MATLAB/Simulink Introduction with Corsica Communication Interface

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Corsica Winter School - ASIPP

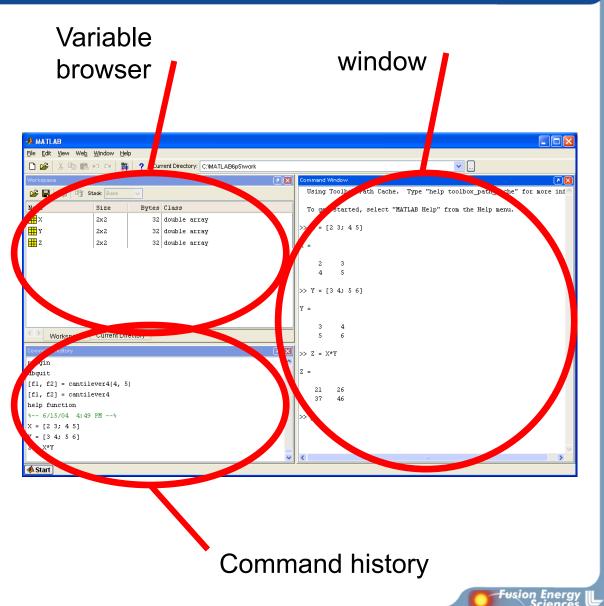
January 26-28, 2016



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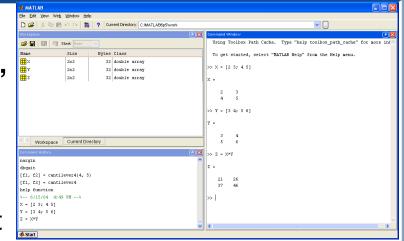
Introduction to Matlab

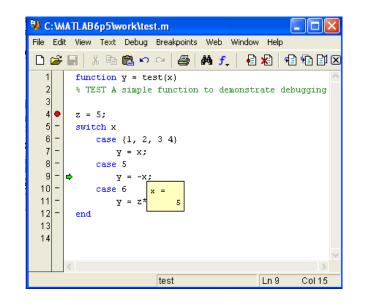
- Click on the Matlab icon/start menu initialises the Matlab environment:
- The main window is the dynamic command interpreter which allows the user to issue Matlab commands
- The variable browser shows which variables currently exist in the workspace



Matlab Programming Environment

- Matlab (Matrix Laboratory) is a dynamic, interpreted, environment for matrix/vector analysis
- Variables are created at run-time, matrices are dynamically re-sized, ...
- User can build programs (in .m files or at command line) using a C/Java-like syntax
- Ideal environment for model building, system identification and control (both discrete and continuous time
- Wide variety of libraries (toolboxes) available





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Numbers and variables and similar in Matlab

- Smallest positive floating point number 2.2251e-308, and the highest is 1.7977e+308.
- Spacing of floating point numbers (calculation precision) is 2.2204e-016.
- 1/0 gives infinite Inf.
- 0/0 or Inf-Inf gives NaN (not-a-number).
- Matlab is case sensitive; a = 10 is not equal to A = 10.
- If the command is concluded with semicolon, the result will not be shown on the screen.
- For decimal numbers, dot is used, for example 2.45.
- Formats: format short, format long, fomat long e...format.
- % Comment.



Numbers and variables and similar in Matlab

- 2.4e-12 is 2.4*10⁻¹²
- *pi* is the variable with defined name.
- *i* or *j* is complex unit (it can be overwritten).
- For trigonometric functions [rad] is used.
- clear all, clears all defined variables.
- close all, closes all graphical windows.
- *clear all, close all*, very usefull combination!
- *clc,* clears the screen, but nothing else.
- CRTL+C stop the execution of the program in Matlab.
- *dir*, current directory.
- who, list of all defined variables.

