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# Power system fault detection and notification with Wi-Fi

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## ABSTRACT

In this study, a prototype model was designed and implemented for power system failure. A mobile application was developed for notification of faults that may occur in power systems. The line current data was transmitted with Wi-Fi via module on mobile application and so negative impacts of the production sector was eliminated and the ordinary flow of life by minimizing the duration of power outages due to technical failures were prevented. By measuring the current in the prototype, it was possible to determine a short circuit situation, and to warn the operator with the mobile application on the mobile phone, and then to quickly dispatch them to the defective area. Protection in the power system is carried out more healthily with instant data flow with the mobile application.

**Keywords**: Power system fault, Wi – Fi, mobile application

## INTRODUCTION

Power systems and wireless communication are two different but related areas of electrical engineering. The production, transmission, and distribution of electrical energy are all concerns with power systems. They entail designing and putting in place the electrical infrastructure necessary to guarantee the secure and effective transport of electricity from generators to consumers. Power systems come in a variety of sizes, from tiny microgrids to massive, globally interconnected grids. Generators, transformers, transmission lines, and distribution networks make up the foundation of a power system (Ilic et al., 2004).

Wireless communication is a rapidly expanding field that has completely changed the way people obtain information and communicate. Mobile telephony, wireless local area networks (WLANs), and satellite communication are just a few of the uses for wireless communication systems (Hussain et al., 2020). Power systems and wireless technology are actually tightly related, despite their initial discordance. Considering the criticality of the power systems, it can be said that the occurrence of any fault affects the users negatively. A power systems depend on wireless communication for the remote monitoring and management of electrical infrastructure, while wireless communication depends on power systems for the electrical energy required to run communication equipment. Therefore, for the design and operation of contemporary, effective, and trustworthy electrical systems, a solid understanding of both power systems and wireless communication is necessary.

A power system fault is an abnormal condition that occurs in an electrical power system, causing a disruption in the normal functioning of the system. Faults in power systems can occur due to various reasons such as equipment failure, human error, natural disasters, and other reasons. It's important to detect and isolate faults in a power system as soon as possible to avoid equipment damage and to minimize the disruption of power supply to the customers. These faults must be informed to the operator via the fastest communication channel and they must be sent to the fault location for intervention.

There are various wireless communication systems and tools for power system failure notification as SCADA (Supervisory Control and Data Acquisition) interface system, Bluetooth, GSM (Global System for Mobile Communications), and Wi-Fi (Wireless Fidelity) etc. in the literature (Abir et al., 2021). Fault monitoring method over SCADA is currently used for fault notification in power systems (Ortiz et al., 2016). SCADA is a type of industrial control system that is used to monitor and control industrial processes and infrastructure such as power generation and distribution, water and wastewater treatment, oil and gas pipelines, and manufacturing operations. SCADA systems typically consist of a central computer or server that collects data from a network of remote devices and sensors. While SCADA system offers many benefits, it has also some disadvantages to consider as cost, complexity, security risks, data overload, and

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latency. A system that employs Bluetooth technology to transmit alerts of defects or alarms from remote devices to a central control station is known as a Bluetooth-based fault notification system. Remote devices in this kind of system, including sensors, actuators, and other control elements, are outfitted with Bluetooth radios that enable wireless communication with a central control station. A GSM-based power system fault notification system uses a GSM network to send notifications of faults or alarms from remote devices to a central control station.

Wi-Fi (based on IEEE 802.11) wireless communication technology is preferred for fault notification in addition to GSM and Bluetooth. As Wi-Fi has a much larger range compared to both GSM and Bluetooth. Wi-Fi allows multiple devices to connect to the same network at the same time, while both GSM and Bluetooth are designed to connect only two devices at a time.

