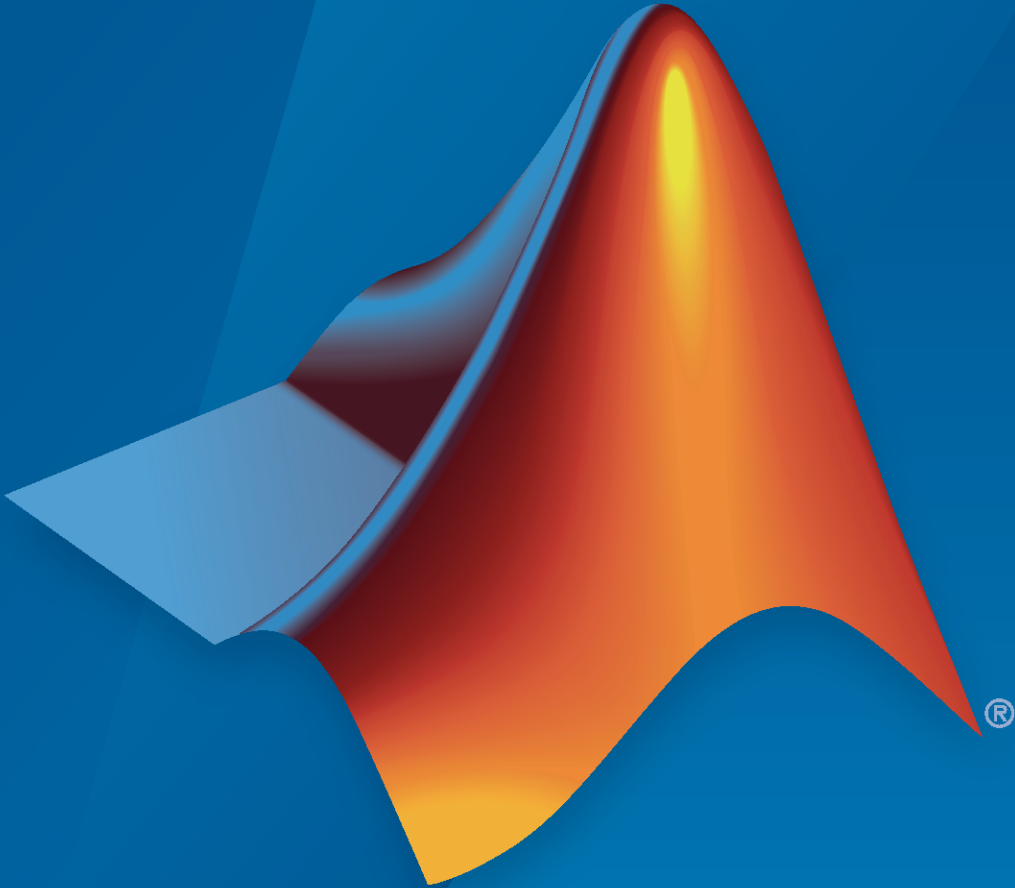


Bluetooth® Toolbox Release Notes



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The MathWorks, Inc.
1 Apple Hill Drive
Natick, MA 01760-2098

Bluetooth® Toolbox Release Notes

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R2023a

Version: 1.2

New Features

Compatibility Considerations

Bluetooth BR/EDR Waveform Generator app

Use the **Bluetooth BR/EDR Waveform Generator** app to perform these tasks.

- Generate Bluetooth basic rate/enhanced data rate (BR/EDR) waveforms with BR, EDR2M, and EDR3M physical layer (PHY) transmission modes.
- Distort a waveform by adding radio frequency (RF) impairments, such as additive white Gaussian noise (AWGN), phase offset, frequency offset, DC offset, IQ imbalance, and memoryless cubic nonlinearity.
- Transmit a waveform by using a software-defined radio (SDR) or a lab test instrument (requires “Instrument Control Toolbox”). You can also transmit the waveform over the air at full radio device rates with “Wireless Testbench” and these USRP™ radios: N310, N320, N321, and X410, as well as X310 with a UBX 160 daughterboard.
- Visualize a waveform by using the spectrum analyzer, time scope, and constellation diagram.
- Export a waveform to your workspace or to a .mat or .bb file. You can also export the waveform generation parameters to a runnable MATLAB® script or a Simulink® block.

