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Remote monitoring system of telecommunication digital equipment

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Abstract

Namibia exhibits typical desert climatic conditions classified as generally arid, implying that the potential evaporation is higher than the precipitation. This results in very low humidity, and temperatures exceeding 45°C. This high ambient temperature adversely affects the performance of temperature sensitive telecommunication equipment and devices which experience device shut down or exhibit continuous system reboot. Thus, affecting the quality of telecommunication broadband network services provided. The research paper presents an innovative intelligent system monitoring Digital Subscriber Line Access Multiplexer (DSLAM) equipment rooms; designed using a mobile phone with GSM technology and temperature and biometric sensors. The system is designed to remotely monitor access and environmental conditions of the DSLAM unit using a low-cost microchip (18F45K22PIC). The microcontroller (18F45K22PIC) is at the heart of the system collecting the data from the temperature and the biometric sensors, and transmitting the data via AIRLINK GSM portal to the registered remote mobile phone user by GSM in real time for remedial action. The microcontroller monitors the system and enables an external cooling in cases when the ambient temperature goes above the set threshold. Monitoring of access and environmental conditions plays an important role in the effective management and delivery of the telecommunication broadband network. Monitoring and timely action greatly eases the daily maintenance and management, boosting network operation reliability and ensuring network Quality of Success (QoS). This embedded system can prove to be beneficial to Telecom Namibia in tracking and avoiding malfunction of the telecommunication broadband equipment's.

Keywords: AIRLINK GSM Modem, Biometric sensor, GSM, MCU, Digital Subscriber Line Access Multiplexer (DSLAM), Microcontroller, Temperature sensor, Quality of Service (QoS).

Introduction

Namibia is a country with a vast area of 824,292 sq. km and a population density of 2.6 persons per square km[1]. Namibia exhibits typical desert climatic conditions classified as generally arid, implying that the potential evaporation is higher than the precipitation. This results in very low humidity and high temperatures. In summer the ambient temperatures reach above the device threshold temperature resulting in device shutdown or demonstrating continuous reboot of the system. This affects the network Quality of Service (QoS). Hence temperature monitoring is one of the crucial environment parameter for successful broadband networking.

'Telecom Namibia (TN)' is one of Namibia's telecommunication and mobile communication service provider. TN provides telecommunication services e.g. analogue and digital subscriber links, Integrated Services Digital Network (ISDN) and Direct Inward dialling (DID) etc. Figure-1 illustrates the various services provided and the mobile GSM network coverage of TN[2].

Telecom Namibia provides broadband services countrywide to users through the SmartAX MA5600 Series Multi-service Access Module[3]. It is crucial to Telecom Namibia as a telecommunication operating company to ensure that the Smart AX MA5600 product series are operational at all times.

It has been noted that many a times the SmartAX MA5600 system reports operational failure. There are two major causes identified for failure. This operational failure is attributed mainly due to high ambient temperature which sometimes exceeds 45ºC, which is beyond equipment threshold and secondly due poor access control to equipment rooms in the digital line units (DLU).

It has been noted that the equipment rooms of the digital line units (DLU) which are spread far and wide (due to the large sq. km area of Namibia) have been a frequent target by thieves. These DLU units are pilfered and vandalized thus affecting smooth operation of the telecommunication network. Hence it is imperative to monitor the access to the equipment rooms and its temperature. Thus, maintaining a favorable ambient temperature in the digital line units (DLU). It is against this background that this research paper puts forward a solution to these challenges.

The Intelligent Remote Monitoring System is designed to monitor the access to the equipment rooms namely the digital line units (DLU) and its ambient temperature. The objective is to notify the control room/ administrator about these conditions

in real time. GSM wireless technology has been integrated in the device. In case of increase in temperature above the threshold the Intelligent Monitoring System is programmed to activate an external cooling system.

The device integrates GSM technology for transmitting data. GSM is selected due to the widespread coverage of GSM by Telecom Namibia.

Principle and Design of the prototype

Principle of the intelligent monitoring system: Maintaining the broadband network equipment in operational condition always is crucial to a telecommunication supplier. The intelligent monitoring system implemented uses a temperature sensor, biometric sensor, GSM module and a LCD display module[4].The Intelligent Remote Monitoring System is designed with automated transmission of data in real time using a GSM modem and a registered mobile phone[5,6].

Figure-2 illustrates the system block diagram. This system uses a microchip 18F45K22PIC at the heart of its design. The GSM modem is connected to the microchip through MAX232 board using a RS232 cable. The fingerprint scanner, temperature sensor, magnetic door sensor and electronic lock are connected to the microchip. The analogue data from the sensors is converted to digital data and sent to the microcontroller, where the data is stored in the EPROM and displayed on the LCD.

