Agilent Technologies

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cdma2000-Compliant Design Library

Acknowledgments

Errata The ADS product may contain references to "HP" or "HPEESOF" such as in file names and directory names. The business entity formerly known as "HP EEsof" is now part of Agilent Technologies and is known as "Agilent EEsof". To avoid broken functionality and to maintain backward compatibility for our customers, we did not change all the names and labels that contain "HP" or "HPEESOF" references.

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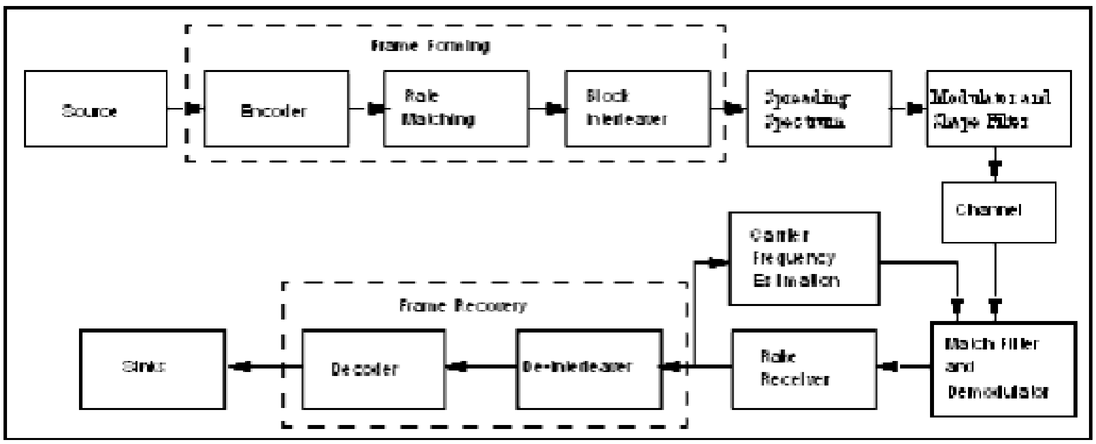
About cdma2000-Compliant Design Library

cdma2000 evolved from the TIA/EIA-95 (formerly known as IS-95) family of standards. The Agilent EEsof cdma2000-Compliant Design Library provides models for end-to-end system modeling and simulation of the physical layer of cdma2000 systems. The models provide a baseline system for designers to get an idea of nominal ideal system performance. They also can help the researchers in this field, or system designers evaluate their designs and improve their work efficiency.

The cdma2000 physical layer provides coding and modulation. The transmission and receiving structure of cdma2000 systems is shown in the following figure.



Transmission and Receiving Structure of cdma2000 Systems

cdma2000 features include:

- High-speed data for new applications
- Improved coding. For forward link, 3/8 rate convolutional code instead of 3/4 for 14.4 kbps services is used. For reverse link, 1/4 rate convolutional code is used. Turbo code for data rates greater than 14.4 kbps are optional. Code with 1/2 and 1/3 rates are used on reverse link at the higher data rates.
- Improved modulation. For forward link, QPSK modulation is used rather than dual BPSK; for reverse link, pilot-aided HPSK modulation is used.
- Reverse link uses coherent pilot-based reverse radio interface. Coherent demodulation is possible.
- Continuous reverse radio interface waveform is provided for all data rates, including continuous pilot and continuous data-channel waveforms; this enables interleaving to be performed over the entire frame to achieve the full benefit of the frame time diversity.
- Fast transmission power control on forward and reverse links. Fast closed-loop power control compensates for slow-to-medium fading and for inaccuracies in open-loop

power control; this is effective for adapting to dynamically changing interference conditions.
- Auxiliary pilot to support beam forming applications and increase capacity.
- Forward radio interface multi-carrier and orthogonal transmit diversity.

Agilent Instrument Compatibility

This cdma2000 design library is compatible with Agilent E443xB ESG-D Series Digital RF Signal Generator.

This cdma2000 design library is also compatible with Agilent E4406A VSA Series Transmitter Tester and Agilent 89600 Series Vector Signal Analyzer.

The following table shows more information of instrument models, Firmware revisions, and options.

cdma2000 Design Library	**ESG Models**	**VSA Models**
SpecVersion=10-2000	E443xB, Firmware Revision B.03.60 Option 101 - "cdma2000" Personality Option 201 - "Real-time cdma2000" Personality	E4406A, Firmware Revision A.04.21 Option B78 - "cdma2000" Measurement Personality 89600 Series, software version 2.0 Option B7N - "W-CDMA and CDMA2000 Modulation Analysis"

For more information about Agilent ESG Series of Digital and Analog RF Signal Generator and Options, please visit

http://www.agilent.com/find/ESG

For more information about Agilent E4406A VSA Series Transmitter Tester and Options, please visit

http://www.agilent.com/find/VSA

For more information about Agilent PSA Series Spectrum Analyzer and Options, please visit

http://www.agilent.com/find/PSA

Radio Configurations

In cdma2000 systems, a radio configuration (RC) is defined based on channel data rate. RC1 and RC2 are backward compatible with IS-95B, based on 9600 bps and 14400 bps traffic, respectively. RCn (!cdma2k-02-1-2.gif!) uses cdma2000 coding for improved capacity. The spreading rate is defined in terms of 1.2288 Mcps: a 1.2288 Mcps system is called an SR1 system; a 3.6864 Mcps system is called an SR3 system.

The following table shows radio configurations characteristics for reverse link.

Radio Configuration Characteristics for the Reverse Channel

Radio Configuration	Spreading Rate	Data Rates, Forward Error Correction, and General Characteristics
1	1	1200, 2400, 4800, and 9600 bps data rates with R=1/3, 64-ary orthogonal modulation
2	1	1800, 3600, 7200, and 14400 bps data rates with R=1/2, 64-ary orthogonal modulation
3	1	1500, 2700, 4800, 9600, 19200, 38400, 76800, and 153600 bps with R=1/4, 307200 bps data rate with R=1/2, BPSK modulation with a pilot
4	1	1800, 3600, 7200, 14400, 28800, 57600, 115200, and 230400 with R=1/4, BPSK modulation with a pilot
5	3	1500, 2700, 4800, 9600, 19200, 38400, 76800, and 153600 bps with R=1/4, 307200 and 614400 bps data rate with R=1/3, BPSK modulation with a pilot
6	3	1800, 3600, 7200, 14400, 28800, 57600, 115200, 230400, and 460800 bps with R=1/4, 1036800 bps data rate with R=1/2, BPSK modulation with a pilot

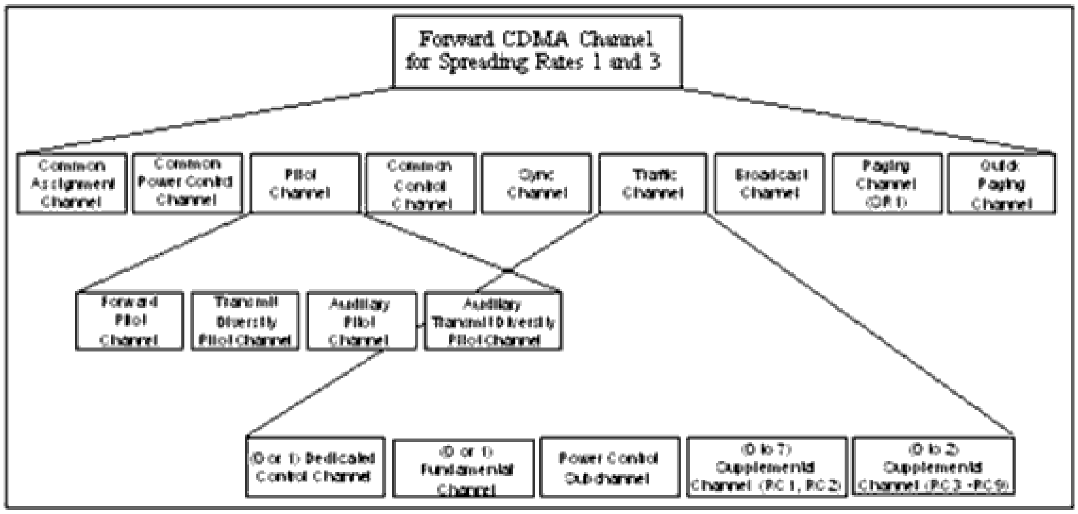
The following table shows radio configurations characteristics for forward link.

Radio Configuration Characteristics for the Forward Channel

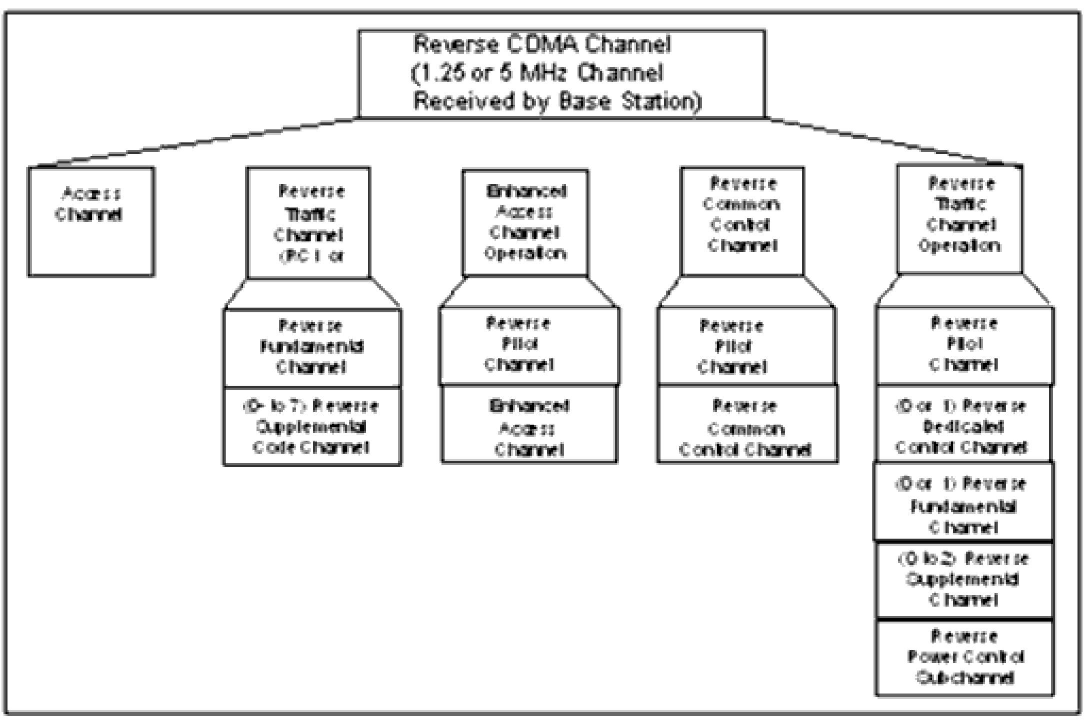
Radio Configuration	Spreading Rate	Data Rates, Forward Error Correction, and General Characteristics
1	1	1200, 2400, 4800, and 9600 bps data rates with R=1/2, BPSK pre-spreading symbols
2	1	1800, 3600, 7200, and 14400 bps data rates with R=1/2, BPSK pre-spreading symbols
3	1	1500, 2700, 4800, 9600, 19200, 38400, 76800, and 153600 bps data rates with R=1/4, QPSK pre-spreading symbols, OTD allowed
4	1	1500, 2700, 4800, 9600, 19200, 38400, 76800, 153600, and 307200 bps data rates with R=1/2, QPSK pre-spreading symbols, OTD allowed
5	1	1800, 3600, 7200, 14400, 28800, 57600, 115200, and 230400 bps data rates with R=1/4, QPSK pre-spreading symbols, OTD allowed
6	3	1500, 2700, 4800, 9600, 19200, 38400, 76800, 153600, and 307200 bps data rates with R=1/6, QPSK pre-spreading symbols, DS or MC modes, OTD allowed
7	3	1500, 2700, 4800, 9600, 19200, 38400, 76800, 153600, 307200, and 614400 bps data rates with R=1/3, QPSK pre-spreading symbols, DS or MC modes, OTD allowed
8	3	1800, 3600, 7200, 14400, 28800, 57600, 115200, 230400, and 460800 bps data rates with R=1/4 or 1/3 (5 msec), QPSK pre-spreading symbols, DS or MC modes, OTD allowed
9	3	1800, 3600, 7200, 14400, 28800, 57600, 115200, 230400, 460800, and 1036800 bps data rates with R=1/2 or 1/3 (5 msec), QPSK pre-spreading symbols, DS or MC modes, OTD allowed

Channel Structures

The assignment of the channels transmitted from a base station is shown in Forward CDMA Channels Transmitted from a Base Station; the assignment of the channels transmitted from a mobile station is shown in Reverse CDMA Channels Transmitted from a Mobile Station. The use of each channel is described in the following paragraphs.



Forward CDMA Channels Transmitted from a Base Station



Reverse CDMA Channels Transmitted from a Mobile Station

- Forward Pilot Channel: unmodulated spread spectrum signals used for synchronization by a mobile station operating within the coverage area of the base station.
- Forward Sync. Channel: encoded, interleaved, spread, and modulated spread spectrum signal that is used by mobile stations operating within the coverage area of the base station to acquire initial time synchronization.
- Forward Paging Channel (up to 7): encoded, interleaved, spread, and modulated spread spectrum signal that is used by mobile stations operating within the coverage area of the base station. The base station uses the Paging Channel to transmit system overhead information and mobile station-specific messages.
- Forward Broadcast Channel (0 or 1): encoded, interleaved, spread, and modulated spread spectrum signal that is used by mobile stations operating within the coverage area of the base station.
- Forward Quick Paging Channel (0 or 1): uncoded, spread, and On-Off-Keying (OOK) modulated spread spectrum signal that is used by mobile stations operating within the coverage area of the base station. The base station uses the Quick Paging Channel to inform mobile stations, operating in the slotted mode while in the idle state, whether or not they should receive the Forward Common Control Channel or the Paging Channel starting in the next Forward Common Control Channel or Paging Channel slot.
- Forward Common Power Control Channel (0 or 1): used by the base station for transmitting common power control subchannels (one bit per subchannel) for the power control of multiple Reverse Common Control Channels and Enhanced Access Channels.

  Forward Common Power Control Channel and Forward Common Assignment Channel are optional for reducing the interference and collisions associated with system access.

- Forward Common Assignment Channel (0 or 1): designed to provide fast response reverse link channel assignments to support transmission of random access packets on the reverse link. This channel controls the Reverse Common Control Channel and the associated common power control subchannel in the Reservation Mode and provides a fast acknowledgement in the Power Controlled Access Mode. It also implements congestion control.

  Forward Common Power Control Channel and Forward Common Assignment Channel are optional for reducing the interference and collisions associated with system access.

- Forward Common Control Channel (0 or more): encoded, interleaved, spread, and modulated spread spectrum signal that is used by mobile stations operating within the coverage area of the base station. The base station uses the Forward Common Control Channel to transmit system overhead information and mobile station-specific messages.
- Forward Dedicated Control Channel (0 or more): transmission of user and signaling information to a specific mobile station during a call. Each Forward Traffic Channel may contain one Forward Dedicated Control Channel.
- Forward Traffic channels, each consisting of:
  - Forward Fundamental Channel: transmission of user and signaling information to a specific mobile station during a call.
  - Forward Supplemental Channel (0 to 7) for RC1 and RC2

  - Forward Supplemental Channel (0 to 2) for RC3 through RC9: transmission of user information to a specific mobile station during a call.

A traffic channel has at least one Forward Fundamental Channel; if high-speed data is being sent, one or more Forward Supplemental Channels will be used. If the base station is sending RC1 or RC2 Forward Fundamental Channels, data is sent on one of seven Forward Supplemental Channels that are the same as IS-95B traffic channels. If the base station uses one of the new cdma2000 radio configurations (RC3-RC9), then one or two cdma2000 Forward Supplemental Channels are used.

- Reverse Pilot Channel (1): unmodulated spread spectrum signal used to assist the base station in detecting a mobile station transmission. It also includes power control sub-channel when operating on the Reverse Traffic Channel with RC3 through RC6.
- Reverse Access or Enhanced Access Channel (1): used by the mobile station to initiate communication with the base station and to respond to Paging Channel messages.
- Reverse Common Control Channel (0 or 1): transmission of user and signaling information to the base station when Reverse Traffic Channels are not in use.
- Dedicated Control Channel (0 or 1): transmission of user and signaling information to the base station during a call.
- Reverse Fundamental Channel (0 or 1): for transmission of user and signaling.
- Reverse Supplemental Channel (0 to 2) for RC3 through RC6: for transmission of user information to the base station during a call.

Overview of Component Libraries

The cdma2000-Compliant Design Library of 128 behavioral models and subnetworks are organized in libraries that are described in the following sections.

Channel Components

Channel components provide multipath Rayleigh fading channel based on a tapped-delay line model that is characterized by the number of taps, the time delay relative to the first tap, the average power relative to the strongest tap, and the Doppler spectrum of each tap. They can be used in various test environments: indoor office, outdoor to indoor and pedestrian, and vehicular.

Filters with flat and classic Doppler spectrum are provided. Doppler shift is measured according to mobile speed and carrier frequency. The input signal is delayed according to the parameters given by ITU, then Doppler shift is applied. Signals on different paths are combined before being exported.

Channel Coding Components

Channel coding components provide frame generation and channel coding in the transmit end, and channel decoding and frame recovery in the receiving end.

