Ryerson University
Department of Electrical, Computer and Biomedical Engineering

BME639: CONTROL SYSTEMS BIOROBOTICS

Appendix B

Quanser Rotary Servo Module Interface

This manual demonstrates how to configure the SRV02 and design QUARC controllers for the Quanser SRV02 system using a tachometer, potentiometer and encoder sensors.

A. Configuring the SRV02 Rotary Servo Motor

In this section, it is shown how to design a Simulink model using QUARC blocks to feed a voltage to the SRV02. The blocks from the `QUARC Targets` library are used to interact with the data acquisition board Q2-USB. Before you begin this laboratory make sure:

1. QUARC is installed in the PC.
2. A QUARC compatible data acquisition board, Q2-USB, installed in the PC.
3. SRV02 and power amplifier VoltPAQ-X1 are connected to the data acquisition board.

Follow these steps to design the Simulink diagram:
1. Start MATLAB up from the `Start` menu and then create a new Simulink model. The standard Simulink window is shown in Figure(1).

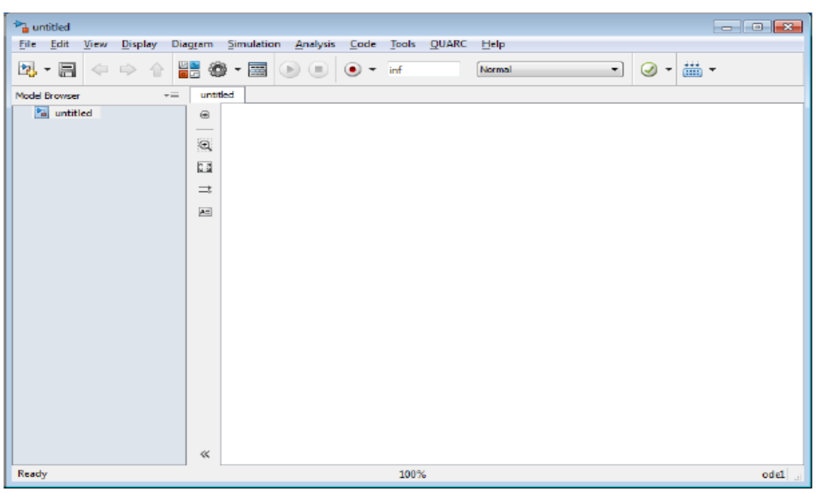

Figure 1: Standard Simulink model

2. Set up following settings to connect up to the Quanser data acquisition board.
`Simulation` → `Mode` → `External`
`Simulation` → `Configuration Parameters` → `Solver` → `Stop time`→ `inf`
`Simulation` → `Configuration Parameters` → `Solver` → `Type`→ `Fixed-step`
`Simulation` → `Configuration Parameters` → `Solver` → `Fixed-step size`→ `0.002`

If there is no continuous state on the model change the solver type from `ode1` to `discrete`
`Simulation` → `Configuration Parameters` → `Solver` → `discrete`

Once the above changes are applied the `Connect to Target` icon is appeared on the Simulink menu bar, as shown in Figure(2).

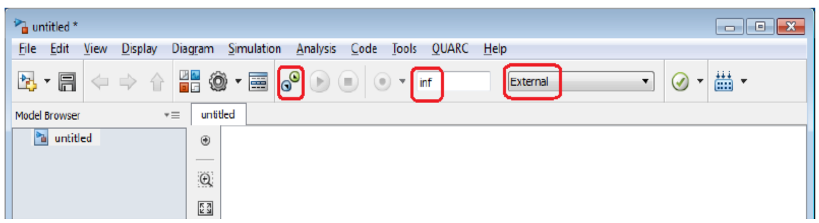

Figure 2: Configured Simulink model

3. To add the Quanser data acquisition unit to the model, first open the Simulink Library Browser window, expand the `QUARC Targets` item and go to the following category,
`QUARC Targets`→ `Data Acquisition` → `Generic` → `Configuration`

Figure(3) shows the block icon and location within the Simulink Library Browser.

