2

LTI Viewer

The LTI Viewer is a graphical user interface (GUI) that supports ten plot responses, including step, impulse, Bode, Nyquist, Nichols, zero/pole, sigma (singular values), `lsim`, and `initial` plots. The latter two are only available at the initialization of the LTI Viewer; see `ltiview` for more information.

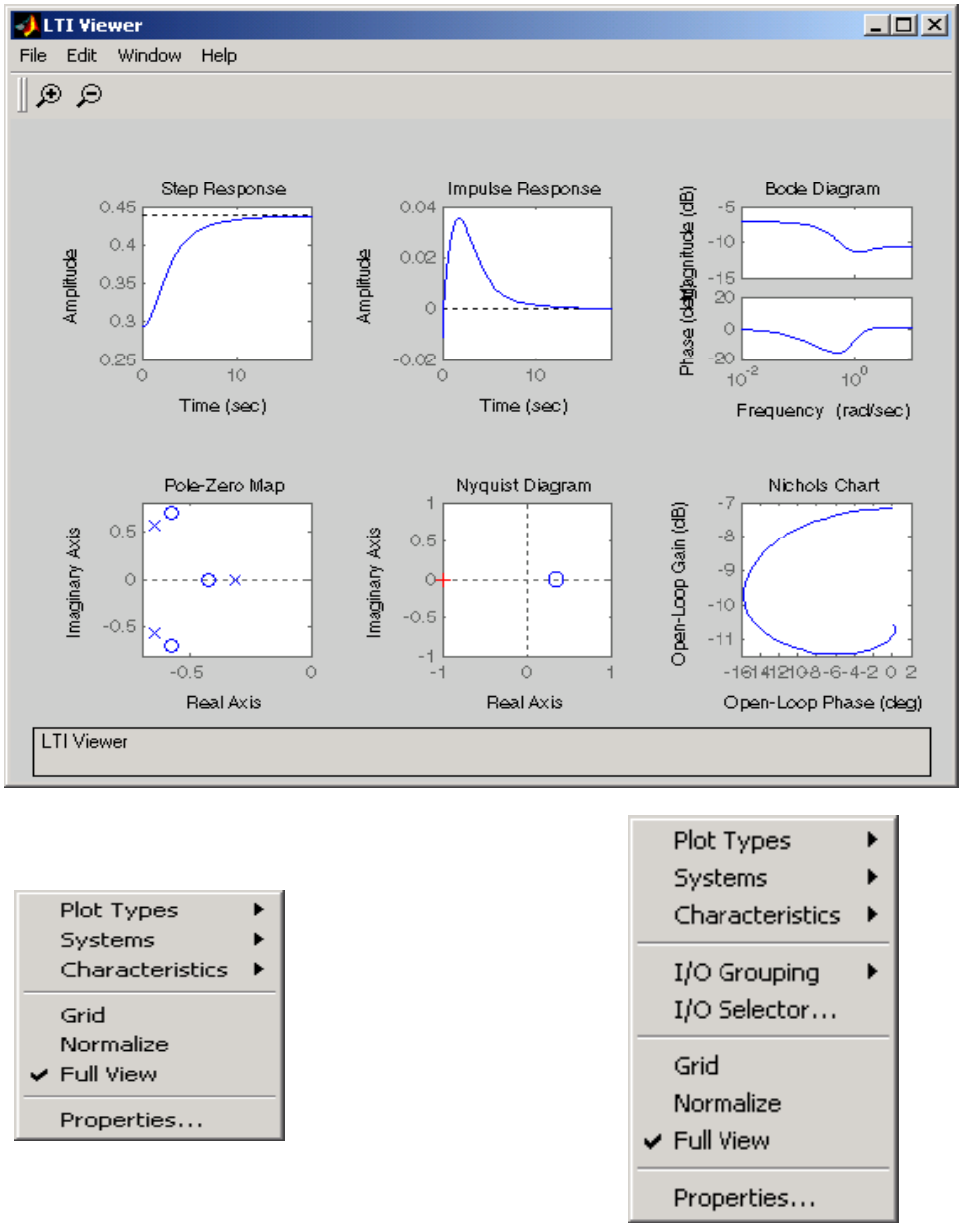
The LTI Viewer is configurable and can display up to six plot type and any number of models in a single viewer. In addition, you can display information specific to the response plots, such as peak response, gain and phase margins, and so on.