Basic mathematical operation

- +, ,*, /,
- sqrt (a), square root,
- a[^] b, power,
- *log(a),* natural algorithm,
- exp(a), log10(a),
- abs(a), absolute value ,
- cos(a), sin(a), acos(a), asin(a),
- sinh(a), cosh(a), tanh(a),
- mod(a), Modulus after division,
- rem(a) Remainder after division,
- floor(a), ceil(a), round(a), Round towards ...

Science

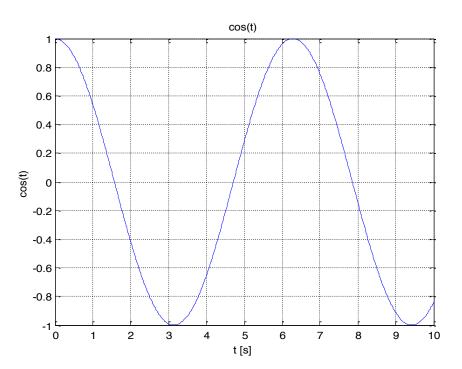
Matrixes and vectors

- *x* = [1,2,3], vector-row,
- *y=[1;2;3]*, vector-column,
- *x=0:0.1:0.8*, vector *x=[0,0.1,0.2,0.3....0.8]*,
- *A* = [1,3,5;5,6,7;8,9,10], matrix,
- A(1,2), element of matrix, 1. row, 2. column,
- A(:,2), second column of matrix,
- A(1,:), first row of matrix ,
- *C=[A;[10,20,30]]* matrix with additional row,
- A(:,2)=[], deleting of second column,
- *B=A(2:3,1:2)*, part of matrix,
- *x'*, transpose.



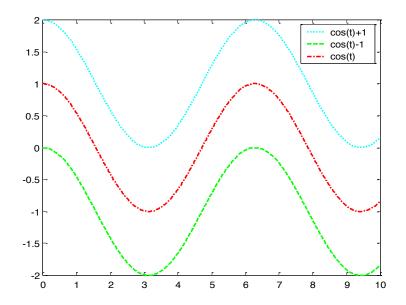
- *t=[0:0.01:10];*
- figure(1), plot(t,cos(t))
- title('cos(t)')
- xlabel('t [s]'), ylabel('cos(t)')
- grid

 Copy the figure: MENU: Edit->Copy Figure

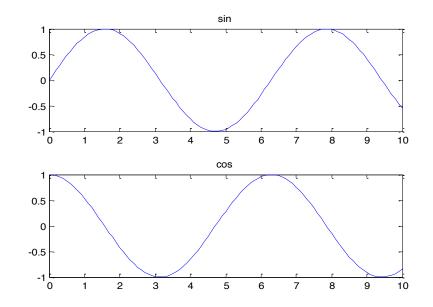




- figure(1), ahandle=plot(t,cos(t)+1,':c',t,cos(t)-1,'--g',t,cos(t),'-.r');
- set(ahandle,'LineWidth',[2]);
- *legend('cos(t)+1','cos(t)-1','cos(t)');*



- *t=[0:0.1:10];*
- subplot(2,1,1),plot(t,sin(t)),title('sin')
- subplot(2,1,2),plot(t,cos(t)),title('cos')

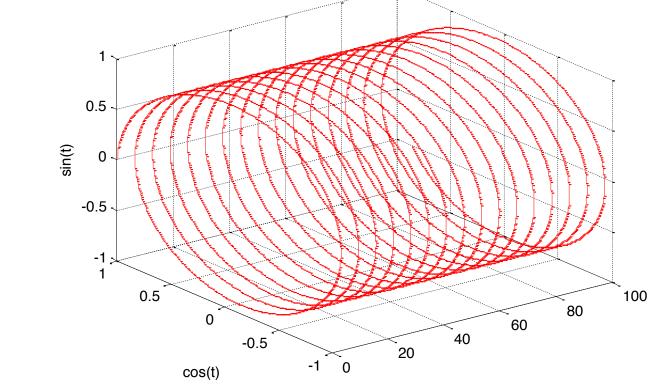


• *t=[0:0.02:100];*

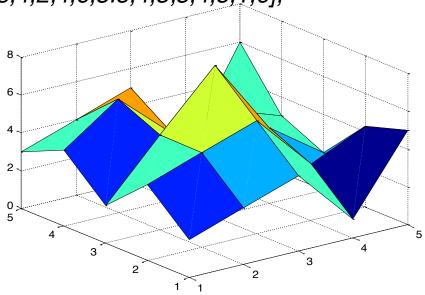
grid

•

plot3(t,cos(t),sin(t),'r'), xlabel('t'), ylabel('cos(t)'), zlabel('sin(t)')



