GOAL: BRING UP AND TEST BOARD 4

The seven steps for this Project- : `

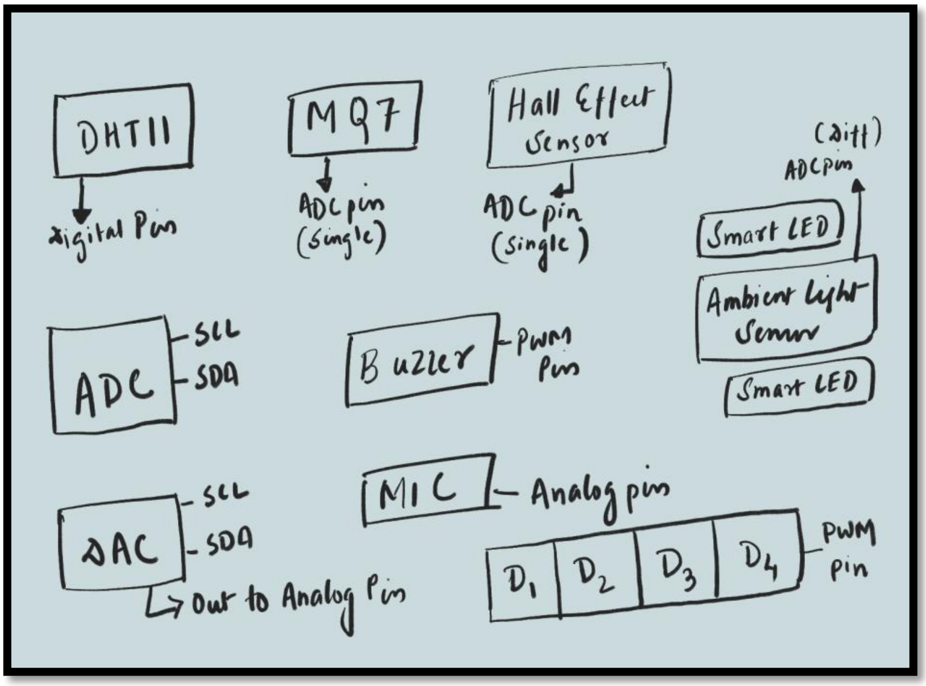
1. Completing the plan of record (POR)

- For this particular board, we have to a make a 4 layer sensor shield which will have a number of sensors connected to it along with some new footprints and symbols. This sensor shield will then be integrated with my arduino board and it will be made functional using code written on it.
- Six different sensor and four different components have been integrated on our sensor shield which are- :

    - Heartbeat sensor
    - Temperature-humidity sensor
    - Hall Effect magnetic field sensor
    - CO, carbon monoxide sensor
    - Microphone
    - 4 smart LEDs
    - Buzzer
    - 12-bit DAC
    - 16-bit ADC

The datasheets of each and every component have been checked and analyzed for which separate connections to be added simultaneously with sensors and components to utilize it better on our design. Also as part of the plan, DHT11 and MQ7 were to be placed on the female socket and no separate footprint and symbols were needed for these sensors. So 4 pin female headers footprints and symbols were one of the requirements to make and place on the design to integrate with these both sensors.

- Also to test some cases and for debugging proposes, some test points or LEDs should be considered before going to layout part.



Rough sketch before schematic

2. Completing the preliminary bill of materials (BOM)

The list of materials includes many commodity parts such as capacitors and resistors, also non-commodity parts such as 16bit ADC1115, 12 bit DAC MCP4725, Ambient Light sensor (ALS-PT19-315C/L177/TR8), Microphone (CMEJ-0415-42-P), Smart LEDs (IN-PI55QATPRPGPBPW-60), Buzzer (AT-1224-TWT-5V-2-R), and some male pin headers as the preliminary Bill of materials.

3. Completing the final schematic capture and final BOM

Ultimately, the schematic was drawn with the planned approach along mentioned in the plan with certain changes wherever needed. Later the final BOM was taken from the schematic which is shown below.