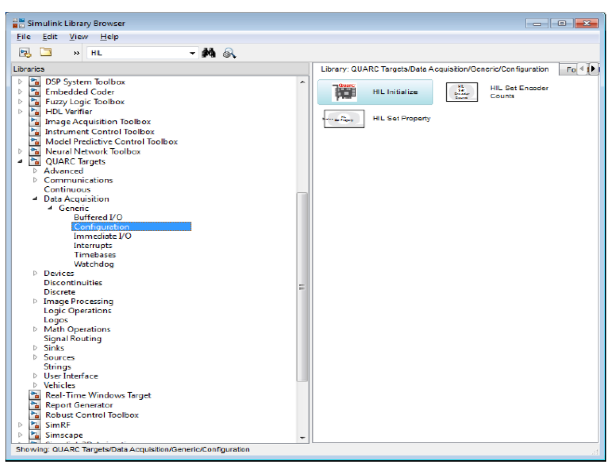

Figure 3: QUARC Targets in Simulink Library Browser and HIL Initialize Block

4. Click-and-drag the `HIL Initialize` block from the library window into the blank Simulink model. This block is used to configure your data acquisition device, Q2-USB hardware-in-the-loop (HIL) boards. Figure(4) shows the HIL Initialize block in the configured Simulink model.

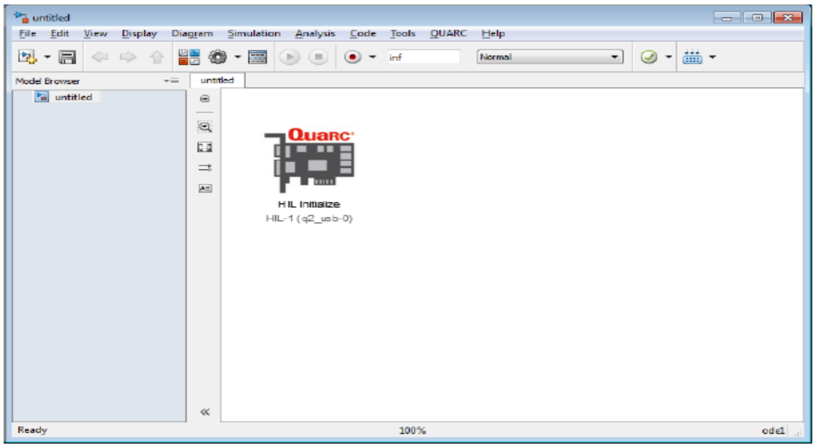

Figure 4: HIL Initialize Block in the Simulink model

5. To configure the `HIL Initialize` block, double-click on the block, in the `Board Type` field, select the board that is installed in the PC, Q2-USB. Figure(5) shows the device that is installed with in the PC after the Q2-USB is selected. At this point the Quanser data acquisition unit is selected and configured within the empty Simulink model.

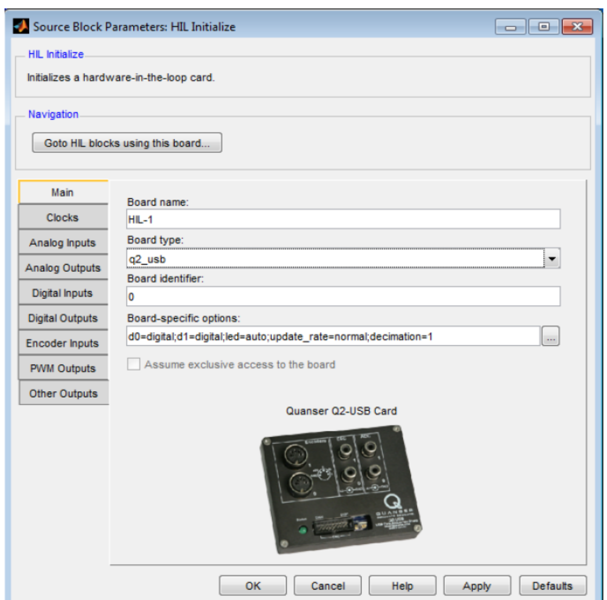

Figure 5: Configuring the HIL Initialize Block

B. Applying a Voltage to SRV02 Rotary Servo Motor

In this section, we will modify the Simulink diagram designed in Section A using QUARC blocks to feed a voltage to the SRV02 servo motor.

Here are the basic steps to apply a sinusoidal voltage to the SRV02 motor using QUARC:

1. First open the Simulink Library Browser window, expand the `QUARC Targets` item and go to the following category. This contains various blocks used to interact with actuators and sensors.
`QUARC Targets`→ `Data Acquisition` → `Generic` → `Immediate I/O`

Figure(6) shows the block icon and location within the Simulink Library Browser.

