

# VisSim/Embedded Controls Developer

Model-Based Design of Embedded Systems

# v8.0

Modeling The Future

*When I used C code to develop and debug my digital control algorithms, it was like I was fumbling around a twisty maze with high walls. When I switched to VisSim, I got a bird's eye view of that maze and a clear view of the path to solution. I will never go back to C coding for my digital power and digital control applications.*

**Anthony Boon**  
Chief Engineer  
ETA Electronic Design

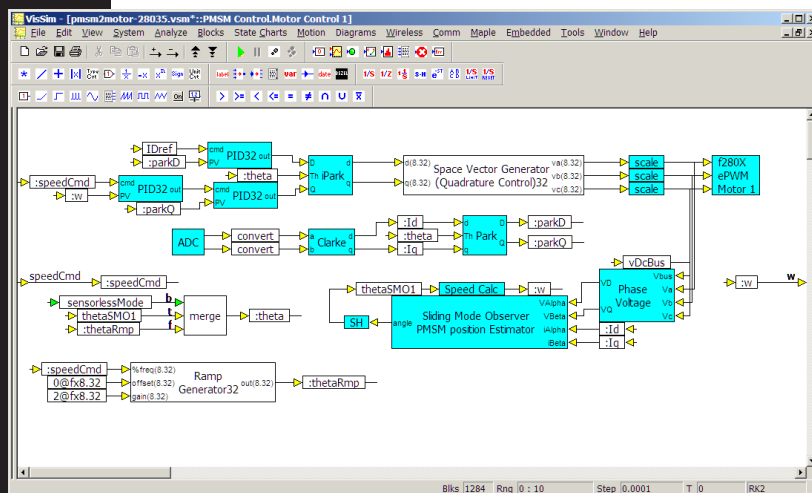
VisSim/Embedded Controls Developer is a graphical environment for modeling, simulation, verification, and code generation of embedded systems. The generated code is both highly-optimized and compact, which is essential for low-cost microprocessors and high-speed sampling rates.

By performing system identification, simulation, and prototyping earlier in the development process, you can identify and correct problems in control algorithms earlier in the design cycle, resulting in lower cost and faster time to market.

You can extend VisSim/Embedded Controls Developer to target unsupported platforms using the VisSim Support Library Source Code (available separately). The generated fixed-point and floating-point code can be compiled on any platform with an ANSI C compiler.

## HIGHLIGHTS

- Intuitive graphical interface for model-based design and simulation of embedded systems
- Rapid prototyping and code generation for Texas Instruments MCUs, DSPs, and DSCs
- Automatic programming of on-chip peripherals
- Production-quality C code with automatic scaling of fixed-point operations
- Algorithm validation using off-line simulation
- Automatic compilation, linking, and download of algorithm to the target
- JTAG hotlink for target-in-the-loop verification
- Retain the VisSim GUI while the algorithm executes on the target



Subsystem 1 of two sensorless PMSM motors using sliding mode observer estimation of rotor position. Sample rate is 10 kHz running both motors on a Piccolo F28036 with 50% utilization.

## System Requirements

- Windows XP, Vista, or 7
- 1 GB RAM
- Texas Instruments CCS v3+
- Target hardware
- JTAG emulator (TI, Spect. Digital, Blackhawk, or compatible)

## Model-Based Design

Using VisSim/Embedded Controls Developer, you can build a model of your entire system, including the control algorithm and the plant. The controller system can be built in scaled, fixed-point arithmetic, while the plant is built in full-precision, floating point arithmetic.

For model construction, VisSim/Embedded Controls Developer provides extensive block libraries, including:

- TI C2000 Motor Control block library
- On-chip peripheral block library
- Fixed-point block library
- Motor block library (available separately)

