A USB Based ECG Portable System and Analysis of Cardiovascular Diseases

Om Prakash Singh[1]
Assistant Professor
Bio Medical Engineering
AIET, North Ext. M.I.A.,
Alwar, India
bioom85@yahoo.com

Dr. Hemraj Saini[2]
Professor
Computer Science Engineering
AIET, North Ext., M.I.A
Alwar, India
hemraj1773@yahoo.co.in

S. Kalaivani[3]
Assistant Professor
Bio Medical Engineering
REC, Thandalam
Chennai, India
vanisen06@gmail.com

***Abstract* – Heart diseases is one of the leading causes of death worldwide. To help cardiologists in treating these conditions, medical technology has been researching ways to improve Electro – Cardiogram (ECG), the main tool to find out the health of patient's health. These large machines that are once exclusively found at hospitals can now be at a patient's disposal. The goal of this is: i) developed a USB Based ECG Portable system and displayed the acquired ECG signal and stored it in Laptop format .doc using print screen. It gives a larger degree of freedom to the patient, using a Microcontroller (PIC), an Analog circuit, Universal serial bus technology; ii) Found the arrhythmia condition with good accuracy and sensitive in an automated way. It is a simple portable and thereby it records the ECG Signal of the patient, in and around the places. Further, a patient himself can carry out the device and subsequently, he/she can record his own heart activity over a period of time in a day. An automated ECG Signal analysis will give a report of an individual.**

Keep up with the trend of USB health care, this device has been given a feasible solution that is reliable, portable, easy for the subject to use, and with good power efficiency so that the person could be monitored for a long period of time. It helped to reduce the time the patient spends in the hospital and helped health care professionals to take care of him even when they are not in direct contact with him.

Keywords – Instrumentation Amplifier (IN 118), Notch Filter Universal Active Filter (UAF42), Microcontroller (PIC), Universal Serial Bus – 2.0, Software (Visual Basic)

I. INTRODUCTION

Recent studies indicate that cardiovascular diseases is the leading cause of death for several million people annually. New habits, practices and lifestyles have introduced newer ailments that the public health care system of a country has not always been able to cope up with. Of late, need for effective preventive cardiology has been advocated by several researchers. An important component of effective preventive cardiology is to collect, monitor and maintains health data of the target population over an extended period of time. [1, 2]

"Signal processing has become an essential part of contemporary scientific and technological activity." This statement marks an attempt by the author Yves Meyer, in his book, to explain to his readers the status of signal processing in the modern world. Signal processing has always been a fundamental ability in the day to day functions since the beginning of time. Perhaps unnoticed, people have always practiced such skills as reading, listening, and seeing. However, the importance of signal processing has only risen to a new height due to the recent developments in machine automation, which brings out the emphasis focused on by the scope of this thesis. ECG monitoring and interpretation have always been tasks conventionally assigned to trained medical care personals. Although being more comprehensive in the related knowledge, the constraints to manpower are also very obvious. Fatigue factors and overwhelming workloads are both possible causes to delayed emergency response that may have reduced the chances for patients' survival. By automating this process, the system frees the medical professionals of the tedious tasks to center their attentions on something much more demanding. There is still a significant gap between the existing sensor network solutions and the needs in medical care. This thesis is an endeavor to help close the gap by suggesting a solution for a ECG vital sign monitoring system designed to reduce the medical response time for the patients in need. This monitoring system provides many useful applications, giving support to the current medical care structure, especially for ICU patients and under emergency relief situations. Under these scenarios, the physiological statuses of multiple patients are continuously observed for immediate medical decisions that may well increase their chances of survival. [1, 9]

Based on these motivations, there have been numeral attempts to develop medical systems similar to the proposed work in this thesis. Such efforts are primarily led by the academia but extending deeply into the industries. However, most research efforts have been focusing on either the vital sign monitoring aspect or the ECG feature extraction using standard databases both falling short of expectation. Having analyzed the existing solutions, this thesis vows to bridge the two major research efforts and bring out a more realizable product to directly benefit the consumers in the medical field.

This thesis offers the following contributions to the proposed system, foremost is the wearable ECG monitoring platform based on a 3-Lead System and a design under the USB Based project. The ECG data collected using these USB platforms are then transmitted the ECG signal to PC/Laptop.

The received patient data on the workstation is processed using wavelet transforms to provide feature extraction capabilities in order to locate the characteristic points of the ECG waves In addition to the above deliverables, another important feature; device location tracking is proposed and studied as a future expansion to the product to ensure the goal of shortened medical response time. The rest of this document is organized as the following. [5, 6]

The new specifications include continuous recording for a minimum of few days, two-channel recording capabilities with an optional Right-Leg Drive, and download to computer capabilities via USB technology [22, 24, 25].

