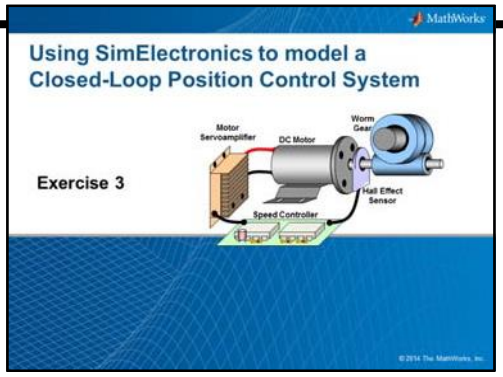
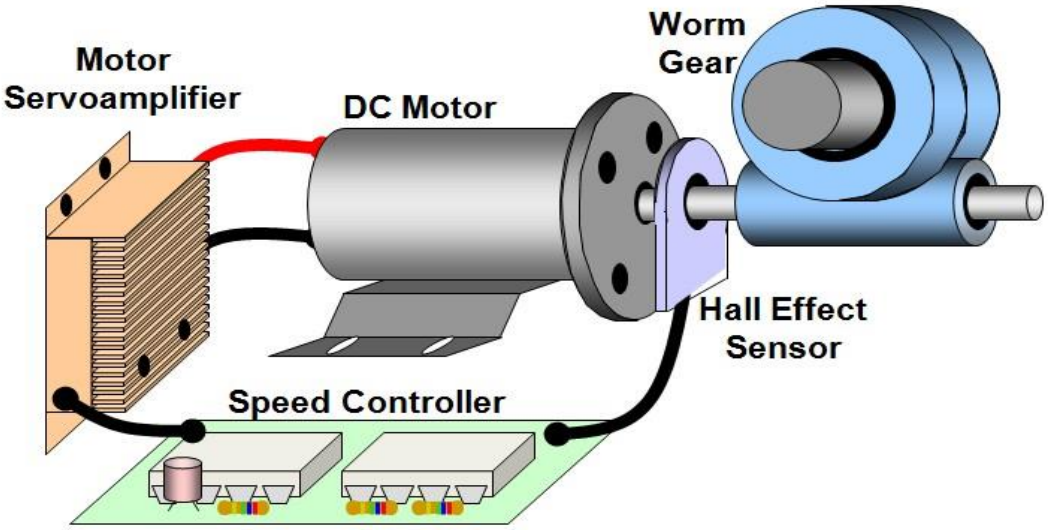
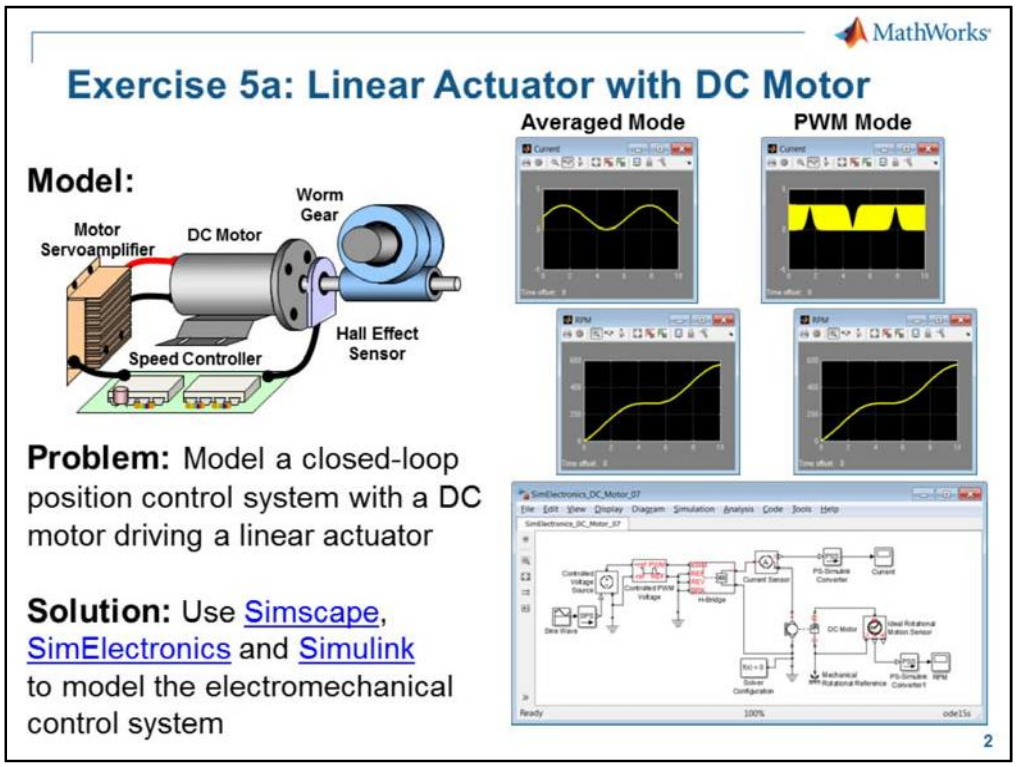


Note:
ALL changes are in bold, italic and time new roman font like this statement

Exercise 3

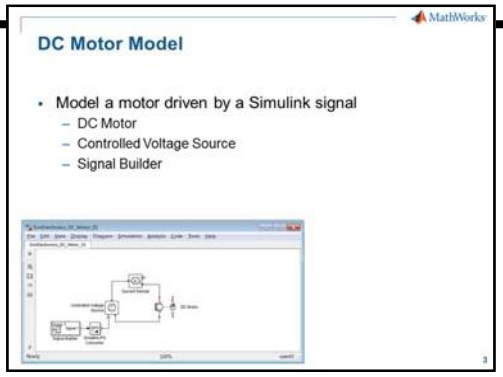
Using SimElectronics to model a Closed-Loop Position Control System





In this exercise, we will model an linear actuator with a DC motor using SimElectronics The system will include a PWM driver, H-bridge, DC Motor, and sensor for measuring the speed. We will see how you can combine Simulink components in order to create reusable subsystems. In addition, we will look at a demonstration model from the product to learn more about what you can do with this tool. It is recommended to save your model regularly as you progress through the exercise.

