Intelligent system for fault detection of phase failure and temperature

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Abstract. Recently, most countries began utilizing Electronic governance (EG), which is the application of intelligence technique (IT) for delivering government services, exchange information, communicate transactions, and integrate various stand-alone systems between governments and citizen. The lack of electricity (from unstable power supply) tends to severely interrupt e-governance, as EG needs power in 24 hours per day. The phase failure, over-voltage, and frequency instability can result in the lack of electricity. This paper details the design and implementation of an intelligent fault detection system that controls the feeding power for IT equipment by calling the engineer or utilizing another power source. The system was implemented based on the Global System for Mobile communication (GSM)-sim900and Arduino microcontroller, where the Arduino code is used to implement the software. The result show that the system will try feeding the IT system the power via other power sources line until the service engineers arrive to address the problems. The intelligent system improves the reliability and stability of EG, which improves its performance and the delivery of public services to citizens.

1. Introduction

Recently, the use of smart systems has been ubiquitous, encompassing the health, security, public industries[1][2][3]. In developing countries such as Iraq, interrupted power is a problem due to unreliable distribution stations and transmission lines. Most of these applications uses the three-phase power supply due to its suitable energy amount, protection systems, and convenience [4][5][6]. However, there are many kinds of faults in the three phase distribution system, such as over-voltage, under-voltage, and phase failures[7][8][9]. A phase failure will lead to power outage, which requires a service engineer to get involved for repairs, while another power supply takes up the shortcomings (lack of power). The lack of power is disruptive, as it affects many services, primarily among them E-governance (EG) [10].

An electronic server (computer) is the core of E-governance. An Electronic –server (E- server)is a piece of computer software and hardware that delivers various functionalities, such as sharing

information , execution computation for a client , or sharing resources between clients. The E-government service in Iraq faces many problems therefore it is still not as widely spread. These devices can monitor and protect via intelligent systems. The intelligent protection system can include Global Positioning System (GPS) devices to exchange/inform service engineers about a fault or abnormal situations [10].GSM has the ability to receive/send SMS , make phone call, and send fax at low power [11][12].

Kalia R. and Abrol P. implemented a protection system focused on the transformer fault. The transformer circuit breaker is auto-cut off, and is capable of sending the fault situation and location via a WiFi network. Messages are sent to service engineers to inform them about the fault information via GSM[13]. In [14], there are protection system that can detect transformer fault and automatically take action to protect it using the microcontroller and GSM. The system schedule will create an action that addresses the faults, which is expected to protect the transformer from damages. **Epemu A. and** Enalume K. designed the monitoring system of distribution transformer to protect itself from bigger faults that appears on the transformers . The system is made up of a PIC microcontroller, GSM, and the LCD. The system will localize the disconcerted fuse and the phase post-overloading, which allows the engineer to direct the technician to the fault and have it repaired[4].

Kareem O. and AL-Sulaifanie A. proposed an intelligent system that consists of two nodes; the first is called the smart node, which measures the current, voltage, and real power, While the second is called the central node, which is a hybrid of GSM. This node controls the system via the received SMS from cellphones. The important point in the proposed system is that it does not require a dedicated hardware/software for systems control. The proposed system focuses on the power consumption of homes that can be used to personally manage a problem. [15]. It cannot use with industrial or E-governance applications due to design for home management only. **David G. and Oña O.** designed and implemented a smart device in car that can send and receive SMS to control the multiple parameters in the car. Arduino and GSM are the component of the device; the location is pinpointed by GPRS [16]. The system sends a car location and controls some component, but it is not detected or process faults that happen in-car. Mohamad O. and Hameed R. reported techniques that can be used to monitor sounds and faces, which would be beneficial to the elderly in emergency situations. The system is implemented a sound sensor, face detector, arduino microcontroller, and a GMS. The system will text doctors/nurses detailing the case if an abnormal situation occurs. The technique focuses on health application without control in room of elderly[1]. The system is data monitoring only, and not possess any action inside the elderly room. In this work, it is connected to avoid power losing from data server. The power supply could fail due to the temporary or permanent faults. Left unaddressed, these faults could permanently damage the equipment of EG such as data server.