Parts	Description	Designator	Footprint	LibRef	Quantity	LCSC Part#
AT-1224-TWT-5V-2-R	AUDIO TRANSDUCER 5		XDCR_AT-1224-TWT-5	AT-1224-TWT-5V-2-R	1	
ALS-PT19-315C/L177/	Phototransistors 630n	A1	XDCR_ALS-PT19-315C	ALS-PT19-315C/L177/	1	
22uF	22uF ±10% 25V X5R 1	C1	1206_Passive_Capacit	C_22uF_1206	1	C12891
22uF	22uF ±10% 25V X5R 1	C2	1206_Passive_Capacit	C_22uF_1206	1	C12891
22uF	22uF ±10% 25V X5R 1	C3	1206_Passive_Capacit	C_22uF_1206	1	C12891
1uF	MULTILAYER CERAMIC	C4	1206_Passive_Capacit	C_1uF_1206	1	C1848
22uF	22uF ±10% 25V X5R 1	C5	1206_Passive_Capacit	C_22uF_1206	1	C12891
22uF	22uF ±10% 25V X5R 1	C6	1206_Passive_Capacit	C_22uF_1206	1	C12891
22uF	22uF ±10% 25V X5R 1	C7	1206_Passive_Capacit	C_22uF_1206	1	C12891
22uF	22uF ±10% 25V X5R 1	C8	1206_Passive_Capacit	C_22uF_1206	1	C12891
22uF	22uF ±10% 25V X5R 1	C9	1206_Passive_Capacit	C_22uF_1206	1	C12891
22uF	22uF ±10% 25V X5R 1	C10	1206_Passive_Capacit	C_22uF_1206	1	C12891
22uF	22uF ±10% 25V X5R 1	C11	1206_Passive_Capacit	C_22uF_1206	1	C12891
IN-PI55QATPRPGPBPV	Digital Series Cascade I	D1	SERIAL_LED	LED_Smart_5050	1	
IN-PI55QATPRPGPBPV	Digital Series Cascade I	D2	SERIAL_LED	LED_Smart_5050	1	
IN-PI55QATPRPGPBPV	Digital Series Cascade I	D3	SERIAL_LED	LED_Smart_5050	1	
IN-PI55QATPRPGPBPV	Digital Series Cascade I	D4	SERIAL_LED	LED_Smart_5050	1	
IN-PI55QATPRPGPBPV	Digital Series Cascade I	D5	SERIAL_LED	LED_Smart_5050	1	
IN-PI55QATPRPGPBPV	Digital Series Cascade I	D6	SERIAL_LED	LED_Smart_5050	1	
3 PIN	3 2.54mm Straight 1 H	J1	3_PIN_100mil	J_3_PIN_HEADER	1	C49257
MALE	Male header- 6 pin 1 r	J2	6_PIN_100MIL	JF_6_PIN_MALE	1	C37208
MALE 10PIN	Pin Header 10 1 right-a	J3	10_PIN_100MIL	JF_10_PIN_MALE	1	C124372
MALE 8PIN	Pin Header 8 1 right-ar	J4	8_PIN_100MIL	JF_8_PIN_MALE	1	C492407
MALE 8PIN	Pin Header 8 1 right-ar	J5	8_PIN_100MIL	JF_8_PIN_MALE	1	C492407
4-pin header		J6	4pinheader	J	1	
CMEJ-0415-42-P	4.0 Ð¼Ð¼, Ð²ÑÐµÐ½Ð	MK	MIC_CMEJ-0415-42-P	CMEJ-0415-42-P	1	
1k	CHIP RESISTOR - SURF	R1	1206_Passive_Resitor	R_1K_1206	1	C4410
1k	CHIP RESISTOR - SURF	R2	1206_Passive_Resitor	R_1K_1206	1	C4410
10k	10 kOhms ±5% 0.25W	R3	1206_Passive_Resitor	R_10KOhm_1206	1	C17902
1k	CHIP RESISTOR - SURF	R4	1206_Passive_Resitor	R_1K_1206	1	C4410
1k	CHIP RESISTOR - SURF	R5	1206_Passive_Resitor	R_1K_1206	1	C4410
1k	CHIP RESISTOR - SURF	R6	1206_Passive_Resitor	R_1K_1206	1	C4410
1k	CHIP RESISTOR - SURF	R7	1206_Passive_Resitor	R_1K_1206	1	C4410
1k	CHIP RESISTOR - SURF	R8	1206_Passive_Resitor	R_1K_1206	1	C4410
1k	CHIP RESISTOR - SURF	R9	1206_Passive_Resitor	R_1K_1206	1	C4410
10x Probe TP	Test Point 300 mil cent	TP1	TP10x_Probe	TP_10x_Probe	1	
10x Probe TP	Test Point 300 mil cent	TP2	TP10x_Probe	TP_10x_Probe	1	
MCP4725A0T-E/CH	12 Bit Digital to Analog	U	SOT95P270X145-6N	MCP4725A0T-E/CH	1	
DRV5053RAQDBZT	SENSOR LINEAR ANALO	U1	SOT95P237X112-3N	DRV5053RAQDBZT	1	
ADS1115IDGSR	16-Bit ADC with Integr	U2	ADC_ADS1115IDGSR	U_ADC_ADS1115IDGS	1	C37593

Final BOM

4. Completing the board layout and order all the parts.

After the schematic, the board layout part was completed with better routing as possible and short traces of the cross under path connections to reduce the noise as much as possible. (The schematic and layout are both attached on the later section of this report).

5. Completing the assembly.

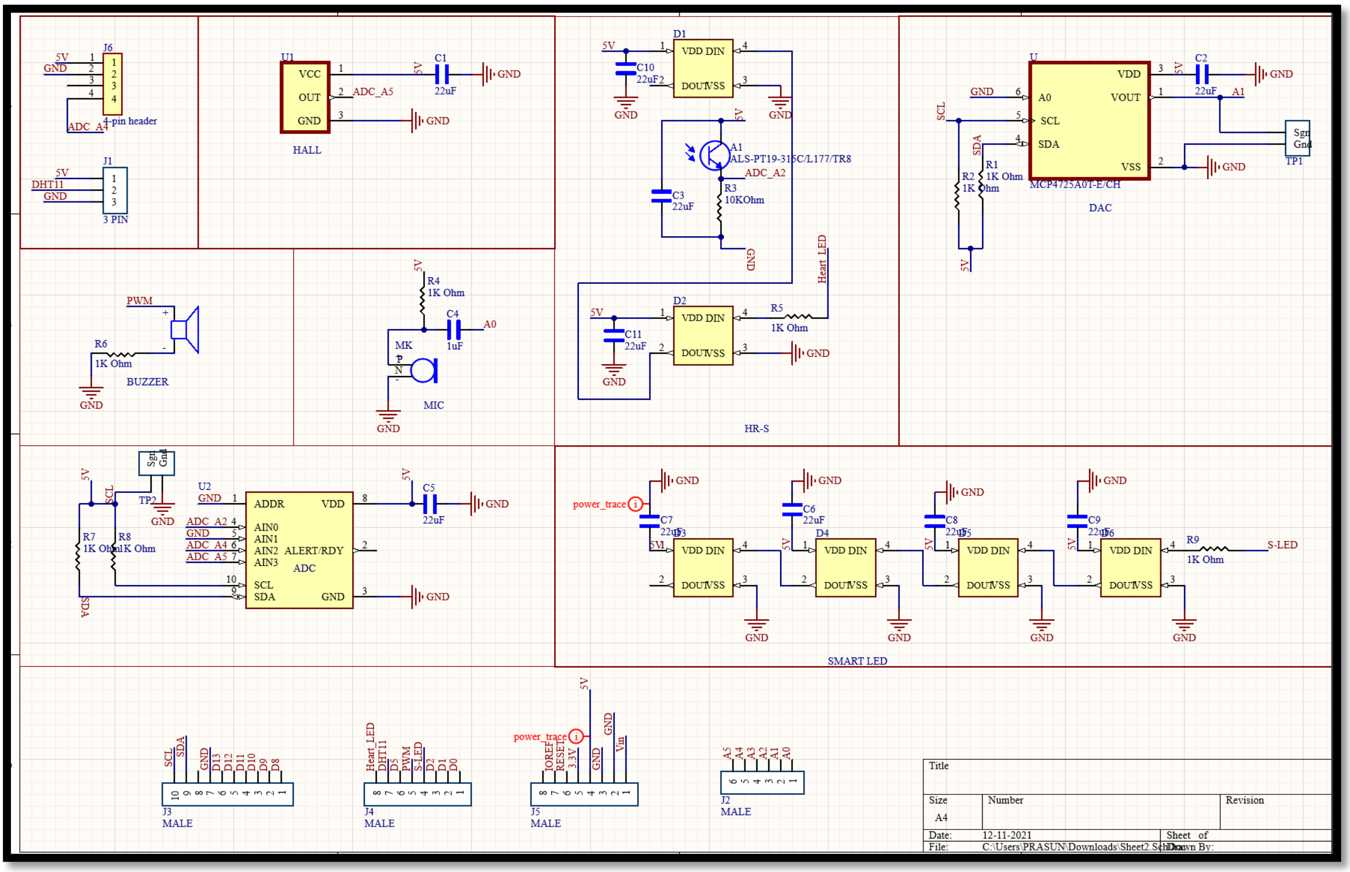
For this board, one of the main tasks was to assemble the board ourselves. So we had taken the required components and soldered ourselves and check the connectivity after soldering to make sure it was solder correctly.

