SISOTool Controller Design Environment

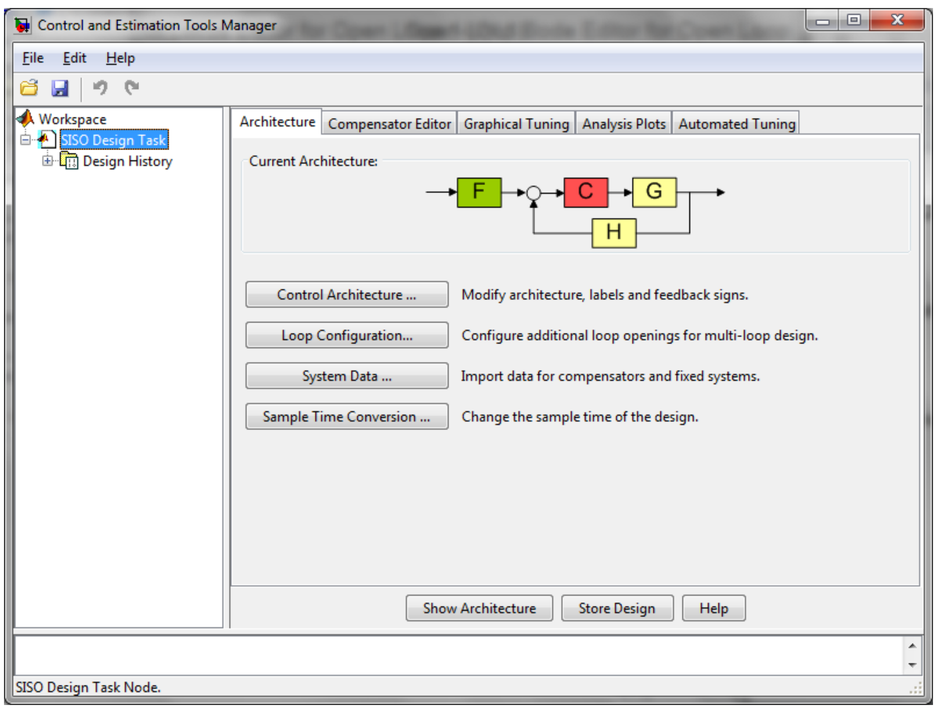
SISOTool is an interactive controller design environment in the Control System Toolbox

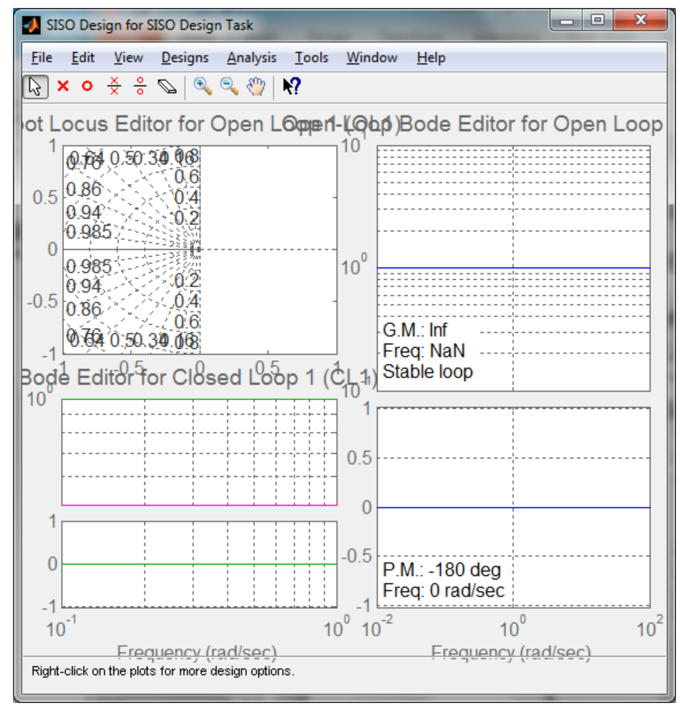
- It is a tool for the compensator design and parameter tuning of feedback control systems
- It simplifies the control design process, in several ways:
  1. The control design specifications on time, frequency, and pole/zero response plots can be defined graphically
  2. Compensator parameters can be tuned and validated, via:
     – Interactively moving poles and zeros in the design plots (Bode and root locus)
     – Automated design algorithms, such as Ziegler Nichols, IMC, and LQG
     – Optimization techniques using Simulink Design Optimization tools
  3. The closed-loop and open-loop responses and plots are dynamically updated, as the design parameters are adjusted, to provide feedback to the designer

