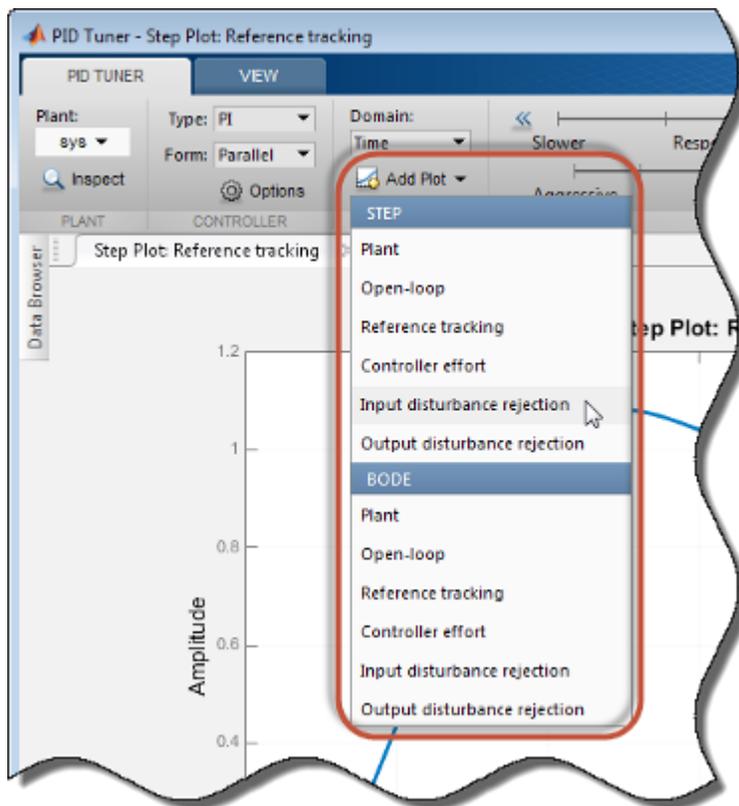


# Analyze Your Design in the PID Tuner App

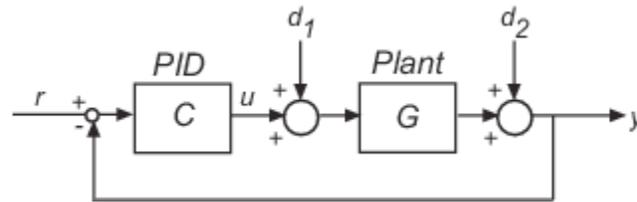
Control System Toolbox™ provides *tools* for manipulating and tuning PID controllers through the PID Tuner app as well as command-line functions. This example shows you to analyze and refine your compensator design.

## Plot System Responses

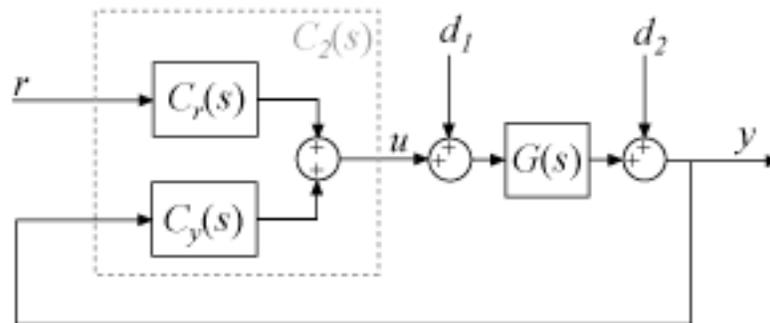
To determine whether the compensator design meets your requirements, you can analyze the system response using the response plots. In the **PID Tuner** tab, select a response plot from the **Add Plot** menu. The **Add Plot** menu also lets you choose from several step plots (time-domain response) or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



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:



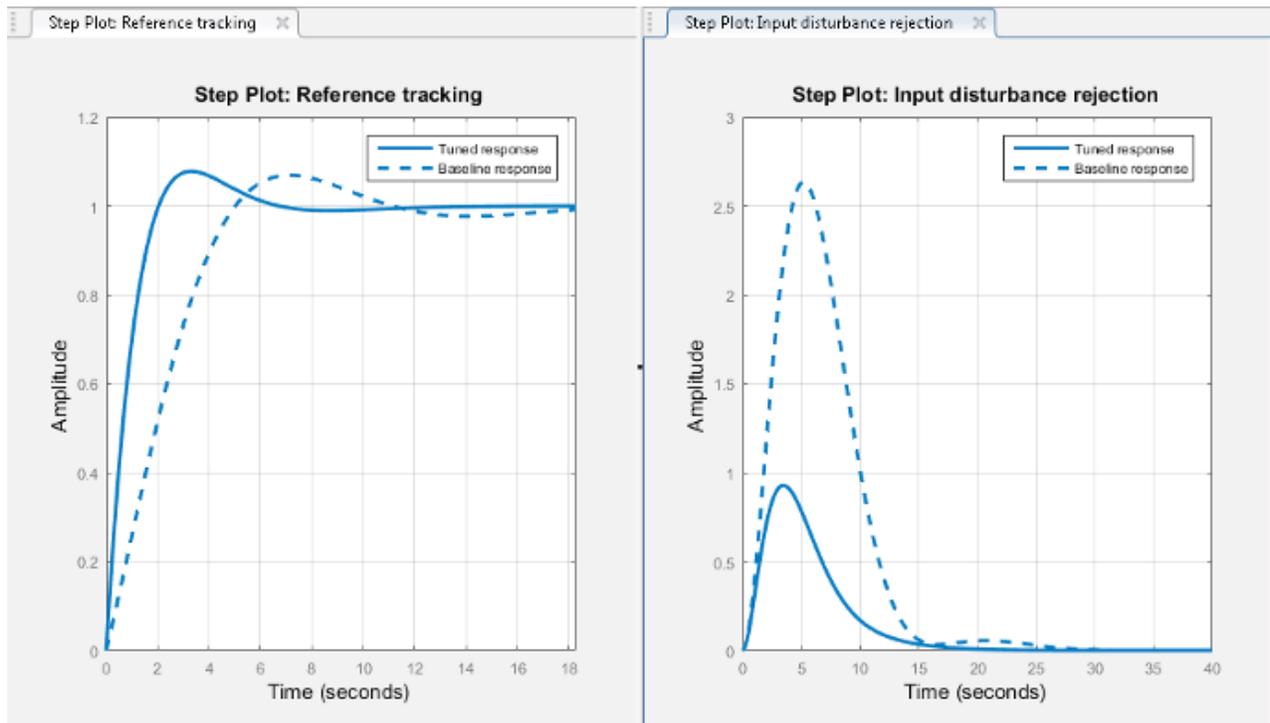
The system responses are based on the decomposition of the 2-DOF PID controller,  $C_2$ , into a setpoint component  $C_r$  and a feedback component  $C_y$ , as described in *Two-Degree-of-Freedom PID Controllers*.

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.

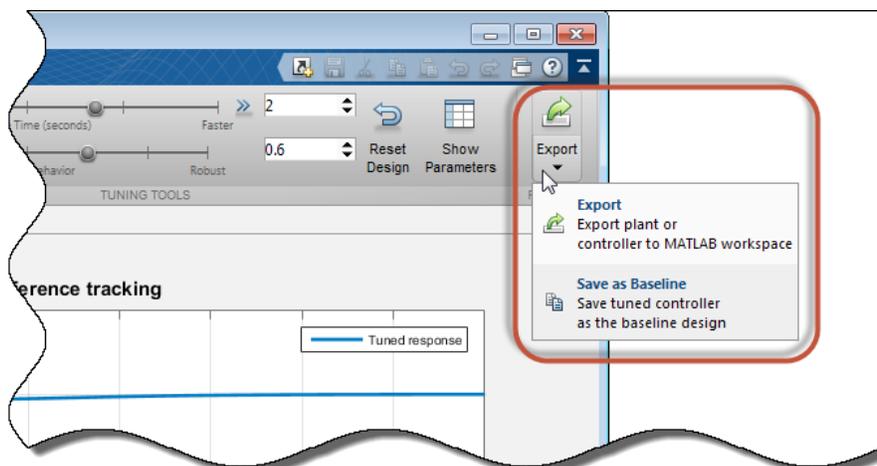
## Compare the Tuned Response to the Baseline Response

