Supplementary document for sensors

1. A diagram of a person's body

   Description automatically generatedIntroduction

Figure 1. Overview of each sensor on the body.

Figure 1 illustrates four different sensors on the body, namely skin temperature, hand position, body position, and cadence. The sensors advertise their respective measurements through Bluetooth Low Energy (BLE) protocol to a nearby mobile application, where the measured data is then computed and displayed on a User Interface (UI). A summary regarding the components used, placement and power consumption of each sensor is tabulated in Table 1.

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| --- | --- | --- | --- |
| **Sensor** | **Component Used** | **Body Placement** | **Average Power Consumption (uW)** |
| Skin Temperature | TMP117 | Abdomen | 14.91 |
| Body Position (Standing) | Force-Sensing Resistor (FSR) | Upper thigh and glutes | 44.42 |
| Body Position (Seating) | Force-Sensing Resistor (FSR) | Upper thigh and glutes | 415.90 |
| Cadence | LIS2DW12 | Lower thigh | 127.90 |
| Hand Position | LSM6DSM | Forearm | 791.33 |

Table 1. The component used, body placement, and average power consumption of each sensor.

To obtain the average power consumption of each sensor, capacitors were used to determine the energy over time, where the energy, E is computed from:

C is 1.32mF and V is the voltage. The capacitor without a load has a loss of 8.86uW, which was taken into consideration when computing the average power for each sensor.

1. **Skin Temperature**

A graph showing a charge battery

Description automatically generated with medium confidenceA digital temperature sensor, TMP117 was selected and used due to its low operating current of 3.5uA. In addition, this sensor has a range of -55°C to 150°C, with a resolution of 16-bit (0.0078°C). The sensor is placed on the abdomen of the cyclist. Based on Figure 2, the average power consumption was found to be 14.91uW and a discharge time of 185.78s. A snippet of a BLE advertisement was also shown in Figure 2.

Figure 2. The capacitor discharge voltage and power consumption of a TMP117 sensor.

1. **Hand Position**

A graph of a power line

Description automatically generatedLSM6DSM was chosen to determine the arm position of the cyclist, where the sensor is placed on the forearm, close to the wrist. This sensor comes with a 3-axis digital accelerometer and a gyroscope, which enables it to determine top, drop and road signals. The discharge duration of the capacitor was found to be 5.52s, with an average power consumption of 0.79mW, as depicted in Figure 3.

Figure 3. The capacitor discharge voltage and power consumption of a LSM6DSM sensor.

1. **Body Position**

A graph with red lines and blue lines

Description automatically generatedA pair of force sensing resistances (FSR) were placed on either side of each glute to determine the position of the user seated or standing. The more the force applied onto the FSR, the lower the resistance. Thus, the resistance is inversely proportional to the applied force. Based on Figure 4, the capacitor discharge duration was found to be 10.47s and 83.44s for seating and standing. Additionally, the average power consumption was computed to be 0.42mW and 53.29uW, respectively.

Figure 4. The capacitor discharge voltage and power consumption for seating and standing.

1. **Cadence**

A graph showing a number of capacitors

Description automatically generatedA 3-axis accelerometer, LIS2DW12 was selected and used to measure the cycling cadence of the cyclist, where the sensor is placed at the lower thigh, above the knee. This sensor has an ultra-low current consumption of less than 1uA in active state and a 16-bit output data. The computed average power consumption based on Figure 5 was found to be 0.14mW and a discharge time of 32.34s.

Figure 5. The capacitor discharge voltage and power consumption of a LIS2DW12 sensor.