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Heart Rate Monitoring System based on IOT

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Abstract: *Detection of atrial fibrillation is done by checking the variation in the period of heart rate, if a patient has atrial fibrillation then the period between each heart beat will vary. But in this Paper, we developed a heart rate sensor which can be used to detect the variations in the heart rate, this is done by using PPG(Photo Plethysmo Graphy). The heart rate sensor is a thumb-sized heart rate monitor designed for ATMEGA328PU Microcontroller. A pulse sensor which is developed based on PPG techniques, used to detect the blood volume changing in the micro vascular bed of tissues. It is relatively easy to detect the pulsatile component of cardiac cycle.According to this theory, the sensor has two holes that you can used to attach to your belt. You can wrap on your finger, wrist, earlobe or other areas where it has contact with skin. The heart rate monitoring system has two kinds of output mode – analog pulse mode and digital square wave mode. You can change the output mode using dial switch to detect the heart rate. The GSM modem used to make a processor to communicate over a network through SIM card and stored the datas in the cloud.*

Keywords: *ATMEGA328PC Microcontroller, Heart Rate Sensor, GSM Modem,LCD Display, Rectifier, Transformer, USB to TTL Convertor, Voltage Regulator.*

I. Introduction

Cardiovascular disease is one of the main causes of death in many countries and thus it accounts for the over 15 million deaths worldwide. In addition, several million people are disabled by cardiovascular disease. The delay between the first symptom of any cardiac ailment and the call for medical assistance has a large variation among different patients and can have fatal consequences. One critical inference drawn from epidemiological data is that deployment of resources for early detection and treatment of heart disease has a higher potential of reducing fatality associated with cardiac disease than improved care after hospitalization. Hence new strategies are needed in order to reduce time before treatment. Monitoring of patients is one possible solution. Also, the trend towards an independent lifestyle has also increased the demand of personalized non-hospital based care. Cardiovascular disease has shown that heart beat rate plays a key role in the risk of heart attack. Heart disease such as heart attack, coronoary heart disease, congestive heart failure, and congenital heart disease is the leading cause of death for men and women in many countries. Most of the time, heart disease problem harm the elderly person. Very frequently, they live with their own and no one is wilingto monitor them for 24 houres a day.

In this proposed device, the heart beat and temperature of patients are measured by using sensors as analog data, later it is converted into digital data using analog to digital converter(ADC) which is suitable for wireless transmission using SMS messagethrough GSM moderm. Micro controller device is used for temporary storage of the data used for transmission. For a patient who is already diagnosed with fatal heart disease, their heart rate condition has to be monitored continuously. This project proposes and focues on the design of the heartbeat monitor that is able to monitor the heart beat rate condition of patient continuously. This signal is processed using the microcontroller to determine the heart beat rate per minute. Then, it sends short message service alert to the mobile phone of medical experts or patient's family members, or their relativesabout the condition of the patient and abnormal details via SMS. Thus, can monitor and diagnose the patient's condition continuously and could suggest earlier precaution for the patients themselves. This will also alert the family members to quickly attend to the patient. The remote hearbeat monitor prpposed in this work can be used in hospital and also for patients who can be under continuous monitoring while traveling from place to place, since the sytem is continuously monitoring the patient.

II. Atmega 328 Microcontroller

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 a AC-to-DC adapter or battery to get started.

The Uno differs from all preceding boards in that it does not use the FTDI USB-to-serial driver chip. Instead, it features the Atmega16U2 (Atmega8U2 up to version R2) programmed as a USB-to-serial converter. Revision 2 of the Uno board has a resistor pulling the 8U2 HWB line to ground, making it easier to put into DFU mode.

Power:

The Arduino Uno can be powered via the USB connection or with an external power supply. The power source is selected automatically. External (non-USB) power can come either from an AC-to-DC adapter (wall-wart) or battery. The adapter can be connected by plugging a 2.1mm center-positive plug into the board's power jack. Leads from a battery can be inserted in the Gnd and Vin pin headers of the POWER connector.

