Senior Design 2018/2019

Notorious EMG

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Test Plan

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Specification Test Plan – ***You should have one table for each test***

Team/Project:	Notorious EMG/Muscle Guide
Test Name:	Wire Length
Test ID Number:	T001
Relevant functional specification(s) being tested:	S001 – Wire Length
Type of test (circle)	Black Box White Box
Purpose of test and test summary including number of replicates of test	The purpose of this test is to ensure that the user is not subjected to unsafe conditions resulting from loose wires becoming entangled. A visual inspection of the wearable EMG unit will suffice for verifying if the specification can be met. First, don the conductive sleeve. Line the enclosure up with the cable-electrode snaps and lower it into place. Connect the EMG cables to the snaps and to the PCB, then verify that all cables are contained within the enclosure and secure the lid in place. Observe the unit with the aid of a mirror or any such device that will allow for a complete visual inspection of the unit while it is being worn. If the entire package is completely contained within the enclosure with no external wires visible, then S001 will be met. Unless concerns warrant a second iteration, one visual inspection of the EMG unit should suffice.
Equipment List:	Conductive Sleeve, EMG Enclosure, EMG Cables, PCB, Mirror (if required)
Necessary dummy inputs, their source, and mechanism for validation of dummy inputs:	Inputs are not required for this test as it is simply a visual inspection to ensure that there are not any external wires on the EMG unit.
Description and / or images of test setup	First, slide the conductive sleeve onto your arm. Line the enclosure up with the electrode cable snaps on the sleeve and place the snaps into the enclosure. Snap the respective signal cables onto the button snaps and connect the other end of the cables to the correct pins on the PCB. Secure the lid in place and observe the EMG unit from several different viewing angles to ensure that there are not any external wires visible.
Inputs or input ranges to be used (include number or test points and increments)	Inputs are not required for this test as it is simply a visual inspection to ensure that there are not any external wires on the EMG unit.
Anticipated results/outcomes	If no external wires are visible after observing the EMG unit from several different viewing angles, then S001 can be considered met.

Team/Project:	Notorious EMG/Muscle Guide
Test Name:	Sleeve Conductivity
Test ID Number:	T002
Relevant functional specification(s) being tested:	S002 – Sleeve Conductivity
Type of test (circle)	Black Box White Box
Purpose of test and test summary including number of replicates of test	The purpose of this test is to verify that an electrical connection exists between the wearable sleeve and the internal electronics. Specifically, this test will ensure that the sleeve will detect the muscle signal at the surface electrodes and transmit it through the electrode cables to the SCU. This test will verify if continuity exists between the button snaps and surface electrodes. This test will be done with the use of a multimeter. Place the multimeter leads between button snap and surface electrode with the meter set to check continuity (an electrical path for current to flow). If there is continuity, then the meter will display 0 on the screen and may be accompanied by an audible tone. Repeat this test three times and conduct each test after the sleeve has been subjected to conditions that would be expected during normal use such as fabric movement coinciding with arm movement. Note that you will have completed nine tests if you have tested three buttons/electrodes each three times. This will ensure that movement between tests has not broken the electrical connection between the button snap and surface electrode.
Equipment List:	Conductive Sleeve with Button Snaps, Digital Multimeter
Necessary dummy inputs, their source, and mechanism for validation of dummy inputs:	No dummy inputs are required; the multimeter will provide the necessary input to the circuit to then output whether two items are electrically connected.
Description and / or images of test setup	Place the conductive sleeve onto your arm as if you were preparing to use the product. This will undoubtedly subject the conductive thread securing the conductive fabric to the elastic sleeve to stress. While this is not desirable it is unavoidable, and it must be determined that this does not break the electrical connection. Remove the sleeve and connect the multimeter leads between the conductive strip of fabric and the electrode button snap. If the connection is intact then the meter will display 0 ohms of resistance and may be accompanied by an audible tone. Check the connection between each of the three button snaps and conductive fabric three times while ensuring that the sleeve is subjected to comparable conditions expected during use between tests (movement).
Inputs or input ranges to be used	No inputs are required for this test. The digital multimeter will output the required input of approximately 1 mA of current.

(include number or test points and increments)	
Anticipated results/outcomes	The test passes if the digital multimeter displays 0 or near 0 on the screen. Further, most multimeters will beep if continuity exists. If there isn’t a beep, then the feature is either disabled or unavailable on that specific meter.

