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Wireless ECG monitoring system

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Abstract:
The Electrocardiogram (ECG) is an essential diagnostic tool that measure and record the electrical activity of the heart. A wide range of heart conditions can be detected when interpreting the recorded ECG signals. These qualities make the ECG a perfect instrument for patient monitoring and supervision. With the recent advance in technology, there are possibilities to create a small sized wireless ECG system capable of transmitting. The result of this project is an off-the-shelf Android Bluetooth ECG monitoring device that communicates wirelessly to a computer or smart phone.

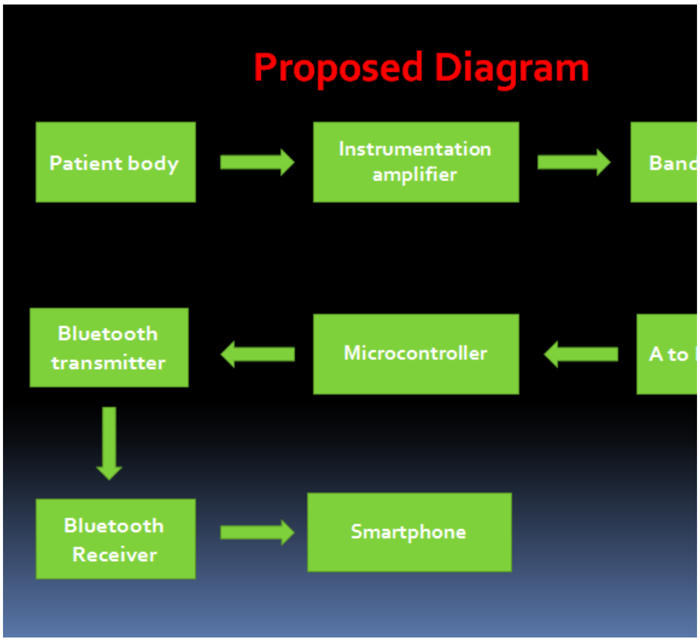
There were two parts of the project that was designed, the user interface software that controls the wireless ECG device function, set user options, and displays the data results. The wireless ECG monitoring device has components that allow for sensing heart electrical activity, signal conditioning, data conversion, data storage and wireless communication.Software code was written and tested on computer and smart phone as well as the wireless ECG monitoring device. Writing the software code took about three months to be complete and function perfectly.

Introduction

- We followed while researching, designing, and constructing the Android Bluetooth ECG Monitor.
- Heart disease causes almost 25% of all deaths in the United States each year but it is something that's detectable and preventable if caught early on.
- Mobile ECG monitoring devices used as preventive prognoses already exist (e.g. Holter Monitors) but they are unwieldy and require seeing a doctor before being able to use them, which limits how often a person can use them as well as a person ability to get one at all.
- After a day or two of monitoring, the patient takes the unit back and the data is then analyzed. Using an app on a smart phone and/or a computer that communicates with a wireless ECG monitoring device will allow a person to see the results immediately.
- The smart phone will not only display the heart activity but also save the data to be used for further analysis at any time as well as informing the user of any current problems that may or may not need to be addressed immediately.

- With the review of literature survey on similar projects like FM Based ECG, Micromedical, BlueNurse. The survey will be considered in this project and the previous research with different methodology.The theory ECG Background, Electrode Theory, Existing Wireless Technologies — Bluetooth and PIC microcontroller — ADC and USART modules.
- The methodology for Hardware and Software used in the work. Hardware Methodology covers block diagram / circuit diagram.
- Software Methodology, on the other hand covers all software used during the project development for simulation of Analog and Digital ECG data from the output of PIC microcontroller, Bluetooth — PC interfacing software.

Block diagram-



Electrodes-

Electrodes are used for sensing bio-electric potentials as caused by muscle and nerve cells. ECG electrodes are generally of the direct-contact type. They work as transducers converting ionic flow from the body through an electrolyte into electron current and consequentially an electric potential measurable by the front end of the ECG system. In this project we use the piezoelectric sensor type electrode which is shown in figure 2 and piezoelectric sensor is a device that uses the piezoelectric effect to measure pressure, acceleration, strain or force by converting them to an electrical charge. The voltage is in the range of 1 mV ~ 5 mV.

Instrumentation Amplifier-

- The instrumentation amplifier is basically a differential amplifier that amplifies the difference between the two input signals.
- Hence the common mode signal is effectively eliminated. Two buffer amplifiers at the input of each signal, is provided to offer very high input impedance.