II. LITERATURE REVIEW

A. Microcontroller Based ECG Monitoring System

This project report aims to give a clear and concise overview of the problems associated with designing an ECG monitoring system. The use of ECG monitoring system is now in widespread use today in places ranging from: Nursing Homes to Intensive Care Unit. At the moment most of the ECG monitoring systems are Analogue Filter based. The cost of complex analogue filters is quite high and generally they are quite large. This means that ECG monitoring systems are very cumbersome and quite expensive in general, ranging from about €1000. This project aims to solve the ECG problem using a microcontroller, giving a “System on a Chip” implementation of an ECG Monitoring System. Using this technology it is envisaged that an ECG Monitoring System could implemented for about €250. [3, 4]

The report firstly gives a brief overview of the heart and its pumping operation. It then goes to describe the how the electric activity of the heart is captured using Bio-Potential electrodes. Once these basics have been outlined, the report then describes the advantages of a microcontroller based ECG monitoring system over the traditional analogue filter based ECG monitoring system. The components used in the system design are outlined, giving their requirements and the specification of the component used. One of the biggest problems in any Bio-Medical system is the presence of noise; this problem is discussed at length in the report. The Digital Filter Design is also described at length and the Magnitude Response of the Filters is shown. The code developed for the ADuC842 and the P.C. is then explained. Future enhancements for the ECG monitoring system are then outlined. Finally, the report’s conclusions are outlined [12].

B. Analogue Filtering Based ECG System

In the analogue system it can be seen that the filtering of the raw ECG signal is done in Analogue domain and all the microcontroller does is controlled the flow of data between the PC and the microcontroller over RS232. This means we have to implement high cost circuitry to implement an accurate filtering mechanism for the ECG signal mechanism. On the other hand there are microcontrollers available, which are a lot cheaper than the analogue filters implementation, that are capable of implementing these DSP algorithms a lot more accurately. Also the power requirements for a DSP implementation are quite smaller. In addition implementing the ECG monitoring using a microcontroller will decrease the cost of ECG measuring systems, thereby allowing more ECG measuring systems to be bought. Hopefully this will decrease the mortality rate due to Cardio-Vascular Disease [13].

III. HARDWARE DESCRIPTION

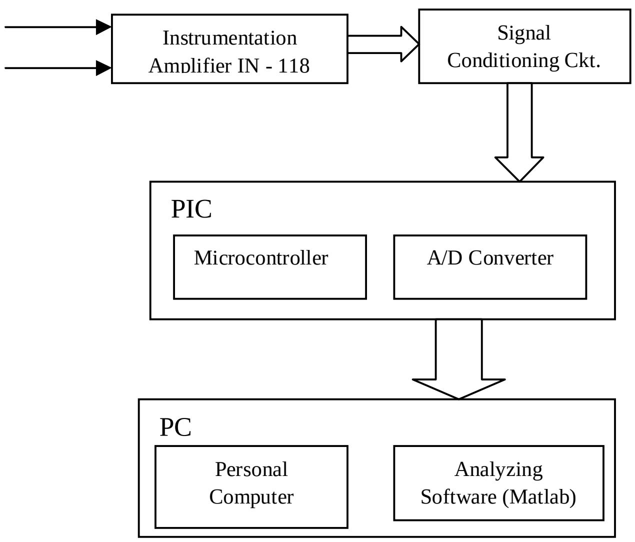

Figure 1

The various circuits and chips used in this device require appropriate DC voltages to operate correctly. The PIC16F877 microcontroller requires 2.0 V to 5.5 V, the LM555 timer IC in the pulse detection circuit requires 4.5 V to 16 V, and each IN 118 used in signal conditioning requires 2.6 V to 16 V. Standard Ag/AgCl electrodes will be used to acquire the natural biological signal from the user/patient and transfer the body's electrical signal into a usable voltage in our circuit. The input to the signal conditioning unit is the noisy analog ECG signal from the electrodes by way of cables. This unit outputs the filtered, amplified ECG. The PIC16F877 is a programmable 40-pin integrated circuit package which functions as a microcontroller and is also capable of performing analog-to-digital conversion, which may also be utilized in this project to convert the actual ECG signal to digital data that could be stored on the personal computer (PC). In order for output from the PIC16F877 to be transferred to the computer's USB port using the USART port of the PIC, a UART to USB bridge is necessary. After receiving ECG data via a USB port, the PC's software analyzes the user's heart rate and the frequency of missing QRS complexes of the ECG. This software will be created using PC Software to perform calculations and produce displays on the monitor [7, 8].

A. Electrodes or Sensor

The basic function of the electrodes is to convert a physical parameter into an electrical output. It is necessary to remember that the metal in the electrodes is not responsible for conducting the electrical changes in the body; hence the electrodes must have a transducer. The function of the transducer is to convert biological information into a quantifiable electrical signal. This transducer interface is provided using an electrode-electrolyte interface. There is also another interface with the skin. If Ag/AgCl electrodes are used this reduces the low frequency noise in the ECG signal due to movement, but the gel creates motion artefacts [10].