Team/Project:	Notorious EMG/Muscle Guide
Test Name:	Battery/Electrical Safety
Test ID Number:	T003
Relevant functional specification(s) being tested:	S003 – Current Exposure S006 - Battery/Electrical Safety
Type of test (circle)	Black Box White Box
Purpose of test and test summary including number of replicates of test	The purpose of this test is to ensure that the user is not subjected to unsafe conditions resulting from current back feeding through the electrode cables from the PCB or fire resulting from unapproved energy sources. This test will be done by placing three meters in series with the three electrode cables. Circuit protection on the PCB will ensure that potential leakage current does not backflow, so the meter will be used to ensure that a constant flow of current is not detected through any electrode cable. Since the EMG signal is registered as a spike on the oscilloscope, any constant flow of current indicates that the circuit is malfunctioning. Since the meter needs to be placed in series, the enclosure lid will need to be removed to provide access to the electrode cable connection at the PCB. This test does not need to be repeated. If leakage current isn't detected, then the incorporated circuit protection is working as designed by diverting stray currents away from the user's arm and to the floating ground. S006 can be considered a partially successful test if circuit protection exists. For S006 to be considered a fully successful test then the power source will need to have been obtained from an authorized retailer of approved consumer products. In other words, if the lithium-ion polymer batteries were obtained from an authorized retailer then the batteries were previously approved by UL 2595 – Underwriter's Laboratory Standard for Safety for General Requirements for Battery-Powered Appliances. The commercially-available batteries construction and test requirements are evaluated by the standard and previously-approved batteries are considered to provide adequate and effective protection against electrical shock and risk-of-fire.
Equipment List:	EMG Unit (Conductive sleeve, PCB, 3.7 V – 300 mAh battery), Multimeter
Necessary dummy inputs, their source, and mechanism for validation of dummy inputs:	Dummy inputs are not required for this test.

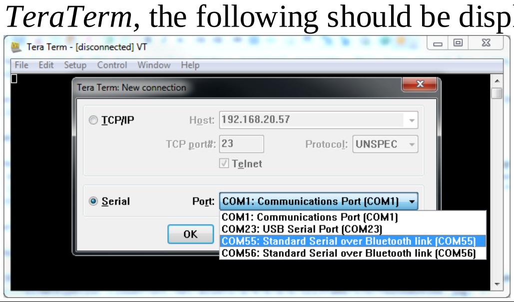
Description and / or images of test setup	Remove the lid from the enclosure. Disconnect each of the electrode cables from the PCB and then reconnect each of the electrode cables to the PCB with each of the three multimeters in series. This can be accomplished by disconnecting the electrode cable from the PCB and then connecting one multimeter lead to the electrode cable and the other to the PCB. This will allow current to flow from the PCB and through the meter, should any exist. Next, connect the battery to V_{in+} and V_{in-} and carefully connect the electrode cables to the button snaps (if not previously accomplished). Ensure that the meter is set up to measure current and observe the meter display while closing the push-button switch. With the switch closed no current flow should be detected with the multimeter.
Inputs or input ranges to be used (include number or test points and increments)	The only input for this test is the power source for the EMG unit: 3.7 V, 300 mAh Lithium-Ion Polymer Battery.
Anticipated results/outcomes	Constant current flow will immediately indicate test failure. With the meter connected in series between electrode cables and the PCB a reading of 0 A is expected for this test. Any other non-zero reading indicates that current is back feeding from the PCB and into the user's arm since constant current flow from the surface electrodes is not expected under any situation. Adequate and effective protection against electrical shock and risk-of-fire exists as all batteries have previously been evaluated against the Underwriter's Laboratory standards for lithium-ion polymer (LiPo) batteries.

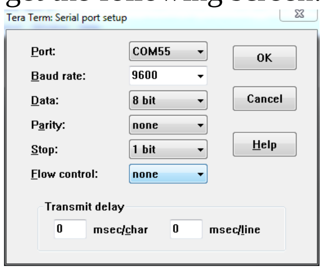
Team/Project:	Notorious EMG/Muscle Guide
Test Name:	Power Supply/Battery Life
Test ID Number:	T004
Relevant functional specification(s) being tested:	R006 – Power Supply R007 – Battery Life
Type of test (circle)	Black Box White Box
Purpose of test and test summary including number of replicates of test	The purpose of this test is to ensure that the product has appeal with the customer and, ultimately, that the product is reliable. LiPo batteries were selected for increased energy densities in smaller packages. In other words, the product can be powered for longer and the power source does not significantly contribute to size and weight. In order to view the LiPo batteries the enclosure's cover must be removed. Since there won't be any modifications and this is a quick visual inspection the test is considered a Black Box test. Recognize the LiPo battery for its characteristic slim design and partially-exposed circuitry for protection near the leads. The system can be recharged once it has been determined that the power source is a LiPo battery. The cover can be re-installed for testing the battery life. Simply power on both the EMG Unit and the RTC Box and record how long the devices have been powered once one of the devices fully discharges (since one is useless without the other). Battery life can be determined by monitoring the illumination of the LEDs on each unit, respectively. Alternatively, the battery life can be determined at the point the Bluetooth connection is lost and data is no longer being transmitted. Repetition is not necessary for either portion of this test as inconsistent current consumption is not expected under normal operating conditions that would lead to faster discharge.
Equipment List:	RTC Box, EMG Unit, Stopwatch/Timer
Necessary dummy inputs, their source, and mechanism for validation of dummy inputs:	Dummy inputs are not required for this test.
Description and / or images of test setup	Remove the cover from the EMG Unit and observe the battery. If the battery does not explicitly state that it is a LiPo battery, then it can be recognized for its characteristic slim design and partially-exposed circuitry near the top. If the battery type cannot be determined through visual inspection, then the BOM can be referenced to determine what item is installed.