### TI C2000 Motor Control Blocks

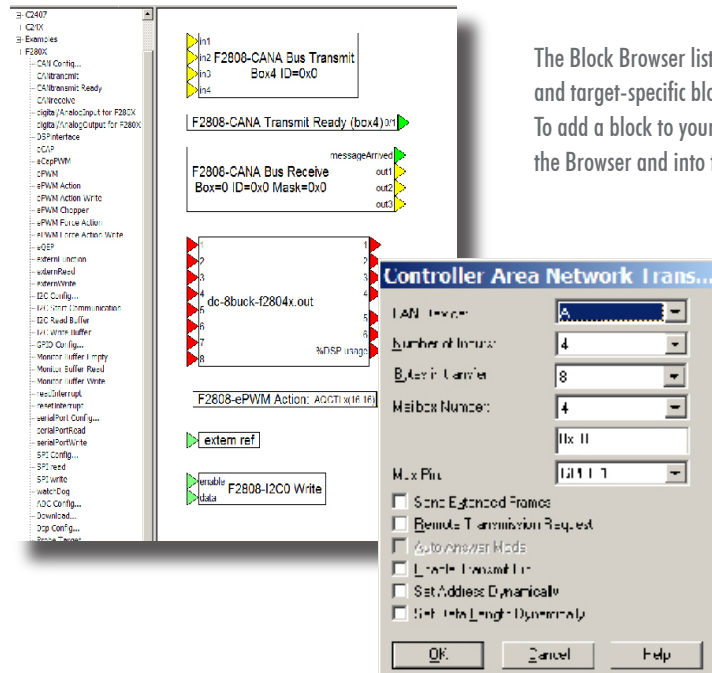
The TI C2000 Digital Motor Control blocks are used to design motion control systems based on AC induction, brushless DC, PMSM, and stepper motors.

VisSim/Embedded Controls Developer provides both 16- and 32-bit digital motor control blocks, including PID, 3-Phase PWM Drivers, Space Vector Waveform Generators, Park and Clarke Transforms, Volts-to-Hertz Profiles, sensorless flux and rotor speed estimation, and quadrature-encoder-based speed calculator.

Sample diagrams are included with VisSim/Embedded Controls Developer for sensed and sensorless vector control of PMSM and AC induction motors.

### Target-Specific Blocks

The target-specific blocks let you easily program on-chip devices. Using built-in These blocks include analog ADC, ePWM, eCAP (event capture), SPI,



The Block Browser lists all C2000, MSP430, and target-specific 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.

SCI (RS232 serial), I2C, digital GPIO, QEP(quadrature encoder), and CAN 2.0.

**CAN Bus Support:** CAN bus blocks offer an extensive range of capabilities to support the development of systems with CAN communication.

The CAN transmit and receive blocks support up to 32 CAN mailboxes on the TI C2000 series. Baud rates to 2 megabits are supported. Mailboxes are configurable from 0- to 8-byte data packet size. User-configurable addressing can be 11 or 23 bits. Remote frame requests and auto-answer are also supported.

**Serial LCD:** Serial LCD blocks support up to 4-line-by-20-column serial interfaced LCDs. You can compose text prompts, numeric formatting, field placement, and page address for each block. Additionally, runtime paging commands are supported. Serial baud rate, serial protocol, and LCD vendor format are user-configurable.

### Scaled, Fixed-Point Algorithms

The Fixed-Point blockset lets you perform simulation and efficient code generation of scaled, fixed-point operations.

Overflow and precision loss effects are easily seen and corrected at simulation time. Auto-scaling speeds fixed-point development, while in-line code generation creates fast target code.

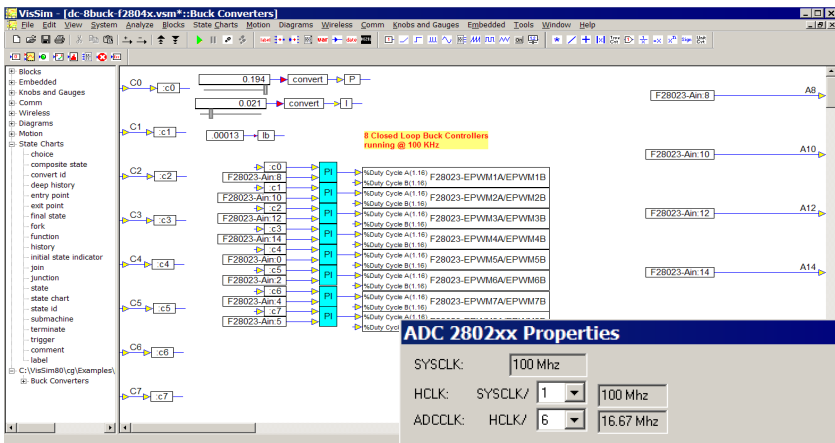
### Off-line Simulation

During initial simulation of the controller and plant, you can verify, debug, and tune your control algorithms, and view the results interactively in graphical plots.