Band pass filter-

- To remove the unwanted frequency in this case requires.The attenuation of low-frequency components Is designed to remove the baseline (or DC) drift and obtain stable ECG recording.
- In this project we use the VEGAKIT VK559 which is heart bit monitor circuit and one piezoelectric electrode connected to piezo port of this circuit. This circuit consist of IC LM386N which is basically a audio amplifier. So this circuit work as instrumentation amplifier as well as band pass filter. ECG bandwidth is ~200Hz, according to the low pass cutoff frequency should not be any lower than 2kHz to keep the filter out of the way of the in band ECG signal.

A to D convertor-

- A/D is a device that converts a continuous physical quantity (usually voltage) to a digital number that represents the quantity's amplitude.

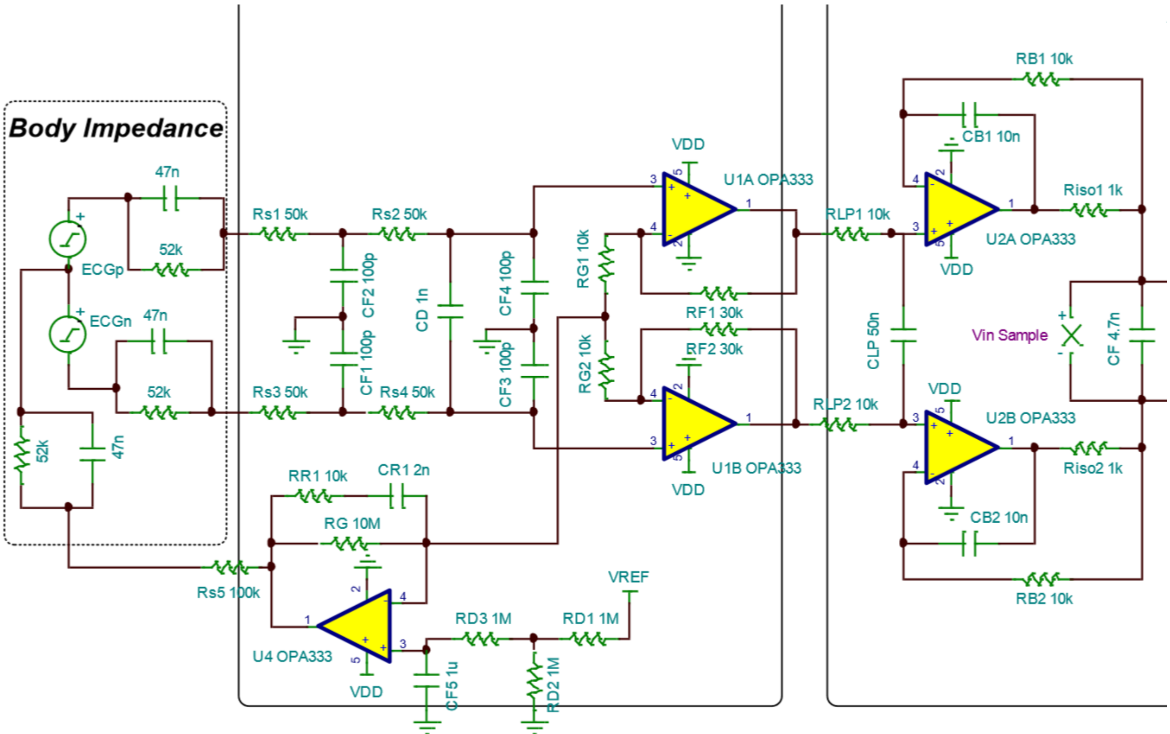
Microcontroller (ATmega16/32U4)**-**

- As the project developed, we have decided to utilize the ATmega16/32U4 family of microcontrollers because of their ease of use, general availability, and flexibility to create powerful applications with pre-existing libraries During the early design stages, we recognized that we had to minimize the size of the hardware.

Memory card-

- This component was used to store the data that is sent from microcontroller. It is capable of saving 4GB of data.

Circuit Diagram-



BODY

1. Body Impendance

The impedance of the electrode (along with the contact to the skin) can be lumped into a battery in series with a parallel RC combination of 47nF and 52kΩ. The battery model is ideally be 0V; however, over time and with varying external conditions it is possible for the Ag-AgCl voltage to become ±300mV, a factor that must be carefully considered when designing the front end gain stage.

2. Filter circuit

This is the stage of circuit .The input from the patient is given to the filtering circuit in which the ECG signal is in mv and microvolt. The frequency of ECG signal is 0-200hz.

