DESIGN AND DEVELOPMENT OF AN EMBEDDED SYSTEM FOR AUTOMATIC BLOOD PRESSURE MONITORING

K.Y. Rokde[1], P.B.Dahikar[2], S.S.Shende[3]
Assistant Professor, Department of Electronics, K.R.Pandav Mahavidyalaya, Nagpur, India [1]
Professor, Department of Electronics, Kamla Nehru Mahavidyalaya, Nagpur, India[2]
Assistant Professor, Department of Electronics, Shivaji Science College, Nagpur, India [3]

Abstract-
This paper presents a design and development of an Embedded System for Automatic blood pressure Monitoring. The real-time blood pressure biomedical vital signal is measured using an optical measurement circuit based Plethysmography technique (PPG) continuously for a long period of time. The blood pressure sensing system will give the diastolic and systolic pressure reading on the display. The automatic Blood pressure numerical reading values of systolic and diastolic blood pressure calculated is then displayed on a LCD. For measurment of BP a special BP sensor MPS 3117 and BP pump is used. The result is calculated and then it is sent to central location system using RF module. The results were compared with existing devices data as a Sphygmomanometer technique to verify the accuracy of the developed instrument.

Key Words:- Blood Pressure, Embedded, Wireless, photoplethysmography, LCD etc.

I. INTRODUCTION

Blood pressure measurement is one of the basic clinical examinations. The origin of blood pressure is the pumping action of the heart and its value depends on the relationship between cardiac output and peripheral resistance. Therefore, blood pressure is considered as one of the most important physiological variables with which to assess cardiovascular hemo-dynamics.
It is the force created by the heart as it pushes blood into the arteries through the circulatory system. Each time the heart contracts or "beats" the blood is pumped out and creates a surge of pressure in the arteries. Blood pressure is the force exerted by circulating blood on the walls of blood vessels.

Blood pressure is the most often intensively studied parameters in medical and physiological practice. The determination of only its maximum and minimum levels during each cardiac cycle supplemented by information about other physiological parameters is a valuable diagnostic aid to access the vascular condition and certain other aspects to cardiac performance. Blood is pumped by the left side of the heart into the aorta, which supplies it to the arterial circuit. Due to the load resistance of the arterioles and the precapillaries, it losses most of its pressure and returns to the heart at low pressure vie highly distensible veins. The right side of the heart pumps it to the pulmonary circuit, which operates at lower pressure. The heart supplies blood to both circuits as simultaneous intermittent flow pulses of variable rate and volume. The maximum pressure reached during cardiac ejection was called systolic pressure and the minimum pressure occurring at the end of ventricular relaxation is termed as diastolic pressure. The mean arterial pressure over one cardiac cycle is approximated by adding one third of the pulse pressure (difference between systolic and diastolic values) to the diastolic pressure.[1]

II. METHODOLOGY

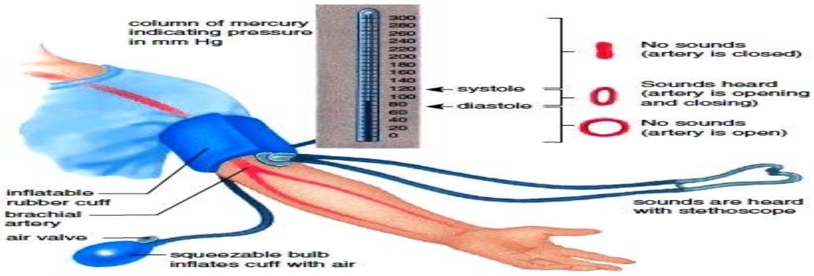

Fig 2.1 Blood pressure Measurement using Sphygmomanometer

A Sphygmomanometer worked on the principle that when the Cuff was placed on the upper arm and was inflated, the arterial blood flowed past the Cuff only when the Arterial Pressure exceeds the Pressure in the cuff. When the Cuff was inflated to a Pressure that occluded the Brachial Artery only partially, turbulence was generated in the blood as it spurted through the tiny arterial opening during each Systole. The sounds generated by the turbulence, Korotkoff sounds, was heard through a Stethoscope placed over the Artery downstream from the Cuff.[2]