Add DC motor and electrical input



1. Create a new Simulink model
   1. In the Simulink Library Browser, select File->New->Model.

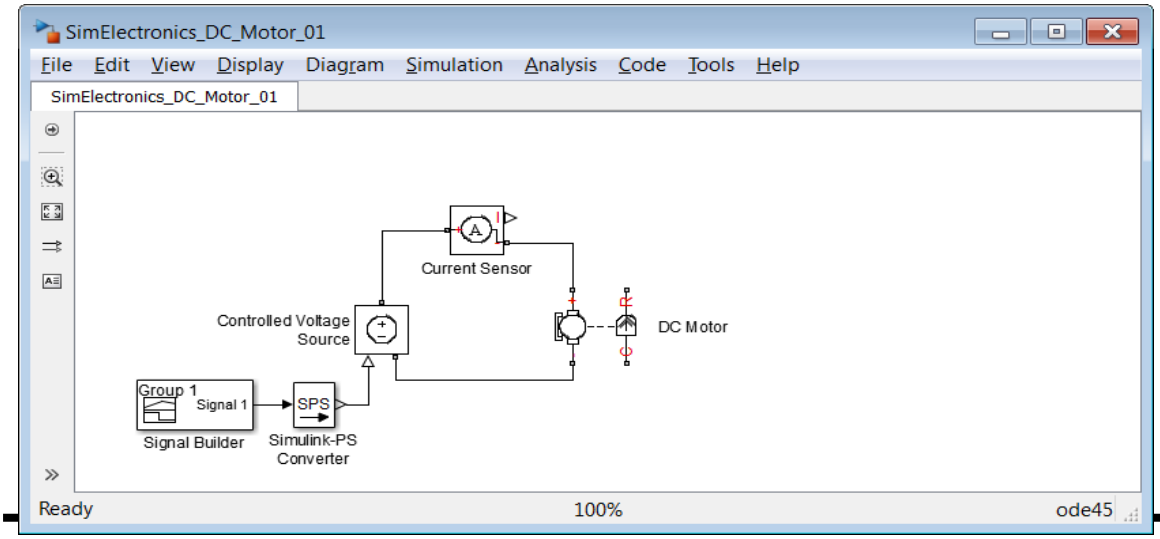
2. From library "***Simscape/Electronics/Actuators & Drivers/Rotational Actuators***" drag a "DC Motor" into your model.

3. From library "Simscape/Foundation Library/Electrical/Electrical Sources" drag a "Controlled Voltage Source" into your model.

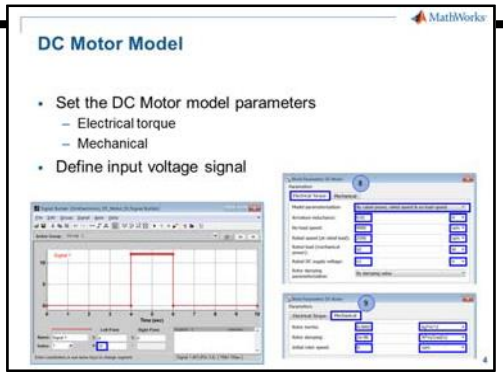
4. From the library "Simscape/Foundation Library/Electrical/Electrical Sensors " drag a "Current Sensor" block into your model.

5. From the library "Simscape/Utilities" drag a "Simulink-PS Converter" into your model.

6. From the library "Simulink/Sources" drag a "Signal Builder" into your model. Connect the blocks as shown below.



Parameterize DC Motor

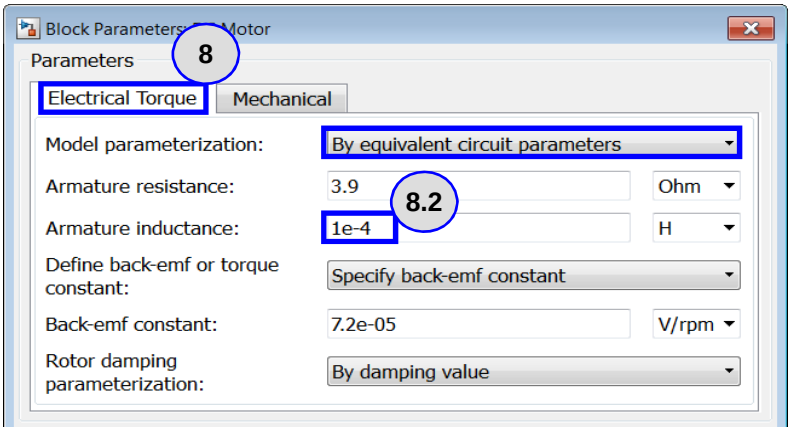


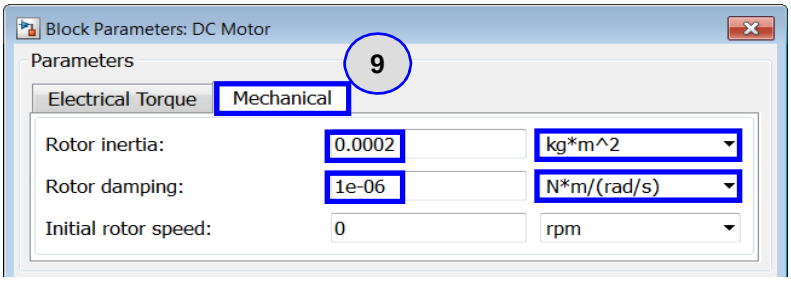
7. Double-click on the **DC Motor** and modify the parameters as shown:

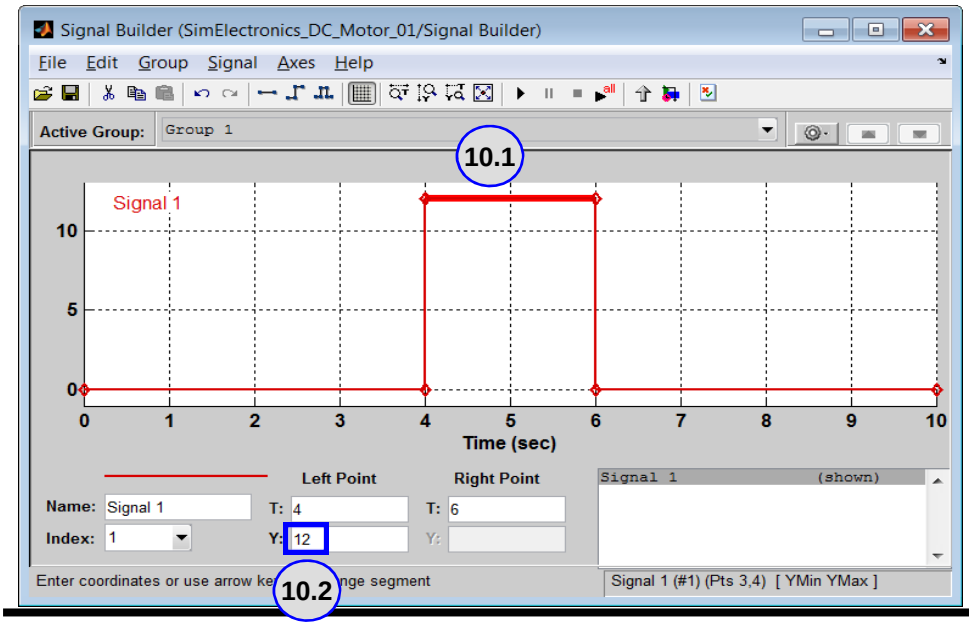
8. Click on the **Electrical Torque** tab
   1. Set **Model parametrization** to **By equivalent circuit parameters.**
   2. Set **Armature Inductance** to **1e-4 H**

9. Click on the **Mechanical** tab
   1. Set **Rotor inertia** to **0.0002 kg*m^2**
   2. Set **Rotor damping** to **1e-06 N*m/(rad/s)**
   3. Click **OK**

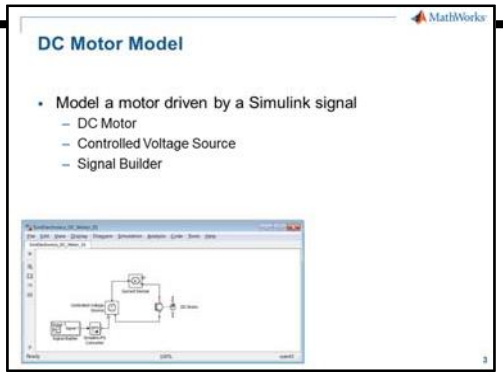
10. Double-click on the Signal Builder block to open the editor.
    1. Click on the high segment of the pulse
    2. Change the **Y** value to **12**







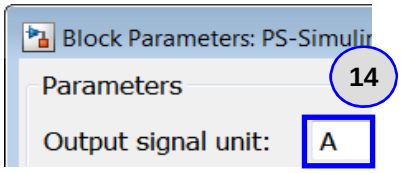
Add Sensors and Scopes



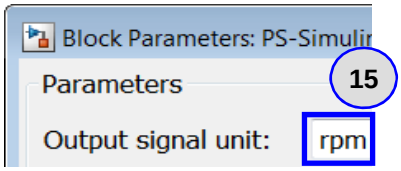
11. From library ***Simscape/Foundation Library/Mechanical/ Mechanical Sensors*** drag an **Ideal Rotational Motion Sensor** block into your model and connect mechanical ports to **DC Motor** as shown below

12. From library **Simscape/Utilities** drag two **PS-Simulink Converter** into your model and connect to sensors as shown below

13. Double-click on the **PS-Simulink Converter** block for the **Ideal Rotational Motion Sensor** and change parameter **Output signal unit** to ***Rad/s***.



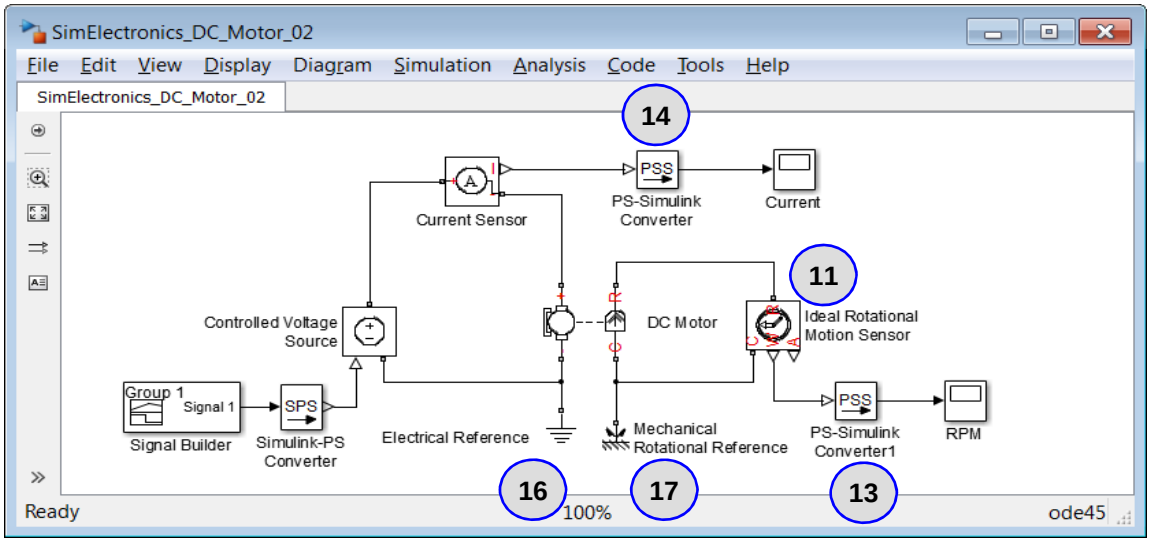
14. Double-click on the **PS-Simulink Converter** block for the **Current Sensor** and change parameter **Output signal unit** to **A**.