You can open the LTI Viewer by typing

```
ltiview
```

at the MATLAB prompt. You can also open an LTI Viewer from the SISO Design Tool; see "SISO Design Tool" on page 1-1 for more information.

Note Click on any of the plots of the LTI Viewer, shown below, to get help on selecting characteristics for the plot. Click on the menu bar to get help on its contents. Click on the right-click menus, also shown below, to get help on right-click menu features.



The LTI Viewer and Right-Click Menus for SISO and MIMO/LTI Array Models.

LTI Viewer Menu Bar

Note Click on **File**, **Edit**, **Window**, or **Help** on the menu bar pictured below to get help on the menu items.

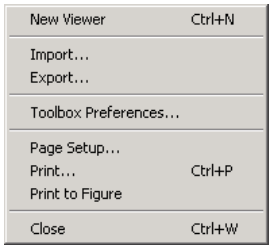
This picture shows the LTI Viewer menu bar.

Tasks that you can perform using the LTI Viewer menu bar include:

- Importing and exporting models
- Printing plot responses
- Reconfiguring the Viewer (add or remove plot responses)
- Displaying critical values (peak responses, etc.) and markers on each plot

File

Note Click on any of the items listed in the **File** menu pictured below to get help contents.



You can use the **File** menu to do the following:

- Open a new LTI Viewer

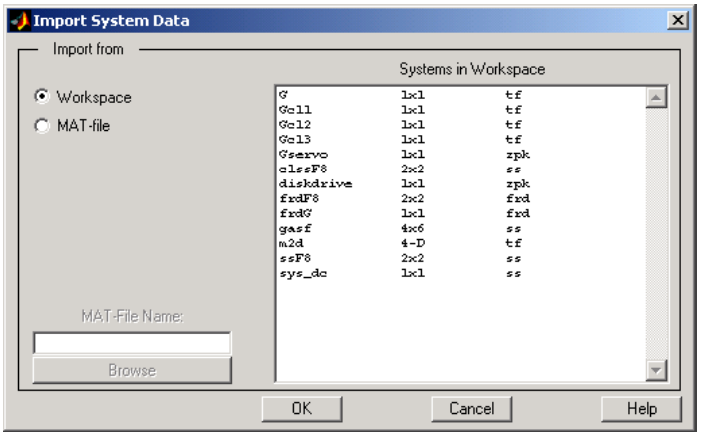
- Import and export models
- Set plot preferences for all the plots generated by the Control System Toolbox
- Print response plots
- Close the LTI Viewer

New Viewer

Select this option to open a new LTI Viewer.

Import Using the Import System Data Window

Import in the **File** menu opens the **Import System Data** window.



You can use the **LTI Browser** to import LTI models into the LTI Viewer.

To import a model

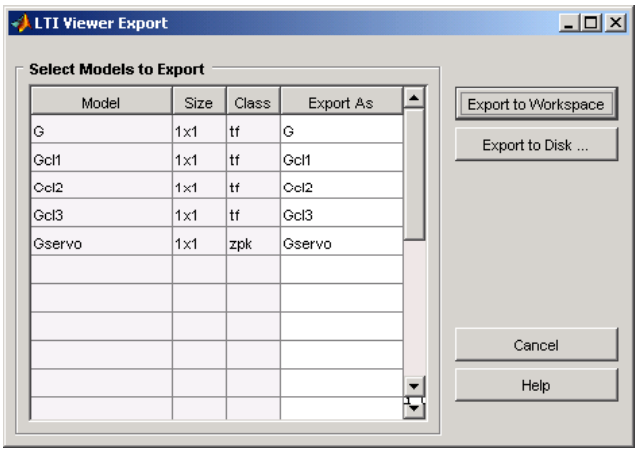
- Click on the desired model in the LTI Browser List. To perform multiple selections:
  a. Hold the **Control** key and click on the names of nonadjacent models.
  b. Hold the **Shift** key while clicking, to select a set of adjacent models.
- Click the **OK** or **Apply** Button

