SIGNAL ACQUISITION AND PROCESSING SYSTEM FOR DIAGNOSIS OF CARDIAC MALFUNCTIONING

By

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ABSTRACT

The aim of the project was to design a signal acquisition and processing system for diagnosis of cardiac malfunctioning. The electrocardiograph (ECG) machine currently being used employs conducting gel and contact electrodes and gives out fused output. This project gives independent outputs corresponding to each sensor data and makes use of sophisticated signal processing tools. As the oxygen is pumped into the blood, the colour of blood changes from blue to red. Light is passed through the blood and then detected on the other side by the receiver. The received light indicates the change in intensity of the signal, which in turn reflects heartbeat.

Received signal from receiver was amplified, filtered and then passed to the computer via analog to digital converter. Matlab was used to process the signal and a ‘C’ program is used to receive signal from computer port. The required information about signal was to be displayed on to computer screen, which was printable as well.

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CHAPTER # 1

PROJECT BRIEF

1.1 Introduction

The heart has got its own importance amongst the organs of the body and is the main source of pumping blood in to the body through veins and arteries. The importance of the heart is signified by the fact that if heart fails, every thing fails unlike any other part of the body. Hence the knowledge about problems of the heart, techniques to overcome them and the research to detect the malfunctioning of the heart has been a major field in medical sciences.

In mid 1930's initial work started to detect the working of heart need without physical operation; hence the idea of a machine was generated which could give valuable information about the heart. The machine which has undergone many changes till now and has come up as electrocardiograph. The collection of valuable information about the heart through electrical activities of the heart is known as ECG (Electrocardiography).

Although there are many techniques of collecting information about the heart, the widely used technique world over is the detection of heart condition through the minute electrical pulses generated by the heart during its regular activities. The information gathered regarding the condition of heart could be seen on CRT (Cathode-Ray-Tube) or hard copy can be produced. The diagnosis of heart through electrical equipment is termed as Electro-diagnosis.

1.2 Electro-Diagnosis

There are three major kinds of Electro-diagnostic procedures used clinically. Each is based on the principle that living cells have an electrical potential difference between their interior and exterior surfaces.

The potential difference of up to 100 mili volts exists across the cell boundary. Cell metabolic energy is used to maintain the difference in the concentration of ions inside and outside the cell membrane that creates electrical potential. Electro-diagnosis utilizes equipment that amplifies and records charges in potential, especially in those type of cells that are highly specialized electrical conductors (heart or nerve cells) and whose principal function is related thereto.

1.3 Electro Cardiography

This method is used in the diagnosis of heart lesions. By means of electrodes contacting the extremities at various points, it is possible to record voltage changes due to heart muscle contraction and so to detect and locate regions within the heart it self where damage has occurred. Some lesions escape notice, but occasionally the technique detects damage when other diagnostic signs are absent. Interpretation of an electrocardiogram necessitates the correlation of the measured charges in the amplitude and the pattern of electrical potential. It is most often used to diagnose and record the rate of healing of myocardial infarcts (localized heart muscle death). It is also useful as a diagnostic aid in detecting abnormalities in impulse conduction in the heart, electrolyte imbalance, myocardial heart (hypertrophy), decreased heart oxygen supply, and other less common diseases.

1.4 Electro Cardiogram

A record of the electrical activity of the heat is called Electro-cardiogram. Minute voltage of the heart auricles and ventricles are transmitted to a recording instrument (an electrocardiograph) by means of metal electrodes placed on the arms, legs and chest.

The Electro-cardiogram amplifies these voltages which then activate a stylus to write upon moving paper strip. The electric event in the chamber of the heart are reflected in characteristic fluctuation or waves of the ECG. Certain changes in these waves have been associated with various heart conditions and other disorders.

The ECG is extremely important in the diagnosis of enlargement of the heart and heart beat irregularities.

Although there are many methods being used in the market for detecting the malfunctioning of the heart, the most common is the detection of the heartbeat by the electrical signals generated by the heart. This technique is being used in today's ECG machines. In this technique contact electrodes and the conducting gel is applied onto different parts of the body and hence the electrical activity is measured. But the technique in the undergoing project is quite unique and uncommon in the industry. In this technique red beam and its sensor is used. The beam of infrared and red light is applied onto the feet fingers, hand fingers and the ear lobes and sensed at the other end by the sensor. The intensity of the received signal light, basically depends upon the amount of oxygen being absorbed by the heart and indirectly gives the rate of heart beat and other information.

1.5 Introduction To Matlab

MATLAB is a high-performance language for technical computing. It integrates computation, visualization, and programming in an easy-to-use environment where problems and solutions are expressed in familiar mathematical notation. Typical uses include:

- Math and computation

- Algorithm development
- Modeling, simulation, and prototyping
- Data analysis, exploration and visualization
- Scientific and engineering graphics

Application development is an interactive system whose basic data element is an array that does not require dimensioning. This allows to solve many technical-computing problems, especially those with matrix and vector formulations, in a fraction of the time it would take to write a program in a scalar non-interactive language such as C or Fortran.

The name MATLAB stands for matrix laboratory. MATLAB was originally written to provide easy access to matrix. MATLAB has evolved over a period of years with input from many users. In university environments, it is the standard instructional tool for introductory and advanced courses in mathematics, engineering, and science. In industry, MATLAB is the tool of choice for high-productivity research, development, and analysis.

MATLAB features a family of application-specific solutions called toolboxes. Very important to most users of MATLAB, toolbox allows to learn and apply specialized technology. Toolboxes are comprehensive collections of MATLAB functions (M-files) that extend the MATLAB environment to solve particular classes of problems. Areas in which toolboxes are available include signal processing, control systems, neural networks, fuzzy logic, wavelets, simulation, and many others.

1.5.1.1 The MATLAB Language

This is a high-level matrix/array language with control flow statements, functions, data structures, input/output, and object-oriented programming features. It allows both "programming in the small" to rapidly create quick and dirty throw-away programs, and "programming in the large" to create complete large and complex application programs.

1.5.1.2 The MATLAB working environment

This is the set of tools and facilities that you work with as the MATLAB user or programmer. It includes facilities for managing the variables in your workspace and importing and exporting data. It also includes tools for developing, managing, debugging, and profiling M-files, MATLAB's applications.

1.5.1.3 Handle Graphics.

This is the MATLAB graphics system. It includes high-level commands for two-dimensional and three-dimensional data visualization, image processing, animation, and presentation graphics. It also includes low-level commands that allow to fully customize the appearance of graphics as well as to build complete Graphical User Interfaces on your MATLAB applications.

1.5.1.4 The MATLAB Application Program Interface (API)

This is a library that allows to write C and Fortran programs that interact with MATLAB. It include facilities for calling routines from MATLAB (dynamic linking), calling MATLAB as a computational engine, and for reading and writing MAT-files.

Simulink, a companion program to MATLAB, is an interactive system for simulating nonlinear dynamic systems. It is a graphical mouse-driven program that allows to model a system by drawing a block diagram on the screen and manipulating it dynamically. It can work with linear, nonlinear, continuous-time, discrete-time, multivariable, and multirate systems.

1.5.1.5 MATLAB's Command Window.

The menus are particularly convenient for interactive work, while the command-line approach is very useful for running a batch of simulations. Using scopes and other display blocks, one see the simulation results while the simulation is running. In addition, one can change parameters and immediately see what happens, for "what if" exploration. The simulation results can be put in the MATLAB workspace for post processing and visualization.

Model analysis tools include linearization and trimming tools, which can be accessed from the MATLAB command line, plus the many tools in MATLAB and its application toolboxes.

Toolboxes are more than just collections of useful functions; they represent the efforts of some of the world's top researchers in fields such as controls, signal processing, and system identification. All toolboxes are built using MATLAB.

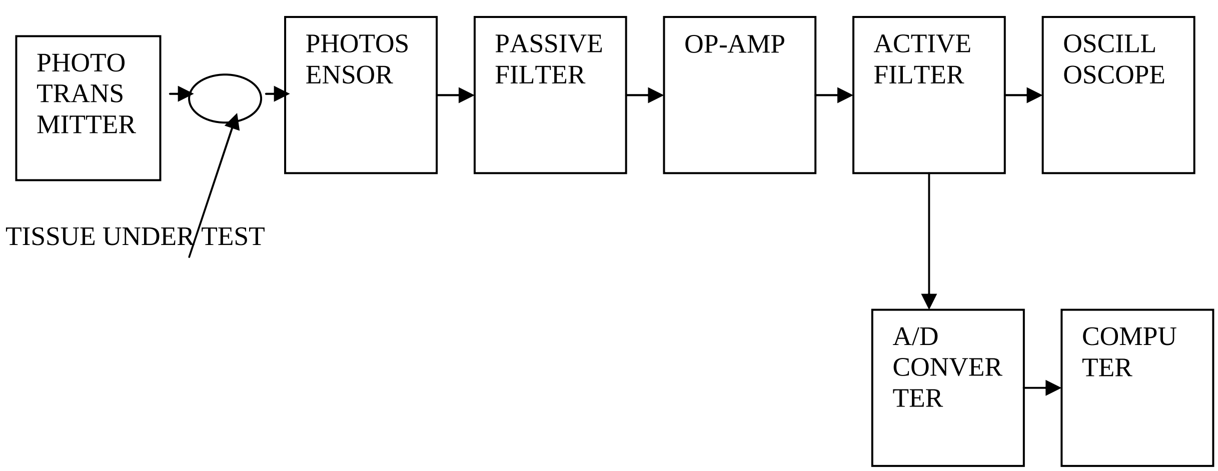
CHAPTER # 2

PROJECT SPECIFICATIONS

2. The project measures the amount of oxygen saturation in the blood by examining colour change in blood. To examine such changes, LASER light was passed through the soft tissues of human body and detected by photo sensors.

