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Real Time Data Acquisition and Logging Using Gsm Technology

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ABSTRACT

Data acquisition, logging and analysis is an all important aspect and an indispensable tool in information systems and communication technology. This work presents a system that is capable of providing a mechanism for sensing analog signals and coding them into a digital device which also enables the data to be logged periodically while also alerting and recording the status of any given physical quantity at intervals thereby ensuring no redundancy or lag in the acquisition system. The work aims at the implementation of a low cost but efficient and flexible GSM protocol, used in any environment to create a real-time data log. It is designed in such a way to achieve faster data acquisition and log time through the use of acknowledged communications between devices rather than the manually outdated passive methods. Thus this paper presents a system that is location independent, continuous, real time, speedy recording and logging of any given physical quantity which ensures complete elimination of lags and errors irrespective of the volume of data involved.

Keywords: Analog signals, Data log, Recording, GSM, Acquisition, Real time, Physical quantity, Location

Aims Research Journal Reference Format:
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1. INTRODUCTION

The global system for mobile communication (GSM) is a digital wireless technology standard based on the notion that users want to communicate wirelessly without limitations created by network or national borders. In a short period of time, GSM has become a global phenomenon. The explanation for its success is the cooperation and coordination of technical and operational evolution that has created a virtuous circle of growth built on three principles: Inter-operability based on open platforms, roaming, and economies of scale. GSM standards are now adopted by more than 200 countries and territories.Modern enterprises rely on their data acquisition or their existence. The data log is the lifeline of many organizations, technological and human processes. Data loss or mismanagement translates to potential disastrous loss of critical and sensitive information, technological efficiency as well as system confidence and productivity.

The general method of data acquisition is manual, a process that could be both time and labor wasting. Manual method of data acquisition is generally costly and error-prone as man is susceptible to fatigue, carelessness, negligence and mistake. With a traditional stand-alone data logger, you must first record the data and then manually transfer it to a PC before you can import it into a spreadsheet program or other tool to graph and visualize the data. Weather agencies commonly keep temperature logs for a number of locations, with temperatures being taken several times a day, year round. These logs are used to provide general temperature data, and for the purpose of weather forecasting. Information about temperatures can be useful for people who work outdoors, and for people like farmers and gardeners, for whom prevailing temperatures are a concern when it comes to scheduling planting and this need cannot be manually met.

Today's healthcare organizations face a wide range of complex challenges, including a growing population of aging patients, staffing shortages, reduced budgets, higher service expectations and increased regulations. In order to meet the demands of this tight-margin, competitive market- place, hospitals and other healthcare providers can no longer afford to rely on manual processes and outdated technology. Thus this work proposes a Global System for Mobile (GSM) communication based data acquisition system to mitigate the limitations of the manual and outdated technology methods of data acquisition because of its portability, cost effective, precision and availability nature. GSM based data acquisition systems can be sent to places that humans cannot easily get to or stay for a long period of time e.g. an island, non-resident offshore platform, or onto a roof of a tall building to get to a weather station.

The earliest form of recording data involved manually taking measurements, recording them to a written log, and plotting them on graph paper. In the late 19th century, this process was automated with the use of strip chart recorders that mechanically record measurements. Today, the more popular method of recording data is with a data logger (or paperless chart recorder). Data loggers are stand-alone box instruments that measure signals, convert them to digital data, and store the data internally (Xuemei, L. et al, 2011). Many data loggers include built-in displays and the ability to transfer the data to a Personal Computer (PC) for offline analysis. For over two decades, mobile network technologies have evolved from simple First Generation (1G) to today's Third Generation (3G) networks, which are capable of high-speed data transmission allowing innovative applications and services. The evolution of the communication networks is fueling the development of the mobile Internet and creating new types of devices. GSM based mobile phone is a versatile communication tool which has become an everyday tool in modern day life of many, even in our own country. GSM mobile phones come with lots of features including the ability to make Voice calls and to send/receive text, this very feature could be utilized to provide remote data acquisition, and to operate other electrical/electronic based equipment from a geographically remote location (Wikipedia, 2015).

2. REVIEW OF RELATED WORKS

In (Peng Liu et al, 2007) Peng developed a web services based data acquisition system for remote monitoring of embedded systems which integrates web services into emails. It uses a general purpose email messaging framework to connect devices and manipulators. But this model fits only for systems with low connection bandwidth and has very slow data transportation speed. Also here Hongping and Kangling proposed the architecture of an embedded data acquisition system based on Internet. The system adopts embedded web server as a central logging node and results in improvement in stability and reliability of system. Moreover, utilization of dynamic logging web based on Java Applet improves the response capability and brings convenience for complex data logging web design. Also, web usage requires resources like flawless Internet connections and hosting servers, which may not always fit to the concept of remote data acquisition (Peng Liu et al, 2007).This web based system has a high operation cost.

