Getting Started with the MapleSim Control Design Toolbox

Getting Started with the MapleSim Control Design Toolbox

This document was produced using a special version of Maple and DocBook.

Printed in Canada

Contents

Introduction

The MapleSim™ Control Design Toolbox provides control design tools that extends the plant modeling capabilities of MapleSim to support control design. Using a symbolic approach, you can design, analyze, and test control systems.

You can also use the technical documentation tools available with MapleSim to document your design decisions.

Features of this toolbox include:

- Model linearization
- Standard PID tuning techniques: Ziegler-Nichols time response, Ziegler-Nichols frequency response and Cohen-Coon
- Advanced PID tuning techniques: Dominant pole placement, pole placement in a specified region, and gain and phase margin
- State Feedback Control: Single input pole placement (Ackermann), multiple input pole placement, and LQR
- State Estimation: Single output pole placement (Ackermann), multiple output pole placement, and Kalman filter
- Access to commands in the **ControlDesign** and **DynamicSystems** packages

Scope of Model Support

MapleSim Control Design Toolbox is a very comprehensive modeling tool where it is possible to design linear controllers for models created in MapleSim. The Control Design Toolbox can linearize systems of any complexity, including systems of DAEs of any index.

Systems that contain any type of discontinuity, including discrete transforms, switches, logic gates, relational and Boolean operations are not supported by the current release of this product.

1 Getting Started

1.1 Getting Help

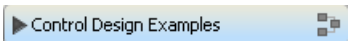
In Maple, enter **?ControlDesign** at a prompt in a worksheet.

1.2 Using the MapleSim Control Design Templates

The MapleSim Control Design Toolbox provides templates in the form of a Maple worksheet for linearizing MapleSim models and creating PID controllers. These templates contain pre-built embedded components that allow you to generate a linearized representation of your model subsystems, as well as custom components of your system controllers.

Viewing MapleSim Control Design Examples

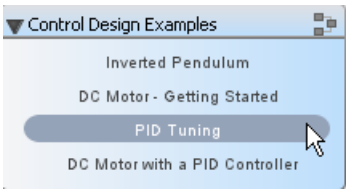
Toolbox examples are available in the **Control Design Examples** palette in MapleSim.



Each example includes a linearization or PID tuning template in its **Attachments** palette.

To view an example:

1. In the **Control Design Examples** palette at the left side of the MapleSim window, click the entry for the model that you want to view.



2. In the **Project** tab, expand the **Attachments** palette and then expand **Documents**.
3. Right-click (**Control**-click for Macintosh®) **PIDTuning** and select **View**. The template opens in Maple.

Some models include additional documents, such as templates that display model equations or define custom components. You can open any of these documents by right- or **Control**-clicking its entry and selecting **View**.