Nur et al. (2014, 2014) designed a system to detect the transmission line fault for the user via Bluetooth and GSM to easily recognize the current condition of the distribution line. They could monitor the distribution line status continuously and hence guard the fault of distribution line due to the constraints. Tan et al. (2007) designed a prototype of GSM automatic power meter reading system. Ojo et al. (2022) implemented a GSM-based Monitoring System for a Distribution Transformer. This system contains a server module that receives and stores transformer parameter information from all of a utility's distribution transformers in a database application regularly. Bekiroglu and Daldal(2009) developed a microcontroller-based, remote monitoring and automation system for distribution transformers operating in medium voltage networks.

Wireless fault monitoring is also very important for renewable power systems. A failure detection system for solar module arrays was created by Chao et al. (2022). They linked a fault detection module to the Wi-Fi on the case site, mounted it in the junction box on the rear of each photovoltaic module (PVM), and transferred data and information to the server for data analysis. The maintenance staff was immediately informed of the PVM's data results through an exception alert notification, allowing them to promptly rule out any potential failures. Real-time implementation of the prototype model for the street lights' failure was realized by Rani et al. (2016). The fault was detected and it was intimated by vehicle containing Wi-Fi.

In this study, a prototype model was designed and implemented for power system failure. A mobile application was developed. With this project, it is determined that a short circuit occurs in the transmission line based on the rising or falling current values or voltage values in case of any failure. The data received from the current sensor is transferred to the microcontroller and after the values are compared, it is transmitted to the mobile application over the internet. In case of malfunctions, an audible warning sounds in the mobile application and the measured values are displayed. With this project, the technical team is informed about the malfunction through the application installed on the mobile device they are using without waiting for any notice. The faster you are aware of the fault, the faster the solution will be. The disruption of the normal flow of life due to a power outage is reduced to even shorter time. With this rapid communication, the rate of disruption in the production sector is also reduced.

## Wireless Communication Methods for Power System Failure

A notification of a power system fault normally refers to an alarm or warning that there is an issue with the electrical power system. This could be a simple problem, like a broken fuse, or a serious issue, like a power outage. The alert could be conveyed electronically to a control center, as a visible or aural indication, or both. To avoid potential danger to equipment and workers, as well as to save downtime and disruption to operations, it is crucial to act quickly in the case of a power system malfunction notification. Depending on how serious the defect is, the right course of action can be to reset a circuit breaker, replace a blown fuse, or turn off the device until it can be safely fixed.

Although SCADA systems provide many advantages, there are also drawbacks to take into account as especially cost and security risks. SCADA systems are susceptible to cyberattacks. Also, SCADA systems produce a lot of data, which can be challenging to manage and evaluate. As an alternative for failure notification, Bluetooth or GSM can be preferred. When a fault is detected by a remote device, a notification is sent to the control station over the Bluetooth and GSM connection. The control station then processes the notification and can take appropriate actions, such as triggering an alarm or sending a message. However, like any wireless system, Bluetooth-based and GSM-based fault notification systems can be at risk to interference and security risks.

The wireless industry is currently dominated by the Bluetooth and Wi-Fi protocols, which specify the physical layer and medium access control (MAC) for wireless communications over short action ranges (from a few to several hundred meters) and with low power consumption (from less than 1 mW to hundreds of milliwatts).The standards cover a variety of techniques at the physical layer, including infrared communications and various radio signal multiplexing techniques, including complementary code keying (CCK), orthogonal frequency-division multiplexing (OFDM), direct sequence spread spectrum (DSSS), which is used in IEEE 802.11 commercial devices, and frequency hopping spread spectrum (FHSS), which is used by Bluetooth devices (Potorti& Ferro, 2005).

The aim of the IEEE 802.11 standard (Wi-Fi) is to provide wireless connectivity to devices that require quick installation, such as portable computers, PDAs, or generally mobile devices inside a wireless local area network (WLAN). The range of Wi-Fi is larger and the speed is faster than GSM and Bluetooth. Considering these features, Wi-Fi was used for fault notification in this study.