III DETAIL ANALYSIS OF SENSORS USED

A. Variations in Blood Pressure

Normal BP for adults is defined as 120/80 mmHg. But this changed with different activities and due to various reasons. The measurements were different when the person was asleep, awake, active, nervous or excited. Once the activity stopped, BP returned to the baseline range. Blood Pressure normally rose with age and body size. Newborn babies often had very low Blood Pressure numbers, considered normal for babies, while older teens had numbers similar to adults.

Approximate Age (in years)	Systolic mmHg	Diastolic mmHg	Heart Rate per min	Respiratory Rate per min
1 – 11 (months)	74-100	50-70	120-160	30-60
1 - 3	80-112	50-80	90-140	20-40
4 - 5	80-110	50-78	90-140	22-34
6 - 12	84-120	54-80	75-100	18-30
13 - 18	94-140	62-88	60-90	12-16

Table 1. Common Range of BP, Respiratory Rate and Heart Rate in Children

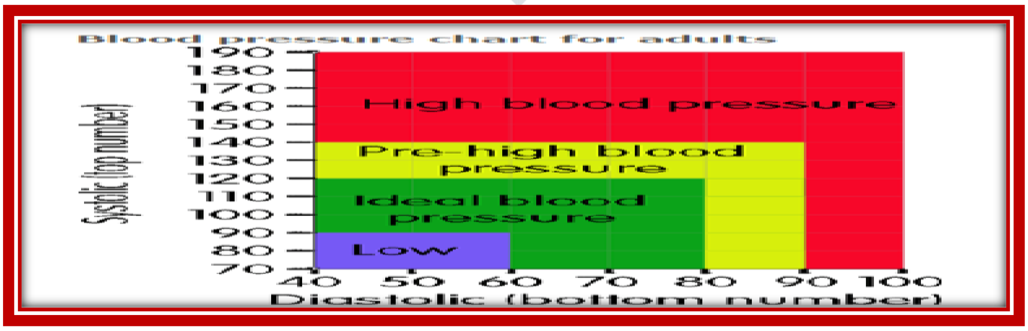

Fig 3.2 Blood Pressure Chart for Adults

B. Blood Pressure sensor

In choosing the sensor for the blood pressure monitoring device many sensors were considered. Many factors were taken into account including the voltage input range for operation, current range for operation, as well as what is actually being sensed. Blood pressure through electronic means was often done in an indirect method in which information was derived from a signal and information known about signals and pressure. Therefore what is actually being sensed directly is not blood pressure. The signal received from the sensor starts as a mechanical signal and a transducer changes it into a voltage to be fed into a processor for deducting information.For the Circuit design we have used a MPS 3117 sensor.

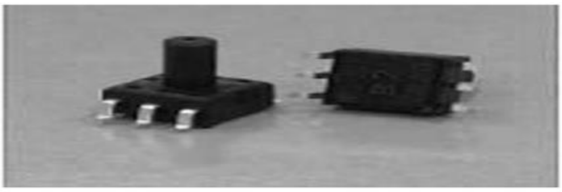

Fig 3.3 Blood pressure sensor MPS-3117

The MPS-3117 pressure sensor from Taiwan Metro dyne System Corporation, utilizes a special case of the Wheatstone bridge, the Wien Bridge which was driven by a constant current source of 1mA to 3mA and requires 2-5V of supply voltage. Utilizing the Wien Bridge allows the capacitance of two capacitors to be compared because the resistance values of the circuit were known. The pressure sensor was therefore able to send the double-ended output differential signals depending on profile of the air pressure wave. The signal was an analog mixed signal with an output voltage in the range of 0-40mV that is proportional to the differential input mechanical air pressure.[3]

