IJCRT.ORG ISSN : 2320-2882

INTERNATIONAL JOURNAL OF CREATIVE RESEARCH THOUGHTS (IJCRT)

An International Open Access, Peer-reviewed, Refereed Journal

Heart Rate Measurement System Using PSoC1

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Abstract: A prototype hardware module for the heart rate measurement system is presented in this study. This research concentrates on real-time heart rate monitoring, which is necessary for mobility from the user's perspective. A HB (Heart Beat) sensor is being developed for acquiring the input signal using BPW34 photodiode and LED (Light Emitting Diode). BPW34 photodiode senses the HB of a person and converts it in the form of electrical output voltage using a Transimpedance amplifier. The electrical output voltage processed by PSoC1 (Programmable System On-Chip) CY8C28433 microcontroller. This work has tried to make easy short distance wireless Bluetooth data acquisition system for heart rate measurement system using advance PSoC1 microcontroller. In this system PSoC used as a transmitter and PC (Personal Computer) /Laptop used as receiver.

***Index Terms*–PSoC1, Heart rate System, Wireless, Bluetooth HC-05 Module, BPW34.**

I. INTRODUCTION

Medical field is having very good era in our country due to the advancement of globalization and digitalization. But people those who are living in the countryside have very less access to the technology. In the bio- medical field vital signs are plays very important role of the body's basic functions. The basic four main important signs that are usually monitored like:

- Temperature of Body
- Heart rate (pulse rate)
- Respiration Rate (Rate of breathing)
- Blood pressure (BP)

In this research work we focus on Heart rate or Pulse rate. The pulse rate is a measurement of the heart rate, or the number of times the heart beat per minute. [1]American heart association state that the normal heart rate in adult is 60 to 100 beats per minute.
The pulse rates may fluctuate due to exercise, illness, injury and emotions. [2]
The HB system uses BPW34optical sensor module for calculating pulse rate of patients. The device will be mounted on the finger or ear lobe of the patient. This device will detect the optical change during blood flow process and easily calculate heart rate. The device uses Optical Sensor Module, Bluetooth HC-05 Module and PSoC (Programmable System On-chip) CY8C28433 microcontroller. The hardware programming for the device is done in the PSoC Designer 5.0 IDE.

II. PROPOSED METHODOLOGY

Optical Sensor Module is placed on the finger. This sensor module changes physical quantity light into analog voltage using Transimpedance amplifier and provides the analog value to the CY8C28433 microcontroller.
PSoCCY8C28433 microcontroller plays important role in this system. It sends the real time heart rate signal to the Laptop application through HC-05 Bluetooth module. This Bluetooth device is setup communication with laptop when application runs. The internal block diagram of HB System as follows:

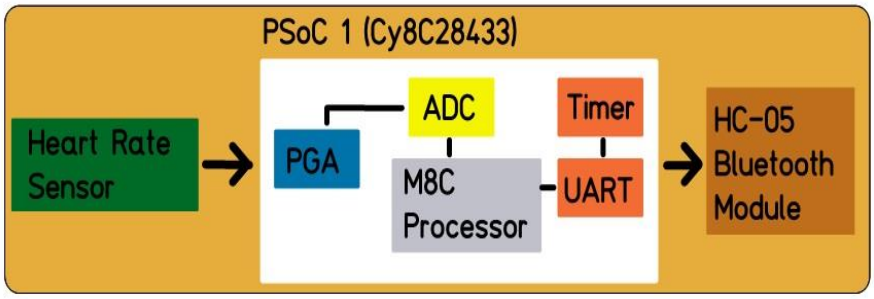

Figure 1 Internal Block Diagram of HB System

III. HARDWARE IMPLEMENTATION OF PROPOSED SYSTEM

3.1PSoC1 CY8C28433 Microcontroller

Cypress semiconductor provides large number of evaluation kits and documentation for development of hardware and software. In the present work a CY8C28433 Evaluation Board designed by ENTESLA Pvt. Ltd has been used. Figure 2 shows image of development board.

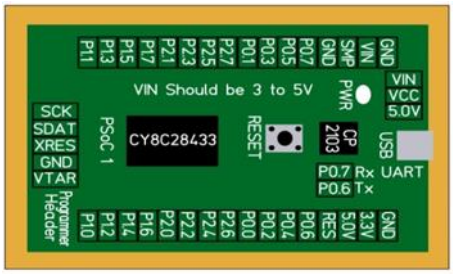

Figure 2 Development Board of CY8C28433

The development board consists of all the required functionality which is helpful in development of the system. On the development board CY8C28433 SSOP chip, reset, Oscillator circuit, USB to UART circuit and ISSP programmer header is available.