- *X*=[1,2,3,4,5];
- *Y=*[1,2,3,4,5];
- *Z*=[2,3,4,1,5;4,5,6,3,4.3;2,5,8,4,2;4,6,3.5,4,3;3,4,5,1,6];
- *surf(X,Y,Z)*



Program flow

• For loop

for I = 1:0.2:N, for J = 1:N, A(I,J) = 1/(I+J-1);end end



Program flow

• While loop

while (a<b) c(a)=sin(a); a=a+1; end



Program flow

• If-else statement

if I == J A(I,J) = 2;elseif abs(I-J) == 1 A(I,J) = -1;else A(I,J) = 0;end



Help in Matlab

- *help sqrt*, looking for known command,
- lookfor algorithm, looking for the key words,
- *help*, help topics are shown,
- *help*, interrogation point in menu, Mtalb help windows opens,
- *demo*, window with (many!) examples opens.

M-files

- Matlab files with program and/or definitions.
- Name of the files most be without special characters and spaces.
- Path to the directory with m-file must be set (if it is not *work* directory).
 - path(,,<my directory",path)</pre>
- To run, type the name of the file in the Command window or run directly from Matlab editor.
 - \$CWD/startup.m run at startup
- New m-file is created in Matlab menu under File/New/M-file

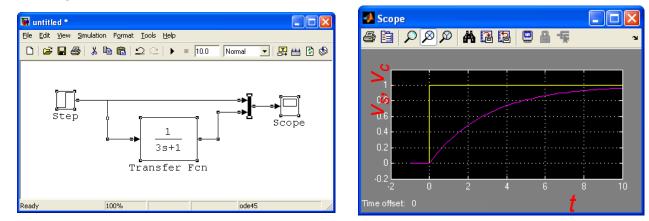


MTConnect.m

<pre>pe gd yww jwmai tas tep bash-3.25 cat MTconnect.m %</pre>	Terminal	
<pre>% This assumes that localhost (127.0.0.1) has been tunneled to % Corsica. The local end of the tunnel is at port 1609 % host = 'localhost' port = 1606 cport = corsicaconnect(host,port) corsicaparser('rpc real foobar= 0.0',cport) corsicaparser('rpc real foobar= 0.0',cport) sim('SIMconnect') corsicaparser('rpc, foobar2',cport) corsicaparser('return') exit bash-3.25 Corsicaconnect & bash-3.25 Corsica checkout of corsica checkout corsica parser part of corsica checkout bash-3.25 Corsica checkout corsica checkout bash-3.25 Corsica checkout corsica checkout</pre>		
	<pre>File Edit View Jerminal Table Help bash-3.2\$ cat MTconnect.m % % This assumes that localhost (127.0.0.1) has % Corsica. The local end of the tunnel is at % host = 'localhost' port = 1606 cport = corsicaconnect(host,port) corsicaparser('rpc chameleon simver="MTconnect corsicaparser('rpc real foobar= 0.0',cport) corsicaparser('rpc real foobar2= 0.0',cport) sim('SIMconnect') corsicaparser('rpc.foobar2',cport) corsicaparser('return') exit Corsicaparser('return') exit bash-3.2\$</pre>	<pre>port 1609 t"',cport) read 1gnorebeg1n # # This port number (1606) is arbitrary. It can be any number # in the range 1025-65535 as long as long as it's not already # in use by another application. Ports numbers <=1024 can only # be used by processes run as the root user. Whatever is used # it must match what is connected to from Matlab, or if tunneled, # the local end of the tunnel must end up at this port. # # Corsica level_1 test rpcinit(1606) read ignoreend rpcserver if (simver <> "MTconnect") then << "Wrong Simulink simulation run: " << simver</pre>
		<< "Wrong Simulink simulation run: " << simver