C. BP pump and Motor

Fig 3.4 BP pump

Product Description

- Mini Air Pump 6V
- Air flow: 1liters per minute to 2.2liters per minute.
- Current: Under 100mA to 600mA
- Volt: DC 6V
- Power consumption: about 2.4W.
- Noise: Under 55DB
- Can work with WV120-6V solenoid valve the keep pressure and release pressure

D. Cuff

The cuff is an integral part of the blood pressure is normally placed smoothly and snugly around an upper arm, at roughly the same vertical height as the heart while the subject is seated with the arm supported. It is essential that the correct size of cuff is selected for the patient. When too small a cuff results in too high a pressure, while too large a cuff results in too low a pressure, so it comes in four sizes, for children up to obese adults. Also, it is made of a non-elastic material, and the cuff used is about 20% bigger than the arm. The cuff is inflated until the artery is completely occluded. Then, the sensor takes action sensing the brachial artery at the cuff; the microcontroller controls the valve which slowly releases the pressure in the cuff. As the pressure in the cuffs falls, a pulsation sound is heard when blood flow first starts again in the artery. The pressure at which this sound began was known and recorded as the systolic blood pressure. Furthermore, the cuff pressure was further released until the sound can no longer be heard. This was recorded as the diastolic blood pressure. There were two main blood pressure flows such as systolic blood pressure and diastolic blood pressure. Below are the definitions of each blood flow.

Systolic blood pressure - is the amount of pressure that blood exerts on vessels while the heart is beating. In a blood pressure reading (such as 120/80), it is the number on the top.

Diastolic blood pressure – is the pressure in the bloodstream when the heart relaxes and dilates, filling with blood. In a blood pressure reading (such as 120/80), it is the number on the bottom.

Fig 3.5 D ring Cuff

D-ring cuffs come in different sizes of small, standard and large. It was important to pick out the right size cuff based on your individual arm circumference. Expandable Cuff was a pre-formed upper arm cuff that expands to fit both regular and large sized arms. It was designed to ensure more comfortable, accurate readings. There was a reasonable standard expandable D-Ring cuff which had a circumference between 9" to 13" – 22 to 32 cm which was being used for this research work. It was very important to use the appropriate size cuff for your arm in order to get accurate measurement results when using your home blood pressure monitor. If you use the wrong sized cuff, you were likely experiencing inaccurate readings, inconsistent readings and error messages from the device. To determine the arm size, we used a cloth tape measure and place midway between the elbow and the shoulder around the circumference of the upper arm.[4]