6. Completing the bring up, Troubleshoot, and final test.

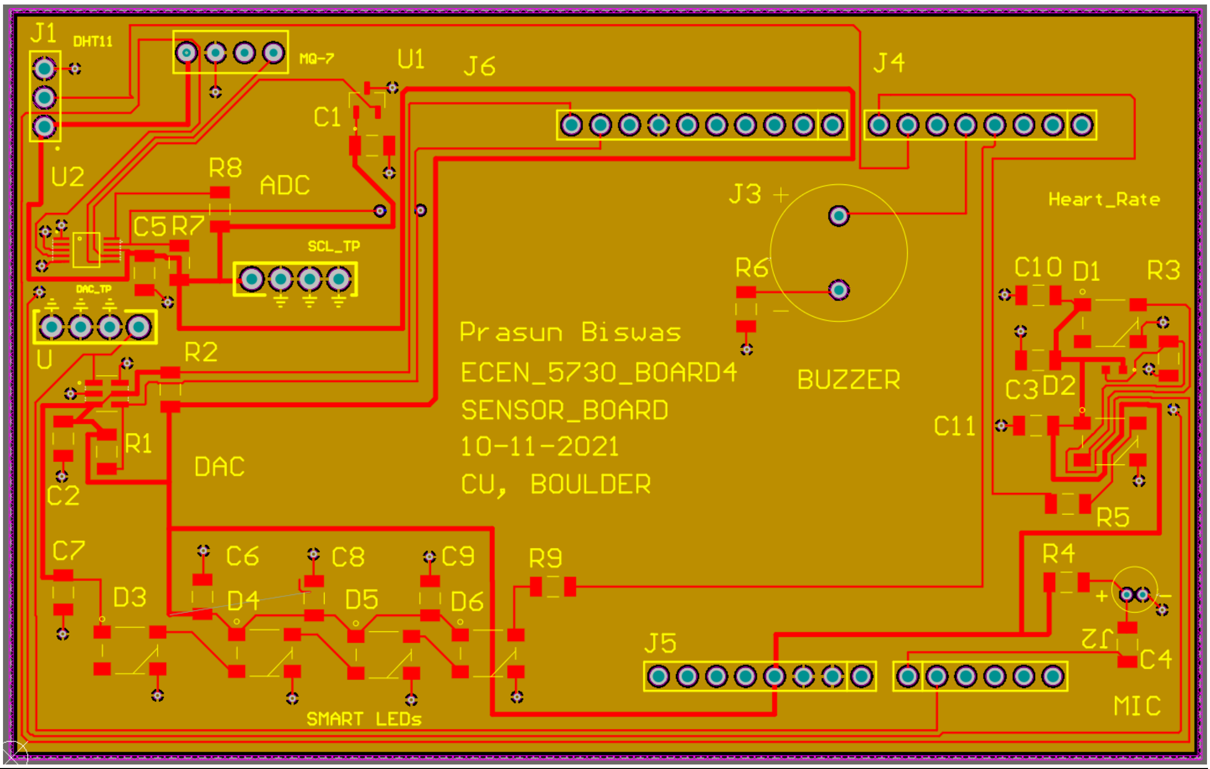
Finally, after the sensor shield was assembled with the required components, it was time to check whether all the sensors were functioning properly or not. Different codes were run on the board for different sensors and components and moreover troubleshooting was also done when some sensors were not running or working as anticipated.

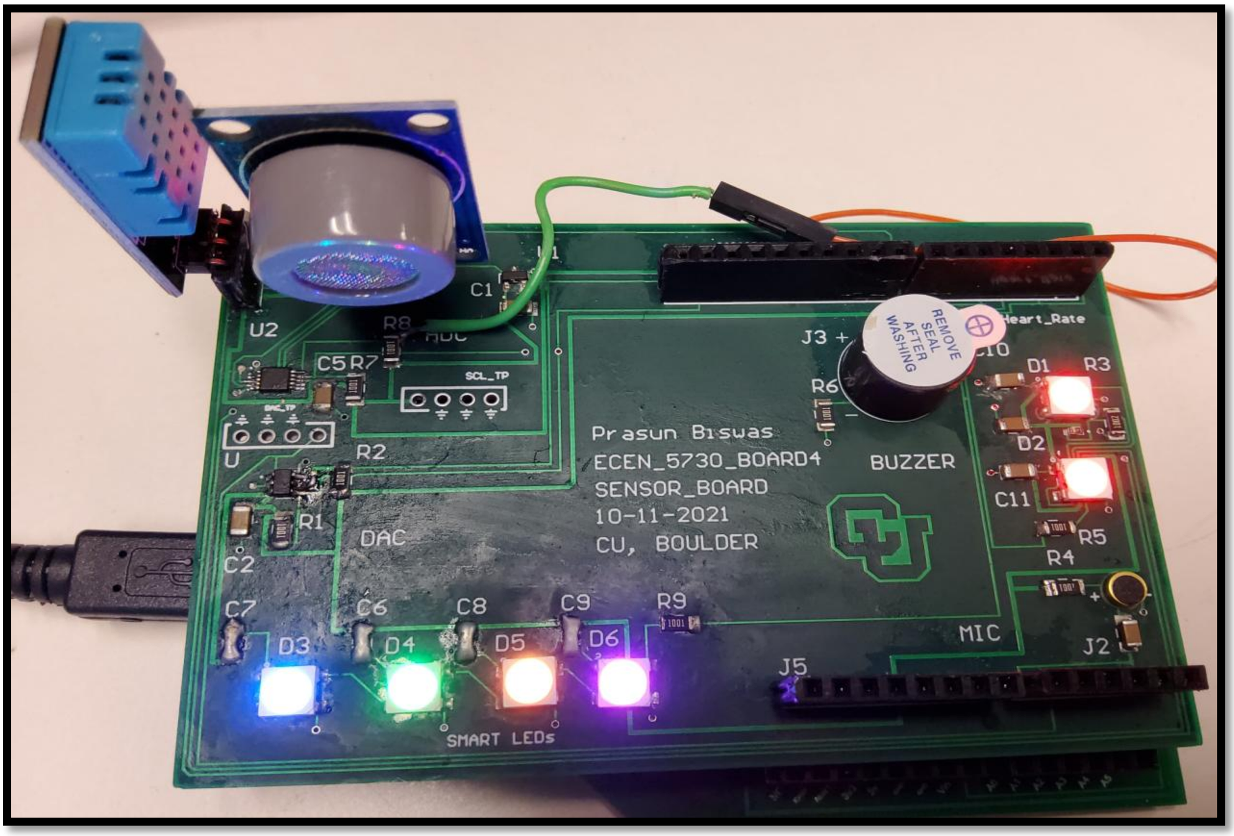
7. Completing the documentation.