As the signal was weak so passive filter was used. An operational amplifier was used to amplify the signal. The combination of passive filter and operational amplifier makes a high pass filter which stops the frequencies below 0.05 Hz. This signal is then passed to low pass active filter, which stops the frequencies above 10 Hz. The freq is selected because the heartbeat can be in the range of 1 to 7 Hz. The signal then can be viewed on an oscilloscope or a computer after being digitized.

The overall block diagram is as under.



The output of hardware was connected with parallel port of computer via A/D converter after the initial stages.
MATLAB was used to process the signal and get required information from the signal. The digital signal from the parallel port was scanned through a “C” program. The processed signal with required information was displayed on computer screen.

CHAPTER # 3

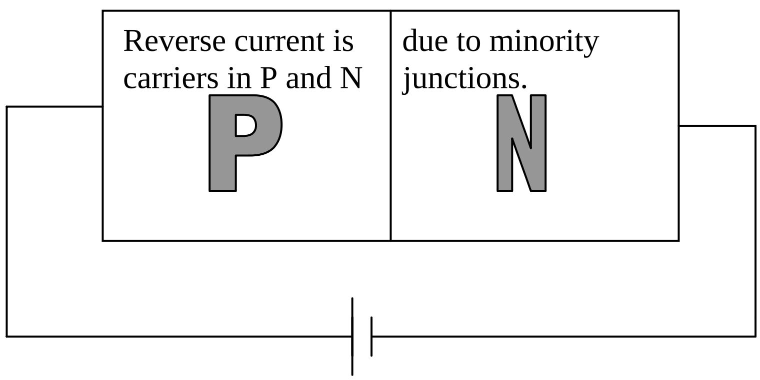
3. HARDWARE ANALYSIS AND DESIGN

LASER light was passed through soft tissues of the human body. At the other end photo sensor was used to receive the light and detect its intensity thus measuring heartbeat depending on colour change in the blood. In photo sensor different options were available like photocell, photodiode ,phototransistor and photo Darlington transistor.

Photo cell (light dependent resistor) belongs to the family of photosensitive devices whose resistance varies with incident radiant energy or with light. Materials such as cadmium sulfide and silicon, whose conductivity is a function of light, are used for photoconductive cells. It is typically composed of a ceramic base, a layer of photoconductive material , a moisture proof enclosure and metallic leads.The resistance of photocell is typically on the order of 100 k ohms.

The photocell was not used because of lack of linearity. The graph between intensity and voltage is not linear which is not required.

Photodiode is a diode in which the reverse current varies directly with the amount of light. It is a PN junction that operates in reverse bias. The photodiode has a small transparent window that allows light to strike the PN junction. When light falls, the reverse current increases with the intensity of light. When there is no incident light the reverse current is almost negligible and is called the dark current. Though it is fast but has less power. Where as the requirement was of more power and less speed, hence it was not used.



Light intensity is expressed as irradiance. Its units of measure are mw/cm2.

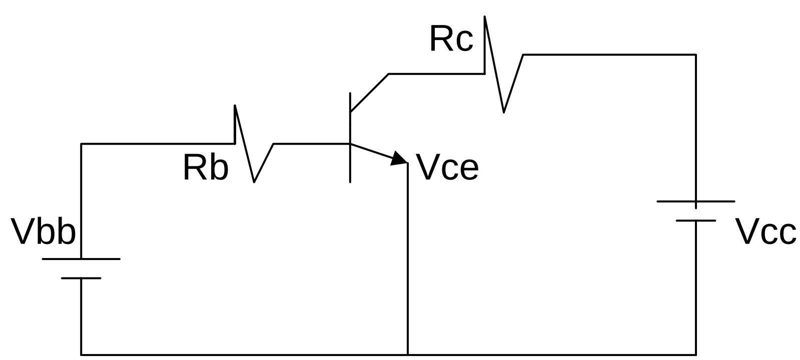
A phototransistor is a transistor in which base current is produced when light strikes the photosensitive semiconductor base region. It has a light sensitive, collector-base PN junction.
It behaves like a normal bipolar transistor except the way the way base current is generated. It can be either a two lead or a

three lead device. In three lead it acts like a normal bipolar transistor with or without additional light sensitive features. In two lead base is not electrically available and device can be used only with light as input.

Phototransistor is used in common emitter configuration.

3.1 COMMON EMITTER CONFIGURATION

In this configuration common or ground side of each voltage source is connected to emitter so is the name common emitter. The circuit has two loops. Left loop is base circuit and right loop is collector circuit.



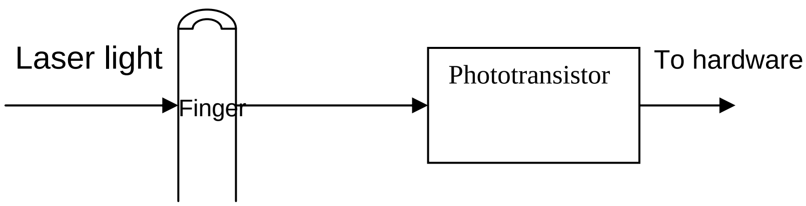
Where Vbb and Vcc are supply voltages and Rb, Rc are current limiting resistors.(Malvino 163)

Vbb must be greater than Vbe to turn on emitter diode.

Typically Vbb is in range of 5 to 15V.

And Vcc is in range of 1 to 15 V.

Although phototransistor has more power and less speed than photodiode but lesser than photo Darlington transistor hence the later was used.



After phototransistor a filter was required so that only the required frequency passes through the circuit. The filter is a frequency selective circuit that passes a specified band of frequencies and block others.

Filters broadly can be divided as passive and active filter. Passive filters are the one, which uses resistors, capacitors and inductors i.e. passive devices. On the other hand active filters also include active devices like operational amplifiers or transistors in addition to capacitors and resistors.

RC (resistor-capacitor) filters are used for audio or low frequency operations. As the frequency of signal from phototransistor is very small as heartbeat in range of 1Hz to 7 Hz so RC filter was used. The values calculated were from 0.05 to 10 Hz to remain on safer side.

The values of high pass passive filter was

R = 1/2 (3.14) fc

As frequency is 0.05Hz, so by many tries the values of

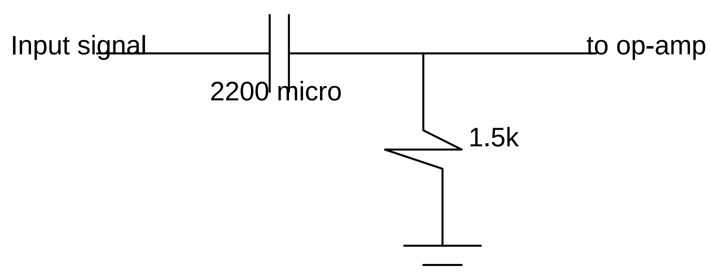
R=1.5k and c = 2200 microfarads

R = 1/2*3.14*10*2200micro

=1449.2

=~1.5k ohms

Passive filter is used because the signal is low and it has less input impedance as compared to active one. The passive filter used is as follow

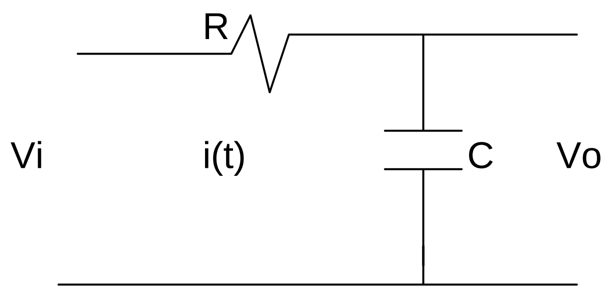


Order of passive filter is directly proportional to number of RC network.

Higher order is designed using second order. Gain decreases (20dB) = 20 log 10 each time the frequency is increased by 10.

To check whether high, low or band bass following procedure was carried out:-

The input and output equations of a passive filter with resistance R, capacitance C , input voltage Vi, output voltage Vo and current i(t) are



Vi = i(t) R + z i(t)

Vo = i(t) z

Where z is the impedance of capacitor.

