Simulation and Design of PID Controllers

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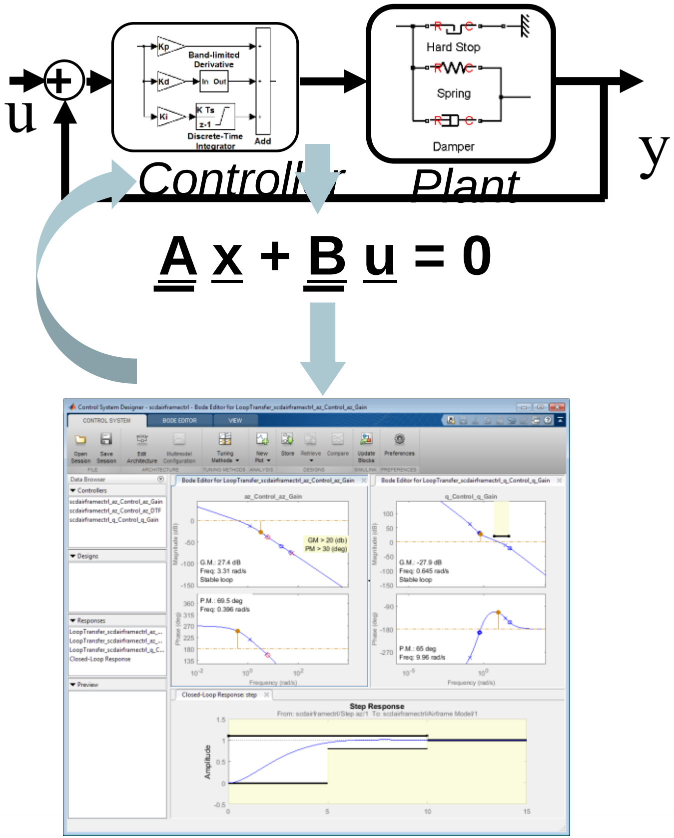
MathWorks

Introduction to Control Design

- Automatically tune arbitrary SISO and MIMO control systems modeled in Simulink

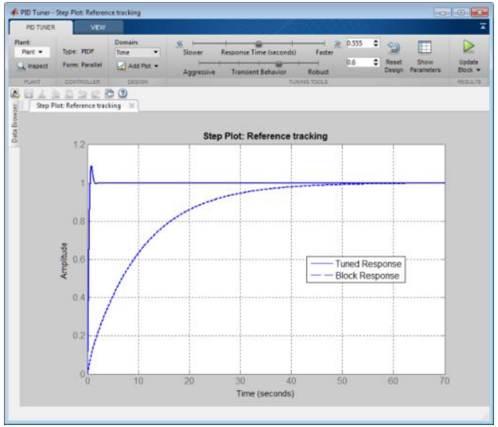
- Deploy PID Autotuning algorithm to embedded software

- Rapidly perform advanced linear analysis and control design for plants modeled in Simulink

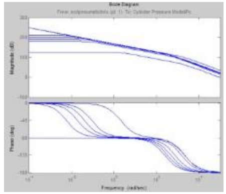


Key Features

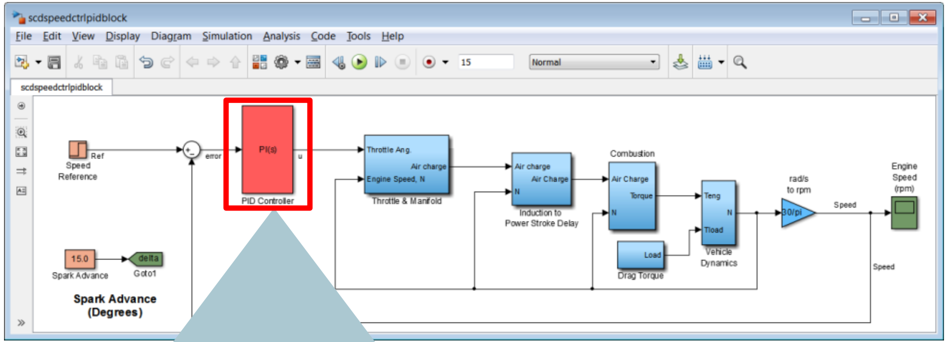
- Automatic tuning of PID, gain-scheduled, and arbitrary SISO and MIMO control systems in Simulink
- PID autotuning algorithm deployable to embedded software
- Operating-point calculation (trimming) and model linearization
- Frequency response estimation from simulation data
- Batch linearization for varying parameters and operating points

