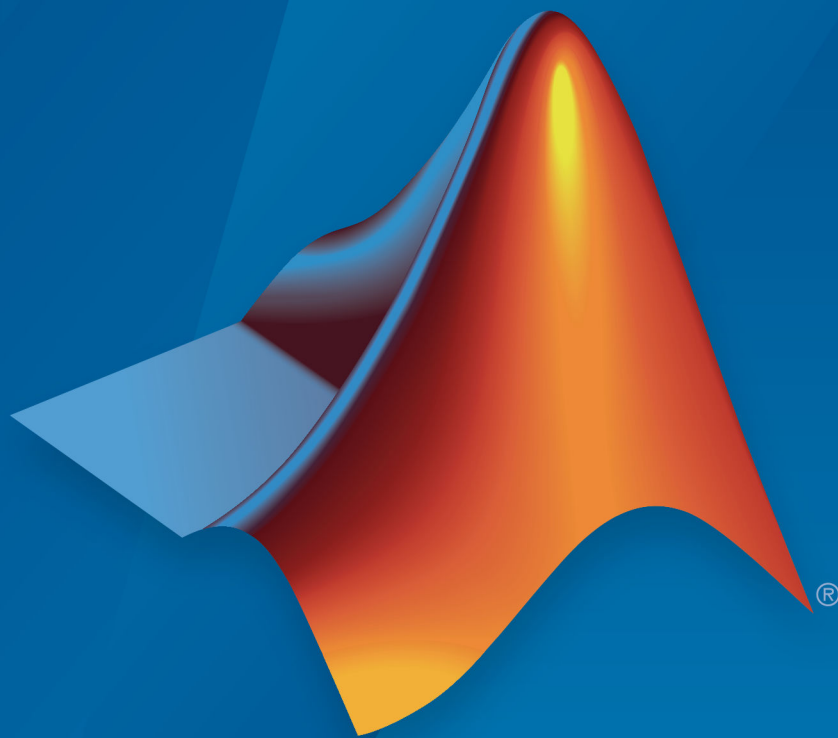


# Communications Toolbox™ Release Notes



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## *Communications Toolbox™ Release Notes*

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**Version: 7.0**

**New Features**

**Compatibility Considerations**

## **Wireless Waveform Generator App: Create, impair, visualize, and export modulated waveforms**

Using the **Wireless Waveform Generator** app you can:

- Create OFDM, QAM, or PSK modulated waveforms or a sine wave test waveform.
- Create WLAN waveforms that are compliant with various 802.11™ modulation schemes (a/b/g/j/p/n/ac/ad/ah). Use of the WLAN feature in the Waveform Generator app requires “WLAN Toolbox”.
- Add RF impairments to your waveforms.
- Plot waveforms in constellation diagram, spectrum analyzer, and time scopes.
- Export waveforms from the app to your MATLAB® workspace or a file.

## **APSK Modulator and Demodulator Blocks: Simulate amplitude phase shift keying (APSK) modulation and demodulation for satellite applications**

Use these blocks to perform APSK modulation and demodulation:

- M-APSK Modulator Baseband and M-APSK Demodulator Baseband
- DVBS-APSK Modulator Baseband and DVBS-APSK Demodulator Baseband, as specified in the Digital Video Broadcasting (DVB) Satellite Communications standards defining DVB-S2, DVB-S2X, and DVB-SH
- MIL188-QAM Modulator Baseband and MIL188-QAM Demodulator Baseband, as specified in the Military HF Modem standard MIL-STD-188-110 B & C and STANAG-4539

## **Turbo Product Code Encoder and Decoder Blocks: Simulate block product codes for defense and satellite communications**

The TPC Encoder and TPC Decoder blocks perform 2-D turbo product code encoding and decoding, as used for defense and satellite communications.

---

## **Multichannel Constellation Diagram Plot Support: Plot multichannel signals in constellation diagram displays**

You can now use the Constellation Diagram block and `comm.ConstellationDiagramSystem` object™ to plot multichannel modulated single-carrier signals on a single set of axes.

## **ADS-B example for HDL code generation**

This “Airplane Tracking with ADS-B Captured Data” example shows how to implement the Automatic Dependent Surveillance - Broadcast (ADS-B) receiver for HDL code generation and hardware implementation. The algorithm decodes ADS-B extended squitter messages from captured over-the-air data. These messages contain position information, which can be used to track airplanes.

## **Communications Toolbox Support Package for Analog Devices ADALM-Pluto Radio supports burst mode reception**

If the Pluto Receiver block or `comm.SDRRxPluto` System object™ cannot keep up with the ADALM-Pluto radio hardware, then your model or code is not processing data in real time. Burst mode enables you to buffer a set of contiguous samples without losing samples by setting the number of frames in a burst.

## **Communications Toolbox Support Package for Xilinx Zynq-Based Radio transitions to libiio-based infrastructure**

### **Compatibility Considerations**

The support package adopted Analog Devices® industrial I/O (IIO) drivers and the corresponding libiio library (version 0.14) for interfacing with Linux® IIO devices. This transition gives access to advanced device properties through new objects and blocks. For more information, see “Compatibility with Previous Releases” (Communications Toolbox Support Package for Xilinx Zynq-Based Radio).

## Updated WINNER2 Channel Filtering: Filter provides flatter bandedge response in fading channel System object

The `comm.WINNER2Channel` System object uses a new filter. This filter provides flatter bandedge response than the previous filter.

### Compatibility Considerations

Regression tests comparing numerics of the `comm.WINNER2Channel` System object do not match those from previous releases.

## Functionality being removed or changed

### Compatibility Considerations

The following functionality has changed.

Functionality	What Happens When You Use This Functionality?	Use This Instead	Compatibility Considerations
qammod and qamdmod	Still runs for syntaxes that don't use <code>iniPhase</code> .	To model QAM with an initial phase offset, see the <b>Compatibility Considerations</b> section on <code>qammod</code> and <code>qamdmod</code> .  You can also use <code>genqammod</code> and <code>genqamdmod</code> .	The behavior of <code>qammod</code> and <code>qamdmod</code> changed in R2018b.  Removed the <code>iniPhase</code> input argument.
Binary Symmetric Channel	Still runs	<ul style="list-style-type: none"> <li>Specify <b>Initial Seed</b> as a scalar.</li> </ul>	The behavior changed in R2018b.  Removed support for specifying <b>Initial Seed</b> as a vector.

The following functionality may be removed in a future release.

Functionality	What Happens When You Use This Functionality?	Use This Instead	Compatibility Considerations
comm.PAMModulator	Still runs	pammod	comm.PAMModulator is not recommended, use pammod instead.
comm.PAMDemodulator	Still runs	pamdemod	comm.PAMDemodulator is not recommended, use pamdemod instead.

The following functionality will be removed in a future release.

Functionality	What Happens When You Use This Functionality?	Use This Instead	Compatibility Considerations
comm.BinarySymmetricChannel	Still runs	bsc	Replace all instances of comm.BinarySymmetricChannel with bsc.
comm.RectangularQAMModulator	Still runs	qammod	Replace all instances of comm.RectangularQAMModulator with qammod.
comm.RectangularQAMDemodulator	Still runs	qamdemod	Replace all instances of comm.RectangularQAMDemodulator with qamdemod.
Gaussian Filter	Warns	A model that includes both gaussdesign and Discrete FIR Filter	See “Gaussian Filter Compatibility Considerations” on page 1-6.
comm.LTEMIMOChannel	Warns	comm.MIMOChannel	Replace all instances of comm.LTEMIMOChannel with comm.MIMOChannel.

The following functionality has been removed.

Functionality	What Happens When You Use This Functionality?	Use This Instead	Compatibility Considerations
<code>modem.qammod</code>	Errors	<code>qammod</code>	Replace all instances of <code>modem.qammod</code> with <code>qammod</code> .
<code>modem.qamdemod</code>	Errors	<code>qamdemod</code>	Replace all instances of <code>modem.qamdemod</code> with <code>qamdemod</code> .

### Gaussian Filter Compatibility Considerations

Replace all instances of the Gaussian Filter block with a modeling solution that includes the `gaussdesign` function and the Discrete FIR Filter block. “Model Gaussian Filter in Simulink” demonstrates using the `gaussdesign` function along with the Discrete FIR Filter block to model a Gaussian filter. In Simulink®, you can use the `PreLoadFcn` callback to specify the filter coefficients as workspace variables. You can specify coefficients for Gaussian filter designs that apply various normalization methods, that you assign in a Discrete FIR Filter block.

### Rectangular QAM Modulation-Demodulation Compatibility Considerations

Replace all instances of `comm.RectangularQAMModulator` and `comm.RectangularQAMDemodulator` with `qammod` and `qamdemod`, respectively.

Constellation normalization by `PeakPower` and `AveragePower` (other than unit average power), as supported by the System objects, is not inherently provided by the `qammod` and `qamdemod` functions. For code samples that achieve such constellation normalization when using these functions, see the **Compatibility Considerations** section on `comm.RectangularQAMModulator` and `comm.RectangularQAMDemodulator`.



# R2018a

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**Version: 6.6**

**New Features**

**Compatibility Considerations**

## **APSK Modulator and Demodulator: Simulate amplitude phase shift keying modulation for satellite applications**

The following functions perform APSK modulation and demodulation:

- Generic APSK (`apskmod` and `apskdemod`)
- Digital Video Broadcasting standard-specific APSK (`dvbsapskmod` and `dvbsapskdemod`), as specified in the Digital Video Broadcasting (DVB) Satellite Communications standards defining DVB-S2, DVB-S2X, and DVB-SH
- MIL-STD APSK (`mil188qammod` and `mil188qamdemod`), as specified in the Military HF Modem standard MIL-STD-188-110 B & C and STANAG-4539

## **Turbo Product Code Encoder and Decoder: Simulate block product codes for defense and satellite communications**

The `tpcenc` and `tpcdec` functions perform 2-D turbo product code encoding and decoding, as used for defense and satellite communications.

## **Massive MIMO Example: Simulate an end-to-end MIMO link using hybrid beamforming**

The Massive MIMO Hybrid Beamforming example demonstrates hybrid beamforming employed at the transmit end of a massive MIMO communications system.

The example uses full channel sounding for determining the channel state information at the transmitter. Using different techniques for multi-user and single-user systems, the required precoding is partitioned into digital baseband and analog RF components. Simplified all-digital receivers recover the multiple transmitted data streams to present the resulting EVM and BER.

## **OFDM Modulator and Demodulator: Simulate orthogonal frequency division modulation**

The `ofdmmod` and `ofdmmodemod` functions perform OFDM modulation and demodulation.

---

## **Enhanced Fidelity of Phase Noise: Model close-in phase noise more precisely**

The fidelity of close-in phase noise modeled by the `comm.PhaseNoise` System object and Phase Noise block has been enhanced.

## **Frequency Correction Support: Adjust ADALM-Pluto Radio frequency to correct frequency offset (Introduced November 2017)**

The correction of frequency offset error and A/D and D/A clock error is available when using the ADALM-Pluto Radio blocks (Pluto Receiver, Pluto Transmitter) and System objects (`comm.SDRRxPluto`, `comm.SDRTxPluto`). The Frequency Correction for ADALM-PLUTO Radio example demonstrates this feature in MATLAB.

## **Custom Filter Wizard: Design custom filtering for ADALM-Pluto Radio (Introduced November 2017)**

Use the Analog Devices filter wizard to design custom pulse shape filtering for the ADALM-Pluto Radio. For more information, see `designCustomFilter`.

## **Low IF Receiver Architecture Example: Simulate a low IF receiver architecture RF model**

The Low IF Receiver example models a receiver design using components from RF Blockset™. The example evaluates BER performance with and without phase noise.

## **ALOHA and CSMA/CA Packetized Wireless Network Example: Simulate an ALOHA or CSMA/CA medium access controller**

The ALOHA and CSMA/CA Packetized Wireless Networks example simulates a PHY with an ALOHA or CSMA/CA MAC using Simulink, Stateflow®, and the Communications System Toolbox™.

## Examples added to library for ZigBee Protocol

The Communications Toolbox Library for the ZigBee® Protocol now includes these examples:

- ZigBee Light Link Frame Generation and Decoding — Generate and decode ZigBee Light Link application profile frames.
- ZigBee Frame Generation and Decoding for General Commands — Generate and decode ZigBee specification General Command frames.
- ZigBee Smart Energy Frame Generation and Decoding — Generate and decode ZigBee Smart Energy frames.

## Examples added to library for NFC Protocol

The Communications Toolbox Library for the NFC Protocol now includes these examples:

- Introduction to Communications System Toolbox Library for the NFC Protocol Video — Get started using the library.
- NFC Application Layer — Exchange data between application layers of two Near Field Communication (NFC) devices.

## Updated Fading Channel Filtering: Filter provides flatter bandedge response in fading channel System objects and blocks

The `comm.MIMOChannel`, `comm.RayleighChannel`, and `comm.RicianChannel` System objects and the MIMO Fading Channel block use a new filter.

This filter provides flatter bandedge response than the previous filter.

## Compatibility Considerations

Regression tests comparing numerics of the `comm.MIMOChannel`, `comm.RayleighChannel`, and `comm.RicianChannel` System objects and the MIMO Fading Channel block do not match those from previous releases.

---

## Functionality being removed or changed

### Compatibility Considerations

The following functionality has changed.

Functionality	What Happens When You Use This Functionality	Use This Instead	Compatibility Considerations
<code>commsrc.combinedjitter</code>	Still runs	Added <code>SamplingFrequency</code> and <code>PeriodicFrequencyHz</code> properties.	The behavior changed in R2018a. Use <code>PeriodicFrequencyHz</code> instead of <code>PeriodicFrequency</code> .

The following functionality will be removed in a future release.

Functionality	What Happens When You Use This Functionality?	Use This Instead	Compatibility Considerations
<code>huffmandict</code>	Still runs	Not applicable	The behavior changed in R2018a. When duplicate dictionary symbols are input, <code>huffmandict</code> merges duplicated symbols by summing their probabilities.
<code>modem.dpskmod</code>	Warns	<code>comm.DPSKModulator</code>	See “DPSK Modulation-Demodulation Compatibility Considerations” on page 2-9.
<code>modem.dpskdemod</code>	Warns	<code>comm.DPSKDemodulator</code>	
<code>modem.mskmod</code>	Warns	<code>comm.MSKModulator</code> or <code>mskmod</code>	See “MSK Modulation-Demodulation Compatibility

<b>Functionality</b>	<b>What Happens When You Use This Functionality?</b>	<b>Use This Instead</b>	<b>Compatibility Considerations</b>
modem.mskdemod	Warns	comm.MSKDemodulator or mskdemod	Considerations” on page 2-10.
modem.oqpskmod	Warns	comm.OQPSKModulator	See “OQPSK Modulation-Demodulation Compatibility Considerations” on page 2-11.
modem.oqpskdemod	Warns	comm.OQPSKDemodulator	See “OQPSK Modulation-Demodulation Compatibility Considerations” on page 2-11.
modem.genqammod	Warns	genqammod or comm.GeneralQAMModulator	See “General QAM Modulation-Demodulation Compatibility Considerations” on page 2-12.
modem.genqamdemod	Warns	genqamdemod or comm.GeneralQAMDemodulator	See “General QAM Modulation-Demodulation Compatibility Considerations” on page 2-12.
modem.pammod	Warns	pammod	See “PAM Modulation-Demodulation Compatibility Considerations” on page 2-14.
modem.pamdemod	Warns	pamdemod	See “PAM Modulation-Demodulation Compatibility Considerations” on page 2-14.
modem.pskmod	Warns	pskmod or comm.PSKModulator	See “PSK Modulation-Demodulation Compatibility Considerations” on page 2-15.
modem.pskdemod	Warns	pskdemod or comm.PSKDemodulator	See “PSK Modulation-Demodulation Compatibility Considerations” on page 2-15.
rayleighchan	Warns	comm.RayleighChannel	See “Rayleigh Channel Compatibility Considerations” on page 2-16.
ricianchan	Warns	comm.RicianChannel	See and “Rician Channel Compatibility Considerations” on page 2-18.

<b>Functionality</b>	<b>What Happens When You Use This Functionality?</b>	<b>Use This Instead</b>	<b>Compatibility Considerations</b>
doppler.jakes	Warns	doppler	To generate a Jakes Doppler spectrum use <code>doppler('Jakes')</code> instead.
doppler.flat	Warns	doppler	To generate a flat Doppler spectrum use <code>doppler('Flat')</code> instead.
doppler.bell	Warns	doppler	To generate a bell Doppler spectrum use <code>doppler('Bell')</code> instead.
doppler.rounded	Warns	doppler	To generate a rounded Doppler spectrum use <code>doppler('Rounded')</code> instead.
doppler.rjakes	Warns	doppler	To generate a restricted Jakes Doppler spectrum use <code>doppler('Restricted Jakes')</code> instead.
doppler.ajakes	Warns	doppler	To generate an asymmetrical Jakes Doppler spectrum use <code>doppler('Asymmetric Jakes')</code> instead.
doppler.gaussian	Warns	doppler	To generate a Gaussian Doppler spectrum use <code>doppler('Gaussian')</code> instead.

Functionality	What Happens When You Use This Functionality?	Use This Instead	Compatibility Considerations
<code>doppler.bigaussian</code>	Warns	<code>doppler</code>	To generate a bi-Gaussian Doppler spectrum use <code>doppler('BiGaussian')</code> instead.
<code>stdchan(ts, fd, channType)</code>	Warns	<code>stdchan(channType, rs, fd)</code>	See “stdchan Compatibility Considerations” on page 2-20.
<code>legacychannelsim</code>	Warns	<code>comm.RayleighChannel</code> or <code>comm.RicianChannel</code>	See “Legacy Channel Simulation Compatibility Considerations” on page 2-21.
<code>oqpskmod</code>	Warns	<code>comm.OQPSKModulator</code>	Replace all instances of <code>oqpskmod</code> with <code>comm.OQPSKModulator</code> .
<code>oqpskdemod</code>	Warns	<code>comm.OQPSKDemodulator</code>	Replace all instances of <code>oqpskdemod</code> with <code>comm.OQPSKDemodulator</code> .
<code>comm.CPMCarrierPhaseSynchronizer</code>	Warns	<code>comm.CarrierSynchronizer</code>	Replace all instances of <code>comm.CPMCarrierPhaseSynchronizer</code> with <code>comm.CarrierSynchronizer</code> .
<code>commscope.ScatterPlot</code>	Errors	<code>comm.ConstellationDiagram</code>	Replace all instances of <code>commscope.ScatterPlot</code> with <code>comm.ConstellationDiagram</code> .



---

## DPSK Modulation-Demodulation Compatibility Considerations

Replace all instances of `modem.dpskmod` and `modem.dpskdemod` with `comm.DPSKModulator` and `comm.DPSKDemodulator`.

- User-defined symbol mapping is not supported.
- The `comm.DPSKModulator` System object does not support initial phase specification. However, this code sample shows you how to specify initial phase for DPSK-modulated signals:

```
%% Initial Phase
x = randi([0,7],10,1);
phRot = pi/8;
initPh = pi/4;

%% Using modem.dpskmod modulate the signal
m = modem.dpskmod('M',8,'PhaseRotation',phRot,'InitialPhase',initPh);
ym = modulate(m, x);

%% Using comm.DPSKModulator modulate the signal
s = comm.DPSKModulator('PhaseRotation',phRot,'SymbolMapping','Binary');
ys = s(x);
ys1 = ys .* exp(1i * initPh);

%% Compare results
err = max(abs(ys1 - ym))
```

```
err =
```

```
2.6390e-15
```

- This code sample shows you how to simulate multichannel input/output for DPSK-modulated signals:

```
%% Multichannel input/output
x = randi([0,7],10,3);
phRot = pi/8;

%% Using modem.dpskmod modulate the signal
m = modem.dpskmod('M',8,'PhaseRotation',phRot);
ym1 = m.modulate(x);
% Process one more frame to verify interframe state handling
ym2 = m.modulate(x);

%% Using comm.DPSKModulator modulate the signal
% Create as many System objects as number of channels
s1 = comm.DPSKModulator('PhaseRotation',phRot,'SymbolMapping','Binary');
s2 = comm.DPSKModulator('PhaseRotation',phRot,'SymbolMapping','Binary');
s3 = comm.DPSKModulator('PhaseRotation',phRot,'SymbolMapping','Binary');

ys1 = complex(zeros(size(x),'like',x));
ys2 = ys1;

% Process first frame
% Process each channel by its specific System object
```

```
ys1(:,1) = s1(x(:,1));
ys1(:,2) = s2(x(:,2));
ys1(:,3) = s3(x(:,3));

% Process second frame
ys2(:,1) = s1(x(:,1));
ys2(:,2) = s2(x(:,2));
ys2(:,3) = s3(x(:,3));

%% Compare results
err1 = (max(abs(ys1(:) - ym1(:))))
err2 = (max(abs(ys2(:) - ym2(:))))

err1 =

    2.0411e-15

err2 =

    2.4431e-15
```

### **MSK Modulation-Demodulation Compatibility Considerations**

Replace instances of `modem.mskmod` and `modem.msksdemod` with `comm.MSKModulator` and `comm.MSKDemodulator`. For precoded MSK modulation or demodulation, use `mskmod` and `msksdemod`.

- This code sample shows you how to simulate multichannel input/output for MSK-modulated signals:

```
%% Multichannel input/output
x = randi([0,1],4,3);

%% Modulation
% Using modem.mskmod modulate the multiple channel signal
m_msk = modem.mskmod;
ym1 = m_msk.modulate(x);
% Process one more frame to verify interframe state handling
ym2 = m_msk.modulate(x);

% Using mskmod modulate the multiple channel signal
[yf1, phOut] = mskmod(x,8);
yf2 = mskmod(x,8,[],phOut);

% Compare the modulation results
err1 = max(abs(ym1(:) - yf1(:)))
err2 = max(abs(ym2(:) - yf2(:)))
```

---

```

err1 = 5.4672e-16

err2 = 5.4672e-16

%% Demodulation
% Using modem.mskdemod demodulate the multiple channel signal
dm_msk = modem.mskdemod;
ym1_dm = dm_msk.demodulate(ym1)
% Process one more frame to verify interframe state handling
ym2_dm = dm_msk.demodulate(ym2)

% Using mskdemod demodulate the multiple channel signal
[yf1_dm, phOut] = mskdemod(yf1,8)
yf2_dm = mskdemod(yf2,8,[],phOut)

% Compare the demodulation results to transmission signal
%isequal(x,yf1_dm)
%isequal(x,yf2_dm)

% For the modem object must account for two bit output delay
%isequal(x(1:end-2,:),ym1_dm(3:end,:))
%isequal(x(1:end-2,:),ym2_dm(3:end,:))

```

## QPSK Modulation-Demodulation Compatibility Considerations

Replace all instances of `modem.oqpskmod` and `modem.oqpskdemod` with `comm.OQPSKModulator`, `comm.OQPSKDemodulator`, or `qamdemod`.