The digital line units (DLU) parameters sensed and monitored are displayed on the LCD in the DLU equipment room. A notification (SMS) is transmitted via GSM in real time to the registered mobile (control room/ administrator).

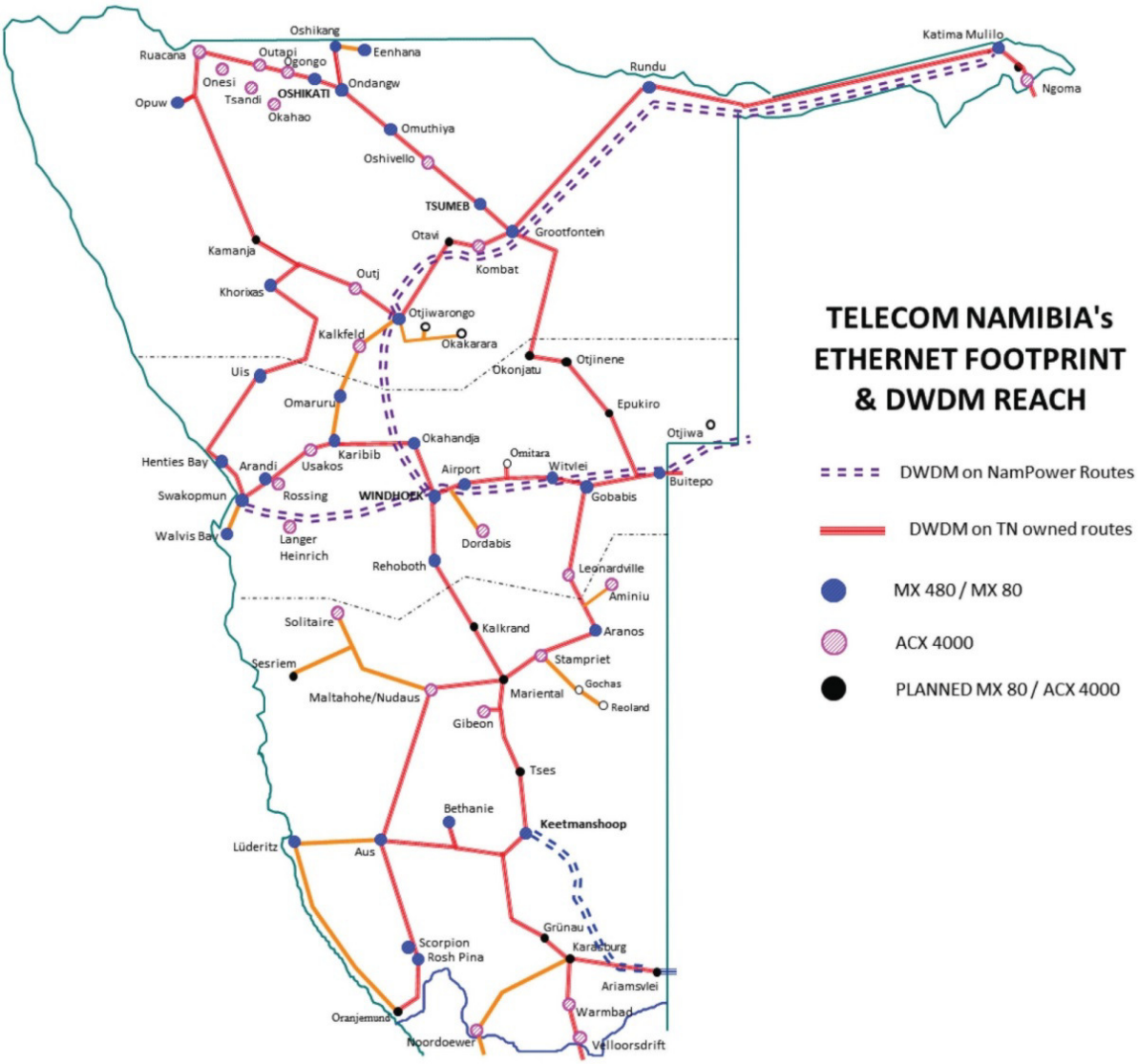

Figure-1: Telecom Namibia's network coverage[2].

