Keysight EEsof EDA
W1918 LTE-Advanced Baseband Verification Library

Data Sheet

Baseband PHY Libraries
for SystemVue

Offering the Fastest Path from Algorithms to R&D Verification

Key Benefits:

- Accelerate your Physical Layer (PHY) design process with a superior modeling environment
- Save time with a trusted, independent IP reference from Keysight
- Validate BB & RF integration early, reducing project risk
- Reduce functional verification and NRE in R&D, with a streamlined process
- Fill strategic gaps using simulation, such as missing hardware and MIMO effects for early throughput testing
- Interoperate with test equipment, while the standard itself is still evolving
- Re-use the same Keysight IP and test assets throughout process

The W1918 LTE-Advanced Baseband Verification Library saves time, reduces engineering effort and accelerates the maturity of 4G baseband PHY designs for next-generation 3rd Generation Partnership Project (3GPP) Long Term Evolution LTE-Advanced systems. It enables system architects, algorithm developers and baseband hardware designers to investigate, implement and verify their Layer 1 signal processing designs in the presence of meaningful RF and test signals. The library gives the user piece of mind that a physical layer (PHY) meets or exceeds real-world performance requirements from the European Telecommunications Standards Institute (ETSI).

The Keysight Technologies, Inc. W1918 LTE-Advanced Library provides the industry's first commercial design support for the physical layer of 3GPP Release 11, enabling system and algorithm developers to deploy next-generation 4G performance with greater insight and greater confidence.

The W1918 LTE-A Baseband Verification Library is a Layer 1 simulation reference library option for Keysight SystemVue. The blockset, reference designs, and test benches assist the design and verification of next-generation communication systems, by providing configurable physical layer waveforms and data for 3GPP Releases 8/9 (LTE) and 10-11 (LTE-Advanced). The library is useful for simulation-based exploration of challenging algorithms, up to 8x8 MIMO throughput verification, and can be easily integrated with Keysight signal sources and analyzers.

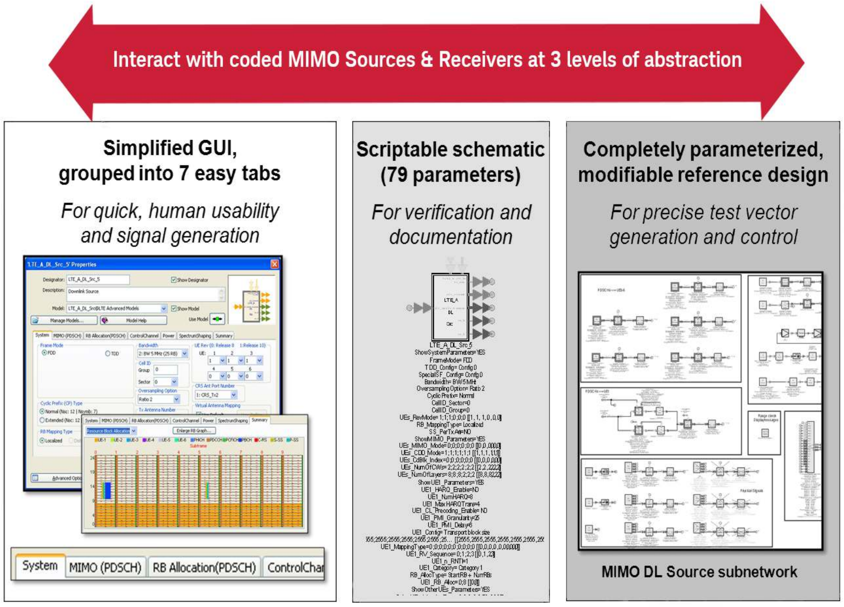


Figure 1. The W1918 LTE-Advanced Baseband Verification Library offers pre-packaged reference sources and receivers with a choice of three levels of user interfaces, as shown in this LTE-A MIMO downlink source example.

Features

- Working simulation-based baseband reference designs for UE & eNodeB
- Open, parameterized block diagrams allow unrestricted exploration and customization inside the signal processing chain
- Generate any Layer 1 signal conditions, at any point inside the signal processing, or elsewhere in the environmental system
- Compare your internal test vectors against a trusted IP reference
- Use Keysight simulation blocks to:
  - supply missing functions/models
  - create complete Layer 1 scenarios
  - add MIMO, fading, RF, interferences
  - simulate BER/Throughput, before HW
  - interoperate seamlessly with real test

Configuration

The W1918 LTE-Advanced Baseband Verification Library can be added as an option to any SystemVue environment or bundle. It interoperates especially well with the W1715 MIMO Channel Builder modelset, and can be used with the W1716 Digital Pre-Distortion Builder module. The W1918 library adds LTE-Advanced algorithmic reference models to an existing modelset for LTE, and is therefore a superset of the W1910 LTE library.

Requirements

The W1918 library requires SystemVue 2011.03 release, or later

- SystemVue runs on Windows 7, 8. Remote/distributed simulation is also supported on versions of RedHat Linux. Affordable network licensed configurations are available for workgroups to share.
- W1918 is available as a perpetual software license with an annual support, or as a cost effective time-based license.

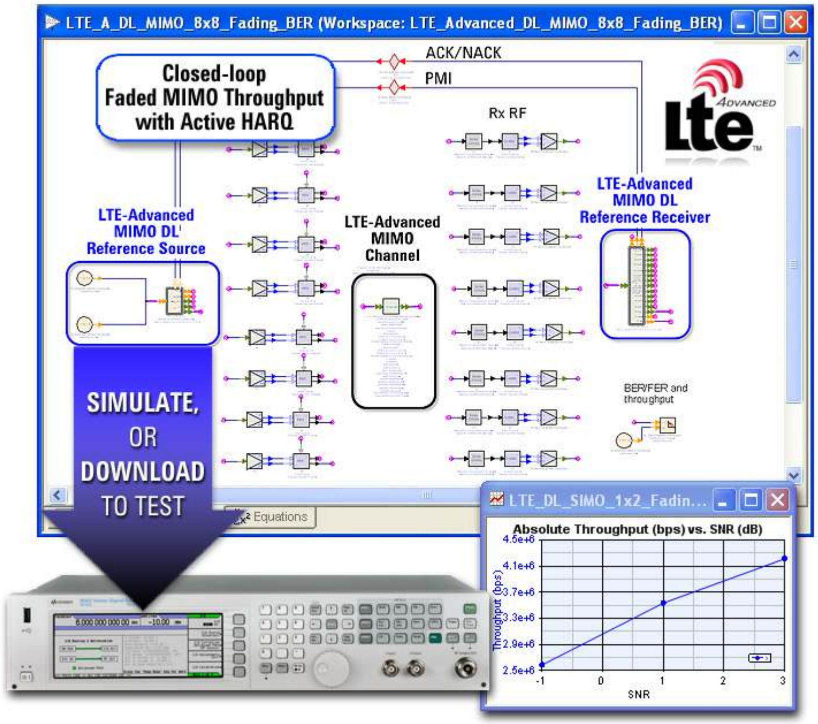


Figure 2. SystemVue's LTE-Advanced reference library provides the industry's first major design library support for 3GPP Releases 8-11, and integrates with Keysight test equipment for early R&D design validation.

Table 1. W1918 LTE-Advanced Baseband Verification Library Overview

W1918 LTE-Advanced library includes:	Release 8/9 LTE	Release 10/11/12 LTE-Advanced
Compiled dataflow simulation blocks	139 parts	71 parts
C++ "exploraton" source code	Optional, add-on	Optional, add-on
Packaged MIMO Sources/receivers, w/GUI	10 ref designs	4 ref designs
Testbenches/reference exmples	20 examples	10 examples
Works with existing instrument H/W	Yes	Yes
Works with Keysight 89600 VSA and SignalStudio software personalities	Yes, also generates ".setx" files	Yes
Works with Keysight W1716 DPD	Yes	Yes
Works with Keysight W1715 MIMO Channel	Yes	Yes

Note: Support for Release 8/9 is also available as part of the SystemVue W1910 LTE baseband verification library.