Convolutional code is applied in forward and reverse links to provide forward error correction; turbo code is optional for high data rates.

Two types of convolutional encoders and Viterbi decoders are included: one for fixed data rate signals with tail bits; one for variable data rate signals with tail bits. For Viterbi decoder, soft decision algorithm is used. Turbo encoders and decoders are provided; the MAP algorithm is used in the turbo decoder.

The cdma2000 system uses several approaches to match data rates to Walsh spreader input rates. These include adjusting the code rate, using symbol repetition with or without symbol puncturing, and sequence repetition. A channel rate not equal to a given channel data rate is realized by sequence repetition or by symbol repetition with symbol puncturing to match the desired channel data rate. Puncture and de-puncture, framing and de-framing, rate matching and rate dematching are provided. Rate detector is included.

Interleavers and de-interleavers are provided for all types of channels and radio configurations, turbo encoder and decoder.

Receiver Components

Receiver components provide channel estimation, maximal ratio combination, and automatic frequency control for forward link and reverse link.

- Channel estimation components for forward and reverse links search the strongest paths, with their strengths and delays estimated.
- In coherent receivers, coherent demodulation and despreading are performed and maximal ratio combination is carried out using the channel coefficients derived from channel estimator.
- An automatic frequency control loop that consists of phase detector, LPF and NCO, is used to recover carrier frequency.

RF Subsystem Components

RF subsystem components include RF modulation and demodulation.

- CDMA2K_RF_Mod provides RF modulation. Input signals are used to modulate in-phase and quadrature-phase carriers of a QAM modulator.
- CDMA2K_RF_Demod provides RF demodulation. Output signals are the baseband I and Q components of the RF input signal.

Signal Source Components

Signal source components include different radio configurations and data rates of forward and reverse link signals.

- CDMA2K_FwdRCsrc and CDMA2K_RevRCsrc provide forward and reverse link signal sources of different radio configurations and data rates.
- CDMA2K_FwdOTDsrc and CDMA2K_FwdSTSsrc provide forward link orthogonal transmit diversity and space time spread signal sources of different radio configurations and data rates.
- CDMA2K_FwdPilotSrc produces the forward pilot signal.

Transmission Components

Transmission components provide modulation, code generation and spreading, transmission power adjustment, and signal shaping.

- CDMA2K_FwdQPSK performs forward channel QPSK modulation. Data of I and Q channels are complex multiplied against a pair of I and Q channel short PN codes.
- CDMA2K_RevHPSK performs reverse channel hybrid PSK modulation.
- CDMA2K_LongCodeGenerator and CDMA2K_SR3LongCode generate long codes for SR1 and SR3, respectively.
- CDMA2K_VL_Walsh generates variable length Walsh code; CDMA2K_WalshModulator spreads input data by Walsh code.
- CDMA2K_FwdPowerAllocation and CDMA2K_RevPowerAllocation allocate power for different channels on forward link and reverse link, respectively.
- CDMA2K_FwdSIREstimate and CDMA2K_RevSIREstimate estimate SIR for forward

and reverse link, respectively, when power control is performed.

- CDMA2K_FIR and CDMA2K_BaseFilter are pulse-shaping filters on the transmit end or matched filters on the receiving end with floating-point and complex inputs, respectively.
- CDMA2K_PowerControl generates power control bits for forward or reverse link.
- CDMA2K_SyncChSource generates the synchronization channel source.
- CDMA2K_SyncChUtilitySublayer performs the utility sublayer process.
- CDMA2K_SyncChSARSublayer performs the segmentation and reassembly (SAR) sublayer process.

Test Components

Test includes auxiliary models such as BER and FER measurement, power measurement, code domain power and Rho measurement, and signal source of multiple users.

- CDMA2K_BFER compares values of two inputs and then calculates BER and FER.
- CDMA2K_PowerMeasure measures the average power of the input signal.
- CDMA2K_FwdMultiUserSrc provides signal source of multiple users on forward link.
- CDMA2K_CDP measures code domain power.
- CDMA2K_FwdRho and CDMA2K_RevRhoWithRef measure forward and reverse link waveform quality (Rho).

Overview of Example Designs

Example designs are provided with the cdma2000-Compliant Design Library, in the **/examples/cdma2k** directory. Workspaces and their corresponding design examples are listed here.

CDMA2K_BER_wrk

- DsnCDMA2K_FwdRC3AWGN
- DsnCDMA2K_RevRC3AWGN

CDMA2K_Measurement_wrk

- DsnCDMA2K_FwdSR1Trans
- DsnCDMA2K_FwdSR3Trans
- DsnCDMA2K_H_Q_PSK_PAPR
- DsnCDMA2K_RevSR1Hpsk
- DsnCDMA2K_RevSR3Hpsk

CDMA2K_Rake_wrk

- DsnCDMA2K_FwdRake
- DsnCDMA2K_RevRake

CDMA2K_RC_TD_wrk

- DsnCDMA2K_MCRC8
- DsnCDMA2K_FwdRC6AWGN
- DsnCDMA2K_FwdRC3OTD
- DsnCDMA2K_FwdRC3DS
- DsnCDMA2K_FwdRC3AWGN
- DsnCDMA2K_RevRC6AWGN
- DsnCDMA2K_RevRC3AWGN
- DsnCDMA2K_RevRC3Fade

CDMA2K_TPC_wrk

- DsnCDMA2K_FwdPC
- DsnCDMA2K_RevPC

CDMA2K_TurboCode_wrk

- DsnCDMA2K_TurboCode

BS_RX_wrk

- BS_RxAdjacentSelectivityRC3
- BS_RxDemodRC4AWGN
- BS_RxDnmcRngRC3
- BS_RxIntermodulationRC3
- BS_RxSingleToneRC3
- BS_RxTxLeakageRC3

BS_TX_wrk

- BS_TxCDP_RC3
- BS_TxCDP_RC3OTD
- BS_TxMeanPower
- BS_TxPilotPower
- BS_TxRho
- BS_TxSR1Spectrum
- BS_TxVSA_RC3
- FwdRC3_Transmission

MS_RX_wrk

- MS_RxAdjacentSelectivityRC3
- MS_RxDemodRC4AWGN
- MS_RxDnmcRngRC3
- MS_RxIntermodulationRC3
- MS_RxSingleToneRC3
- MS_RxTxLeakageRC3

MS_TX_wrk

- MS_TxCDP_RC3
- MS_TxMeanPowerSR1
- MS_TxPowerAccuracyRC3
- MS_TxRhoRC3
- MS_TxSR1Spectrum

SignalSource_wrk

- BS_PilotSrc
- BS_SR1Src
- MS_SR1Src

Glossary of Terms

AFC	automatic frequency control
AWGN	additive white Gaussian noise
BER	bit error rate
bps	bits per second
BPSK	binary phase shift keying
BS	base station
CC	convolutional code
CCDF	complementary cumulative distribution function
CDMA	code division multiple access
CRC	cyclic redundancy code
DS	direct spread
FER	frame error rate
HPSK	hybrid phase shift keying
MAP	maximum a posteriori
MC	multi-carrier
MS	mobile station
NRZ	non-return-to-zero
OTD	orthogonal transmit diversity
PN code	pseudo noise sequence
QPSK	quadrature phase shift keying
RC	radio configuration
SIR	signal-to-interference ratio
SNR	signal-to-noise ratio
SR	spread rate
STS	space time spread
TPC	transmit power control

Base Station Receiver Design Examples

Introduction

The BS_RX_wrk workspace shows cdma2000 base station receiver characteristics, including receiver sensitivity and dynamic range, single-tone desensitization with and without transmitter leakage, intermodulation spurious response attenuation, adjacent channel selectivity, and reverse traffic channel demodulation performance. Designs for these measurements include:

- BS_RxAdjacentSelectivityRC3 for base station receiver adjacent channel selectivity
- BS_RxDemodRC4AWGN for reverse traffic channel demodulation performance
- BS_RxDnmcRngRC3 for base station receiver sensitivity and dynamic range
- BS_RxIntermodulationRC3 for base station receiver intermodulation spurious response attenuation
- BS_RxSingleToneRC3 for base station receiver single-tone desensitization
- BS_RxTxLeakageRC3 for base station receiver single-tone desensitization with transmitter leakage

Designs under this workspace consist of:

- MS signal source in baseband
  CDMA2K_RevRCsrc provides the uplink signal source of different radio configurations and data rates.
- Transmit modulation and up-convertor
  The data source of base band output from CDMA2K_RevRCsrc is up-converted to IF signal with CDMA2K_RF_Mod, then modulated into RF signal with RF_TX_IFin.
- Channel loss and interfering signal combination
  The transmitted RF signal is then attenuated by RF channel (GainRF model) and combined with interfering signals (modulated or continuous waveform) at given frequency offsets.
- Down-convertor and demodulation
  At the receiver side, the received signal is demodulated to be the baseband signal by RF_RX_IFout and CDMA2K_RF_Demod models.
- Base station receiver in baseband
  CDMA2K_RevRCreceiver is used to demodulate and decode the received baseband signals.

Adjacent Channel Selectivity

- BS_RxAdjacentSelectivityRC3

Features

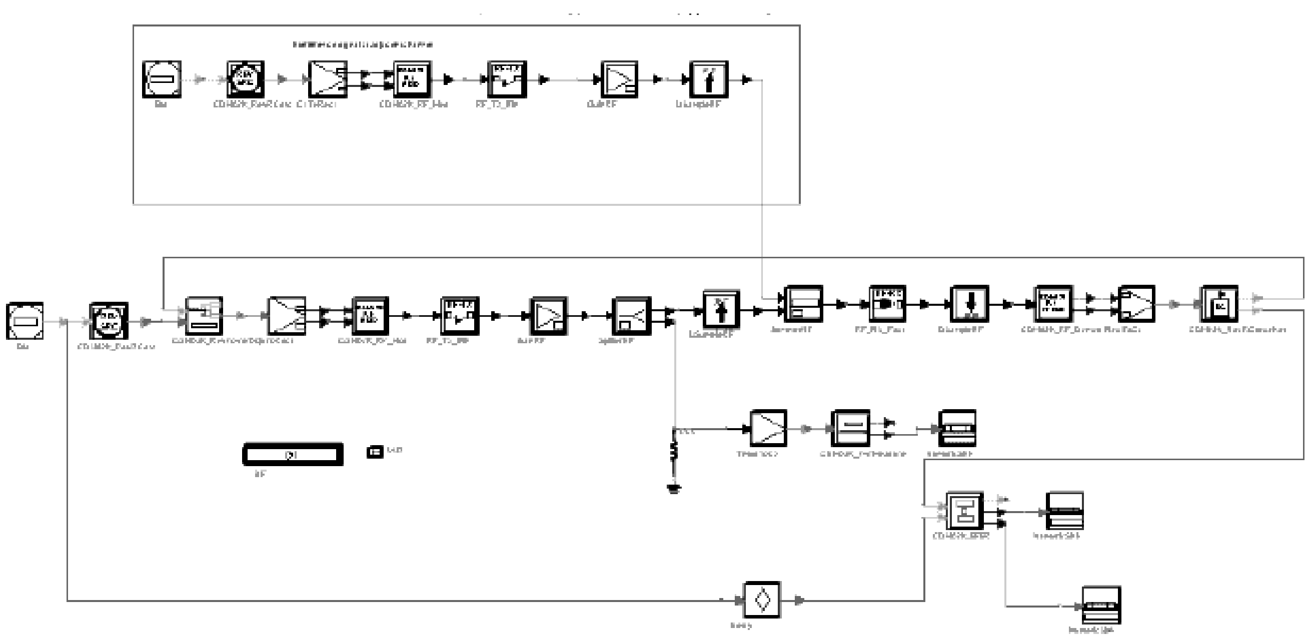
- Reverse pilot and fundamental channel
- Power control mechanisms are enabled
- FER of fundamental channel and output power are measured

Description

This example measures the receiver adjacent channel selectivity. RC3 is used as an example and the frequency offset of the adjacent channel is 2.5 MHz.

As defined in section 3.5.5 of 3GPP2 C.S0010-A. FER must be less than 1.5% and the output power of mobile station cannot increase by more than 3 dB.

Schematic



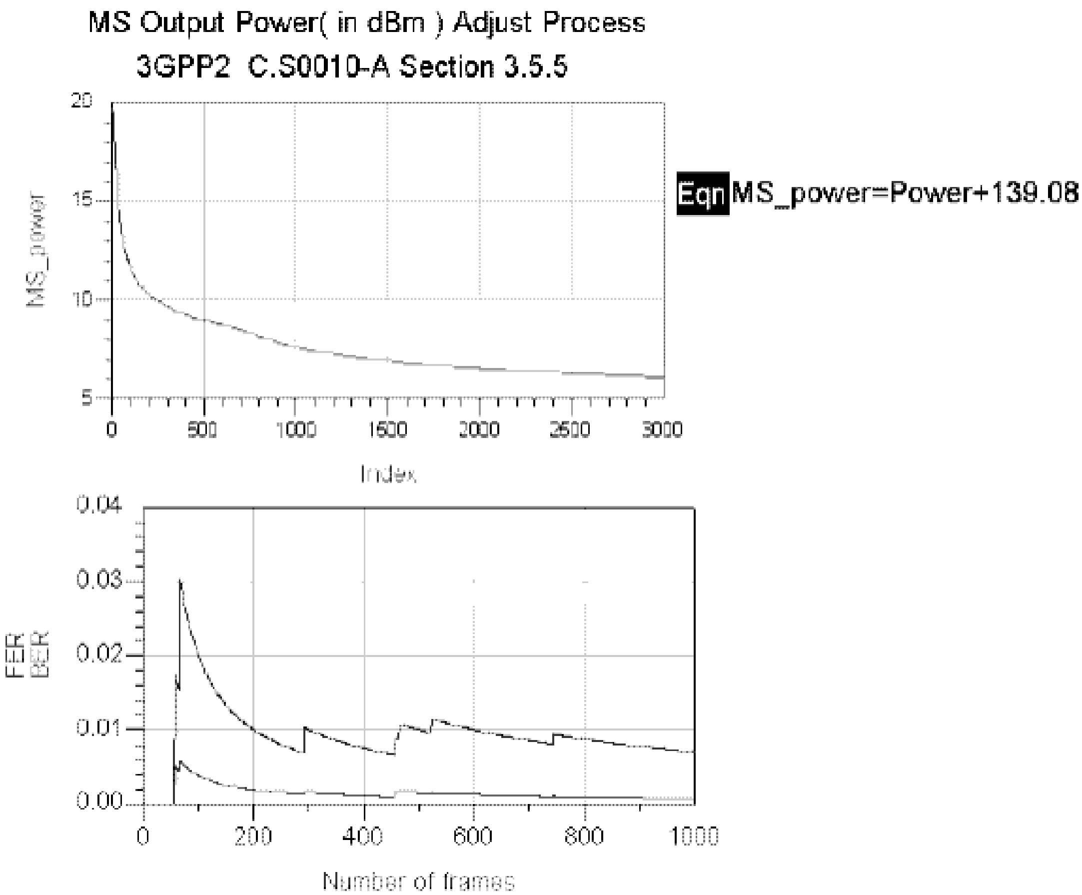
BS_RxAdjacentSelectivityRC3 Schematic

Notes

Outer loop power control is enabled to adjust the SIR threshold.

Simulation Results

Simulation results displayed in BS_RxAdjacentSelectivityRC3.dds are shown in the following figure.



BS_RxAdjacentSelectivityRC3 Simulation Results

Benchmark

- Hardware Platform: Pentium III 1000 MHz, 512 MB memory
- Software Platform: Windows NT 2000, ADS 1.5
- Data Points: 1000 frames.
- Simulation Time: approximately 42.5 hours

Reverse Traffic Channel Demodulation Performance

- BS_RxDemodRC4AWGN

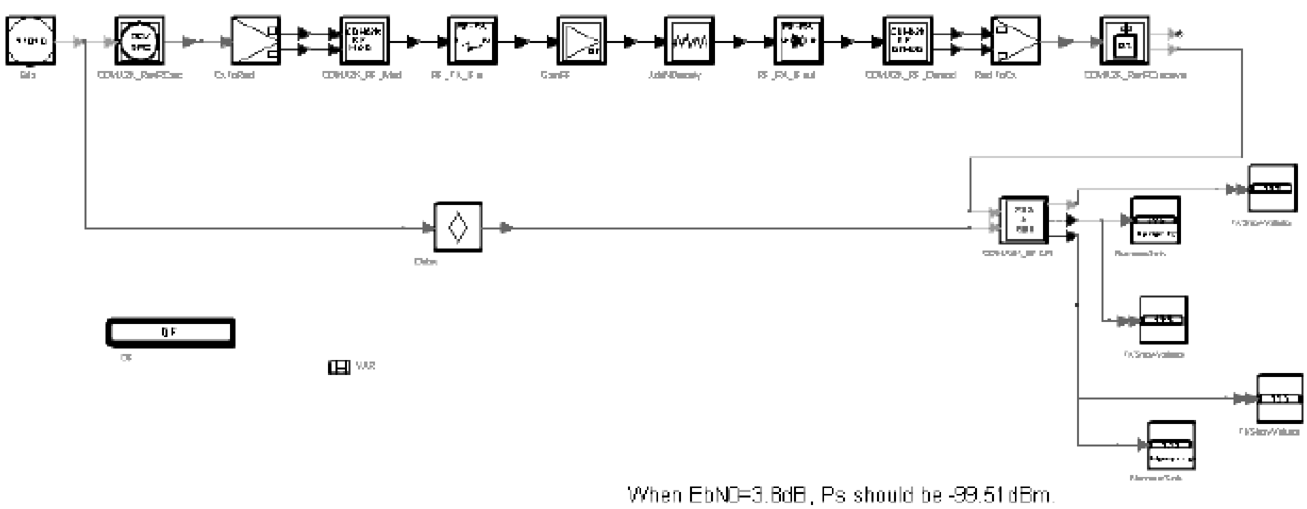
Features

- Reverse pilot and fundamental channel
- AWGN with a noise power spectral density of −84 dBm/1.23 MHz is added at the receiver input
- FER and BER of fundamental channel measurements

Description

This example verifies the demodulation performance of reverse traffic channel under AWGN conditions, as defined in section 3.4.1, C.S0010-A. RC4 is used as an example.