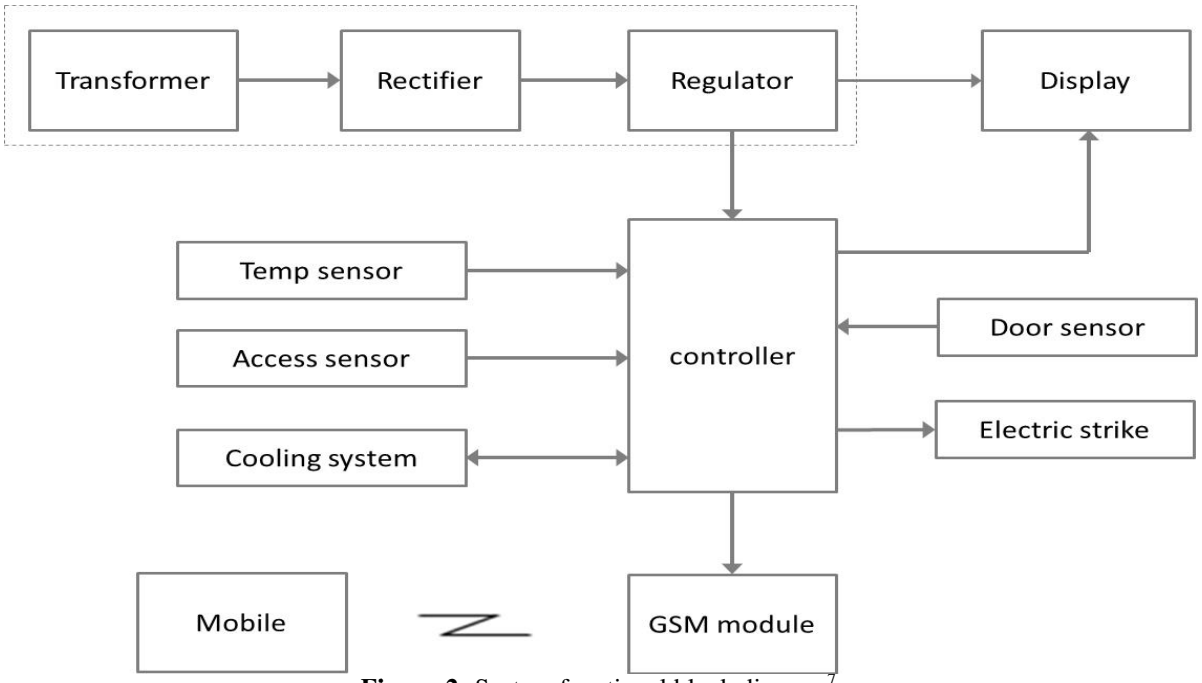

Figure-2: System functional block diagram[7]

Monitoring of ambient temperature: The device is programmed to display data from the temperature sensor in real time on the LCD. The threshold temperature is set to a value of 36°C. If the recorded ambient temperature goes higher than the threshold of 36°C an external fan is switched on and an alert text notification is transmitted to the registered mobile phone user.

In the eventuality of fan being switched on and as a result of which the ambient temperature sensed is below the threshold value of 36°C a second text message is transmitted citing new temperature conditions.

The ambient temperature is monitored continuously, if the temperature is still maintained high an alert message is transmitted again.

Monitoring access control: The biometric sensor monitors the access to the equipment room and the entrance through the door. Once the door is accessed by authorized personnel through the biometric sensor, an alert message is displayed "Authorized entry" on LCD and an alert text message is transmitted to the registered mobile phone user (control room/ administrator) which reads "Authorized entry".

If there is an unauthorized entry to the equipment room an alert message is displayed "Unauthorized entry" on LCD and an alert text message is transmitted to the registered mobile phone user number which reads "Unauthorized entry".

Thus, monitoring both, the temperature status of the equipment room enables real time action against equipment failure and vandalism leading to maintaining a good network quality of service.

Sensors and modules used in the design of the intelligent remote system: The sensors and modules used in the design are: i. Biometric Finger scanner at 12V, 100mA, ii. Temperature sensor (LM35) at5V, 60uA, iii. AirLink FXT009 GSM at 12V, 600mA, iv. Electronic strike at 12V, 240mA, v. Fan AFB0712HHB-F00 at 12V, 260mA, vi. LCD JHD162A at 5V, 2.5mA, vii. PIC18F45K22 at 5V, 25mA.

Prototype device sensors: Temperature sensor: LM 35 is selected as the temperature sensor, since the output voltage is linearly proportional to the sensed ambient temperature. LM 35exhibits low output impedance with high reliability ease of interface and cheap. LM35 can work in the temperature range of −55°C to 150°C and exhibits a high accuracy ranging from ±¼°C and ±¾°C at room temperature at its full range respectively.

Figures-3 and 4 illustrate the packaging and PIN layout of LM 35[8].