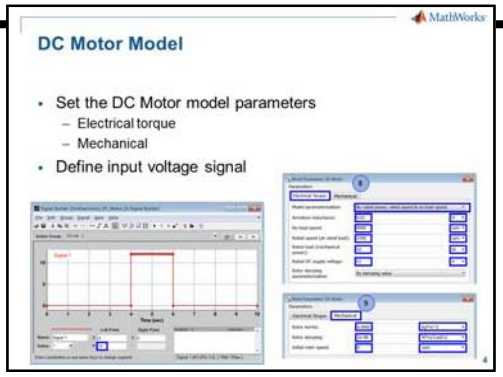
15. From library **Simulink/Sinks** drag two **Scope** blocks and connect to the **PS-Simulink Converter** blocks as shown. Rename them **Current** and ***Rad/s*** as shown below.

16. From tlibrary **Simscape/Foundation Library/Electrical/ Electrical Elements**, drag an **Electrical Reference** into your model and connect as shown below

17. From library **Simscape/Foundation Library/Mechanical/ Rotational Elements**, drag an **Mechanical Rotational Reference** into your model and connect as shown below.



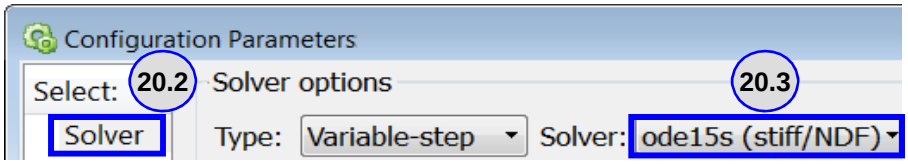
Create the electrical portion of the motor

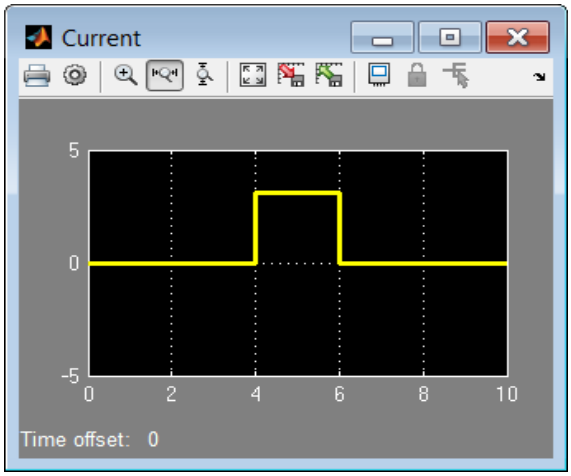


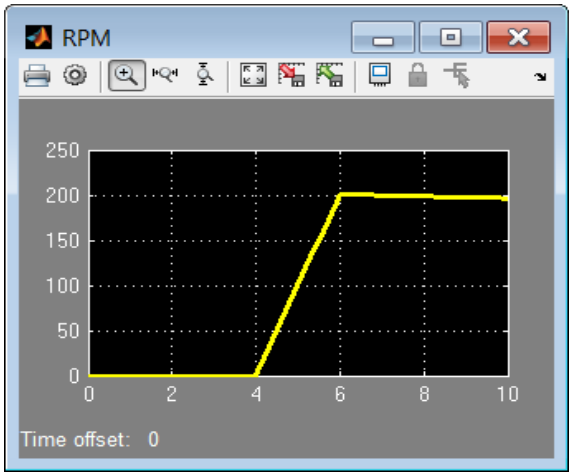
19. From the library **Simscape/Utilities**:
    1. Drag a **Solver Configuration** block into your model.
    2. Connect to any physical connection as shown below.

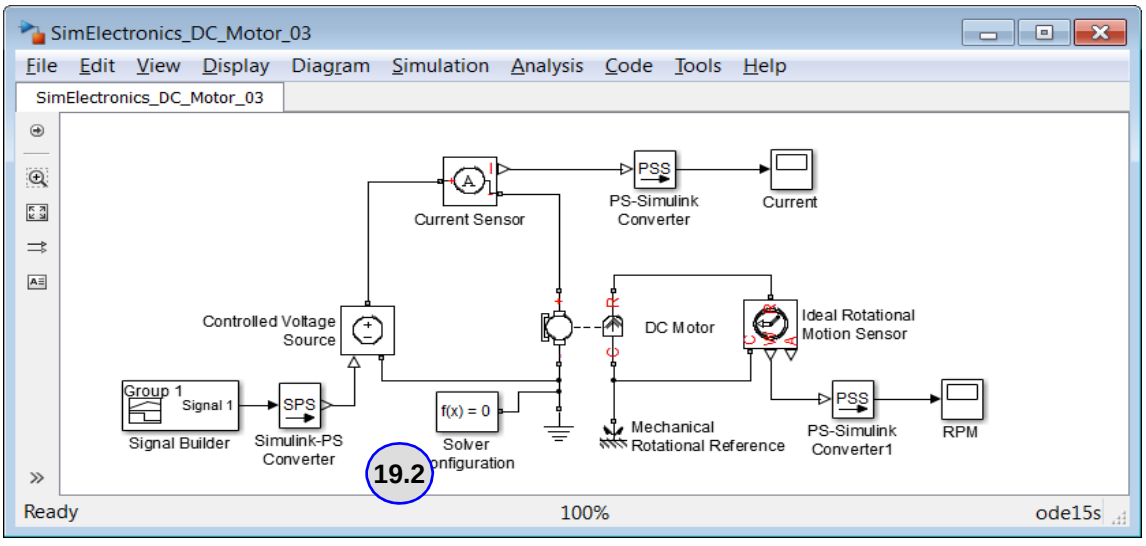
20. Change the Simulink solver type to ODE15s.
    1. Select menu item **Simulation->Model Configuration Parameters**.
    2. On the left hand side, select **Solver**.
    3. In the **Solver Options** area, set the **Solver** parameter to **ode15s**.