- This code sample shows you how to simulate multichannel input/output for QPSK-modulated signals:

```

%% Multichannel input/output QPSK modulation
m = 4;
numChan = 3;
x = randi([0,m-1],10,numChan);
sps = 2; % Samples per symbol

% Using modem.oqpskmod modulate the signal
m_oqpsk = modem.oqpskmod();
ym1 = m_oqpsk.modulate(x);
% Process one more frame to verify interframe state handling
ym2 = m_oqpsk.modulate(x);

% Using comm.OQPSKModulator modulate the signal
% Create as many System objects as number of channels
s1_oqpsk = comm.OQPSKModulator('SymbolMapping','Binary','SamplesPerSymbol',sps);
s2_oqpsk = comm.OQPSKModulator('SymbolMapping','Binary','SamplesPerSymbol',sps);
s3_oqpsk = comm.OQPSKModulator('SymbolMapping','Binary','SamplesPerSymbol',sps);

% Preallocate output matrix
ys1 = complex(zeros(sps*length(x),numChan,'like',x));

```

```

ys2 = ys1;

% Process first frame
% Process each channel by its specific System object
ys1(:,1) = s1_oqpsk(x(:,1));
ys1(:,2) = s2_oqpsk(x(:,2));
ys1(:,3) = s3_oqpsk(x(:,3));

% Process second frame
ys2(:,1) = s1_oqpsk(x(:,1));
ys2(:,2) = s2_oqpsk(x(:,2));
ys2(:,3) = s3_oqpsk(x(:,3));

% The modulated signals are not compared because the
% comm.OQPSKModulator performs joint filtering and
% modulation of the signal, while the modem.oqpskmod
% only modulates the signal.

```

- The `comm.OQPSKDemodulator` System object does not support soft decision output for OQPSK-modulated signals. However, this code sample shows you how to simulate soft decision output for OQPSK-modulated signals:

```

%% Soft decision OQPSK demodulation
% Create an OQPSK signal and add noise to the signal
sps = 4;
msg = randi([0 1],1000,1);
oqpskMod = comm.OQPSKModulator('SamplesPerSymbol',sps,'BitInput',true);
oqpskSig = oqpskMod(msg);

impairedSig = awgn(oqpskSig,15);

% Soft-demodulate using the QPSK demodulator

% Align I and Q (create QPSK equivalent signal)
impairedQPSK = complex(real(impairedSig(1+sps/2:end-sps/2)), imag(impairedSig(sps+1:end)));

% Apply matched filtering to the received OQPSK signal
halfSinePulse = sin(0:pi/sps:(sps)*pi/sps);
matchedFilter = dsp.FIRDecimator(sps, halfSinePulse, 'DecimationOffset', sps/2);
filteredQPSK = matchedFilter(impairedQPSK);

% To perform soft demodulation of the filtered OQPSK signal use the
% qamdemod function. Align symbol mapping of qamdemod with the symbol
% mapping used by the comm.OQPSKModulator, then demodulate the signal.
oqpskModSymbolMapping = [1 3 0 2];
demodulated = qamdemod(filteredQPSK,4,oqpskModSymbolMapping,'OutputType','llr');

```

## General QAM Modulation-Demodulation Compatibility Considerations

Replace instances of `modem.genqammod` and `modem.genqamdmod` with `genqammod` and `genqamdmod`. To generate soft decision output, use `comm.GeneralQAMModulator` and `comm.GeneralQAMDemodulator`.

- This code sample shows you bit input and multichannel input support for general QAM modulated signals:

---

```

%% Bit Input
% Multichannel input
x = randi([0,1],16,3);

M = 16;
nBits = log2(M);
inSize = size(x);
outSize = inSize;
% nBits bits make one symbol
outSize(1) = outSize(1)/nBits;

% M-QAM constellation
const = qammod((0:M-1)',M);

% Modulate
m1 = modem.genqammod('InputType','Bit','Constellation',const);
yml = m1.modulate(x);

% Convert bit input to integer
% Each column is a bit representation of an integer
xTmp = reshape(x,nBits,numel(x)/nBits);
% each row is a bit representation of an integer, left-MSB
xTmp = xTmp';
xIntCol = bi2de(xTmp,'left-msb');
xIntMat = reshape(xIntCol,outSize);

% Compare modulator function output
yf1 = genqammod(xIntMat,const);
err = max(abs(yml(:) - yf1(:)))

err =
    0

```

- This code sample shows you how to simulate multichannel input/output and soft decision output for general QAM-modulated signals:

```

%% Soft decision output
% Multichannel input
x = randi([0,1],16,3);

M = 16;
nBits = log2(M);
inSize = size(x);
outSize = inSize;
% nBits bits make one symbol
outSize(1) = outSize(1)/nBits;

% 16-QAM constellation

```

```
const = qammod((0:M-1)',M);

% Modulate
m1 = modem.genqammod('InputType','Bit','Constellation',const);
ym1 = m1.modulate(x);

% Convert bit input to integer
% Each column is a bit representation of an integer
xTmp = reshape(x,nBits,numel(x)/nBits);
% Each row is a bit representation of an integer, left-MSB
xTmp = xTmp';
xIntCol = bi2de(xTmp,'left-msb');

% Compare System object output
s1 = comm.GeneralQAMModulator('Constellation',const);
ysTmp = s1(xIntCol);
ys1 = reshape(ysTmp,outsizes);

err1 = max(abs(ym1(:) - ys1(:)))

% Demodulate (LLR)
m2 = modem.genqamdemod('Constellation',const,'OutputType','Bit', ...
    'DecisionType','LLR','NoiseVariance',0.2);
ym2 = m2.demodulate(ym1);

s2 = comm.GeneralQAMDemodulator('Constellation',const,'BitOutput',true, ...
    'DecisionMethod','Log-likelihood ratio','Variance',0.2);
% Columnize ys1 as System object supports only column vector input
ys2 = s2(ys1(:));
ys2 = reshape(ys2,insizes);
err2 = max(abs(ym2(:) - ys2(:)))

err1 =

    0

err2 =

    0
```

## PAM Modulation-Demodulation Compatibility Considerations

Replace all instances of `modem.pammod` and `modem.pamdemod` with `pammod` and `pamdemod`.

- To model PAM-modulated signals, follow guidance in “General QAM Modulation-Demodulation Compatibility Considerations” on page 2-12 for bit input support, multichannel input-output support, and soft decision output.
- This code sample shows how to apply user-defined symbol mapping for PAM-modulated signals:

```
%% User-defined symbol mapping
M = 8;
```

---

```

% Custom symbol mapping
symMap = [3,7,4,0,2,6,1,5];
m = modem.pammod('M',M,'SymbolOrder','User-defined', ...
    'SymbolMapping',symMap);
c = m.Constellation;
[~,lb] = ismember((0:M-1),symMap);

% Specify the constellation in General QAM System object
% in the right order
s = comm.GeneralQAMModulator('Constellation',complex(c(lb)));

x = randi([0,M-1],100,1);
ym = m.modulate(x);
ys = s(x);

err = max(abs(ym - ys))

err =

    0

```

## PSK Modulation-Demodulation Compatibility Considerations

Replace instances of `modem.pskmod` and `modem.pskdemod` with `pskmod` and `pskdemod`. If you require bit input, user-defined symbol mapping, or soft decision output, use `comm.PSKModulator` and `comm.PSKDemodulator` System objects.

- This code sample shows you how to simulate multichannel input/output for PSK-modulated signals:

```

%% Multi-channel input-output
M = 16;
numChan = 1;
x = randi([0,M-1],16,3);
phOff = pi/8;

% Using modem object modulate and demodulate
% Modulate using modem.pskmod modulate the signal
mpsk = modem.pskmod('M',M,'PhaseOffset',phOff);
ym1mod = mpsk.modulate(x);

% LLR demodulate using modem.pskdemod
demodpsk = modem.pskdemod('OutputType','Bit','PhaseOffset',phOff, ...
    'DecisionType','LLR','NoiseVariance',0.2);
ym1demod = demodpsk.demodulate(ym1mod);

% Using System objects modulate and demodulate
% Modulate using comm.PSKModulator
% Create as many System objects as number of channels
slmod = comm.PSKModulator('ModulationOrder',M, ...
    'SymbolMapping','Binary');

```

```

s2mod = clone(s1mod);
s3mod = clone(s1mod);

ys1mod = complex(zeros(size(x),'like',x));

% Process each channel by it's specific System object
ys1mod(:,1) = s1mod(x(:,1));
ys1mod(:,2) = s2mod(x(:,2));
ys1mod(:,3) = s3mod(x(:,3));

% LLR Demodulate using comm.PSKDemodulate
% Create comm.PSKDemodulator objects for each channel
% Create as many System objects as number of channels
s1demod = comm.PSKDemodulator('ModulationOrder',M, ...
    'DecisionMethod','Log-likelihood ratio', ...
    'Variance',0.2,'SymbolMapping','Binary');
s2demod = clone(s1demod);
s3demod = clone(s1demod);

% Using comm.PSKDemodulator demodulate the signal, process each
% channel by it's specific System object
ys1demod = complex(zeros(length(x),numChan,'like',x));
ys1demod(:,1) = s1demod(ys1mod(:,1));
ys1demod(:,2) = s2demod(ys1mod(:,2));
ys1demod(:,3) = s3demod(ys1mod(:,3));

%% Compare modulation and demodulation for System object and modem object
% Residual modulation error is small
err1 = (max(abs(ys1mod(:) - ym1mod(:))))
% Check to see that demodulated data signal equals the original data
t_f = isequal(ys1demod,x)

err1 =

    2.4493e-16

t_f =

    logical

     1

```

## Rayleigh Channel Compatibility Considerations

Replace instances of `rayleighchan` with a `comm.RayleighChannel` System object. Note the mapping between function parameters and object properties:

Comparison Between <code>rayleighchan</code> and <code>comm.RayleighChannel</code>				
<code>rayleighchan</code>		<code>comm.RayleighChannel</code>		Notes
Properties	Associated functions	Properties	Object functions	



ChannelType				Indicated by System object name
InputSamplePeriod		SampleRate		Value is reciprocal
DopplerSpectrum		DopplerSpectrum		
MaxDopplerShift		MaximumDopplerShift		
PathDelays		PathDelays		
AvgPathGaindB		AveragePathGains		
NormalizePathGains		NormalizePathGains		
StoreHistory				Adjacent with the plot function of rayleighchan
PathGains			object call (step)	Second output returned by a call of the object (step)
ChannelFilterDelay			info	Returned by a call to info
ResetBeforeFiltering			reset	Call reset before each object function call (step)
NumSamplesProcessed			info	Returned by a call to info
	filter		object call (step)	First output returned by a call of the object (step)

	reset		reset	
	plot	Visualization SamplesToDisplay PathsForDopplerDisplay	object call (step)	The Visualization property setting controls display of graphics during an object call (step).
StorePathGains		PathGainsOutputPort		

### Rician Channel Compatibility Considerations

Replace instances of ricianchan with a comm.RicianChannel System object. Note the mapping between function parameters and object properties:

<b>Comparison Between ricianchan and comm.RicianChannel</b>				
<b>ricianchan</b>		<b>comm.RicianChannel</b>		<b>Notes</b>
<b>Properties</b>	<b>Associated functions</b>	<b>Properties</b>	<b>Object functions</b>	
ChannelType				Indicated by System object name
InputSamplePeriod		SampleRate		Value is reciprocal
DopplerSpectrum		DopplerSpectrum		
MaxDopplerShift		MaximumDopplerShift		
PathDelays		PathDelays		
KFactor		KFactor		
DirectPathDopplerShift		DirectPathDopplerShift		
DirectPathInitialPhase		DirectPathInitialPhase		

AvgPathGaindB		AveragePathGains		
NormalizePathGains		NormalizePathGains		
StoreHistory				Adjacent with the plot function of ricianchan
StorePathGains		PathGainsOutputPort		
PathGains			object call (step)	Second output returned by a call of the object (step)
ChannelFilterDelay			info	Returned by a call to info
ResetBeforeFiltering			reset	Call reset before each object function call (step)
NumSamplesProcessed			info	Returned by a call to info
	filter		object call (step)	First output returned by a call of the object (step)
	reset		reset	
	plot	Visualization SamplesToDisplay PathsForDopplerDisplay	object call (step)	The Visualization property setting controls display of graphics during an object call (step).

## stdchan Compatibility Considerations

Compatibility considerations for the `stdchan` function includes addition of a function syntax, and announcing removal of one syntax and removal of configuration support for several channel models.

- The syntax `chan = stdchan(ts, fd, chantype)` will be removed in a future release. A System object is returned using the new syntax. See this new syntax in `stdchan`.
- In the future `stdchan` will remove support for configuration of several channel models by supported standards and associated syntax, compatibility considerations are indicated here:

Standard	Previous Syntax	New Syntax to Return System Object	Notes
3GPP, CDMA	<code>stdchan(ts, fd, '3gppXXX')</code>	<code>stdchan('cdmaXX X', rs, fd)</code>	Prefix changed from '3gpp' to 'cdma'.  ts and rs are reciprocal values.
GSM	<code>stdchan(ts, fd, 'gsmXXX')</code>	<code>stdchan('gsmXXX , rs, fd)</code>	ts and rs are reciprocal values.
ITU-R HF	<code>stdchan(ts, fd, 'iturHFXXX')</code>	<code>stdchan('iturHF XXX', rs, fd)</code>	ts and rs are reciprocal values.
COST207	<code>stdchan(ts, fd, 'cost207XXX')</code>	N/A	In the future <code>stdchan</code> will not configure these channels. Use <code>comm.RayleighChannel</code> or <code>comm.RicianChannel</code> to configure the channel models for COST207, ITU-R 3G, JTC, HIPERLAN/2, and
ITU-R 3G	<code>stdchan(ts, fd, 'itur3GXXX')</code>	N/A	
JTC	<code>stdchan(ts, fd, 'jtcXXX')</code>	N/A	
HIPERLAN/2	<code>stdchan(ts, fd, 'hiperlan2XXX')</code>	N/A	

802.11a/b/g	<code>stdchan(ts,fd,'802.11X')</code>	N/A	802.11a/b/g standards.  For guidance mapping parameters, see “Rayleigh Channel Compatibility Considerations” on page 2-16 and “Rician Channel Compatibility Considerations” on page 2-18.
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### Legacy Channel Simulation Compatibility Considerations

- For `legacychannelsim(true)` and a Rayleigh channel, you can achieve equivalent functionality to `rayleighchan` using a `comm.RayleighChannel` System object, configured as shown in this code sample:

```
% Set the RNG seed value to 10 and generate a vector
% of random complex numbers.
seed = 10;
x = complex(rand(100,1),rand(100,1));
%%
% Create a Rayleigh channel System object. Set RandomStream to
% 'Global stream', and set the random number generator to 'v5normal'.
chan = comm.RayleighChannel('RandomStream','Global stream');
rng(seed,'v5normal');
chan(x);
```

Similarly for a Rician channel, equivalent functionality to `ricianchan` can be achieved with the above code using a `comm.RicianChannel` System object.

- For `legacychannelsim(false)` and a Rayleigh channel, you can achieve equivalent functionality to `rayleighchan` using a `comm.RayleighChannel` System object, configured as shown in this code sample:

```
% Set the RNG seed value to 10 and generate a vector
% of random complex numbers.
seed = 10;
x = complex(rand(100,1),rand(100,1));
%%
```

```
% Option 1 - Create a Rayleigh channel System object, set
% RandomStream to 'Global stream', and set the random
% number generator to 'twister'.
chan = comm.RayleighChannel('RandomStream','Global stream');
rng(seed, 'twister');
chan(x);
%%
% Option 2 - Create a Rayleigh channel System object setting
% RandomStream to 'mt19937ar with seed'.
chan = comm.RayleighChannel('RandomStream', ...
    'mt19937ar with seed','Seed',seed);
chan(x);
```

Similarly for a Rician channel, equivalent functionality to `ricianchan` can be achieved with the above code using a `comm.RicianChannel` System object.

# R2017b

---

**Version: 6.5**

**New Features**

**Bug Fixes**

**Compatibility Considerations**

## **Library for ZigBee Protocol: Simulate ZigBee low-rate wireless personal area network (LRWPAN) technologies**

The Communications Toolbox Library for the ZigBee Protocol uses MATLAB to design and verify practical ZigBee systems. Using the examples in this library, you can generate and decode waveforms and frames formatted for transmission in these layers of the protocol stack:

- IEEE® 802.15.4 physical (PHY) and medium-access control (MAC) layers
- ZigBee network (NWK) layer and application (APL) layer

You can download the Communications Toolbox Library for the ZigBee Protocol from Add-On Explorer. For more information, see [Get Add-Ons \(MATLAB\)](#) and [Manage Your Add-Ons \(MATLAB\)](#).

## **Library for NFC Protocol: Simulate Near Field Communication (NFC) wireless technologies**

The Communications Toolbox Library for the NFC Protocol uses MATLAB to design and verify practical NFC systems. Using the examples in this library, you can generate and decode waveforms and frames formatted for transmission in the NFC standard.

You can download the Communications Toolbox Library for the NFC Protocol from Add-On Explorer. For more information, see [Get Add-Ons \(MATLAB\)](#) and [Manage Your Add-Ons \(MATLAB\)](#).

## **OQPSK Simulation: Simulate practical OQPSK links with modulation, frequency and timing synchronization, and demodulation functions**

The following System objects now enable easier simulation of practical OQPSK links: `comm.OQPSKModulator`, `comm.OQPSKDemodulator`, `comm.CoarseFrequencyCompensator`, `comm.CarrierSynchronizer`, and `comm.SymbolSynchronizer`.



---

## **MIMO Channel Enhancements: Specify an arbitrary number of antennas and include antenna polarization when you simulate MIMO fading channels**

The `comm.MIMOChannel` System object and MIMO Fading Channel block now allow you to specify antenna polarization and an arbitrary number of antennas in your system.

In addition, you can now use the MIMO Fading Channel block to specify Rayleigh or Rician fading for MIMO channels.

## **Path Loss Functions: Account for path loss due to free space, fog, gas, and rain**

Functions are added to model path loss due to free space (`fspl`), fog and clouds (`fogpl`), atmosphere (`gaspl`), and rain (`rainpl`).

## **Communications System Toolbox Support Package for Analog Devices ADALM-Pluto Radio: Lower minimum baseband sample rate (Introduced in May 2017)**

You can specify baseband sample rates as low as 65.104 kHz. Previously, the minimum sample rate permitted was 520.841 kHz.

## **Communications System Toolbox Support Package for Xilinx Zynq-Based Radio: PicoZed SDR renamed to ADI RF SOM**

The PicoZed™ SDR product has been renamed to ADI RF SOM. Support for the ADI RF SOM product is available through new MATLAB objects and Simulink blocks.

New Product Name	Analog Devices Part Number	Description	MATLAB Support	Simulink Support	I/O Peripheral Support	HW/SW Co-Design Support
ADI RF SOM	ADRV9361	XC7Z035 / AD9361 SOM	comm.SDR DevADIRFSOM radio object  comm.SDR RxADIRFSOM receiver System object  comm.SDR TxADIRFSOM transmitter System object	ADI RF SOM Receiver block  ADI RF SOM Transmitter block	Yes	Yes

For more information, see ADI RF SOM (Communications System Toolbox Support Package for Xilinx® Zynq®-Based Radio).

## Compatibility Considerations

Starting in R2018a, the name 'PicoZed SDR' will no longer work in function calls, and the PicoZed SDR library will be removed from Simulink. As of R2017b, use the name 'ADI RF SOM' in function calls, and use the new ADI RF SOM features for all PicoZed SDR products supported in previous releases. See PicoZed SDR (Before R2017b) Communications System Toolbox Support Package for Xilinx Zynq-Based Radio.

Feature Removed	Result	Use Instead	Compatibility Considerations
<code>comm.SDRDevPicoZed</code> SDR radio object	Object creation warns and <code>comm.SDRDevADIRFSOM</code> radio object is created instead.	<code>comm.SDRDevADIRFSOM</code> radio object	Replace 'PicoZed SDR' with 'ADI RF SOM' in all calls to <code>sdrdev</code> .
<code>comm.SDRRxPicoZed</code> SDR receiver System object	System object creation warns and <code>comm.SDRRxADIRFSOM</code> receiver System object is created instead.	<code>comm.SDRRxADIRFSOM</code> receiver System object	Replace 'PicoZed SDR' with 'ADI RF SOM' in all calls to <code>sdr rx</code> .
<code>comm.SDRTxPicoZed</code> SDR transmitter System object	System object creation warns and <code>comm.SDRTxADIRFSOM</code> transmitter System object is created instead.	<code>comm.SDRTxADIRFSOM</code> transmitter System object	Replace 'PicoZed SDR' with 'ADI RF SOM' in all calls to <code>sdr tx</code> .
PicoZed SDR Receiver block	Warns and forwards library link to ADI RF SOM Receiver block.	ADI RF SOM Receiver block	Replace all PicoZed SDR Receiver blocks with ADI RF SOM Receiver blocks.
PicoZed SDR Transmitter block	Warns and forwards library link to ADI RF SOM Transmitter block.	ADI RF SOM Transmitter block	Replace all PicoZed SDR Transmitter blocks with ADI RF SOM Transmitter blocks.

## USRP® E312 Support: Prototype and test USRP® E312 software-defined radio (SDR) systems

Support for USRP® <sup>1</sup>E312 embedded series radio is now available with the Communications System Toolbox Support Package for USRP® Embedded Series Radio. The support is seamlessly integrated through the features and functionality already available for USRP® E310.

1. USRP, USRP2, UHD, and Ettus Research are trademarks of National Instruments Corp.

Product Name	MATLAB Support	Simulink Support	I/O Peripheral Support	HW/SW Co-Design Support
USRP® E312	comm.SDRDevE310 radio object  comm.SDRRxE310 receiver System object  comm.SDRTxE310 transmitter System object	E310 Receiver block  E310 Transmitter block	Yes	Yes

### Key Features

- Use USRP® E312 as an I/O peripheral to transmit and receive real-time arbitrary waveforms using MATLAB System objects and Simulink blocks.
- Transmit and receive RF signals out of the box, enabling the testing of SDR designs quickly, under real-world conditions.
- Transmit and receive data on one or two channels.
- Configure RF radio settings easily.
- Acquire high-bandwidth signals by using burst mode.
- Customize and prototype SDR algorithms in Simulink, and deploy partitioned hardware-software co-design implementations across the ARM® processor and the FPGA fabric of the device (Windows® operating system only).
- Run all USRP® E310-based application examples for the USRP® E312.

### Communications System Toolbox Support Package for Xilinx FPGA-Based Radio: Support removed

Communications System Toolbox Support Package for Xilinx FPGA-Based Radio has been discontinued for R2017b.

### Compatibility Considerations

The support package is available for use with previous releases.

---

## Functionality being removed or changed

The following functionality will be removed in a future release.

Functionality	What Happens When You Use This Functionality?	Use This Instead	Compatibility Considerations
Multipath Rayleigh Fading Channel	SISO Fading Channel is loaded, retaining parameter settings for legacy model	SISO Fading Channel	Existing models automatically replace instances of Multipath Rayleigh Fading Channel with SISO Fading Channel.
Multipath Rician Fading Channel	SISO Fading Channel is loaded, retaining parameter settings for legacy model	SISO Fading Channel	Existing models automatically replace instances of Multipath Rayleigh Fading Channel with SISO Fading Channel.
oqpskmod	Still runs	comm.OQPSKModulator	Replace all instances of oqpskmod with comm.OQPSKModulator.
oqpskdemod	Still runs	comm.OQPSKDemodulator	Replace all instances of oqpskdemod with comm.OQPSKDemodulator.
commsrc.pn	Still runs	comm.PNSequence	Replace all instances of commsrc.pn with comm.PNSequence.
commscope.eyediagram	Warns	comm.EyeDiagram	Replace all instances of commscope.eyediagram with comm.EyeDiagram.