Getting Started with the SISOTool

SISOTool can be used for model-based controller design of single-input, single-output (SISO) systems using root locus, Bode diagram, Nyquist plot and Nichols chart methods

- SISOTool can be invoked by typing “sisotool” in the Matlab workspace
  - Two windows will appear
    - Control and Estimation Tools Manager (CETM)
    - SISO Design for SISO Design Task (DT)





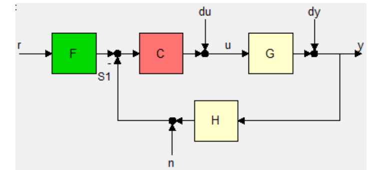
Importing A System Model Into SISOTool

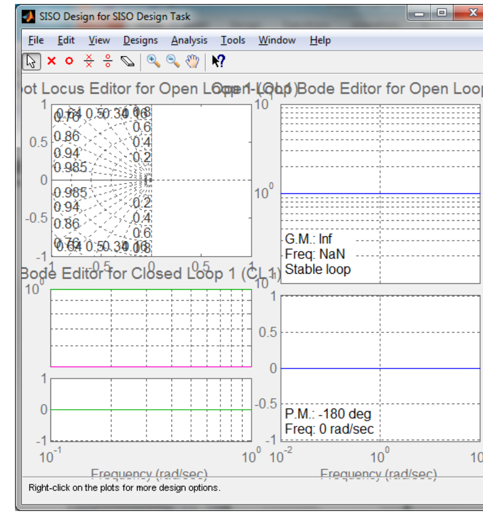
1. Define the system model in Matlab workspace
2. Invoke the SISOTool
   - In “SISO Design for SISO Design Task” window
     - click on File -> Import…
   - In “System Data” window
     - Highlight G and click on Browse…
   - In “Model Import” window
     - Select the system model (e.g., G)
     - Click Import and then click Close
   - In “System Data” window click OK
     - The root-locus and Bode plots of the system will be shown in the “SISO Design for SISO Design Task” window

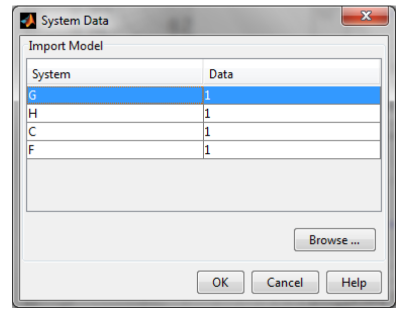
To simultaneously invoke SISOTool and import the system model G(s)

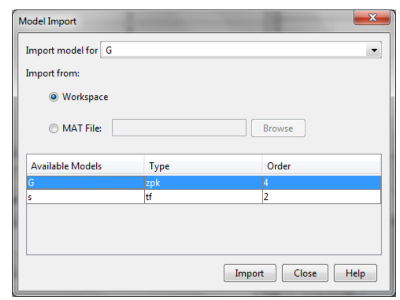
- Type “sisotool(G)” in Matlab window

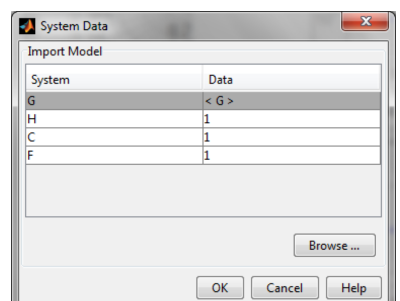
<u>Syntax</u>: sisotool(plant,comp,sensor,prefilt)