	For battery life, don the EMG Unit and ensure that it is powered up. If not previously accomplished, connect the battery to V_{in+} and V_{in-} and close the push-button switch. Repeat the connection for the RTC Box and close the push-button switch. Ensure that the Bluetooth modules are connected, and that data is being transmitted. Record the time that the first unit is fully de-energized. This can be determined by monitoring the battery-life LEDs or noting when the Bluetooth connection is lost.
Inputs or input ranges to be used (include number or test points and increments)	The inputs are the respective power sources for the RTC Box and EMG Unit. Each are a 3.7 V LiPo battery, but the RTC Box has a capacity of 1.2 Ah and the EMG Unit has a battery capacity of 0.3 Ah.
Anticipated results/outcomes	The test is successful if it can be determined that the power sources for both the EMG Unit and RTC Box are LiPo batteries and the Muscle Guide is powered for at least 4 hours.

Team/Project:	Notorious EMG/Muscle Guide
Test Name:	Signal Conditioning
Test ID Number:	T005
Relevant functional specification(s) being tested:	R003 – Signal Conditioning: Noise Reduction and Magnitude Amplification of Signal
Type of test (circle)	Black Box White Box
Purpose of test and test summary including number of replicates of test	The purpose of this test is to ensure that the envelope (rectified and integrated signal) is a suitable input to the MCU ADC in terms of noise and magnitude. This test will be done by measuring the peak amplitude of the signal on an oscilloscope and viewing how much noise is present. Refer to the schematic for pinouts. Grab the output from the final stage (pin 7 of IC3B) and display it on an oscilloscope. The enclosure's cover will need to be removed to gain access to the final output stage pin. Carefully place a jumper wire or connect the oscilloscope probe to this pin to obtain the required reading. This test shall be conducted three times to establish confidence in the results.
Equipment List:	EMG Unit (with 3.7 V, 0.3 Ah Battery) Oscilloscope with Probe, Jumper Wire or Appropriate Connection – as needed
Necessary dummy inputs, their source, and mechanism for validation of dummy inputs:	Dummy inputs are not required for this test. Since the conductive sleeve is available and functioning justification cannot be provided for needing to use dummy inputs.
Description and / or images of test setup	Ensure that the pushbutton switch is opened (raised position). Remove the lid from the EMG Unit. Use the schematic to locate the final-stage output of the SCU (pin 7 of IC3B) and use a suitable jumper wire or other connection as needed to connect the output to an oscilloscope. If not previously accomplished, then place the conductive sleeve onto the arm. Close the pushbutton switch (lowered position) and use the "AUTOSET" feature to automatically capture and display the signal. Manually zoom in and use cursors as desired to improve screen captures of the signal. The detected signal should be conditioned such that smooth peaks are easily differentiable from equilibrium without the presence of noise. The measured peak amplitude shall be at least 30 mV and should be at least 50 mV.
Inputs or input ranges to be used (include number or test points and increments)	The power source for the EMG Unit is the only required input for this test: 3.7 V, 0.3 Ah battery. If not previously accomplished, then connect V_+ to $+V_{in}$ and V_- to $–V_{in}$.

Anticipated results/outcomes	The test will pass if the signal is noise reduced and amplified to at least 30 mV. Initial testing of the SCU output signals with peak amplitudes of ~53 mV, so the anticipated outcome is a result that is within 10% of 53 mV.

Team/Project:	Notorious EMG/Muscle Guide
Test Name:	Data Rate
Test ID Number:	T006
Relevant functional specification(s) being tested:	R009 – Data Rate: Bluetooth signal transmitted at 1.5 kBps
Type of test (circle)	Black Box White Box
Purpose of test and test summary including number of replicates of test	The purpose of this test is to ensure that data is sampled at the correct rate so that the continuous processing of data is not corrupted or stopped. If the signal is oversampled, then the system is unnecessarily overworking and consuming excessive power. The packet size will be larger which will increase transmission times resulting in further power consumption. Finally, the storage capabilities of the RTC Box may be inadequate if the transmitted data packet size is larger than what was planned for. This test will be accomplished by opening a terminal and measuring the throughput of a typical transaction. That is, the transmission size in bytes will be measured along with the time needed for the transaction. This will give us the ratio we are interested in to check against the final specification. Don the EMG Unit and ensure that it is powered on. Establish a Bluetooth connection between EMG Unit and the computer terminal. Transmit an EMG signal to the terminal and read the transaction size and time from the terminal screen. Repeat the test three times to establish confidence in the transmitted data rate.
Equipment List:	EMG Unit, Computer Terminal
Necessary dummy inputs, their source, and mechanism for validation of dummy inputs:	Dummy inputs are not required for this test.
Description and / or images of test setup	Don the EMG Unit and ensure that the pushbutton switch is closed (lowered position). Establish a BLE connection to a PC by opening *TeraTerm* or some other terminal of your choosing. Upon opening *TeraTerm*, the following should be displayed: 

	Select the Serial radio button and select the desired port from the drop-down menu. Go to **File > New Connection** if the above window is not displayed upon opening *TeraTerm*. *TeraTerm* defaults to a 9600 bps baud rate so go to **Setup** > **Serial Port** to get the following screen:  Increase the baud rate to account for the expected 16.1 kb/s and then establish the connection. If the title of the terminal window changes to "COM##:9600baud" or whatever the baud rate is set to then the connection has been established. Read the throughput direct from the terminal screen.
Inputs or input ranges to be used (include number or test points and increments)	The only required input for this test will come from the EMG Unit (the muscle signal).
Anticipated results/outcomes	If the reported throughput does not exceed 2.01 kB/s then the test will pass and confidence can be established in that data will not become corrupted or lost. The anticipated outcome for this test is that the MTU will be closer to 267.5 bytes which would lead to a throughput measurement of 1.77 kB/s.

