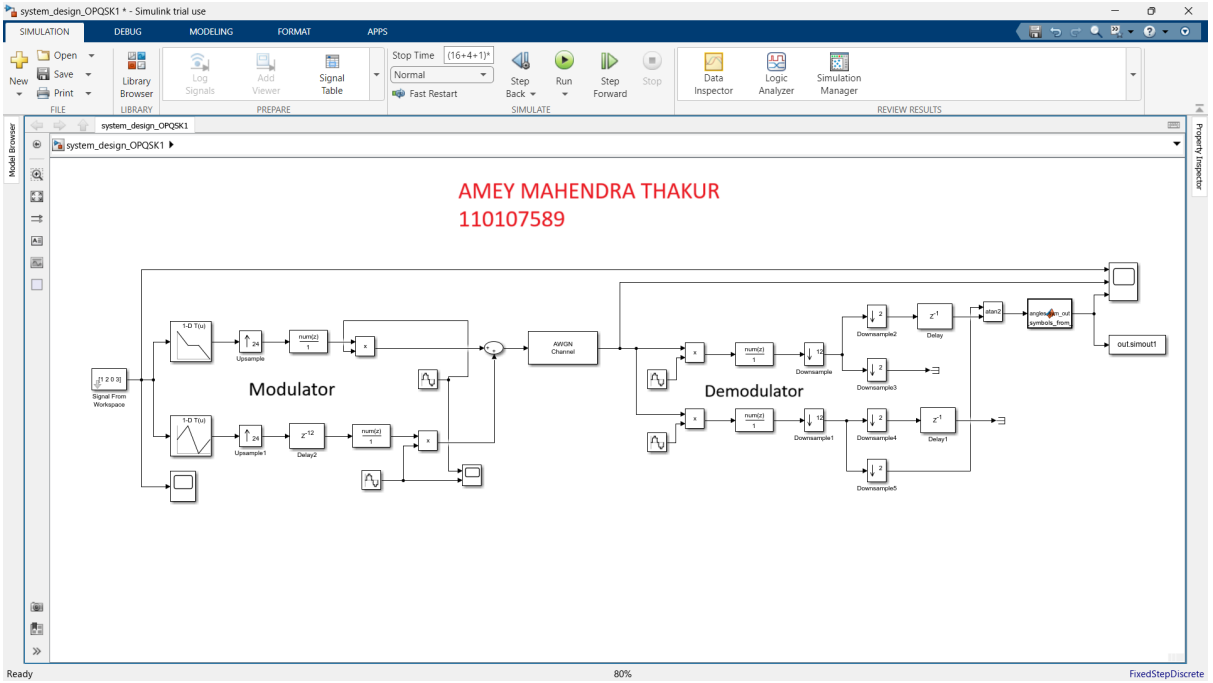
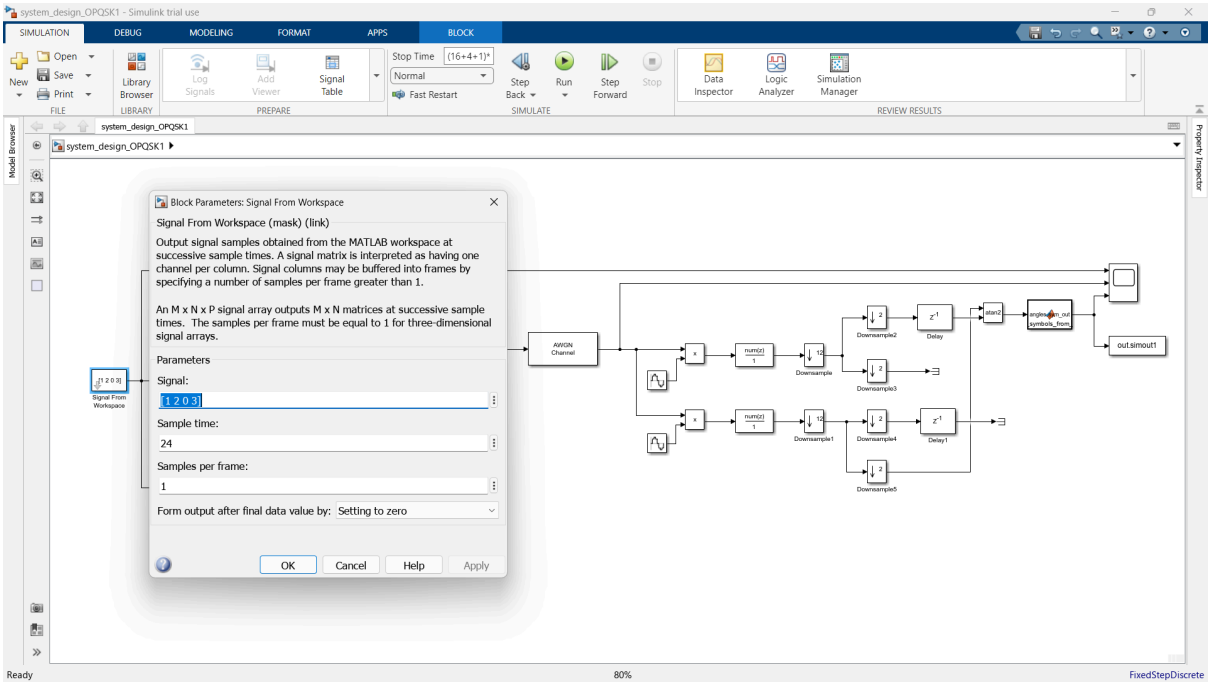
Task 5: Offset Quadrature Phase Shift Keying (OQPSK)