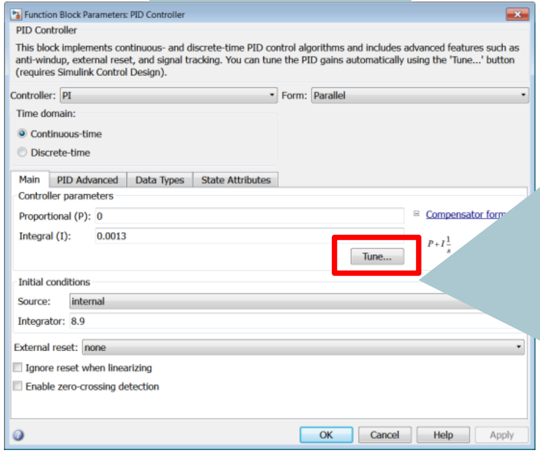


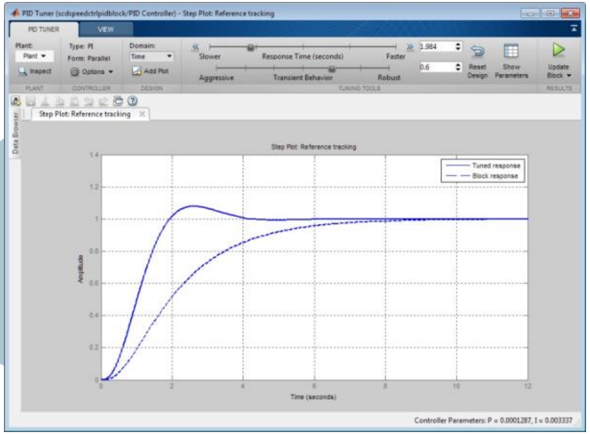

```
%% Gathering Simulation Snapshots
% To get operating point snapshots at various instants
% of the simulation use
op = findop('scdpneumaticlin',[0 10 20 30 40 50 60]);
%% The operating point is now ready for linearization.
% First specify the input and output points using the commands:
io(1) = linio('scdpneumaticlin/x',1,'in');
io(2) = linio('scdpneumaticlin/Cylinder Pressure Model',1,'out');
%% Linearize the model and plot the Bode plot for each condition
% to see the variablity in the linearizations.
sys = linearize('scdpneumaticlin',op,io);
bode(sys)
```



Design and Tuning of PID Controllers

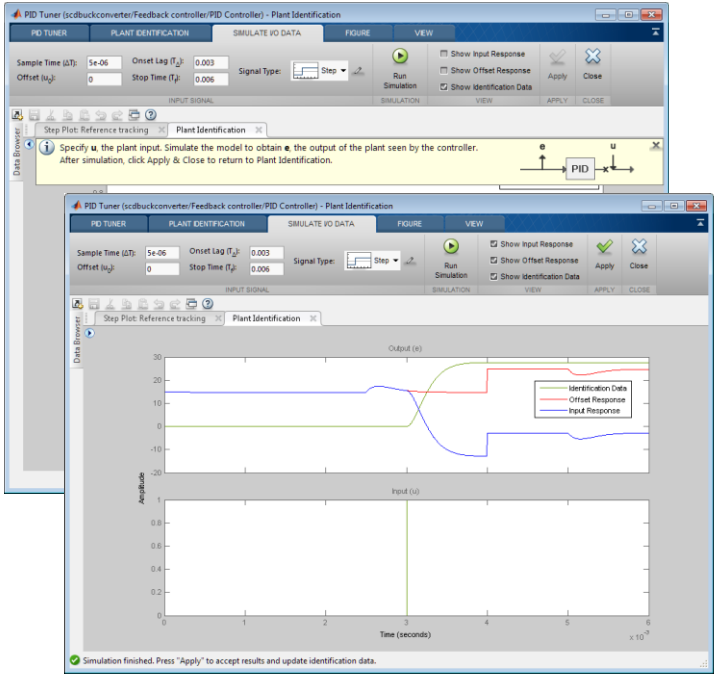






System Identification Integrated into PID Tuner

- Tune PID Controllers for Simulink models with discontinuities such as PWM and Stateflow logic
- Compute plant transfer function from simulation input-output data when exact linearization fails
- Inject a step or an impulse at the plant input
- Interactively or automatically fit the transfer function to simulation input-output data