Technical Specifications – LTE-Advanced (3GPP Release 10/11)

LTE-Advanced Downlink baseband sources and receivers

- FDD and TDD
- Up to 8 TX and 8 RX antennas
- Localized and Distributed RB mapping
- Transmission Modes TM1-4, and 6-9
- Virtual antenna mapping, the mapping matrix can be configured
- Release 10 PDSCH transmission and Release 8 PDSCH transmission in the downlink source
- Closed-loop HARQ simulation by employing Dynamic Data Flow (DDF) and Matrix Data Type. Each codeword have one individual HARQ feedback loop.
- PDSCH
  - Full coding and decoding procedures for DL-SCH with or without HARQ retransmission
  - Three RB (resource block) allocations (StartRB+NumRBs, RB indices (1D), RB indices (2D))
  - Three transport block allocations (MCS index, transport block size and target code rate)
- Physical signals
  - Cell-specific reference signals
  - UE-specific reference signals (port 5, 7-14)
  - Synchronization signals, including primary and secondary synchronization signals
- Control channels
  - Full procedures for PCFICH, PHICH, PDCCH and PBCH, including information bits generation and channel coding
  - CSI reference signals (port 15-22)
- Downlink power allocation according to TS36.213
- Receiver baseband algorithm
  - Support downlink timing and frequency synchronization, including:
    - Cross-correlation with two received P-SCH
    - Auto-correlation with local P-SCH
    - Two stages for timing synchronization: raw and fine synchronization
    - Integer and fractional frequency synchronization
  - Linear, MMSE-2D channel estimation
  - ZF (Zero Forcing) and ML (maximum likelihood) decoding for spatial multiplexing
  - Alamouti decoding for transmit diversity
  - Received soft bits combining for HARQ retransmission
  - Soft turbo decoder with specified iteration number

The W1918 LTE-Advanced Baseband Verification Library is based on 3GPP LTE Release 11 (Dec 2013). Keysight library updates are issued regularly to remain compatibility with the evolution of the standard.

- 3GPP TS 36.211 v11.5.0, “Physical Channels and Modulation,” December 2013.
- 3GPP TS 36.212 v11.4.0, “Multiplexing and Channel Coding,” December 2013.
- 3GPP TS 36.213 v11.5.0, “Physical Layer Procedures,” December 2013.

LTE-Advanced Uplink baseband source and receivers

- FDD and TDD
- Up to 4 Tx antennas and 4 Rx antennas
- Cluster SC-FDMA
- Simultaneous PUSCH and PUCCH transmission
- Maximal ratio combining (MRC) method for receiver diversity
- Adaptive Modulation and Coding (AMC)
- Coordinated Multi-point (CoMP, or Dynamic Point Selection)
- Closed-loop HARQ simulation by employing Dynamic Data Flow (DDF) and Matrix Data Type.
- PUSCH
  - Full coding and decoding procedures for UL-SCH with or without HARQ retransmission
  - PUSCH Hopping
  - Full multiplexing modes for PUSCH
    - UL-SCH Data and control multiplexing (as in 5.2.2 of 36.212)
    - Uplink control information only without UL-SCH data (as in 5.2.4 of 36.212)
  - Three RB (resource block) allocations (StartRB+NumRBs, RB indices (1D), RB indices (2D))
  - Three transport block allocations (MCS index, transport block size and target code rate)
  - DMRS for PUSCH
- PRACH
  - Preamble sequence generation and baseband signal generation
  - PRACH demodulation and detection
- PUCCH transmission
  - PUCCH Format 1, 1a, 1b, Shorten 1, Shorten 1a, Shorten 1b, 2, 2a, 2b, and 3.
  - PUCCH modulation and demodulation, coding and decoding
  - DMRS for PUCCH
- Sounding Reference Signal (SRS) transmission
- Uplink power allocation
- Receiver baseband algorithm
  - Uplink timing and frequency synchronization
  - Linear and MMSE channel estimation
  - Soft turbo decoder with specified iteration number

Carrier aggregation

- Carrier aggregation examples are provided, including both contiguous and non-contiguous carrier aggregation

Technical Specifications – LTE (3GPP Release 8/9)

LTE Downlink Baseband MIMO sources and MIMO receivers

Downlink Sources

- FDD-LTE and TDD-LTE
- Transmission modes TM1-4, and 6-8
- Both Localized and Distributed RB mapping
- Closed-loop HARQ simulation by employing Dynamic Data Flow (DDF) and Matrix Data Type. Each codeword have one individual HARQ feedback loop.
- Closed-loop MIMO precoding for PDSCH, as described in 8.2.1.4 (Closed-loop spatial multiplexing) of 36.101
- Provides native downlink EVM measurements that are algorithmically compatible with Keysight 89600 VSA software v11.20 and later
- PDSCH
  - Full coding and decoding procedures for DL-SCH with or without HARQ retransmission
  - Three RB (resource block) allocations (StartRB+NumRBs, RB indices (1D), RB indices (2D))
  - Three transport block allocations (MCS index, transport block size and target code rate)
- Physical signals
  - Cell-specific reference signals
  - Synchronization signals, including primary and secondary synchronization signals
  - UE-Specific Reference signals (port 5, port 7, port 8)
  - Positioning Reference signals (port 6) and PMCH transmission
- Control channels
  - Full procedures for PCFICH, PHICH, PDCCH and PBCH, including information bits generation and channel coding, and MBSFN reference signals
- Downlink power allocation according to TS36.213
- Coded downlink signal sources provided for 1, 2, or 4 antenna ports

Downlink Receivers

- Downlink receiver solutions are provided for
  - 1 antenna, 2 antennas and 4 antennas
  - SISO (1x1), SIMO (1x2,1x4)
  - MIMO (2x2, 4x2, 4x4).
- Downlink HARQ performances meet the requirements defined in 8.2 Demodulation of PDSCH (Cell-Specific Reference Symbols) of TS36.101
- Control channel demodulation and decoding
- Auto generation of .setx configuration file for LTE personalities of Keysight 89600 VSA software

Downlink Receiver baseband algorithms

- Downlink timing and frequency synchronization, including
  - Cross-correlation with two received P-SCH
  - Auto-correlation with local P-SCH
  - Two stages for timing synchronization: raw and fine synchronization
  - Integer and fractional frequency synchronization
- Linear, MMSE-2D channel estimation, also the channel estimation for EVM measurement (defined in TS36.101) is provided
- Maximal ratio combining (MRC) method for receiver diversity
- ZF (Zero Forcing) , MMSE (minimum mean square error) and ML (Maximum likelihood) decoding for spatial multiplexing
- Alamouti decoding for transmit diversity
- Received soft bits combining for HARQ retransmission
  - soft turbo decoder with specified iteration number

The W1910 LTE Baseband Verification Library is based on 3GPP LTE Release 8/ 9 (March 2010). This LTE library is also included as part of the larger W1918 LTE-Advanced library, which further adds Release 10.

- 3GPP TS 36.211 v9.1.0, “Physical Channels and Modulation”, March, 2010.
- 3GPP TS 36.212 v9.1.0, “Multiplexing and Channel Coding”, March, 2010.
- 3GPP TS 36.213 v9.1.0, “Physical Layer Procedures”, March, 2010

LTE Uplink Baseband Sources and Receivers

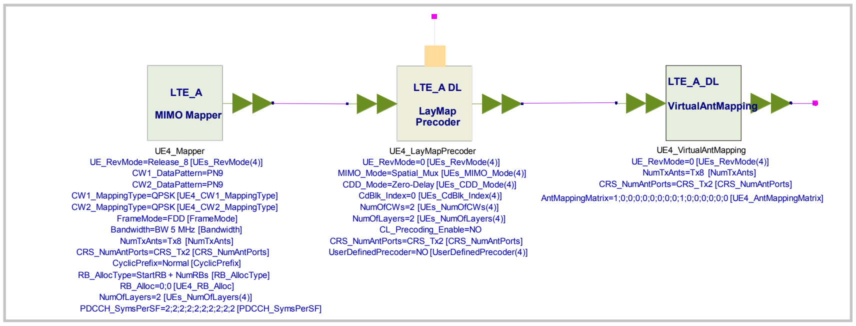
- FDD-LTE and TD-LTE
- Uplink receivers with 1, 2 and 4 antenna ports
- Maximal ratio combining (MRC) method for receiver diversity
- Closed-loop HARQ simulation by employing Dynamic Data Flow (DDF) and Matrix Data Type.
- Provides Uplink EVM measurements that are algorithmically compatible with Keysight 89600 VSA software v11.20 and later
- PUSCH
  - Full coding and decoding procedures for UL-SCH with or without HARQ retransmission
  - PUSCH Hopping
  - Full multiplexing modes for PUSCH
  - UL-SCH Data and control multiplexing (as in 5.2.2 of TS36.212)
  - Uplink control information only without UL-SCH data (as in 5.2.4 of TS36.212)
  - Three RB (resource block) allocations (StartRB+NumRBs, RB indices (1D), RB indices (2D))
  - Three transport block allocations (MCS index, transport block size and target code rate)
  - DMRS for PUSCH
- PRACH
  - Preamble sequence generation and baseband signal generation
  - PRACH demodulation and detection
- PUCCH
  - PUCCH Formats 1, Shorten 1, 1a, Shorten 1a, 1b, Shorten 1b, 2, 2a and 2b.
  - Channel coding for control information bits on PUCCH
  - DMRS for PUCCH
- Sounding Reference Signal (SRS)
  - SRS as defined in 5.5.3 of TS36.211
  - SRS as defined in 8.2 of TS36.213
- Uplink power allocation
- Control information decoding
- Uplink receiver solutions are provided for
  - 1 antenna.
  - HARQ SISO (1x1)
  - Non-HARQ SISO (1x1)

Uplink Receiver baseband algorithm

- Uplink timing and frequency synchronization
- Linear and MMSE channel estimation
- Soft turbo decoder with specified iteration number

W1918 Baseband Block Set

The W1918 LTE-Advanced Baseband Verification Library for SystemVue provides roughly 210 simulation reference blocks for LTE and LTE-Advanced. In addition, lower-level primitives have been combined into 14 fully-coded MIMO UL/DL source and receiver reference designs with a tabbed user interface. Use them as algorithmic references to compare test vectors at any point in the signal-processing chain, or to complete a working PHY.