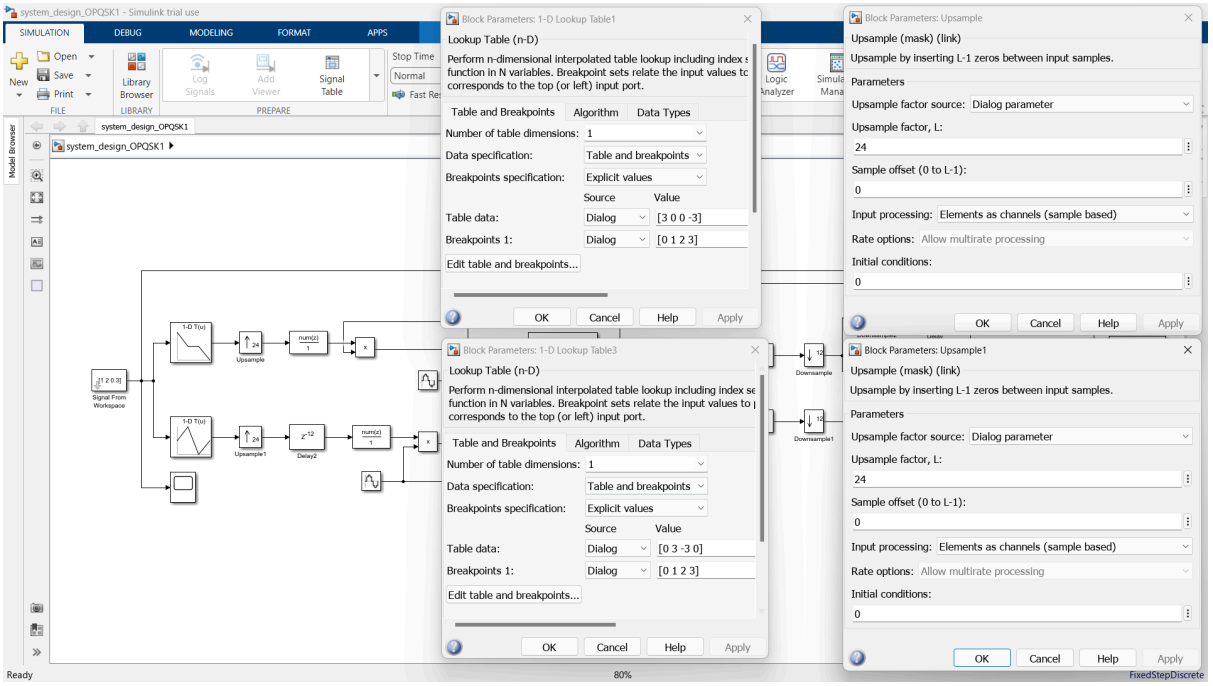
OQPSK system design & Subtask 1

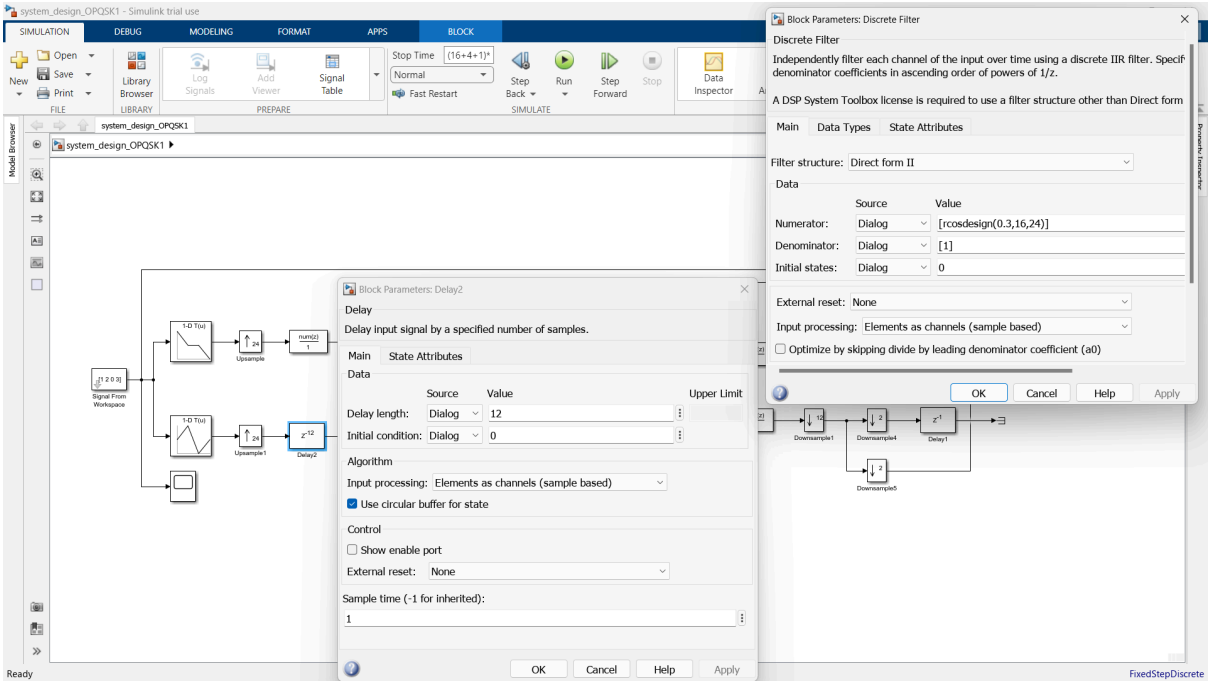
OQPSK system design

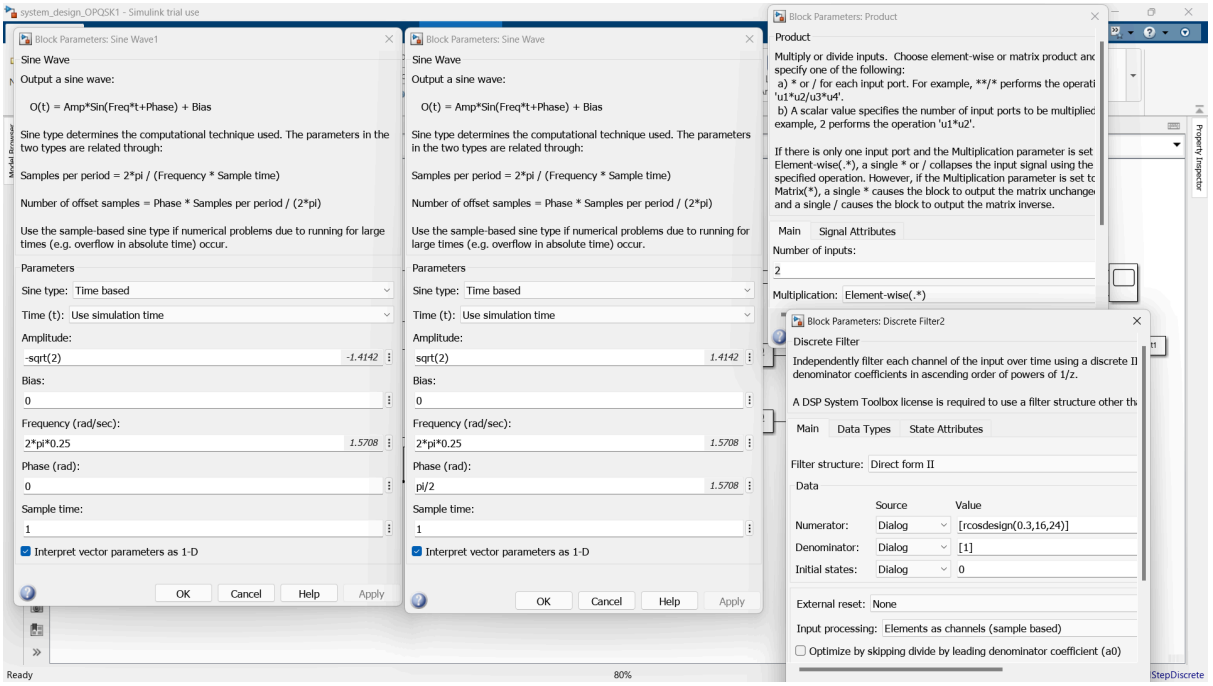


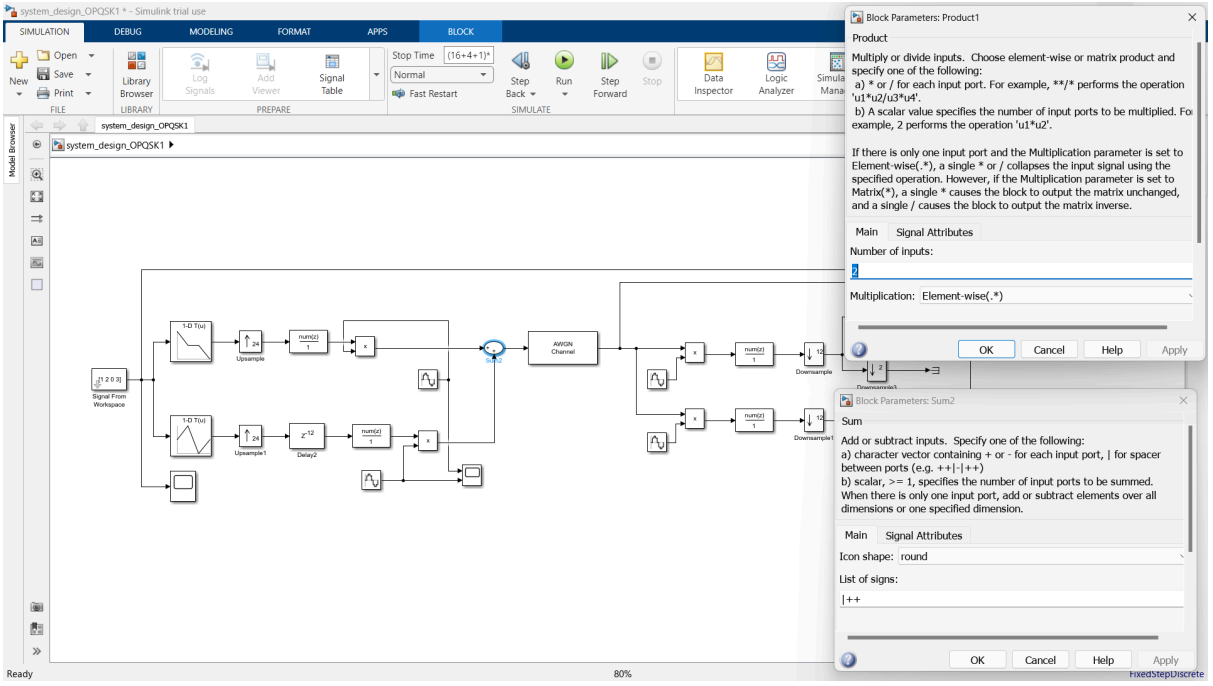
Modulator:



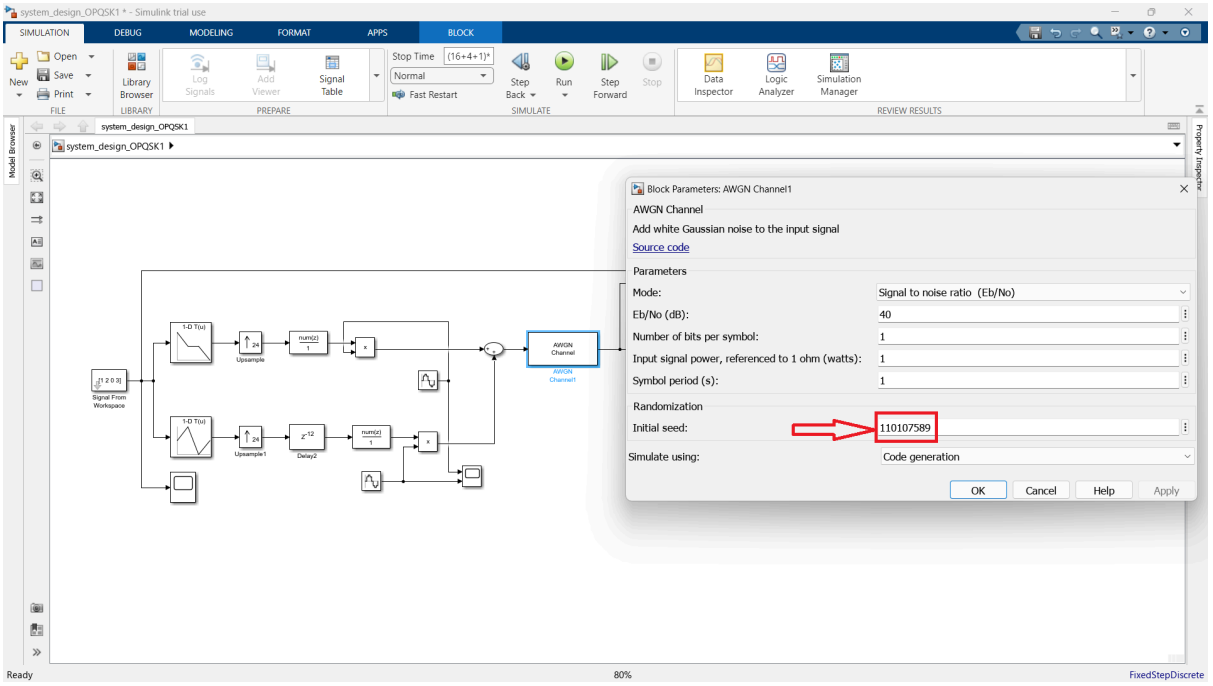

system_design_OPQSK1 - Simulink trial use
SIMULATION
DEBUG
MODELING
FORMAT
APPS
Block Parameters: 1-D Lookup Table1
Lookup Table (n-D)
Perform n-dimensional interpolated table lookup including index s
function in N variables. Breakpoint sets relate the input values tc
corresponds to the top (or left) input port.
Table and Breakpoints
Algorithm
Data Types
Number of table dimensions: 1
Data specification: Table and breakpoints
Breakpoints specification: Explicit values
Source
Value
Table data: Dialog [3 0 0 -3]
Breakpoints 1: Dialog [0 1 2 3]
Edit table and breakpoints...
OK
Cancel
Help
Apply
Block Parameters: Upsample
Upsample (mask) (link)
Upsample by inserting L-1 zeros between input samples.
Parameters
Upsample factor source: Dialog parameter
Upsample factor, L:
24
Sample offset (0 to L-1):
0
Input processing: Elements as channels (sample based)
Rate options: Allow multirate processing
Initial conditions:
0
Block Parameters: 1-D Lookup Table3
Lookup Table (n-D)
Perform n-dimensional interpolated table lookup including index se
function in N variables. Breakpoint sets relate the input values to
corresponds to the top (or left) input port.
Table and Breakpoints
Algorithm
Data Types
Number of table dimensions: 1
Data specification: Table and breakpoints
Breakpoints specification: Explicit values
Source
Value
Table data: Dialog [0 3 -3 0]
Breakpoints 1: Dialog [0 1 2 3]
Edit table and breakpoints...
OK
Cancel
Help
Apply
Block Parameters: Upsample1
Upsample (mask) (link)
Upsample by inserting L-1 zeros between input samples.
Parameters
Upsample factor source: Dialog parameter
Upsample factor, L:
24
Sample offset (0 to L-1):
0
Input processing: Elements as channels (sample based)
Rate options: Allow multirate processing
Initial conditions:
0
OK
Cancel
Help
Apply
Ready
80%
FixedStepDiscrete


system_design_OPQSK1 - Simulink trial use
SIMULATION
DEBUG
MODELING
FORMAT
APPS
BLOCK
Block Parameters: Discrete Filter
Discrete Filter
Independently filter each channel of the input over time using a discrete IIR filter. Specif
denominator coefficients in ascending order of powers of 1/z.
A DSP System Toolbox license is required to use a filter structure other than Direct form
Main
Data Types
State Attributes
Filter structure: Direct form II
Data
Source
Value
Numerator: Dialog [rcosdesign(0.3,16,24)]
Denominator: Dialog [1]
Initial states: Dialog 0
External reset: None
Input processing: Elements as channels (sample based)
Optimize by skipping divide by leading denominator coefficient (a0)
OK
Cancel
Help
Apply
Block Parameters: Delay2
Delay
Delay input signal by a specified number of samples.
Main
State Attributes
Data
Source
Value
Upper Limit
Delay length: Dialog 12
Initial condition: Dialog 0
Algorithm
Input processing: Elements as channels (sample based)
Use circular buffer for state
Control
Show enable port
External reset: None
Sample time (-1 for inherited):
1
OK
Cancel
Help
Apply
Ready
FixedStepDiscrete