IV. EXPERIMENTAL WORK

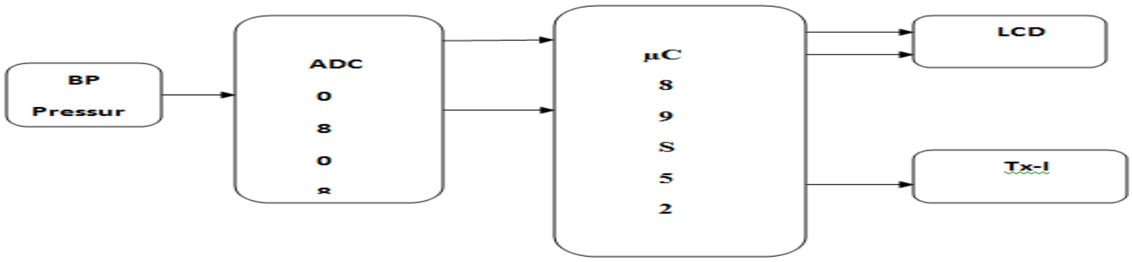

Fig 4.1 Block diagram BP system

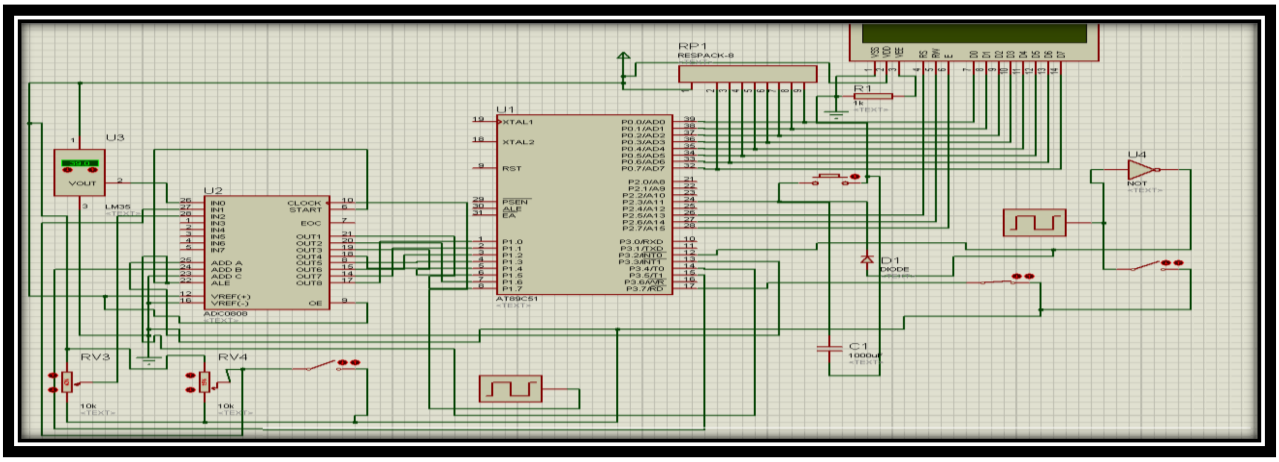

Fig 4.2 Circuit diagram of BP Measuring system

ADC 0809 is used to convert analog signals from temperature sensor, and pressure sensor to digital values to read by microcontroller. Heart beats are monitored in any digital pin of microcontroller. Here we are using pin 12 of microcontroller. A switch is provided to measure the BP. In this mode only BP will be measured and the values are stored in memory. And by changing position of switch all parameters will be measured and send to receiver. Data pins of ADC are connected to pin 1 to 8 of microcontroller. Select pin 25 of ADC is connected to pin 13 of microcontroller for selecting channnels. Pin 24 is connected to pin 16 of microcontroller. And third select pin is grounded. Start of convertion pin 6 and 22 are shorted and used as start of convertion and is connected to pin 14 of microcontroller.clock at pin 10 is provided by IC555, and this IC is used as astable multivibrator.and provide 20KHz clock. LCD data pins are connected to pin 32 to 39 of microcontroller. RS pin is connected to pin 26 of microcontroller, RW pin is connected to pin 27 and Enable pin to pin 28 of microcontroller.

Microcontroller measures Temperature then pressure from pressure sensor in BP switching. And then measure the pulse stop to pump motor. And measure higher blood pressure. And when again pulse atarts that time it measures lower pressure. The data will be continiously transmitted using RF transmitter. The parameters measured are displayed on LCD display

