Design of a Wireless Patient Monitoring System

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***ABSTRACT*:** *In hospitals, the patients in the ICU need a constant monitoring of their body temperature, SPO2 (Pulse Oximeter Oxygen Saturation) and pulse rate. This paper provides a working model which incorporates sensors to measure important parameters which were mentioned above namely the body temperature, respiratory temperature and pulse rate and transmits the collected data from these sensors to the user through GSM. Thus it reduces the doctor's work load as the collected data can easily conveyed to the doctor using wireless communication of GSM and also gives more accurate and high precision results. This application has a desired impact on industrial, defense and hospital automation. The hardware of the proposed model is built on a printed circuit board, constituting of microcontroller PIC16F877. The program required to implement the proposed model has written in hi-tech C using MPLAB.*

Keywords: GSM Technology, Monitoring System, Wireless Sensor Network Node

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1. Introduction

The objective of patient monitoring is to have a quantitative assessment of the important physiological variables of patients during critical periods of natural functions. For diagnostic and research purposes, it is necessary to know their genuine value or inclination of change. The Patient monitoring systems are used for measuring continuously or at regular intervals, automatically, the values of the patient's important physiological parameters [1]. The extended term objective of patient monitoring is to decrease mortality. And mortality and morbidity by

- Organizing and displaying information in a significant form to improve patient care.
- Correlating many parameters for clear demonstration of clinical problems.
- Processing the data to set alarms on the development of abnormal conditions.
- Providing information, based on automated data, concerning therapy.
- Ensuring better care with fewer staff members.

Complete Body parameters System deals with real time continuous monitoring and recording of some of the parameters like body temperature, SPO2, pulse rate as well as their analysis, and also deals with the alarm system for patient call, temperature level [2]. With the advent of computerization in bio-medical field, this proposed model has very wide scope, due to the computerized data gaining, monitoring and control incorporated in it. It reduces the workload of doctors and also gives more accurate results.

The conceptual model will be discuss about the PIC16F877 Controller of the port declaration in section 2, and the particular port connection and brief discussion on sensors are shown in section 3. The GSM Technology, its frequencies, SIM300 amplifier and MPLAB is discussed in section 4. Then finally conclusion is discussed in following section.

2. Hardware Design of Patient Monitoring

2.1 The Hardware Architecture

The core of wireless patient monitoring system is the design of wireless monitoring system, and the development of system software. The monitoring is generally consists of three modules: first one is the sensor module, second one is the control module and third one is the wireless communication module. The sensor module is used for acquire medical information from the outside, and then converts the received analog signals into digital signals. The control module is compared with the parameters of monitoring terminal, which is in charge of coordinating the task of different modules, controlling the sensors, processing data, and executing communication protocols. The wireless communication system mainly deals with the wireless broadcast of information.

Now a days, there are various kinds of wireless communication protocols. But since the main task of a monitoring system is to realize the transmission of signals such as heart rate, body temperature and SPO2 [3]. Moreover because of the monitoring terminal is worn on patients, which needs to be supplied by the battery, it puts a high demand on reducing of power dissipation of wireless module. Having taken these comprehensive factors into consideration, the proposed model is implemented using GSM technology as wireless communication protocol [4]-[5]. GSM technology is a developed for wide range and low-power wireless communication technology. It has a powerful ability and flexible methods of network forming, large network capacity, high security and low power consumption; for this reason GSM technology is suitable for usage in the wireless patient monitoring system. The communication module used in the proposing model is SIM 300 GSM Module.

The control chip uses PIC16F877 which belongs to PIC16F series; a fully integrated mixed-signal micro-controller, also 8K*14 words of flash memory and hardware implementation of the SPI Interface.

It is a multipurpose micro controller with in-built features such as 10 bit multi-channel Analog to Digital Converter, USART, synchronous serial port, programmable low voltage finding circuit etc, which is further interfaced with a to personal computer system through RS232 Channel.

The wireless monitoring terminal block diagram is shown in Figure 1. whose core is the PIC16F877A MCU. It is connected to the sim300 GSM modem, and can read and write inner registers of sim300, realize the Wireless transceiver of information. It can get information such as psychological parameters from external sensors which have in-built ADC and DAC modules are having. It is connected to with the simulator and PC by JTAG and UART series interface, therefore realizing the download and on-line debug of programs. Through the external interrupt, it could control the calling button to get the calling in order from patients, and process by interrupts.

