# CHAPTER 1
# INTRODUCTION

## 1.1 Background of Study

The Blood Pressure Monitoring Device with Wireless Capabilities utilizes the personal computer to monitor blood pressure. The system is interfaced to the computer through wireless. It sense these parameters and produces analog voltage level that will amplified and digitized before transmit to the computer.

An interface circuit is designed in order to convert analog voltage produced by the pressure sensor to digital data by using PIC in order to allow the data to be read. Then it will be transmit via wireless to send to the computer.

In computer part is now to configure the digital data received and display the reading measured. Then the data will be compiled and save in a simple database

## 1.2 Problem Statement

The blood pressure are known as one of the “silent killer” because usually there are no symptoms, yet it can lead to serious and even life-threatening problems if left untreated but there are ways to manage hypertension. The best way is to have your blood pressure checked by using blood pressure monitoring devices.

There were a research by other student on the device which is able to send the daily test results to other people via the Short Message Service (SMS) function. So, the project will be continued by adding another function by using wireless capabilities. The test results would be sent to the hospital or clinic for their records. This will help the doctors , where they can monitor their patient's current condition health even though the patient is living at home and not under the doctor's direct supervision in the hospital.

## 1.3 Objectives

The main objectives of this research are :

- To study on blood pressure or hypertension which lead to many type of health problem such as heart problem and stroke.
- To study and research more on the technology of SMS and wireless capabilities.
- To experiment the effectiveness of wireless capabilities in sending the patient's test result and records all the data in a database.

## 1.4 Scope of Project

The project is to design and build a portable blood pressure monitor device that can measure a user's blood pressures and heart rate through an inflatable hand cuff. The device is consisted of three main parts : external hardwares (consist of cuff, motor, and valve), analog circuit, and microcontroller. The anolog circuit converts the pressure value inside the cuff into readable and usable analog waveforms. The PIC samples the waveforms and performs A/D convertion so that further calculations can be made. In addition, the PIC also controls the operation of the devices to transmit the data from transmitter to the receiver. Then the data will be captured in the database and compiled in the computer.

It is undeniable that nowadays people are more aware of the health conditions. One of the most widely used methods to test the health conditions of an individual is to measure his/her blood pressures and heart rate. So, as ones of those who are concerned about their health, decided to work on this subject matter because i would like to build something that is useful and useable in real life.

# CHAPTER 2
# LITERATURE REVIEW / THEORY

## 2.1 Blood Pressure Monitoring

Blood is carried from the heart to all parts of the body in vessels called arteries. Each time the heart beats (about 60-70 times a minute at rest), it pumps out blood into the arteries. Force of the blood pushing against the walls of the arteries has produce the blood pressure. [1]

The researcher has found that blood pressure in a population follows a Gaussian (bell shaped) distribution. Consequently, blood pressure readings falling beyond a certain portion of the curve, for example beyond the 95th percentile of the curve, are considered high. There is no clear threshold after which increased morbidity and mortality rises with increasing BP in a continuous graded curve.

When the blood pressure is at its highest when the heart beats, pumping the blood. It is called systolic pressure. After a while the heart is at rest, between beats, your blood pressure falls. This is the diastolic pressure. While blood pressure can change from minute to minute with changes in posture, exercise, stress or sleep, it should normally be less than 120/80 mm Hg (less than 120 systolic and less than 80 diastolic) for an adult age 20 or over.

In most observational studies the risk curve increases somehow more over that level, therefore a diastolic blood pressure (DBP) of 90 mm Hg and Systolic blood pressure (SBP) of 140 mm Hg are chosen as the threshold for hypertension. Table 1 below show the definitions and classification of blood pressure levels (WHO/ISH) [2]

Table 1: Definitions and Classification of Blood Pressure Levels (WHO/ISH)

| **CATEGORY** | **SYSTOLIC (MM HG)** | **DIASTOLIC (MM HG)** |
|---|---|---|
| Optimal | < 120 | < 80 |
| **Normal** | **<130** | **<85** |
| High Normal | 130-139 | 85-89 |
| Grade 1 Hypertension (Mild) | 140-159 | 90-99 |
| Subgroup: Borderline | 140-149 | 90-94 |
| Grade 2 Hypertension (Moderate) | 160-179 | ≥ 110 |
| Grade 3 Hypertension (Severe) | ≥ 180 | |
| Isolated Systolic Hypertension | ≥ 140 | < 90 |
| Subgroup : Borderline | 140-149 | < 90 |

### 2.1.1 How To Measure Blood Pressure

Blood pressure should be measured correctly. It can be measured directly or indirectly. There are four common devices used for the indirect measurement of blood pressure namely :

- mercury column sphygmomanometer
- aneroid sphygmomanometer
- electronic devices
- automated ambulatory BP devices

The simplest way to measure the blood pressure is auscultatory method by using mercury column sphygmomanometer device. As shown in the figure 1, make sure to place the round end of the stethoscope 'under' the blood pressure cuff and inflate the sphygmomanometer (blood pressure cuff) to a little above 180 mm Hg. This collapses the major arteries to the arm which will make the patient feel uncomfortable. Then you release the air slowly by gently turning the air valve, and watch the pressure drop.

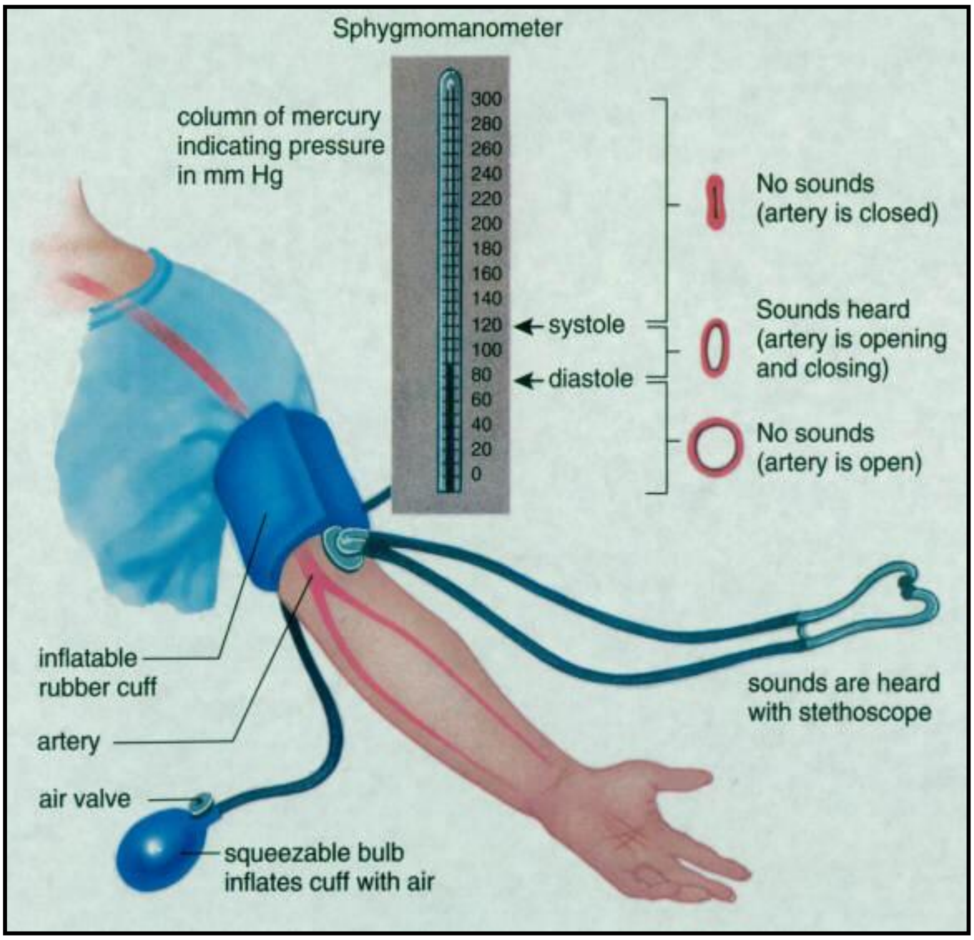


Figure 1 : Measure Blood Pressure [4]

When you first hear a sound, that will be the Systolic blood pressure. The sound you hear is the blood now flowing in the artery of the arm. This means that the systolic pressure is now greater than the pressure in the blood pressure cuff. As you continue to watch the pressure drop, when you no longer hear any sounds, that willbe the Diastolic blood pressure. Figure 2 below show the behavior of artery during the measurement process.[3]