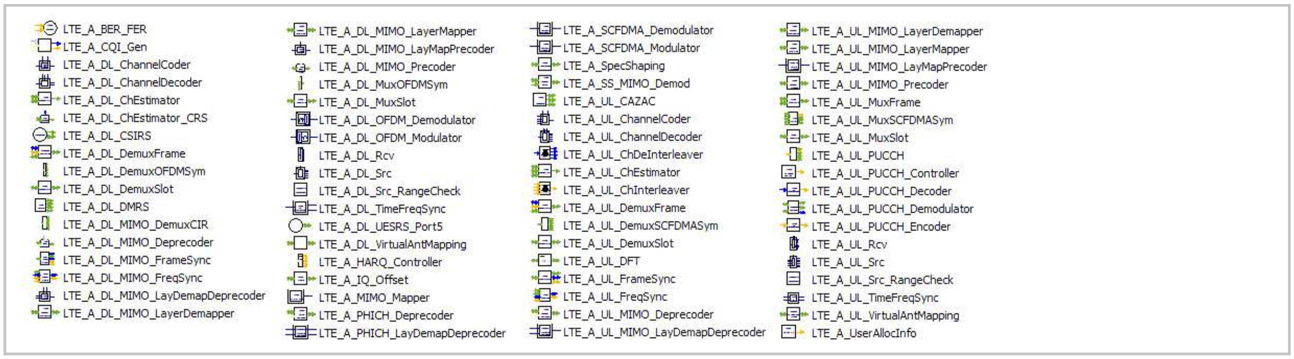


UE4_Mapper
UE_RevMode=Release_8 [UEs_RevMode(4)]
CW1_DataPattern=PN9
CW2_DataPattern=PN9
CW1_MappingType=QPSK [UE4_CW1_MappingType]
CW2_MappingType=QPSK [UE4_CW2_MappingType]
FrameMode=FDD [FrameMode]
Bandwidth=BW 5 MHz [Bandwidth]
NumTxAnts=Tx8 [NumTxAnts]
CRS_NumAntPorts=CRS_Tx2 [CRS_NumAntPorts]
CyclicPrefix=Normal [CyclicPrefix]
RB_AllocType=StartRB + NumRBs [RB_AllocType]
RB_Alloc=0;0 [UE4_RB_Alloc]
NumOfLayers=2 [UEs_NumOfLayers(4)]
PDCCH_SymsPerSF=2;2;2;2;2;2;2;2;2;2 [PDCCH_SymsPerSF]

UE4_LayMapPrecoder
UE_RevMode=0 [UEs_RevMode(4)]
MIMO_Mode=Spatial_Mux [UEs_MIMO_Mode(4)]
CDD_Mode=Zero-Delay [UEs_CDD_Mode(4)]
CdBlk_Index=0 [UEs_CdBlk_Index(4)]
NumOfCWs=2 [UEs_NumOfCWs(4)]
NumOfLayers=2 [UEs_NumOfLayers(4)]
CL_Precoding_Enable=NO
CRS_NumAntPorts=CRS_Tx2 [CRS_NumAntPorts]
UserDefinedPrecoder=NO [UserDefinedPrecoder(4)]

UE4_VirtualAntMapping
UE_RevMode=0 [UEs_RevMode(4)]
NumTxAnts=Tx8 [NumTxAnts]
CRS_NumAntPorts=CRS_Tx2 [CRS_NumAntPorts]
AntMappingMatrix=1;0;0;0;0;0;0;0;0;1;0;0;0;0;0;0 [UE4_AntMappingMatrix]

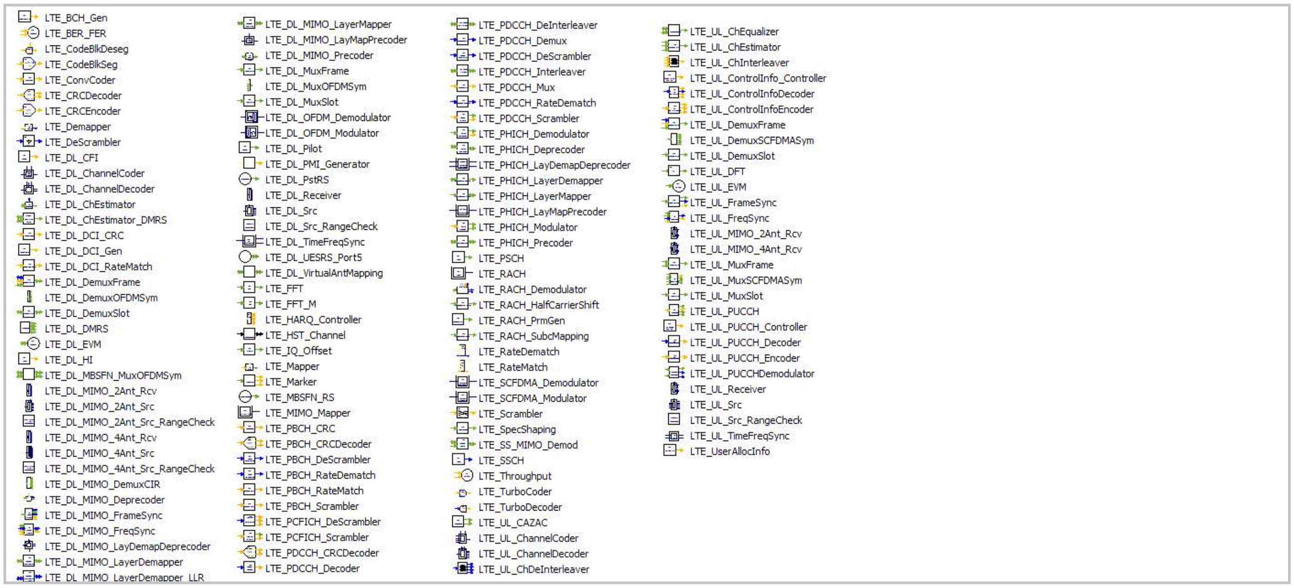
LTE-Advanced simulation models (W1918 only)