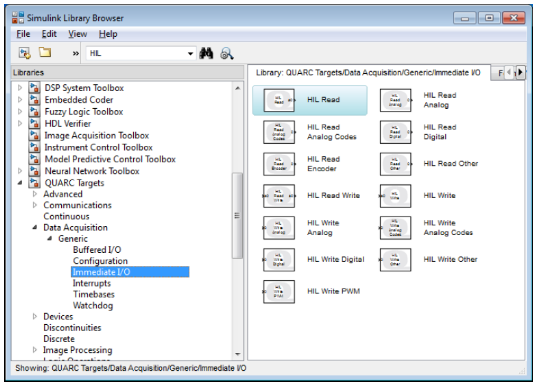

Figure 6: QUARC Targets in Simulink Library Browser and HIL I/O Blocks

2. Click-and-drag the `HIL Write Analog` block from the library into the Simulink diagram. This block is used to output a voltage from an Analog Output (AO) channel, i.e. DAC, on the data acquisition device.

3. Add the `Signal Generator` block, found in the Simulink `Source` folder, and the `Gain` block, from the Simulink `Math Operations` category, into the Simulink model. Connect the blocks as shown in Figure(7).

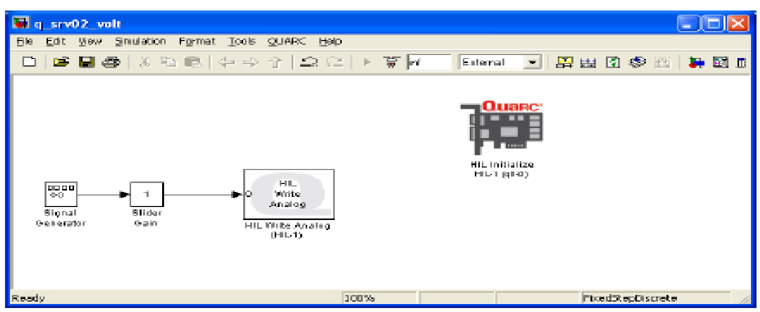

Figure 7: Simulink model with QUARC to apply voltage to SRV02

4. Double-click on the `HIL Write Analog` block, the pane is shown in Figure(8). Make sure board name is set to `HIL-1` (i.e. points to the `HIL Initialize block`). Set Channels to `0` (default setting). Recall that, as instructed in Appendix A, the servo motor is connected to DAC Channel 0, (Analog Output), on the data acquisition board. Therefore, Channels should be set to `0`. Set Sample time to `-1` (default setting). This implies that the sampling interval is inherited from the previous block. Click on the `OK` button to save and close the `HIL Write Analog` block properties.

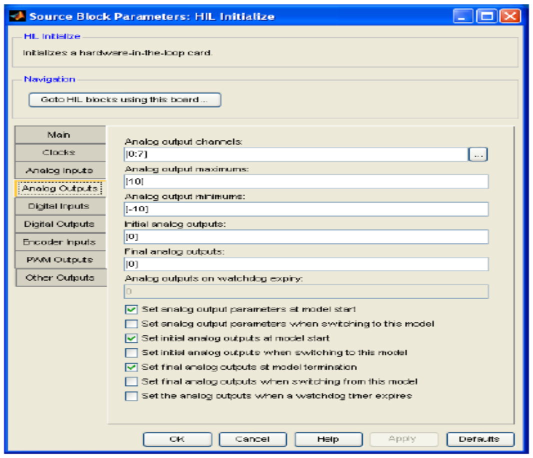

Figure 8: Configuring Analog Output Channel on Data Acquisition Device

C. Measuring Speed Using Tachometer

In this section, we will modify the Simulink diagram designed in Section B using QUARC blocks to read from the tachometer.

Here are the basic steps to read voltage from the SRV02 motor using QUARC:

1. Expand the `QUARC Targets` item and go to the following category,
`QUARC Targets`→ `Data Acquisition` → `Generic` → `Immediate I/O`

2. Click-and-drag the `HIL Read Analog` block into the Simulink diagram created in Section B. This block will be used to read a voltage from an Analog Input (AI) channel, i.e. ADC, on the data acquisition device. The output of the `HIL Read Analog` block will be the analog voltage returned by the tachometer that corresponds to the angular velocity of the motor.

3. Double-click on the `HIL Read Analog` block, the pane is shown in Figure(9). Make sure board name is set to `HIL-1` (i.e. points to the `HIL Initialize block`). Set Channels to 0 (default setting). Recall that, as instructed in Appendix A, the tachometer is connected to ADC Channel 0 (Analog Input) on the data acquisition board.