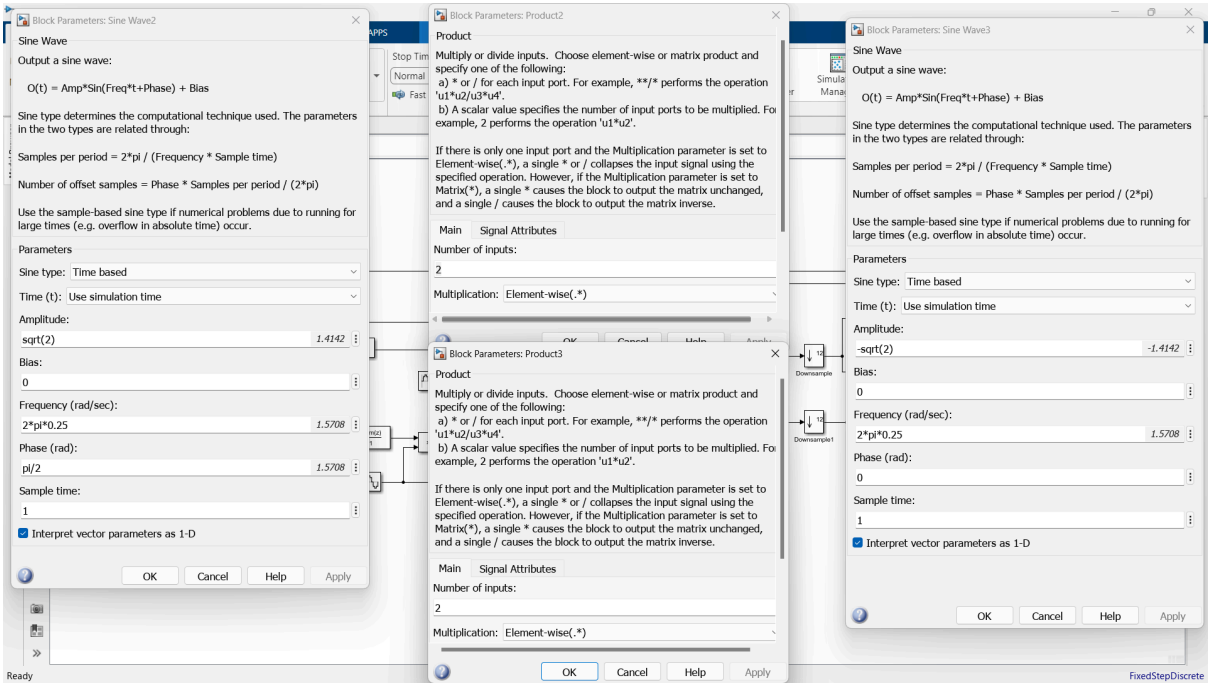

system_design_OPQSK1 - Simulink trial use
Block Parameters: Sine Wave1
Sine Wave
Output a sine wave:
O(t) = Amp*Sin(Freq*t+Phase) + Bias
Sine type determines the computational technique used. The parameters in the two types are related through:
Samples per period = 2*pi / (Frequency * Sample time)
Number of offset samples = Phase * Samples per period / (2*pi)
Use the sample-based sine type if numerical problems due to running for large times (e.g. overflow in absolute time) occur.
Parameters
Sine type: Time based
Time (t): Use simulation time
Amplitude: -sqrt(2) -1.4142
Bias: 0
Frequency (rad/sec): 2*pi*0.25 1.5708
Phase (rad): 0
Sample time: 1
Interpret vector parameters as 1-D
OK Cancel Help Apply
Block Parameters: Sine Wave
Sine Wave
Output a sine wave:
O(t) = Amp*Sin(Freq*t+Phase) + Bias
Sine type determines the computational technique used. The parameters in the two types are related through:
Samples per period = 2*pi / (Frequency * Sample time)
Number of offset samples = Phase * Samples per period / (2*pi)
Use the sample-based sine type if numerical problems due to running for large times (e.g. overflow in absolute time) occur.
Parameters
Sine type: Time based
Time (t): Use simulation time
Amplitude: sqrt(2) 1.4142
Bias: 0
Frequency (rad/sec): 2*pi*0.25 1.5708
Phase (rad): pi/2 1.5708
Sample time: 1
Interpret vector parameters as 1-D
OK Cancel Help Apply
Block Parameters: Product
Product
Multiply or divide inputs. Choose element-wise or matrix product and specify one of the following:
a) * or / for each input port. For example, **/* performs the operation 'u1*u2/u3*u4'.
b) A scalar value specifies the number of input ports to be multiplied. For example, 2 performs the operation 'u1*u2'.
If there is only one input port and the Multiplication parameter is set to Element-wise(.*), a single * or / collapses the input signal using the specified operation. However, if the Multiplication parameter is set to Matrix(*), a single * causes the block to output the matrix unchanged, and a single / causes the block to output the matrix inverse.
Main Signal Attributes
Number of inputs: 2
Multiplication: Element-wise(.*)
Block Parameters: Discrete Filter2
Discrete Filter
Independently filter each channel of the input over time using a discrete II denominator coefficients in ascending order of powers of 1/z.
A DSP System Toolbox license is required to use a filter structure other th
Main Data Types State Attributes
Filter structure: Direct form II
Data
Source Value
Numerator: Dialog [rcosdesign(0.3,16,24)]
Denominator: Dialog [1]
Initial states: Dialog 0
External reset: None
Input processing: Elements as channels (sample based)
Optimize by skipping divide by leading denominator coefficient (a0)
Ready
80%
StepDiscrete

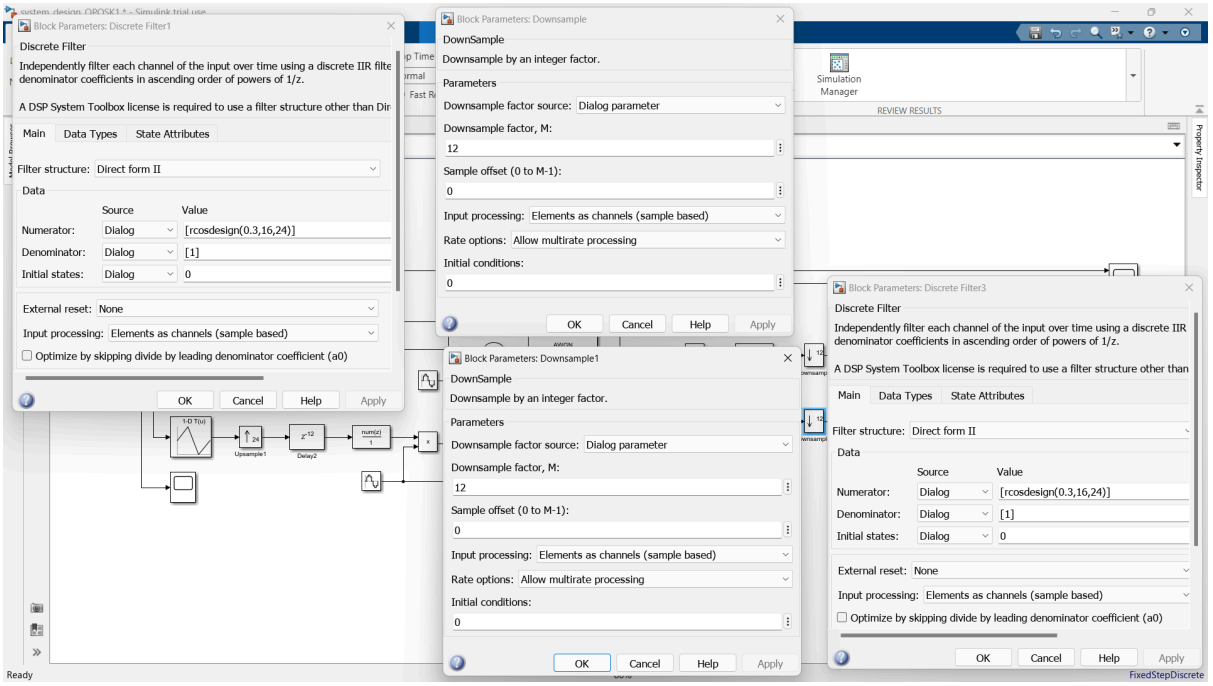

system_design_OPQSK1 * - Simulink trial use
SIMULATION DEBUG MODELING FORMAT APPS BLOCK
New Open Save Print
Library Browser
Log Signals Add Viewer Signal Table
Stop Time (16+4+1)*
Normal
Fast Restart
Step Back Run Step Forward Stop
Data Inspector Logic Analyzer
FILE LIBRARY PREPARE SIMULATE
system_design_OPQSK1
Signal From Workspace
Upsample
Upsample1
Delay2
AWGN Channel
Downsample
Downsample1
Block Parameters: Product1
Product
Multiply or divide inputs. Choose element-wise or matrix product and specify one of the following:
a) * or / for each input port. For example, **/* performs the operation 'u1*u2/u3*u4'.
b) A scalar value specifies the number of input ports to be multiplied. For example, 2 performs the operation 'u1*u2'.
If there is only one input port and the Multiplication parameter is set to Element-wise(.*), a single * or / collapses the input signal using the specified operation. However, if the Multiplication parameter is set to Matrix(*), a single * causes the block to output the matrix unchanged, and a single / causes the block to output the matrix inverse.
Main Signal Attributes
Number of inputs: 2
Multiplication: Element-wise(.*)
OK Cancel Help Apply
Block Parameters: Sum2
Sum
Add or subtract inputs. Specify one of the following:
a) character vector containing + or - for each input port, | for spacer between ports (e.g. ++|-|++)
b) scalar, >= 1, specifies the number of input ports to be summed. When there is only one input port, add or subtract elements over all dimensions or one specified dimension.
Main Signal Attributes
Icon shape: round
List of signs: |++
OK Cancel Help Apply
Ready
80%
FixedStepDiscrete

