Altair Embed® SE

Model-Based Design and Dynamic Simulation Software

High fidelity modeling of large scale projects can be done with Embed SE. From a financial standpoint, it is extremely worthwhile to the process control community. There are tremendous cost savings in reduced downtime due to offline tuning and control design, as well as operator training.

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Senior Designer
Emerson Control

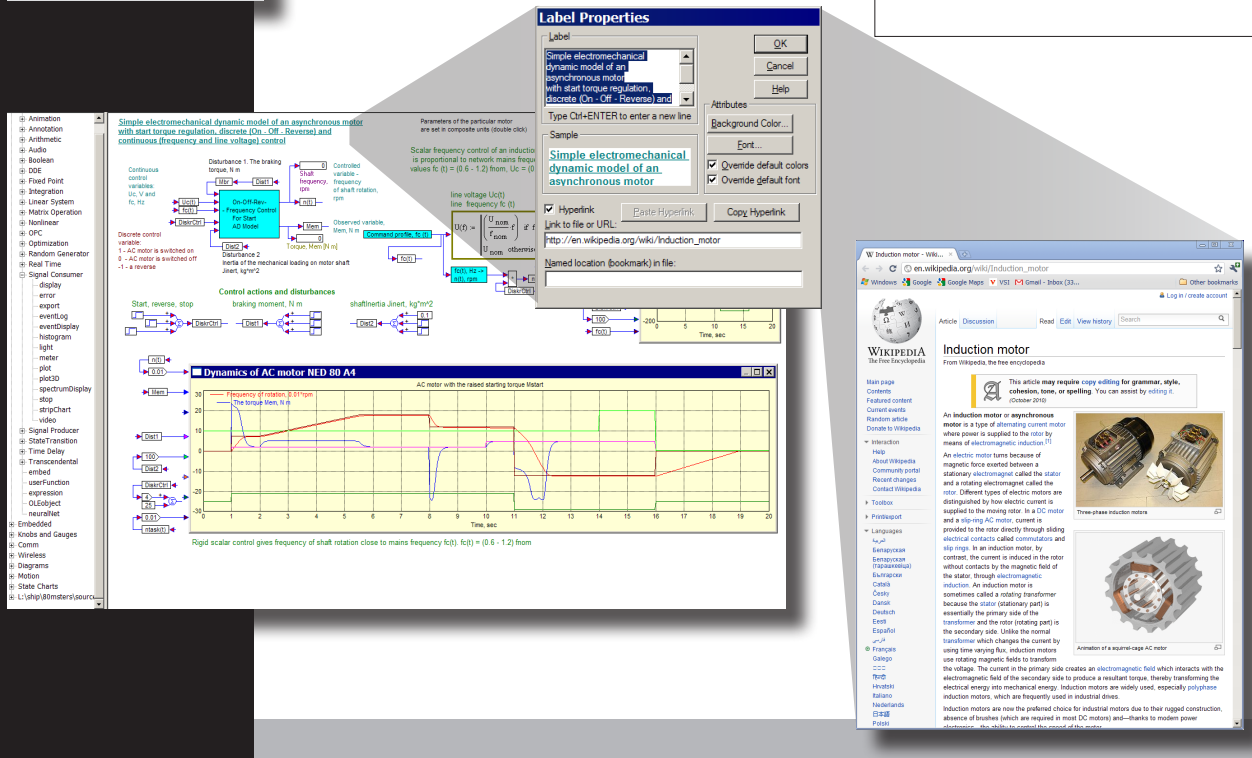
Altair Embed® SE is a visual environment for Model-Based Design and dynamic simulation of complex systems. It combines an intuitive graphical interface with a powerful simulation engine to accurately represent linear and nonlinear systems, and simulate their behavior in continuous time, sampled time, or a combination of both.

In addition, Altair Embed SE's tightly integrated development environment makes it easy to pass freely among the stages of model construction, simulation, optimization, and visualization, allowing you to create, verify, and validate prototypes before committing to the design.

If you design requirements include code generation, you can step up to Altair Embed, which—in addition to all the features and capabilities of Embed SE—lets you rapidly prototype embedded controllers for Texas Instruments™, STMicroelectronics®, Arduino®, and Raspberry Pi® MCUs.