A. BP amplifier circuit

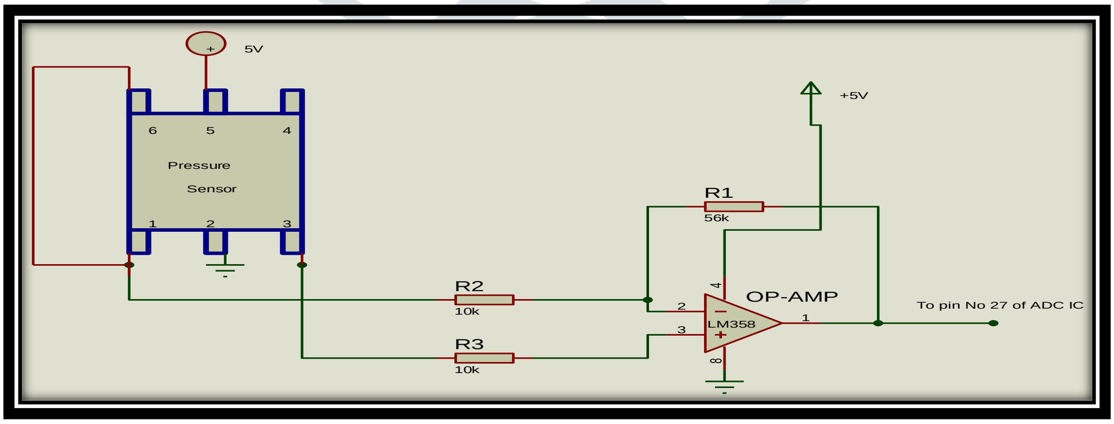

Fig 4.3 BP amplifier Circuit

Fig 4.4 Hardware ckt of BP Amplifier Ckt

The signals from pressure sensor were very weak so it was necessary to amplify the signals to read by ADC. So for this we were used an op- amp circuit constructed with LM 368 IC. The inputs from sensor were connected to pin 2 and pin 3 of this op-amp IC. Amplification factor was selected by using 96K resistor connected at pins 2 and pin 1 of this IC so at the output amplified signals were available and it was connected to pin 27 of ADC to read pressure.

B. Microcontrollers: (AT 89S52)

A microcontroller is a dedicated computer in electronics that was used to perform specific tasks. For the purpose of this research, a microcontroller was used because, besides being a low-power device, it has a low cost and it was designed to be as compact as possible. The microcontroller would take input from the device that it was controlling and it would be sending signals constantly to different components of the device so it performs the desired tasks. Among all the microcontrollers available at the market, the research uses the 89S52.

It is a Low-power, high-performance CMOS 8-bit microcontroller with 8KB of ISP flash memory. The device uses Microchip high-density, nonvolatile memory technology and is compatible with the industry-standard 89S52 instruction set and pinout. On-chip flash allows the program memory to be reprogrammed in-system or by a conventional nonvolatile memory programmer. This powerful microcontroller is suitable for many embedded control applications.

In this research work the Embedded C language programming is done in microcontroller IC 89S52 to controlling the Blood pressure. The software aspects i.e Proteus and Ride software is used for designing and programming.

V. RESULT AND DISCUSSION

The Systolic and Diastolic Blood Pressure for Seventy two different patients were recorded using the designed hardware instrument and were compared with the values obtained by standard means. The values recorded were tabulated and is shown in the tables given below.

BP - Systolic			
Sr No	Patients Data		Deviation
	Standard Device	Experimental Measures	
1	80	77	3
2	81	79	2
3	83	79	4
4	85	80	5
5	86	85	1
6	88	72	6

7	89	85	4
8	92	91	1
9	93	93	0
10	95	91	4
11	96	97	-1
12	98	93	5
13	98	96	2
14	100	102	-2
15	102	97	5
16	103	98	5
17	104	103	1
18	106	106	0
19	108	102	6
20	113	107	6
21	116	114	2
22	118	120	-2
23	124	121	3
24	126	125	1
25	126	127	-1
26	129	125	4
27	130	128	2
28	134	131	3
29	138	132	6
30	141	141	0
31	143	139	4
32	143	142	1
33	144	139	5
34	145	143	2
35	146	147	-1
36	146	145	2
37	148	140	8
38	149	147	2
39	150	144	6
40	152	143	9
41	152	148	4
42	154	154	0
43	155	145	10
44	157	150	7
45	158	153	5
46	160	161	-1
47	162	159	3
48	162	163	-1
49	163	160	3
50	164	160	4
51	165	161	4
52	166	163	3
53	168	168	0
54	168	166	2
55	169	161	8
56	170	166	4
57	171	175	-4
58	173	167	6
59	173	172	1
60	174	168	6
61	176	178	-2
62	177	171	6
63	178	174	4
64	180	172	8
65	180	178	2

