A Portable Low Power Health Monitoring & Assistance for Critical Patients during Natural Disasters

MD. Fazil khan[1] K. Snehalatha[2]
M. Tech. Student
[1,2]Department of Biomedical Signal Processing & Instrumentation
[1,2]J.B. Institute of Engineering & Technology Moinabad, Hyderabad- 500 075

Abstract— Durable Medical Equipments (DME) such as ventilators, dialysis machines, and patient monitoring devices are life-supporting devices which are used extensively by the patients at home. These devices are electrically operated. While convenient and economical at home use of DME is susceptible to power outages, especially the ones caused by natural disasters that occur in large area and for a long time. To overcome this difficulty there is a technology which allows the hospitals to monitor DME- dependent patients without using the current infrastructure, such as the landlines, the cell towers, Ethernet cable or the Internet, which utilizes a radio ad hoc network to automatically report the patient's information and location, DME information and status to a nearby hospital when a power outage is detected. The system consists of two parts: a hospital-based receiving device called the Base station node and the multiple transmitting devices called User nodes, each connected to the DME at patient's home. The two stations communicate with each other; transmit the data using Xbee radio implementing Zigbee protocol. The system is provided with rechargeable battery which can be recharged by mechanical system in the absence of electricity. The system works without relying on the infrastructure, and allows hospital staff to know the information and locations of DME and their users and provide help needed during natural disasters.

Key words: ARM, Battery, DM, LCD, ZigBee

I. INTRODUCTION

Durable medical equipment (DME) is any medical device used at home by patients for monitoring and/or treating diseases [1]. There are types of DME: passive equipment and active equipment, the latter reliant on electricity to operate Life-supporting active DME include dialysis machines, ventilators, oxygen concentrators, etc.[2]. At home use of DME is not only convenient and economical, but also leads to better quality of life for the patient.

Despite aforementioned benefits, at-home DME are susceptible to power outages, especially those caused by natural disasters. During natural disasters, the DME dependent patients had to face the life-threatening situation because their machines could not work due to power loss [3]. So the most DME users are provided with the Batteries to keep functioning without any interrupt during power outages. So these batteries can drive the devices for several hours to have a communication between patient and doctor. Different batteries [4] such as lead-acid, lithium ion batteries are available which lasts for several hours.

The information can be transmitted from one station to other station using Xbee module implementing the Zigbee protocol [5]. The system does not rely on any internet cables, ethernet infrastructure or wired technology. So the system implements wireless [6] transmission of data.

The block diagram with various required modules is shown below,

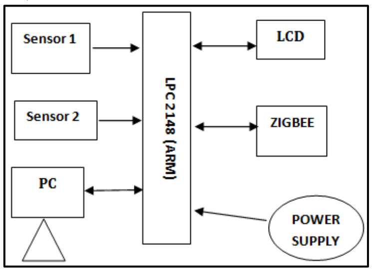

Fig. 1: Block Diagram of Home Based Station

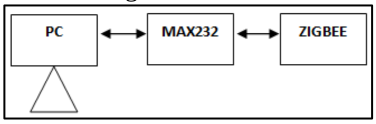

Fig. 2: Hospital Based Station

The data between the two stations is transmitted via zigbee module at a baud rate of 9600 bits per second. The health parameters such as respiration rate and temperature are measured by smoke gas and temperature sensors respectively.

II. HARDWARE IMPLEMENTATION

A. *Engineering Goal*

To solve the communication issue between when the infrastructure is disabled and help DME-dependent patients, a low power consuming system to be designed for transmitting the data wireless and without relying on the infrastructure and the data is transmitted at fast rate without much loss of information. Two stations are designed with the same features and components for effective functioning. The system to be designed must be economical.

B. *ARM Controller*

A microcontroller consists of a powerful CPU tightly coupled with memory (RAM, ROM or EPROM), various I/O features such as serial ports, parallel ports, timer/ counters, Inerrupt controller, data acquisition interfaces-analog to digital converter, digital to analog converter, everything integrated onto a single silicon chip.

The microcontroller used is ARM7 LPC2148 [7] which is based on RISC processors. It is the member of the ARM family of general-purpose 32-bit microprocessors. The ARM family offers high performance for very low-power Consumption and gate count. It is available in a tiny LQFP64 package. Serial communication through UART is done. 60 MHz maximum CPU clock available from programmable on-chip PLL with settling time of 100µs. Conversion time to convert analog to digital input is as low as 2.44µs per channel.

The ARM7 controller is based on RISC architecture in which a single-clock, reduced instruction set is provided. Low cycles per second, large code sizes are the features of this system.

