Московский государственный технический университет им. Н.Э. Баумана
Факультет «Радиоэлектроника и лазерная техника»
Кафедра «Технологии приборостроения» (РЛ6)

Лабораторная работа №13 – Моделирование многоканальных систем связи по дисциплине «Информационные РЭС»

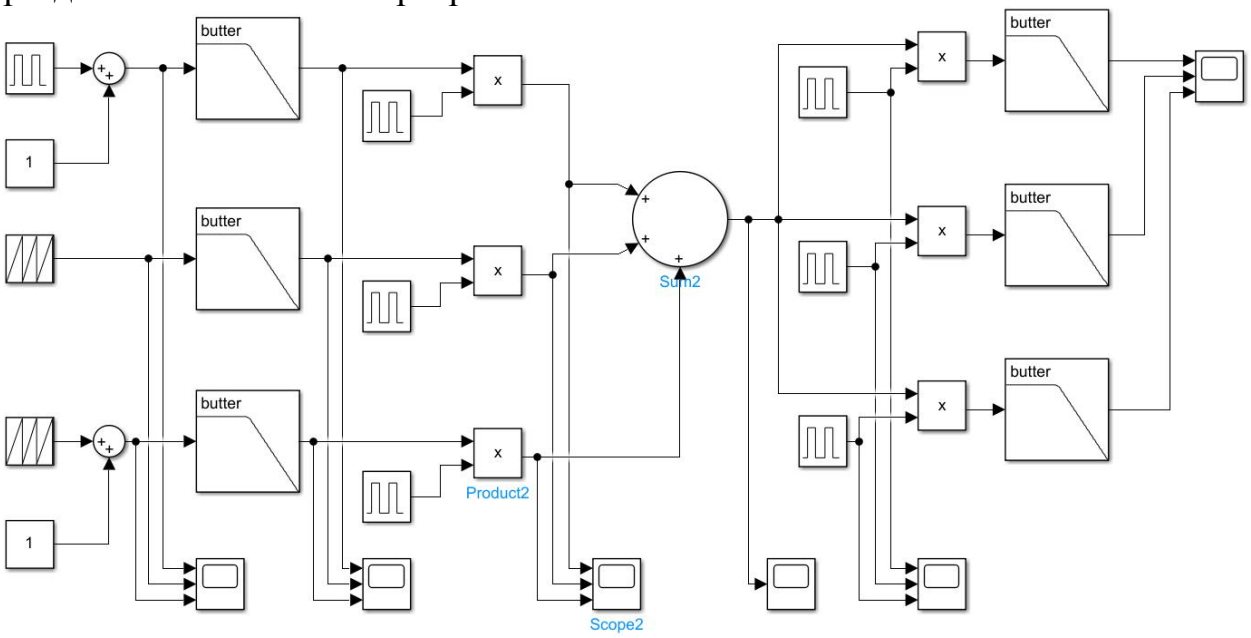
Выполнил ст. группы РЛ6-91
Филимонов С.В.

Преподаватель Руденко Н.Р.

Москва, 2025

Моделирование многоканальных систем связи с временным разделением каналов

Соберём модель многоканальной системы связи с временным разделением каналов в программном пакете MATLAB Simulink:

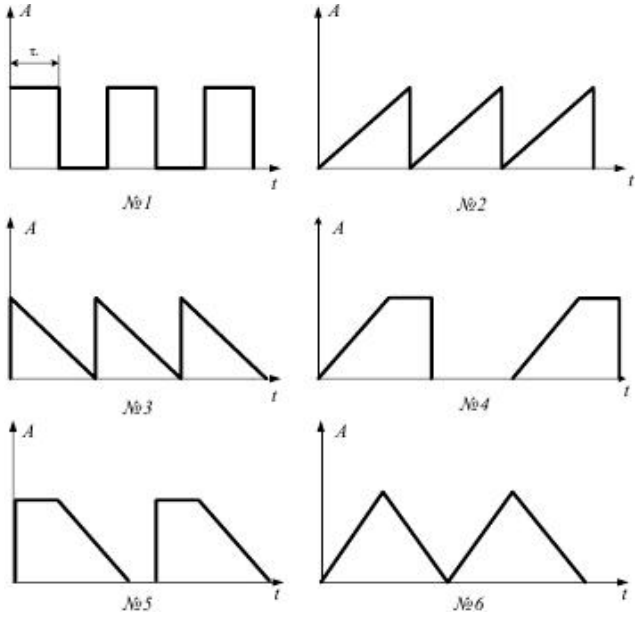


Настроим параметры элементов схемы, основываясь на формах, длительности и амплитуде сигналов, выбранных из таблицы 1 из документа с заданием в соответствии с вариантом (9).

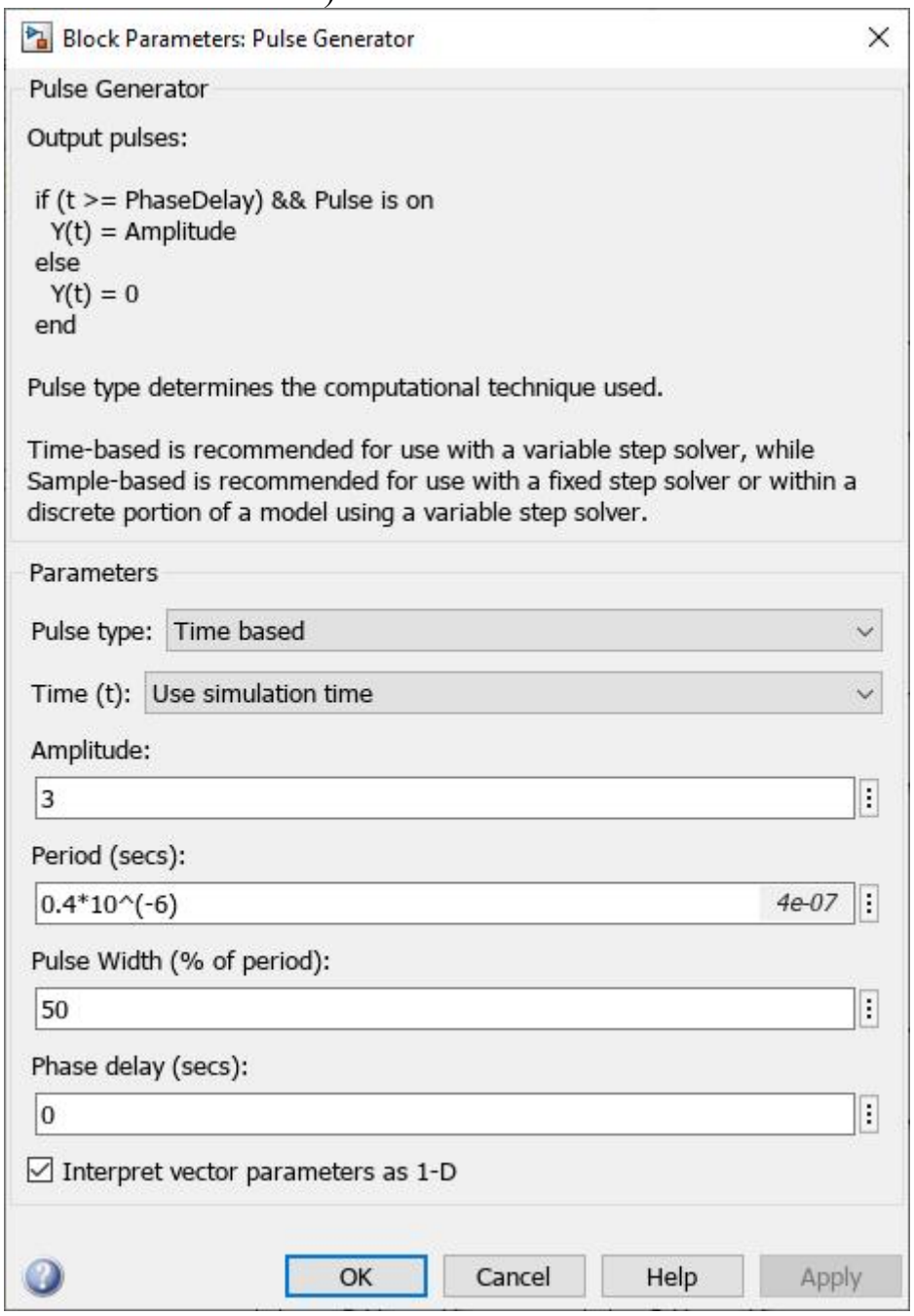
Часть таблицы 1 с нашим вариантом:

№ варианта	Виды сигналов	Длительность элемента сигнала, мкс	Амплитуда
9	126	0.2	3

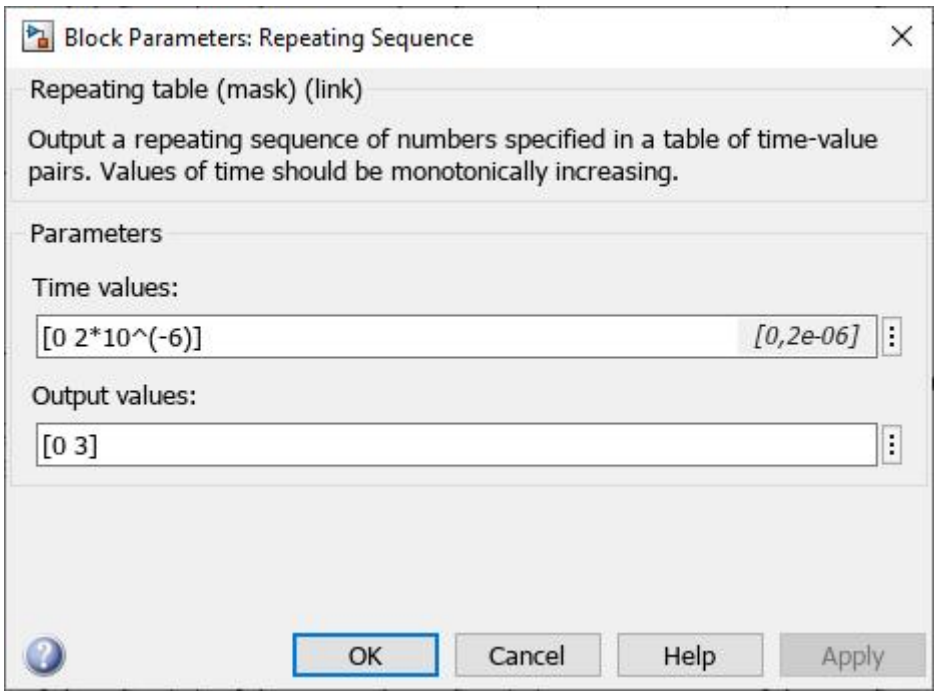
Формы сигналов:



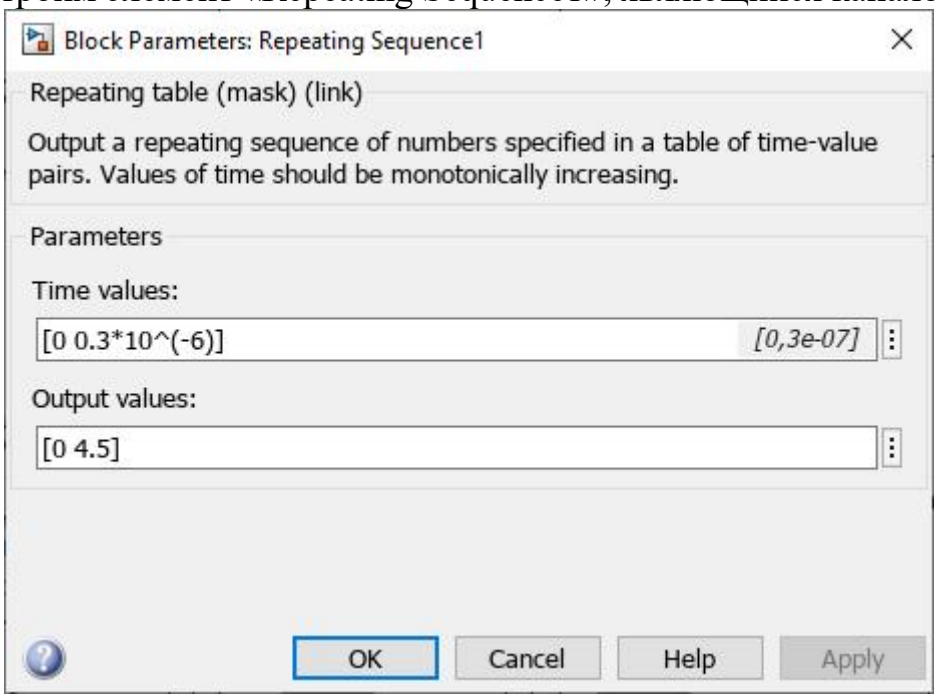
Настройка для всех элементов «Pulse Generator» (в том числе и для того, который является каналом №1):



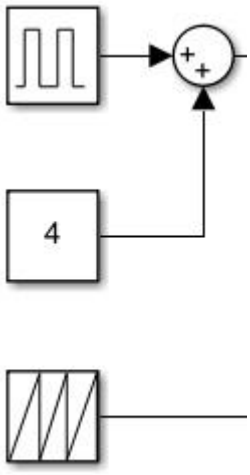
Настроим элемент «Repeating Sequence», являющийся каналом №2:

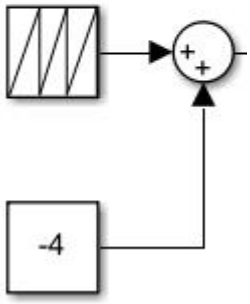


Настроим элемент «Repeating Sequence1», являющийся каналом №3:

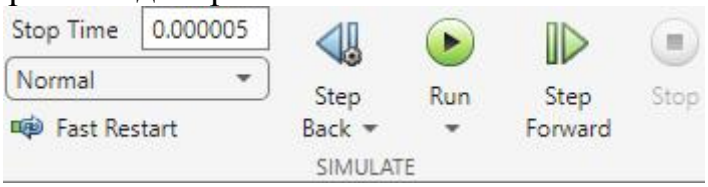


Установим на элементах «Constant» такое значение, чтобы графики входных сигналов не перекрывали друг друга:



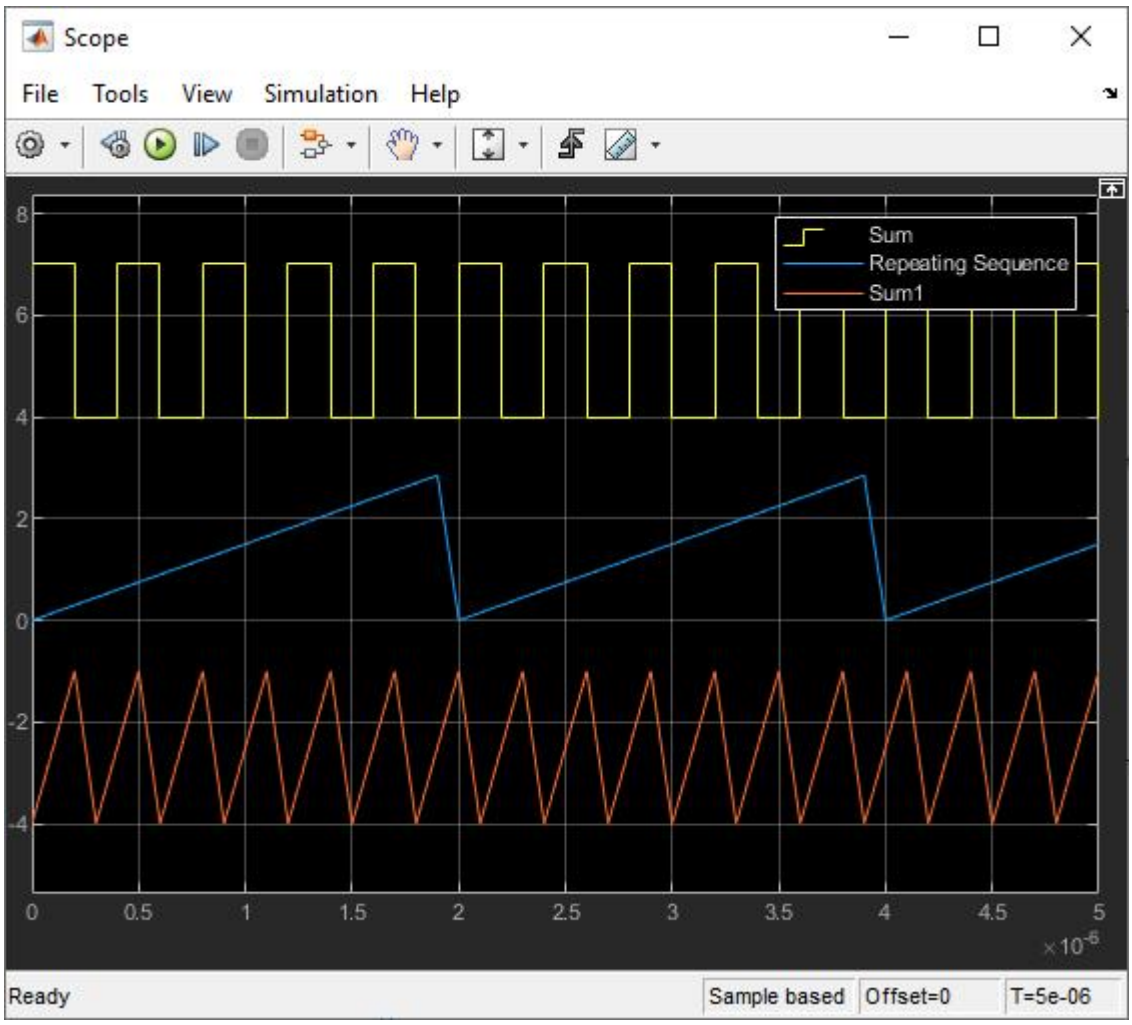


Настроим время моделирования:

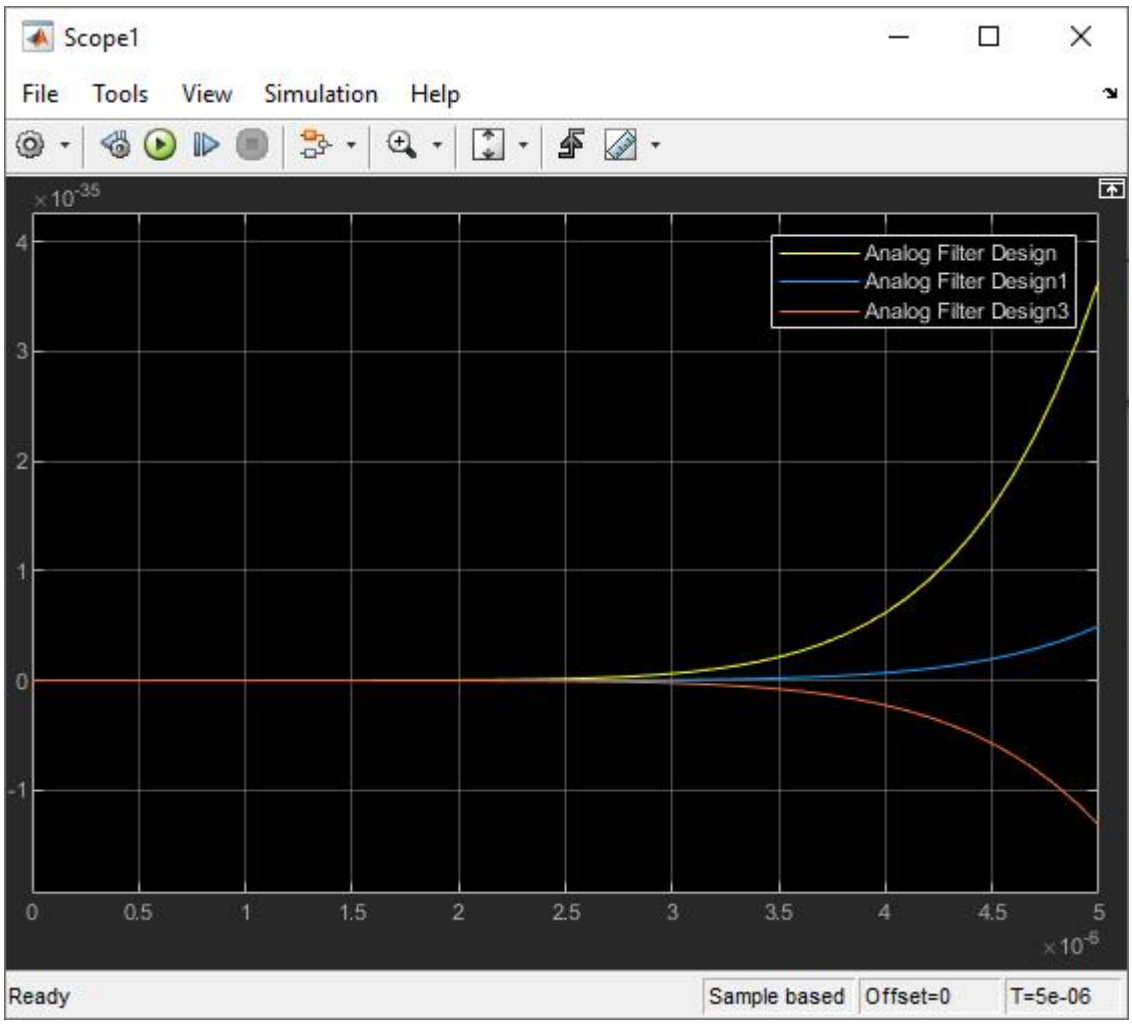


Запустим процесс моделирования и зарисуем осциллограммы сигналов с осциллографов, располагая их друг под другом:

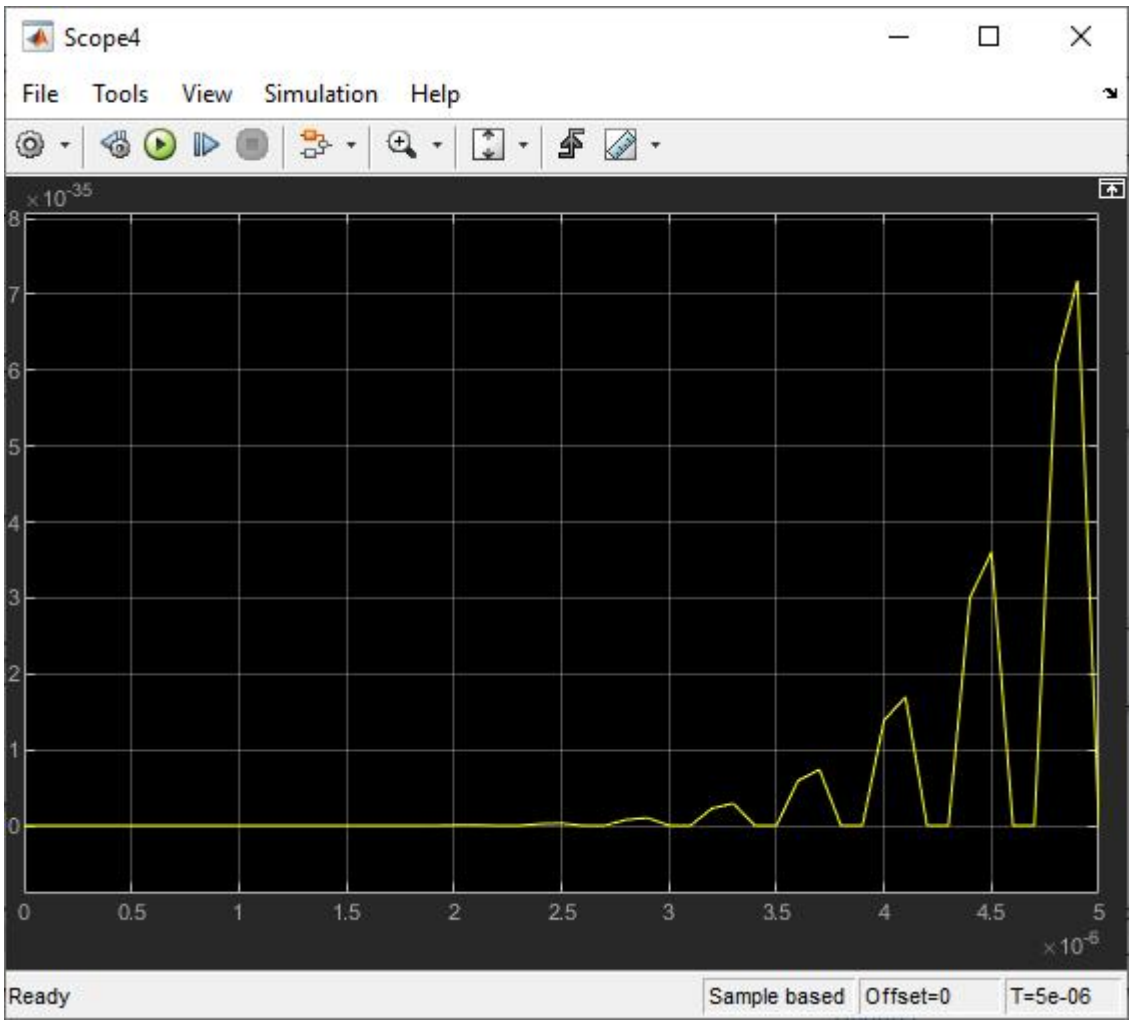
- временные диаграммы входных сигналов:



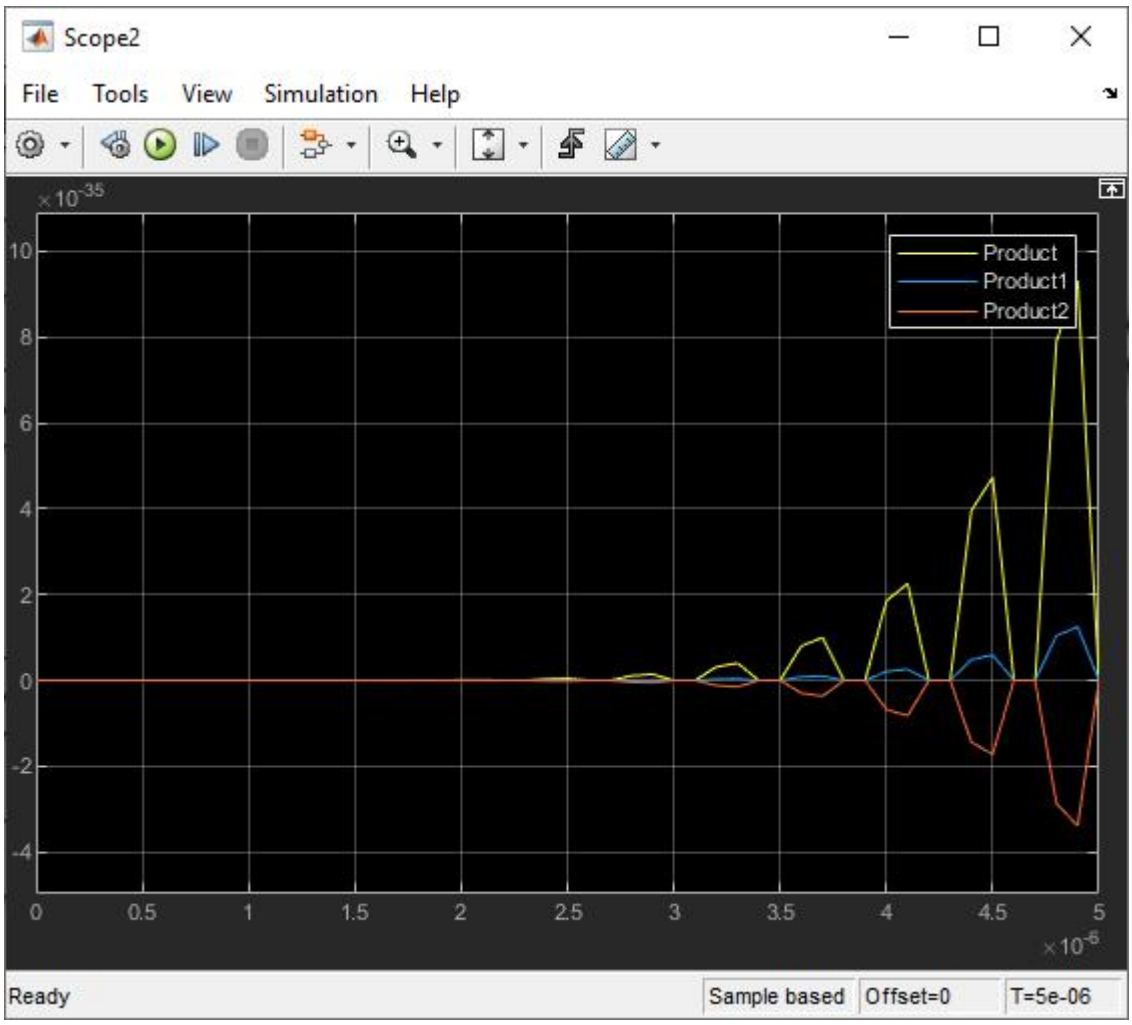
- временные диаграммы последовательностей прямоугольных импульсов для различных каналов:



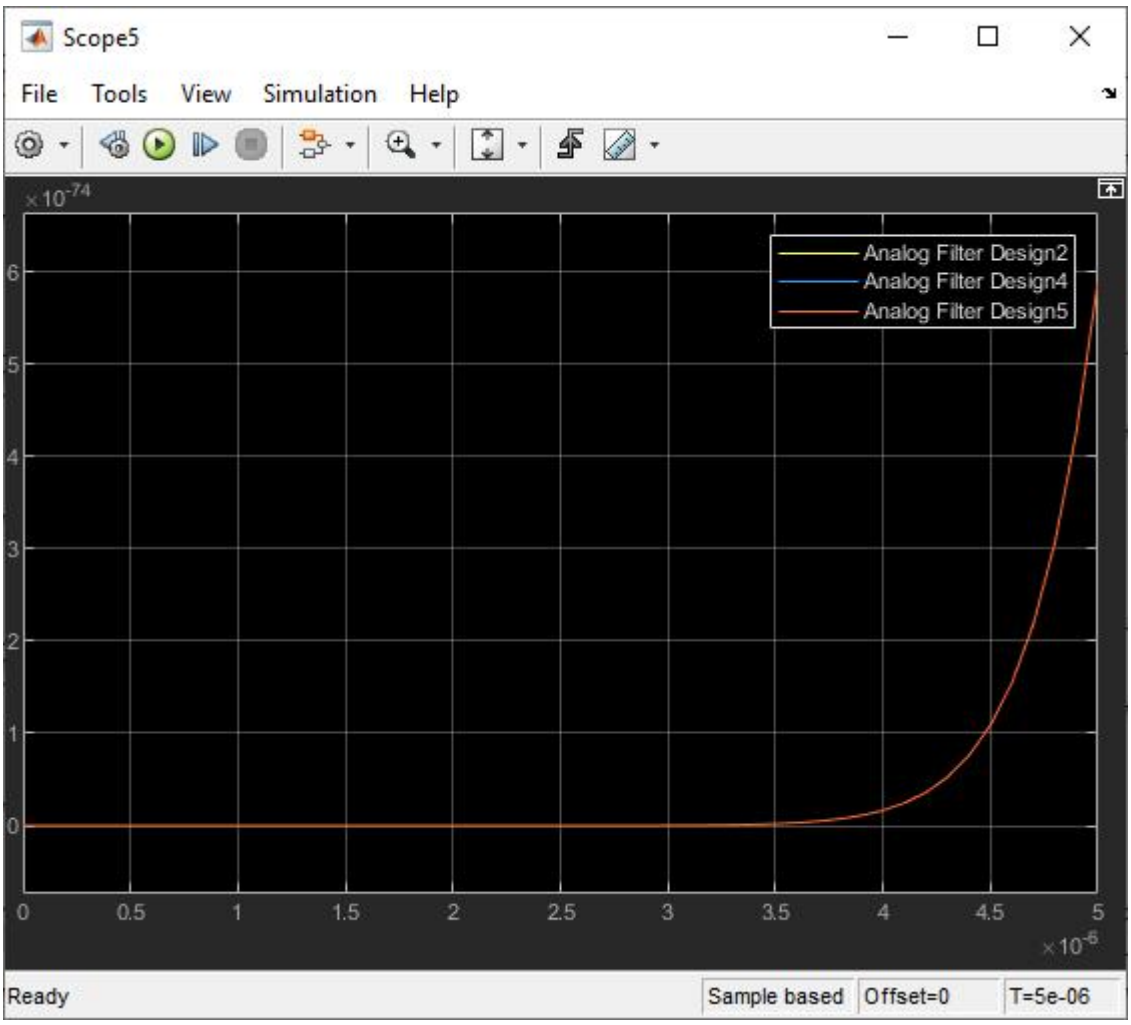
- временная диаграмма группового сигнала:



- временные диаграммы на выходе канальных селекторов:

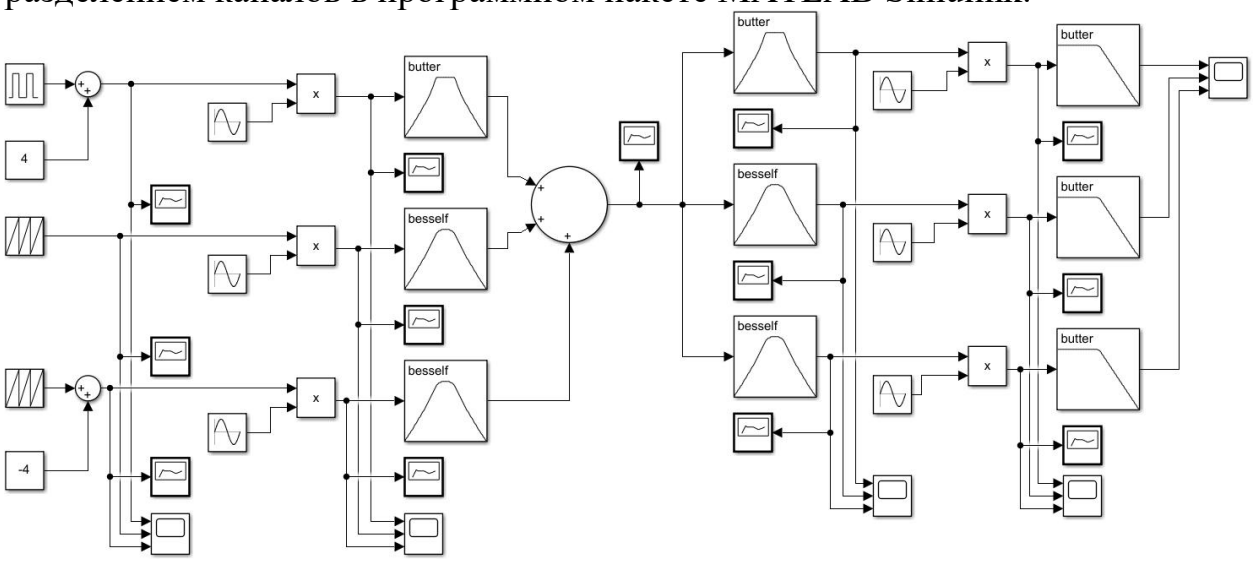


- временные диаграммы выходных сигналов:



Моделирование многоканальных систем связи с частотным разделением каналов

Соберём модель многоканальной системы связи с частотным разделением каналов в программном пакете MATLAB Simulink:

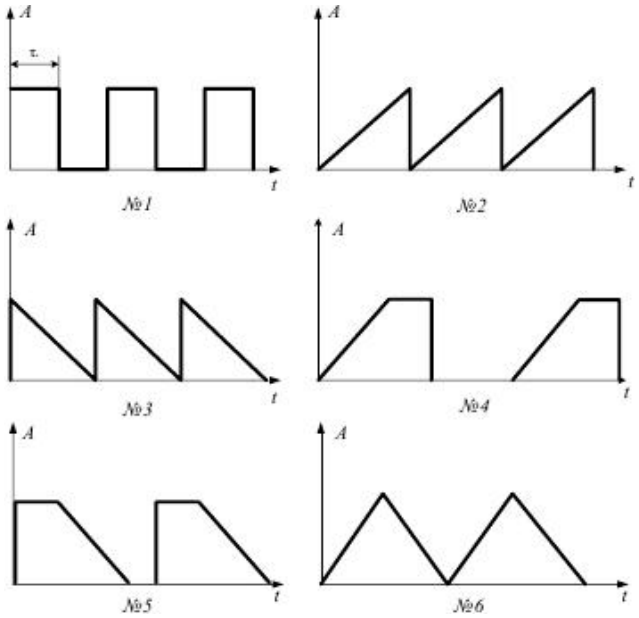


Настроим параметры элементов схемы, основываясь на формах, длительности и амплитуде сигналов, выбранных из таблицы 1 из документа с заданием в соответствии с вариантом (9).

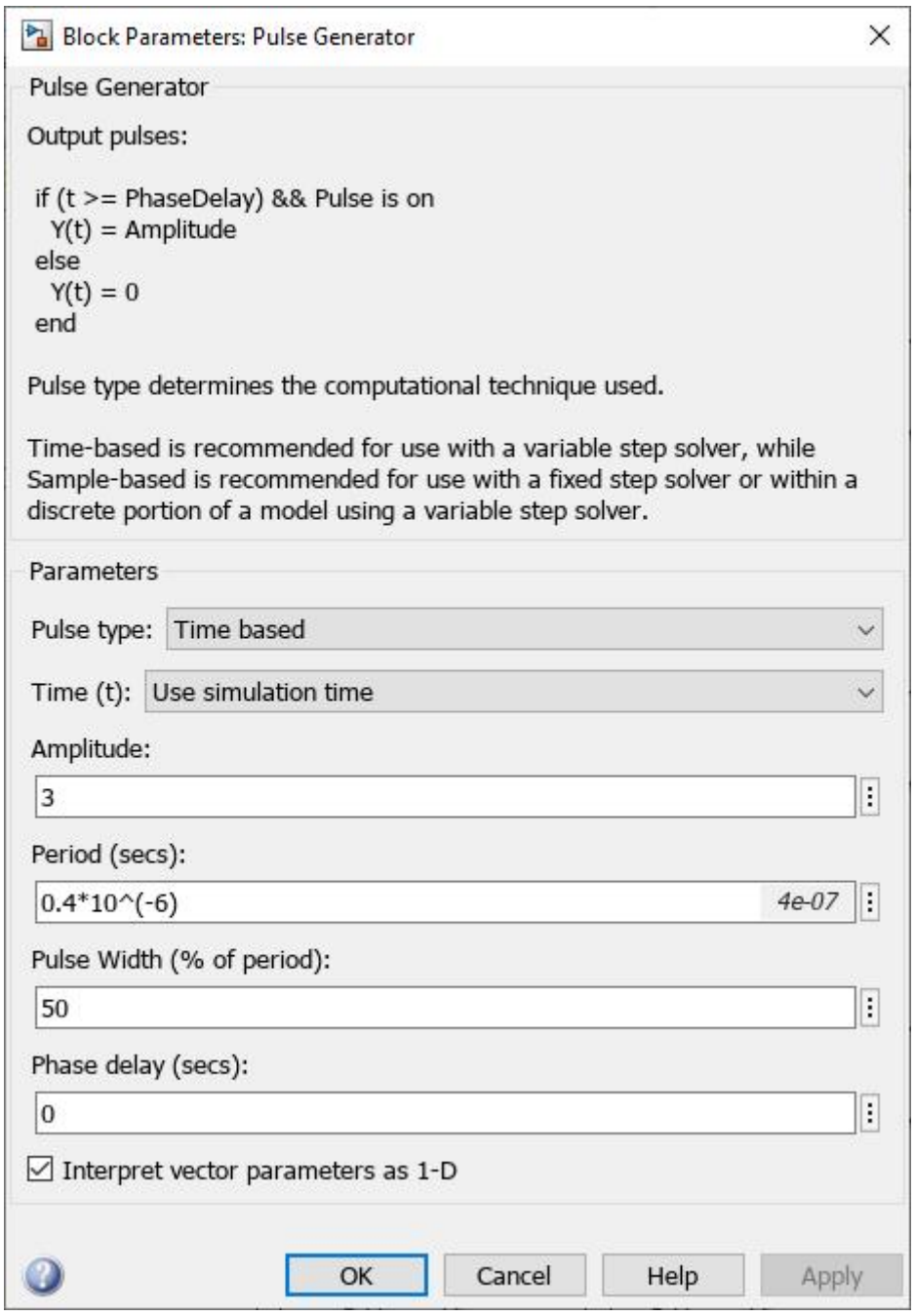
Часть таблицы 1 с нашим вариантом:

№ варианта	Виды сигналов	Длительность элемента сигнала, мкс	Амплитуда
9	126	0.2	3

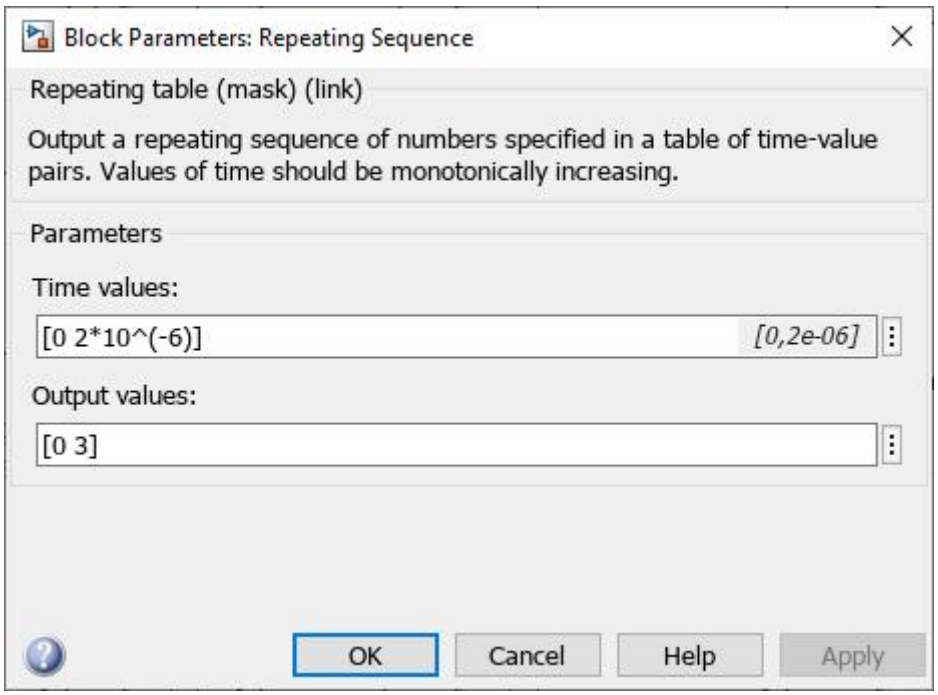
Формы сигналов:



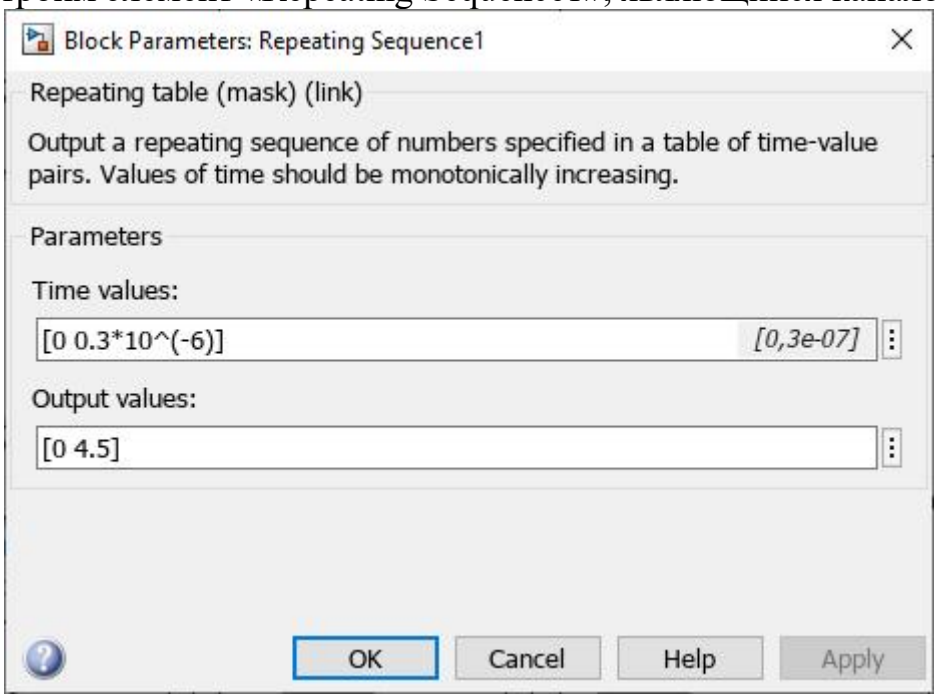
Настройка для всех элементов «Pulse Generator» (в том числе и для того, который является каналом №1):