HIGHLIGHTS

- Intuitive graphical interface for block diagram creation and maninpulation
- Extensive and expandable block libraries containing
- Hierarchical model construction with password protection for linear, nonlinear, time-varying, discrete-time, continuous-time, and hybrid systems
- Fixed, adaptive, and stiff system integration algorithms
- Parameter optimization
- "What if" simulation scenarios
- Simulink translator
- Exchange data with MatLab and Mathcad, and import/export data using ActiveX and DDE
- UML 2 state transition editor to simulate event-driven systems
- Functional Mock-Up Interface for importing dynamic models for model exchange or co-simulaiton
- 3D interactive animation and plotting
- Interactive XY, time domain, FFT, and discrete plots



Implementation of an AC motor model for an autocontrol system component (far left). Embed labels are linked to explanatory documentation on the internet (left).

MODEL CREATION

Using Embed Blocks

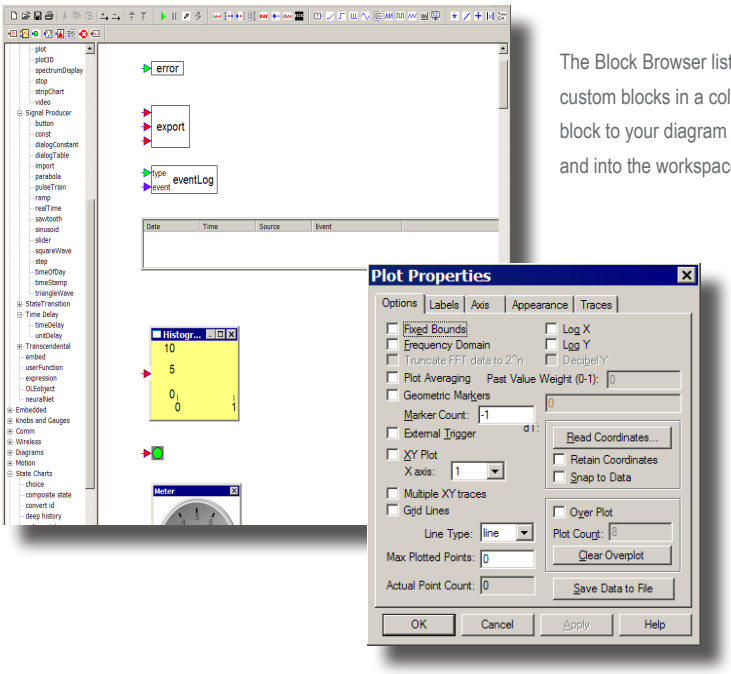
In Embed SE, blocks are your basic design component. You can choose from over 200 mathematical, engineering, and scientific blocks, allowing you to realize system models of any degree of complexity.

Blocks are categorized by function and listed in both the Blocks menu and Block Browser.

Toolbox Libraries: Toolbox libraries expand Embed modeling capabilities for mechanical and electrical systems, eMotors, hydraulics, signal generation, and analog and digital filter design.

Additional Block Libraries: These block libraries (available separately) target specific engineering disciplines, including communications and digital power design.

Custom Blocks: If your requirements extend beyond the standard block and toolbox libraries, you can create custom blocks in C, C++, Fortran, and Pascal and add them to the Blocks menu for use in other models.



The Block Browser lists all standard blocks and custom blocks in a collapsible tree. To add a block to your diagram just slide it off the Browser and into the workspace.

Right-click over a block to access customizable parameters and options.