Introduction to Simulink

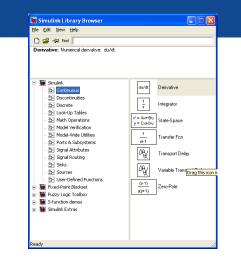
- Simulink is a graphical, "drag and drop" environment for building simple and complex signal and system dynamic simulations.
- It allows users to concentrate on the structure of the problem, rather than having to worry (too much) about a programming language.
- The parameters of each signal and system block is configured by the user (right click on block)
- Signals and systems are simulated over a particular time.

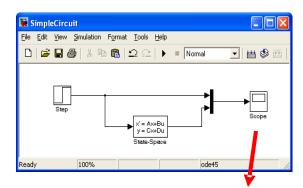


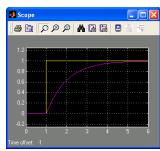
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Starting and Running Simulink

- Type the following at the Matlab command prompt
- >> simulink
- The Simulink library should appear
- Click File-New to create a new workspace, and drag and drop objects from the library onto the workspace.
- Selecting **Simulation-Start** from the pull down menu will run the dynamic simulation. Click on the blocks to view the data or alter the run-time parameters







Signals and Systems in Simulink

Discrete Transfer Fcn

Discrete Zero-Pole

Discrete State-Space

Discrete-Time Integrator

First-Order Drag this icon into

Fusion Energy

Sciences

Discrete Filter

Memory

Unit Delay

Zero-Order Hold

📓 Simulink Library Browser <u>File Edit View H</u>elp 🗋 🚔 -🖾 Find

descending powers of z.

2- Continuous 2- Discontinuities

Discrete

Look-Up Tables

2- Math Operations

2 Model Verification

Andel-Wide Utilities

2- Ports & Subsystems 2- Signal Attributes

2- Signal Routing

≱- Sinks

😼 Simulink

Discrete Transfer Fcn: Matrix expression for numerator, vector expression for denominator. Output width equals the number of rows in the numerator. Coefficients are for

1

z+0.5

(z-1)

z(z-0.5)

1

1+0.5z-1

т

z-1

- Two main sets of libraries for building simple . simulations in Simulink:
- Signals: Sources and Sinks •
- Systems: Continuous and Discrete •

		👿 Simulink Library Browser			Sources
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Ready

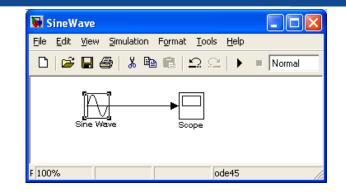
Simulink-libraries

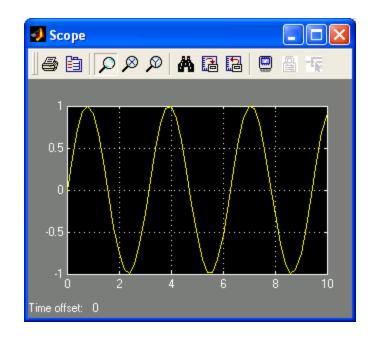
- Continuous; integrator, transfer function..
- *Discrete*; discrete transfer function, unite delay, memory...
- *Math operations*; gain, product, sum, trigonometric functions..
- *Sinks*; blocks that have only input, scope, to worspace..
- Sources; blocks that have only output, generators, constant,...
- User defined functions: S-function, S-function builder,...



Basic Simulink Example

- Copy "sine wave" source and "scope" sink onto a new Simulink work space and connect.
- Set sine wave parameters modify to 2 rad/sec
- Run the simulation:
- Simulation Start
- Open the scope and leave open while you change parameters (sin or simulation parameters) and re-run
- Many other Simulink demos ...