Also z = 1/Xc = 1/ jwc

And s = jw

The ratio of input and output is

Vo / Vi = i(t) z / i(t) [R+z] ------------------(1)

Taking Laplace of equation (1) we get

Z = 1/ Xc = 1/ s * c

i(t) = I (s)

R = R

$$Vo(s) / Vi(s) = [I(s)*1/sc] / I(s) [R + 1/ sc]$$

$$= [1/sc] / [R s c + 1]/ s c$$

$$= 1 / [1 + Rsc] \text{ -----------------(2)}$$

if z indicates zeros and p indicates pole then

$$Vo / Vi = k [(s + z1) / (s + p1)] \text{ --------------(3)}$$

From (2) taking Rc common

$$Vo(s) / Vi(s) = 1/ Rc[s + (1/Rc)]$$

$$= (1/ Rc) * [1/(s + Rc)]$$

$$Vo/Vi = k [1/ (s + Rc)]$$

Here pole = s = - 1/Rc

$$G = Vo/Vi$$

$$= k [1/(jw + 1/Rc)]$$

for gain plot taking log

$$20 \log G = 20 \log k [1/(jw + 1/Rc)]$$

$$20 \log G = 20 \log k + 20 \log [1/(jw + 1/Rc)]$$

let R = 1k ohm

and c = 1 micro farad then

k = 1/Rc = 1000

$$20\log G = 20\log 1000 + 20\log\left[\frac{1}{(jw + 1000)}\right]$$

$$G = 20\log 1000 - 10\log\left[\omega^2 + 1000^2\right]^{-}$$

3.2 OPERATIONAL AMPLIFIER

In this project the signal from passive filter is passed to an operational amplifier for amplification. Operational amplifiers broadly can be divided into two main groups:

- General purpose
- Special purpose

General purpose op-amps are used for a variety of applications such as integration, differentiation, summing amp and others. For example 741 is a general-purpose amplifier. Where as special purpose are used only for specific applications they are designed for. For example LM 380 Op-amp can be used only for audio power applications.

The general purpose 741 Op-amp is made up of differential amplifiers, which was used in this project.

3.3 OPEN LOOP OP-AMP CONFIGURATION

Following configurations are being used:

- Differential amplifier: it amplifies the difference of two voltages.
- Inverting amplifier: it amplifies input at inverting terminal.
- Non-inverting amplifier: amplifies at non-inverting terminal and other terminal is grounded.

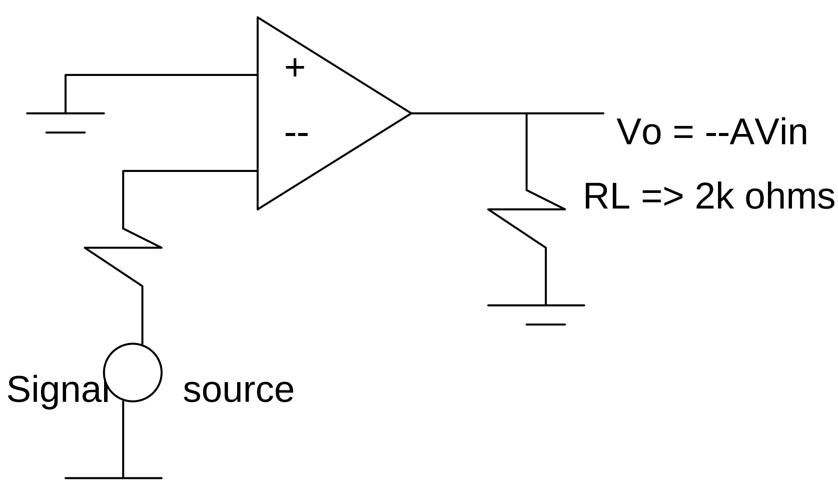
Vo = A Vid = A(V1-V2)-------------(4)

3.4 INVERTING AMPLIFIER:

In inverting amplifier input to negative terminal and ground with positive terminal.

Since V1 = 0V and V2 = Vin so from equation (4)

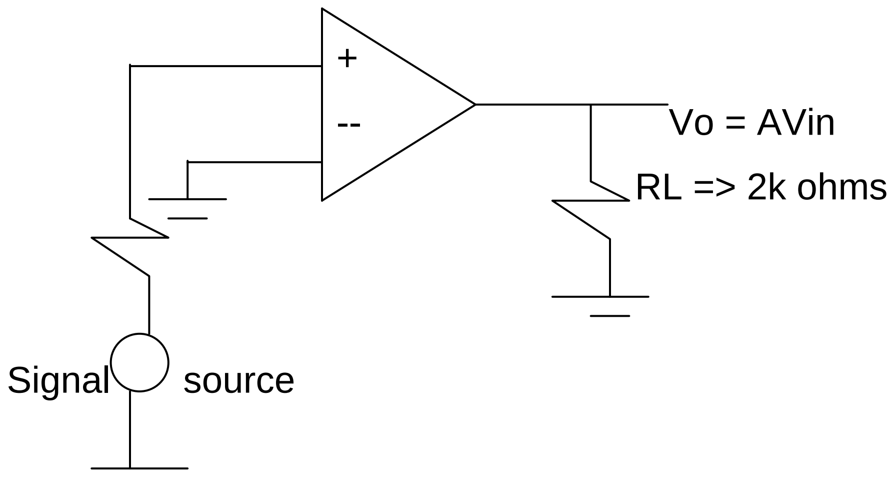
Therefore Vo = -A Vin



3.5 NON-INVERTING AMPLIFIER

Input to non-inverting terminal and ground with inverting terminal.

The figure is as follow:



Output of the operational amplifier is either negative or positive saturation or switches between positive and negative saturation levels. So for this reason open loop operational amplifiers are not used in linear applications.

3.6 REAL OPERATIONAL AMPLIFIER

Real op-amp has some dc output voltage called output offset voltage even both input are grounded. This is an error voltage and is undesirable, denoted as Voo and is produced due to Vio i.e. due to mismatching between two input terminals because exactly same is not possible.To reduce Voo to zero, one need to have a circuit at input terminals of Op-amp that will give the flexibility of obtaining Vio of proper amplitude and polarity.

Such a circuit is called as input offset voltage-compensating network.

The operational amplifier is then said to be null or balanced. This is not required with op-amp that has offset null pins, such as 741, 748, 777 and 301.

3.7 GAIN OF NON-INVERTING AMPLIFIER:

In non-inverting amplifier

Acl = 1 + Rf/Ri

So it can give a high gain because the band width can be low.

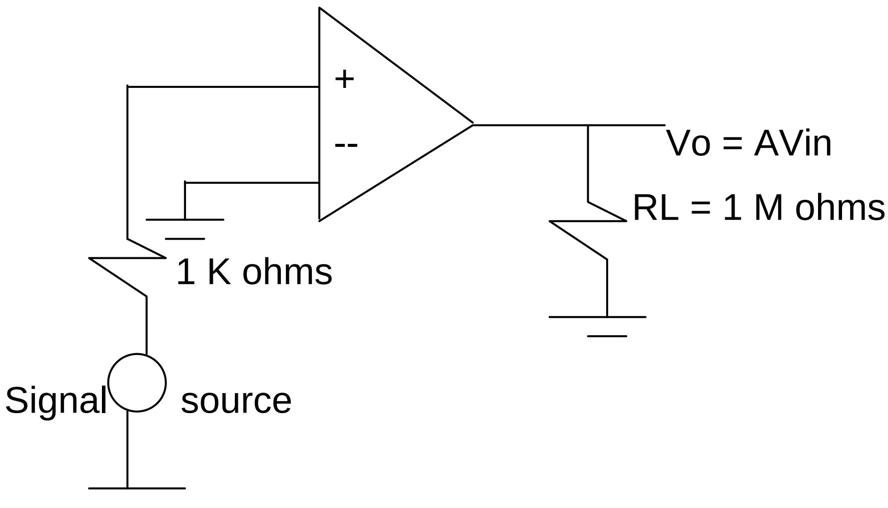
Gain bandwidth product = constant at a – 20 dB roll off

If bandwidth is low, gain is high.

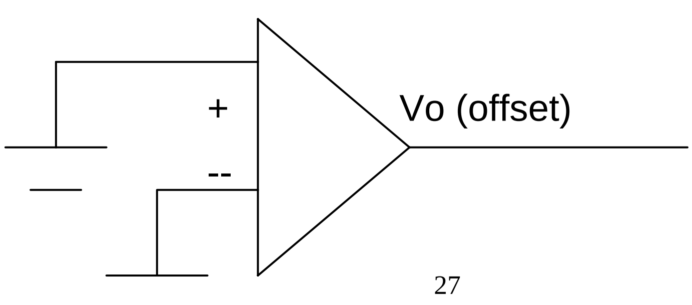
In this project non-inverting voltage amplifier is used because it is approximately an ideal voltage amplifier because of its high input impedance, low output impedance and stable voltage gain.

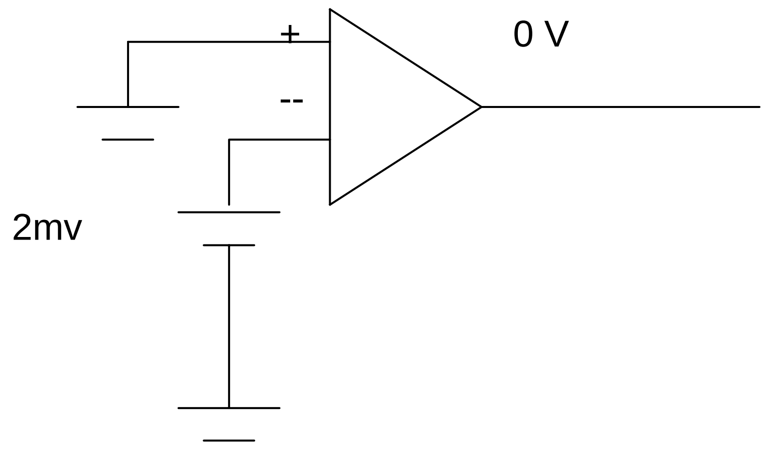
Acl (NI) = 1+Rf / Ri

The values used are



When the input of an operational amplifier is grounded, there is always an output-offset voltage because input transistor have different Vbe values. The input offset voltage is caused by difference in Vbe curves. e.g operational amplifier used (741) have an input offset voltage of + - 2 milli volts. This difference of 2 mv is an unwanted input signal that is amplified to produce an output offset voltage.