Building and Managing Models

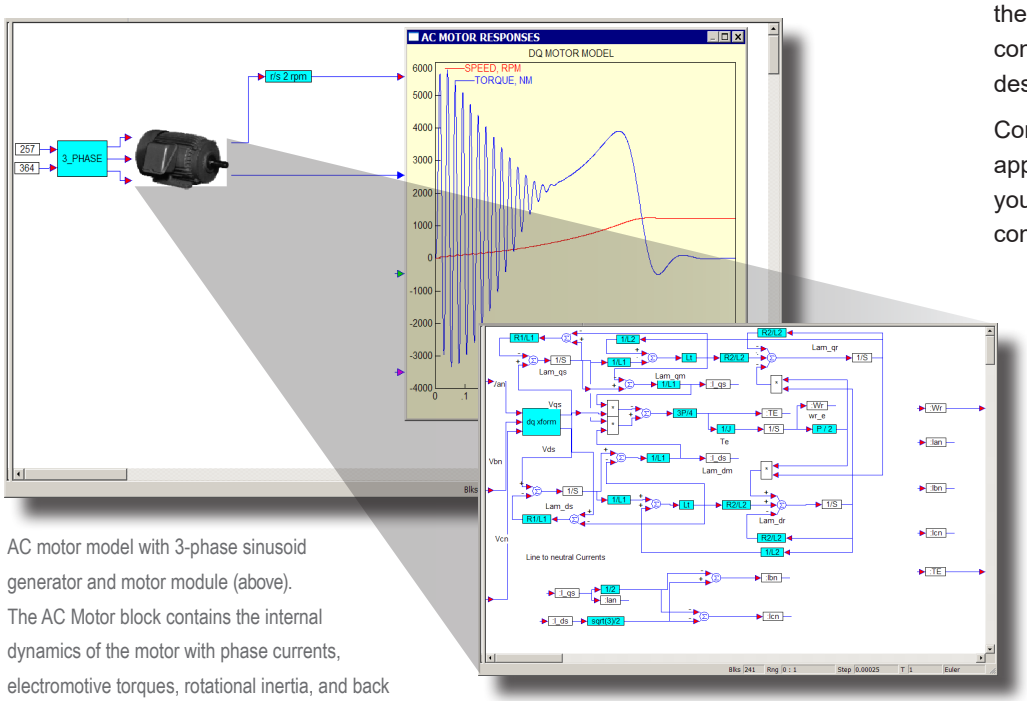
A block diagram provides a clear and concise representation of the structure of a system model. In Embed SE, you build block diagrams by sliding blocks into the workspace and wiring them together with the mouse. You can change block orientation and signal flow, and specify display modes, colors, and fonts to customize diagram appearance.

Organizing and Navigating Models

Organizing block diagrams into logical subsystems lets you build models using a top-down or bottom-up approach. Subsystems are encapsulated in compound blocks, where the top level blocks display major component connectivity, leaving the underlying levels to describe the logic of each component.

Compound blocks encourage a modular approach to diagram construction by letting you design and test functionally independent components concurrently.

Compound blocks can be saved separately and reused in other models.



AC motor model with 3-phase sinusoid generator and motor module (above). The AC Motor block contains the internal dynamics of the motor with phase currents, electromotive torques, rotational inertia, and back EMF calculations (right).

Transmitting Signals

Signals travel from one block to another via the wires that connect them. Signals can be defined according to:

- **Data type:** single, double, signed or unsigned 8-, 16-, or 32-bit integers, fixed-point, or Boolean.
- **Dimension:** scalar, vector, or matrix.
- **Complexity:** real, imaginary, or complex number.
- Range and units.

You can also transmit signals throughout your diagrams without wires, and restrict the portions of the diagram referenced by the wireless signals.

Performing Time and Frequency Domain Analysis

Embed SE lets you generate a linear approximation of a nonlinear system at a specified operating point and linearize the system in both time and frequency domain representations. You can perform Bode magnitude and phase analysis; root locus analysis; pole-zero and gain analysis; and Nyquist stability analysis.

Modeling Events and Time-Based Conditions

With State Charts, you can model each state in a finite-state system, as well as the transitions between states. You can create state charts anywhere in a diagram and exchange data with the continuous portion of the diagram. You can interactively simulate the diagram and generate code to run on an embedded target. (Available in Altair Embed.)

Image Processing and Pattern Recognition

The OpenVision block set lets you enhance or alter the appearance of an image or examine the image for specific patterns. You can interactively simulate the diagram and you can generate code to run on Raspberry Pi devices. (Available in Altair Embed.)