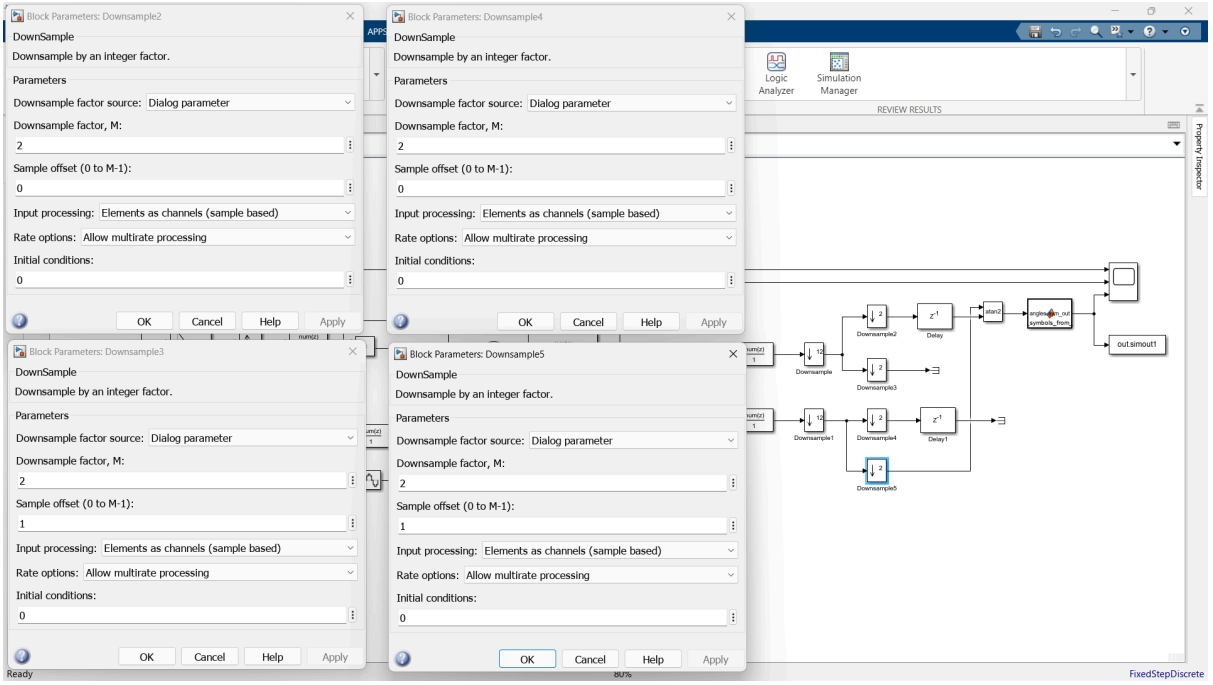
AWGN Channel:

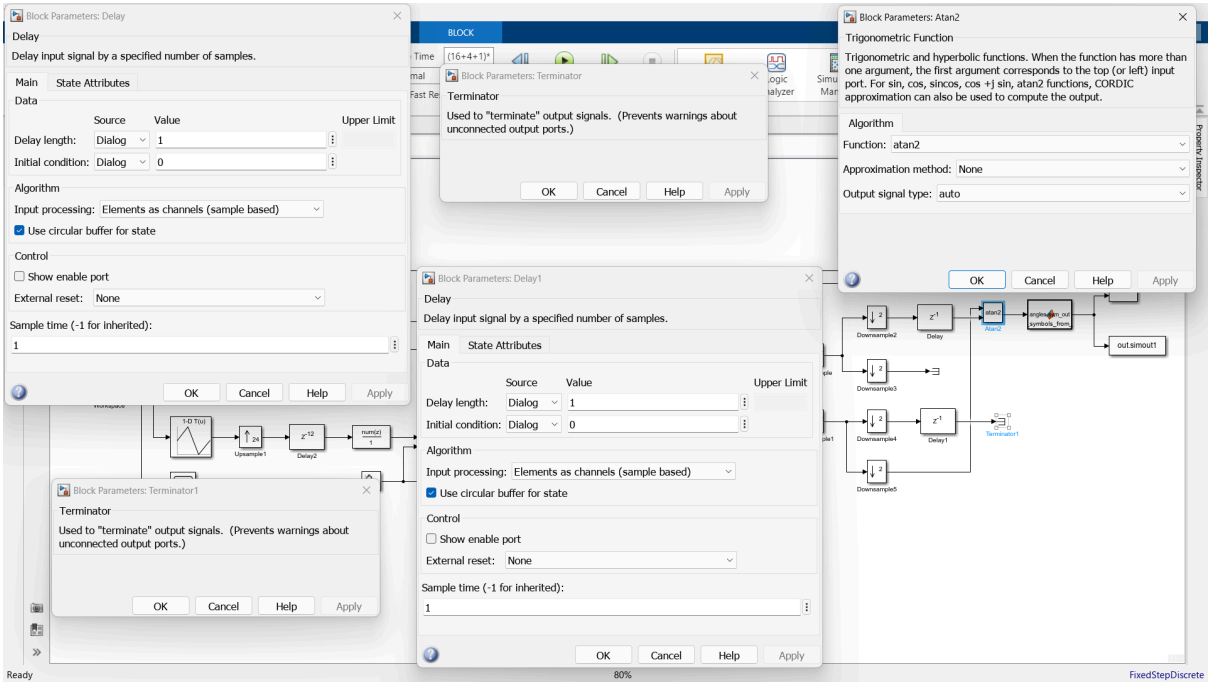


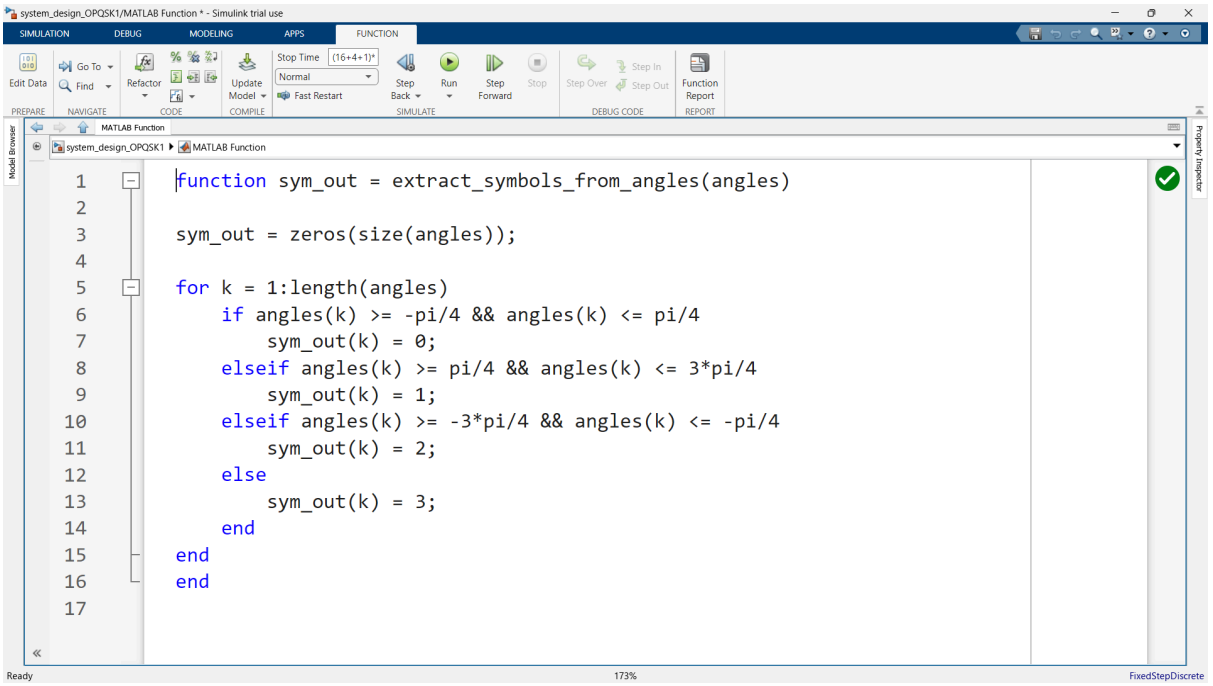
Demodulator:

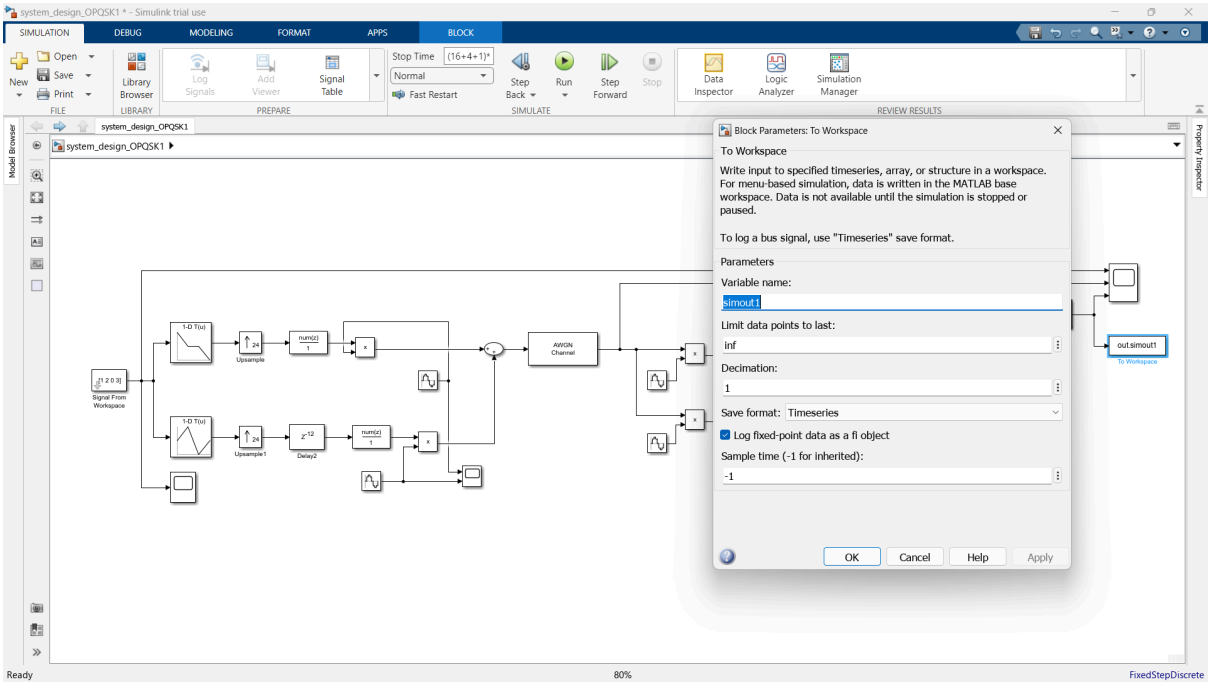



Block Parameters: Discrete Filter1
Discrete Filter
Independently filter each channel of the input over time using a discrete IIR filte
denominator coefficients in ascending order of powers of 1/z.
A DSP System Toolbox license is required to use a filter structure other than Dir
Main
Data Types
State Attributes
Filter structure: Direct form II
Data
Source
Value
Numerator: Dialog [rcosdesign(0.3,16,24)]
Denominator: Dialog [1]
Initial states: Dialog 0
External reset: None
Input processing: Elements as channels (sample based)
Optimize by skipping divide by leading denominator coefficient (a0)
OK
Cancel
Help
Apply
Block Parameters: Downsample
DownSample
Downsample by an integer factor.
Parameters
Downsample factor source: Dialog parameter
Downsample factor, M:
12
Sample offset (0 to M-1):
0
Input processing: Elements as channels (sample based)
Rate options: Allow multirate processing
Initial conditions:
0
Block Parameters: Downsample1
Block Parameters: Discrete Filter3
Simulation Manager
REVIEW RESULTS
Property Inspector
Ready
FixedStepDiscrete

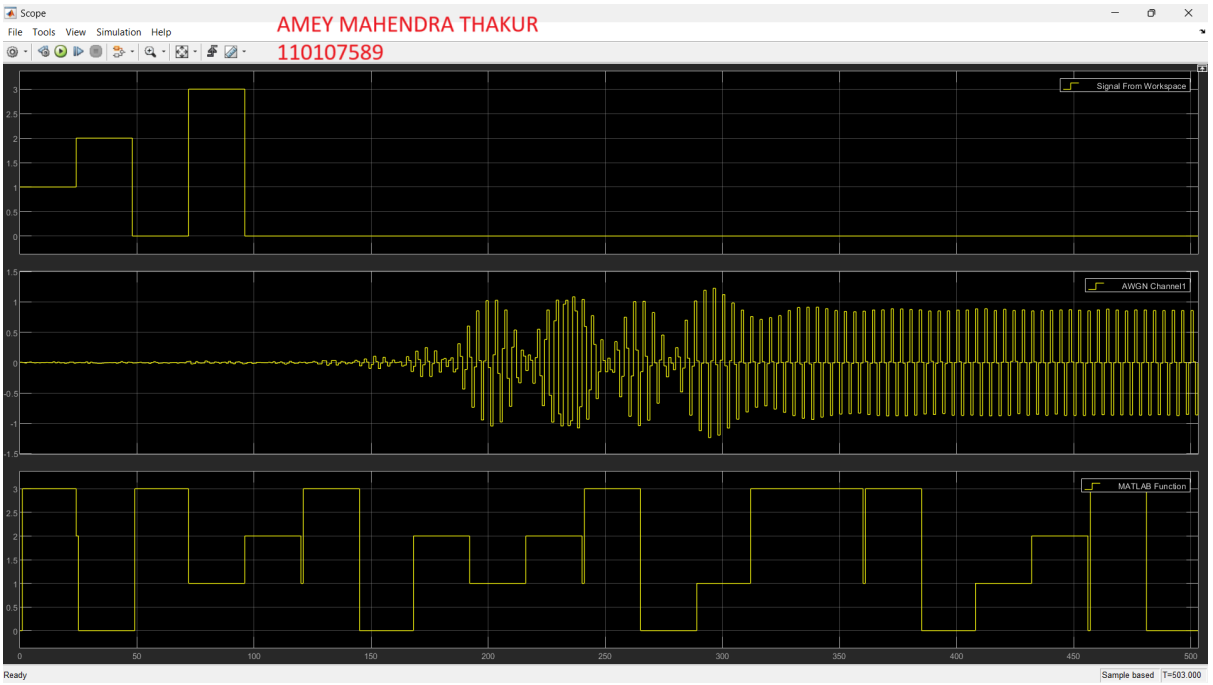

Block Parameters: Downsample2
Block Parameters: Downsample4
Block Parameters: Downsample3
Block Parameters: Downsample5
DownSample
Downsample by an integer factor.
Parameters
Downsample factor source: Dialog parameter
Downsample factor, M:
2
Sample offset (0 to M-1):
0
1
Input processing: Elements as channels (sample based)
Rate options: Allow multirate processing
Initial conditions:
OK
Cancel
Help
Apply
Logic Analyzer
Simulation Manager
REVIEW RESULTS
Property Inspector
out.simout1
Ready
FixedStepDiscrete


Block Parameters: Delay
Delay
Delay input signal by a specified number of samples.
Main
State Attributes
Data
Source
Value
Upper Limit
Delay length:
Initial condition:
Algorithm
Input processing:
Elements as channels (sample based)
Use circular buffer for state
Control
Show enable port
External reset:
None
Sample time (-1 for inherited):
OK
Cancel
Help
Apply
Block Parameters: Terminator
Terminator
Used to "terminate" output signals. (Prevents warnings about unconnected output ports.)
Block Parameters: Atan2
Trigonometric Function
Trigonometric and hyperbolic functions. When the function has more than one argument, the first argument corresponds to the top (or left) input port. For sin, cos, sincos, cos +j sin, atan2 functions, CORDIC approximation can also be used to compute the output.
Function:
atan2
Approximation method:
Output signal type:
auto
Block Parameters: Delay1
Block Parameters: Terminator1
out.simout1
Ready
80%
FixedStepDiscrete


system_design_OPQSK1/MATLAB Function * - Simulink trial use
SIMULATION
DEBUG
MODELING
APPS
FUNCTION
Edit Data
Go To
Find
Refactor
Update Model
Stop Time
Normal
Fast Restart
Step Back
Run
Step Forward
Stop
Step Over
Step In
Step Out
Function Report
PREPARE
NAVIGATE
CODE
COMPILE
SIMULATE
DEBUG CODE
REPORT
MATLAB Function
system_design_OPQSK1
MATLAB Function
function sym_out = extract_symbols_from_angles(angles)
sym_out = zeros(size(angles));
for k = 1:length(angles)
if angles(k) >= -pi/4 && angles(k) <= pi/4
sym_out(k) = 0;
elseif angles(k) >= pi/4 && angles(k) <= 3*pi/4
sym_out(k) = 1;
elseif angles(k) >= -3*pi/4 && angles(k) <= -pi/4
sym_out(k) = 2;
else
sym_out(k) = 3;
end
end
end
Ready
173%
FixedStepDiscrete



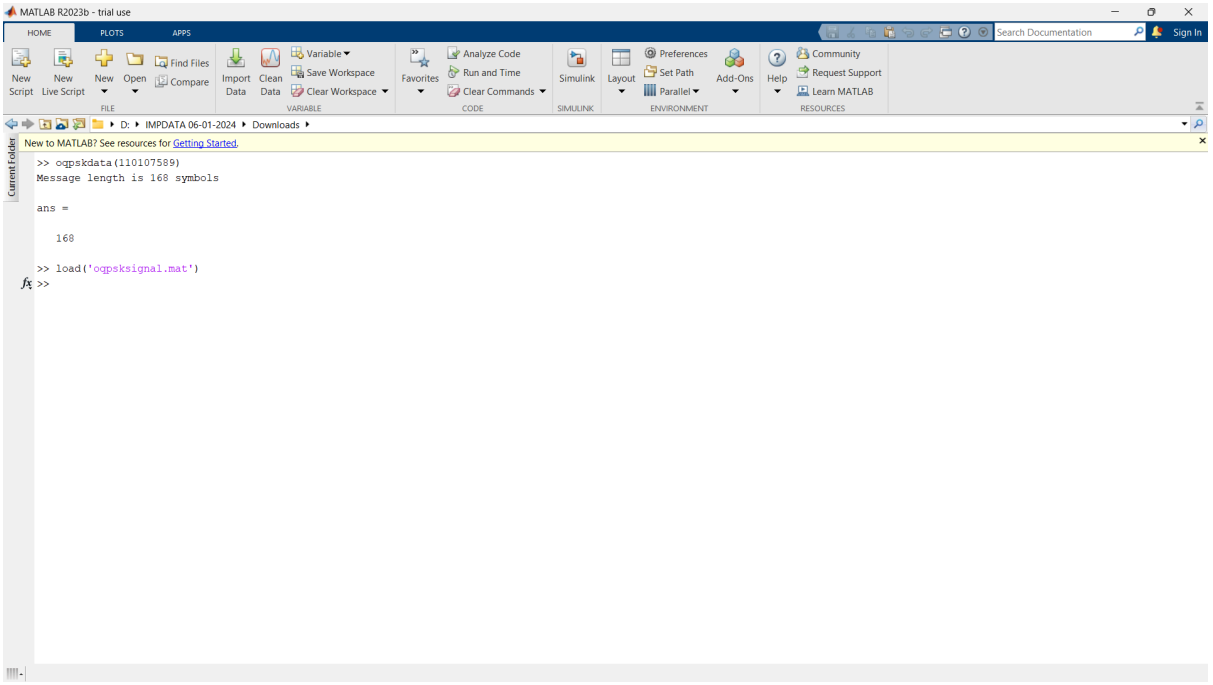
Scope and workspace output:

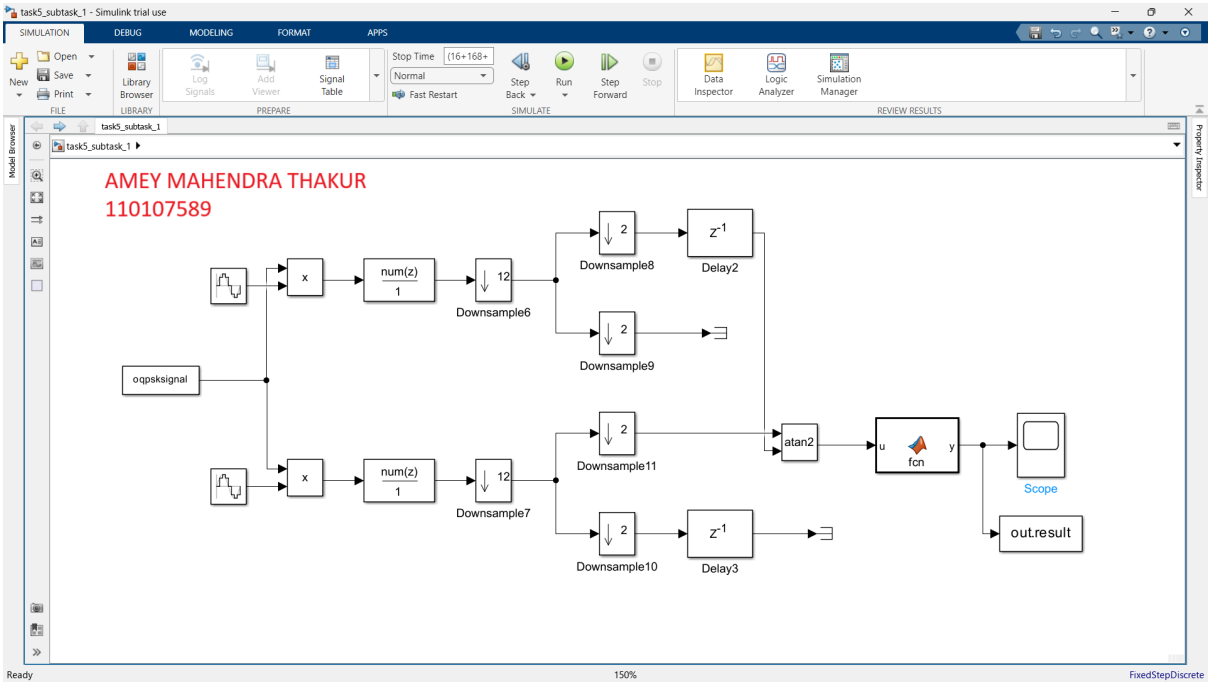


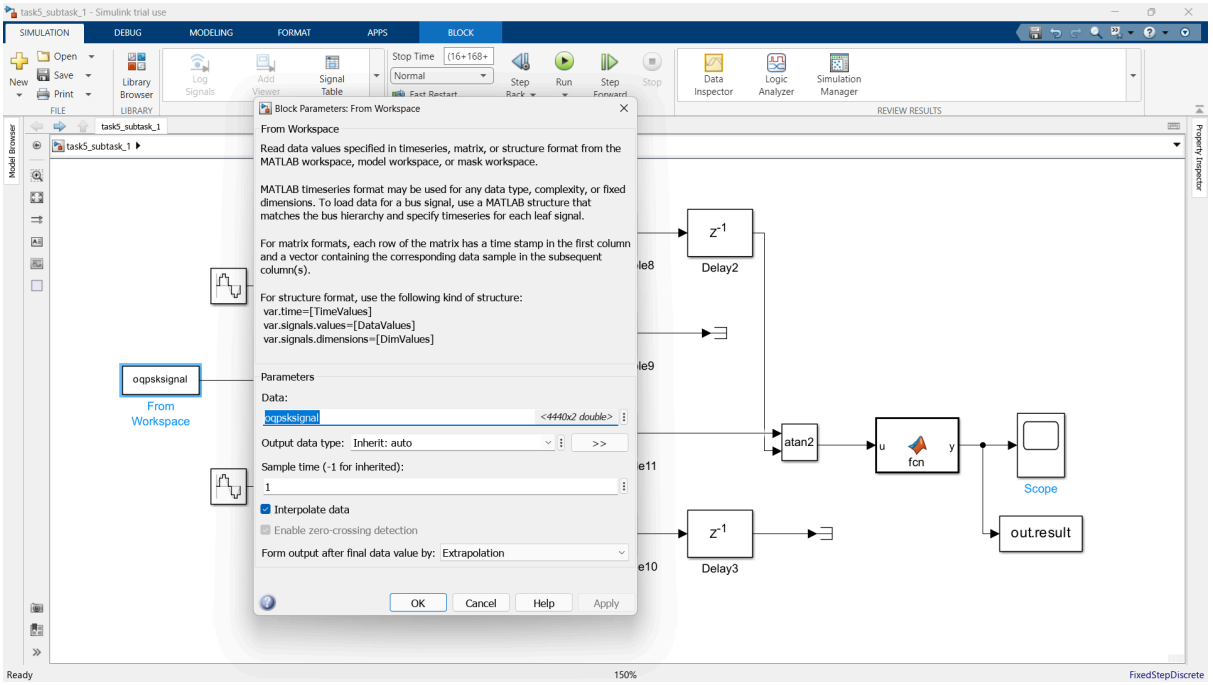
subtask 1

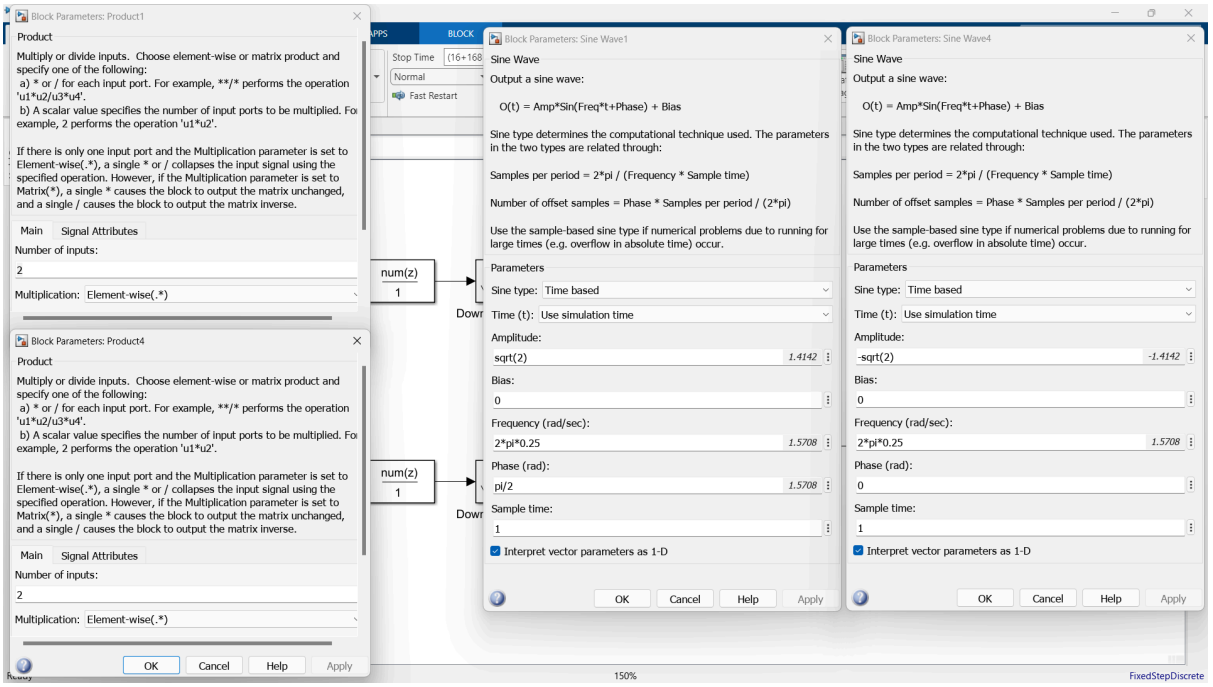
Locate oqpskdata file in matlab directory.
(K = 168)

