**Parameter Estimation Protocol**

The following is the procedure that should be followed to collect the necessary data to perform the parameter estimation of the neuroprosthesis leg extension model. If at any time the participant asks to discontinue the tests STOP IMMEDIATELY. The participant may also discontinue any of the procedures by using the emergency stop button. Read the document in its entirety before conducting tests.

1. Test the emergency stop button:
   1. Plug the wireless receiver into the 9V battery.
   2. Build and run the Simulink model on the desktop titled SafetyTest.slx.
   3. When the model is running press the wireless button, which should stop terminate the Simulink model.
   4. If the model does not terminate DO NOT PROCEED WITH EXPERIMENTS. Try to resolve the problem and repeat the test of the emergency stop button. Do not proceed until this test has confirmed that the emergency stop button is working correctly.
2. Test the stimulator:
   1. Make sure that the stimulator unit is connected to the PC that you are running the experiments on through the RS232 port.
   2. Turn the stimulator on.
   3. Once the stimulator is on press the HV button to turn off the output of the stimulator.
   4. Connect one of the channels of the stimulator to a 100Ω resistor in parallel with an oscilloscope.
   5. Open the TestStim.slx Simulink model, set the channel to the output that the resistor is connected to, and set the amplitude to 20mA.
   6. Press the HV button on the stimulator, then build and run the TestStim.slx Simulink model.
   7. Use the oscilloscope to confirm that the stimulator parameters are the same as the ones that were specified in the settings of the stimulator block.
   8. Once you have completed the test stop the Simulink model and press the HV button again to turn off the output of the stimulator.
3. Place electrodes on quadriceps of the participant following directions from <http://www.axelgaard.com/>. Once the electrodes are place on the muscles and the wires are connected press the HV button to turn on the output stimulator.
4. Situate the participant in the leg extension machine:
   1. Make sure that the arm of the leg extension machine is unpinned (not locked in position).
   2. Have the participant sit in the leg extension machine, and adjust the back seat for comfort and to approximately align their knee joint with the axis of rotation of the leg extension machine.
   3. Strap their leg to the arm of the leg extension machine and adjust the position and orientation of the padded load cell for comfort.
   4. Plug in the power supply that powers the load cell of the leg extension machine.
5. Run parameter estimation tests:
   1. Open Main.m.
   2. DO NOT RUN THE SCRIPT! Instead evaluate the script one section at a time, in order from top to bottom. This will allow you to evaluate results of each tests in between each procedure, give the participant rest periods if required, and give you time to prepare for the next procedure. You will be prompted by Matlab at the beginning of each procedure to ensure that you are prepared to proceed.
   3. Run the section of Main.m titled “Preamble”. This will setup some things for the upcoming sections.
   4. Run the section of Main.m titled “Subject Information”. This section will allow you to select the subject ID for the participant, and the leg that you are performing the procedure on.
   5. Procedure 1) Setup the Encoder
      1. Run the section of Main.m titled “Procedure 1) Setup the Encoder”.
      2. You will be prompted to move the leg to full extension. Hold the leg at full extension until you are prompted to release the leg. This procedure will tare the encoder at full extension so that full extension results in an encoder measurement of zero for all participants.
   6. Procedure 2) Pendulum Test
      1. Run the section of Main.m titled “Procedure 3) Push/Pull Test”.
      2. Bring the leg to full extension, and release once the Simulink model begins running. This data will be used to estimate inertial and damping parameters.
   7. Procedure 3) Push/Pull Test
      1. Run the section of Main.m titled “Procedure 3) Push/Pull Test”.
      2. Follow the prompts on the screen and move. When the screen displays a blue figure move the leg to full extension and hold it there until the color changes. Once the screen displays a green figure move the leg toward hyperflexion and hold it there until the figure color changes. Once the screen displays a red figure the test has concluded and the leg may be released. This data will be used to determine the joint stiffness in the regions of hyperextension and hyperflexion.
   8. Procedure 4) Warmup
      1. Fix the leg extension machine in an isometric configuration. You can start at any healthy/normal position.
      2. Run the section of Main.m titled “Procedure 4) Warmup”.
      3. You will be prompted to enter the amplitude of the stimulation for the pulses and the number of pulses. This will potentiate (warmup) the muscles, and prepare them for the upcoming procedures.
   9. Procedure 5) Stimulation Ramp
      1. Run the section of Main.m titled “Procedure 5) Stimulation Ramp”.
      2. You will be prompted to specify the minimum and maximum stimulation amplitudes. Once this is specified the procedure will begin.
      3. This section will automatically determine the threshold and saturation amplitude of each participant, which are necessary in the later procedures.
   10. Procedure 6) Isometric Contractions
       1. Run the section of Main.m titled “Procedure 6) Isometric Contractions”.
       2. The Simulink model will run in a loop, allowing you to reposition the leg and measure the isometric contraction joint torque at multiple positions.
       3. Allow sufficient time in between each isometric contraction tests such that the participant’s muscles do not become fatigued.
   11. Procedure 7) Sinusoidal Stimulation Test
       1. Have the participant extend their leg to full extension.
       2. Tighten the strap that prevents hyperextension until the participant’s leg cannot exceed an extension that is approximately ten degrees before full extension.
       3. Adjust the parameters “U1” and “U2” in the section of Main.m titled “Procedure 7) Sinusoidal Stimulation”. This will determine the minimum and maximum normalized stimulation amplitudes to be used in the sinusoidal stimulations. Select these values such that the leg performs a sufficiently large range of motion (approximately 40 degrees).
       4. Run the section of Main.m titled “Procedure 7) Sinusoidal Stimulation”.
       5. If the range of motion is to low or high reset the values of U1 and U2 and run the section again.
   12. Save the collected data:
       1. Run the section of Main.m titled “Save Collected Data”.
       2. This will create a .mat file of the results of the procedures. This file should be relocated to the secure location that has been designated by the investigators. Any previous versions or copies of the saved results should be deleted.
6. Once you have concluded all procedures turn off the stimulator before disconnecting the participant, unplug the power supply that powers the load cell, and unplug the 9V battery that powers the emergency stop button.