Patient monitoring system using MSP430 microcontroller

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Abstract— **In medical field during treatment of patient, it is highly important to monitor physiological signals of the patient. Physiological signals including heat rate, blood glucose, ECG, temperature etc are important signals. It is hard job for doctor and medical personnel to monitor each patient for 24 hours. In this paper introduce system in which collect physiological signals of patient transfer this signals to personal computer using Ethernet controller. So hear patient can be analyzing by doctor or other paramedical staff from central observation center or from their personal computer. Also this physical signal is shown on LCD screen. Texas Instrument Company MSP 430 microcontroller is used to save energy efficiently.**

***Index Terms*— Physiological information, Ethernet controller, MSP430**

I. INTRODUCTION

The implications of aging populations on health care management are increasingly attracting the attention of all governments. Predictions about the worldwide population of over-65 persons set the number at 761 million by 2025, more than double the 1990 [1]. As this aging population mainly suffer from different chronicle diseases. Different chronic diseases like diabetes, congestive heart failure and also other diseases required to monitor physiological signal of patient. Today many hospital uses traditional bade side patient monitoring system. These currently available patient monitoring systems suffer from certain technical limitations. This system is very expensive also to handle this system more number of staff is required. The rapid evolution of electronics and information technology is resulting in more powerful health care system. In hospital physiological signals including heat rate, blood glucose, ECG, temperature etc are important signals. It is hard job for doctor and medical personnel to monitor each patient for 24 hours. Here system is proposed in which collect physiological signals of patient transfer this signals to personal computer using Ethernet controller. So hear patient can be analyzing by doctor or other paramedical staff from central observation center or from their personal computer.

Here patient monitoring system uses three sensors heat rate, blood glucose and temperature. These three sensors collect physiological signal from patient and transfer this signal to the personal computer of doctor or other paramedical staff using communication module. In order to save energy effectively, low power microcontroller of Texas Instrument MSP430 is used for complete data processes and Ethernet controller is used to transfer all physiological information to personal computer.

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II. PROPOSED SYSTEM

As figure 1 shows block diagram of proposed system in which different sensors are connected as shown in diagram. Digital temperature sensor is directly connected to microcontroller. Whereas heart rate sensor and blood glucose sensor first given to amplifier and connected to microcontroller. LCD is directly connected to microcontroller and Ethernet controller module is connected to serial port of microcontroller. Personal computer or laptop is connected to hardware through the RJ45 connector and cat cable.

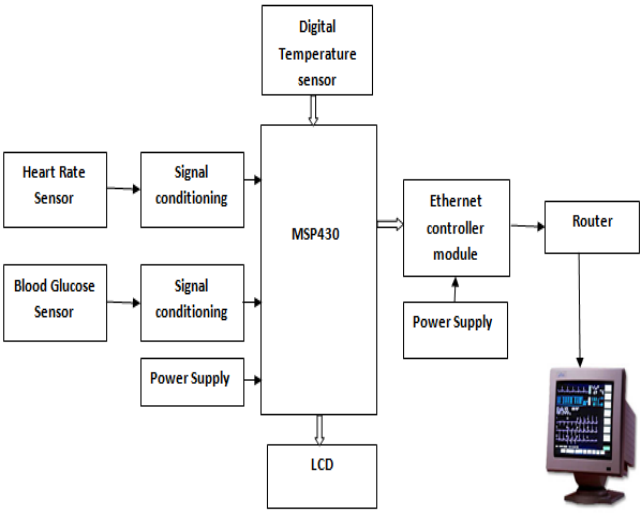

Figure 1: Proposed system block diagram

The GUI is created using Visual Basics through which Temperature, heart rate and blood glucose is display on personal computer in observation center.

III. HARDWARE IMPLEMENTATION

A. Microcontroller MSP430

The power consumption of any digital system depends upon power supply, operating frequency and load capacitance. Designer not able to control load capacitance of design [3]. So supply voltage has the greatest impact on the

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systematic energy consumption. In proposed system Texas Instruments MSP430 family of ultra low-power microcontrollers is used. The architecture, combined with five low-power modes to achieve extended battery life in portable measurement applications.

