|  |  |
| --- | --- |
| **9V Alkaline Battery (3 Points)** | |
| 1. Must supply voltage that is above the dropout range of the voltage regulator at a current draw of up to 100mA (2pt) | 1. Design a variable load test circuit with the multimeter monitoring the voltage across the supply  2. Tune the load resistance to adjust the load current to 100mA, measure the supply voltage drop and check if it is above the 4.3V margin(regulator voltage plus dropout voltage); |
| 2. The battery needs to support normal operation of the device for at least 1 hour (1pt) | 1. Connect a load to the battery that draws consistent current;  2. Check if the voltage of the battery is above 5V after 1 hour. |
| **Voltage Regulator (5 Points)** | |
| 1. Output voltage must be regulated to +3.3V ± 5% at a range of current draw (up to 100mA) as required by the modules (5pts) | 1. Connect the multimeter across the voltage regulator;  2. Check if the voltage drop between the input and output of the voltage regulator matches specification;  3. Use multimeter to track if the output voltage is stable;  4. Adjust the load current to 15mA and 30mA, respectively, repeat the above process. |

Table 5: Power Supply Unit RV Table

|  |  |
| --- | --- |
| **Status LED (0 Points)** | |
| 1. At forward current of 10mA, the LED should emit red light and visible at direct viewing angle | 1. Connect the LED in series with a 330 Ohm resistor;  2. Use the multimeter to measure current through the LED;  3. At 10mA, make sure the LED light is visible from direct viewing angle |

Table 6: Status LED RV Table

|  |  |
| --- | --- |
| **Sync Button (0 Points)** | |
| 1. Buttons should be debounced and should indicate correct signal transition upon pressed | 1. Connect the button in series with a 330 Ohm resistor;  2. Supply 3.3 V;  2. Use the oscilloscope to monitor the voltage transition across the resistor, make sure the signal is debounced and correspond to correct digital value (digital “High” when pressed and “Low” when released) |

Table 7: Buttons RV Table

|  |  |
| --- | --- |
| **Requirements** | **Verification** |
| **AVR Microcontroller (15 Points)** | |
| 1. Module is capable of running UART at a baud rate of 115200 (3pts) | 1. Program the AVR to send 0x55 repetitively through the UART Tx pin 2. Probe the Tx pin with the oscilloscope 3. Verify the presence of a square wave with each pulse lasting ~8.68µs |
| 1. Device is capable of writing text files to the microSD card that can be read from a PC (7pts) | 1. Write a simple test program onto the AVR that uses the roland-riegel MMC/SD/SDHC card library to write 16-bit signed integers onto the microSD card 2. Verify on the PC that the number are readable and consistent with what was written |
| 1. Device is capable of monitoring the voltage of the battery when the MOSFET is ON. The reported voltage should be within ± 5%.(2pt) | 1. Get readings from the analog pin 25 that reports the voltage of the battery by using the formula Vbattery = 3\*Vadc;  2. Check if the voltage matches voltmeter readings. |
| 1. Device is capable of receiving data from the IMU via I2c at a minimum bitrate of 5580 bps (calculated requirement for maintaining the target 180 Hz sampling rate) (3pts) | 1. Orient the IMU such that the gyroscope has a constant non-zero reading  2. Pull data from the IMU at 180 Hz for a second  3. Verify that the quantity and validity of data received meets expectations |

Table 8: Microcontroller RV Table

|  |  |
| --- | --- |
| **Bluetooth Module (5pts)** | |
| 1. Module is capable of receiving and transmitting over UART at a baud rate of 115200 (4pts) | 1. Program an Arduino to start serial communication at the baud rate of 115200 2. Use the Arduino to program the Bluetooth module to operate at baud rate 115200 3. Connect the Bluetooth module to an Arduino (Tx->Rx, Rx->Tx) 4. Short the Tx and Rx pins 5. Pair computer with Bluetooth module 6. Use a terminal program (eg. puTTY), connect to the correct serial line at baud rate 115200 7. Verify that what’s typed into the terminal is echoed back. If so, the loopback test is successful |
| 2. Two of such modules are capable of performing at the speed mentioned above when placed 2 ± 5% meters apart (1pt) | 1. Repeat steps 1-6 from the verification above 2. Pre-populate a string field of length 115200kb 3. Move the HC-05 2 meters away from the testing PC 4. Send the pre-populated string and check for accurate echo response |