Schematic



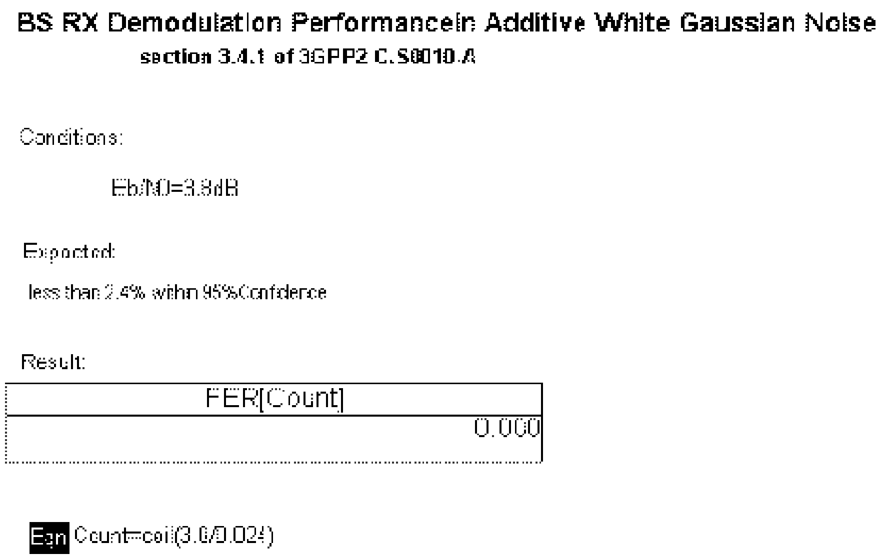
BS_RxDemodRC4AWGN Schematic

Notes

Users can set up system parameters or replace a component according to their particular requirements.

Simulation Results

Simulation results displayed in BS_RxDemodRC4AWGN.dds are shown in the following figure.



Demodulation with AWGN Simulation Results

Benchmark

- Hardware Platform: Pentium III 1000 MHz, 512 M memory
- Software Platform: Windows 2000, ADS 1.5
- Data Points: 300 frames
- Simulation Time: approximately 10 hours

Receiver Sensitivity and Dynamic Range

- BS_RxDnmcRngRC3

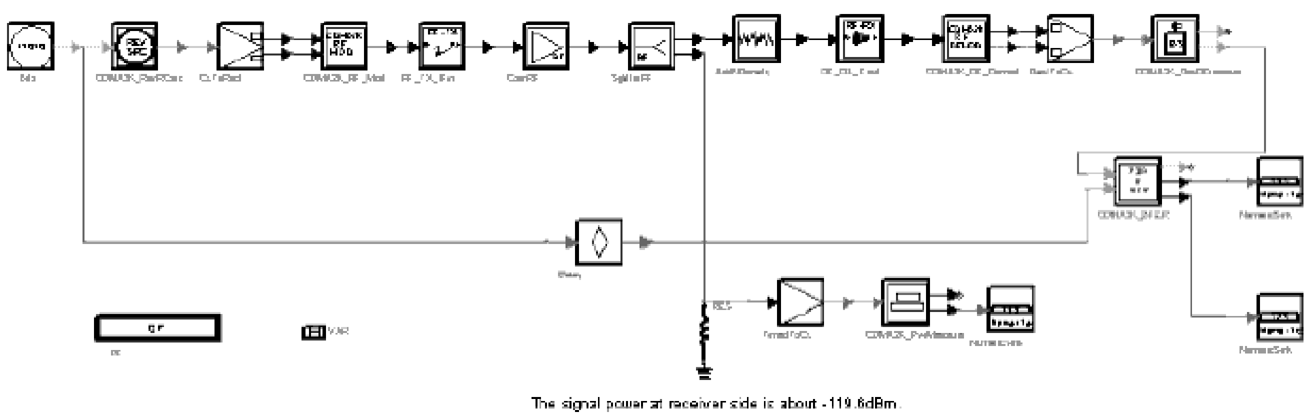
Features

- Reverse pilot and fundamental channel
- Dynamic range determined through parameter sweeping
- FER and BER of fundamental channel measurement

Description

This example measures the receiver sensitivity and dynamic range, as defined in section 3.5.1 and 3.5.2 of 3GPP2 C.S0010-A. FER is maintained at 1%. RC3 is used as an example.

Schematics



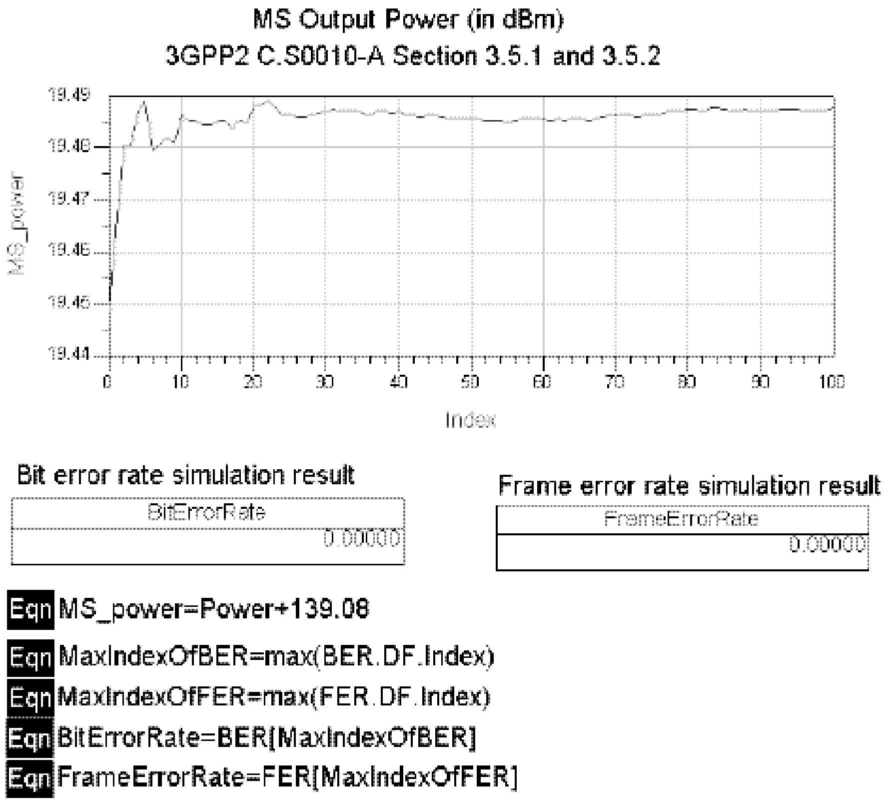
BS_RxDnmcRngRC3 Schematic

Notes

The dynamic range can be measured through changing the signal power at receiver side.

Simulation Results

Simulation results displayed in BS_RxDnmcRngRC3.dds. are shown in the following figure.



BER and FER of Fundamental Channel

Benchmark

- Hardware Platform: Pentium II 400 MHz, 512 MB memory
- Software Platform: Windows NT 4.0 Workstation, ADS 1.5
- Data Points: 100 frames.
- Simulation Time: approximately 4.1 hours

Intermodulation Spurious Response Attenuation

- BS_RxIntermodulationRC3

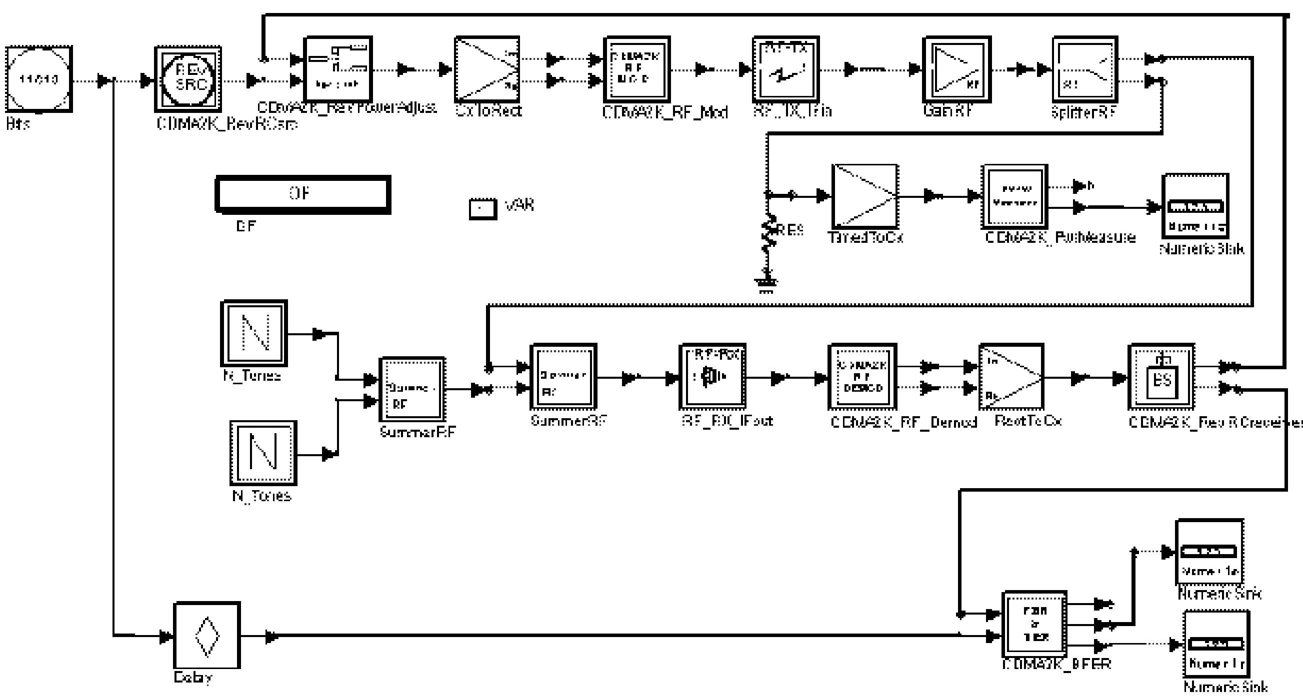
Features

- Reverse pilot and fundamental channel
- Power control mechanisms are enabled
- FER and BER of fundamental channel measurements

Description

This example measures the receiver intermodulation spurious response attenuation, as defined in section 3.5.4 of 3GPP2 C.S0010-A. FER must be less than 1.5% and the output power of the mobile station cannot increase by more than 3 dB. RC3 is used as an example.

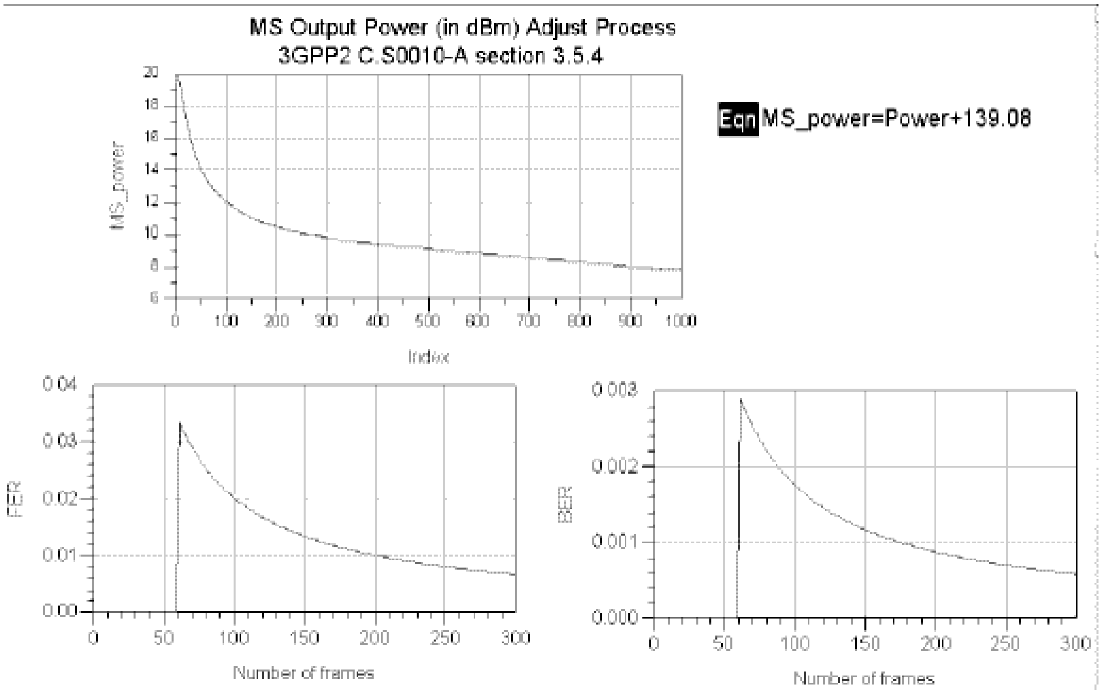
Schematic



BS_RxIntermodulationRC3 Schematic

Simulation Results

Simulation results displayed in BS_RxIntermodulationRC3.dds are shown in the following figure.



BS_RxIntermodulationRC3 Simulation Results

Benchmark

- Hardware Platform: Pentium II 400 MHz, 512 MB memory
- Software Platform: Windows NT 4.0 Workstation, ADS 1.5
- Data Points: 300 frames.
- Simulation Time: approximately 19 hours

Single-Tone Desensitization

- BS_RxSingleToneRC3

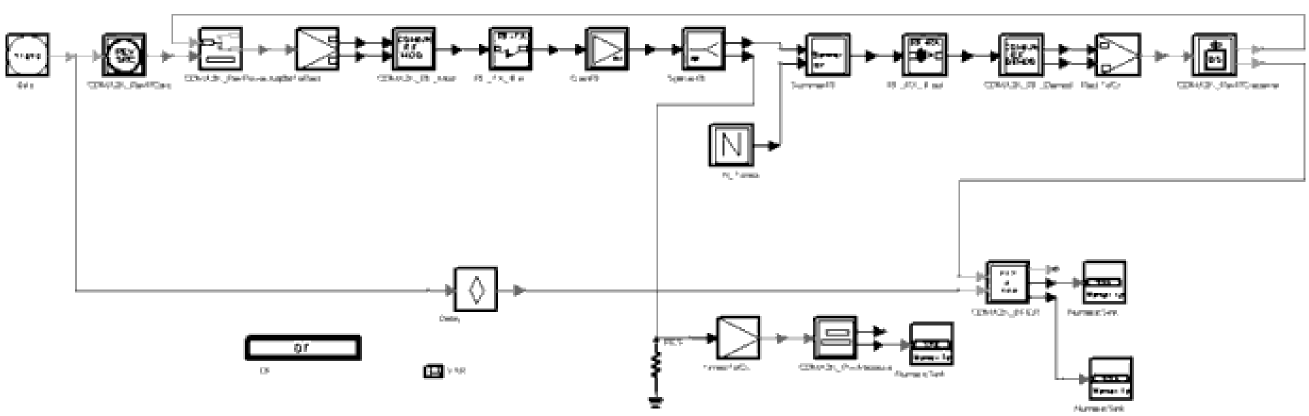
Features

- Reverse pilot and fundamental channel
- Power control mechanisms are enabled
- FER and BER of fundamental channel measurements

Description

This example measures the receiver single tone desensitization, as defined in section 3.5.3 of 3GPP2 C.S0010-A. FER must be less than 1.5% and the output power of the mobile station cannot increase by more than 3 dB. RC3 is used as an example.

