

J-DSP-C[®] Editor

J-DSP-CONTROL: A CONTROL SYSTEMS SIMULATION ENVIRONMENT



Modeling, Identification, and Control, MIC'2003

February 10-13, 2003

Innsbruck, Austria



J-DSP-C

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J-DSP concept by Andreas Spanias
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Sponsored by NSF-CCLI

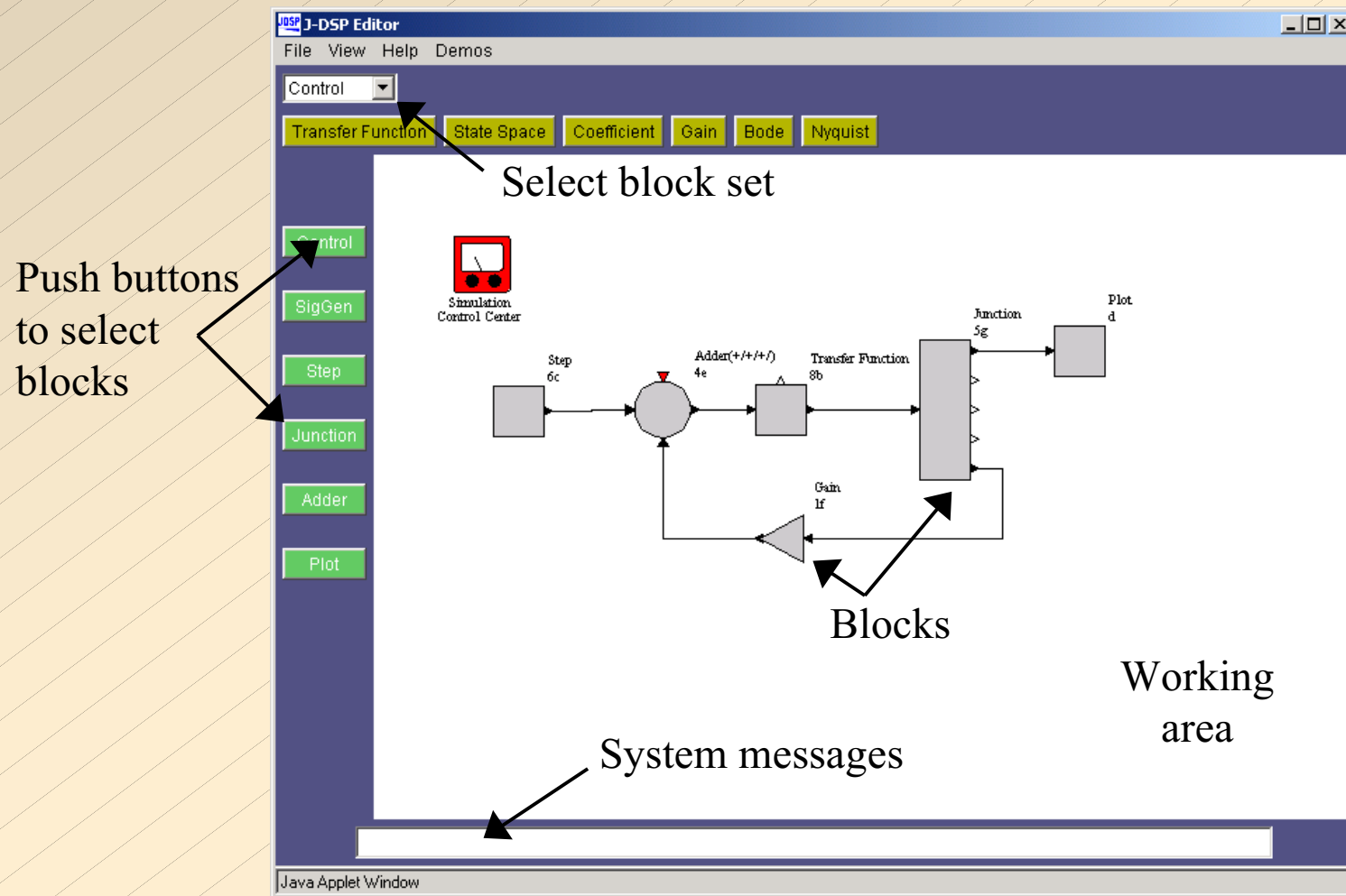
J-DSP-C basics

- ◆ J-DSP-C is an on-line, object-oriented graphical control systems editor written as a Java applet
- ◆ Quick and easy simulation of feedback control systems
- ◆ Graphical or numerical results
- ◆ Simple and user-friendly interface

