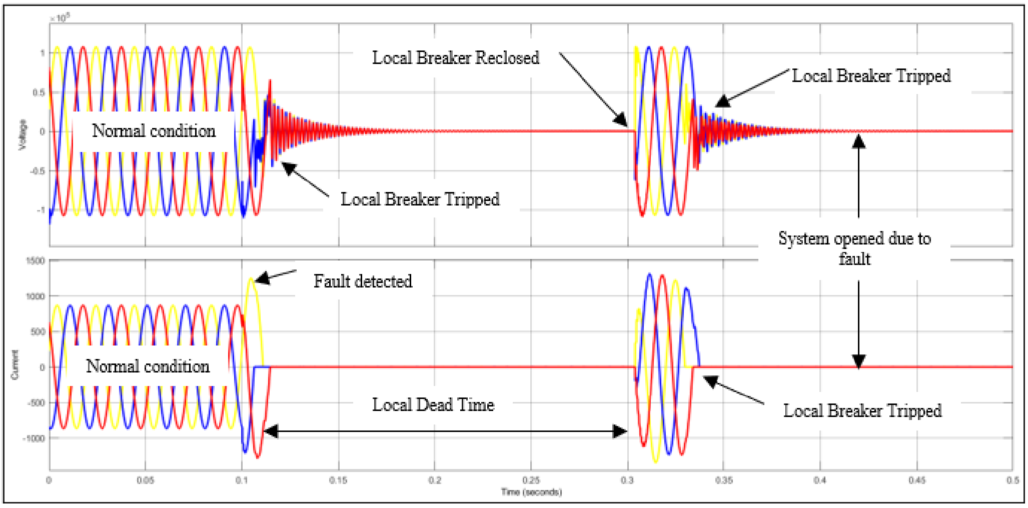

Figure 6: Waveforms for a permanent fault condition

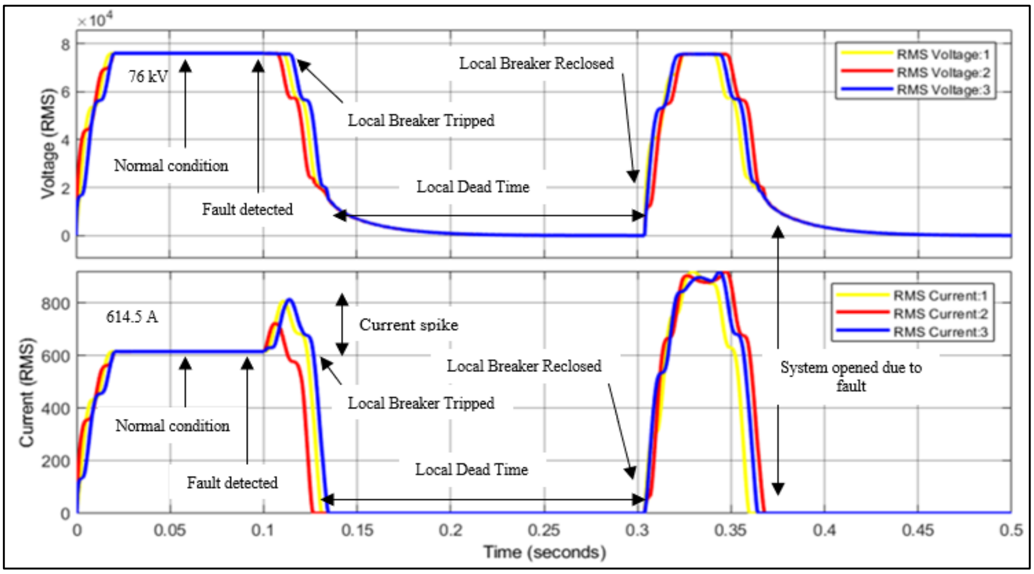

Figure 7: RMS value for a permanent fault condition

From all figures, after normal condition, the fault was detected at around 0.1 s when fault current was higher than pickup current (Ipickup = 700 A). The current became very high from nominal current while voltage has a slight dropped from nominal value during a fault condition. After fault was detected, a trip signal was sent to the circuit breaker instantaneously and the line current became zero due to the open circuit along with the voltage.

At the same time as the trip signal was sent, a signal was also sent to the auto-reclose relay to initiate/start the auto-reclose relay. The dead time of 0.2 s for the local auto-reclose relay was started and after the dead time had been elapsed, the local circuit breaker was reclosed. For the case of temporary fault, after the circuit breaker is successfully reclosed, current and voltage are back to the nominal value. However, in the case of a permanent fault, the circuit breaker will trip again, and the system will remain tripped until the operators were notified and action is taken to reclose the system manually.

3.2 GSM module for fault monitoring system (Simulation)

In this section, the results of the GSM module for the fault monitoring system will be shown. The fault condition simulated using the monitoring system is overcurrent and overvoltage.