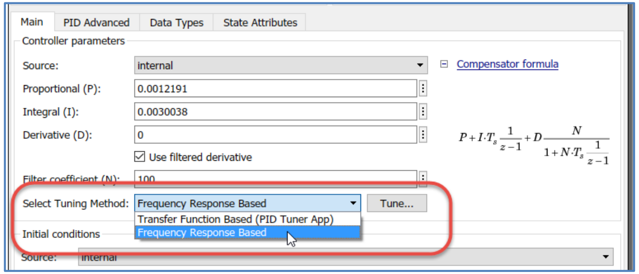
PID Autotuning

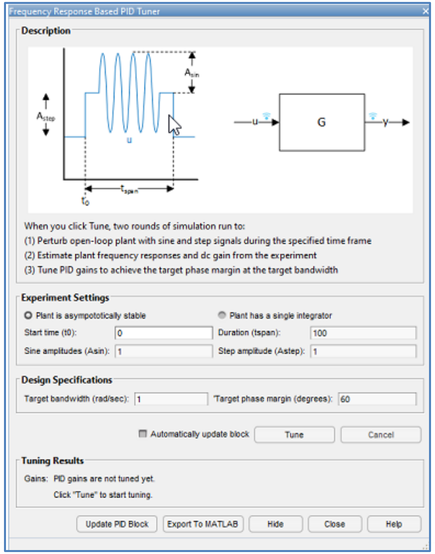
Automatically tune PID controller gains for models with plants that do not linearize

- Frequency-response based PID Tuner simulates the model to estimate its frequency response at a few frequencies near control bandwidth

- Controller gains are automatically computed from this frequency response

- The method can be used for models that do not linearize, for example, power electronics systems





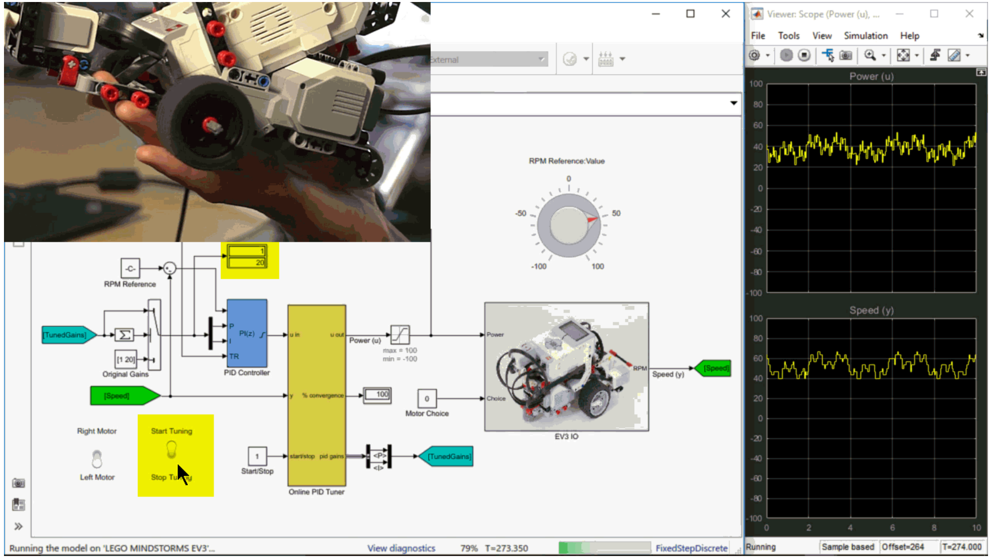
PID Autotuning

Deploy PID autotuning algorithm to embedded software

- Use Online PID Tuner block to generate autotuning code and deploy to embedded software