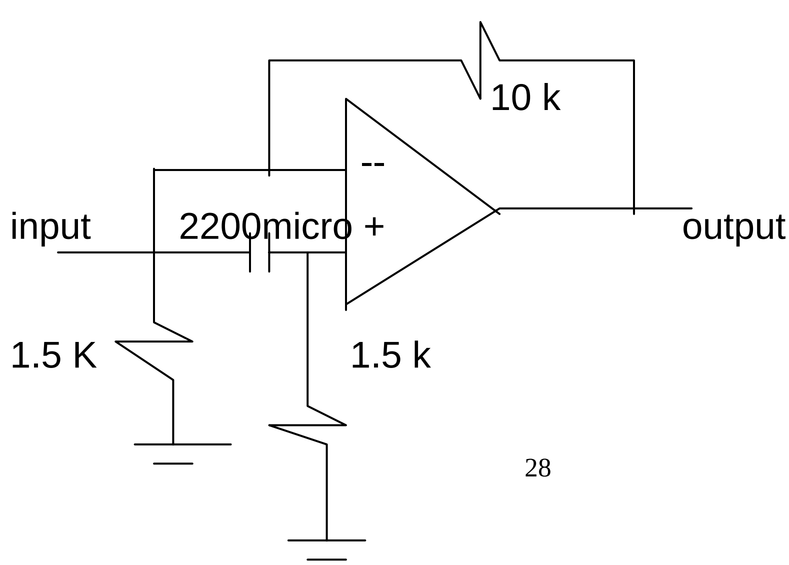




To eliminate output-offset voltage a voltage of 2mv can be applied to inverting input.Then the output offset voltage V decreases to zero. Since the offset can have either polarity it might be necessary to reverse the polarity.

Ideal operational amplifier produces zero voltage. However a small dc voltage appears at output even no differential input voltage is applied.

The combination of high pass and the operational amplifier takes the following shape:



3.8 ACTIVE FILTER

At this stage the signal has been amplified by the previous stage of operational amplifier. Moreover very accurate frequencies are required at this stage hence active filter was used at this stage before oscilloscope/computer. This is low pass filter, which stops frequencies below 0.05 Hz. A low pass has a constant gain from 0 Hz to a certain frequency called the cut off freq at which the gain is down by 3dB.

Passive filters have inherent problems, at low frequencies bulky inductors have to be used, which is practically not possible to implement. And as only passive components are used so gain of filter will never be greater than unity.

Because of heavy inductors, there are losses associated with them, core loss IIR (I square R) losses. Which need high signal power input and also don't give proper response. So to overcome these problems active filter is used in the later stage of project.

In case of active filter since inductors are not used, so the above mentioned problems are shed away.

- Since an active component is being used, normally an operational amplifier filter with gain more than unity can be designed.

- Because of the very high input impedance and very low output impedance of operational amplifier the impedance matching problem is over.

3.8 MEHTODS OF ACTIVE IMPLEMENTATION

1. Direct implementation

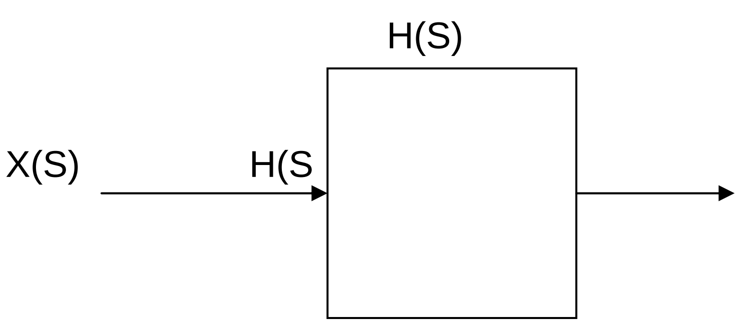
In this method transter function of system is taken and implemented in a single circuit. If a complicated transfer function is there so is the complicated circuit. So standard prototype cannot be made as circuit changes due to transfer function.

2. Cascade implementation

In this case given specimen is implemented using different circuit blocks. So for this circuit there is prototype for first and second order.

3.9 TRANSFER FUNCTION

If voltage, current and impedance are expressed in 's' domain, then the output of system divided by its input is called its Transfer Function.



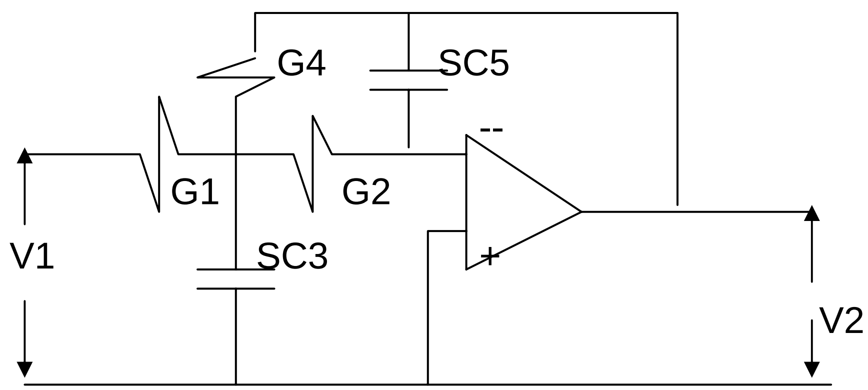
H(S) = Y(S) / X(S)

Transfer function does not depend on output or input , it is function of the system alone.

3.11 IGMFB IMPLEMENTATION

Low Pass Prototype

The low pass prototype is as under:-



Low pass transfer function

H(S) = k / [S2 + a1S + Wo2] ; a1 = Wo / Q (3 dB gain)

H(S) = k / [S2 + (Wo/Q)S + Wo2]---------------(5)

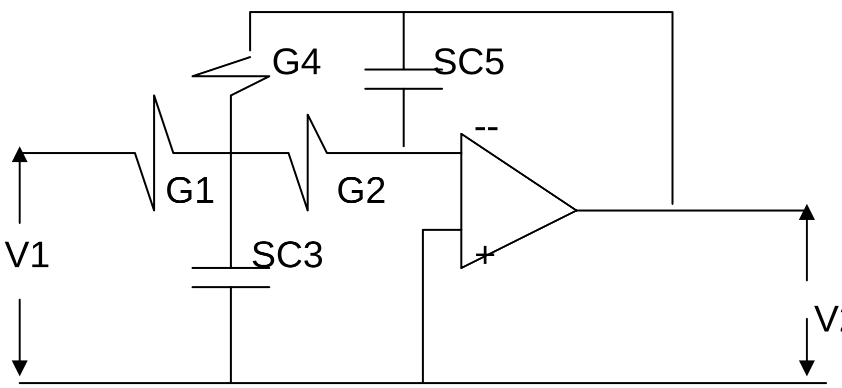
Example of low pass filter:-

Where PBE = pass band edge = Wo = 250 rad / sec

SBE = stop bans edge = 5000 rad / sec

step 1:-

low pass prototype:-



H(S) = k / [S2 + (Wo/Q)S + Wo2]

V2 / V1 = - Y1Y2 / [Y5 (Y1 + Y2 + Y3 + Y4) + Y4Y2]

V2 / V1 = - G1G2 / [SC5 (G1 + G2 + SC3 + G4) + G4G2]

Comparing with standard form of low pass

V2/V1= -G1G2/[SC5G1+SC5G2+S2C5C3+SG5G4+ G4G2]

V2 / V1 = - G1G2 / [S2C5C3+SC5(G1+G2+G4) + G4G2]

V2 / V1 = - [G1G2 /C5C3]/[S2+(S/C3)[G2+G1+G4)]+ G4G2/C5C3]

As K = -[G1G2 / C5C3] -------------(6)

Wo/Q = [G1 + G2 + G4] / C3--------(7)

$$\omega_0 = \sqrt{\frac{G2G4}{C3C5}} \longrightarrow (8)$$

$$Q = \sqrt{\frac{G2G4}{C3C5}} * C3/[G1+G2+G4].........(9)$$

Gain = k / [(jWo)2 + (Wo/Q)jWo + Wo2]

= k / jWo2/Q

|peak gain| = KQ / jWo2 ----------------(10)

step 2 :-

PBE = 250 rad/sec, SBE = 5000 rad /sec

Standard transform function of low pass is

H(S) = 1 / (S+1)

Comparing with transform function of second order low pass

H(S) = 1 / (S2 + (Wo/Q)S + Wo2)

As Wo(normalized) = 1 rad / sec

SBE = 5000/250 = 20 rad / sec

Step 3 :-

From equatoin (8)

$$\omega_0 = \sqrt{\frac{G2G4}{C3C5}}$$

Let C3 = C5 = 1F

And G2 = 1S

So G4 = 1

Wo / Q = 3 Db BW

Q = Wo / 3Db BW

Q = 1 / 20 = 0.05

From equation (7)