Team/Project:	Notorious EMG/Muscle Guide
Test Name:	Data Calculation
Test ID Number:	T007
Relevant functional specification(s) being tested:	L001 – The values of the maximum and minimum voltage potentials stored will not exceed an array size of 50 L003 – The power calculated by the RTC algorithm is within 5% of actual EMG potentials L004 - The initial maximum voltage potential value and the absolute maximum voltage potential value will be written and saved to an SD card
Type of test (circle)	Black Box White Box *Testing L001 & L004 will be "black box" (algorithm), while testing L003 will be "white box" (GLCD screen)
Purpose of test and test summary including number of replicates of test	The arrays will be used to hold the values of the calculated maximum and minimum voltages read from the user's muscles. By restraining the size of the input to be 50, the muscle guide can report maximum and minimum muscle values relatively quickly, since the rate of muscle signal is approximately 1,00Hz. If one rep takes approximately 1 second, the array size limits the samples up to 50 repetitions over a single period. We will be conducting this test at least 3 times with each individual team member. Verification will take place during output analysis following code execution by printing out when the array is full and can start over and take in more samples. Once the arrays have calculated minimum and maximum values of the voltages, it will be stored into the appropriate array. The dummy output would be a print statement to indicate when the arrays are full. This print statement would then trigger for the arrays to be wiped clean to take in new data. This allows the array to not overflow and crash the overall algorithm. Using the MyoWare Muscle Sensor as theoretical/desired values for calculated maximum power and muscle fatigue, we will also test for the accuracy of these two values, running the code on both the sensor and PCB to ensure the values from the PCB are within 5% of the sensor's values. At this time, the transmitter will also write and save the microSD card. The micoSD card can be read via a computer and displayed a text file.
Equipment List:	Laptop, power supply, PSU cables, MCU1, MyoWare Muscle Sensor, Lithium Ion Battery, GLCD screen, microSd card
Necessary dummy inputs, their source, and mechanism for validation of dummy inputs:	We will be using the power supply as a dummy input for voltages being read by the muscles guide. The supply voltage will be altered as if to represent how the voltage potentials from firing muscles would behave. These dummy inputs are appropriate, because the muscle guide will be reading and storing voltages as well, just at a smaller fraction. For this test, the values of the voltages are not important, but the quantities of them. The voltages from the power supply would be read and stored into the array. The MyoWare Muscle sensor's inputs will also be used as a dummy variable to compare its values to the PCB's values.

Description and / or images of test setup	There will be two jumper cables connected from the power supply to the two inputs of the MCU1's input. A GLCD screen and microSD card will be connected to the MCU1 via GPIO pins. This will be positive voltage and ground. The user will then run the code, alongside a terminal to view the print statements and the state of the code. Once the array is filled, the user will see a print statement indicating that the array is full. This will verify that the code has detected a full array and will empty it to take in more data. By seeing this print statement multiple times, the test will prove that the array is continuously taking in data without exceeding the size of the array. The sensor will be powered by the lithium ion battery and the outputs will be connected to the inputs. The two calculated values will be displayed on the GLCD screen so we can compare the values of the PCB and sensor for accuracy.
Inputs or input ranges to be used (include number or test points and increments)	The input range coming from the MyoWare muscle signal will be approximately 50uV to 30mV. Because the MCU can take in only a maximum of 5V, the dummy inputs from the voltage supply will range from 0.0V to 5.0V.
Anticipated results/outcomes	To pass the test, the code will print out a print statement indicating the arrays are full multiple times and the overall code/algorithm will not overflow/crash, Additionally, the values calculated using the PCB must be within 5% of the calculated values using the MyoWare Muscle Sensor. The values displayed on the GLCD screen will be compared the values accessed from the SD card to ensure that the values were properly written to and saved to the SD card.

