Heart Rate Monitor with MAX 30105

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**Goals:**

* Display the heartbeat signal in its entirety using the MAX30105 sensor
  + Utilize the MAX30105 Arduino code to interface the sensor
  + Collect and display data from MAX30105 on to the UART terminal
  + Use a BLE module to transmit the data from AVR to host using BLE communication and display the live data on the host
  + Apply smoothing / filtering algorithms to raw data in post-processing

**Deliverables:**

*This final project is intended to implement a particle sensor to process a heart rate while delivering data to the user using Bluetooth technology. The Bluetooth technology allows the optical data recorded to be easily accessible across devices that are both near and far for the user’s convenience.*

# Literature survey[[1]](#footnote-1)

The idea of the “Freshman 15”, gaining 15 pounds during a student’s freshman year, is a tall tale told to incoming college students to scare them away from their campus’s cafeterias to prevent long lines. However, in more recent years, it is an increasingly occurring phenomenon within college students. Due to the consumption of engineered junk foods, physical inactivity, and over-eating during the late night or stressful nights (like finals week), obesity in college students have been on the rise. However, this issue is combatable with something as simple as being knowledgeable in taking care of oneself. Knowledge includes tracking ones BMI (body mass index), their calories in taken, but most importantly, a heart rate. Tracking the heart rate can allow one to monitor their fitness level and potentially spot developing health problems. An optical data sensor like the one in the MAX30105 installed in a smart watch, for example, can provide the user access to their heart health information instantly and through multiple devices using Bluetooth. In turn, this could potentially decrease the user’s chances of being an overweight college student.

Optical pulse detection, also known as pulse oximetry, is the key component to tracking the heart rate with the MAX30105. A pulse oximeter is a device that measures pulse and oxygen saturation in blood levels. This type of sensor contains a light in the red spectrum, infrared spectrum, and green spectrum. To read a pulse, the user may place a finger on to the sensor, so the light frequency can penetrate through the skin and tissue. The device passes two wavelengths of light to a photodetector, and the absorption is measured with a photodiode. The measurement between the absorbed red, green, and IR lights will be different depending on the amount of oxygen in the user’s blood stream. This ratio makes it possible to calculate a heart rate by reading the oxygen levels in the user’s hemoglobin.

The Bluetooth (BLE) HC-06 device plays an essential role in transmitting the data from the AVR to the host using BLE communication. I was unfortunately unable to reach this step, however, in theory, it is supposed to utilize AT commands and correct baud settings to modify the BLE settings. Once the appropriate settings are given to the BLE device and data has been transmitted through Bluetooth, real time heart rate data would be graphed on the Data Visualizer in Atmel Studio 6. This makes it easier for the user to view their heart rate on a computer, or even a phone, so the user can keep track their health.

The MAX30105 uses the Inter-Integrated Circuit (I2C) interface as a communication protocol to interact with the AVR microcontroller. The I2C connects to a bus with two pins, formally named as the Two Wire Interface (TWI) allowing master-slave devices to be connected. The bus features two bidirectional lines, the Serial Data Line (SDA) and Serial Clock Line (SCL). The SDL transfers data among the devices, and the SCL is used to synchronize all the devices and the data transfer together. Stop and start conditions are generated by the master device and it can communicate with multiple devices by addressing device addresses. When the SCL is high and the SDA goes from high to low, it marks the beginning of the transaction with the master and slaves. When the SDA goes from low to high while the SCL is still high, it marks the end of the transaction of that master with the slaves. The device addresses contain 7 bits, and the eighth bit represents a READ or WRITE operation, so the master will be able to determine whether it should READ or WRITE to the slave. The I2C transfers data 8 bits (1 byte) at a time, and after the transfer is complete it is acknowledged by the receiver. The receiver can acknowledge the data transfer by sending an ACK (acknowledge) bit back to the transmitter, or a NACK (not acknowledged) bit. If the ACK bit is sent, the master will read the data sent, but if the NACK bit is set, the slave will halt any communications and the master will regain control.