66	184	182	2
67	185	180	5
68	186	180	6
69	188	174	14
70	189	196	-7
71	192	186	6
72	192	193	-1

Table 2 .BP- Systolic data Recorded by Different Means and the Deviation

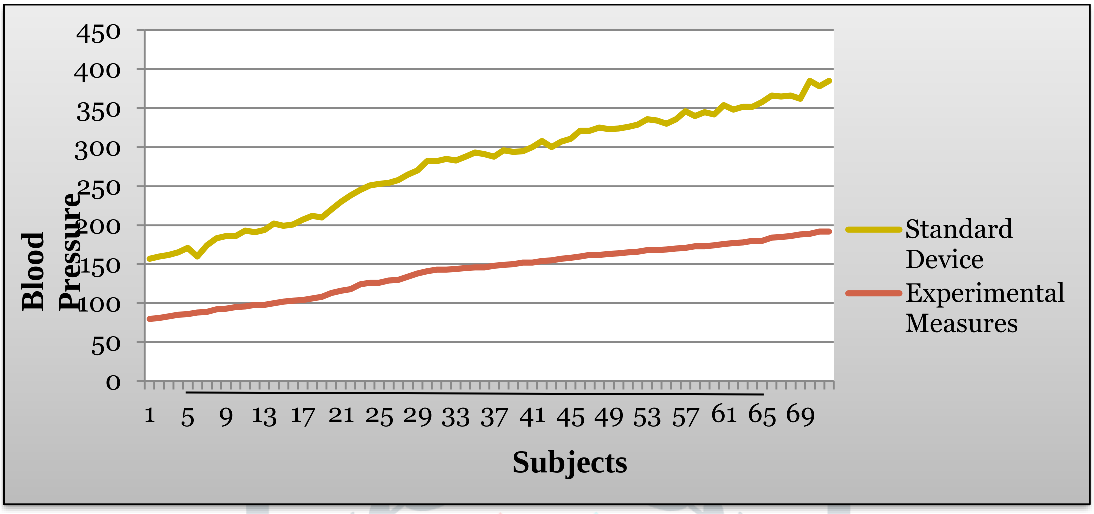

Fig 5.1 Plot Showing the BP for Various Patients

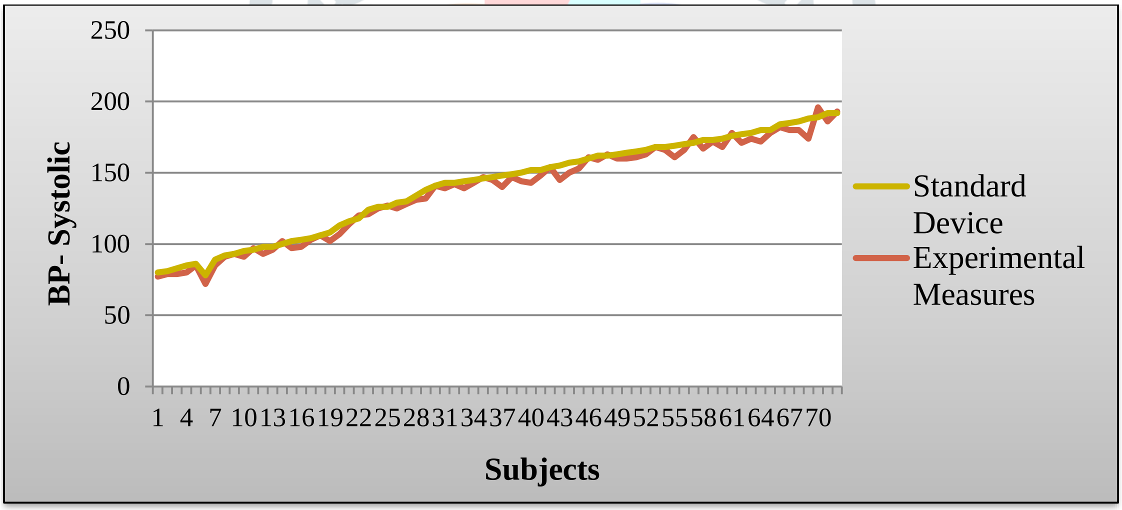

Fig 5.2 Plot Showing the Comparison of Data for BP - Systolic

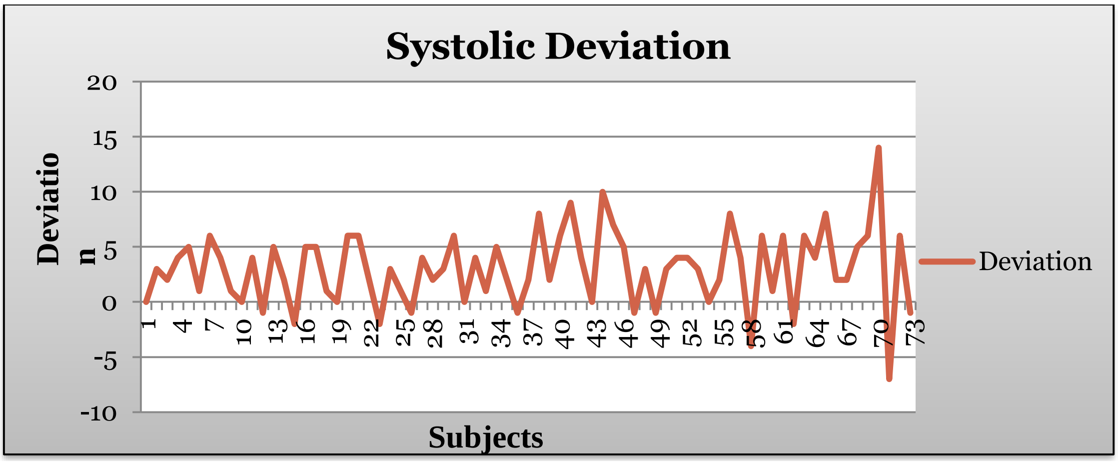

Fig 5.3 Plot Showing the Deviation for BP - Systolic

BP - Diastolic			
Sr No	Patients Data		Deviation
	Standard Device	Experimental Measures	
1	52	49	3
2	53	48	5
3	53	51	2
4	54	51	3
5	55	55	0
6	56	54	2
7	56	53	3
8	57	56	1
9	57	58	-1
10	57	53	4
11	58	56	2
12	59	58	1
13	60	62	-2
14	61	57	4
15	61	60	1
16	63	60	3
17	63	58	5
18	65	63	2
19	66	62	4
20	68	67	1
21	68	65	3
22	69	67	2
23	70	69	1
24	70	66	4
25	72	68	4
26	73	67	6
27	73	74	-1
28	74	71	3
29	76	75	1
30	78	74	4
31	82	79	3
32	82	82	0
33	83	78	5
34	84	87	-3
35	86	81	5

36	87	86	1
37	88	86	2
38	88	90	-2
39	89	83	6
40	90	86	4
41	92	89	3
42	93	91	3
43	93	94	-1
44	94	92	2
45	96	94	2
46	97	92	5
47	97	96	1
48	98	95	3
49	99	96	3
50	101	95	7
51	101	97	4
52	102	100	2
53	103	102	1
54	104	105	-1
55	106	99	7
56	106	106	0
57	107	102	5
58	108	105	3
59	108	100	8
60	110	107	3
61	112	108	4
62	112	111	1
63	114	115	-1
64	117	114	3
65	118	124	-6
66	120	118	2
67	121	121	0
68	122	116	6
69	122	118	4
70	124	121	3
71	126	126	0
72	126	128	-2