3.2 Heart rate Sensor Module

A generic low power amplifier LM358 has been used to construct the circuit. In this circuit BPW34 photodiode is used to convert light value in the voltage form using a Transimpedance amplifier. A Transimpedance amplifier is a circuit which converts the input current to a proportional output voltage. [3]

Figure 3 Heart Rate Sensor Module

3.3 Bluetooth HC-05 Module

Bluetooth HC-05 consists of BC417 Bluetooth IC which is operated at the frequency of 26MHz with on board crystal. Bluetooth module operates on 3.3V. Hence a regulator is used on the board. One push button is present on the board to configure module in AT command mode.

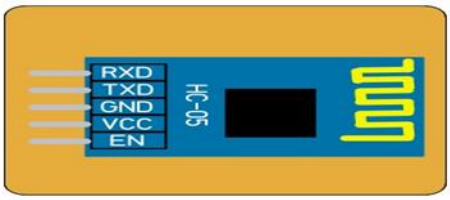

Figure 4 HC-05 Bluetooth Module

3.4 Interface Heart Rate Sensor Module with PSoC 1 CY8C28433 Microcontroller

The Heart Rate Module is used to acquire PPG signals is connected to the port pin P0.0 and Bluetooth HC 05 module is connected to the port pin P0.6 to receive the data another port pin P0.7 is connected to send the data. Figure 5 shows the PSoC1 port pin connections with Heart Rate Sensor Module and Bluetooth.

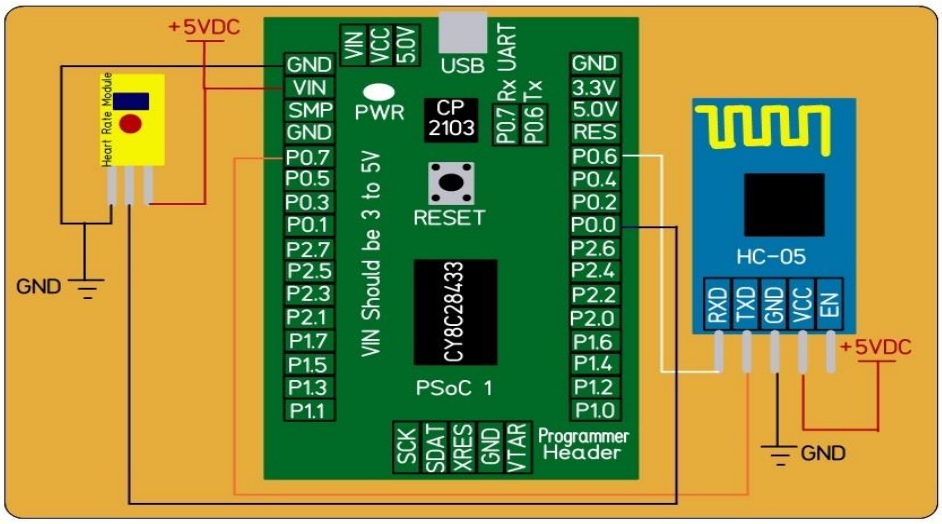

Figure 5 Interconnection Diagram of Heart Rate System

In PSoC Designer 5.0 hardware configuration for CY8C28433 setup as given in the following table 1:

Table 1: Hardware Configuration of Heart rate System

Sr. No.	User Module	Parameters	Configured value
1	Global Resource		
		Power Setting [VCC/SysClkfreq]	5.0V / 24MHz
		CPU_Clock	SysClk/8
		32K_select	Internal
		PLL_Mode	Disable
		Sleep Timer Period	1.95ms
		VC1=SysClk/N	12
		VC2=VC1/N	6
		VC3 Source	VC2
		VC3 Divider	256
		SysClk Source	Internal
		SysClk*2 Disable	No
		Analog Power	SC On/Ref High
		Ref Mux	(Vdd/2)+/-(Vdd/2)
		AGndBypass	Disable
		Op-amp Bias	Low
		Switch Mode Pump	Off
		Trip Voltage [LVD (SMP)]	4.81V [5.0V]
		LVD ThrottleBack	Disable
		Watchdog Enable	Disable
2	PGA_1		
		Version	3.2
		Gain	1.000
		Input	AnalogColumnMUXBusSwitch_1
		Reference	VSS
		AnalogBus	Disable
3	ADCINCVR_1		
		Version	3.1
		Input	ACC01
		ClockPhase	Norm
		Clock	VC2
		ADC Resolution	10 Bit
		Calc Time	100
		Data format	Unsigned
4	UART_1		
		Version	5.2
		Clock	Row_1_Output_0
		RX Input	Row_1_Input_2
		TX Output	Row_1_Output_3
		TX Interrupt Mode	TXComplete
		Clock Sync	Sync to SysClk
		RxCmdBuffer	Enable
		RxBufferSize	16
		Command Terminator	13
		Param_Delimiter	32
		IgnoreCharsBelow	32
		Enable Back Space	Disable
		RX Output	None
		RX Clock Out	None
		TX Clock Out	None
		Invert Rx Input	Normal
5	Timer8_1		
		Version	2.6
		Clock	VC1
		Capture	Low
		TerminalCountOut	None
		CompareOut	Row_1_Output_0
		Period	26
		Compare Value	13