4. Add a `Scope` block and two `Gain` blocks, from the `Sinks` and `Math Operations` folders in the Library Browser into the Simulink model. Connect the blocks as shown in Figure(10). Connect one `Gain` block between the previous `Gain` and `HIL Write Analog` blocks and label it `Motor Calibration` (V/V). Another `Gain` block between the `HIL Read Analog` and `Scope` blocks and denote it `Tachometer Calibration` (rpm/V).

5. Set the `Signal Generator` frequency parameter to $1.0Hz$ and the `Gain` block to `1`. Currently when the voltage goes positive the load gear rotates in the clockwise direction. However, the desired convention is for the load gear to rotate in the counter-clockwise direction when the voltage goes positive. Thus, set the `Motor Calibration` block to `-1`.

6. The back-emf constant of the tachometer sensor is $0.0015V/rpm$. However, the measurement is

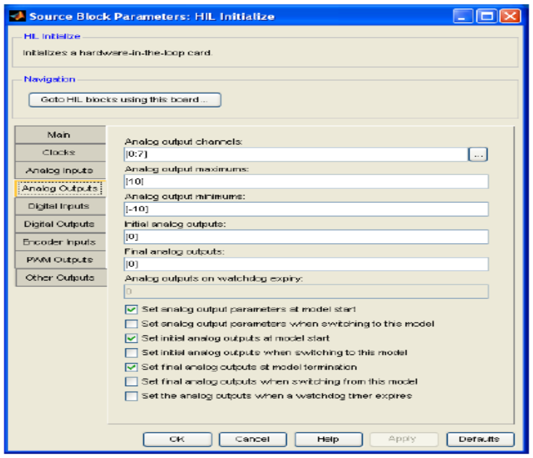

Figure 9: Configuring Analog Input Channel on Data Acquisition Device

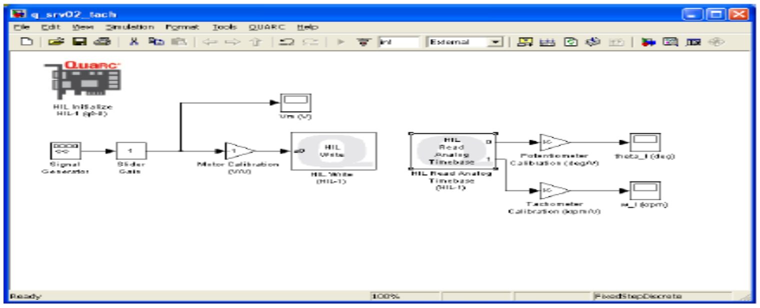

Figure 10: Simulink model with QUARC to send voltage to SRV02 and read the tachometer

taken directly from the motor itself. Thus, to read the velocity of the gear, the tachometer calibration gain must be divided by the gear ratio. Enter `1 / 0.0015 / 70` (rpm/V) in the `Tachometer Calibration` gain block when using the SRV02 in the high-gear configuration or `1 / 0.0015 / 14` (rpm/V) if using the low-gear configuration.

D. Reading Position Using Potentiometer

In this section, we will modify the Simulink diagram designed in Section B using QUARC blocks to obtain readings from the potentiometer sensor.

Here are the basic steps to read voltage from the SRV02 motor using QUARC:

1. Expand the `QUARC Targets` item and go to the following category,
`QUARC Targets`→ `Data Acquisition` → `Generic` → `Immediate I/O`

2. Click-and-drag the `HIL Read Analog` block into the Simulink diagram created in Section B. This block will be used to read a voltage from an Analog Input (AI) channel, i.e. ADC, on the data acquisition device. The output of the `HIL Read Analog` block will be the analog voltage returned by the potentiometer that corresponds to the angular position of the motor.

3. Double-click on the `HIL Read Analog` block, the pane is shown in Figure(11). Make sure board

name is set to `HIL-1` (i.e. points to the `HIL Initialize block`). Set Channels to 0 (default setting). Recall that, as instructed in Appendix A, the potentiometer is connected to ADC Channel 0 on the data acquisition board.