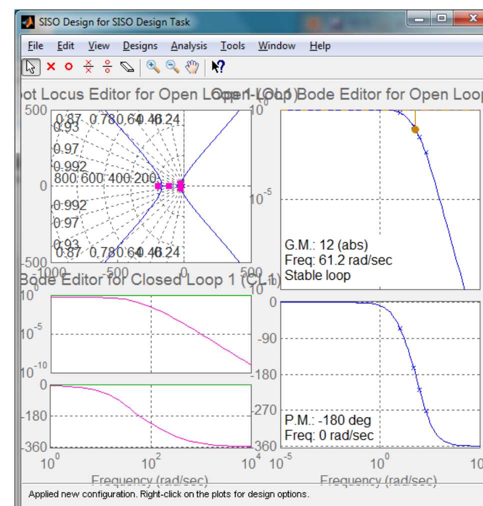




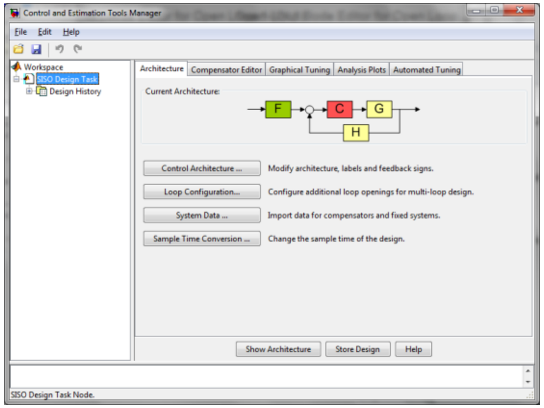




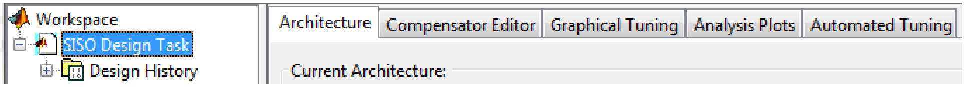




SISOTool Utilities

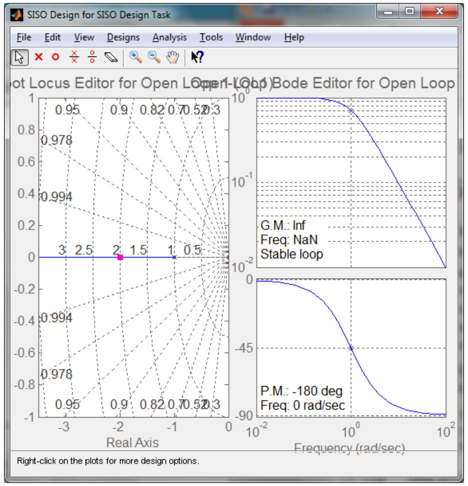


In CETM window, the **SISO Design Task** node allows to configure the controller design options, via the tabs:



- Architecture: to select the feedback set-up
- Compensator Editor: to assign and edit compensator's pole/zero/gain
- Graphical Tuning: to display various design plots
- Analysis Plots: to display various analysis plots
- Automated Tuning: to automatically tune selected control parameters

In DT window,



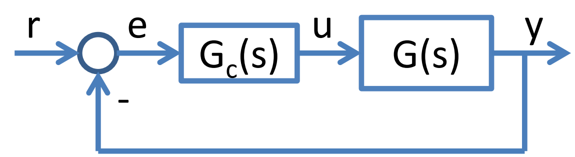
1. Design requirements can be defined:
   – Right-click on the plot and choose: Design Requirements>New…
2. Compensator poles/zeros can be assigned:

   – To add pole/zero, drag and drop the appropriate pole/zero icon at any desired location on the root-locus plot
   – To remove pole/zero, use the eraser icon
3. Response plots can be viewed
   – Root-locus, Bode plot, closed-loop step response, …