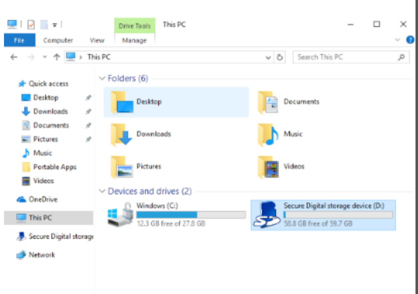
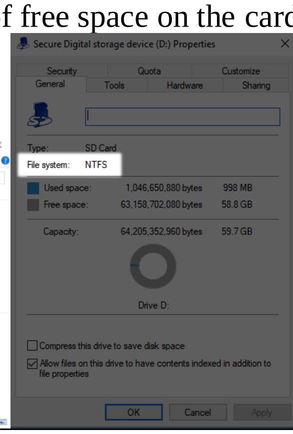
Team/Project:	Notorious EMG/Muscle Guide
Test Name:	Muscle Integration & Display
Test ID Number:	T008
Relevant functional specification(s) being tested:	L002 – The change in muscle potential will be displayed graphically on an LCD screen R001 – The electrodes will be integrated with MCU1
Type of test (circle)	Black Box White Box
Purpose of test and test summary including number of replicates of test	This test is to ensure that the data collected by the electrodes are properly being sent to the EMG device MCU to then be sent to the RTC MCU to ultimately be read by the user. By displaying individual voltage potentials from the user's muscle as pixels, the Muscle Device will be able to display the change in the user's muscle potential through a waveform. This waveform will not only ensure that the MCU is detecting a change in the user's muscle during use, but also ensures that the data collected from the electrodes is integrated with the MCU and are being sent properly to the MCU. This test will be conducted at least 3 times for each individual team member.
Equipment List:	MCU1, GLCD screen, Lithium Ion Battery, MyoWare Muscle Sensor, power supply
Necessary dummy inputs, their source, and mechanism for validation of dummy inputs:	Without a properly working PCB immediately, we are still able to test using the MyoWare Muscle Sensor to give us proper muscle readings powered by a lithium ion battery. This is an appropriate dummy variable because the MyoWare Muscle Sensor is what our PCB should be doing/the theoretical values of the muscle signals. We can also use a voltage supply as dummy variable in place of the MyoWare Muscle sensor purely to test the waveform displayed on the screen. These dummy inputs are appropriate, because the muscle guide will be reading and storing voltages as well, just at a smaller fraction.
Description and / or images of test setup	A 3.7V Lithium Ion battery will be used to power both the MyoWare Muscle Sensor, along with the MCU and the GLCD screen. The GLCD screen will be connected to MCU1 via GPIO pins, while powered by the lithium ion battery. The output of the MyoWare Muscle Sensor will be connected to the input of the MCU1. The verification will be seen on the GLCD of an unsteady line of pixels moving horizontal as a function of time when the input voltages are varied. The dummy power supply inputs can be used to see a clearer waveform since muscle voltages are not as consistent. But we will need the muscle signals from the MyoWare Muscle Sensor to verify that the electrodes are gathering correct data and being sent/integrate with the MCU1.
Inputs or input ranges to be used (include number	The input range coming from the MyoWare muscle signal will be approximately 50uV to 30mV. Because the MCU can take in only a maximum of 5V, the dummy inputs from the voltage supply will range from 0.0V to 5.0V.

or test points and increments)	
Anticipated results/outcomes	If the GLCD displays uneven/changing line (somewhat resembling a changing waveform) when there is a change in voltage potential, then L001 and R001 can be considered met.

Team/Project:	Notorious EMG/Muscle Guide
Test Name:	Data Acquisition
Test ID Number:	T009
Relevant functional specification(s) being tested:	R002 - MCU 2 shall receive detected muscle activity from the signal conditioning unit wirelessly from 4.5 feet
Type of test (circle)	Black Box White Box
Purpose of test and test summary including number of replicates of test	The purpose of this test is to show the functionality of the Bluetooth capability of the Muscle Guide. The tests will be conducted by receiving data from the EMG device, print the values it is receiving, send that same data in real-time to the RTC device, and print out the results. If the results printed out from the receiver are the same as the transmitter, we ensure that the data is being sent continuously and real-time to the RTC. The distance between the receiver and the transmitter will also test how far they can communicate. This test will be simply conducted by printing results on one laptop connected to the receiver and print results on another laptop connected to the transmitter and measure how far apart they can be, while still sending and receiving data. This test will be conducted at least 3 times for each individual team member.
Equipment List:	Tape measure, (2) laptops, MCU1, MCU2, Lithium Ion Batteries, MyoWare Musle Sensor
Necessary dummy inputs, their source, and mechanism for validation of dummy inputs:	Without a properly working PCB immediately, we are still able to test using the MyoWare Muscle Sensor to give us proper muscle readings powered by a lithium ion battery. This is an appropriate dummy variable because the MyoWare Muscle Sensor is what our PCB should be doing/the theoretical values of the muscle signals.
Description and / or images of test setup	MCU1 will be connected to one laptop with a terminal while MCU1 will be connected to another laptop with a terminal. Both MCU will be pwoered by the latops. The MyoWare muscle sensor will be on the user powered by a lithium ion battery. The output of the MyoWare Muscle sensor will be connected to the transmitter MCU's inputs. The two laptops will be separated by a certain distance, 2.5 feet at a minimum, and will continue moving apart until continuous data is no longer being sent to the receiver MCU.
Inputs or input ranges to be used (include number or test points and increments)	The laptops will supply 5V to each MCU while the input range coming from the MyoWare muscle signal will be approximately 50uV to 30mV.
Anticipated results/outcomes	If the results printed out from the receiver are the same as the transmitter, we ensure that the data is being sent continuously and real-time to the RTC at a minimum distance of 2.5 feet, then R002 can be considered met.