EDR support for Bluetooth node

The `bluetoothNode` object now supports the enhanced data rate (EDR) functionality. You can specify the EDR configuration for Bluetooth BR/EDR Central and Peripheral nodes by using the `bluetoothConnectionConfig` object. For more information, see the “Bluetooth BR/EDR Data and Voice Communication with WLAN Signal Interference” example.

Bluetooth BR/EDR full-duplex data and voice communication

“Bluetooth BR/EDR Full-Duplex Data and Voice Communication with WLAN Interference” — This example enables you to model full-duplex data and voice communication in a Bluetooth BR/EDR piconet. Run the model and visualize the power spectral density of Bluetooth BR/EDR waveforms in the presence of wireless local area network (WLAN) interference and an additive white Gaussian noise (AWGN) channel. The simulation results display the bit error rate (BER) and throughput of Bluetooth BR/EDR waveforms with and without WLAN interference.

Bluetooth LE RF-PHY receiver test and measurement

“Bluetooth LE Packet Error Rate Report Integrity Tests” — This example enables you to test the packet error rate (PER) report integrity of a Bluetooth LE RF-PHY receiver. The example simulates these tests and verifies whether the measured values are within the limits specified by the Bluetooth RF-PHY Test Specifications.

Bluetooth LE end-to-end simulation with multipath fading

“End-to-End Bluetooth LE PHY Simulation with Multipath Fading Channel, RF Impairments, and Corrections” — This example enables you to perform Bluetooth LE PHY end-to-end simulation in the presence of a multipath fading channel, RF impairments, and corrections. The example performs the end-to-end simulation between a transmitter and a receiver in a 3-D indoor environment of a conference room. The simulation results show the estimated BER and PER at different E_b/N_0 values in the presence of Rayleigh and raytracing channel models.

Baseband scheduler configuration at Bluetooth BR/EDR node

The `configureScheduler` object function of the `bluetoothNode` object enables you to configure the baseband scheduler at the Bluetooth BR/EDR Central node. You can also use this object function to configure the round-robin (RR) scheduler at the Central node. For more information about how to configure the baseband scheduler in a Bluetooth BR/EDR piconet, see the “Evaluate the Performance of Scheduler in a Bluetooth BR/EDR Piconet” example.

Bluetooth LE waveform generator updates

The `bleWaveformGenerator` function now enables you to perform these tasks.

- Specify the length of the frequency pulse shape by using the `PulseLength` name-value argument.
- Specify the Bluetooth low energy (LE) modulation index for Gaussian frequency-shift keying (GFSK) modulation, in the range [0.45, 0.55], by using the `ModulationIndex` name-value argument.

Enhanced support to configure payload length of eSCO packets

The `bluetoothPhyConfig` object now enables you to configure the payload length of the extended synchronous connection-oriented (eSCO) packets by using the new properties `HasExtendedSCO` and `ExtendedSCOPayloadLength`.

Bluetooth LE node updates

The `bluetoothLENode` object now closes the connection event if the node in a piconet fails to receive a packet. For more information, see the “Piconet” featured examples.

Functionality being removed or changed

runNode object function will be removed in a future release

Warns

The `runNode` object function of the `bluetoothLENode` object will no longer be supported in a future release. To run the Bluetooth LE node, use the `wirelessNetworkSimulator` object, instead. For more information on how to use the `wirelessNetworkSimulator` object to run the Bluetooth LE node, see the “Noncollaborative Bluetooth LE Coexistence with WLAN Signal Interference” example.