As a means of making data acquisition systems cost effective and flexible, the work "Research on Data Acquisition Methods" (Wijetunge et al, 2008), was conceived by researchers. Wijetunge here proposes the design and implementation of a general purpose controlling module with the capability of controlling and sensing devices. The communication between the controlling module and the remote server is done using Bluetooth technology. This system has the limitation of portability because the Bluetooth technology can only be used within a specified distance. Here also, Kanma proposed a data acquisition system for control of home appliances over Bluetooth with a cellular phone, which enables remote monitoring for home appliances through Java applications on a cellular phone. The communication adapter hardware consists of a 20MHz 16bit CPU, SRAM and a Bluetooth module. The communication adapter board is connected to the home appliance and to the cellular phone through serial ports.

The appliances can communicate with the cellular phone control terminal via Bluetooth SPP but only when the cellular phone is within the operating range of the Bluetooth module. Harms also in (Wijetunge et al, 2008) also described the wireless sensor networks (WSN) for autonomous Structural Health monitoring (SHM) systems for bridges. In Smart Brick Network, the base station and sensor nodes collect data from the on board and external sensors. The sensor nodes communicate their data from quasi-static sensors, e.g. temperature sensors, strain gauges and seismic detectors to the base station over the Zigbee connection. The base station processes these data and communicates them, along with any alerts generated, to a number of destinations over the GSM/GPRS link provided by the cellular phone infrastructure. The data are reported by email and FTP to redundant servers, via the Internet, at regular intervals or on an event-triggered basis. The alerts are sent directly by SMS text messaging and by email. But the development and deployment cost of wireless sensor network is very high due to need of motes, sensors, radio transceivers, etc. spread over a large area (Wijetunge et al, 2008).

Data acquisition systems, as the name implies, are products or processes used to collect information to document or analyze some phenomenon (Chen Chao, et al, 2009). In the simplest form, a technician logging the temperature of an oven on a piece of paper is performing data acquisition. As technology has progressed, this type of process has been simplified and made more accurate, versatile, and reliable through electronic equipment. Equipment ranges from simple recorders to sophisticated computer systems. Data acquisition products serve as a focal point in a system, tying together a wide variety of products, such as sensors that indicate temperature, flow, level, or pressure (Puneet Gupta, 2009).There are several types of data acquisition and they include: Wireless Data Acquisition Systems, Serial Communication Data Acquisition System, USB Data Acquisition Systems, and Data Acquisition Plug-in Boards

3. SYSTEM DESIGN AND ANALYSIS

This works presents a lot of considerations and improvements that were incorporated in to the functionality of the device so as to reflect desired features such as cost, design complexity, size, software development, weight, lack of portability etc. This system is a low cost, continuous, simple but fast means of data acquisition at any remote locations irrespective of location and size. Although fast and simple, it can be applied to both simple home automation and also to complex industrial automation. This system also has no limited operability as the user with any GSM based mobile phone having simple messaging and calling function in any path of the world with GSM network can monitor any location. With small size and portability in mind, the choice of the LCD display and miniaturized sensor aims at eliminating the need for a PC display, while making it easier to carry the system about, for continuous monitoring. It thus ensures flexibility in real-time remote monitoring regardless of distance and location. Another interesting feature of this particular design is the reprogrammable and open source nature of the product, which makes it easier to re-specify the particular heart rate to watch out for, as well as play with the system parameters, to suit the users need better. This is necessary due to varying environmental and physical conditions. The block diagram of the proposed system is given in figure 1.

