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Professional VisSim

Model-Based Design and Dynamic Simulation Software

Introduction

VisSim is a visual environment for model-based development 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, VisSim's tightly integrated development environment makes it easy to pass freely among the stages of model construction, simulation, optimization, validation, and code generation, allowing you to create, verify, and validate prototypes before committing to the design.

With thousands of engineers and scientists – spanning a broad range of industries and disciplines – already using VisSim, it has become a recognized leader in system modeling and dynamic simulation.

VisSim labels are linked to explanatory documentation on the internet

Implementation of an AC motor model for an autocontrol system component

High fidelity modeling of large scale projects can be done with VisSim. 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.

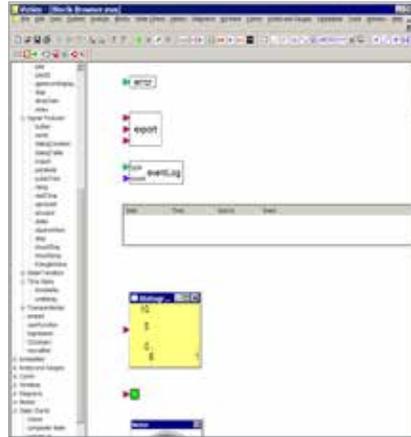**Andy Waite**, Senior Designer, Emerson Control

Using VisSim Blocks

In VisSim, 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. See page 8 for the complete blockset.

Toolbox Libraries: Toolbox libraries (included with VisSim) expand VisSim's modeling capabilities for mechanical and electrical systems, hydraulics, signal generation, and analog and digital filter design.

Additional Block Libraries: These block libraries (available separately) target specific engineering disciplines, including communications design, fixed-point algorithm

development, neural network creation, embedded system design, and hardware-in-the-loop simulation.

Custom Blocks: If your requirements extend beyond the standard block and toolbox libraries, you can create custom blocks in

The Block Browser lists all standard blocks, add-on 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.
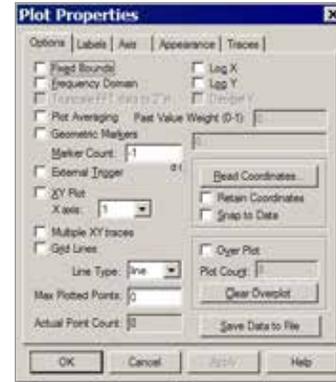
*Right-click over a block to access customizable parameters and options.*

C, C++, Fortran, and Pascal and add them to the Blocks menu for use in other models.

Building and Managing Models

A block diagram provides a clear and concise representation of the structure of a system model. In VisSim, 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.
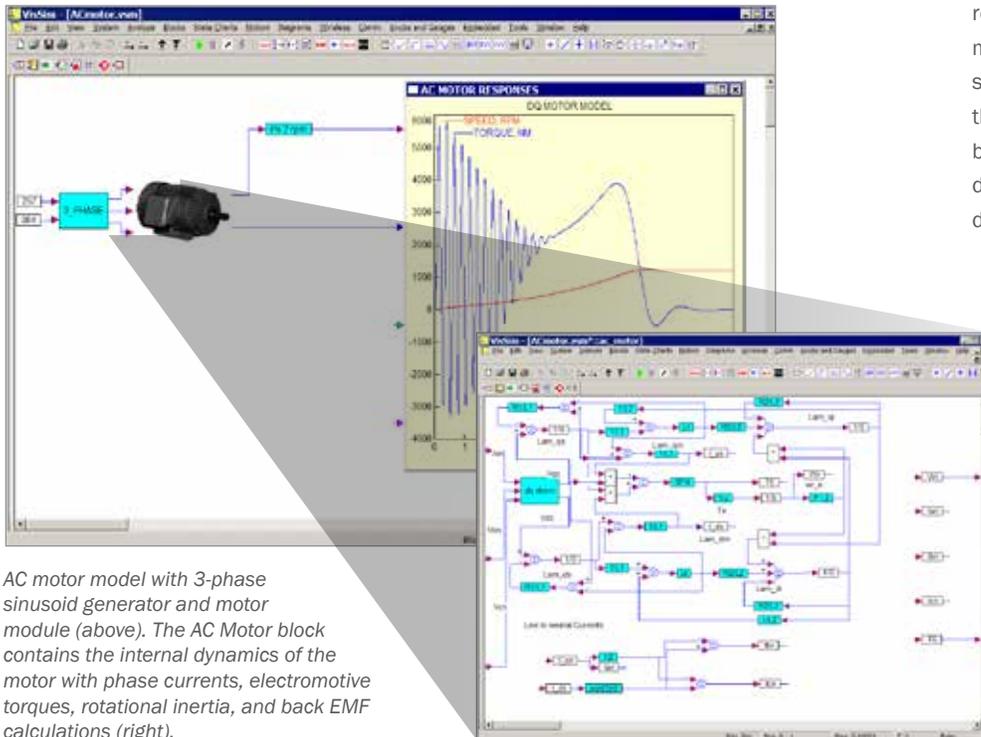
AC motor model with 3-phase sinusoid generator and motor module (above). The AC Motor block contains the internal dynamics of the motor with phase currents, electromotive torques, rotational inertia, and back EMF calculations (right).