Functionality	What Happens When You Use This Functionality?	Use This Instead	Compatibility Considerations
eyescope	Warns	comm.EyeDiagram	Replace all instances of eyescope with comm.EyeDiagram.  For more information, see Eye Diagram Measurements.
commscope.ScatterPlot	Warns	comm.ConstellationDiagram	Replace all instances of commscope.ScatterPlot with comm.ConstellationDiagram.
comm.CPMCarrierPhaseSynchronizer	Warns	comm.CarrierSynchronizer	Replace all instances of comm.CPMCarrierPhaseSynchronizer with comm.CarrierSynchronizer.
modem.qamdemod	Warns	qamdemod	Replace all instances of modem.qamdemod with qamdemod.
modem.qammod	Warns	qammod	Replace all instances of modem.qammod with qammod.

The following functionality has been removed.

Functionality	What Happens When You Use This Functionality?	Use This Instead	Compatibility Considerations
mimochan	Errors	comm.MIMOChannel	Replace all instances of mimochan with comm.MIMOChannel.

<b>Functionality</b>	<b>What Happens When You Use This Functionality?</b>	<b>Use This Instead</b>	<b>Compatibility Considerations</b>
comm.PSKCarrierPhaseSynchronizer	Errors	comm.CarrierSynchronizer	Replace all instances of comm.PSKCarrierPhaseSynchronizer with comm.CarrierSynchronizer.
comm.MuellerMullerTimingSynchronizer	Errors	comm.SymbolSynchronizer	Replace all instances of comm.MuellerMullerTimingSynchronizer with comm.SymbolSynchronizer.
comm.GardnerTimingSynchronizer	Errors	comm.SymbolSynchronizer	Replace all instances of comm.GardnerTimingSynchronizer with comm.SymbolSynchronizer.
comm.EarlyLateGateTimingSynchronizer	Errors	comm.SymbolSynchronizer	Replace all instances of comm.EarlyLateGateTimingSynchronizer with comm.SymbolSynchronizer.
Squaring Timing Recovery	Errors	Symbol Synchronizer	Replace all instances of Squaring Timing Recovery with Symbol Synchronizer.
Early-Late Gate Timing Recovery	Errors	Symbol Synchronizer	Replace all instances of Early-Late Gate Timing Recovery with Symbol Synchronizer.
Gardner Timing Recovery	Errors	Symbol Synchronizer	Replace all instances of Gardner Timing Recovery with Symbol Synchronizer.

<b>Functionality</b>	<b>What Happens When You Use This Functionality?</b>	<b>Use This Instead</b>	<b>Compatibility Considerations</b>
Mueller-Muller Timing Recovery	Errors	Symbol Synchronizer	Replace all instances of Mueller-Muller Timing Recovery with Symbol Synchronizer.



# R2017a

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**Version: 6.4**

**New Features**

**Compatibility Considerations**

## **WINNER II Channel Model: Model and simulate spatially defined MIMO channels**

Releases R2017a and R2016b (since October 2016) add the WINNER II Channel Model for Communications System Toolbox. Using WINNER II channel models, you can model and simulate spatially defined channels for multi-user MIMO wireless systems. You can specify an arbitrary number of base stations (BS) and mobile stations (MS) together with their geometry and location information.

The channel model enables you to simulate both line-of-sight (LOS) and non-LOS propagation conditions. It also enables you to apply multiple indoor and outdoor propagation scenarios. You can perform channel filtering in a streaming fashion with WINNER-generated channel coefficients.

The channel model supports:

- RF frequencies up to 6 GHz and signal bandwidths up to 100 MHz
- LOS and non-LOS propagation
- 12 indoor and outdoor propagation scenarios
- Arbitrarily large antenna arrays (for massive MIMO applications)
- Isotropic, dipole, and custom-defined antenna element patterns
- Linear, circular, and custom-defined antenna arrays

You can get the WINNER II Channel Model for Communications System Toolbox download from Add-On Explorer. For more information, see [Get Add-Ons \(MATLAB\)](#) and [Manage Your Add-Ons \(MATLAB\)](#).

## **USRP® E310 Support: Prototype and test USRP® E310 software-defined radio (SDR) systems**

The Communications System Toolbox Support Package for USRP® Embedded Series Radio is available for releases R2017a and R2016b (since October 2016). With this support package, you can design, prototype, and verify practical wireless communications systems on USRP® embedded series radio hardware.

### **Key Features**

- Use the USRP® embedded series radio as an I/O peripheral to transmit and receive real-time arbitrary waveforms using MATLAB System objects or Simulink blocks.

- 
- Transmit and receive RF signals out of the box, enabling the testing of SDR designs quickly, under real-world conditions.
  - Transmit and receive data on one or two channels.
  - Easy configuration of the RF radio settings.
  - Burst mode option for acquiring high-bandwidth signals.
  - In Simulink, customize and prototype SDR algorithms deploying partitioned hardware-software co-design implementations across the ARM processor and the FPGA fabric of the USRP® device (Windows operating system only).
  - Application examples for getting started.

### **Required MathWorks Products**

To use the I/O mode features of the support package, the following MathWorks® products are required:

- MATLAB
- Communications System Toolbox
- Signal Processing Toolbox™
- DSP System Toolbox™

To work with the hardware-software co-design workflow, the following MathWorks products are also required:

- Simulink
- To target the FPGA fabric on the device: HDL Coder™ Support Package for Xilinx Zynq Platform (requires HDL Coder)
- To target the ARM processor on the device: Embedded Coder® Support Package for Xilinx Zynq Platform (requires Embedded Coder, Simulink Coder™, and Embedded Coder Support Package for ARM Cortex®-A Processors)

### **Required Third-Party Tools**

- Third-party tools required by the I/O mode features are automatically downloaded and installed during the support package installation.
- To work with the hardware-software co-design workflow, you must manually install the following third-party tools:
  - Xilinx Vivado® development tools version 2015.4

- Xilinx SDK development tools version 2015.4

### Hardware Support

Development Board	I/O Peripheral Support	Hardware-Software Co-Design Support
USRP® E310	Yes	Yes

For more information, see Communications System Toolbox Support Package for USRP® Embedded Series Radio.

### **Bundled USRP® Radios: Synchronize multiple USRP® radios in frequency and time for transmission and reception**

Since R2016b (since October 2016), the Communications System Toolbox Support Package for USRP Radio enables you to bundle multiple radios to support Multiple Input Multiple Output (MIMO) on more than two channels. Synchronize frequency and timing of bundled channels by connecting the multiple radios to an external 10 MHz clock source and an external PPS source.

MIMO using multiple radios is available for N-series and X-series USRP radios.

For more information, see Multiple Channel Input and Output Operations (Communications System Toolbox Support Package for USRP Radio).

### **Example of Proposed 5G Modulations: Simulate end-to-end links by using universal filtered multicarrier (UFMC) and filtered OFDM (F-OFDM)**

The 5G Waveforms with LTE example demonstrates the integration of the new F-OFDM and UFMC waveforms into an existing LTE processing chain in place of Cyclic-Prefix OFDM (CP-OFDM).

The F-OFDM vs. OFDM Modulation example compares Orthogonal Frequency Division Multiplexing (OFDM) with filtered OFDM (F-OFDM) and highlights the merits of the new candidate modulation scheme for emergent Fifth Generation (5G) communication systems.

---

## **Packetized Modem Example: Model PHY and MAC layer operations in transmission of packetized waveforms**

The Packetized Modem with Data Link Layer example demonstrates a PHY and MAC model that transmits packetized QPSK.

## **Communications System Toolbox Support Package for Analog Devices ADALM-Pluto Radio: Prototype and test ADALM-Pluto radio systems**

The Communications System Toolbox Support Package for Analog Devices ADALM-Pluto Radio enables you to design, prototype, and verify practical wireless communications systems on a software-defined radio (SDR). With this support package, you can use a Pluto SDR as a standalone peripheral for live RF data I/O over USB.

## **Radio Broadcast Data System Transmitter: Generate RBDS-compliant waveforms**

Generate configurable standard-compliant baseband RBDS waveforms in MATLAB using the `comm.RBDSWaveformGenerator` System object. Such waveforms can be modulated at the 57 kHz band of the baseband FM radio signals.

## **RBDS Modulation and Demodulation: Modulate and demodulate RBDS waveforms using the FM broadcast modulator and demodulator**

To modulate the baseband RBDS waveform:

- In MATLAB, set the RBDS property of the `comm.FMBroadcastModulator` System object to `true`.
- In Simulink, select the **RBDS modulation** parameter of the FM Broadcast Modulator Baseband block.

To demodulate the RBDS waveform:

- In MATLAB, set the RBDS property of the `comm.FMBroadcastDemodulator` System object to `true`.

- In Simulink, select the **RBDS demodulation** parameter of the FM Broadcast Demodulator Baseband block.

The RBDS waveforms are modulated at the 57 kHz band.

## **MIMO-OFDM Precoding with Phased Arrays Example**

The MIMO-OFDM Precoding with Phased Arrays example demonstrates using phased arrays in a MIMO-OFDM communication system employing beamforming. The Phased Array System Toolbox™ is used to model the transmit and receive antenna arrays. The channel is modeled using the WINNER II Channel Model for Communications System Toolbox.

## **Tab Completion: Complete parameter names and options in select MATLAB function calls**

You can now use tab completion in select MATLAB function calls.

## **Remove antenna limitations on comm.OFDMModulator and comm.OFDMDemodulator**

Maximum number of antenna limitations have been removed for `comm.OFDMDemodulator` and `comm.OFDMModulator` System object usage.

## **Compatibility Considerations**

Removal of the maximum number of antennas constraint means you can model MIMO systems larger than 8-by-8. A warning is issued if the output data will exceed 1e6 bytes.

## **Parameter names changed for comm.FMBroadcastModulator and comm.FMBroadcastDemodulator**

This change renames two fields returned by the `info` method for `comm.FMBroadcastModulator` and `comm.FMBroadcastDemodulator`. `DecimationFactor` and `InterpolationFactor` have been renamed to `AudioDecimationFactor` and `AudioInterpolationFactor`, and two more fields (`RBDSInterpolationFactor` and `RBDSDecimationFactor`) have been added for RBDS.

## Compatibility Considerations

Up to R2016b, the `info` method for `comm.FMBroadcastModulator` and `comm.FMBroadcastDemodulator` returned a structure containing two fields: `DecimationFactor` and `InterpolationFactor`.

In R2017a, the `info` method for these functions returns a structure containing four fields: `AudioDecimationFactor`, `AudioInterpolationFactor`, `RBDSInterpolationFactor`, and `RBDSDecimationFactor`.

Functionality	New Behavior (as of R2017a)	Old Behavior (up to R2016b)	Compatibility Considerations
<pre>fmbMod = comm.FMBroadcastMo dulator;  fmbMod.info</pre>	<pre>Returns: &gt;&gt; fmbMod.info  ans =  struct with fields:  AudioDecimationFac tor: 1  AudioInterpolation Factor: 5  RBDSDecimationFact or: 19  RBDSInterpolationF actor: 384</pre>	<pre>Returned: &gt;&gt; fmbMod.info  ans =  struct with fields:  DecimationFactor: 1  InterpolationFacto r: 5</pre>	<p>Existing code that assigns the field names returned by the <code>info</code> method must be updated. Replace all instances of old field names with new field names.</p>

Functionality	New Behavior (as of R2017a)	Old Behavior (up to R2016b)	Compatibility Considerations
<pre>fmbDemod = comm.FMBroadcastDe modulator;  fmbDemod.info</pre>	<pre>Returns: &gt;&gt; fmbDemod.info  ans =  struct with fields:  AudioDecimationFac tor: 20  AudioInterpolation Factor: 19  RBDSDecimationFact or: 20  RBDSInterpolationF actor: 19</pre>	<pre>Returned: &gt;&gt; fmbDemod.info  ans =  struct with fields:  DecimationFactor: 20  InterpolationFacto r: 19</pre>	Existing code that assigns the field names returned by the info method must be updated. Replace all instances of old field names with new field names.

## Functionality being removed

These functions will be removed in a future release.

Functionality	What Happens When You Use This Functionality?	Use This Instead	Compatibility Considerations
commscope.ScatterPlot	still runs	comm.ConstellationDiagram	Replace all instances of commscope.ScatterPlot with comm.ConstellationDiagram.
commscope.eyediagram	still runs	comm.EyeDiagram	Replace all instances of commscope.eyediagram with comm.EyeDiagram.



---

Functionality	What Happens When You Use This Functionality?	Use This Instead	Compatibility Considerations
eyescope	still runs	comm.EyeDiagram	Replace all instances of eyescope with comm.EyeDiagram.

### **Communications System Toolbox Support Package for Xilinx FPGA-Based Radio: Support package being removed**

Communications System Toolbox Support Package for Xilinx FPGA-Based Radio will be removed in a future release.

### **Communications System Toolbox Support Package for Xilinx Zynq-Based Radio: FMCOMMS1 support removed**

Hardware support for the Analog Devices FMCOMMS1 Rev B/C RF card has been removed.



# R2016b

---

**Version: 6.3**

**New Features**

**Bug Fixes**

**Compatibility Considerations**

## **Eye Diagram Object and Block: Measure signal quality, and visualize histograms and bathtub curves**

The `comm.EyeDiagram` System object and Eye Diagram block enable you to plot eye diagrams and characterize signal quality through a variety of measurements. In addition, you can visualize noise and jitter histograms as well as vertical and horizontal bathtub curves.

## **Baseband File Reader and Writer: Record captured baseband signals as files and use the files to test wireless designs**

The Baseband File Reader and Baseband File Writer blocks `comm.BasebandFileReader` and `comm.BasebandFileWriter` System objects support file operations with a new binary file type.

## **UFMC and FBMC Examples: Characterize the performance of 5G modulation techniques**

The FBMC vs. OFDM Modulation and UFMC vs. OFDM Modulation examples demonstrate the performance of universal filtered multicarrier (UFMC) and filter bank multicarrier (FBMC) modulation schemes.

## **Preamble Detector: Determine the location of the preamble in a packet**

The `comm.PreambleDetector` System object and Preamble Detector block determine the location of the preamble in a communication packet.

## **I/Q Imbalance: Apply amplitude and phase imbalance to baseband signal**

The `iqimbal` function applies an in-phase and quadrature (I/Q) amplitude and phase imbalance to baseband signals.

---

## **MATLAB Compiler support added to constellation diagram**

The `comm.ConstellationDiagram` System object now supports MATLAB Compiler™.

## **Printer support added to constellation and eye diagrams**

The Constellation Diagram and Eye Diagram blocks and `comm.ConstellationDiagram` and `comm.EyeDiagram` System objects now support printing to figures and printers.

## **Simpler way to call System objects**

Instead of using the `step` method to perform the operation defined by a System object, you can call the object with arguments, as if it were a function. The `step` method will continue to work. This feature improves the readability of scripts and functions that use many different System objects.

For example, if you create a `comm.AGC` System object named `agc`, then you call the System object as a function with that name.

```
agc = comm.AGC;  
rxSig = agc(txSig);
```

The equivalent operation using the `step` method is:

```
agc = comm.AGC;  
rxSig = step(agc, txSig);
```

When the `step` method has the System object as its only argument, the function equivalent has no arguments. This function must be called with empty parentheses. For example, `step(sysobj)` and `sysobj()` perform equivalent operations.

## **Functionality being removed**

These functions have been removed.

<b>Functionality</b>	<b>What Happens When You Use This Functionality?</b>	<b>Use This Instead</b>	<b>Compatibility Considerations</b>
randint	Errors	randi	Replace all instances of randint with randi.

# R2016a

---

**Version: 6.2**

**New Features**

**Bug Fixes**

**Compatibility Considerations**

## **EVM Measurements: Measure error vector magnitude with added flexibility**

The EVM System object and block now support:

- Flexible measurement intervals
- Reference constellations that can be used instead of a reference signal
- N-dimensional input signals
- Variable-sized input signals
- Scalar inputs

## **Eye Diagram Block: Plot histograms of time-varying signals**

Histogram plots can now be generated by the Eye Diagram block using one of three oversampling methods.

## **Quadrature Amplitude Modulation: Modulate binary data and demodulate binary and soft-decision outputs**

The `qammod` and `qamdemod` functions support these additional capabilities:

- Soft-decision demodulation (`qamdemod` only)
- Bit inputs and outputs
- Constellation plots
- Code generation (requires MATLAB Coder)

---

**Note** The `qammod` and `qamdemod` functions will not support the initial phase input argument in a future release.

---



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## Communications System Toolbox Support Package for USRP Radio: Transmit and receive RF signals using B200mini

The Communications System Toolbox Support Package for USRP Radio now supports the B200mini radio by Ettus Research®. This radio is similar to the B200 but has a smaller form factor. It supports  $1 \times 1$  communication links.

### Class definition now available for `comm.LDPCDecoder` System object

You can now view the MATLAB code for `LDPCDecoder.m` in the `<matlabroot>/toolbox/comm/comm/+comm` folder.

---

**Note** By default, `comm.LDPCDecoder` does not support code generation. To generate code, specify the `ParityCheckMatrix` property as a non-sparse row-column index matrix.

For example, you can create an LDPC decoder for the DVB-S.2 standard by using this syntax:

```
dec = comm.LDPCDecoder(dvbs2ldpc(1/2, 'indices'));
```

Because `dvbs2ldpc(1/2, 'indices')` returns a non-sparse index matrix, the object, `dec`, can be used in code generation.

---

### Function definitions now available for `qammod`, `qamdemod`, and `vitdec`

You can now view the MATLAB code for the `qammod`, `qamdemod`, and `vitdec` functions in the `<matlabroot>/toolbox/comm/comm` folder.

### Functions now supporting code generation

If you have MATLAB Coder, you can generate code for these functions:

- `convenc`
- `vitdec`

- `dpskmod`
- `dpskdemod`

## Inherited option removed from filters

The **Inherited** option has been removed from the **Input Processing** parameter for these blocks:

- Raised Cosine Transmit Filter
- Raised Cosine Receive Filter
- Ideal Rectangular Pulse Filter
- Windowed Integrator

## Functionality being removed

The following features will be removed in a future release.

Function, Block, or System Object	Use This Instead
<code>modem.qammod</code>	<code>qammod</code>
<code>modem.qamdemod</code>	<code>qamdemod</code>
<code>comm.CPMCarrierPhaseSynchronizer</code>	<code>comm.CarrierSynchronizer</code>
CPM Phase Recovery	Carrier Synchronizer

These functions have been removed.

Functionality	What Happens When You Use This Functionality?	Use This Instead	Compatibility Considerations
<code>fec.bchdec</code>	Errors	<code>comm.BCHDecoder</code>	Replace all instances of <code>fec.bchdec</code> with <code>comm.BCHDecoder</code> .
<code>fec.bchenc</code>	Errors	<code>comm.BCHEncoder</code>	Replace all instances of <code>fec.bchenc</code> with <code>comm.BCHEncoder</code> .

Functionality	What Happens When You Use This Functionality?	Use This Instead	Compatibility Considerations
<code>fec.ldpcdec</code>	Errors	<code>comm.LDPCDecoder</code>	Replace all instances of <code>fec.ldpcdec</code> with <code>comm.LDPCDecoder</code> .
<code>fec.ldpcenc</code>	Errors	<code>comm.LDPCEncoder</code>	Replace all instances of <code>fec.ldpcenc</code> with <code>comm.LDPCEncoder</code> .
<code>fec.rsdec</code>	Errors	<code>comm.RSDecoder</code>	Replace all instances of <code>fec.rsdec</code> with <code>comm.RSDecoder</code> .
<code>fec.rsenc</code>	Errors	<code>comm.RSEncoder</code>	Replace all instances of <code>fec.rsenc</code> with <code>comm.RSEncoder</code> .

## Communications System Toolbox Support Package for Xilinx Zynq-Based Radio updates (Introduced in April 2016)

### Hardware/Software Co-Design

Design algorithms for hardware and software implementation on SDR hardware. Hardware-software (HW/SW) co-design involves implementing algorithms on the Zynq radio platform that are partitioned across the ARM and the FPGA fabric. When deployed, you can control and tune parameters on the HDL logic. For more information, see Hardware-Software Co-Design.

HW/SW co-design is supported for Simulink on Windows only.

This feature requires the following MathWorks software:

- Communications System Toolbox Support Package for Xilinx Zynq-Based Radio
- HDL Coder Support Package for Xilinx Zynq Platform (requires HDL Coder)
- Embedded Coder Support Package for Xilinx Zynq Platform (requires Embedded Coder and, for use with HW/SW co-design, Simulink Coder and the ARM Cortex-A support package)

For more about HW/SW co-design requirements, see Hardware-Software Co-Design for Zynq SDR Applications.

# R2015b

---

**Version: 6.1**

**New Features**

**Bug Fixes**

**Compatibility Considerations**

## **cdma2000 and 1xEV-DO Waveform Generators: Model the physical layer of North American CDMA standards and provide reference channels and waveforms**

Define cdma2000 and 1xEV-DO standards compliant reference channels and waveforms.

## **Coarse Frequency Compensator: Correct carrier frequency offsets in PAM, PSK, and QAM signals**

Correct for coarse carrier frequency offsets in PAM, PSK, and QAM signals. Used with the CarrierSynchronizer System object, you can accurately and quickly compensate for a wide range of frequency offsets.

## **Polynomial Strings: Specify Galois field polynomials as strings for error correction coding and sequence generation**

In addition to binary and numeric vectors, you can specify polynomials as strings for coding, sequence generation, and scrambling functions. The new syntax allows you to specify polynomials in either ascending or descending order. This improvement allows you to use polynomial specifications as they appear in text books and journal articles.

## **AGC object and block have simplified interfaces, better dynamic range, and faster convergence times**

The AGC System object and block are improved to incorporate a simplified interface, tolerate a significantly larger input signal power range, and converge more quickly.

## **Compatibility Considerations**

The algorithm and some properties have been changed in this release. The properties and behavior of the previous releases can be accessed by setting the hidden LegacyMode property to true. By default, LegacyMode is false. The properties associated with the two legacy mode states are summarized.

<b>Property</b>	<b>LegacyMode = true</b>	<b>LegacyMode = false</b>
AdaptationStepSize		X

Property	LegacyMode = true	LegacyMode = false
ReferenceLevel		X
AveragingLength		X
MaximumGain	X	X
DetectorMethod	X	
LoopMethod	X	
UpdatePeriod	X	
StepSize	X	
GainOutputPort	X	

---

**Note** For Simulink models in which the output gain port is enabled, the legacy mode is automatically enabled. This is required because the port is not available from the updated AGC block.

---

## Improved interface on the constellation diagram object and block facilitates easier application of reference constellations and EVM/MER measurements

The improvements to the constellation diagram object and block allow you to easily access EVM and MER measurements. In addition, you can now display common reference constellations by selecting them from a drop down menu.

## Source blocks output frames of contiguous time samples but do not use the frame attribute

Source blocks output frames of contiguous time samples but do not use the frame attribute. Frame processing is still supported.

For the Bernoulli Binary Generator, Poisson Integer Generator, and the Random Integer Generator blocks, the following changes were made:

- Removed **Frame-based outputs** and **Interpret vector parameters as 1-D** parameters. Blocks always output a sample-based 2-D vector.
- Introduced **Source of initial seed** parameter.