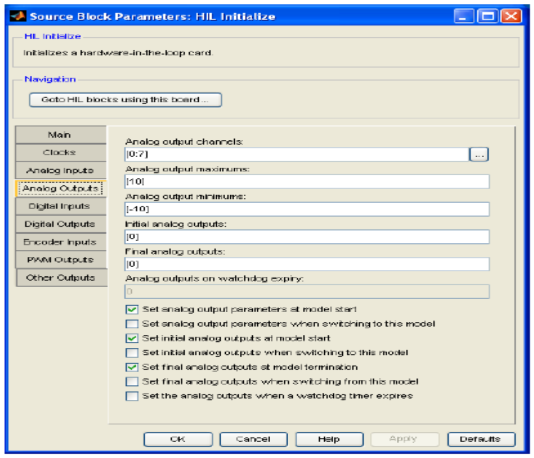

Figure 11: Configuring Analog Input Channel on Data Acquisition Device

4. Add a `Scope` block and two `Gain` blocks, from the `Sinks` and `Math Operations` folders in the Library Browser into the Simulink model. Connect the blocks as shown in Figure(12). Connect one `Gain` block between the previous `Gain` and `HIL Write Analog` blocks and label it `Motor Calibration` (V/V). Another `Gain` block between the `HIL Read Analog` and `Scope` blocks and denote it `Potentiometer Calibration` (deg/V).

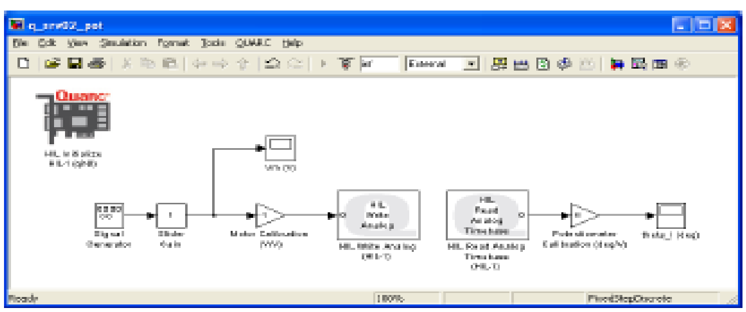

Figure 12: Simulink model with QUARC to send voltage to SRV02 and read the potentiometer

5. Since, the potentiometer outputs between $\pm 5V$ when it rotated $352deg$. Enter the value `352/10` in the `Potentiometer Calibration` block.

E. Reading Position Using Encoder

In this section, we will modify the Simulink diagram designed in Section B using QUARC blocks to obtain readings from the optical encoder sensor.

Here are the basic steps to read voltage from the SRV02 motor using QUARC:

1. Expand the `QUARC Targets` item and go to the following category,
`QUARC Targets`→ `Data Acquisition` → `Generic` → `Immediate I/O`

2. Click-and-drag the `HIL Read Encoder` block into the Simulink diagram created in Section B. This block will be used to read a voltage from an Encoder Input Channel on the data acquisition device. The output of the `HIL Read Encoder` block will be the digital count returned by the optical encode that corresponds to the angular position of the motor.

3. Recall that, as instructed in Appendix A, the encoder is connected to Encoder Input 0 on the data acquisition board. The `HIL Read Encoder` block is already configured for to read Channel 0 and the default encoder configurations in the `HIL Initialize` block are fine, the pane is shown in Figure(13).

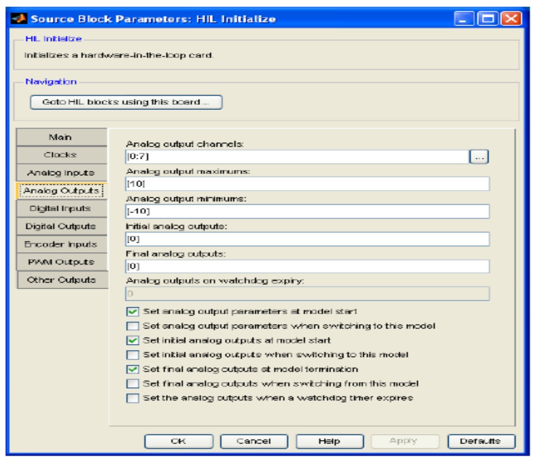

Figure 13: Configuring Digital Input Channel on Data Acquisition Device

4. Add a `Scope` block and two `Gain` blocks, from the `Sinks` and `Math Operations` folders in the Library Browser into the Simulink model. Connect the blocks as shown in Figure(14). Connect one `Gain` block between the previous `Gain` and `HIL Write Analog` blocks and label it `Motor Calibration` (V/V). Another `Gain` block between the `HIL Read Encoder` and `Scope` blocks and denote it `Encoder Calibration` $(deg/count)$.