2. Methodology

The intelligent system was constructed based on two schemes; the first is fault detection of power loss and room temperature increase, while the second is the automatic processing of diverting the system to an alternative power source and alerting the service engineers via texts. The flow chart in Figure 1 details the methodology. C^{++} under Arduino functions was utilized for constructing the main code of the system.

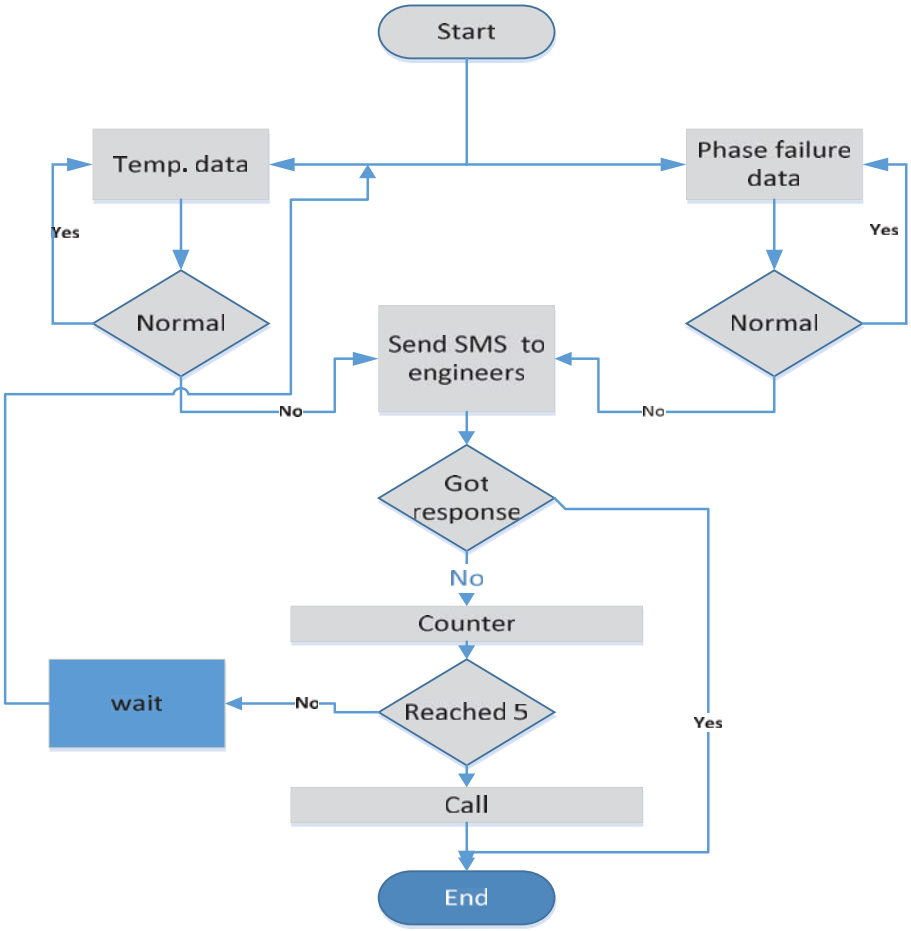


Figure 1. System schedule

3. System materials

The developed intelligent protection system will provide an easy and safe access into the E-governance system. The system is contained the following components.

3.1. Sensors implemented

The two types of data were collected using sensors. The room temperature and phase data are fed to the MC for processing. The temperature sensor was designed based on the LM35, which is an IC for temperature sensing that is accurate. The LM35 output is proportional to its surrounding temperatures, with a range of -55 to 150 °C. Each 10 mV output represents 1 °C. This sensor does not require calibration prior to use. Its technical details are shown in table 1, while Figure 2 shows the schematic of the sensor.