Status of Clocks at different low power modes in MSP430 controller is shown in Table I. The basic clock module provides the following three clock signals as auxiliary clock, main clock and sub main clock.

Table 1 Low power modes in MSP430

Low Power Modes	LPM0, LPM1	LPM2, LPM3	LPM4
MCLK	OFF	OFF	OFF
SMCLK	ON	OFF	OFF
ACLK	ON	ON	OFF

It has strong processing ability, high performance simulation technology and rich chip peripheral modules. It adapts to wide range of temperature, 62.5ns instruction cycle time, serial onboard programming, on-chip emulation logic.

Clock system has the ability to enable and disable various clocks and oscillators which allow the device to enter various low-power modes.[4]The flexible clocking system optimizes overall current consumption by only enabling the required clocks when appropriate. MSP430 controller supports several power management features. Table I shows the status of main clock, sub-main clock and auxiliary clock at different low power modes of operation. The different operating modes are explained as below [4]. The MSP430 MCU can wake-up immediately from LPMs. This ultra-fast wake-up is enabled by the MSP430 MCU's internal digitally controlled oscillator, which can source up to 16MHz and be active and stable in 1μs.

Its features are shown as follows.

- Low Supply-Voltage Range:1.8 V to3.6 V
- Ultralow-Power Consumption:
  - Active Mode: 250 μA at 1 MHz, 2.2 V
  - Standby Mode: 1.3 μA
  - Off Mode (RAM Retention): 0.1 μA
- Five Power-Saving Modes
- Ultra fast Wake-Up from standby mode in less very less time
- 10-Bit A/D Converter With Internal Reference, Sample-and-Hold
- Two 16-Bit Timer A With Capture/Compare Registers
- On-Chip Comparator for Analog signal
- Two Inter-Integrated Circuit Bus (I2C Bus) Multi-Master and Slave Interfaces
- Universal Serial Communication Interface (USCI)
- Auto-Baud rate Detection
- Brownout Detector
- Serial Onboard Programming
- On-Chip Emulation Logic With Spy-Bi-Wire Interface

B. Digital temperature sensor

This small thermometer board uses the TCN75 device. The temperature sensor is a serially programmable temperature sensor. Communication with the TCN75 goes via the serial I2C two-wire bus. The output temperature of sensor offer excellent temperature accuracy (±0.5°C typical) with a very low operating current of less than 250 μA. These temperature sensors are fully specified from 2.7V to 5.5V and allow temperature measurement over an extended -55°C to +125°C temperature range. Following figure show the digital temperature sensor which is having fore connection. This four connection are supply voltage, ground, CLK and DLK.

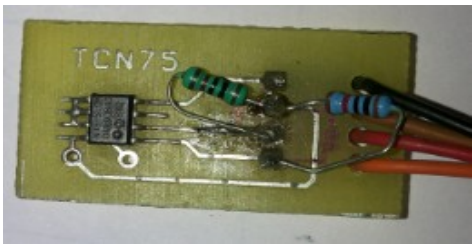

Figure 2: digital temperature sensor

Feature of digital temperature sensor:

- Solid-State Temperature Sensing:0.5°C Accuracy (Typ.)
- Operates from -55°C to +125°C
- Operating Supply Range: 2.7V to 5.5V
- Programmable Trip Point and Hysteresis with Power-up Defaults
- Standard 2-Wire Serial Interface
- Thermal Event Alarm Output Functions as Interrupt or Comparator/Thermostat Output
- Up to 8 TCN75s may Share the Same Bus
- Shutdown Mode for Low Standby Power Consumption
- 5V Tolerant I/O at VDD = 3V
- Low Power:
- 250 μA Operating Mode
- 1 μA Shutdown Mode
- 8-Pin SOIC and MSOP Packaging

C. Heart rate sensor

Heart beat rate sensor is used to measure the heart rate of the patient. Heart rate refers to speed of the heartbeat specifically the number of heartbeats per units of time. The heart can vary according to body's physical need, including the need to absorb oxygen and excrete carbon dioxide. Activities that affect heart rate are physical exercise, sleep, anxiety, stress, illness, ingesting and drugs.