J-DSP-C Supports:

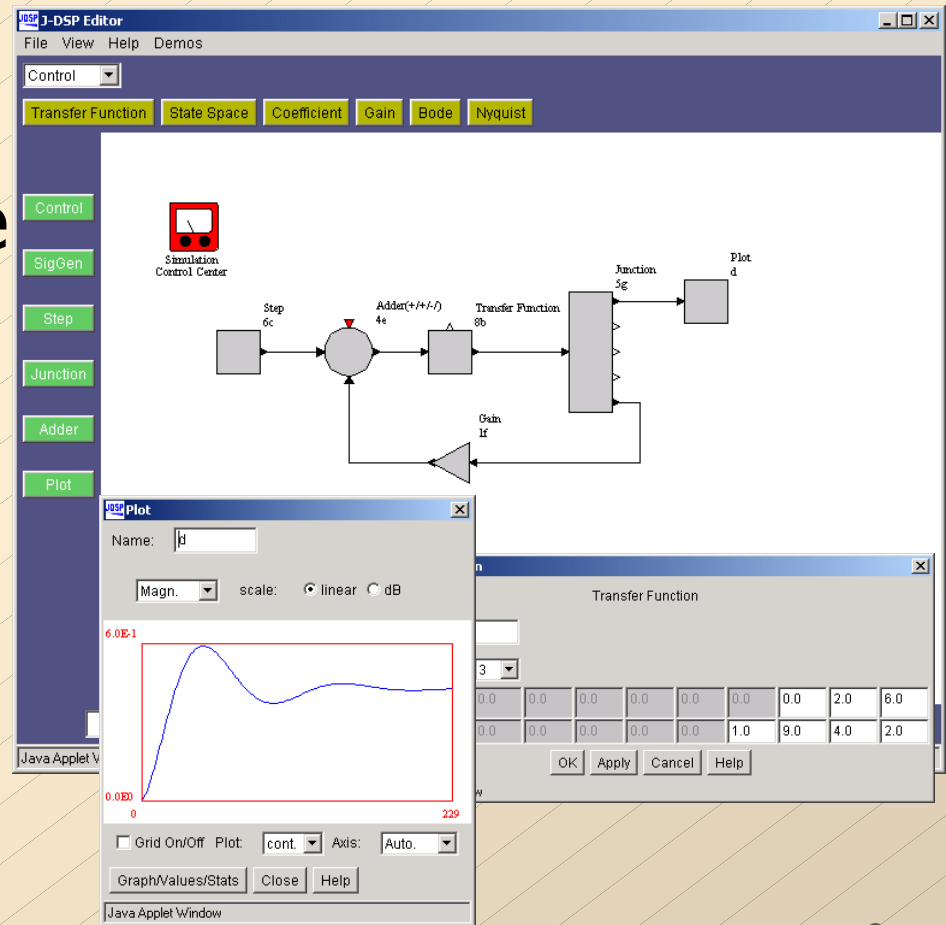
- ◆ Arbitrary interconnection topology
 - ◆ Including feedback systems
- ◆ Signal generators and various arithmetic operations
- ◆ Basic control systems building blocks
- ◆ State-space or transfer function models
- ◆ Plotting and visualization blocks

J-DSP-C Environment



Simulating Systems

- ◆ Each block represents a system
- ◆ Simulation models are built by connecting blocks together



Editing Blocks

- ◆ Each block can be edited through a dialog window
 - ◆ Edit block parameters values
- ◆ Display of results

Typical block dialog box
(State Space model)

The image shows a 'State Space Model' dialog box with the following fields and controls:

- Name: 3h
- Select number of states, inputs and outputs:
 - States: 3
 - Inputs: 1
 - Outputs: 1
- Buttons: Load Matrix A, Load, L, OK, Appl
- Select differentia: (dropdown menu)
- Matrix is: Canonical (dropdown menu)
- Buttons: OK, Update, Cancel

