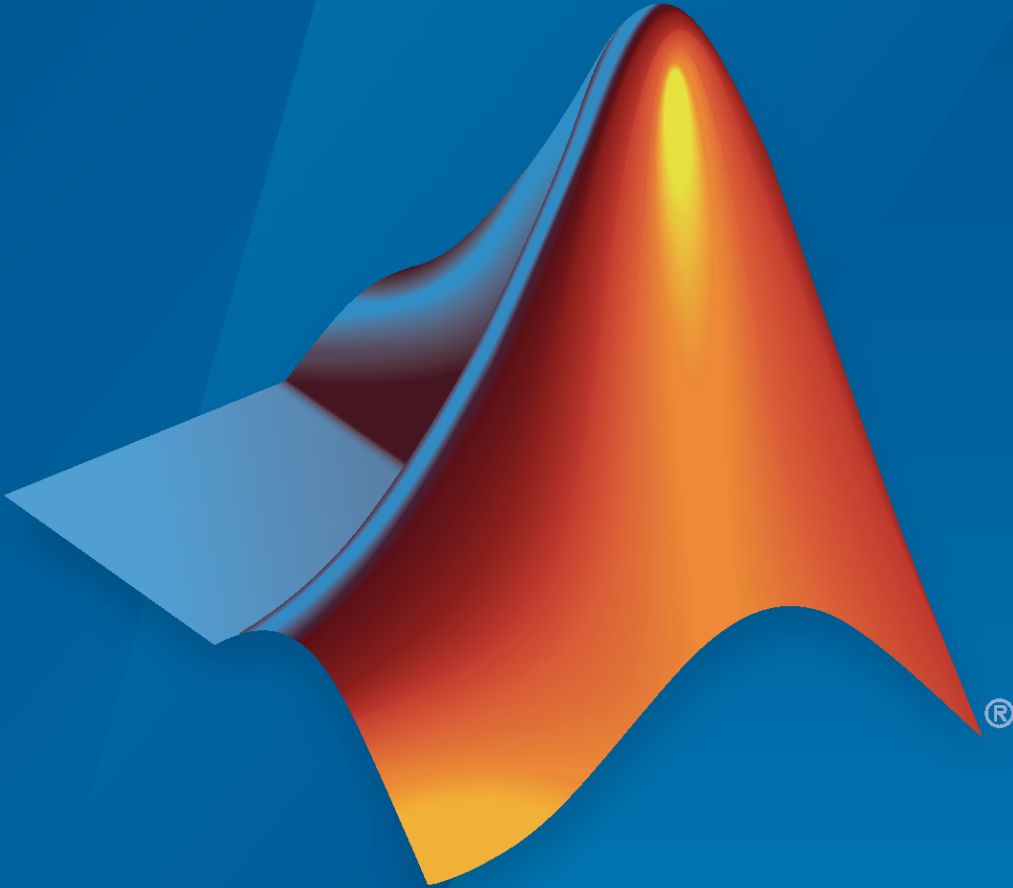


5G Toolbox™ Release Notes



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5G Toolbox™ Release Notes

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R2020a

Version: 2.0

New Features

Bug Fixes

Compatibility Considerations

App support for NR-TM, NR uplink FRC, and NR downlink FRC waveform generation

Use the **5G Waveform Generator** app to generate NR test models (NR-TM) and NR uplink and downlink fixed reference channel (FRC) waveforms.

Support for PRACH

Use these functions and this object to model the physical random access channel (PRACH).

Function	Description
nrPRACH	Generate PRACH symbols
nrPRACHIndices	Generate PRACH resource element indices
nrPRACHGrid	Generate PRACH resource grid

Object	Description
nrPRACHConfig	PRACH configuration parameters

For more information on PRACH time resources, preambles, configurations, and how to map PRACH symbols to the resource grid, see “5G NR PRACH Configuration”.

You can configure and generate time-domain waveform for a single PRACH configuration in a single carrier. For an example, see “5G NR PRACH Waveform Generation”.

You can measure the probability of correct detection of the PRACH preamble in the presence of a preamble signal. For an example, see “5G NR PRACH Detection Test”.