Protecting Your Work

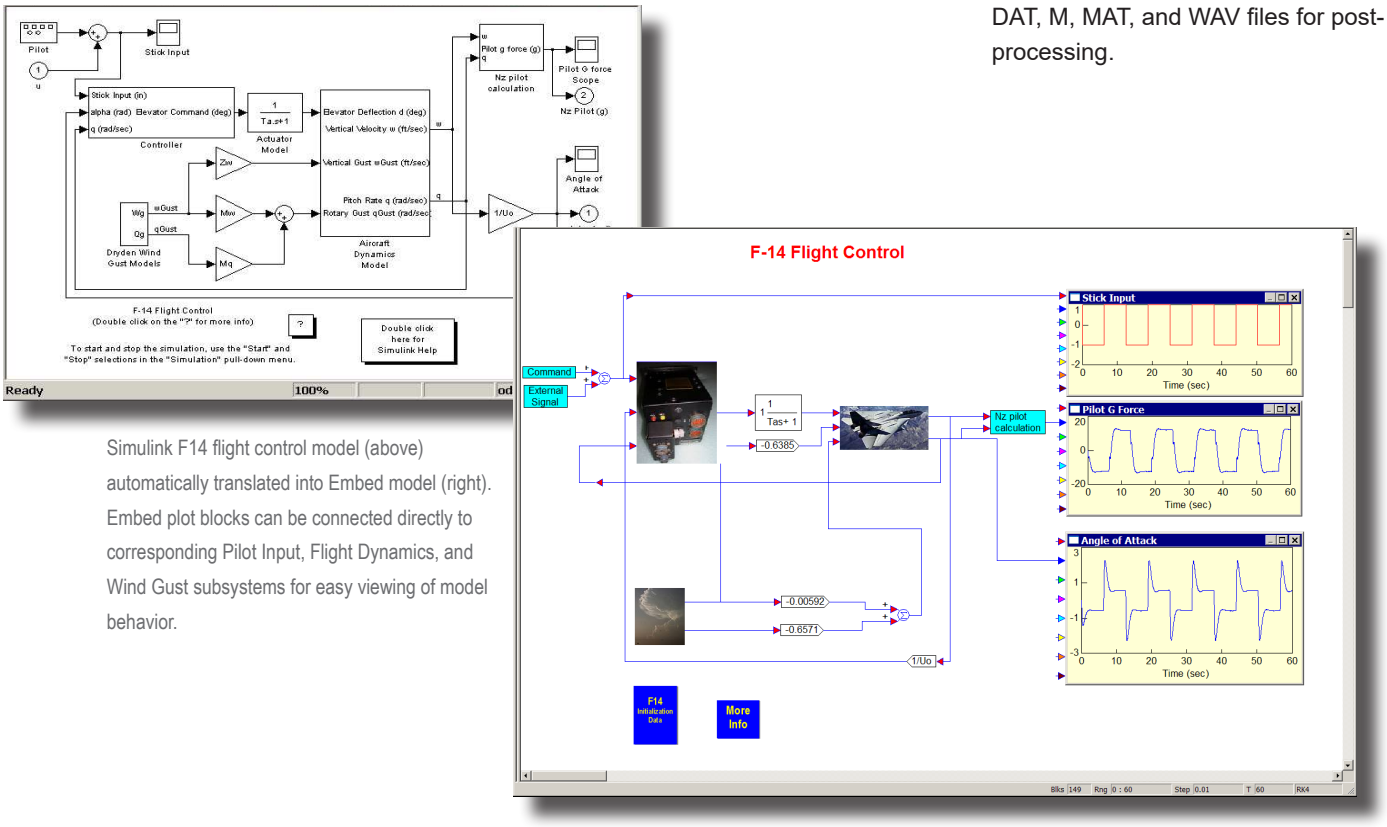
In large project development, where multiple engineering groups are working on the same project, you can restrict access to your designs by applying password protection. Protection can be applied to entire models or to specific modules within a model.

Working with Other Applications

Increased interoperability with other Altair products, as well as leading mathematical and engineering software extends Embed computational power.

- Post data to an IoT platform and analyze and visualize the data with **Altair SmartCore** and **Altair SmartSight**.
- Interface with **Altair Compose** to calculate general matrix expressions, and read/write variables.
- Use the **Functional Mock-Up Interface** for model exchange and co-simulation.
- Import and translate **Simulink MDL files** into Embed SE models. The translator displays model translation information, including Simulink version and blocks created, and provides a log file with translation details.
- Use **ActiveX** for real-time, interprocess communication.
- Embed, edit, and execute **MathCad** documents in an Embed model.