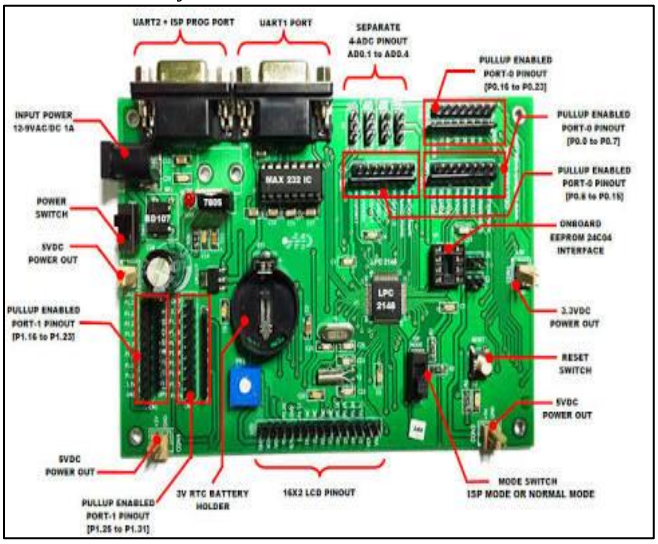

Fig. 3: ARM7 LPC2148 Controller

C. Liqiud Crystal Display

A liquid crystal display (LCD) [8] is a thin, flat display device made up of any number of colour or monochrome pixels arrayed in front of a light source or reflector. The liquid crystal twists the polarization of light entering one filter to allow it to pass through the other.

LCD displays designed around Hitachi's LCD HD44780 module, are inexpensive, easy to use and it is even possible to produce a read out using the 8x80 pixels of the display.

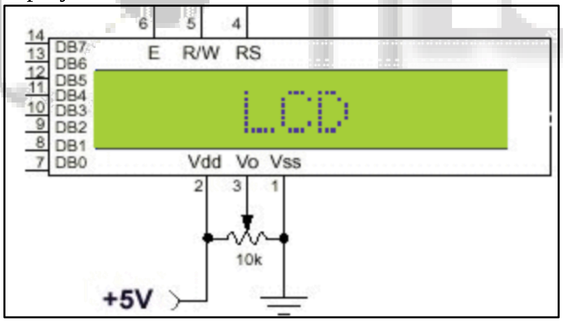

Fig. 4: Pin Diagram of LCD

D. Sensor Modules

The measured in an instrumentation system makes its first contact with a Primary Detection Element or an Input device. There is a multiplicity and variety of measured to be measured. This includes process variables like temperature, pressure and flow rate which are widely employed in process and production plants. All this quantities require a primary detection element and/or a transducer to be converted into another analogous format which is acceptable by the later stages of measurement system.

1) Sensors

A sensor or transducer [9] is a device that provides a usable output in response to a specified measurand. In this context two sensors modules used are temperature sensor and smoke gas sensor.

a) Temperature Sensor

Temperature sensor is a device which senses variations in temperature across it. LM-35 [10] is a basic temperature that can be used for experimental purpose. Working principle is that "the temperature rises whenever the voltage increases. The sensor records any voltage drop between the transistor base and emitter. When the difference in voltage is amplified, the device generates an analog signal that's proportional to the temperature".

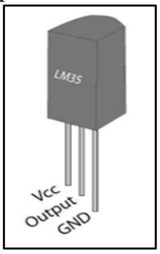

Fig. 4: LM-35 Package with Pins

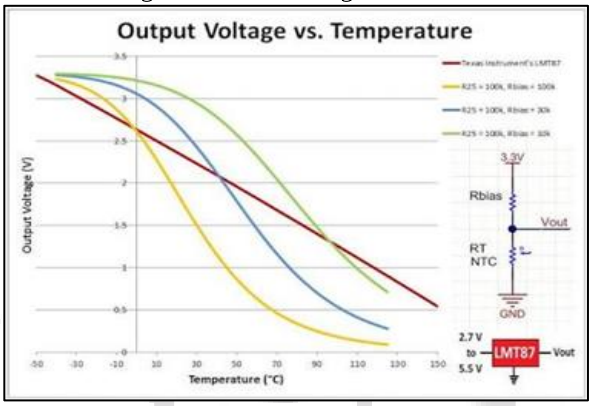

Fig. 5: Temperature-Voltage Characteristics of LM-35

The LM-35 has the advantage of accuracy, sealed circuitry, higher output voltage, highly sensitive and economically low cost.

2) Smoke Gas Sensor

Sensitive material of MQ-2 gas sensor [11] is SnO_2, with lower conductivity in clean air. When the target conductivity is higher along with the gas concentration rising.

The working principle of gas sensor is "when a gas interacts with this sensor, it is first ionized into its constituents and is then absorbed by the sensing element.

This adoption creates a potential difference on the element which is conveyed to the processor unit through output pins in form of current".