Table 9: Bluetooth RV Table

|  |  |
| --- | --- |
| **Accelerometer (5 Points)** | |
| 1. Accurate data output such that location tracking is within 5 cm of accuracy. Ensures accurate data for analysis | 1. Download the phone app Sensor Kinetics, by INNOVATIONS, Inc. from iOS’s app store or Android’s Play Store. The Pro version is required  2. Connect the accelerometer to a microcontroller. Load test code onto the microcontroller. The test code will collect and store data from the accelerometer  3. Open the Sensor Kinetics app and press the graph button to the right of the “Accelerometer Sensor” header. This will bring the app to the accelerometer tracking mode.  4. Attach the accelerometer to the phone so it that it will not move when the phone is in motion.  5. Start the data collection for the phone app and the microcontroller at the same time. Then grab the phone and move around with varying speeds; shaking the phone and sweeping the phone in all directions.  6. After about 10 seconds stop the data collection for the phone and the microprocessor at the same time.  7. On the phone app, press the downward arrow at the top right and then press” Files & Sharing” to view the data collected from the phone’s accelerometer  8. Compare the data collected from the phone and accelerometer to verify that the specification is met |
| 3. Samples at a rate of at least 180 Hz in order to give enough resolution to represent movement | 1. Connect the accelerometer to the microprocessor and load a test code that will collect and log the data from the accelerometer  2. Obtain a stopwatch to record the time data is collected. Collect data for 10 seconds.  3. Analyze the data collected to ensure that there are enough entries to meet the requirement of 180 Hz (for 10 seconds example there should be at least 1800 entries) |
| **Gyroscope (5 Points)** | |
| 1. Accurate up to ± 7 degrees in order to assure accuracy in data | 1. Download the phone app Sensor Kinetics, Pro version, by INNOVATIONS, Inc. available from iOS’s app store or Android’s Play Store.  2. Connect the gyroscope to a microcontroller. Load test code onto the microcontroller. The test code will collect and store data from the gyroscope  3. Open the Sensor Kinetics app and press the graph button to the right of the “Gyroscope Sensor” header. This will bring the app to the gyroscope tracking mode.  4. Attach the gyroscope to the phone so it that it will not move when the phone is in motion  5. Start the data collection for the phone app and the microcontroller at the same time. Then grab the phone and move around with varying speeds; twisting the phone and sweeping the phone in all directions.  6. After about 10 seconds stop the data collection for the phone and the microprocessor at the same time.  7. On the phone app, press the downward arrow at the top right and then press” Files & Sharing” to view the data collected from the phone’s gyroscope  8. Compare the data collected from the phone and gyroscope to verify that the measurement is within ± 5 degree difference |
| 2. Samples at a rate of at least 180 Hz in order to give enough resolution to represent movement | 1. Connect the gyroscope to the microprocessor and load a test code that will collect and log the data from the gyroscope  2. Obtain a stopwatch to record the time data is collected. Collect data for 20 seconds.  3. Analyze the data collected to ensure that there are enough entries to meet the requirement of 180 Hz (for 20 seconds example there should be at least 3600 entries) |

Table 10: IMU RV Table

|  |  |
| --- | --- |
| **Force Sensitive Resistor and Low-pass Filter (12 Points)** | |
| 1. Pressure measurement range needs to be from 1psi to at least 6.409psi (Equivalent: force measurement range needs to be between 14-90N);  The measurement needs to be within ±10% of the theoretical value at the two boundary values. (4pts)  \*see derivation of the values used here in the calculation and simulation section | 1. Place the FSR on a flat surface and connect the FSR in series with a 20 kOhm reference resistor Rref;  2. Supply 3.3V voltage across the two resistors;  3. Place a 1.4kg weight on top of the FSR;  4. After the readings stabilize, measure the voltage drop across the reference resistor, Vref;  5. Find VFSR by using the relation VFSR = 3.3V - Vref and then find the current across the components I = Vref / Rref;  6. Use the voltage and current found to calculate FSR resistance, compare with theoretical value and check if it is within 10% error margin;  7. If the value does not match the standards, change the weight until the value meets the requirement, record the adjusted value and check if it is among a reasonable range;  8. If the value matches the standards, move on to replace the 1.4kg weight with a 9.2kg weight and repeat the above steps. |
| 2. Measurement result needs to be accurate within ±10% of the theoretical value (3pts) | 1. Select 5-10 weight values between the two threshold values;  2. Repeat the same steps as specified in part 1 of FSR verification and record the corresponding measurements;  3. Use the values obtained to plot the Pressure vs Force curve, fit a trend line;  3. Check if the trendline matches theoretical curve as shown in Fig. 4 and the points have less than ±10% error. |
| 3. Must draw current less than 1uA at resting state (2pt) | 1. Supply 3.3V voltage across the resistor;  2. Measure the current drawn from the supply using the multimeter; |
| 4. The low-pass filter must have -3dB frequency of 20Hz ± 10%; (3pt) | 1. Use the function generator to generate a sinusoidal input with amplitude of 50mV at frequency of 5Hz and slowly increase the frequency to 30Hz while using the oscilloscope to monitor the amplitude;  3. When the amplitude dropped to , verify that it is within ± 10% of 20Hz. |

Table 11: FSR RV Table