B. Instrumentation Amplifier

This is the Bio-Potential Amplifier used in this system. The IN 118 is an integrated single-supply instrumentation amplifier that delivers rail-to-rail output swing on a 3 V to 12 V supply. The AD623 offers superior user flexibility by allowing single gain set resistor programming and by conforming to the 8-lead industry standard pin out configuration. With no external resistor, the IN 118 is configured for unity gain (G = 1), and with an external resistor, the IN 118 can be programmed for gains up to 1000.

The IN 118 is an instrumentation amplifier based on a modified classic 3-op-amp approach, to assure single or dual supply operation even at common-mode voltages at the negative supply rail. Low voltage offsets, input and output, as well as absolute gain accuracy, and one external resistor to set the gain, make the IN 118 one of the most versatile instrumentation amplifiers in its class.

The input signal is applied to PNP transistors acting as voltage buffers and providing a common-mode signal to the input amplifiers. An absolute value 50 kΩ resistor in each amplifier feedback assures gain programmability.

The differential output is

$$V_O = \left(1 + \frac{100\ \text{k}\Omega}{R_G}\right) V_C$$

The differential voltage is then converted to a single-ended voltage using the output amplifier, which also rejects any common-mode signal at the output of the input amplifiers.

Because the amplifiers can swing to either supply rail, as well as have their common-mode range extended to below the negative supply rail, the range over which the IN 118 can operate is further enhanced [20].

C. 50 Hz. Notch Filter

The UAF42 is a universal active filter which can be configured for a wide range of low-pass, high-pass, and band-pass filters. It uses a classical state-variable analog architecture with an inverting amplifier and two integrators. The integrators include on-chip 1000pF capacitors trimmed to 0.5%. This solves one of the most difficult problems of active filter design— obtaining tight tolerance, low-loss capacitors.

A DOS-compatible filter design program allows easy implementation of many filter types such as Butterworth, Bessel, and Chebhyshev. A fourth, uncommitted FET-input op amp (identical to the other three) can be used to form additional stages, or for special filters such as band-reject and Inverse Chebhyshev.

The classical topology of the UAF42 forms a time continuous filter, free from the anomalies and switching noise associated with switched-capacitor filter types.

The UAF42 is available in 14-pin plastic DIP and SOL-16 surface-mount packages, specified for the – 25°C to +85 ° C temperature ranges [22].

Design Equations

1. $$\omega_n^2 = \frac{R_2}{R_1 R_{F1} R_{F2} C_1 C_2}$$

2. $$Q = \frac{1 + \frac{R_4 (R_G + R_Q)}{R_G R_Q}}{1 + \frac{R_2}{R_1}} \left(\frac{R_2 R_{F1} C_1}{R_1 R_{F2} C_2} \right)^{1/2}$$

3. $$QA_{LP} = QA_{HP} \left(\frac{R_1}{R_2} \right) = A_{BP} \left(\frac{R_1 R_{F1} C_1}{R_2 R_{F2} C_2} \right)^{1/2}$$

4. $$A_{LP} = \frac{1 + \frac{R_1}{R_2}}{R_G \left(\frac{1}{R_G} + \frac{1}{R_Q} + \frac{1}{R_4} \right)}$$

5. $$A_{HP} = \frac{R_2}{R_1} A_{LP} = \frac{1 + \frac{R_2}{R_1}}{R_G \left(\frac{1}{R_G} + \frac{1}{R_Q} + \frac{1}{R_4} \right)}$$

6. $$A_{BP} = \frac{R_4}{R_G}$$

The Low Pass Filter Transfer Function

$$\frac{V_O(s)}{V_I(s)} = \frac{A_{LP} \omega_n^2}{s^2 + s\,\omega_n/Q + \omega_n^2}$$

The High Pass Filter Transfer Function

$$\frac{V_{HP}(s)}{V_I(s)} = \frac{A_{HP} s^2}{s^2 + s\,\omega_n/Q + \omega_n^2}$$

The Band Pass Filter Transfer Function

$$\frac{V_{BP}(s)}{V_I(s)} = \frac{A_{BP} (\omega_n/Q)\, s}{s^2 + s\,\omega_n/Q + \omega_n^2}$$

The Band Reject Filter Transfer Function

$$\frac{V_{BR}(s)}{V_I(s)} = \frac{A_{BR} (s^2 + \omega_n^2)}{s^2 + s\,\omega_n/Q + \omega_n^2}$$

C - I PCB Layout of 50 Hz Notch Filter

The layout was made as a single layer and was designed in Eagle. In order to create a PCB layout for the board the whole project had to be redesigned in Eagle as it is not possible to import the schematics from Pspice.