## Power System Prototype and Fault Detection Hardware Design

Potential failures can be reduced with robust design, proper operating conditions, and regular equipment maintenance in power systems. However, possible malfunctions are not completely eliminated. In this case, it is important to protect the network elements from failures as much as possible. Protection relays are used to prevent faults in power systems. In case of a fault in the system, the relay closest to the fault will detect the fault and open the breaker in the circuit and cut the power of the faulty section. After removing the faulty place from the system, maintenance teams will be provided to fix the fault. Fast and accurate fault detection extends equipment life by eliminating mechanical effects caused by high currents and heating.

In this study, a transmission line with 1 phase and 1 neutral was implemented as a prototype. As a consumer, AC Motor was added to the end of the system as a load. The current value for the load was adjusted by an AC chopper. It was assumed that a short circuit occurred when the current drawn by the motor in the system exceeds 1.5 Amps. This was an obvious increase in current in the flowing current in case of any short circuit that may occur in the transmission line. This value was entered into the system as a reference value with the codes run with the Arduino IDE software. Through the Wi-Fi Module, instant data flow from the system could be followed over the designed mobile application. Firebase Database was used as database. If the current value exceeded 1.5 A, a warning was sent to the mobile application and as a result of this warning, the system was automatically deactivated and an audible alarm sounded in mobile application. In addition, it was seen on the mobile application that the energy of the system is automatically cut off.

A fault that might occur in the transmission line was transmitted instantly with the mobile application installed on the mobile phone used by the fault repair team, in this way, dispatching the team for repair was very fast.

The designed and implemented power system failure detection system via Wi–Fi can be seen from **Figure 1.** The equipment list used for the system is shown in **Table 1.**

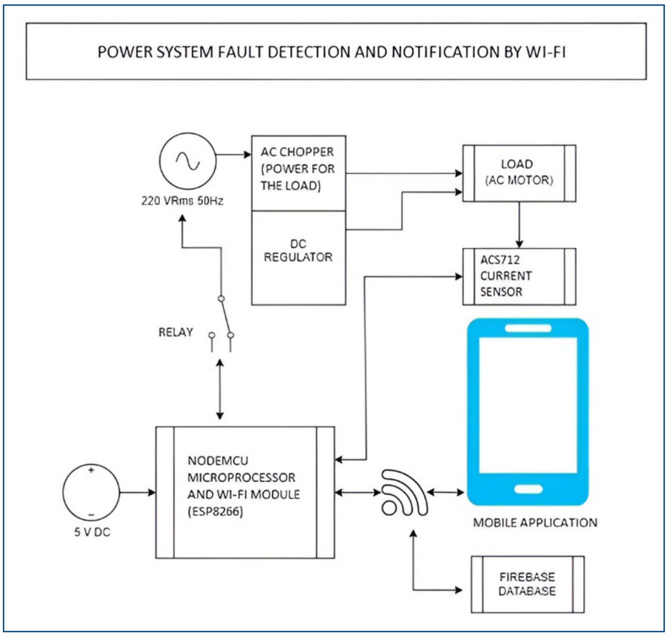



**Figure 1.** Block diagram of the implemented system.

**Table 1. The equipment list used for the power system fault detection prototype**

| | Equipment | Property |
|---|---|---|
| 1 | Microcontroller with W-Fi module | NodeMCU V3 ESP8266 ESP-12E |
| 2 | Current Sensor | ACS712 |
| 3 | Load | AC Motor |
| 4 | AC Clamper | Circuit with triac |
| 5 | Regulator | Excitation |
| 6 | Power Supply | 18 V Adapter |
| 7 | Computer | Installed Arduino IDE |
| 8 | Telephone | Installed Mobile Application |
| 9 | Relay | SRD-05VDC-SL-C |

The developed algorithm can be seen from **Figure 2**. As seen from this flowchart that, the operation condition is written on the mobile screen as “System ON” or “System OFF”. The current data is obtained from ACS712 current sensor and if there is a short circuit; the system changes the position as alarm. The system is disabled automatically and an alarm is run.