Wo/Q = [G1 + G2 + G4] / C3

20 = [G1 + G2 + G4] / C3

20 = [G1 + 1 + 1] /1

= 2 + G1

20 – 2 = G1

Hence G1 = 18

So the component values are

C3 = C5 = 1F,

R1 = 1/G1 = 1/18 = 0.05 ohms

R2 = 1 ohm

R4 = 1 ohm

Now frequency scaling :-

Kf = 250

C3 = 1/250 = 0.004F = 4000 micro F

C5 = 0.004 F = 4000 micro F

Now magnitude scaling :-

Km = 10,000

R1 = 0.05 * 10000

= 500 ohms

R2 = 10 K ohms

R4 = 10 K ohms

C3 = 4000 / 1000 = 0.4 micro F

C5 = 0.4 micro F

Hence the values calculated were as follows :-

G1 = 1.8 M ohms

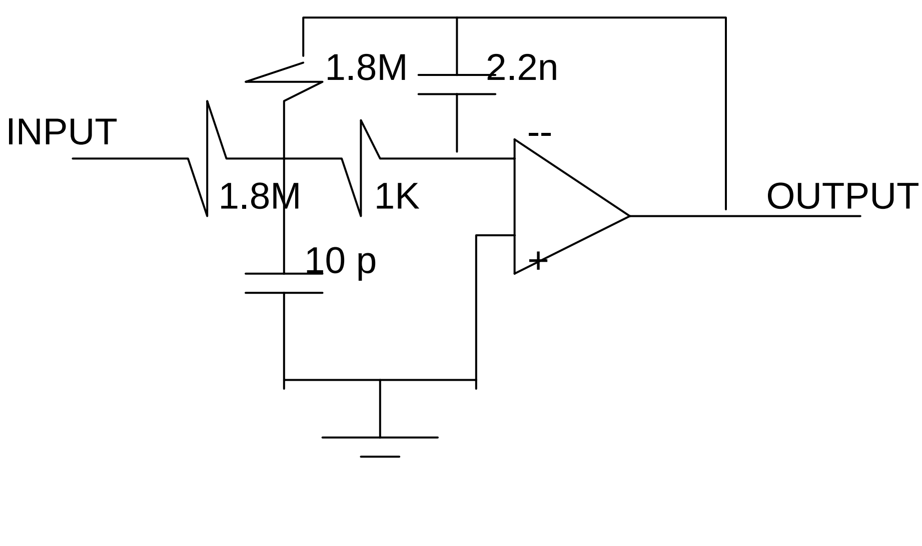
G2 = 1 k

G4 = 1.8 M ohms

SC3 = 10 p

SC5 = 2.2 n

The second order active filter was designed as shown :-



The design of active was of eighth order hence four such second order filters were cascaded to make a eight order active filter. It was designed and the output was checked on Electronic Workbench. The gain checked on Electronic Workbench of second order was not sufficient

Eighth order was designed by cascading four such second order active filters. The operational amplifier used in active filter and after passive filter was 741. The pin configuration of 741 is attached as annex A.

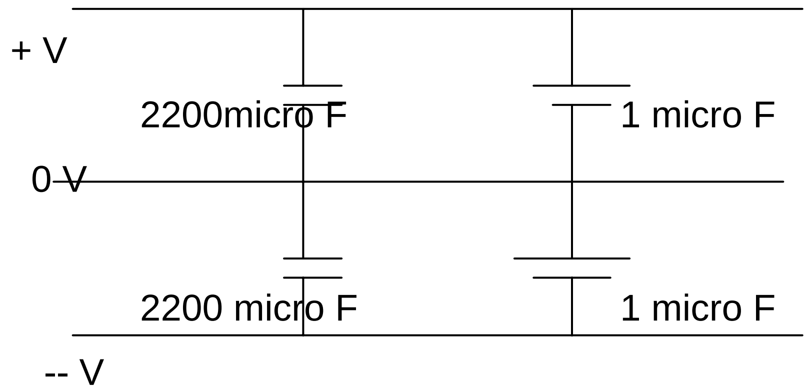
3.12 Hard Ware Implementaion:

In designing of the project specially the active filter the syndicate lacked the required information.

The first step after design, in implementation of project was simulation of the designed project. This was done on Electronic Workbench, which gave the required information and simulation. First the simulation of individual components were carried out and then complete hardware designed, was simulated. The output signal was as per requirement. Then the next step was collection of components. As mentioned earlier photo darlington transistor was to be used as photo sensor. MEL 12 was fulfilling the requirements, but its availability was a big problem.

In order to reduce noise following circuit was used:-

Grounding positive and negative supplies:



Moreover an amplifier was used to enhance the signal.

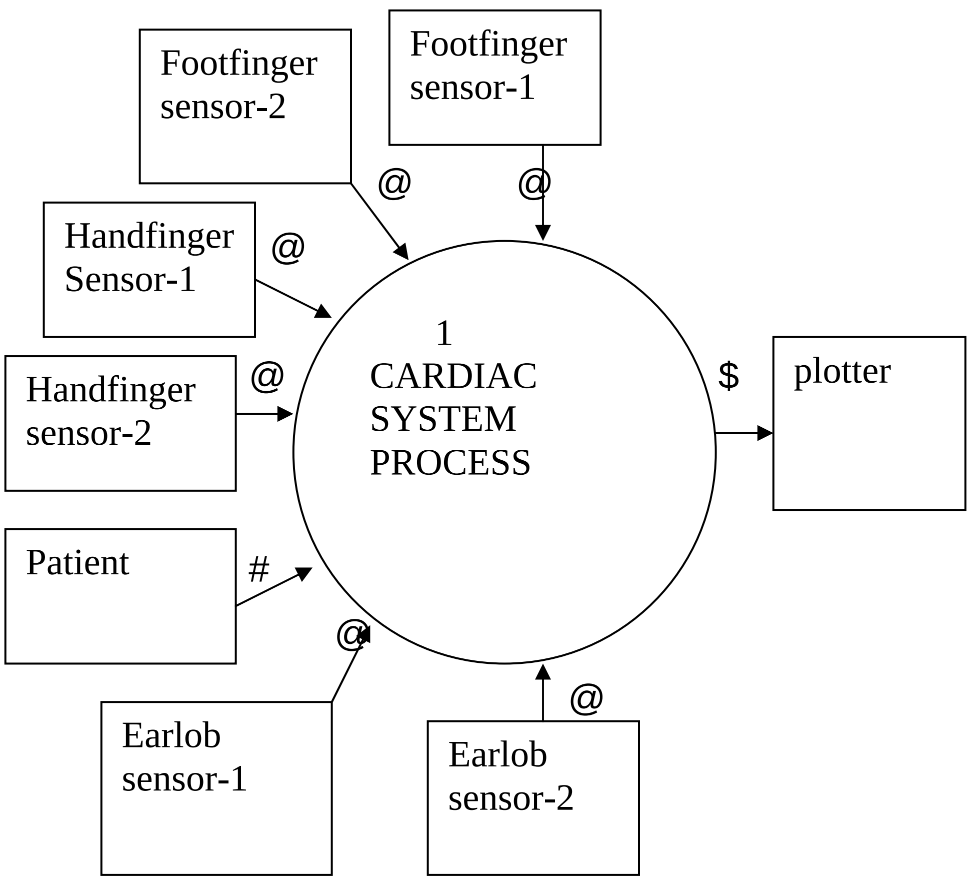
CHAPTER # 4

4. SOFTWARE ANALYSIS AND DESIGN

4.1 DATA FLOW DIAGRAMS

The DFDs are as under:-

4.1.1 LEVEL-0 DIAGRAM

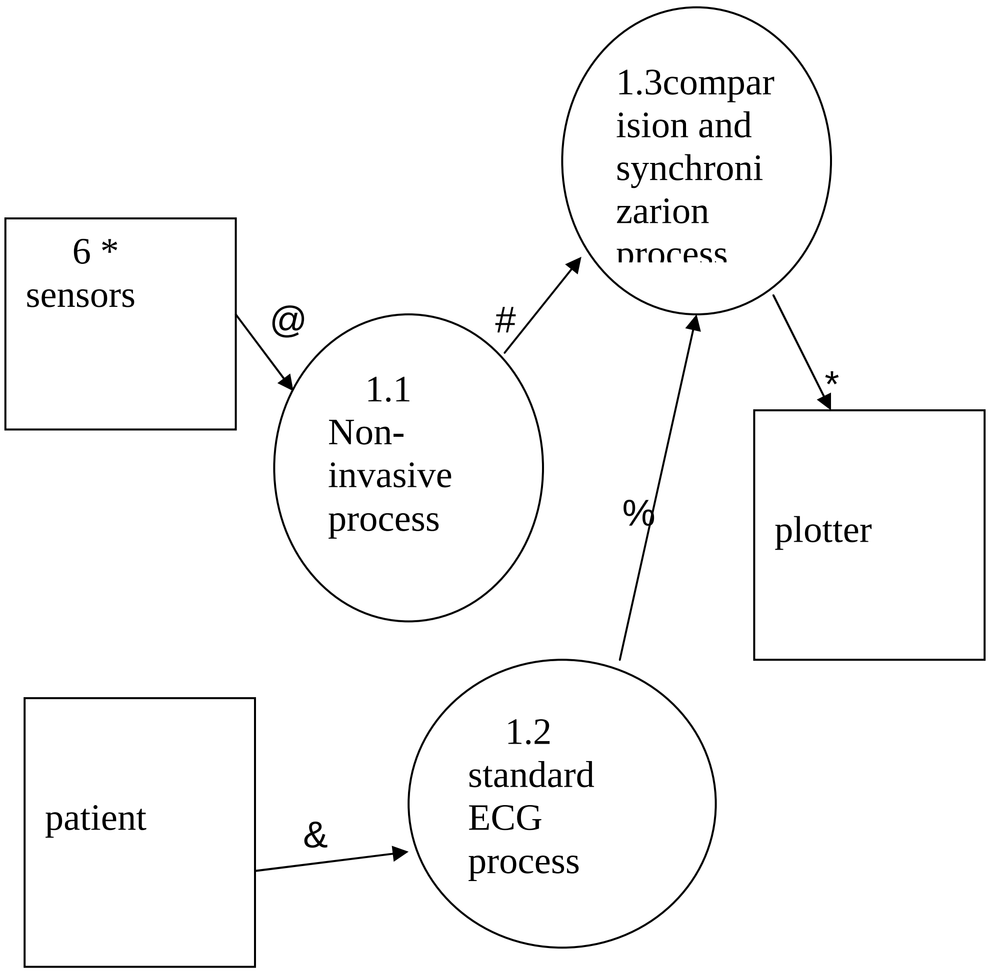


where @ = light beam ,

= ECG,

and $ = digitized signal.