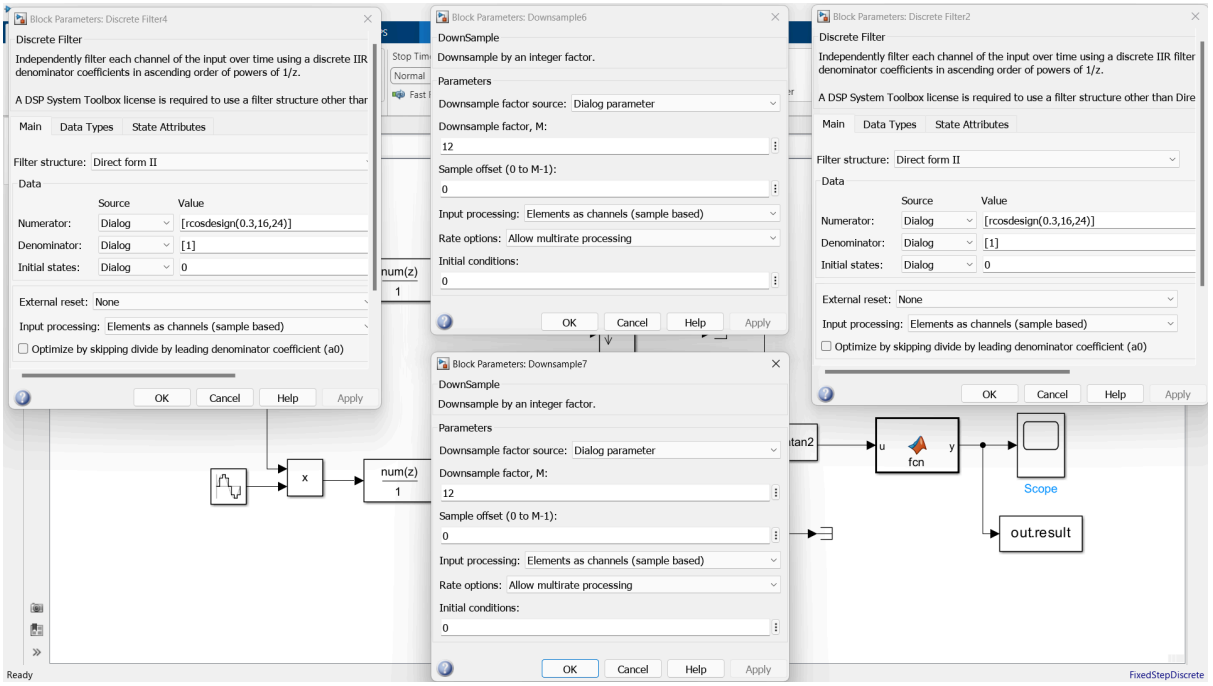
Load qam16signal.mat

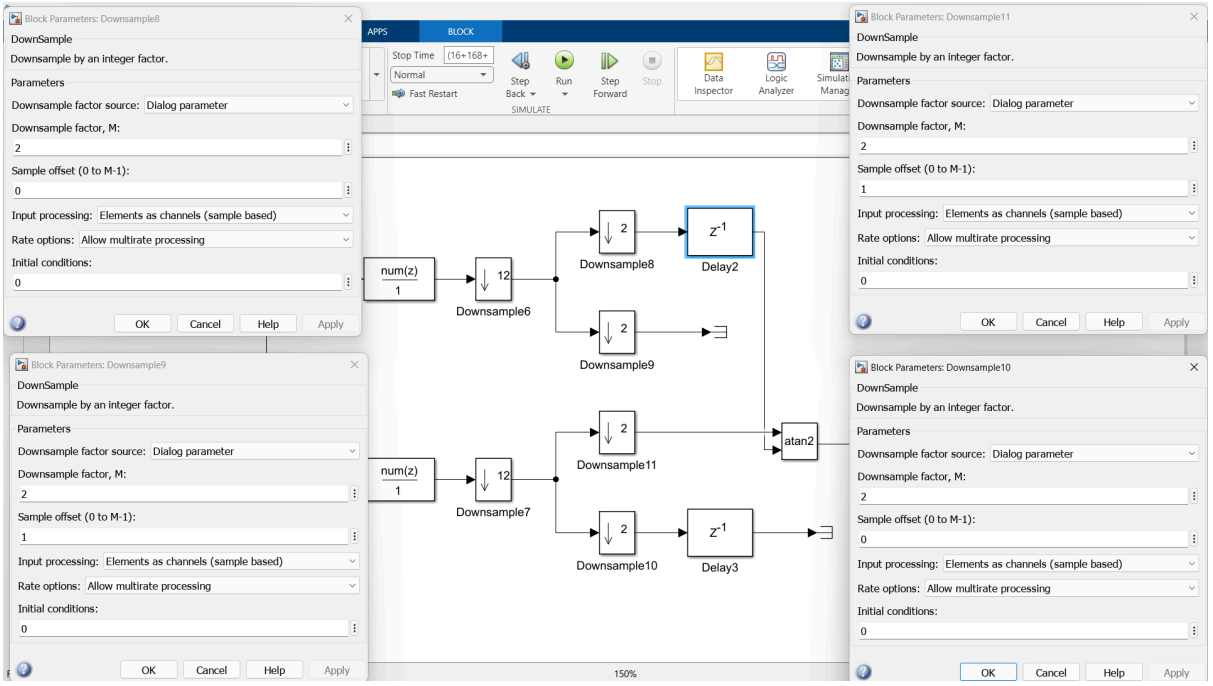


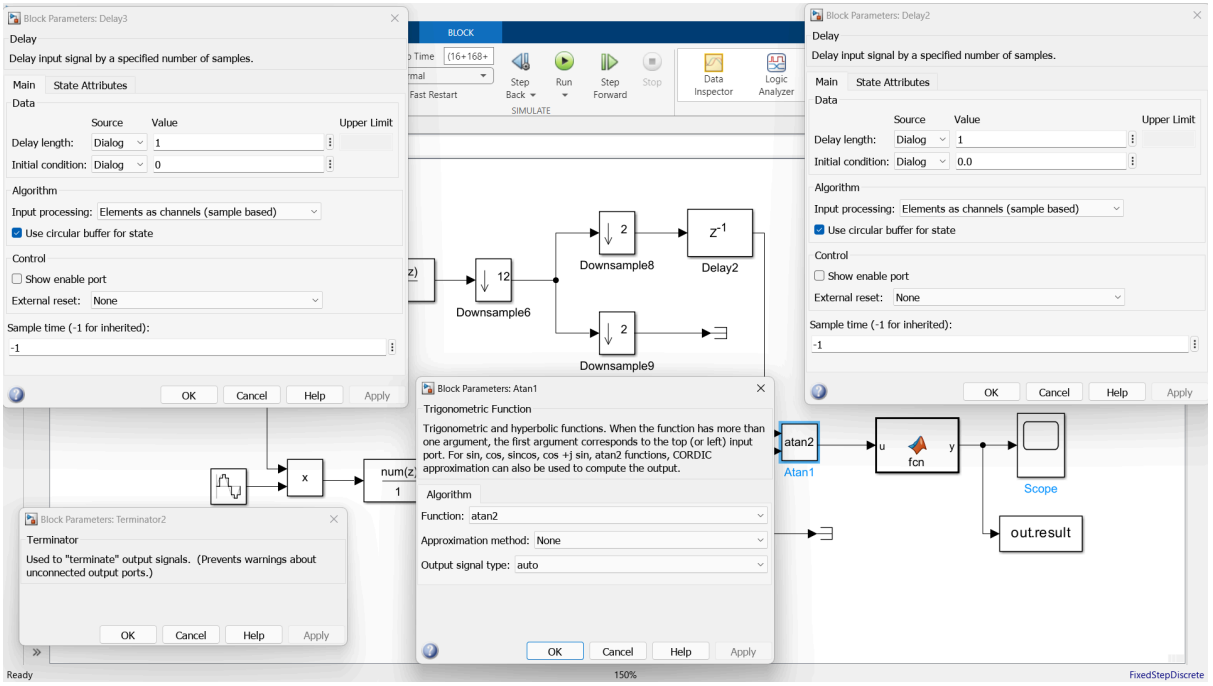


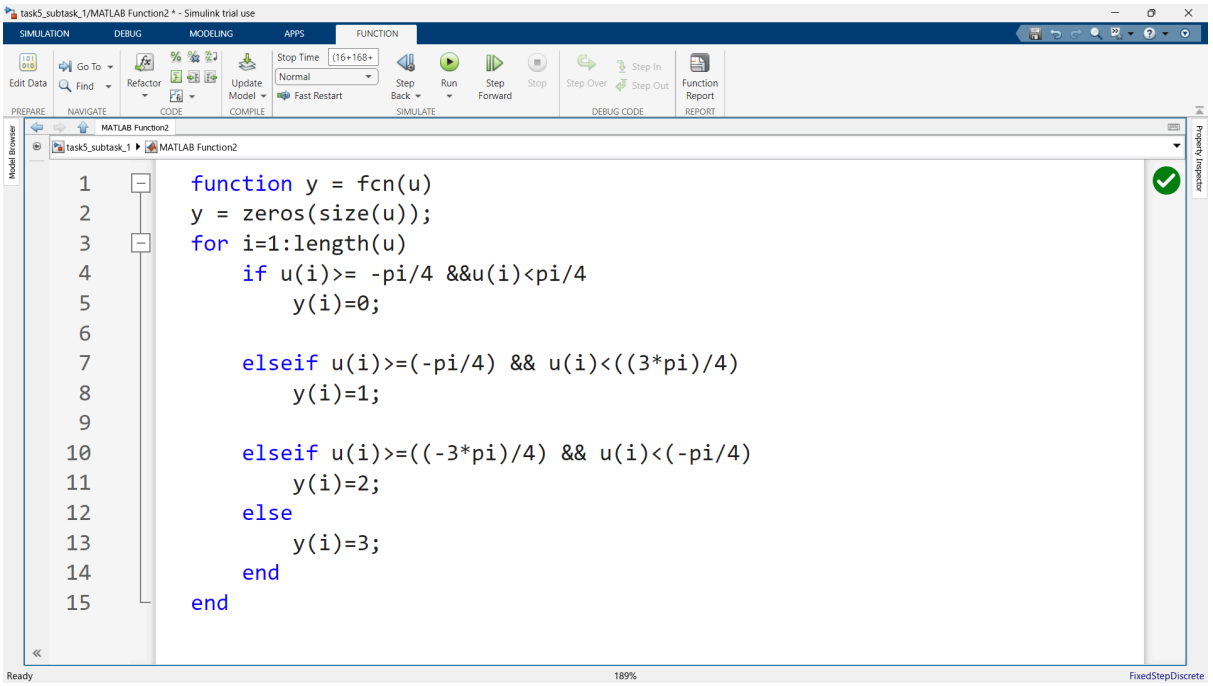

task5_subtask_1 - Simulink trial use
SIMULATION
DEBUG
MODELING
FORMAT
APPS
BLOCK
Block Parameters: From Workspace
From Workspace
Read data values specified in timeseries, matrix, or structure format from the MATLAB workspace, model workspace, or mask workspace.
MATLAB timeseries format may be used for any data type, complexity, or fixed dimensions. To load data for a bus signal, use a MATLAB structure that matches the bus hierarchy and specify timeseries for each leaf signal.
For matrix formats, each row of the matrix has a time stamp in the first column and a vector containing the corresponding data sample in the subsequent column(s).
For structure format, use the following kind of structure:
var.time=[TimeValues]
var.signals.values=[DataValues]
var.signals.dimensions=[DimValues]
Parameters
Data:
oqpsksignal
<4440x2 double>
Output data type: Inherit: auto
Sample time (-1 for inherited):
1
Interpolate data
Enable zero-crossing detection
Form output after final data value by: Extrapolation
OK
Cancel
Help
Apply
oqpsksignal
From Workspace
Delay2
Delay3
atan2
fcn
Scope
out.result
Ready
150%
FixedStepDiscrete