Table 2: Average heart beat rate

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AGE	RANGE (bpm)	AVERAGE RATE (bpm)
0-1 Month	100-180	140
2-3 Month	110-180	145
4-12 Month	80-180	130
1-3 Years	80-160	120
4-5 Years	80-120	100
6-8 Years	70-115	92.5
9-11Years	60-110	85
12-16 Years	60-110	85
>16 Years	60-100	80

Figure 3: Heart rate sensor module

The sensor consists of a super bright red LED and light detector. The LED needs to be super bright as the maximum light must pass spread in finger and detected by detector. Now, when the heart pumps a pulse of blood through the blood vessels, the finger becomes slightly more opaque and so less light reached the detector. With each heart pulse the detector signal varies. This variation is converted to electrical pulse. This signal is amplified and triggered through an amplifier which outputs +5V logic level signal. This sensor operating voltage is +5V DC regulated and operating current is 100 mA.

D. Blood glucose sensor

There are different methods for detection of blood glucose and amperometric is one of them. In amperometric method test strip is used. A test strip consists of an electrode with chemical elements where a blood sample is deposited. The elements present in the strip generate a reaction and an electric current is produced. This current is proportional to saturation of glucose in blood. This current is converted in to voltage. The output voltage is proportional to the input current. This voltage signal is amplified and then given to microcontroller.

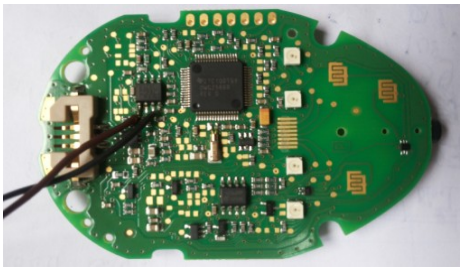

Figure 4: blood glucose sensor module

Figure 4 shows the Blood glucose sensor module which can provide the analog output signal. That is when test strip is connected to this blood glucose sensor module and sample is applied then depending upon the concentration on glucose in blood sample it can provide analog output signal. Then for further processing this analog signal is applied to microcontroller board. Table 3.4 shows normal blood glucose level at different ages.

Table 3: Normal Blood glucose level

AGE	Fasting (mg/dL)	Pp (mg/dL)
1-6 Years	100-180	110-200
7-12 Years	90-180	100-180
>12 Years	70-110	90-140

E. Ethernet controller module

Ethernet was commercially introduced in 1980 and the IEEE created a group designated the 802 working group standardize network technologies. This group created standards that they would later number 802.x, where x stands for subcommittee that developing particular standard. The subcommittee that developed the standard for the CSMA/CD was IEEE 802.3. Later in 1985 official standards were released for the IEEE 802.3. The Ethernet standards comprise several wiring and signaling variants of the OSI physical layer in use with Ethernet. It is true that the Internet is global in nature while Ethernet is local area network. The LAN generally covers under only a single building or premises that are close to each other. Ethernet allows many computers in single building to connect to one another through the network. This is done with the help of Ethernet hardware and Ethernet protocols.

Ethernet standard were for Carrier Sensing Multiple Access with Collision Detection (CSMA/CD) access method. CSMA/CD simply means that the computers all have access to the transmission medium, and can send and receive data, whenever the network is idle. The benefit of Ethernet is that it has the ability to sense collisions on the network. When a node on an Ethernet network wishes to send information to another node, it first listens to the network to see if there is network traffic. And If there is no traffic, it will begin sending the frames of data. CSMA/CD system send information throw network using MAC data frame.

Ethernet Controller Features:
• IEEE 802.3 compatible Ethernet controller

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• Integrated MAC and 10BASE-T PHY
• Compatible with all controllers having an SPI interface
• Fully Compatible with 10 or 100Base-T Networks
• Supports Full and Half-Duplex modes
• Industrial Temperature Range
• Programmable Transmit Automatic Padding and CRC Generation
• Programmable Transmit Automatic Re-transmission on Collision
• Programmable Receive Auto-Switch Between DMA and On-Chip Memory

IV. SOFTWARE IMPLEMENTATION

The microcontroller is used to processes data coming from sensors. The microcontroller drives a LCD display which shows the measured physiological information locally. Also this information is send to the personal computer through the Ethernet controller. Fig. 6 shows flowchart of the algorithm of the system.