4.1.2 LEVEL-1 DIAGRAM



where

@ = light beam

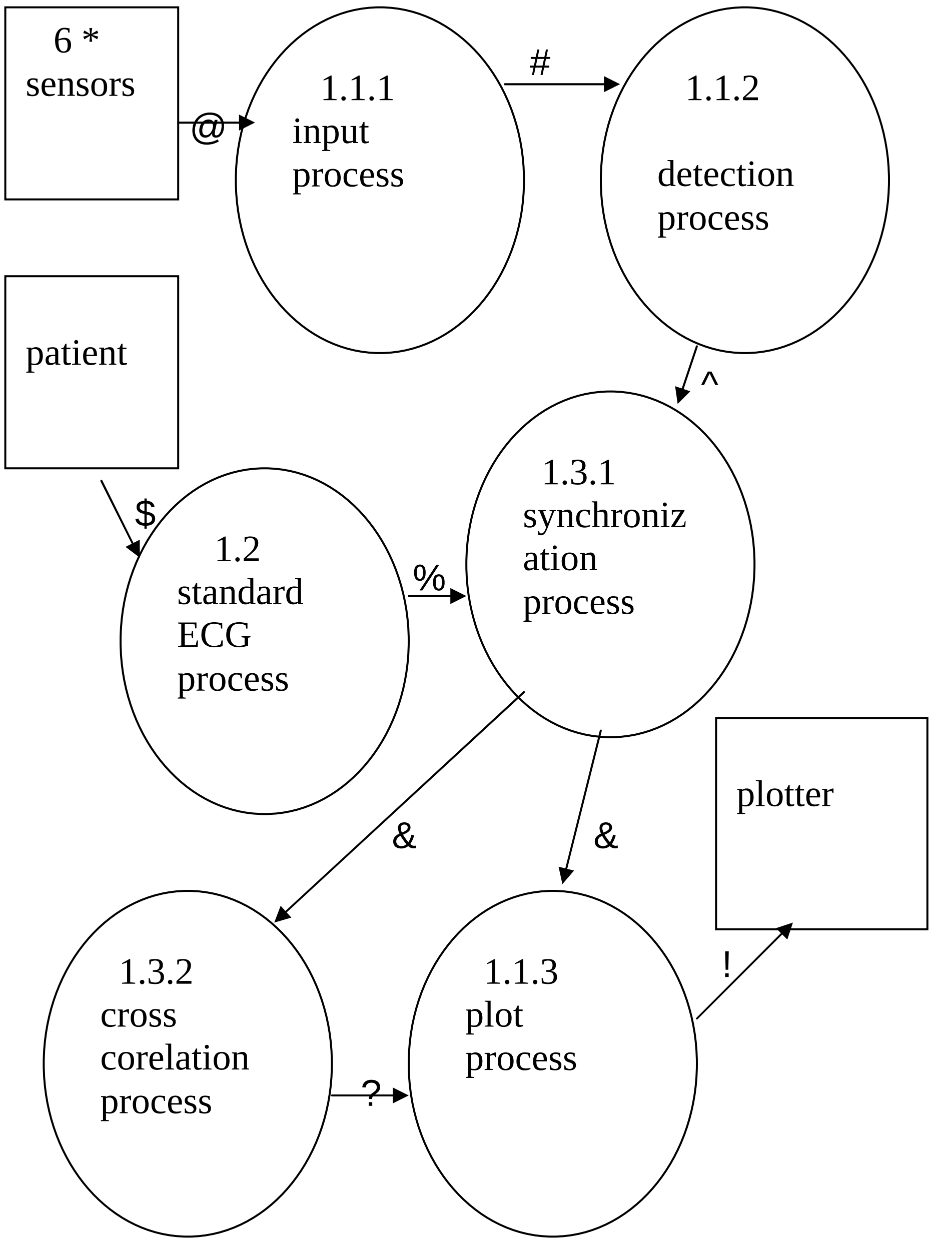
= red beam

& = ECG

% = standard signals

* = digitized signals

4.1.3 LEVLE-2 DIAGRAM



where @ = light beam

= red beam

$ = ECG

^ = emergent red beam

% = standard signals

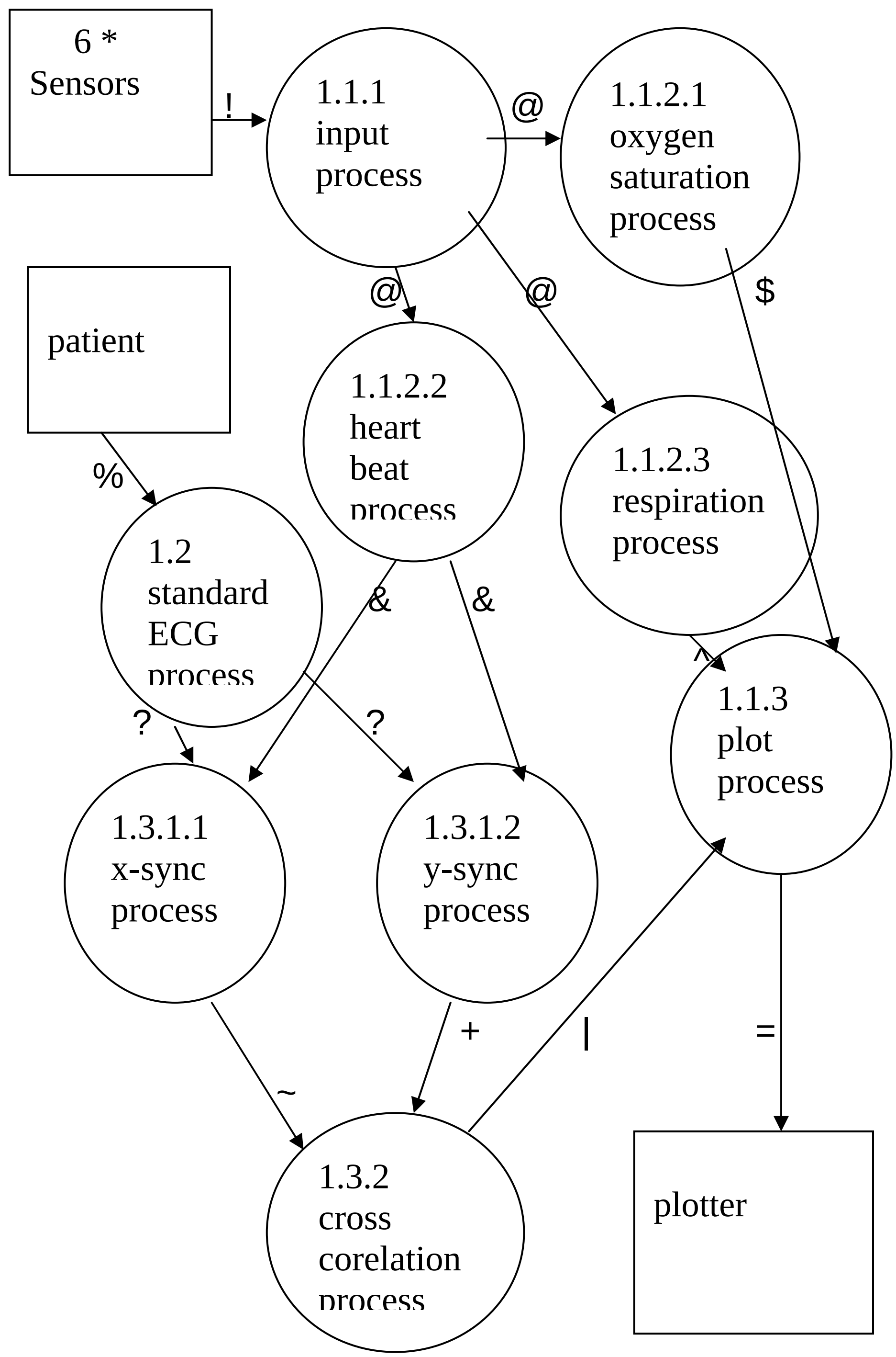
& = synchronized signals

? = compared signals

! = digitized signals

Level-3 diagram is on next page.