Model No.	MQ-2
Sensor Type	Semiconductor
Standard Encapsulation	Bakelite (Black Bakelite)
Detection Gas	Combustible gas and smoke
Concentration	300-10000 ppm (Combustibe gas)

Table 1: Sensitive Parameters of MQ-2 gas sensor

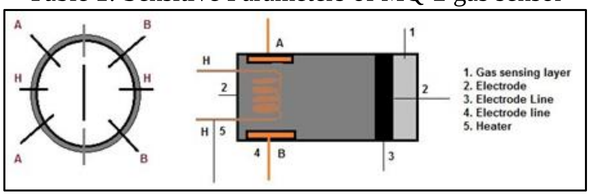

Fig. 6: Pin Configuration of MQ-2 sensor

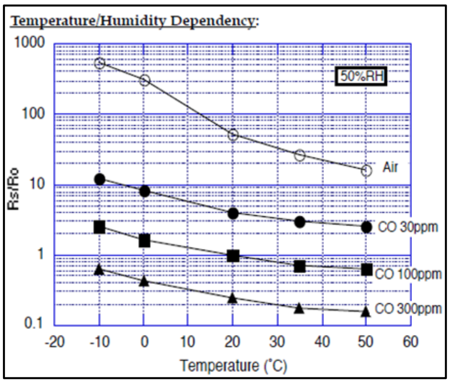

Fig. 7: Typical Temperature and Humidity Characteristics

Figure8 shows the typical temperature and humidity characteristics. The MQ-2 sensor can be applied in domestic gas leakage detector, portable gas detector.

E. Zigbee Module

Zigbee is an established set of specifications for wireless personal area networking (WPAN), i.e. digital connections between computers and related devices. It provides specifications for devices that have low data rates, consume very low power and are thus characterized by long battery life.

Zigbee[12] has the following specifications due to which it is widely used, i.e. Standard IEEE 802.15.4 protocal, bandwidth of 2.4 GHz , addressing space of up to 64 bit IEEE address devices, 65,535 networks.

Fig. 8: Zigbee Module

Zigbee stack architecture follows the standard Open Systems Interconnection (OSI) reference model, Zigbee's protocol stack is structured in layers. The first two layers physical (PHY) and media access (MAC) are defined by the IEEE.802.15.4 standard.

Security and integrity are key benefits of the Zigbee technology.

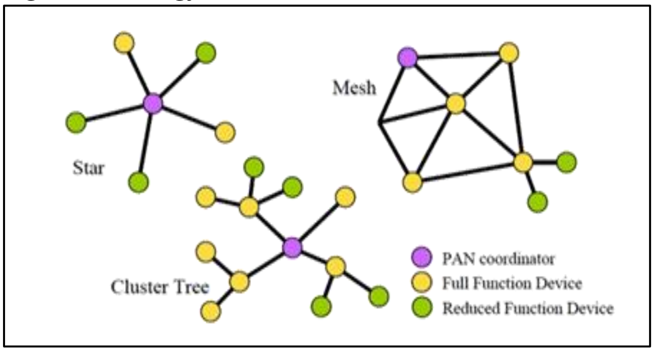

Fig. 9: Multiple Network Topologies

F. Power Consumption

Power requirement is the important factor for any system to run. It can be AC or DC power supply. Since the system consumes low power, DC power supply is used. Here AC power can also be used by converting it into DC with the help of rectifiers [13].

Microcontroller uses the input power or voltage 3.3 V which can be attained by using a regulated power supply. Since the ARM controllers consume low power a DC power with a mechanical rechargeable battery is used. The battery can give maximum of 9-12 V output voltage which is sufficient to run the controller and all the devices which are interfaced with controller. The batteries used may be typically lasts for only one hour with lead-acid batteries and 2-3 hours with newer lithium-ion batteries.

III. Software Design

Software gives the platform to interface the various modules with each other and is the important tool for the user. Software used is the µ keil software [14].

The code can uploaded using the driver software Flash Magic and at the same the simulation design can be done through is ISIS Proteus.

An integrated development environment or interactive environment is a software application that comprehensive facilities to computer programmers for software development. An IDE mainly consists of source code editor, build automation tools [15] and debugger. Several modern IDEs integrate with Intelli-sense coding features.