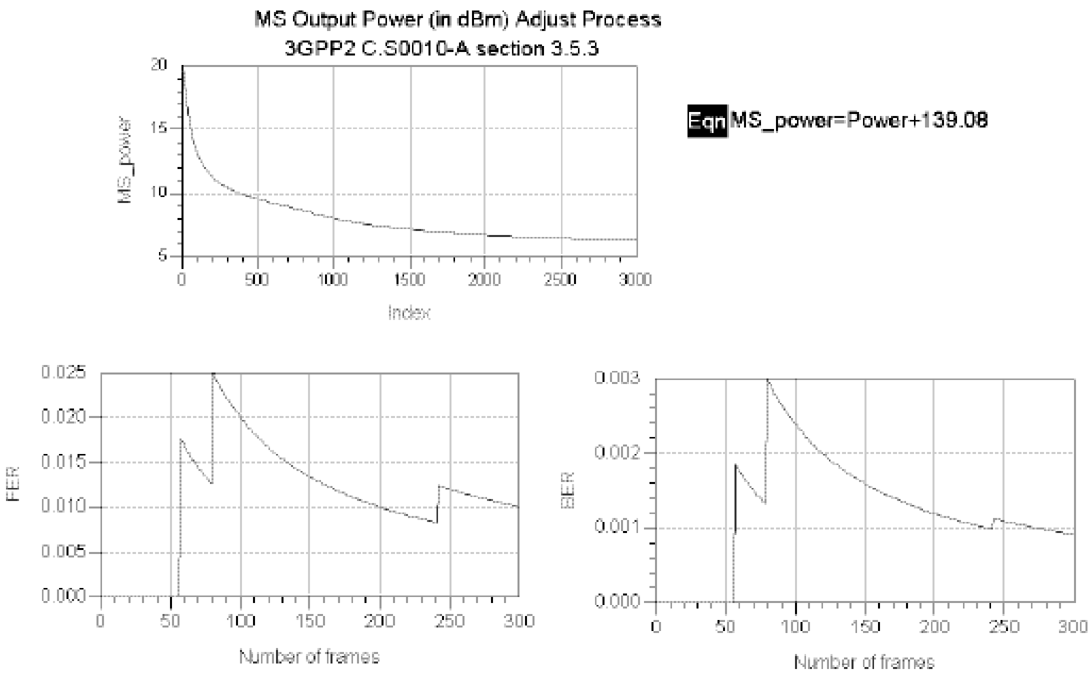
Schematic



BS_RxSingleToneRC3 Schematic

Simulation Results

Simulation results displayed in BS_RxSingleToneRC3.dds are shown in the following figure.



BS_RxSingleToneRC3 Simulation Results

Benchmark

- Hardware Platform: Pentium III 1000 MHz, 512 MB memory
- Software Platform: Windows 2000, ADS 1.5
- Data Points: 300 frames
- Simulation Time: approximately 8.8 hours

Single-Tone Desensitization with Transmit Leakage

- BS_RxTxLeakageRC3

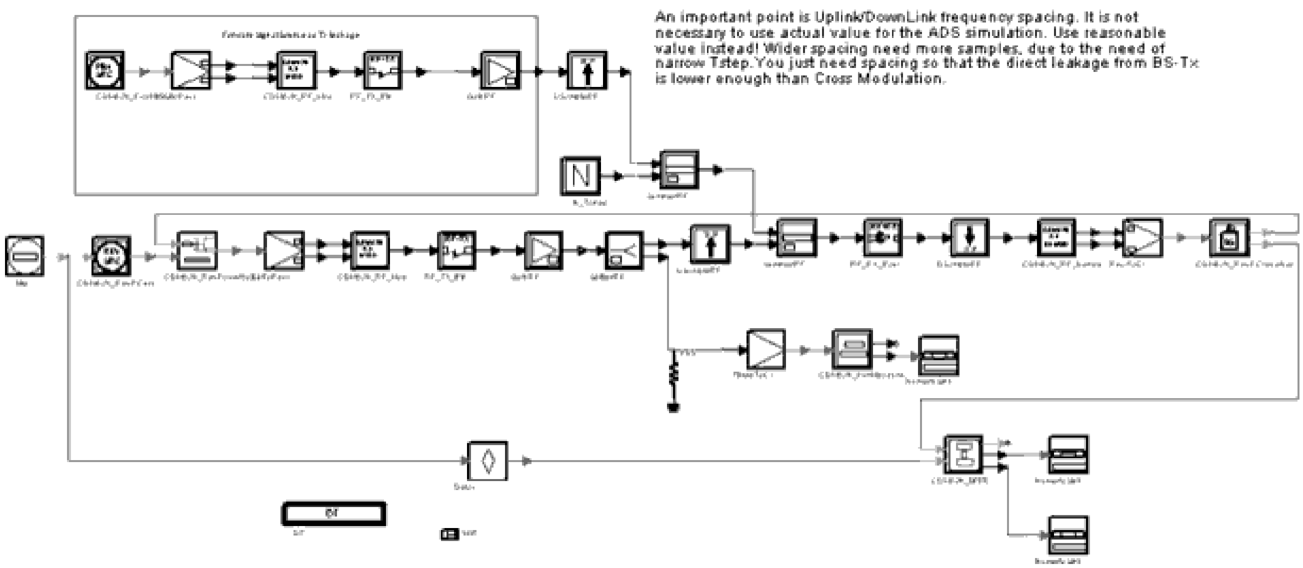
Features

- Reverse pilot and fundamental channel
- Power control mechanisms are enabled
- Forward pilot is used as the transmit leakage and is transmitted at maximum power (approximately 43 dBm in this setup).
- Isolation of duplexer is 100 dBm
- FER and BER of fundamental channel

Description

This example measures the receiver single-tone desensitization, with transmitter leakage. RC3 is used as an example.

Schematic



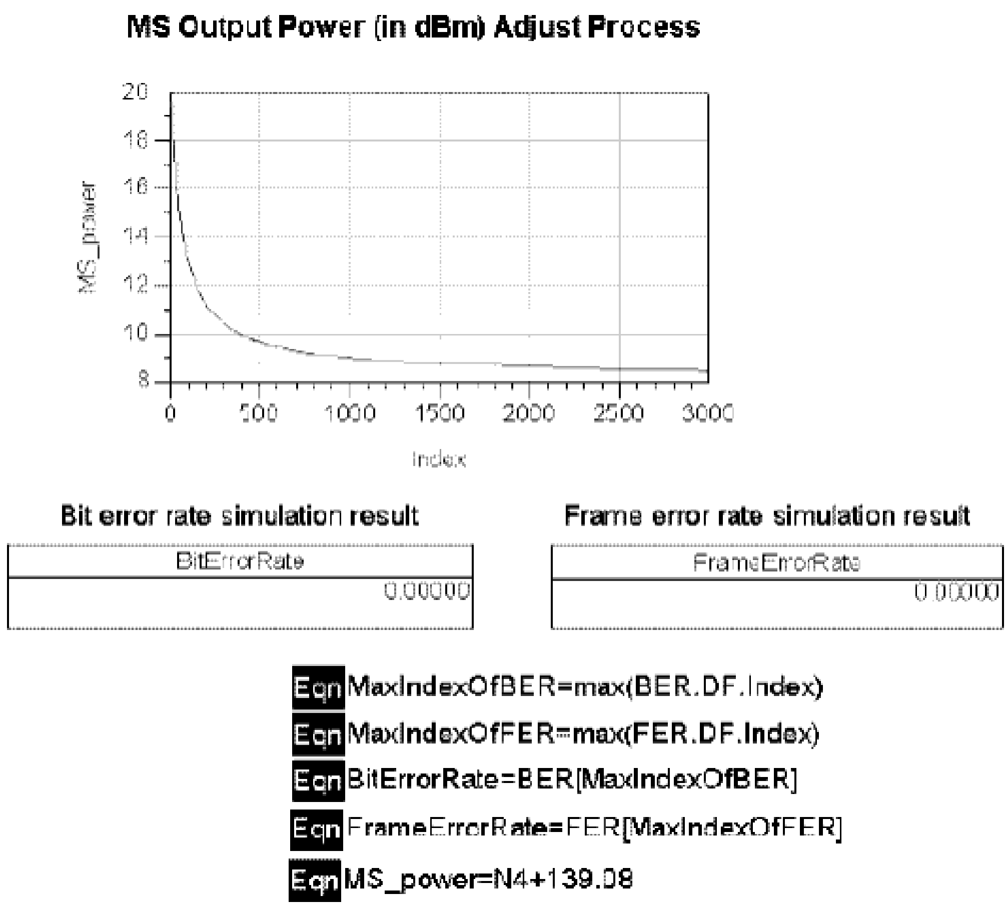
BS_RxTxLeakageRC3 Schematic

Notes

For uplink/downlink frequency spacing, use a reasonable value-it is not necessary to use the actual value for ADS simulation. Wider spacing requires more samples due to narrow Tstep. This spacing is necessary in order for the direct leakage from the base station transmitter to be lower than cross modulation.

Simulation Results

Simulation results displayed in BS_RxTxLeakageRC3.dds are shown in the following figure.



BS_RxTxLeakageRC3 Simulation Results

Benchmark

- Hardware Platform: Pentium III 1000 MHz, 512 MB memory
- Software Platform: Windows 2000, ADS 1.5
- Data Points: 300 frames.
- Simulation Time: approximately 19.8 hours

Base Station Transmitter Design Examples for cdma2000-Compliant Design Library

Introduction

The BS_TX_wrk workspace shows cdma2000 base station transmitter characteristics, including waveform quality (rho), mean power, pilot power, code domain power and conducted spurious emissions. Designs for these include:

- BS_TxCDP_RC3 and BS_TxCDP_RC3OTD measures code domain power with and without transmit diversity
- BS_TxMeanPower measures mean power of RF output
- BS_TxPilotPower measures pilot channel power to total power ratio
- BS_TxRho for waveform quality measurement
- BS_TxSR1Spectrum for conducted spurious emissions measurement
- BS_TxVSA_RC3 for connected solution with VSA

Designs under this workspace consist of:

- BS signal source in baseband
  CDMA2K_FwdRCsrc and CDMA2K_FwdOTDsrc provide the downlink signal source of different radio configurations and data rates without and with transmit diversity. CDMA2K_FwdPilotSrc provides the signal transmitted on the forward pilot channel.
- Transmit modulation and up-convertor
  The data source of base band output from CDMA2K_FwdRCsrc is up-converted to IF signal with CDMA2K_RF_Mod, then modulated into RF signal with RF_TX_IFin.
- Code domain power measurement
  CDMA2K_CDP is used to measure the code domain power.
- Mean power measurement
  CDMA2K_PwrMeasure is used to measure the mean power of input signal.
- Rho measurement
  CDMA2K_FwdRho is used to measure the waveform quality.

Code Domain Power

- BS_TxCDP_RC3

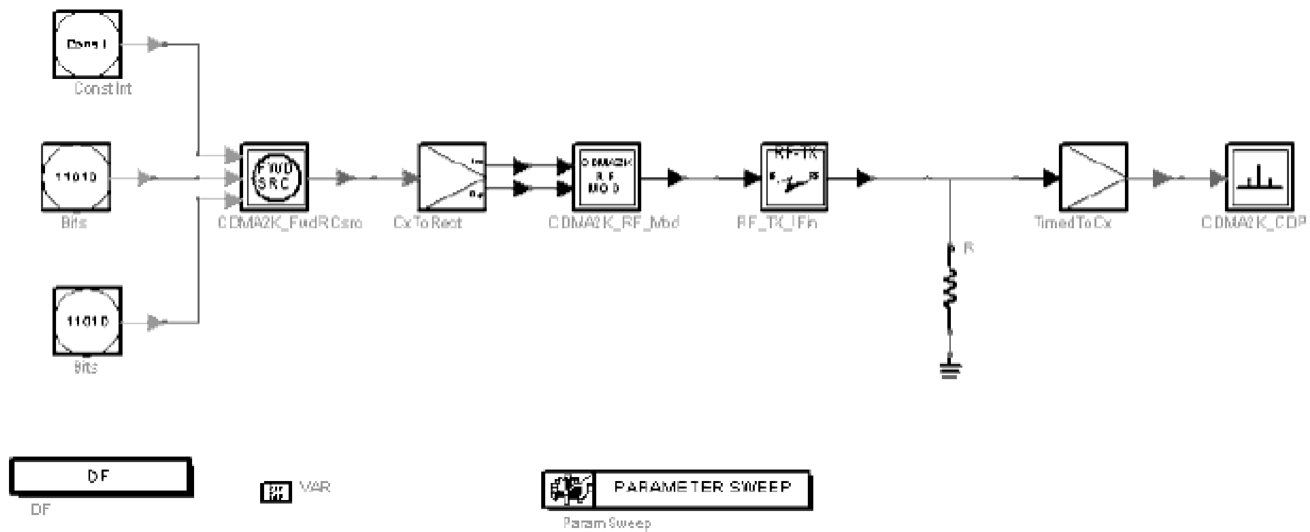
Features

- Walsh length is variable
- Multiple code channels
- Code domain powers for different Walsh length are measured

Description

This example measures the code domain power of RC3 for the forward link, as defined in section 4.3.3 of 3GPP2 C.S0010-A.

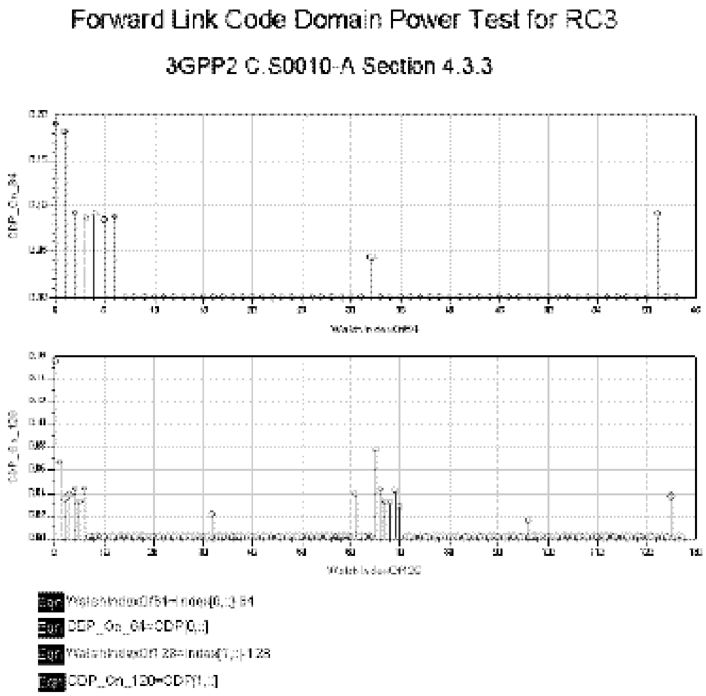
Schematic



BS_TxCDP_RC3 Schematic

Simulation Results

Simulation results displayed in BS_TxCDP_RC3.dds are shown in the following figure.



RC3 Forward Link Code Domain Power Simulation Results

Benchmark

- Hardware Platform: Pentium II 400 MHz, 512 MB memory
- Software Platform: Windows NT 4.0 Workstation, ADS 1.5
- Simulation Time: approximately 90 seconds

Code Domain Power with Transmit Diversity

- BS_TxCDP_RC3OTD

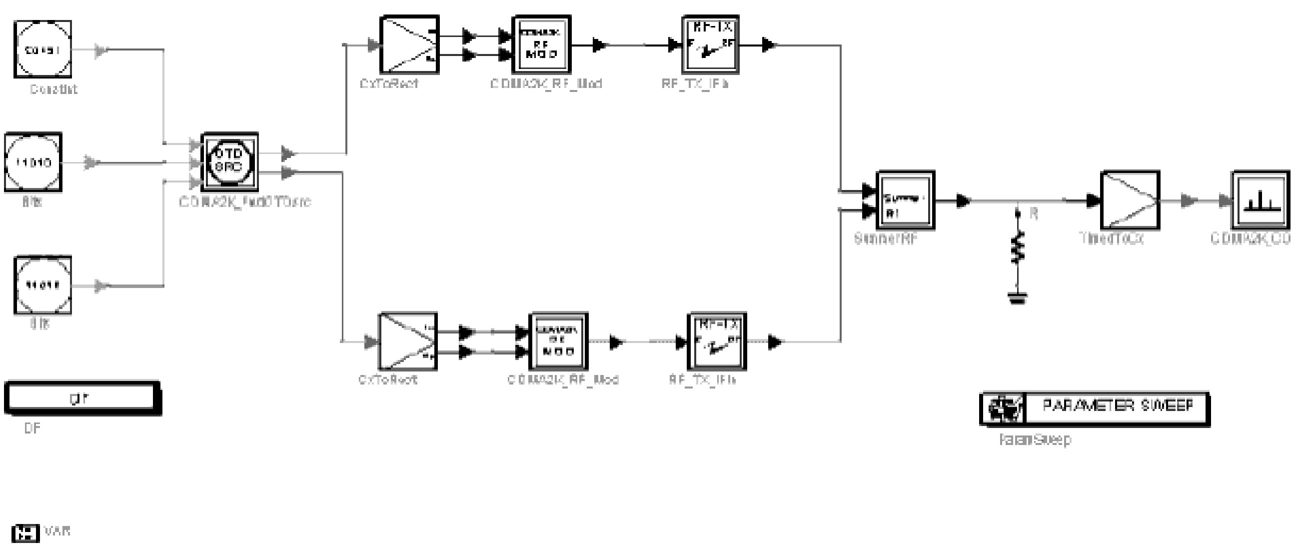
Features

- Walsh length is variable
- Multiple code channels
- Orthogonal transmit diversity
- Code domain powers for different Walsh length

Description

This example measures the code domain power with OTD for RC3 of the forward link, as defined in section 4.3.3 of 3GPP2 C.S0010-A.

