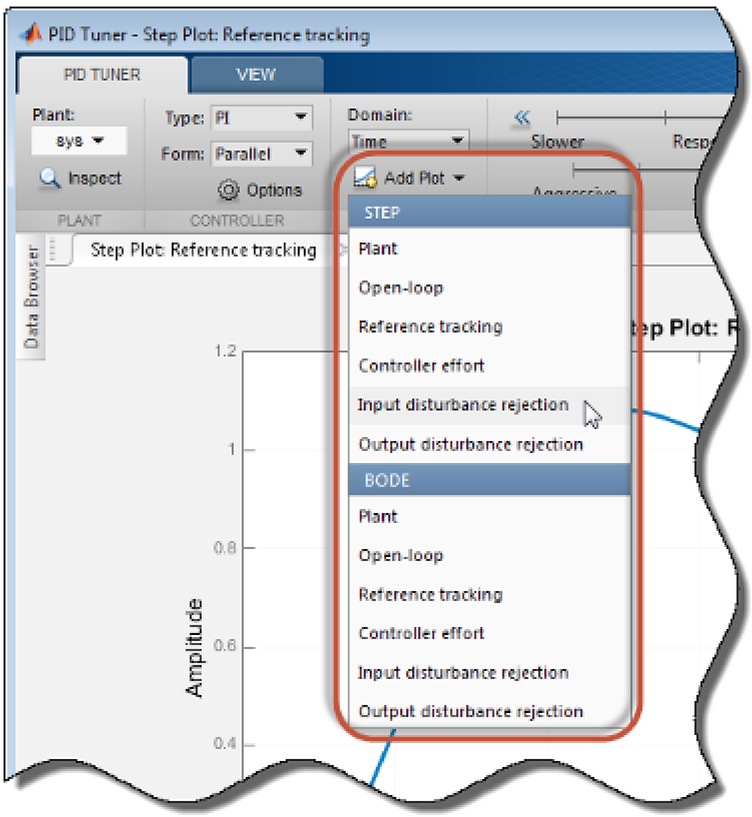
Analyze Your Design in the PID Tuner App

Control System Toolbox™ provides *tools* for manipulating and tuning PID controllers through the PID Tuner app as well as command-line functions. This example shows you to analyze and refine your compensator design.

Plot System Responses

To determine whether the compensator design meets your requirements, you can analyze the system response using the response plots. In the **PID Tuner** tab, select a response plot from the **Add Plot** menu. The **Add Plot** menu also lets you choose from several step plots (time-domain response) or Bode plots (frequency-domain response).



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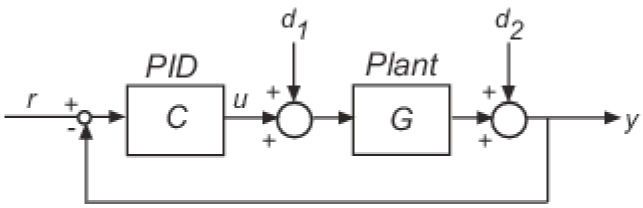
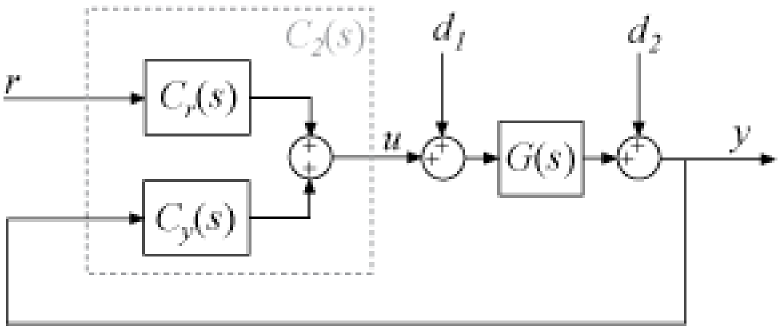
For 1-DOF PID controller types such as PI, PIDF, and PDF, PID Tuner computes system responses based upon the following single-loop control architecture:



For 2-DOF PID controller types such as PI2, PIDF2, and I-PD, PID Tuner computes responses based upon the following architecture:



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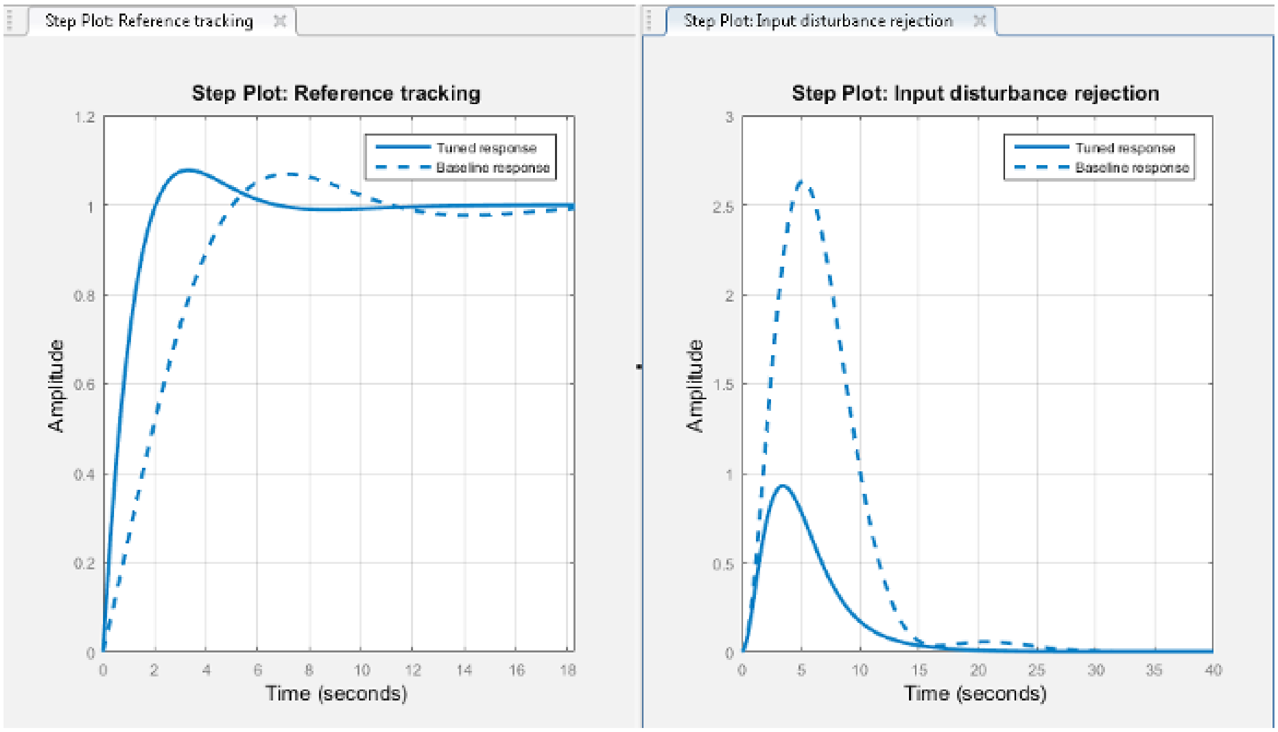
The system responses are based on the decomposition of the 2-DOF PID controller, C_2, into a setpoint component *Cr* and a feedback component *Cy*, as described in *Two-Degree-of-Freedom PID Controllers.*

The following table summarizes the available responses for analysis plots in PID Tuner.

Response	**Plotted System (1-DOF)**	**Plotted System (2-DOF)**	**Description**
Plant	G	G	Shows the plant response. Use to examine plant dynamics.
Open-loop	GC	$-GC_y$	Shows response of the open-loop controller-plant system. Use for frequency-domain design. Use when your design specifications include robustness criteria such as open-loop gain margin and phase margin.
Reference tracking	GC/(1+GC) (from *r* to *y*)	$GC_r/(1-GC_y)$ (from *r* to *y*)	Shows the closed-loop system response to a step change in setpoint. Use when your design specifications include setpoint tracking.
Controller effort	C/(1+GC) (from *r* to *u*)	$C_r/(1-GC_y)$ (from *r* to *u*)	Shows the closed-loop controller output response to a step change in setpoint. Use when your design is limited by practical constraints, such as controller saturation.
Input disturbance rejection	G/(1+GC) (from d_1 to *y*)	$G/(1-GC_y)$ (from d_1 to *y*)	Shows the closed-loop system response to load disturbance (a step disturbance at the plant input). Use when your design specifications include input disturbance rejection.
Output disturbance rejection	1/(1+GC) (from d_2 to y)	$1/(1-GC_y)$ (from d_2 to y)	Shows the closed-loop system response to a step disturbance at plant output. Use when you want to analyze sensitivity to measurement noise.

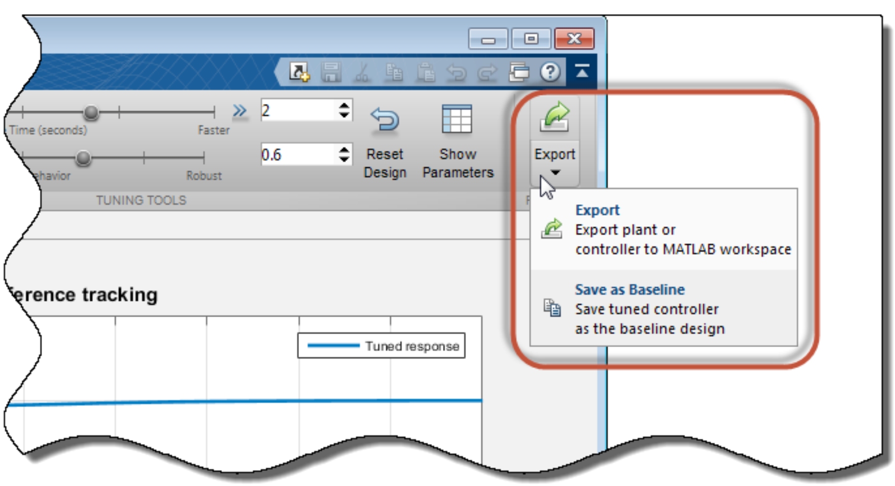
Compare the Tuned Response to the Baseline Response

If you have defined a baseline controller, then by default PID Tuner displays both the responses using the current PID Tuner design and the responses using the baseline controller.