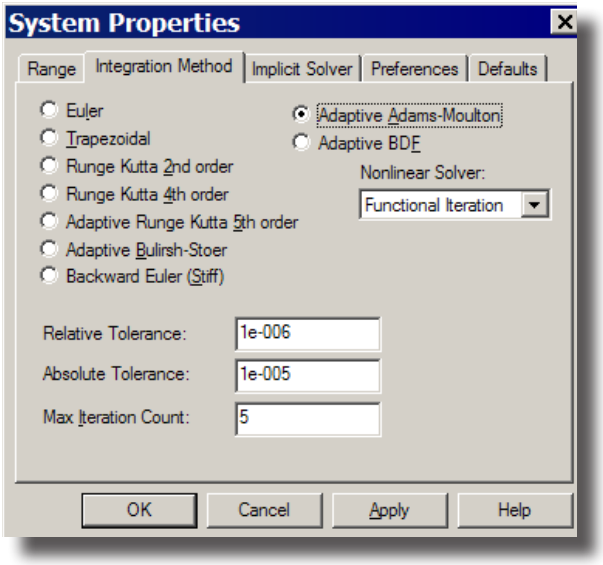
Simulation data can also be logged in DAT, M, MAT, and WAV files for post-processing.



Simulink F14 flight control model (above) automatically translated into Embed model (right). Embed plot blocks can be connected directly to corresponding Pilot Input, Flight Dynamics, and Wind Gust subsystems for easy viewing of model behavior.

SIMULATING MODELS

When Embed SE simulates a model, it solves the equations that define the model and computes model outputs with no intervening steps. You can easily perform “what if” scenarios: Embed SE lets you change system parameters as the simulation progresses, and view the results immediately in plots and display blocks.



Embed SE provides nine fixed- and adaptive-step integration algorithms. The adaptive algorithms let you set the minimum step size and maximum iteration count. For adaptive Adams-Moulton and BDF, you can specify Newton Iteration for stiff systems or Function Iteration for non-stiff systems to more accurately control the step size around discontinuities.

Using Integration Solvers

Simulating dynamic systems generally includes the numerical integration of differential equations. Embed SE offers a full range of integration solvers, including fixed step, adaptive step, and stiff system solvers that support linear, nonlinear, continuous-time, discrete-time, and hybrid simulations. These solvers control the speed and accuracy of the simulation results.

Simulating Hybrid Systems

Hybrid models contain both discrete and continuous time blocks. In hybrid systems, the outputs of the discrete blocks are held constant between successive sample times, and updated at times that correspond to the specified discrete sample time. The outputs of continuous blocks are updated at every time step. Similarly, the inputs to the discrete blocks are updated at times that correspond to the discrete time interval while the inputs to continuous blocks are updated at every time step.

Hybrid systems can also contain multi-rate sampling for discrete transfer functions.

Conditionally Executing Subsystems

Triggered compound blocks are subsystems that are executed conditionally through an external trigger. Any portion of a model can be encapsulated in a triggered compound block, allowing you to significantly speed up your simulations. Applying a local time step to a triggered compound block accommodates multi-rate simulations.

Executing Modes

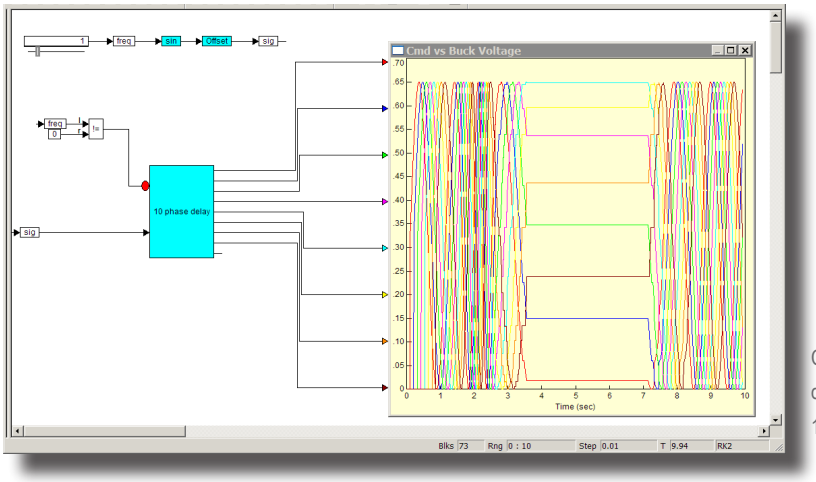
You typically run a simulation from the Embed GUI; however, if you only need to see the outcome of the simulation, you can run it in batch mode. You also have these execution mode choices:

- **Normal mode:** the model is interpretively simulated.
- **Rapid mode:** components in the model are translated into executable code and incorporated back into the model as Embed-generated DLLs.