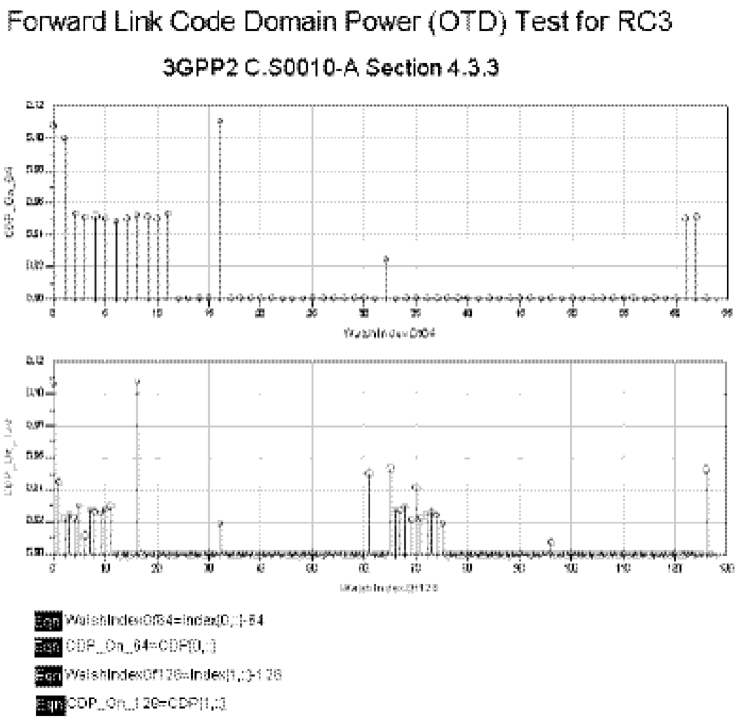
Schematic



BS_TxCDP_RC3OTD Schematic

Simulation Results

Simulation results displayed in BS_TxCDP_RC3OTD.dds are shown in the following figure.



RC3 Forward Link Code Domain

Power with Transmit Diversity Simulation Results

Benchmark

- Hardware Platform: Pentium II 400 MHz, 512 MB memory
- Software Platform: Windows NT 4.0 Workstation, ADS 1.5
- Simulation Time: approximately 100 seconds

Pilot Channel Power to Total Power Ratio

- BS_TxPilotPower

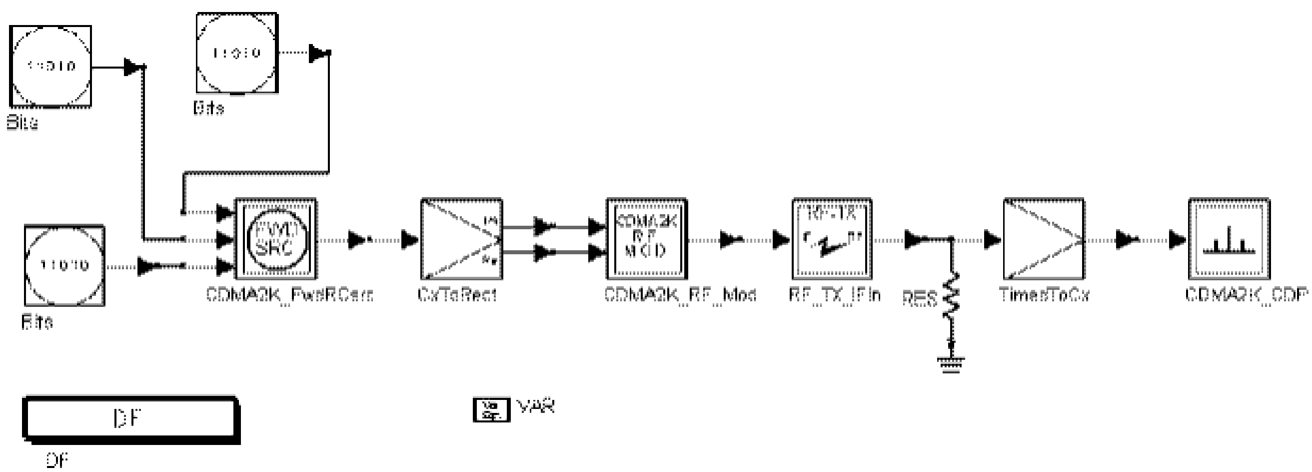
Features

- Pilot, sync, paging and 6 traffic channels
- Pilot channel power to total transmit power ratio

Description

This example measures the pilot channel power to total power ratio, as defined in section 4.3.2, 3GPP2 C.S0011-A.

Schematic



BS_TxPilotPower Schematic

Simulation Results

Simulation results displayed in BS_TxPilotPower.dds are shown in the following figure.

BS Pilot to Total Power Ratio

Section 4.4.9.2, 3GPP2 C.S.0011-A

LowerLimit_dB	PilotRatio_dB	UpperLimit_dB
-7.500	-7.202	-6.500

Eqn PilotRatio_dB=10*log(mean(CDP[0::64::max_index(CDP)]))

Eqn ConfiguredPilotRatio_dB=-7

Eqn UpperLimit_dB=ConfiguredPilotRatio_dB+0.5

Eqn LowerLimit_dB=ConfiguredPilotRatio_dB-0.5

Pilot Channel Power to Total Power Ration Simulation Results

Benchmark

- Hardware Platform: Pentium II 400 MHz, 512 MB memory
- Software Platform: Windows NT 4.0 Workstation, ADS 1.5
- Simulation Time: approximately 4 minutes

RF Output Mean Power

- BS_TxMeanPower

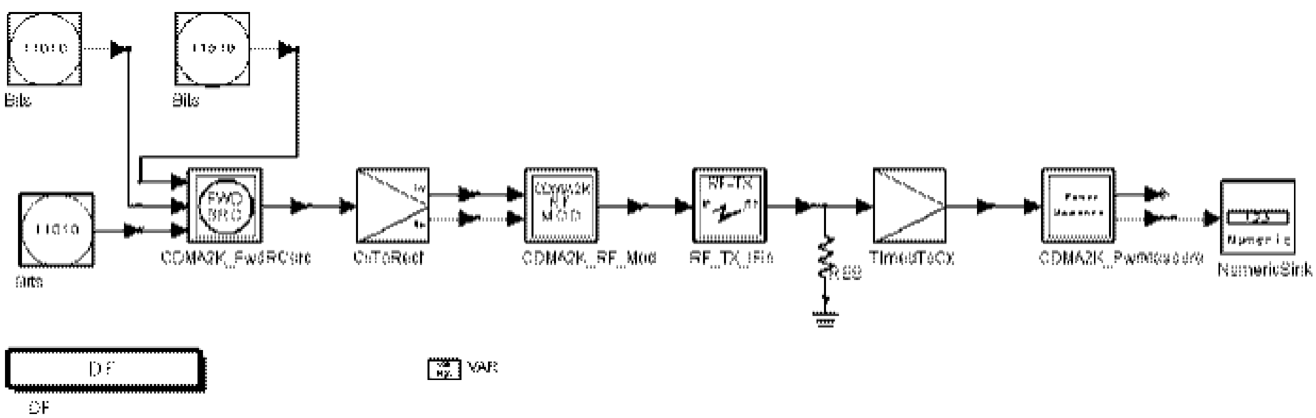
Features

- Pilot, sync, paging and 6 traffic channels
- Total transmit power measurement

Description

This example measures the mean power of the base station RF output as defined in section 4.3, 3GPP2 C.S0011-A.

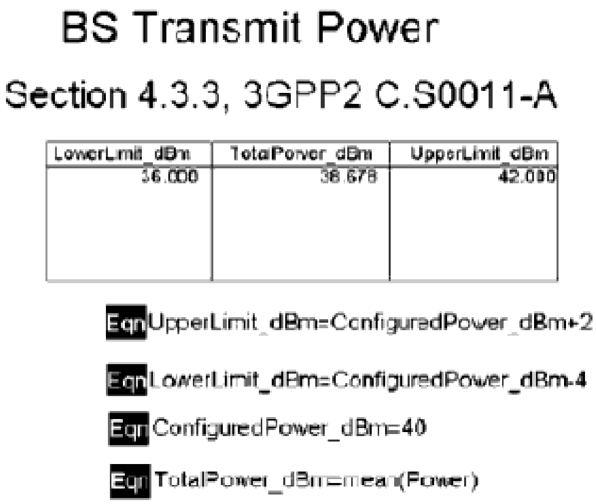
Schematic



BS_TxMeanPower Schematic

Simulation Results

Simulation results displayed in BS_TxMeanPower.dds are shown in the following figure.



Transmit Power Simulation Results

Benchmark

- Hardware Platform: Pentium II 400 MHz, 512 MB memory
- Software Platform: Windows NT 4.0 Workstation, ADS 1.5
- Simulation Time: approximately 3 minutes

Waveform Quality

- BS_TxRho

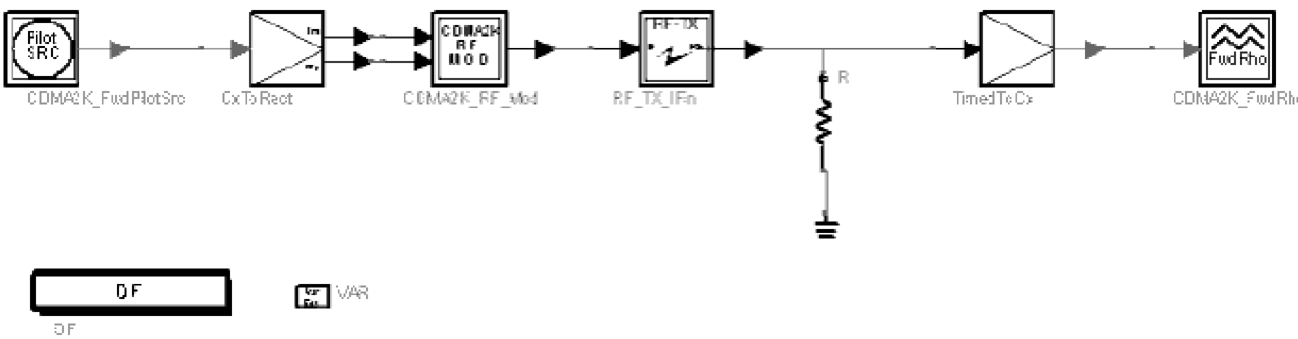
Features

- Forward pilot channel is transmitted
- Normalized correlated power, rho, measurement

Description

This example measures the normalized correlated power, rho, for the forward link. Only the forward pilot channel is transmitted, as defined in section 4.2.2 of 3GPP2 C.S0010-A.

Schematic



BS_TxRho Schematic

Simulation Results

Simulation results displayed in BS_TxRho.dds are shown in the following figure.

Rho Measurement for the Forward Link

3GPP2 C.S0010-A Section4.2.2

Test results for frequency error in hertz and rho

Dlt_F	Rho
-1.2106	0.9502

Waveform Quality Simulation Results

Benchmark

- Hardware Platform: Pentium II 400 MHz, 512 MB memory
- Software Platform: Windows NT 4.0 Workstation, ADS 1.5
- Simulation Time: approximately 140 seconds

Conducted Spurious Emissions

- BS_TxSR1Spectrum

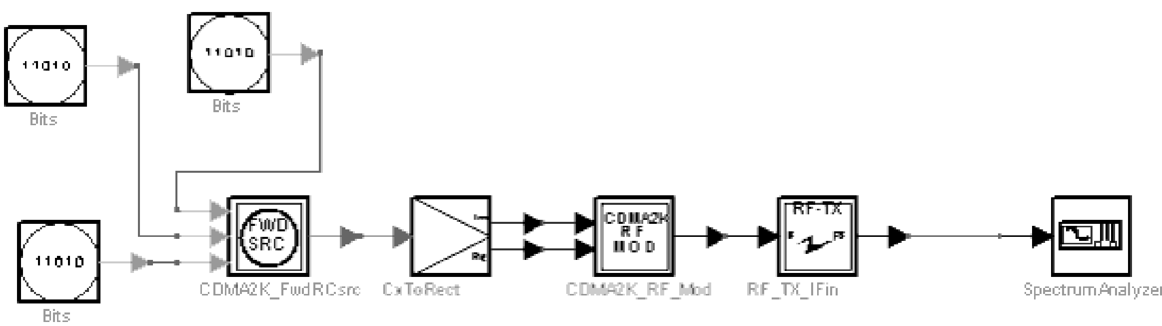
Features

- Pilot, sync, paging, and 6 traffic channels
- Emission at frequencies outside assigned CDMA channel for SR1 are measured

Description

This example measures the emission at frequencies that are outside the assigned CDMA channel for SR1 as defined in section 4.4, C.S0011-A.

Schematic



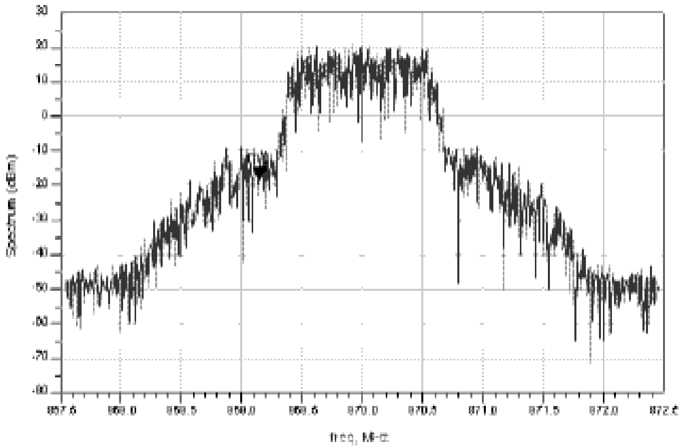
BS_TxSR1Spectrum Schematic

Simulation Results

Simulation results displayed in BS_TxSR1Spectrum.dds are shown in the following figure.

BS Limitation on Emission

Move marker with left/right arrow keys or mouse to the frequency you are interested in to find whether the transmitter emission in 30KHz at that frequency is within the limitaion specified in section 4.4, 3GPP2 C.S0010-A.



P30K_dBc	P30K_dBm
-47.580	-8.913

m1
freq=869.2MHz
dBm(Spectrum)=-18.343

The test result for the transmitter emission within 30KHz at this frequency is **Passed**

Spurious Emissions Simulation Results

Connected Solution

- BS_TxVSA_RC3

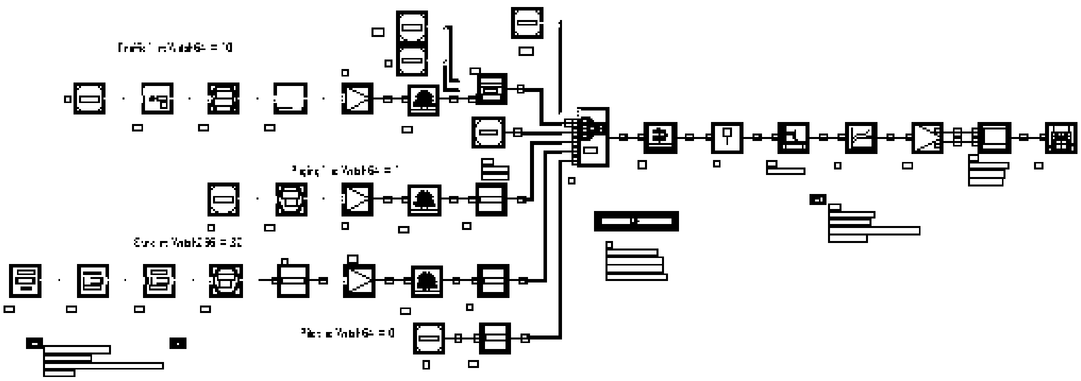
Features

- Full coded synchronization channel source
- Connected with VSA to demodulate ADS source signal

Description

This example demonstrates the connected solution of CDMA2K library between ADS and VSA.

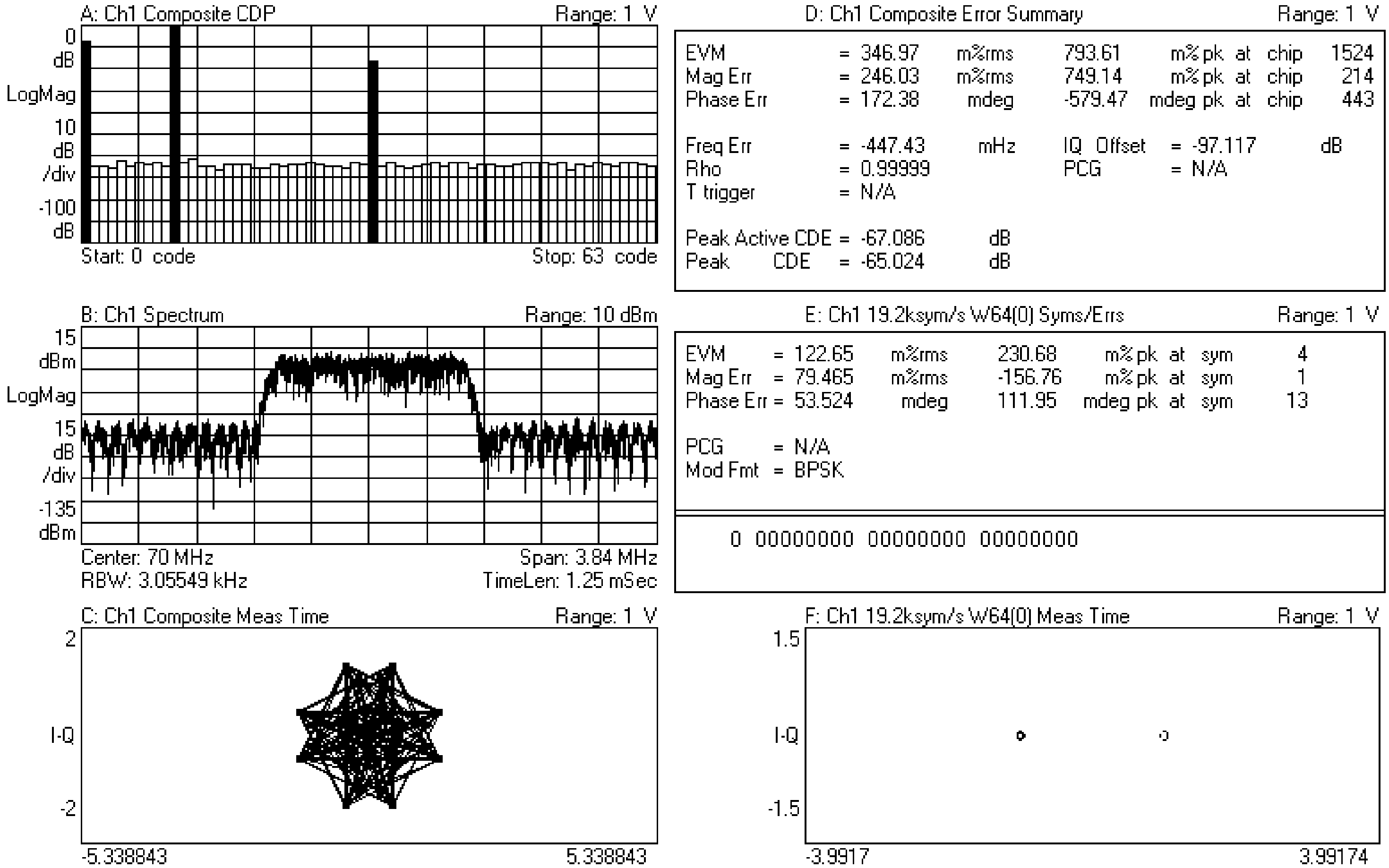
Schematic



BS_TxVSA_RC3 Schematic

Simulation Results

Simulation results displayed in VSA display windows.