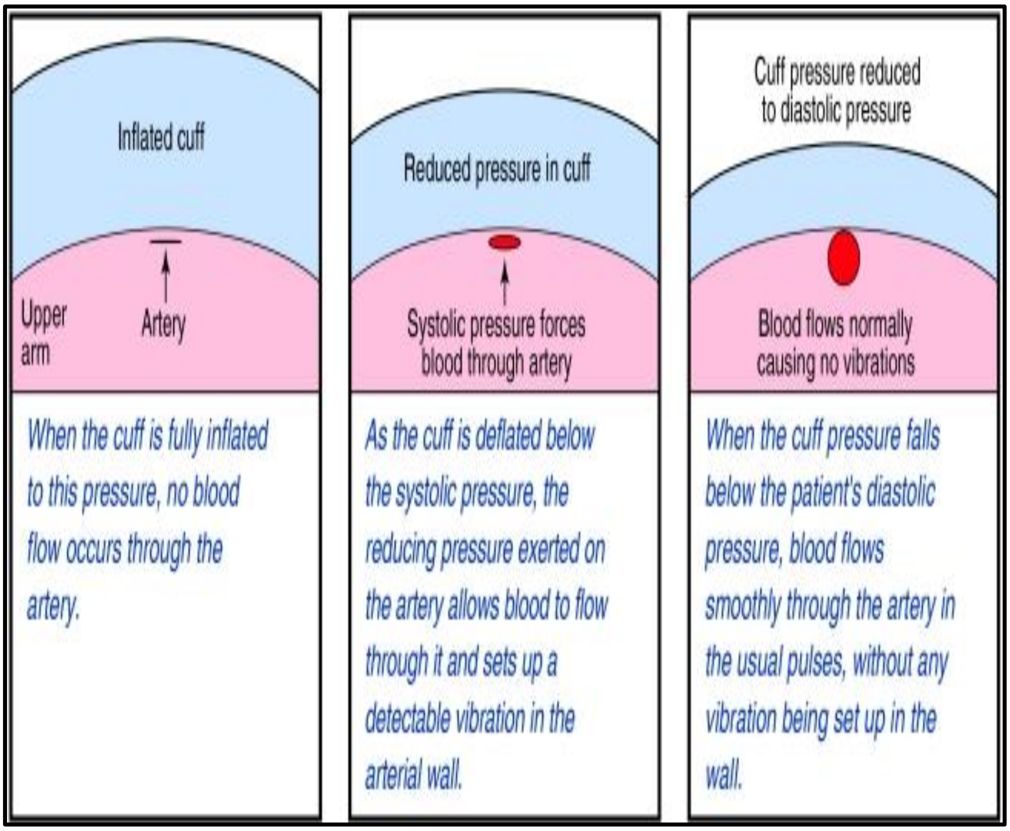


Figure 2 : Artery during measurement process [5]

### 2.1.2 Blood Pressure Monitoring Devices

There various type of blood pressure monitoring device. Nowdays, the modern technology has allowed the devices used to measure blood pressure to become more sophisticated. Table 2 below are the list from the old until the latest inovation of blood pressure monitoring device [6] :

Table 2 : List of Blood Pressure Monitoring Devices

| | |
|---|---|
| Mercury Sphygmomanometer  | • Includes a mercury manometer, an upper arm cuff, a hand inflation bulb with a pressure control valve<br>• Requires the use of a stethoscope to listen to the Korotkoff sounds. Relies on the ausculatory technique. |
| Aneroid  Sphygmomanometer | • An aneroid gauge replaces the mercury manometer. The aneroid gauge can be desk mounted or attached to the hand bulb. Again relies on the ausculatory technique. |
| Automated device  | • An electronic monitor and electrically driven pump raises the pressure in the cuff.<br>• The device automatically inflates and deflates the cuff and displays the systolic and diastolic values.<br>• Devices may also have a memory facility that stores the last measurement or up to 10 or more previous readings. Is battery powered and uses the ocillometric |

| | |
|---|---|
| Wrist device<br><br> | • The device itself attached to the wrist.<br>• Battery powered and uses the oscillometric technique. |
| Finger device<br> | • The device itself attached to the finger.<br>• Battery powered in general, and uses the oscillometric, pulse-wave or plethysmographic methods. |
| Automatic Non-Invasive Blood Pressure (NIBP) Monitor<br> | • With the addition of an automatic-cycling facility to record to the patient's blood pressure at set time intervals. There may also be an option to measure temperature. Alarm limits can usually be set to alert nursing staff when or more patient functions have exceeded limits.<br>• Battery powered, uses the oscillometric technique. |
| Ambulatory BloodPressure Monitor<br> | • The unit is programmed to record the patient's blood pressure over a 24-hour period during normal activities and stores the data for future analysis.<br>• Battery powered, and uses ausculatory and oscillometric techniques. |

### 2.2 PC – Based Data Acquisition for Blood Pressure Monitoring

#### 2.2.1 End to End Data Acquisition (DAQ)

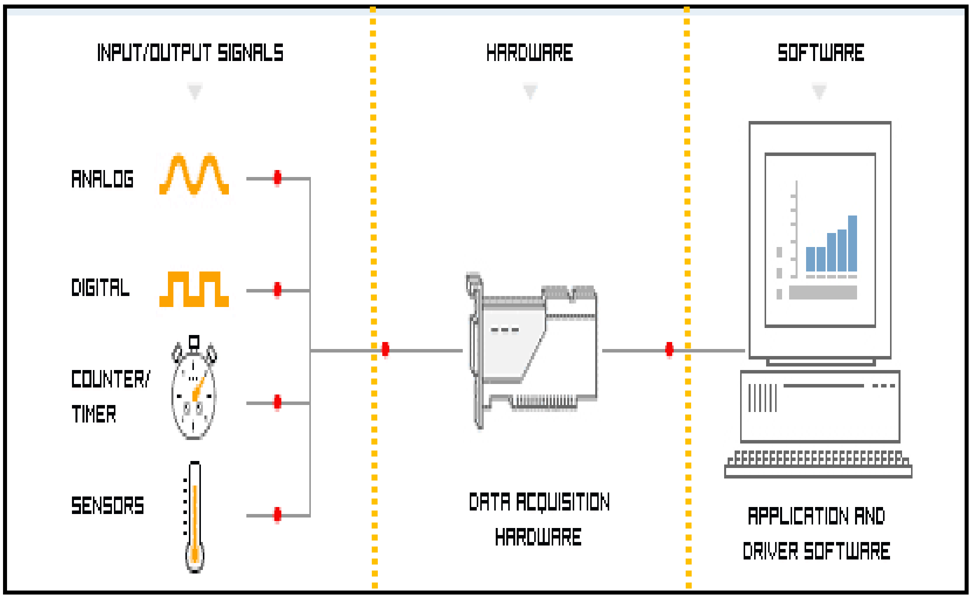


Figure 3 : PC – Based Data Acquisition for Blood Pressure Monitoring

Based on figure 3 above, the purpose of using PC – based data acquisition is to measure an electrical or physical phenomenon such as voltage, current, temperature, pressure, or sound. PC-based data acquisition uses a combination of modular hardware, application software, and a computer to take measurements. While each data acquisition system is defined by its application requirements, every system shares a common goal of acquiring, analyzing, and presenting information.

Data acquisition (DAQ) systems come in many different PC technology forms for great flexibility when choosing your system. Scientists and engineers can choose from PCI, PXI, PCI Express, PXI Express, PCMCIA, USB, Wireless and Ethernet data acquisition for test, measurement, and automation applications.

There are five components to be considered when building a basic DAQ system [7] :

i. Transducers and sensors - device that converts a physical phenomenon into a measurable electrical signal, such as voltage or current. The ability of a DAQ system to measure different phenomena depends on the transducers to convert the physical phenomena into signals measurable by the DAQ hardware.

ii. Signals - The appropriate transducers convert physical phenomena into measurable signals. However, different signals need to be measured in different ways.Signals can be categorized into two groups:

- Analog
- Digital

iii. Signal conditioning - Sometimes transducers generate signals too difficult or too dangerous to measure directly with a DAQ device. Signal conditioning maximizes the accuracy of a system, allows sensors to operate properly, and guarantees safety. Signal conditioning accessories can be used in a variety of applications including:

- Amplification
- Attenuation
- IsolationBridge completion
- Simultaneous sampling
- Sensor excitation
- Multiplexing

iv. DAQ hardware - DAQ hardware acts as the interface between the computer and the outside world. It primarily functions as a device that digitizes incoming analog signals so that the computer can interpret them. Other data acquisition functionality includes:

- Analog Input/Output
- Digital Input/Output
- Counter/Timers
- Multifunction

v. Driver and application software - Software transforms the PC and the DAQ hardware into a complete data acquisition, analysis, and presentation tool. Without software to control or drive the hardware, the DAQ device will not work properly .

### 2.2.2 PC Based Data using LabVIEW VI's

LabVIEW is a graphical programming environment used by millions of engineers and scientists to develop sophisticated measurement, test, and control systems using intuitive graphical icons and wires that resemble a flowchart. LabVIEW offers unrivaled integration with thousands of hardware devices and provides hundreds of built-in libraries for advanced analysis and data visualization [8]

In LabVIEW, it is programmed on the basis of block diagrams and front panel elements. These elements are connected by means of a wiring tool. The main application areas are data acquisition, system management and the simulation of a digital signal processing system. In cases where real input/output connections are required, IEC, VXI and MXI compatible equipment with serial links or plug-in boards for the PC can be accessed via available drivers. After having tested a virtual instrument, the graphical language built from an application, compiles standalone executable code.

The complied code is executed with a speed comparable to normal compiled C-programs. The execution code may also contain communication calls for different types of supported platforms. A test executive, available in diagram source code, can be added in order to support tests and modifications at runtime. Also, the LABVIEW provides an easy-to-use graphical environment that permits the system operators to process easily the collected data, using complex data-processing algorithms, without detailed knowledge of the data-acquisition system design.