		Compare Type	Less then or Equal
		Interrupt Type	Compare True
		ClockSync	Sync to SysClk
		TC_Pulsewidth	Full Clock
		Invert Capture	Normal

3.5 Digital and Analog Routing of Heart Rate Measurement System

The chip level editor connects the user module and port pins as per parameter configuration. The digital and analog user module routing in chip level editor for Heart rate measurement module is as shown in Figure 6 and 7 respectively.

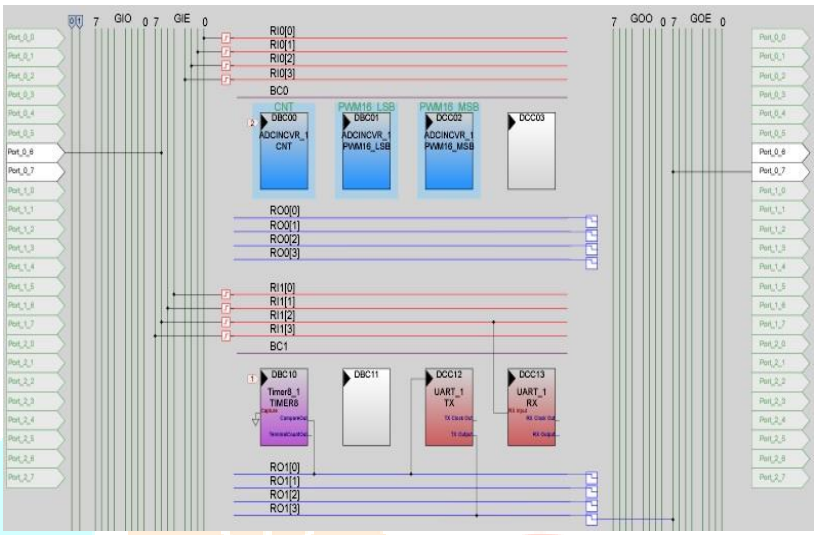

Figure 6 Digital Routing View

PSoC 1 CY8C28433 Board Connections:

Port0_pin6 -> RX = HC-05 Bluetooth Module RX

Port0_pin7 -> TX = HC-05 Bluetooth Module TX

Used Digital Block:

DCC10 -> Timer8_1

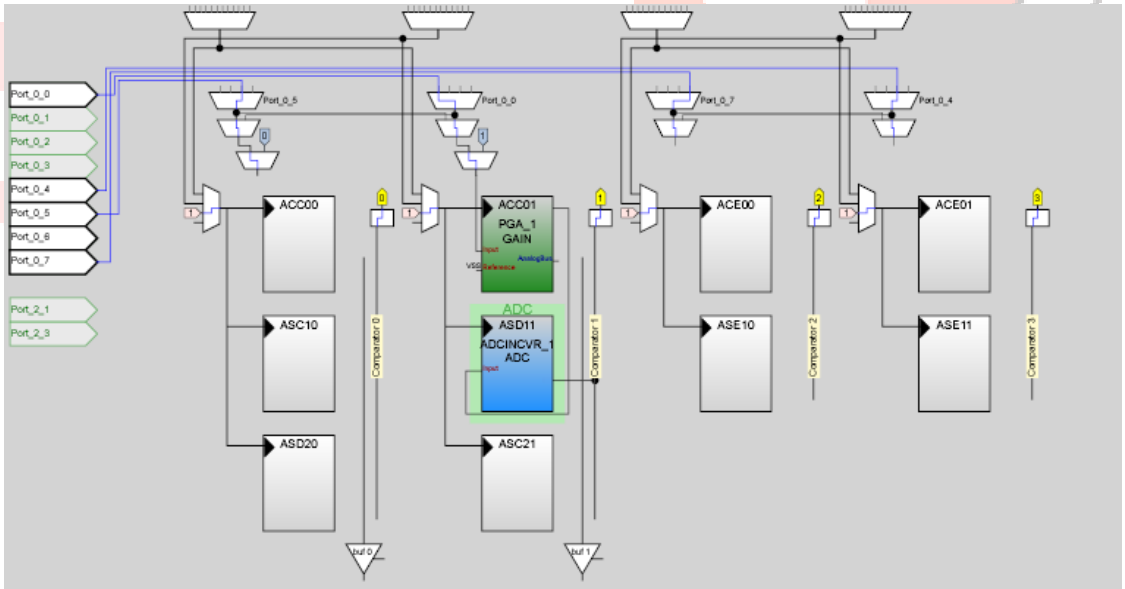

Figure 7 Analog Routing View

PSoC 1 CY8C28433 Board Connection:

Port0_pin0 -> Sensor Input = Heart Rate Sensor Module

Used Analog Block:

ACC01 -> PGA_1

ASD11 -> ADCINCVR_1

3.6 Developed Heart Rate Hardware Module

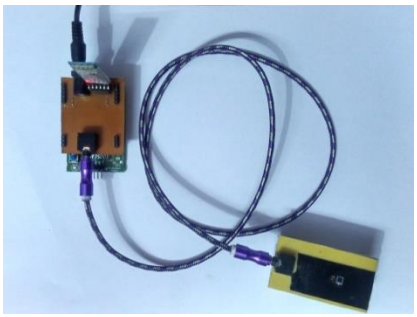

Figure 8 Hardware Module of Heart Rate System

IV. SOFTWARE IMPLEMENTATION

4.1 Hardware programming:

A basic "C" programming has been used to program the hardware module in PSoC Designer 5.0 and is transferred to PSoC device through MiniProg 3 Programmer Kit. The flow chart of hardware code module given in the Figure9:

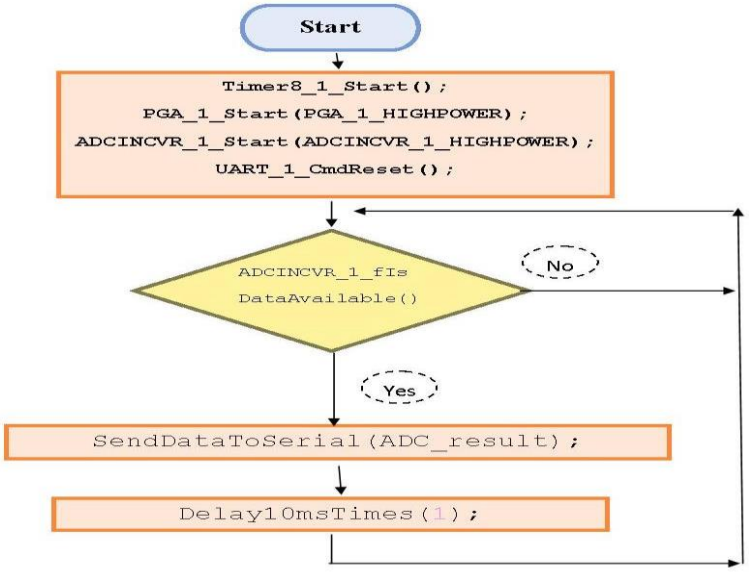

Figure 9 Flowchart of Real-time Heart Rate System

4.2 PC software programming :

The JAVA mode in processing3.0software has been used to design GUI (Graphical User Interface) for this system. The Heart Rate Sensor data will be continuously transferred from Bluetooth module to PC (Personal Computer) /Laptop. The Heart Rate data transferred is in arbitrary values. This data from Bluetooth is received and converted in Heart Rate signal and displayed on the screen using Processing 3.0 software. Output GUI shown in Figure 10:

Figure 10 GUI Output of Heart Rate System

V. RESULTS AND DISCUSSION

The developed sensor module for measurement of Heart rate has been calibrated using pulse Oxi-meter. Hundreds of sample readings have been taken out of which some of readings are given in the Table2 along with accuracy of the developed system. The mentioned values are the number of heart beat per minute i.e. Respiration Rate.

Table 2: Comparative Result of Heart Rate Measurement

Sr. No.	System Result (BPM)	Pulse Oxi-meter (BPM)	Accuracy In (%)
Person 1	70	69	98.55
Person 2	90	91	98.90
Person 3	80	78	97.43
Person 4	75	73	97.26
Person 5	73	72	98.61
Person 6	88	89	98.87
Person 7	94	94	100.0
Person 8	75	74	98.64
Person 9	69	70	98.57
Person 10	68	69	98.55

From the comparative result values it is clear that, the designed Heart rate system accuracy is about 98.54%

VI. ACKNOWLEDGMENT

We hereby thank our Research guide Professor Dr. S. N. Helambe for supporting us at each and every level in this project whenever we were blank; he has guided us to what to do next. We also thank all other faculty members of Department of Electronics, Physics and Computer Science, Deogiri College for helping us and taking out time from their busy schedule.
We are especially indebted to our parents for their love and support. Our full dedication to the work would have not been possible, without their blessings and moral support.

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