Control System Design

Control System Design Process

The first step in designing a controller is the development of a high-fidelity model of the plant to be controlled. Then a controller can be designed to control the plant within the design specifications. To do this, use Embed's frequency domain analysis and global optimization capabilities.
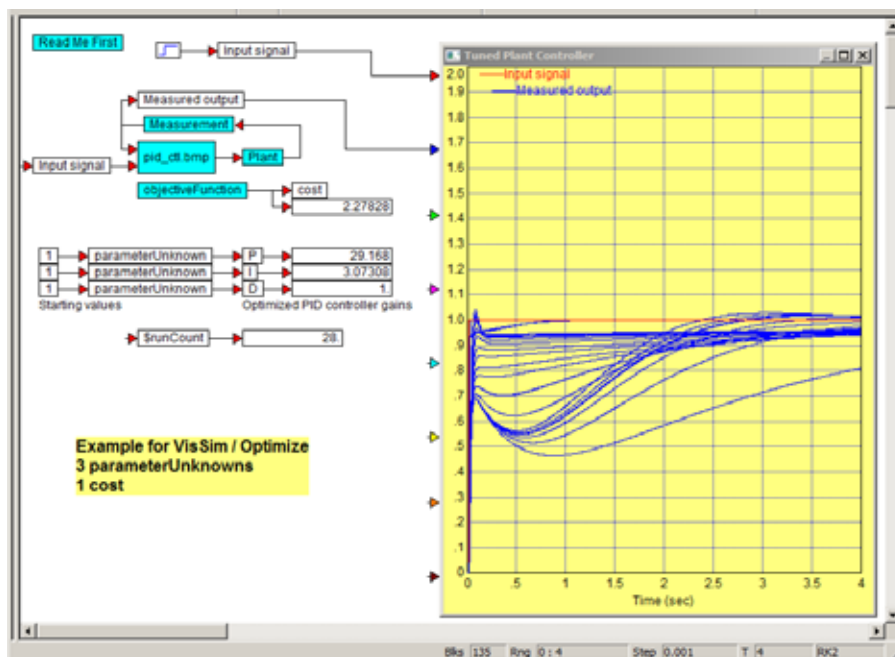
Modeling the Plant

The Embed mathematical engine provides fast and accurate solutions for linear, nonlinear, continuous time, discrete time, time varying, and hybrid systems. Embed lets you easily build plant models by simply selecting and connecting function blocks. Models can be linear, nonlinear, continuous, discrete, hybrid, SISO or MIMO.

Embed supports hierarchical design by letting you group blocks into compound block subsystems. You can also create custom blocks using C, Fortran or Pascal and add them to the Embed block library. There is virtually no limit to model size or complexity.

Once assembled, a click of the GO button simulates the plant model. Data import blocks allow easy comparison of model output to actual plant output. In Embed, responses are immediately visualized with plots, stripcharts, meters and gauges. The plant model can be refined until the model accurately reflects the desired response. Plant models can also be derived through system identification methods which "reverse engineer" the plant model from measured plant data.

Frequency Domain Analysis

After the plant model is verified, the dynamics of a plant can be analyzed: Embed approximates the dynamics of a nonlinear system by linearizing the system about the current operating point. Linearized systems can be represented in ABCD state-space or transfer function form. With Embed, you can easily access transfer function information, edit zeros and poles, and obtain Nyquist, Bode, and root locus plots.

Parameter optimization of PID gains using the Embed global optimizer

Controller Design

The next step is to design a controller for the plant model by interactively editing compensator zeroes and poles, and observing their combined behavior in Bode and root locus plots. Once the desired responses are obtained, the pole placement controller block is simply inserted into the Embed diagram.

The preliminary pole placement controller is then connected to the plant model creating a feedforward or a feedback control loop. A simulation is run and the results of the simulation can be viewed in plots. The stability of

the closed-loop system can then be determined using Nyquist plots. In addition to pole placement controllers, Embed provides pre-configured PI, PD and PID controllers that can be easily customized or optimized for specific user requirements.

Simulation

Simulations can be set up to run in interactive, batch, or single-step modes. Embed's highly interactive interface makes it easy to perform "what if" simulations. For example, you can dynamically change parameter values like controller gains and Embed will immediately display the corresponding changes in system behavior.

Both linear and nonlinear systems can be simulated with Embed. Nine different integration algorithm options are available that offer a trade-off between speed and accuracy.

Embed can determine optimal values for design variables subject to user-defined constraints starting from initial user guess values. For example, Embed can automatically calculate optimal PID controller gains that give minimal time to setpoint, plus minimal overshoot. It allows user-specified cost functions that can consider controller behavior, such as steady-state error, overshoot and rise and settling times. Embed can even work with a physical system when coupled with Embed's hardware analog I/O interface.

Authorized Distributors

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