LTE_A_BER_FER
LTE_A_CQI_Gen
LTE_A_DL_ChannelCoder
LTE_A_DL_ChannelDecoder
LTE_A_DL_ChEstimator
LTE_A_DL_ChEstimator_CRS
LTE_A_DL_CSIRS
LTE_A_DL_DemuxFrame
LTE_A_DL_DemuxOFDMSym
LTE_A_DL_DemuxSlot
LTE_A_DL_DMRS
LTE_A_DL_MIMO_DemuxCIR
LTE_A_DL_MIMO_Deprecoder
LTE_A_DL_MIMO_FrameSync
LTE_A_DL_MIMO_FreqSync
LTE_A_DL_MIMO_LayDemapDeprecoder
LTE_A_DL_MIMO_LayerDemapper
LTE_A_DL_MIMO_LayerMapper
LTE_A_DL_MIMO_LayMapPrecoder
LTE_A_DL_MIMO_Precoder
LTE_A_DL_MuxOFDMSym
LTE_A_DL_MuxSlot
LTE_A_DL_OFDM_Demodulator
LTE_A_DL_OFDM_Modulator
LTE_A_DL_Rcv
LTE_A_DL_Src
LTE_A_DL_Src_RangeCheck
LTE_A_DL_TimeFreqSync
LTE_A_DL_UESRS_Port5
LTE_A_DL_VirtualAntMapping
LTE_A_HARQ_Controller
LTE_A_IQ_Offset
LTE_A_MIMO_Mapper
LTE_A_PHICH_Deprecoder
LTE_A_PHICH_LayDemapDeprecoder
LTE_A_SCFDMA_Demodulator
LTE_A_SCFDMA_Modulator
LTE_A_SpecShaping
LTE_A_SS_MIMO_Demod
LTE_A_UL_CAZAC
LTE_A_UL_ChannelCoder
LTE_A_UL_ChannelDecoder
LTE_A_UL_ChDeInterleaver
LTE_A_UL_ChEstimator
LTE_A_UL_ChInterleaver
LTE_A_UL_DemuxFrame
LTE_A_UL_DemuxSCFDMASym
LTE_A_UL_DemuxSlot
LTE_A_UL_DFT
LTE_A_UL_FrameSync
LTE_A_UL_FreqSync
LTE_A_UL_MIMO_Deprecoder
LTE_A_UL_MIMO_LayDemapDeprecoder
LTE_A_UL_MIMO_LayerDemapper
LTE_A_UL_MIMO_LayerMapper
LTE_A_UL_MIMO_LayMapPrecoder
LTE_A_UL_MIMO_Precoder
LTE_A_UL_MuxFrame
LTE_A_UL_MuxSCFDMASym
LTE_A_UL_MuxSlot
LTE_A_UL_PUCCH
LTE_A_UL_PUCCH_Controller
LTE_A_UL_PUCCH_Decoder
LTE_A_UL_PUCCH_Demodulator
LTE_A_UL_PUCCH_Encoder
LTE_A_UL_Rcv
LTE_A_UL_Src
LTE_A_UL_Src_RangeCheck
LTE_A_UL_TimeFreqSync
LTE_A_UL_VirtualAntMapping
LTE_A_UserAllocInfo

Figure 3. The W1918 LTE-Advanced baseband verification library provides these 71 simulation blocks and 4 MIMO UL/DL source & receiver reference designs for Release 10 and 11.

LTE simulation models (W1918 and W1910)

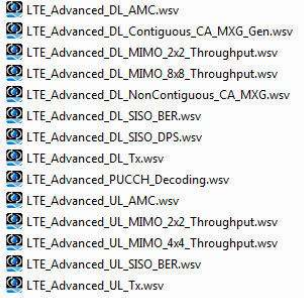


LTE_BCH_Gen
LTE_BER_FER
LTE_CodeBlkDeseg
LTE_CodeBlkSeg
LTE_ConvCoder
LTE_CRCDecoder
LTE_CRCEncoder
LTE_Demapper
LTE_DeScrambler
LTE_DL_CFI
LTE_DL_ChannelCoder
LTE_DL_ChannelDecoder
LTE_DL_ChEstimator
LTE_DL_ChEstimator_DMRS
LTE_DL_DCI_CRC
LTE_DL_DCI_Gen
LTE_DL_DCI_RateMatch
LTE_DL_DemuxFrame
LTE_DL_DemuxOFDMSym
LTE_DL_DemuxSlot
LTE_DL_DMRS
LTE_DL_EVM
LTE_DL_HI
LTE_DL_MBSFN_MuxOFDMSym
LTE_DL_MIMO_2Ant_Rcv
LTE_DL_MIMO_2Ant_Src
LTE_DL_MIMO_2Ant_Src_RangeCheck
LTE_DL_MIMO_4Ant_Rcv
LTE_DL_MIMO_4Ant_Src
LTE_DL_MIMO_4Ant_Src_RangeCheck
LTE_DL_MIMO_DemuxCIR
LTE_DL_MIMO_Deprecoder
LTE_DL_MIMO_FrameSync
LTE_DL_MIMO_FreqSync
LTE_DL_MIMO_LayDemapDeprecoder
LTE_DL_MIMO_LayerDemapper
LTE_DL_MIMO_LayerDemapper_LLR
LTE_DL_MIMO_LayerMapper
LTE_DL_MIMO_LayMapPrecoder
LTE_DL_MIMO_Precoder
LTE_DL_MuxFrame
LTE_DL_MuxOFDMSym
LTE_DL_MuxSlot
LTE_DL_OFDM_Demodulator
LTE_DL_OFDM_Modulator
LTE_DL_Pilot
LTE_DL_PMI_Generator
LTE_DL_PstRS
LTE_DL_Receiver
LTE_DL_Src
LTE_DL_Src_RangeCheck
LTE_DL_TimeFreqSync
LTE_DL_UESRS_Port5
LTE_DL_VirtualAntMapping
LTE_FFT
LTE_FFT_M
LTE_HARQ_Controller
LTE_HST_Channel
LTE_IQ_Offset
LTE_Mapper
LTE_Marker
LTE_MBSFN_RS
LTE_MIMO_Mapper
LTE_PBCH_CRC
LTE_PBCH_CRCDecoder
LTE_PBCH_DeScrambler
LTE_PBCH_RateDematch
LTE_PBCH_RateMatch
LTE_PBCH_Scrambler
LTE_PCFICH_DeScrambler
LTE_PCFICH_Scrambler
LTE_PDCCH_CRCDecoder
LTE_PDCCH_Decoder
LTE_PDCCH_DeInterleaver
LTE_PDCCH_Demux
LTE_PDCCH_DeScrambler
LTE_PDCCH_Interleaver
LTE_PDCCH_Mux
LTE_PDCCH_RateDematch
LTE_PDCCH_Scrambler
LTE_PHICH_Demodulator
LTE_PHICH_Deprecoder
LTE_PHICH_LayDemapDeprecoder
LTE_PHICH_LayerDemapper
LTE_PHICH_LayerMapper
LTE_PHICH_LayMapPrecoder
LTE_PHICH_Modulator
LTE_PHICH_Precoder
LTE_PSCH
LTE_RACH
LTE_RACH_Demodulator
LTE_RACH_HalfCarrierShift
LTE_RACH_PrmGen
LTE_RACH_SubcMapping
LTE_RateDematch
LTE_RateMatch
LTE_SCFDMA_Demodulator
LTE_SCFDMA_Modulator
LTE_Scrambler
LTE_SpecShaping
LTE_SS_MIMO_Demod
LTE_SSCH
LTE_Throughput
LTE_TurboCoder
LTE_TurboDecoder
LTE_UL_CAZAC
LTE_UL_ChannelCoder
LTE_UL_ChannelDecoder
LTE_UL_ChDeInterleaver
LTE_UL_ChEqualizer
LTE_UL_ChEstimator
LTE_UL_ChInterleaver
LTE_UL_ControlInfo_Controller
LTE_UL_ControlInfoDecoder
LTE_UL_ControlInfoEncoder
LTE_UL_DemuxFrame
LTE_UL_DemuxSCFDMASym
LTE_UL_DemuxSlot
LTE_UL_DFT
LTE_UL_EVM
LTE_UL_FrameSync
LTE_UL_FreqSync
LTE_UL_MIMO_2Ant_Rcv
LTE_UL_MIMO_4Ant_Rcv
LTE_UL_MuxFrame
LTE_UL_MuxSCFDMASym
LTE_UL_MuxSlot
LTE_UL_PUCCH
LTE_UL_PUCCH_Controller
LTE_UL_PUCCH_Decoder
LTE_UL_PUCCH_Encoder
LTE_UL_PUCCHDemodulator
LTE_UL_Receiver
LTE_UL_Src
LTE_UL_Src_RangeCheck
LTE_UL_TimeFreqSync
LTE_UserAllocInfo

Figure 4. Both the W1918 (LTE-Advanced) and W1910 (LTE) baseband verification libraries provide these 139 simulation blocks and 10 MIMO UL/DL source & receiver reference designs for Releases 8 and 9. (March 2010).