Schematic -



LAYOUT-

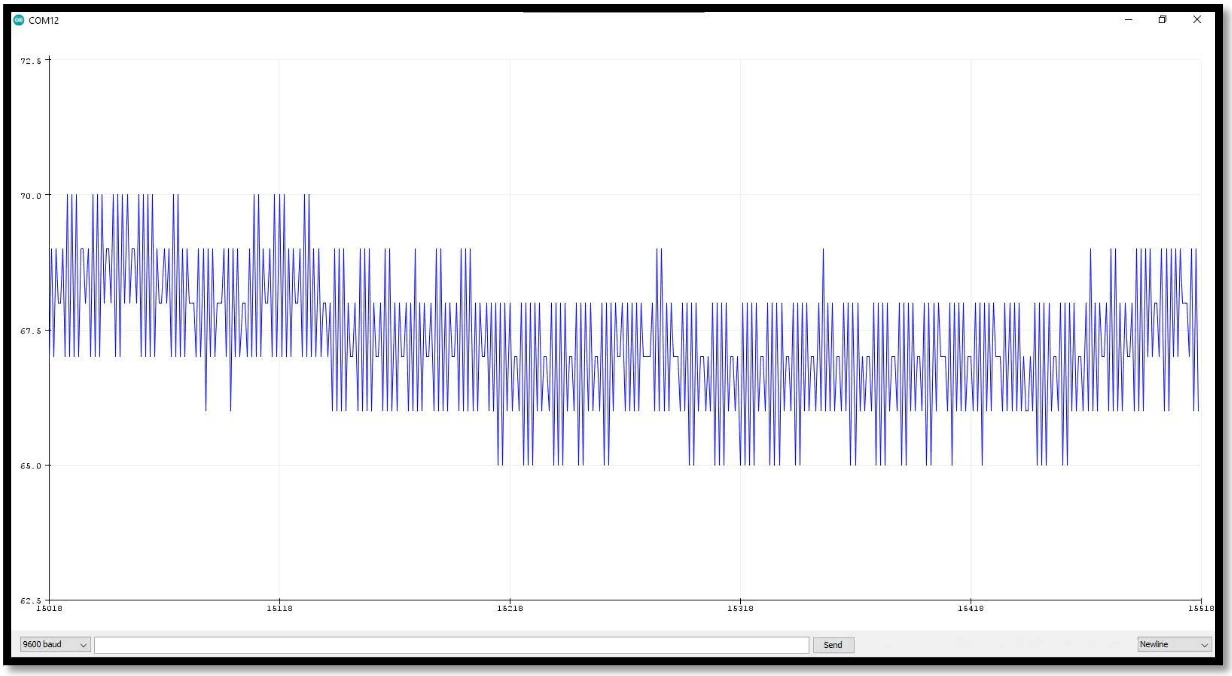




Assembled and powered on board

➤ Functioning Part and Observation

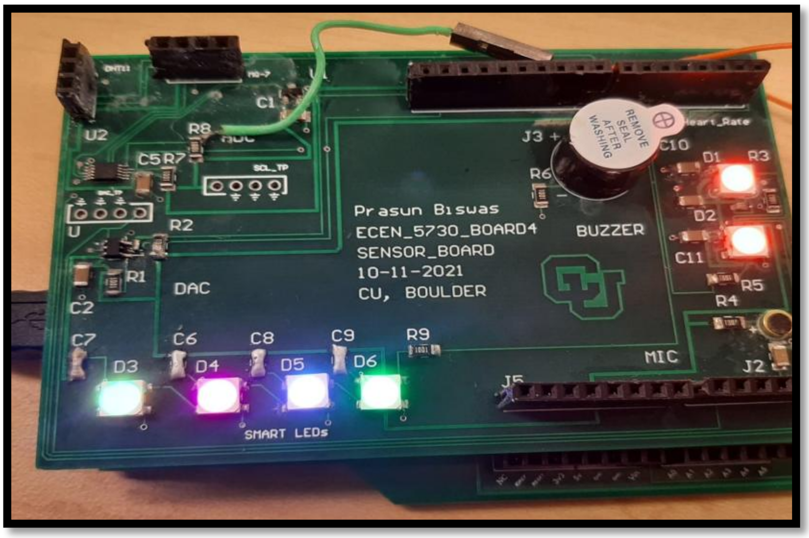
- The heartbeat sensor is using two smart LEDs alongside the phototransistor using the principle of photoplethysmography (PPG). When finger is placed over the two LEDS the light scatter from the finger back to the phototransistor depends on the amount of blood flowing through the finger.
- The capacitor has been connected across to reduce the switching noise when the transistor turns on. I have used a 22 uF capacitor value and a resistor is also used alongside the circuit to convert the current passing through the phototransistor to voltage. The value of the resistor depends on the calculation done for maximum voltage (5V) and maximum current passing (500uA) hence the resistor value is taken as 10k ohms.
- The interfacing of this sensor is done using the differential reading of the sensor which is connected to the A0 and A1 pin of the 16 bit ADC. The ground path has also been connected directly from ADC ground to sensor ground.
- Finally the heartbeat detection code has been checked using running of the differential code in Arduino.