An 'Input Values' sub-dialog box is overlaid on top, titled 'Enter Matrix A (3x3)'. It contains a 3x3 grid of input fields with the following values:

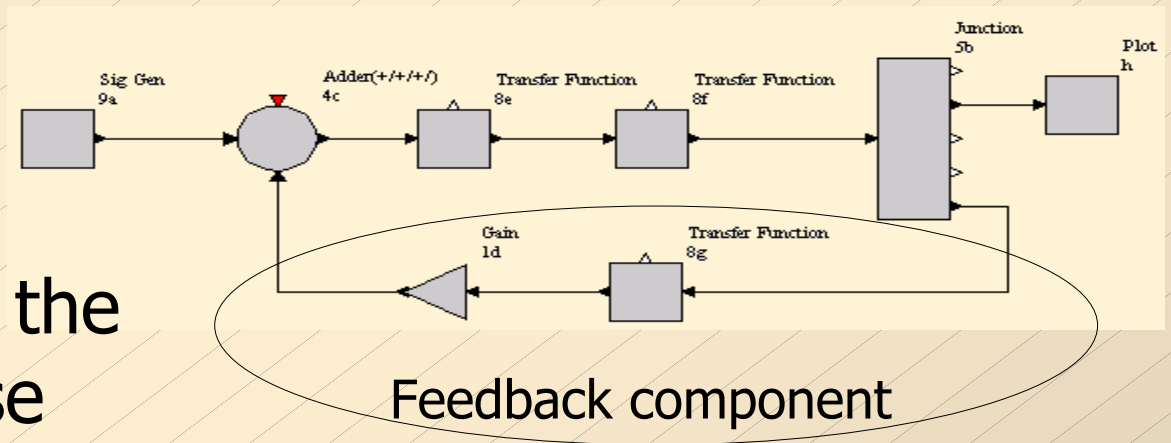
0.0	1.0	0.0
0.0	0.0	1.0
-2.0	-4.0	-9.0

An arrow points from the text 'State space system representation' to the 'Input Values' dialog box.

State space system
representation

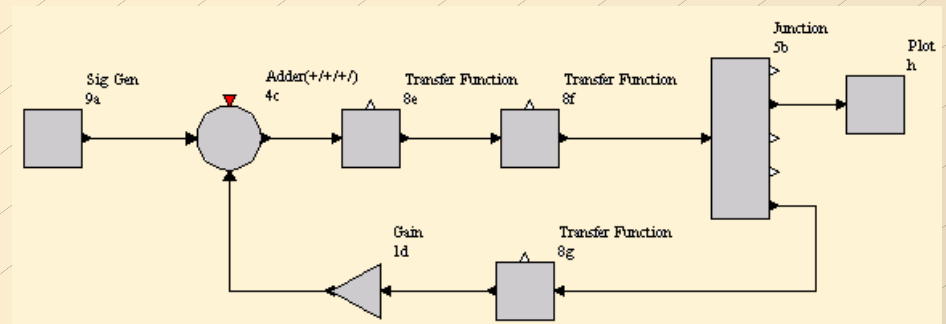
Feedback systems

- ◆ Manual start of simulation
- ◆ Recursive and iterative computation of the system response
 - ◆ Discrete-time approx.