21. Simulate and look at results for current and RPM
    (menu item **Simulation->Run**)

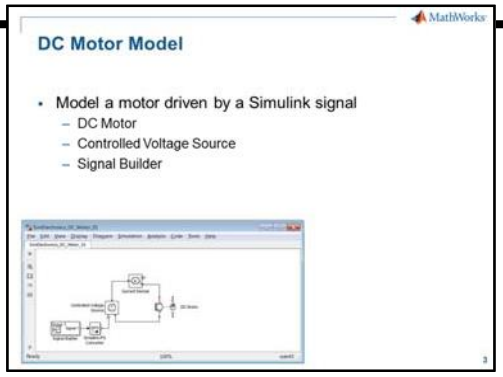








Add H-Bridge Control

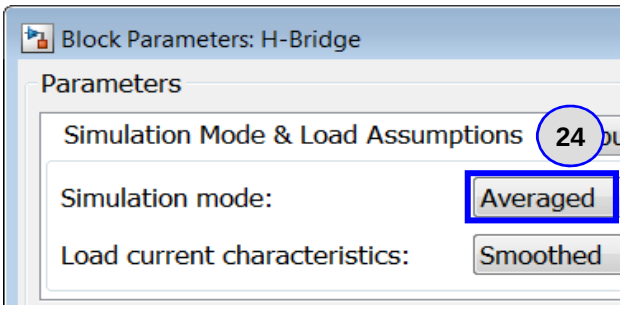


22. Delete the Controlled Voltage Source, Signal Builder and S PS blocks

23. From library ***Simscape/Electronics/Actuators & Drivers/Drivers***

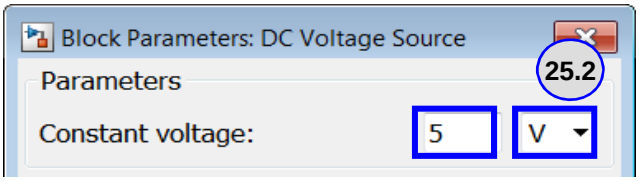
1. Drag the **H-Bridge** block into your model.
2. Connect the electrical outputs to the current sensor and ground.
3. Connect the REF, REV and BRK ports to ground

24. Double-click on the **H-Bridge** Block and change parameter **Simulation Mode** to **Averaged**

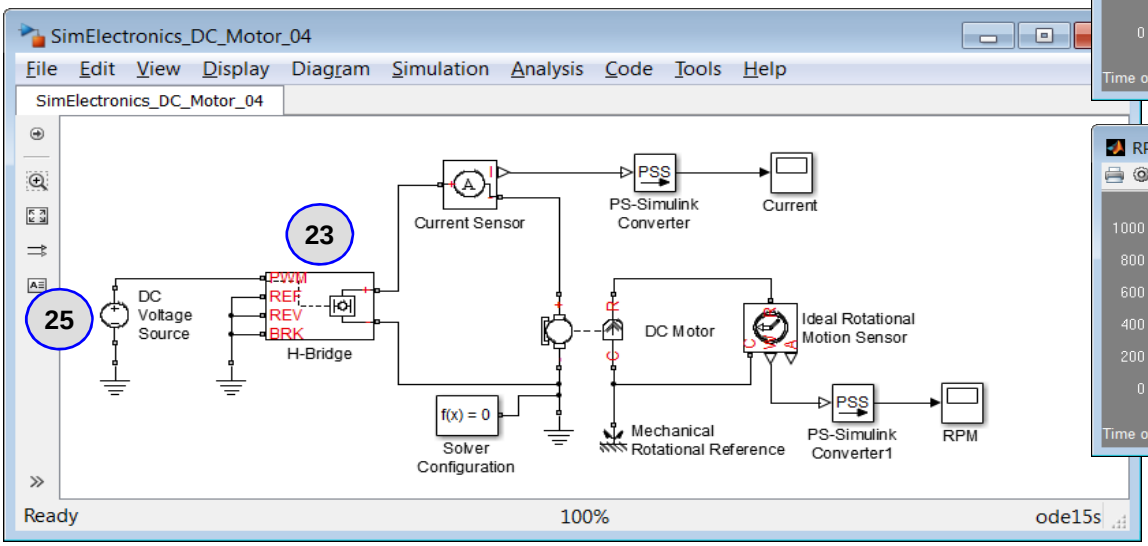


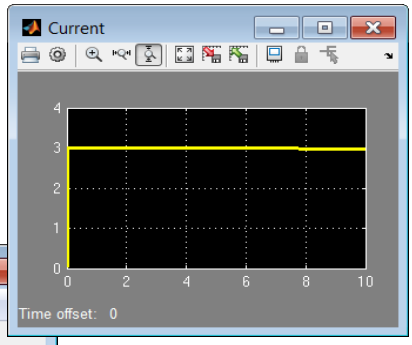
25. From the library **Simscape/Foundation Library/ Electrical/Electrical Sources**

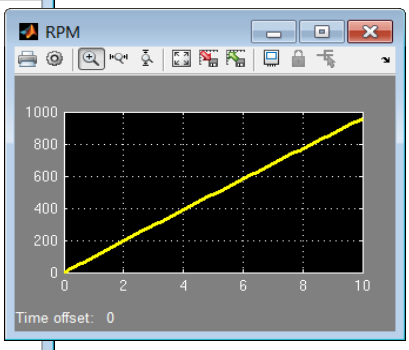
1. Drag a **DC Voltage Source** into your model.
2. Double-click on the **DC Voltage Source** and set the parameter **Constant Voltage** to **5V**
3. Connect to **H-Bridge** and ground as shown below.



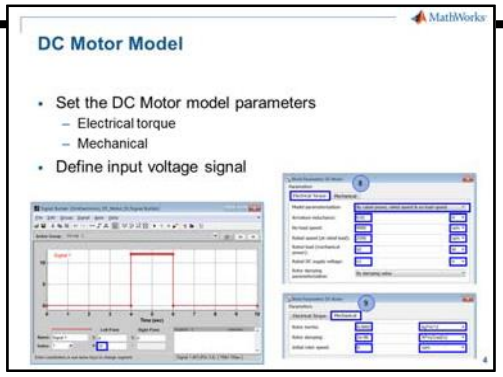
26. Re-run simulation and observe the motor RPM