This step lets you interact with and assess the simulated controller and the simulated plant.

### Automatic Code Generation

Once the model is verified, you can automatically generate code for the



**ADC 2802xx Properties**

SYSCLK: 100 Mhz  
 HCLK: SYSCLK / 1 100 Mhz  
 ADCCLK: HCLK / 6 16.67 Mhz

ADCRESULT	Src	Trigger	Sample Clks	Dual Sample
ADCRESULT0	A0	ePWM1-SOCA	7	<input type="checkbox"/>
ADCRESULT1	A1	ePWM2-SOCA	7	<input type="checkbox"/>
ADCRESULT2	A2	ePWM3-SOCA	7	<input type="checkbox"/>
ADCRESULT3	A3	ePWM4-SOCA	7	<input type="checkbox"/>
ADCRESULT4	A4	ePWM5-SOCA	7	<input type="checkbox"/>
ADCRESULT5	A5	ePWM6-SOCA	7	<input type="checkbox"/>
ADCRESULT6	A6	ePWM7-SOCA	7	<input type="checkbox"/>
ADCRESULT7	A7	ePWM7-SOCB	7	<input type="checkbox"/>
ADCRESULT8	B0	Timer 2	7	<input type="checkbox"/>
ADCRESULT9	B1	Timer 2	7	<input type="checkbox"/>
ADCRESULT10	B2	Timer 2	7	<input type="checkbox"/>
ADCRESULT11	B3	Timer 2	7	<input type="checkbox"/>
ADCRESULT12	B4	Timer 2	7	<input type="checkbox"/>
ADCRESULT13	B5	Timer 2	7	<input type="checkbox"/>
ADCRESULT14	B6	Timer 2	7	<input type="checkbox"/>
ADCRESULT15	B7	Timer 2	7	<input type="checkbox"/>

OK Cancel Help

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).

```

dc-buck-f2804x.c - Notepad
File Edit Format View Help
t232 = (MUL_SHIFT16( t247 ,29707,16)+ t239 );
t232 = MIN(1564, t232);
t232 = MAX(t232, 2);
t215 = (MUL_SHIFT16( t230 ,29707,16)+ t222 );
t215 = MIN(1564, t215);
t215 = MAX(t215, 2);
t198 = (MUL_SHIFT16( t213 ,29707,16)+ t205 );
t198 = MIN(1564, t198);
t198 = MAX(t198, 2);
t181 = (MUL_SHIFT16( t196 ,29707,16)+ t188 );
t181 = MIN(1564, t181);
t181 = MAX(t181, 2);
t164 = (MUL_SHIFT16( t179 ,29707,16)+ t171 );
t164 = MIN(1564, t164);
t164 = MAX(t164, 2);
if ((+ pulsecnt26 > 999? pulsecnt26=0,1:0) )
/* blink LED @ 100Hz */
subsystem26();
}
{ long_duty32 = (long)(int)((long)( t77 )<<1)*250;
CMPA1 = (int)(_duty32>>15);
}
{ long_duty32 = (long)(int)((long)( t96 )<<1)*250;
CMPA2 = (int)(_duty32>>15);
}
{ long_duty32 = (long)(int)((long)( t113 )<<1)*250;
CMPA3 = (int)(_duty32>>15);
}
{ long_duty32 = (long)(int)((long)( t130 )<<1)*250;
CMPA4 = (int)(_duty32>>15);
}
    
```

controller and download the code to the target MCU. The code is optimized for speed and memory usage.

You can execute the generated code with your plant model within VisSim to verify successful translation of model to code.

### Efficient ANSI C Code

VisSim/Embedded Controls Developer generates efficient and compact ANSI C code for discrete, continuous, and hybrid systems.

MCU target support includes a report to display the COFF section sizes of the generated execution file. For example, code generated for closed-loop motor control — including, PI controller, digital output, PWM, and encoder peripherals — runs at 300KHz on a 150MHz F28335 DSC.

The memory footprint is:

Code size: 2095 bytes

Initialized data: 501 bytes

Uninitialized data: 504 bytes

### MCU-in-the-Loop Simulation

In MCU-in-the-loop simulation, the plant model runs on the host computer in VisSim while the control algorithm runs in real time on the target MCU.

Real-time communication between the target MCU and VisSim is performed via a JTAG hotlink. The VisSim GUI is retained while you tune parameters and monitor real-time data.