Note that models must have identical numbers of inputs and outputs to be imported into a single LTI Viewer.

For importing, the LTI Browser lists only the LTI models in the main MATLAB workspace.

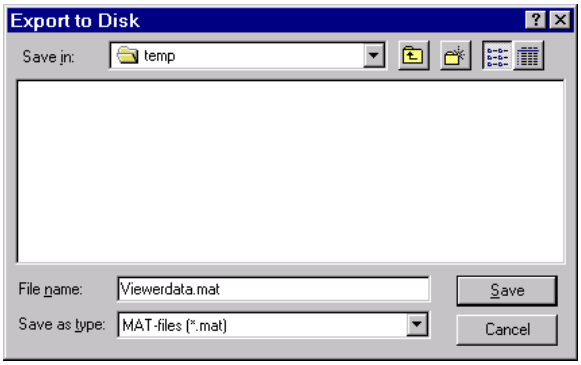
Export Using the LTI Viewer Export Window

Export in the **File** menu opens the **LTI Viewer Export** window.



The LTI Viewer Export window lists all the models with responses currently displayed in your LTI Viewer. You can export models back to the MATLAB workspace or to disk. In the latter case, the Control System Toolbox saves the files as MAT-files.

If you select **Export to Disk**, this window appears.



Choose a name for your model(s) and click **Save**. Your models are stored in a MAT-file.

Toolbox Preferences

Select **Toolbox Preferences** to open the Toolbox Preferences editor, which sets preferences for all response objects in the Control System Toolbox, including the viewer.

Page Setup and Print

Page Setup opens a GUI with selections for page layout, etc. **Print** sends the entire LTI Viewer window to your printer.

Print to Figure

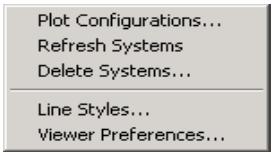
Print to Figure sends a picture of the selected system to a new figure window. Note that this new figure is a MATLAB figure window and not an LTI Viewer.

Close

Close closes the LTI Viewer.

Edit

Note Click on any of the items listed in the **Edit** menu pictured below to get help contents.



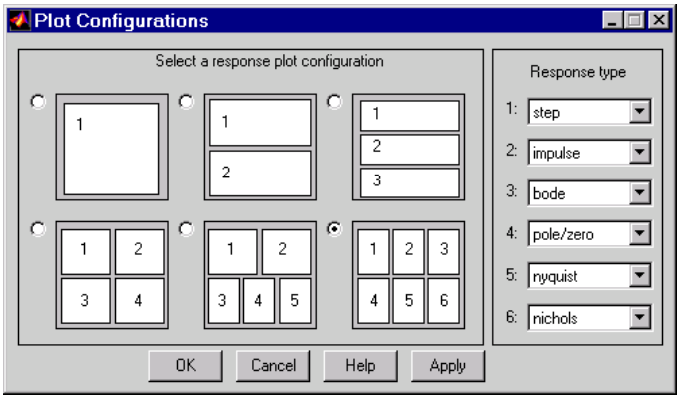
The **Edit** menu contains the following options:

- Plot Configurations — Opens the Plot Configurations window
- Refresh Systems — Updates imported systems
- **Delete** opens the LTI Viewer Delete window

- Line Styles — Opens the Line Styles editor
- Viewer Preferences — Opens the Viewer Preferences editor

Plot Configurations Window — Selecting Response Types

Plot Configuration under the **Edit** menu opens the **Plot Configurations** window.