Optimizing Parameters

Embed SE includes several built-in parameter optimizers to improve system performance by finding optimal parameters for controller gains, system constants, and curve-fitting coefficients.

You can also calculate optimal PID controller gains subject to user-defined constraints.



Conditional execution of subsystem that prevents divide-by-zero for the zero frequency case in a 10-phase sine generator.

Real-Time Data Monitoring and Acquisition

You can communicate and exchange data with devices outside the Embed SE environment in the following ways:

- Interface with a USB Controller Area Network (CAN) device and read and write CAN messages on a CAN bus. You can view data in plots and strip charts, or log it for later analysis.
- Connect to any OPC server and log data or run a virtual plant in Embed SE for off-line tuning.
- Interface to popular analog and digital I/O boards from National Instruments and Measurement Computing to perform real-time data acquisition and signal generation. You can couple your model directly with a real PLC or DCS system for off-line tuning or to prototype a control with a real plant.
- Exchange data with any RS232 device. You can configure serial port settings, parity, and stop bits.
- Read and write standard UDP packages with packet layout specifications of up to 256 offsets into the packet.

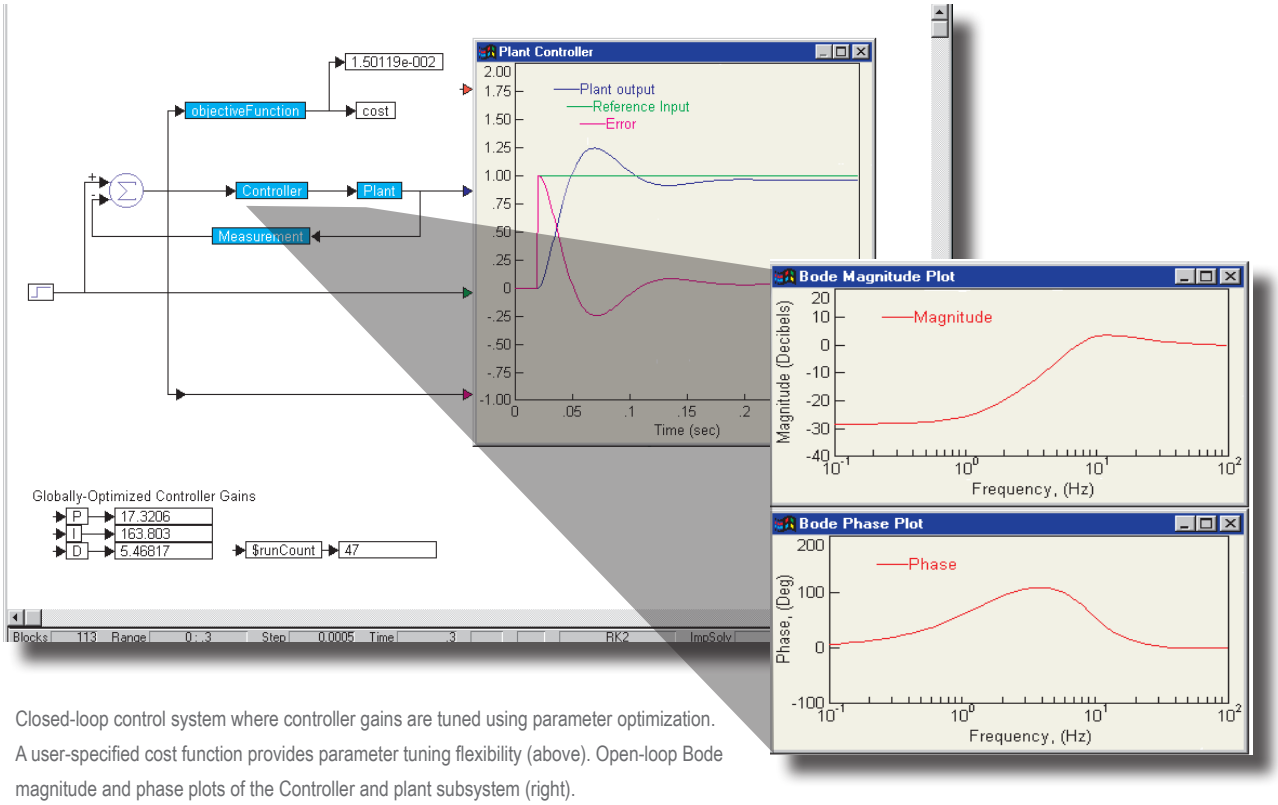
Debugging Simulations

Embed SE provides a collection of debugging tools for examining, locating, and correcting inconsistent system behavior.

- **Execution control:** The Start, Stop, and Continue control buttons let you step through a simulation, one time step at a time.