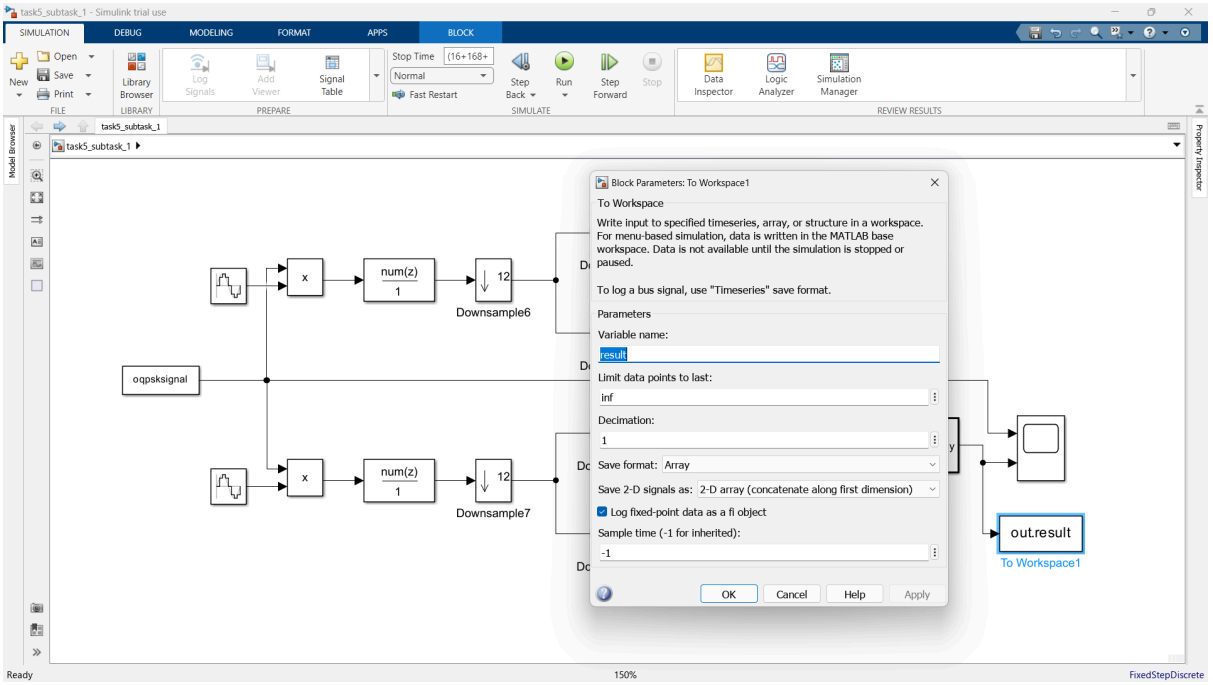

Block Parameters: Product1
Product
Multiply or divide inputs. Choose element-wise or matrix product and specify one of the following:
Main
Signal Attributes
Number of inputs:
2
Multiplication: Element-wise(.*)
Block Parameters: Product4
Block Parameters: Sine Wave1
Sine Wave
Output a sine wave:
O(t) = Amp*Sin(Freq*t+Phase) + Bias
Parameters
Sine type: Time based
Time (t): Use simulation time
Amplitude:
sqrt(2)
Bias:
0
Frequency (rad/sec):
2*pi*0.25
Phase (rad):
pi/2
Sample time:
1
Interpret vector parameters as 1-D
OK
Cancel
Help
Apply
Block Parameters: Sine Wave4
-sqrt(2)
num(z)
1
150%
FixedStepDiscrete


Block Parameters: Discrete Filter4
Discrete Filter
Independently filter each channel of the input over time using a discrete IIR denominator coefficients in ascending order of powers of 1/z.
A DSP System Toolbox license is required to use a filter structure other thar
Main
Data Types
State Attributes
Filter structure: Direct form II
Data
Source
Value
Numerator: Dialog [rcosdesign(0.3,16,24)]
Denominator: Dialog [1]
Initial states: Dialog 0
External reset: None
Input processing: Elements as channels (sample based)
Optimize by skipping divide by leading denominator coefficient (a0)
OK
Cancel
Help
Apply
Block Parameters: Downsample6
DownSample
Downsample by an integer factor.
Parameters
Downsample factor source: Dialog parameter
Downsample factor, M: 12
Sample offset (0 to M-1): 0
Input processing: Elements as channels (sample based)
Rate options: Allow multirate processing
Initial conditions: 0
Block Parameters: Downsample7
DownSample
Downsample by an integer factor.
Parameters
Downsample factor source: Dialog parameter
Downsample factor, M: 12
Sample offset (0 to M-1): 0
Input processing: Elements as channels (sample based)
Rate options: Allow multirate processing
Initial conditions: 0
Block Parameters: Discrete Filter2
Discrete Filter
Independently filter each channel of the input over time using a discrete IIR filter denominator coefficients in ascending order of powers of 1/z.
A DSP System Toolbox license is required to use a filter structure other than Dire
Main
Data Types
State Attributes
Filter structure: Direct form II
Data
Source
Value
Numerator: Dialog [rcosdesign(0.3,16,24)]
Denominator: Dialog [1]
Initial states: Dialog 0
External reset: None
Input processing: Elements as channels (sample based)
Optimize by skipping divide by leading denominator coefficient (a0)
OK
Cancel
Help
Apply
num(z)
1
x
atan2
u
y
fcn
Scope
out.result
Ready
FixedStepDiscrete

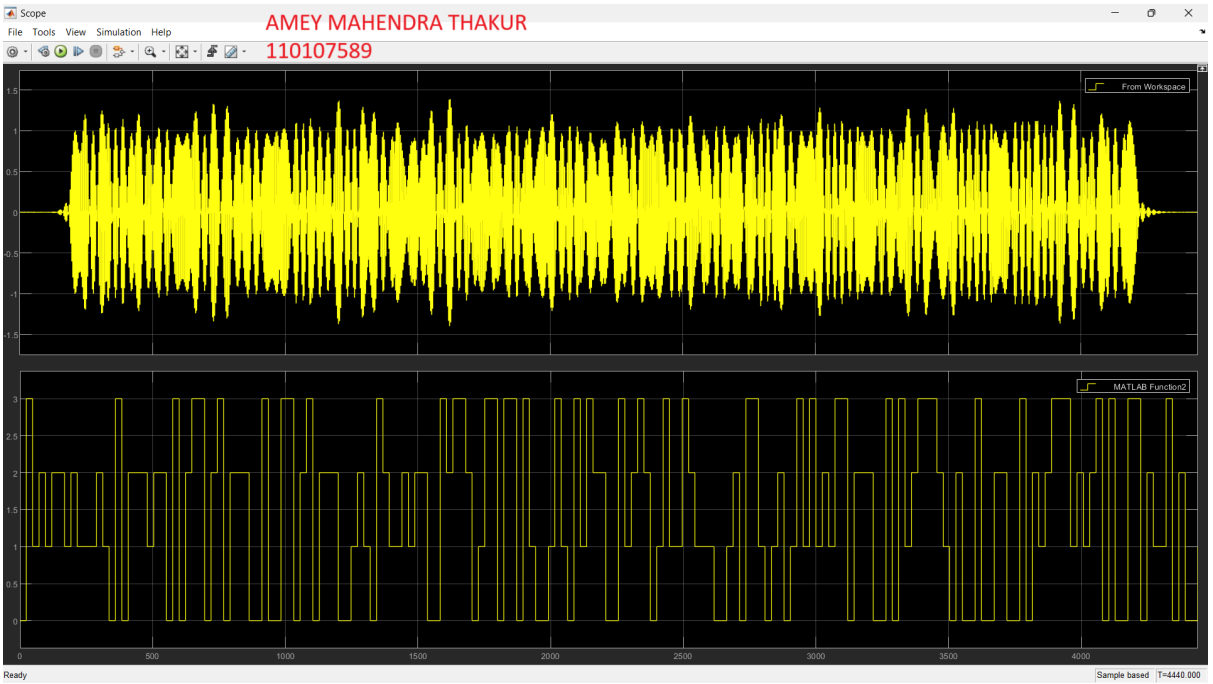

Block Parameters: Downsample8
DownSample
Downsample by an integer factor.
Parameters
Downsample factor source: Dialog parameter
Downsample factor, M: 2
Sample offset (0 to M-1): 0
Input processing: Elements as channels (sample based)
Rate options: Allow multirate processing
Initial conditions: 0
Block Parameters: Downsample9
DownSample
Downsample by an integer factor.
Parameters
Downsample factor source: Dialog parameter
Downsample factor, M: 2
Sample offset (0 to M-1): 1
Input processing: Elements as channels (sample based)
Rate options: Allow multirate processing
Initial conditions: 0
Block Parameters: Downsample11
DownSample
Downsample by an integer factor.
Parameters
Downsample factor source: Dialog parameter
Downsample factor, M: 2
Sample offset (0 to M-1): 1
Input processing: Elements as channels (sample based)
Rate options: Allow multirate processing
Initial conditions: 0
Block Parameters: Downsample10
DownSample
Downsample by an integer factor.
Parameters
Downsample factor source: Dialog parameter
Downsample factor, M: 2
Sample offset (0 to M-1): 0
Input processing: Elements as channels (sample based)
Rate options: Allow multirate processing
Initial conditions: 0
APPS
BLOCK
Stop Time
Normal
Fast Restart
Step Back
Run
Step Forward
Stop
SIMULATE
Data Inspector
Logic Analyzer
num(z)
1
12
Downsample6
Downsample8
Downsample9
Downsample7
Downsample11
Downsample10
z-1
Delay2
Delay3
atan2
150%


Block Parameters: Delay3
Delay
Delay input signal by a specified number of samples.
Main
State Attributes
Data
Source
Value
Upper Limit
Delay length:
Initial condition:
Algorithm
Input processing:
Elements as channels (sample based)
Use circular buffer for state
Control
Show enable port
External reset:
None
Sample time (-1 for inherited):
OK
Cancel
Help
Apply
Downsample8
Downsample6
Downsample9
Delay2
Block Parameters: Delay2
Block Parameters: Atan1
Trigonometric Function
Trigonometric and hyperbolic functions. When the function has more than one argument, the first argument corresponds to the top (or left) input port. For sin, cos, sincos, cos +j sin, atan2 functions, CORDIC approximation can also be used to compute the output.
Function: atan2
Approximation method: None
Output signal type: auto
Block Parameters: Terminator2
Terminator
Used to "terminate" output signals. (Prevents warnings about unconnected output ports.)
atan2
Atan1
fcn
Scope
out.result
Ready
150%
FixedStepDiscrete


task5_subtask_1/MATLAB Function2 * - Simulink trial use
SIMULATION
DEBUG
MODELING
APPS
FUNCTION
MATLAB Function2
task5_subtask_1
function y = fcn(u)
y = zeros(size(u));
for i=1:length(u)
if u(i)>= -pi/4 &&u(i)<pi/4
y(i)=0;
elseif u(i)>=(-pi/4) && u(i)<((3*pi)/4)
y(i)=1;
elseif u(i)>=((-3*pi)/4) && u(i)<(-pi/4)
y(i)=2;
else
y(i)=3;
end
end
Ready
189%
FixedStepDiscrete



Scope and workspace output:



Secret message:

sym_msg = out.result(end-168:end-1);
ascii_msg = char(bin2dec(num2str(reshape(dec2bin(sym_msg,log2(2)).',7,[]).')))'

Secret message is **'There are 293 ways to make change for a dollar. '**