VSA Demodulation Results

Benchmark

- Hardware Platform: Pentium II 400 MHz, 512 MB memory
- Software Platform: Windows NT 4.0 Workstation, ADS 1.5
- Simulation Time: approximately 4 minutes

BER and FER Design Examples

Introduction

The CDMA2K_BER_wrk workspace shows design examples for measuring forward and reverse link BER and FER, including AWGN. The following sections describe the designs and provide schematics and simulation results.

Forward Link Radio Configuration 3 BER and FER

- DsnCDMA2K_FwdRC3AWGN

Features

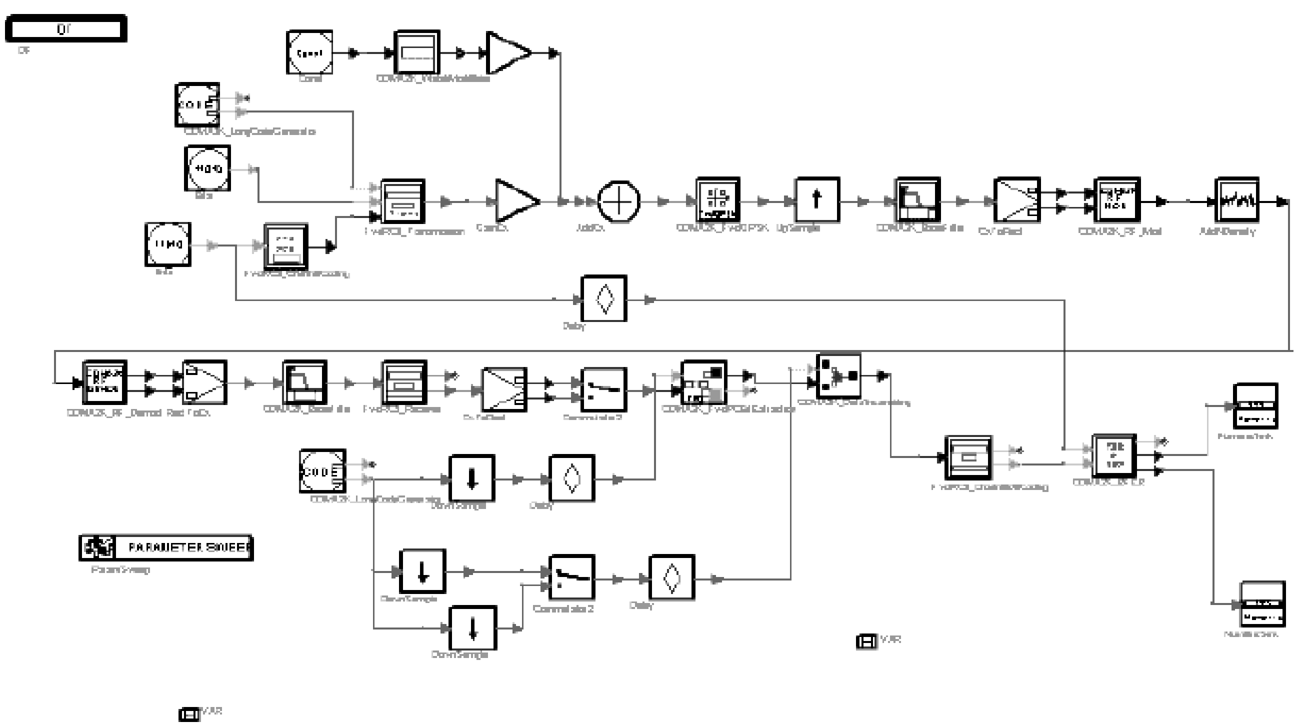
- Forward pilot channel and one fundamental channel
- FER and BER vs. Eb/N0 of fundamental channel performance curves

Description

This example shows performance of a forward link of RC3 with 9600 bps data rate, and 20 ms frame under AWGN condition. One pilot channel and one fundamental channel are included. It is assumed that the pilot channel occupies 20% of total power and the fundamental channel occupies 3% of total power.

Schematics

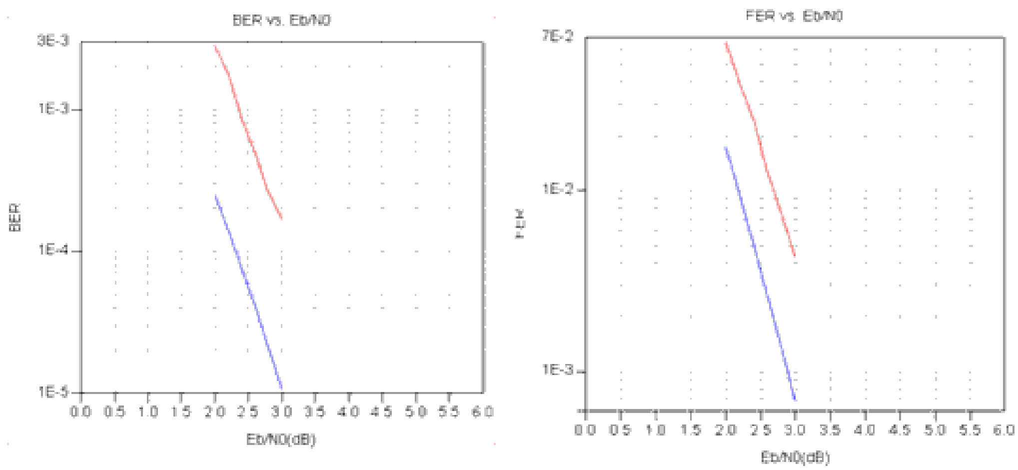
The schematic for *DsnCDMA2K_FwdRC3AWGN* is shown in the following figure.



DsnCDMA2K_FwdRC3AWGN

Simulation Results

Simulation results displayed in FwdRC3AWGN.dds are shown in the following figure.



Forward Traffic Channel RC3 in AWGN Channel

(blue = theoretical upper bound under ideal conditions; red = simulation results; performance decrease of simulation results is caused by channel estimation and power control bit puncture)

For forward fundamental channel of RC3, QPSK and 1/4 convolutional coding with constraint length 9 are used. Power control bits are punctured. System performance is improved over that for an uncoded QPSK system due to channel coding.

In the *.dds* file, the theoretical upper bound and simulation results are displayed. The theoretical upper bound is found in Chapter 8-2-3, equation (8-2-26) of book "Digital Communications" (3rd ed.) by John G. Proakis, which is determined under ideal conditions based on the assumption that the code bits are transmitted by BPSK or QPSK.

The upper bound on the first-event error probability is

$$P_e \le \sum_{d = d_{free}}^{\infty} \alpha_d Q\left(\sqrt{2\frac{E_b}{N_0}R_c d}\right)$$

where α_d denotes the number of paths of distance d from the all-zero path that merge with the all-zero path for the first time and R_c is the code rate. And

$$Q(x) = \frac{1}{\sqrt{2\pi}}\int_x^{\infty} e^{-t^2/2} dt \qquad (x \ge 0)$$

For a frame of length *l*, the frame error probability P_F is upper bounded by P_e, i.e.,

$$P_F \le 1 - (1 - P_e)^l$$

In general, the transfer function for the code can be expressed as

$$T(D,N) = \sum_{d = d_{free}}^{\infty} \alpha_d D^d N^{f(d)} \Big|_{D = e^{-\frac{Eb}{N0}Rc}}$$

where *f(d)* denotes the exponent of *N* as a function of *d*. Taking the derivative of *T(D,N)* with respect to *N* and setting *N*=1, we obtain $\beta_d = \alpha_d f(d)$. Thus, the bit error probability is upper-bounded by

$$P_b \le \sum_{d = d_{free}}^{\infty} \beta_d Q\left(\sqrt{2\frac{E_b}{N_0}R_c d}\right)$$

d_{free} of this 1/4 rate convolutional code is 24.

At 1% FER, this upper bound is very tight, and the simulation result is approximately 0.5 dB worse than the theoretical threshold; this is because:

- Channel estimation through forward pilot channel is performed in the receiver, which cannot be perfect, especially under low SNR.
- Power control bits are punctured in the traffic channel, which causes energy loss and coding gain decrease. On the traffic channel, 11/12 power is used to transmit traffic bits and 1/12 is used to transmit power control bits, which causes a 0.38 dB energy loss. And, the coding gain will be less than pure 1/4 convolutional coding.

Simulation results show that at 1e-3 BER, the coded channel provides the same performance at 4.5 dB lower E_b/N_0 than does the channel with no coding (QPSK performance), that is, the coding gain is approximately 4.5 dB.

Benchmark

- Hardware platform: Pentium III 800 MHz, 512 MB memory
- Software platform: Windows NT 2000, ADS 1.5
- Data points: 6 Eb/N0 values
- Simulation time: approximately 47.8 hours

Reverse Link Radio Configuration 3 BER and FER

- DsnCDMA2K_RevRC3AWGN design

Features

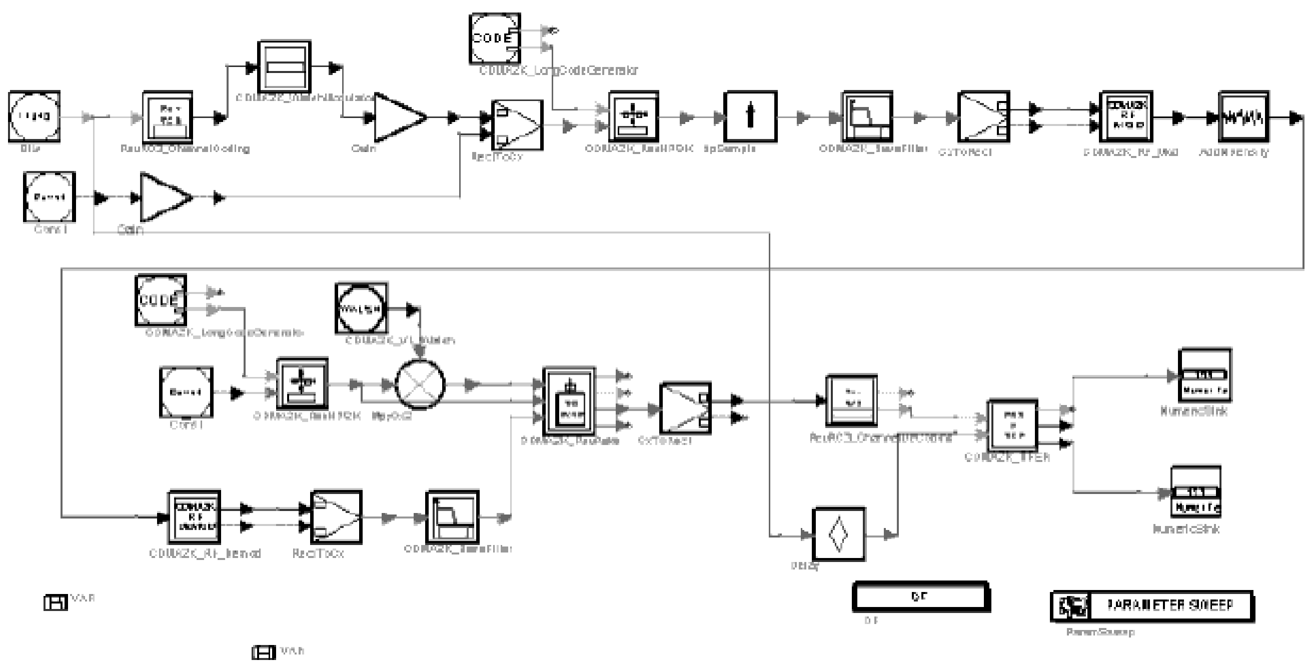
- Reverse pilot channel and one fundamental channel
- FER and BER vs. Eb/N0 of fundamental channel performance curves

Description

This example shows performance of a reverse link RC3 with 9600 bps data rate and 20 msec frame under AWGN condition. One pilot channel and one fundamental channel are included. It is assumed that the power ratio between the fundamental channel and pilot channel is approximately 3.75dB.

Schematic

The schematic for *DsnCDMA2K_RevRC3AWGN* is shown in the following figure.

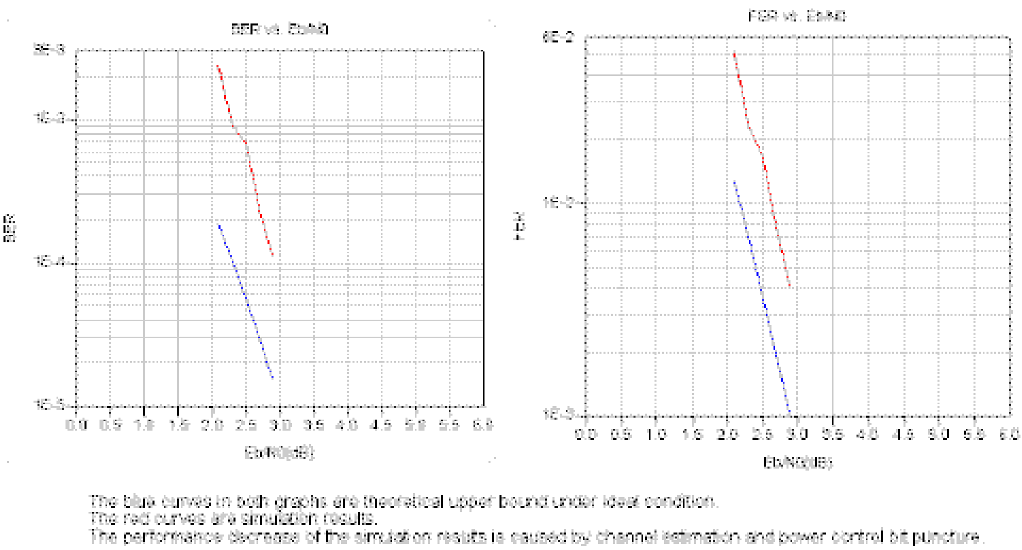


DsnCDMA2K_RevRC3AWGN

Simulation Results

Simulation Results

Simulation results displayed in RevRC3AWGN.dds are shown in the following figure.



Reverse Traffic Channel RC3 in AWGN Channel

(blue = theoretical upper bound under ideal conditions; red = simulation results; performance decrease of simulation results is caused by channel estimation and power control bit puncture)

For reverse fundamental channel RC3, BPSK and 1/4 convolutional coding with constraint length 9 are used. Power control bits are punctured on the pilot channel. System performance is improved over that for an uncoded BPSK system due to channel coding.

In the *.dds* file, the theoretical upper bound and simulation results are displayed. The theoretical upper bound is found in Chapter 8-2-3, equation (8-2-26) of book "Digital Communications" (3rd ed.) by John G. Proakis, which is determined under ideal conditions based on the assumption that the code bits are transmitted by BPSK or QPSK.

The upper bound on the first-event error probability is

$$P_e \le \sum_{d = d_{free}}^{\infty} \alpha_d Q\left(\sqrt{2\frac{E_b}{N_0}R_c d}\right)$$

where α_d denotes the number of paths of distance d from the all-zero path that merge with the all-zero path for the first time and R_c is the code rate. And

$$Q(x) = \frac{1}{\sqrt{2\pi}}\int_x^{\infty} e^{-t^2/2}dt \qquad (x \ge 0)$$

For a frame of length l, the frame error probability P_F is upper bounded by P_e, i.e.,

$$P_F \le 1 - (1 - P_e)^l$$

In general, the transfer function for the code can be expressed as

$$T(D, N) = \sum_{d = d_{free}}^{\infty} \alpha_d D^d N^{f(d)} \Big|_{D = e^{-\frac{Eb}{N0}Rc}}$$

where *f(d)* denotes the exponent of *N* as a function of d. Taking the derivative of *T(D,N)* with respect to N and setting *N*=1, we obtain $\beta_d = \alpha_d f(d)$. Thus, the bit error probability is upper-bounded by

$$P_b \le \sum_{d = d_{free}}^{\infty} \beta_d Q\left(\sqrt{2\frac{E_b}{N_0}R_c d}\right)$$

dfree of this 1/4 rate convolutional code is 24.