4.1.4 LEVEL-3 DIAGRAM



Where ! = light beam

@ = red beam

$ = oxygen saturation information

% = ECG

? = standard signals

& = emergent beam

^ = respiration information

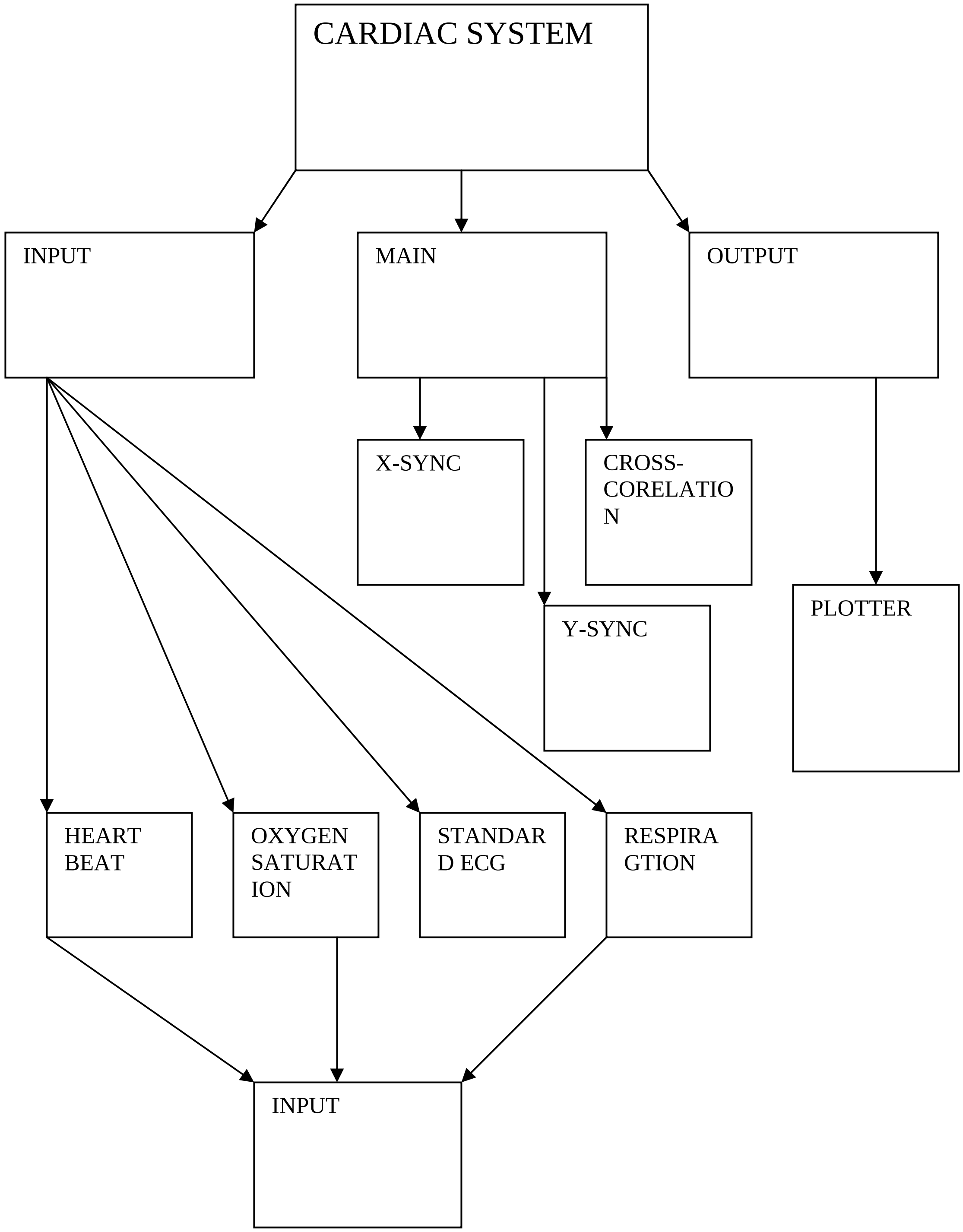
~= x-synchronized signals

+= y-synchronized signals

| = compared signals

= = digitized signals

4.2 STRUCTURE CHART



4.3 SOFTWARE IMPLEMENTATION

4.3.1 ACQUISITION, SCANNING AND STORAGE OF SIGNAL

As, already discussed in the hardware implementation part, the analog signal from the hardware was passed to the A/D converter, which converted the analog signal into a digital signal.

This digital signal from the A/D converter was scanned by the computer through a ‘C‘. program which is shown as annex A. The ‘C’ program used the inp() and outp() functions to scan the signal from the A/D converter. The scanned signal was stored in a binary file in the specified directory. This binary file contained the actual heart signal of the patient.

4.3.1 . PROCESSING OF SIGNAL IN THE COMPUTER

The signal stored in the binary file was required to to be plotted on the computer screen. For this purpose a thorough study of SIMULINK. (a component program of MATLAB) was carried out. The signal was plotted using the SIMULINK, but it was not a very refined signal, furthermore, the analysis of the signal became complicated in SIMULINK.

So, an attempt was made to plot the signal using MATLAB functions. This attempt was very successful and a refined heartbeat signal was displayed on the computer screen using the plot function of the MATLAB. The analysis of the signal was also carried out using MATLAB functions like psd, auto-corr, xcorr2 etc.

To read the signal from the binary file there was a requirement of opening the file in MATLAB. This was done using the fopen function of MATLAB. The fread function read all the binary entries in the file, which were stored in a vector(say A) using the format,

```
[A,count]=fread(fid,n)
```

After making a vector of the binary values, different MATLAB functions were called to process and analyze the signal.

4.3.3.CREATION OF GUI

It was very important to create a user friendly graphical user interface. For this purpose again MATLAB was used. The MATLAB functions of uimenu, uicontrol were very useful in creation of GUI.

The outlook of the GUI is shown in the first figure, whereas, the second figure shows the GUI when some function was called.

4.3.4 FUNCTIONS USED

A number of Matlab functions were used during the course of acquiring , processing and analyzing the signal from the hardware. Following is the list of different Matlab functions used:-

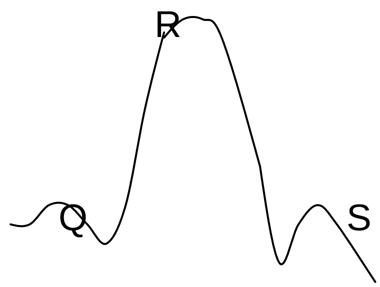
- fopen()
- fread()
- fclose()
- uimenu()
- uicontrol()
- gcf()
- plot()
- psd()
- xcorr()
- autocorr()
- selfcorr()

The output of the hardware was given to the computer parallel port via analog to digital converter.

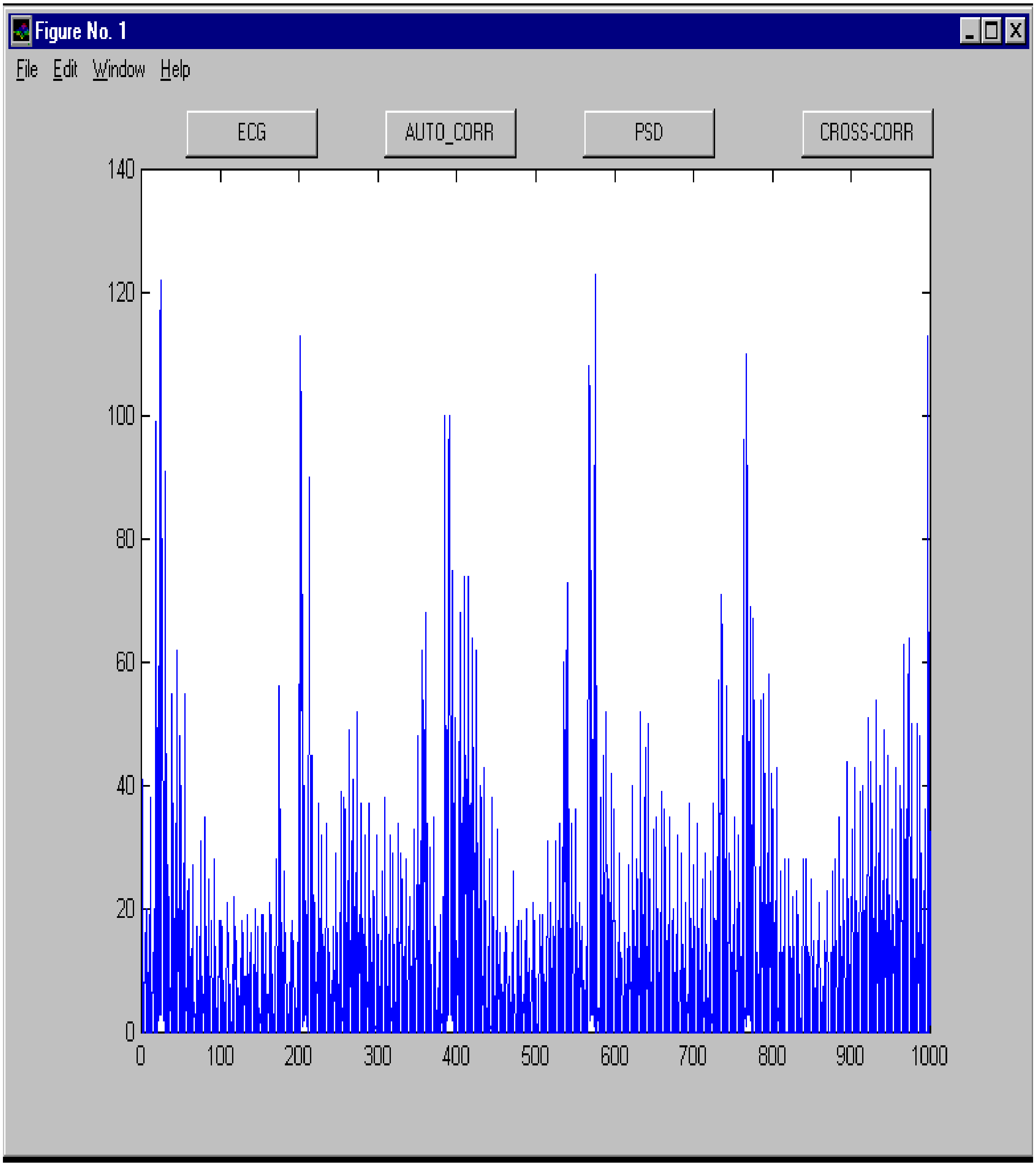
And then the acquired signal was to be processed for information by MATLAB.