### 2.3 Communication

Communication is the process of establishing connection between two point for information exchange.The communication are based on[9]:

- Sender or Transmitter : To sends any information
- Receiver : Receive any information from transmitter
- Communication Channel : The path for signal to propagate (as shown in figure 4 below )

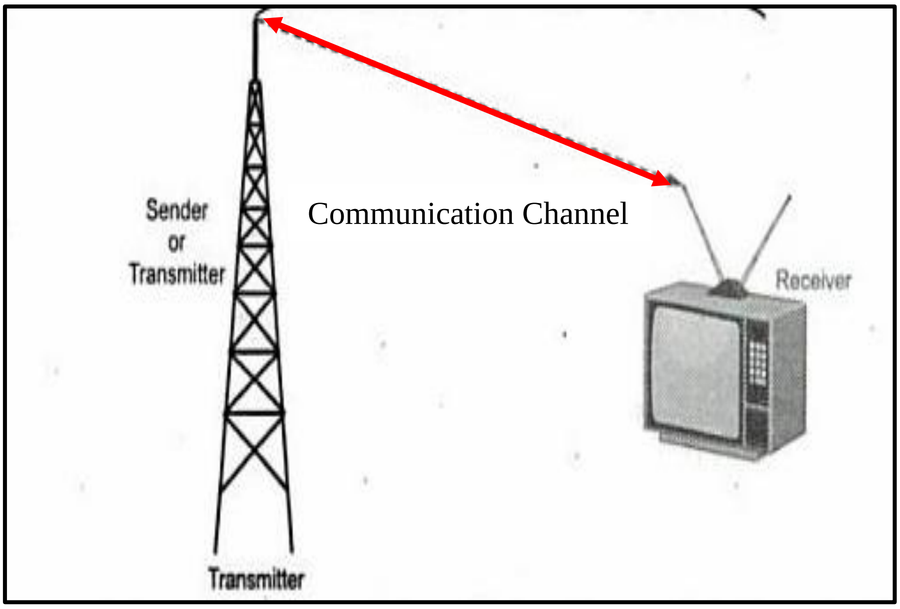


Figure 4 : Communication Channel

### 2.3.1 Radio Frequency

Radio frequency is an electromagnetic wave propagated by an antenna. Radio waves have different frequencies, and by tuning a radio receiver to a specific frequency. They are above human hearing and extend into microwave spectrum up to infrared region. It is around 10000 Hz to many gigahertz.Figure 5 below are the frequency wavelength. [10]

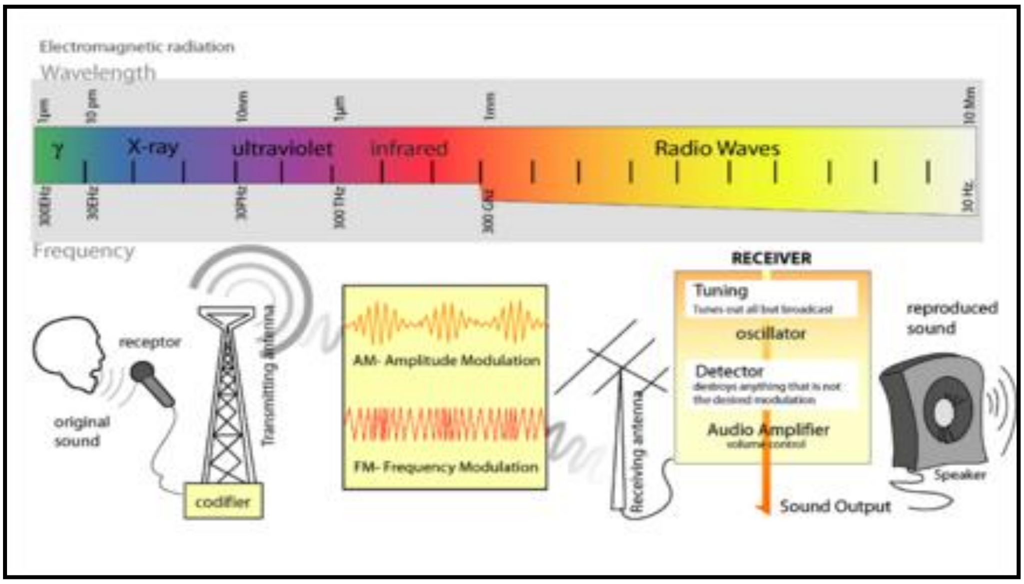


Figure 5 : Frequency Wavelength

2.3.1.1 RF Transmitter

A transmitter is an electronic device which with the aid of an antenna propagates an electromagnetic signal such as radio, television, telecommunications, etc. A transmitter usually has a power supply, an oscillator, a modulator and audio, IF (intermediate frequency) and RF (radio frequency) amplifiers. Sometimes a device, for example, a cell phone contains both a transmitter and a radio receiver or transceiver. The modulator is the device which piggybacks (or modulates) the signal information [11]

2.3.1.2 RF Receiver

A radio receiver is an electronic device that takes a transmitted signal, extracts the original signal from it and amplifies that signal. The process of extracting the signal is called demodulation. A radio station, for example, will broadcast a signal which is then detected by a radio receiver. The receiver, in turn, will separate that signal from many others and then play it through its speakers. There are several different types of signals that the receiver can be designed to demodulate and decode including sounds, pictures and digital data, to name a few.[12]

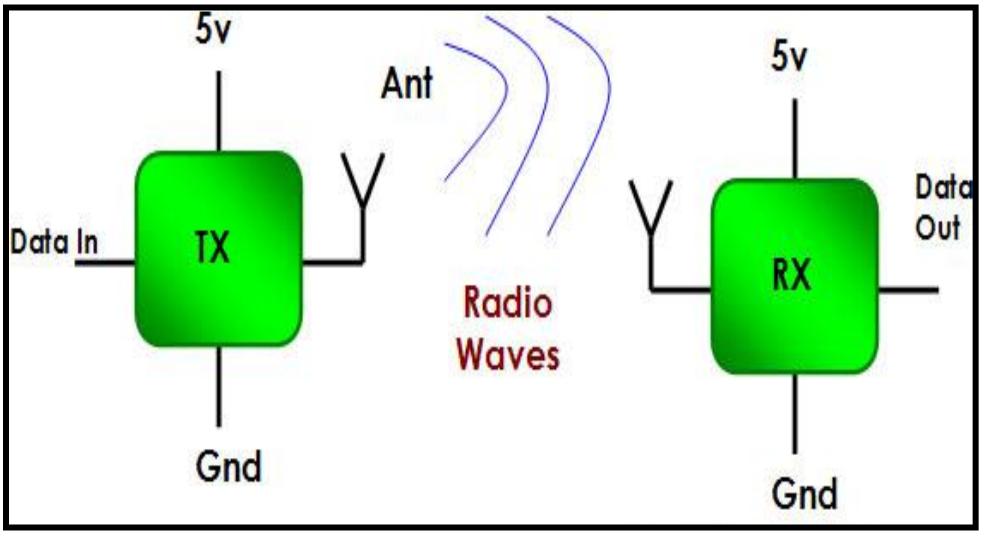


Figure 6 : How RF Transmitter and Receiver Work

# CHAPTER 3

# METHODOLOGY / PROJECT WORK

## 3.1 Flow Chart

Figure 7 below show the flow chart of the project

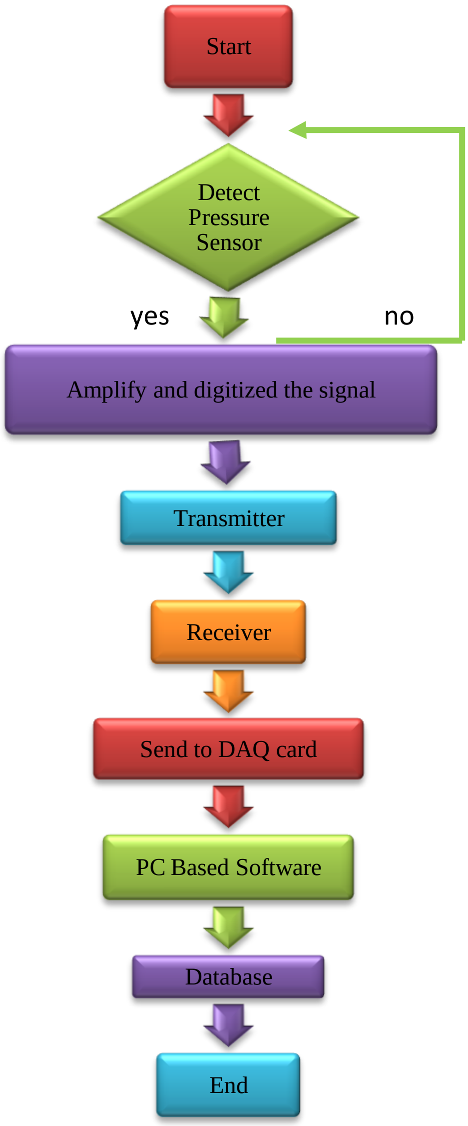


Figure 7: Flow Chart

**3.2** Procedure Identification

The "Blood Pressure Sensor with Wireless Capabilities" system is divided into several modules in order to simplify the order of the system development work. Figure 7 shows the block diagram of the project divided into 4 modules :

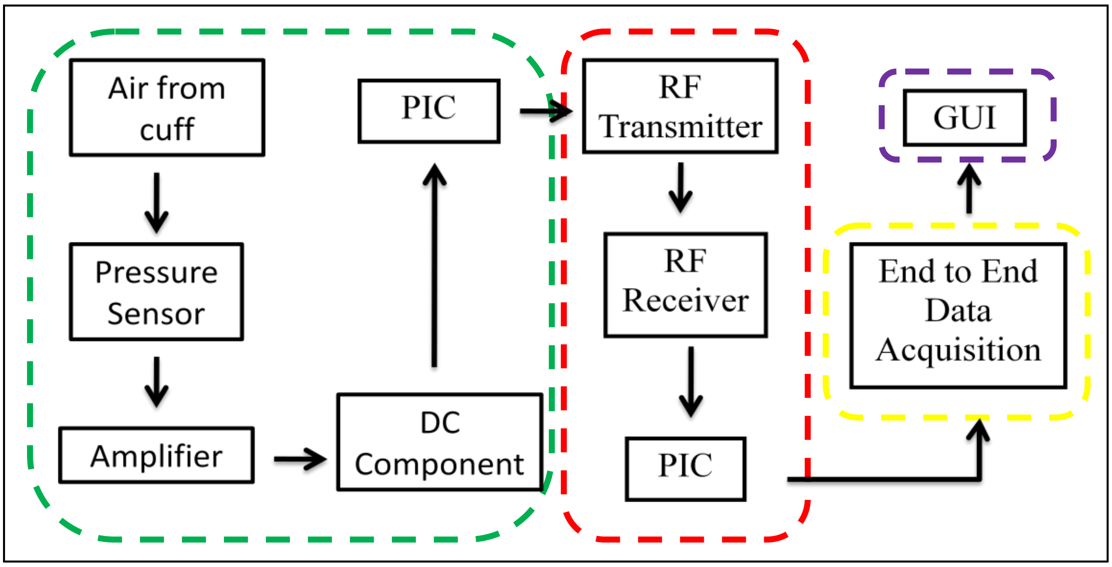


Figure 8 : System Configuration

1. Blood Pressure Sensor Module :

   Main hardware consist with inflatable cuff, rubber bulb, pressure sensor and instrumentation amplifier.