Enhanced support for DM-RS and PT-RS

DM-RS and PT-RS for PUSCH

You can now use these functions and objects to model demodulation reference signals (DM-RS) and phase-tracking reference signals (PT-RS) for the physical uplink shared channel (PUSCH). These enhancements replace the example-specific implementations in previous releases.

Function	Description
nrPUSCHDMRS	Generate PUSCH DM-RS symbols
nrPUSCHDMRSIndices	Generate PUSCH DM-RS indices
nrPUSCHPTRS	Generate PUSCH PT-RS symbols
nrPUSCHPTRSIndices	Generate PUSCH PT-RS indices

Object	Description
nrPUSCHDMRSConfig	PUSCH DM-RS configuration parameters
nrPUSCHPTRSConfig	PUSCH PT-RS configuration parameters

For more information on how to configure and generate the PUSCH reference signals, see “NR PUSCH Resource Allocation and DM-RS and PT-RS Reference Signals”.

DM-RS and PT-RS for PDSCH

You can now use these functions and objects to model DM-RS and PT-RS for the physical downlink shared channel (PDSCH). These enhancements replace the example-specific implementations in previous releases.

Function	Description
nrPDSCHDMRS	Generate PDSCH DM-RS symbols
nrPDSCHDMRSIndices	Generate PDSCH DM-RS indices
nrPDSCHPTRS	Generate PDSCH PT-RS symbols
nrPDSCHPTRSIndices	Generate PDSCH PT-RS indices

Object	Description
nrPDSCHDMRSConfig	PDSCH DM-RS configuration parameters
nrPDSCHPTRSConfig	PDSCH PT-RS configuration parameters

For more information on how to configure and generate the PDSCH reference signals, see “NR PDSCH Resource Allocation and DM-RS and PT-RS Reference Signals”.

Enhanced support for PDSCH indices and PDSCH configuration

You can now use this function and these objects to configure and generate PDSCH resource element indices. These enhancements replace the example-specific implementation in previous releases.

Function	Description
nrPDSCHIndices	Generate PDSCH resource element indices

Object	Description
nrPDSCHConfig	PDSCH configuration parameters
nrPDSCHReservedConfig	PDSCH reserved physical resource block (PRB) configuration parameters

The nrPDSCH and nrPDSCHDecode functions now enable you to specify carrier and PDSCH configuration parameters by using the nrCarrierConfig and nrPDSCHConfig objects, respectively.

Enhanced support for PUSCH indices and PUSCH configuration

You can now use this function and object to configure and generate physical uplink shared channel (PUSCH) resource element indices. These enhancements replace the example-specific implementation in previous releases.

Function	Description
nrPUSCHIndices	Generate PUSCH resource element indices

Object	Description
nrPUSCHConfig	PUSCH configuration parameters

The `nrPUSCH` and `nrPUSCHDecode` functions now enable you to specify carrier and PUSCH configuration parameters by using the `nrCarrierConfig` and `nrPUSCHConfig` objects, respectively.

Enhanced support for PDCCH resources, CORESET, and search spaces

You can now use these functions to generate physical downlink control channel (PDCCH) resources and PDCCH DM-RS resources. These enhancements replace the example-specific implementation in previous releases.

Function	Description
<code>nrPDCCHResources</code>	Generate PDCCH and PDCCH DM-RS resources
<code>nrPDCCHSpace</code>	Generate PDCCH resources for all candidates and aggregation levels

You can now use these objects to configure the control-resource element set (CORESET), the PDCCH, and the search space set. These enhancements replace the example-specific implementation in previous releases.

Object	Description
<code>nrCORESETConfig</code>	CORESET configuration parameters
<code>nrPDCCHConfig</code>	PDCCH configuration parameters
<code>nrSearchSpaceConfig</code>	Search space set configuration parameters

For more information on how to configure the CORESET, the PDCCH, and the search space set, see “Downlink Control Processing and Procedures”.

Enhanced support for SRS

You can now use these functions and this object to model the sounding reference signal (SRS). These enhancements replace the example-specific implementation in previous releases.