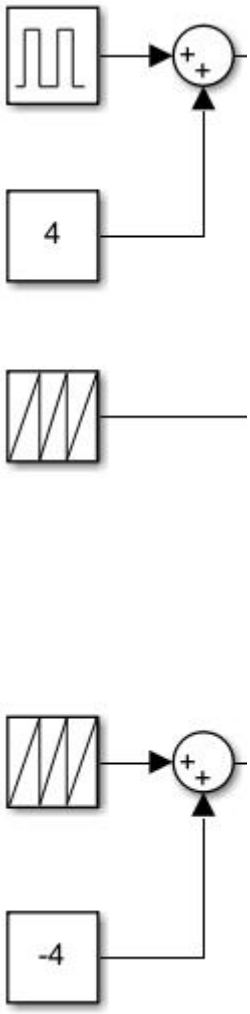
Настроим элемент «Repeating Sequence», являющийся каналом №2:



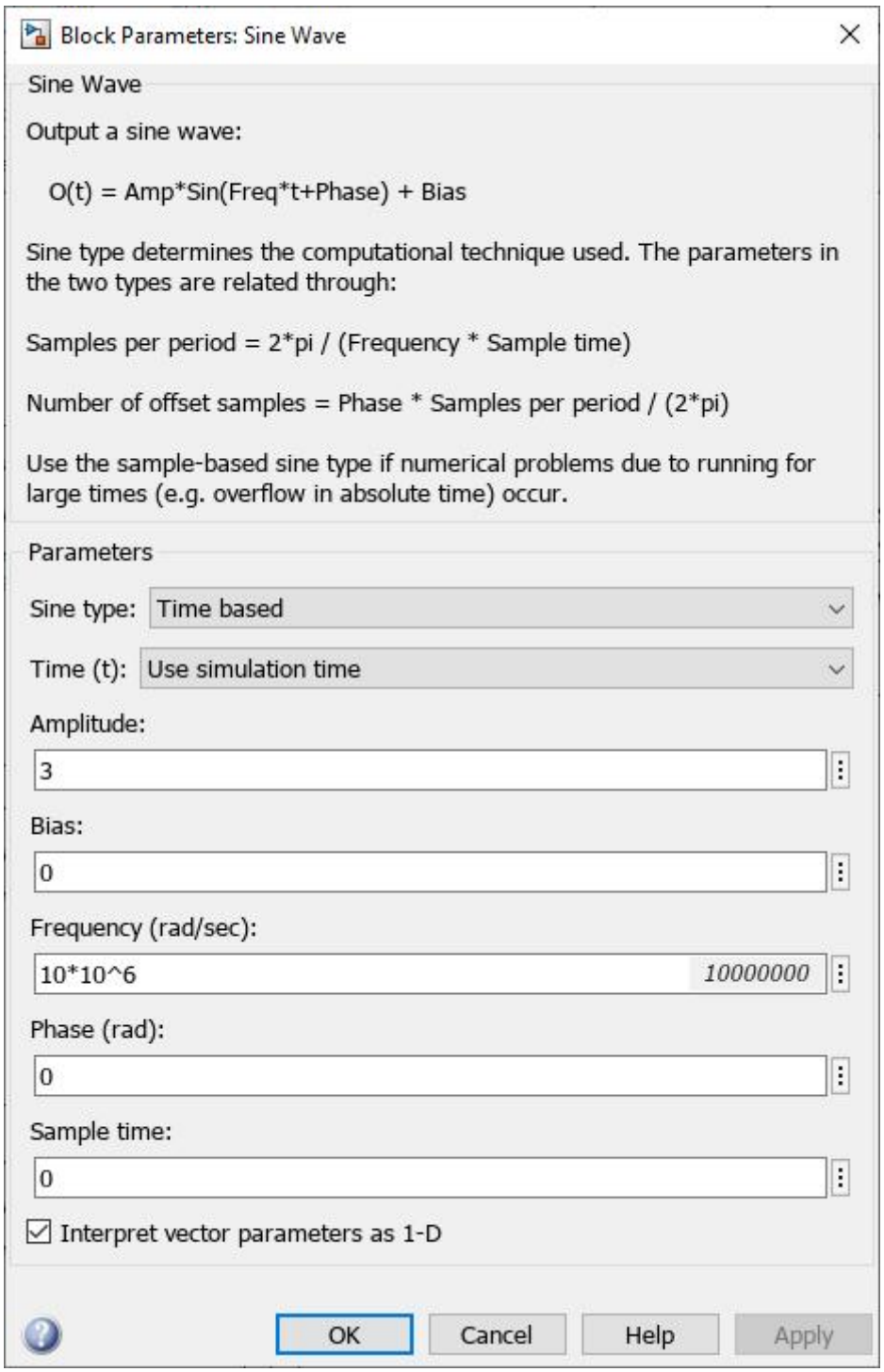
Настроим элемент «Repeating Sequence1», являющийся каналом №3:

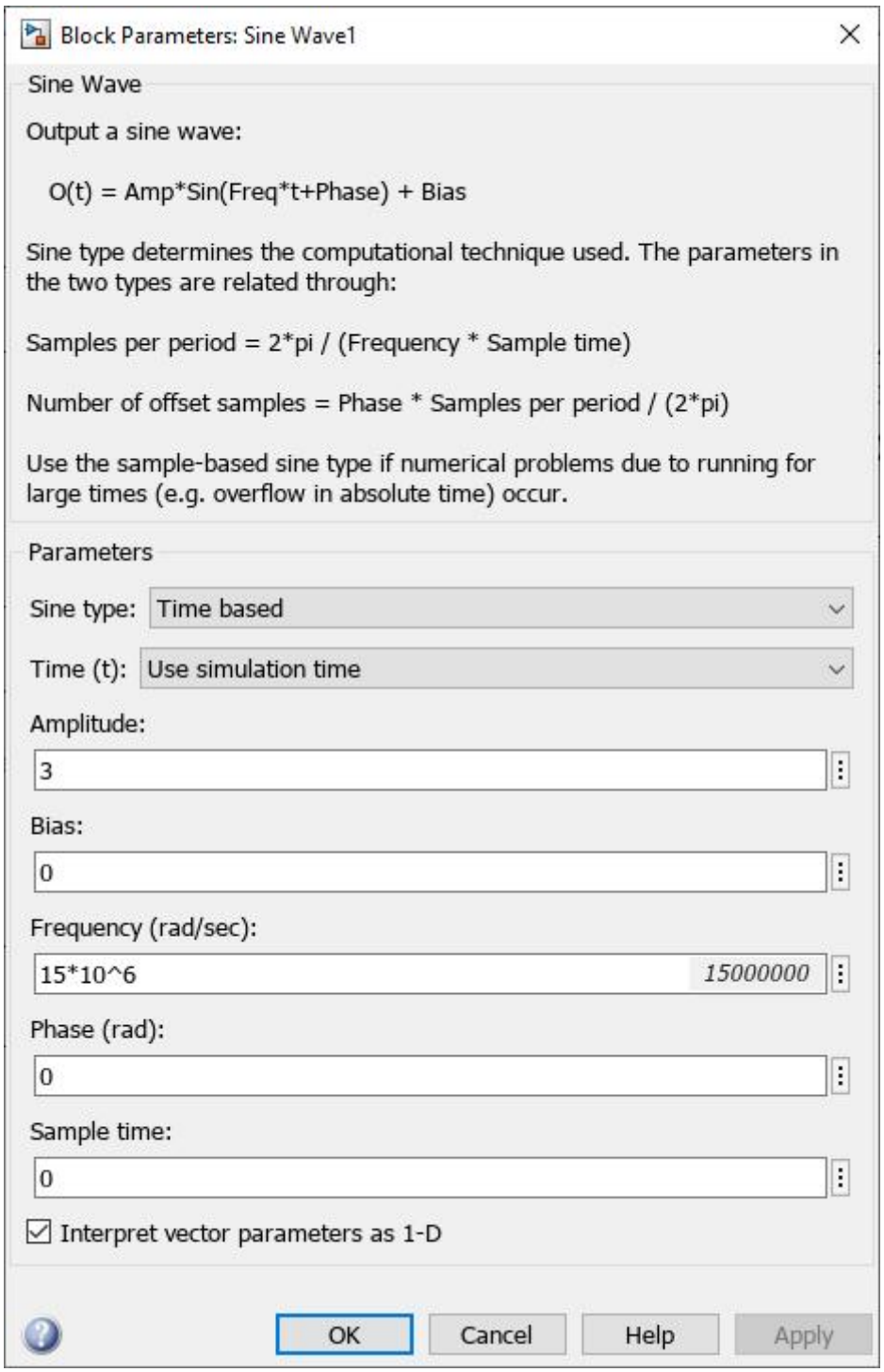


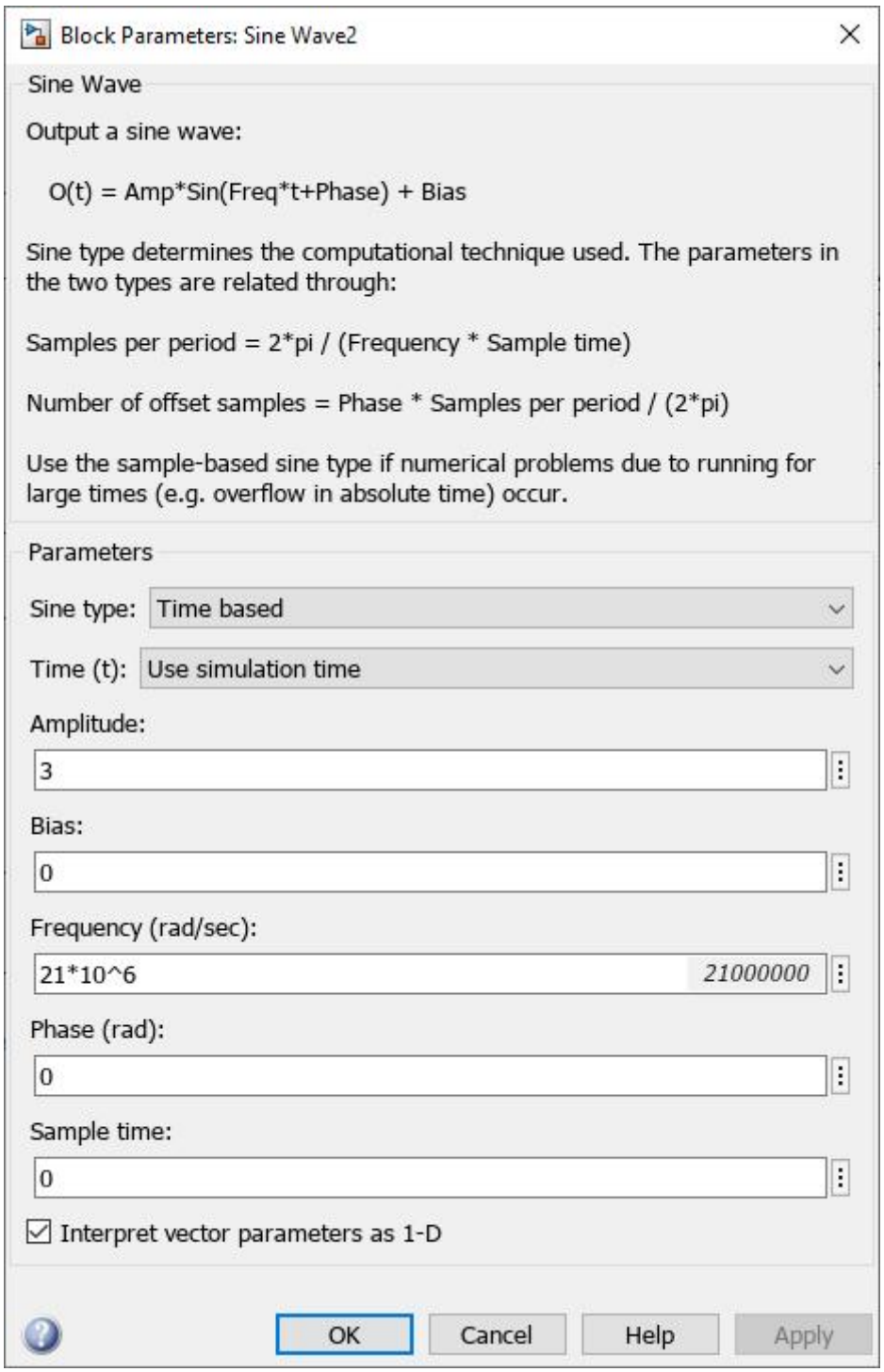
Установим на элементах «Constant» такое значение, чтобы графики входных сигналов не перекрывали друг друга:

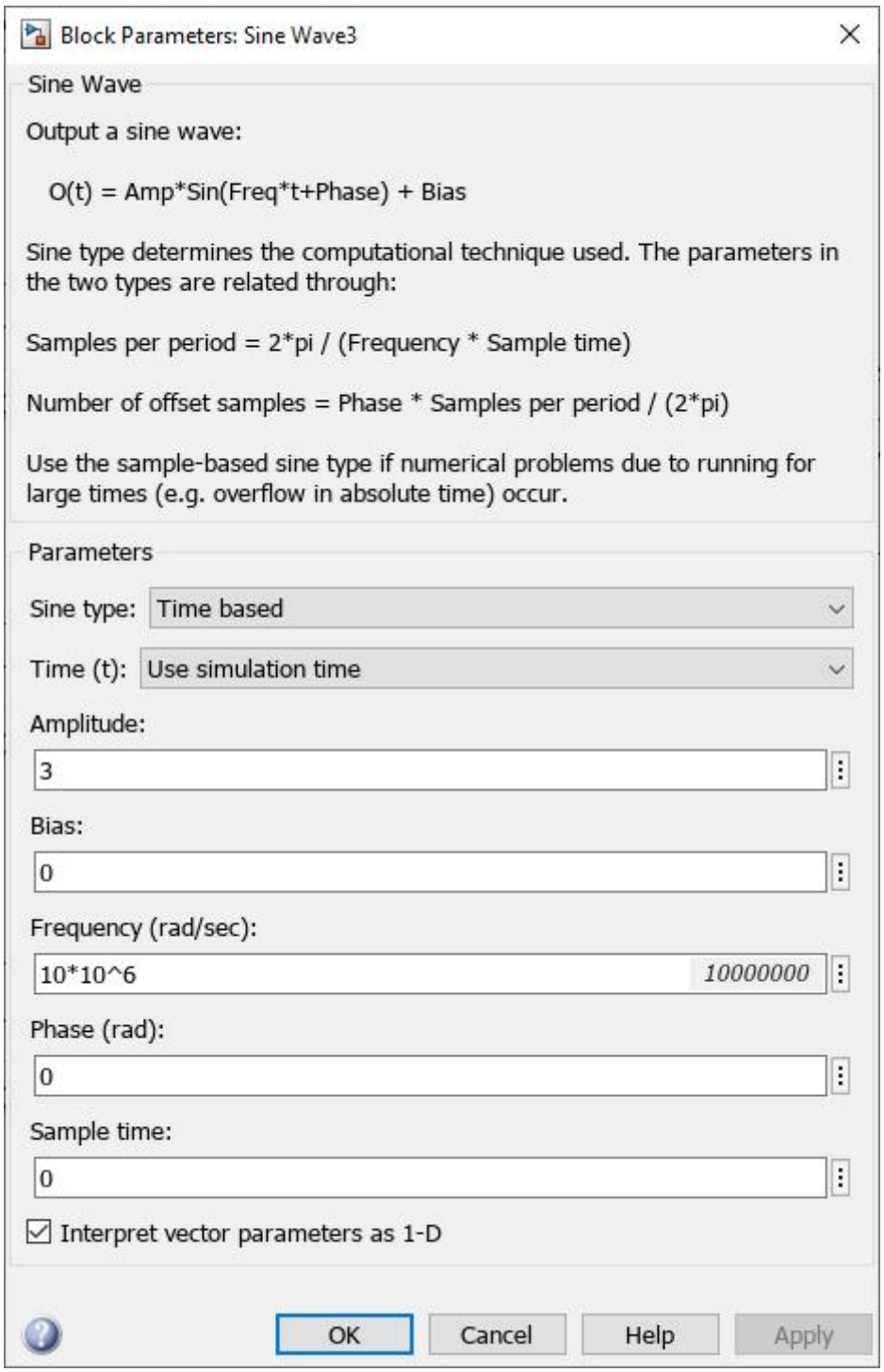


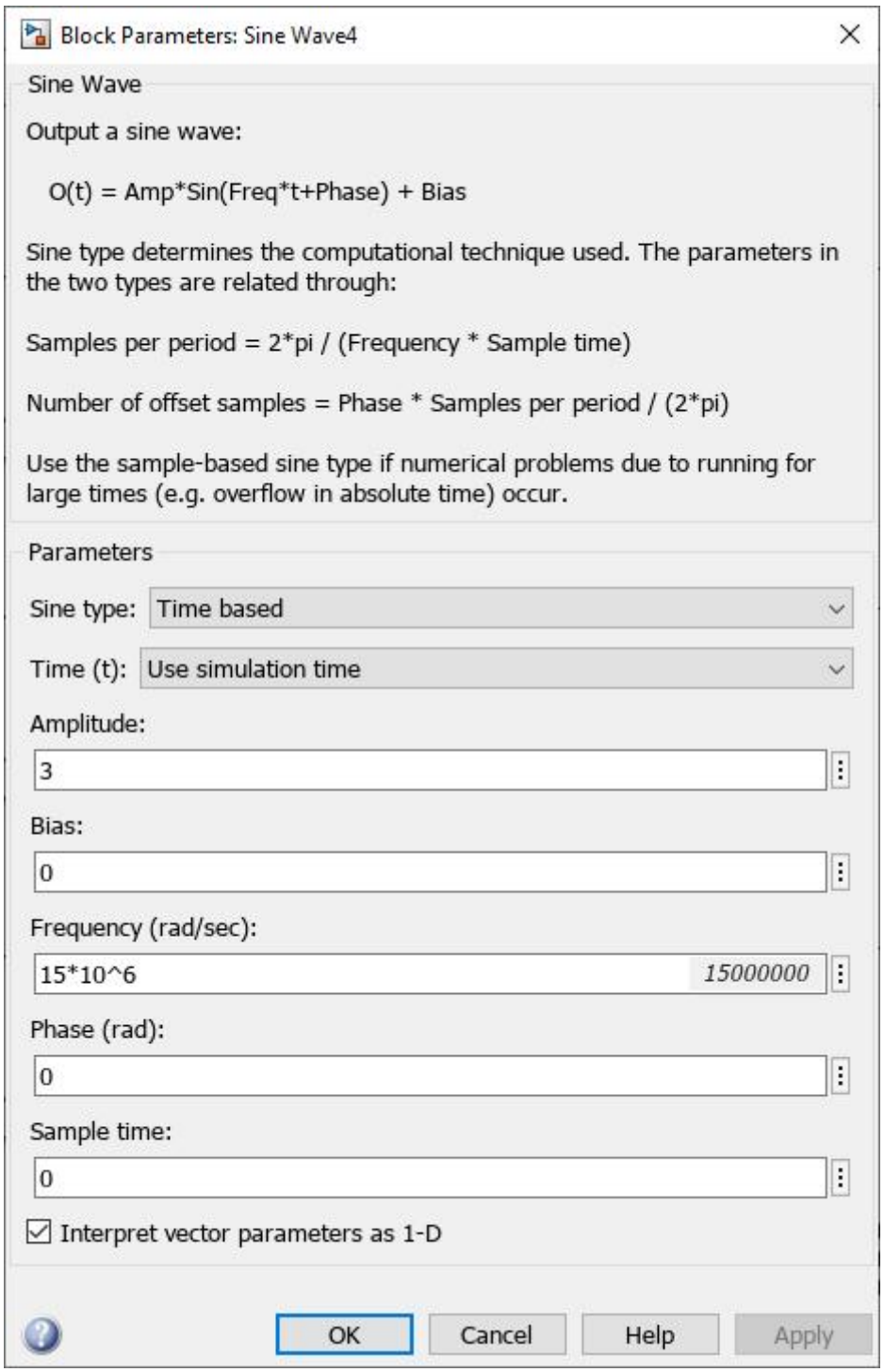
Настройка элементов «Sine Wave»:

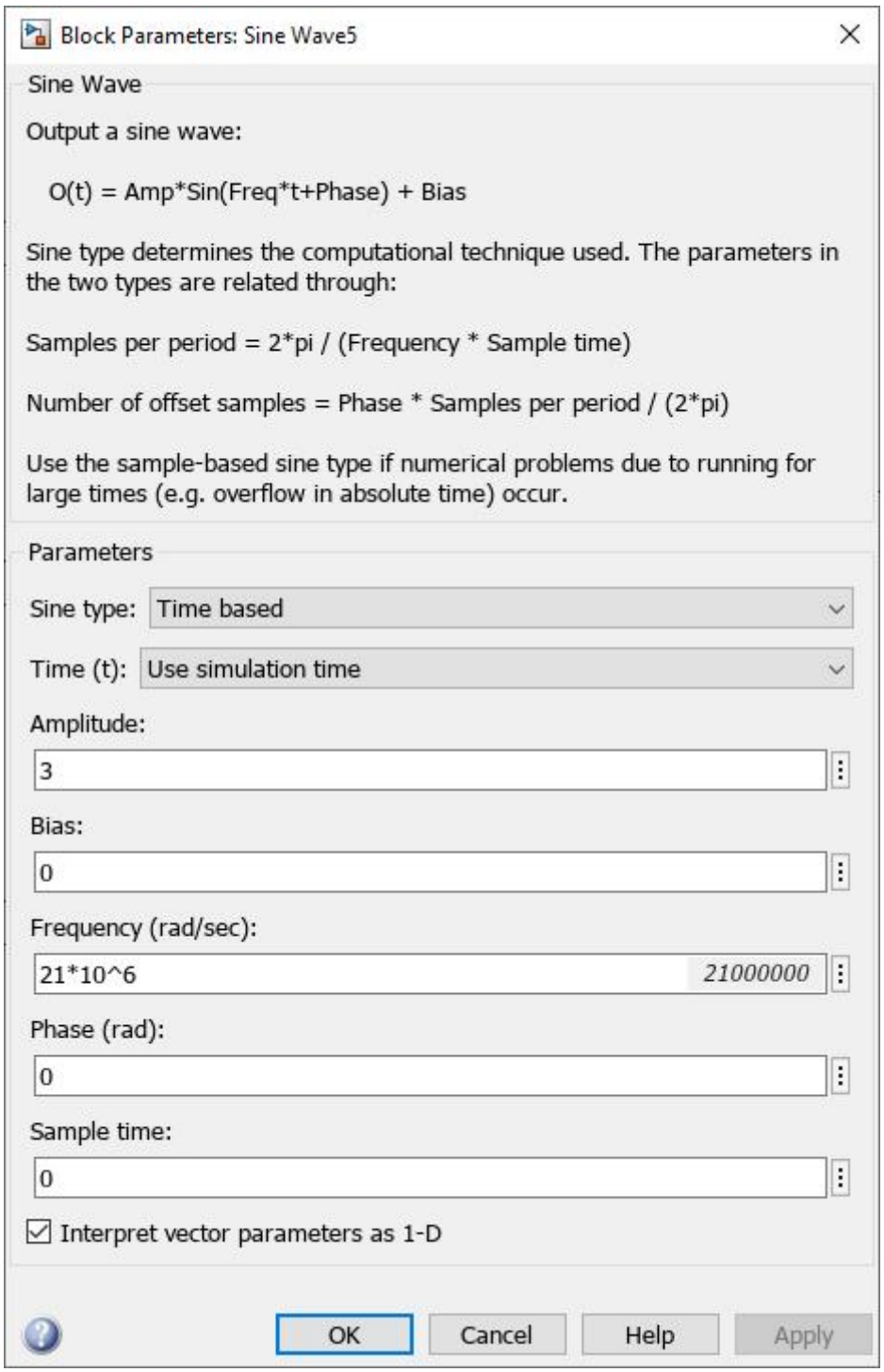

Block Parameters: Sine Wave
Sine Wave
Output a sine wave:
O(t) = Amp*Sin(Freq*t+Phase) + Bias
Sine type determines the computational technique used. The parameters in the two types are related through:
Samples per period = 2*pi / (Frequency * Sample time)
Number of offset samples = Phase * Samples per 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:
3
Bias:
0
Frequency (rad/sec):
10*10^6
10000000
Phase (rad):
0
Sample time:
0
Interpret vector parameters as 1-D
OK
Cancel
Help
Apply