LTE-Advanced Testbench Samples

Available LTE–Advanced Test bench Samples:



- LTE_Advanced_DL_AMC.wsv
- LTE_Advanced_DL_Contiguous_CA_MXG_Gen.wsv
- LTE_Advanced_DL_MIMO_2x2_Throughput.wsv
- LTE_Advanced_DL_MIMO_8x8_Throughput.wsv
- LTE_Advanced_DL_NonContiguous_CA_MXG.wsv
- LTE_Advanced_DL_SISO_BER.wsv
- LTE_Advanced_DL_SISO_DPS.wsv
- LTE_Advanced_DL_Tx.wsv
- LTE_Advanced_PUCCH_Decoding.wsv
- LTE_Advanced_UL_AMC.wsv
- LTE_Advanced_UL_MIMO_2x2_Throughput.wsv
- LTE_Advanced_UL_MIMO_4x4_Throughput.wsv
- LTE_Advanced_UL_SISO_BER.wsv
- LTE_Advanced_UL_Tx.wsv

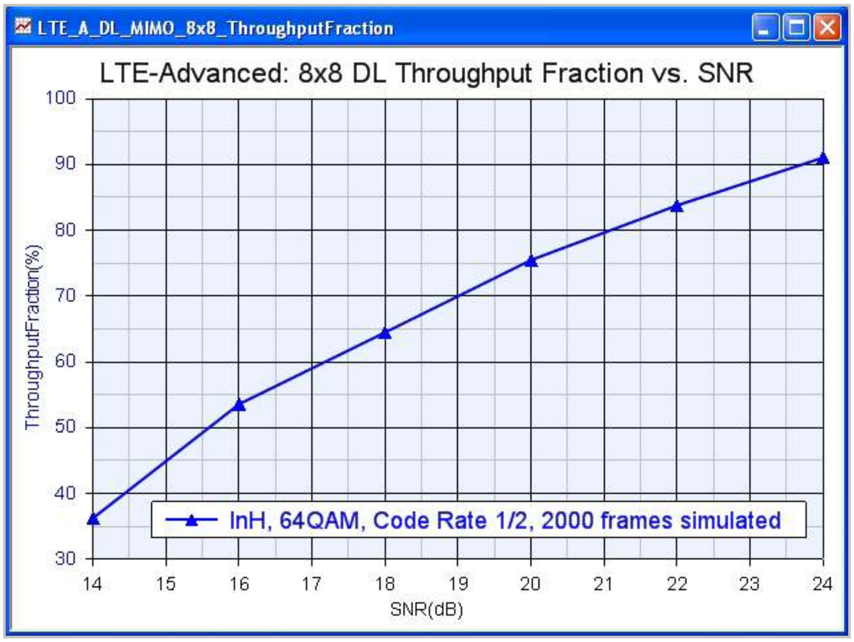


Figure 5. This 8x8 MIMO downlink transmitter example calculates the closed-loop throughput fraction for an LTE Advanced downlink transmitter with an 8-layer MIMO. Since 2000 frames of LTE-Advanced data for 8 MIMO channels represents a large number of simulated bits, these long verification simulations can be scripted and run automatically, for more convenience.

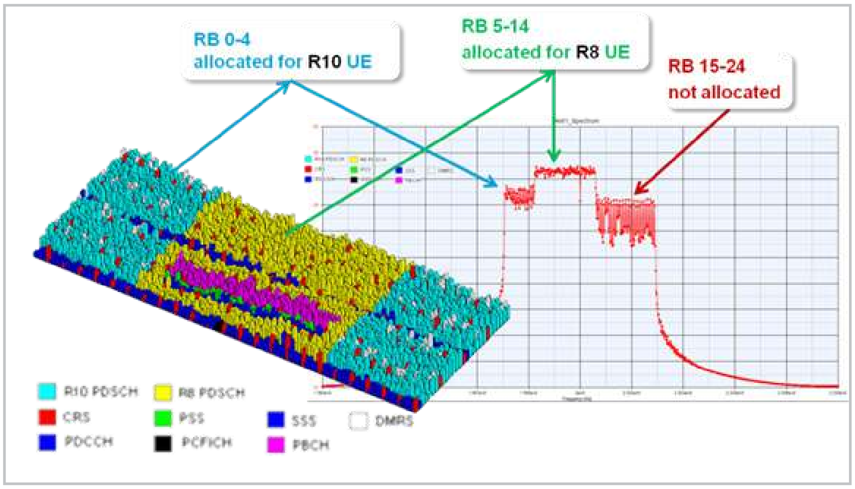
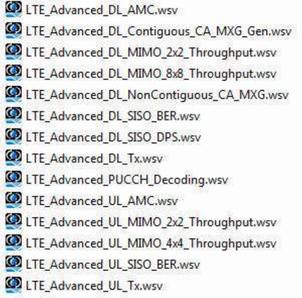


Figure 6. SystemVue LTE-Advanced allows you to configure algorithmic reference test vectors for the downlink transmitter, and mix allocations of Release 8 and Release 10 resource blocks.

LTE-Advanced Test bench Samples, continued

Available LTE–Advanced Test bench Samples:


- LTE_Advanced_DL_AMC.wsv
- LTE_Advanced_DL_Contiguous_CA_MXG_Gen.wsv
- LTE_Advanced_DL_MIMO_2x2_Throughput.wsv
- LTE_Advanced_DL_MIMO_8x8_Throughput.wsv
- LTE_Advanced_DL_NonContiguous_CA_MXG.wsv
- LTE_Advanced_DL_SISO_BER.wsv
- LTE_Advanced_DL_SISO_DPS.wsv
- LTE_Advanced_DL_Tx.wsv
- LTE_Advanced_PUCCH_Decoding.wsv
- LTE_Advanced_UL_AMC.wsv
- LTE_Advanced_UL_MIMO_2x2_Throughput.wsv
- LTE_Advanced_UL_MIMO_4x4_Throughput.wsv
- LTE_Advanced_UL_SISO_BER.wsv
- LTE_Advanced_UL_Tx.wsv

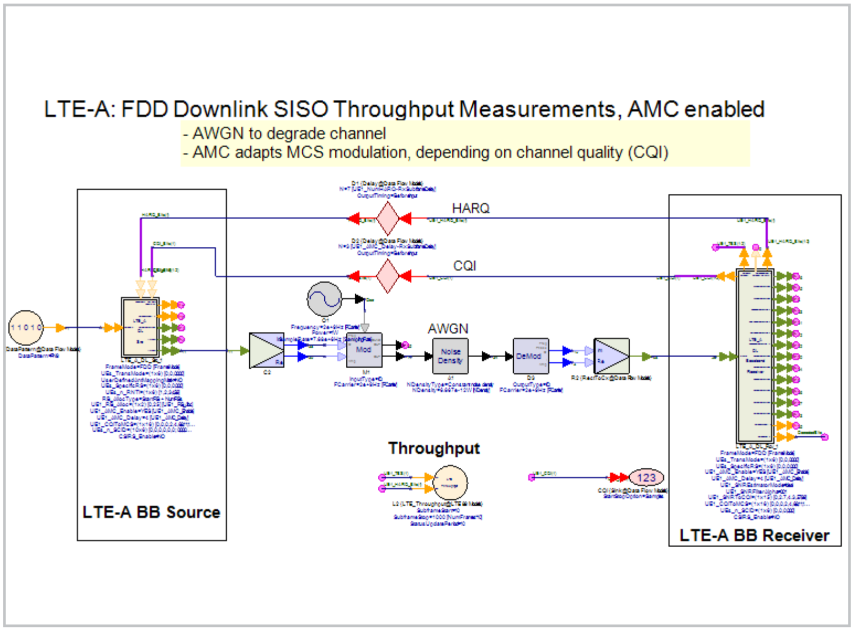


Figure 7. This Adaptive Modulation Coding (AMC) example shows how LTE-Advanced throughput adapts to changing channel conditions (S/N Ratio) during the simulation, allowing optimum throughput based on the CQI.