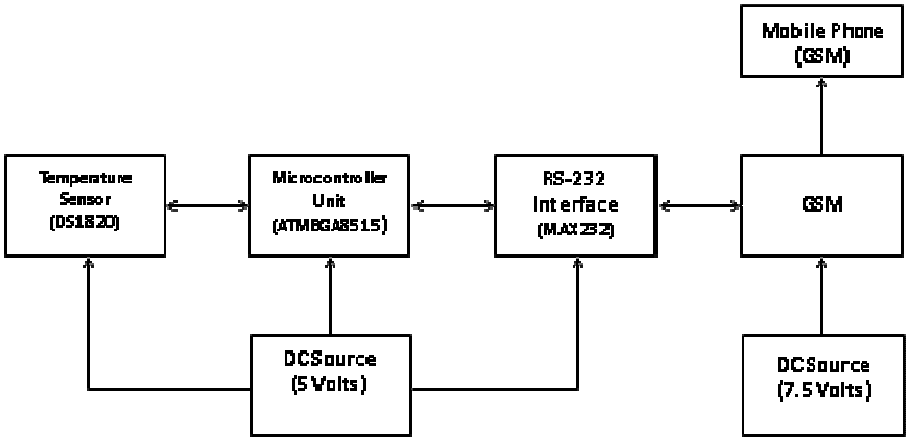

Fig.1: Block diagram of GSM based data acquisition system

A. Hardware Subsystem Design

This system was designed based on modular level system design since the major components that made up the system are modules with few discrete components such as resistors and capacitors. Each of these components has a special function it performs in the system. There are various components that were used to actualize the proposed project. These components are; the power module, voltage regulator (LM7805), the temperature sensor (DS1820), the microcontroller board (ATMEGA8515), the GSM module (SIM 900), resistors, capacitors, LCD and buzzer. These components were laid out and their pins were joined appropriately with lines. These lines are similar to the conductors on the printed circuit board (PCB). The DS1820 senses the temperature, represent it in digital form and serially send it to the microcontroller, the microcontroller which has been programmed sends this result from the sensor to the GSM modem in the form of AT commands through MAX232 using the RS232 serial communication standard, every three minutes. The MAX232 bridges the voltage level compatibility gap between the microcontroller and the GSM modem. The GSM modem now sends the result from the microcontroller to a prescribed GSM mobile phone number. The prototype system worked as expected after several trials.

i. Temperature Sensor (DS1820)

The pin out of temperature sensor DS1820 is shown in Figure 2. The DS1820 Digital Thermometer provides 9-bit temperature readings which indicate the temperature of the device. Information is sent to/from the DS1820 over a 1-Wire interface, so that only one wire (and ground) needs to be connected from a central microprocessor to a DS1820. Power for reading, writing, and performing temperature conversions can be derived from the data line itself with no need for an external power source because each DS1820 contains a unique silicon serial number, thus, DS1820 was used in this project to eliminate the need for an analog to digital converter since the physical quantity to be logged is in analog form and the controller used is a digital device. This helps bridge the compatibility gap between them.

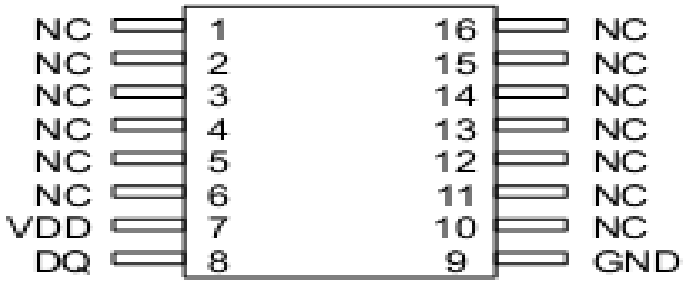

Fig. 2: The DS1820 Pin configuration

ii. The Microcontroller (ATMEGA8515)

The ATmega8515 is a low-power CMOS 8-bit microcontroller based on the AVR enhanced RISC architecture. By executing powerful instructions in a single clock cycle, the ATmega8515 achieves throughputs approaching 1MIPS per MHz allowing the system designed to optimize power consumption versus processing speed. It has a Programmable Serial USART. ATMEGA8515 was used as the controller in this project due to its flexibility nature, to achieve effective and efficient result.