- **Signal value probes:** Hover the cursor over a block output pin to examine the data exiting the block, or connect a display block to any output to continuously update displayed values.
- **State Chart breakpoints and watch windows:** Set breakpoints on state events or transitions, and add watch windows to view variables.

You can also set warnings for unconnected blocks, algebraic loops, and math faults.

If you are developing an embedded system with Altair Embed, additional debugging capabilities are provided, including monitoring register values, recording event statistics, capturing execution timing, and displaying heap and stack usage.



Closed-loop control system where controller gains are tuned using parameter optimization. A user-specified cost function provides parameter tuning flexibility (above). Open-loop Bode magnitude and phase plots of the Controller and plant subsystem (right).

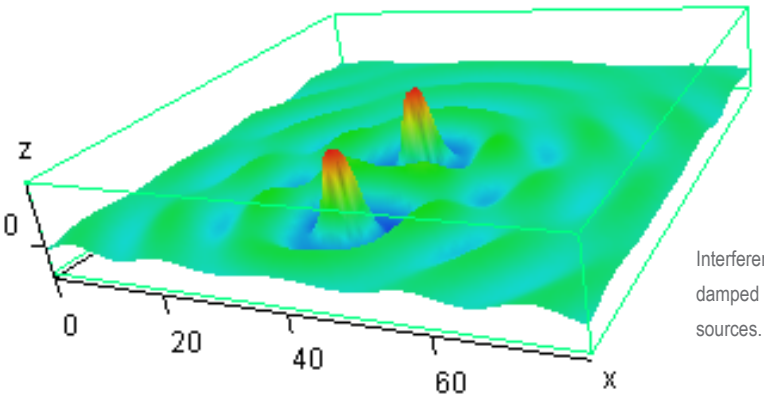
VIEWING SIMULATION RESULTS

Viewing model behavior as a simulation executes provides added insight into the dynamics of your model. Embed SE provides a wide range of blocks for visualizing, analyzing, animating, and collecting simulation data.

Interactively Plotting Time Domain, XY, and FFT Data

One of the more powerful and useful blocks in Embed SE is the plot block. This block displays up to eight color-coded signals in customizable time and frequency domain graphs. You can control the plots in the following ways:

- Specify x- and y-axis bounds
- Specify x-axis scaling
- Display signal traces in separate windows
- Apply external trigger to acquire data at different rate
- Create independent XY plots
- Plot data in logarithmic and semi-logarithmic coordinate systems