The signal was to be scanned by a 'C' program. The inp (port address) and outp (portaddress) are the functions of 'C' to deal with the information at ports in form of binary signals.

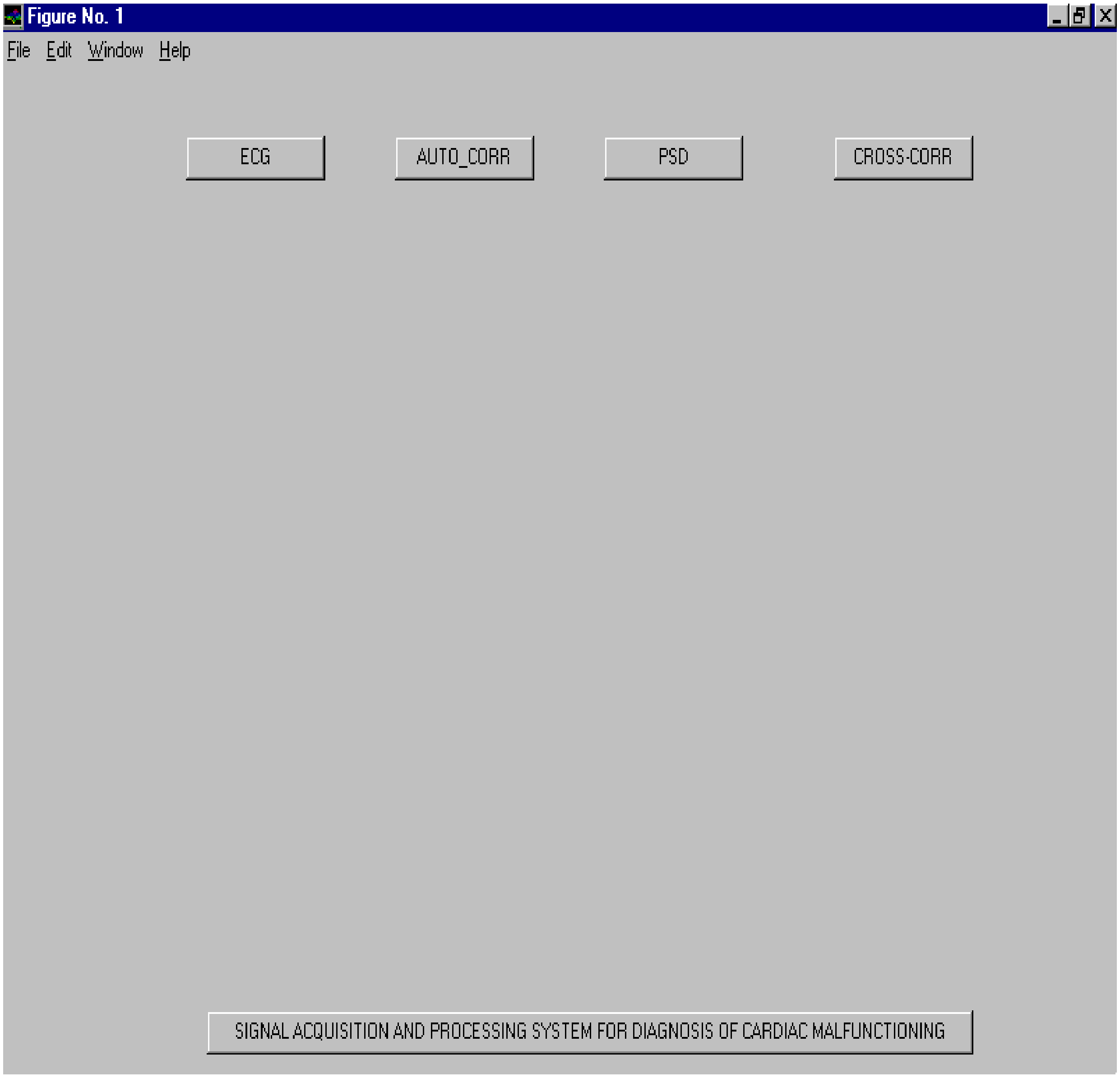
The processed signal takes the shape of QRS complex, which gives the analysit, the required information. The QRS complex is of following shape:-



The GUI outlook of the project after some function is called.



The GUI outlook of the project before some function is called.



5. CONCLUSION

The project was started with a very limited knowledge of electronics and Matlab which formed the major portion of the project. A detailed study was carried out in these subjects to cover the scope of the project. Despite these efforts the syndicate got strucked up at times, where the guidance of the supervisor was seeked. During the course of implementation, non-availability of devices like bio-medical oscilloscope and IC tester created many problems. Another major hindrance which resulted in wastage of time and efforts was non-serviceability of electronic components (741 Op-amp and 0804/0809 ADC). It was experienced that only around 15% electronic components procured from the market were serviceable. Another sore experience from the market showed that a 14 pin IC was marked as ADC 0804, where as the actual ADC 0804 is 28 pin. Many such experiences were met during the procurement of electronic components.

During the course of the project the syndicate learnt three subjects of electronics, matlab and software-hardware interfacing. The syndicate was able to acquire the signal sensed from the patient’s body tissue. This signal was further processed and analyzed by the software successfully.

There is still a room of improvement in the project. A more amplified signal is required from hardware. The front end can also be improved and more functions can be added to it to carry out further detailed analysis of the signal.

6. FUTURE PROSPECTS

In future the project can be enhanced by adding extra features in it like storing the requisite information of a healthy person, and that of the patient. A more amplified signal is required from hardware. The front end can also be improved and more functions can be added to it to carry out further detailed analysis of the signal. An accurate and reliable cardiograph machine can be made basing on this technique.

Moreover these signals can be compared at any time. The stored information could be used by other computers by taking this on the floppy disk.

7. SUMMARY:

The project was signal acquisition and processing system for diagnosis of cardiac malfunctioning. Unlike the existing electrocardiography mechanism it is cheaper and very simple to use. This project gives independent output and makes use of sophisticated signal processing. As the heart pumps oxygen into the blood, the colour of blood changes from blue to red. Light is passed through the body and then detected on the other side by the receiver. The received light indicates the intensity in change of colour , which in turn reflects heart beat.

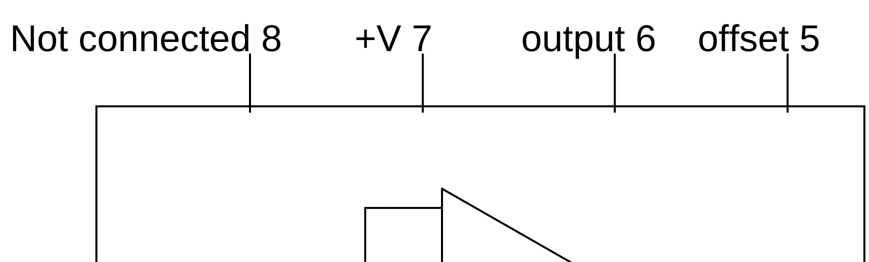
Received signal from receiver is amplified, filtered and then passed to the computer via analog to digital converter.

Broadly, project was divided into two main portions i.e. software and hardware. Hardware as mentioned earlier includes phototransistor for measuring intensity of light, then a passive filter (as signal is weak so active filter is not affordable at this stage) followed by an operational amplifier for amplification of signal. Then an active as sharp cutoff frequency is required. The project works in range of 0.05 Hz to 10 Hz as it easily covers heartbeat. The signal from this hardware was checked on oscilloscope. An analog to digital converter was required to interface with computer. The EPP (enhanced parallel port) was used for receiving the digital signal from hardware. Initially LASER light was passed through the finger and earlobes and intensity of light was checked received at phototransistor, which indirectly showed the heartbeat.

This received signal shows the intensity of heart beat on oscilloscope and later on computer's screen. On software side

MATLAB was used for processing of signal and from with in MALAB a ‘C’ code to scan the binary information from port.

<u>Annex A</u>



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--ve input +ve input

offset 1 2 3 -- V 4

Figure 741 operational amplifier.

Reference:

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