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.

The Diagram Browser provides an expandable "tree" representation of your diagram, listing each level of hierarchy by compound block name. Using the Diagram Browser, you can quickly jump to any location in your diagram.

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.

Working with Other Applications

Increased interoperability with leading mathematical and engineering software extends VisSim's computational power.

- Interface with MatLab to calculate general matrix expressions, and read/write MatLab variables.
- Import and translate Simulink .MDL files into VisSim models. The translator displays model translation information, including Simulink version and blocks created, and provides a log file with translation details.
- Exchange symbolic and algebraic data with Maple.
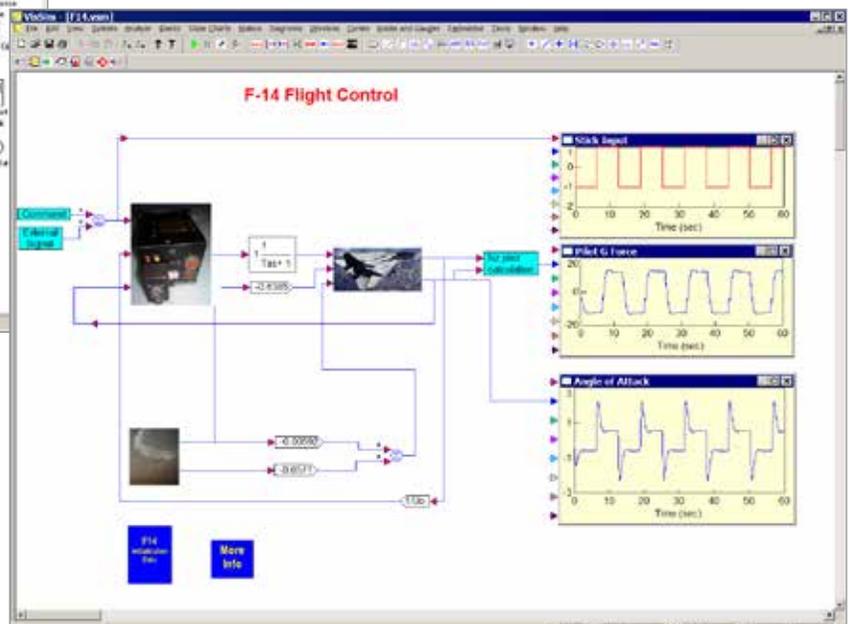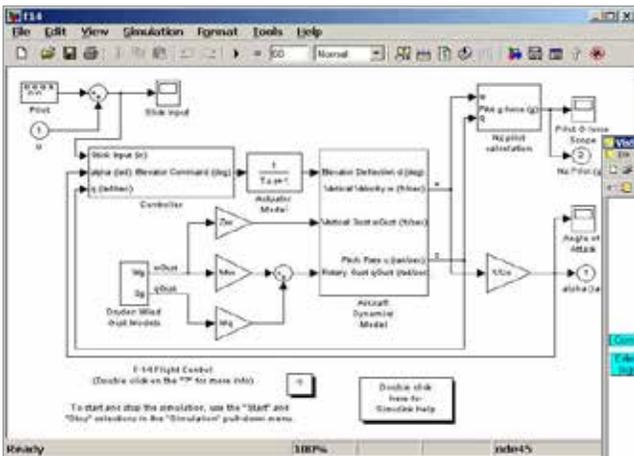
Simulink F14 flight control model (above) automatically translated into VisSim model (right). VisSim plot blocks can be connected directly to corresponding Pilot Input, Flight Dynamics, and Wind Gust subsystems for easy viewing of model behavior.