NodeMCU was used as a microcontroller. This open-source firmware and development kit is appropriate for prototype. The module is based on ESP-12/ESP8266 Wi-Fi Module. Module integrates 3.3V Regulator, GPIO, PWM, IIC, 1-Wire and ADC all in one board. One ADC channel was used for this project for reading the current. The pinots of the microcontroller can be seen from **Figure 3.**

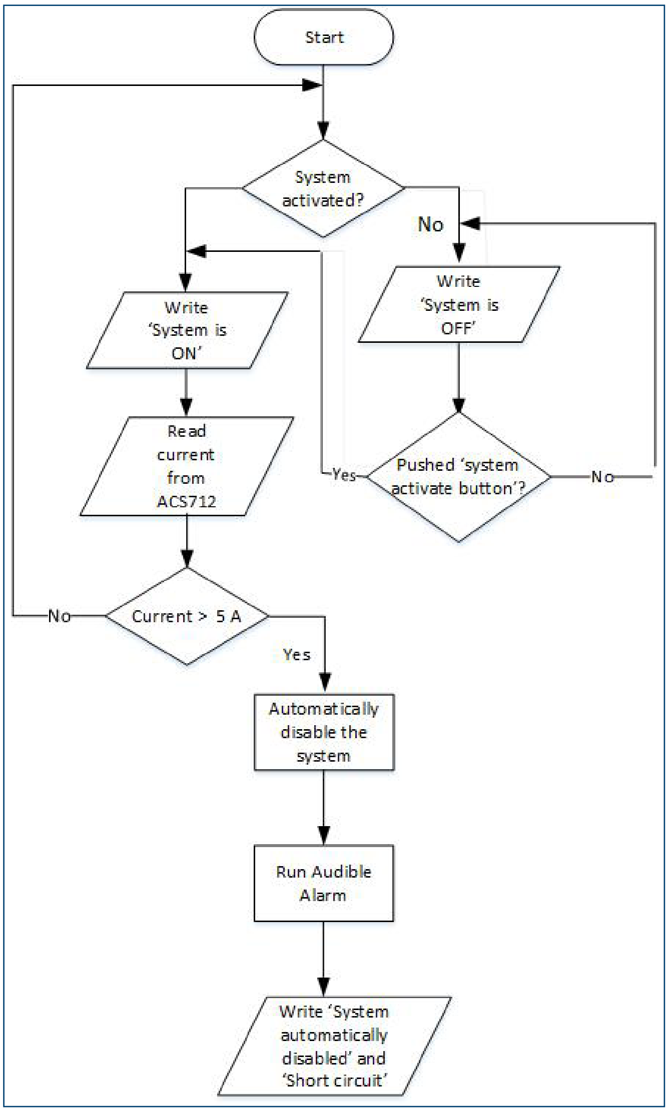



**Figure 2.** The flowchart of the study.

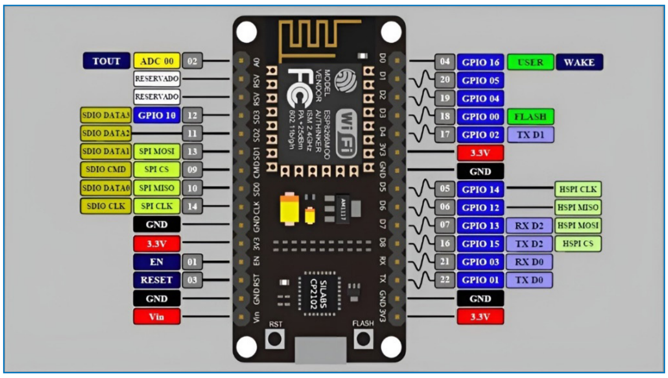


**Figure 3.** NodeMCU Pinout.

ACS712 current sensor was used to sense the line current. The board is a simple carrier of Allegro's ±30 A ACS712T ELC-5B Hall effect-based linear current sensor.

Switching capacity of the SRD relay is available by 10A in spite of small size design. It was used to cut the current in an abnormal condition.