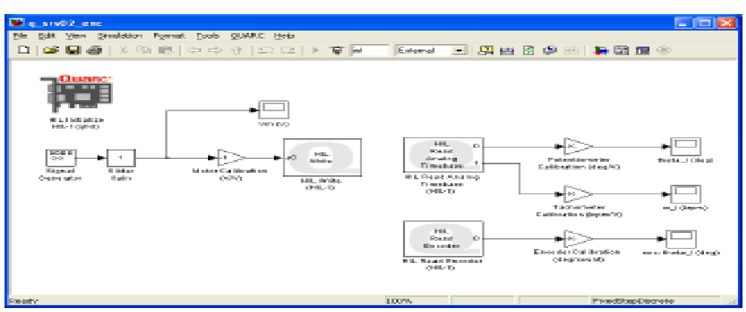

Figure 14: Simulink model with QUARC to send voltage to SRV02 and read the encoder sensor

5. Since, the encoder outputs $4096 counts$ for every full revolution, i.e. $360 deg$. To measure the load

gear angle, set the `Encoder Calibration` block to `360/4096` degrees per count.

F. Compiling the Simulink Model and Running QUARC Code

In this section, we will use the Simulink diagrams designed in previous sections to generate code using QUARC.

Here are the basic steps to generate code from a Simulink diagram:

1. Click the `build` button on the top right hand side of the Simulink model window Figure(15). Various lines in the MATLAB Command Window should be displayed as the model is being compiled. It should look the same as Figure (16).

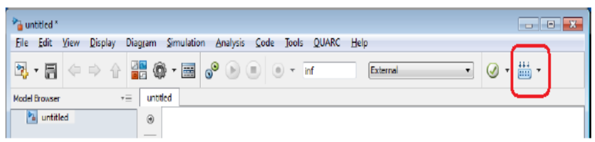

Figure 15: Build Button in the Simulink Model

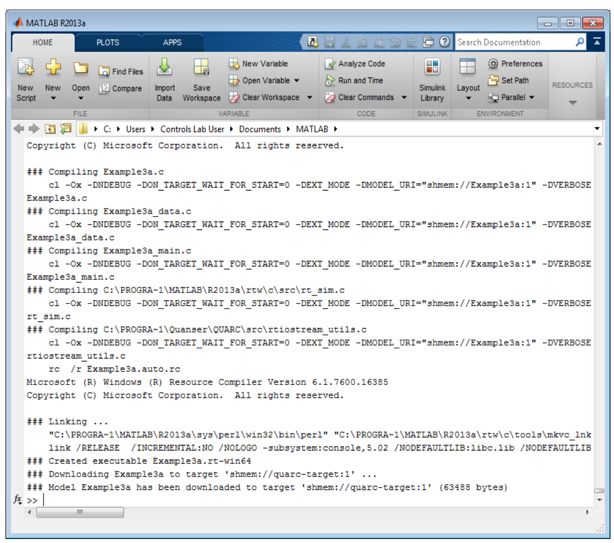

Figure 16: MATLAB Command Window after Compiling the Simulink Model

Once the Simulink model has been compiled, the code can be executed and the voltage set in the Simulink model can be sent to the SRV02 motor.

2. Power ON the power amplifier VoltPAQ-X1. Make sure you set the GAIN on the VoltPAQ-X1 to 1 when using any Rotary Servo Base Unit experiment.

3. To begin executing the code, click on the `Connect to Target` icon in the Simulink model tool bar.

4. After connecting the Simulink model to the target, click the `Run` button and the servo should begin rotating back-and-forth. These buttons are shown in Figure(17).

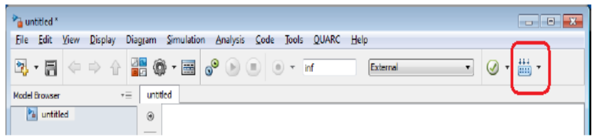

Figure 17: Build Button in the Simulink Model

5. Click on the `Stop` button in the Simulink model tool bar to stop the code execution. The button is shown in Figure(18).

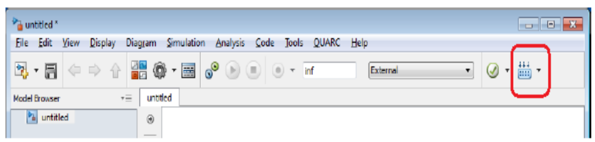

Figure 18: Build Button in the Simulink Model

6. Power OFF the power amplifier at the end of the experiment.