channelInvokeDecision object function will be removed in a future release

Warns

The `channelInvokeDecision` object function of the `bluetoothLENode` object will no longer be supported in a future release. To determine whether to apply the channel to the incoming Bluetooth LE signal and simulate the Bluetooth LE node, use the `wirelessNetworkSimulator` object, instead. For more information on how to use the `wirelessNetworkSimulator` object to apply the channel to the incoming Bluetooth LE signal, see the “Noncollaborative Bluetooth LE Coexistence with WLAN Signal Interference” example.

pushChannelData object function will be removed in a future release

Warns

The `pushChannelData` object function of the `bluetoothLENode` object will no longer be supported in a future release. To push data from the channel to the reception buffer of the Bluetooth LE node, use the `wirelessNetworkSimulator` object, instead. For more information on how to use the `wirelessNetworkSimulator` object to push data from the channel to the reception buffer of the Bluetooth LE node, see the “Noncollaborative Bluetooth LE Coexistence with WLAN Signal Interference” example.

bluetoothNode, bluetoothLENode, wirelessNetworkSimulator and networkTrafficOnOff features now require the Communications Toolbox Wireless Network Simulation Library
Behavior change

To use the `bluetoothNode`, `bluetoothLENode`, `wirelessNetworkSimulator`, and `networkTrafficOnOff` functionalities, download and install the Communications Toolbox Wireless Network Simulation Library add-on, introduced in R2023a. For more information, see “Get and Manage Add-Ons”.

R2022b

Version: 1.1

New Features

Compatibility Considerations

Wireless network simulator

Simulate a multinode Bluetooth basic rate (BR) or low energy (LE) wireless network by using the `wirelessNetworkSimulator` object and the associated object functions. Use this object to perform these tasks.

- Add nodes to the simulation.
- Perform scheduled actions.
- Perform channel modeling.
- Run the nodes and distribute the packets.

For more information on how to use this object, see the Estimate Packet Delivery Ratio of LE Broadcast Audio in Residential Scenario example.

Bluetooth node

- The `bluetoothNode` object and the associated object functions enable you to create and configure a Bluetooth BR node. Use this object to configure `Central` and `Peripheral` roles for a Bluetooth BR node. For more information on how to use this object, see the Bluetooth BR Data and Voice Communication with WLAN Signal Interference example.
- Configure a connection between a Bluetooth Central and Peripheral node by using the `bluetoothConnectionConfig` object and the associated `configureConnection` object function.

For more information, see the Create, Configure, and Simulate Bluetooth BR Piconet and Simulate Multiple Bluetooth BR Piconets with ACL Traffic examples.

Path loss estimation

Use the `bluetoothPathLoss` function to estimate the path loss between Bluetooth BR/EDR or low energy (LE) devices in an outdoor, home, office, or industrial environment. Use the `bluetoothPathLossConfig` object to set configuration parameters for the `bluetoothPathLoss` function.

Whitening or dewatering of input data

The `bluetoothWhiten` System object™ enables you to whiten or dewater the input data bits by using a linear feedback shift register (LFSR).

Bluetooth BR RF receiver test and measurement

The Bluetooth BR Blocking, Intermodulation, and Carrier-to-Interference Performance Tests example enables you to perform Bluetooth BR radio frequency (RF) receiver tests specific to blocking, intermodulation, and carrier-to-interference (C/I). The example simulates these tests and verifies whether the measured values are within the limits specified by the Bluetooth RF-PHY Test Specifications.

Localization updates

The `bleAngleEstimate` function and the `bleAngleEstimateConfig` object now support custom antenna arrays for angle of arrival (AoA) and angle of departure (AoD) estimation.