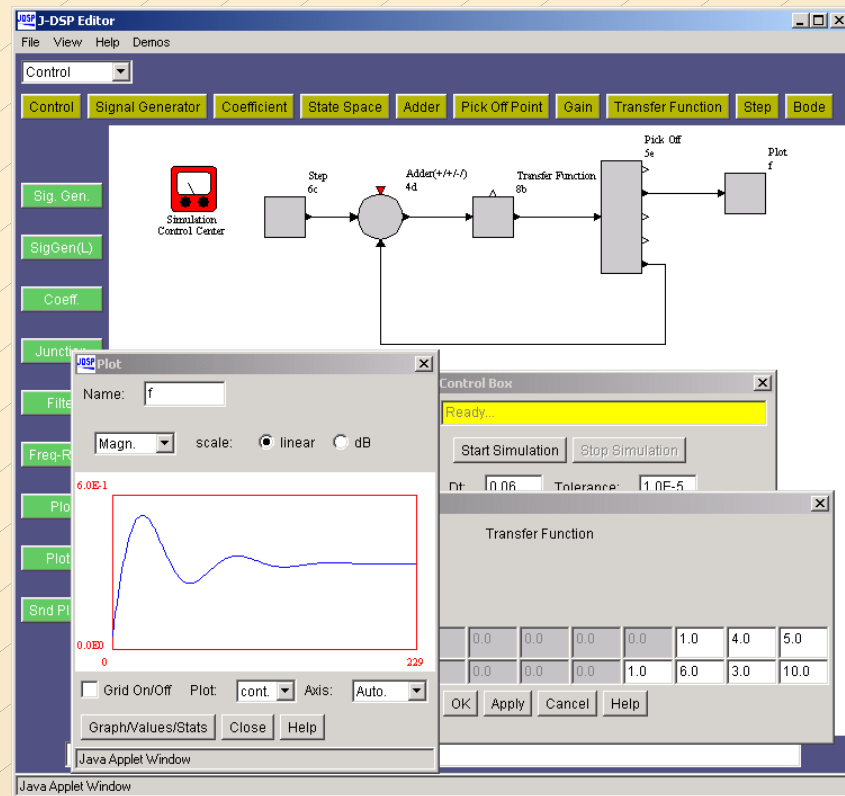
Arbitrary connection topology

- ◆ Rotate and flip blocks
- ◆ Modify connections
- ◆ Square, round and triangle blocks (as commonly used in feedback systems literature)



Control Systems

- ◆ Feedback systems
- ◆ Dynamical systems
 - Transfer Functions
 - State Space Models
 - Multiple inputs/outputs
- ◆ Bode plots and time responses

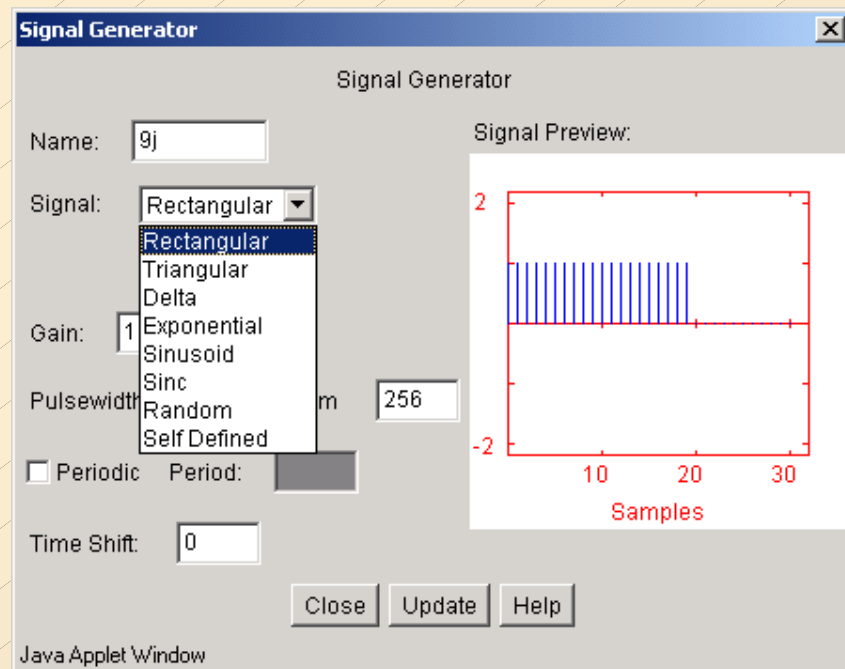


Step response

Signal generators

◆ Various types of signals

- Pulses
- Sinusoids
- Random
- ... etc



Dynamical Systems

◆ Transfer functions

$$H(s) = \frac{\sum_{i=0}^n b_i s^i}{\sum_{i=0}^n a_i s^i}$$

◆ State space

$$\dot{\underline{x}} = \underline{A}\underline{x} + \underline{B}u$$
$$y = \underline{C}\underline{x} + \underline{D}u$$