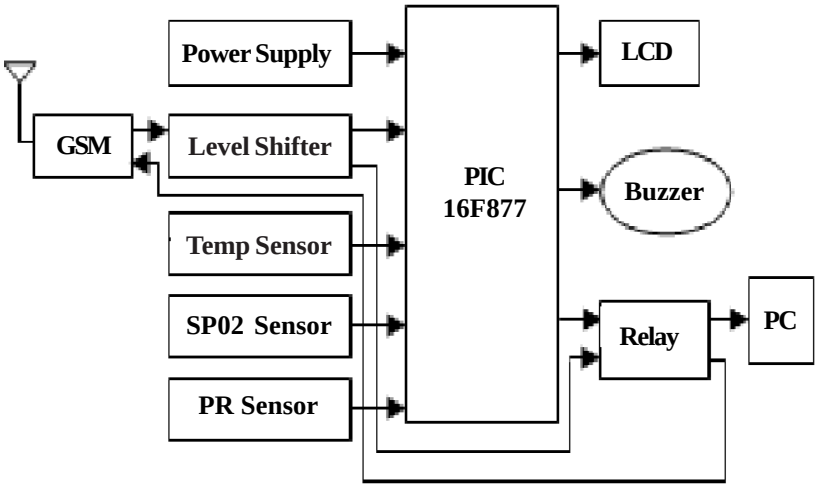

Figure 1. The Wireless Patient Monitoring Terminal Block Diagram

2.2 Port Allocation Of Micro-controller

Many of the digital resources could only be used through five I/O ports: PA, PB, PC, PD and PE. Every pin of PA, PB, PC, PD and PE could be defined as the individual I/O pin of general ports, and can be allocated to a digital peripheral or a function. In this system, peripherals that need I/O ports are UART0, SPI0, T0, T1, T2, and INT0. The allocation of pins is shown in Figure 2 according to the order of priority of cross-switch configuration of PIC16F877A.

This PIC16F877A microcontroller has 35 instruction cycles, three timers and 8 analog to digital pins are available in inbuilt microcontroller, RA and RE ports are analog to digital ports. RC0, RC1, RC2 Ports are timers. RC6 is transmitter, RC7 is receiver pins. To collect the signals of heart rate and pulse rate temperature sensors are to be connected with port RB4 to RB7. The collected information from sensors is in analog form. To convert from analog to digital, these sensors output should be connected to ADCs of PIC microcontroller. The PIC16F877A controller should be connected to the RA0 port, because the RA0 port has in-built analog modules.