Plotting my heart rate on the serial plotter

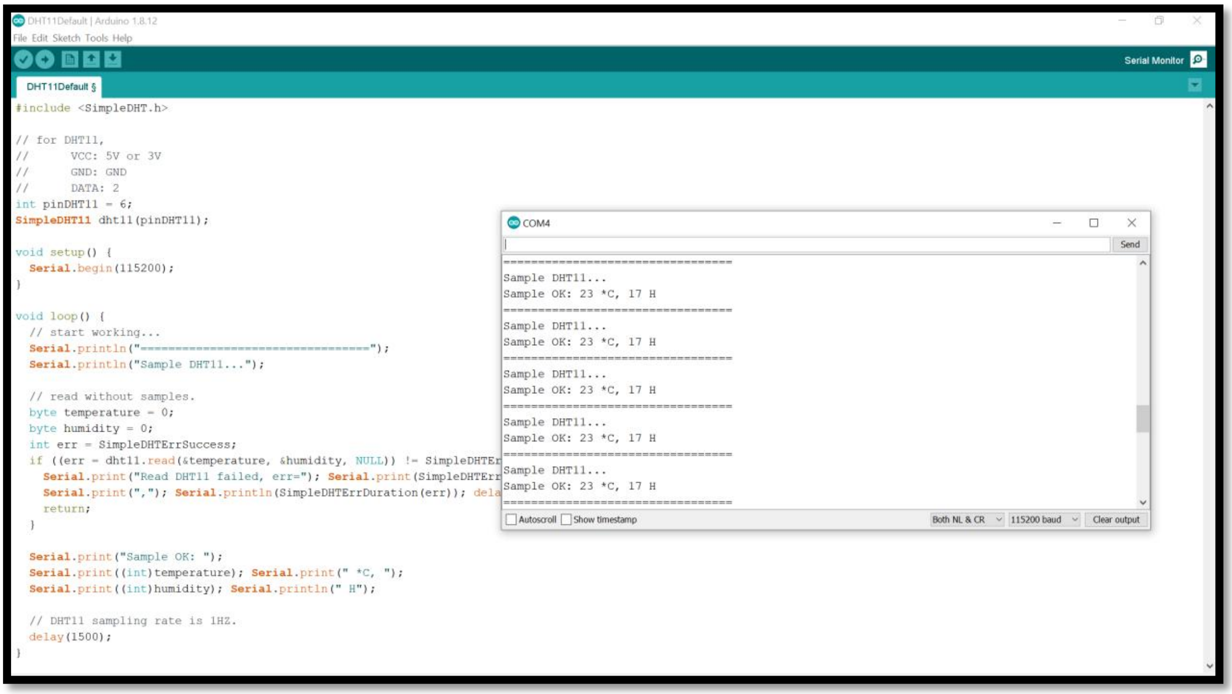
- The smart LEDs are connected to the PWM pins on the digital pin panels so that they can be programmable. 4 Smart LEDs are kept in series and 2 Smart LEDs are taken for the case of the heart beat sensor and are configured in the code separately.

- For running the Smart LEDs code I have used the NeoPixel library and tested with different example but I have used the RGBW Strand test example and configured the LED count and pin number along with brightness to make that run successfully.

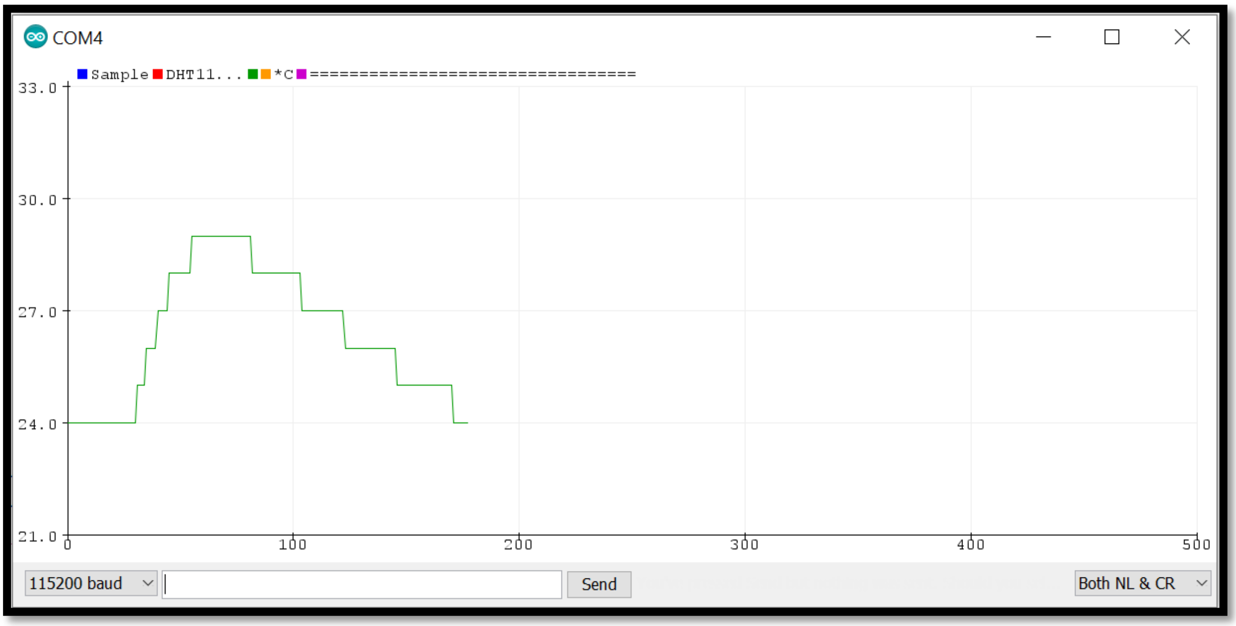


Configured the smart LEDs

- For the temperature and humidity readings, SimpleDHT11 library was installed in the arduino to use the example of it and measuring the DHT11 readings. I have configured the same using the correct pin number done on my board and found the temperature and humidity readings on the serial monitor.