Transfer Function

Name: 8a

Select order: 3

0	0	0	0	0	0	0	0	0	1	4	5
0	0	0	0	0	0	0	0	1	6	3	10

OK Apply Cancel Help

Java Applet Window

State Space

Name: 3b

Select number of states, inputs and outputs:

States: 1 Inputs: 1 Outputs: 1

Press 1-8 on the numeric keypad below to enter A,B,C,D and x0

Load Matrix A Load Matrix B Load Matrix C Load Matrix D

Load Initial Conditions

Select differentiation method: Backward Euler

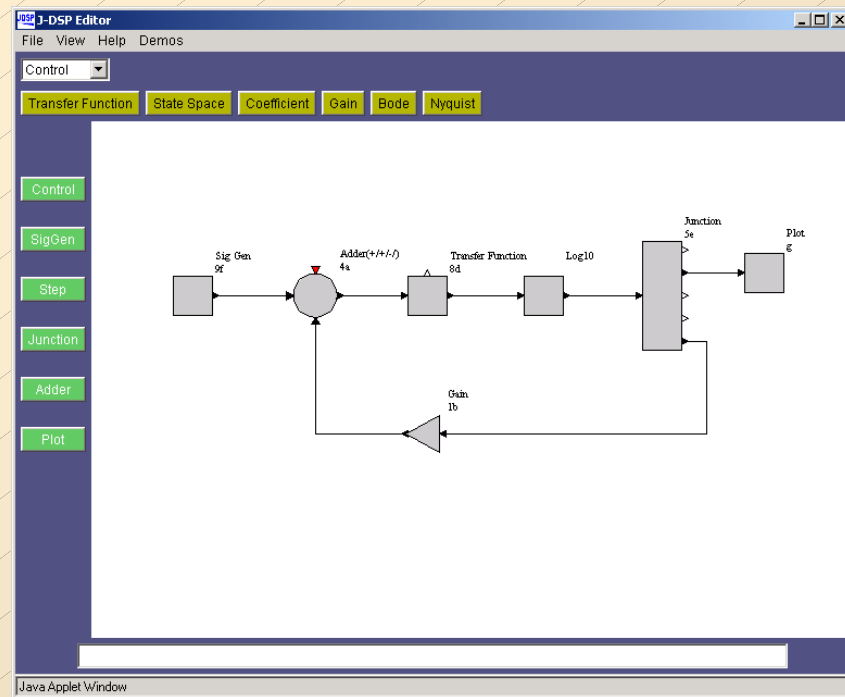
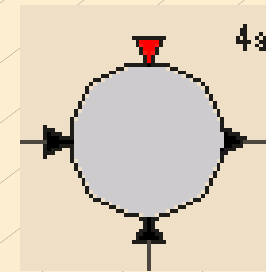
OK Apply Clear All Cancel Help

Java Applet Window

Arithmetic operations

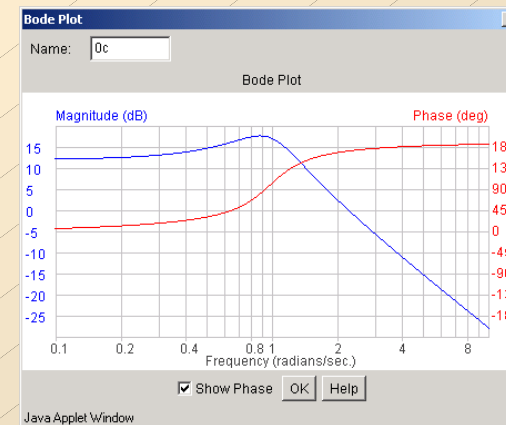
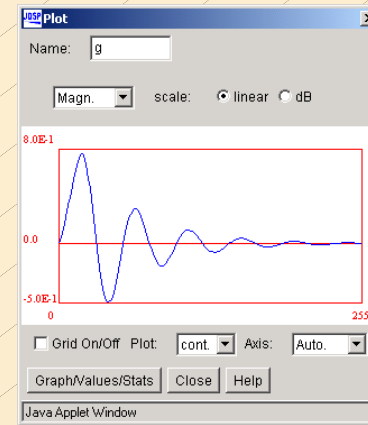
◆ Various types of math functions