At 1% FER, this upper bound is very tight, and the simulation result is approximately 0.45 dB worse than the theoretical threshold; this is because:

- Channel estimation through reverse pilot channel is performed in the coherent receiver and the power of reverse pilot channel is relatively low, which cannot be perfect, especially under low SNR.
- Power control bits are punctured in the reverse pilot channel, so decision-feedback is used during this period for channel estimation. The error decision of power control bits will cause error channel estimation, which is sensitive for coherent receiver.

Simulation results show that at 1e-3 BER, the coded channel provides the same performance at 4.5 dB lower E_b/N_0 than does the channel with no coding (BPSK performance), that is, the coding gain is approximately 4.5 dB.

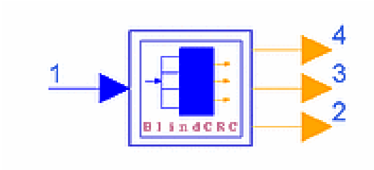
Benchmark

- Hardware platform: Pentium III 800 MHz, 512 MB memory
- Software platform: Windows NT2000, ADS 1.5
- Data points: 5 Eb/N0 values
- Simulation time: approximately 33.5 hours

Channel Coding Components for cdma2000-Compliant Design Library

- *CDMA2K BlindCRC* (cdma2k)
- *CDMA2K BlindDecoder* (cdma2k)
- *CDMA2K BlindRevRC1 2* (cdma2k)
- *CDMA2K BlockDeIntlvr* (cdma2k)
- *CDMA2K BlockIntlvr* (cdma2k)
- *CDMA2K CC WithTail* (cdma2k)
- *CDMA2K CRC Coder* (cdma2k)
- *CDMA2K CRC DeCoder* (cdma2k)
- *CDMA2K DCC WithTail* (cdma2k)
- *CDMA2K DePuncture* (cdma2k)
- *CDMA2K FR RateDematch* (cdma2k)
- *CDMA2K FR RateMatch* (cdma2k)
- *CDMA2K FwdChannelCoding* (cdma2k)
- *CDMA2K FwdChannelDecoding* (cdma2k)
- *CDMA2K MAPDecoder1* (cdma2k)
- *CDMA2K MAPDecoder2* (cdma2k)
- *CDMA2K MCMode DeIntlvr* (cdma2k)
- *CDMA2K MCMode Intlvr* (cdma2k)
- *CDMA2K OneWay* (cdma2k)
- *CDMA2K OnewayRevRC1 2* (cdma2k)
- *CDMA2K Puncture* (cdma2k)
- *CDMA2K RevChannelCoding* (cdma2k)
- *CDMA2K RevChannelDecoding* (cdma2k)
- *CDMA2K SymCyclicShift* (cdma2k)
- *CDMA2K TurboDecoder* (cdma2k)
- *CDMA2K TurboDeIntlvr* (cdma2k)
- *CDMA2K TurboDeMux* (cdma2k)
- *CDMA2K TurboEncoder* (cdma2k)
- *CDMA2K TurboIntlvr* (cdma2k)
- *CDMA2K TurboMAPDecoder* (cdma2k)
- *CDMA2K TurboMux* (cdma2k)
- *CDMA2K TurboRSCEncoder* (cdma2k)
- *CDMA2K VR AmpAdjust* (cdma2k)
- *CDMA2K VR CCwithTail* (cdma2k)
- *CDMA2K VR Coding* (cdma2k)
- *CDMA2K VR Compare* (cdma2k)
- *CDMA2K VR DCCwithTail* (cdma2k)
- *CDMA2K VR DeFraming* (cdma2k)
- *CDMA2K VR Framing* (cdma2k)
- *CDMA2K VR RateDeMatch* (cdma2k)
- *CDMA2K VR RateMatch* (cdma2k)
- *CDMA2K VR Src* (cdma2k)

CDMA2K_BlindCRC



Description Blind Decoder with CRC Check
Library cdma2000, Channel Coding
Class SDFCDMA2K_BlindCRC

Parameters

Name	Description	Default	Type
RadioConfig	radio configuration: Fwd RC2, Fwd RC3, Fwd RC4, Fwd RC5, Fwd RC6, Fwd RC7, Fwd RC8, Fwd RC9, Rev RC3, Rev RC4, Rev RC5, Rev RC6	Fwd RC2	enum

Pin Inputs

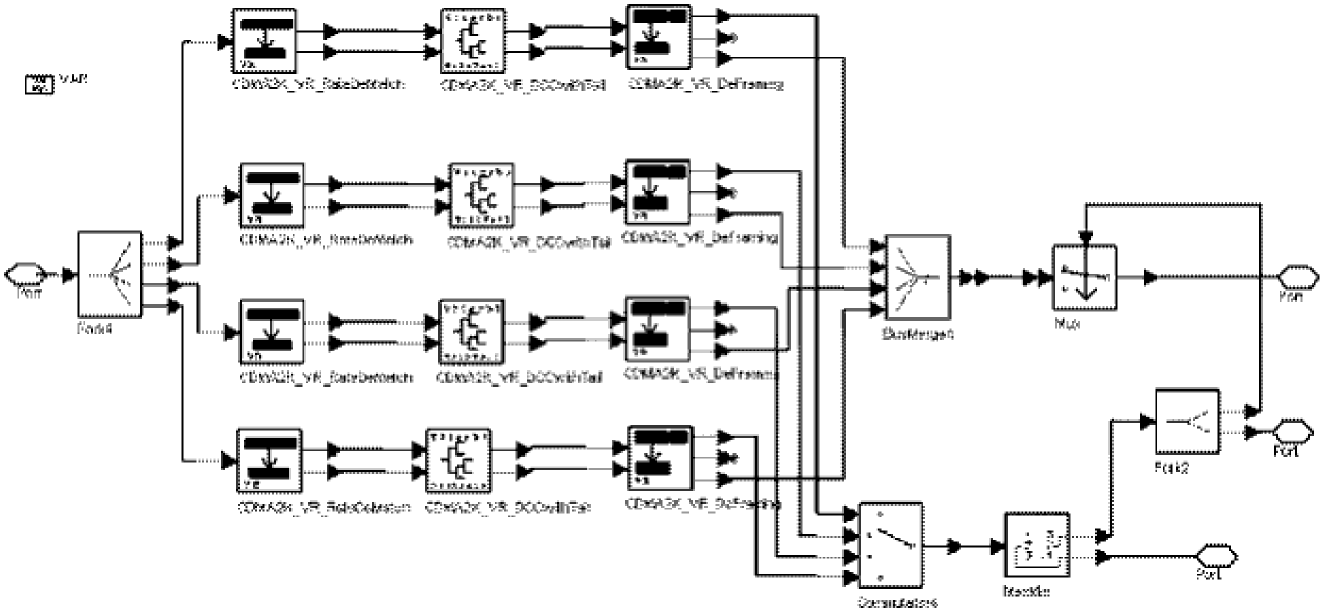
Pin	Name	Description	Signal Type
1	D_in	input data	real

Pin Outputs

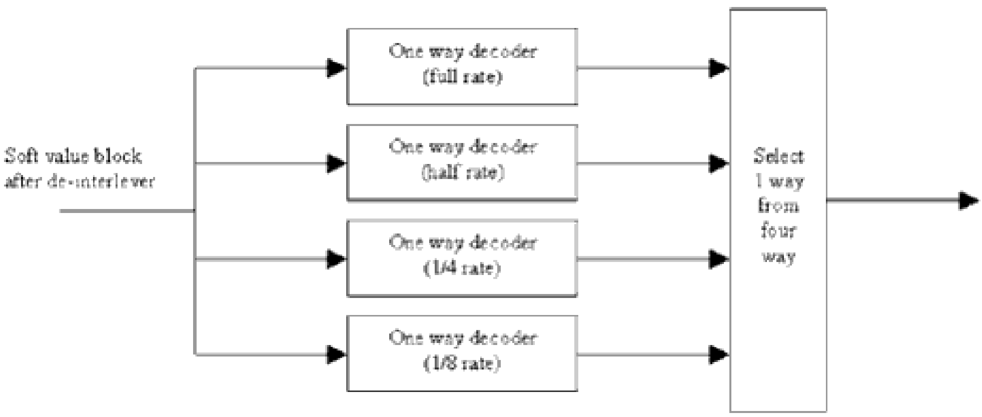
Pin	Name	Description	Signal Type
2	D_out	decoded bits	int
3	rate0	data rate of output frame	int
4	FrmErr	frame quality indicator	int

Notes/Equations

1. This subnetwork is used to implement blind detecting, decoding and de-framing for variable data rate fundamental traffic channels. Input symbols are de-interleaved before processing. CDMA2K_BlindCRC Subnetwork shows the schematic for this subnetwork.
2. Input data is soft decision value from the Rake receiver. Rate 1/4 and rate 1/8 use CRC bits for all radio configurations (except RC1) to determine the data rate of received frame. (Reverse RC2 is not an option for this subnetwork because continuous waveform transmission is used.) If all decoded frames contain errors, a full rate frame will be output.
   4- way Blind Detector Block Diagram shows the 4-way blind detector block diagram.



CDMA2K_BlindCRC Subnetwork

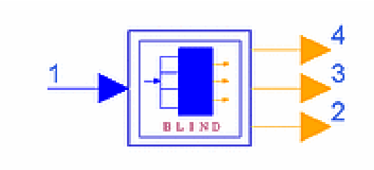


4- way Blind Detector Block Diagram

References

1. TIA/EIA/IS-2000.2 (PN-4428), Physical Layer Standard for cdma2000 Spread Spectrum Systems, July, 1999.

CDMA2K_BlindDecoder



Description Blind Decoder with BER Comparison
Library cdma2000, Channel Coding
Class SDFCDMA2K_BlindDecoder

Parameters

Name	Description	Default	Type
RadioConfig	radio configuration: Fwd RC1, Fwd RC2, Fwd RC3, Fwd RC4, Fwd RC5, Fwd RC6, Fwd RC7, Fwd RC8, Fwd RC9, Rev RC3, Rev RC4, Rev RC5, Rev RC6	Fwd RC1	enum

Pin Inputs

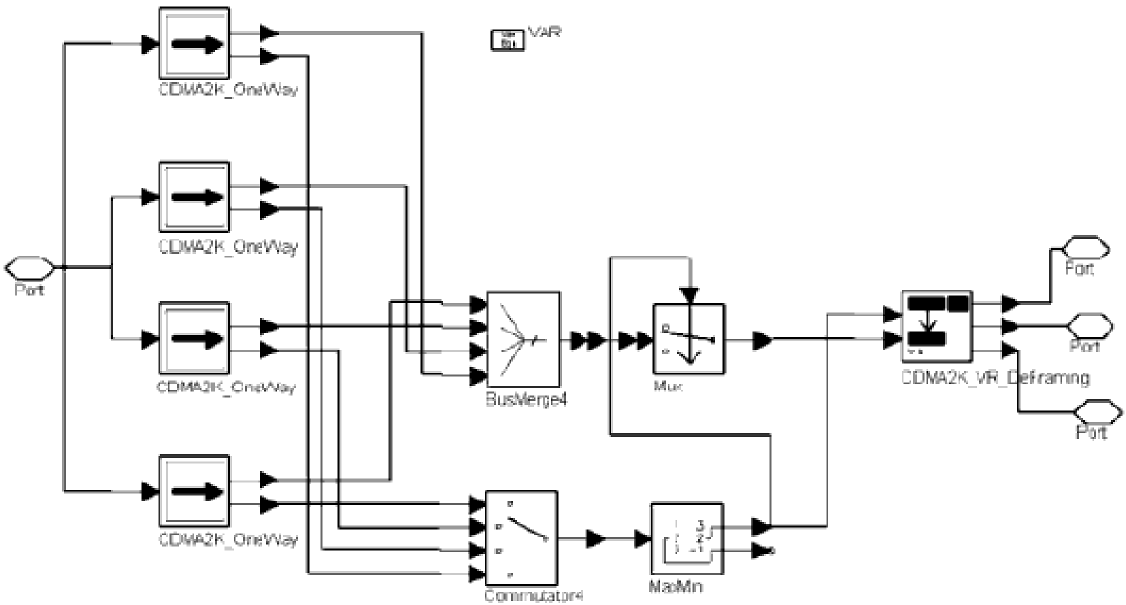
Pin	Name	Description	Signal Type
1	D_in	input data	real

Pin Outputs

Pin	Name	Description	Signal Type
2	D_out	decoded bits	int
3	rate0	data rate of output frame	int
4	FrmErr	frame quality indicator	int

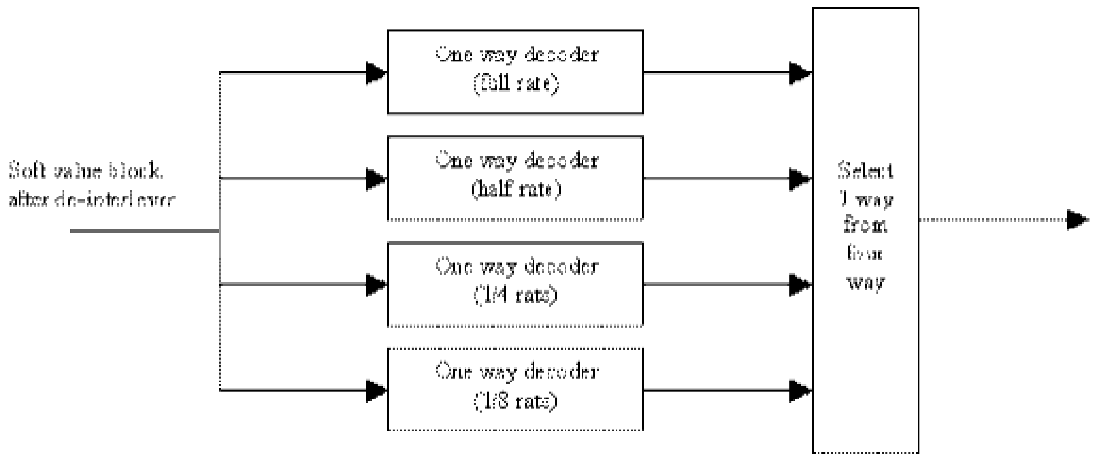
Notes/Equations

1. This subnetwork is used to implement blind detecting, decoding, and de-framing for data rates in fundamental channels. The input symbols are de-interleaved before processing.
   the following figure shows the schematic for this subnetwork.



CDMA2K_BlindDecoder Subnetwork

2. Input data is from the Viterbi decoder with soft decision. In one-way decoder, decoding is performed according to data rate and the BER of this output frame is measured. The date rate with minimum BER is used as the transmit data rate; the frame with minimum BER is output.
   the following figure shows the 4-way blind detector block diagram.

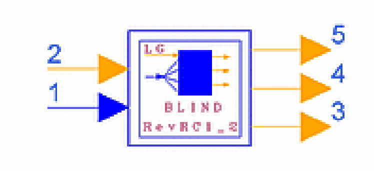


4-Way Blind Detector Block Diagram

References

1. TIA/EIA/IS-2000.2 (PN-4428), Physical Layer Standard for cdma2000 Spread Spectrum Systems, July, 1999.

CDMA2K_BlindRevRC1_2



Description Blind Decoder for Reverse Link RC1 or RC2
Library cdma2000, Channel Coding
Class SDFCDMA2K_BlindRevRC1_2

Parameters

Name	Description	Default	Type
RadioConfig	radio configuration: Rev RC1, Rev RC2	Rev RC1	enum

Pin Inputs

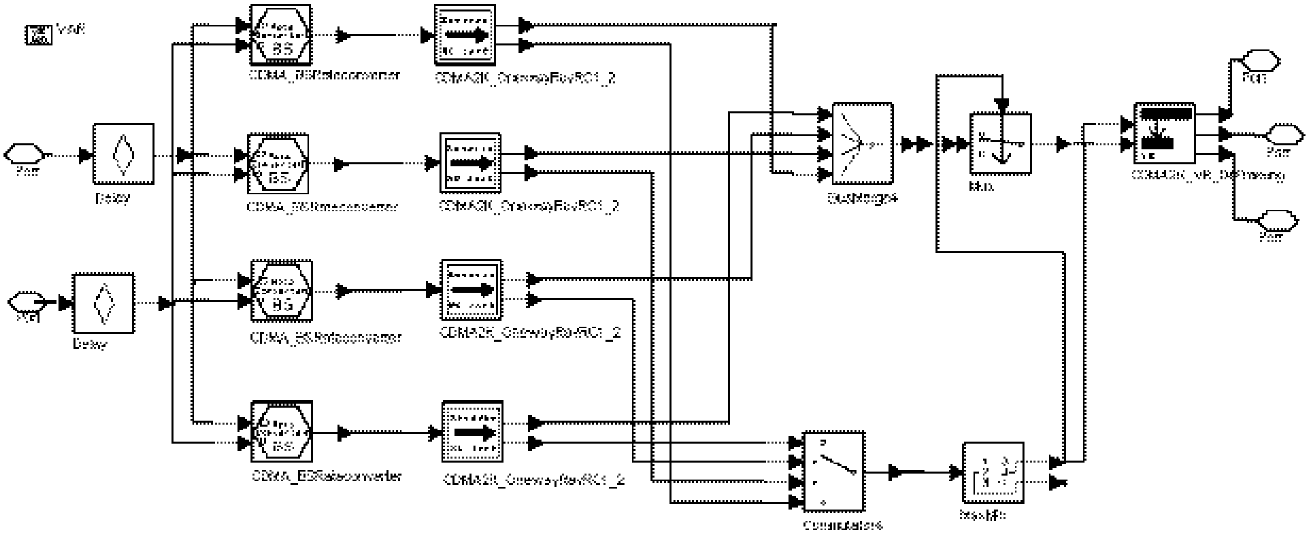
Pin	Name	Description	Signal Type
1	D_in	input data	real
2	LgCode	long PN code	int

Pin Outputs

Pin	Name	Description	Signal Type
3	D_out	decoded bits	int
4	rate0	data rate of output frame	int
5	FrmErr	frame quality indicator	int

Notes/Equations

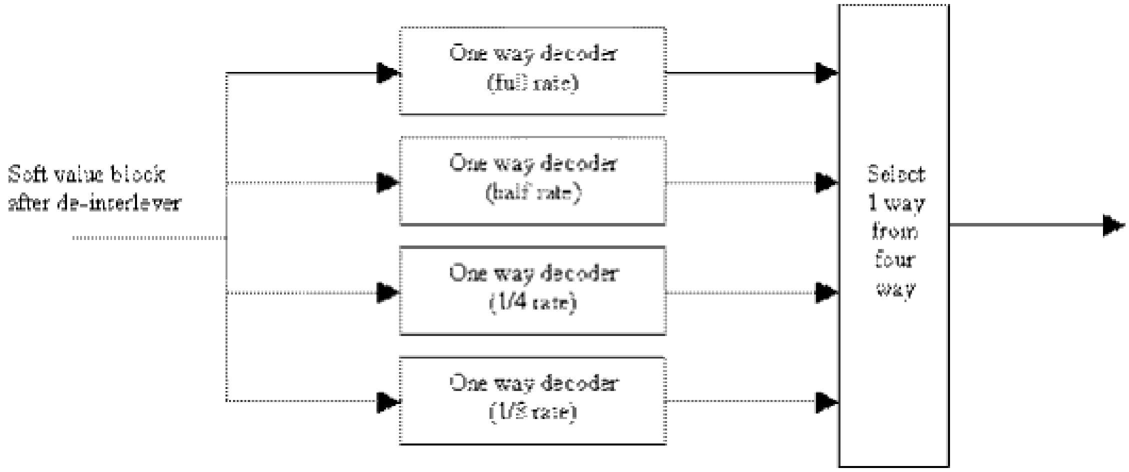
1. This subnetwork is used for blind detection and decoding for data rates in reverse link RC1 or RC2 fundamental channels. The input symbols are produced by the reverse non-coherent Rake receiver.
   The following figure shows the schematic for this subnetwork.