To use the default MATLAB random number generator, leave the **Source of initial seed** parameter set to Auto. To set an initial seed, set **Source of initial seed** to Parameter and then set the **Initial seed** value.

- Behavior of the random number generator is changed. The statistics are improved.

For the Poisson Integer Generator block, the **Lambda** parameter is now **Poisson parameter (lambda)**. For the Random Integer Generator block, the **M-ary number** parameter is now **Set size**.

These source blocks do not support the Upgrade Advisor. To update your model to use the new functionality, replace each block as follows:

- 1 Open the Simulink Library Browser and add the new source block to your model from the Random Data Sources sublibrary of the Comm Sources library.
- 2 Configure the new block to use the same settings as the original source block.
- 3 Replace the old block with the new one.

The **Frame-based outputs** parameter was removed for these blocks:

- Barker Code Generator
- Gold Sequence Generator
- Hadamard Code Generator
- Kasami Sequence Generator
- OVSF Code Generator
- PN Sequence Generator
- Walsh Code Generator

They always output sample-based 2-D vectors. These blocks can be upgraded using the Upgrade Advisor.

## Functionality being changed or removed

The following functions are being removed:

Function	Use This Instead
mimochan	comm.MIMOChannel

The following blocks will be removed in a future release.



<b>Block</b>	<b>Use This Instead</b>
Gaussian Noise Generator	MATLAB Function and randn
Rayleigh Noise Generator	MATLAB Function and randn
Rician Noise Generator	MATLAB Function and randn
Uniform Noise Generator	MATLAB Function and rand

## **Communications System Toolbox Support Package for RTL-SDR Radio Updates (v 15.2.0)**

- “Deploy SDR models for standalone applications” on page 7-5
- “Code deployment to external host hardware” on page 7-5

### **Deploy SDR models for standalone applications**

Create standalone applications to simulate SDR models on target machines that do not have MATLAB installed. Create a standalone executable by using the codegen function.

Key features:

- Generate an executable file for validation and testing.
- Create static or dynamic library files for reusing or sharing algorithms.

MATLAB Coder required. Your executable may require deploying additional MATLAB libraries. All operating systems supported by MATLAB Coder are supported for RTL-SDR code generation. See [Generating Standalone C/C++ Executables from MATLAB Code](#) for details.

### **Code deployment to external host hardware**

Deploy code to external hardware for prototyping and faster processing. With Simulink, Simulink Support Package for Raspberry Pi Hardware , and the Communications System Toolbox Support Package for RTL-SDR Radio , generate and deploy code on Raspberry Pi hardware with a connected RTL-SDR radio.

For more information, see the documentation for [Communications System Toolbox Support Package for RTL-SDR Radio](#).

## **Communications System Toolbox Support Package for USRP Radio Updates (v 15.2.0)**

### **2x2 MIMO Support for USRP Radio B210 and X Series Boards (Introduced April 2015)**

The Communications System Toolbox Support Package for USRP Radio now supports 2x2 MIMO operations for the B210, X300, and X310 boards from Ettus Research.

## **Communications System Toolbox Support Package for Xilinx Zynq-Based Radio Updates (v 15.2.0)**

- “PicoZed SDR Support” on page 7-6
- “Simultaneous transmission and reception on a single board” on page 7-7
- “Third-Party Software Support Update” on page 7-7

### **PicoZed SDR Support**

Support for PicoZed SDR platform is now available with the Communications System Toolbox Support Package for Xilinx Zynq-Based Radio. This feature support for the combination of a carrier board and a system-on-module (SOM) enables you to take your design from the prototype stage all the way up to deployment in the field using the Support Package for Xilinx Zynq-Based Radio and MATLAB or Simulink.

Key features include:

- PicoZed SDR platform as an I/O peripheral for streaming RF signals
- Burst mode option for high bandwidth signal acquisition
- Fast prototyping
- Easily transition from prototype to deployment
- Automated workflow for customizing FPGA fabric using HDL Coder (Xilinx Vivado® Design Suite required. See "Hardware and Software Support" in the Communications System Toolbox Support Package for Xilinx Zynq-Based Radio documentation to determine the version you need.)
- Works with all AD9361 application examples included with this support package

Supported PicoZed SDR platforms:

---

Product Name	Avnet Part Number	Description
PicoZed SDR 7035/AD9361	AES-PZSDR-Z7035-AD9361-G	Z7035 / AD9361 SOM

### **Simultaneous transmission and reception on a single board**

To transmit and receive signals at the same time on the same board, use the `transmitRepeat` function together with normal receive functionality using the support package blocks and System objects. For an example of this feature, see "Transmit and Receive LTE MIMO Using a Single Analog Devices AD9361/AD9364" (shipped with the Communications System Toolbox Support Package for Xilinx Zynq-Based Radio).

### **Third-Party Software Support Update**

For FPGA Targeting, the following software updates are required:

- Xilinx Vivado development tools version 2014.4.
- Xilinx SDK development tools version 2014.4.



# R2015a

---

**Version: 6.0**

**New Features**

**Bug Fixes**

**Compatibility Considerations**

## **Symbol Timing Synchronizer: Correct for symbol timing clock skew between a transmitter and receiver**

This release adds a new `comm.SymbolSynchronizer` System object and Symbol Synchronizer block to provide symbol timing synchronization between a single-carrier transmitter and receiver.

## **Carrier Synchronizer: Synchronize phase and frequency on a received waveform**

This release adds a `comm.CarrierSynchronizer` System object and Carrier Synchronizer block to provide carrier phase and frequency synchronization between a single-carrier transmitter and receiver for PSK and QAM modulation schemes.

## **Baseband and Broadcast FM: Modulate and demodulate baseband and broadcast FM signals**

This release adds the following System objects and blocks to provide baseband and broadcast FM modulation and demodulation capability.

- `comm.FMBroadcastModulator`
- `comm.FMBroadcastDemodulator`
- `comm.FMModulator`
- `comm.FMDemodulator`
- FM Broadcast Modulator
- FM Broadcast Demodulator
- FM Modulator
- FM Demodulator

## **Interactive QAM Example: Simulate an end-to-end QAM link with RF impairments and corrections**

This release adds an interactive MATLAB example, featuring a graphical user interface, which shows the effects of RF impairments and corrections on an end-to-end QAM link simulation. See End-to-End QAM Simulation.

---

## **Communications System Toolbox Simulink Model Template: Automatically configure the Simulink environment for communications modeling**

The Communications System Toolbox Simulink model template enables reuse of settings, including configuration parameters. Create models from the template to encourage best practices and take advantage of previous solutions to common problems. Instead of the default canvas of a new model, use the template model to create a skeletal model using settings recommended for Communications System Toolbox.

You can use the built-in template or create templates from models that you already configured for your environment or application.

For more information, see [Configure the Simulink Environment for Communications Models](#).

## **Library for HDL-supported Communications System Toolbox blocks**

To find Communications System Toolbox blocks that support HDL code generation, from the Simulink library browser, open the 'Communications System Toolbox HDL Support' library. Alternatively, at the MATLAB command prompt, enter `commhdllib`.

The blocks in this library have parameters set for HDL code generation. To generate HDL code, you must have an HDL Coder license.

## **Frame-based processing**

As part of general product-wide changes pertaining to Frame-Based processing, certain block options that use the frame attribute of the input signal now cause an error.

The following sections provide more detailed information about the specific R2015a Communications System Toolbox software changes for frame-based processing:

- “Input processing parameter set to Inherited” on page 8-4
- “Rate options parameter set to Inherit from input” on page 8-5

## Input processing parameter set to Inherited

Setting the Input processing parameter to Inherited now causes an error in these blocks:

- AWGN Channel
- Gaussian Filter
- Windowed Integrator
- Derepeat
- Ideal Rectangular Pulse Filter
- Raised Cosine Transmit Filter
- Raised Cosine Receive Filter
- Repeat

## Compatibility Considerations

To ensure consistent results for models created in previous releases, set **Input processing** to:

- `Columns as channels (frame based)`, for frame-based input signals (double-line)
- `Elements as channels (sample based)`, for sample-based signal input signals (single-line)

After compiling the model, frame-based signals appear as double lines. Sample-based signals appear as single lines.

For models created in R2015a:

- To treat each column of the input signal as an independent channel, set **Input processing** to `Columns as channels (frame based)`.
- To treat each element of the input signal as an independent channel, set **Input processing** to `Elements as channels (sample based)`.

## Simulink Upgrade Advisor

If you are not sure which **Input processing** option applies to your model and choose Inherited instead, use the Simulink Upgrade Advisor to update your model.



---

For more information, see the DSP System Toolbox release notes.

### **Rate options parameter set to Inherit from input**

Setting the **Rate options** parameter to `Inherit from input` now causes an error for these blocks:

- M-FSK Modulator Baseband
- M-FSK Demodulator Baseband
- OQPSK Modulator Baseband
- OQPSK Demodulator Baseband
- CPM Modulator Baseband
- CPM Demodulator Baseband
- GMSK Modulator Baseband
- GMSK Demodulator Baseband
- MSK Modulator Baseband
- MSK Demodulator Baseband
- CPFSK Modulator Baseband
- CPFSK Demodulator Baseband
- Repeat
- Derepeat
- Raised Cosine Receive Filter
- Raised Cosine Transmit Filter

### **Compatibility Considerations**

To ensure consistent results for models created in older releases, set **Rate options** to:

- `Allow multirate processing`, for sample-based input signals
- `Enforce single-rate processing`, for frame-based input signals

For models created in R2015a:

- To run the block in single-rate mode, set **Rate options** to `Enforce single-rate processing`.

- To run the block in multirate mode, set **Rate options** to Allow multirate processing.

### **Simulink Upgrade Advisor**

If you are not sure which option to choose, run these Simulink Upgrade Advisor checks:

- Check model for block upgrade issues requiring compile time information, for blocks in a model
- Check model for custom library blocks that rely on frame status of the signal, for blocks in a custom library

### **Class definitions now available for MATLAB-authored System objects**

You can now view the MATLAB code for the following System object class definitions in the <matlabroot>/toolbox/comm/comm/+comm folder:

- ACPR.m
- AGC.m
- AWGNChannel.m
- BarkerCode.m
- BinarySymmetricChannel.m
- CarrierSynchronizer.m
- CCDF.m
- ConstellationDiagram.m
- DifferentialDecoder.m
- DifferentialEncoder.m
- DiscreteTimeVCO.m
- FMBroadcastDemodulator.m
- FMBroadcastModulator.m
- FMDemodulator.m
- FMModulator.m
- GeneralQAMTCMModulator.m

- 
- GoldSequence.m
  - HadamardCode.m
  - HelicalDeinterleaver.m
  - HelicalInterleaver.m
  - IQImbalanceCompensator.m
  - LTEMIMOChannel.m
  - MemorylessNonlinearity.m
  - MIMOChannel.m
  - OFDMDemodulator.m
  - OFDMModulator.m
  - OVSFCode.m
  - PhaseNoise.m
  - PSKCoarseFrequencyEstimator.m
  - PSKTCMModulator.m
  - QAMCoarseFrequencyEstimator.m
  - RaisedCosineReceiveFilter.m
  - RaisedCosineTransmitFilter.m
  - RayleighChannel.m
  - RectangularQAMTCMModulator.m
  - RicianChannel.m
  - RSDecoder.m
  - RSEncoder.m
  - SphereDecoder.m
  - SymbolSynchronizer.m
  - ThermalNoise.m
  - TurboDecoder.m
  - TurboEncoder.m
  - WalshCode.m

You can also view the MATLAB code for the following System object class definitions in the <matlabroot>/toolbox/comm/comm/+comm/+internal folder:

- CDF.m
- CDFEvaluation.m
- CoarseFrequencyEstimatorBase.m
- ConstellationBase.m
- DopplerVisualization.m
- FadingChannel.m
- FMModemBase.m
- GoldSequenceXor.m
- MeasureBase.m
- MultiBandFilter.m
- OFDMBase.m
- PathGainsVisualization.m
- Percentile.m
- PowerMeasurements.m
- Probability.m
- RaisedCosineFilterBase.m

## Functionality being changed or removed

The following functions are being removed:

Function	Use This Instead
rsdecof	comm.RSDecoder
rsencof	comm.RSEncoder

The following blocks will be removed in a future release.

Block	Use This Instead
M-PSK Phase Recovery	Carrier Synchronizer
Squaring Timing Recovery	Symbol Synchronizer
Early-Late Gate Timing Recovery	Symbol Synchronizer
Gardner Timing Recovery	Symbol Synchronizer

<b>Block</b>	<b>Use This Instead</b>
Mueller-Muller Timing Recovery	Symbol Synchronizer

The following System objects will be removed in a future release.

<b>System object</b>	<b>Use This Instead</b>
comm.PSKCarrierPhaseSynchronizer	comm.CarrierSynchronizer
comm.EarlyLateGateTimingSynchronizer	comm.SymbolSynchronizer
comm.GardnerTimingSynchronizer	comm.SymbolSynchronizer
comm.MuellerMullerTimingSynchronizer	comm.SymbolSynchronizer

## **Support Package for USRP® Radio B Series and X Series Board Support (Introduced November 2014)**

The Communications System Toolbox Support Package for USRP Radio now supports the B200, B210, X300, and X310 boards from Ettus Research.

### **Key Features**

- System object and block support for B Series and X Series Radio SDR development:
  - SDRu Receiver
  - SDRu Transmitter
  - comm.SDRuReceiver
  - comm.SDRuTransmitter
- Updated UHD support version 003.007.003
- Functions `findsdru` and `probesdru` updated to find and report information for Bus Series and X Series radios.
- Function `sdruLoad` updated to provide firmware/FPGA loading support for Bus Series and X Series radios.

These blocks and System objects provide SISO support and enable you to configure the master clock rate.

---

**Note** The master clock rate is different for the Bus Series and X Series radios than it is for the N Series radios. As such, the interpolation and decimation factors specified for N Series radios give different results for the Bus Series and X Series radios. Adjust your interpolation and decimation factors for USRP® blocks and System objects to achieve the same baseband rates that you used for the N Series radios.

---

### **Limitations**

- Communications System Toolbox Support Package for USRP Radio is not supported on Windows 8 operating systems.

### **Support Package for Xilinx Zynq-Based Radio (Introduced November 2014)**

Design and prototype SDR applications with Zynq-based radio hardware. Supports the use of Zynq-based radio as an I/O peripheral to send and receive arbitrary waveforms from and to MATLAB and Simulink. Includes MATLAB System objects, Simulink blocks, and a full Zynq-based hardware design to transmit and receive data from the hardware using a Gigabit Ethernet connection. In addition, this support package enables you to customize the FPGA logic for prototyping your SDR applications from Simulink using HDL Coder (FPGA Targeting).

For more information, see [Xilinx Zynq-Based Radio Support from Communications System Toolbox](#).

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## Supported Hardware and Software

### Hardware Support

Development Board	RF Boards	I/O Peripheral Support	FPGA Targeting Support
Xilinx Zynq-7000 All Programmable SoC ZC706 Evaluation Kit	<ul style="list-style-type: none"><li>Analog Devices FMCOMMS1 Rev B/C</li><li>Analog Devices FMCOMMS2</li><li>Analog Devices FMCOMMS3</li></ul> <p>Avnet Zynq-7000 All Programmable SoC / AD9361 Software-Defined Radio Systems Development Kit (includes ZC706 and FMCOMMS3)</p>	Yes	Yes
Avnet ZedBoard™	<ul style="list-style-type: none"><li>Analog Devices FMCOMMS1 Rev B/C</li><li>Analog Devices FMCOMMS2</li><li>Analog Devices FMCOMMS3</li></ul> <p>Avnet Zynq-7000 All Programmable SoC / AD9361 Software-Defined Radio Evaluation Kit (includes ZedBoard and FMCOMMS2)</p>	Yes	No

---

**Caution** ZedBoard Rev B and earlier revisions must have a heat sink attached. (Rev C and later revisions have the heat sink attached already.) If your board has an FMC radio attached but no heat sink, the Zynq processor overheats and stops working.

To acquire a heat sink you can attach yourself, see the Avnet Express website: CTS BDN09-3CB/A01 Extruded Heat Sink.

For more information, see <http://zedboard.org/content/updated-rev-c-schematicbom>.

---

**Note** If you find that the FMCOMMS RF card tends to fall out of the slot on the Zynq development board, especially when using a heavy antenna, use the standoffs that come with the SDR development kit.

---

**Required Third-Party Software**

There is no required third-party software to use any of the supported radios in I/O mode.

For FPGA Targeting (ZC706 only), the following software is required:

- Xilinx Vivado development tools version 2013.4.
- Xilinx SDK development tools version 2013.4.

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**Note** You must install Xilinx SDK at the same time that you install Vivado.

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**Required MathWorks Products**

For all Support Package for Xilinx Zynq-based Radio software functionality, the following MathWorks products are required:

- MATLAB
- Signal Processing Toolbox
- DSP System Toolbox
- Communications System Toolbox

For FPGA Targeting, the following products are also required:

- Simulink
- HDL Coder

Recommended products:

- MATLAB Coder



# R2014b

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**Version: 5.7**

**New Features**

**Bug Fixes**

**Compatibility Considerations**

## **I/Q Imbalance Compensator System object and block that remove I/Q amplitude and phase imbalance**

This release adds an I/Q imbalance compensator to remove the amplitude and phase imbalance between the in-phase and quadrature components of a modulated signal. In addition to the compensator System object and block, two blocks and two functions were added which converts an imbalance into a compensator coefficient and vice versa.

## **Eye Diagram block that plots eye diagrams faster than its predecessor**

This release adds a new Eye Diagram Simulink block to the Comm Sinks library.

## **Compatibility Considerations**

The Eye Diagram block is a replacement for the Discrete-Time Eye Diagram Scope block. When existing models are loaded for the first time, the new eye diagram will automatically replace the old Discrete-Time Eye Diagram Scope.

## **Channel visualization for plotting impulse response, frequency response, and Doppler spectrum added to the Rayleigh, Rician, and MIMO Channel System objects**

Visualization capabilities for the `comm.MIMOChannel`, `comm.RayleighChannel`, and `comm.RicianChannel` System objects and for the MIMO Channel block have been added for this release.

## **Sum-of-sinusoids modeling technique added to the Rayleigh, Rician, and MIMO Channel System objects**

This release adds sum-of-sinusoids modeling to the `comm.MIMOChannel`, `comm.RayleighChannel`, and `comm.RicianChannel` System objects. Sum-of-sinusoids is ideally suited to modeling bursty channels and is an addition to the filtered Gaussian noise technique.

---

## Trajectory diagram visualization added to the Constellation Diagram block and System object

This release adds a signal trajectory diagram capability to the Constellation Diagram block and the `comm.ConstellationDiagram` System object.

### Compatibility Considerations

The enhanced Constellation Diagram block replaces the Discrete-Time Signal Trajectory Scope block. When existing models are loaded for the first time, the Constellation Diagram block with the **Show Signal Trajectory** option enabled will automatically replace the old Discrete-Time Signal Trajectory Scope block.

## Support Package for RTL-SDR Radio Update

### Linux Support

With release R2014b, support has been added for using the Support Package for RTL-SDR Radio on Linux operating systems.

Versions of Linux supported by MATLAB can be found in System Requirements.

### Mac Support

With release R2014b, support has been added for using the Support Package for RTL-SDR Radio on Mac operating systems.

Versions of Mac supported by MATLAB can be found in System Requirements.



# R2014a

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**Version: 5.6**

**New Features**

**Bug Fixes**

**Compatibility Considerations**

## **OFDM modulator and demodulator System objects and blocks**

This release adds OFDM modulation and demodulation capability by the addition of System objects and blocks. For more information, see the `comm.OFDMModulator` and `comm.OFDMDemodulator` System object Help pages.

## **DC blocker System object and block**

The release adds a new DC blocker System object and block. For more information, see the `dsp.DCBlocker` Help page.

## **Direct and nondirect modes for HDL-optimized CRC generator and detector**

This release allows the selection of either the direct or non-direct algorithm for CRC checksum calculations for the HDL-optimized CRC generator and detector System objects and blocks. For more information, see the `comm.HDLCRCDetector` and the `comm.HDLCRCGenerator` System object Help pages.

## **Additional featured examples such as 802.11 OFDM synchronization and HDL Optimized QAM Transmitter and Receiver**

Additional featured examples:

- 802.11 synchronization
- HDL Optimized QAM Transmitter and Receiver

Generate HDL code from hardware-optimized 64-QAM transmitter and receiver. This example addresses real-world communications issues and generates HDL code for FPGA implementation (HDL Coder license required).

- HDL Optimized QPSK Transmitter

This example shows how Simulink blocks that support HDL code generation can be used to implement the baseband processing of a digital communications transmitter (HDL Coder license required).

---

## APP Decoder System object parameter change

Beginning in release R2012a, the `Algorithm` property replaced the `MetricMethod` property for the `comm.APPDecoder` System object. At this time, an error will occur in legacy code that uses the `MetricMethod` property.

## Compatibility Considerations

If you have any existing System object code that uses the `MetricMethod` property, you must change the property to `Algorithm`.

## GPU System Object Support in System Block

GPU System objects are now supported in the System Block. The following System objects are supported in the current release:

- `comm.gpu.AWGNChannel`
- `comm.gpu.BlockDeinterleaver`
- `comm.gpu.BlockInterleaver`
- `comm.gpu.ConvolutionalDeinterleaver`
- `comm.gpu.ConvolutionalEncoder`
- `comm.gpu.ConvolutionalInterleaver`
- `comm.gpu.PSKDemodulator`
- `comm.gpu.PSKModulator`
- `comm.gpu.TurboDecoder`
- `comm.gpu.ViterbiDecoder`

See System Block Support for GPU System Objects.

## System object templates

The MATLAB **New > System object** menu now has three new class-definition file templates. The **Basic** template sets up a simple System object. The **Advanced** template includes additional features of System objects. The **Simulink Extension** template provides additional customization of the System object for use in the MATLAB System block.

## **System objects infer number of inputs and outputs from stepImpl method**

When you create a new kind of System object that has a fixed number of inputs or outputs specified in the `stepImpl` method, you no longer need to include `getNumInputsImpl` or `getNumOutputsImpl` in your class definition file. The correct number of inputs and outputs are inferred from the `stepImpl` inputs and outputs, respectively.

## **System objects setupImpl method enhancement**

When you create a new kind of System object and include the `setupImpl` method, you do not have to match the `setupImpl` method inputs to the `stepImpl` method inputs. If your `setupImpl` method does not use any input characteristics, such as, data type or size), you can include only the System object as the input argument.

## **System objects base class renamed to matlab.System**

The System object base class, `matlab.system.System` has been renamed to `matlab.System`. If you use `matlab.system.System` when defining a new System object, an error message results.

## **Compatibility Considerations**

Change all instances of `matlab.system.System` in your System objects code to `matlab.System`.

## **System objects Propagates mixin methods**

Four new methods have been added to the Propagates mixin class. You use this mixin when creating a new kind of System object for use in the MATLAB System block in Simulink. You use these methods to query the input and specify the output of a System object.

- `propagatedInputComplexity`
- `propagatedInputDataType`
- `propagatedInputFixedSize`
- `propagatedInputSize`



---

## System objects infoImpl method allows variable inputs

When you create a new kind of System object, you can use the `info` method to provide information specific to that object. The `infoImpl` method, which you include in your class-definition file, now allows `varargin` as an input argument.