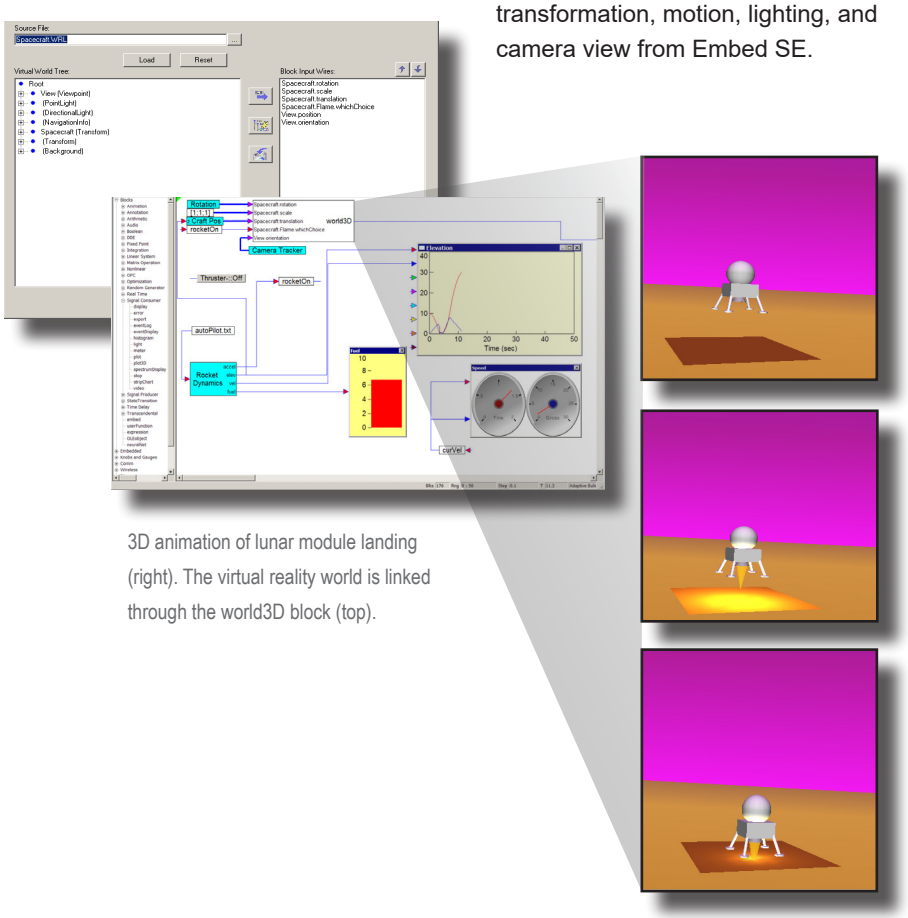


Interference pattern of two damped sinusoidal energy sources.

Plots can display frequency power spectrum data through FFT algorithms. And they can also show vector and matrix data as 3D objects and control surface characteristics and lighting.

Animating and Visualizing Models in 3D

Using the Virtual Reality Modeling Language (VRML), you can create 3D virtual realities and control object transformation, motion, lighting, and camera view from Embed SE.



3D animation of lunar module landing (right). The virtual reality world is linked through the world3D block (top).

EXTENDING THE POWER OF EMBED SE

Code Generation and Embedded Development

If you step up to **Altair Embed**, then at the push of a button, you can translate all or part of your models into code that can run on thousands of MCUs from popular hardware manufacturers, including Texas Instruments, STMicroelectronics, Arduino, and Raspberry Pi.

Communications Module

The COMM module lets you model end-to-end communication systsems at the signal or physical level.

Digital Power Designer Module

The Digital Power Designer module provides high-level blocks for simulation and code generation of power supply and digital power components and controls. You can develop a working controller that can be directly downloaded to the MCU for digital power applications.

WHERE TO GO FROM HERE

To learn more about Embed or Embed SE, talk to your ESS sales representative or go online to download a free trial of the software.

About Embedded Systems Solutions

Founded in 1996, Embedded Systems Solutions (ESS) has been a leading one-stop provider of hardware and software solutions for the embedded real-time systems market..

ESS is an Electro Systems Associates (ESA) group company. ESA was incorporated in 1986 by a small group of highly qualified technocrats with sound business acumen and strong technical skills.

ESS is particularly well known for in-depth expertise and vast experience with real-time embedded systems and development tools.

ESS partners with technology experts and leaders worldwide to bring together a tools ecosystem of highly integrated embedded hardware and software solutions for the Indian market.

ESS product portfolio has a range of offerings from Embedded Development Suites and Debuggers, Embedded Middleware, Embedded Security Solutions, In-Circuit Debuggers and Emulators, Flashers and Programmers, Connectivity Solutions, Protocol Analyzers, Storage Emulation Tools, Digital Storage Oscilloscopes, JTAG Boundary Scan Tools, Model-Based Design and Development Tools, Hardware Subsystems, and Single-Board Computers, among many others product offerings.

This synergetic tools ecosystem offers comprehensive solutions for design, development, and debugging processes in embedded systems.

Contact us now for more information on the Embed product line.

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