- Gain
- Summation nodes
- Logarithms
- Exponentials
- Multipliers

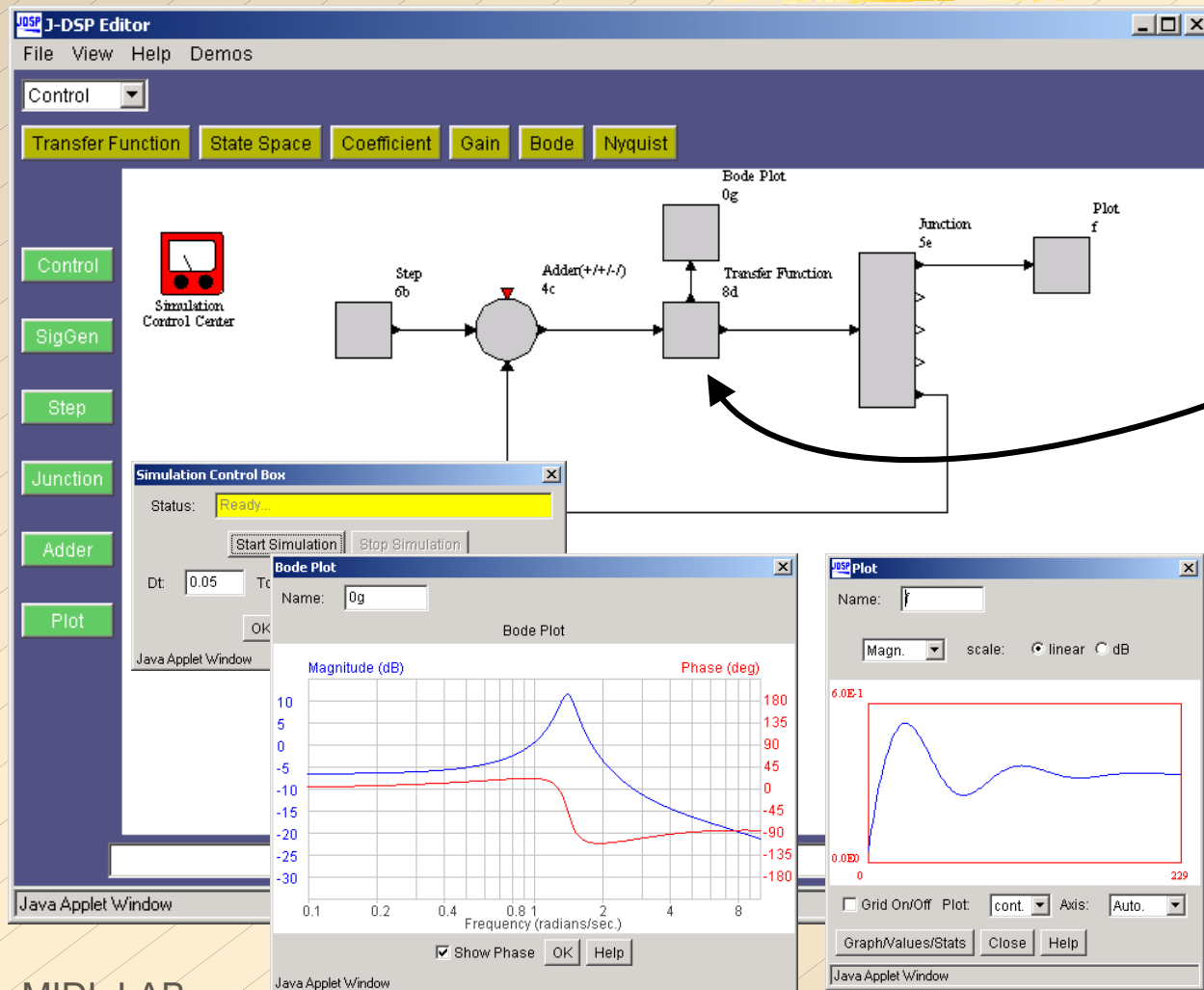


Plot and visualization

- ◆ Plotting blocks
 - Plot
 - Zoom-in, dB plots
 - Bode plot
 - Magnitude and phase response