- Use ActiveX for real-time, interprocess communication.
- Embed, edit, and execute MathCad documents in a VisSim model.

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

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.

Simulating Models

When VisSim 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: VisSim lets you change system parameters as the simulation progresses, and view the results immediately in plots and display blocks.

Using Integration Solvers

Simulating dynamic systems generally includes the numerical integration of differential equations. VisSim offers a full range of integration solvers, including fixed step, adaptive step, and stiff
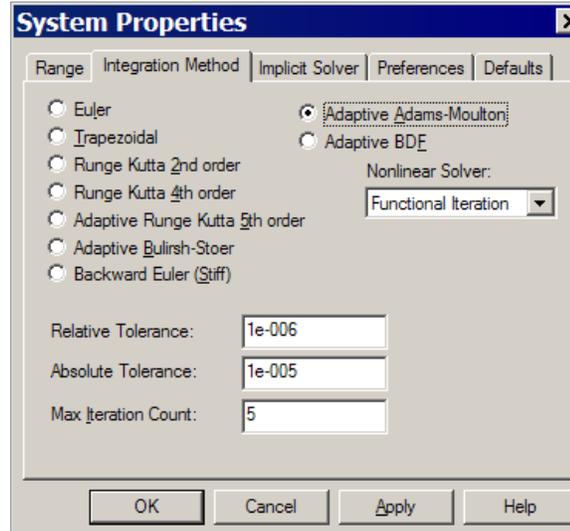
VisSim provides nine fixed- and adaptive-step integration algorithms. The adaptive algorithms let you set the minimum step size and maximum iteration count. For adaptive Adams-Moulton and BDF, you can specify Newton Iteration for stiff systems or Function Iteration for non-stiff systems to more accurately control the step size around discontinuities.

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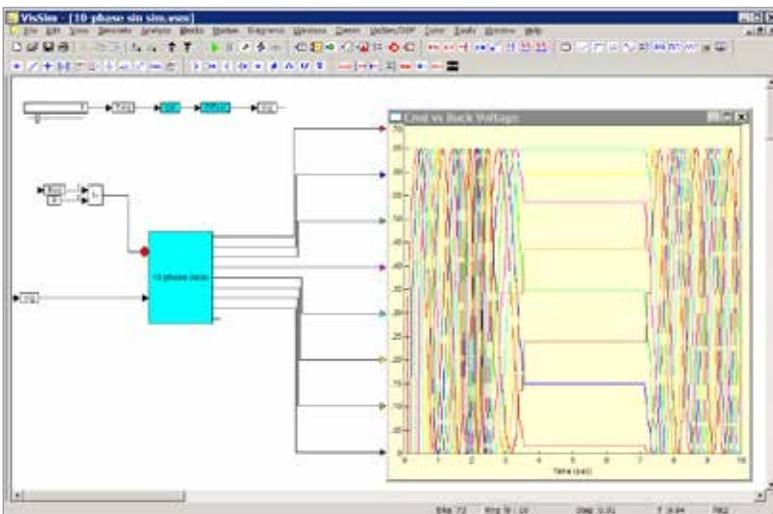
Conditional execution of subsystem that prevents divide-by-zero for the zero frequency case in a 10-phase sine generator.