So, I have designed a separate prototype circuit board is also developed for this project. The advantages of this that while designing hardware part there is no fault and I got exact output whatever required for this. [10, 11]

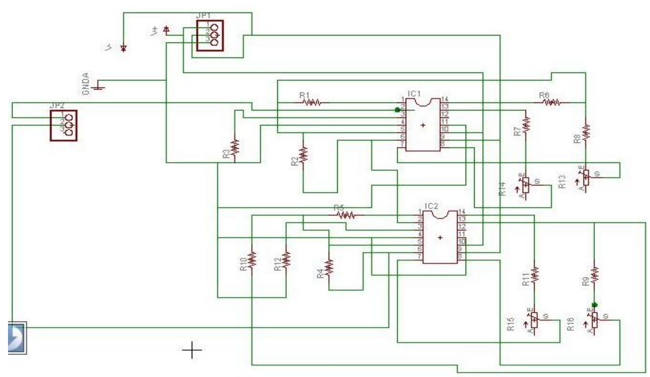

Figure 2 Schematic Layout of Notch Filter

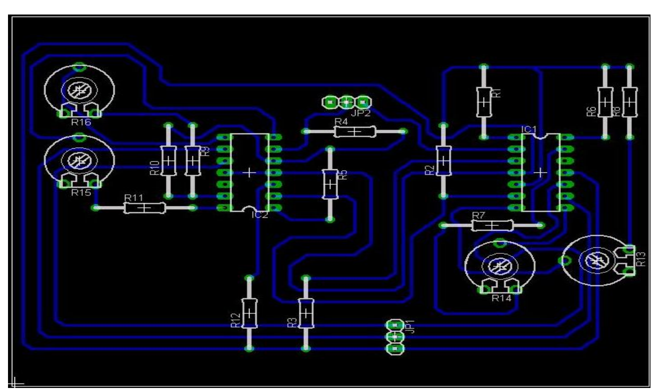

Figure 3 PCB Layout of Notch Filter

D. Microcontroller (PIC 16F877A)

The PIC16F877 is a programmable 40-pin integrated circuit package which functions as a microcontroller and is also capable of performing analog-to-digital conversion, which may also be utilized in this project to convert the actual EKG signal to digital data that could be stored on the personal computer (PC). If we are able to successfully implement pulse detection and missed beat statistics on the PC, then we will turn our efforts to conversion and digital storage of the EKG waveform. Results of operations performed on the PIC16F877 will be output through the Addressable Universal Synchronous/Asynchronous Receiver Transmitter (USART) [21].

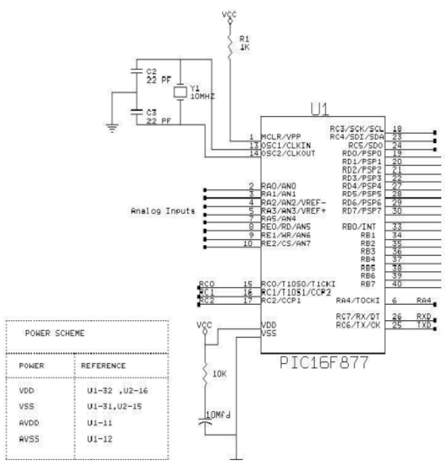

Figure 4. PIC Microcontroller

D – I Analog to Digital Converter (A/D)

The analog-to-digital (A/D) converter module can have up to eight analog inputs for a device.

The analog input charges a sample and hold capacitor. The output of the sample and hold capacitor is the input into the converter. The converter then generates a digital result of this analog level via successive approximation. This A/D conversion, of the analog input signal, results in a corresponding 10-bit digital number. The analog reference voltages (positive and negative supply) are software selectable to either the device's supply voltages (AVDD, AVss) or the voltage level on the AN3/VREF+ and AN2/VREF pins. The A/D converter has a unique feature of being able to operate while the device is in SLEEP mode.

D – II USB-UART Bridge

In order for output from the PIC16F877 to be transferred to the computer's USB port using the USART port of the PIC, a UART to USB Bridge is necessary. This is also powered by the power supply circuit.

The Universal Synchronous Asynchronous Receiver Transmitter (USART) module is one of the two serial I/O modules (other is the SSP module). The USART is also known as a Serial Communications Interface or SCI. The USART can be configured as a full duplex asynchronous system that can communicate with peripheral devices such as CRT terminals and personal computers, or it can be configured as a half duplex synchronous system that can communicate with peripheral devices such as A/D or D/A integrated circuits, Serial EEPROMs etc.

D – III Universal Synchronous Bus (USB – SL811HS)

Universal Serial Bus (**USB**) is a serial bus standard to connect devices to a host computer. USB was designed to allow many peripherals to be connected using a single standardized interface socket and to improve plug and play capabilities by allowing hot swapping; that is, by allowing devices to be connected and disconnected without rebooting the computer or turning off the device. Other convenient features include providing power to low-consumption devices, eliminating the need for an external power supply; and allowing many devices to be used without requiring manufacturer-specific device drivers to be installed.