3. Amplifier circuit

This is the second stage of circuit. In this circuit amplifier amplifies signals and reduce the noise. the output of filtering circuit is given to the amplifier circuit. In this circuit frequency is 0-200hz, voltage is mv and microvolt and ECG signal potential is 200microvolt to 2 milivolt.

4. Buffer circuit

This is the last stage of this circuit. The amplified signal is given to the buffer circuit in which frequency is 0-200hz and voltage is 1v. A buffer is a unity-gain amplifier that has an extremely high input resistance and an extremely low output resistance. The output of buffer circuit is 0-1v.

5. Bluetooth socket

We chose the hc-06 because of its low power and highly flexible Bluetooth socket module. It is simple to design in and fully certified and its low cost.

6.OP333

The OPA333 series of CMOS operational amplifiers These miniature, high-precision, low quiescent current amplifiers offer high-impedance inputs that have a common-mode range 100 mV.

code for ADC

```
/*******************************/

void adc_init(char );

char adc_get (char );

int adc_get_int(char);

/*******************************/
char ladj=0;
void adc_init(char vref)
{

   ADMUX=0;
   ADCSRA=0x85;

   if(vref==0)   //AREF
   ADMUX=0;
   else
   {
      if(vref==1)          //AVCC
      ADMUX=0x40;
      else
      if(vref==2)          // INT REF
      ADMUX=0xC0;
   }

}

char adc_get (char ch )
{
   char temp=0;

   ADMUX&=0xf0;
   ADMUX|=ch;

   if(ladj==0)
   {ADMUX|=0x20;
    ladj=1;}

   ADCSRA|=0x40;
   //dsp_s("A b4 ");

   while(!(ADCSRA&0x10));

   temp=ADCH;
   ADCSRA|=0x10;

   return temp;

}

int adc_get_int(char ch)
{  int temp=0;
   int t;

   if(ladj==1)
   {ADMUX&=0xD0;
    ladj=0;}
   ADMUX&=0xf0;
   ADMUX|=ch;
   //ADMUX|=0x20;
   ADCSRA|=0x40;
   while(!(ADCSRA&0x10));
   t=ADCL;
   temp=ADCH;
   temp=temp<<8;
   temp+=t;
   //ADCSRA|=0x10;

   return temp;


}
```