2. Transmitter and Receiver Module :

   Transferring analog data to digital data from blood pressure sensor to the receiver using wireless.

3. End to End Data Acquisition (DAQ) :

   Medium to connect between the hardware and software

4. Graphical User Interface Module :
   Consists of ADQ card interface and the programming language where the readings that have been obtained from the receiver will be displayed on the monitor

### 3.2.1 Blood Pressure Sensor Module

#### 3.2.1.1 Inflatable Cuff

The inflatable cuff is placed around the upper arm, around the height of heart while the second tube is attached to the pressure sensor.It used to restrict the blood flow for blood pressure measurement. The cuff is filled with the air until the artery is completely occluded then slowly released from the cuff through the valve on the rubber bulb.

It is extremely important to make sure patient are using the correct size of blood pressure cuff. If they do not use the correct-sized cuff, they will be basing your medical diagnosis and treatment plan on INVALID DATA. It is *essential* that this number be accurate. [13]

Below is few steps on how to know what size cuff to use :

1. Find out the arm size : measure around the middle of the upper part of arm, at the midpoint. Compare results to the table 3 found below.

Table 3 - Inches and Centimeter Conversion Chart

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **inches** | 11.4" | 12.2" | 13" | 13.7" | 15.7" | 16" | 17" | 17.3" | 17.7" |
| **centimeters** | 29 | 31 | 33 | 35 | 40 | 41 | 43 | 44 | 45 |

2. Discover whether you really need a larger cuff : the most common rule of thumb is that if the arm circumference is greater than 13 inches (33 cm) or so, a larger cuff size is definitely needed. Although most large people will be served by an "Adult Large" cuff, some will need an even bigger cuff.

3. Figure Out Which Cuff Size Needed : There are several sizes of large cuffs available, depending on the circumference of your arm:

   - Adult 'Standard' or 'Regular' Cuff - fits most average-sized people
   - Large Adult Cuff - fits most plus-sized people
   - Adult 'Thigh' Cuff - fits most supersized people or mid-sized people with heavy arms

   The measurements for each cuff are shown in Table 4 below.

Table 4 : Cuff Size Guidelines

| **Cuff** | **Arm Circumference Range at Midpoint (cm)** | **Arm Circumference Range at Midpoint (inches)** |
|---|---|---|
| Adult | 27-34 cm | up to 13.38 inches |
| Large Adult | 35-44 cm | 13.7 inches to 17.3 inches |
| Adult thigh Cuff | 45-52 cm | 17.7 inches to 20.4 inches |

3.2.1.2 Pressure Sensor

The MPX2050 series device is a silicon piezoresistive pressure sensor providing a highly accurate and linear voltage output - directly proportional to the applied pressure. The sensor is a single, monolithic silicon diaphragm with the strain gauge and a thin–film resistor network integrated on–chip. The chip is laser trimmed for precise span and offset calibration and temperature compensation. Figure 9 and 10 below show the dimension and schematics of MPX 2050.

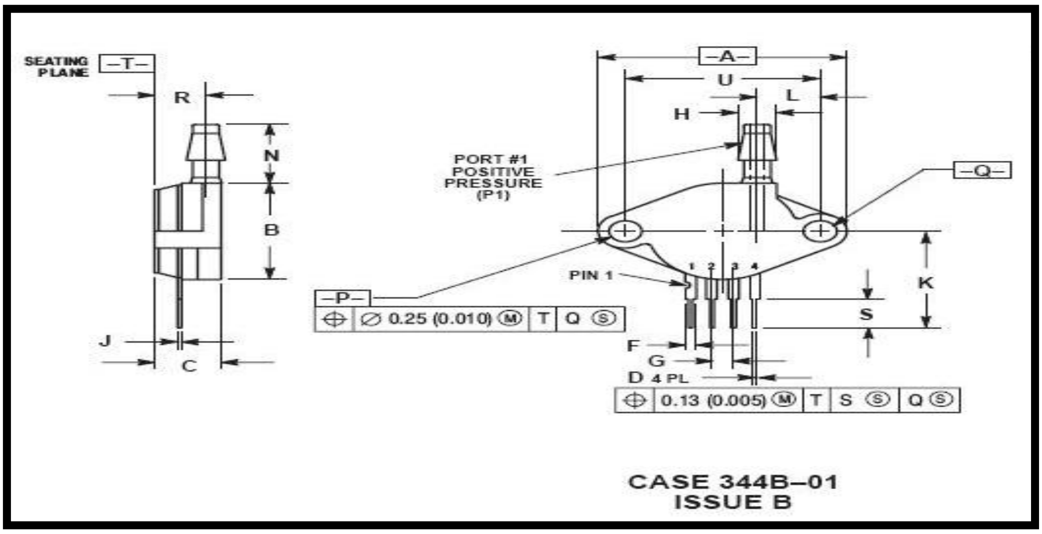


Figure 9 : Motorola MPX2050 Pressure Sensor Dimension [14]

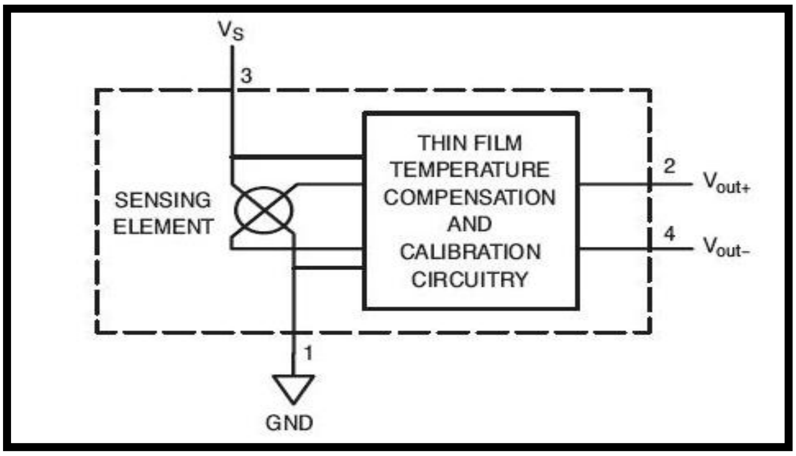


Figure 10 : Motorola MPX2050 Schematics [14]

### 3.2.2 Transmitter and Receiver Module

Low Cost and Robust Design make these hybrid modules be suitable for a Easy Link of Wireless applications. The typical range is 500ft for open area. There are 433.92 Mhz, 418 Mhz and 315 Mhz (which is use in this project) available.

#### 3.2.2.1 Transmitter

This ASK transmitter module as shown in figure 11 consist with an output of up to 8mW depending on power supply voltage. The TLP transmitter is based on SAW resonator and accepts both linear and digital inputs, can operate from 2 to 12 Volts-DC, and makes building RF enabled products very easy.

Figure 11 :Transmitter

#### 3.2.2.2 Receiver

The receiver in figure 12 has a sensitivity of 3uV. It operates from 4.5 to 5.5 volts-DC and has both linear and digital outputs. The typical sensitivity is -103db and the typical current consumption is 3.5mA for 5V operation voltage.

Figure 12 : Receiver

### 3.2.3 End to End Data Acquisition (DAQ)

Data acquisition and control systems need to get real-world signals into the computer. These signals come from a diverse range of instruments and sensors, and each type of signal needs special consideration. It is the most suitable interface to get the measurements of voltage signals.

The pressure sensor will produce the voltage signals while the data acquisition hardware will condition the signal (amplify it or filter it for instance) and then convert it to a digital number using an analogue-to-digital converter. This digital value is then stored or processed by the computer.

Data acquisition systems are usually capable of directly handling low-voltage inputs. By low-voltage,it mean from a few millivolts up to a few volts. There are 3 major aspects of your voltage signal that will be need to consider which are :

i. Amplitude: The signal is smaller which is 40millivolts.So,need to amplify it. If it is larger than the maximum range of the analogue input hardware ( typically ±10 V), need to divide the signal down using a resistor network.

ii. Frequency: Need to decide the highest frequency want to record. This is because the higher frequencies may be present as noise However,it can remove by filtering the signal before digitising it.The highest frequency component of the signal determines how often should sample the input (at least twice the highest component). To plot the signal showing the high frequency components,it need 10 to 20 points in a cycle to get a reasonable picture of a sinusoid. For slower changing, essentially

DC signals,only consider the minimum time for a significant change in the signal.

iii. Duration: Determines the duration for recording the data needed so that the storage required are enough, which may be in computer memory or on disk. The format of the stored data also affects the amount of storage space required. Data stored in ASCII format, for example, takes more space than data stored in binary format.