# Components

## MAX 30105

The MAX 30105 is a particle sensor used to detect a heart rate by detecting oxygen levels in the hemoglobin of the user’s finger. The sensor contains three LEDs (red, green, and infrared) to pulse into the skin of the user, and it can detect the types of materials that shine back. The chip is designed to operate at 5V and communicate with other devices using the I2C interface. The MAX 30105 can also be used as a distance sensor, smoke detection, and eye blink detection, but is not used within this project.

## ATMEGA 328

The ATMEGA 328 is a low-power CMOS 8-bit microcontroller based on AVR C or assembly code. The microcontroller combines 32KB ISP flash memory with reading and writing capabilities, 1KB EEPROM, 2KB SRAM, 23 general purpose I/O lines, 32 general purpose working registers, three timers, programmable USART, SPI, TWI, A/D converter, and an internal oscillator. This microcontroller can carry out instructions within one clock cycle, being the perfect balance between power consumption and processing speed.

## BLE HC-06

The BLE HC-06 is a Bluetooth device that can communicate using its 2.4GHz antenna for wireless transmitting and receiving. This device can operate at 3.3 volts and can display data using UART. It is a Bluetooth class 2 power level, has low power consumption, a high-performance wireless transceiver system, and is offered at a low cost. This Bluetooth device can be applied in a car as a handsfree device, GPS system, PCMCIA, or general data transfer. This project is intended to utilize the later.

# Schematics

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Figure 1: Schematic of the heart rate plotter. The Xplained Mini has a built in FTDI chip

# Implementation

* MAX 30105 utilized I2C to interface itself and to communicate with the ATMEGA 328P. The sensor acted as the slave device that received commands and transmitted data back to the ATMEGA 328P.
  + I2C communication was implemented using the <Wire.h> Arduino library
  + Serial print was used to translate the heartrate data into data displayed in the terminal and graph
    - Xplained Mini supplied 5 volts to the board (xplained has an internal FTDI chip for power)
  + Utilized the Arduino Sparkfun MAX30105 library to translate the code
  + MAX30100 library utilized for main code filtering calculations (dc removal filter & mean/median filter code used)
  + Collected the RR data (beats per minute) and displayed in the terminal of Data Visualizer
* BLE HC-06 module is intended to receive and transmit data to and from the microcontroller.
  + The device is interfaced using AT commands
  + Correct baud rates settings needed to be implemented so the module could work properly
* ATMEGA 328 was intended to link the MAX 30105 with the BLE HC-06.
  + As I was unfortunately unable to use the Bluetooth module, the ATMEGA 328 instead acted as a connection between the sensor and Xplained Mini.

# Snapshots and Links

All snapshots (INCLUDING PICTURES OF FLOW CHARTS):

<https://drive.google.com/open?id=17_apV_VEeNWnyZdA0hA20NXEYDBeLiA->

Video of project implementation: https://youtu.be/GIjEE2mk8kM

Video Presentation: <https://youtu.be/Co3Kc_-ELfg>

# Code

**Main Code**

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References

1. **ATMEGA 328 Datasheet:** <http://ww1.microchip.com/downloads/en/DeviceDoc/Atmel-42735-8-bit-AVR-Microcontroller-ATmega328-328P_Datasheet.pdf>
2. **BLE HC-06 Datasheet:** <https://www.olimex.com/Products/Components/RF/BLUETOOTH-SERIAL-HC-06/resources/hc06.pdf>
3. **MAX 30105 Datasheet:** <https://www.mouser.com/ds/2/256/MAX30105-967526.pdf>
4. **MAX 30105 library and heartbeat library:**

<https://github.com/sparkfun/MAX30105_Particle_Sensor_Breakout>

[5] **MAX 30100 library:** https://github.com/xcoder123/MAX30100

**[6] Obesity in college students facts:** http://www.obesityaction.org/educational-resources/resource-articles-2/weight-loss-surgery/preventing-the-freshman-5-10-15-40

1. [↑](#footnote-ref-1)