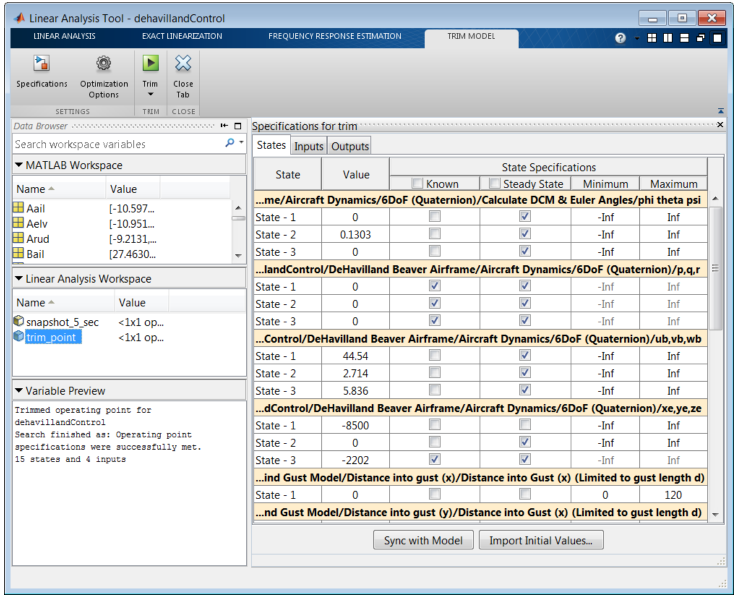
- PID autotuning is model-free, no a priori model of the plant is required

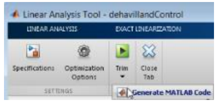
- PID autotuning generated code can be used completely independently from Simulink or through External Mode



Nonintrusive Trimming of Simulink Models

- Find trim points using optimization methods
- Trim at specific times or events during simulation
- Automatically generate MATLAB code from the Graphical User Interface



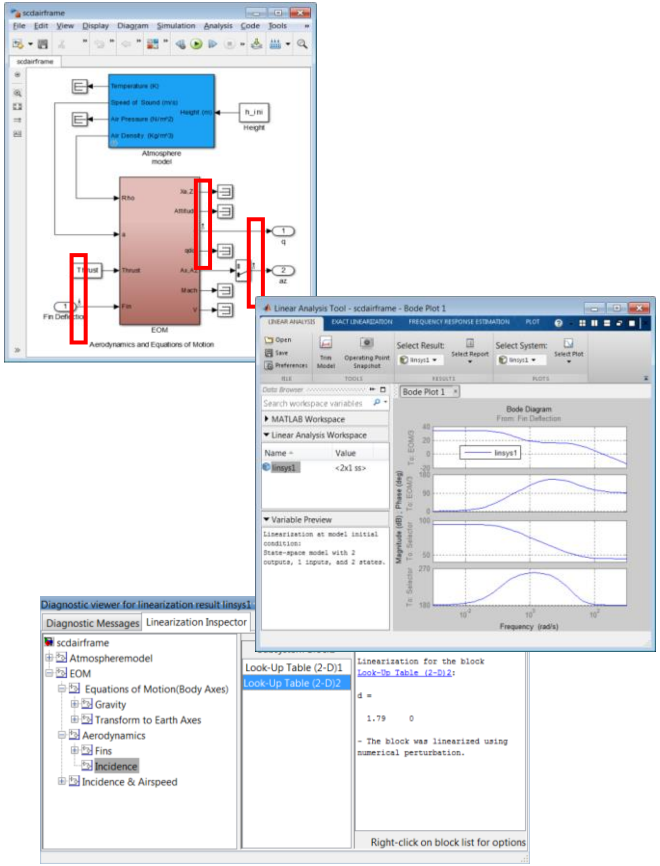



```
function op = myoperatingpointsnapshot
%
% MATLAB(R) file generated by MATLAB(R) 7.13 and Simulink Control Design (TM) 3.4.
%% Specify the model name
model = 'dehavillandControl';

%% Run simulation to extract snapshots.
op = findop(model,[5]);
```

Nonintrusive Linearization of Simulink Models

- Linearize without having to modify model structure
- Linearize whole model, portion of model, single block, or subsystem
- Specify linearization behavior of any number of blocks in the model
  - Linearize models containing discontinuities or event-based logic
  - Compute uncertain linear models for use with Robust Control Toolbox
- Use linearization Inspector to view and plot linearization results



Simulation-Based Computation of a Simulink Model Frequency Response

- Compute frequency response for models with strong discontinuities or event-based dynamics
- Verify results of a linearization
- Study the effects of excitation signal amplitude on nonlinear system’s gain and phase characteristics