### 3.2.4 Graphical User Interface Module

The graphical user interface part is the main system which will be used to control the blood pressure sensor. It will displayed the Systolic and Diastolic blood pressure values as well as the pulse rate on the monitor for easy viewing and database compilation. For this project, LabVIEW will be used as an option for ideal database system programming.

## 3.3 Tools and Equipments Used

### 3.3.1 Hardware and Software

Table 5 : Hardware and Software

| Hardware | Software |
| --- | --- |
| Transmitter (315 MHz) | LabVIEW VI's |
| Receiver (315 MHz) | Pspice Student Version |
| Pressure Sensor Motorola MPX 2050GP | MPLab ver 8.0 |
| | Microsoft Office 2007 |

### 3.3.2 Cost

The Table 6 and 7 below show the cost on material and components needed for the project

Table 6 : Direct Cost for the Project

| No. | Item | Quantity | Price (RM) | Total Price (RM) |
|---|---|---|---|---|
| 1. | Pressure Sensor MPX2050GP | 1 | 35.00 | 35.00 |
| 2. | 315Mhz RF Transmitter and Receiver | 1 | 40.00 | 40.00 |
| 3. | MAX232 | 1 | 3.50 | 3.50 |
| 4. | PIC16F87 | 2 | 35.00 | 70.00 |
| 5. | Motor 5V | 1 | 5.00 | 5.00 |
| 6. | AD620 | 1 | 27.00 | 27.00 |
| 7. | OP2277 | 2 | 3.00 | 6.00 |
| 8. | DB9 USB Cable | 1 | 20.00 | 20.00 |
| 9. | Inflatable Cuff | 1 | 25.00 | 25.00 |
| 10. | Valve | 1 | 20.00 | 20.00 |
| | TOTAL | | | 251.50 |

Table 7 : Indirect Cost for the Project

| No. | Tools and Equipment | Cost (RM) |
|---|---|---|
| 1 | PC | 1500.00 |
| 2 | Labview Software | 200.00 |
| 2 | Resistor | 5.80 |
| 3. | Transistor | 7.50 |
| | Total | 1713.30 |

# CHAPTER 4
# RESULTS / DISCUSSION

## 4.1 Circuit Design

### 4.1.1 Blood Pressure Sensor and Transmitter Schematic

In figure 13 below are shown the schematics of blood pressure sensor and transmitter using Pspice software

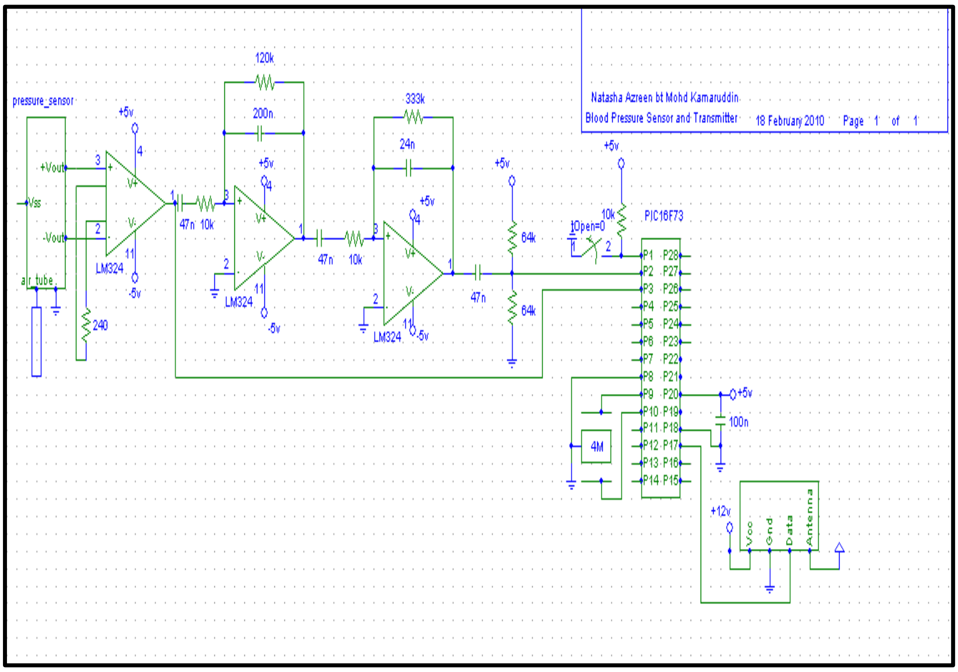


Figure 13: Blood Pressure Sensor and Transmitter Schematics

### 4.1.2 Receiver Module

For the schematics of receiver part is shown in figure 14.

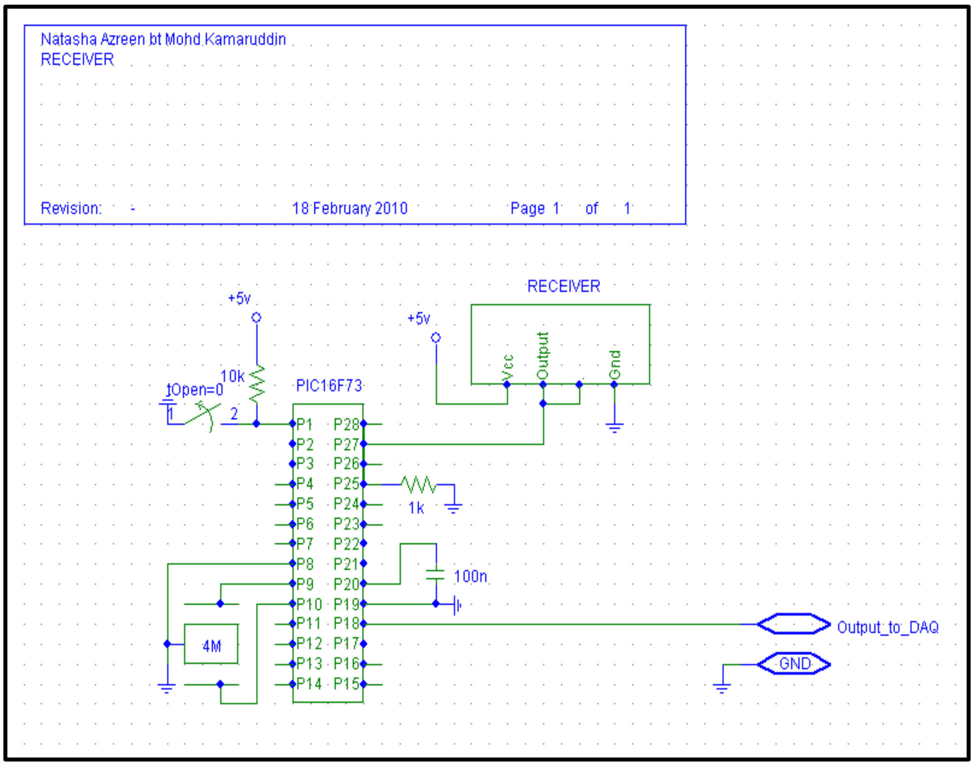


Figure 14 : Receiver Schematics

## 4.2 Circuit Module

Figure 15 and 16 below show blood pressure sensor with inflattable cuff, transmitter and receiver circuit