Functionality being removed or changed

runNode object function being removed in future release

Still runs

The `runNode` object function of the `bluetoothLENode` object will be removed in a future release. To run the Bluetooth LE node, use the `wirelessNetworkSimulator` object, instead. For more information on how to use the `wirelessNetworkSimulator` object to run the Bluetooth LE node, see the Noncollaborative Bluetooth LE Coexistence with WLAN Signal Interference example.

channelInvokeDecision object function being removed in future release

Still runs

The `channelInvokeDecision` object function of the `bluetoothLENode` object will be removed in a future release. To determine whether to apply the channel to the incoming Bluetooth LE signal and simulate the Bluetooth LE node, use the `wirelessNetworkSimulator` object, instead. For more information on how to use the `wirelessNetworkSimulator` object to apply the channel to the incoming Bluetooth LE signal, see the Noncollaborative Bluetooth LE Coexistence with WLAN Signal Interference example.

pushChannelData object function being removed in future release

Still runs

The `pushChannelData` object function of the `bluetoothLENode` object will be removed in a future release. To push data from the channel to the reception buffer of the Bluetooth LE node, use the `wirelessNetworkSimulator` object, instead. For more information on how to use the `wirelessNetworkSimulator` object to push data from the channel to the reception buffer of the Bluetooth LE node, see the Noncollaborative Bluetooth LE Coexistence with WLAN Signal Interference example.

R2022a

Version: 1.0

New Features

Introducing Bluetooth Toolbox

MathWorks Bluetooth Toolbox provides standard-based tools to design, simulate, and verify Bluetooth communications systems. It supports test waveform generation, golden reference verification, and Bluetooth network modeling.

With the toolbox, you can configure, simulate, and analyze end-to-end Bluetooth communication links. You can create and reuse test benches to verify that your designs, prototypes, and implementations comply with the Bluetooth standard, including Bluetooth basic rate/enhanced data rate (BR/EDR) and low energy (LE). You can also assess coexistence, interference, localization, and LE Audio scenarios by modeling multiple layers of the Bluetooth protocol stack.

Bluetooth physical layer processing

- Generate, decode, and visualize Bluetooth waveforms. Use the `bluetoothWaveformGenerator` and `bluetoothIdealReceiver` functions for Bluetooth BR/EDR waveforms and the `bleWaveformGenerator` and `bleIdealReceiver` functions for Bluetooth LE waveforms. For an example showing how to generate and visualize Bluetooth LE waveforms with different physical layer (PHY) modes, see [Bluetooth LE Waveform Generation and Visualization](#).
- To compute the Bluetooth BR/EDR or LE packet duration given the type of Bluetooth packet, the specified PHY transmission mode, and the payload length, use the `bluetoothPacketDuration` function.
- The PHY features of the toolbox enable you to add radio frequency (RF) impairments and path loss to the generated Bluetooth waveforms. For examples showing how to add RF impairments and path loss to generated Bluetooth waveforms, see [Generate Bluetooth LE Waveform and Add RF Impairments](#) and [Generate and Attenuate Bluetooth BR/EDR Waveform in Industrial Environment](#), respectively.

For more information, see [PHY Modeling](#).

Coexistence modeling between Bluetooth and WLAN

- You can model, simulate, and visualize noncollaborative coexistence between Bluetooth and WLAN and mitigate interference by using adaptive frequency hopping (AFH). See the following examples.
 - [Noncollaborative Bluetooth LE Coexistence with WLAN Signal Interference](#) — This example shows how to simulate Bluetooth LE coexistence with WLAN signal interference. Add WLAN signal interference from a baseband file or by using WLAN Toolbox™ features. You can also add a custom channel selection algorithm.
 - [PHY Simulation of Bluetooth BR/EDR, LE, and WLAN Coexistence](#) — This example performs PHY simulation to model homogenous and heterogeneous noncollaborative coexistence between Bluetooth BR/EDR, LE, and WLAN. Perform AFH by classifying the channels as good or bad and compute the bit error rate (BER) and signal-to-interference plus noise ratio (SINR).
 - [End-to-End Bluetooth BR/EDR PHY Simulation with WLAN Interference and Adaptive Frequency Hopping](#) — This example performs an end-to-end Bluetooth BR/EDR simulation and computes the BER and packet error rate (PER) values of the Bluetooth BR/EDR waveforms in the presence of WLAN interference with AFH and basic frequency hopping.
 - [Bluetooth Full Duplex Data and Voice Transmission in MATLAB](#) — This example shows how to model and simulate a full duplex communication in a Bluetooth piconet with WLAN interference and with support for AFH. You can compute the PER of each Bluetooth node in the

presence of WLAN interference and with AFH. Additionally, you can add your own channel classification algorithm to analyze the simulation results.