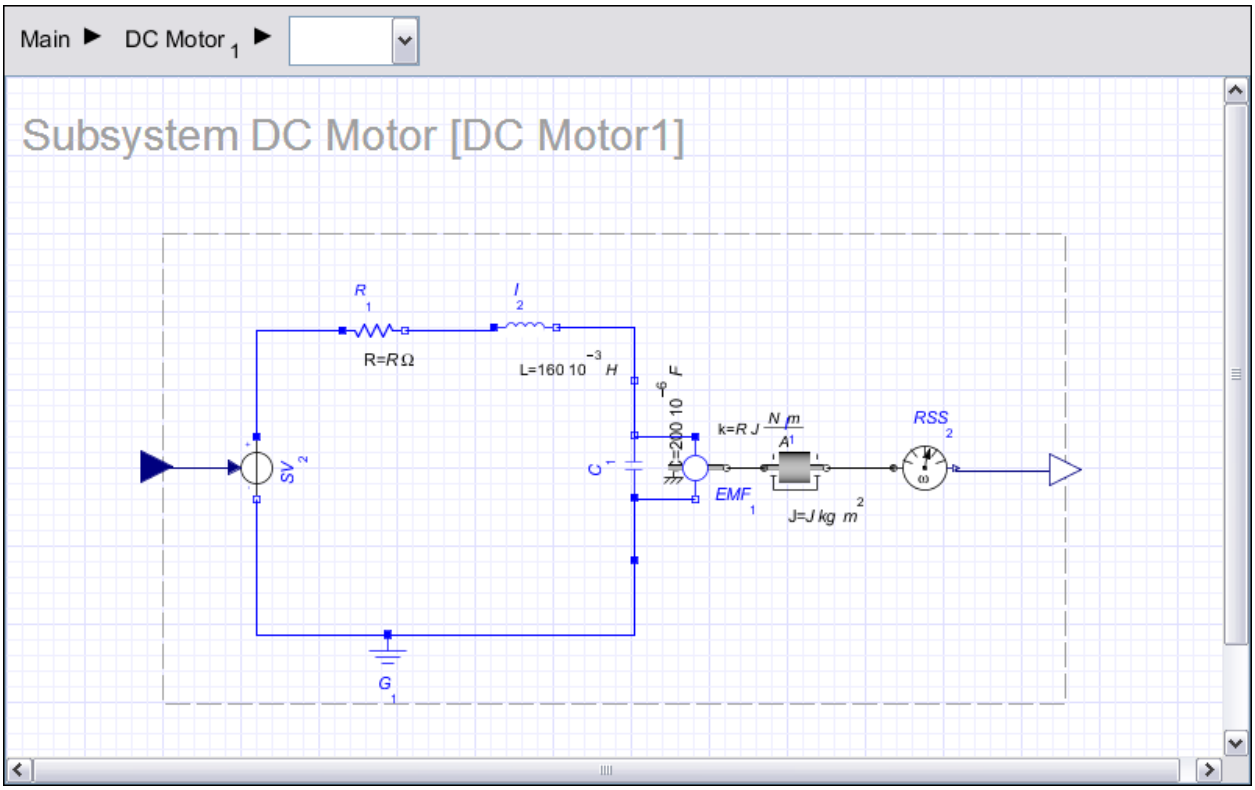
1.3 Example: DC Motor

In this example, you will generate a linearized state-space model of the models you created in MapleSim. You will then use this linearized model to create and tune a PID controller.

Generating a Linearized Model

To generate a linearized model:

1. In the **Control Design Examples** palette, open the **DC Motor - Getting Started** model.
2. Click the templates button () in the main toolbar.
3. From the list, select **Linearization**.
4. In the **Attachment** field, enter **Linearized Motor** as the worksheet name and click **Create Attachment**. Your MapleSim model opens in the **MapleSim Linearization Template** in Maple.
5. Using the navigation controls above the model, browse to the **DC Motor** subsystem.



6. Click **System Update**. The **Model Summary** fields are populated with information specific to the subsystem. You can now specify the equilibrium points manually or have Maple automatically calculate them for you.
7. To manually specify the equilibrium values of the state and input variables, select the variables from the drop-down menu and enter the appropriate values. Alternatively, to calculate the equilibrium point automatically, click the **Compute Equilibrium Point** button.
8. Click the **Linearize/Generate State Space** button to generate the linearized model.

The **Variable Map** and **Linearized Model** fields are automatically updated. You can now select and view the state, input, and output mappings in the **Variable Map** fields. In the **Linearized Model** field, you can select and view the matrices of your linearized model.

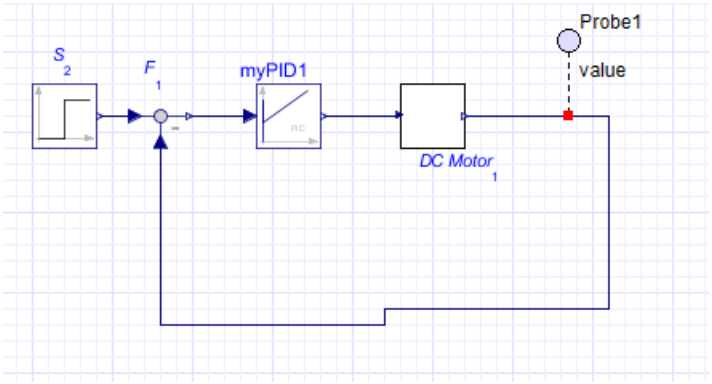
9. Scroll to the bottom of the template.
10. In the **Name** field, enter **MyMotor**. The description field shows a detailed summary of your model description. You can add more information about your model in this area.
11. Click **Save** to create the linearized state-space model. The file **MyMotor.msys** now appears in the **Attachments** palette in MapleSim.
12. Close the **Linearization Template** and return to the **DC Motor** model in MapleSim.

Creating a Custom Controller

To create a custom controller:

1. Click the templates button ( ) in the main toolbar.
2. From the list, select **PID Tuning**.
3. In the **Attachments** field, enter **Motor PID** as the worksheet name and click Create **Attachment**. Your MapleSim model opens in the **PID Tuning Template** in Maple.

4. In the **Model Input from an .msys File** section of the template, select **MyMotor.msys** from the drop-down list. The **Name**, **Description**, and matrix fields are automatically populated.
5. Click **Assign to Variable** to create a DynamicSystems object and assign it to a variable name for further manual analysis. In the **Controller Design** section of the template, you can select the method and controller type you wish to create. For this example, create a Ziegler-Nichols Time Domain PID controller.
6. From the **Method** drop-down menu, select **Ziegler-Nichols Time Domain (MZN)**. From the **Controller** drop-down menu, select **PID**. If additional information is required for your control design method, the fields below these menus will be populated and you can enter the required information.
7. In the field below the table with controller parameters, enter **MyPID** and then click the **Design Controller** button, then click the **Export to MapleSim** button. A custom component generates and exports to MapleSim.
8. Optionally, you can view the Modelica® code generated for the custom component by expanding the **Modelica** text area. To analyze properties, you can use the plotting tools, such as Zero pole, Bode, Step Response, and Nyquist in the **Analysis** section of the template.
9. Return to your model in MapleSim.
10. In the **Project** tab, expand the **Definitions** palette. The custom component **MyPID** appears.
11. Drag the custom component from the palette to add it to your model.
12. In the **Libraries** tab, expand the **Signal Blocks > Common** menu and drag **Feedback** and **Step** signal components into the model workspace.
13. Connect the components to your model, as shown below.



14. Click the probe button ( ) in the toolbar and then click the connection line between the **DC Motor** and **Feedback** component.
15. Click the probe once to position it.
16. In the **Inspector** tab, select **Real.**
17. Click the simulation button ( ) in the main toolbar to simulate your model.

You can change the parameters of your controller directly in your model in MapleSim by selecting the PID controller component and editing the parameters in the **Inspector** tab.

Index