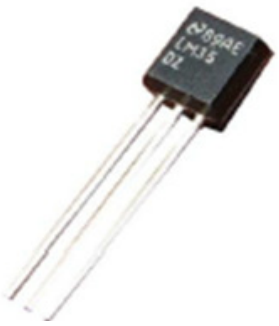

Figure-3: Plastic package LM35[8].

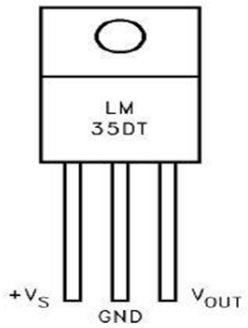

Figure-4: LM35 Pin layout[8].

The LM35 sensor output voltage is obtained in millivolts which is converted to digital value.

Biometric sensor: The biometric sensor used is the BR-004 sensor. BR-004 is a compact standalone single door access control device supporting various interface access e.g. fingerprint, access card and PIN. These various interface access assist in enabling 3rd party controller as a reader. BR-004 supports downloading and uploading of user information by using a USB. This is portable and simple to apply, hence selected in this design. Figure-5 depicts the BR-004 sensor. BR-004 is selected as it has a user capacity of 1500 and operates at 12 VDC with a resolution of 500 DPI[9].

Figure-5: Biometric BR-004[9].

AirLink FX GSM modem: The AirLink FX is selected as it supports the open AT application framework. The software package for developing embedded application is based on the C/C++, which is applied in this design. Airlink_FX series works with any wireless interface. It is selected in this project due to simplicity in application and interfacing with GSM technology. Figure-6 illustrates the functional Architecture of AIRLINK FX Series[10].

Figure-7 illustrates the FX series architecture.

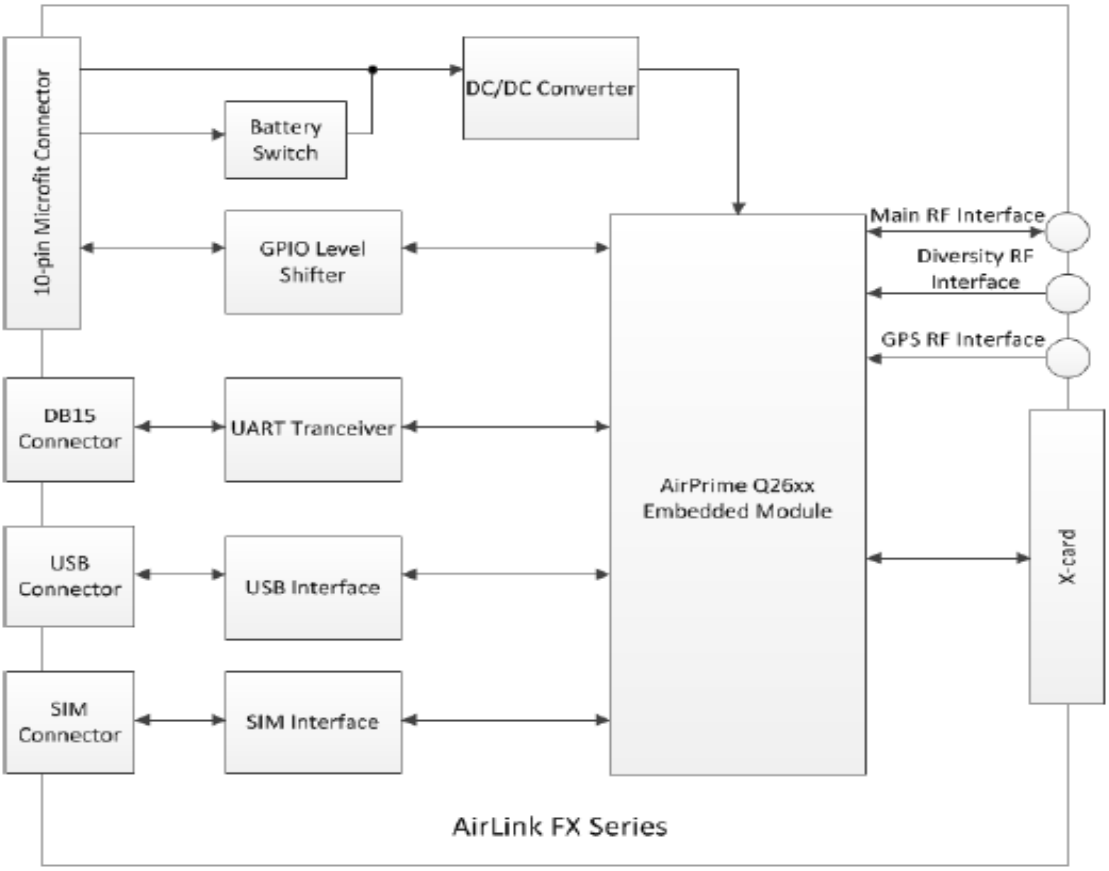

Figure-6: Functional Architecture of AIRLINK FX Series[10].