The board can operate on an external supply of 6 to 20 volts. If supplied with less than 7V, however, the 5V pin may supply less than five volts and the board may be unstable. If using more than 12V, the voltage regulator may overheat and damage the board. The recommended range is 7 to 12 volts. The power pins are as follows:

VIN: The input voltage to the Arduino board when it's using an external power source (as opposed to 5 volts from the USB connection or other regulated power source). You can supply voltage through this pin, or, if supplying voltage via the power jack, access it through this pin.

5V: This pin outputs a regulated 5V from the regulator on the board. The board can be supplied with power either from the DC power jack (7 - 12V), the USB connector (5V), or the VIN pin of the board (7-12V). Supplying voltage via the 5V or 3.3V pins bypasses the regulator, and can damage your board. We don't advise it.

3V3: A 3.3 volt supply generated by the on-board regulator. Maximum current draw is 50 mA.

GN:. Ground pins.

Input and Output:

Each of the 14 digital pins on the Uno can be used as an input or output, using pin Mode (), digital Write(), and digital Read() functions. They operate at 5 volts. Each pin can provide or receive a maximum of 40 mA and has an internal pull-up resistor (disconnected by default) of 20-50 ohms. In addition, some pins have specialized functions:

Serial: 0 (RX) and 1 (TX). Used to receive (RX) and transmit (TX) TTL serial data. These pins are connected to the corresponding pins of the ATmega8U2 USB-to-TTL Serial chip.

External Interrupts: 2 and 3. These pins can be configured to trigger an interrupt on a low value, a rising or falling edge, or a change in value. See the attachInterrupt() function for details.

PWM: 3, 5, 6, 9, 10, and 11. Provide 8-bit PWM output with the analogWrite() function.

SPI: 10 (SS), 11 (MOSI), 12 (MISO), 13 (SCK). These pins support SPI communication using the SPI library.

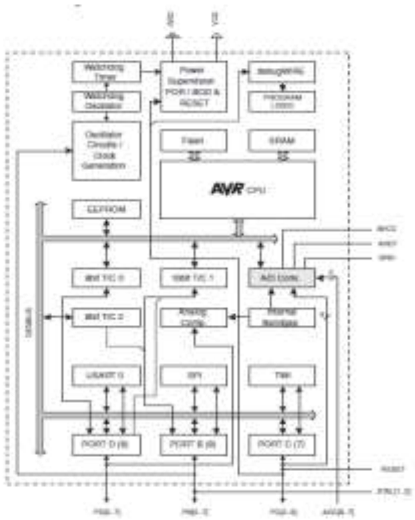
LED: 13. There is a built-in LED connected to digital pin 13. When the pin is HIGH value, the LED is on, when the pin is LOW, it's off. The Uno has 6 analog inputs, labeled A0 through A5, each of which provide 10 bits of resolution (i.e. 1024 different values). By default they measure from ground to 5 volts.though is it possible to change the upper end of their range using the AREF pin and the analogReference() function. Additionally, some pins have specialized functionality:

TWI: A4 or SDA pin and A5 or SCL pin. Support TWI communication using the Wire library.

There are a couple of other pins on the board:

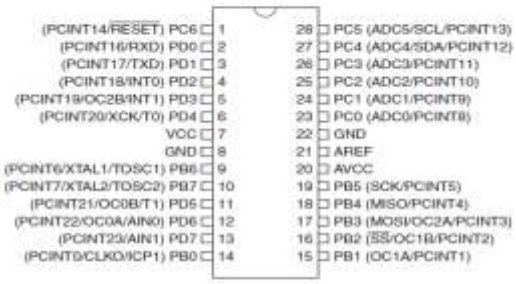
AREF: Reference voltage for the analog inputs. Used with analogReference().

ATMEGA328 ARCHITECTUR



Memory:
The ATmega328 has 32 KB (with 0.5 KB used for the bootloader). It also has 2 KB of SRAM and 1 KB of EEPROM (which can be read and written with the EEPROM library).
Reset: Bring this line LOW to reset the microcontroller. Typically used to add a reset button to shields which block the one on the board.
See also the mapping between Arduino pins and ATmega328 ports. The mapping for the Atmega8, 168, and 328 is identical.