Table 1. Technical information of LM35

Range of temperature	-55..150C
Current consumption	> 60 µA
operation voltage	4 to 30 volts
Scale Factor	Linear + 10 mV/°C

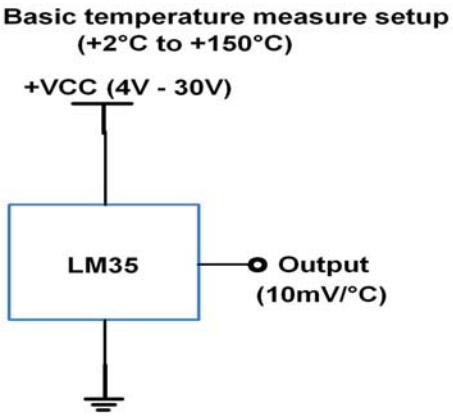


Figure 2. LM35

The phase failure control protects the device supplied by a 3-phase network from faults such as relay for sequence, unbalance voltage (40%) from normal value, and phase failure of the main power line. Figure 3 shows the phase failure, while table 2 details the operational information.

Table 2. Phase failure detail

Brand	KRK
Protective functions	3-phase system
Power supply	100-240VAC~ 50/60Hz
Contact type	1 invers or , 10A/250Vac
Environment Ambient temperature	from-5 to 55 °C
Voltage unbalance	40%

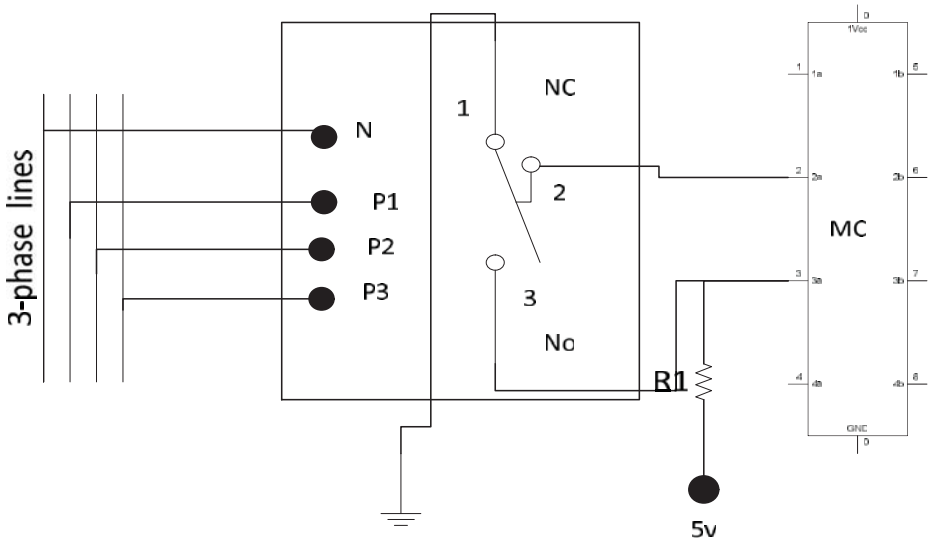


Figure 3. Phase failure circuit

3.2. Microcontrollers

The Arduino UNO is an electronic board that is reliant on a ATmega328 microcontroller. It is constructed a 16 MHz crystal oscillator, a USB connection, 6 A/D inputs, and 14 digital inputs. The USB connection of the arduino UNO is used as a power supply and uploading code post-design. The phase failure pins are connected to the digital inputs of Arduino, which gives it direct access to the power situation, while the temperature sensor is connected to the microcontroller via the analog-to-digital pin. The temperature output is proportional to the input value, where each 10 mV represents 1°C. Formula (1) can be used to calculate the temperature collected by the LM 35 [17].

$$\text{Temperature (°C)} = (5.0 * \text{analogRead(LM35pin)} * 100.0) / 1024 \quad (1)$$

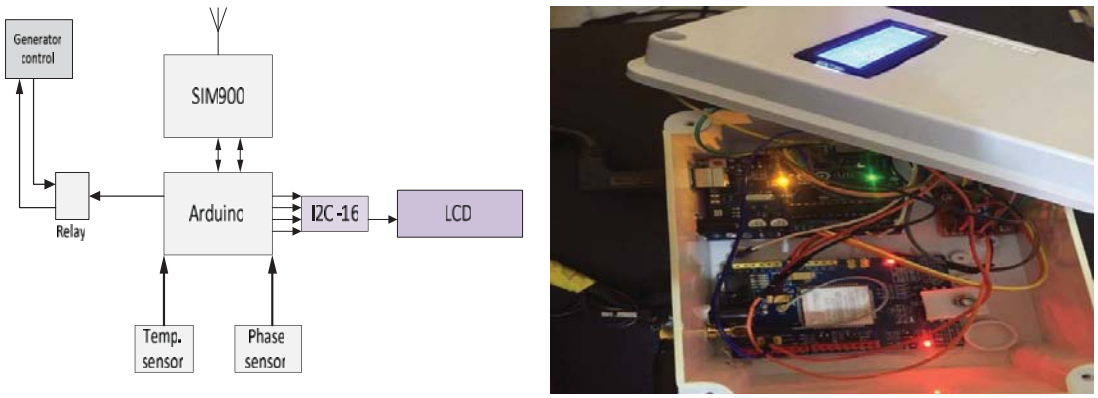
Where the 1024 is the pin resolution of the microcontroller