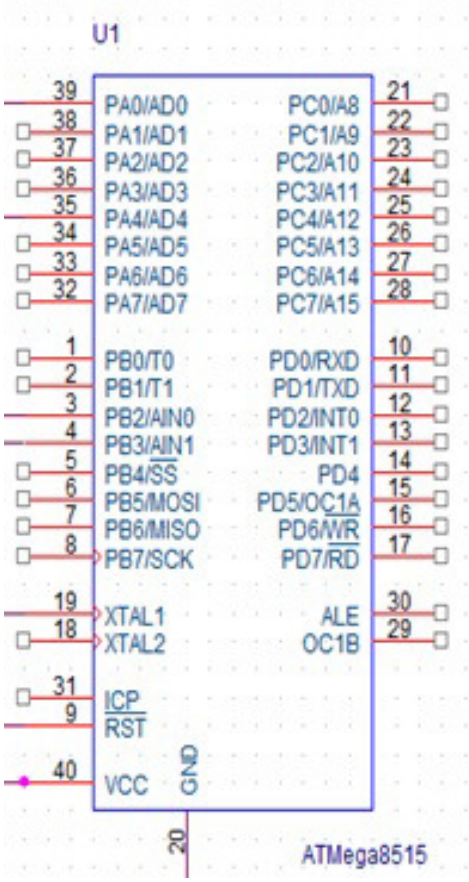

Fig. 3: ATMEGA8515 Pin out

Another interesting feature is the introduction of the arduino board. Arduino is a tool for making computers that can sense and control more of the physical world than your desktop computer. It's an open-source physical computing platform based on a simple microcontroller board, and a development environment for writing software for the board. Arduino can be used to develop interactive objects, taking inputs from a variety of switches or sensors, and controlling a variety of lights, motors, and other physical outputs. Arduino projects can be stand-alone, or they can communicate with software running on your computer (e.g. Flash, Processing, MaxMSP.) The boards can be assembled by hand or purchased preassembled; the open-source IDE can be downloaded for free. The Arduino programming language is an implementation of Wiring, a similar physical computing platform, which is based on the Processing multimedia programming environment. The Arduino Uno is a microcontroller board based on the ATmega328 (datasheet). It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz ceramic resonator, a USB connection, a power jack, an ICSP header, and a reset button.

The Arduino Uno is a microcontroller board based on the ATmega328 (datasheet). It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz ceramic resonator, a USB connection, a power jack, an ICSP header, and a reset button. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with an AC-to-DC adapter or battery to get started. It's an open-source physical computing platform based on a simple microcontroller board, and a development environment for writing software for the board.

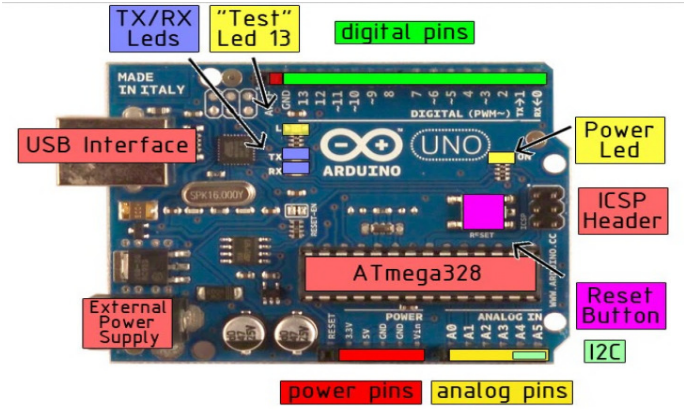

Fig. 4: Block diagram of the Arduino Board

The Basic Features of Arduino Board

- The micro-controller used is ATmega328, built with Harvard architecture advanced RISC (Reduced Instruction Set Computing) technology.
- Operating voltage is 5v.
- The recommended input voltage is 7-12v.
- Input power supply voltage range: 6v - 20V.
- Digital I/O Pins are 14 (of which 6 provide PWM output).
- The analog input pins are 6.
- The DC Current per I/O Pin is 40 mA.
- The DC Current for 3.3V Pin is 50 mA.
- The Flash Memory is 32 KB of which 0.5 KB used by boot loader.
- The SRAM size is 2 KB.
- The EEPROM size is 1 KB.
- The Clock Speed is 16 MHz

iii. The Max232

The MAX232 is a dual driver/receiver that includes a capacitive voltage generator to supply TIA/EIA-232-F voltage levels from a single 5-V supply. Each receiver converts TIA/EIA-232-F inputs to 5-V TTL/CMOS levels. These receivers have a typical threshold of 1.3 V, a typical hysteresis of 0.5 V, and can accept ± 30V inputs. Each driver converts TTL/CMOS input levels into TIA/EIA-232-F levels. MAX232 was used in this project as the TTL/CMOS input levels converter to TIA/EIA-232-F levels between the controller and the modem.

iv. The GSM Module (SIM900)

The diagram of GSM module for SIM900 is shown in Figure 4.6. The SIM900 is a complete Quad-band GSM/GPRS solution in a SMT module which can be embedded in the customer applications. Featuring an industry-standard interface, the SIM900 delivers GSM/GPRS 850/900/1800/1900MHz performance for voice, SMS, Data, and Fax in a small form factor and with low power consumption. With a tiny configuration of 24mm x 24mm x 3mm, SIM900 can fit almost all the space requirements in your M2M application, especially for slim and compact demand of design. SIM900 is designed with a very powerful single-chip processor integrating AMR926EJ-S core.