Sample Simulation (1)



$$H(s) = \frac{s^2 + 4s + 5}{s^3 + 6s^2 + 3s + 10}$$

Sample Simulation (2)

The screenshot shows the J-DSP Editor interface with a control system simulation. The main window displays a block diagram with the following components:

- Step 6b**: Input signal source.
- Adder(+/-/-) 4c**: Summing junction.
- Transfer Function 8d**: Receives input from the adder and outputs to the plot.
- StateSpace 3h**: Receives input from the adder and outputs to the plot.
- StateSpace Coeff 2i**: Provides coefficients for the state space model.
- Plot f**: Displays the system output.

Two dialog boxes are open:

- State Space Model** (Name: 3h): Shows 3 states, 1 input, and 1 output. The matrix A is set to Canonical.
- Input Values** (Name: 8d): Shows the matrix A (3x3) with values:

0.0	1.0	0.0
0.0	0.0	1.0
-2.0	-13.0	-3.0

A plot window shows a damped oscillation signal with a peak value of 9.0E+1 and a time axis up to 229.

$$H_1(s) = \frac{s^2 + 4s + 5}{s^3 + 6s^2 + 3s + 10}$$

$$H_2(s) = \frac{s + 2}{s^3 + 3s^2 + 13s + 2}$$

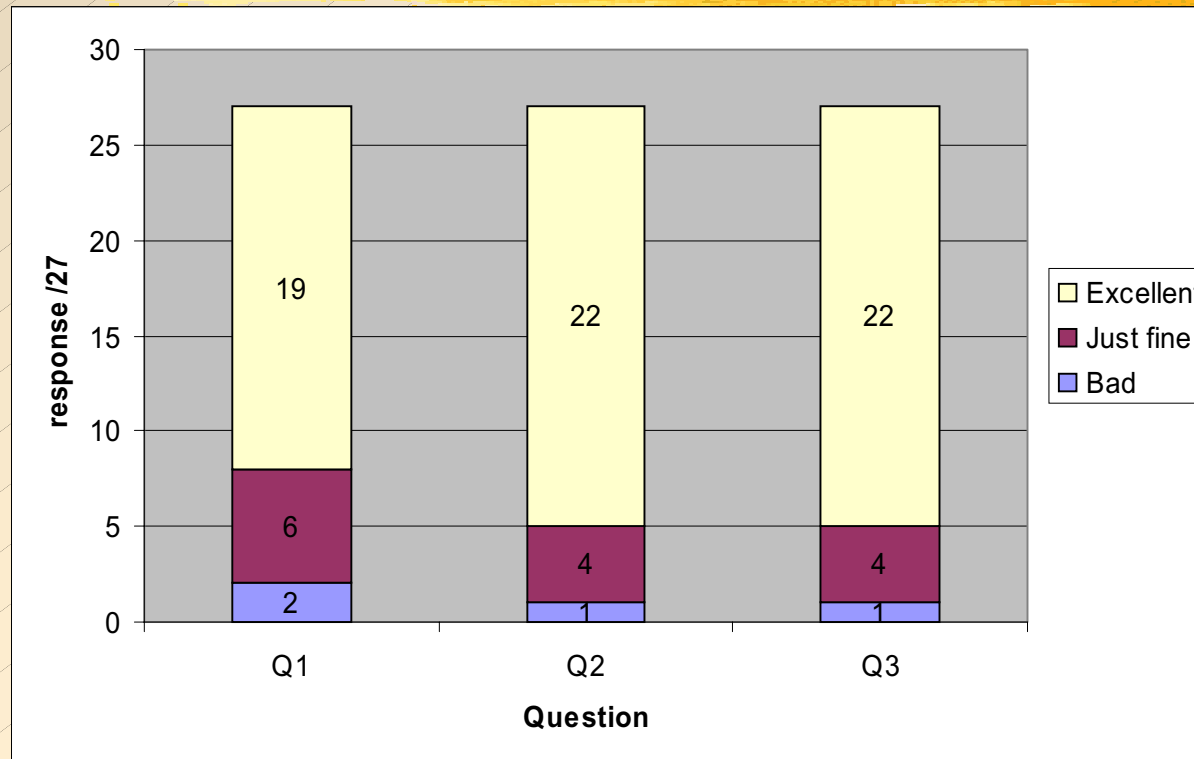
General J-DSP-C evaluation

Evaluations derived out of a sample of 27 students taking EEE480 ASU Control systems class, Fall 2002