Reverse Motor Using H-Bridge Control

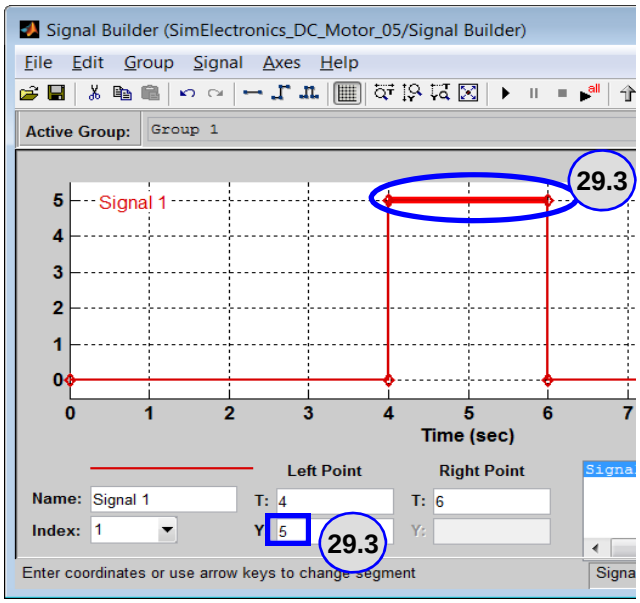


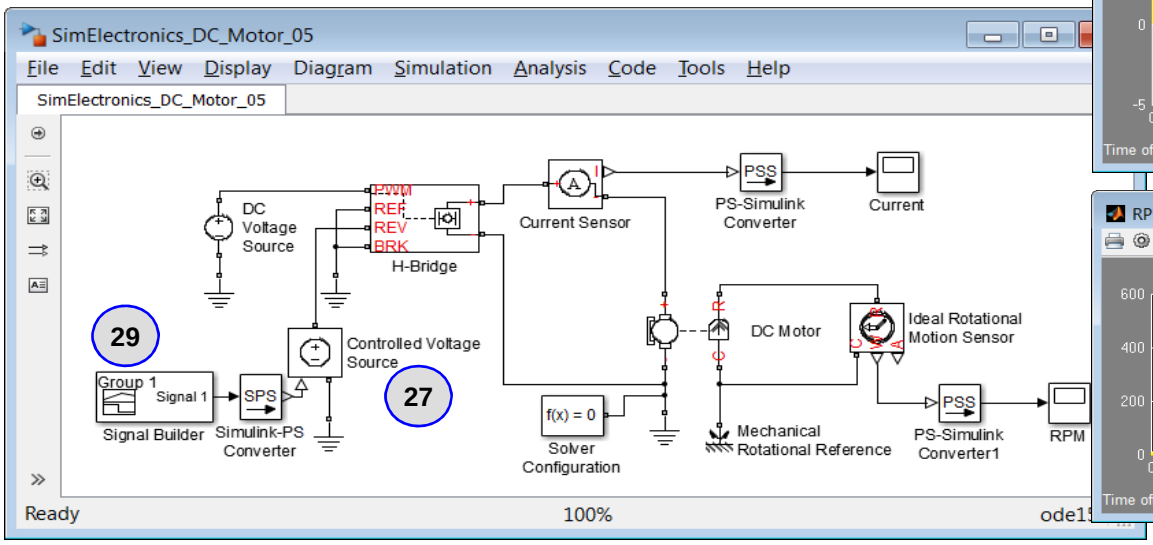
27. Control the REV pin with a signal
    1. From library **Simscape/Foundation Library/Electrical/ Electrical Sources** Drag a **Controlled Voltage Source** into your model.
    2. Connect the + port to the REV port on the H-Bridge shown below (be sure to disconnect the REV port from ground)
    3. Connect the – port to ground

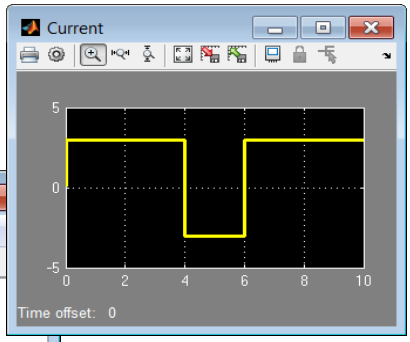
28. From the library **Simscape/Utilities** drag a **Simulink-PS Converter** block into your model Connect its output to the **Controlled Voltage Source** input as shown below.

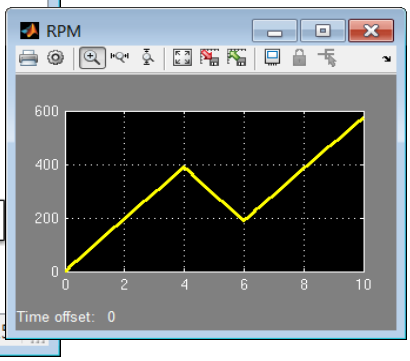
29. Add a pulse signal
    1. From the library **Simulink/Sources** drag a **Signal Builder** block into your model
    2. Connect it as shown below.
    3. Double-click on the **Signal Builder**
    4. Click the top of the pulse and set parameter **Y** to **5**