Fig. 5: Diagram of the GSM module

The overall design of the circuit as generated from the software design tool is shown in figure 6.

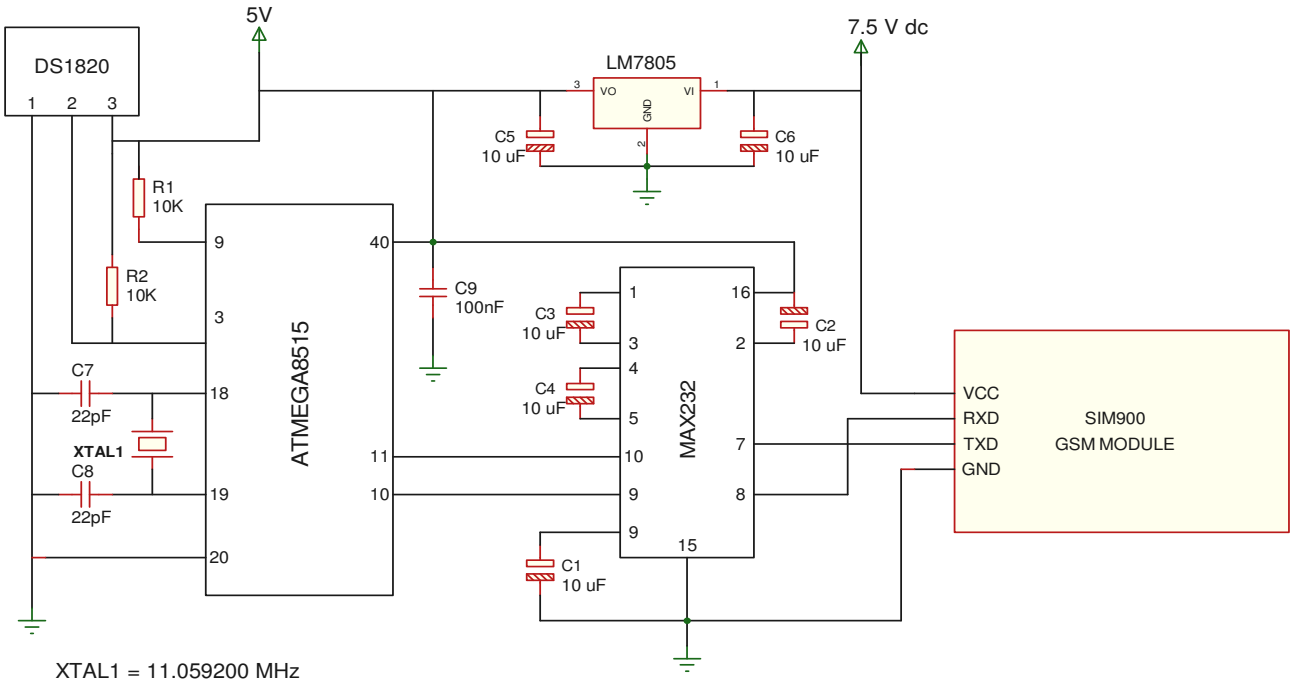

Figure 6: Circuit diagram of the data acquisition unit

B. Software Subsystem Design

The microchip used in this system, AVR microcontroller was programmed before installation. High-level coding was done in c language using the available IDE (integrated development environment) and compiler, mikroC Pro for AVR. Figure 7 describes the operation of the whole system:

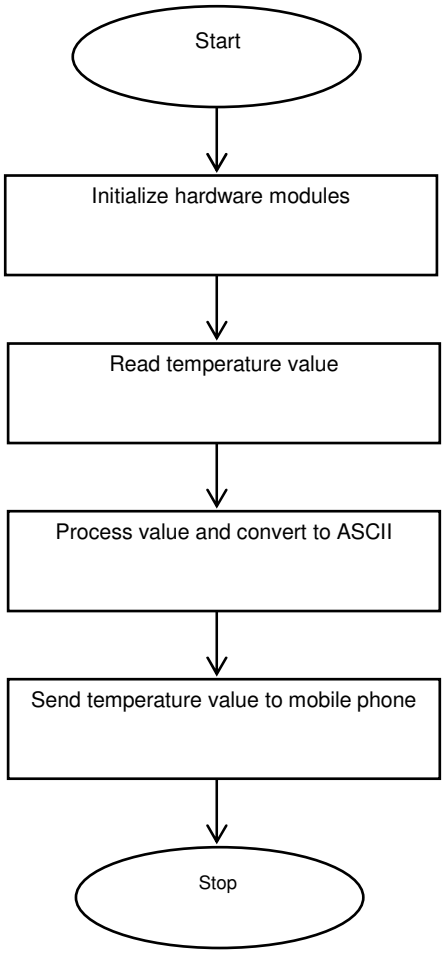

Figure 7: Design chart

The USART (Universal Synchronous and Asynchronous serial Receiver and Transmitter) module was configured as required for communication between the GSM module and the microcontroller. Table 1 defines the parameters uses for this configuration:

Table 1: Serial Port Parameters

Baud Rate	9600
Data bit(s)	8
Parity bit(s)	None
Stop bit(s)	1

The serial port baud rate defines the no of bits to be transferred per second between the transmitter and the receiver. The AVR USART module consists of a separate baud rate generator which can be accessed by the user to generate the desired baud rate. USART Baud Rate Register (UBRR) was configured to generate a baud rate of 9600 which was calculated from the equation below, as obtained in the manufacturer's application note:

$$BAUD = \frac{f_{osc}}{16 \times (UBRR+1)} \quad \text{..... (4.1)}$$

BAUD is the desired baud rate;

f_{OSC} = input clock frequency to the microcontroller;

UBRR = the register that holds the value that determines the baud.

A DALLAS one-wire digital thermometer chip was used as transducer in the circuit. The chip utilizes Dallas one-wire protocol for communication which is explained in the application note. The chart below (figure 8) describes the software implementation of this process

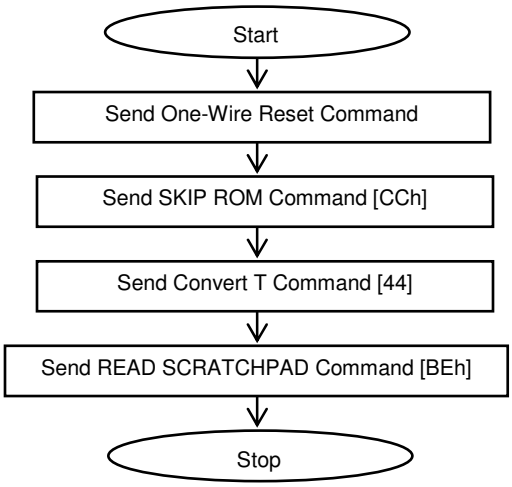

Figure 8: Read temperature flow chart.

As the device measures both negative and positive temperature values, it stores the converted value in equivalent 2's complement. The read value should then be checked against sign bit to determine whether it is positive or negative.

The values read from the register are in binary values. It is necessary to be in ASCII format, since the display decodes only ASCII numbers. This was simply done by adding 48 decimal (ASCII zero) to the binary value. This process is illustrated in the chart given in figure 9.

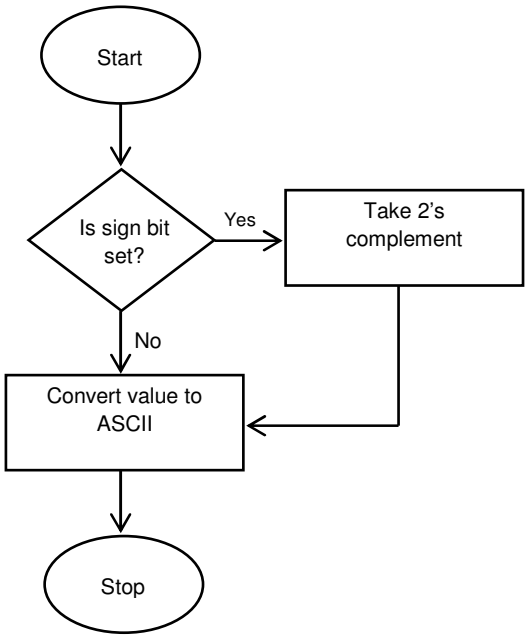

Figure 9: Process and Convert to ASCII

Communication with the mobile phone involves sending some required AT (Attention) commands, and then the message to the GSM modem incorporated in the circuit. In this project, few AT commands were used to send text message to the mobile. These used are:

- AT+CMGF=1 : this command sets the modem to text format
- AT+CMGS : this command is used to select the SIM number of the modem in use.

4. RESULT ANALYSIS/DISCUSSION

The essence of implementing a data acquisition system using GSM was to compare the efficiencies in terms of Fidelity, Sensitivity, availability, portability and low cost to the existing methods of acquiring data. This is shown in the result obtained from the different locations in at different times using this GSM based data acquisition system.