## Support Package for RTL-SDR Radio (v 14.1.0)

Design and prototype software-defined radio (SDR) systems using MATLAB and Simulink with the Communications System Toolbox Support Package for RTL-SDR Radio.

For full access to features and documentation, download the support package from the [Hardware Support](#) page. To get help for the RTL-SDR Radio support package after you install it, enter `help sdr` at the MATLAB command line.

- “Key Features” on page 10-5
- “Blocks and System Objects” on page 10-5
- “RTL-SDR Examples” on page 10-5
- “Hardware and Software Requirements” on page 10-6

### Key Features

- RTL-SDR radio as an I/O peripheral to receive streaming RF signals
- Configurable center frequency and sample rate
- NooElec™ NESDR Mini USB Stick (R820T) and NooElec NESDR Nano USB Stick (R820T) SDR devices with frequency range 30MHz - 1.8GHz
- Compatible with other RTL-SDR USB radios (for example, Terratec T-Stick E4000).
- Several application examples for getting started

### Blocks and System Objects

- Simulink radio receiver block: RTL-SDR Receiver
- MATLAB radio System object: `comm.SDRRTLReceiver`

### RTL-SDR Examples

- Spectrum Analysis with RTL-SDR Radio for MATLAB and Simulink
- Frequency Offset Calibration with RTL-SDR Radio for MATLAB and Simulink

- FM Monophonic Receiver with RTL-SDR Radio for MATLAB and Simulink
- FM Stereo Receiver with RTL-SDR Radio for MATLAB and Simulink
- FRS/GMRS Walkie-Talkie Receiver with RTL-SDR Radio for MATLAB and Simulink

Enter `sdrexamples` at the MATLAB command prompt for a full index of SDR support package examples.

### **Hardware and Software Requirements**

For both MathWorks and third-party software and hardware requirements, see RTL-SDR Support from Communications System Toolbox.

## **Support Package for Xilinx FPGA-Based Radio updates (v 14.1.0)**

- “Intermediate frequency tuning” on page 10-6
- “DC blocking filter” on page 10-7
- “QPSK targeting examples” on page 10-7

### **Intermediate frequency tuning**

This feature supports a second stage tuning for both transmit and receive data paths. Then tuner is configurable at run-time (tunable). It has a finer resolution compared to the primary tuner on RF card, and the ability to remove unwanted interference from the pass band of interest.

- Transmitter and Receiver blocks: Set the **Intermediate Frequency** parameter in the block mask.

The intermediate frequency (IF) tuner allows you to account for the error in tuning between target frequency and actual frequency.

- Transmitter and Receiver System objects: Set the `IntermediateFrequency` property for the System object. For example:

```
so = comm.SDRADIFMCOMMSTransmitter;  
so.IntermediateFrequency = txIFValue
```

See the reference pages for `comm.SDRADIFMCOMMSReceiver`, `comm.SDRADIFMCOMMSTransmitter`, or `comm.SDREpiqBitsharkReceiver`.

- 
- With the HDL Coder workflow advisor (for Simulink only): Choose to include or not include the Intermediate Frequency tuner in the FPGA when using the targeting workflow.

At step 4.1, Set SDR Options:

- For transmit, select **Include transmitter intermediate frequency tuner**.
- For receiver, select **Include receiver intermediate frequency tuner**.

### **DC blocking filter**

Choose to bypass the DC bias removal filter. Use this feature when the filter is also blocking some signal and you need to use a different DC bias compensation scheme. By default, this option is not selected, which means to include the automatic DC blocking filter.

- Blocks: Select parameter **Bypass DC blocking filter**.

See the reference pages for the Analog Devices FMCOMMS Receiver block, the Analog Devices FMCOMMS Transmitter block, or the Epiq Bitshark Receiver block.

- System objects: Set property `BypassDCBlockingFilter` to true.

See the reference pages for `comm.SDRADIFMCOMMSReceiver`, `comm.SDRADIFMCOMMSTransmitter`, or `comm.SDREpiqBitsharkReceiver`.

### **QPSK targeting examples**

- **Targeting HDL Optimized QPSK Receiver with SDR Platform:** Learn how to model an HDL-optimized QPSK receiver and prototype it on the SDR hardware using the HDL Coder workflow advisor.
- **Targeting HDL Optimized QPSK Transmitter with SDR Platform:** Learn how to model an HDL-optimized QPSK transmitter and prototype it on the SDR hardware using the HDL Coder workflow advisor.



# R2013b

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**Version: 5.5**

**New Features**

**Bug Fixes**

**Compatibility Considerations**

## **Simulink blocks for MIMO channel, sphere decoder, and constellation diagram**

This release includes a new MIMO Channel, sphere decoder, and constellation diagram blocks.

The MIMO Channel block filters an input signal using a multiple-input multiple-output (MIMO) multipath fading channel. For more information, see MIMO Channel.

The Sphere Decoder block offers MIMO receiver processing for communications systems using spatial multiplexing with high data rates, such as 802.11n, LTE, and WiMAX. This implementation offers maximum likelihood performance with reduced complexity. For more information, see Sphere Decoder.

The Constellation Diagram block plots constellation diagrams and provides the ability to perform EVM and MER measurements. The Constellation Diagram block replaces the Discrete-Time Scatter Plot block. For more information, see Constellation Diagram.

### **Compatibility Considerations**

The Constellation Diagram block display enforces a 1:1 aspect ratio. The Discrete-Time Scatter Plot block, which the Constellation Diagram block replaces, does not enforce a 1:1 aspect ratio. For a non-unity display aspect ratio, you can use the Simulink XY Graph block.

### **Code generation for all MIMO channel Doppler spectra**

The `comm.MIMOChannel` System object now generates C code for the following Doppler spectra:

- Rounded
- Bell
- Asymmetric Jakes
- Restricted Jakes
- Gaussian
- BiGaussian
- Flat

- 
- Jakes

## **Open-loop PSK and QAM carrier synchronizers in MATLAB**

This release provides new open-loop carrier synchronizer System objects, which allow you to estimate and compensate for carrier offset due to transceiver impairments. For more information, see:

- `comm.PSKCoarseFrequencyEstimator`
- `comm.QAMCoarseFrequencyEstimator`

## **HDL-Optimized QPSK Receiver with Captured Data**

The example HDL Optimized QPSK Receiver with Captured Data shows how to optimize an QPSK receiver for HDL code generation and hardware implementation. The HDL-optimized model shows a QPSK receiver that addresses real-world communications issues like carrier frequency, phase offset, and timing recovery for the hardware implementation.

## **Raised cosine transmit and receive filter System objects**

This release provides new raised cosine transmit and receive filter System objects. For more information, see:

- `comm.RaisedCosineTransmitFilter`
- `comm.RaisedCosineReceiveFilter`

## **Rayleigh and Rician fading channel System objects**

This release provides new fading channel System objects. For more information, see:

- `comm.RayleighChannel`
- `comm.RicianChannel`

## System objects `matlab.system.System` warnings

The `System` object base class, `matlab.system.System`, has been replaced by `matlab.System`. If you use `matlab.system.System` when defining a new `System` object, a warning message results.

## Compatibility Considerations

Change all instances of `matlab.system.System` in your `System` objects code to `matlab.System`.

## Restrictions on modifying properties in `System` object Impl methods

When defining a new `System` object, certain restrictions affect your ability to modify a property.

You cannot use any of the following methods to modify the properties of an object:

- `cloneImpl`
- `getDiscreteStateImpl`
- `getDiscreteStateSpecificationImpl`
- `getNumInputsImpl`
- `getNumOutputsImpl`
- `getOutputDataTypeImpl`
- `getOutputSizeImpl`
- `isInputDirectFeedthroughImpl`
- `isOutputComplexImpl`
- `isOutputFixedSizeImpl`
- `validateInputsImpl`
- `validatePropertiesImpl`

This restriction is required by code generation, which assumes that these methods do not change any property values. These methods are validation and querying methods that are expected to be constant and should not impact the algorithm behavior.

Also, if either of the following conditions exist:



- You plan to generate code for the object
- The object will be used in the MATLAB System block

you cannot modify tunable properties for any of the following runtime methods:

- `outputImpl`
- `processTunedPropertiesImpl`
- `resetImpl`
- `setupImpl`
- `stepImpl`
- `updateImpl`

This restriction prevents tunable parameter updates within the object from interfering with updates from outside the generated code. Tunable parameters can only be changed from outside the generated code.

## Compatibility Considerations

If any of your class definition files contain code that changes a property in one of the above `Impl` methods, move that property code into an allowable `Impl` method. Refer to the System object `Impl` method reference pages for more information.

## Block parameter prompt changes for raised cosine filter blocks

In this release, several block parameter prompts on the Raised Cosine Transmit Filter block and the Raised Cosine Receive Filter block have changed.

### How to map old block property names to new block property names

To map the old Raised Cosine Transmit Filter block parameter prompts to the new block parameter prompts, refer to the following table.

Old Parameter Name	New Parameter Name	Notes
Filter type	Filter shape	N/A

Old Parameter Name	New Parameter Name	Notes
<b>Group delay (number of symbols)</b>	<b>Filter span in symbols</b>	Set the <b>Filter span in symbols</b> as twice the value of the <b>Group delay (number of symbols)</b> parameter.
<b>Upsampling factor (N)</b>	<b>Samples per symbol</b>	N/A
<b>Filter gain</b>	N/A	The block only allows a user-specified gain.

To map the old Raised Cosine Receive Filter block parameter prompts to the new block parameter prompts, refer to the following table.

Old Parameter Name	New Parameter Name	Notes
<b>Filter type</b>	<b>Filter shape</b>	N/A
<b>Group delay (number of symbols)</b>	<b>Filter span in symbols</b>	Set the <b>Filter span in symbols</b> as twice the value of the <b>Group delay (number of symbols)</b> parameter.
<b>Output mode</b>	N/A	By default, the new block acts as if you select <b>Downsampling</b> . If you have saved an old model with <b>None</b> selected, the new block sets the <b>Decimation factor</b> parameter to 1, implying no decimation.
<b>Downsampling factor</b>	<b>Decimation factor</b>	N/A
<b>Sample offset</b>	<b>Decimation offset</b>	N/A
<b>Filter gain</b>	N/A	The block only allows a user-specified gain.

---

## Compatibility Considerations

The updated Raised Cosine Transmit Filter and Raised Cosine Receive Filter blocks design a unit energy filter and then apply the linear amplitude filter gain to the filter coefficients. If you open a model that was saved in a prior version of the software, the software updates the block parameters. The blocks set the **Filter span in symbols** as twice the value of the **Group delay (number of symbols)** parameter. Similarly, the blocks set the linear amplitude filter gain to use the same filter coefficients as the old model. If you define a parameter value using a variable, you should confirm that the variable propagates correctly after you open the model.

Each time you open a model that was created using a prior release, Simulink automatically sets the block parameter values to obtain the same filter coefficients. If you save the model, the updates become permanent. As a best practice, you should confirm that the parameter values of the filter blocks are valid before saving the updated models.

## NumTransmitAntennas and NumReceiveAntennas properties added back to MIMOChannel System object.

In the previous release, the NumTransmitAntennas and NumReceiveAntennas properties were removed from the MIMO Channel System object. This release, the properties were added back to the object. For more information, see `comm.MIMOChannel`.

## Functionality Being Changed or Removed

Effective this release, you should not use the following block or functions when simulating digital communications systems.

Functionality	What Happens When You Use This Functionality?	Use This Instead	Compatibility Considerations
Discrete-Time Scatter Plot block	Still runs	Constellation Diagram	Replace all instances of Discrete-Time Scatter Plot block with Constellation Diagram

Functionality	What Happens When You Use This Functionality?	Use This Instead	Compatibility Considerations
Gaussian Filter block	Still runs	<code>gaussdesign</code> function and Discrete FIR Filter, FIR Interpolation, or FIR Decimation block	Replace all instances of Gaussian Filter block with Discrete FIR Filter, FIR Interpolation, or FIR Decimation blocks. Use <code>gaussdesign</code> to generate filter coefficients for these blocks.
<code>rcosfir</code>	Still runs	<code>rcosdesign</code>	Replace all instances of <code>rcosfir</code> with <code>rcosdesign</code> .
<code>rcosflt</code>	Still runs	<code>rcosdesign</code> function and either <code>filter</code> or <code>upfirdn</code> functions	Replace all instances of <code>rcosflt</code> with <code>rcosdesign</code> and either <code>filter</code> or <code>upfirdn</code> .
<code>rcosiir</code>	Still runs	<code>rcosdesign</code> function for FIR raised cosine filters	Replace all instances of <code>rcosiir</code> with <code>rcosdesign</code> .
<code>rcosine</code>	Still runs	<code>rcosdesign</code>	Replace all instances of <code>rcosine</code> with <code>rcosdesign</code> .

### Migrate Code from `firrcos` and `rcosfir` to `rcosdesign`

This section helps you update your legacy code using `firrcos` and `rcosfir` to use the recommended `rcosdesign`.

#### `firrcos` to `rcosdesign`

Design an order 16 FIR raised cosine filter with a carrier frequency of 1 kHz, a roll-off factor of 0.25, and a sampling frequency of 8 kHz.

---

```

N = 16;
Fc = 1000;
R = 0.25;
Fs = 8000;
b1 = firrcos(N,Fc,R,Fs,'rolloff','normal');

```

To obtain the identical filter using the recommended `rcosdesign`, use

```

b1n = rcosdesign(R, N/(Fs/Fc/2), Fs/Fc/2,'normal');
b1n = b1n / max(b1n) / (Fs/Fc/2);

```

The following code constructs the same raised cosine filter as the previous example. This example demonstrates the equivalence between the input arguments for `firrcos` and `rcosdesign`. The plot and comparison of the filter coefficient values show that the two filters are identical.

```

beta = R;
sps = Fs/(2*Fc);
span = N / sps;
b1n = rcosdesign(beta, span, sps,'normal');
b1n = b1n / max(b1n) / sps;figure
plot(b1)
hold on
plot(b1n, 'r-.')
grid on
legend('firrcos', 'rcosdesign');
max(abs(b1n-b1))

```

Design a square-root raised cosine filter using `firrcos` and obtain the identical filter using `rcosdesign`.

```

b2 = firrcos(N,Fc,R,Fs,'rolloff','sqrt');
b2n = rcosdesign(R, N/(Fs/Fc/2), Fs/Fc/2, 'sqrt');
b2n = b2n / max(b2n) * ((-1 ./ (pi.*(Fs/Fc/2))) .* (pi.*(R-1) - 4.*R));

```

The following code constructs the same square-root raised cosine filter as the previous example. This example demonstrates the equivalence between the input arguments for `firrcos` and `rcosdesign`. The plot and comparison of the filter coefficient values show that the two filters are identical.

```

beta = R;
sps = Fs/(2*Fc);
span = N / sps;
b2n = rcosdesign(R, span, sps, 'sqrt');

```

```
b2n = b2n / max(b2n) * ((-1 ./ (pi.*sps) .* (pi.*(R-1) - 4.*R)));
figure
plot(b2)
hold on
plot(b2n, 'r-.')
grid on
legend('firrcos', 'rcosdesign')
max(abs(b2-b2n))
```

### **rcosfir to rcosdesign**

Design a raised cosine filter using `rcosfir` with sampling period of 1 second, an oversampling rate of 6 (6 output samples for every input sample), and a roll-off factor of 0.3.

```
R = 0.3;
N_T = 4;
RATE = 6;
T = 1;
% filter length is 2*N_T*RATE+1
b3 = rcosfir(R, N_T, RATE, T, 'normal');
```

Design the same filter using the recommended `rcosdesign`.

```
b3n = rcosdesign(R, 2*N_T, RATE, 'normal');
b3n = b3n / max(b3n);
```

The following code constructs the same raised cosine filter as the previous example. This example demonstrates the equivalence between the input arguments for `rcosfir` and `rcosdesign`. The plot and comparison of the filter coefficient values show that the two filters are identical.

```
beta = R;
sps = RATE;
span = 2*N_T;
b3n = rcosdesign(beta, span, sps, 'normal');
b3n = b3n / max(b3n)
figure
plot(b3)
hold on
plot(b3n, 'r-.')
grid on
legend('rcosfir', 'rcosdesign')
max(abs(b3-b3n))
```

---

Design a square-root raised cosine filter using `rcosfir` and obtain the identical filter using `rcosdesign`.

```
b4 = rcosfir(R, N_T, RATE, 1, 'sqrt')
b4n = rcosdesign(R, 2*N_T, RATE, 'sqrt');
b4n = b4n / max(b4n) * ((-1 ./ (pi.*RATE) .* (pi.*(R-1) - 4.*R ))) * sqrt(RATE);
```

The following code constructs the same square-root raised cosine filter as the previous example. This example demonstrates the equivalence between the input arguments for `rcosfir` and `rcosdesign`. The plot and comparison of the filter coefficient values show that the two filters are identical.

```
beta = R;
sps = RATE;
span = 2*N_T;
b4n = rcosdesign(R, span, sps, 'sqrt');
b4n = b4n / max(b4n) * ((-1 ./ (pi.*sps) .* (pi.*(R-1) - 4.*R))) * sqrt(RATE)
figure
plot(b4)
hold on
plot(b4n, 'r-.')
grid on
legend('rcosfir', 'rcosdesign')
max(abs(b4-b4n))
```

## Support Package for Xilinx FPGA-Based Radio

Design SDR applications for use with FPGA-based radio. Supports both fixed bitstream (Support Package for Xilinx FPGA-Based Radio software provides all logic) and custom bitstream (user-provided logic) workflows (SDR Targeting). This support package includes Simulink receiver and transmitter blocks for use with Simulink and receiver and transmitter System objects for use with MATLAB. These blocks and System objects enable communication with an FPGA-based radio, allowing for development work in software-defined radio applications.

### Main Features

- Simulink blocks
  - Analog Devices FMCOMMS Receiver
  - Analog Devices FMCOMMS Transmitter
  - Epiq Bitshark Receiver
- System objects
  - `comm.SDRADIFMCOMMSReceiver`

- `comm.SDRADIFMCOMMSTransmitter`
- `comm.SDREpiqBitsharkReceiver`
- SDR Targeting

SDR Targeting allows you to implement your baseband processing algorithm on the FPGA of the Xilinx development board. By moving part of all of your algorithm to the hardware, you will speed up the host processing. See Implement SDR Targeting.

- Examples
  - HDL Optimized QPSK Receiver with Captured Data demonstrates a hardware-friendly solution that performs baseband processing to handle a time-varying frequency offset and a time-varying symbol delay.
  - QPSK Transmitter and Receiver shows a digital communications system using QPSK modulation.
  - IEEE 802.11 WLAN - HDL Optimized Beacon Frame Receiver with Captured Data shows the reception of beacon frames in an 802.11 based wireless local area network (WLAN).

### Supported Hardware and Software

- Hardware support

FPGA Development Board	RF Board	Fixed Bitstream Support	SDR Targeting Support
Virtex-6 ML605	Epiq Bitshark RevB	Yes	Yes
Virtex-6 ML605	Epiq Bitshark RevC	Yes	Yes
Xilinx ML605	ADI FCOMMS1 RevB	Yes	Yes



- 
- Software requirements
    - SDR fixed bitstream and SDR targeting are tested with Xilinx ISE 13.4.
    - For fixed bitstream, Xilinx iMPACT is required.



# R2013a

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**Version: 5.4**

**New Features**

**Bug Fixes**

**Compatibility Considerations**

## **Sphere Decoder System object for MIMO receiver processing**

The Sphere Decoder System object offers MIMO receiver processing for communications systems using spatial multiplexing with high data rates, such as 802.11n, LTE, and WiMAX. This implementation offers maximum likelihood performance with reduced complexity.

For more information, see the `comm.SphereDecoder` Help page.

## **Constellation Diagram System object with measurements**

The constellation diagram System object plots constellation diagrams and provides the ability to perform EVM and MER measurements. For more information, see the `comm.ConstellationDiagram` System object Help page.

## **LTE space-frequency block coding and LTE GPU-accelerated turbo coding examples**

This release includes new LTE examples illustrating space-frequency block coding and GPU-accelerated turbo coding.

The LTE Downlink PDSCH with Transmit Diversity example highlights LTE Downlink PDSCH processing with transmit diversity, including two transmit antenna and four transmit antenna configurations.

The LTE Downlink Shared Channel Processing with GPU Acceleration example shows how you can use GPUs to accelerate bit error rate simulations.

In addition, the existing LTE PHY Downlink with Spatial Multiplexing example includes two new MATLAB-based implementations.

## **HDL code generation for CRC Generator, CRC Detector, RS Encoder, and RS Decoder System objects**

Effective this release, the following System objects provide HDL code generation:

- `comm.HDLCRCDetector`
- `comm.HDLCRCGenerator`

- 
- `comm.HDLRSDecoder`
  - `comm.HDLRSEncoder`

To generate HDL code, you must have an HDL Coder license.

## **Variable-size support for AWGN, MIMO, and LTE MIMO Channel System objects**

This release includes variable-size support for the AWGN, MIMO Channel, and LTE MIMO Channel System objects. This support enables you to:

- Vary the number of transmit and receive antennas, which is necessary for LTE modeling
- Vary the number of samples per channel, which is helpful for LTE and WiMAX modeling

For more information see:

- `comm.AWGNChannel`
- `comm.MIMOChannel`
- `comm.LTEMIMOChannel`

## **IEEE 802.11 WLAN - HDL optimized beacon frame receiver example with captured data**

This example shows a hardware friendly model that receives beacon frames in an 802.11 wireless local area network (WLAN).

## **Automatic gain controller block and System object**

This release includes a new automatic gain controller (AGC) block and System object. The AGC adaptively adjusts its gain to achieve a constant signal level at the output.

For more information see the AGC block and `comm.AGC` System object Help pages.

## Additional CRC algorithm implementation

Effective this release, the CRC blocks and System objects support the direct algorithm, input byte reflection, checksum reflection, and final XOR operation. These features enable more straightforward Ethernet CRC generation and detection. For more information see:

- General CRC Generator
- `comm.CRCGenerator`
- General CRC Syndrome Detector
- `comm.CRCDetector`

## ATSC digital television example

The ATSC Digital Television example shows the vestigial sideband modulation with 8 discrete amplitude levels (8-VSB) transmission subsystem of the Advanced Television Systems Committee (ATSC) digital television standard.

## Disable second output port on APP Decoder

Beginning in this release, you can disable the second output port, containing coded bit log-likelihood ratios, on the APP Decoder System object and block.

For the System object, disable the `CodedBitLLROutputPort` property.

For the block, select the **Disable L(c) output port** check box.

## Behavior change of locked System objects for loading, saving, and cloning

In the previous release, saving, loading, and cloning a locked System object would result in an unlocked System object. This System object had the same property values as the one from which it was cloned, but not the same internal state.

In this release, it does not matter whether you save a locked System object into a MAT file and load it later or clone a locked System object using the `clone` method. In either case, the result is a locked System object with the same property values and the same internal states.