Function	Description
<code>nrSRS</code>	Generate uplink SRS symbols
<code>nrSRSIndices</code>	Generate uplink SRS resource element indices

Object	Description
<code>nrSRSConfig</code>	SRS configuration parameters

For more information on how to configure and generate the SRS for uplink transmission, see “NR SRS Configuration”.

You can use the SRS for synchronization, channel estimation, and uplink channel state information (CSI) estimation. For an example, see “NR Uplink Channel State Information Estimation Using SRS”.

Specify RNTI for polar and DCI decoding

The `nrPolarDecode` and `nrDCIDeCode` functions now enable you to specify the radio network temporary identifier (RNTI) used for masking the CRC parity bits at the transmit end.

Uplink FRC generation

Generate standard-compliant 5G NR uplink fixed reference channels (FRCs) for frequency range 1 (FR1) and frequency range 2 (FR2). For more information, see “5G NR-TM and FRC Waveform Generation”.

Characterize the impact of RF impairments in NR transmitter and receiver

Characterize the impact of radio frequency (RF) impairments, such as in-phase and quadrature (IQ) imbalance, phase noise, and power amplifier (PA) nonlinearities in the performance of a NR RF transmitter. For more information, see “Modeling and Testing an NR RF Transmitter”.

Characterize the impact of RF impairments in the RF reception of an NR waveform when coexisting with a long-term evolution (LTE) interference. For more information, see “Modeling and Testing an NR RF Receiver with LTE Interference”.

Measure EVM of NR-TM

Measure the error vector magnitude (EVM) of NR test models (NR-TM) with phase noise and memoryless nonlinearity impairments. For an example, see “EVM Measurement of 5G NR-TM Waveforms”.

Measure CSI-RSRP, CSI-RSSI, CSI-RSRQ and report CQI using CSI-RS

Measure the channel state information (CSI) reference signal received power (CSI-RSRP), the CSI received signal strength indicator (CSI-RSSI), and the CSI reference signal received quality (CSI-RSRQ). For an example, see “5G NR CSI-RS Measurements”.

Calculate and compare CQI values using CSI-RS with practical and perfect channel estimation. For an example, see “5G NR CQI Reporting”.

System-level simulation updates

Schedule 5G NR PUSCH and PDSCH resources for TDD mode with symbol based scheduling

Schedule PUSCH and PDSCH resources in time division duplexing (TDD) mode with radio link control (RLC) layer functionality in unacknowledged mode (UM). You can use slot or symbol based scheduling, choose from various MAC scheduling strategies, and evaluate the scheduling performance. For more information, see “NR TDD Symbol Based Scheduling Performance Evaluation”.

Schedule 5G NR PUSCH and PDSCH resources for FDD mode

Schedule PUSCH and PDSCH resources in frequency division duplexing (FDD) mode with RLC UM and MAC logical channel prioritization (LCP) procedure. You can choose from various MAC scheduling strategies and evaluate the scheduling performance. For more information, see “NR FDD Scheduling Performance Evaluation”.

Use RLC and LCP for 5G NR PUSCH FDD scheduling

PUSCH scheduling in frequency division duplexing (FDD) mode now includes radio link control (RLC) layer functionality in UM and MAC LCP procedure. For more information, see “NR PUSCH FDD Scheduling”.

Generate data for deep learning data synthesis

Train a convolutional neural network (CNN) for 5G channel estimation using Deep Learning Toolbox™ and data generated with 5G Toolbox. For an example, see “Deep Learning Data Synthesis for 5G Channel Estimation”.

Functionality being removed or changed

Polar decoding metric update

Behavior change

In releases R2019b and before, the function `nrPolarDecode` uses the exact form of the expression $\log(1 + e^x)$ for the internal metric evaluation of polar decoding. Because the exact form leads to numerical instability for high SNR ranges, polar decoding now uses an approximation. The function `nrPolarDecode` approximates $\log(1 + e^x)$ as 0 for $x < 0$ and as x for $x \geq 0$.

Polar decoding is a common component in the broadcast channel, downlink control information, and uplink control information decoding. Therefore, the polar metric approximation affects the results of the `nrBCHDecode`, `nrDCIDeCode`, and `nrUCIDeCode` functions, resulting in a marginal degradation of the BLER performance in a link-level simulation.