ATMEGA328 pin diagram



Pin Descriptions
- VCC Digital supply voltage.
- GND Ground.

Port B (PB7:0)
- Port B is an 8-bit bi-directional I/O port with internal pull-up resistors (selected for each bit). The Port B output buffers have symmetrical drive characteristics with both high sink and source capability. As inputs, Port B pins that are externally
- pulled low will source current if the pull-up resistors are activated. The Port B pins are tri-stated when a reset condition becomes active, even if the clock is not running.Depending on the clock selection fuse settings, PB6 can be used as input to the inverting Oscillator amplifier and input to the internal clock operating circuit. Depending on the clock selection fuse settings, PB7 can be used as output from the inverting Oscillator amplifier. If the Internal Calibrated RC Oscillator is used as chip clock source, PB7.6 is used as TOSC2.1 input for the Asynchronous Timer/Counter2 if the AS2 bit in ASSR is set.

Port C (PC5:0)
- Port C is a 7-bit bi-directional I/O port with internal pull-up resistors (selected for each bit). The PC5..0 output buffers have symmetrical drive characteristics with both high sink and source capability. As inputs, Port C pins that are externally pulled low will source current if the pull-up Resistors are activated. The Port C pins are tri-stated when a reset condition becomes active, even if the clock is not running.

PC6/RESET

- If the RSTDISBL Fuse is programmed, PC6 is used as an I/O pin. Note that the electrical characteristics of PC6 differ from those of the other pins of Port C.
- If the RSTDISBL Fuse is programmed, PC6 is used as a Reset input. A low level on this pin for longer than the minimum pulse length will generate a Reset, even if the clock is not running. The minimum pulse length is given in Table 28-3 on page 308. Shorter pulses are not guaranteed to generate a Reset.

Port D (PD7:0)

- Port D is an 8-bit bi-directional I/O port with internal pull-up resistors (selected for each bit). The Port D output buffers have symmetrical drive characteristics with both high sink and source capability. As inputs, Port D pins that are externally pulled low will source current if the pull-up resistors are activated.
- Port D pins are tri-stated when a reset condition becomes active, even if the clock is not running.

AVCC

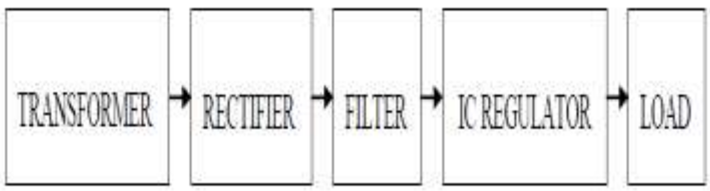
- AVCC is the supply voltage pin for the A/D Converter, PC3:0, and ADC7:6. It should be externally connected to VCC, even if the ADC is not used. If the ADC is used, it should be connected to VCC through a low-pass filter. Note that PC6..4 use digital supply voltage, VCC.

AREF

- AREF is the analog reference pin for the A/D Converter.1.1.9 ADC7:6 (TQFP and QFN/MLF Package Only)In the TQFP and QFN/MLF package, ADC7:6 serve as analog inputs to the A/D converter. These pins are powered from the analog supply and serve as 10-bit ADC channels.

Power supply

- The ac voltage, typically 220V rms, is connected to a transformer, which steps that ac voltage down to the level of the desired dc output. A diode rectifier then provides a full-wave rectified voltage that is initially filtered by a simple capacitor filter to produce a dc voltage. This resulting dc voltage usually has some ripple or ac voltage variation.
- A regulator circuit removes the ripples and also remains the same dc value even if the input dc voltage varies, or the load connected to the output dc voltage changes. This voltage regulation is usually obtained using one of the popular voltage regulator IC units.