Conditionally Executing Subsystems

Triggered compound blocks are subsystems that are executed conditionally through an external Boolean trigger. Any portion of a VisSim 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 VisSim 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 VisSim-generated DLLs. (Requires VisSim/C-Code).

Optimizing Parameters

VisSim 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 alternatively use VisSim/OptimizePRO (available separately) to calculate optimal PID controller gains subject to user-defined constraints.

Debugging Models

VisSim provides debugging tools for examining, locating, and correcting inconsistent system behavior. You can step through the simulation, one time step at a time or set breakpoints, and examine data and signal values for suspect blocks.

You can also set warnings for unconnected blocks, algebraic loops and math faults.
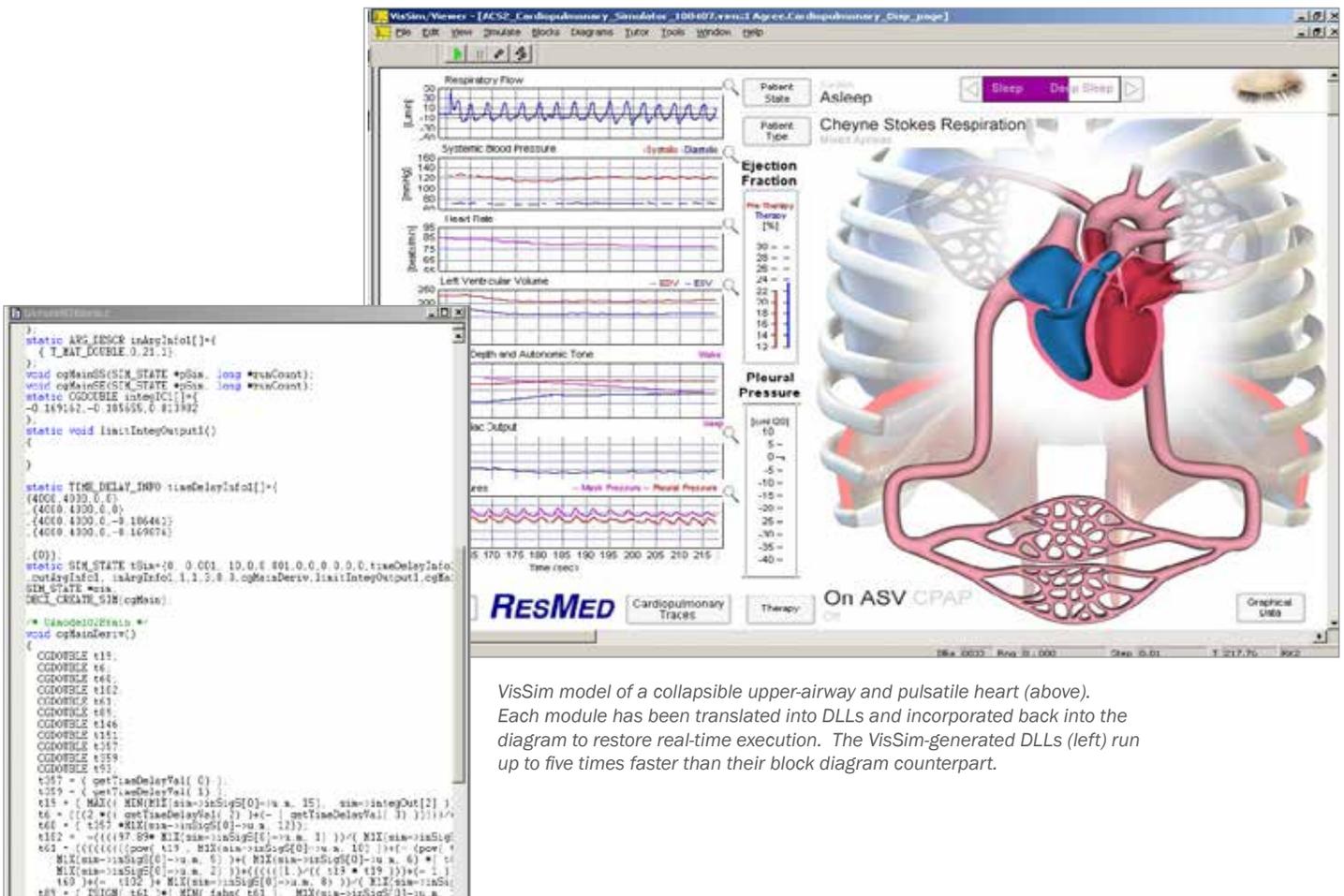
VisSim model of a collapsible upper-airway and pulsatile heart (above). Each module has been translated into DLLs and incorporated back into the diagram to restore real-time execution. The VisSim-generated DLLs (left) run up to five times faster than their block diagram counterpart.