- For additional information, see SISOTool documentation

SISOTool Control Design Example

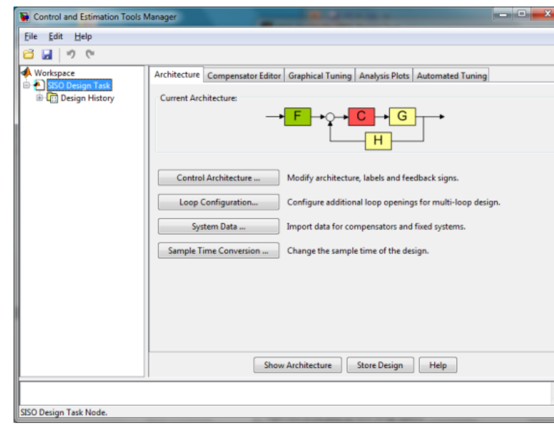
Example: Design a compensator $G_c(s)$ for the system $G(s) = \frac{1}{s+1}$, with design requirements:



- Steady-state error $e_{ss}(step) = 0$
- Rise-time $t_r(80\%) \leq 1$ sec
- Settling-time $t_s(1\%) \leq 2$ sec
- Overshoot $M_p \leq 20\%$
- Crossover frequency $\omega_c \leq 5$ rad/sec

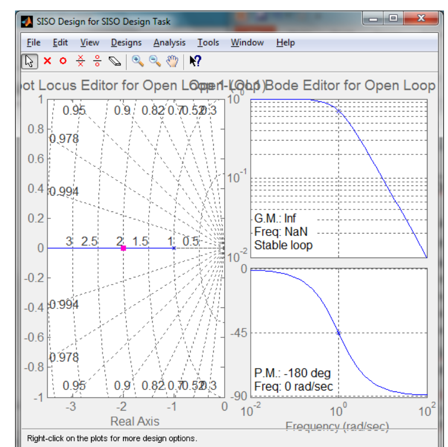
Approx:
$\omega_n \geq 1.8$
$\zeta\omega_n \geq 4.6$
$\zeta \geq 0.46$

Launch SISOTool and import the system model in default standard feedback structure



Matlab code:

```
G=tf(1,[1,1]);
sisotool(G)
```



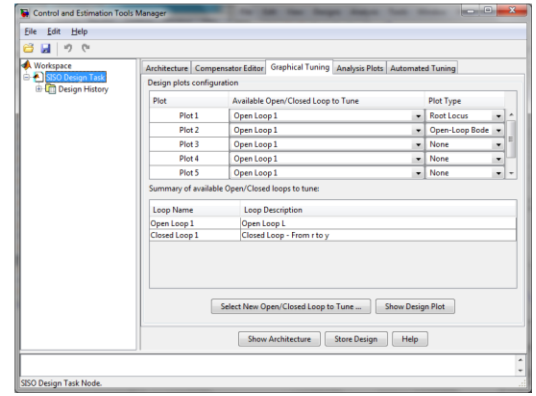
This will open two windows:

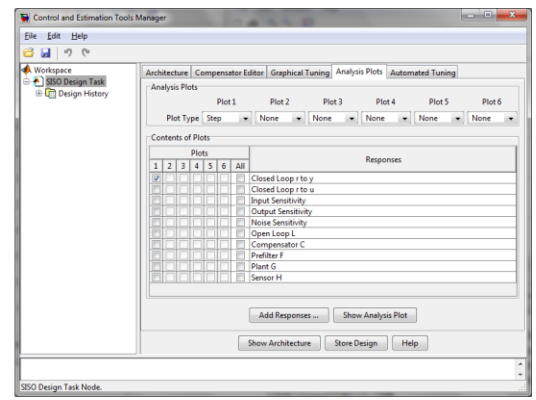
1. Control and Estimation Tools Manager (CETM)
2. SISO Design for SISO Design Task (DT) window