Simulink – creating a model

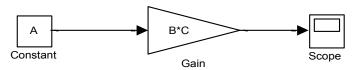
- Model is created by choosing the blocks from different libraries, dragging them to model window and linking them.
- The parameters of block (shown on picture, sine wave parameters), can be reached with double click on the block.

	Block Parameters: Sine Wave
	_ D X Sine Wave
<u>File Edit View Simulation Format Tools H</u> elp	Output a sine wave.
- 🗅 🛎 🖶 🎒 👗 🖻 💼 🕰 😂 🦆 🛅 🦫 🛞 🕨 = 🛛 Normal	
	Amplitude:
	1
	Frequency (rad/sec):
	1
	Phase (rad):
Sine Wave Scope	0
	Sample time:
Ready 100% ode45	Interpret vector parameters as 1-D
	OK Cancel Help Apply

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Simulink

- The parameters in the blocks can be variables, that are defined in m-file. M-file must be executed before simulation start, so that variables are defined in Command window, where Simulink can reach them.
- Never give the same name to Simulink model and m-file!
- Example: A, B and C must be defined with values in the Command window.





Simulink- configuration parameters

• Numerical solver method, start time, stop time (it can be also set directly)...

🐱 Configuration Parame	ters: untitled/Confi	guration			
Select:	Simulation time				
Solver Data Import/Export Optimization	Start time: 0.0		Stop time: 🔟	10	
 Diagnostics 	-Solver options				
- Sample Time	Туре:	Variable-step 🛛 💌	Solver:	ode45 (Dormand-Prince)	~
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Type Conversion Connectivity	Min step size:	auto	Absolute tolerance:	auto	
- Compatibility	Initial step size:	auto			
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Hardware Implementation	Automatically han	dle data transfers betwe	en tasks		
─ Model Referencing					
Comments					
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Sciences

Simulink Library libcorsica.mdl

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🗀 rpc Folder 2/29/	
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,#corsicasink.c.1.2 2 File 9 KB 4/2/1	🔹 Library:Ilbcorsica 📃 🗆 🗙
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CorsicaSrc S-Function

Insert data from Corsica into simulation

Library:libcorsica File Edit View Format Help	Parameters are 'variable',length, optional (pre) command (corsica),port
<pre> >Data >Enable CorsicaSink >Enable Data CorsicaSrc * file Edit View Simulation Format Tools >Enable Data CorsicaSrc </pre>	S-Function User-definable block. Blocks can be written in C/M (level-1), Fortran, and Ada and must conform to S-function standards. The variable t, x, u, and flag are automatically passed to the S-function by Simulink. You can specify additional parameters in the 'S-function parameters' field. If the S-function block requires additional source files for the Real-Time Workshop build process, specify the filenames in the 'S-function modules' field. Enter the filenames only; do not use extensions or full pathnames, e.g., enter 'src src1', not 'src.c src1.c'. Parameters S-function name: corsicasource Edit S-function parameters: 'foobar',1,",0 S-function modules: '
	<u>OK</u> <u>Cancel</u> <u>Help</u> <u>Apply</u>