IC voltage regulators :

Voltage regulators comprise a class of widely used ICs. Regulator IC units contain the circuitry for reference source, comparator amplifier, control device, and overload protection all in a single IC. IC units provide regulation of either a fixed positive voltage, a fixed negative voltage, or an adjustable set voltage. The regulators can be selected for operation with load currents from hundreds of milli amperes to tens of amperes, corresponding to power ratings from milli watts to tens of watts

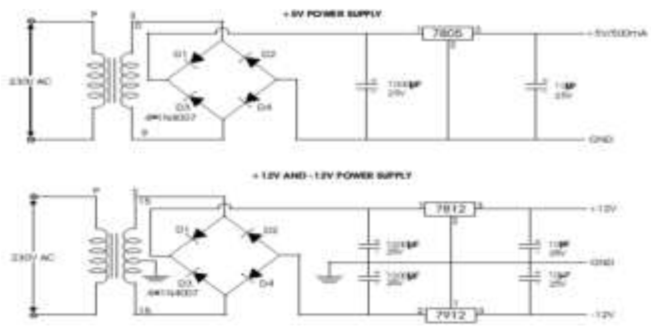
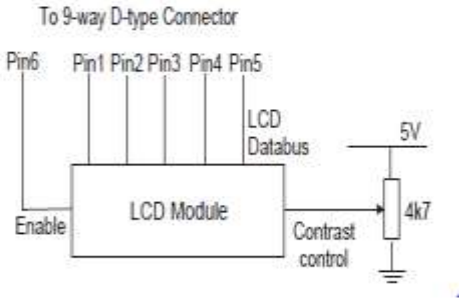


Fig Circuit diagram (Power supply)

A fixed three-terminal voltage regulator has an unregulated dc input voltage, Vi, applied to one input terminal, a regulated dc output voltage, Vo, from a second terminal, with the third terminal connected to ground. The series 78 regulators provide fixed positive regulated voltages from 5 to 24 volts. Similarly, the series 79 regulators provide fixed negative regulated voltages from 5 to 24 volts.



III. Liquid-Crystal Display (Lcd)

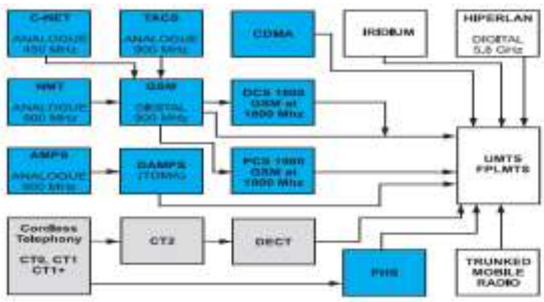
It is a flat-panel display or other electronic visual display that uses the light-modulating properties of liquid crystals. Liquid crystals do not emit light directly.

LCDs are available to display arbitrary images (as in a general-purpose computer display) or fixed images with low information content, which can be displayed or hidden, such as preset words, digits, and 7-segment displays as in a digital clock. They use the same basic technology, except that arbitrary images are made up of a large number of small pixels, while other displays have larger elements

LCDs are used in a wide range of applications including computer monitors, televisions, instrument panels, aircraft cockpit displays, and signage. They are common in consumer devices such as DVD players, gaming devices, clocks, watches, calculators, and telephones, and have replaced cathode ray tube (CRT) displays in nearly all applications. They are available in a wider range of screen sizes than CRT and plasma displays, and since they do not use phosphors, they do not suffer image burn-in. LCDs are, however, susceptible to image persistence.

The LCD screen is more energy-efficient and can be disposed of more safely than a CRT. Its low electrical power consumption enables it to be used in battery-powered electronic equipment more efficiently than CRTs. It is an electronically modulated optical device made up of any number of segments controlling a layer of liquid crystals and arrayed in front of a light source (backlight) or reflector to produce images in color or monochrome. Liquid crystals were first discovered in 1888. By 2008, annual sales of televisions with LCD screens exceeded sales of CRT units worldwide, and the CRT became obsolete for most purposes.