### VisSim Code Composer Studio Plug-In

The VisSim/Code Composer Studio plug-in creates a CCS project that includes the generated code targeted for the TI MC, allowing the code to be

integrated with other user-developed code. The project includes the generated .C file, as well as the necessary VisSim support libraries.

After simulation, the controller can run on the target MCU, and take inputs from VisSim and write outputs to VisSim.

You replace the simulated controller with a MCU interface block, which automatically configures with the controller .OUT file and performs a JTAG download to the target MCU.

### Unsupported Platforms

You can extend VisSim/Embedded Controls Developer to target unsupported platforms using the VisSim Support Library Source Code (available separately). The generated fixed-point and floating-point code can be compiled on any platform with an ANSI C compiler.

# 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  
export  
histogram  
light  
meter  
plot  
plot3D  
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 8 blocks and new features to existing blocks**

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

# Embedded Blocks

## SUMMARY OF BLOCKS

### Fixed Point Blocks

abs  
and  
atan2  
const  
convert  
cos  
div  
gain  
limit  
limitedIntegrator  
merge  
mu  
not  
or  
PI Regulator  
PID Regulator  
sampleHold  
shift  
sign  
sin  
sqrt  
sum  
transferFunction  
unitDelay  
xor  
-X  
>  
<  
<=  
>=  
==  
!=

### Target-Specific Blocks

ADC10/12  
CANtransmit  
CANtransmit Ready  
CAN receive  
comparator  
comparator DAC  
DAC12  
digital in  
digital out  
digital/analogInput  
digital/AnalogOutput  
eCAP  
eCapPWM  
ePWM  
ePWM Action

### Target-Specific Blocks

ePWM Action Write  
ePWM Chopper  
ePWM Force Action  
ePWM Force Action Write  
eQEP  
eventCapture  
externFunction  
externRead  
externWrite  
fullCompareAction  
fullComparePWM  
I2C Start Communication  
I2C Read Buffer  
I2C Write Buffer  
I/O memoryRead  
I/O memoryWrite  
LCD  
LCD Control  
Monitor Buffer Empty  
Monitor Buffer Read  
Monitor Buffer Write  
opAmp  
PWM  
quadratureEncoder  
readInterrupt  
readTargetMemory  
resetInterrupt  
SD16  
SD16A  
segment LCD  
serialPortRead  
serialPortWrite  
SPIread  
SPIwrite  
targetInterface  
watchDog

### Digital Motor Control Blocks

ACI Motor  
ACI Speed Estimator  
ACI Flux Estimator  
Clarke Transform  
Current Model  
Inverse Clark Transform  
Inverse Park Transform  
Park Transform  
Phase Voltage Calc

### Digital Motor Control Blocks

PID Regulator  
QEP Speed  
Ramp Generator  
Resolver Decoder  
SMO Position Estimator  
Space Vector Generator (Mag/Freq)  
Space Vector Generator (Quad Control)  
Space Vector PWM  
Speed Calculator  
V/Hz Profile Generator

### Motion Blocks *(available separately)*

Amplifiers  
Controllers  
Filters  
Loads  
Motors  
Sensors  
Sources  
Tools  
Transforms

## About Visual Solutions

Visual Solutions is a pioneer in the development of world-class software for modeling and simulating complex dynamic systems and for Model-Based Design of embedded systems.

VisSim is a visual environment for developing system models and performing dynamic simulations. Its unparalleled power, ease of use, and reliability has made it an essential tool on thousands of engineering projects spanning a diverse range of industries and disciplines, including motion control, closed-loop control, automotive, HVAC, aerospace, medical devices, and embedded controls development.

Since its founding in 1989, Visual Solutions has maintained a strong connection with the academic community. Visual Solutions software products have been incorporated into the curricula and research laboratories at thousands of universities and colleges. It has enhanced and improved teaching methods, learning skills, and research strategies.



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

Phone: 1-800-VISSIM-1

Email: [sales@vissol.com](mailto:sales@vissol.com)

[www.vissim.com](http://www.vissim.com)

Distribuito da:

**PATRUCCO snc**  
Via Clemente, 12  
10143 TORINO  
Tel. 011-4375549  
Fax 011-4375986  
[info@patrucco.it](mailto:info@patrucco.it)  
[www.patrucco.it](http://www.patrucco.it)

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