The programming is done using the basic C and Embedded C. A flowchart according to hardware implementation is described

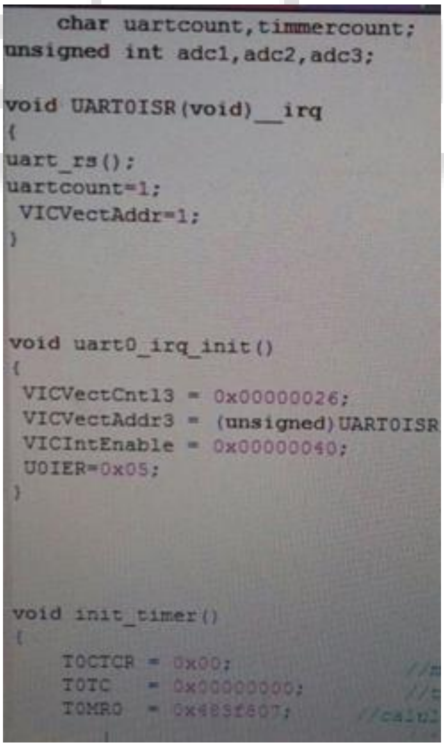

Fig. 10: Interrupt Functions

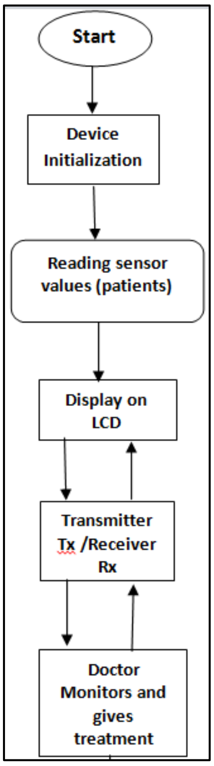

Fig. 11: Flow chart showing the system functions

The code is implemented in such a way that as soon as the system starts, the device initialization takes place; the micro-controller gets the analog values from sensors, transmits to the other end (hospital) through zigbee and receives the information through the zigbee. Here zigbee can act as the reciever and transmitter.

IV. TESTS CONDUCTED

In order to ascertain the functionality of the routing protocol, as well as to determine the time used to relay the data various tests were conducted.

A. Field Test & Network Test

Field test is a test which is carried out in an environment in which a product or device is to be used. The communication between the modules is tested internally within the microcontroller board, and the externally between the systems, through network test. The Data is transmitted within the range typically 50m – 75m and is transmitted with a baud rate of 9600 bits/second.

The data is transmitted without any loss and the prototype model designed is reliable and data transmitted is at a fast rate within a range of 75m of distance between the two systems.

V. RESULTS TO BE OBTAINED

The result gives the execution of the project which any reader can understand the process in which the output of the system is executed.

The data is transmitted and received from one station to other station without relying on current infrastructure, internet technology, gps etc…

The figures shown describe the result obtained.

Fig. 12: LCD displaying Patient’s Health Parameters

Here the project status is shown in the LCD which displays the characters/ strings which are nothing but the values obtained from the sensors.

The information is transmitted and displayed at the other station where doctor monitors the data and gives the first aid / treatment to the patients who are in critical state.

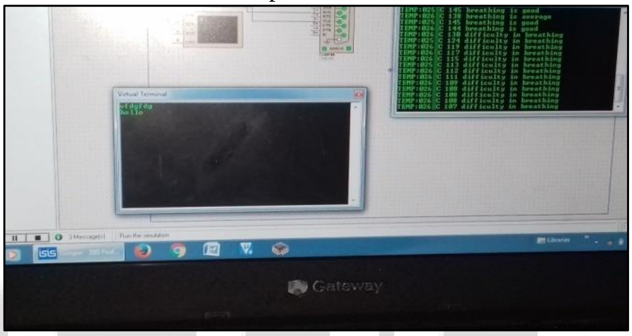

Fig. 13: Doctor Retrieving the Data at Hospital

VI. ADVANTAGES & FUTURE SCOPE

The system designed has the several advantages and used in the applications where there is need to monitor the patient conditions at home, during the war to give treatment for the injured people, can be installed easily at the places where the disasters have taken place.

The system designed can retrieve the data of a single patient and data can be sent through text messaging. System designed is prototype; the data can be transmitted within the limited range.

In future the system designed can be extended to meet the following requirements: multiple user system, transmission range can be increased by using high frequency modules, can be used for multiple parameter monitoring, audi calling feature can be added, and live communication such as video calling can be implemented by using low power CMOS camera.

VII. CONCLUSION

From the tests conducted, it was concluded that the prototype design of the DME system is easy to implement and could meet the requirement for securely transmitting the patient’s data, information and location without relying on the current infrastructure. The system designed consumes low power, is portable and reliable. It is user friendly system in which user could develop the program through user interface using Embedded C programming. The system designed is of low-cost, Sensors used are highly accurate and response time is fast, can detect minor changes in the surroundings. In order to transmit data, keypad interface is included by which user can send the data through text messaging.

The system is designed on the basis of Bio-Telemetry concept in which data transmission require cables where as in this system the data is transmitted without using the cables (wireless technology) through Zigbee module.

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