- Select Bluetooth LE channel index for connection, periodic advertising, and isochronous events by using the `bleChannelSelection` System object. For an example showing how to select Bluetooth LE channel index, see Bluetooth LE Channel Selection Algorithms.
- Generate Bluetooth BR/EDR hopping sequence for inquiry, paging, and connection procedures by using the `bluetoothFrequencyHop` object.

For more information, see Coexistence Modeling.

Bluetooth location and direction-finding and ranging capabilities

- Estimate the angle of arrival (AoA) or angle of departure (AoD) by using the `bleAngleEstimate` function. To parameterize this function, use the `bleAngleEstimateConfig` configuration object and the associated object functions. For more information about AoA and AoD direction finding capabilities, see Bluetooth Location and Direction Finding and Parameterize Bluetooth LE Direction Finding Features.
- Estimate the range between two Bluetooth BR/EDR or LE devices by using the `bluetoothRange` function. Use the `bluetoothRangeConfig` object to parameterize this function.
- The `bleCTEIQSample` function enables you to perform in-phase and quadrature (IQ) sampling on the constant tone extension (CTE) field of the Bluetooth LE packet. Using this function, you can estimate the AoA and AoD between the Bluetooth LE transmitter and receiver.
- To estimate the position of a Bluetooth LE node, use the `blePositionEstimate` function. The Bluetooth LE Positioning by Using Direction Finding reference example enables you to estimate the 2-D or 3-D position of a Bluetooth LE node by implementing Bluetooth direction finding functionality and the triangulation-based location estimation technique. You can measure the positioning accuracy of the Bluetooth LE node related to the bit energy-to-noise density ratio (Eb/No).
- The Bluetooth LE Direction Finding for Tracking Node Position example shows how to track the Bluetooth LE node position by using Bluetooth direction finding functionalities and position estimation techniques. Simulate the direction finding packet exchange in the presence of radio frequency (RF) front end impairments, path loss model, and additive white Gaussian noise (AWGN) and measure the positioning accuracy at each node position.

For more information, see Localization.

Bluetooth transmitter and receiver testing and support for software-defined radio (SDR)

- The `bluetoothRFPHYTestConfig` object enables you to set Bluetooth LE RF-PHY transmitter and receiver test configuration parameters based on RF-PHY.TS.p15.
- Generate Bluetooth BR/EDR or LE test waveforms by using the `bluetoothTestWaveform` function. The function supports all the PHY transmission modes of Bluetooth BR/EDR and LE. To parameterize this function, use the `bluetoothTestWaveformConfig` object.
- These reference examples show how to perform RF tests on Bluetooth BR/EDR waveforms.
 - Bluetooth BR/EDR Power and Spectrum Tests
 - Bluetooth BR RF-PHY Transmitter Tests for Modulation Characteristics, Carrier Frequency Offset, and Drift

- Bluetooth EDR RF-PHY Transmitter Tests for Modulation Accuracy and Carrier Frequency Stability
- These reference examples show how to perform RF-PHY tests on Bluetooth LE waveforms.
 - Bluetooth LE IQ samples Coherency and Dynamic Range Tests
 - Bluetooth LE Modulation Characteristics, Carrier Frequency Offset and Drift Tests
 - Bluetooth LE Blocking, Intermodulation and Carrier-to-Interference Performance Tests
 - Bluetooth LE Output Power and In-Band Emissions Tests
- You can generate, transmit, and receive Bluetooth BR/EDR and LE waveforms by using the ADALM-PLUTO radio. For more information, explore these examples.
 - Bluetooth BR/EDR Waveform Generation and Transmission Using SDR
 - Bluetooth BR/EDR Waveform Reception Using SDR
 - Bluetooth LE Waveform Generation and Transmission Using SDR
 - Bluetooth LE Waveform Reception Using SDR

For more information, see Test and Measurement.