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:
3
Bias:
0
Frequency (rad/sec):
15*10^6
15000000
Phase (rad):
0
Sample time:
0
Interpret vector parameters as 1-D
OK
Cancel
Help
Apply

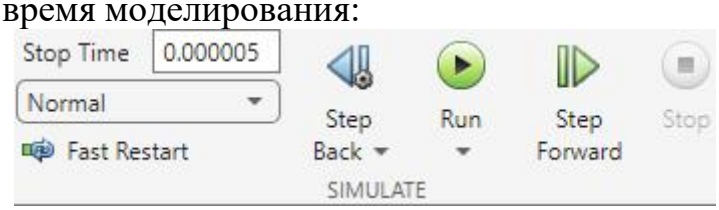

Block Parameters: Sine Wave2
Sine Wave
Output a sine wave:
O(t) = Amp*Sin(Freq*t+Phase) + Bias
Sine type determines the computational technique used. The parameters in the two types are related through:
Samples per period = 2*pi / (Frequency * Sample time)
Number of offset samples = Phase * Samples per 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:
3
Bias:
0
Frequency (rad/sec):
21*10^6
21000000
Phase (rad):
0
Sample time:
0
Interpret vector parameters as 1-D
OK
Cancel
Help
Apply


Block Parameters: Sine Wave3
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:
3
Bias:
0
Frequency (rad/sec):
10*10^6
10000000
Phase (rad):
0
Sample time:
0
Interpret vector parameters as 1-D
OK
Cancel
Help
Apply

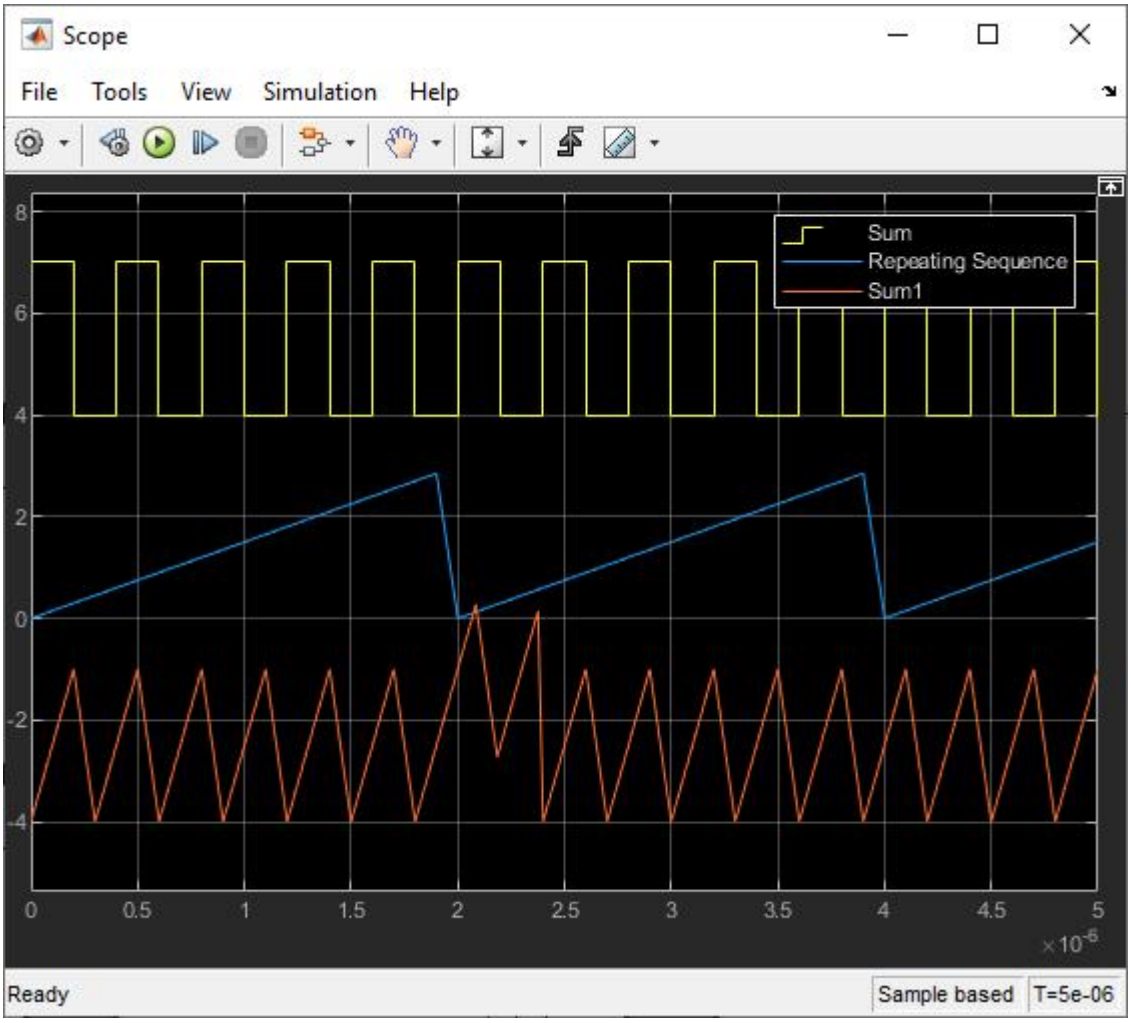

Block Parameters: Sine Wave4
Sine Wave
Output a sine wave:
O(t) = Amp*Sin(Freq*t+Phase) + Bias
Sine type determines the computational technique used. The parameters in the two types are related through:
Samples per period = 2*pi / (Frequency * Sample time)
Number of offset samples = Phase * Samples per 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:
3
Bias:
0
Frequency (rad/sec):
15*10^6
15000000
Phase (rad):
0
Sample time:
0
Interpret vector parameters as 1-D
OK
Cancel
Help
Apply

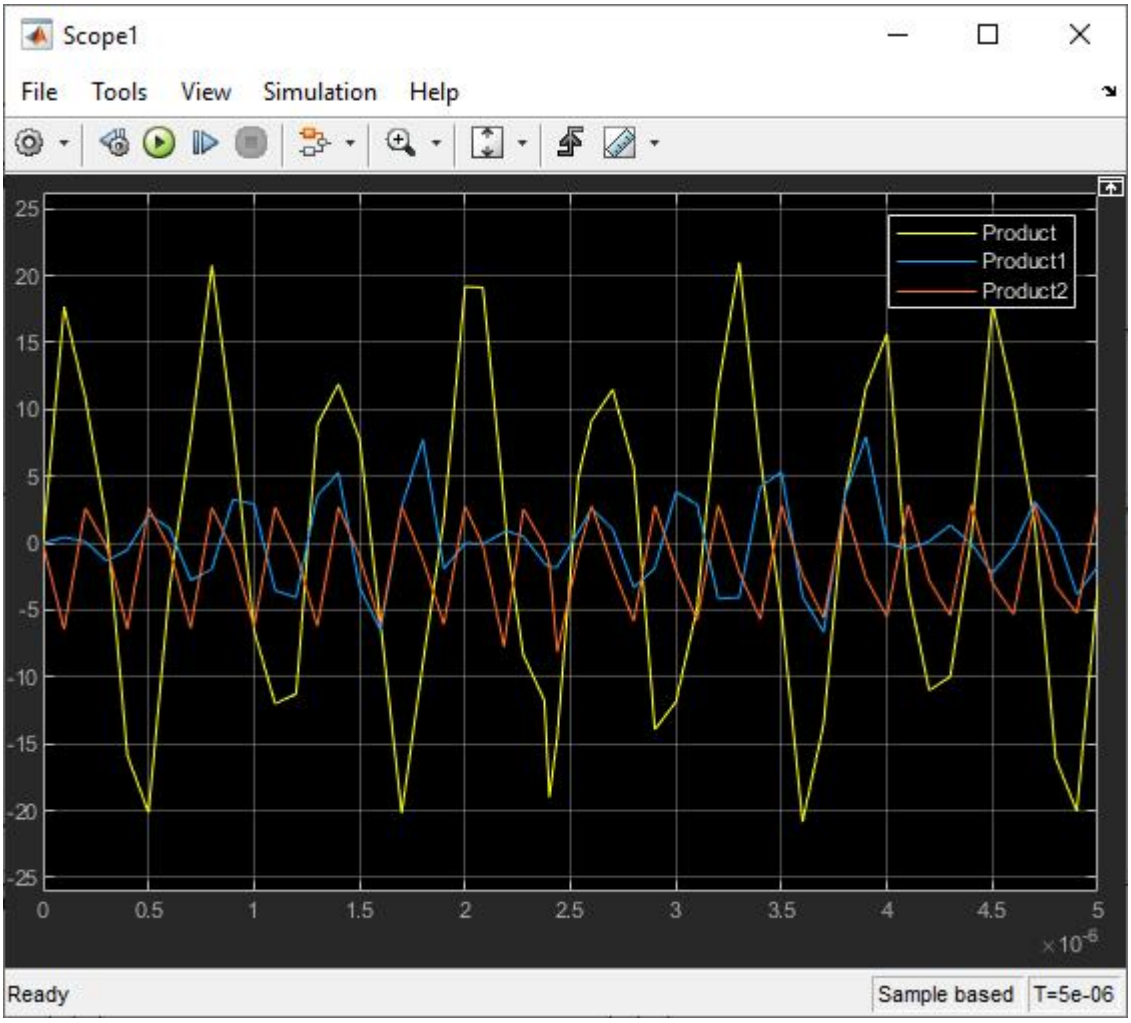


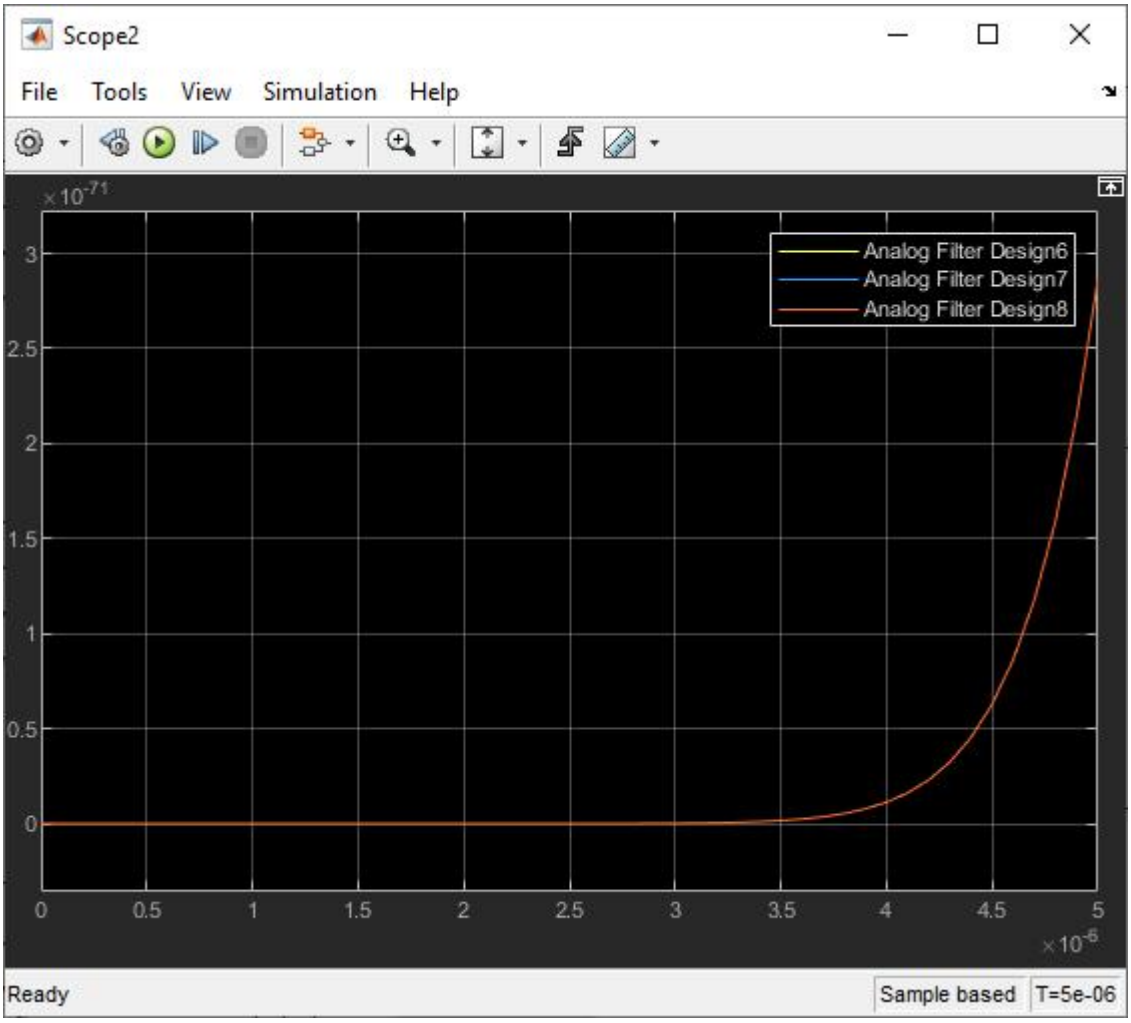
Настроим время моделирования:

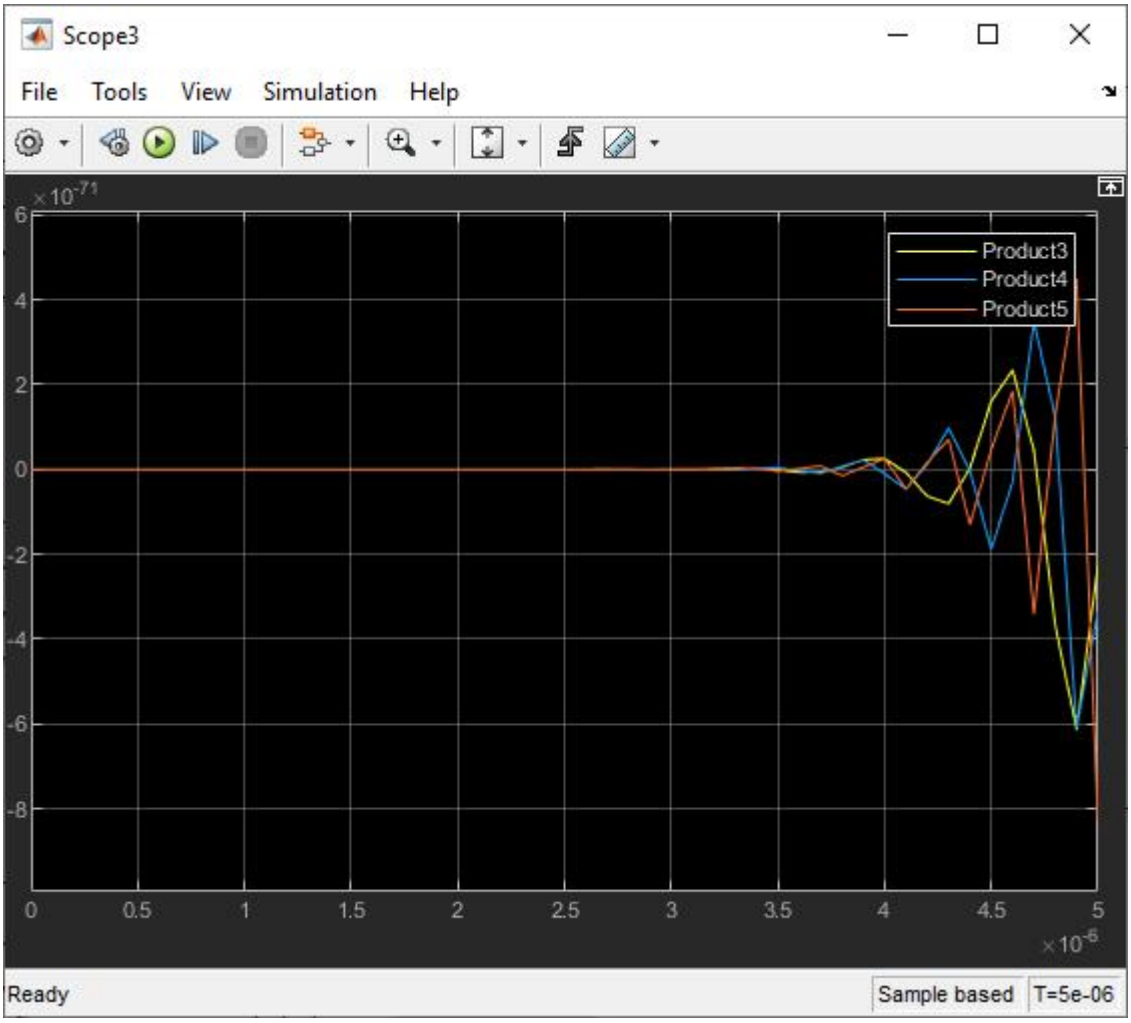


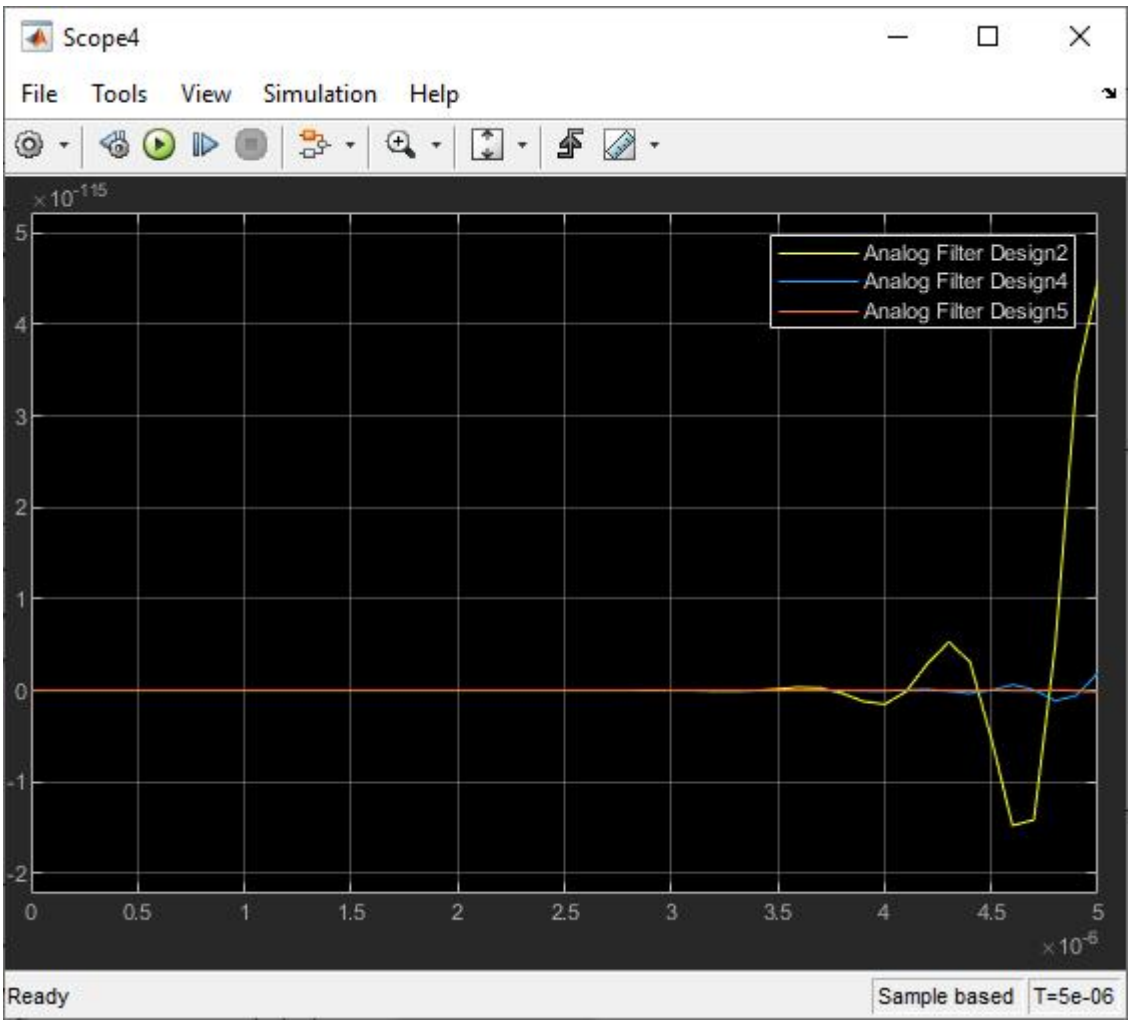
Запустим процесс моделирования и зарисуем осциллограммы сигналов с осциллографов, располагая их друг под другом:


Scope
File
Tools
View
Simulation
Help
Sum
Repeating Sequence
Sum1
8
6
4
2
0
-2
-4
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5
×10^-6
Ready
Sample based
T=5e-06


Scope1
File
Tools
View
Simulation
Help
Product
Product1
Product2
25
20
15
10
5
0
-5
-10
-15
-20
-25
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5
×10^-6
Ready
Sample based
T=5e-06

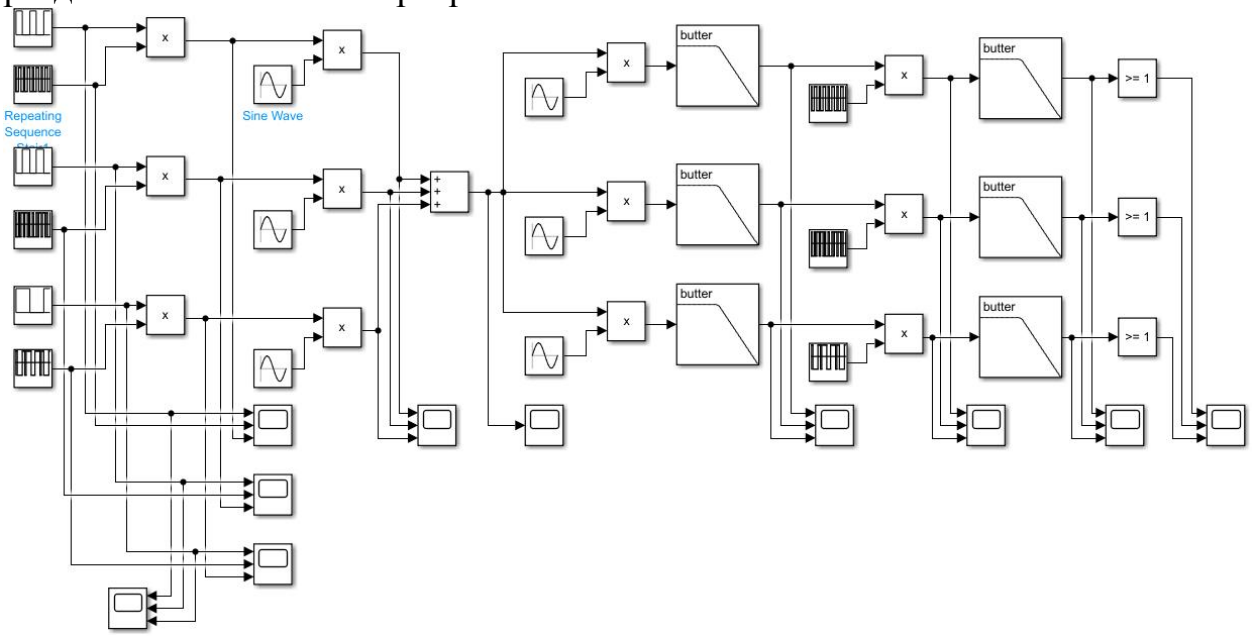

Scope2
File
Tools
View
Simulation
Help
×10^-71
3
2.5
2
1.5
1
0.5
0
Analog Filter Design6
Analog Filter Design7
Analog Filter Design8
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5
×10^-6
Ready
Sample based
T=5e-06


Scope3
File
Tools
View
Simulation
Help
×10^-71
6
4
2
0
-2
-4
-6
-8
Product3
Product4
Product5
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5
×10^-6
Ready
Sample based
T=5e-06



Моделирование многоканальных систем связи с кодовым разделением каналов

Соберём модель многоканальной системы связи с кодовым разделением каналов в программном пакете MATLAB Simulink:

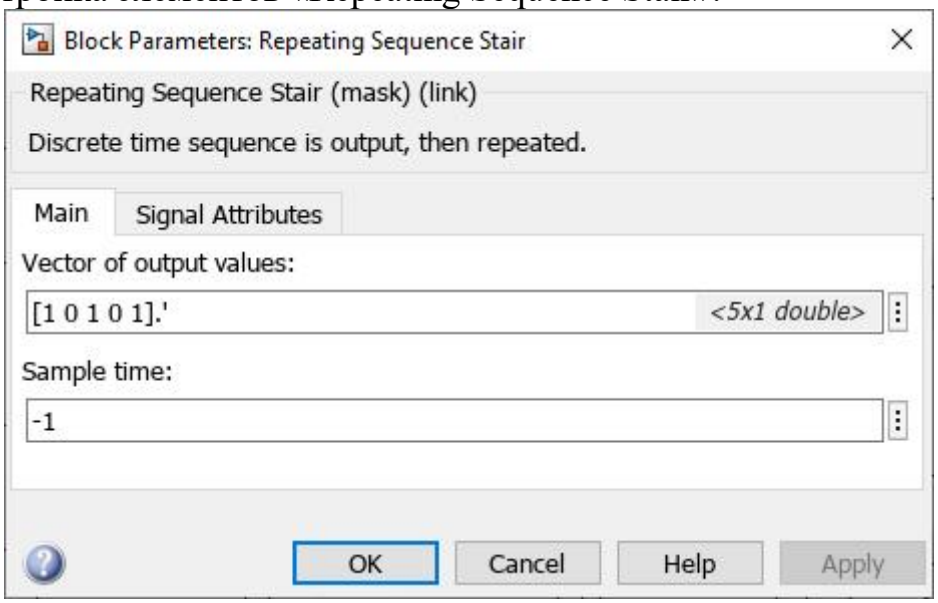


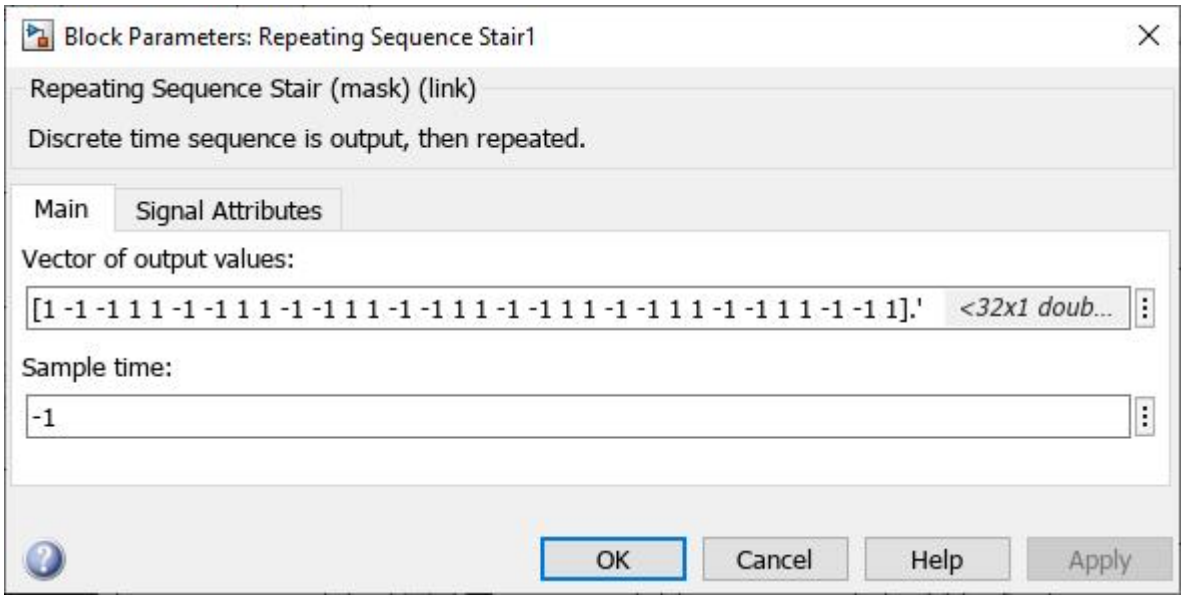
Настроим параметры элементов схемы, основываясь на приведённой в документе с заданием системе кодов Уолша, а также на данных таблицы 1 из этого же документа в соответствии с вариантом (9).

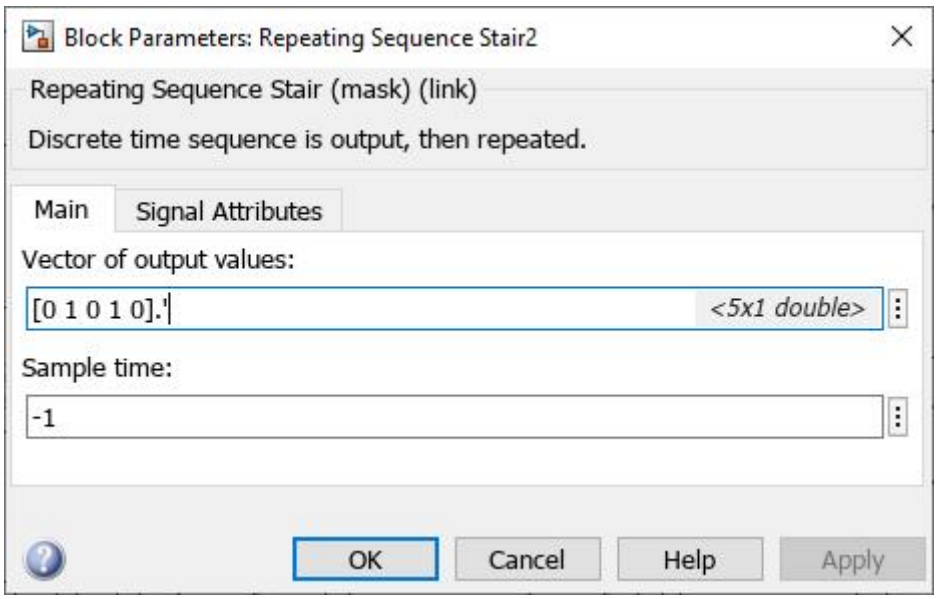
Часть таблицы 1 с нашим вариантом:

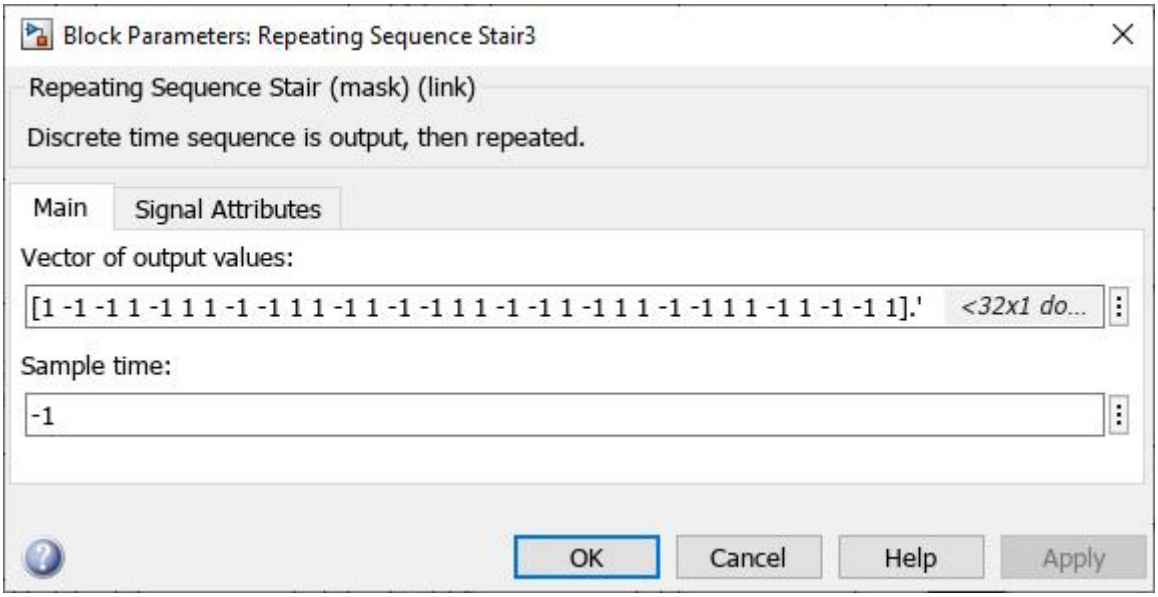
№ варианта	Канал 1	Канал 2	Канал 3
9	10101	01010	11001

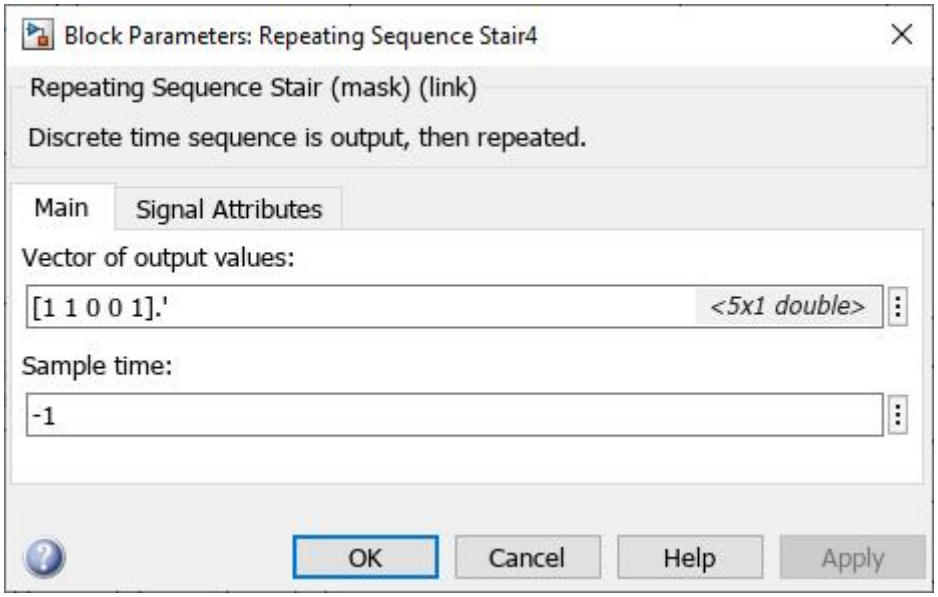
Настройка элементов «Repeating Sequence Stair»:

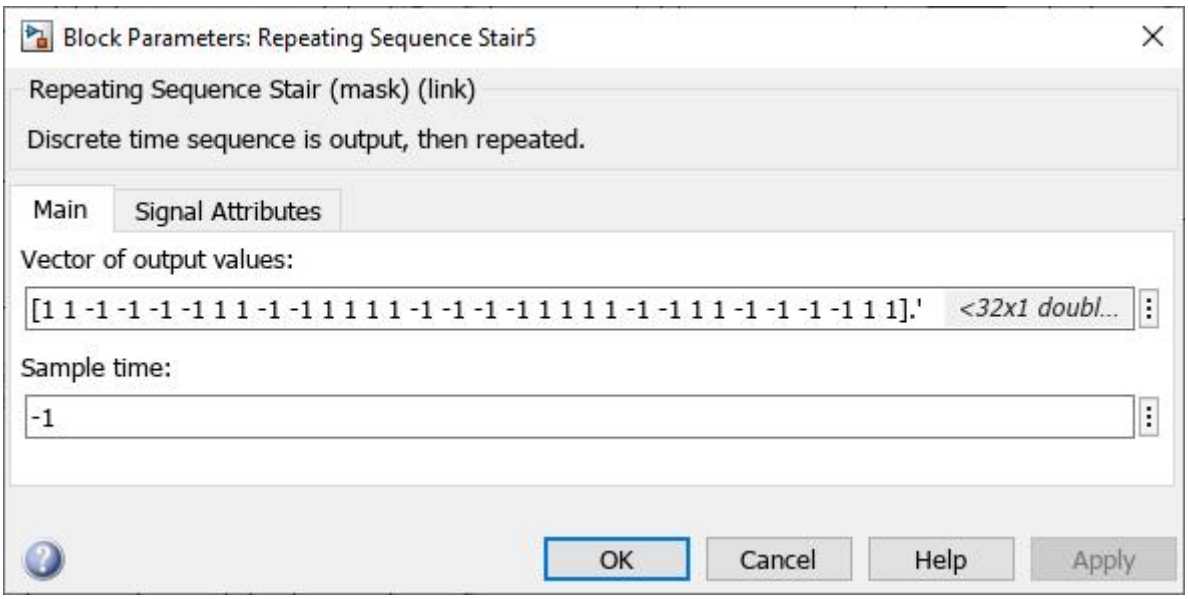


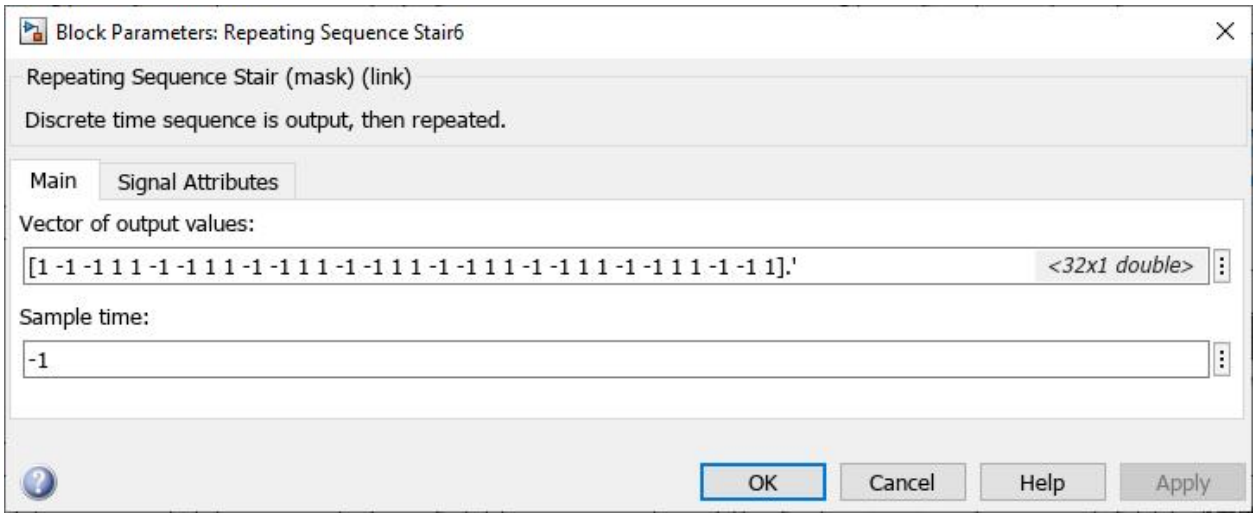


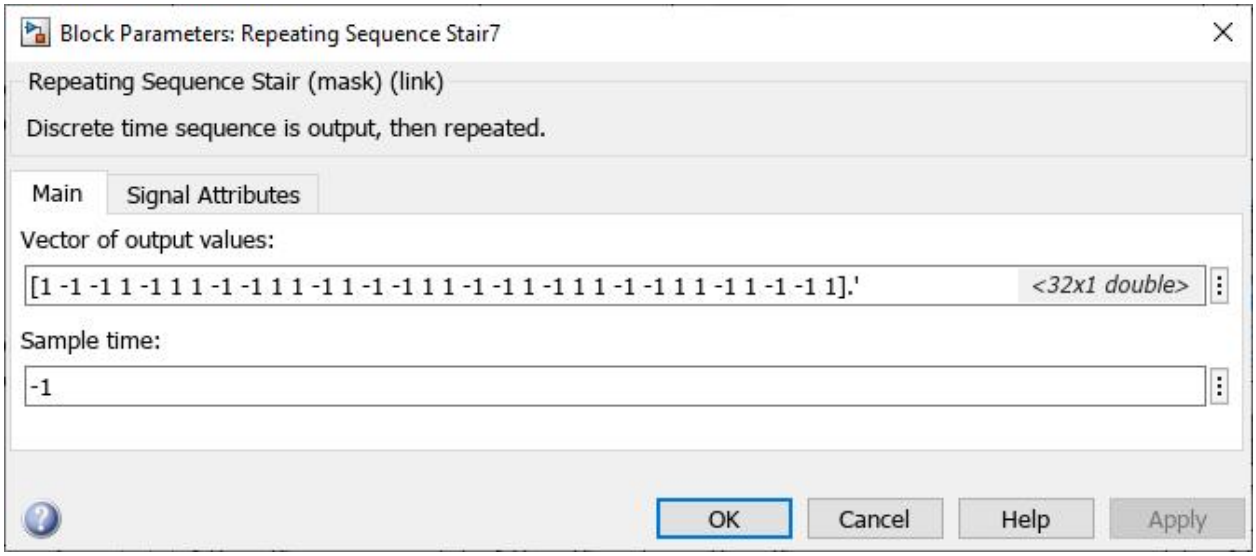

Block Parameters: Repeating Sequence Stair2
Repeating Sequence Stair (mask) (link)
Discrete time sequence is output, then repeated.
Main
Signal Attributes
Vector of output values:
[0 1 0 1 0].'
<5x1 double>
Sample time:
-1
OK
Cancel
Help
Apply

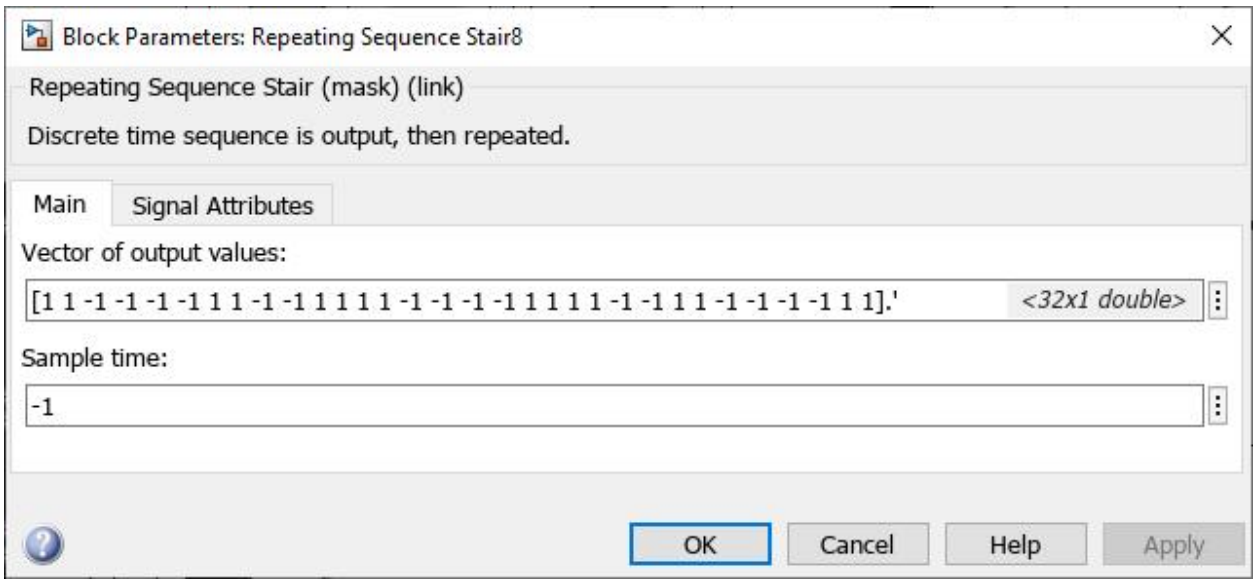

Block Parameters: Repeating Sequence Stair3
Repeating Sequence Stair (mask) (link)
Discrete time sequence is output, then repeated.
Main
Signal Attributes
Vector of output values:
[1 -1 -1 1 -1 1 1 -1 -1 1 1 -1 1 -1 -1 1 1 -1 -1 1 1 -1 -1 1 1 -1 -1 1 1 -1 1 -1 -1 1].'
<32x1 do...
Sample time:
-1
OK
Cancel
Help
Apply