USB is intended to replace many varieties of serial and parallel ports. USB can connect computer peripherals such as mice, keyboards, PDAs, gamepads and joysticks, scanners, digital cameras, printers, personal media players, flash drives, and external hard drives. For many of those devices, USB has become the standard connection method. USB was designed for personal computers, but it has become commonplace on other devices such as PDAs and video game consoles, and as a power cord between a device and an AC adapter plugged into a wall plug for charging. As of 2008, there are about 2 billion USB devices sold per year, and about 6 billion totals sold to date [15, 16].

The design of USB is standardized by the USB Implementers Forum (USB-IF), an industry standards body incorporating leading companies from the computer and electronics industries. Notable members have included Agree (now merged with LSI Corporation), Apple Inc., Hewlett-Packard, Intel, NEC, and Microsoft.

A USB system has an asymmetric design, consisting of a host, a multitude of downstream USB ports, and multiple peripheral devices connected in a tiered-star topology. Additional USB hubs may be included in the tiers, allowing branching into a tree structure with up to five tier levels. A USB host may have multiple host controllers and each host controller may provide one or more USB ports. Up to 127 devices, including the hub devices may be connected to a single host controller.

USB devices are linked in series through hubs. There always exists one hub known as the root hub, which is built into the host controller. So-called "sharing hubs", which allow multiple computers to access the same peripheral device(s), also exist and work by switching access between PCs, either automatically or manually. They are popular in small-office environments. In network terms, they converge rather than diverge branches.

A physical USB device may consist of several logical sub-devices that are referred to as device functions. A single device may provide several functions, for example, a webcam (video device function) with a built-in microphone (audio device function). USB endpoints actually reside on the connected device: the channels to the host are referred to as pipes.

USB device communication is based on *pipes* (logical channels). Pipes are connections from the host controller to a logical entity on the device named an endpoint. The term endpoint is occasionally used to incorrectly refer to the pipe. A USB device can have up to 32 active pipes, 16 into the host controller and 16 out of the controller.

Each endpoint can transfer data in one direction only, either into or out of the device, so each pipe is uni-directional. Endpoints are grouped into interfaces and each interface is associated with a single device function. An exception to this is endpoint zero, which is used for device configuration and which is not associated with any interface.

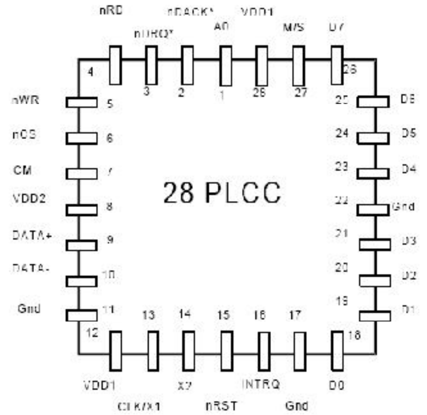

Figure 5. 28-pin PLCC USB Host/Slave Controller — Pin Layout

The SL811HS is an Embedded USB Host/Slave Controller capable of communicating in either full speed or low speed. The SL811HS interfaces to devices such as microprocessors, microcontrollers, DSPs, or directly to a variety of buses such as ISA, PCMCIA, and others. The SL811HS USB Host Controller conforms to USB.

The SL811HS incorporates USB Serial Interface functionality along with internal full or low speed transceivers. The SL811HS supports and operates in USB full speed mode at 12 Mbps, or in low speed mode at 1.5 Mbps. When in host mode, the SL811HS is the master and controls the USB bus and the devices that are connected to it. In peripheral mode, otherwise known as a slave device, the SL811HS operates as a variety of full- or low speed devices.

The SL811HS data port and microprocessor interface provide an 8-bit data path I/O or DMA bidirectional, with interrupt support to allow easy interface to standard microprocessors or microcontrollers such as Motorola or Intel CPUs and many others. The SL811HS has 256-bytes of internal RAM which is used for control registers and data buffer. The available package types offered are a 28-pin PLCC (SL811HS) and the lead-free packages are a 28-pin (SL811HS-JCT) and a 48-pin (SL811HST-AXC) package. All packages operate at 3.3 VDC. The I/O interface logic is 5V-tolerant. The SL811HS microprocessor interface provides an 8-bit bidirectional data path along with appropriate control lines to interface to external processors or controllers [23].

III. SOFTWARE DESCRIPTION

III – A. VISUAL BASIC

In personal computer or Laptop, to plot ECG waveform and storing the ECG waves, programming is done in Visual Basic. Universal Serial Bus (USB) module is connected to PC. To interface this USB module to computer or Laptop, programming is done in Visual Basic. With the help of this software, we transfer the ECG data from Microcontroller to Laptop[14 , 16].