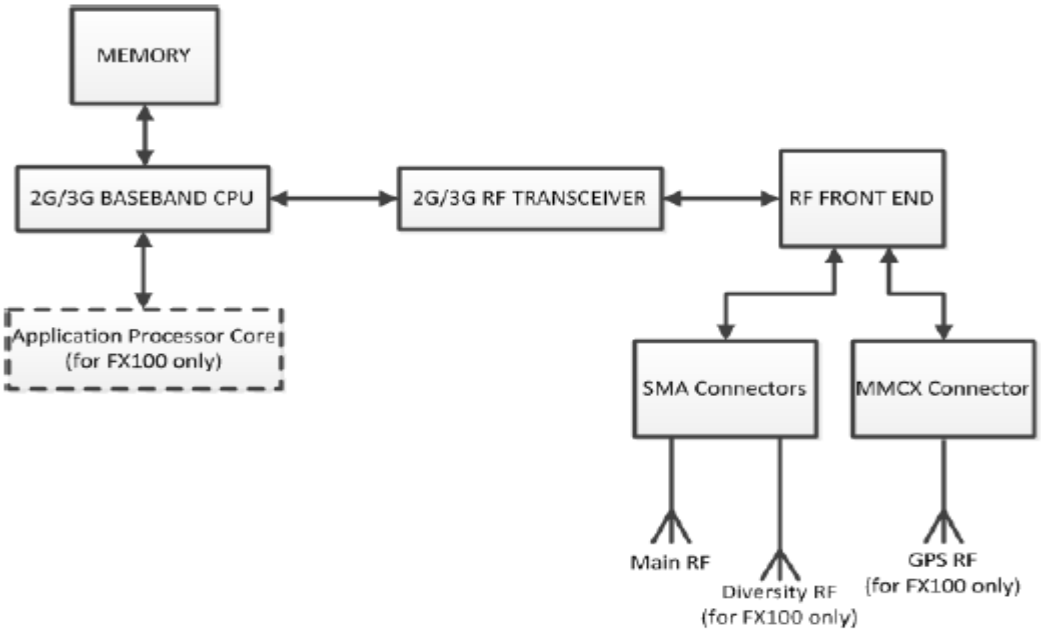

Figure-7: AIRLINK FX series architecture[10]

Microcontroller: Microcontroller selected in this design is the chip 18F45K22 PIC. This is used in digital applications as control units. Some microcontrollers come with in-build circuits like analog to digital convertors or digital to analog convertors. With high level programming of microcontrollers, it brings the advantage of not having a different program for each microcontroller manufacturer[11,12].

AFB0712HHB-F00 Fan: Fan is a critical cooling and ventilating device. The AFB0712HHB-F00 Fan actively cools the processor and equipment's by ventilating and aerating the air; thus, preventing thermal damage. The AFB0712HHB-F00 fan is selected as it operates on DC voltage with a voltage operating range of 4.0 to 13.8 VDC[13].

Figure-8: Fan AFB0712HHB-F00[13].

Electronic strike: Electronic strike is an electric lock can be integrated into an access control system. The advantages of electronic lock lie mainly in its key control, where keys can be added and removed without re-keying the lock cylinder and remote monitoring.

LCD JHD162A: JHD 162A LCD is electronic visual display based on the light modulating properties of liquid crystals. The display of the LCD is controlled by action of the two polarizing plates with a liquid crystal solution in between the plates. When an electric current is incident on the LCD, this causes the liquid crystals to align blocking out light. LCD functions in the temperature range of -10º to 60° with an operating lifetime of longer than 50000 hours (at room temperature without direct irradiation of sunlight)[11,14].

MAX232 board: The MAX232 device is selected here due to the inherent dual driver/receiver. MAX232 device works with input voltages of ±30-V with TTL/CMOS 5 V input levels, exhibiting a typical threshold voltage of 1.3 V[15]. Figures-9 and 10 illustrate the MAX232 board and the schematic connection diagram of the MAX232 board.