3.2.1 Monitoring system in normal condition

Figure 8 shows the sensors of the monitoring system when it is in normal condition.

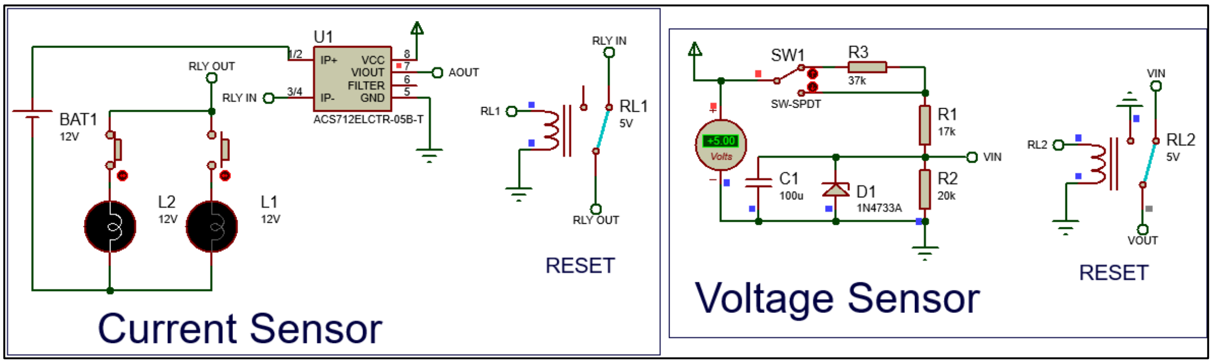

Figure 8: Sensors in normal condition

Figure 9 shows the value of current and voltage, and the status of the system, displayed on the LCD, while Figure 10 shows the SMS sent to the operators when the system is back to normal condition. The current value of the system is 0.53 A, which is <1 A, and the voltage value is 6.09 V, which is <10 V, indicating that the system is operating within the normal range of value set to the sensors.

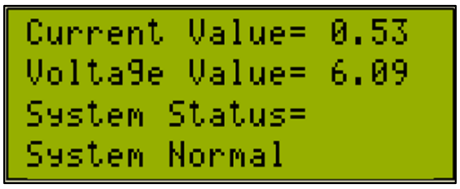

Figure 9: Current and voltage value in normal condition

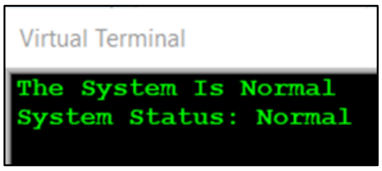

Figure 10: SMS sent for normal condition

3.2.2 Monitoring system in a fault condition

Figure 11 shows the sensors of the monitoring system when it is in a fault condition. In this case, both overcurrent and overvoltage will be simulated separately.

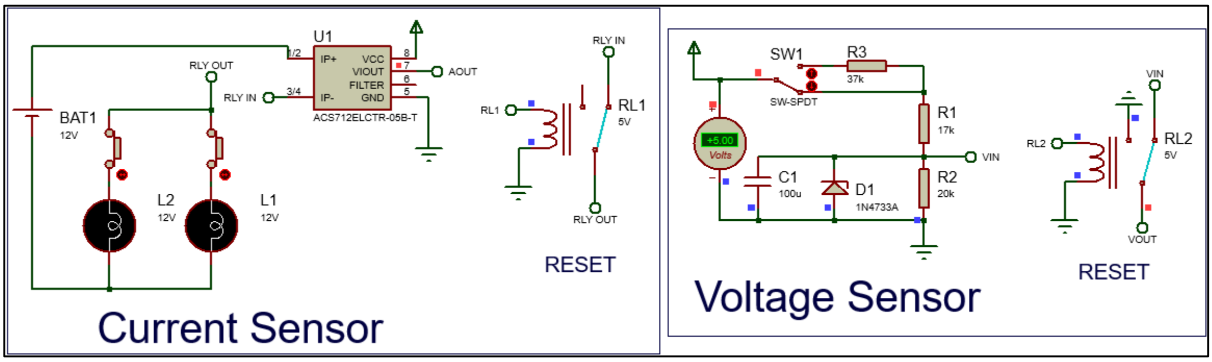

Figure 11: Sensors in a fault condition

Figure 12 shows the current value when in a fault condition. The current value is 1.06 A, which is >1 A, so this will send a signal to the microcontroller and then change the system's status from "Normal" to "Fault Occurred". The same concept is applied to the voltage, where based on Figure 13, the voltage value in fault condition is 12.16 V, which is >10 V. After the fault were detected, an SMS will be sent to the power system operator to notify the status of the power system as shown in Figure 14.