III – B VISUAL BASIC PROGRAMMING FLOW CHART-

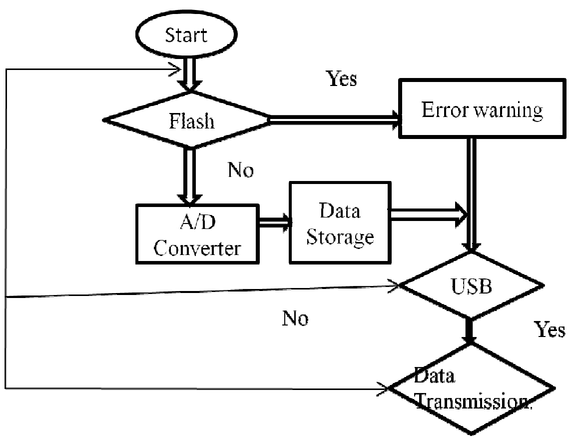

Figure 6. Flow Chart for VB Program

III – C Flow Chart for ADC & USART Configuration in PIC

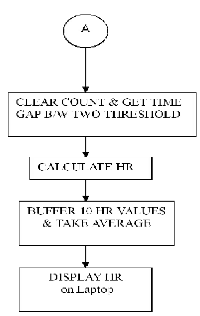

Figure 7. Flow Chart

III – D FLOW CHART FOR WAVEFORM PLOTTING USING VB

The chart has given below illustrates that how the graph is getting plot on the system and it also tells that how the waveform is getting extract from the external hardware to internal:-

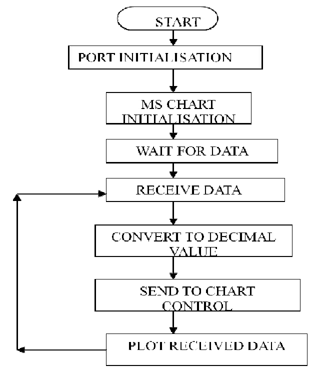

Figure 7. Flow Chart

III – E Heart Rate Calculation

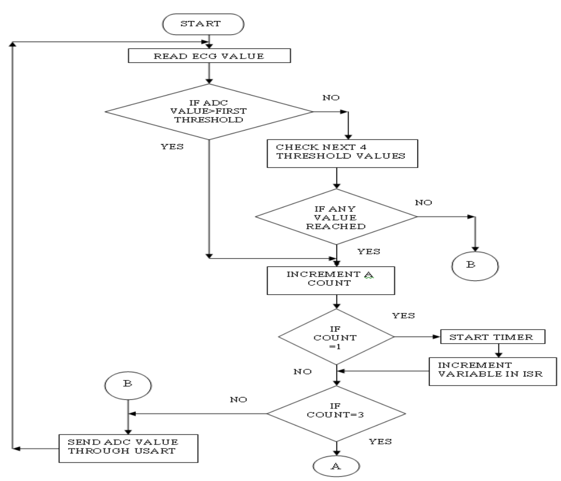

Figure 9. Flow Chart

It is used to add a serial communication facility. At first MS comm. is initialized and properties are set. The main properties are the communication port number, handshaking which sets the hardware handshaking as none, Threshold which sets the number of characters to be received as 1, RTS Enable to enable the request to send line, Input mode to set type of data retrieved as binary, Settings to set baud rate, parity, stop bit, data bit parameters. Then OnComm event is selected. Input property of MSComm is used to read data from receive buffer [17, 18].

III – F ALGORITHM

1. Start Program
2. The O/P Goes to Memory of PIC Controller
3. If There is error then It won't accept
4. No, The Analog Data converts in the Digital Form
5. Data Storage has done
6. After getting O/P from PIC It is transferred the data to Laptop through USB
7. Finally the O/P ECG data display on the Laptop

IV - GRAPH PLOTTING

The Microsoft Chart component is used for waveform plotting. At first set row and column count, maximum and minimum scale of the graph. Then set reference point as zero. Received data is converted into ASCII and plotted with respect to reference point

The Program has written in Visual Basic for displaying the ECG data given below:

IV – A Programming Coding

```
Private Declare Sub Sleep Lib "kernel32" (ByVal dwMilliseconds As Long)
Dim S, col As String
Dim timer3C As Boolean
Dim cnt, sec, bp, obp, obp1, st, st1 As Variant

Private Sub Command1_Click()
End
End Sub
Private Sub Form_Load()
timer3C = False
pacnt = 0
pptr = 0
pptr1 = 0
For i = 1 To 250
Egra1(i) = 50
Next

For i = 1 To 250
Egra2(i) = 50
Next

cnt = 0
inn = 2
ptr = 19
ptr1 = 19

'Bflg = 3.1
cnt = 0
sec = 0
MSComm1.PortOpen = 3
Sleep (20)

End Sub

Private Sub Heartbeat_Click()
If Heartbeat.Value = False Then
   timer3C = False
   Timer2.Enabled = False
   Text4 = "No Input"
   Text5 = "-"
   Text6 = "-"
   Text7 = "-"
Else
   timer3C = True
   Timer2.Enabled = True
End If
End Sub

Private Sub Timer1_Timer()

MSComm1.Output = "[40]"
Sleep (20)
buf = MSComm1.Input

inp = val("&h" & Mid$(buf, 2, 4))
Text1.Text = inp

'MSComm1.Output = "[41]"
'Sleep (20)
'buf = MSComm1.Input
'
'inp = val("&h" & Mid$(buf, 2, 4))
'Label8.Caption = inp

If val(Text1.Text) < 500 Or inp < 500 Then
a0(0) = 5
a0(1) = 5
a0(2) = 5
a0(3) = 6
a0(4) = 5
a0(5) = 5
a0(6) = 5
a0(7) = 5
a0(8) = 3
a0(9) = 10
a0(10) = 1
a0(11) = 5
a0(12) = 5
a0(13) = 5
a0(14) = 7
a0(15) = 5
a0(16) = 6
a0(17) = 5
a0(18) = 5
a0(19) = 5
pptr = 0
Strt = 1
End If
```

```
Label2.Caption = Time
Label3.Caption = Date
End Sub
Private Sub Timer2_Timer()
Dim val As Integer
Dim val1 As Integer

val = Rnd(4) * 180

If val > 60 And val < 100 Then
val1 = -val
val1 = val1 + 140
   Text4 = val
   Text5 = (val - 60) / 625 + 0.12
   Text6 = (val1 / 142.85) + 0.04
   Text7 = (val - 60) / 1000 + 0.05
Else
      Text5 = "-"
      Text6 = "-"
      Text7 = "-"
   If val > 100 Then
      Text4 = ""
   Else
      Text4 = ""
   End If
End If

End Sub

Private Sub Timer3Timer()
If Strt = 1 And ptr >> 0 Then
   If timer3C = True Then
      Egra1(1) = 50 - ((ptr) * 10) / (200# / 50#))
   Else
      Egra1(1) = 35
   End If
ptr = ptr - 1

Else
'Egra1(1) = 5 '0 - (Val(Text1.Text) / (200# / 20#))

ptr = 19 + pptr
Strt = 0
End If

For i = 250 To 2 Step -1
Egra1(i) = Egra1(i - 1)

Next
Picture1.Cls
vvv = 1
For i = 1 To 249
Picture1.Line (vvv, Egra1(i))-(vvv + inn, Egra1(i + 1)), vbYellow
vvv = vvv + inn
Next
End Sub
```

V. IMPLEMENTATION AND TESTING

Design of ECG Acquisition Circuit and Interfacing Circuit

The first stage of the project is to design ECG acquisition circuit, designing is done step by step very carefully.ECG amplifier using IN118 is done first and the output voltage is checked for given inputs and it is verified that the gain of 1000 is available.

TESTED GAIN

Desired Gain	Standard Value of Rg	Calculated Gain
2	51.1 k	1.988
5	12.7k	4.976
10	5.62k	9.986
20	2.67k	19.91
33	1.58k	32.96
40	1.3k	39.85
50	1.02k	50.50
65	787	65.17
100	511	99.83
200	255	199.0
500	102	496.1
1000	51.1	989.3

Table 1. Gain of IN118

VI. RESULT

The prototype of the Electro Cardiograph monitor is designed successfully. This project also works as a heart rate monitor that uses pre gelled disposable ECG electrodes to detect electrocardiogram. They are kept on the chest as it will work as V1, V2, V3 and V4 as specification requested and 5^{th} electrode is kept on the right leg of the subject which works as a reference electrode. Device works in 12V adaptor and draw 40 mA current while transmitting. Even if no isolation circuit is used, no shock observed for patient and it’s thus a safe product to use. Different application platforms are used for displaying acquired ECG signals and all methods are successfully done. Software used for displaying ECG on Laptop and Acquiring is successfully done.

Although the readings on the device are accurate while the wearer is stationary, they are susceptible to electrode placements. When the user is exercising or moving around, these readings can be compromised. This problem would need to be investigated for future prototypes. It is expected that more sophisticated electrodes made from silver plates would help with this problem.