3.3. SIM900 GSM

Sim900 can be used to develop a very compact electronic device. It is also suitable for smart application requirements of a variety of intelligent home and smart industrial applications. It also has the property of a dual-frequency GSM. SIM900A GSM is the global standard for mobile communications, qualified as a digital, circuit-switched network optimized for full-duplex voice telephony. This component gives the ability to call or (send - receive) texts to phones. It also act as an interface between the system and the user[18][14][19]. Posited that the data collected from the sensors will be monitored using a Liquid crystal display (LCD), which is displayed data in real-time.

3.4. Integrated system

The integrated system consists of an LCD (16*2) for data monitoring, I2C for interfacing between the LCD and microcontroller, arduino microcontroller for controlling and processing the system, sim900 GSM, temperature sensor, and phase failure, as shown in Figure 4



(a) **(b)**

Figure 4. Integrate intelligent system (a) drawing system (b) hardware system

4. Result and discussion

The main aim of this work is to save the main data server in the government operational 24/7. However, the unreliable power system in Iraq remains a problem. Especially, Iraq situation is

suffering from main problems in connection with the inconstancy of electricity voltage level of distribution. Generated power covered 50-60% of the Iraq full load. Therefore, the main power shutdown daily many times and utilized a standby generator. This problem leads to fluctuations that happen on the power supply system such as phase loss, over-voltage, and wrong phase sequence . The service engineers, who are far from the servers, would require time to show up and address the problems should one arise, which represents another challenge for the system.

The engineers need to be informed should a problem arise during the lack of internet connections and they are far from the system, such as phase failures or temperature increases. The system was designed to prevent a disconnection between the government and citizens for improving E-governance reliability. The data server room contains uninterruptible power supply (UPS) to provide power for at least 3 hours if the servers are disconnected from its main power source. Therefore, the ample time allow the system to connect to an alternative power source while inviting the service engineers to check the system before it suffers a shut down.

The phase failure device is affected by three functions. Firstly, if the system has lost one of the phases, the output contacts close without delay. Secondly, if the sequence of the phases is wrong the output contact close. Thirdly, if system's phase – neutral value is over normal that leads to close the contact also. The contact close leads to change case of digital pin 3 in the microcontroller from the high input to low input, as illustrated in figure (3). Thus, the microcontroller will start the process to inform the engineers about the fault, as shown in figure 6-b. Moreover, LM35 is the temperature sensor. The output of the temperature sensor is an analog signal proportional to the current temperature. The output voltage of the sensor feeds to the microcontroller for processing temperature data in Celsius. The results of many tested to read temperature and the sensor output voltage illustrated in figure 5 that proves the linear proportional between them.