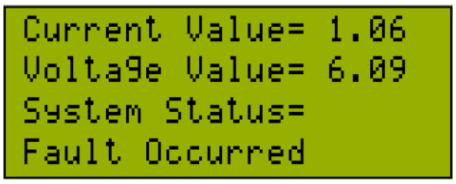

Figure 12: Current value in a fault condition

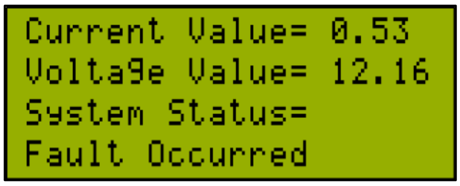

Figure 13: Voltage value in a fault condition

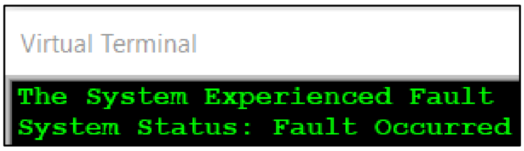

Figure 14: SMS sent for a fault condition

3.2.3 Monitoring system in trip condition

Figure 15 shows the sensors of the monitoring system when it is in trip condition.

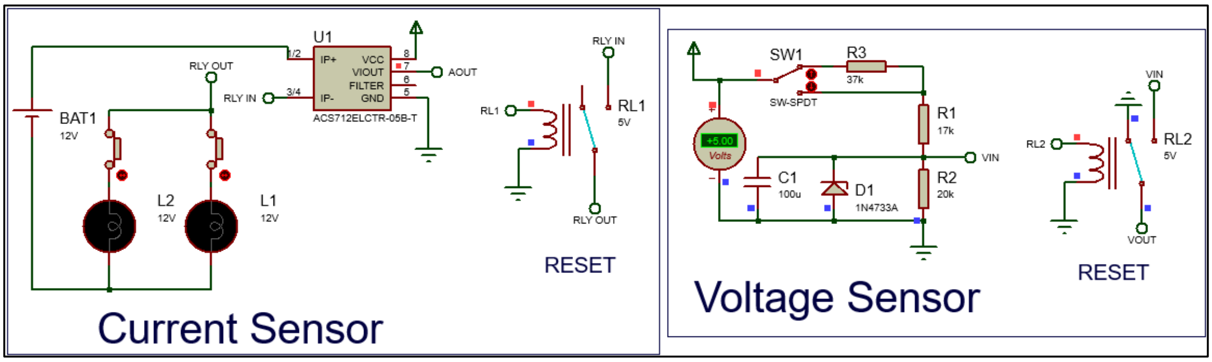

Figure 15: Sensors in trip condition

In Figure 15, it can be seen that the reset button is triggered simultaneously. When triggered, the system will be opened and the current and voltage will be cut off as shown in Figure 16.

Subsequently, the reset button will try to reclose again after the dead time of 0.2 s, and if the fault is absent then the system will return to normal, however, if the fault is still present, the reset button will trigger again until the fault is attended by the operators. Finally, the monitoring system will send an SMS to the operator to notify that the system is tripped and now opened, as shown in Figure 17. The operator will also be notified again whether the system is still in trip condition or not after an attempt of reclosing.

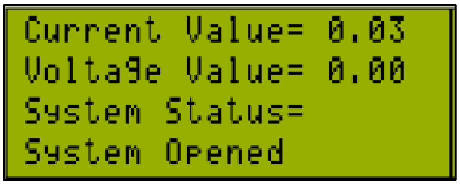

Figure 16: Current and voltage value in a trip condition

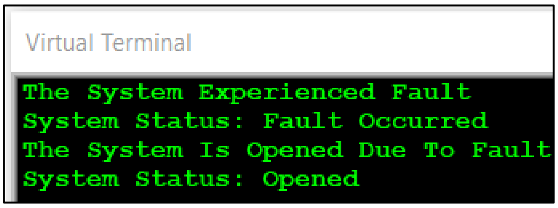

Figure 17: SMS sent for trip condition

4. Conclusion

In this study, the proposed protection scheme that has auto-reset for temporary fault and trip for permanent fault features is analyzed and achieved as shown in the results and analysis. However, the protection scheme designed in this study is only focused on the fault for overcurrent relay, but overall, the designed protection scheme does tally with the first objective. Next, the design of the protection scheme in this study managed to reduce the outage time due to the faults that occurred by implementing the most suitable parameters for the relay. With the reduction of outage time, the efficiency and the quality of the power system will be maintained. Lastly, a fault monitoring system equipped with a voltage and current sensor is also designed to use a GSM module to represent the fault condition of the power system. Even though the monitoring system is designed separately with the protection scheme, it is functioning properly, and it can distinguish a faults condition whether it is a temporary or permanent fault.

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