30. Re-run simulation and observe the effect of the reverse signal on the motor RPM

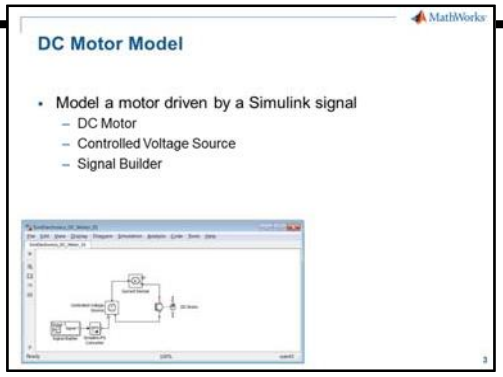








Apply Braking Using H-Bridge Control



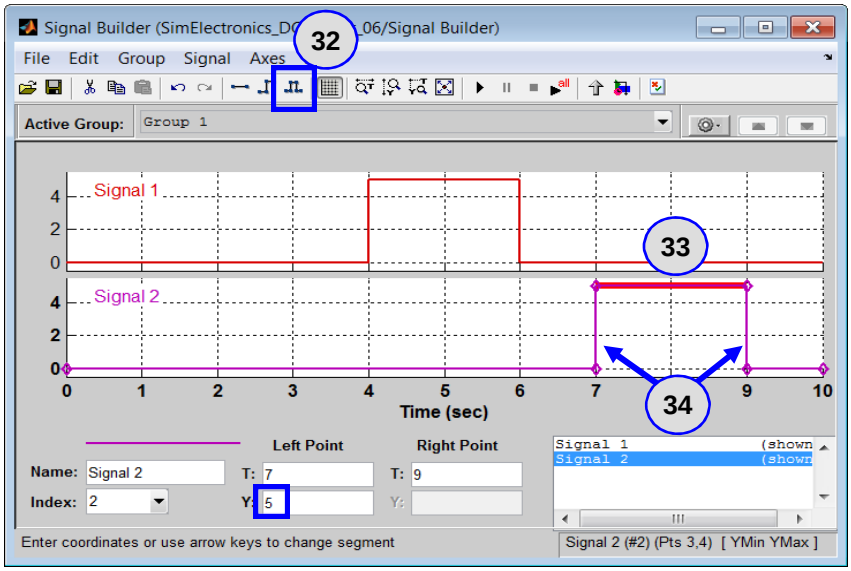
31. Copy the **Simulink-PS Converter**, **Controlled Voltage Source**, and **Electrical Reference** blocks and connect to the BRK port on the **H-Bridge** as shown below

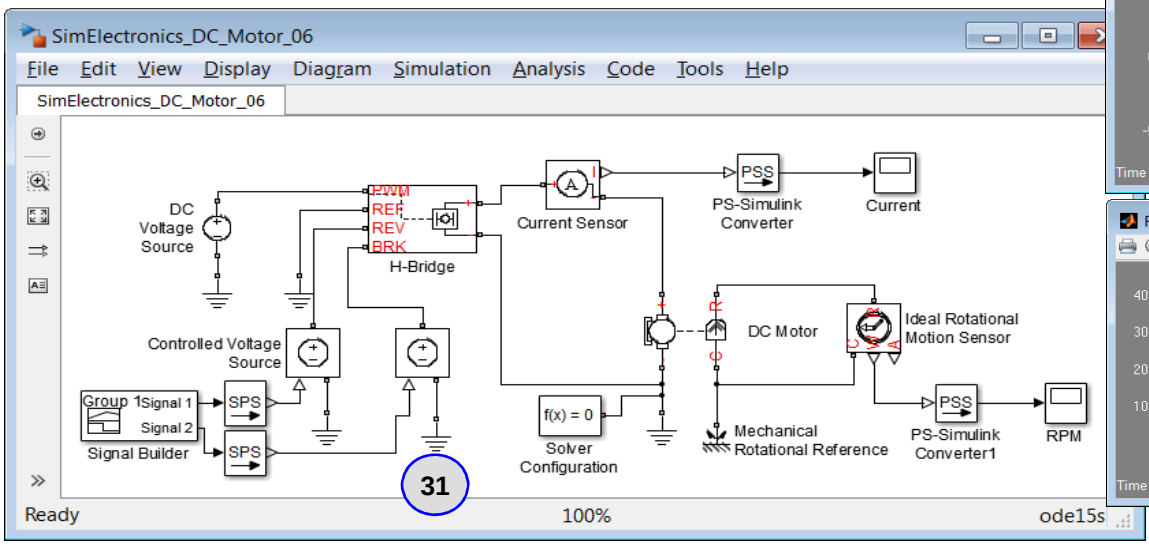
32. Double-click on the **Signal Builder** block and add a second pulse signal

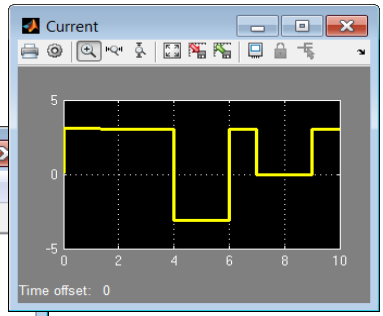
33. Click on the max level and change value to 5.

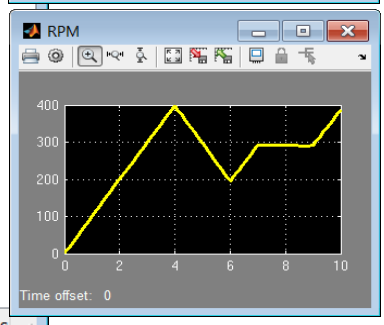
34. Drag the pulse edges to 7 sec and 9 sec

35. Re-run simulation to observe the effect of the breaking signal on RPM

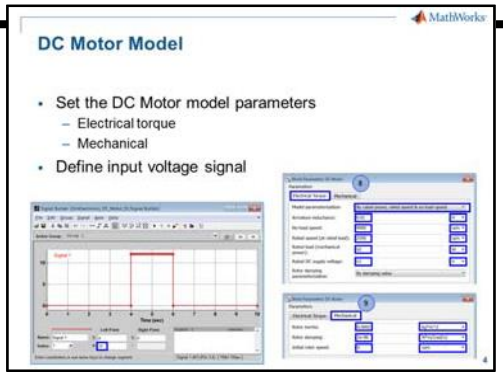








Add PWM Driver Control



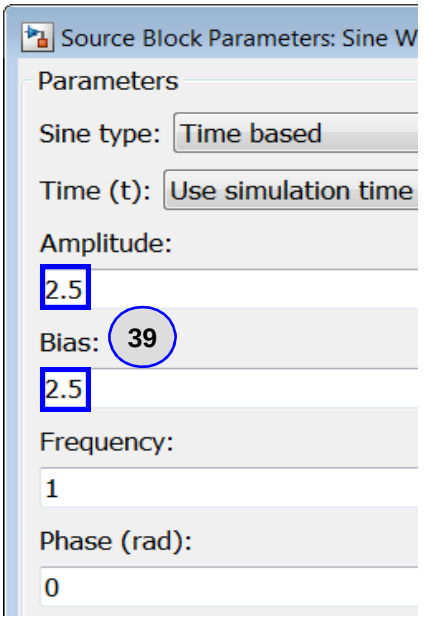
36. Drive the circuit with a PWM signal
    1. Delete one **DC Voltage Source**, **Signal Builder**, and **Simulink-PS Converter**.
    2. Connect REF, REV, and BRK pins to ground.
    3. From library ***Simscape/Electronics/Actuators & Drivers/Drivers*** drag a **Controlled PWM Voltage** block into your model. Connect as shown below.
    4. Double-click on the **Controlled PWM Voltage** block and change **Simulation mode** to **Averaged**