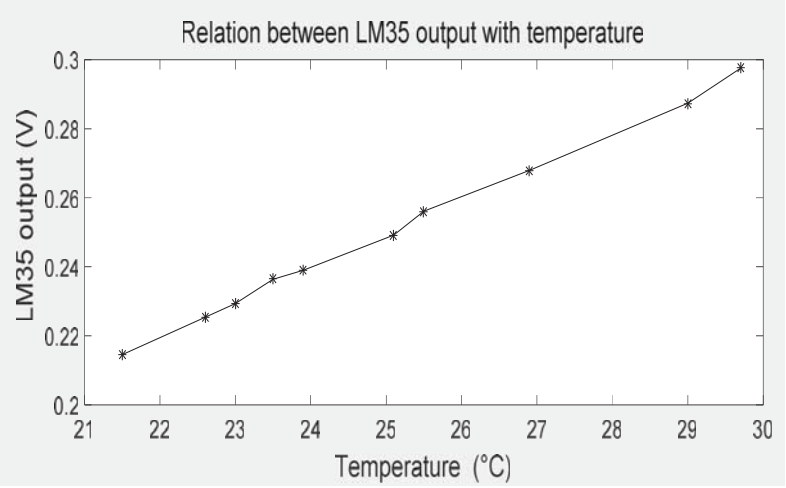
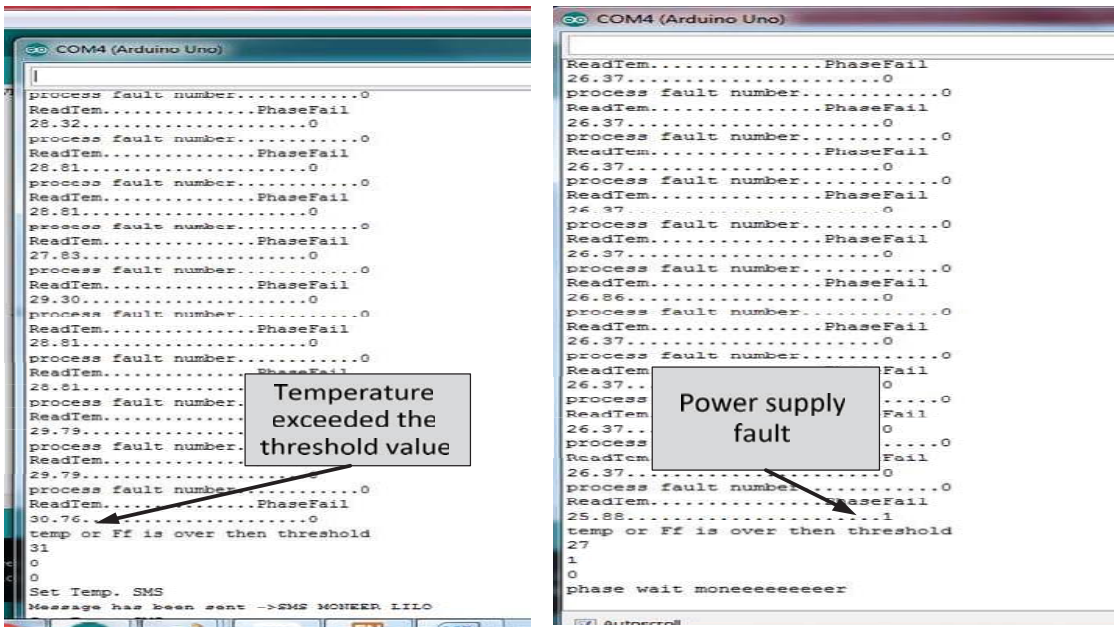


Figure 5. Temperature sensor output (LM35)

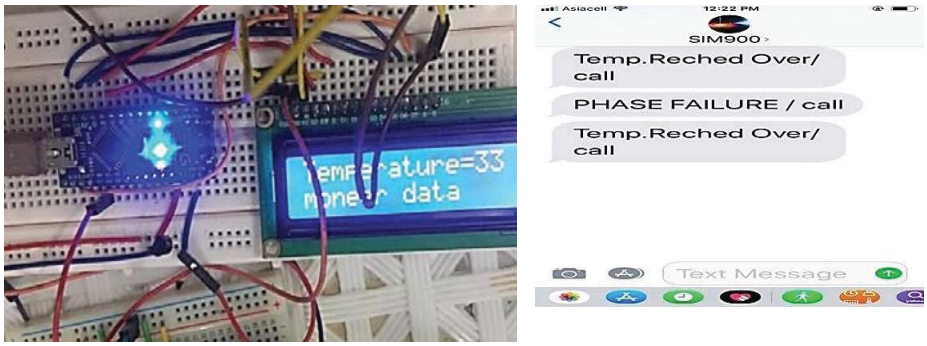
The system sends texts to engineers based on two conditions. First, the temperature of the room increases to over than 25 ^{o}C, and second condition is the occurrence of the phase failure fault. If both or one of the conditions are met, the system will send a text to the administrator and engineers with specifics about the faults situation. After that, the process is delayed for a minute to re-check if the problem has been resolved based on the collected data and the subsequent analyses, as per Figure 1. The second step is where the system repeats that process 5 times. Sometimes engineers might miss the texts, and when this happens the system calls them on their phones until the call is answered. Once