Block Parameters: Repeating Sequence Stair4
Repeating Sequence Stair (mask) (link)
Discrete time sequence is output, then repeated.
Main
Signal Attributes
Vector of output values:
[1 1 0 0 1].'
<5x1 double>
Sample time:
-1
OK
Cancel
Help
Apply

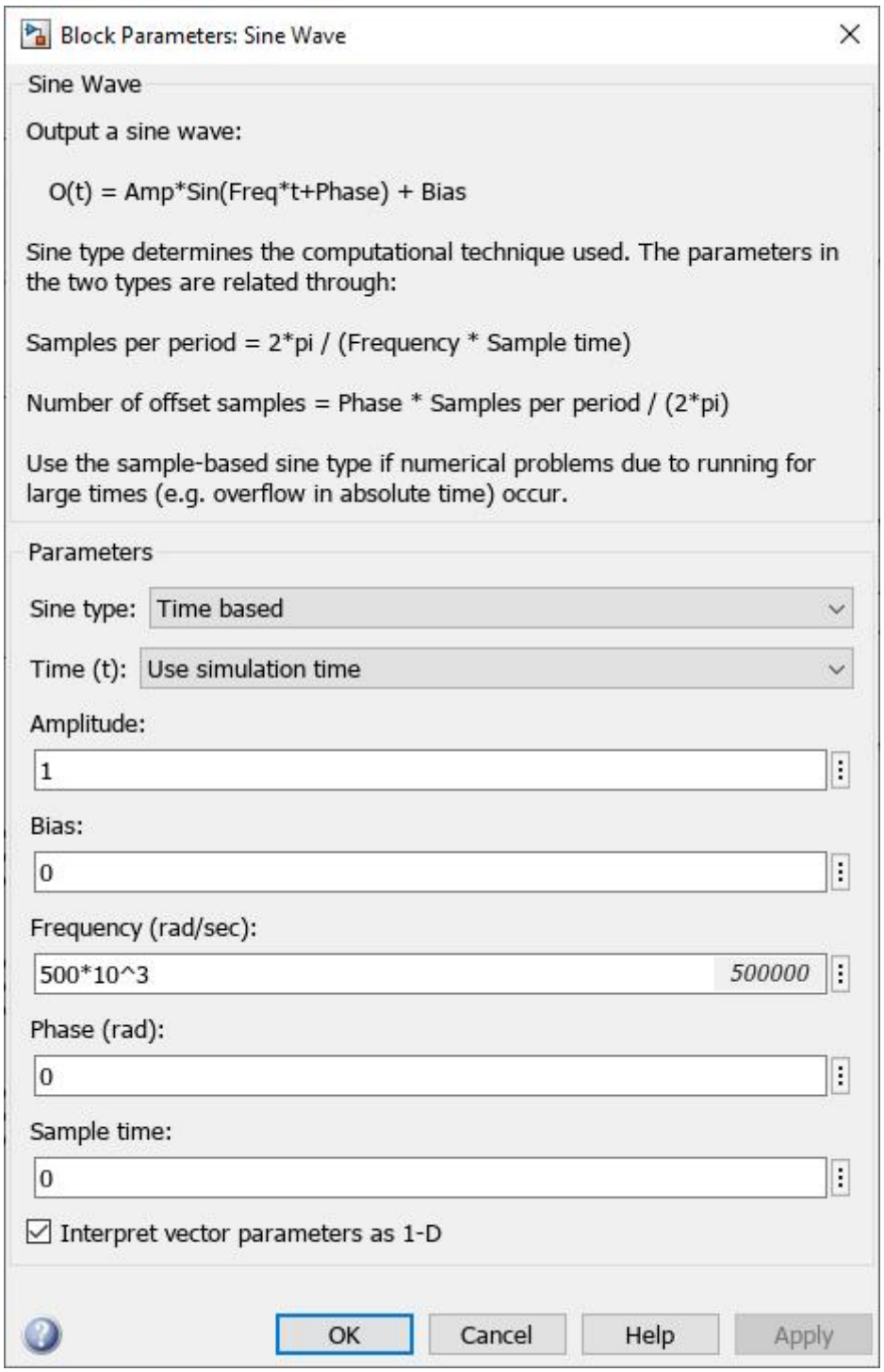

Block Parameters: Repeating Sequence Stair5
Repeating Sequence Stair (mask) (link)
Discrete time sequence is output, then repeated.
Main
Signal Attributes
Vector of output values:
[1 1 -1 -1 -1 -1 1 1 -1 -1 1 1 1 1 -1 -1 -1 -1 1 1 1 1 -1 -1 1 1 -1 -1 -1 -1 1 1].'
<32x1 doubl...
Sample time:
-1
OK
Cancel
Help
Apply

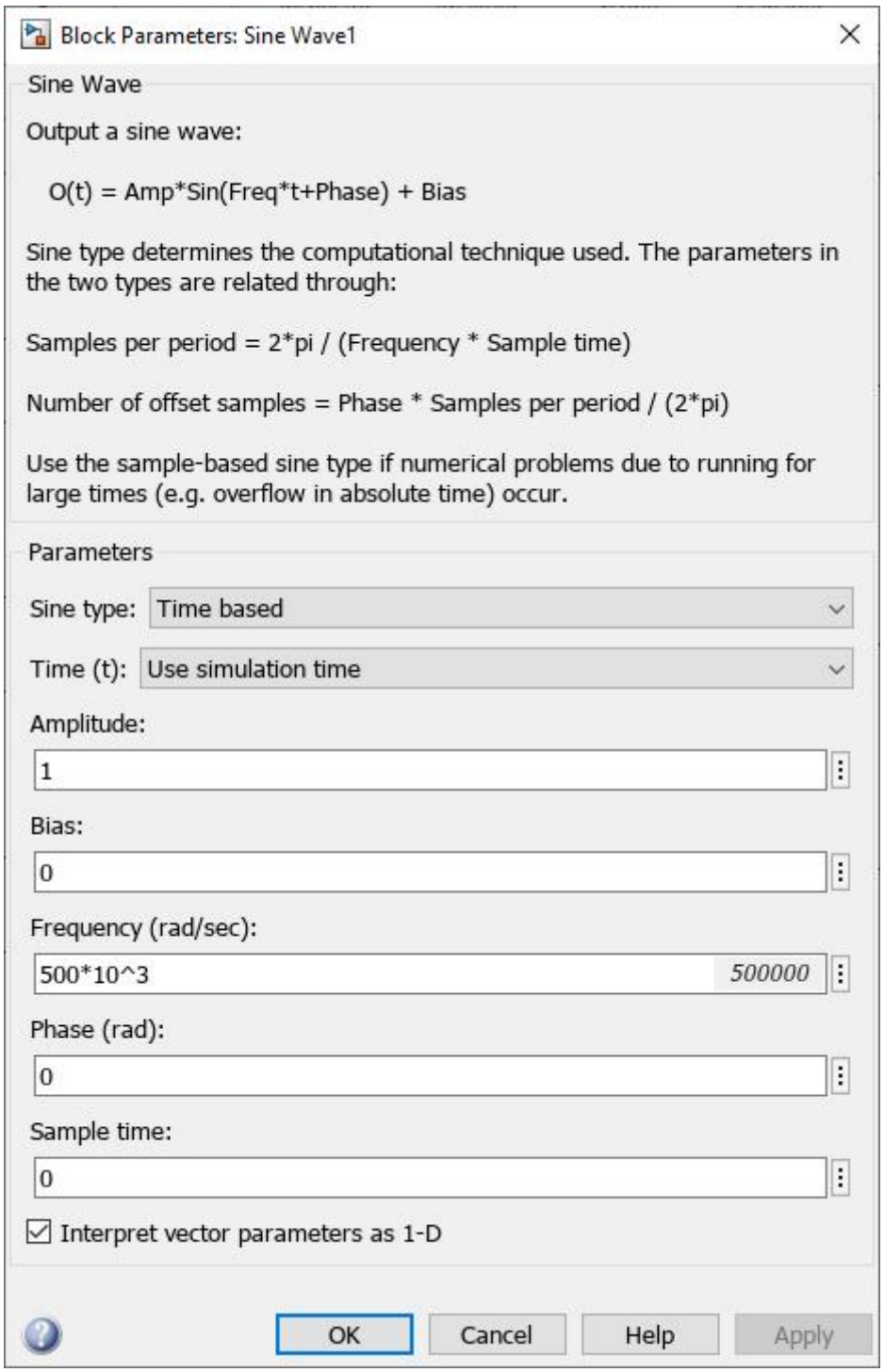

Block Parameters: Repeating Sequence Stair6
Repeating Sequence Stair (mask) (link)
Discrete time sequence is output, then repeated.
Main
Signal Attributes
Vector of output values:
[1 -1 -1 1 1 -1 -1 1 1 -1 -1 1 1 -1 -1 1 1 -1 -1 1 1 -1 -1 1 1 -1 -1 1 1 -1 -1 1].'
<32x1 double>
Sample time:
-1
OK
Cancel
Help
Apply

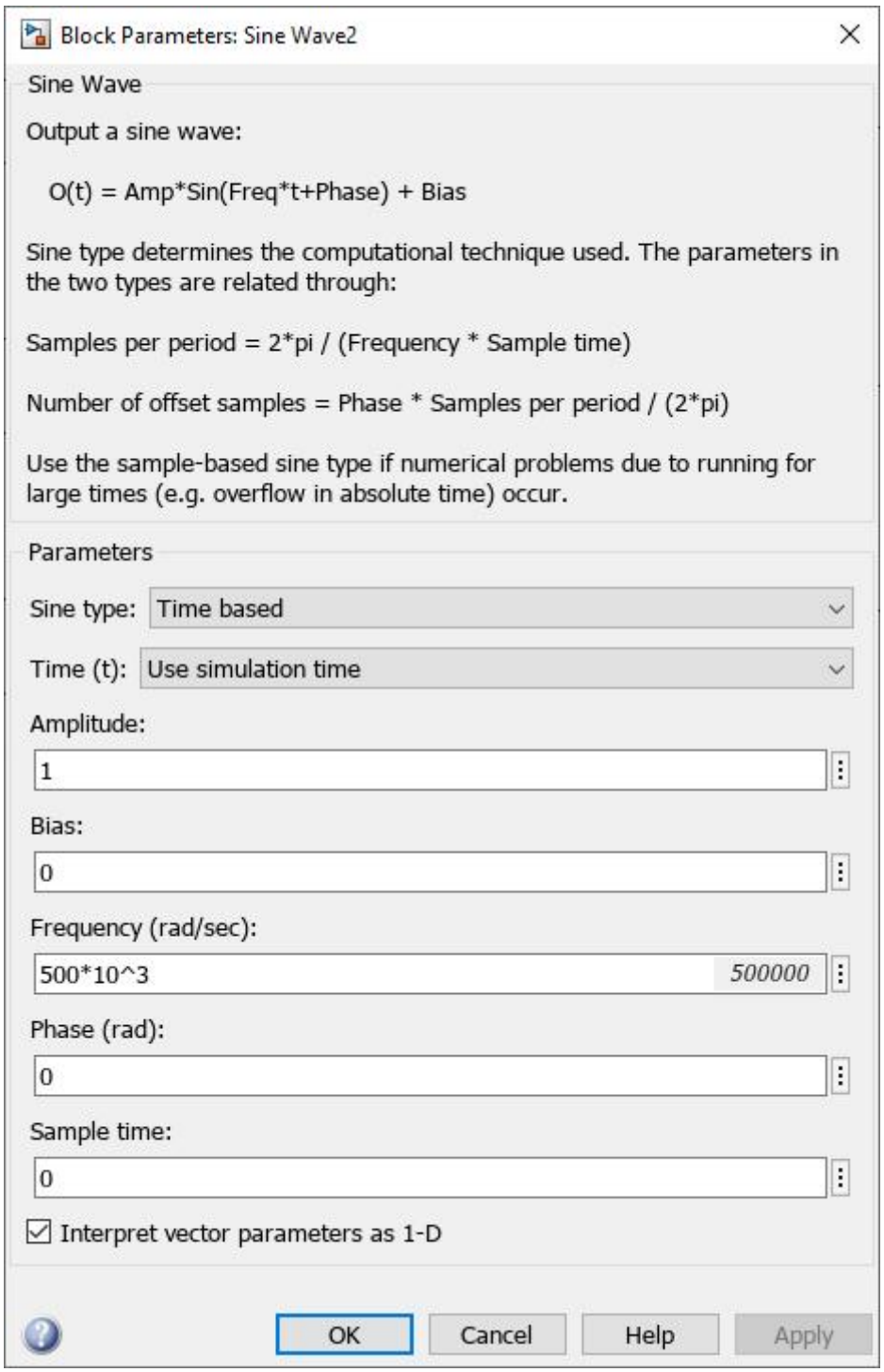

Block Parameters: Repeating Sequence Stair7
Repeating Sequence Stair (mask) (link)
Discrete time sequence is output, then repeated.
Main
Signal Attributes
Vector of output values:
[1 -1 -1 1 -1 1 1 -1 -1 1 1 -1 1 -1 -1 1 1 -1 -1 1 -1 1 1 -1 1 -1 -1 1 1 -1 1 1 -1 1 -1 -1 1].'
<32x1 double>
Sample time:
-1
OK
Cancel
Help
Apply

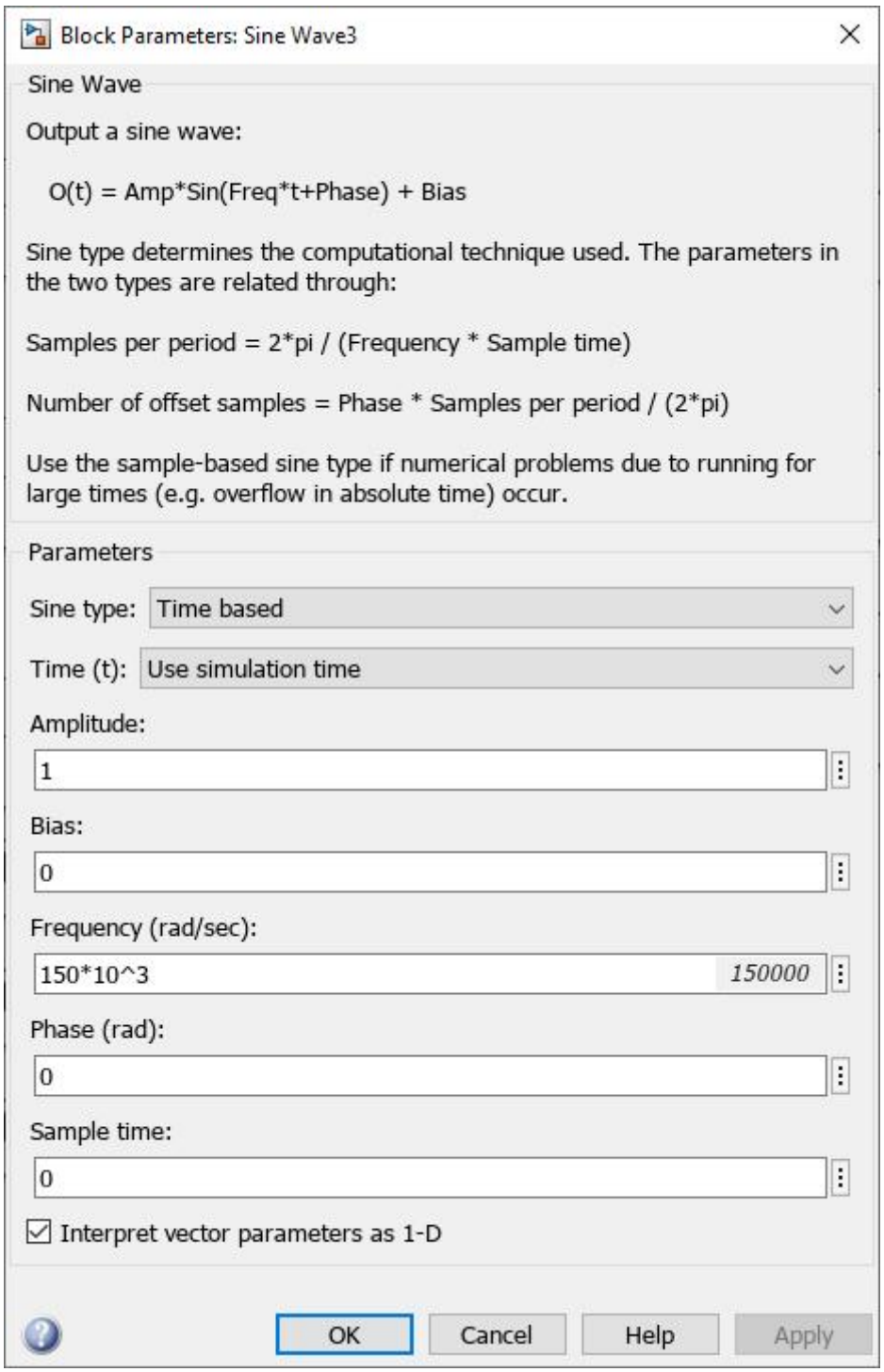


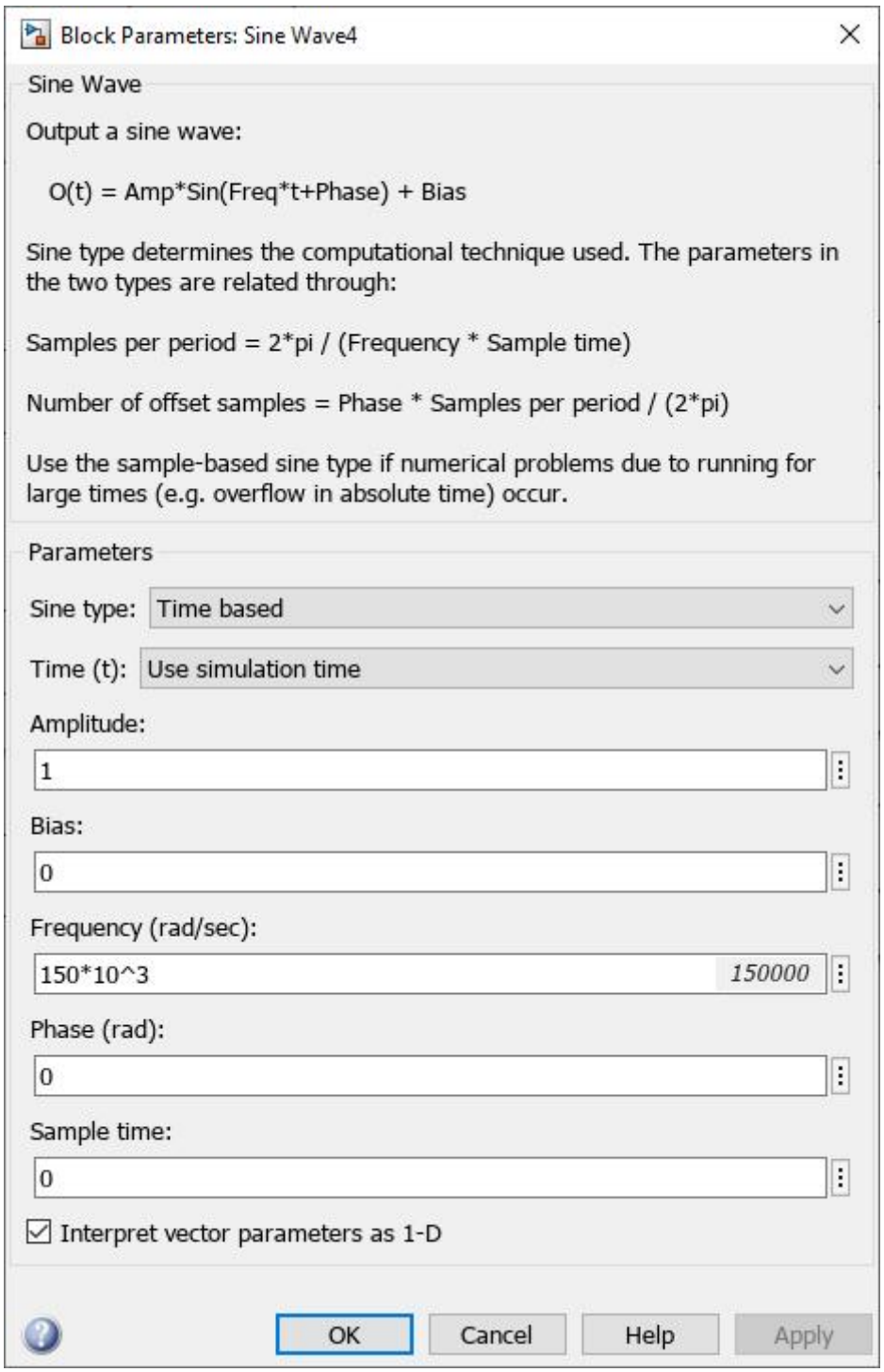
Настройка элементов «Sine Wave»:

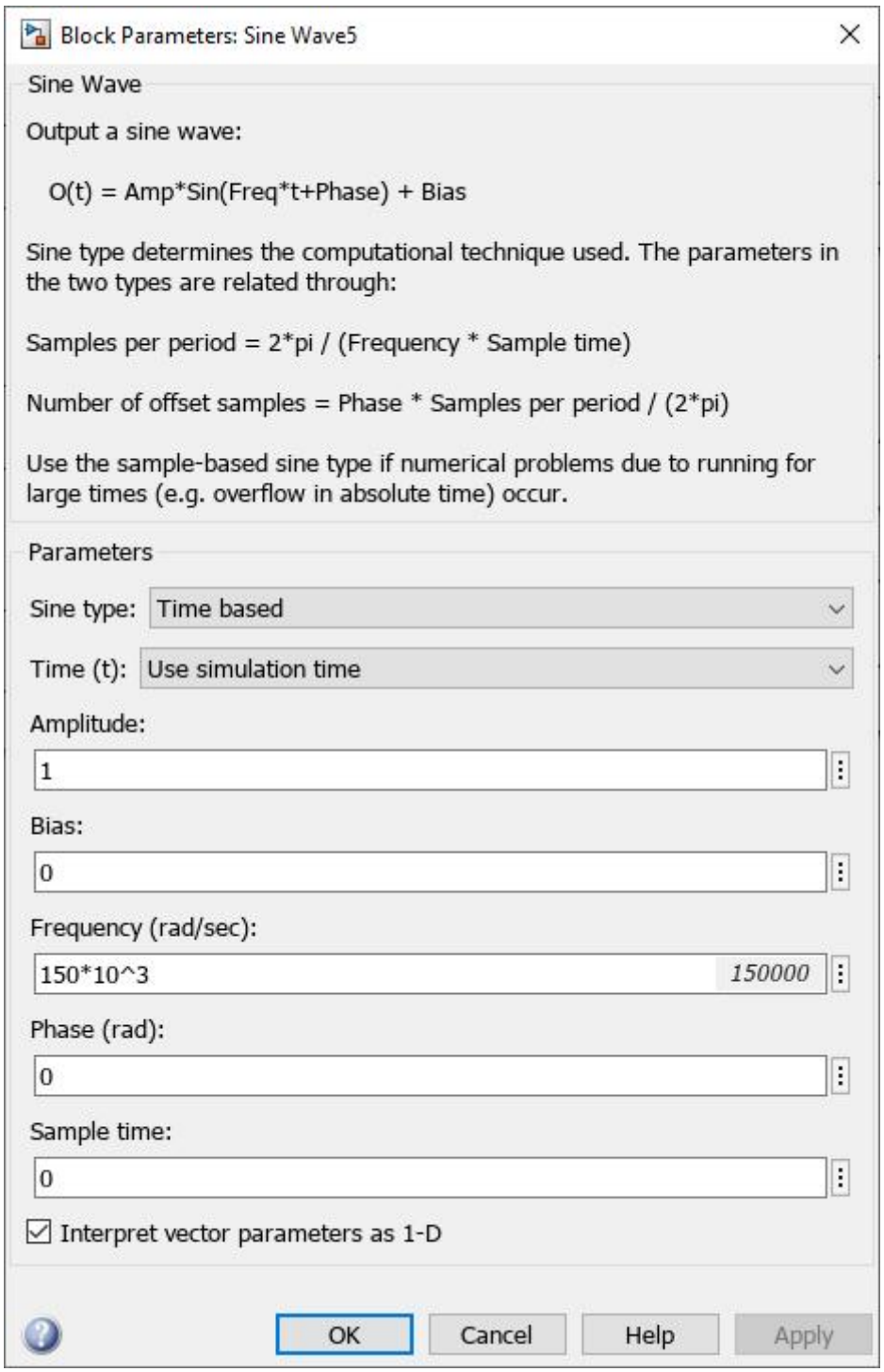

Block Parameters: Sine Wave
Sine Wave
Output a sine wave:
O(t) = Amp*Sin(Freq*t+Phase) + Bias
Sine type determines the computational technique used. The parameters in the two types are related through:
Samples per period = 2*pi / (Frequency * Sample time)
Number of offset samples = Phase * Samples per 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:
1
Bias:
0
Frequency (rad/sec):
500*10^3
500000
Phase (rad):
0
Sample time:
0
Interpret vector parameters as 1-D
OK
Cancel
Help
Apply


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:
1
Bias:
0
Frequency (rad/sec):
500*10^3
500000
Phase (rad):
0
Sample time:
0
Interpret vector parameters as 1-D
OK
Cancel
Help
Apply

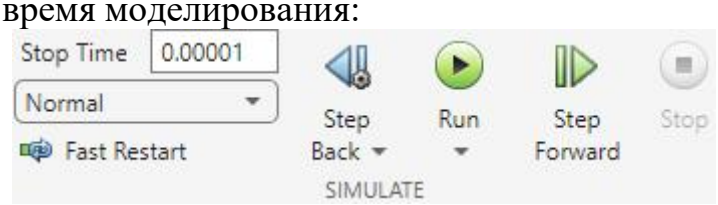

Block Parameters: Sine Wave2
Sine Wave
Output a sine wave:
O(t) = Amp*Sin(Freq*t+Phase) + Bias
Sine type determines the computational technique used. The parameters in the two types are related through:
Samples per period = 2*pi / (Frequency * Sample time)
Number of offset samples = Phase * Samples per 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:
1
Bias:
0
Frequency (rad/sec):
500*10^3
500000
Phase (rad):
0
Sample time:
0
Interpret vector parameters as 1-D
OK
Cancel
Help
Apply


Block Parameters: Sine Wave3
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:
1
Bias:
0
Frequency (rad/sec):
150*10^3
150000
Phase (rad):
0
Sample time:
0
Interpret vector parameters as 1-D
OK
Cancel
Help
Apply

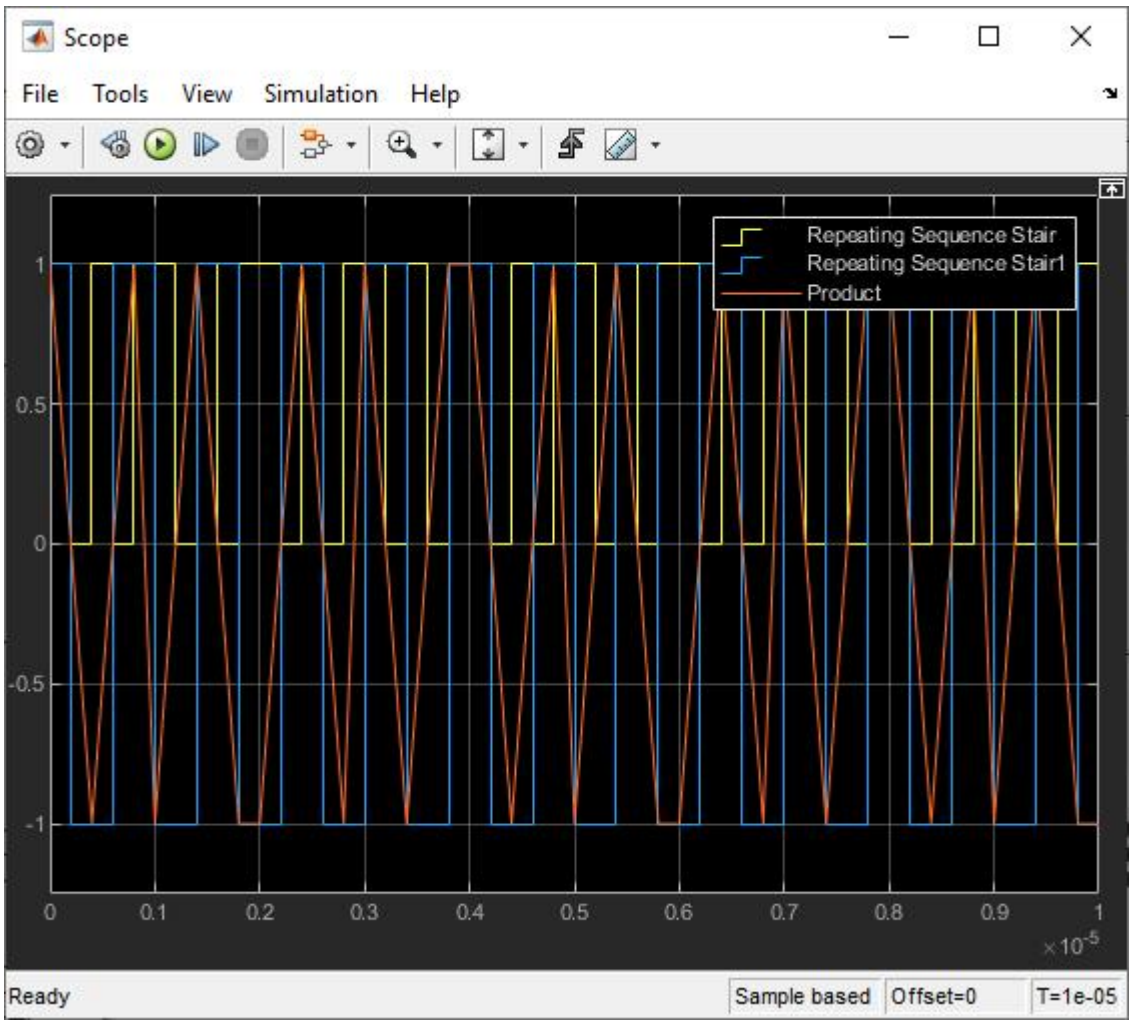

Block Parameters: Sine Wave4
Sine Wave
Output a sine wave:
O(t) = Amp*Sin(Freq*t+Phase) + Bias
Sine type determines the computational technique used. The parameters in the two types are related through:
Samples per period = 2*pi / (Frequency * Sample time)
Number of offset samples = Phase * Samples per 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:
1
Bias:
0
Frequency (rad/sec):
150*10^3
150000
Phase (rad):
0
Sample time:
0
Interpret vector parameters as 1-D
OK
Cancel
Help
Apply

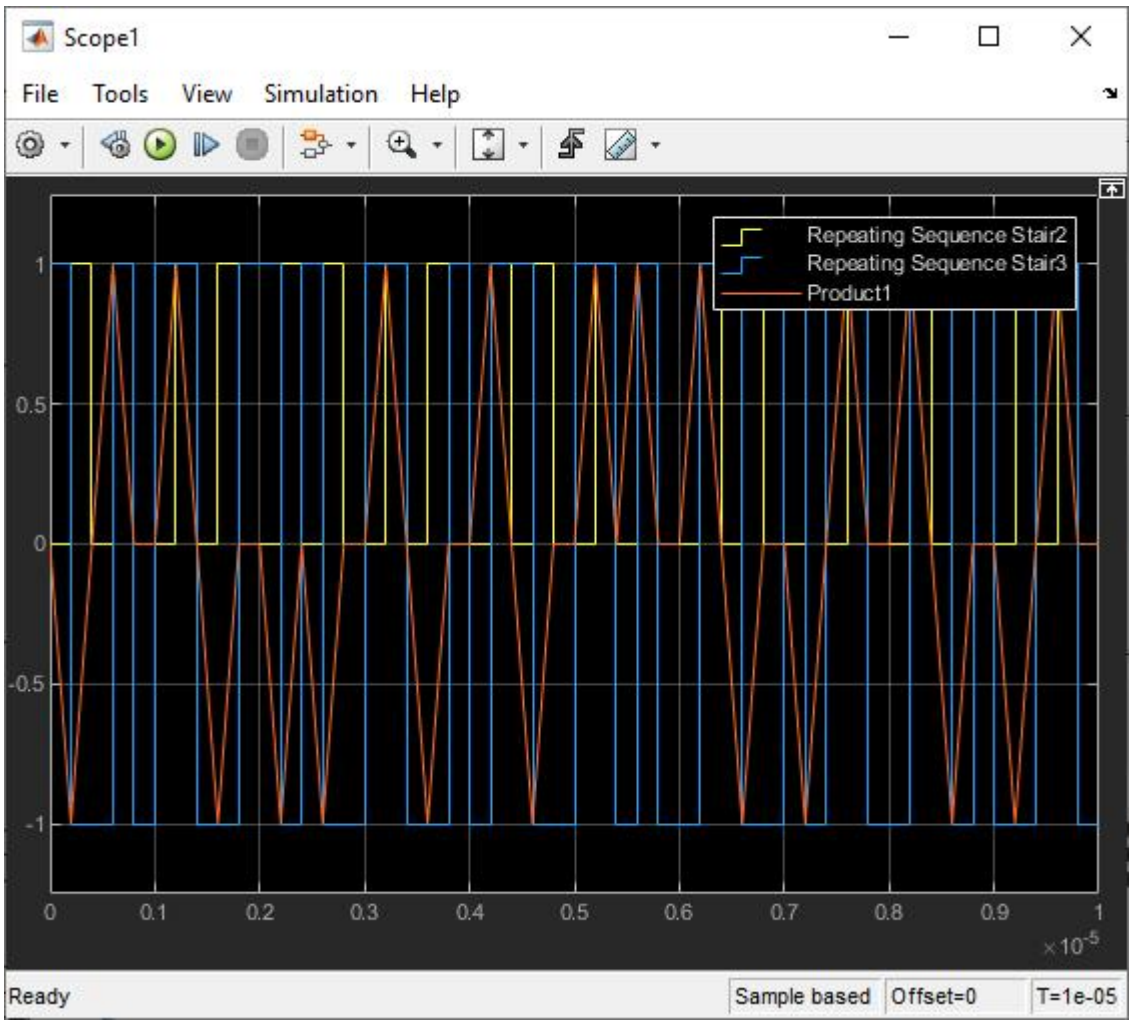


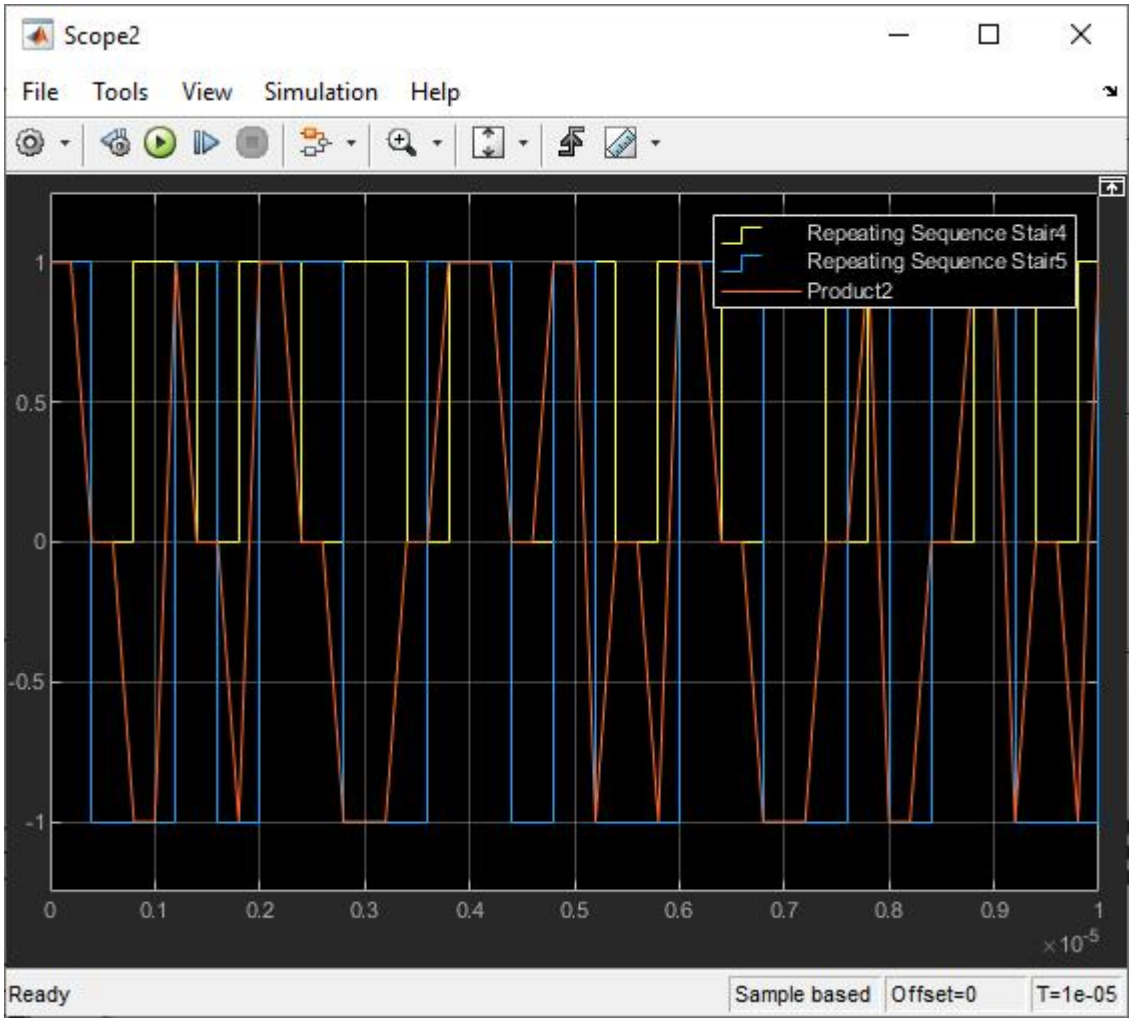
Настроим время моделирования:

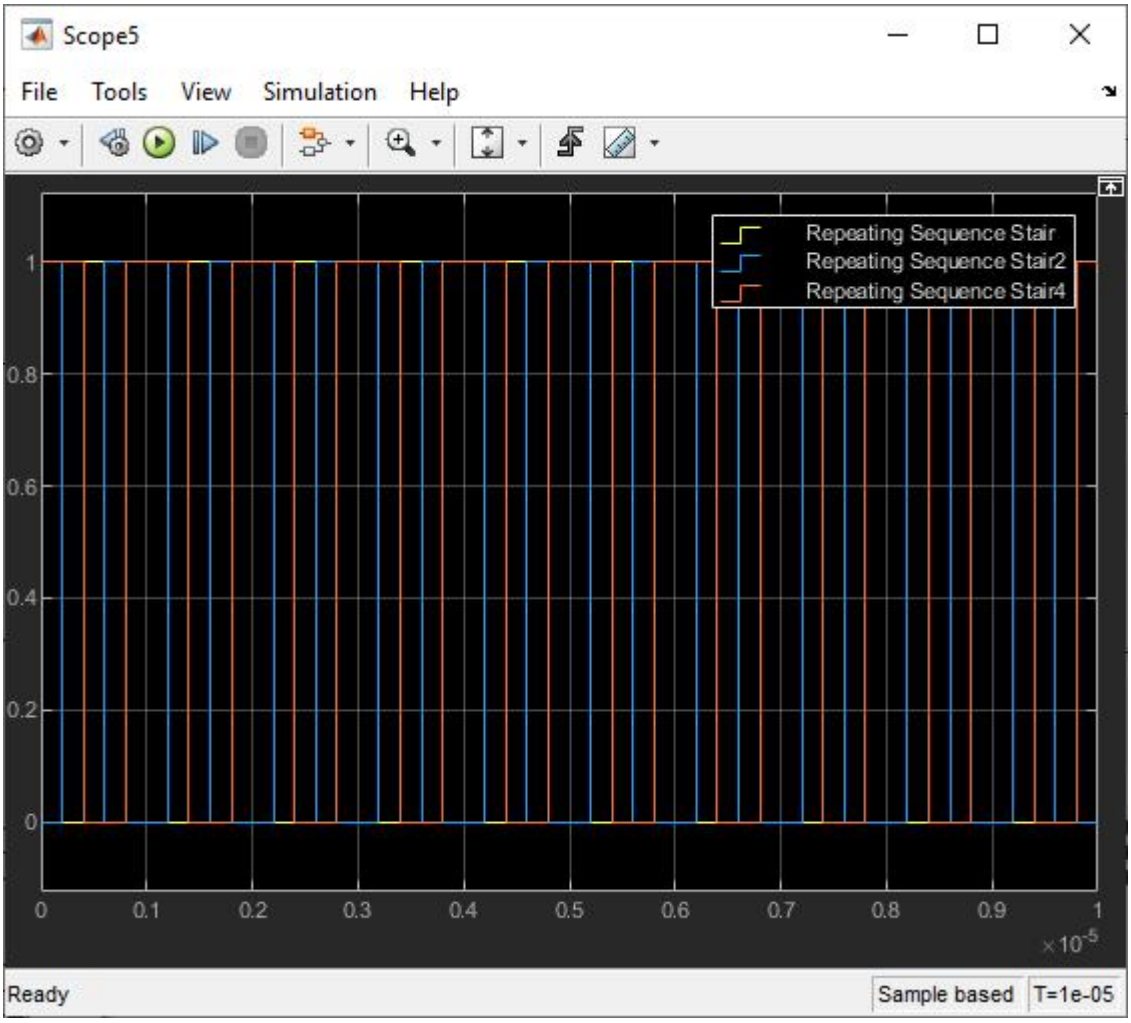


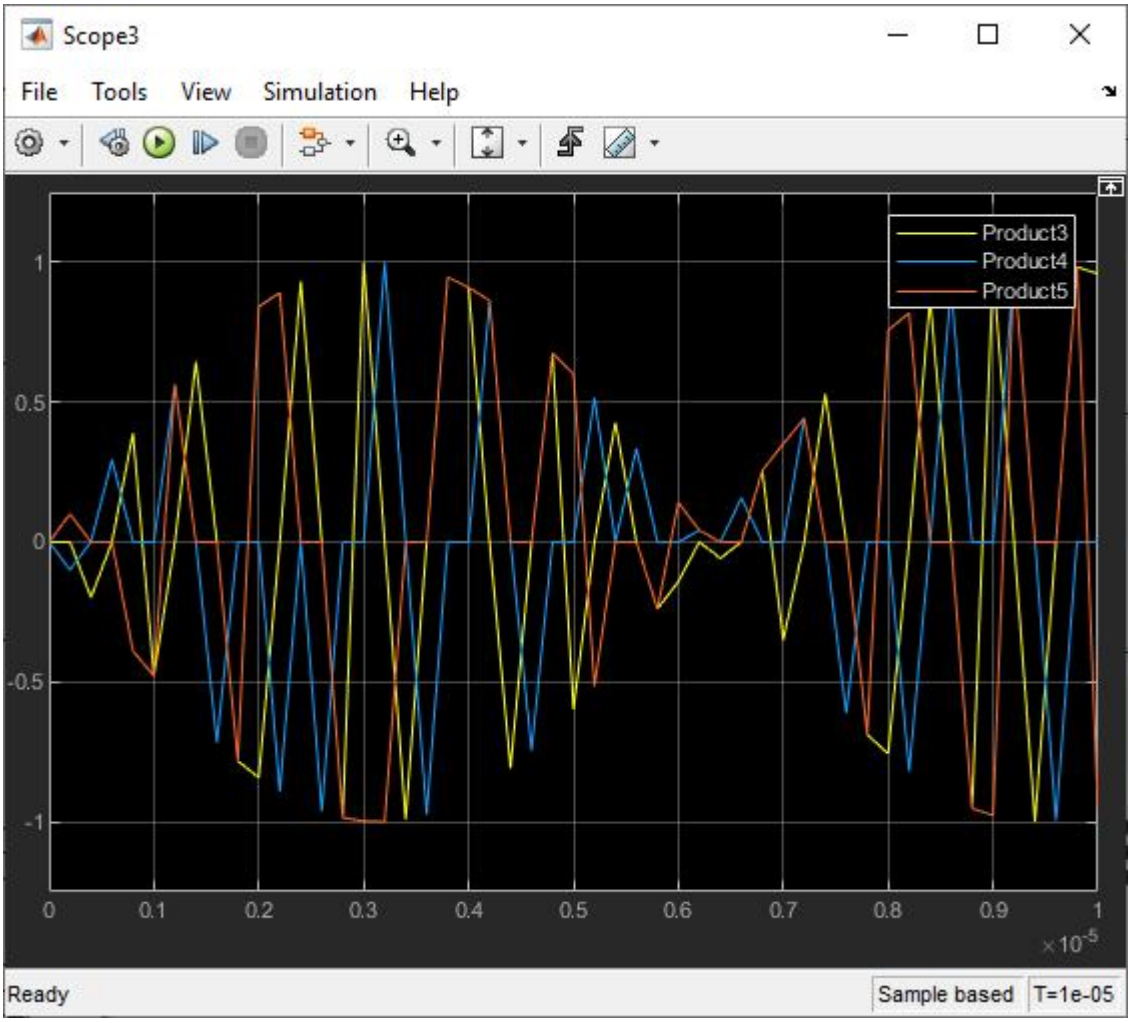
Запустим процесс моделирования и зарисуем осциллограммы сигналов с осциллографов, располагая их друг под другом:

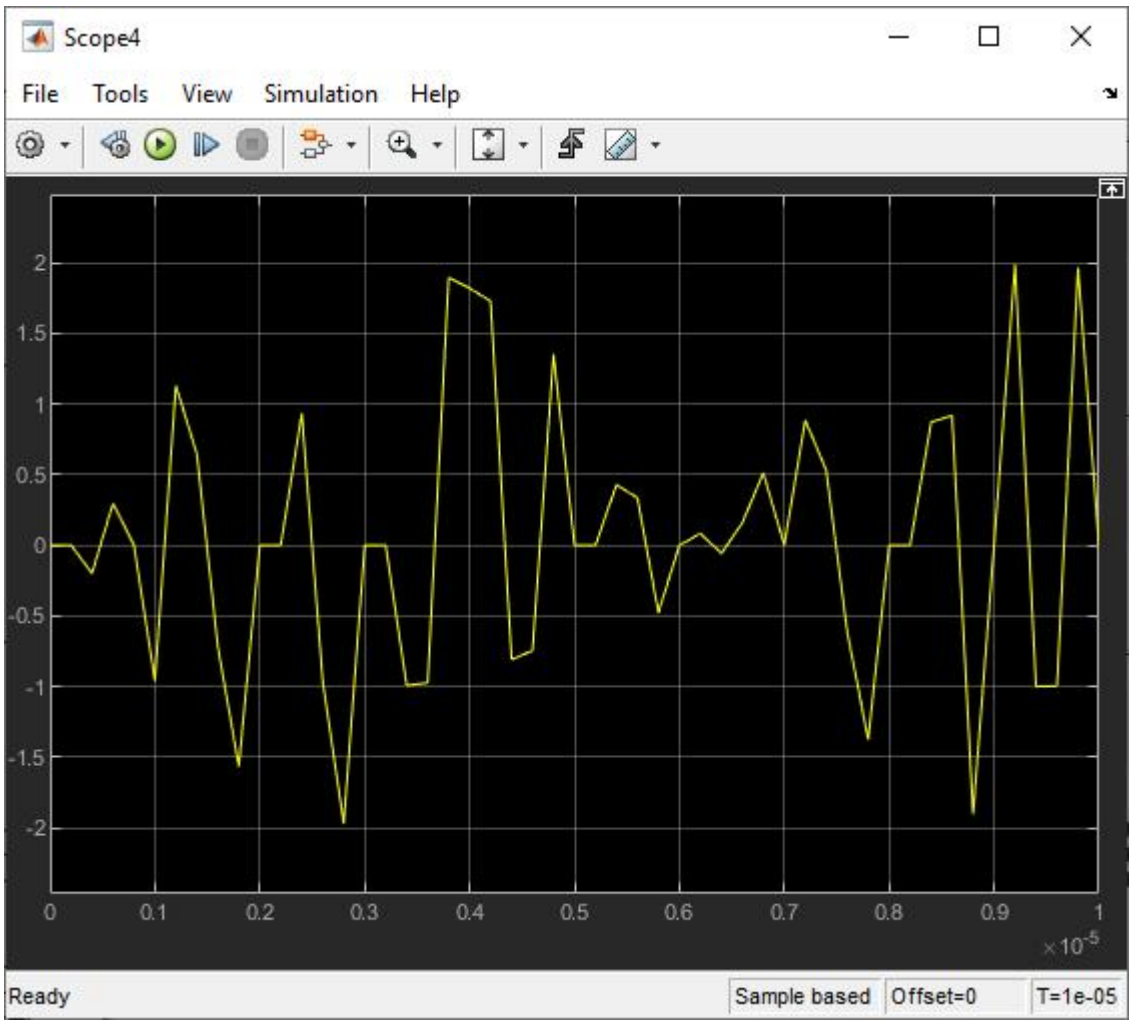

Scope
File
Tools
View
Simulation
Help
Repeating Sequence Stair
Repeating Sequence Stair1
Product
1
0.5
0
-0.5
-1
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
×10^-5
Ready
Sample based
Offset=0
T=1e-05

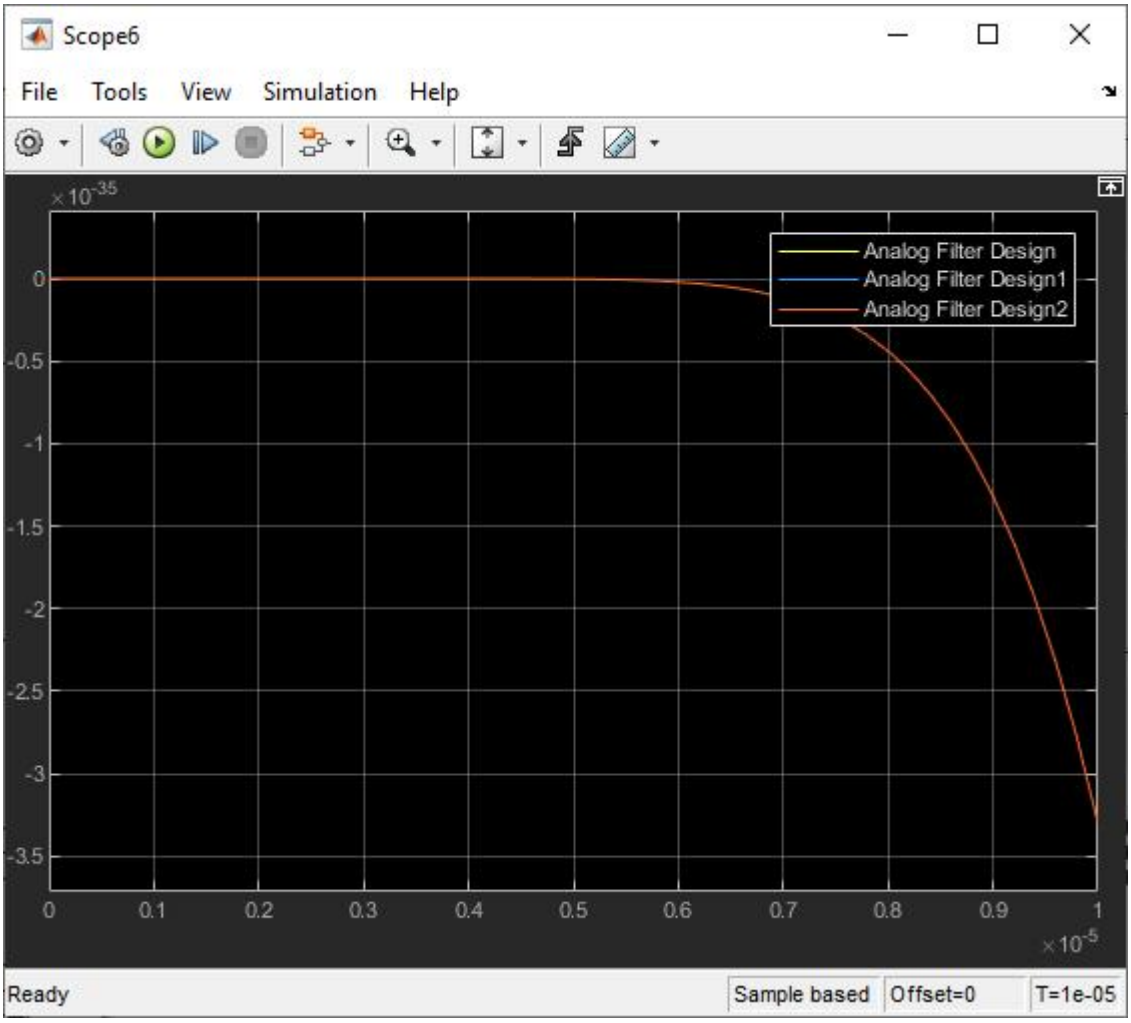

Scope1
File
Tools
View
Simulation
Help
Repeating Sequence Stair2
Repeating Sequence Stair3
Product1
1
0.5
0
-0.5
-1
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
×10^-5
Ready
Sample based
Offset=0
T=1e-05

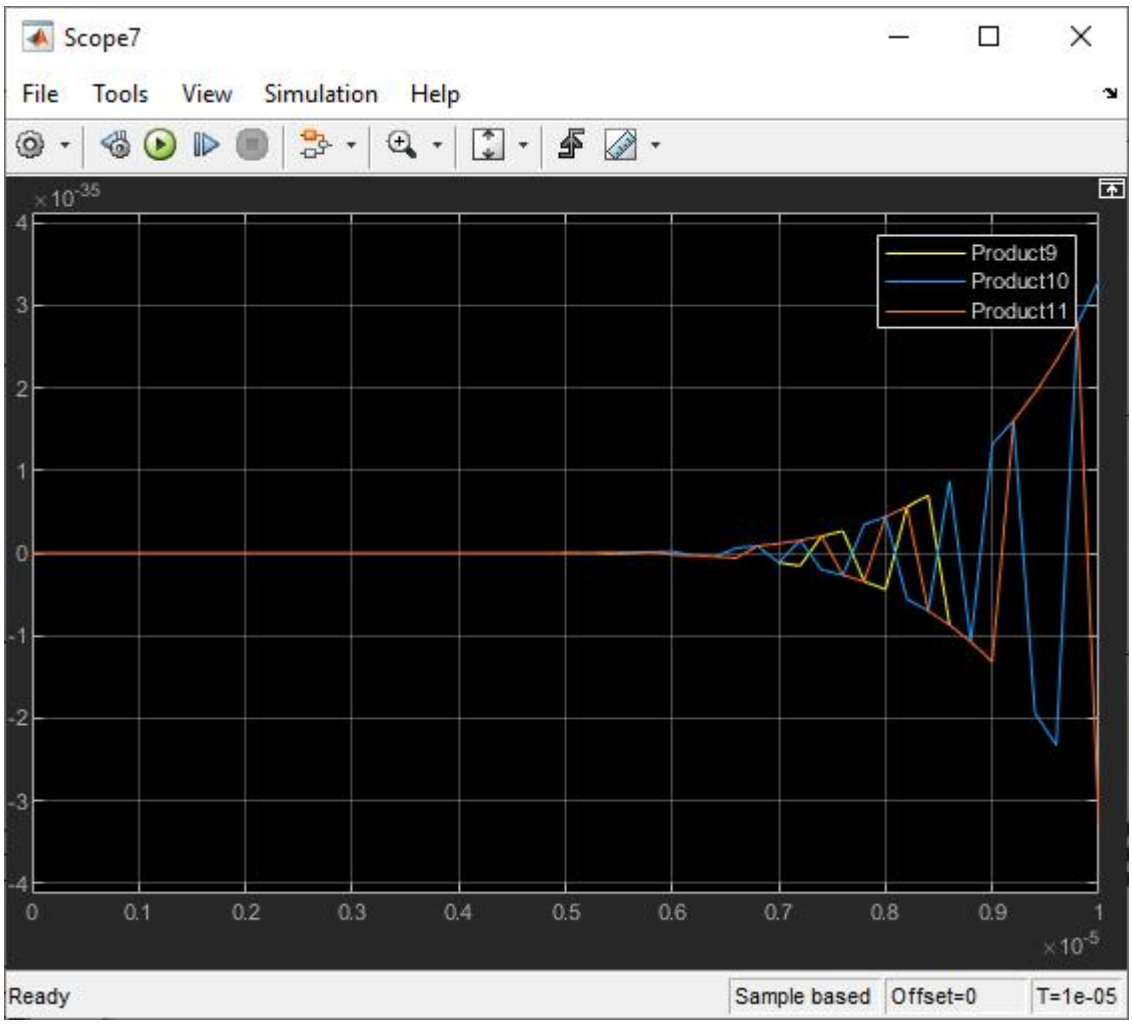

Scope2
File
Tools
View
Simulation
Help
Repeating Sequence Stair4
Repeating Sequence Stair5
Product2
1
0.5
0
-0.5
-1
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
×10^-5
Ready
Sample based
Offset=0
T=1e-05

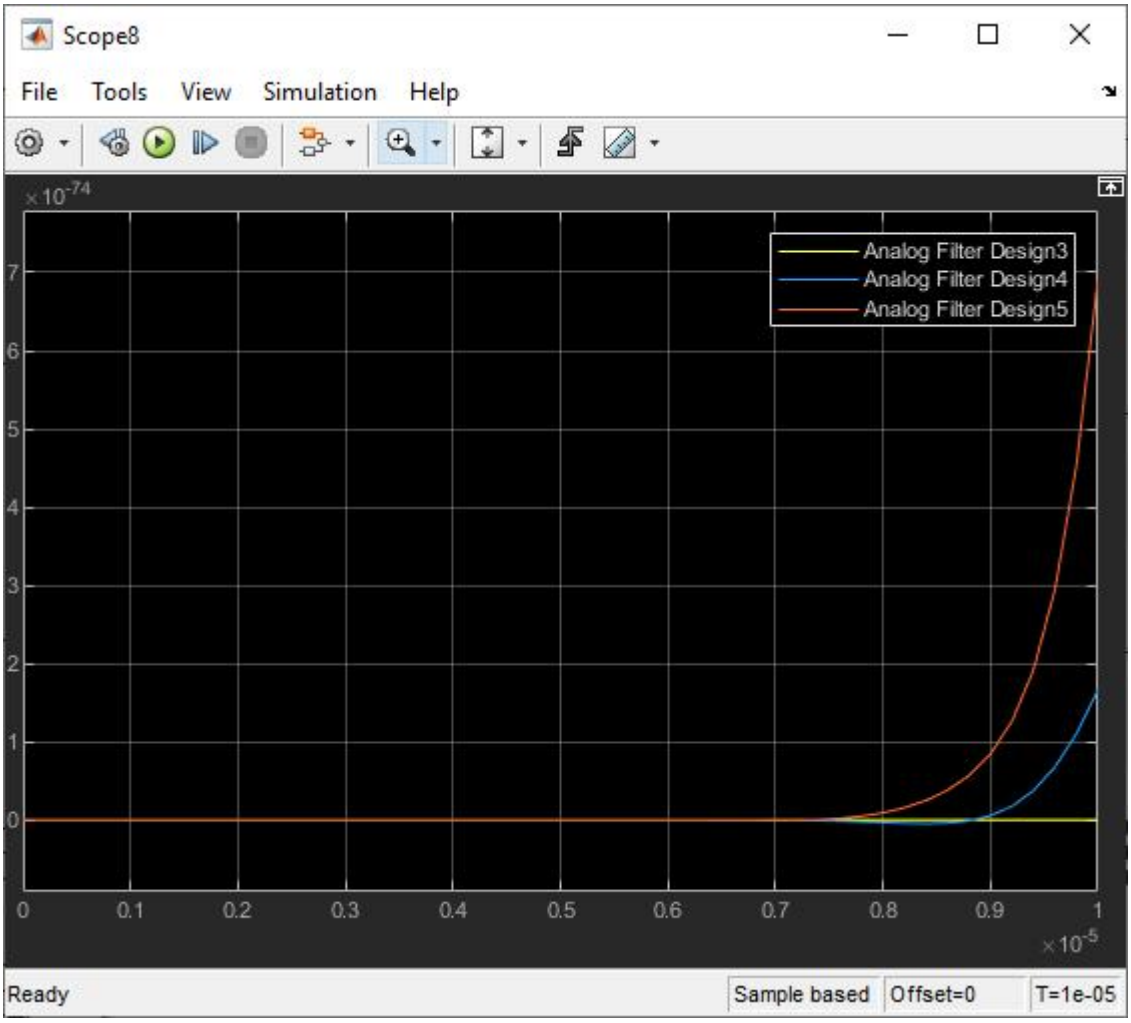

Scope5
File
Tools
View
Simulation
Help
Repeating Sequence Stair
Repeating Sequence Stair2
Repeating Sequence Stair4
1
0.8
0.6
0.4
0.2
0
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
×10^-5
Ready
Sample based
T=1e-05

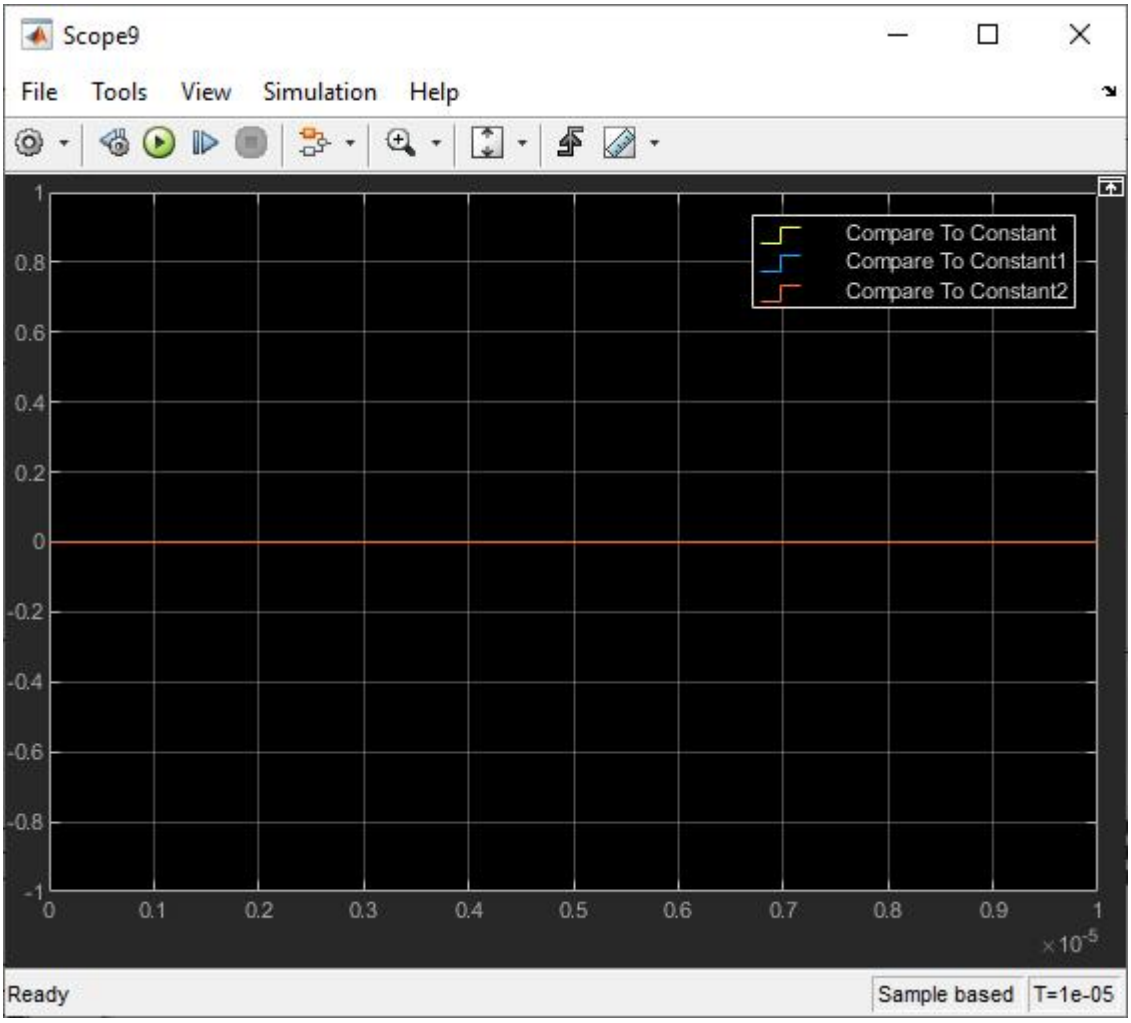

Scope3
File
Tools
View
Simulation
Help
Product3
Product4
Product5
1
0.5
0
-0.5
-1
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
×10^-5
Ready
Sample based
T=1e-05


Scope4
File
Tools
View
Simulation
Help
2
1.5
1
0.5
0
-0.5
-1
-1.5
-2
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
×10^-5
Ready
Sample based
Offset=0
T=1e-05


Scope6
File
Tools
View
Simulation
Help
×10^-35
0
-0.5
-1
-1.5
-2
-2.5
-3
-3.5
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
×10^-5
Analog Filter Design
Analog Filter Design1
Analog Filter Design2
Ready
Sample based
Offset=0
T=1e-05


Scope7
File
Tools
View
Simulation
Help
×10^-35
4
3
2
1
0
-1
-2
-3
-4
Product9
Product10
Product11
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
×10^-5
Ready
Sample based
Offset=0
T=1e-05


Scope8
File
Tools
View
Simulation
Help
×10^-74
7
6
5
4
3
2
1
0
Analog Filter Design3
Analog Filter Design4
Analog Filter Design5
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
×10^-5
Ready
Sample based
Offset=0
T=1e-05


Scope9
File
Tools
View
Simulation
Help
Compare To Constant
Compare To Constant1
Compare To Constant2
1
0.8
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
-0.8
-1
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
×10^-5
Ready
Sample based
T=1e-05