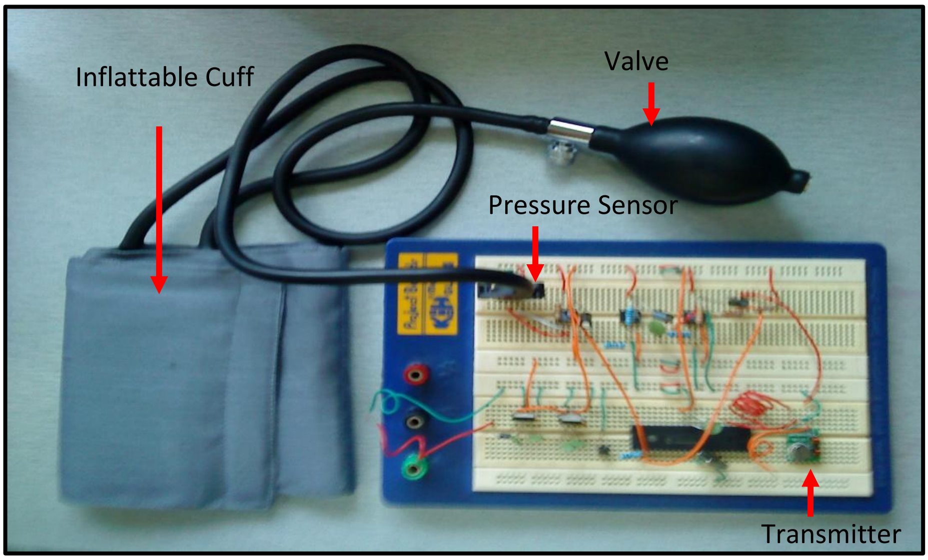


Figure 15 : Pressure Sensor with Transmitter Part

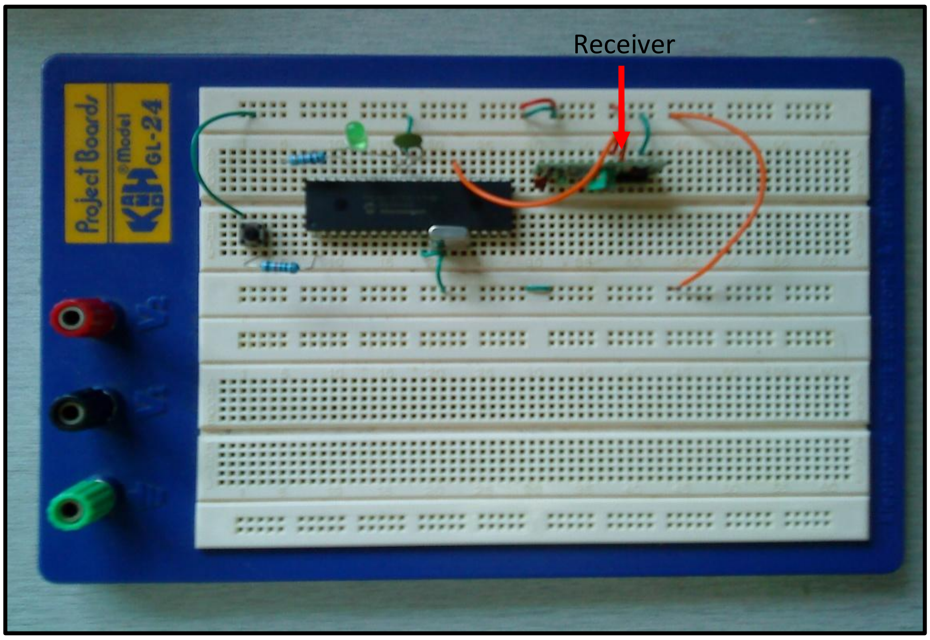


Figure 16 : Receiver Part

### 4.3 DC Amplifier

Since the output voltage of the pressure transducer is very small, we have to amplify the signal for further processing. We use the instrumentation amplifier AD620 from Analog Devices. The resistor R G is used to determine the gain of the amplifier according to the equation .

$$R_G = \frac{49.4k\Omega}{G-1}$$

Since we need the gain of approximately 200, we choose the resistor R G to be 240 ohms. This will give us the gain of 206 according to the equation. However, we have measured the gain from the finished circuit, and the measured gain is 213. The schematic of the amplifier is shown in figure 17.

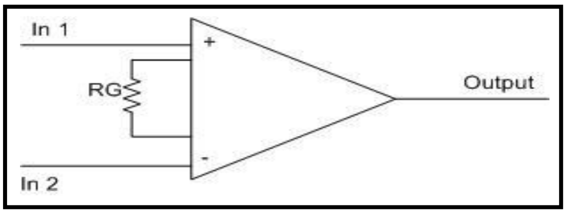


Figure 17: Schematic of DC amplifier

### 4.4 Band-pass Filter

The band-pass filter stage is designed as a cascade of the two active band-pass filters. The reason for using two stages is that the overall band-pass stage would provide a large gain and the frequency response of the filter will have sharper cut off than using only single stage. This method will improve the signal to noise ratio of the output. The schematics for both filters are shown in figure 18.

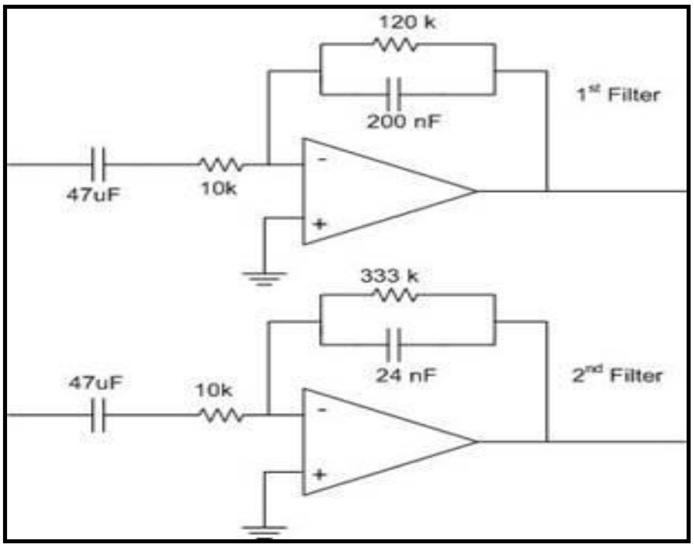

Figure 18: Bandpass Filter Stage

First Band-pass filter :

The lower frequency cutoff is $f_{low} = \dfrac{1}{2\pi(47uF)(10k)} = 0.338Hz$

The higher frequency cutoff is $f_{high} = \dfrac{1}{2\pi(200nF)(120k)} = 6.631Hz$

The mid-band gain of the first filter is $A = -\dfrac{120k}{10k} = -12$

Second Band-pass filter :

The lower frequency cutoff is $f_{low} = \dfrac{1}{2\pi(47uF)(10k)} = 0.338Hz$

The higher frequency cutoff is $f_{high} = \dfrac{1}{2\pi(24nF)(333k)} = 19.91Hz$

The mid-band gain of the first filter is $A = -\dfrac{333k}{10k} = -33.3$

Thus for the band-pass filter stage, the overall gain is 399.6. Combining this gain with the gain from the DC amplifier, the total AC gain for the circuit is $8.51 \times 10^4$ . The choice of high and low cut-off frequency is good enough to give us very clean AC waveform.

### 4.5 AC coupling stage

The ac coupling stage is used to provide the DC bias level. We want the DC level of the waveform to locate at approximately half Vdd, which is 2.5 V. The schematic for AC coupling stage is shown in figure 19. Given this bias level, it is easier for us to process the AC signal using the on-chip ADC in the microcontroller.

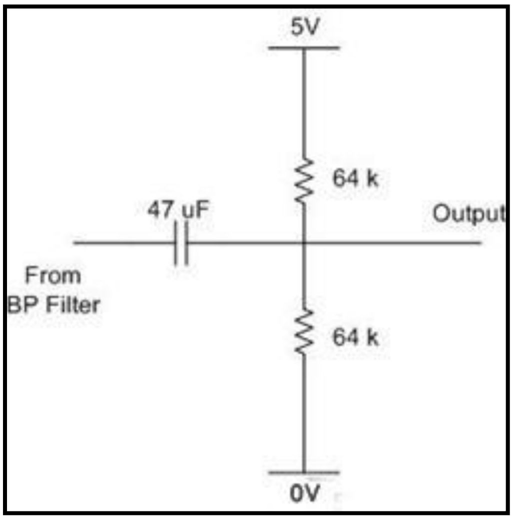


Figure 19 : AC coupling stage for DC bias level

### 4.6 Calculation for Systolic and Diastolic Pressure

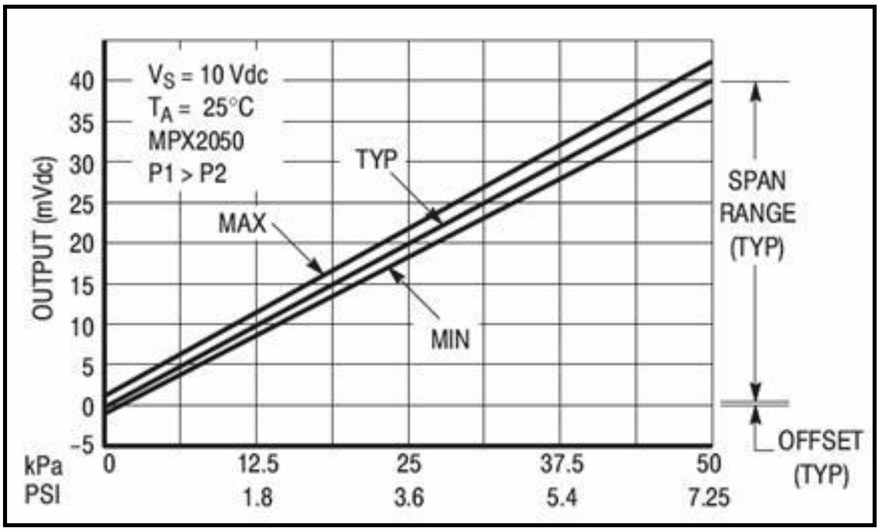


Figure 20 : Voltage Output vs. Pressure Differential for Motorolla MPX 2050 [14]

The systolic pressure can be determine by looking at the DC voltage from the transfer characteristic of the pressure transducer and the measured gain of the DC amplifier as shown in figure 20. The differential voltage that comes out of the DC amplifier is calculated as:

$$Transducer\ voltage = \frac{DC\ voltage}{DC\ Gain}.$$

From the pressure transducer's transfer characteristic given in figure 20 in the circuit design part, we can calculate the pressure based on the transducer_voltage. The slope of the typical curve is calculated as

$$slope\ = \frac{40mV}{50kPa} = 8 \times 10^{-4}\ V/kPa.$$

Thus, the pressure in the cuff in the unit of kPa can be calculated as :

$$pressure\ kPa = \frac{transducer\ voltage}{slope}$$

Then we can convert the pressure back to mmHg.So, the pressure in the mmHg unit is expressed as :

$$pressure\ mmHg = pressure\ kPa\ \times \frac{760mmHg}{101.325kPa}$$

Combining these conversions all together, we obtain the formula for converting the DC voltage to the pressure in the cuff as

$$pressure\ mmHg = \frac{DC\ output}{DC\ gain} \times 9375$$

### 4.7 Graphical User Interface (GUI)

The user interface for this project is LabVIEW VI’s. This software is used to convert,record and also to save the data in a systematic database.It will calculate the value of Systolic pressure, Diastolic pressure. The front panel of LabVIEW VI’s is shown in figure 21.