Use this window to select the number and kind of response plots you want in a single instance of the LTI Viewer. You can plot up to six response plots in a single viewer. Click the radio button to the upper left of the configuration you want the viewer to use.

You can select among eight response types for each plot in the viewer. These are the available response types:

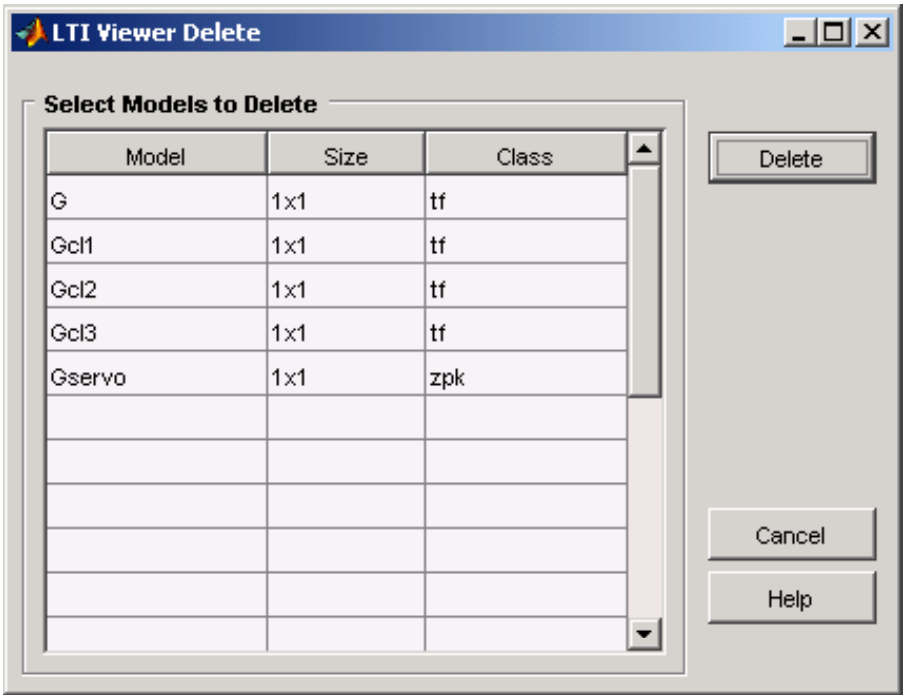
- Step
- Impulse
- Bode — Plots the Bode magnitude and phase
- Bode mag. — Plots the Bode magnitude only
- Nyquist
- Nichols
- Singular Values
- Pole/Zero map
- I/O pole/zero map

Refresh Systems

Refresh updates imported models to reflect any changes made in the MATLAB workspace since you imported them.

Delete Systems

Delete under **Systems** in the **Edit** menu opens the **LTI Viewer Delete** window

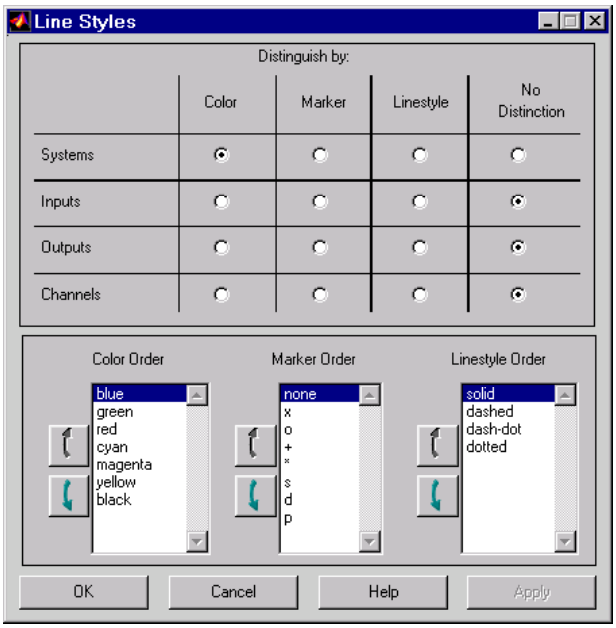


To delete a model

- Click on the desired model in the Model ist. To perform multiple selections:
  - a Click and drag over several variables in the list.
  - b Hold the Control key and click on individual variables.
  - c Hold the Shift key while clicking, to select a range.
- Click the **OK** or **Apply** Button