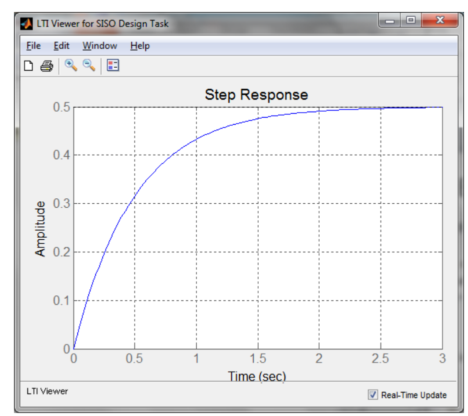
SISOTool Example…

Configure the design environment:

- Choose “Root Locus” and “Open-Loop Bode” for design plots, as follows:
  - In CETM, click on “Graphical Tuning” tab, or
  - In DT, select “View->Design Plots Configuration…”
- Choose “Closed-Loop Step Response” for analysis plot, as follows:
  - In CETM, click on “Analysis Plots” tab
    - Select “Step” for the first plot and check the box for the response “Closed-Loop r to y”
    - Now the “LTI Viewer” window will appear displaying the closed-loop step response from r to y



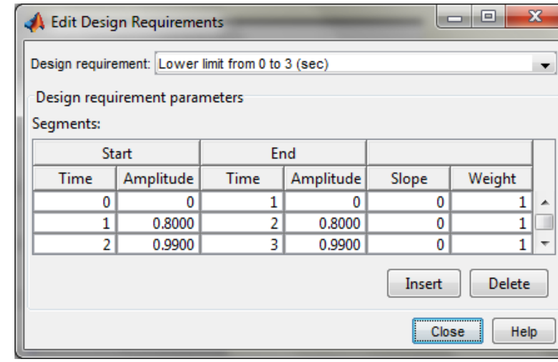


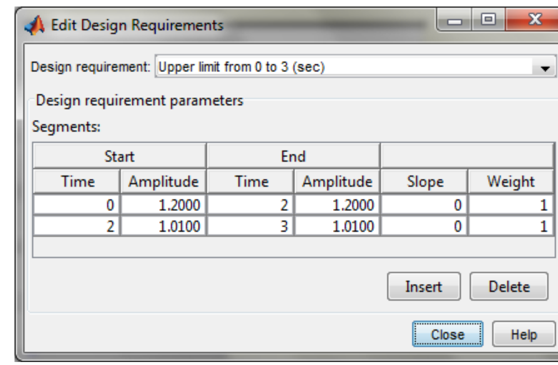


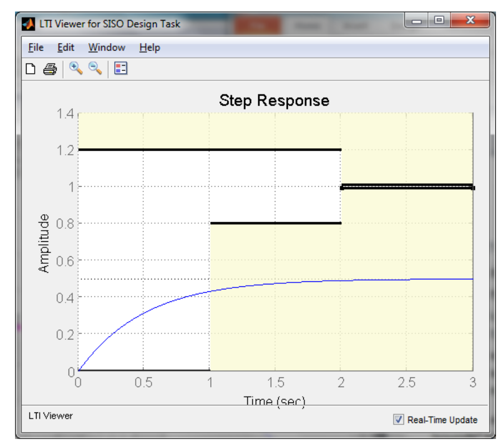
SISOTool Example…

Define the design requirements:

- Add the time-domain design requirements to the step response plot
  - Right click on the step response plot in “LTI Viewer” and select: “Design Requirements -> New…”
  - Specify the design requirements (t_r, t_s, %MP, …): choose the “Upper time response bound” and “Lower time response bound” and set up the limits
  - Alternatively, you may choose “Step response bounds” to set up the design requirements
- Use this time response plot with highlighted requirements to view the performance of the compensator design