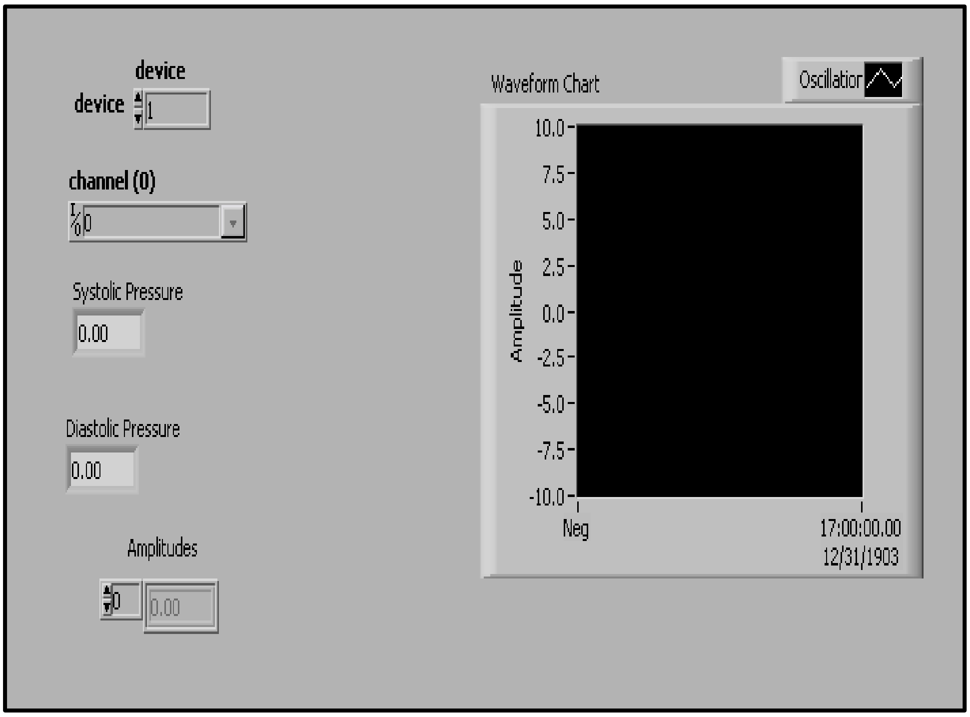


Figure 21: Front Panel on LabVIEW VI’s

# CHAPTER 5

# CONCLUSION AND RECOMMENDATIONS

## 5.1 Conclusions

This project can help the patient to monitor their blood pressure from a remote location without any direct supervision from doctor or expertise. This is because, their readings will be taken by the blood pressure monitoring system and then will be transmitted directly to the host computer.

All the results received will be kept by them and also for the hospitals or clinics safekeeping. So, this will help and make easier for patient to take their blood pressure measurement. The database system will also help the doctors to keep track their patient's health.

## 5.2 Recommendations

The current implementation as discussed above is the first version of project. Future enhancements to the system include :

- Upgrade the circuit by change it to full automatic to control the valve for inflattable cuff.

- The database part change to another software such as Visual Basic and make it more compatible and interactive for user. Possible features can be added to the project such as include history of patient's health and store as many data as possible.

- Increase the integration and feasibility with existing hospital systems and database

- The patients able to view their health record remotely from their PDA or phone with similar technology.

## REFERENCES


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12. http://www.wisegeek.com/what-is-a-radio-receiver.htm

13. http://www.plus-size-pregnancy.org/lgbpcuffs.htm

14. Datasheet MPX 2050 Motorola SEMICONDUCTOR TECHNICAL DATA

15. Design of Analog CMOS Integrated Circuits, Behzad Razavi, August 15, 2000, McGraw-Hill

16. Datasheet Low Cost, Low Power Instrumentation Amplifier AD620

# APPENDICES

# APPENDIX A

**Gant Chart for FYP 2**

| No | Detail/ Week | 1 | 2 | 3 | 4 | 5 | 6 | 7 | Mid Semester Break | 8 | 9 | 10 | 11 | 12 | 13 | 14 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Project Work Continue | ■ | ■ | ■ | | | | | | | | | | | | |
| 2 | Submission of Progress Report 1 | | | | ■ | | | | | | | | | | | |
| 3 | Project Work Continue | | | | ■ | ■ | ■ | ■ | | | | | | | | |
| 4 | Submission of Progress Report 2 | | | | | | | | | ■ | | | | | | |
| 5 | Seminar (compulsory) | | | | | | | | | | ■ | ■ | ■ | | | |
| 5 | Project work continue | | | | | | | | | ■ | ■ | ■ | ■ | | | |
| 6 | Poster Exhibition | | | | | | | | | | | ■ | | | | |
| 7 | Submission of Dissertation (soft bound) | | | | | | | | | | | | | ■ | | |
| 8 | Oral Presentation | | | | | | | | | | | | | | ■ | |
| 9 | Submission of Project Dissertation (Hard Bound) | | | | | | | | | | | | | | | ■ |

Figure 22: FYP 2 Gant Chart

# APPENDIX B

**MOTOROLA** **Freescale Semiconductor, Inc.**
SEMICONDUCTOR TECHNICAL DATA

Order this document by MPX2050/D

## 50 kPa On-Chip Temperature Compensated & Calibrated Silicon Pressure Sensors

**MPX2050 SERIES**

**0 to 50 kPa (0 to 7.25 psi)**
**40 mV FULL SCALE SPAN**
**(TYPICAL)**

The MPX2050 series device is a silicon piezoresistive pressure sensors providing a highly accurate and linear voltage output — directly proportional to the applied pressure. The sensor is a single, monolithic silicon diaphragm with the strain gauge and a thin–film resistor network integrated on–chip. The chip is laser trimmed for precise span and offset calibration and temperature compensation.

**Features**

- Temperature Compensated Over 0°C to +85°C
- Unique Silicon Shear Stress Strain Gauge
- Easy to Use Chip Carrier Package Options
- Ratiometric to Supply Voltage
- Differential and Gauge Options
- ±0.25% Linearity (MPX2050)

**Application Examples**

- Pump/Motor Controllers
- Robotics
- Level Indicators
- Medical Diagnostics
- Pressure Switching
- Non–Invasive Blood Pressure Measurement

Figure 1 shows a block diagram of the internal circuitry on the stand–alone pressure sensor chip.

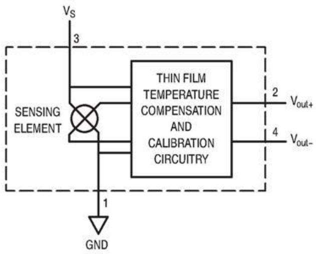
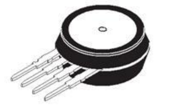



**Figure 1. Temperature Compensated Pressure Sensor Schematic**

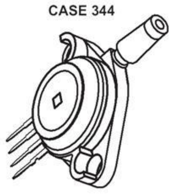
**VOLTAGE OUTPUT versus APPLIED DIFFERENTIAL PRESSURE**

The differential voltage output of the sensor is directly proportional to the differential pressure applied.

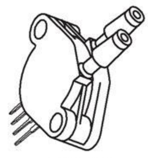
The output voltage of the differential or gauge sensor increases with increasing pressure applied to the pressure side (P1) relative to the vacuum side (P2). Similarly, output voltage increases as increasing vacuum is applied to the vacuum side (P2) relative to the pressure side (P1).



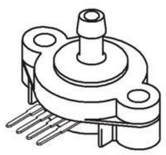
**MPX2050D**
**CASE 344**



**MPX2050GP**
**CASE 344B**



**MPX2050DP**
**CASE 344C**



**MPX2050GSX**
**CASE 344F**

| PIN NUMBER | | | |
|---|---|---|---|
| 1 | Gnd | 3 | $V_S$ |
| 2 | $+V_{out}$ | 4 | $-V_{out}$ |

NOTE: Pin 1 is noted by the notch in the lead.

REV 8



**For More Information On This Product, Go to: www.freescale.com**

MOTOROLA intelligence everywhere digital dna



Figure 23: Datasheet for MPX 2050

## LINEARITY

Linearity refers to how well a transducer's output follows the equation: $V_{out} = V_{off}$ + sensitivity x P over the operating pressure range. There are two basic methods for calculating nonlinearity: (1) end point straight line fit (see Figure 2) or (2) a least squares best line fit. While a least squares fit gives the "best case" linearity error (lower numerical value), the calculations required are burdensome.

Conversely, an end point fit will give the "worst case" error (often more desirable in error budget calculations) and the calculations are more straightforward for the user. Motorola's specified pressure sensor linearities are based on the end point straight line method measured at the midrange pressure.

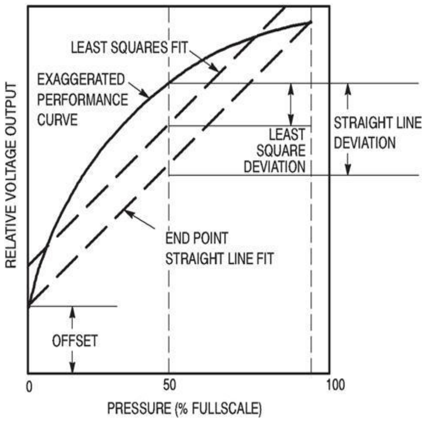



Figure 2. Linearity Specification Comparison

## ON–CHIP TEMPERATURE COMPENSATION and CALIBRATION

Figure 3 shows the minimum, maximum and typical output characteristics of the MPX2050 series at 25°C. The output is directly proportional to the differential pressure and is essentially a straight line.

The effects of temperature on Full–Scale Span and Offset are very small and are shown under Operating Characteristics.