Comparison between Standard ECG Parameter & Tested:

The *PR interval* is the duration of time between the beginning of the P wave, signifying atria depolarization, and the beginning of the QRS complex. It represents the time between the beginning of the contraction of the atrium and the beginning of the contraction of the ventricle. The *QT interval* extends from the beginning of the Q wave to the end of the T wave. It represents the time of ventricular contraction and repolarization. The *ST interval* extends from the S wave to the end of the T wave. The standard ECG parameter values are listed in the table below:

STANDARD ECG PARAMETER

Parameter	Range	Units
Heart Rate	60 – 100	Beats Per Minute
PR Interval	0.12 – 0.20	Seconds
QT Interval	0.39 ± 0.04	Seconds
P Wave Duration	0.12	Seconds
QRS Width	0.05 – 0.1	Seconds
T Wave Duration	0.08	Seconds

Table 2. Standard ECG Parameter [4]

TESTED ECG PARAMETER

Tested ECG Parameters for different age groups: First Subject taken as a Normal & the ECG Parameters are given below

Parameter	Range	Unit
Heart Beat	76	BPM
PR Intervals	0.1264	Second
PQ Interval	0.5720	Second
QRS Interval	0.054	Second
P Amplitude	0.124	Milivolt
R Amplitude	0.134	Milivolt

Table 3. Tested ECG for Subject A

Parameter	Range	Unit
Heart Beat	80	BPM
PR Intervals	0.152	Second
PQ Interval	0.0.460	Second
QRS Interval	0.07	Second
P Amplitude	0.14	Milivolt
R Amplitude	0.15	Milivolt

Table 4. Tested ECG for Subject B

Parameter	Range	Unit
Heart Beat	110	BPM
PR Intervals	0.0.1744	Second
PQ Interval	0.3620	Second
QRS Interval	0.084	Second
P Amplitude	0.154	Milivolt
R Amplitude	0.164	Milivolt

Table 5. Tested ECG for Subject C

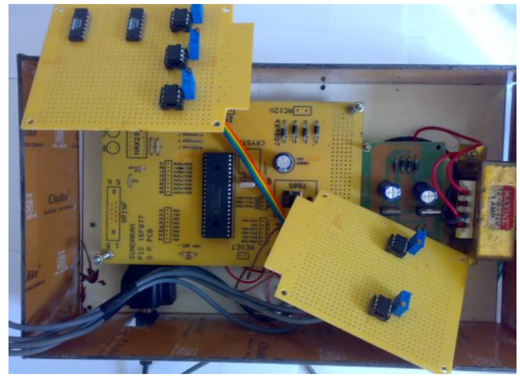

Figure 10. Complete ECG Kit

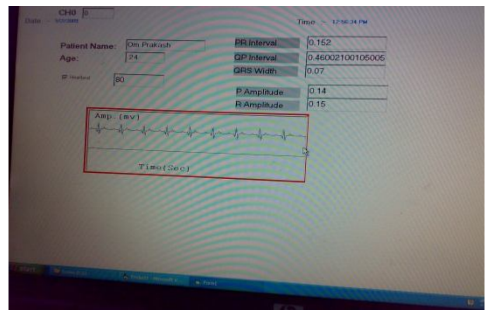

Figure 11. ECG Waveform Displayed on Laptop

VII. CONCLUSION

This "A USB BASED ECG PORTABLE SYSTEM" implementation of an ECG monitoring system has taken a step towards decreasing the cost of ECG monitoring systems thereby allowing hospitals to buy more systems. This would lead to the conclusion that this will reduce the mortality rate due to cardiovascular diseases.

The ECG machine is a vital instrument for monitoring the electrical activity of the heart. Currently it is prone to human error simply because the wires are constantly getting in the way and being knocked off by the nurses, doctors or the patient himself.

This project is developed a low cost system for ECG acquisition and visualization on Laptop/ PC enabled, which is easy to install for a patient, as well as for a physician with a little previous knowledge. Its design allows for easy technological updates and further development to provide more intelligence to the system. Incorporating technologies such as and the development of software tools both for a computer and for universal Serial Bus devices enables a large range of application scenarios.

Even if the patient is moving or sitting ECG monitoring can be done. ECG signal processing using Visual Basic is an important scope as far as this project is concerned.

VIII. FUTURE WORKS

In the near future this project can be expanded to allow the data to be stored on the Liquid Crystal Display (LCD) and to allow the analyzed data to be transmitted via USB to a health care provider. In this case the ECG is recorded as video and saved in the LCD and this can give a real time analysis of cardiovascular diseases.

The microcontroller based heart rate monitoring system designed in this project has a lot of advantages, but can also be improved on. There is a lot of improvement that can be made to the firmware portion of the project that would result in a more reliable system as stated in the recommendations section.

Looking ahead, as microcontrollers get more and more advanced, there will be a shift from analog amplification to digital amplification. Biological signals from the electrodes can be fed directly into the microcontroller, where the front end, core, and back end work can be processed. This will significantly reduce the surface area consumed by a circuit and would lead to a smaller, more compact, and portable system.

More work can be done in the processes leading to the acquisition of these small biological signals. There are many challenges that still pose big problems in the design of systems like this. The skin/electrode interface, motion artifact, as well as AC power noise are problematic areas which would significantly increase reliability and efficiency if there are ways to minimize their effects.

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