IV. Gsm Architecture



GSM became popular very quickly because it provided improved speech quality and, through a uniform international standard, made it possible to use a single telephone number and mobile unit around the world.TheEuropeanTelecommunications Standardization Institute (ETSI) adopt the GSM standard in 1991 and GSM is now used in 135 countries.

The benefits of GSM include:

- Support for international roaming Distinction between user and device identification
- Excellent speech quality
- Wide range of services
- Interworking (e.g. with ISDN, DECT)

- Extensive security features
- GSM also stands out from other technologies with its wide range ofservices1:
- Telephony
- Asynchronous and synchronous data services (2.4/4.8/9.6 kbit/s)
- Access to packet data network (X.25)
- Telematic services (SMS, fax, videotext, etc.)

The mobile station (MS):

A mobile station may be referred to as a ªhandsetº, a ªmobileº, a ªportable terminalº or ªmobile equipmentº ME). It also includes a subscriber identity module (SIM) that is normally removable and comes in two sizes. Each SIM card has a unique identification number called IMSI (international mobile subscriber identity). In addition, each MS is assigned a unique hardware identification called IMEI (international mobile equipment identity).

In some of the newer applications (data communications in particular), an MS can also be a terminal that acts as a GSM interface, e.g. for a laptop computer. In this new application the MS does not look like a normal GSM telephone.

The seemingly low price of a mobile phone can give the (false) impression that the product is not of high quality. Besides providing a transceiver (TRX) for transmission and reception of voice and data, the mobile also performs a number of very demanding tasks such as authentication, handover, encoding and channel encoding.

The base station subsystem (BSS):

The base station subsystem (BSS) is made up of the base stationController (BSC) and the base transceiver station (BTS).

The base transceiver station (BTS):

GSM uses a series of radio transmitters called BTSs to connect the mobiles to a cellular network. Their tasks include channel coding/decoding and encryption/decryption. A BTS is comprised of radio transmitters and receivers, antennas, the interface to the PCM facility, etc. The BTS may contain one or more transceivers to provide the required call handling capacity. A cell site may be omni-directional or split into typically three directional cells.

The base station controller (BSC):

A group of BTSs are connected to a particular BSC which manages the radio resources for them. Today's new and intelligent BTSs have taken over many tasks that were previously handled by the BSCs. The primary function of the BSC is call maintenance. The mobile station normally send a report of their received signal strength to the BSC every 480 ms. With this information the BSC decides to initiate handovers to other cells, change the BTS transmitter power, etc….

The Network subsystem:

The mobile switching center (MSC):

Acts like a standard exchange in a fixed network and additionally provides all the functionality needed to handle a mobile subscriber. The main functions are registration, authentication, location updating, handover and call routing to a roaming subscriber. The signaling between functional entities (registers) in the network subsystem uses Signaling System 7 (SS7). If the MSC also has a gateway function for communicating with other networks, it is called Gateway MSC.

The home location registers (HLR):

A database used for management of mobile subscribers. It stores the international mobile subscriber identity (IMSI), mobile station ISDN number (MSISDN) and current visitor location register (VLR) address. The main information stored there concerns the location of each mobile station in order to be able to route calls to the mobile subscribers managed by each HLR. The HLR also maintains the services associated with each MS. One HLR can serve several MSCs.

The visitor location registers (VLR):

Contains the current location of the MS and selected administrative information from the HLR necessary for call control and provision of the subscribed services for each mobile currently located in the geographical area controlled by the VLR. A VLR is connected to one MSC and is normally integrated into the MSC's hardware.

The authentication center (AuC):

A protected database that holds copy of the secret key stored in each subscriber's SIM card, which is used for authentication and encryption over the radio channel. The AuC provides additional security against fraud. It is normally located close to each HLR within a GSM network. The equipment identity register (EIR): The EIR is a database that contains a list of all valid mobile station equipment within the network, where each mobile station is identified by its international mobile equipment identity (IMEI).