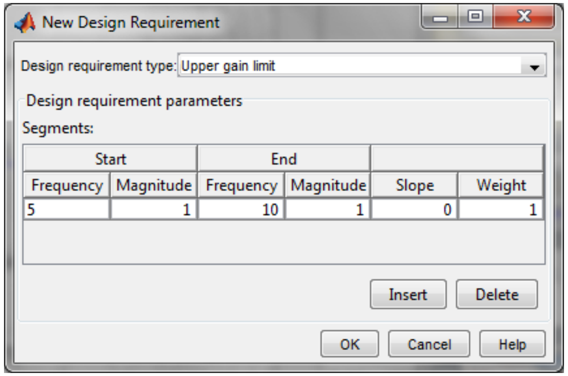


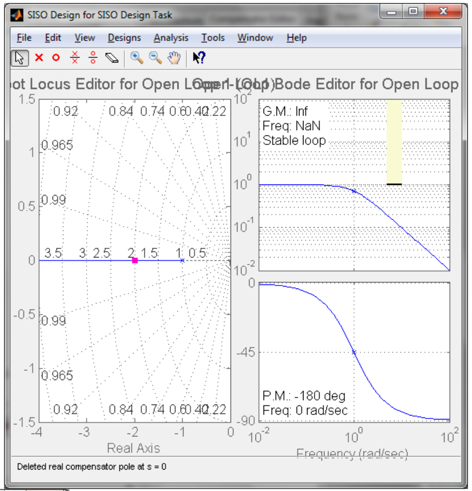


SISOTool Example…

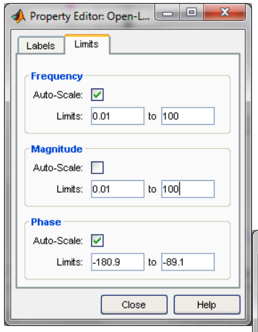
Define the frequency-domain requirements:

- Add the crossover frequency requirement to the Bode plot
  - Right click on the Bode plot in “DT” and select: “Design Requirements -> New…”
  - Specify the design requirements (ω_c)
    - Choose the “Upper gain limit” and set up the limit appropriately

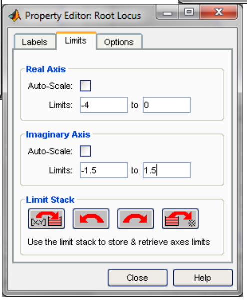




  - Right click on Bode plot, choose “Properties…”, select “Limits” and change “Magnitude” Limits to display the frequency-domain requirements



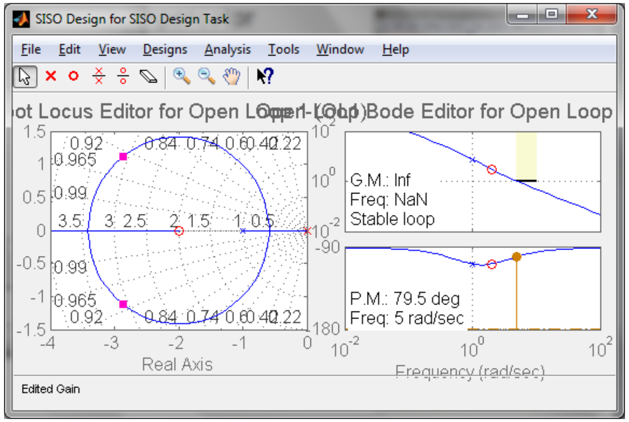
  - Right click on root-locus plot, choose “Properties…”, select “Limits” and change Real- and Imaginary-axis Limits to display the entire root-locus