R2019b

Version: 1.2

New Features

Bug Fixes

Receiver Design and Synchronization: Perform practical timing and channel estimation

When processing received signals, use these functions to perform practical timing or channel estimation.

Functions	Description
<code>nrTimingEstimate</code>	Practical timing estimation
<code>nrChannelEstimate</code>	Practical channel estimation

The NR PDSCH Throughput and NR PUSCH Throughput examples now include practical timing and channel estimation in addition to perfect timing and channel estimation.

LDPC decoder enhancements and support for layered belief propagation and min-sum approximation

Low-density parity-check (LDPC) decoding now uses multicore processing. Additional LDPC decoding algorithms, such as layered belief propagation, normalized min-sum approximation, and offset min-sum approximation, are also available. These enhancements apply to these decoders: `nrLDPCDecode` function, `nrDLSCHDecoder` System object™, and `nrULSCHDecoder` System object.

Support for CSI-RS

Use these functions and objects to model standard-compliant channel state information reference signals (CSI-RS).

Functions	Description
<code>nrCSIRS</code>	Generate CSI-RS symbols
<code>nrCSIRSIndices</code>	Generate CSI-RS resource element indices

Objects	Description
<code>nrCSIRSConfig</code>	CSI-RS configuration parameters
<code>nrCarrierConfig</code>	Carrier configuration parameters

5G NR-TM waveform generation

Generate standard-compliant 5G NR test models (NR-TMs) for frequency range 1 (FR1) and frequency range 2 (FR2). For NR-TM waveform generation, you can specify the NR-TM name, the channel bandwidth, the subcarrier spacing, and the duplexing mode. For an example, see 5G NR-TM and FRC Waveform Generation.

NR downlink ACLR measurement

Measure the adjacent channel leakage ratio (ACLR) for 5G NR test models in FR1 and FR2. For an example, see 5G NR Downlink ACLR Measurement.

System-Level Simulation: Schedule 5G NR PUSCH resources

Schedule physical uplink shared channel (PUSCH) resources in FDD mode and evaluate scheduling performance. You can choose from various MAC scheduling strategies. For more information, see NR PUSCH FDD Scheduling.

Enhanced 5G NR waveform generation, including CSI-RS, SRS, and PT-RS

Downlink waveform generation now includes CSI-RS and physical downlink shared channel (PDSCH) phase tracking reference signal (PT-RS). For more information, see 5G NR Downlink Carrier Waveform Generation.

Uplink waveform generation now includes sounding reference signal (SRS) and PUSCH PT-RS. For more information, see 5G NR Uplink Carrier Waveform Generation.

R2019a

Version: 1.1

New Features

Bug Fixes

Support for uplink physical channels PUSCH and PUCCH

Use these functions to model the physical uplink shared channel (PUSCH) and the physical uplink control channel (PUCCH) formats 0, 1, 2, 3, and 4.

New Feature	Description
nrPUSCH	Generate PUSCH modulation symbols
nrPUSCHCodebook	Generate PUSCH precoding matrix
nrPUSCHDecode	Decode PUSCH modulation symbols
nrPUSCHDescramble	Perform PUSCH descrambling
nrPUSCHPRBS	Generate PUSCH scrambling sequence
nrPUSCHScramble	Perform PUSCH scrambling
nrPUCCH0	Generate PUCCH format 0 modulation symbols
nrPUCCH1	Generate PUCCH format 1 modulation symbols
nrPUCCH2	Generate PUCCH format 2 modulation symbols
nrPUCCH3	Generate PUCCH format 3 modulation symbols
nrPUCCH4	Generate PUCCH format 4 modulation symbols
nrPUCCHPRBS	Generate PUCCH pseudorandom scrambling sequence
nrPUCCHHoppingInfo	Get PUCCH hopping information
nrLowPAPRS	Generate low peak-to-average power ratio (low-PAPR) sequence
nrTransformPrecode	Generate transform precoded symbols
nrTransformDeprecode	Generate transform decoded symbols

For more information, see Uplink Physical Channels.