Viewing Simulation Results

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

Interactively Plotting Time Domain, XY, and FFT Data

VisSim's plot block displays up to 16 color-coded signals in customizable time and frequency domain graphs.

Plots can display frequency power spectrum data through FFT algorithms. They can also show vector and matrix data as 3D objects and control surface characteristics and lighting.
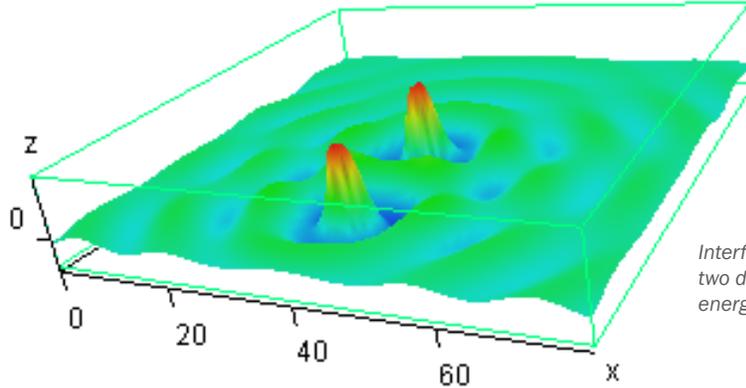
Interference pattern of two damped sinusoidal energy sources.

Animating and Visualizing VisSim 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 VisSim.

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

Distributing Models

The VisSim Viewer is a tool for sharing VisSim models with colleagues and clients not licensed to use VisSim.
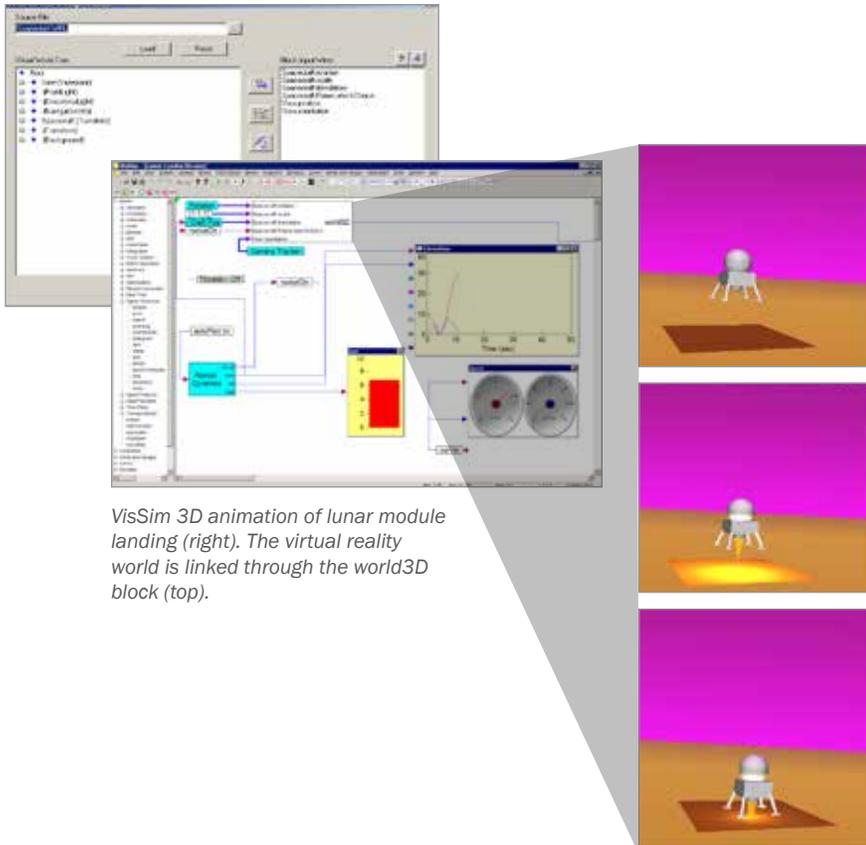
The Viewer lets you open and simulate VisSim models of any size; change block and simulation parameters to test design scenarios; customize plots and other display blocks to present simulation data in different formats; and make printed copies of VisSim models for presentation or archiving.