	C Excellent	Just Fine	D Bad
How would you rate the J-DSP-C concept?	89%	0%	11%
The graphical interface of J-DSP-C is intuitive and user friendly	59%	26%	15%
Should the J-DSP-C be established as a full-fledged tool?	70%	15%	15%
Establishing and connecting blocks is easy	81%	11%	8%

Specific lab evaluation

Evaluations derived out of a sample of 27 students taking EEE480 ASU Control systems class, Fall 2002

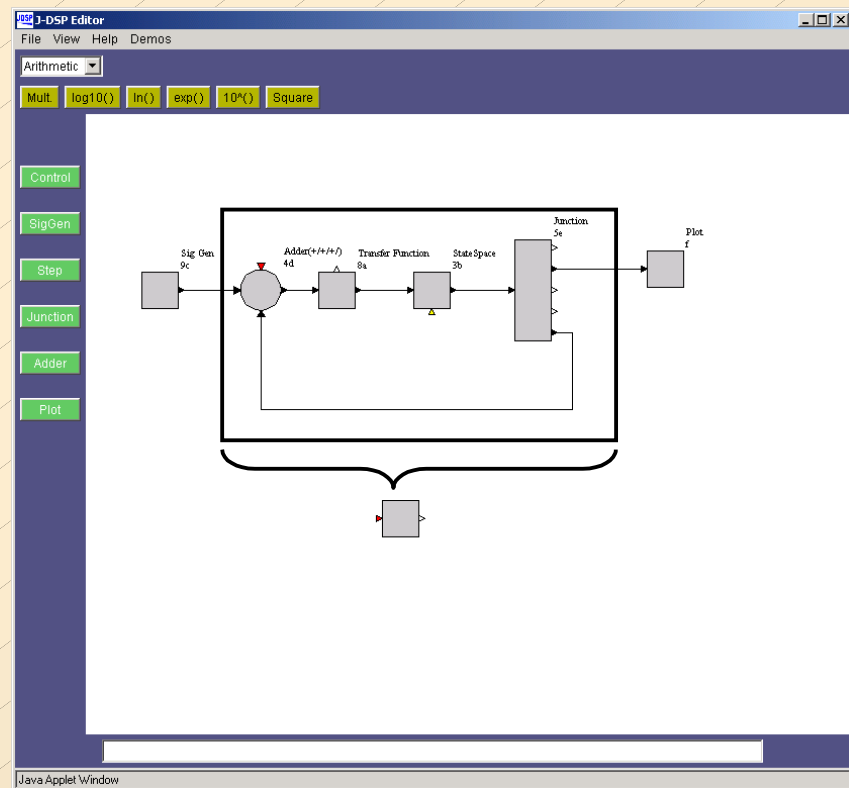


Questions asked after completion of a J-DSP based lab related to simple system concepts

- ◆ Q1: Your understanding of the time constant on the step and frequency response of a system has now improved
- ◆ Q2: The effect of the damping ratio on the step response is now clearer
- ◆ Q3: The simulations allowed you to better comprehend the overall parameters affecting the system overshoot

Future work

- ◆ Matrix manipulations
- ◆ Least squares approx.
- ◆ Adaptive systems
- ◆ Multivariable
- ◆ Grouping of several blocks to create a composite one



Summary

- ◆ J-DSP-C simulates control systems in a straightforward manner
- ◆ J-DSP-C maintains a classical textbook appearance
- ◆ J-DSP-C runs in any computer through a web browser
- ◆ J-DSP-C can be used to integrate interactive examples into classroom web content

Other J-DSP Extensions:

- ◆ Basic DSP systems
- ◆ Speech analysis-synthesis
- ◆ Image processing
- ◆ Communications systems
- ◆ Time frequency representations