Support for uplink shared channel (UL-SCH) and uplink control information (UCI)

UL-SCH

These functions and System objects support UL-SCH encoding and decoding.

New Feature	Description
nrULSCH	Apply UL-SCH encoder processing chain
nrULSCHDecoder	Apply UL-SCH decoder processing chain
nrULSCHInfo	Get uplink shared channel (UL-SCH) information

For more information, see Uplink Transport Channels.

UCI

These functions support UCI encoding and decoding, including support for polar coding and channel coding of small block lengths.

New Feature	Description
nrUCIEncode	Encode uplink control information (UCI)
nrUCIDecode	Decode uplink control information (UCI)

For more information, see Uplink Control Information.

Parity-check support for polar coding

Polar coding functions nrPolarEncode and nrPolarDecode now support parity-check polar coding.

Addition of new downlink shared channel (DL-SCH) System objects

Use these System objects for DL-SCH encoding and decoding. These System objects replace the example-specific DL-SCH implementations in the previous release.

New Feature	Description
nrDLSCH	Apply DL-SCH encoder processing chain
nrDLSCHDecoder	Apply DL-SCH decoder processing chain

5G NR uplink waveform generation

You can now generate a 5G NR uplink waveform, including physical signals and channels. You can also parameterize and generate multiple bandwidth parts (BWP), and multiple instances of the PUSCH and PUCCH channels over different BWPs. For an example, see 5G NR Uplink Carrier Waveform Generation.

5G NR PUSCH link-level reference simulation

You can measure the PUSCH throughput for various propagation conditions and parameter sets. For an example, see NR PUSCH Throughput.

R2018b

Version: 1.0

New Features

Introducing 5G Toolbox

5G Toolbox provides standard-compliant functions and reference examples for the modeling, simulation, and verification of 5G communications systems. The toolbox supports link-level simulation, golden reference verification and conformance testing, and test waveform generation.

With the toolbox you can configure, simulate, measure, and analyze end-to-end communications links. You can modify or customize the toolbox functions and use them as reference models for implementing 5G systems and devices.

The toolbox provides reference examples to help you explore baseband specifications and simulate the effects of RF designs and interference sources on system performance. You can generate waveforms and customize test benches to verify that your designs, prototypes, and implementations comply with the 3GPP 5G New Radio (NR) standard.

Standard-compliant models for 3GPP 5G NR Release 15

5G Toolbox provides standard-compliant functions and reference examples for the modeling, simulation, and verification of 5G communications systems. For more information, see Scope of 5G Toolbox.

Link-level simulation with reference examples, including 5G NR PDSCH throughput simulation

5G Toolbox provides standard-compliant functions for end-to-end physical layer transmit and receive processing. You can measure the PDSCH throughput for various propagation conditions and parameter sets. For an example, see NR PDSCH Throughput.

OFDM waveform generation with NR subcarrier spacings and frame numerologies

With 5G Toolbox, you can generate NR waveforms, including physical signals and channels. The process includes all the stages from channel coding to OFDM modulation. You can explore the effect of different subcarrier spacings and frame numerologies.

TR 38.901 propagation channel models, including tapped delay line (TDL) and clustered delay line (CDL)

5G Toolbox provides TDL and CDL channel modeling capabilities. For more details, see the `nrCDLChannel` and `nrTDLChannel` System objects.

Downlink transport and physical channels (shared, control, broadcast); synchronization and demodulation reference signals

5G Toolbox provides functions to model transport and physical channels, including shared, control, and broadcast channels. You can also model synchronization and demodulation reference signals. For more information, see Downlink Channels.

Signal processing functions, including channel coding (LDPC and polar codes), channel estimation, synchronization, and equalization

5G Toolbox provides low-level functions that model subcomponents in the processing chain for transport channels, physical channels, and physical signals. For more information, see Physical Layer Subcomponents. The toolbox also provides signal reception capability. Using 5G Toolbox functions, you can perform channel estimation, timing estimation, synchronization, and minimum mean-squared error (MMSE) equalization. For more information, see Signal Reception.

C and C++ code generation support

All 5G Toolbox functions and System objects support ANSI®/ISO® compliant C/C++ code generation.