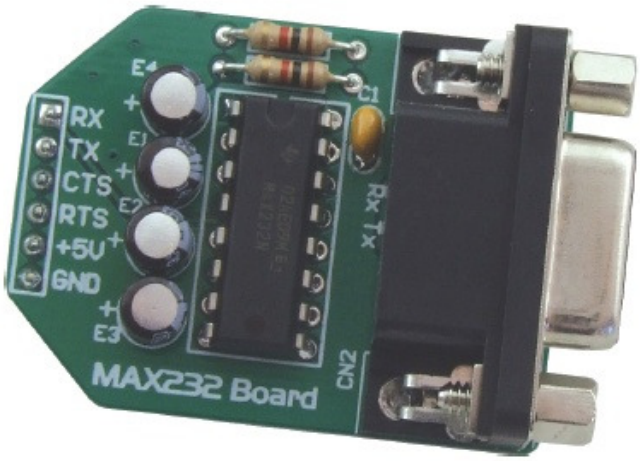

Figure-9: MAX232 Board[15].

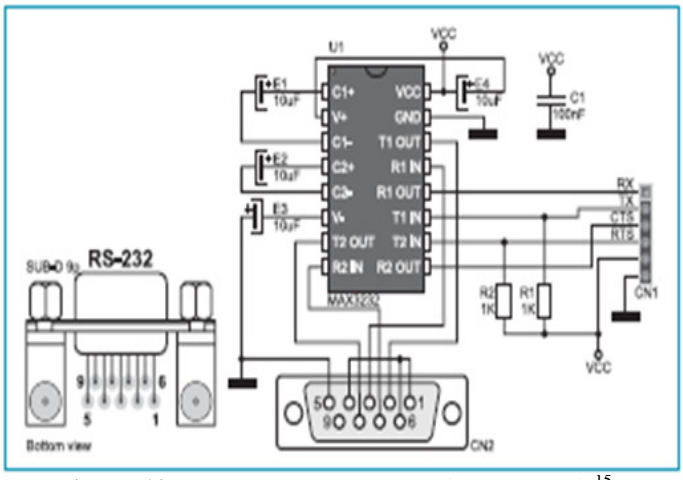

Figure-10: MAX232 Board connection schematic[15].

Magnetic door switch: The magnetic door switch is selected here to monitor access to the DLU equipment room. The magnetic switch can be mounted on the door of the equipment room. The Proposed web monitoring model is shown in the Figure-11.

The sensors will generate the value and this value is passed to the microcontroller. The microcontroller reads the analog value from the sensors and then converts it into the digital value so that it is readable by the computer[6].

System operation

The temperature sensor LM 35, LCD, magnetic door sensor and electronic lock, biometric sensor and the GSM modem are connected to the microcontroller.

The ambient temperature of the DLU equipment room is monitored and displayed on the LCD screen. Fluctuations in the sensed ambient temperature values above and below the threshold level are displayed and transmitted and in real time to the registered mobile user. The access to the equipment room is monitored via the magnetic door lock and the biometric sensor. Authorized and unauthorized access to the DLU equipment room is transmitted in real time to the registered mobile user. Figure-11 is an illustration of the interfacing and circuit diagram of the prototype.

Software design: The software program is implemented in Embedded C in AVR Studio 4. The AVR Studio is selected in this project due to its ease to write and debug AVR applications in Windows based operating systems and other advantages. AVR Studio includes a project management tool, with a simulator and an assembler with a source file editor in C/C++. This design in AVR Studio is created under AVR GCC type.

The AVR GCC plug-in exhibits a GUI front-end to GNU make. It uses the WINAVR tool to convert C Language to a HEX File. This HEX file is deposited into the 18F45K22 microcontroller using microprogram[12].