The EIR has three databases:

- White list: for all known, good IMEIs
- Black list: for bad or stolen handsets
- Grey list: for handsets/IMEIs that are uncertain

Operation and Maintenance Center (OMC)

The OMC is a management system that oversees the GSM functional blocks. The OMC assists the network operator in maintaining satisfactory operation of the GSM network. Hardware redundancy and intelligent error detection mechanisms help prevent network down-time. The OMC is responsible for controlling and maintaining the MSC, BSC and BTS. It can be in charge of an entire public land mobile network (PLMN) or just some parts of the PLMN.

V. Serial Communication

UART:

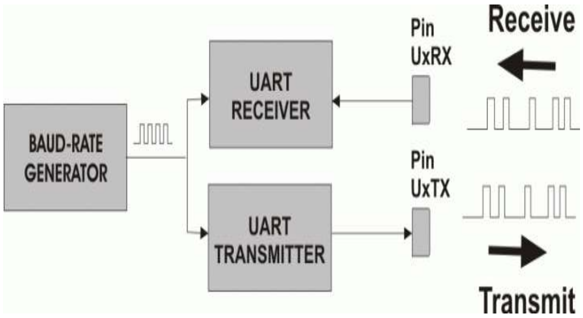
The final piece to this serial puzzle is finding something to both create the serial packets and control those physical hardware lines.A universal asynchronous receiver/transmitter (UART) is a block of circuitry responsible for implementing serial communication. Essentially the UART acts as an intermediary between parallel and serial interfaces. On one end of the UART is a bus of eight-or-so data lines (plus some control pins), on the other is the two serial wires RX and TX.

UARTs do exist as stand-alone ICs, but they're more commonly found inside microcontrollers. You'll have to check your microcontroller's datasheet to see if it has any UARTs. Some have none, some have one, and some have many. For example, the Arduino Uno based on the "old faithful" ATmega328 has just a single UART, while the Arduino Mega built on an ATmega2560 has a whopping four UARTs.

As the *R* and *T* in the acronym dictate, UARTs are responsible for both sending and receiving serial data. On the transmit side, a UART must create the data packet appending sync and parity bits - and send that packet out the TX line with precise timing (according to the set baud rate). On the receive end, the ART has to sample the RX line at rates according to the expected baud rate, pick out the sync bits, and spit out the data.

More advanced UARTs may throw their received data into a **buffer**, where it can stay until the microcontroller comes to get it. UARTs will usually release their buffered data on a first-in-first-out (FIFO) basis. Buffers can be as small as a few bits, or as large as thousands of bytes.

UART block diagram:



Software UARTs:

If a microcontroller doesn't have a UART (or doesn't have enough) the serial interface can be **bit-banged** - directly controlled by the processor. This is the approach Arduino libraries like Software Serial take. Bit-banging is processor-intensive, and not usually as precise as a UART, but it works in a pinch.

VI. Conclusion

Biomedical engineering is the application of engineering principles and techniques to the medical field. It combines the design and problem solving skills of engineering with medical and biological sciences to improve patient's health care and the quality of life of individuals. A medical device is intened for use in the diagnosis of disease, or in the care, treatment, or prevention of diseases. Cardiovascular disease is one of the major causes of untimely deaths in world, heart beat readings are by far the only viable diagnostic tool that could promote early detection of cardiac events.

Wireless and mobile technologies are key components that would help enable from chronic heart disease to live in their own homes and lead their normal life, while at the same time being monitored for any cardiac events. This will not only serve to reduce the burden on the resources of the healthcare center but would also improve the quality of healthcare sector. This wirless communications would not only provide us with safe and accurate monitoring but also the freedom of movement. For a patient who is already diagnosed with fatal heart disease, their heart rate condition has to be monitored continuously.

This work propose and focuses on the heartbeat monitoring and alert system tat is able to monitor the heart beat rate condition of patient. The system determine the heart rate per minute and then sends short message service alert to the mobile phone of medical experts or patient's family members, or their relatives via SMS. Thus, doctors can monitor and diagnose the patient's condition continuously and could suggest earlier precaution for the patients themselves. This will also alert the family members to quickly attened to the patient. This system is cost effective and user friendly and thus 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 monitoring and alert system.

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