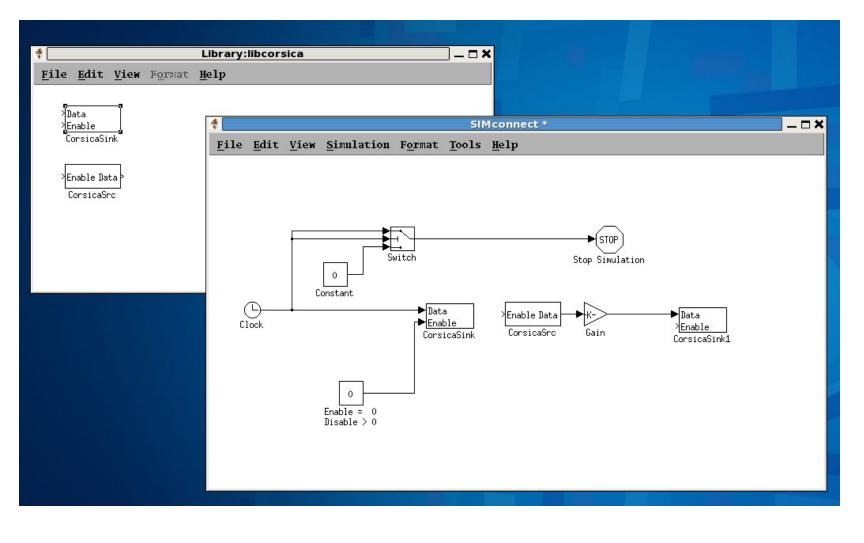
CorsicaSink S-Function

Send data from simulation into Corsica

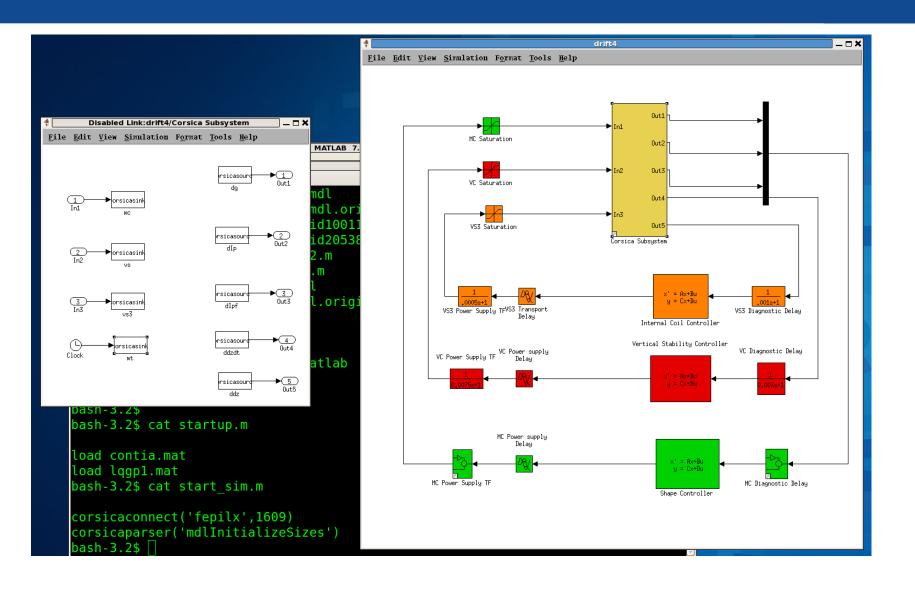
Library:libcorsica File Edit View Format Help	Parameters are 'variable',length, optional (post) command (corsica),port
> Data > Enable CorsicaSink > Enable Data CorsicaSrc * Eile Edit Yiew Simulation Format Tools > Enable Data CorsicaSrc * Enable Data CorsicaSrc * Enable Data CorsicaSrc * Enable Data CorsicaSrc	S-Function User-definable block. Blocks can be written in C, M (Jevel-1), Fortran, and Ada and must conform to S-function standards. The variables t, x u, and flag are automatically passed to the S-function by Simulink. You can specify additional parameters in the 'S-function parameters' field. If the S-function block requires additional source files for the Real-Time Workshop build process, specify the filenames in the 'S-function modules' field. Enter the filenames only; do not use extensions or full pathnames, e.g., enter 'src src1', not 'src.c src1.c'. Parameters S-function name corsicagint Edit S-function modules: " QK Cancel Help Apply