Generating Production-Quality Code

All or part of a VisSim model can be translated into highly optimized ANSI C code for real-time simulation or embedded system development.

Accelerating Simulation Speed

Using VisSim/C-Code (available separately), you can generate code that can be compiled and run on any platform that supports an ANSI C compiler. The resulting executables run up to five times faster than their block diagram counterparts, which is particularly useful for applications with high sampling rates.

VisSim model of a 400 kHz digital buck voltage converter that uses a built-in optimizer to tune the PI control against the simulated buck circuit (left). Once the controller gains are tuned, the embedded control is created with ADC input synchronized to the PWM output, along with background tasks to monitor temperature and set status LED bank (below, left). VisSim auto-code generation creates the .C file used to implement the control on the target (below, right).

Performing Model-Based Design

Model-Based Design lets you design, test, and verify embedded control algorithms without having to wait for the hardware to test your systems. Using this approach, you can identify and correct problems in control algorithms earlier in the design cycle resulting in lower cost and faster time to market.

With VisSim Embedded (available separately), you can rapidly prototype embedded controllers for Texas Instruments DSPs, DSCs, and MSP430 microcontrollers. VisSim Embedded Controls Developer has unique support of

common on-chip peripherals, including PWM, quadrature encoder, event capture, CAN, I2C, serial, SPI, ADC, and GPIO, allowing a faster and deeper coverage of commercial actuators, sensors, and communication buses.

Typically, system models include both the control algorithm and the plant. The controller subsystem can be scaled, fixed-point, while the plant is full-precision floating point. You can perform off-line simulation to verify, debug, and tune your algorithms, providing detection and resolution of typical low-cost controller issues with precision loss and overflow before ever generating code.

Once the model is verified, you can generate production code for the controller and download the code to the target DSP. VisSim Hotlink technology lets you interactively change controller gains on the target from VisSim, and observe on-target signals, like phase currents and internal controller terms in VisSim digital scopes.

VisSim Blocks
Summary of Standard Blocks

Animation
animate
animation3D
camera3D
light3D
lineDraw
mesh3D
world3D

Annotation
bezel
comment
date
index
label
scalarToStruct
scalarToVec
StructToScalar
variable
vecToScalar
wirePositioner

Arithmetic
-X
*
/
abs
complexToReIm
convert
gain
magPhase
pow
sign
summingJunction
unitConversion

Audio
audioIn
audioOut

Boolean
>
<
>=
<=
==
!=
and
not
or
xor

DDE
DDE
DDEreceive
DDEsend

Integration
integrator
limitedIntegrator
resetIntegrator

Linear Systems
stateSpace
transferFunction

MatLab Interface
MatLab Expression
MatLab Read Variable
MatLab Write Variable

Matrix Operations
buffer
diag
dotProduct
eigenvalues
fft
ifft
indexAssigned
invert
linearSolve
maxElement
minElement
matrixConst
matrixIn
matrixMerge
matrixOut
matrixSize
meanSmooth
medianSmooth
multiply
polyFit
polyRoots
psd
reshape
splineFit
transpose
vectorSort
vsum