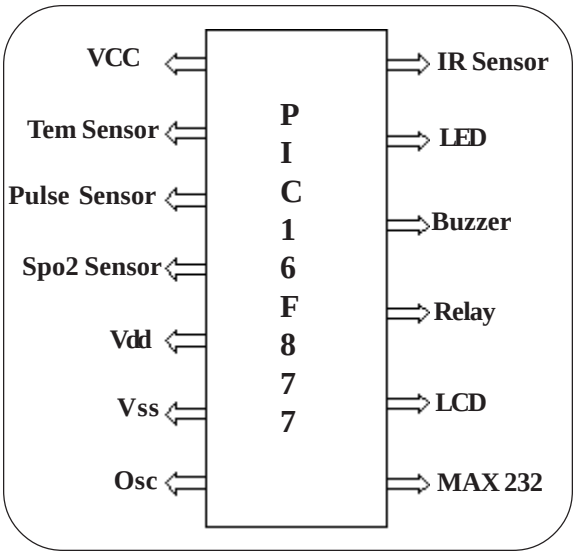

Figure 2. Port allocation of PIC16F877A

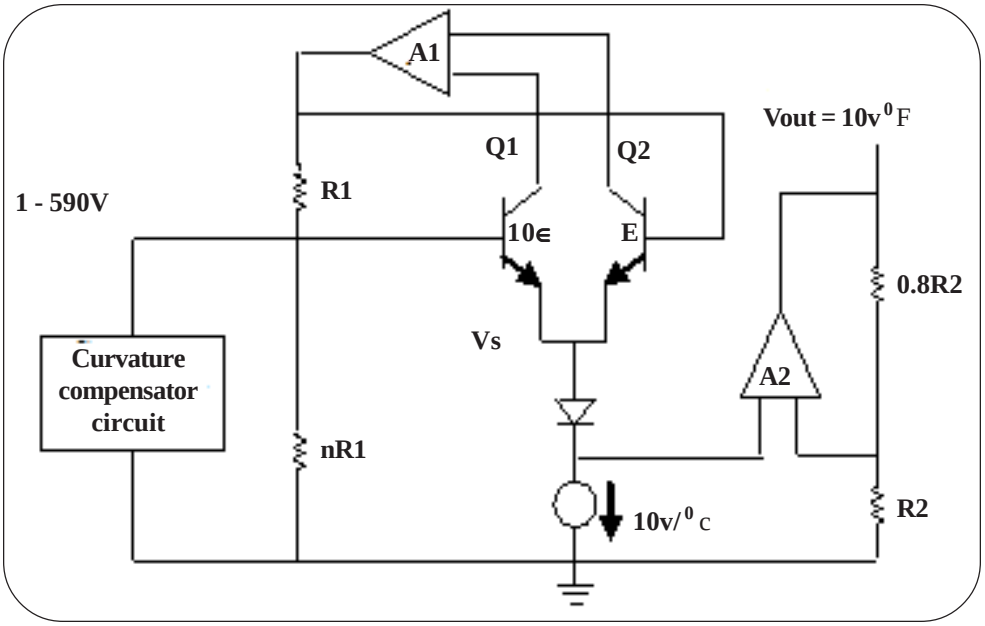

Figure 3. LM35 Sensor Circuit Diagram

3. Sensors Used For the Implementation

3.1 About Temperature Sensors

The LM35 series are precision integrated-circuit temperature sensors, whose output of the voltage is linearly proportional to the Celsius temperature. The LM35 thus has an advantage of linear temperature sensors calibrated in Kelvin, as the user does not need to subtract a large constant voltage from its output to obtain convenient centigrade scaling. The LM35 does not require any of the external calibration or trimming to provide typical accuracies of ±1/4 °C at room temperature and ±3/4 °C over a full -55 to +150 °C temperature range.

Figure 4. LM35

3.2 SPO2 Sensor

The SPO2 is the Saturation of human body Hemoglobin with Oxygen, expressed as percentage ratio compared to fully saturated Hemoglobin. When the Haemoglobin is fully loaded with oxygen, then it is 100% saturated [4]. It is SpO2, because this is normally measured by placing a probe on the finger which illuminates red light of two different types through the finger, and the calculation is carried out based on how much of each type of light is absorbed, which tells us how much the Hemoglobin is loaded up or saturated. A normal Human body Spo2 should be around 95-100%. The spo2 sensor module is to be connected to the PIC16F877A microcontroller.

$$SPO2 = RED / IR * 100$$

3.3 Pulse Rate Sensor

The pulse rate sensor is to count the heart beat or trained fingertips. The average healthy human pulse rate is 72 bpm, the adult of pulse rate is 60 to 100 bpm [3]. The pulse rate is mainly dependent on the human body condition. The different body conditions are Active level, fitness level, air temperature, body position, emotions, body size and medication.

Different positions in pulse rate can be observed from the Table 1.

	Age	Pulse Rate
New born Baby	1 to 7 months	120 to 160
Child	1to 2 years	80 to 130
Child	7 to 12	75 to 110
Adult	18+	60 to 100
Adult Athlete		40 to 60

Table 1. Pulse Rate Values

3.4 GSM Module

Construction of the system in the GSM wireless network used the digital technology and time division multiple access transmission methods [5]. GSM supports data transfer maximum speeds up to 9.6 kbps, allowing the transmission of basic data services such as SMS. One of the major benefits is international roaming capability. There are five different cell sizes in a GSM network they are macro cells, micro cells, pico cells, femto cells and umbrella cells [5]-[6].