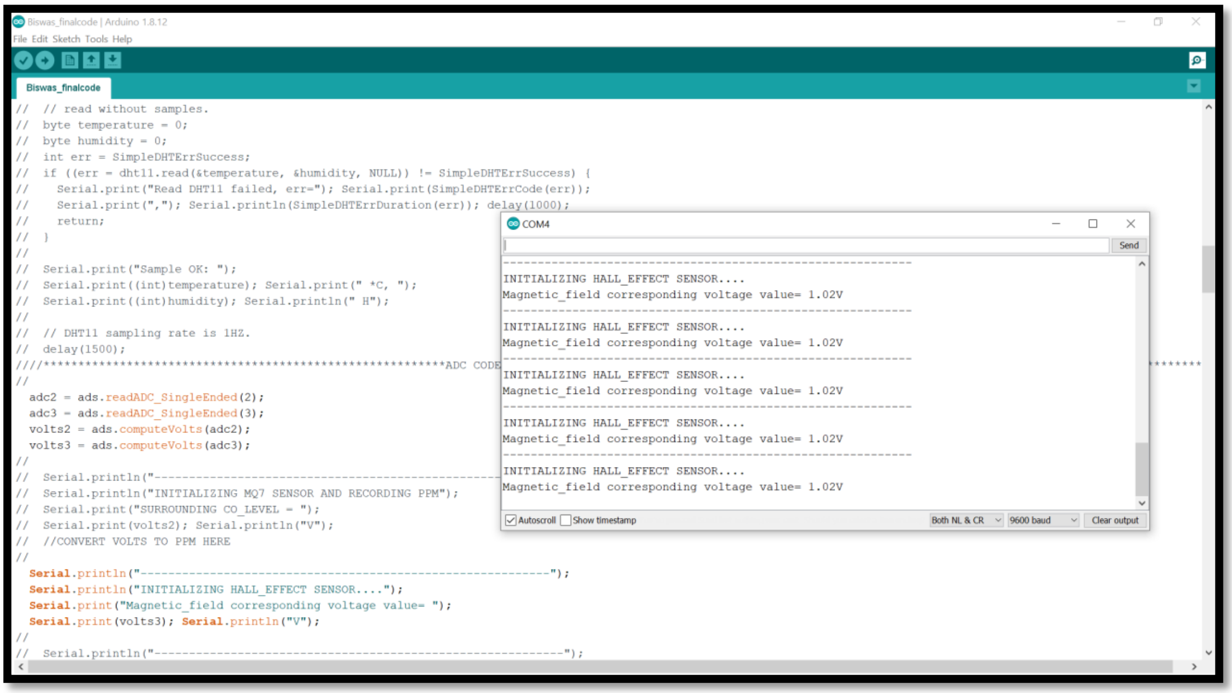
DHT11- Temp and Humidity readings on Serial monitor



DHT11 Temp Plotting on Serial plotter

✓ When a hand is placed over it for certain time the temperature increased as shown and then again decreased slowly when hand is released

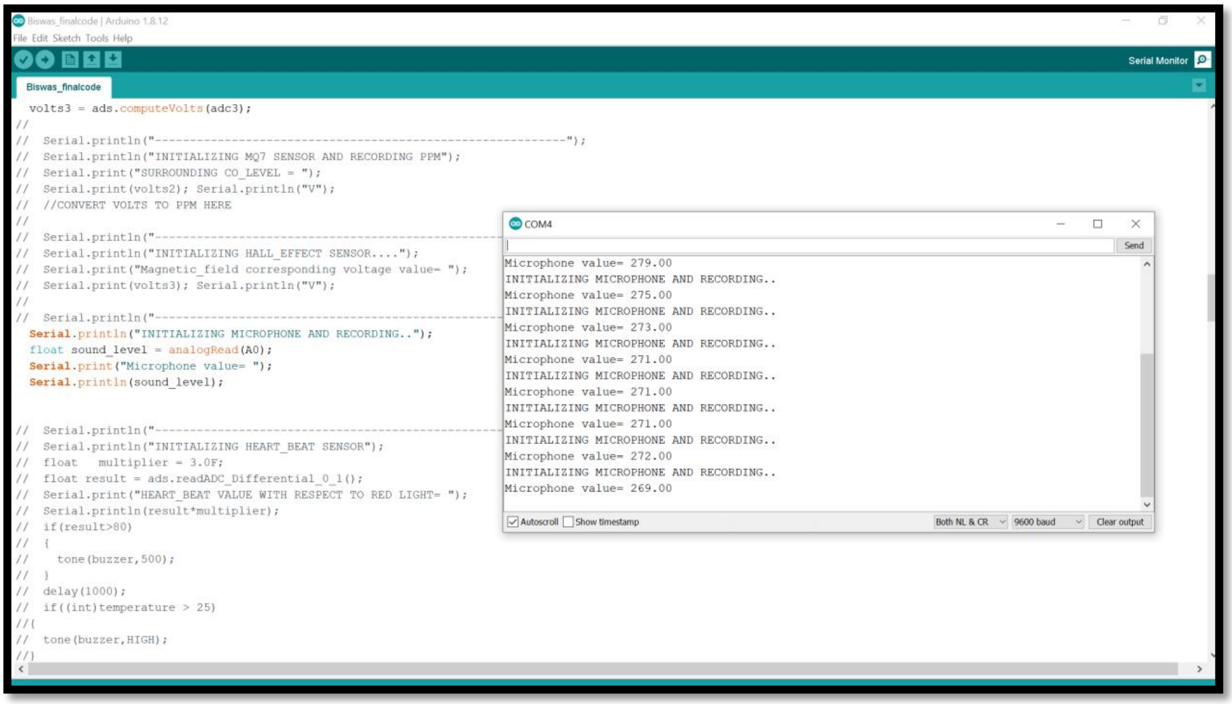
- For Hall Effect sensor, we have configured it using the single ended measurement coming from the ADC. The value in voltage as output is actually equivalent to the magnetic field going around it. The value we will be getting from the sensor will be very less which is why we used the high gain parameters in ADC to get the value in some volts. Currently I am getting approx 1 Volt when there is no magnetic field which is also true as specified in the Hall Effect sensor datasheet. Later while testing, it is found that with an external sensor placed close to the Hall Effect sensor it is giving the output in some change in voltages as anticipate due to the change in magnetic field.