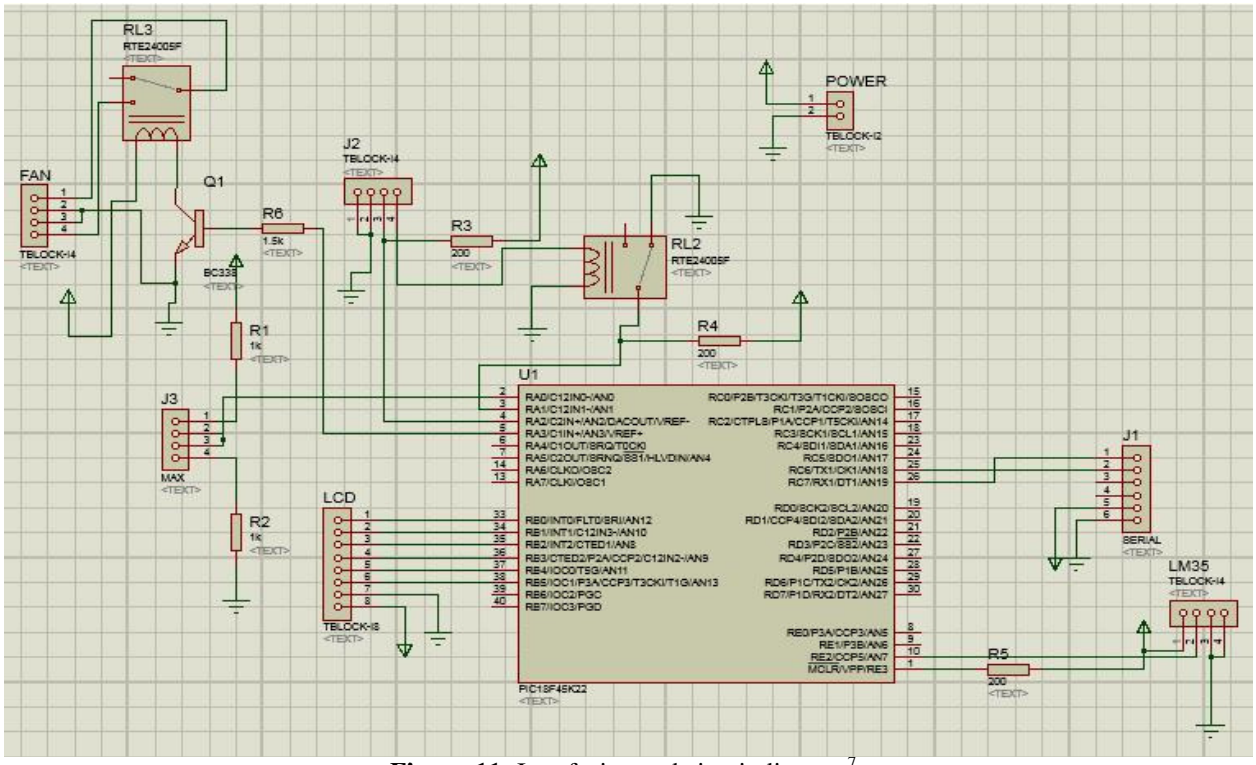

Figure-11: Interfacing and circuit diagram[7].

System operation and flow charts: ADC conversion flow chart: Figure-12 illustrates the ADC conversion flow chart.

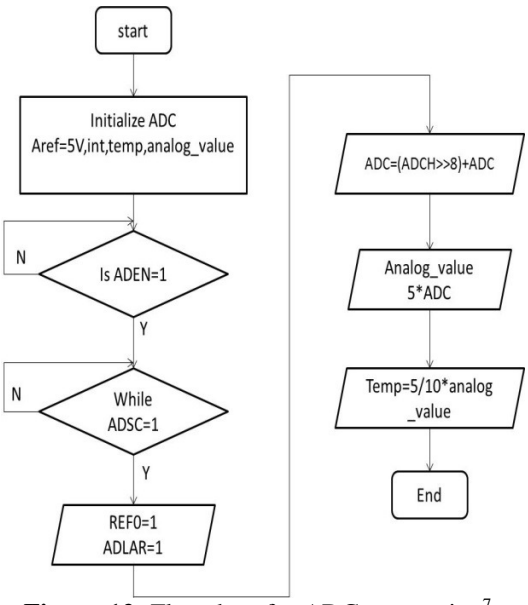

Figure-12: Flowchart for ADC conversion[7].

Flowchart for auto transmission of monitoring of ambient temperature sending of SMS (1): When Temp > threshold temp: i. Display temp, ii. Ext. Fan "ON", iii. Send "high temp, fan on". When Temp < threshold temp: i. Display temp, ii. Ext. Fan "OFF", iii. Send "temp normal, fan off".

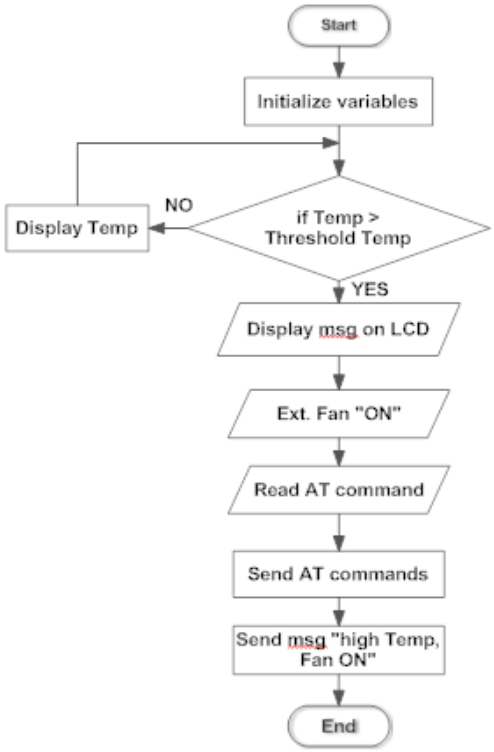

Figure-13: Flowchart for sending message[7].