Nonlinear
case
crossDetect
deadband
delayedSwitch
init
limit
map
max
merge
min

quantize
relay
sampleHold

Optimization
constraint
cost
globalConstraint
parameterUnknown
unknown

Random Generator
beta
cauchy
erlang
gamma
gaussian
pareto
PRBS
rayleigh
triangular
uniform
weibull

Real-Time
rt-DataIn
rt-DataOut
ActiveXread
ActiveXwrite

State Chart
statechart
trigger

State Transition
stateTransition

Signal Consumer
display
error
eventDisplay
eventLog
execOrder
export
histogram
light
meter
plot
plot3D
polarPlot
spectrumDisplay
stop
stripChart
video

Signal Producer
button
const
dialogConstant
dialogTable
import
parabola
pulseTrain
ramp
realTime
sawtooth
sinusoid
slider
squareWave
step
timeStamp
triangleWave

Time Delay
timeDelay
unitDelay

Transcendental
acos
asin
atan2
bessel
cos
cosh
exp
ln
log10
sin
sinh
sqrt
tan
tanh

General
embed*
expression
OLEobject
userFunction*

Bold blocks indicate new version 9 blocks and new features to existing blocks

Blocks followed by an asterisk (*) are not included in the Personal or Student Edition of VisSim

VisSim Features and System Requirements
Summary of Features

Modeling

- Drag-and-drop block diagram construction
- 120+ linear and nonlinear blocks
- Toolbox functions for control, electromechanical design, hydraulics, signal processing, process, chemical, thermal, and turbines
- ActiveX support
- Dialog box generation for compound blocks
- Vector and matrix operations
- Automatic dialog table construction
- Visual diagram comparisons
- DLL wizard for custom blocks in C, C++, Fortran, or Pascal (not available in VisSim PE)
- FIR and IIR filter design
- Hierarchical models with protection
- Diagram Browser
- Embedded subdiagrams with editing
- Enhanced search capability
- Automatic wiring
- Goto tags
- Global and local variables
- Layering bezel blocks
- Font and digit control for numeric displays
- Data I/O in ASCII, M, MAT, WAV formats
- DDE with Copy Link and Paste Link
- Customizable toolbar

- Allow use of comma as decimal point
- Support time format for data import files

Simulation

- Linear, nonlinear, continuous-time, discrete-time, time-varying, and hybrid simulation
- Interactive, batch, auto-restart, and single step execution modes
- Integration algorithms
  - Euler
  - Trapezoidal
  - Runge Kutta 2nd and 4th orders
  - Adaptive Runge Kutta 5th order
  - Adaptive Bulirsh-Stoer
  - Adaptive Adams-Moulton, adaptive BDF
  - Stiff backward Euler
- MatLab, Mathcad, and Maple integration
- Triggered compound blocks
- Local bounds for compound blocks
- Real-time scaling controls simulation rate
- 1-D, 2-D, and 3-D look-up table
- "What-If" scenarios
- 28 matrix operators
- Complex number support
- 11 random distribution functions
- Reset states

- Parameter optimization
- Variables for initial conditions and block parameters
- State checkpointing
- Implicit system solvers
- Conversion of s- and z-domain transfer functions

Debugging

- Multi-level undo and redo
- Error highlighting
- Custom pop-up messages
- Quiet background logging of system errors and events
- Wire checking
- Single step execution mode

Visualization

- Spectrum display
- 3D animation
- Interactive XY, time domain, FFT, and discrete plots and strip charts
  - Right-hand side plot axis
  - 16 signal traces
  - Log, semi-log and linear scales
  - Automatic Y scaling and selectable time axis scaling
  - Multi-XY traces
  - Multi-plot windows
  - Snap to data points
  - Matrix input
  - ASCII, M, MAT, and WAV
  - Polar plots
- 3D plotting
- PID faceplates

- Audio and visual alarms
- Dynamic graphs, meters, and histograms
- Publication-quality presentation mode

General

- Integrated VisSim Viewer
- VisSim Tutor
- Multiple diagram windows
- Read and write audio data
- Diagram reports
- Automatic reload of last diagram
- String processing
- Global, local, and nested path aliases
- Hyperlink to internet or external document
- Edit in place