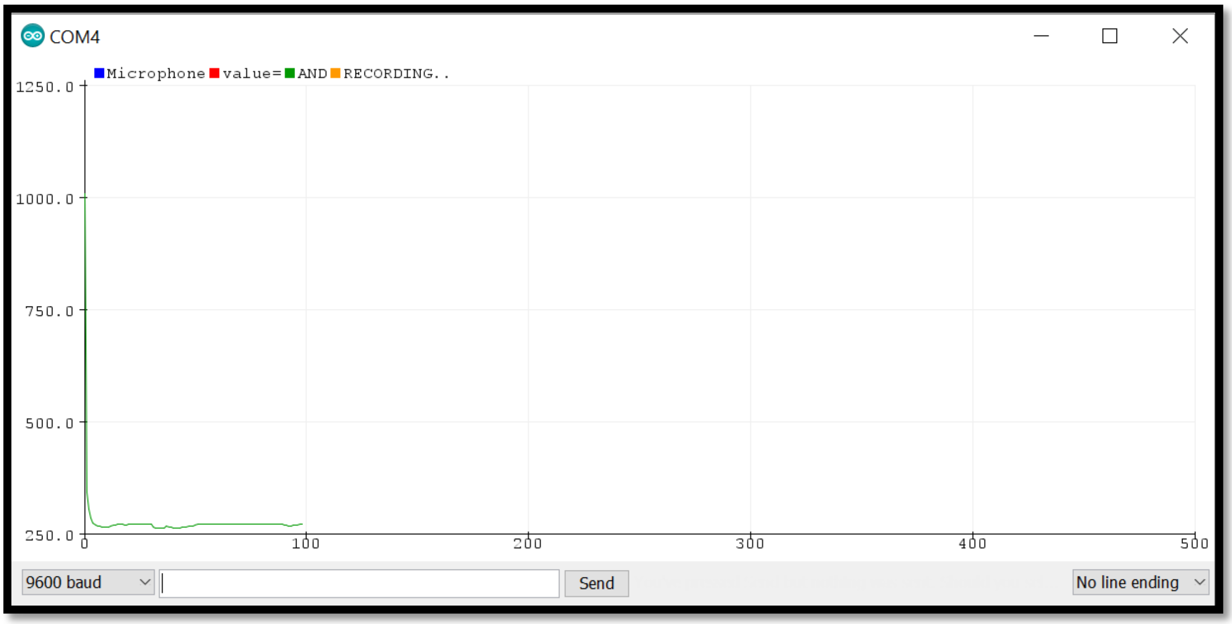
<u>Hall Effect sensor reading on Serial Monitor</u>

- The buzzer is connected to the PWM pin on the digital pin header- (Pin 4). The reason behind using that is getting the modulated digital signal at a modulated frequency if we want to. I am using the tone function in arduino to start it for some time at 5 KHz depending on a threshold value of the temperature and humidity I get.

- The microphone is connected to the analog pin A0. It is being read directly using the analogRead function in arduino.

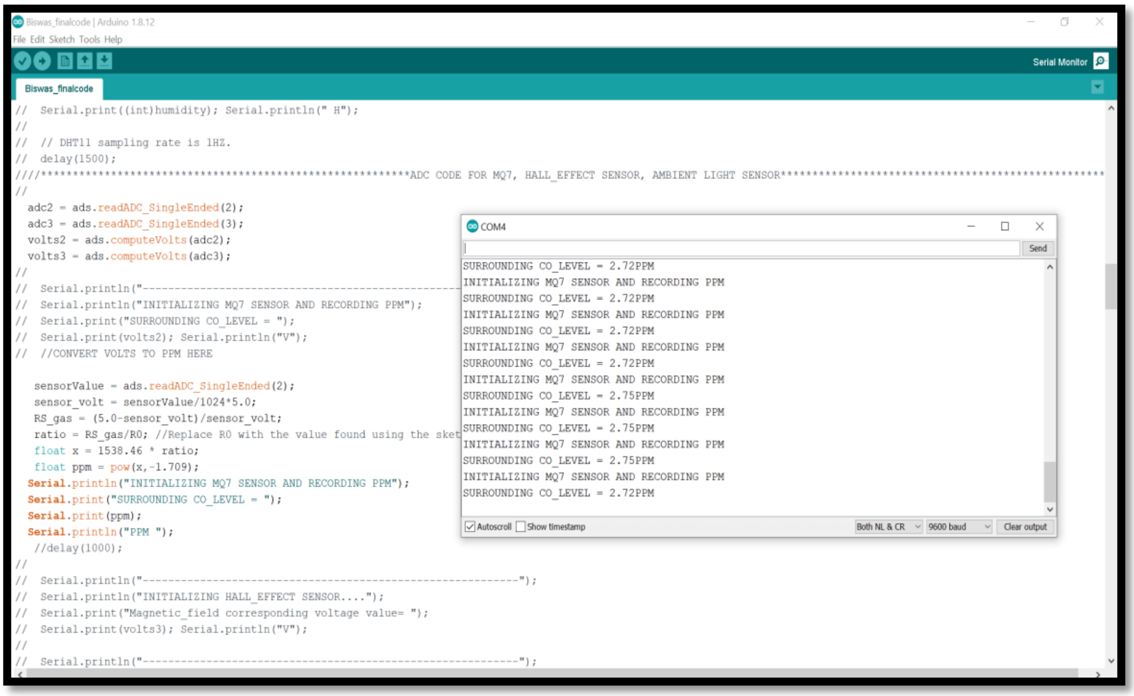


Microphone value on serial monitor



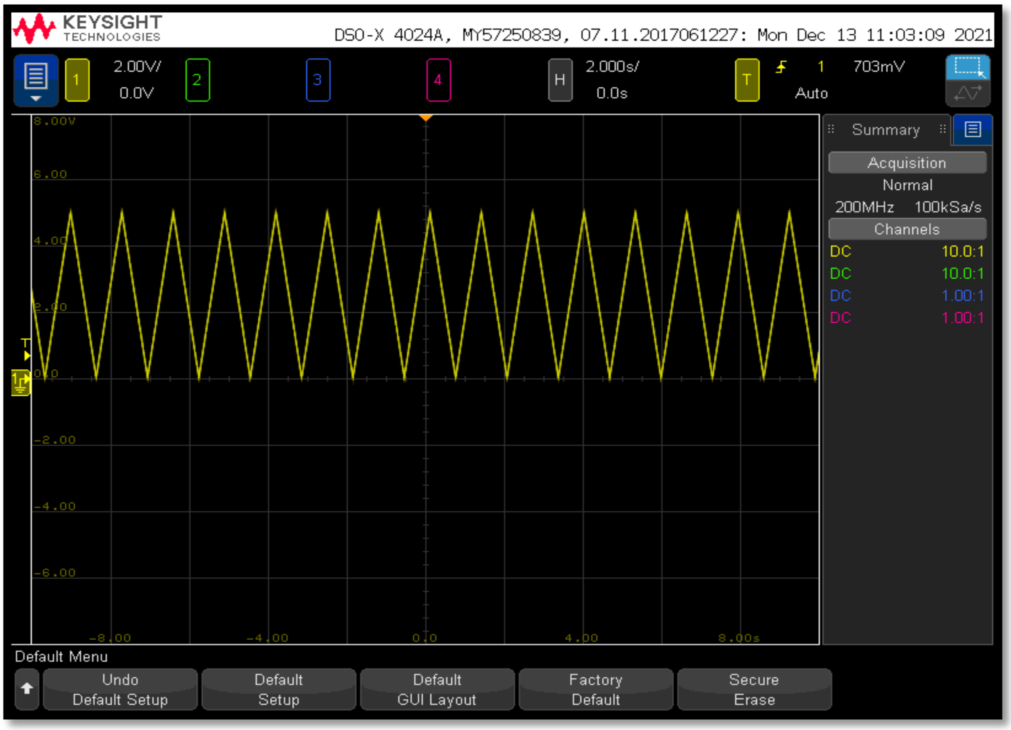
Microphone value on serial Plotter

- The CO sensor (MQ7) is also connected to one of the ADC pin and is also measured using single ended measurement. The ADC value we are getting are computed to volts using compute volt function and later mapped to ppm values with some calculations based on the range of the CO sensor.