---

## Dynamic memory allocation based on size

By default, dynamic memory allocation is now enabled for variable-size arrays whose size exceeds a configurable threshold. This behavior allows for finer control over stack memory usage. Also, you can generate code automatically for more MATLAB algorithms without modifying the original MATLAB code. The following System objects support dynamic memory allocation for C code generation:

- `comm.BPSKDemodulator`
- `comm.BPSKModulator`
- `comm.PSKDemodulator`
- `comm.PSKModulator`
- `comm.QPSKDemodulator`
- `comm.QPSKModulator`
- `comm.GeneralQAMDemodulator`
- `comm.GeneralQAMModulator`
- `comm.PAMDemodulator`
- `comm.PAMModulator`
- `comm.RectangularQAMDemodulator`
- `comm.RectangularQAMModulator`
- `comm.BitToInteger`
- `comm.IntegerToBit`
- `comm.OSTBCCombiner`
- `comm.OSTBCEncoder`
- `comm.CRCDetector`
- `comm.CRCGenerator`
- `comm.ConvolutionalEncoder` (Dynamic memory allocation not supported for punctured applications.)
- `comm.ViterbiDecoder` (Dynamic memory allocation not supported for punctured applications.)
- `comm.TurboEncoder`

## Compatibility Considerations

If you use scripts to generate code and you do not want to use dynamic memory allocation, you must disable it. For more information, see [Controlling Dynamic Memory Allocation](#).

## Naming convention change for LTE examples

Effective this release, there is a new naming convention for LTE examples. See the following table for more information.

Example Title	Old File Name	New File Name
Downlink Transport Channel (DL-SCH) Processing	commlteDLSCH	LTEDLSCHExample
LTE PHY Downlink with Spatial Multiplexing	commlteDownlink	LTEDownlinkExample

## Compatibility Considerations

Typing the old file names at the MATLAB command line no longer opens example models. To open the example models, you must type the new file names.

## APP Decoder System Object parameter change

Beginning in release R2012a, the `Algorithm` property replaced the `MetricMethod` property for the `comm.APPDecoder` System object. At this time, any legacy code that uses the `MetricMethod` property generates a warning.

## Compatibility Considerations

If you have any existing System object code that uses the `MetricMethod` property, you must use the `sysobjupdate` function to update your code. For more information, type `help sysobjupdate` at the MATLAB command line.

## Functions to remain in the product

The following functions, which were previously announced for removal, will remain in the product.



- 
- bchdec
  - bchenc
  - dpskdemod
  - dpskmod
  - eyediagram
  - oqpskdemod
  - oqpskmod
  - pandemod
  - pammod
  - pskdemod
  - pskmod
  - qamdemod
  - qammod
  - rsdec
  - rsenc

## Communications System Toolbox Functionality Being Changed or Removed

The following function will be removed in a future release.

Functionality	What Happens When You Use This Functionality?	Use This Instead	Compatibility Considerations
mimochan	Warns	comm.MIMOChannel	Replace all instances of mimochan with comm.MIMOChannel.

### Update Legacy Code to use System object

For help updating your legacy code so that it uses the comm.MIMOChannel System object, see the following table.

### Map mimochan Properties and Methods to comm.MIMOChannel

mimochan Property	comm.MIMOChannel Property	Note
NumTxAntennas	N/A	This information is derived from the TransmitCorrelationMatrix property.
NumRxAntennas	N/A	This information is derived from the ReceiveCorrelationMatrix property.
InputSamplePeriod	SampleRate	Sample rate is the reciprocal of the input sample period.
DopplerSpectrum	DopplerSpectrum	
MaxDopplerShift	MaximumDopplerShift	
PathDelays	PathDelays	
AvgPathGaindB	AveragePathGains	
TxCorrelationMatrix	TransmitCorrelationMatrix	
RxCorrelationMatrix	ReceiveCorrelationMatrix	
KFactor	KFactor	
DirectPathDopplerShift	DirectPathDopplerShift	
DirectPathInitPhase	DirectPathInitialPhase	
NormalizePathGains	NormalizePathGains	

<b>mimochan Property</b>	<b>comm.MIMOChannel Property</b>	<b>Note</b>
ResetBeforeFiltering	N/A	Use the reset method for the System object before calling the step method  <pre>h = comm.MIMOChannel; step(h, ones(10,2)); reset(h); step(h, ones(20,2));</pre>
StorePathGains	N/A	Set the PathGainsOutputPort to true so the step method for the object outputs the path gains.
PathGains	N/A	Set the PathGainsOutputPort to true so the step method for the object outputs the path gains.
ChannelFilterDelay	N/A	Use the info method to display this information.
NumSamplesProcessed	N/A	Use the info method to display this information.
ChannelType	N/A	This read-only property was removed.

<b>mimochan Method</b>	<b>comm.MIMOChannel Method</b>
filter	step
reset	reset

**Note** mimochan and comm.MIMOChannel have different APIs. Refer to the following syntax examples when updating your legacy code:

<b>mimochan</b>	<b>comm.MIMOChannel</b>
<pre>chan = mimochan(2, 2, 1e-4, 60, [0 2.5e-4 3e-4]); chan.StorePathGains = 1;</pre>	<pre>chan = comm.MIMOChannel(2, 2, ...     'SampleRate', 1e4, ...     'PathDelays', [0 2.5e-4 3e-4], ...     'AveragePathGains', [0 -2 -3], ...     'MaximumDopplerShift', 60, ...     'TransmitCorrelationMatrix', eye(2), ...     'ReceiveCorrelationMatrix', eye(2), ...     'PathGainsOutputPort', true);</pre>
<pre>y = filter(chan, ones(20, 2)); pathGains = chan.PathGains;</pre>	<pre>[y, pathGains] = step(h, ones(20, 2));</pre>

# R2012b

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**Version: 5.3**

**New Features**

**Compatibility Considerations**

## **Support for C code generation for all System objects in Communications System Toolbox**

Effective this release, the following System objects provide C code generation:

- `comm.ACPR`
- `comm.BCHDecoder`
- `comm.CCDF`
- `comm.CPMCarrierPhaseSynchronizer`
- `comm.GoldSequence`
- `comm.LDPCDecoder`
- `comm.LDPCEncoder`
- `comm.LTEMIMOChannel`
- `comm.MemorylessNonlinearity`
- `comm.MIMOChannel`
- `comm.PhaseNoise`
- `comm.PSKCarrierPhaseSynchronizer`
- `comm.RSDecoder`
- `comm.ThermalNoise`

All CPU-based System objects in the Communications System Toolbox product generate C code. The GPU-based System objects do not generate C code.

## **Support for HDL code generation for Reed-Solomon encoder, decoder, and CRC detector blocks**

Effective this release, the following blocks provide HDL code generation:

- General CRC Syndrome Detector HDL Optimized
- Integer-Input RS Encoder HDL Optimized
- Integer-Output RS Decoder HDL Optimized

To generate HDL code, you must have an HDL Coder license.

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## Support for HDL code generation for Rectangular QAM and PSK Demodulator System objects

Effective this release, the following System objects provide HDL code generation:

- `comm.BPSKDemodulator`
- `comm.QPSKDemodulator`
- `comm.PSKDemodulator`
- `comm.RectangularQAMDemodulator`

To generate HDL code, you must have an HDL Coder license.

## LTE Zadoff-Chu sequence generator function

Communications System Toolbox includes a Zadoff-Chu sequence generator function. This function is useful when modeling 3GPP LTE physical layer characteristics, downlink primary synchronization signals, or the uplink reference signals and random access preamble sequences. For more information, see the `lteZadoffChuSeq` Help page.

## LTE downlink shared channel example

The LTE PHY Downlink with Spatial Multiplexing shows the Downlink Shared Channel (eNodeB to UE) processing of the Long Term Evolution (LTE) physical layer (PHY) specifications developed by the Third Generation Partnership Project (3GPP). LTE-Advanced is one of the candidates for fourth generation (4G) communications systems, approved by the International Telecommunication Union (ITU), with expected downlink peak data rates in excess of 1Gbps (for Release 10 and beyond). Using the Release 10 specifications, this example highlights the multi-antenna transmission scheme that enables such high data rates.

## Phase Noise block and System object, specifying phase noise spectrum with a vector of frequencies

The Phase Noise block and System object now have more flexibility for specifying spectral noise characteristics. You can specify a vector of phase noise levels, at more than one frequency value. Previously, the software allowed the specification of a single-phase noise level point. The new implementation enables more realistic noise modeling in your

communications models, and allows you to visualize the phase noise spectrum that the block or System object generates.

## **IEEE 802.11 beacon with captured data example**

This example shows reception of beacon frames in an 802.11 wireless local area network (WLAN). You can select one of several captured signals and view the data the beacon frame carries.

## **P25 spectrum sensing example**

This example shows how to use cyclostationary feature detection to distinguish signals with different modulation schemes, including P25 signals. It defines four cases of signals: noise only, C4FM, CQPSK, and one arbitrary type. The example applies the detection algorithm to signals with different SNR values and determines when the signals can be classified as one of the four types.

## **MATLAB-based QPSK transceiver example**

The QPSK Transmitter and Receiver example now includes a MATLAB implementation that uses System objects. This example models a digital communications system to simulate the QPSK transmitter - receiver chain. In particular, this example illustrates a method for tackling real-world wireless communication issues, such as: carrier frequency/phase offset, timing recovery, and frame synchronization.

## **Design Iteration Workflow**

This example illustrates a design workflow and the typical iterations involved in designing a wireless communications system with the Communications System Toolbox. Because Communications System Toolbox supports both MATLAB and Simulink, this examples showcases separate design iterations using MATLAB functions or Simulink models.

The workflow starts with a simple QPSK modulator system that transmits a signal through an AWGN channel and calculates the bit error rate. To make the system more realistic and improve system performance, the example gradually introduces Viterbi decoding, turbo coding, multipath fading channels, OFDM-based transmission and equalization, and multiple-antenna techniques.



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## Constellation method for modulator and demodulator System objects

Effective this release, modulator and demodulator System object have a `constellation` method. This method calculates or plots the ideal signal constellation, depending on object settings. The following System objects have the `constellation` method:

- `comm.PSKModulator`
- `comm.PSKDemodulator`
- `comm.RectangularQAMModulator`
- `comm.RectangularQAMDemodulator`
- `comm.PAMModulator`
- `comm.PAMDemodulator`
- `comm.QPSKModulator`
- `comm.QPSKDemodulator`
- `comm.BPSKModulator`
- `comm.BPSKDemodulator`
- `comm.OQPSKModulator`
- `comm.OQPSKDemodulator`
- `comm.gpu.PSKModulator`
- `comm.gpu.PSKDemodulator`

## Specify initial states of Gold Sequence Generator and PN Sequence Generator System objects

You can specify the initial states for the PN Sequence Generator and Gold Sequence Generator System objects as inputs to the `step` method. You can use these System objects as scrambling sequence generators. For packet-based systems, including WiMAX and LTE, the initial conditions are a function of time. Therefore, for simulation purposes, you must specify the initial states as an input.

## System object tunable parameter support in code generation

You can change tunable properties in user-defined System objects at any time, regardless of whether the object is locked. For System objects predefined in the software, the object

must be locked. In previous releases, you could tune System object properties only for a limited number of predefined System objects in generated code.

## **save and load for System objects**

You can use the `save` method to save System objects to a MAT file. If the object is locked, its state information is saved, also. You can recall and use those saved objects with the `load` method.

You can also create your own `save` and `load` methods for a System object you create. To do so, use the `saveObjectImpl` and `loadObjectImpl`, respectively, in your class definition file.

## **Save and restore SimState not supported for System objects**

The **Save and Restore Simulation State as SimState** option is no longer supported for any System object in a MATLAB Function block. This option was removed because it prevented parameter tunability for System objects, which is important in code generation.

## **Compatibility Considerations**

If you need to save and restore simulation states, you may be able to use a corresponding Simulink block, instead of a System object.

## **Functionality Being Changed or Removed**

The following function, which was previously announced for removal and warned at run time, has been removed from the product.

- `seqgen.pn`

The following functions will be removed in a future release.

<b>Functionality</b>	<b>What Happens When You Use This Functionality?</b>	<b>Use This Instead</b>	<b>Compatibility Considerations</b>
<code>commmeasure.ACPR</code>	Warns	<code>comm.ACPR</code>	Replace all instances of <code>commmeasure.ACPR</code> with <code>comm.ACPR</code> .
<code>commmeasure.EVM</code>	Warns	<code>comm.EVM</code>	Replace all instances of <code>commmeasure.EVM</code> with <code>comm.EVM</code> .
<code>commmeasure.MER</code>	Warns	<code>comm.MER</code>	Replace all instances of <code>commmeasure.MER</code> with <code>comm.MER</code> .
<code>fec.bchdec</code>	Warns	<code>comm.BCHDecoder</code>	Replace all instances of <code>fec.bchdec</code> with <code>comm.BCHDecoder</code> .
<code>fec.bchenc</code>	Warns	<code>comm.BCHEncoder</code>	Replace all instances of <code>fec.bchenc</code> with <code>comm.BCHEncoder</code> .
<code>fec.ldpcdec</code>	Warns	<code>comm.LDPCDecoder</code>	Replace all instances of <code>fec.ldpcdec</code> with <code>comm.LDPCDecoder</code> .
<code>fec.ldpcenc</code>	Warns	<code>comm.LDPCEncoder</code>	Replace all instances of <code>fec.ldpcenc</code> with <code>comm.LDPCEncoder</code> .
<code>fec.rsdec</code>	Warns	<code>comm.RSDecoder</code>	Replace all instances of <code>fec.rsdec</code> with <code>comm.RSDecoder</code> .
<code>fec.rsenc</code>	Warns	<code>comm.RSEncoder</code>	Replace all instances of <code>fec.rsenc</code> with <code>comm.RSEncoder</code> .

### **Update Legacy Code to use System objects**

For help updating your legacy code so that it uses the new System objects, refer to the following sections.

### Map commmeasure.ACPR Properties and Methods to comm.ACPR

commmeasure.ACPR property	comm.ACPR property	Note
Fs	SampleRate	
MainChannelMeasBW	MainMeasurementBandwidth	
AdjacentChannelMeasBW	AdjacentMeasurementBandwidth	
MeasurementFilter	MeasurementFilterSource	
SpectralEstimatorOption	SpectralEstimation	
WindowOption	Window	
SidelobeAtten	SidelobeAttenuation	
FrequencyResolutionOption	FrequencyResolution	
FFTLength	CustomFFTLength	
	MainChannelPowerOutputPort(new property)	<p>When you set <code>MainChannelPowerOutputPort</code> to <code>true</code>, the main channel power measurement becomes an output.</p> <hr/> <p><b>Note</b> Previously, for the <code>commmeasure.ACPR</code> object, this was the second output argument.</p>

<b>commmeasure.ACPR property</b>	<b>comm.ACPR property</b>	<b>Note</b>
	AdjacentChannelPowerOutputPort (new property)	When you set AdjacentChannelPowerOutputPort to true, the adjacent channel power measurement becomes an output.  <b>Note</b> Previously, for the commmeasure.ACPR object, this was the third output argument.
Type	N/A	This read-only property was removed.
FrameCount	N/A	This read-only property was removed.

<b>commmeasure.ACPR method</b>	<b>comm.ACPR method</b>
run	step
reset	reset
copy	clone
disp	N/A

**Note** commmeasure.ACPR and comm.ACPR have a different API. Refer to the following syntax examples when updating your legacy code:

<b>commmeasure.ACPR</b>	<b>comm.ACPR</b>	<b>Note</b>
commmeasure.ACPR	comm.ACPR	The default settings of the following are different:  'NormalizedFrequency' 'MainMeasurementBandwidth' 'AdjacentChannelOffset' 'AdjacentMeasurementBandwidth' 'MeasurementFilterSource'
h = commmeasure.ACPR(... 'PowerUnits','linear',... 'SpectralEstimatorOption',... 'SegmentLength',100); [act_ACPR, actMainPow, actAdjPow] = step(h,yPulse); fd = h.MeasurementFilter;	h = comm.ACPR(... 'PowerUnits','Watts',... 'SpectralEstimatorOption',... 'SegmentLength',100,... 'MainMeasurementBandwidth',... 'AdjacentChannelPowerOutputPort', true,... 'AdjacentChannelPowerOutputPort', true,... 'MeasurementFilterSource', 'property'); [act_ACPR, actMainPow, actAdjPow] = step(h,yPulse); fdnumerator = h.MeasurementFilter;	MeasurementFilter changes from a structure to a variable.  Specify window parameters,...

### Map commmeasure.EVM Properties and Methods to comm.EVM

<b>commmeasure.EVM properties</b>	<b>comm.EVM properties</b>	<b>Note</b>
NormalizationOption	Normalization	
AveragePower	AverageConstellationPower	
PeakPower	PeakConstellationPower	
RSMEVM	N/A	RSMEVM is an output.
MaximumEVM	MaximumEVMOutputPort	When you set MaximumEVMOutputPort to true, MaximumEVM becomes an output.
Percentile	XPercentileValue	XPercentileValue appears when you set the XPercentileEVMOutputPort to true.

<b>commmeasure.EVM properties</b>	<b>comm.EVM properties</b>	<b>Note</b>
PercentileEVM	XPercentileEVMOutputPort	When you set XPercentileEVMOutputPort to true, PercentileEVM becomes an output.
NumberOfSymbols	SymbolCountOutputPort	When you set SymbolCountOutputPort to true, NumberOfSymbols becomes an output.
Type	N/A	This read-only property was removed.

<b>commmeasure.EVM methods</b>	<b>comm.EVM methods</b>
update (no outputs)	step (multiple outputs)
reset	reset
copy	clone

**Note** commmeasure.evm and comm.evm have a different API. Refer to the following syntax examples when updating your legacy code:

<b>commmeasure.EVM</b>	<b>comm.EVM</b>
hEVM = commmeasure.EVM('Percentile', hEVM);	hEVM = comm.EVM('XPercentileEVMOutputPort', true,
update(hEVM, rcv, xmv) rmsevm = hEVM.RMSEVM	rmsevm = step(hEVM, rcv, xmv)
update(hEVM, rcv, xmv) rmsevm = hEVM.RMSEVM maxevm = hEVM.MaximumEVM pevm =hEVM.PercentileEVM numsym = hEVM. NumberOfSymbols	[rmsevm,maxevm,pevm,numsym] = step(hEVM, rcv, xmv)

### Map commmeasure.MER Properties and Methods to comm.MER

<b>commmeasure.MER properties</b>	<b>comm.MER properties</b>	<b>Note</b>
MERdb	N/A	MERdb is an output.
MinimumMER	MinimumMEROutputPort	When you set MinimumMEROutputPort to true, MinimumMER becomes an output.
Percentile	XPercentileValue	XPercentileValue appears when you set the XPercentileMEROutputPort to true.
PercentileMER	XPercentileMEROutputPort	When you set XPercentileMEROutputPort to true, PercentileMER becomes an output.
NumberOfSymbols	SymbolCountOutputPort	When you set SymbolCountOutputPort to true, NumberOfSymbols becomes an output.
Type	N/A	This read-only property was removed.

<b>commmeasure.MER methods</b>	<b>comm.MER methods</b>
update (no outputs)	step (multiple outputs)
reset	reset
copy	clone

**Note** commmeasure.MER and comm.MER have a different API. Refer to the following syntax examples when updating your legacy code:



<b>commmeasure.MER</b>	<b>comm.MER</b>
hMER = commmeasure.MER('Percentile	hMER = comm.MER('XPercentileMEROutputPort', true, 'XPercentileValue', 90)
update(hMER, rcv, xmv) merdb = hMER.	merdb = hMER(rcv, xmv)
update(hMER, rcv, xmv) merdb = hEVM.MERdB minimummer = hEVM.MinimumMER pmer = hEVM.PercentileMER numsym = hEVM.NumberOfSymbols	[merdb,minimummer,pmer,numsym] = hMER(rcv, xmv)

### Map fec.bchenc Properties to comm.BCHEncoder

<b>fec.bchenc property</b>	<b>comm.BCHEncoder property</b>	<b>Note</b>
N	CodewordLength	
K	MessageLength	
T	The ErrorCorrectionCapability element of the Info method	
ShortenedLength	N/A	This information is included in the CodewordLength and MessageLength properties.
ParityPosition	N/A	Always 'end'.
PuncturePattern	PuncturePattern	This property appears when you set PuncturePatternSource to Property.
GenPoly	GeneratorPolynomial	This property appears when you set GeneratorPolynomialSource to Property.
Type	N/A	This read-only property was removed.

**Note** `fec.bchenc` and `comm.BCHEncoder` have a different API. Refer to the following syntax examples when updating your legacy code:

<b>fec.bchenc</b>	<b>comm.BCHEncoder</b>	<b>Note</b>
<code>h=fec.bchenc</code>	<code>h = comm.BCHEncoder('CodewordLength',7,'MessageLength',4, ... 'PuncturePatternSource',defaultConfigurationOfPuncturePattern', ... [1 1 1].', 'GeneratorPolynomialSource', 'property', ... 'GeneratorPolynomial', [1 0 1 1]);</code>	Use the syntax to <code>MessageLength',4, ...</code> for the default configuration of <code>fec.bchenc</code> .
<code>enc = fec.bchenc(7,4); msg = [0 1 1 0]'; code = encode(enc,msg);</code>	<code>h = comm.BCHEncoder('CodewordLength',7,'MessageLength',4, ... 'PuncturePatternSource', 'property', 'PuncturePattern', ... [1 1 1].', 'GeneratorPolynomialSource', 'property', ... 'GeneratorPolynomial', [1 0 1 1]); msg = [0 1 1 0]'; code = step(h,msg)</code>	<p><code>CodewordLength',7,'MessageLength',4, ...</code> must be a column vector and <code>PuncturePattern</code> must be a row vector.</p> <ul style="list-style-type: none"> <li>The <code>step</code> method replaces use of the <code>encode</code> function.</li> </ul>
<code>encShort = fec.bchenc(7,4); encShort.ShortenedLength = 3; msgShort = [0 1 1]'; codeShort = encode(encShort,msgShort);</code>	<code>h=comm.BCHEncoder(6,3); msg=[0 1 1]'; code = step(h,msg)</code>	The shortened length information is included in the <code>CodewordLength</code> and <code>MessageLength</code> properties.

### Map `fec.bchdec` Properties to `comm.BCHDecoder`

<b>fec.bchdecproperty</b>	<b>comm.BCHDecoder property</b>	<b>Note</b>
N	CodewordLength	
K	MessageLength	
T	The <code>ErrorCorrectionCapability</code> element of the <code>Info</code> method	This information is included in the <code>CodewordLength</code> and <code>MessageLength</code> properties.
ShortenedLength	N/A	
ParityPosition	N/A	

<b>fec.bchdecproperty</b>	<b>comm.BCHDecoder property</b>	<b>Note</b>
PuncturePattern	PuncturePattern	This property appears when you set PuncturePatternSource to Property.
GenPoly	GeneratorPolynomial	This property appears when you set GeneratorPolynomialSource to Property.
Type	N/A	This read-only property was removed.