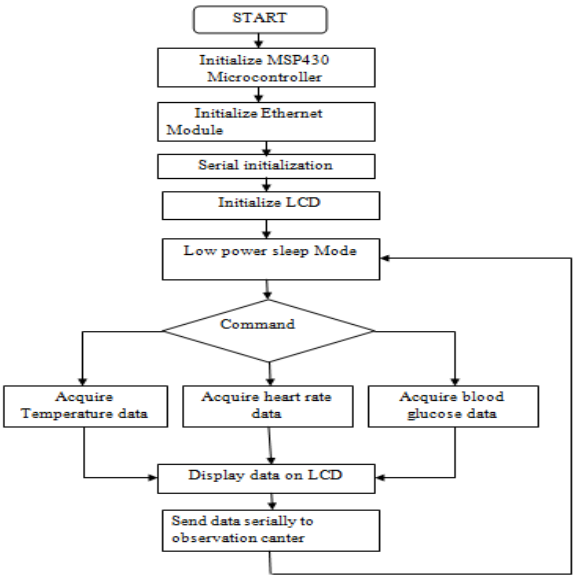

Figure 5: Software flow chart for system

Figure 6 shows the software flow chart for GUI

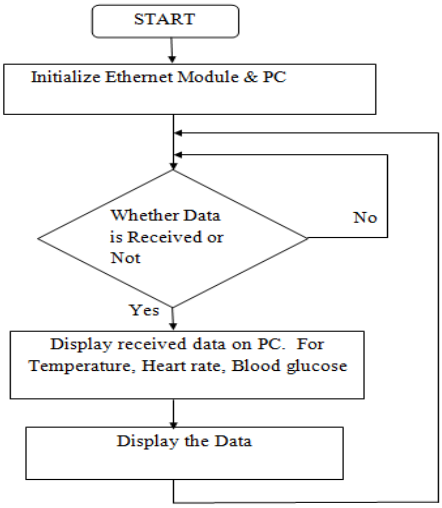

Figure 6: Software flow chart for GUI

V. RESULT

A. LCD Observation:

The figure below shows the output of Heart rate, Temperature and blood glucose (sugar) sensors on LCD.

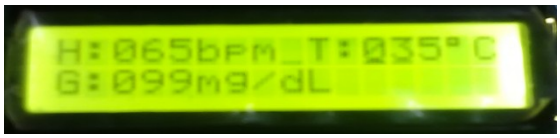

Figure 7: LCD Display observation

B. Graphical user interface (GUI) observation:

The figure below shows main GUI window for the system. In that GUI IP address and port no. is written for the Ethernet controller. After that click on the connect batten on the output GUI window, on the desktop basically three things has been observed by the user first one is Temperature, second thing is Heart rate and third is Blood glucose (sugar) of patient.

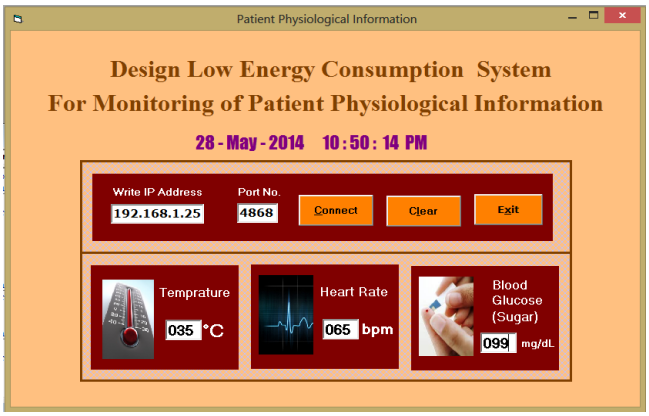

Figure 8: GUI window on Desktop (Laptop) result observation.

VI. CONCLUSION

Currently available systems for monitoring physiological signals suffer from technical limitations. Here system is proposed which collect and transfers physiological measurement signals of patient to personal computer of doctor or other paramedical staff. So patient can be analyzed by doctors from central observation center. Hear from proposed system we can observe temperature, heart rate and blood glucose of different patient. In order to save energy effectively, MSP 430 of TI Company is used for complete data processes and Ethernet controller is used to transfer all physiological information to personal computer.

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