Link-level simulation and analysis in the presence of RF and channel impairments

The toolbox provides reference examples that enable you to perform end-to-end Bluetooth BR/EDR and LE simulation.

- You can evaluate and analyze the link-level performance in the presence of RF impairments, path loss, and WLAN interference. For more information, see these examples.
 - End-to-End Bluetooth BR/EDR PHY Simulation with Path Loss, RF Impairments, and AWGN
 - End-to-End Bluetooth LE PHY Simulation Using Path Loss Model, RF Impairments, and AWGN
 - End-to-End Bluetooth LE PHY Simulation with AWGN, RF Impairments and Corrections
- Compute PER and BER for the Bluetooth BR/EDR and LE waveforms. For examples showing how to compute PER and BER, see Bluetooth LE Bit Error Rate Simulation with AWGN and End-to-End Bluetooth BR/EDR PHY Simulation with AWGN, RF Impairments and Corrections.

For more information, see End-to-End Simulation.

Multinode communication in Bluetooth mesh, piconet, and LE Audio networks

Use these features and reference examples to simulate multinode communication in Bluetooth mesh, piconet, and LE Audio networks.

- The `bluetoothLENode` object and the associated object functions enable you to create and configure a Bluetooth LE node. Configure a link layer (LL) connection between a Bluetooth LE Central and Peripheral by using the `bluetoothLEConnectionConfig` object and the associated object function. For more information, see the Create, Configure, and Simulate Bluetooth LE Network example.
- The `bluetoothMeshProfileConfig` object enables you to configure mesh profile parameters at a Bluetooth LE node based on Bluetooth Mesh Profile v1.0.1. To establish friendship between a

Friend node and a Low Power node (LPN) in a Bluetooth mesh network, use the `bluetoothMeshFriendshipConfig` object and the associated object function. For more information, see Bluetooth Mesh Flooding in Wireless Sensor Networks and Energy Profiling of Bluetooth Mesh Nodes in Wireless Sensor Networks examples.

- Use the `bluetoothLEBIGConfig` object to set broadcast isochronous group (BIG) configuration parameters between a Bluetooth LE isochronous broadcaster and a synchronized receiver. For more information, see the Create, Configure, and Simulate Bluetooth LE Broadcast Audio Network example.

The Estimate Packet Delivery Ratio of LE Broadcast Audio in Residential Scenario example shows how to estimate the packet delivery ratio (PDR) of Bluetooth LE audio isochronous broadcast streams in a residential scenario. You can add WLAN interference and a custom path loss model to the wireless channel and explore the PDR performance of the LE audio broadcast network. The example enables you to visualize PDR at different receiver locations in the residential scenario through a heatmap.

- The Evaluate the Performance of Bluetooth QoS Traffic Scheduling with WLAN Signal Interference example shows how to evaluate the performance of the Bluetooth scheduler. You can simulate multiple applications with different quality-of-service (QoS) requirements (throughput and latency) in the presence of WLAN signal interference. You can also plug-in your own custom scheduler and analyze the throughput and latency performance.
- The protocol data unit (PDU) generation and decoding functions and objects enable you to generate and decode Bluetooth LE LL, the logical link control and adaptation protocol (L2CAP), the generic access profile (GAP), and the attribute protocol (ATT) layer PDUs. For examples showing how to generate and decode PDUs, see Generate and Decode Bluetooth Protocol Data Units, Bluetooth LE Link Layer Packet Generation and Decoding, and Bluetooth LE L2CAP Frame Generation and Decoding.
- To export Bluetooth LE LL packets to packet capture (PCAP) and packet capture next generation (PCAPNG) files, use the `blePCAPWriter` object.

For more information, see Multinode Communication.

C and C++ code generation support

Bluetooth Toolbox supports ANSI®/ISO® compliant C/C++ code generation. For an alphabetized list of features that support C/C++ code generation, see Bluetooth Toolbox - Functions and Objects Filtered by C/C++ Code Generation.