The prototype of the implemented power system failure detection system via Wi–Fi can be seen from **Figure 4.**

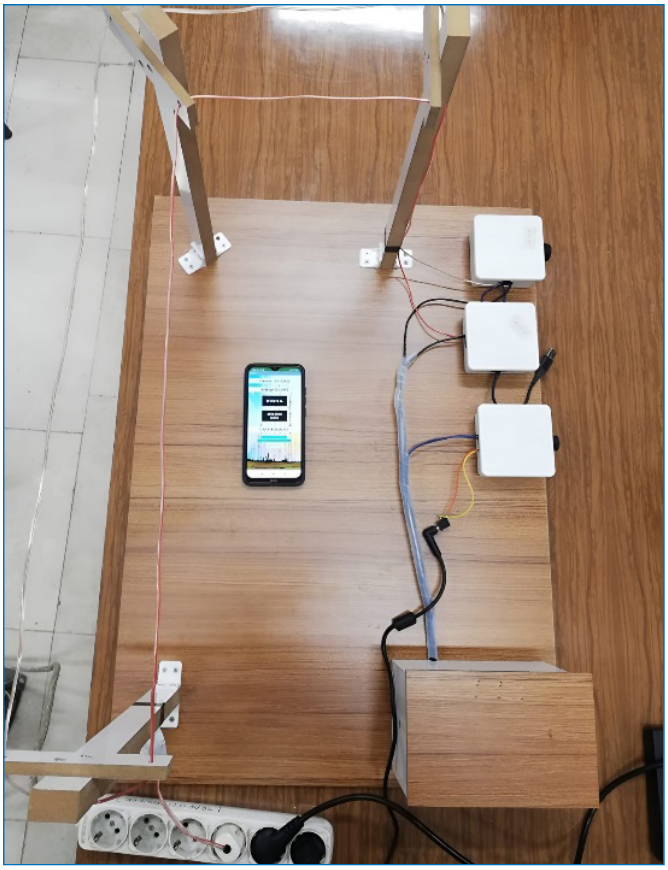


**Figure 4.** The prototype of the implemented system.

## RESULTS AND DISCUSSION

Wi-Fi technology was developed and widely adopted with considerable help from IEEE 802.11, allowing for wireless access and communication in a variety of situations and devices. In this study, a Wi – Fi module with an inner antenna was used to easily connect to Wi-Fi network environment. It can transmit and receive data packages. Wi-Fi networks can provide fast data transfer speeds, allowing users to download and upload.

The mobile application interface was designed with APPINVENTOR. The developed codes can be seen from **Figure 5.**

Line current data was transferred to the system instantly The developed mobile interface screenshot for normal operation situation can be seen from **Figure 6**. If the current flow exceeded 1.5 A, which was defined in the software, the system was automatically deactivated and gave a warning on the mobile application as "System Disabled Automatically". In addition, a warning appeared on the screen as "Short Circuit in the System" and an audible alarm sounds. This situation screenshot can be seen form Figure 7. While the normal values were present, the note "System Enabled" appeared on the screen. If required, the system could be activated and deactivated manually via the mobile application for activities such as maintenance/repair.