the service engineer takes the call or sends text code, the system stops sending texts. Figure 6-a shows the test of the situation when the temperature exceeds over 30 °C, and it proceeds to send texts to a cell phone. While figure 7 shows the short message sent from the system to engineer when the temperature exceeds the threshold or power supply failure. Finally, after multiple tests, the system became stable and reliable with E-governance work. Figure 8 shows the intelligent system during operation, it shows the SIM900 in operation mode with a network of cell phones. Based on the result, and system methodology can add server status to inform the engineer if it goes out of service. Moreover, the system can be utilized with other industrial applications for fault detection. On the other hand, the system is designed easy to use by any technician. Finally, the system will give E-governance reliability by reducing the power supply failure of the server.



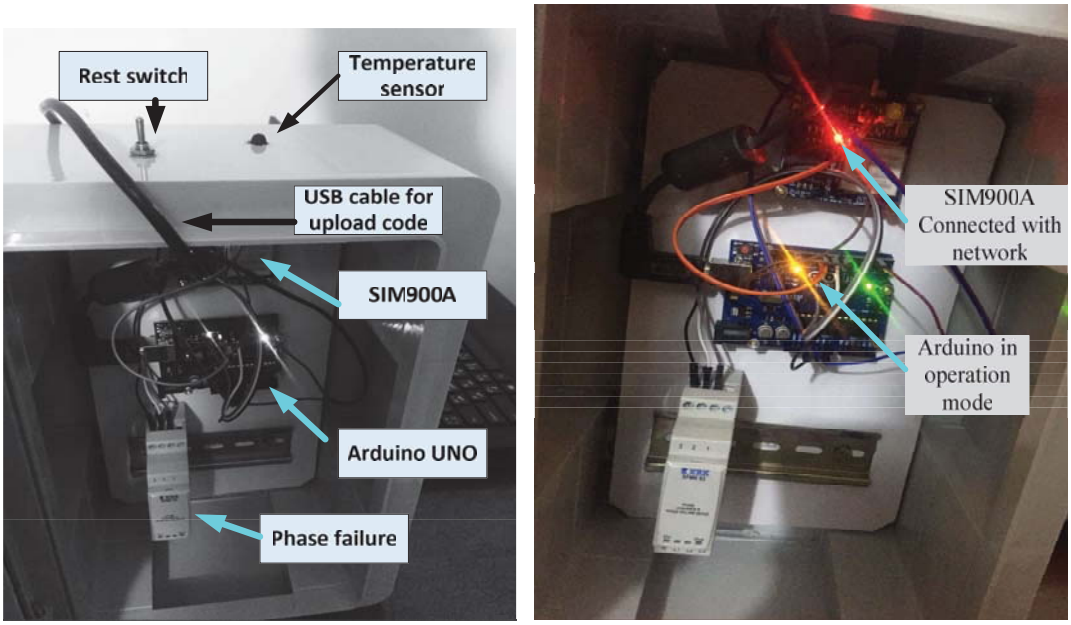
(a) (b)

Figure 6. Arduino serial monitor (a) temperature test (b) phase failure test



(a) **(b)**

Figure 7. Temperature test (a) system test (b) text received from system



(a) **(b)**

Figure 8. Integrate intelligent system (a) describe system equipment's (b)system during operation

5. Conclusion

This system inspects phase fluctuations in the main circuit breaker and the room temperature. The system auto processes the incident and searches for other power supplies while also contacting the administrator and service engineer with details about the faults. Data analyses via microcontroller occurs post temperature and phase failure data collection. The SIM900A GSM module sends a text to the service engineers based on the analyses results of the within microcontroller detailing the faults. The microcontroller also feeds data to the LCD for monitoring purposes. This system possesses characteristics such as scalability, flexibility, usability, reliability, and transparency based on the results and tested with many cases of faults.

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