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`.



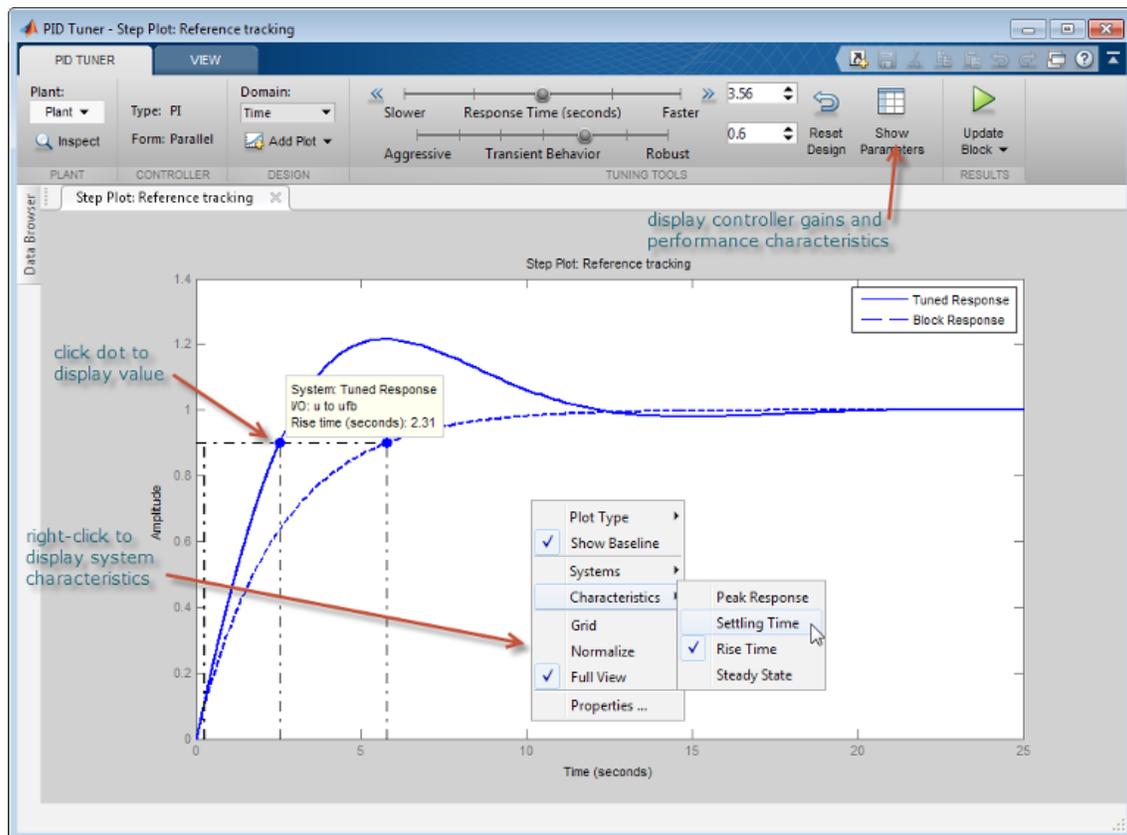
When you do so, the current Tuned response becomes the Baseline response. Further adjustment of the current design creates a new Tuned response line.

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.