**Note** fec.bchdec and comm.BCHDecoder have a different API. Refer to the following syntax examples when updating your legacy code:

<b>fec.bchdec</b>	<b>fec.BCHDecoder</b>	<b>Note</b>
h=fec.bchdec	h = comm.BCHDecoder('CodeWordLength',4, ... 'PuncturePatternSource', defaultConfiguration, ... [1 1 1], 'GeneratorPolynomialSource', 'property', ... 'GeneratorPolynomial', [1 0 1 1])	Use this syntax to MessageLength',4, ... PuncturePattern', ... fec.bchdec
dec = fec.bchdec(7,4); code = [0 1 1 0 0 0 1].'; msg = decode(dec,code);	h = comm.BCHDecoder('CodeWordLength',4, ... 'PuncturePatternSource', mustBeAColumnVector, ... [1 1 1].', 'GeneratorPolynomialSource', 'property', ... 'GeneratorPolynomial', [1 0 1 1]); code = [0 1 1 0 0 0 1].'; msg = step(h,code)	wordLength of 7 Polynomials must be a column vector and a PuncturePattern must be a row vector. <ul style="list-style-type: none"><li>The step method replaces use of the decode function.</li></ul>
decShort = fec.bchdec(7,4) decShort.ShortenedLength = 1; code = [0 1 1 1 0 1].'; msg = decode(decShort,code);	h = comm.BCHDecoder('CodeWordLength',3, ... 'PuncturePatternSource', informationIncludedInPuncturePattern', ... [1 1 1].', 'GeneratorPolynomialSource', 'property', ... 'GeneratorPolynomial', [1 0 1 1]); code = [0 1 1 1 0 1].'; msg = step(h,code)	WordLength of 3 information is included in the CodeWordLength and MessageLength properties.

### Map fec.ldpcenc Properties to comm.LDPCDecoder

fec.ldpcenc property	comm.LDPCDecoder property	Note
ParityCheckMatrix	ParityCheckMatrix	
BlockLength	N/A	This read-only property was removed.
NumInfoBits	N/A	This read-only property was removed.
NumParityBits	N/A	This read-only property was removed.
EncodingAlgorithm	N/A	This read-only property was removed.

**Note** The comm.LDPCDecoder System object does contain all the read-only properties of the old object. However, you can obtain the information from the ParityCheckMatrix.

fec.ldpcenc and comm.LDPCDecoder have a different API. Refer to the following syntax example when updating your legacy code:

fec.ldpcenc	comm.LDPCDecoder	Note
<pre>h1 = fec.ldpcenc; xin = ones(32400,1); yout1 = encode(h1,xin.')</pre>	<pre>h = comm.LDPCDecoder; xin = ones(32400,1); yout = step(h, xin)</pre>	<ul style="list-style-type: none"> <li>The fec.ldpcenc object accepted a row vector input. The comm.LDPCDecoder System object accepts a column vector input.</li> <li>The step method replaces use of the encode function</li> </ul>

---

### Map fec.Ldpcdec Properties to comm.LDPCDecoder

fec.Ldpcdec property	comm.LDPCDecoder property	Note
ParityCheckMatrix	ParityCheckMatrix	
DecisionType	DecisionMethod	
OutputFormat	OutputValue	
DoParityChecks	IterationTerminationCondition	Select Parity check satisfied.
NumIterations	MaximumIterationCount	
ActualNumIterations	NumIterationsOutputPort	
FinalParityChecks	FinalParityChecksOutputPort	
BlockLength	N/A	This read-only property was removed.
NumInfoBits	N/A	This read-only property was removed.
NumParityBits	N/A	This read-only property was removed.

---

**Note** The comm.LDPCDecoder System object does not contain all the read-only properties of the old object. The ActualNumIterations and FinalParityChecks properties become outputs.

fec.Ldpcdec and comm.LDPCDecoder have a different API. Refer to the following syntax example when updating your legacy code.

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<b>fec.ldpcdec</b>	<b>comm.LDPCDecoder</b>	<b>Note</b>
<pre>h1 = fec.ldpcdec; yin = ones(64800,1); yout1 = decode(h1,yin.')</pre>	<pre>h = comm.LDPCDecoder yin = ones(64800,1); yout = step(h,yin)</pre>	<ul style="list-style-type: none"> <li>• The <code>fec.ldpcdec</code> object accepted a row vector input. The <code>comm.LDPCDecoder</code> System object accepts a column vector input.</li> <li>• The <code>step</code> method replaces use of the <code>decode</code> function</li> </ul>

### Map `fec.rsenc` Properties to `comm.RSEncoder`

<b>fec.rsenc</b>	<b>comm.RSEncoder</b>	<b>Note</b>
N	CodewordLength	
K	MessageLength	
T	The <code>ErrorCorrectionCapability</code> element of the <code>Info</code> method	
ShortenedLength	N/A	This information is included in the <code>CodewordLength</code> and <code>MessageLength</code> properties.
ParityPosition	N/A	Always 'end'.
GenPoly	GeneratorPolynomial	This property appears when you set <code>GeneratorPolynomialSource</code> to <code>Property</code> .
Type	N/A	This read-only property was removed.

**Note** `fec.rsenc` and `comm.RSEncoder` have a different API. Refer to the following syntax examples when updating your legacy code:

fec.rsenc	comm.RSEncoder	Note
h=fec.rsenc	<pre>h = comm.RSEncoder('CodewordLength',7,'MessageLength',3, ... 'PuncturePatternSource','default','PuncturePattern', ... [1 1 1].', 'GeneratorPolynomialSource','property', ... 'GeneratorPolynomial',[1 0 1 1]);  h = comm.BCHEncoder('CodewordLength',7,'MessageLength',4, ... 'PuncturePatternSource','property','PuncturePattern', ... [1 1 1].', 'GeneratorPolynomialSource','property', ... 'GeneratorPolynomial',[1 0 1 1]);</pre>	Use this syntax for MessageLength, CodewordLength, and PuncturePatternSource. The default configuration of fec.rsenc is:
<pre>enc = fec.rsenc(7,3); msg = [0 1 0]'; code = encode(enc,msg);</pre>	<pre>h = comm.RSEncoder('CodewordLength',7,'MessageLength',3, ... 'PuncturePatternSource','property','PuncturePattern', ... [1 1 1].', 'GeneratorPolynomialSource','property', ... 'GeneratorPolynomial',[1 3 1 2 3]); msg = [0 1 0]'; code = step(h,msg)</pre>	<p>Use the step method to encode a column vector and PuncturePattern must be a row vector.</p> <ul style="list-style-type: none"> <li>The step method replaces use of the encode function.</li> </ul>
<pre>encShort = fec.rsenc(7,3) encShort.ShortenedLength = 1; msgShort = [0 1]'; codeShort = encode(encShort,msgShort);</pre>	<pre>h = comm.RSEncoder('CodewordLength',7,'MessageLength',2, ... 'PuncturePatternSource','property','PuncturePattern', ... [1 1 1 1].', 'GeneratorPolynomialSource','property', ... 'GeneratorPolynomial',[1 3 1 2 3]); msg = [0 1]'; code = step(h,msg)</pre>	<p>The shortened MessageLength information is included in the CodewordLength and MessageLength properties.</p> <ul style="list-style-type: none"> <li>The step method replaces use of the encode function.</li> </ul>

### Map fec.rsdec Properties to comm.RSDecoder

fec.rsdec	comm.RSDecoder	Note
N	CodewordLength	
K	MessageLength	
T	The ErrorCorrectionCapability element of the Info method	

<b>fec.rsdec</b>	<b>comm.RSDecoder</b>	<b>Note</b>
ShortenedLength	N/A	This information is included in the <code>CodewordLength</code> and <code>MessageLength</code> properties.
ParityPosition	N/A	Always 'end'.
PuncturePattern	PuncturePattern	This property appears when you set <code>PuncturePatternSource</code> to <code>Property</code> .
GenPoly	GeneratorPolynomial	This property appears when you set <code>GeneratorPolynomialSource</code> to <code>Property</code> .
Type	N/A	This read-only property was removed.

**Note** `fec.rsdec` and `comm.RSDecoder` have a different API. Refer to the following syntax examples when updating your legacy code:

<b>fec.rsdec</b>	<b>comm.RSDecoder</b>	<b>Note</b>
<code>h=fec.rsdec</code>	<code>h = comm.RSDecoder('CodewordLength', MessageLength, 'PuncturePatternSource', Property, 'PuncturePattern', [1 1 1 1].', 'GeneratorPolynomialSource', 'property', 'GeneratorPolynomial', [1 3 1 2 3])</code>	Use this syntax for the default configuration of <code>fec.rsdec</code> .
<code>dec = fec.rsdec(7,3); code = [0 1 1 0 0 0 1].'; msg = decode(dec,code);</code>	<code>h = comm.RSDecoder('CodewordLength', MessageLength, 'PuncturePatternSource', Property, 'PuncturePattern', [1 1 1 1].', 'GeneratorPolynomialSource', 'property', 'GeneratorPolynomial', [1 3 1 2 3]); code = [0 1 1 0 0 0 1].'; msg = step(h,code)</code>	<p>Use this syntax for the default configuration of <code>comm.RSDecoder</code>. The <code>MessageLength</code> property must be a column vector and the <code>PuncturePattern</code> must be a row vector.</p> <ul style="list-style-type: none"> <li>The <code>step</code> method replaces use of the <code>encode</code> function.</li> </ul>



fec.rsdec	comm.RSDecoder	Note
<pre>decShort = fec.rsdec(7,3) decShort.ShortenedLength = 1; code = [0 1 1 1 0 1].'; msg = decode(decShort,code)</pre>	<pre>h = comm.RSDecoder('CodewordLength',2, ... 'PuncturePatternSource', 'PuncturePattern', ... [1 1 1 1].', 'GeneratorPolynomialSource', ... [1 3 1 2 3]); code = [0 1 1 1 0 1].'; msg = step(h,code)</pre>	<p>The shortened MessageLength information is included in the CodewordLength and MessageLength properties.</p> <ul style="list-style-type: none"> <li>The step method replaces use of the encode function.</li> </ul>

## Frame-Based Processing

Beginning in R2010b, MathWorks started to significantly change the handling of frame-based processing. In the future, frame status will no longer be a signal attribute. Instead, individual blocks will control whether they treat inputs as frames of data or as samples of data. For more information, see “Frame-Based Processing” on page 16-7.



# R2012a

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**Version: 5.2**

**New Features**

**Compatibility Considerations**

## MIMO Multipath Fading Channel System Objects

The Communications System Toolbox product now includes a Multiple Input Multiple Output (MIMO) Multipath Fading Channel System object, `comm.MIMOChannel`. Multipath MIMO fading channels allow for design of communication systems with multiple antenna elements at the transmitter and receiver. For more information, see the `comm.MIMOChannel` Help page.

The product also includes an LTE MIMO Multipath Fading Channel System object, `comm.LTEMIMOChannel`. This object allows for design of communication systems with multiple antenna elements at the transmitter and receiver using the 3GPP Long Term Evolution (LTE) standard. For more information, see the `comm.LTEMIMOChannel` Help page.

## Multi-H Support for CPM Modulator and Demodulator Simulink Blocks and MATLAB System Objects

The CPM Modulator Baseband and CPM Demodulator Baseband blocks and System objects now support Multi-H CPM modulation. These enhancements allow you to perform research and development work for communication systems designed with the ARTM, JTRS, or MIL-STD-188-181C communications standards. For more information, see:

- `comm.CPModulator`
- `comm.CPMDemodulator`
- CPM Modulator Baseband
- CPM Demodulator Baseband

## GPU System Objects

This release adds new GPU System objects, which use a graphics processing unit (GPU) to procure simulation results more quickly than a CPU. These new objects include:

- `comm.gpu.ConvolutionalInterleaver`
- `comm.gpu.ConvolutionalDeinterleaver`
- `comm.gpu.ConvolutionalEncoder`
- `comm.gpu.PSKDemodulator`
- `comm.gpu.TurboDecoder`

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## **MATLAB Compiler Support for GPU System Objects**

In Release 2012a, you can use the MATLAB Compiler product with GPU System objects. With this capability, MATLAB Compiler software can generate standalone applications from MATLAB files, including files that contain GPU System objects.

### **Code Generation Support**

The following System objects now support C code generation:

- `comm.BCHEncoder`
- `comm.RSEncoder`

The following function now supports C code generation:

- `bchgenpoly`

### **HDL Code Generation from MATLAB code**

The following System objects now support HDL code generation:

- `comm.ViterbiDecoder`
- `comm.PSKModulator`
- `comm.BPSKModulator`
- `comm.QPSKModulator`
- `comm.rectangularQAMmodulator`
- `comm.ConvolutionalInterleaver`
- `comm.ConvolutionalDeinterleaver`

See also HDL Code Generation from MATLAB.

### **HDL Support For HDL CRC Generator Block**

Release R2012a provides HDL code generation support for the new HDL CRC Generator block.

## Enhancements for System Objects Defined by Users

This release contains enhancements for System objects defined by users.

### Code Generation for System Objects

System objects defined by users now support C code generation. To generate code, you must have the MATLAB Coder product.

### New System Object Option on File Menu

The File menu on the MATLAB desktop now includes a **New > System object** menu item. This option opens a System object class template, which you can use to define a System object class.

### Variable-Size Input Support for System Objects

System objects that you define now support inputs that change size at runtime.

### Data Type Support for System Objects

System objects that you define now support all MATLAB data types as inputs and outputs.

### New Property Attribute to Define States

R2012a adds the new `DiscreteState` attribute for properties in your System object class definition file. Discrete states are values calculated during one step of an object's algorithm that are needed during future steps.

### New Methods to Validate Properties and Get States from System Objects

The following methods have been added:

- `validateProperties` - Checks that the System object is in a valid configuration. This applies only to objects that have a defined `validatePropertiesImpl` method
- `getDiscreteState` - Returns a struct containing a System object's properties that have the `DiscreteState` attribute

### `matlab.system.System` changed to `matlab.System`

The base System object class name has changed from `matlab.system.System` to `matlab.System`.

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## Compatibility Considerations

### Compatibility Considerations

The previous `matlab.system.System` class will remain valid for existing `System` objects. When you define new `System` objects, your class file should inherit from the `matlab.System` class.

## New and Enhanced Demos

The following demos are new or enhanced for this release:

- IEEE® 802.11 WLAN - Beacon Frame simulates packetized, non-streaming transmission and reception of beacon frames in an 802.11-based wireless local area network (WLAN).
- IEEE® 802.16-2009 WirelessMAN-OFDMA PHY Downlink PUSC simulates a downlink partial usage of subchannels (PUSC) Physical Layer communication from base station (BS) to two mobile stations. This demo uses variable-size signals to model dynamic channel allocation between the two users.
- QPSK Transmitter and Receiver implements a QPSK transmitter and receiver, including carrier and timing recovery.
- Digital Video Broadcasting - Cable (DVB-C) models part of the ETSI (European Telecommunications Standards Institute) EN 300 429 standard for cable system transmission of digital television signals.
- Downlink Transport Channel (DL-SCH) Processing models part of the transport channel processing for the Downlink Shared Channel (eNodeB to UE) of the Long Term Evolution (LTE) specifications developed by the Third Generation Partnership Project (3GPP) .
- Using GPUs To Accelerate Turbo Coding Bit Error Rate Simulations shows how you can use GPUs to dramatically accelerate bit error rate simulations.
- End to End System Simulation Acceleration Using GPUs compares four techniques that can be used to accelerate bit error rate (BER) simulations.

## Functionality Being Changed or Removed

The following functions will be removed in a future release.

Functionality	What Happens When You Use This Functionality?	Use This Instead	Compatibility Considerations
rsdecof	Warns	comm.RSDecoder	Replace all instances of rsdecof with comm.RSDecoder.
rsencof	Warns	comm.RSEncoder	Replace all instances of rsencof with comm.RSEncoder.

The following functions, which were previously announced for removal in a future release, now warn at run time. You should not use these functions.

Functionality	What Happens When You Use This Functionality?	Use This Instead	Compatibility Considerations
rcosflt	Warns	fdesign.pulseshaping	<ul style="list-style-type: none"> <li>Use fdesign.interpolator and fdesign.decimator to design multirate filters.</li> <li>Use fdesign.pulseshaping to design a single-rate raised cosine filter. Does not support IIR.</li> </ul>
rcosiir	Warns	N/A	Do not use.



Functionality	What Happens When You Use This Functionality?	Use This Instead	Compatibility Considerations
rcosine	Warns	fdesignpulseshaping	<ul style="list-style-type: none"> <li>Use <code>fdesign.interpolator</code> and <code>fdesign.decimator</code> to design multirate filters.</li> <li>Use <code>fdesign.pulseshaping</code> to design a single-rate raised cosine filter. Does not support IIR.</li> </ul>
bchdec	Warns	comm.BCHDecoder	
bchenc	Warns	comm.BCHEncoder	
rsdec	Warns	comm.RSDecoder	
rsenc	Warns	comm.RSEncoder	
randint	Warns	randi	Use <code>randi</code> to generate matrix of uniformly distributed random integers

Several functions, which were previously announced for removal in a future release and warned at run time, have been removed from the Communications System Toolbox product. To see the full list of these removed functions, expand the following section.

### Removed Functions

- `ademod`
- `ademodce`
- `amod`
- `amodce`
- `apkconst`
- `bchdeco`

- bchenco
- bchpoly
- constlay
- convdeco
- convenco
- ddemod
- ddemodce
- demodmap
- dmod
- dmodce
- eyescat
- flxor
- gen2abcd
- gfplus
- htruthb
- imp2sys
- lineprob
- modmap
- oct2gen
- qaskdeco
- qaskenco
- randbit
- rscore
- rsdeco
- rsdecode
- rsenco
- rsencode
- rspoly
- sim2gen
- sim2gen2

- 
- `sim2logi`
  - `sim2tran`
  - `simpassbandex`
  - `simsum`
  - `simsum2`
  - `viterbi`
  - `vitshort`

The following function, which was previously announced for removal in a future release, will remain in the Communications System Toolbox product.

- `rcosfir`

## Frame-Based Processing

Beginning in R2010b, MathWorks started to significantly change the handling of frame-based processing. In the future, frame status will no longer be a signal attribute. Instead, individual blocks will control whether they treat inputs as frames of data or as samples of data. For more information, see “Frame-Based Processing” on page 16-7.

### Inherited Option of the Input Processing Parameter Now Warns

Some Communications System Toolbox blocks are able to process both sample- and frame-based signals. After the transition to the new way of handling frame-based processing, signals will no longer carry information about their frame status. Blocks that can perform both sample- and frame-based processing have a new parameter that allows you to specify the appropriate processing behavior.

To prepare for this change, many blocks received a new **Input processing** parameter in previous releases. You can set this parameter to `Columns as channels (frame based)` or `Elements as channels (sample based)`, depending upon the type of processing you want. The third choice, `Inherited (this choice will be removed - see release notes)`, is a temporary selection that is available to help you migrate your existing models from the old paradigm of frame-based processing to the new paradigm.

In this release your model will warn when the following conditions are all met for any block in your model:

- The **Input processing** parameter is set to Inherited (this choice will be removed - see release notes)
- The input signal is sample-based
- The input signal is a vector, matrix, or N-dimensional array

To see a list of Communications System Toolbox blocks that contain the **Input processing** parameter, expand the following section.

### **Blocks with Input Processing Parameter**

- AWGN Channel (with only two options)
- Derepeat
- Gaussian Filter
- Ideal Rectangular Pulse Filter
- Raised Cosine Receive Filter
- Raised Cosine Transmit Filter
- Windowed Integrator

## **Compatibility Considerations**

### Compatibility Considerations

To eliminate this warning, you must upgrade your existing models using the `slupdate` function. The function detects all blocks that have **Inherited** (this choice will be removed - see release notes) selected for the **Input processing** parameter. It then asks you whether you would like to upgrade each block. If you select yes, the function detects the status of the frame bit on the input port of the block. If the frame bit is 1 (frames), the function sets the **Input processing** parameter to **Columns as channels** (frame based). If the bit is 0 (samples), the function sets the parameter to **Elements as channels** (sample based).

In a future release, the **Inherited** (this choice will be removed - see release notes) option will be removed. At that time, the **Input processing** parameter in models that have not been upgraded will automatically be set to either **Columns as channels** (frame based) or **Elements as channels** (sample based). The option set will depend on the library default setting for each block. If the library default setting does not match the parameter setting in your model, your model will produce unexpected results. Additionally, after the frame bit is removed, you will no

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longer be able to upgrade your models using the `sIupdate` function. Therefore, you should upgrade your existing modes using `sIupdate` as soon as possible.

### **Inherited Option of the Rate Options Parameter Now Warns**

Some Communications System Toolbox blocks support single-rate or multirate processing. After the transition to the new paradigm for handling frame-based processing, signals will no longer carry information about their frame status. Blocks that can perform both single-rate and multirate processing have a new parameter that allows you to specify the appropriate processing behavior. To prepare for this change, many blocks received a new **Rate options** parameter in previous releases. You can set this parameter to `Enforce single-rate processing` or `Allow multirate processing`. The third choice, `Inherit from input` (this choice will be removed - see release notes), is a temporary selection that is available to help you migrate your existing models from the old paradigm of frame-based processing to the new paradigm.

In this release your model will warn when the following conditions are met for any block in your model:

- The **Rate options** parameter set to `Inherit from input` (this choice will be removed - see release notes)
- The input signal is sample-based
- The input signal is a scalar

To see a full list of Communications System Toolbox blocks that have a new **Rate options** parameter, expand the following section.

### **Blocks with Rate Options Parameter**

- OQPSK Modulator Baseband
- OQPSK Demodulator Baseband
- CPM Modulator Baseband
- CPM Demodulator Baseband
- MSK Modulator Baseband
- MSK Demodulator Baseband
- GMSK Modulator Baseband
- GMSK Demodulator Baseband
- CPFSK Modulator Baseband

- CPFSK Demodulator Baseband
- M-FSK Demodulator Baseband
- M-FSK Modulator Baseband

## Compatibility Considerations

### Compatibility Considerations

To eliminate this warning, you must upgrade your existing models using the `supdate` function. The function detects all blocks that have `Inherit from input` (this choice will be removed - see release notes) selected for the **Rate options** parameter. It then asks you whether you would like to upgrade each block. If you select yes, the function detects the status of the frame bit on the input port of the block. If the frame bit is 1 (frames), the function sets the **Rate options** parameter to `Enforce single-rate processing`. If the bit is 0 (samples), the function sets the parameter to `Allow multirate processing`.

In a future release, the `frame bit` and the `Inherit from input` (this choice will be removed - see release notes) option will be removed. At that time, the **Rate options** parameter in models that have not been upgraded will automatically be set to either `Enforce single-rate processing` or `Allow multirate processing`. The option set will depend on the library default setting for each block. If the library default setting does not match the parameter setting in your model, your model will produce unexpected results. Additionally, after the frame bit is removed, you will no longer be able to upgrade your models using the `supdate` function. Therefore, you should upgrade your existing modes using `supdate` as soon as possible.

# R2011b

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**Version: 5.1**

**New Features**

**Bug Fixes**

**Compatibility Considerations**

## New Demos

- The Transceiver Simulation Acceleration demo illustrates simulation acceleration improvements by comparing simulation times using System objects with simulation times using MATLAB functions.
- The Parallel Concatenated Convolutional Coding: Turbo Codes demo now uses the Turbo Encoder and Turbo Decoder blocks and the accompanying MATLAB script uses the `comm.TurboEncoder` and `comm.TurboDecoder` System objects.

## Turbo Codes

Communications System Toolbox now supports turbo codes. These error correction codes approach the Shannon limit, resulting in low error rates for transmission schemes with low signal-to-noise ratios. You can implement turbo codes using either MATLAB System objects or Simulink blocks:

- `comm.TurboDecoder`
- `comm.TurboEncoder`
- Turbo Decoder
- Turbo Encoder

## USRP2 Migration

Support for the UDP-based USRP2 Transmitter and USRP2 Receiver blocks is being removed in release R2011b. New USRP™ blocks and System objects that work with USRP™ radios using the Universal Hardware Driver™ from Ettus Research™ are now available. These new blocks and objects support buffers with arbitrary frame size. If you have Communications System Toolbox, you can download and use these new blocks and System objects.