Figure 5. Snapshot of GSM SIM 300 module

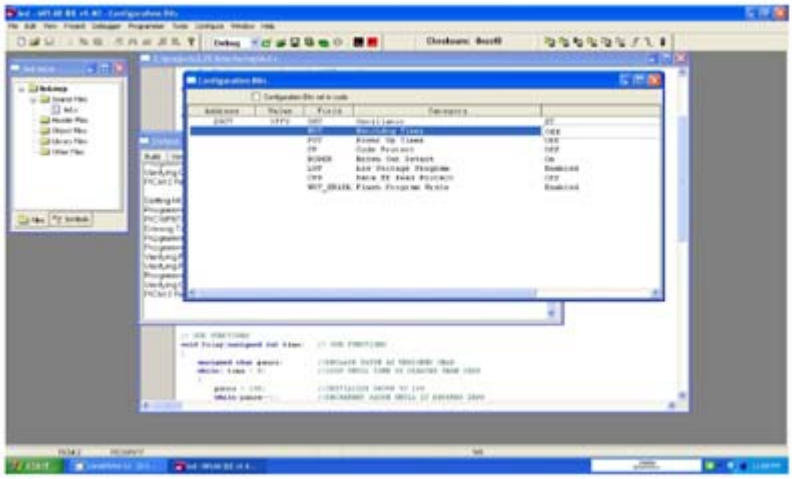

Figure 6. GUI of MPLAB IDE

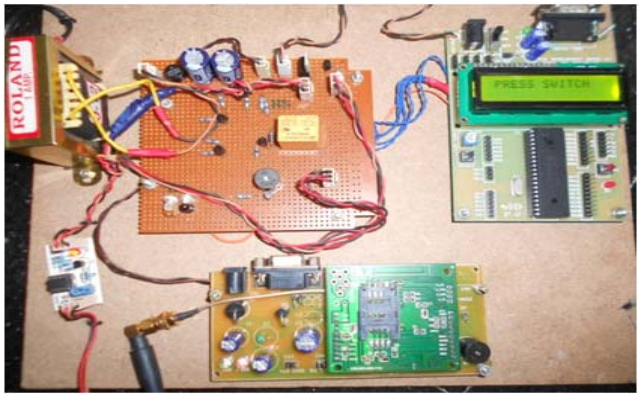

Figure 7. Hardware Kit

Specifications for different personal communication services systems vary among the different personal communication service networks, which is a description of the specifications and characteristics for GSM.

Frequency band: the frequency range specified for GSM is 1,850 to 1,990 MHz.

Duplex distance: it is 80 MHz. Duplex distance is the distance between the uplink and downlink frequencies. A channel has two frequencies, that frequency is 80 MHz.

Channel separation: the separation between adjacent carrier frequencies is 200 kHz in GSM.

Modulation: Modulation is the process of sending a signal by changing the characteristics of a carrier frequency.

Figure 8. Output display of LCD

Transmission rate: GSM is a digital system with an over-the-air bit rate of 270 kbps.

Access method: GSM utilizes the time division multiple access concept. Time division multiple access is a technique in which several different calls may share the same carrier.

Speech coder: GSM uses linear predictive coding. The purpose of linear predictive coding is to reduce the bit rate. The linear predictive coding provides parameters for a filter that mimics the vocal tract. The signal passes through these filters are leaving behind a residual signal. Speed of speech is encoded at 13 kbps.

The GSM used is SIM 300 amplifier, this amplifier will be connected to micro controller, if any one of the patient body parameters are to be changed to the above normal condition the SIM300 will be activated and send the information to the particular persons and doctors about the time to elect and save the patient's life in critical condition.

4. Software Description

The MPLAB IDE is software that uses to develop program for a microchip controllers and digital signal controllers. In this software a programmer can easily develop the programs for microchip controllers. By using C or Assembly languages programmer can write the code. PICKit2, PICKit3 and MPLAB ICD3 are circuit debuggers. MPLAB REAL ICE is circuit emulator, which can program the code into target device.

From the Figure 8 it can be observed that the patient's health conditions of the temperature in degree centigrade as 28.3, SPO2 level as 79% and pulse rate as 72. And these collected information can transfers to the registered mobile from the GSM module attached to the hardware module.

5. Conclusion

Tests find that this system can successfully set up the GSM. The monitoring terminal can precisely check the pulse rate, body temperature and SPO2 of patients, and send them to coordinator and then surveillance center through wireless network. The errors in monitored in body temperature, heart rate, and other information is very slight, which satisfies practical usage. By extending other sensor module, it can realize the monitoring of more psychological parameters and reliable transmission.

Since this system only realized the detecting and transmission of pulse rate SPO2 and body temperature, and the detection accuracy is not enough. The next step focuses on how to improve other body parameters like electro cardio gram with GSM technology. To conduct further research on the monitoring of more psychological parameters. More work should be done concerning this aspect to further reduce the power dissipation and lower the cost.

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