Line Styles Editor

Select **Line Styles** under the **Edit** menu to open the **Line Styles** editor.



The **Line Styles** editor is particularly useful when you have multiple systems imported. You can use it change line colors, add and rearrange markers, and alter line styes (solid, dashed, and so on).

The **Linestyle Preferences** window allows you to customize the appearance of the response plots by specifying:

- The line property used to distinguish different systems, inputs, or outputs
- The order in which these line properties are applied

Each LTI Viewer has its own **Linestyle Preferences** window.

Setting Preferences. You can use the "Distinguish by" matrix to specify the line property that will vary throughout the response plots. You can group multiple plot curves by systems, inputs, outputs, or channels (individual input/output relationships). Note that the Line Styles editor uses radio buttons, which means that you can only assign one property setting for each grouping (system, input, etc.).

Ordering Properties. The Order field allows you to change the default property order used when applying the different line properties. You can reorder the colors, markers, and linestyles (e.g., solid or dashed).

To change any of the property orders, click the up or down arrow button to the left of the associated property list to move the selected property up or down in the list

Viewer Preferences

Viewer Preferences opens the LTI Viewer Preferences editor, which you can use to set response plot defaults for the LTI Viewer that is currently open.

For a complete description of the LTI Viewer Preference editor, as well as all the property and preference editors available in the Control System Toolbox, see "Customization" in the online Control System Toolbox documentation. To go directly to the LTI Viewer Preferences editor documentation, see "LTI Viewer Preferences" in the same document.

Window

Use the **Window** menu to select which of your MATLAB windows is active. This menu lists any window associated with MATLAB and the Control System Toolbox. The MATLAB Command Window is always listed first.

Help

The **Help** menu links to this help file.

LTI Viewer Toolbar

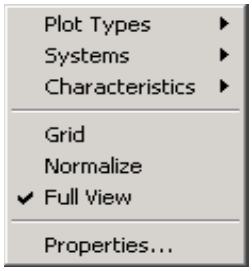
This figure shows the LTI Viewer Toolbar.

From left to right:

- Click the paper icon to open a new LTI Viewer
- Click the printer icon to print the contents of the LTI Viewer
- Click the magnifying glass icons and then click anywhere in a plot region to zoom in and out

Right-Click Menu for SISO Systems

Note Click on items in the right-click menu pictured below for help contents.

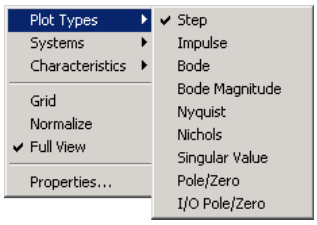


This right-click menu appears when you have a SISO system imported into your LTI Viewer. If you have a MIMO system, or an LTI array containing multiple models, there are additional menu options. See "Right-Click Menus for MIMO Systems and LTI Arrays" on page 2-20 for more information.