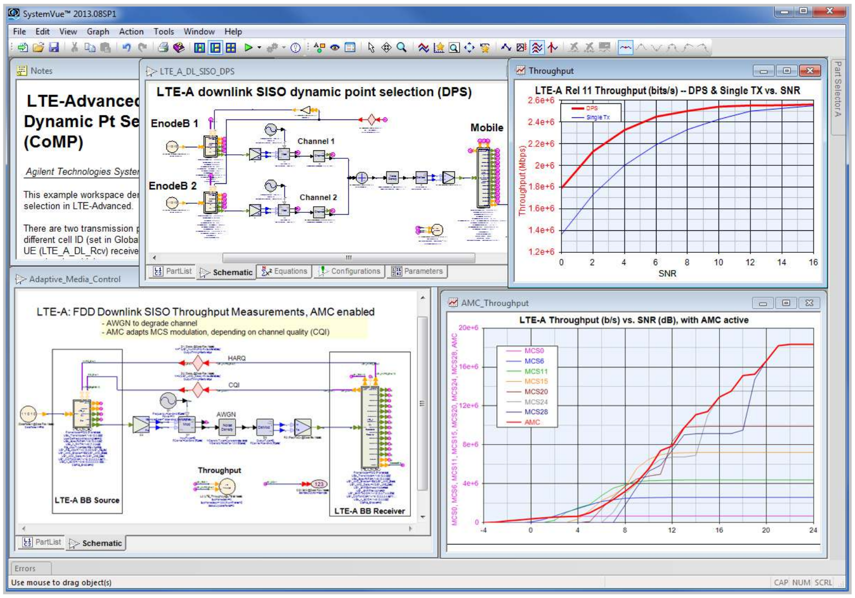
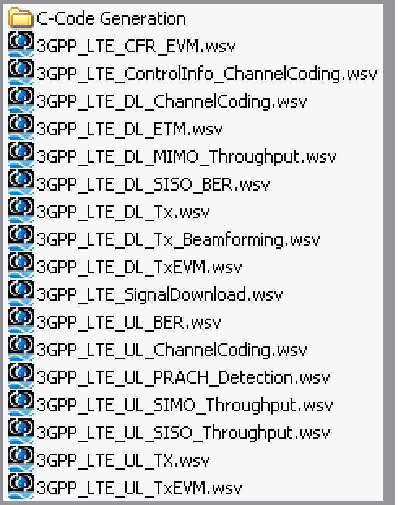
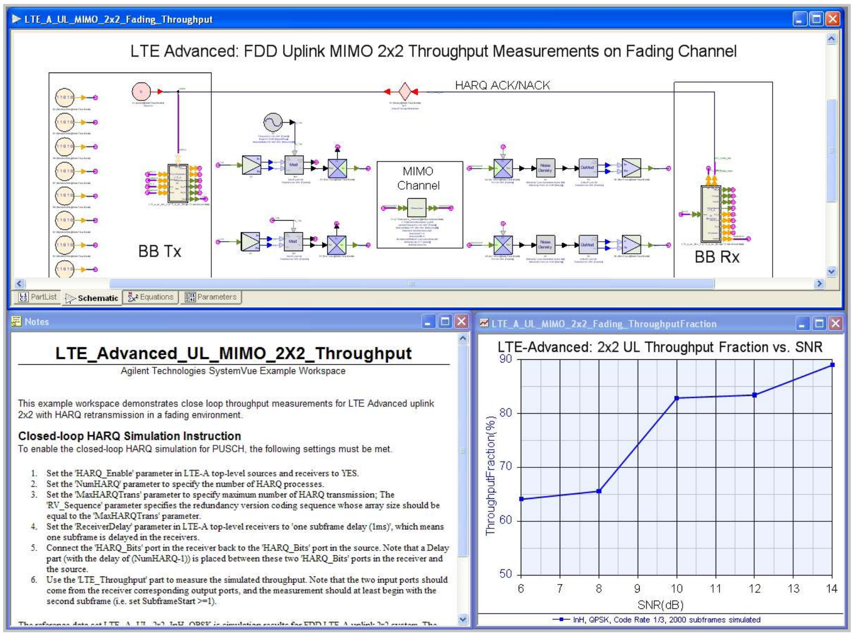


Figure 8. Dynamic AMC results from the schematic in Figure 7. At high SNR, the throughput is optimized. The figure also shows Dynamic Point Selection (DPS), a technique for Coordinated Multi-Point (CoMP) analysis.

LTE-Advanced Test bench Samples, continued

Available LTE–Advanced Test bench Samples:


C-Code Generation
3GPP_LTE_CFR_EVM.wsv
3GPP_LTE_ControlInfo_ChannelCoding.wsv
3GPP_LTE_DL_ChannelCoding.wsv
3GPP_LTE_DL_ETM.wsv
3GPP_LTE_DL_MIMO_Throughput.wsv
3GPP_LTE_DL_SISO_BER.wsv
3GPP_LTE_DL_Tx.wsv
3GPP_LTE_DL_Tx_Beamforming.wsv
3GPP_LTE_DL_TxEVM.wsv
3GPP_LTE_SignalDownload.wsv
3GPP_LTE_UL_BER.wsv
3GPP_LTE_UL_ChannelCoding.wsv
3GPP_LTE_UL_PRACH_Detection.wsv
3GPP_LTE_UL_SIMO_Throughput.wsv
3GPP_LTE_UL_SISO_Throughput.wsv
3GPP_LTE_UL_TX.wsv
3GPP_LTE_UL_TxEVM.wsv



LTE_Advanced_UL_MIMO_2X2_Throughput

Agilent Technologies SystemVue Example Workspace

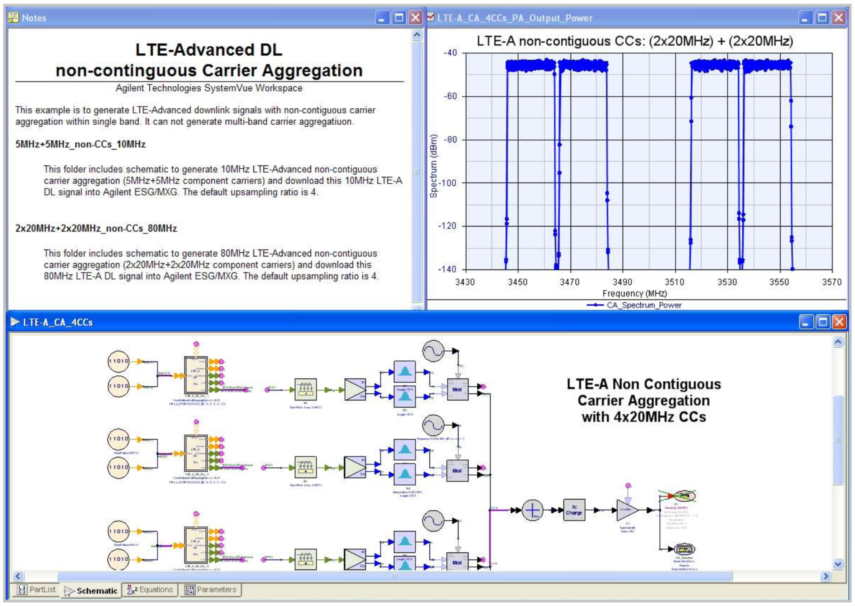
This example workspace demonstrates close loop throughput measurements for LTE Advanced uplink 2x2 with HARQ retransmission in a fading environment.

Closed-loop HARQ Simulation Instruction

To enable the closed-loop HARQ simulation for PUSCH, the following settings must be met.

1. Set the 'HARQ_Enable' parameter in LTE-A top-level sources and receivers to YES.
2. Set the 'NumHARQ' parameter to specify the number of HARQ processes.
3. Set the 'MaxHARQTrans' parameter to specify maximum number of HARQ transmission; The 'RV_Sequence' parameter specifies the redundancy version coding sequence whose array size should be equal to the 'MaxHARQTrans' parameter.
4. Set the 'ReceiverDelay' parameter in LTE-A top-level receivers to 'one subframe delay (1ms)', which means one subframe is delayed in the receivers.
5. Connect the 'HARQ_Bits' port in the receiver back to the 'HARQ_Bits' port in the source. Note that a Delay part (with the delay of (NumHARQ-1)) is placed between these two 'HARQ_Bits' ports in the receiver and the source.
6. Use the 'LTE_Throughput' part to measure the simulated throughput. Note that the two input ports should come from the receiver corresponding output ports, and the measurement should at least begin with the second subframe (i.e. set SubframeStart >=1).

Figure 9. This closed-loop 2x2 MIMO example profiles the data throughput percentage vs. SNR, for an LTE-Advanced uplink transmitter with active HARQ feedback. SystemVue's proprietary "dynamic dataflow" simulation engine makes dynamic radio reconfiguration possible during the simulation, while maintaining timing and carrier frequency information for accurate RF effects.



LTE-Advanced DL non-continguous Carrier Aggregation

Agilent Technologies SystemVue Workspace

This example is to generate LTE-Advanced downlink signals with non-contiguous carrier aggregation within single band. It can not generate multi-band carrier aggregatiuon.

5MHz+5MHz_non-CCs_10MHz

This folder includes schematic to generate 10MHz LTE-Advanced non-contiguous carrier aggregation (5MHz+5MHz component carriers) and download this 10MHz LTE-A DL signal into Agilent ESG/MXG. The default upsampling ratio is 4.

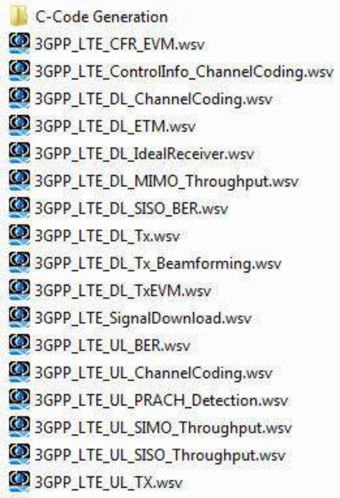
2x20MHz+2x20MHz_non-CCs_80MHz

This folder includes schematic to generate 80MHz LTE-Advanced non-contiguous carrier aggregation (2x20MHz+2x20MHz component carriers) and download this 80MHz LTE-A DL signal into Agilent ESG/MXG. The default upsampling ratio is 4.