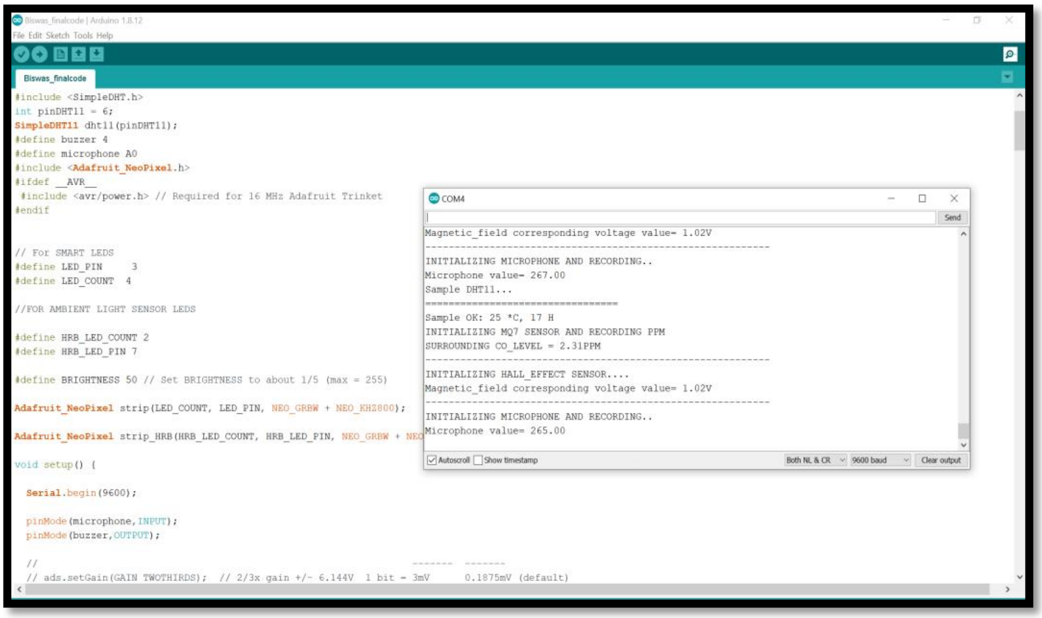
Reading MQ7 values on Serial Monitor

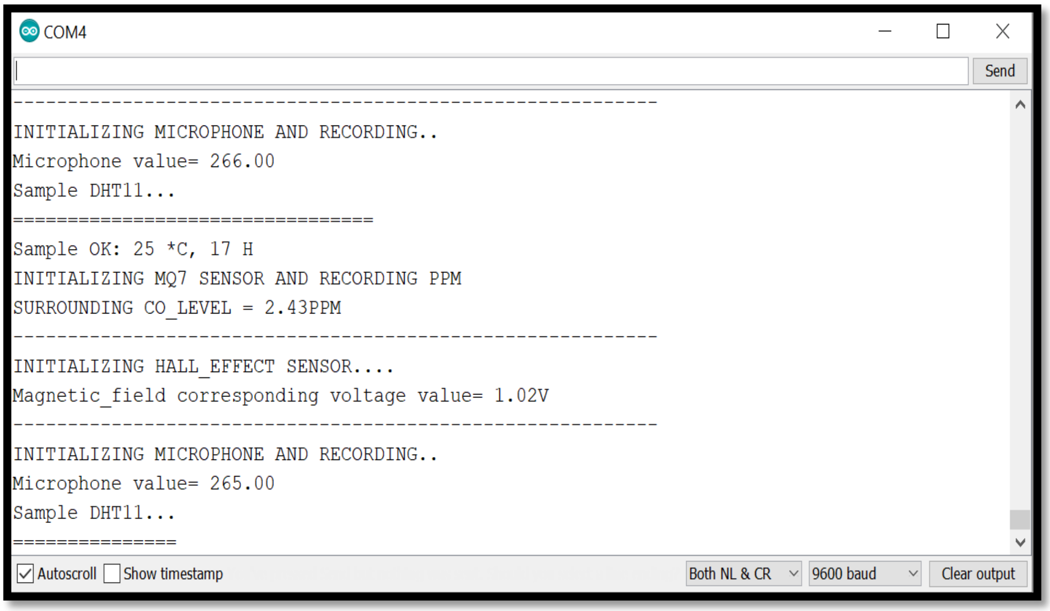
- The DAC output is connected to one of the analog pin and with respect to the code uploaded; a triangular wave was generated and can be seen on the scope as well.



DAC output on Analog pin

Finally all the sensors were integrated together in one single code except the DAC and the output is shown on the serial monitor.





<u>SENSOR READINGS-</u>

Emphasizing on what worked for me and what was a mistake that could be done better the next time.

- In this particular board design I have made two errors:

Firstly, while connecting the decoupling capacitors to the smart LEDs I somehow put that 5v in series with capacitor which was further not allowing the smart LEDs to start after programming because it was not getting the voltage at all. For now I have removed that capacitor and shorted that line using soldering and made those smart LEDs working. I have also corrected that in schematics and layout.

Secondly, I have not made a proper connection from SCL pin of ADC and DAC to the SCL pin on the header which is why even when keeping the shield above the arduino board and checking for the I2C communication the clock signal was not showing a proper output as anticipated. So after debugging that, I had to solder a jumper wire from the SCL pin of ADC and connect that to the SCL pin on the arduino directly to make it functioning properly.

- Apart from that while soldering I found it a bit difficult to solder the components on the left branch of the board because I have placed the components in very close proximity to each other. I would make sure that I should keep some minimal distance between some components to so that it does not create any problem while soldering.

- In addition, I also forgot to add an indicator LED on the board which needed to be added to make sure that the board was getting powered correctly when putting the sensor shield on my arduino.

- Finally, I feel I should also have planned a bit better to place the sensors and components at a much better distance especially the heartbeat sensor because sometimes it was getting difficult to put my finger and take measurements because of the male headers on the both sides which was somehow creating an obstruction.