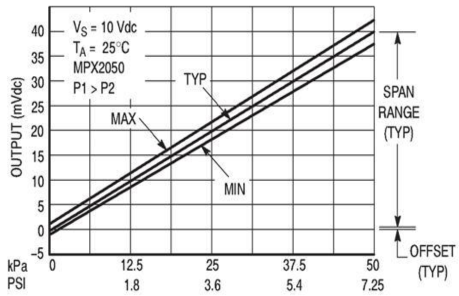



Figure 3. Output versus Pressure Differential

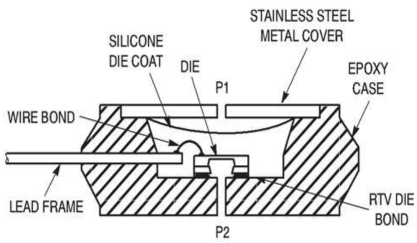
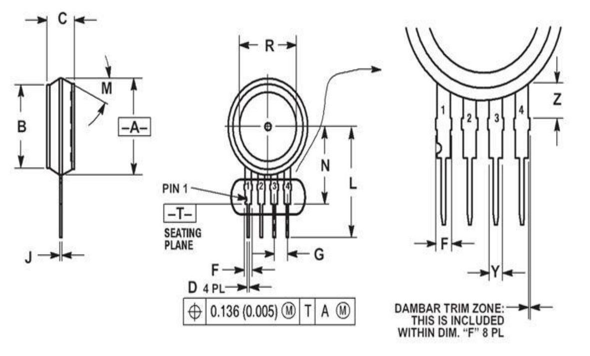



Figure 4. Cross–Sectional Diagram (not to scale)

Figure 4 illustrates the differential or gauge configuration in the basic chip carrier (Case 344). A silicone gel isolates the die surface and wire bonds from the environment, while allowing the pressure signal to be transmitted to the silicon diaphragm.

The MPX2050 series pressure sensor operating characteristics and internal reliability and qualification tests are based on use of dry air as the pressure media. Media other than dry air may have adverse effects on sensor performance and long term reliability. Contact the factory for information regarding media compatibility in your application.

## PACKAGE DIMENSIONS




NOTES:
1. DIMENSIONING AND TOLERANCING PER ASME Y14.5M, 1994.
2. CONTROLLING DIMENSION: INCH.
3. DIMENSION –A– IS INCLUSIVE OF THE MOLD STOP RING. MOLD STOP RING NOT TO EXCEED 16.00 (0.630).

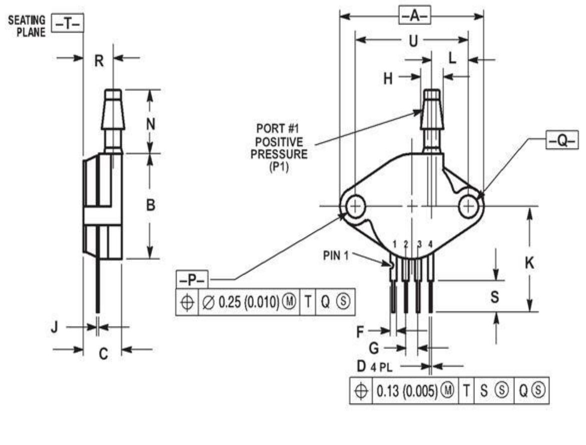
| | INCHES | | MILLIMETERS | |
|---|---|---|---|---|
| DIM | MIN | MAX | MIN | MAX |
| A | 0.595 | 0.630 | 15.11 | 16.00 |
| B | 0.514 | 0.534 | 13.06 | 13.56 |
| C | 0.200 | 0.220 | 5.08 | 5.59 |
| D | 0.016 | 0.020 | 0.41 | 0.51 |
| F | 0.048 | 0.064 | 1.22 | 1.63 |
| G | 0.100 BSC | | 2.54 BSC | |
| J | 0.014 | 0.016 | 0.36 | 0.40 |
| L | 0.695 | 0.725 | 17.65 | 18.42 |
| M | 30° NOM | | 30° NOM | |
| N | 0.475 | 0.495 | 12.07 | 12.57 |
| R | 0.430 | 0.450 | 10.92 | 11.43 |
| Y | 0.048 | 0.052 | 1.22 | 1.32 |
| Z | 0.106 | 0.118 | 2.68 | 3.00 |

STYLE 1:
PIN 1. GROUND
2. + OUTPUT
3. + SUPPLY
4. – OUTPUT

STYLE 2:
PIN 1. $V_{CC}$
2. – SUPPLY
3. + SUPPLY
4. GROUND

STYLE 3:
PIN 1. GND
2. -VOUT
3. VS
4. +VOUT

**CASE 344–15**
**ISSUE Z**




NOTES:
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5, 1982.
2. CONTROLLING DIMENSION: INCH.

| | INCHES | | MILLIMETERS | |
|---|---|---|---|---|
| DIM | MIN | MAX | MIN | MAX |
| A | 1.145 | 1.175 | 29.08 | 29.85 |
| B | 0.685 | 0.715 | 17.40 | 18.16 |
| C | 0.305 | 0.325 | 7.75 | 8.26 |
| D | 0.016 | 0.020 | 0.41 | 0.51 |
| F | 0.048 | 0.064 | 1.22 | 1.63 |
| G | 0.100 BSC | | 2.54 BSC | |
| H | 0.182 | 0.194 | 4.62 | 4.93 |
| J | 0.014 | 0.016 | 0.36 | 0.41 |
| K | 0.695 | 0.725 | 17.65 | 18.42 |
| L | 0.290 | 0.300 | 7.37 | 7.62 |
| N | 0.420 | 0.440 | 10.67 | 11.18 |
| P | 0.153 | 0.159 | 3.89 | 4.04 |
| Q | 0.153 | 0.159 | 3.89 | 4.04 |
| R | 0.230 | 0.250 | 5.84 | 6.35 |
| S | 0.220 | 0.240 | 5.59 | 6.10 |
| U | 0.910 BSC | | 23.11 BSC | |

STYLE 1:
PIN 1. GROUND
2. + OUTPUT
3. + SUPPLY
4. – OUTPUT

**CASE 344B–01**
**ISSUE B**

# APPENDIX C

ANALOG DEVICES

# Low Cost, Low Power Instrumentation Amplifier

## AD620

**FEATURES**

**EASY TO USE**

**Gain Set with One External Resistor**
**(Gain Range 1 to 1000)**
**Wide Power Supply Range (±2.3 V to ±18 V)**
**Higher Performance than Three Op Amp IA Designs**
**Available in 8-Lead DIP and SOIC Packaging**
**Low Power, 1.3 mA max Supply Current**

**EXCELLENT DC PERFORMANCE ("B GRADE")**

**50 μV max, Input Offset Voltage**
**0.6 μV/°C max, Input Offset Drift**
**1.0 nA max, Input Bias Current**
**100 dB min Common-Mode Rejection Ratio (G = 10)**

**LOW NOISE**

**9 nV/√Hz, @ 1 kHz, Input Voltage Noise**
**0.28 μV p-p Noise (0.1 Hz to 10 Hz)**

**EXCELLENT AC SPECIFICATIONS**

**120 kHz Bandwidth (G = 100)**
**15 μs Settling Time to 0.01%**

**APPLICATIONS**

**Weigh Scales**
**ECG and Medical Instrumentation**
**Transducer Interface**
**Data Acquisition Systems**
**Industrial Process Controls**
**Battery Powered and Portable Equipment**

**PRODUCT DESCRIPTION**

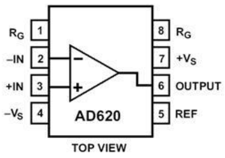
The AD620 is a low cost, high accuracy instrumentation amplifier that requires only one external resistor to set gains of 1 to 1000. Furthermore, the AD620 features 8-lead SOIC and DIP packaging that is smaller than discrete designs, and offers lower power (only 1.3 mA max supply current), making it a good fit for battery powered, portable (or remote) applications.

The AD620, with its high accuracy of 40 ppm maximum nonlinearity, low offset voltage of 50 μV max and offset drift of 0.6 μV/°C max, is ideal for use in precision data acquisition systems, such as weigh scales and transducer interfaces. Furthermore, the low noise, low input bias current, and low power of the AD620 make it well suited for medical applications such as ECG and noninvasive blood pressure monitors.

The low input bias current of 1.0 nA max is made possible with the use of Superβeta processing in the input stage. The AD620 works well as a preamplifier due to its low input voltage noise of 9 nV/√Hz at 1 kHz, 0.28 μV p-p in the 0.1 Hz to 10 Hz band, 0.1 pA/√Hz input current noise. Also, the AD620 is well suited for multiplexed applications with its settling time of 15 μs to 0.01% and its cost is low enough to enable designs with one in-amp per channel.

**CONNECTION DIAGRAM**

**8-Lead Plastic Mini-DIP (N), Cerdip (Q) and SOIC (R) Packages**



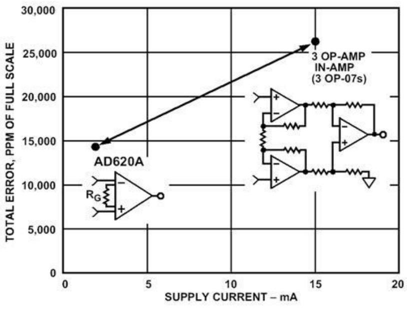




*Figure 1. Three Op Amp IA Designs vs. AD620*

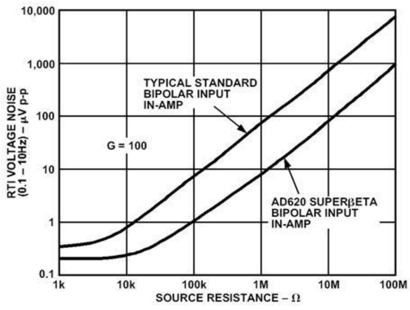



*Figure 2. Total Voltage Noise vs. Source Resistance*

REV. E

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Fax: 781/326-8703



Figure 24 : Datasheet for AD620