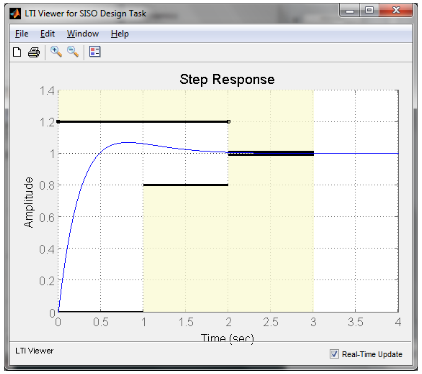


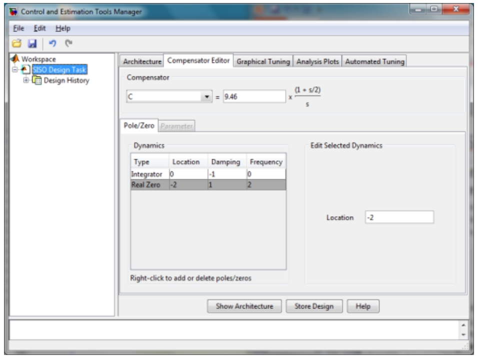
SISOTool Example…

Designing the compensator

- Add an integrator to achieve zero steady-state error to a step command
  - Right-click on root-locus plot and select **Add Pole/Zero->Integrator**
- Add a zero at approximately -2 to achieve the overshoot requirement
  - Right-click on the root-locus plot and select **Add Pole/Zero->Real Zero** and then left-click at approximately -2 on the real axis of the root locus plot
- Adjust the compensator gain to achieve the crossover frequency requirement
  - In the bode plot click and drag the magnitude curve to satisfy the crossover frequency and time-domain constraints
- The designed compensator can then be viewed in the “Compensator Editor” tab in CETM

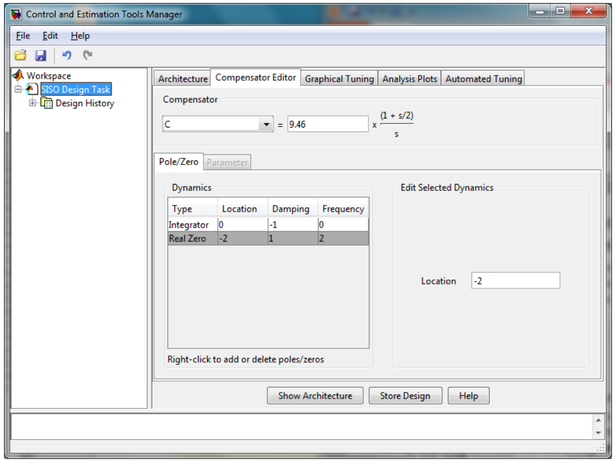






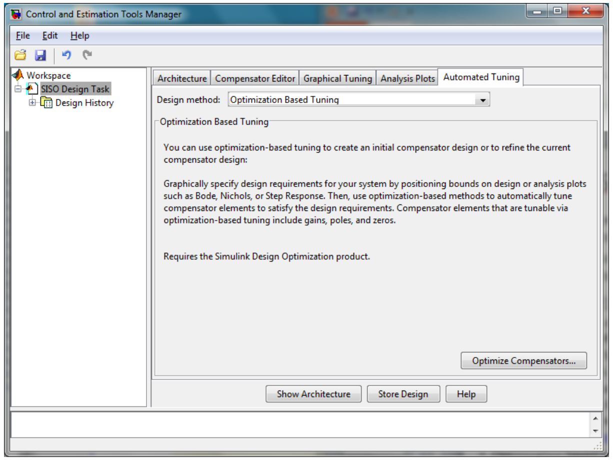
SISOTool Example…

- The control can also be designed directly in the “Compensator Editor” tab in CETM



<u>Automated Tuning of Compensators</u>

- Automated Tuning is available under “Automated Tuning” tab in CETM, with options:
  – Optimization Based Tuning, PID Tuning, Internal Model Control (IMC) Tuning, LQG Synthesis , and Loop Shaping
- PID, IMC, and LQG tuning compute the initial parameters for those controllers based on tuning parameters such as closed-loop time constants
  – See demo "Automated Controller Design in the SISO Design Tool“ (http://www.mathworks.com/products/control/demos.html?file=/products/demos/shipping/control/autotunedemo.html)



- Optimization based tuning requires “Simulink Design Optimization”
  – See demo "DC Motor Controller Tuning" (http://www.mathworks.com/products/control/demos.html?file=/products/demos/shipping/control/dcdemo.html)

Additional Information

- http://www.mathworks.com/help/control/getstart/siso-design-tool.html
- http://www.mathworks.com/products/control/examples.html?file=/products/demos/shipping/control/GSSISOTool.html