You can use the right-click menus to perform the following tasks:

- Change the plot type in the viewer
- Select and deselect imported models for display
- Add or remove grid lines
- Normalize a view
- Go to a full view
- Open the Property Editor

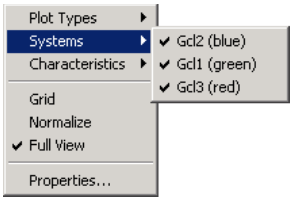
Plot Type



Select which plot type you want to display. The LTI Viewer shows a check to mark which plot is currently displayed. These are the available options:

- **Step** — Step response
- **Impulse** — Impulse response
- **Bode** — Magnitude and phase plots
- **Bode Mag.** — Magnitude only
- **Nyquist** — Nyquist diagram
- **Nichols** — Nichols chart
- **Singular Values** — Singular values plot
- **Pole/Zero** — Pole/Zero map
- **I/O Pole/Zero** — Pole/Zero map for I/O pairs

Systems



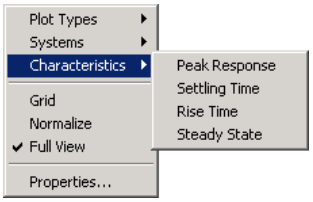
Use **Systems** to select which of the imported systems to display. Selecting a system causes a check mark to appear beside the system. To deselect a system, select it again; the menu toggles between selected and deselected.

Characteristics

The **Characteristics** menu changes for each plot response type. The next sections describe the menu for each of the eight plot types.

Step Response

Step plots the model's response to a step input.

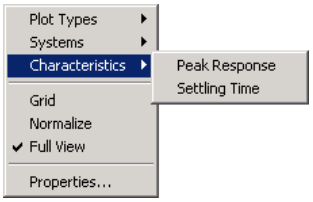


You can display the following information in the step response:

- **Peak Response** — The largest deviation from the steady-state value of the step response
- **Settling Time** — The time required for the step response to decline and stay at 5% of its final value
- **Rise Time** — The time require for the step response to rise from 10% to 90% of its final value
- **Steady-State** — The final value for the step response

Impulse Response

Impulse Response plots the model's response to an impulse.

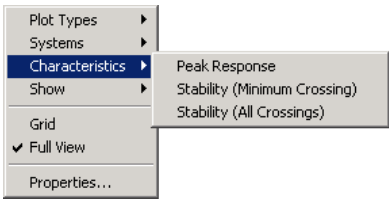


The LTI Viewer can display the following information in the impulse response:

- **Peak Response** — The maximum positive deviation from the steady-state value of the impulse response
- **Settling Time** — The time required for the step response to decline and stay at 5% of its final value

Bode Diagram

Bode plots the open-loop Bode phase and magnitude diagrams for the model.

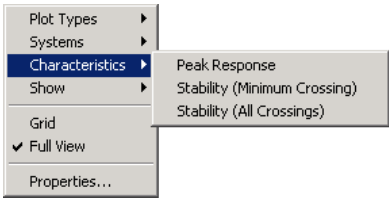


The LTI Viewer can display the following information in the Bode diagram:

- **Peak Response** — The maximum value of the Bode magnitude plot over the specified region
- **Stability Margins (Minimum Crossing)** — The minimum phase and gain margins. The gain margin is defined to the gain (in dB) when the phase first crosses -180°. The phase margin is the distance, in degrees, of the phase from -180° when the gain magnitude is 0 dB.
- **Stability Margins (All Crossings)** — Display all stability margins

Bode Magnitude

Bode Magnitude plots the Bode magnitude diagram for the model.

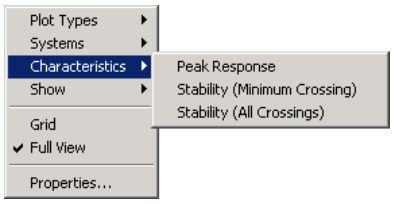


The LTI Viewer can display the following information in the Bode magnitude diagram:

- **Peak Response**, which is the maximum value of the Bode magnitude in decibels (dB), over the specified range of the diagram.
- **Stability (Minimum Crossing)** — The minimum gain margins. The gain margin is defined to the gain (in dB) when the phase first crosses -180°.
- **Stability (All Crossings)** — Display all gain stability margins

Nyquist Diagrams

Nyquist plots the Nyquist diagram for the model.