Flowchart auto transmission of monitoring authorized entry

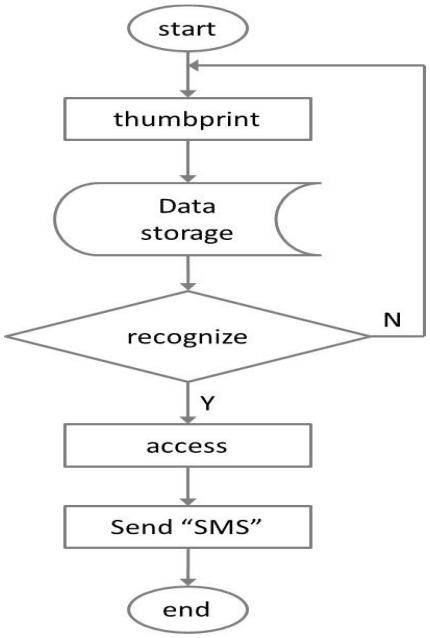

Figure-14: Flowchart for sending message[7].

Flowchart auto sending SMS for unauthorized entry

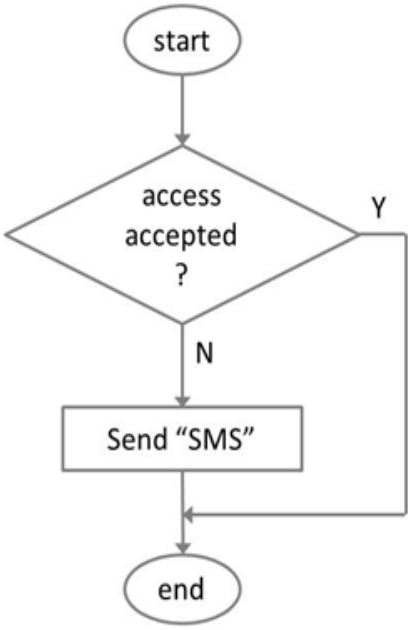

Figure-15: Flowchart for sending message[7].

To cater for high frequency noise that may come over the power line and into the power supply. The decoupling capacitors that are meant to bypass high frequency noise can be used. These are ceramic capacitors (non-polarized) and 0.1uF is a standard value and effective for high frequency response. These capacitors are connected to the input and output of each regulator.

Results and discussion

Testing of the system: The following are the results we obtained while testing:

Monitoring and transmitting temperature condition: The actual test results obtained as the ambient temperature exceeds 36ºC, with temperature above 36ºC, and the normalized temperature are illustrated. The Figure-16 below illustrates the LCD display and the text notification that were transmitted via GSM.

Temeprature < 36 ºC	Temeprature > 36 ºC
	
The temperature is monitored and displayed continuously	The temperature reaches above the threshold ambient temperature of 36°C.
	
The SMS sent "high temp, fan on"	

Figure-16: Illustrates temperature monitoring results and notification via GSM text message[7].

The Figure-17 below illustrates the LCD display and the cellphone text message received in the condition when the ambient temperature decreases the following was displayed on the LCD.

	
the temperature falls back below 36°C	The SMS sent "temp normal, fan off"

Figure-17: Illustrates temperature monitoring results and notification via GSM text message[7].

Condition (external fan malfunctioning): The Figure-18 illustrates the LCD display and the cellphone text message received when the fan has malfunctioned.

	
The LCD displays "check fan"	The SMS sent "high temp, fan faulty"

Figure-18: Illustrates temperature monitoring results and notification via GSM text message[7].

Monitoring access control and transmitting in real time: The actual test results obtained in access monitoring are illustrated in Figure-19 and Figure-20 for authorized entry and unauthorized entry in the equipment room.

Authorized entry

	
The LCD displays "authorized entry"	The SMS sent "authorized entry"

Figure-19: Illustrates authorized access LCD monitoring result notification via GSM text message[7].

Unauthorized entry

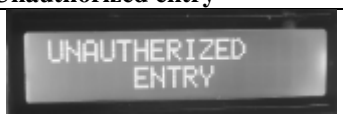	
The LCD displays "unauthorized entry"	The SMS sent "unauthorized entry"

Figure-20: Illustrates unauthorized access LCD monitoring result notification via GSM text message[7].

Conclusion

A prototype device is designed using cheap off the shelf components. The device monitors the ambient temperature and access to the DLU equipment room at the remotely situated Telecom Namibia digital line units. The advantage of this device is the real-time monitoring and transmitting of the monitored parameters.

Acknowledgment

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