Table 3. BP - Diastolic Recorded by Different Means and the Deviation

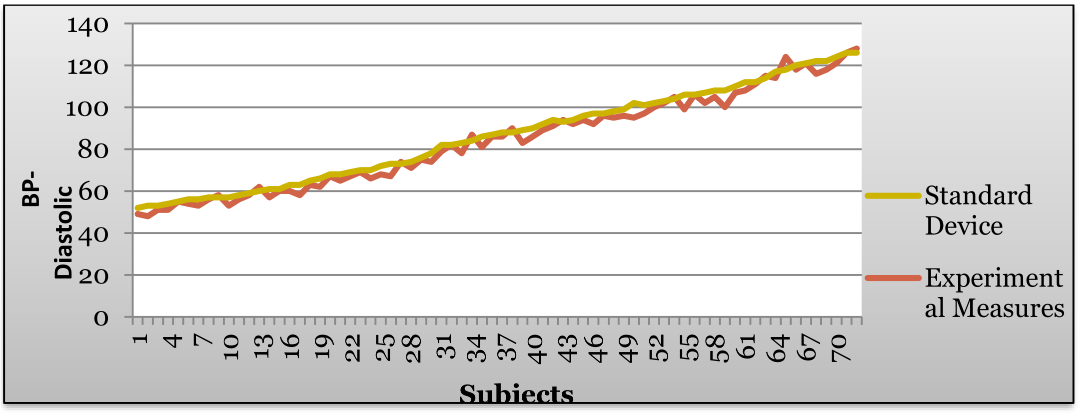

Fig 5.4 Plot Showing the BP for Various Patients

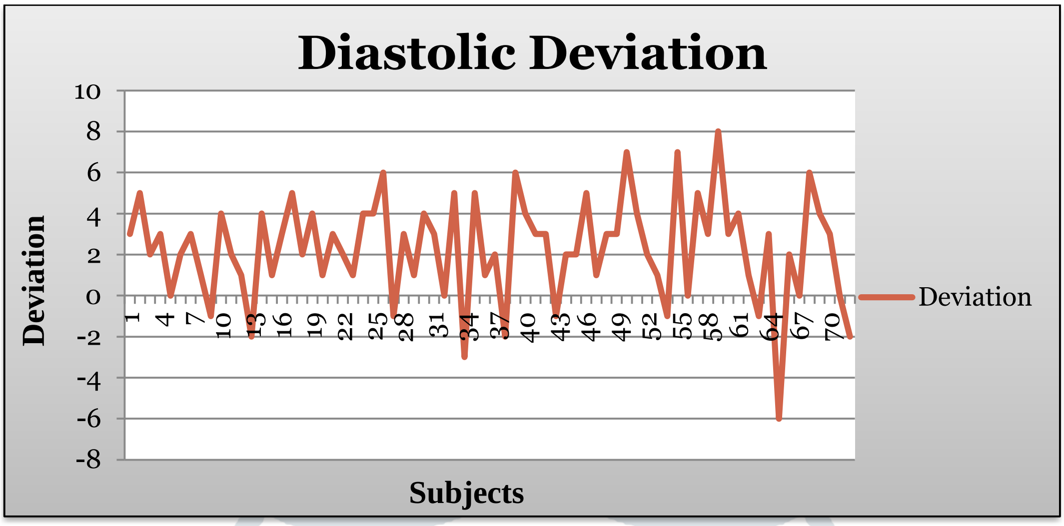

Fig 5.5 Plot Showing the Deviation for BP – Diastolic

The percentage of deviation for each subject was calculated. It was found that the percentage ranged between 0 and 8. Three different ranges were set between 0 and 8% – 0 to 2%, 3 to 5% and 6 to 8%.

VI. CONCLUSION

With this kind of approach and resource simple and very cost effective automatic blood pressure monitoring system using wireless technology can be designed which will be very useful in medical field, laboratories and industries where we can get better and more accurate result as compared to other biomedical devices.

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