Team/Project:	Notorious EMG/Muscle Guide
Test Name:	Sampling Rate
Test ID Number:	T010
Relevant functional specification(s) being tested:	R005- The software will sample the digital muscle signal at 1,000 Hz
Type of test (circle)	Black Box White Box
Purpose of test and test summary including number of replicates of test	The purpose of this test is to ensure that the electrodes are successfully reading in continuous data from the user's muscles. It is imperative that the electrodes take in the same amount of voltage potentials that the muscles give off so that we have precise data. Continuous data is important because we are still able to have usable data with smaller sample sizes, it provides higher sensitivity, and overall more samples means more accurate data that we can then analyze. This test will be conducted by a dummy code that will use a variable to keep track of all samples coming in. Incrementing by one every 10 samples (this is to reduce the bit depth of the code/big-O) each time a voltage potential is read in. Theoretically, this number should be around 100 (1,000/10) to ensure that we have collected continuous muscle data. This test will be conducted at least three times with each individual team member.
Equipment List:	MCU1, Lithium ion battery, laptop
Necessary dummy inputs, their source, and mechanism for validation of dummy inputs:	No dummy inputs are required for this test.
Description and / or images of test setup	MCU1 with the electrodes will be powered by a lithium ion battery and worn by the user. The output of MCU1 will be connected directly to a laptop to display the print statements via a terminal to run the dummy code. A dummy code will be written with a variable to keep track of the number of voltage potentials read in by the electrodes. Incrementing by one every 10 samples (this is to reduce the bit depth of the code/big-O) each time a voltage potential is read in. Theoretically, this number should be around 100 (1,000/10) per second to ensure that we have collected continuous muscle data. The code will then print out the variable every second and display how many samples are essentially being taken in.
Inputs or input ranges to be used (include number or test points and increments)	MCU1 will a require a 3.7V input from the lithium ion battery

Anticipated results/outcomes	If the terminal displays a number approximately 100 (or more since muscle signals can be samples up to 2,000 Hz) every second, R005 can be considered met.

Team/Project:	Notorious EMG/Muscle Guide
Test Name:	Data Storage
Test ID Number:	T011
Relevant functional specification(s) being tested:	R008 - The system will be designed with the ability to store up to 2 GB of data
Type of test (circle)	Black Box White Box
Purpose of test and test summary including number of replicates of test	The purpose of this test is to ensure that the amount of data written and saved to the microSD card from the EMG device do not exceed the overall capacity of the microSD card. Once data is written to the SD card, it will be removed from MCU2 and plugged into a windows computer, where it will let the user know the properties of the card, and more specifically the amount of memory used and the amount of memory free. This test will be conducted at least three times for each individual team member using it for the duration of a 15 minute “workout”.
Equipment List:	Windows computer, microSD card adapter, MCU1, MCU2, Lithium Ion batteries
Necessary dummy inputs, their source, and mechanism for validation of dummy inputs:	No dummy inputs are required for this test.
Description and / or images of test setup	MCU1 and MCU2 will be powered by Lithium Ion batteries. The MicroSD card module will be connected to MCU2 via GPIO pins. The user will use the device for a duration of approximately 15 minutes. Once complete, the microSD card will be plugged into a Windows laptop via a microSD card adapter. Open a file explorer and navigate to This PC. Right click to access the card’s properties, which will tell you the amount of used space and the amount of free space on the card.  
Inputs or input ranges to be used (include number	The microSD card requires a 3V-5V onboard input voltage from MCU2. MCU1 and MCU2 require a 3.7V input

or test points and increments)	
Anticipated results/outcomes	If the properties indicate that the space available is greater than 0 or the space used is less than 2.0GB, then R008 can be considered met.

Team/Project:	Notorious EMG/Muscle Guide
Test Name:	Ease-of-Use
Test ID Number:	T012
Relevant functional specification(s) being tested:	S001 – Wire length CA001 – Arm unit weight CA003 - Size
Type of test (circle)	Black Box White Box
Purpose of test and test summary including number of replicates of test	This product shall be conveniently embedded into a wearable garment, as part of daily clothes, and worn unobtrusively by the operator. We do not want the product to be uncomfortable to the user in any way. This test is to verify that the product is easy to wear and interact with in the given setting it is intended to be used. To achieve this test, the user will first put on the conductive sleeve. Then, attach the surface electrodes from the EMG unit to the conductive sleeve. The male snap on the EMG unit will snap into the receiving female-half of the snaps on the conductive sleeve. Once all three (3) electrodes are connected and the EMG unit is mounted on the user via the conductive sleeve, the test is ready to be implemented. Turn the Muscle Guide to the "on" position and begin using the product how it is intended to be used. Typically, this means doing specific workout regimes such as pushups, bicep curls, or any dynamic exercise the user cares for additional information on. The tester will interact with the device, in previous-mentioned ways, so that the ease of using the device can be made evident and verified. The test needs to adhere to specification(s) S001, CA001, and CA003 but can also operate independently of those. This means that the user has the ultimate say in whether the test "fails" or "passes" the ease-of-use test. The test operator will conduct three (3) independent dynamic exercises as previously mentioned to verify ease of use. Choosing those three exercises, or rather movements, is 100% the decision of the user/tester doing the tests. The reason behind this choice is to express a multitude of dynamic exercises that may result. Once this test is completed by one person, the test should be verified two more times by two different people.
Equipment List:	EMG unit, conductive sleeve, three (3) different human-beings, athletic clothing
Necessary dummy inputs, their source, and mechanism for validation of dummy inputs:	No dummy inputs are required for this test.
Description and / or images of test setup	The user will first put on the conductive sleeve. Then, attach the surface electrodes from the EMG unit to the conductive sleeve. The male snap on the EMG unit will snap into the receiving female-half of the snaps on the conductive sleeve. All three (3) electrodes should be connected and the