CODE FOR SD CARD

```
/*The SD card socket on the development board is connected to the
following I/O ports:

pin1  /CS -----<|----- PORTC bit0
pin2  SI  -----<|----- MOSI
pin3  GND
pin4  +3.3V
pin5  SCK -----<|----- SCK
pin6  GND
pin7  SO  ------------ MISO

For other I/O port connections, you need to make appropriate changes in the
"Project|Configure|C Compiler|Libraries|MMC/SD/SD HC Card and FAT Support"
menu.

The CodeVisionAVR Terminal is used for displaying data received from the
development board.
The Terminal must be configured for:
Baud Rate: 19200
Data Bits: 8
Parity: None
Stop Bits: 1
Emulation: TTY
Handshaking: None
Append LF on Reception: OFF
Appearance|Rows: 40
Appeara4///
*****************************************
*******************************/

#include <mega32.h>
/* FAT on MMC/SD/SD HC card support */
#include <ff.h>
/* printf */
#include <stdio.h>
#include "uart.c"
#include "adc_h.c"

/* Timer1 overflow interrupt frequency [Hz] */
#define T1_OVF_FREQ 100
/* Timer1 clock prescaler value */
#define T1_PRESC 1024L
/* Timer1 initialization value after overflow */
#define T1_INIT (0x10000L-(_MCU_CLOCK_FREQUENCY_/(T1_PRESC*
T1_OVF_FREQ)))
int i=0,d=0;

/* FAT function result */
FRESULT res;
/* number of bytes written/read to the file */
unsigned int nbytes;
/* will hold the information for logical drive 0: */
FATFS fat;
/* will hold the file information */
FIL file;
/* will hold file attributes, time stamp information */
FILINFO finfo;
/* file path */
char path[]="0:/file.txt";
/* text to be written to the file */
char text[]="I like CodeVisionAVR!";
/* file read buffer */
char buffer[256];

/* 100Hz timer interrupt generated by ATmega32 Timer1 overflow */
interrupt [TIM1_OVF] void timer_comp_isr(void)
{
/* re-initialize Timer1 */
TCNT1H=T1_INIT>>8;
TCNT1L=T1_INIT&0xFF;
/* card access low level timing function */
disk_timerproc();
}

/* error message list */
flash char * flash error_msg[]=
{
"", /* not used */
"FR_DISK_ERR",
"FR_INT_ERR",
"FR_INT_ERR",
```

```
"FR_NOT_READY",
"FR_NO_FILE",
"FR_NO_PATH",
"FR_INVALID_NAME",
"FR_DENIED",
"FR_EXIST",
"FR_INVALID_OBJECT",
"FR_WRITE_PROTECTED",
"FR_INVALID_DRIVE",
"FR_NOT_ENABLED",
"FR_NO_FILESYSTEM",
"FR_MKFS_ABORTED",
"FR_TIMEOUT"
};

/* display error message and stop */
void error(FRESULT res)
{
if ((res>=FR_DISK_ERR) && (res<=FR_TIMEOUT))

  USART_Transmit('E');
/* stop here */
while(1);
}

void send_data(unsigned int a1)
{
unsigned int a,b,c;
unsigned char b2;
b=a1%1000;
c=b%100;
b=b/100;
b2=(char) b;
text[i*3+0]=b2;
text[i*3+1]=((c/10)+0x30);
text[i*3+2]=((c%10)+0x30);
USART_Transmit(b2+0x30);
USART_Transmit((c/10)+0x30);
USART_Transmit((c%10)+0x30);
}

void main(void)
{
/* initialize Timer1 overflow interrupts in Mode 0 (Normal) */
TCCR1A=0x00;
/* clkio/1024 */
TCCR1B=(1<<CS12)|(1<<CS10);
/* timer overflow interrupts will occur with 100Hz frequency */
TCNT1H=T1_INIT>>8;
TCNT1L=T1_INIT&0xFF;
/* enable Timer1 overflow interrupt */
TIMSK=1<<TOIE1;

USART_Init();
adc_init(1);

/* globally enable interrupts */
#asm("sei")
while(1){
/* mount logical drive 0: */
if ((res=f_mount(0,&fat))==FR_OK)
   string_trans("Logical drive 0: mounted OK");
else
   /* an error occured, display it and stop */
   error(res);

/* create a new file in the root of drive 0:
and set write access mode */
if
((res=f_open(&file,path,FA_CREATE_ALWAYS
| FA_WRITE))==FR_OK)
   {string_trans("File ");
   string_trans(path);
   string_trans(" created OK");  }
else
   /* an error occured, display it and stop */
   error(res);
while(i<100){
//Acquire Data from ADC channel
d=adc_get_int(1);
//Send the data over bluetooth
send_data(d);

i++;
}
/* write some text to the file,
```

```
without the NULL string terminator sizeof(data)-1
*/
if ((res=f_write(&file,text,sizeof(text)-1,&nbytes))==FR_OK)
  //printf("%u bytes written of %u\r\n",nbytes,sizeof(text)-1);
  USART_Transmit('K');
else
  /* an error occured, display it and stop */
  error(res);

/* close the file */
if ((res=f_close(&file))==FR_OK)
 { string_trans("File closed OK");
  string_trans(path);
  }
else
  /* an error occured, display it and stop */
  error(res);

}
}
```

Advantages

- Low cost.
- Portable.
- User friendly.
- Take appropriate action in emergency services.
- Save patient data.
- Less time consuming.

Specifications

- Input range: 0 – 3V dc
- Throughput Sampling Rate: 10ksps
- Analog/Digital Supply: 3.3V dc
- Input Bandwidth: 200Hz (ECG signals

Application-

- It would be possible to monitor the vital signs of elderly or sick people continuously, while they continue with normal life.
- It also allows for personal use in the home when an individual wishes to check their vital signs, much like when people measure their blood sugar, pulse, or temperature. This device also allows for athletes to monitor and track their hearts condition during exercising.
- It can be used in remote area and also track the heart condition during exercising.
- The current market for a wireless, multi-channel, multi-sensor bio-monitoring system is huge, as indicated by the number of devices trying to fill this spot.
- While devices exist we have an opportunity to bring a device to the market that addresses all the deficiencies of current devices. With a more comfortable monitoring system.

FUTURE SCOPE

- The project can be further developed in adding expert system features like speed variations with moving screen, exact heart rate with analysis, displaying 12 lead graphs, and monitoring ECG wave form on PC monitor.
- We can enhance the feature of the project by enabling the transmission of ECG signals through mobiles,signal transmitters or internet.
- Other vital-sign signals will be appende to this system, including non-invasive blood-pressure and respiratory impedance pneumography.
- There is no means to correlate the patient"s activities (in day to day life) with the problems occurring in the ECG. This is being performed manually i.e. the patient is asked to note down the activities that he performs during the monitoring period. Hence it can be automated.
- This can help the physician to perform more accurate diagnosis which can go a long way in averting tragedies

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