System Requirements

- Windows XP, Vista, 7 or 8
- 128 MB RAM
- 125 MB hard disk space

VisSim Add-On Modules

PRODUCT	DESCRIPTION
VisSim/Analyze	Perform frequency domain analysis of a linearized nonlinear system.
VisSim/CAN	Transmit and receive CAN data.
VisSim/C-Code	Generate highly-optimized ANSI C code that can be compiled and run on any platform that supports an ANSI C compiler.
VisSim/C-Code Support Library Source	Combined with the automatically generated code from VisSim, this provides 100% of the source code for your application. It lets you port VisSim generated code to any target and perform validation and verification on the entire application.
VisSim/Comm	Simulate communication systems at the signal level using 200+ communication, signal processing, and RF blocks. Comm add-on modules are available that support real-time data acquisition from Red Rapids drivers; PCCC turbo codes; Bluetooth, 802.11 a/b/g, and ultrawideband wireless designs; and translation of Comm blocks into ANSI C code.
VisSim Embedded	Rapidly prototype embedded controls for microcontroller units. Simulate and generate scaled, fixed-point ANSI C code, as well as code for on-chip peripherals.
VisSim/Digital Power Designer	Provides high-level blocks for simulation and code generation of power supply and digital power components and controls.
VisSim/Fixed-Point	Simulate fixed-point algorithms prior to code generation and implementation of the algorithm on fixed-point hardware.
VisSim/Knobs and Gauges	Provide realistic GUI for operator interface to VisSim.
VisSim/Motion	Model and simulate motor control systems with customizable amplifiers, controllers, filters, motors, sensors, sources, tools, and transforms.
VisSim/Neural-Net	Perform nonlinear system identification.
VisSim/OPC	Connect to any OPC server and log data or run a virtual plant in VisSim.
VisSim/OptimizePRO	Perform generalized reduced-gradient method of parameter optimization.
VisSim/Real-TimePRO	Perform real-time data acquisition and signal generation using I/O cards, PLCs, and DCS. Develop and validate control strategies, and perform HIL simulations.
VisSim/Serial	Transmit and receive RS-232 serial data.
VisSim/State Charts	Model event-driven systems with graphical UML 2.1-based editor
VisSim/UDP	Transport UDP packet data over the Ethernet.

VisSim Case Studies

COMPANY	PRODUCT	APPLICATION
Air Force Research Laboratory Munitions Directorate	VisSim VisSim/C-Code	High-fidelity 6DOF model that simulates flight dynamics and state-of-the-art weapons system
Ametek	VisSim Embedded	Designing a Hybrid Multi-Rate Model
Carrier	VisSim VisSim/Real-TimePRO	Reciprocating chiller model simulating faults
DuPont	VisSim VisSim/Real-TimePRO	Dynamic process control model of a non-woven sheet manufacturing facility
Electric Motion Systems	VisSim Embedded	Space vector PMSM motor control model with regenerative braking and RS485 supervisory control
Energy Sciences	VisSim Embedded	Embedded controller for high-speed labeling machine
Ericsson	VisSim/Comm	Digital modulation synthesizer with modified PLL circuit
General Electric	VisSim VisSim/Real-TimePRO	Resonance Eliminator Controller (REC) for industrial drive systems used in metals rolling applications
General Motors	VisSim VisSim/Real-TimePRO	Brake control system model
Honeywell	VisSim	LM2500 gas turbine model that shows nonlinearities and evaluates relationship between the turbine and controller
Indramat	VisSim	Frameless motor, drive, and controller model
INEOS Chlor	VisSim VisSim/OPC	Process control model for brine treatment and operator training
ResMed	VisSim VisSim/C-Code VisSim/C-Code Support Library Source	Sophisticated breathing simulator
Sequal Technologies	VisSim VisSim/Real-TimePRO	Oxygen delivery algorithm model
Universal Instruments	VisSim	General Surface Mount Application Machine model that picks surface mount components and places them on printed circuit boards