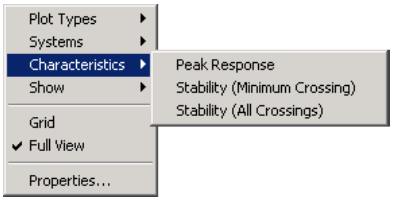


The LTI Viewer can display the following types of information in the Nyquist diagram:

- **Peak Response** — The maximum value of the Nyquist diagram over the specified region
- **Stability (Minimum Crossing)** — The minimum gain and phase margins for the Nyquist diagram. The gain margin is the distance from the origin to the phase crossover of the Nyquist curve. The phase crossover is where the curve meets the real axis. The phase margin is the angle subtended by the real axis and the gain crossover on the circle of radius 1.
- **Stability (All Crossings)** — Display all gain stability margins

Nichols Charts

Nichols plots the Nichols Chart for the model.



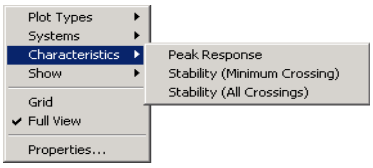
The LTI Viewer can display the following types of information in the Nichols chart:

- **Peak Response** — The maximum value of the Nichols chart in the plotted region.
- **Stability (Minimum Crossing)** — The minimum gain and phase margins for the Nichols chart.

- **Stability (All Crossings)** — Display all gain stability margins

Singular Values

Singular Values plots the singular values for the model.



The LTI Viewer can display the **Peak Response**, which is the largest magnitude of the Singular Values curve over the plotted region.

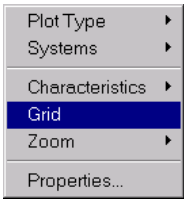
Pole/Zero and I/O Pole/Zero

Pole/Zero plots the poles and zeros of the model with 'x' for poles and 'o' for zeros. I/O Pole/Zero plots the poles and zeros of I/O pairs.

There are no **Characteristics** available for pole-zero plots.

Grid

The **Grid** command activates a grid appropriate to the plot in the region you select.



Normalize

Select **Normalize** to scale responses to fit the view (only available for time-domain plot types).

Full View

Selecting **Full View** causes the LTI Viewer to scale limits so that the entire curve is visible.

Properties

Use **Properties** to open the Property Editor. This GUI allows you to customize labels, axes limits and units, grids and font styles, and response characteristics (e.g., rise time) for your plot.

For a full description of the Property Editor, see "Customizing Response Plot Properties" online in the Control System Toolbox documentation.

Right-Click Menus for MIMO Systems and LTI Arrays

All of the menu options described in Right-Click Menu for SISO Systems hold when you have imported a MIMO model or LTI Array containing multiple models.

Note, however, that when you have a MIMO model or LTI array displayed, the right-click menus contain additional options: **I/O Grouping** and **I/O selector**. These features allow you to quickly reshuffle multiple plots in a single LTI Viewer

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Note Click on items in the right-click menu pictured below to get help contents.

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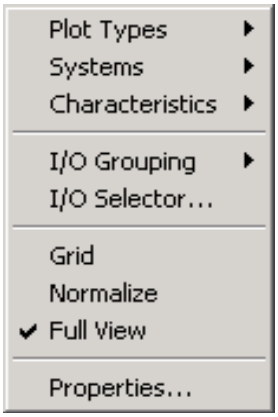
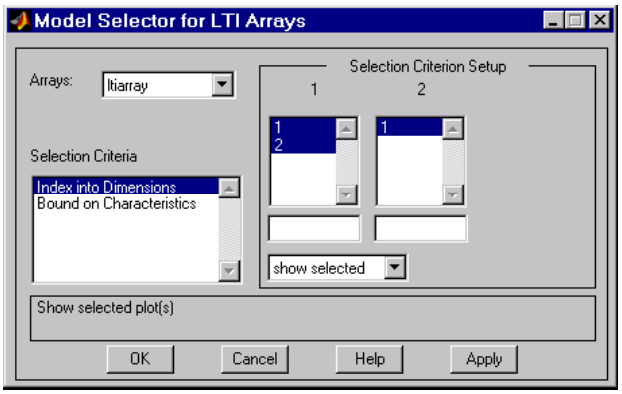


Array Selector

If you import an LTI array into your LTI Viewer, **Array Selector** appears as an option in the right-click menu. Selecting this option opens the **Model Selector for LTI Arrays**, shown below.



