Wearable device for measuring Oxygen Saturation, heart rate and the number of steps

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In our implementation, we have used MAX30100 for measuring Heart rate and supply oxygen and MPU 6050 for counting number of steps. We used STM32F407VG discovery board.

MAX30100:

MAX30100 is interfaced with the microcontroller I2C bus protocol with the clock speed of 100khz. Usually, this sensor consists of two LEDs emitting light: one in Red spectrum (650nm) and the other one in Infrared (950nm). This gives us the relative absorbance value of light for each sample. We need IR led data for measuring Heart rate and both IR and RED LED data for measuring spo2. All the registers in MAX30100 are 8 bit. There are 3 configuration registers in MAX30100 they are the mode configuration, spo2 configuration and LED configuration registers. Mode configuration register is used for selecting the mode either Heart Rate or SPO2 if Heart Rate mode selected then IR LED is only enabled and both are enabled in spo2 mode so we can calculate both heart rate and spo2. We set that register in spo2 mode. In spo2 register, we can set the sampling and LED pulse width, which in turn sets the ADC resolution. We used the high-resolution mode in spo2 mode config register in which we set 100 samples per second and 1.6ms pulse width that gives the 16-bit resolution. LED config register can be used for setting the IR and RED led current. We have set RED LED current as 27.1mA and IR LED current as 50mA according to the paper we have studied. There is a data FIFO which can store 64 bytes of data. We can read FIFO_DATA_REGISTER for reading the data from FIFO. Reading this register multiple times automatically increments the read pointer in FIFO in this way we can read FIFO. We enabled Almost Full interrupt in the status register to clear the FIFO when it is full. So every time the data is read by reading the FIFO_DATA_REGISTER 4 times so that we get 16-bit data of both IR and RED data. So each 16-bit data is considered as a sample.

Spo2 value is the ratio of the oxyhemoglobin and deoxyhemoglobin. oxyHb and deoxy-Hb absorb IR and RED light differently. Oxy Hb absorbs more IR light than red light and Deoxy Hb

absorbs more RED than IR light. So by finding the ratio of the RMS values of each sample can be used for calculation of spo2
R = (log(r_rms)*lambda1)/(log(ir_rms)*lambda2);
spo2 = 110 - 20*R;
Spo2 is calculated using this formula.

We tried to calculate the heart rate by using IR data by following some steps. Which are first we removed the dc offset of the sample, uses a mean median filter to get the peaks, used Butterworth filter for removing the higher harmonics. Then we tried to use the same algorithm that we have used for peak detection in step counting and the time difference between two peaks can be used for calculating beats per minute

MPU 6050:
The MPU6050, like the MAX3000, was interfaced with the microcontroller I2C bus protocol with the clock speed of 100khz.
The algorithm for step counting essentially only required values from the accelerometer of the MPU6050, the X, Y and Z acceleration values. It used these values to calculate the net magnitude of the acceleration, as measured by the MPU6050. The above was then normalised with a pre-calculated average magnitude value and passed through a kalman filter. This gave a highly precise value of the acceleration that would then (along with past values of the latter), attempt a “peak detection” to calculate the number of steps. Effectively, every peak that would be detected as per the code would correspond to 1 step. It is to be noted that the peak would have a value greater than a threshold whose value was decided during testing. Using the above, the number of steps would be incremented as and when a peak was detected.

Zigbee:
We tried to use 2 zigbee modules to communicate wirelessly from discovery board to development board to show the real time data. The above used the UART communication protocol for data transmission/reception. The data sent transferred included number of steps, SPO2 values and the heart rate in beats per minute.