Figure 10: GSM based data acquisition system logging data at umuomaku in Orumba south local government area of Anambra state.

Data collected at umuomaku in Orumba south local government area of Anambra state on the 7th of August, 2015, between the hours of 16:00-16.30hrs at the 3mins interval is shown in table 2. The graphical representation is shown in figure 11.

Table 2: Data collected at Umuomaku in Orumba south LGA.

S/no	Temp. in Celsius	Time	Date
1.	028.0000	16:03	07:08:2015
2.	029.0000	16:06	07:08:2015
3.	029.0000	16:09	07:08:2015
4.	028.0000	16:12	07:08:2015
5.	028.0000	16:15	07:08:2015
6.	029.0000	16:18	07:08:2015
7.	028.0000	16:21	07:08:2015
8.	029.0000	16:24	07:08:2015
9.	028.0000	16:27	07:08:2015
10.	028.0000	16:30	07:08:2015

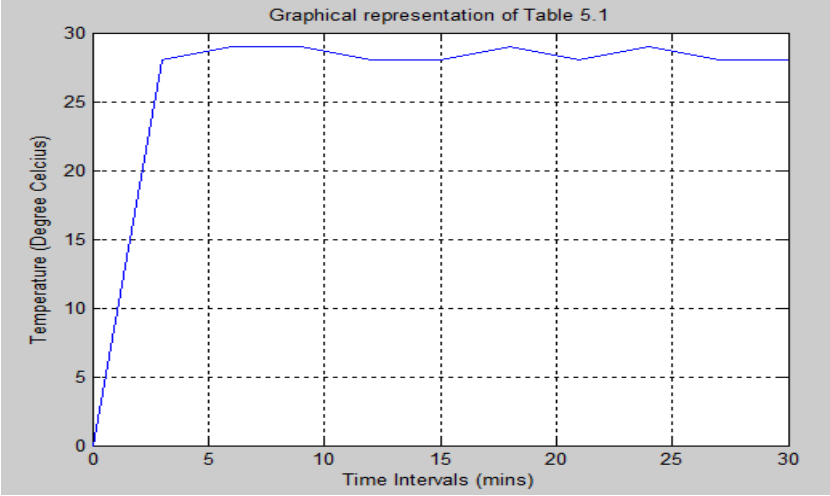

Figure 11: graphical representation of table 2

Figure 12: GSM based data acquisition system taking logging data in a forest close to Haaba River at Agulu in Anaocha local government area of Anambra state.

Data collected in a forest close to Haaba River at Agulu in Anaocha local government area of Anambra state on the 20th of August, 2015 between the hours of 08:00-08.30hrs at the 3mins interval is shown in table 3. Figure 13 shows a graphical representation of the data on table 3.

Table 3: Data collected in a forest close to Haaba River Agulu, Aniocha LGA of Anambra State

s/no	Temp. in Celsius	Time	Date
1.	026.0000	08:03	20:08:2015
2.	026.0000	08:06	20:08:2015
3.	026.0000	08:09	20:08:2015
4.	027.0000	08:12	20:08:2015
5.	027.0000	08:15	20:08:2015
6.	026.0000	08:18	20:08:2015
7.	027.0000	08:21	20:08:2015
8.	028.0000	08:24	20:08:2015
9.	027.0000	08:27	20:08:2015
10.	028.0000	08:30	20:08:2015