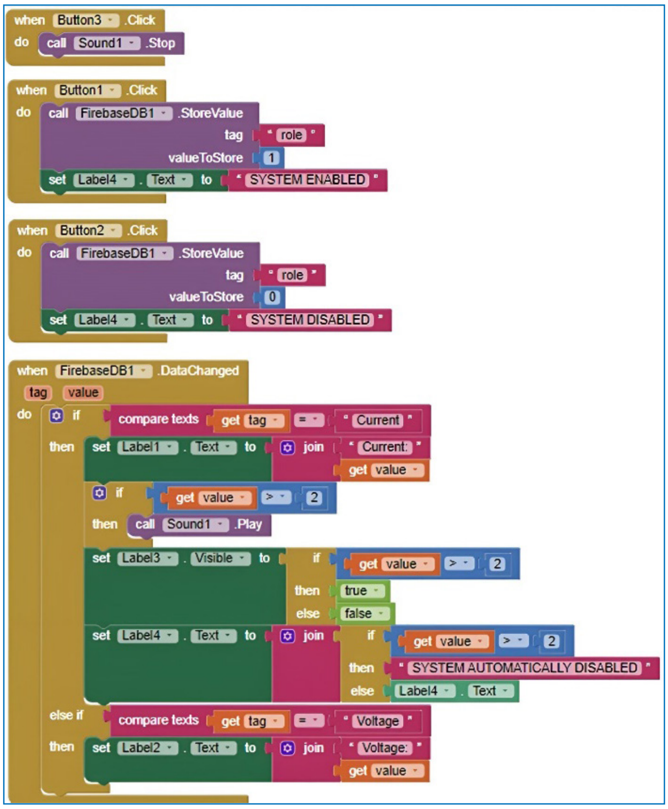
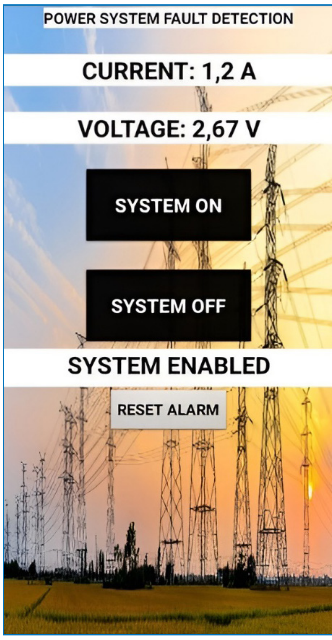



**Figure 5.** Developed mobile application codes.



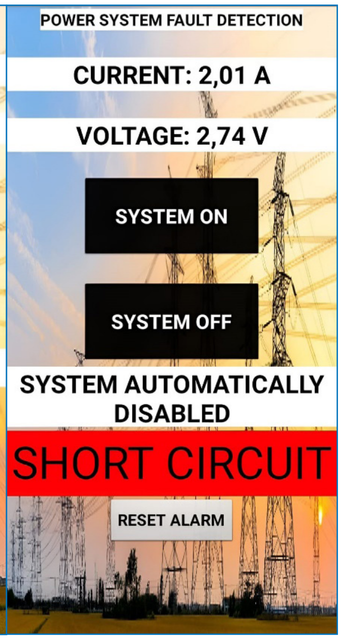




**Figure 6.** Screenshot for normal operation condition

**Figure 7.** Screenshot for fault condition

## CONCLUSION

The operator team should be sent to the defective location as soon as possible in order to fix the primary faults that may arise during energy transmission and distribution. When a failure occurs, the fault notification process may be delayed as most of current detection systems are based on SCADA system. In this case, it slows down and interrupts the normal flow of life and the production sector. In this study, the process could be faster considering Wi–Fi communication. By measuring the current in the prototype with ACS712, it was possible to determine a short circuit situation that may occur on the line, and to warn the operator with the mobile application on the mobile phone, and then to quickly dispatch them to the defective area. The system is appropriate for adding some useful functions. In the future, the system power will be measured and will be monitored on the mobile application. Additionally, the condition of the circuit breaker and disconnector may be displayed on the application,

## ETHICAL DECLARATIONS

**Referee Evaluation Process:** Externally peer-reviewed.

**Conflict of Interest Statement:** The authors have no conflicts of interest to declare.

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**Author Contributions:** All of the authors declare that they have all participated in the design, execution, and analysis of the paper, and that they have approved the final version.

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He works on electrical power systems. He is currently an electrical and electronics engineering student at Gazi University. He completed his summer internship as an Electrical Substation Operation and Automation engineer at the RİNO Söğütsen ceramics factory. He is also graduate of business administration. The Turkuaz Hyperloop Team, in which he is a member, won the first place in the hyperloop development competition held in Türkiye. As a thesis work in the field of electrical and electronic engineering, he performed Power System Fault Detection with Mobile Application and notification by Wi-Fi.