There are two ways to define a baseline controller:

- Load a baseline controller when you open the PID Tuner, using the syntax `pidTuner(sys,C0)`.
- Make the current PID Tuner design the baseline controller at any time, by clicking the Export arrow and selecting `Save as Baseline`.



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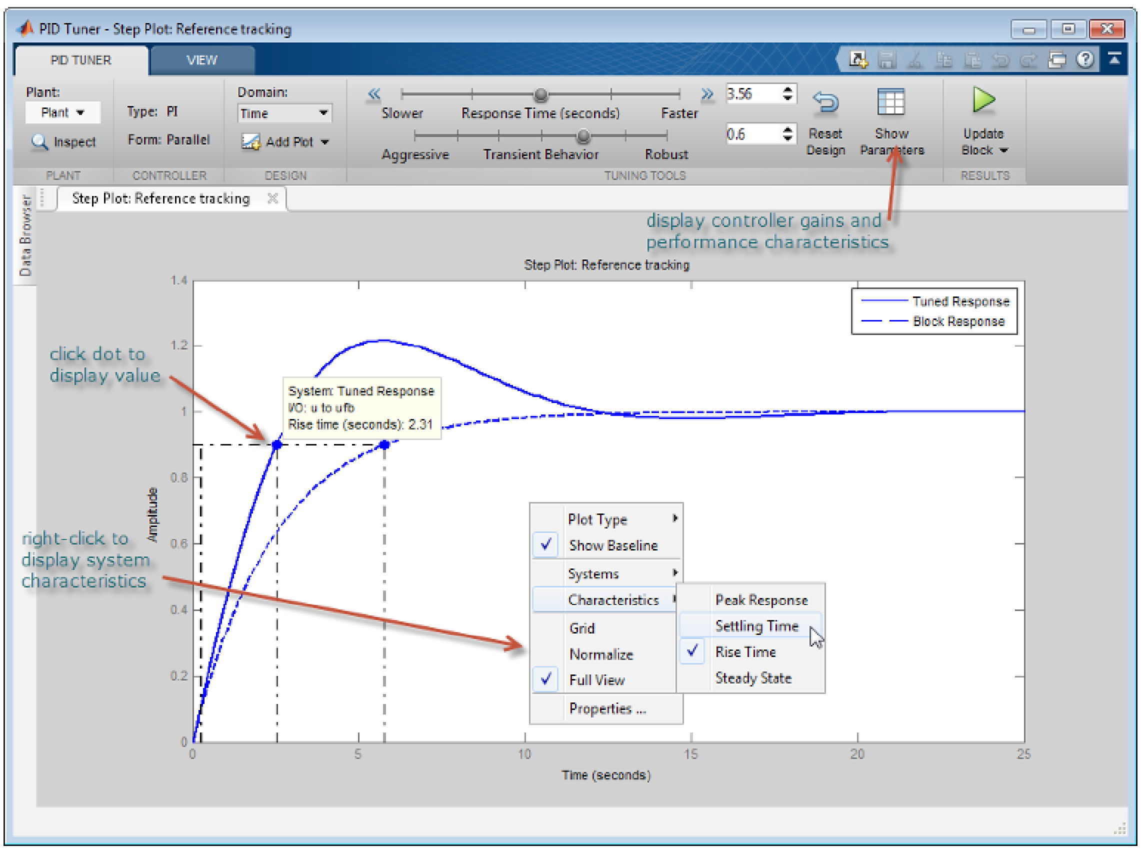
When you do so, the current Tuned response becomes the Baseline response. Further adjustment of the current design creates a new Tuned response line.

To hide the Baseline response, click **Options**, and uncheck **Show Baseline Controller Data.**

View Numeric Values of System Characteristics

You can view the values for system characteristics, such as peak response and gain margin, either:

- Directly on the response plot — Use the right-click menu to add characteristics, which appear as blue markers. Then, left-click the marker to display the corresponding data panel.
- In the **Performance and robustness** table — To display this table, click **Show Parameters.**



Refine Your Design

If the response of the initial controller design does not meet your requirements, you can interactively adjust the design. The PID Tuner gives you two **Domain** options for refining the controller design:

- `Time` domain (default) — Use the **Response Time** slider to make the closed-loop response of the control system faster or slower. Use the **Transient Behavior** slider to make the controller more aggressive at disturbance rejection or more robust against plant uncertainty.
- `Frequency` — Use the **Bandwidth** slider to make the closed-loop response of the control system faster or slower (the response time is $2/w_c$, where w_c is the bandwidth). Use the **Phase Margin** slider to make the controller more aggressive at disturbance rejection or more robust against plant uncertainty.

In both modes, there is a trade-off between reference tracking and disturbance rejection performance. For an example that shows how to use the sliders to adjust this trade-off, see *Tune PID Controller to Favor Reference Tracking or Disturbance Rejection (PID Tuner).*

Tip: To revert to the initial controller design after moving the sliders, click Reset Design.

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