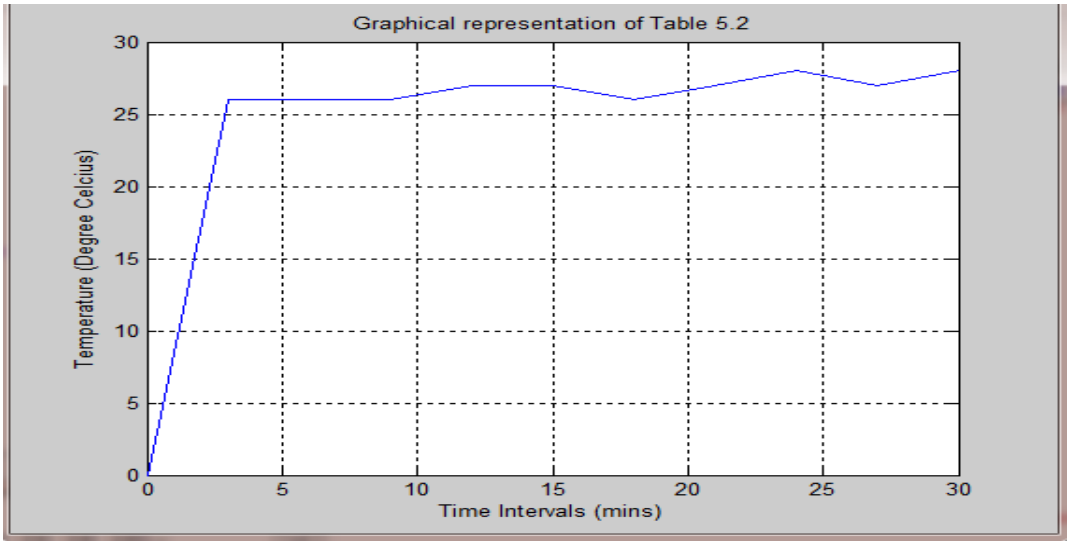

Figure 13: graphical representation of table 3

A System Testing

This stage involves the testing of the whole system. After the integration of the whole units a test program was written and burnt into the microcontroller board and then the system monitored to ensure optimum performance. The temperature of the given location at different time intervals was displayed on the LCD. The temperature signal is from a temperature sensor which is a digital device and can give temperature readings of -125 to 125 degree Celsius. This led to the microcontroller which has been programmed as discussed above. The microcontroller board being a digital device is connected to the GSM modem via MAX232 using RS232 and is made to communicate using the necessary codes. After all the necessary circuitry has been connected with the aid of the connector, the system output was just as expected. The proteus simulator was used in the cause of design of the data acquisition unit of the system. This is because the circuits were first simulated on a system using proteus software.

The temperature signal is from a temperature sensor which is a digital device and can give temperature readings of -50 to 125 degree Celsius. The remaining part of the project was done using prototyping because the software does not have the components. The success of proteus simulation and prototype led to assembling of different blocks of the systems on a Vero board to achieve the system. The design specifications were followed strictly during the construction. The components are carefully laid on the Vero board in other to minimize space. voltage regulator was used to regulate the voltage coming from the 7.5v source to 5v for the sake of other components that is of a lower voltage source and to avoid using another voltage source for such components as this will reduce time, space and cost.

5. CONCLUSION

Data acquisition systems presents the technology that is most frequently selected for use in digital communication networks to meet the requirement for precision real time data synchronization. This project has introduced a viable and sampling data acquisition tool that promotes real time data collation, monitoring, analysis of critical system information. These acquisition systems involves the application of engineering principles and techniques to the construction and design of efficient and high fidelity data loggers which guarantees Increased timing accuracy thereby providing overall improvements in system performance (quality and efficiency). The telecommunications infrastructure uses the data acquisition systems as an integral and basic part of the system.

This work proposes and focuses on the implementation of a low cost device that is very efficient, flexible, location independent while ensuring continuous, real time, speedy recording and logging of any given physical quantity which ensures complete elimination of lags and errors irrespective of the volume of data involved. This system is cost effective and user friendly and thus its usage is not restricted or limited to any class of users. It is a very efficient system and very easy to handle and thus provides great flexibility and serves as a great improvement over other conventional data logging, monitoring and alert systems.
The importance of data acquisition systems in communication systems can never be overemphasized as has been shown by the wide usage of its property in communication systems.

A variety of economic activities around the world all rely on precision real time data timing for synchronization and operational efficiency. The availability of GSM has enabled cost savings in data logging systems that depends on precise time and has led to significant advances in capability and quality delivery. Data acquisition systems saves lives by preventing transportation accidents, aiding search and rescue efforts, and speeding the delivery of emergency services and disaster relief. It also advances scientific aims such as weather forecasting, earthquake monitoring, and environmental protection. The price of data loggers is falling rapidly and the applications are growing. New uses of data loggers are invented every day and are limited only by the human imagination.

This system, just like any other can be improved upon for optimal and operational efficiency. Future advancements on this device would incorporate a steady power supply to feed the power module. It is recommended that this system should incorporate a solar panel or an inverter to ensure a steady power supply. The availability of a specialized bandwidth provision for SMS alert and network coverage would also ensure that delays in alert delivery and data logging is completely eliminated thereby making the system's performance very suitable and adequate to cater for emergencies and real time solutions. The open source nature of the system should be greatly retained and improved upon so as to give room for flexibility and re-specifying of the parameters intended to be logged irrespective of different environmental conditions or geo location..

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