Figure 10. Non-Contiguous Carrier Aggregation (CA) is demonstrated in this example, by combining 4 Component Carriers (CC) that are each 20-MHz bandwidth. Nonlinear RF/Analog impairments can be added to this system, creating EVM and throughput degradations more typical of loaded cells and interference-limited operation.

LTE Test bench Samples

Available LTE Test bench Examples:



C-Code Generation
3GPP_LTE_CFR_EVM.wsv
3GPP_LTE_ControlInfo_ChannelCoding.wsv
3GPP_LTE_DL_ChannelCoding.wsv
3GPP_LTE_DL_ETM.wsv
3GPP_LTE_DL_IdealReceiver.wsv
3GPP_LTE_DL_MIMO_Throughput.wsv
3GPP_LTE_DL_SISO_BER.wsv
3GPP_LTE_DL_Tx.wsv
3GPP_LTE_DL_Tx_Beamforming.wsv
3GPP_LTE_DL_TxEVM.wsv
3GPP_LTE_SignalDownload.wsv
3GPP_LTE_UL_BER.wsv
3GPP_LTE_UL_ChannelCoding.wsv
3GPP_LTE_UL_PRACH_Detection.wsv
3GPP_LTE_UL_SIMO_Throughput.wsv
3GPP_LTE_UL_SISO_Throughput.wsv
3GPP_LTE_UL_TX.wsv
3GPP_LTE_UL_TxEVM.wsv

Note:
The W1918 LTE-Advanced Baseband Verification Library for SystemVue is a superset of the W1910 LTE Baseband Verification Library and includes both LTE and LTE-Advanced support.

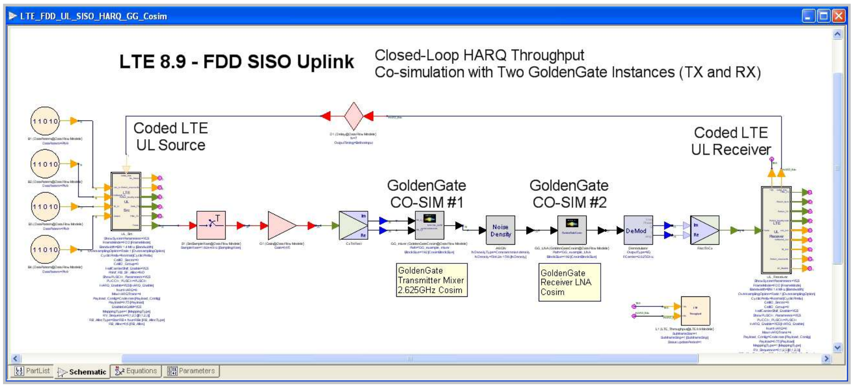


Figure 11. This LTE Throughput simulation includes live co-simulations with Keysight GoldenGate for two CMOS RFIC transceiver components. These are not behavioral models; the true envelope-level dynamic behavior can be verified down to the transistor level in a meaningful, standard-compliant test. This is useful for both the System Architect verifying the overall PHY performance, and also for the RFIC circuit designer prior to tape-out of the wafer.

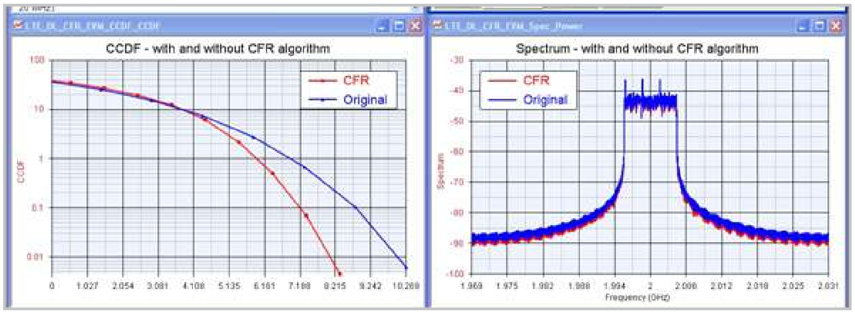
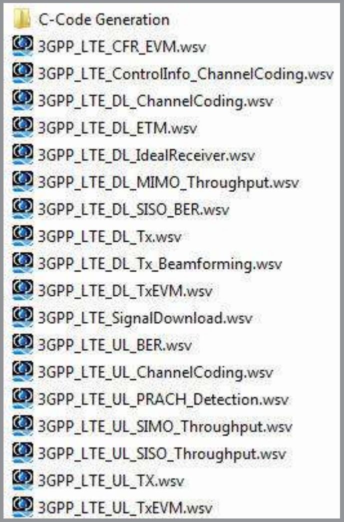


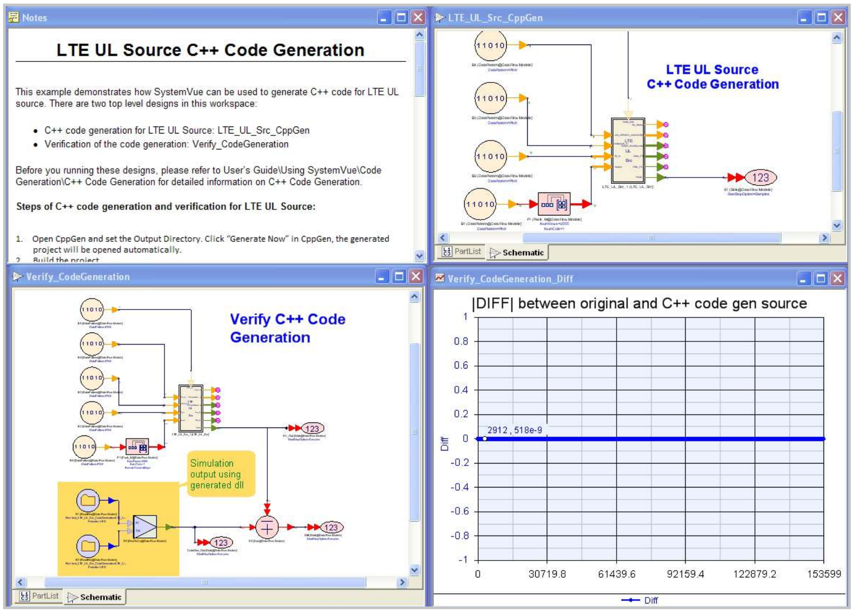
Figure 12. This LTE example evaluates a possible Crest Factor Reduction (CFR) algorithm by plotting the spectrum, CCDF , and other figures of merit for a configurable LTE DL source. Other LTE measurements, such as EVM vs. subcarrier and other channel-specific metrics, are also available. For full analytical power regarding the signal itself, simply co-simulate from SystemVue into the Keysight 89600 VSA software, and use the visualization capabilities of the instrument personality to explore the effects of algorithms and impairments even further.

LTE Test bench Samples, continued

Available LTE Test bench Examples:



- C-Code Generation
- 3GPP_LTE_CFR_EVM.wsv
- 3GPP_LTE_ControlInfo_ChannelCoding.wsv
- 3GPP_LTE_DL_ChannelCoding.wsv
- 3GPP_LTE_DL_ETM.wsv
- 3GPP_LTE_DL_IdealReceiver.wsv
- 3GPP_LTE_DL_MIMO_Throughput.wsv
- 3GPP_LTE_DL_SISO_BER.wsv
- 3GPP_LTE_DL_Tx.wsv
- 3GPP_LTE_DL_Tx_Beamforming.wsv
- 3GPP_LTE_DL_TxEVM.wsv
- 3GPP_LTE_SignalDownload.wsv
- 3GPP_LTE_UL_BER.wsv
- 3GPP_LTE_UL_ChannelCoding.wsv
- 3GPP_LTE_UL_PRACH_Detection.wsv
- 3GPP_LTE_UL_SIMO_Throughput.wsv
- 3GPP_LTE_UL_SISO_Throughput.wsv
- 3GPP_LTE_UL_TX.wsv
- 3GPP_LTE_UL_TxEVM.wsv



LTE UL Source C++ Code Generation

This example demonstrates how SystemVue can be used to generate C++ code for LTE UL source. There are two top level designs in this workspace:

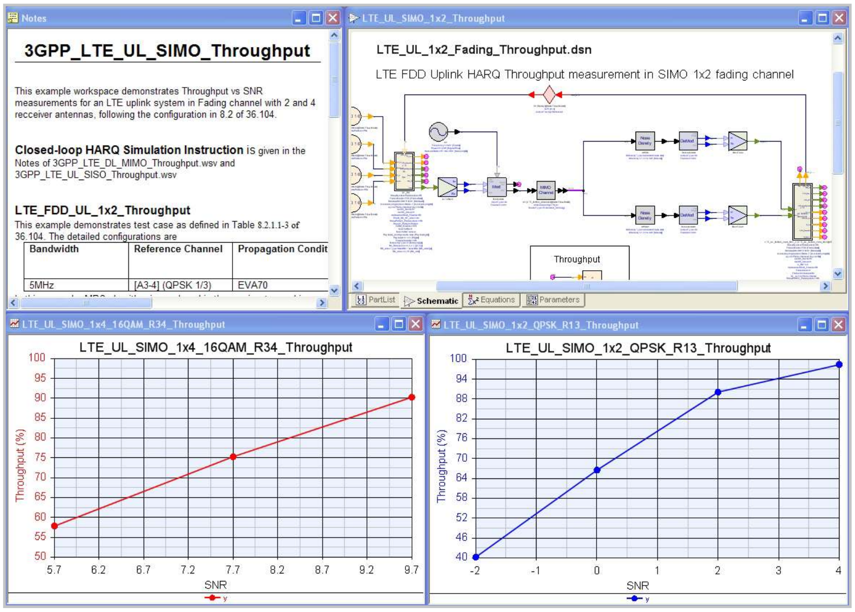
- C++ code generation for LTE UL Source: LTE_UL_Src_CppGen
- Verification of the code generation: Verify_CodeGeneration

Before you running these designs, please refer to User's Guide\Using SystemVue\Code Generation\C++ Code Generation for detailed information on C++ Code Generation.

Steps of C++ code generation and verification for LTE UL Source:

1. Open CppGen and set the Output Directory. Click "Generate Now" in CppGen, the generated project will be opened automatically.
2. Build the project

Figure 13. The LTE library (release 8/9) supports C++ code generation to create compiled Win32 DLLs that can be used in other verification environments, outside SystemVue. Your W1910/W1918 license continues to enable these executable models, even outside SystemVue.



3GPP_LTE_UL_SIMO_Throughput

This example workspace demonstrates Throughput vs SNR measurements for an LTE uplink system in Fading channel with 2 and 4 recceiver antennas, following the configuration in 8.2 of 36.104.

Closed-loop HARQ Simulation Instruction is given in the Notes of 3GPP_LTE_DL_MIMO_Throughput.wsv and 3GPP_LTE_UL_SISO_Throughput.wsv

LTE_FDD_UL_1x2_Throughput

This example demonstrates test case as defined in Table 8.2.1.1-3 of 36.104. The detailed configurations are

Bandwidth	Reference Channel	Propagation Condit
5MHz	[A3-4] (QPSK 1/3)	EVA70

Figure 14. SystemVue 2009 introduced the "Dynamic Dataflow" simulation capability to enable true, faded throughput measurements. Dynamic Dataflow allows the data rate, and therefore the radio modulation format, to change dynamically during the simulation, while maintaining the timing and carrier frequency information needed for accurate RF and channel effects. This quasi-MAC behavior achieves both simulation behavior and physical layer accuracy that many other dataflow and event-driven simulators cannot manage simultaneously.

LTE Test bench Samples, continued

Available LTE Test bench Examples:

- C-Code Generation
- 3GPP_LTE_CFR_EVM.wsv
- 3GPP_LTE_DL_ChannelCoding.wsv
- 3GPP_LTE_DL_ETM.wsv
- 3GPP_LTE_DL_FDD_TestCase.wsv
- 3GPP_LTE_DL_MIMO_Throughput.wsv
- 3GPP_LTE_DL_SISO_BER.wsv
- 3GPP_LTE_DL_Tx.wsv
- 3GPP_LTE_DL_TxEVM.wsv
- 3GPP_LTE_SignalDownload.wsv
- 3GPP_LTE_UL_BER.wsv
- 3GPP_LTE_UL_ChannelCoding.wsv
- 3GPP_LTE_UL_PRACH_Detection.wsv
- 3GPP_LTE_UL_SIMO_Throughput.wsv
- 3GPP_LTE_UL_SISO_Throughput.wsv
- 3GPP_LTE_UL_TX.wsv
- 3GPP_LTE_UL_TxEVM.wsv

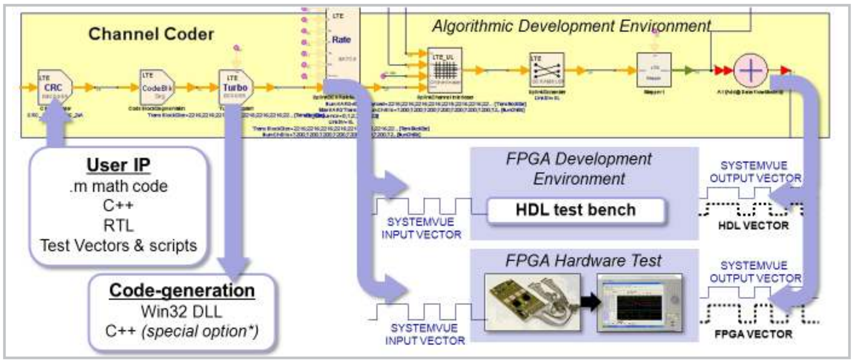
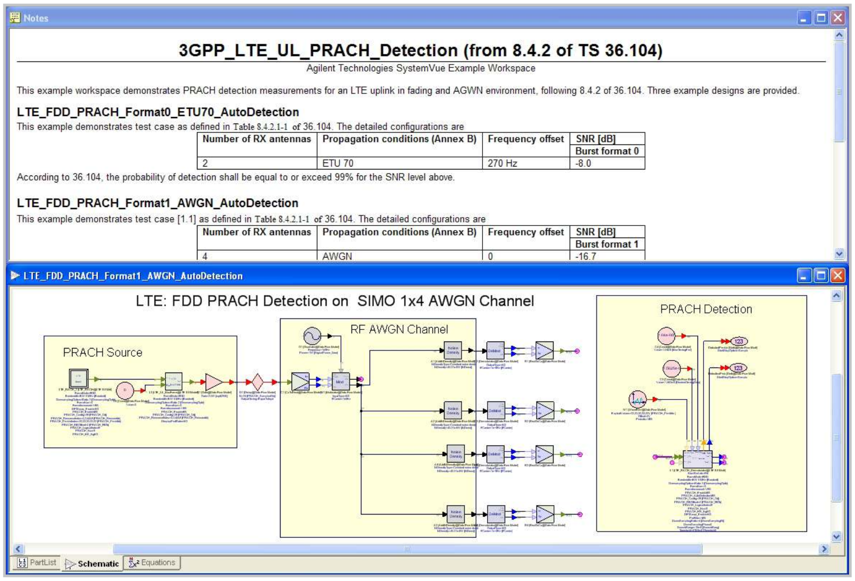


Figure 15. This LTE Channel Coding example exposes the internal signal processing chain, allowing for test vector generation and comparison from any node in the system. This facilitates easy scripting and verification of user algorithms.



3GPP_LTE_UL_PRACH_Detection (from 8.4.2 of TS 36.104)

Agilent Technologies SystemVue Example Workspace

This example workspace demonstrates PRACH detection measurements for an LTE uplink in fading and AGWN environment, following 8.4.2 of 36.104. Three example designs are provided.

LTE_FDD_PRACH_Format0_ETU70_AutoDetection

This example demonstrates test case as defined in Table 8.4.2.1-1 of 36.104. The detailed configurations are

Number of RX antennas	Propagation conditions (Annex B)	Frequency offset	SNR [dB]
			Burst format 0
2	ETU 70	270 Hz	-8.0

According to 36.104, the probability of detection shall be equal to or exceed 99% for the SNR level above.

LTE_FDD_PRACH_Format1_AWGN_AutoDetection

This example demonstrates test case [1.1] as defined in Table 8.4.2.1-1 of 36.104. The detailed configurations are

Number of RX antennas	Propagation conditions (Annex B)	Frequency offset	SNR [dB]
			Burst format 1
4	AWGN	0	-16.7

Figure 16. This LTE example runs a standards-based Physical Random Access Channel (PRACH) Detection test that is specified in TS 36.104 of the 3GPP LTE 8.9 standard. The PRACH channel should be detected more than 99% of the time under certain specified conditions, such as S/N ratio. Pre-built test benches like these save scripting and verification time for the engineer who must validate raw algorithms against the LTE standard.

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