	EMG unit should be mounted on the user with the conductive sleeve. Turn the Muscle Guide to the “on” position and begin using the product how it is intended to be used. Typically, this means doing specific workout regimes such as pushups, bicep curls, or any isometric exercise you can think of. After doing one exercise correctly, do two more different exercises. Interact with the device so that you can wear it unobtrusively. Meaning, see how it feels wearing the Muscle Guide so that the device does not limit or hinder your movements in any way. After the test, indicate whether the test was a pass or fail. The test will only pass if the Muscle Guide has been approved by three or more total peoples.
Inputs or input ranges to be used (include number or test points and increments)	The only input in this test is the EMG unit itself and the conductive sleeve it attaches to.
Anticipated results/outcomes	I believe most people will deem the outcomes as successful or partially passed at best.

Team/Project:	Notorious EMG/Muscle Guide
Test Name:	Arm Unit Weight
Test ID Number:	T013
Relevant functional specification(s) being tested:	CA001 – Arm unit weight
Type of test (circle)	Black Box White Box
Purpose of test and test summary including number of replicates of test	The weight of the system is imperative to the overall interaction and functionality with the product. The purpose of this test is to determine if the EMG arm unit weighs correctly. The EMG arm unit shall weigh 0.5 pounds and should weigh 0.35 pounds. This test will use a digital scale to measure the weight of the product. The test should be completed by two separate individuals at two different times.
Equipment List:	Digital scale, wearable EMG unit
Necessary dummy inputs, their source, and mechanism for validation of dummy inputs:	Will use a five (5) pound mass to verify whether the digital scale is calibrated. This will be done before and after each weigh-in of the test. There are no other dummy inputs for the test.
Description and / or images of test setup	Take the EMG device and place it on the digital scale. If the weight total is a larger value than 0.5 pounds, then the test fails.
Inputs or input ranges to be used (include number or test points and increments)	There are no inputs for this test.
Anticipated results/outcomes	I am assuming at this point that the EMG arm unit weight will be between 0.5 and 0.4 pounds.

Team/Project:	Notorious EMG/Muscle Guide
Test Name:	Size
Test ID Number:	T014
Relevant functional specification(s) being tested:	CA003 CA001 CA002
Type of test (circle)	Black Box White Box
Purpose of test and test summary including number of replicates of test	The purpose of this test is to verify that the final product of the Muscle Guide complies with what was set forth on the specifications list. That is, the final size of the product should not be more than 155x80x30 mm^3. To do this, the dimensions of the EMG and RTC units respectively, will be extracted via SolidWorks CAD dimensioning or digital calipers. This test will only be completed once.
Equipment List:	EMG unit, RTC unit, computer, CAD software, digital calipers
Necessary dummy inputs, their source, and mechanism for validation of dummy inputs:	There are no dummy inputs for this test.
Description and / or images of test setup	Use a pair of digital calipers or CAD software to describe the surface of the EMG and/or the RTC unit. If the total size of the EMG or RTC unit is less than the mentioned size list above of 155x80x30 mm^3 then the test is considered a pass. If the size of the RTC or EMG unit is greater than that mentioned volume, then the test fails. If the EMG unit fails the test and the RTC unit passes, the result of the overall test is a fail. However, if the EMG unit passes and the RTC unit fails, the result of the overall test is a pass. This is attributed to the fact that the size of the RTC unit does not affect anything else.
Inputs or input ranges to be used (include number or test points and increments)	There are no inputs for this test.
Anticipated results/outcomes	I anticipate the results to show that this test will pass. With our new modifications to the PCB, I am expecting the form factor and size of the EMG unit to be dramatically reduced.