You can use this window to include or exclude models within the LTI array using various criteria. The following subsections discuss the features in turn.

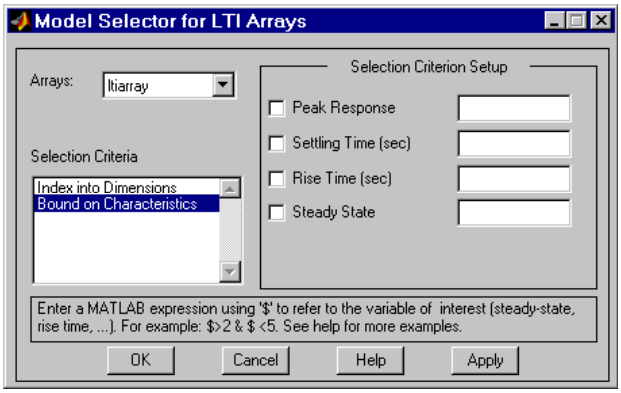
Arrays

Select which LTI array for applying model selection options by using the Arrays pull-down list.

Selection Criteria

There are two selection criteria. The default, **Index into Dimensions**, allows you to include or exclude specified indices of the LTI Array. Select systems from the **Selection Criteria Setup** and specify whether to show or hide the systems using the pull-down menu below the Setup lists.

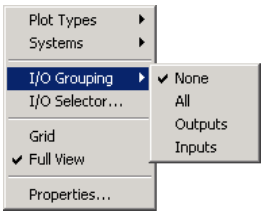
The second criterion is **Bound on Characteristics**. Selecting this options causes the Model Selector to reconfigure. The reconfigured window is shown below.



Use this option to select systems for inclusion or exclusion in your LTI Viewer based on their time response characteristics. The panel directly above the buttons describes how to set the inclusion or exclusion criteria based on which selection criteria you select from the reconfigured **Selection Criteria Setup** panel.

I/O Grouping

You can use **I/O Grouping** to change the grouping of MIMO system plots in your LTI Viewer. This picture shows the menu options.



There are four options:

- **None** — By default, there is no I/O grouping. For example, if you display the step responses for a 3-input, 2- output system, there will be six plots in your LTI Viewer.
- **All** — Groups all the responses into a single plot

- **Inputs** — Groups all the responses by inputs. For example, for a 3-input, 2-output system, selecting Inputs reconfigures the viewer so that there are 3 plots. Each plot contains two curves.
- **Outputs** — Groups all the responses by outputs. For example, for a 3-input, 2-output system, selecting Inputs reconfigures the viewer so that there are 2 plots. Each plot contains three curves.

I/O Selector

I/O Selector opens the **I/O Selector** window, shown below.

The **I/O Selector** window contains buttons corresponding to each I/O pair. In this example, there are 2 inputs and 3 outputs, so there are six buttons. By default, all the I/O pairs are selected. If you click on a button, that I/O pair alone is displayed in the LTI Viewer. The other buttons automatically deselect.

To select a column of inputs, click on the input name above the column. The names are **U(1)**, **U(2)**, and so on. The LTI Viewer displays the responses from the specified input to all the outputs.

To select a row of output, click on the output name to the left of the row. The names are **Y(1)**, **Y(2)**, and so on. The LTI Viewer displays the responses from all the inputs to the specified output.

To reestablish the default setting, click **[all]**. The LTI Viewer displays all the I/O pairs.

Status Panel

The Status Panel is located at the bottom of the LTI Viewer. It contains useful information about changes you have made to the LTI Viewer.