SIMConnect

Checks communication with Corsica

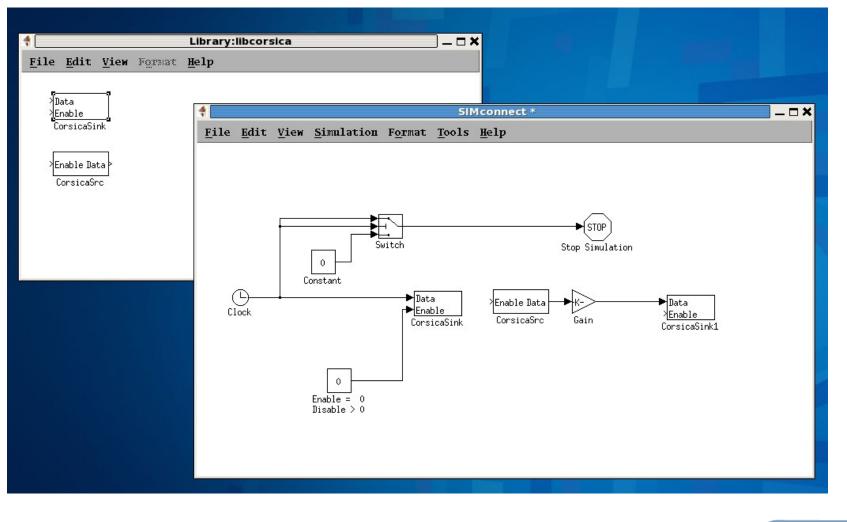


ITER Simulation



What is the value of CorsicaSink1 input?

Clock->CorsicaSink(foobar),CorsicaSrc(foobar)->Gain->CosicaSink1(foobar2)
What if CorsicaSrc->Gain->CorsicaSink1 executes before CorsicaSink



Corsica Subsystem Block Priorities

	Sink Block Parameters: mc	×		
	able block. Blocks can be written in C, M (level-1), Fo			
prity: Sp g: Text t Workshop	5 S-function standards. The variables t, x, u, and flag inction by Simulink. You can specify additional param ys' field. If the S-function block requires additional sour build process, specify the filenames in the 'S-function	Disabled Link:drift4/Cor File Edit View Simulation For		
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Usage Description: Text Priority: Specifies Tag: Text that ap	tation Callbacks S-Function User-definable block. Blocks can be written in C, M (conform to S-function standards. The variables t, x, to the S-function by Simulink. You can specify additic parameters' field. If the S-function block requires add Workshop build process, specify the filenames in the filenames only; do not use extensions or full pathnam	Clock mt	ddzdt Out4	tion standards. The variables t, x, u, and flag are automatically passed by Simulink. You can specify additional parameters in the 'S-function If the S-function block requires additional source files for the Real-Time rocess, specify the filenames in the 'S-function modules' field. Enter the o not use extensions or full pathnames, e.g., enter 'src src1', not 'src.c mee: corsicasource Edit arameters: 'ddz',1,"
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Usage Description: Text Priority: Specifies Tag: Text that ap Description: Priority: 2	attion Callbacks S-function by Simk Block Parame S-Function User-definable block. Blocks can be written in C, M (conform to S-function standards. The variables t, x, to the S-function by Simulink. You can specify additic parameters' field. If the S-function block requires add Workshop build process, specify the filenames in the filenames only; do not use extensions or full pathnam src1.c'. Parameters S-function name: corsicasink S-function parameters: 'mt',1.'return'	Clock mt	ddzdt Out4	ction standards. The variables t, x, u, and flag are automatically passed by Simulink. You can specify additional parameters in the 'S-function If the S-function block requires additional source files for the Real-Time rocess, specify the filenames in the 'S-function modules' field. Enter the o not use extensions or full pathnames, e.g., enter 'src src1', not 'src.c mame: corsicasource Edit arameters: 'ddz'.1," iodules: "

Matlab/Corsica Timing

Start....Start Send MC (Blocked).....Trans(.....) (Blocked)....Calculate local control voltages (Blocked)....Enter Control Hook (Blocked)....Copy Diagnostics into RPC Vars Send VS.. .. Rpcserver (Blocked) 💊 Send VS3.. ..(Blocked) Send Simulation Time and Return....(Blocked until return received) Get Gaps (Block).... Complete step (Blocked).... Start next step (Blocked)....Enter Control Hook (Blocked)....Copy Diagnostics into RPC Vars Get rest of diagnostics....Rpcserver (Blocked) Solve tranfer functions/state models....(Blocked) Send MC....(Blocked)