Team/Project:	Notorious EMG/Muscle Guide
Test Name:	Water Resistance
Test ID Number:	T016
Relevant functional specification(s) being tested:	D001 - Water Resistance
Type of test (circle)	Black Box White Box
Purpose of test and test summary including number of replicates of test	It is crucial that the device is water resistant, as to the safety of the user and the longevity of the product. Our product will likely encounter vast amounts of water, sweat and solids. Given that it will be used in the field repetitively, the device must not be altered by this magnitude of exposure. The purpose for this test is to make sure all the electronics are protected from water, dust, and small solids. If water or other harmful solids interject with the product, the product may, as a result, fail in some sort of failure mode. We do not want any failure with our electronics. It is integral we do not, so this test is to demonstrate the ability to shield harmful solids and liquids from meeting the Muscle Guide and causing damage.
Equipment List:	EMG unit, RTC unit, water, bucket, sink, water hose, 1 mm access probe, spray bottle
Necessary dummy inputs, their source, and mechanism for validation of dummy inputs:	There are no dummy inputs for this test.
Description and / or images of test setup	To achieve an IP56 rating, the electronics need be safe from low-pressure water jets at different directions/orientations and a block solid bodies larger than one (1) mm. To set this test up, the EMG and RTC unit need to be completely sealed and locked into its final display presentation-form. Once the two devices are buttoned-up, the test is ready. First, start with either the EMG or RTC unit. Place the specified unit into a bucket or sink. Use a watering hose with low pressure and start to spray the unit with small bursts of water streams. Spray the unit with the water hose from different directions and orientations. Paying close attention to spray the bottom of the unit(s). While sitting in a bucket or sink, it can be difficult to spray the bottom, but this is imperative to the success of the test. After spraying the unit(s) thoroughly as described, take the unit(s) out of the sink and examine them for leaks. If no leaks, the test has passed the criteria and is deemed successful. The next step is to make sure small bodies such as dust and bodies larger than one (1) mm do not harm the enclosure(s). To do this, place a large amount of dust and loose bodies such as dirt into a bucket that has one of the units placed inside. Toss and

	rotate the bucket to move the bodies around. Making sure that the enclosure unit meets the harmful dust and bodies. The point of the test is to make sure the enclosure can repel bodies as such so that the integrity of the unit itself does not become compromised. To further guarantee that the enclosure unit is compliant with the rating IP5X, an access probe the size of one (1) mm can be used. By using the probe to inspect the enclosure unit, we can ensure that any dust that enters the unit will not interfere with the part's functionality. Once it has been determined by the individual that the enclosure unit has passed or failed the test, the test is ready for publication. If the test has partially passed and partially failed, then the test should be reworked again by the same individual. If the test results are the same the second time, then the test fails. If both parts of the test pass, then the results are proven. In this case, the test should be passed by at least two (2) people to prove the design and implementation worked. In any other case, the test needs to be recorded as to the reasons why the test failed.
Inputs or input ranges to be used (include number or test points and increments)	There are no inputs or input ranges used for this test.
Anticipated results/outcomes	As the mechanical engineer responsible for the test, I am confident that the results will be excellent. I believe the outcome should verify that Notorious EMG's enclosure will meet rating IP56 for both units.

Team/Project:	Notorious EMG/Muscle Guide
Test Name:	Strength
Test ID Number:	T017
Relevant functional specification(s) being tested:	D002 - Strength
Type of test (circle)	Black Box White Box
Purpose of test and test summary including number of replicates of test	The purpose of the strength test is to make sure the device does not fracture or break when accidentally dropped in the field. Given that it will be used in the field repetitively, the device must not be altered by this magnitude of exposure. The test will ultimately mimic the conditions it will face in the field. This means that we must purposefully drop the device(s) onto a hard surface, such as concrete, to test whether the device will break. The overall functionality of the device(s) must operate in its intended way after the test has been implemented.
Equipment List:	Concrete flooring, EMG unit, RTC unit, CAD
Necessary dummy inputs, their source, and mechanism for validation of dummy inputs:	It is possible to use the RTC unit or EMG unit without the components inside for this test. If that is the case, then a dummy housing can be used to mimic the real device(s). If after the test, there is breakage or cracking in the housing then the test failed and will have to revise the product.
Description and / or images of test setup	The enclosure for the electronics should not fracture when dropped from 1.5 meters onto concrete. This test is straight forward in the way that all the tester needs to do is drop the enclosure unit(s). The height was chosen based on realistic drop heights in the field the device may encounter. The device should be dropped approximately five (5) times. After the five drops, if any breakage or fracturing occurs, then the test fails. If the test fails, then more supports, such as ribs, will be implemented into the new iteration of the design via CAD. If no such breakage or fracturing happens after five drops, then the test passes fully.
Inputs or input ranges to be used (include number or test points and increments)	There are no inputs for this test.
Anticipated results/outcomes	I am anticipating that the results of the test will succeed or pass.

Specification Test Log

Date/Time of testing:	
Test participants:	Please identify a single engineer as the test lead, others are considered to be "supporting" the test. The test lead is responsible for adherence to the test plan and the overall quality of the test results.
Test ID Number:	
Relevant functional specification(s) being tested:	

Test Results

Include measured data, observations, etc. here in a format appropriate to your test

Test Deviations

Deviations from the test as written in the test plan

Test Results (circle)

Complete Pass	Partial Pass	Fail

Test Commentary

Additional notes on the test. If partial pass, you must comment on *what passed* and *what didn't*. If fail, you must comment on *why the system failed* and *what would be involved in meeting the specification* (i.e. how much work for the company, how much cost, etc.).

Signoff

Name	**Signature**	**Role**
Marshall Kabat		
Chris Anderson		
Vi Tran		

Jacob Gamboa		