## GPU System Objects

This release adds new GPU System objects, which use a graphics processing unit (GPU) to procure simulation results more quickly than a CPU. These new objects include:

- `comm.gpu.AWGNChannel`
- `comm.gpu.BlockDeinterleaver`



- 
- `comm.gpu.BlockInterleaver`
  - `comm.gpu.PSKModulator`
  - `comm.gpu.ViterbiDecoder`

## Custom System Objects

You can now create custom System objects in MATLAB. This capability allows you to define your own System objects for time-based and data-driven algorithms, I/O, and visualizations. The System object API provides a set of implementation and service methods that you incorporate into your code to implement your algorithm. See Define New System Objects in the DSP System Toolbox documentation for more information.

## Variable-Size Support

The following blocks now support variable-size input and/or output signals:

- APP Decoder
- AWGN Channel (Enter `commvarsize` at the MATLAB command line to access the library containing this implementation of the block)
- CRC-N Generator
- CRC-N Syndrome Detector
- Error Rate Calculation
- General CRC Generator
- General CRC Syndrome Detector
- OSTBC Combiner
- OSTBC Encoder
- Turbo Decoder (Enter `commvarsize` at the MATLAB command line to access the library containing this implementation of the block)
- Turbo Encoder (Enter `commvarsize` at the MATLAB command line to access the library containing this implementation of the block)

The following blocks now support puncturing with variable-size signals:

- Convolutional Encoder
- Viterbi Decoder

The following System objects now support variable-size input and/or output signals:

- `comm.APPDecoder`
- `comm.ConvolutionalEncoder`
- `comm.CRCDetector`
- `comm.CRCGenerator`
- `comm.ErrorRate`
- `comm.OSTBCCCombiner`
- `comm.OSTBCEncoder`
- `comm.TurboDecoder`
- `comm.TurboEncoder`
- `comm.ViterbiDecoder`

## **System Object Code Generation Support**

The following System objects support code generation:

- `comm.BarkerCode`
- `comm.DifferentialDecoder`
- `comm.DifferentialEncoder`
- `comm.DiscreteTimeVCO`
- `comm.HadamardCode`
- `comm.OVSFCode`
- `comm.TurboEncoder`
- `comm.TurboDecoder`
- `comm.WalshCode`

## **Delayed Reset for Viterbi Decoder**

The Viterbi Decoder block and Viterbi Decoder System object now have a delayed reset option. The delay in the reset action allows the block to support HDL code generation. To generate HDL code, you must have an HDL Coder license.

For the Viterbi Decoder block:

- 
- Select **Enable reset input port**
  - Select **Delay reset action to next time step**. This parameter only appears when you set the **Operation mode** parameter to **Continuous**.

The Viterbi Decoder block resets its internal state after decoding the incoming data.

For the `comm.ViterbiDecoder` System object

- Set `ResetInputPort` to `true`
- Set `DelayedResetAction` to `true`. This property only appears when you set the `ResetInputPort` property to `true`.
- Set `TerminationMethod` to `Continuous`

The Viterbi Decoder System object resets its internal state after decoding the incoming data.

## System Objects FullPrecisionOverride Property Added

A `FullPrecisionOverride` property has been added to the System objects listed below. This property is a convenient way to control whether the object uses full precision to process fixed-point inputs.

When you set this property to `true`, which is the default, it eliminates the need to set many fixed-point properties individually. It also hides the display of these properties (such as `RoundingMode`, `OverflowAction`, etc.) because they are no longer applicable individually.

To set individual fixed-point properties, you must first set `FullPrecisionOverride` to `false`.

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**Note** The `CoefficientDataType` property is not controlled by `FullPrecisionOverride`

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This change affects the following System objects:

- `comm.IntegrateAndDumpFilter`
- `comm.PAMDemodulator`
- `comm.RectangularQAMDemodulator`

- `comm.GeneralQAMDemodulator`

## Compatibility Considerations

### Compatibility Consideration

All these System objects have their new `FullPrecisionOverride` property set to the default, `true`. If you had set any fixed-point properties to nondefault values for these objects, those values are ignored. As a result, you may see different numerical answers from those answers in a previous release. To use your nondefault fixed-point settings, you must first change `FullPrecisionOverride` to `false`.

## APP Decoder System Object Parameter Change

For the `comm.APPDecoder` System object, the `Algorithm` property replaces the `MetricMethod` property. At this time, existing customer code continues to work; however, a warning prompts you to update the code.

## Compatibility Considerations

### Compatibility Consideration

If you have any existing System object code that uses the `MetricMethod` property, you should use the `sysobjupdate` function to update your code. For more information, type `help sysobjupdate` at the MATLAB command line.

## System Object `DataType` and `CustomDataType` Properties Changes

When you set a System object, fixed-point `<xxx>DataType` property to `'Custom'`, it activates a dependent `Custom<xxx>DataType` property. If you set that dependent `Custom<xxx>DataType` property before setting its `<xxx>DataType` property, a warning message displays. `<xxx>` differs for each object.

## Compatibility Considerations

### Compatibility Considerations

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Previously, setting the dependent `Custom<xxx>DataType` property would automatically change its `<xxx>DataType` property to 'Custom'. If you have code that sets the dependent property first, avoid warnings by updating your code. Set the `<xxx>DataType` property to 'Custom' before setting its `Custom<xxx>DataType` property.

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**Note** If you have a `Custom<xxx>DataType` in your code, but do not explicitly update your code to change `<xxx>DataType` to 'Custom', you may see different numerical output.

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## Conversion of System Object Error and Warning Message Identifiers

For R2011b, error and warning message identifiers for System objects have changed in Communications System Toolbox software.

### Compatibility Considerations

#### Compatibility Considerations

If you have scripts or functions that use message identifiers that changed, you must update the code to use the new identifiers. Typically, message identifiers are used to turn off specific warning messages. You can also use them in code that uses a `try/catch` statement and performs an action based on a specific error identifier.

For example, the `MATLAB:system:System:inputSpecsChangedWarning` identifier has changed to `MATLAB:system:inputSpecsChangedWarning`. If your code checks for `MATLAB:system:System:inputSpecsChangedWarning`, you must update it to check for `MATLAB:system:inputSpecsChangedWarning` instead.

To determine the identifier for a warning, run the following command just after you see the warning:

```
[MSG,MSGID] = lastwarn;
```

This command saves the message identifier to the variable `MSGID`.

To determine the identifier for an error, run the following command just after you see the error:

```
exception = MException.last;  
MSGID = exception.identifier;
```

Warning messages indicate a potential issue with your code. While you can turn off a warning, a suggested alternative is to change your code so it runs without warnings.

## **Frame-Based Processing**

Beginning in R2010b, MathWorks started to significantly change the handling of frame-based processing. In the future, frame status will no longer be a signal attribute. Instead, individual blocks will control whether they treat inputs as frames of data or as samples of data. For more information, see “Frame-Based Processing” on page 16-7.

# R2011a

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**Version: 5.0**

**New Features**

**Bug Fixes**

**Compatibility Considerations**

## Product Restructuring

The Communications System Toolbox product replaces two pre-existing products: Communications Blockset and Communications Toolbox. You can access archived documentation for both products on the MathWorks Web site.

## LDPC Encoder and Decoder System Objects

This release adds new `comm.LDPCDecoder` and `comm.LDPCDecoder` System objects. These new System objects provide simulation of low-density, parity-check codes.

## LDPC GPU Decoder System Object

This release adds a new `comm.gpu.LDPCDecoder` System object, which uses a graphics processing unit (GPU) to decode low-density, parity-check codes. This new System object procures simulation results more quickly than a CPU.

## Variable-Size Support

The following blocks now support variable-size input signals:

- M-PSK Modulator Baseband
- QPSK Modulator Baseband
- BPSK Modulator Baseband
- M-PAM Modulator Baseband
- Rectangular QAM Modulator Baseband
- General QAM Modulator Baseband
- M-PSK Demodulator Baseband
- QPSK Demodulator Baseband
- BPSK Demodulator Baseband
- M-PAM Demodulator Baseband
- Rectangular QAM Demodulator Baseband
- General QAM Demodulator Baseband
- Bit to Integer Converter



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- Integer to Bit Converter
  - Convolutional Encoder
  - Viterbi Decoder

The following source blocks can now output variable-size signals:

- Gold Sequence Generator
- Kasami Sequence Generator
- PN Sequence Generator

The following System objects now support variable-size input signals:

- comm.PSKModulator
- comm.QPSKModulator
- comm.BPSKModulator
- comm.PAMModulator
- comm.RectangularQAMModulator
- comm.GeneralQAMModulator
- comm.PSKDemodulator
- comm.QPSKDemodulator
- comm.BPSKDemodulator
- comm.PAMDemodulator
- comm.RectangularQAMDemodulator
- comm.GeneralQAMDemodulator
- comm.IntegerToBit
- comm.BitToInteger

The following System objects now output variable-size signals:

- comm.GoldSequence
- comm.KasamiSequence
- comm.PNSequence

## Algorithm Improvements for CRC Blocks

This release introduces a new encoding algorithm for all blocks in the CRC sublibrary residing in the Error Detection and Correction library. In this new implementation, the block processes multiple input bits in one step, resulting in faster processing times. The previous implementation always processed one input bit at each step.

## MATLAB Compiler Support for System Objects

The Communications System Toolbox supports the MATLAB Compiler for most System objects. With this capability, you can use the MATLAB Compiler to take MATLAB files, which can include System objects, as input and generate standalone applications.

The following System objects are not supported by the MATLAB Compiler software:

### 'Internal rule' System Object Property Values Changed to 'Full precision'

To clarify the value of many `DataType` properties, the 'Internal rule' option has been changed to 'Full precision'.

## Compatibility Considerations

Compatibility Consideration

The objects allow you to enter either 'Internal rule' or 'Full precision'. If you enter 'Internal rule', that option is stored as 'Full precision'.

## System Object Code Generation Support

The following System objects support code generation:

- `comm.PSKTCMModulator`
- `comm.RectangularQAMTCMModulator`
- `comm.GeneralQAMTCMModulator`
- `comm.EarlyLateGateTimingSynchronizer`
- `comm.GardnerTimingSynchronizer`

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- `comm.GMSKTimingSynchronize`
  - `comm.MSKTimingSynchronizer`
  - `comm.MuellerMullerTimingSynchronizer`
  - `comm.KasamiSequence`

## LDPC Decoder Block Warnings

Communications System Toolbox software uses a new implementation of the LDPC Decoder block. If you open a previously existing model that contains the LDPC block, the model generates a warning at the MATLAB command line. Simply resave the model to prevent any subsequent warnings.

## Phase/Frequency Offset Block and System Object Change

In previous releases, when the frequency offset input signal to the Phase/Frequency Offset block or `comm.PhaseFrequencyOffset` System object was constant, or time-invariant, the block and System object generated the correct output. However, the block and System object produced incorrect results for a time-varying frequency offset input signal. The new implementation generates the correct output for a time-varying frequency offset input signal.

## Derepeat Block Changes

The Derepeat block now contains the **Input processing** and **Rate options** parameters. See “Sample- and Frame-Based Concepts” (DSP System Toolbox) for more information.

## Version 2, 2.5, and 3.0 Obsolete Blocks Removed

All the obsolete block libraries associated with Communications Blockset version 2 Release 12, version 2.5 Release 13, and version 3.0 Release 14 have been removed from this product. The removal includes the following libraries:

- `commanabbnd2`
- `commcontsrc2`
- `commdigpbndam2`
- `commdigpbndcpm2`

- `commdigpbndfm2`
- `commdigpbndpm2`
- `comminteg2`
- `commanapbnd2`
- `commchan2`
- `commdigbbndam2`
- `commdigbbndpm2`

## Compatibility Considerations

### Compatibility Considerations

Communications System Toolbox software does not support any of the blocks from Release 12 and Release 13. The Communications System Toolbox block libraries provide some of the same functionality in the form of upgraded blocks.

## System Objects Input and Property Warnings Changed to Errors

When a System object is locked (for example, after the `step` method has been called), the following situations now produce an error. This change prevents the loss of state information.

- Changing the input data type
- Changing the number of input dimensions
- Changing the input complexity from real to complex
- Changing the data type, dimension, or complexity of tunable property
- Changing the value of a nontunable property

## Compatibility Considerations

### Compatibility Consideration

Previously, the object issued a warning for these situations. The object then unlocked, reset its state information, relocked, and continued processing. To update existing code so

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that it does not produce an error, use the `release` method before changing any of the items listed above.

## Frame-Based Processing

In signal processing applications, you often need to process sequential samples of data at once as a group, rather than one sample at a time. Communications System Toolbox documentation refers to the former as frame-based processing and the latter as sample-based processing (see “Sample- and Frame-Based Concepts” (DSP System Toolbox)). A frame is a collection of samples of data, sequential in time.

Historically, Simulink-family products that can perform frame-based processing propagate frame-based signals throughout a model. The frame status is an attribute of the signals in a model, just as data type and dimensions are attributes of a signal. The Simulink engine propagates the frame attribute of a signal by means of a frame bit, which can either be on or off. When the frame bit is on, Simulink interprets the signal as frame based and displays it as a double line, rather than the single line sample-based signal.

### General Product-Wide Changes

Beginning in R2010b, MathWorks started to significantly change the handling of frame-based processing. In the future, frame status will no longer be a signal attribute. Instead, individual blocks will control whether they treat inputs as frames of data or as samples of data. To learn how a particular block handles its input, you can refer to the block reference page.

To transition to the new paradigm of frame-based processing, many blocks have received new parameters. The following sections provide more detailed information about the specific Communications System Toolbox software changes that are helping to enable the transition to the new way of frame-based processing:

- “Blocks with a New Input Processing Parameter” on page 16-8
- “Multirate Processing Parameter Changes” on page 16-11
- “Sample-Based Row Vector Processing Changes” on page 16-12

## Compatibility Considerations

### Compatibility Considerations

During this transition to the new way of handling frame-based processing, both the old way (frame status as an attribute of a signal) and the new way (each block controls

whether to treat inputs as samples or as frames) will coexist for a few releases. For now, the frame bit will still flow throughout a model, and you will still see double signal lines in your existing models that perform frame-based processing.

- **Backward Compatibility** — By default, when you load an existing model in R2010b any new parameters related to the frame-based processing change will be set to their backward-compatible option. For example, if any blocks in your existing models received the **Input processing** parameter, the parameter will be set to **Inherited** (this choice will be removed - see release notes) when you load your model. This setting enables your existing models to continue working as expected until you upgrade them. Because the inherited option will be removed in a future release, you should upgrade your existing models as soon as possible.
- **slupdate Function** — To upgrade your existing models to the new way of handling frame-based processing, you can use the `slupdate` function. Your model must be compilable in order to run the `slupdate` function. The function detects all blocks in your model that are in need of updating, and asks you whether you would like to upgrade each block. If you select yes, the `slupdate` function updates your blocks accordingly.
- **Timely Update to Avoid Unexpected Results** — It is important to update your existing models as soon as possible because the frame bit will be removed in a future release. At that time, any blocks that have not yet been upgraded to work with the new paradigm of frame-based processing will automatically transition to perform their library default behavior. The library default behavior of the block might not produce the results you expected, thus causing undesired results in your models. Once the frame bit is removed, you will no longer be able to upgrade your models using the `slupdate` function. Therefore, you should upgrade your existing modes using `slupdate` as soon as possible.

For more detailed information about the specific compatibility considerations related to the R2010b frame-based processing changes, see the following Compatibility Considerations sections.

### **Blocks with a New Input Processing Parameter**

Some Communications System Toolbox blocks are able to process both sample- and frame-based signals. After the transition to the new way of handling frame-based processing, signals will no longer carry information about their frame status. Blocks that can perform both sample- and frame-based processing will require a new parameter that allows you to specify the appropriate processing behavior. To prepare for this change, many blocks received a new **Input processing** parameter. You can select `Columns` as

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channels (frame based) or Elements as channels (sample based), depending upon the type of processing you want. The third choice, Inherited (this choice will be removed - see release notes), is a temporary selection. This additional option will help you to migrate your existing models from the old paradigm of frame-based processing to the new paradigm.

For a list of blocks that received a new **Input processing** parameter, expand the following list.

### **Blocks with New Input Processing Parameter**

- Derepeat
- Gaussian Filter
- Windowed Integrator
- AWGN Channel (with only two options)

## **Compatibility Considerations**

### Compatibility Considerations

When you load an existing model R2010b, any block with the new **Input processing** parameter will show a setting of Inherited (this choice will be removed - see release notes). This setting enables your existing models to continue to work as expected until you upgrade them. Although your old models will still work when you open and run them in R2010b, you should upgrade them as soon as possible.

You can upgrade your existing models, using the `slupdate` function. The function detects all blocks that have Inherited (this choice will be removed - see release notes) selected for the **Input processing** parameter, and asks you whether you would like to upgrade each block. If you select yes for the Gaussian Filter or Windowed Integrator, the function detects the status of the frame bit on the input port of the block. If the frame bit is 1 (frames), the function sets the **Input processing** parameter to Columns as channels (frame based). If the bit is 0 (samples), the function sets the parameter to Elements as channels (sample based).

In a future release, the frame bit and the Inherited (this choice will be removed - see release notes) option will be removed. At that time, the **Input processing** parameter in models that have not been upgraded will automatically be set to either Columns as channels (frame based) or Elements as channels (sample based), depending on the library default setting for each block. If the library default

setting does not match the parameter setting in your model, your model will produce unexpected results. Additionally, after the frame bit is removed, you will no longer be able to upgrade your models using the `supdate` function. Therefore, you should upgrade your existing models using `supdate` as soon as possible.

## AWGN Channel Block Changes

The AWGN Channel block uses the new method of “Frame-Based Processing” on page 16-7. In previous releases, the frame status of the input signal determined how the AWGN Channel block processed the signal. In R2010b, the default behavior of the AWGN Channel block is to always perform frame-based processing.

Unless you specify otherwise, the block now treats each column of the input signal as an individual channel, regardless of its frame status. To enable the behavior change in the AWGN Channel block while still allowing for backward compatibility, an **Input processing** parameter has been added. This parameter will be removed in a future release, at which point the block will always perform frame-based processing.

## Compatibility Considerations

### Compatibility Considerations

The **Input processing** parameter will be removed in a future release. At that point in time, the AWGN Channel block will always perform frame-based processing.

You can use the `supdate` function to upgrade your existing models that contain an AWGN Channel block. The function detects all AWGN Channel blocks in your model and, if you allow it to, performs the following actions:

- If the input to the block is an  $M$ -by-1 or unoriented sample-based signal, the `supdate` function performs three actions. First, a Transpose block is placed in front of the AWGN Channel block in your model. This block transposes the  $M$ -by-1 or unoriented sample-based input into a 1-by- $M$  row vector. By converting the input to a row vector, the block continues to produce the same results as in previous releases. The `supdate` function also sets the **Input processing** parameter to `Columns as channels (frame based)`. This setting ensures that your model will continue to produce the same results when the **Input processing** parameter is removed in a future release. The `supdate` function also adds a Transpose block after the AWGN channel block in your model for an  $M$ -by-1 sample-based input and a Reshape block for unoriented inputs. By converting the row vector output of the AWGN channel to the input dimension, the model continues to behave as in prior releases.



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- If the input to the block is *not* an  $M$ -by-1 or unoriented sample-based signal, the `slupdate` function sets the **Input processing** parameter to `Columns as channels (frame based)`. This setting does not affect the behavior of your current model. However, the change does ensure that your model will continue to produce the same results when the **Input processing** parameter is removed in a future release.

### Multirate Processing Parameter Changes

In R2010a and earlier releases, many Communications System Toolbox blocks that supported multirate processing had a **Framing** parameter. This parameter allowed you to specify whether the block should `Maintain input frame size` or `Maintain input frame rate` when processing the input signal. Beginning in R2010b, a new **Rate options** parameter replaced the **Framing** parameter. The **Rate options** parameter allows you to specify whether the block should `Enforce single-rate processing` or `Allow multirate processing`.

Some blocks that supported multirate processing in R2010a and earlier releases did not have a **Framing** parameter. These blocks used the frame status of the input signal to determine whether they performed single-rate or multirate processing. Because of the upcoming frame-based processing changes, signals will no longer carry their frame status. Thus, multirate blocks can no longer rely on the frame status of the input signal to determine whether they perform single-rate or multirate processing. You must now specify a value for the **Rate options** parameter on the block dialog box.

To see a full list of blocks that have a new **Rate options** parameter, expand the following section.

### Multirate Blocks with a New Rate Options Parameter

- Raised Cosine Receive Filter
- Raised Cosine Transmit Filter
- Ideal Rectangular Pulse Filter
- OQPSK Modulator Baseband
- OQPSK Demodulator Baseband
- CPM Modulator Baseband
- CPM Demodulator Baseband
- MSK Modulator Baseband
- MSK Demodulator Baseband

- GMSK Modulator Baseband
- GMSK Demodulator Baseband
- CPFSK Modulator Baseband
- CPFSK Demodulator Baseband
- M-FSK Demodulator Baseband
- M-FSK Modulator Baseband
- Derepeat

### **Sample-Based Row Vector Processing Changes**

The following blocks do not process sample-based row vectors:

- APP Decoder
- Convolutional Encoder
- Viterbi Decoder
- Algebraic Deinterleaver
- Algebraic Interleaver
- General Block Deinterleaver
- General Block Interleaver
- Matrix Deinterleaver
- Matrix Helical Scan Deinterleaver
- Matrix Helical Scan Interleaver
- Matrix Interleaver
- Random Deinterleaver
- Random Interleaver
- M-PAM Modulator Baseband
- Rectangular QAM Modulator Baseband
- DQPSK Modulator Baseband
- M-DPSK Modulator Baseband
- M-PSK Modulator Baseband
- OQPSK Modulator Baseband
- QPSK Modulator Baseband

- 
- M-FSK Modulator Baseband
  - CPFSK Modulator Baseband
  - CPM Modulator Baseband
  - Insert Zero
  - Puncture
  - Bit to Integer Converter
  - Integer to Bit Converter

## Compatibility Considerations

### Compatibility Considerations

Using existing models that contain these blocks to process sample-based row vectors generates an error message.

### CMA Equalizer Changes

The CMA Equalizer block now handles input signals like the other equalizer blocks in the Communications Blockset library. Therefore, the block no longer accepts scalar input signals in symbol-spaced mode.

### Differential Encoder Changes

The Differential Encoder block supports scalar-valued and column vector input signals. It does not support frame-based or sample-based row vectors.

### Find Delay and Align Signal Block Changes

The **Correlation window length** parameter specifies the number of samples the block uses to calculate the cross-correlation of two signals. You must specify a window length of at least 2 for the cross-correlation calculations. If you set the **Correlation window length** parameter to 1, the block generates an error message. The following blocks contain the **Correlation window length** parameter:

- Find Delay
- Align Signals

## **New Demos**

This release contains the following new demos:

- Parallel Concatenated Convolutional Coding: Turbo Codes
- Go-Back-N ARQ with PHY Layer
- Adaptive MIMO System with OSTBC
- CORDIC-Based QPSK Carrier Synchronization
- DVB-S.2 Link, Including LDPC Coding
- DVB-S.2 System Simulation Using a GPU-Based LDPC Decoder System Object