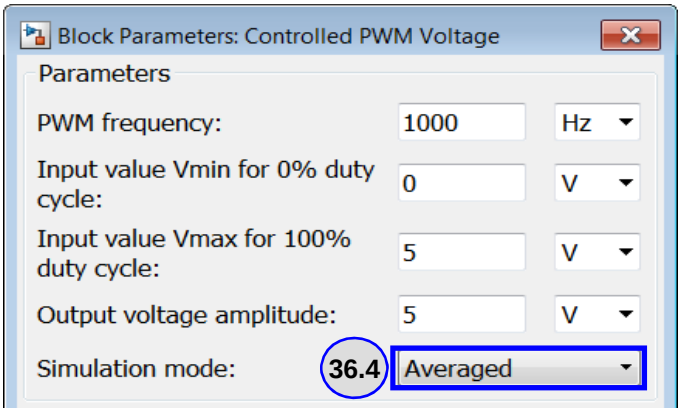
37. Connect one of the Controlled Voltage sources across the +ref and –ref PWM inputs as shown below

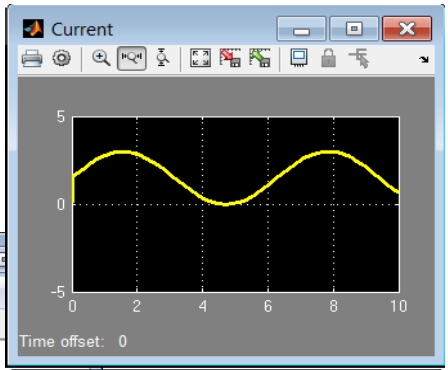
38. From library **Simulink/Sources** drag a **Sine Wave** into your model. Connect to the Controlled Voltage Source input through the **Simulink-PS Converter** block as shown below.

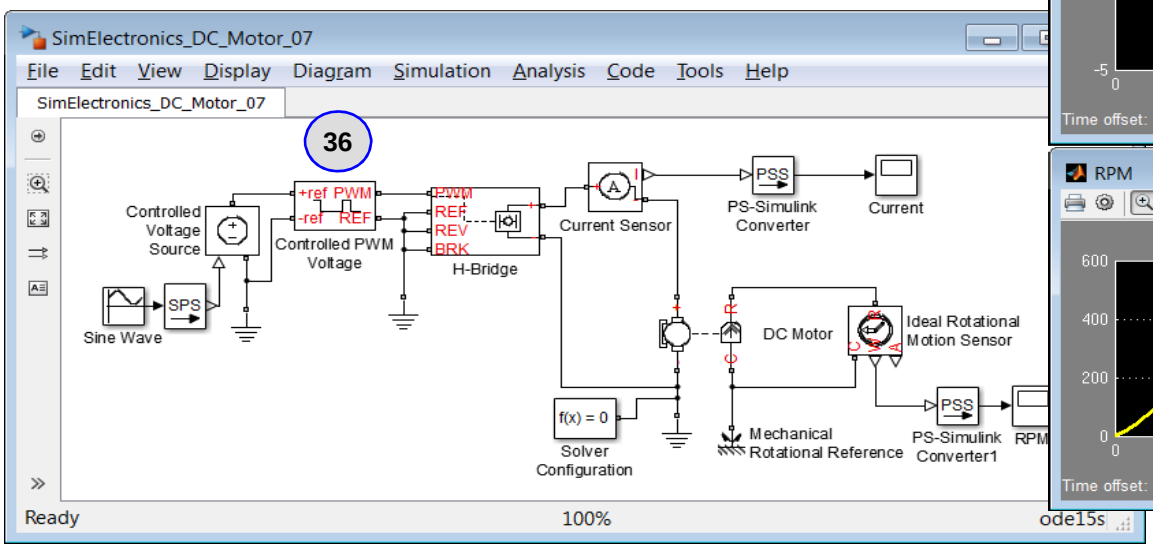
39. Double-click on the **Sine Wave** block and set the **Amplitude** and **Bias** to **2.5**

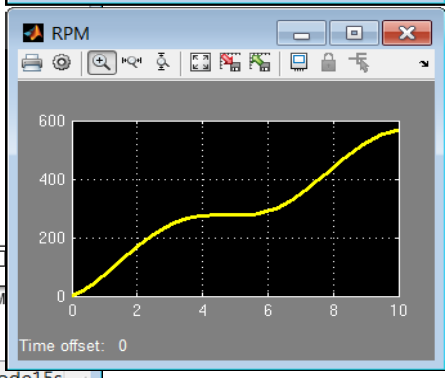
40. Run simulation



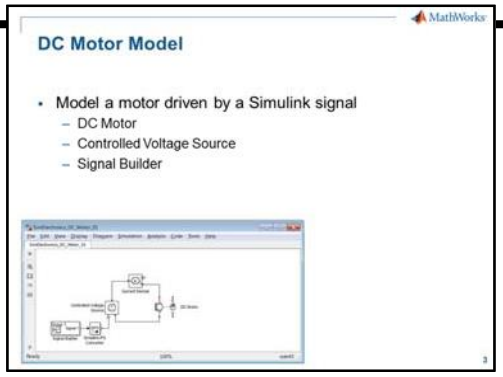








Verify with PWM Model



41. Double-Click on the **Controlled PWM Voltage** block
    1. Change the **Simulation Mode** to **PWM**

42. Double-Click on **H-Bridge** block and change the **Simulation Mode** to **PWM**

43. Remove the limit on data in the Scopes
    1. On the **Current** Scope, click the **Parameter** button
    2. Click on the ***logging*** tab
    3. Clear the **Limit data points to last** checkbox
    4. Repeat these steps for the **RPM** Scope

44. Run the simulation.

45. Examine the simulation output in the scopes using the zoom tools
    1. Note that the voltage applied to the motor is a 1kHz PWM signal (**Current** Scope)
    2. Note that the speed profile is almost identical, but slight variations in speed can be seen during the on/off portions of the PWM signal (**RPM** Scope)