CDMA2K_BlindRevRC1_2 Subnetwork

2. Input data is from the Viterbi decoder with soft decision. In one-way decoder, decoding is performed according to data rate, and the BER of current frame is measured. The date rate with minimum BER is used as the transmit data rate; the frame with minimum BER is output.
   The following figure shows the 4-way blind detector block diagram. When operating with RC1 or RC2, the reverse code channel interleaver output stream is time-gated to allow transmission of some interleaver output symbols and deletion of others. The duty cycle of the transmission gate varies according to the transmit data rate; for example when the transmit data rate is
   - 9600 or 14400 bps, the transmission gate allows all interleaver output symbols to be transmitted
   - 4800 or 7200 bps, the transmission gate allows one-half of the interleaver output symbols to be transmitted

   The gating process divides the 20 msec frame into 16 equal (1.25 msec) periods called power control groups. Some power control groups are gated-on (transmitted), while other groups are gated-off (not transmitted). When operating with other radio configurations in reverse code channel, continuous transmission is used. In this subnetwork, input symbols are first converted to frames with different data rates for 4-way blind decoding.

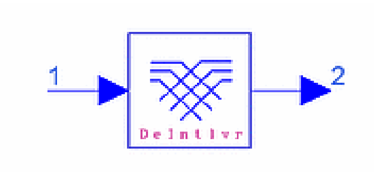


4-Way Blind Detector Block Diagram

References

1. TIA/EIA/IS-2000.2 (PN-4428), Physical Layer Standard for cdma2000 Spread Spectrum Systems, July 1999.

CDMA2K_BlockDeIntlvr



Description Block de-interleaver
Library cdma2000, Channel Coding
Class SDFCDMA2K_BlockDeIntlvr

Parameters

Name	Description	Default	Sym	Type	Range
BlockRow_m	interleaver block row equal to 2^Blockrow_m.	4	m	int	[1, ∞)
BlockColumn_J	interleaver block column	3	J	int	[1, ∞)
IntlvrType	interleaver type: BROIntlvr, Fwd_Backwards	BROIntlvr		enum	

Pin Inputs

Pin	Name	Description	Signal Type
1	D_in	input data	real

Pin Outputs

Pin	Name	Description	Signal Type
2	D_out	deinterleaved data	real

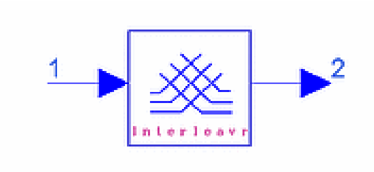
Notes/Equations

1. This model is used to de-interleave input symbols.
   Each firing, 2m × J D_out tokens are produced when 2m × J D_in tokens are consumed.
2. This model is the reverse of the process used for CDMA2K_BlockIntlvr.

References

1. TIA/EIA/IS-2000.2 (PN-4428), Physical Layer Standard for cdma2000 Spread Spectrum Systems, July 1999.

CDMA2K_BlockIntlvr



Description Block interleaver
Library cdma2000, Channel Coding
Class SDFCDMA2K_BlockIntlvr

Parameters

Name	Description	Default	Sym	Type	Range
BlockRow_m	interleaver block row equal to 2^Blockrow_m.	4	m	int	[1, ∞)
BlockColumn_J	interleaver block column	3	J	int	[1, ∞)
IntlvrType	interleaver type: BROIntlvr, Fwd_Backwards	BROIntlvr		enum	

Pin Inputs

Pin	Name	Description	Signal Type
1	D_in	input data	real

Pin Outputs

Pin	Name	Description	Signal Type
2	D_out	output interleaved data	real

Notes/Equations

1. This model is used to interleave the input symbols.
   Each firing, 2m × J D_out tokens are produced when 2m × J D_in tokens are consumed.
2. Interleavers used in this model are described in the following paragraphs.
   BRO Interleaver
   When operating on the Sync Channel, Paging Channel, or Forward Traffic Channel with RC1 or RC2; or the Access Channel, Enhanced Access Channel, Reverse Common Control Channel, or Reverse Traffic Channel with RC3 through RC6, all symbols after symbol repetition and subsequent puncturing (if used) are block interleaved. The symbols input to the interleaver are written sequentially at addresses 0 to block size (N) minus one (where $N = 2^m \times^J$).
   The interleaved symbols are read out in permutated order from address Ai, as follows:
   $$A_i = 2^m \times ((i) mod(J)) + BRO_m\left(int\left(\frac{i}{J}\right)\right)$$
   where i = 0 to N-1; int(x) indicates the largest integer ≤ x; and, BROm(y) indicates the bit-reversed m-bit value of y (for example, BRO3(6) = 3).
   Forward-Backwards Interleaver

When operating on the Broadcast Channel, Common Assignment Channel, Forward Common Control Channel, or Forward Traffic Channel with RC3 through RC9, the symbols input to the interleaver are written sequentially at addresses 0 to the block size (N) minus one.
The even interleaved symbols (i is even) are read out in permutated order from address Ai, as follows:

$$A_i = 2^m \times \left(\left(\frac{i}{2}\right) mod(J)\right) + BRO_m\left(int\left(\frac{\left(\frac{i}{2}\right)}{J}\right)\right)$$

where i = 0, 2,4, ... , N-2; int(x) indicates the largest integer ≤ x; and BROm(y) indicates the bit-reversed m-bit value of y (for example, BRO3(6) = 3).
The odd interleaved symbols (i is odd) are read out in permutated order from address Ai, as follows:

$$A_i = 2^m \times \left(\left(N - \frac{i+1}{2}\right) mod(J)\right) + BRO_m\left(int\left(\frac{\left(N - \frac{i+1}{2}\right)}{J}\right)\right)$$

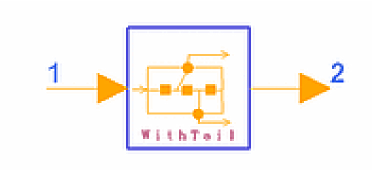
where i = 1,3, ... , N-1; int(x) indicates the largest integer ≤ x; and BROm(y) indicates the bit-reversed m-bit value of y (for example, BRO3(6) = 3).
Forward link interleaver parameters m and J are given in *Forward Link Interleaver Parameters*; reverse link interleaver parameters m and J are given in *Reverse Link Interleaver Parameters*.

Interleaver Size	m	J
48	4	3
96	5	3
192	6	3
384	6	6
768	6	12
1,536	6	24
3,072	6	48
6,144	7	48
12,288	7	96
144	4	9
288	5	9
576	5	18
1,152	6	18
2,304	6	36
4,608	7	36
9,216	7	72
18,432	8	72
36,864	8	144
128	7	1
Interleaver Size	**m**	**J**
384	6	6
768	6	12
1,536	6	24
3,072	6	48
6,144	7	48
12,288	7	96
576	5	18
2,304	6	36
4,608	7	36
9,216	7	72
18,432	8	72

References

1. TIA/EIA/IS-2000.2 (PN-4428), Physical Layer Standard for cdma2000 Spread Spectrum Systems, July 1999.

CDMA2K_CC_WithTail



Description Convolutional encoder with tail
Library cdma2000, Channel Coding
Class SDFCDMA2K_CC_WithTail
Derived From CDMA2K_CnvlCoder

Parameters

Name	Description	Default	Type	Range
ModeSelect	mode for setting parameters: Choose CCType from list, User defined	Choose CCType from list	enum	
CCType	convolutional code type; used when ModeSelect=Choose CCType from list: rate 1/2 K 9 g0 0753 g1 0561, rate 1/3 K 9 g0 0557 g1 0663 g2 0711, rate 1/4 K 9 g0 0765 g1 0671 g2 0513 g3 0473, rate 1/6 K 9 g0 0457 g1 0755 g2 0551 g3 0637 g4 0625 g5_0727	rate 1/2 K 9 g0 0753 g1 0561	enum	
ConstraintLength	constraint length of convolutional code; use when ModeSelect=User defined	9	int	
Polynomial	generator polynomial	0753 0561	int array	
InputFrameLen	input frame length	96	int	[K, ∞)

Pin Inputs

Pin	Name	Description	Signal Type
1	D_in	input data with enough tail bits	int

Pin Outputs

Pin	Name	Description	Signal Type
2	D_out	output encoded data	int

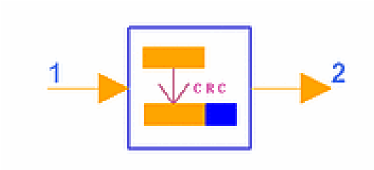
Notes/Equations

1. This model is used to convolutional encode frame by frame; each frame must have at least K-1 tail bits.
   Each firing, if ModeSelect is
   - *Choose CCType from list*, 1/rate (specified by CCType) × InputFrameLen output tokens are produced when InputFrameLen input tokens are consumed.
   - *User defined*, user input N generator functions, N × InputFrameLen output tokens are produced when InputFrameLen input tokens are consumed.

References

1. TIA/EIA/IS-2000.2 (PN-4428), Physical Layer Standard for cdma2000 Spread Spectrum Systems, July 1999.

CDMA2K_CRC_Coder



Description CRC generator
Library cdma2000, Channel Coding
Class SDFCDMA2K_CRC_Coder

Parameters

Name	Description	Default	Type	Range
InputFrameLen	input frame length	172	int	[1, ∞)
ModeSelect	mode for setting parameters: Choose CRCType from list, User defined	Choose CRCType from list	enum	
CRCType	CRC generator polynomial; use when ModeSelect=Choose CRCType from list: CRC16 0x1c867, CRC12 0x1f13, CRC10 0x7d9, CRC8 0x19b, CRC6 0x47, CRC6 0x67	CRC12 0x1f13	enum	
InitialState	initial state of encoder(use when ModeSelect=User defined): all 1's, all 0's	all 1's	enum	
Polynomial	generator polynomial in hex format; used when ModeSelect=User defined	0x1f13	int	(2, ∞)

Pin Inputs

Pin	Name	Description	Signal Type
1	D_in	input data	int

Pin Outputs

Pin	Name	Description	Signal Type
2	D_out	output data	int

Notes/Equations

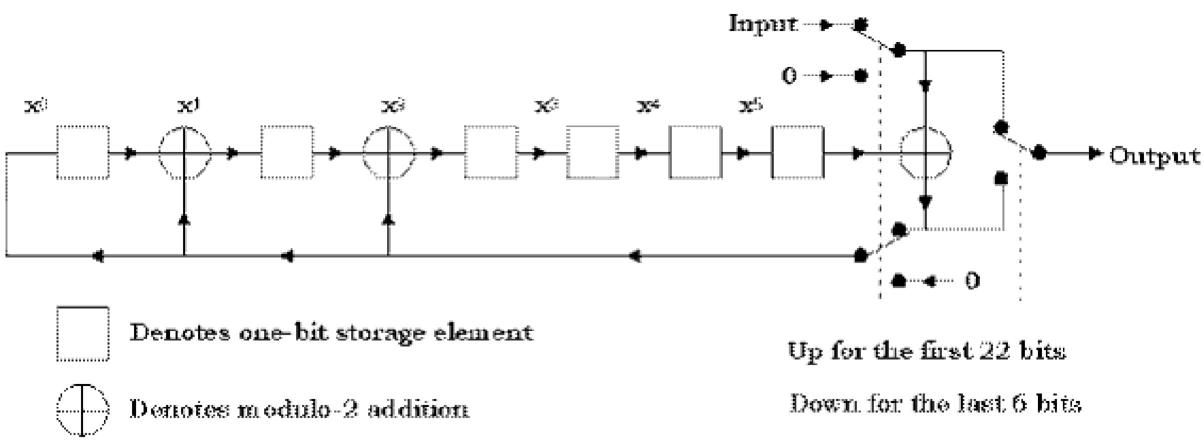
1. This model is used to add CRC bits after the input frames.
   Each firing, (InputFrameLen + CRCLength) tokens are produced when InputFrameLen tokens are consumed. CRCLength is the length of CRC bits added after the input frame.
2. A frame quality indicator is used in many channels. The frame quality indicator (CRC) is calculated on all bits within the frame, except the frame quality indicator itself and the encoder tail bits.
   - The generator polynomials for the frame quality indicator are:
     - g(x) = x16 + x15 + x14 + x11 + x6 + x5 + x2 + x + 1 for the 16-bit frame quality indicator, where g(x) = 0x1c867 (hex format)
     - g(x) = x12 + x11 + x10 + x9 + x8 + x4 + x + 1 for the 12-bit frame quality indicator, where g(x) = 0x1f13 (hex format)
     - g(x) = x10 + x9 + x8 + x7 + x6 + x4 + x3 + 1 for the 10-bit frame quality

indicator, where g(x) = 0x7d9 (hex format)

- g(x) = x8 + x7 + x4 + x3 + x + 1 for the 8-bit frame quality indicator, where g(x) = 0x19b (hex format)
- g(x) = x6 + x2 + x + 1(g(x) = 0x47) for the 6-bit frame quality indicator (RC = 2)
- g(x) = x6 + x5 + x2 + x + 1(g(x)= 0x67) for the 6-bit frame quality indicator (2 ≤ RC ≤ 9)

- The frame quality indicators are calculated according to the following procedure using the logic shown in the following figure (here g(x) = x6 + x2 + x + 1 used as example)
  - Initially, all shift register elements are set to logical one and the switches are set in the up position.
  - The register is clocked a number of times equal to the number of reserved and information bits in the frame with those bits as input.
  - The switches are set in the down position so that the output is a modulo-2 addition with a 0 and the successive shift register inputs are 0.
  - The register is clocked an additional number of times equal to the number of bits in the frame quality indicator (16, 12, 10, 8, or 6).

3. To set generation functions, CRC code length, and the initial states of CRC encoder, set ModeSelect to *User defined* ; then the parameters of InitialState and Polynomial are valid. CRC code length (n) is determined by Polynomial, where 2n ≤ Polynomial ≤ 2n+1.

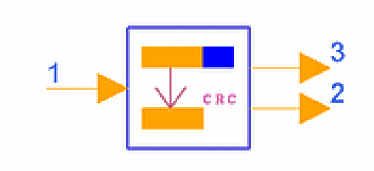


Frame Quality Indicator Calculation

References

1. TIA/EIA/IS-2000.2 (PN-4428), Physical Layer Standard for cdma2000 Spread Spectrum Systems, July 1999.

CDMA2K_CRC_DeCoder



Description CRC bit eraser with frame quality check
Library cdma2000, Channel Coding
Class SDFCDMA2K_CRC_DeCoder

Parameters

Name	Description	Default	Type	Range
InputFrameLen	input frame length	184	int	[1, ∞)
ModeSelect	mode for setting parameters: Choose CRCType from list, User defined	Choose CRCType from list	enum	
CRCType	CRC generator polynomial; use when ModeSelect=Choose CRCType from list: CRC16 0x1c867, CRC12 0x1f13, CRC10 0x7d9, CRC8 0x19b, CRC6 0x47, CRC6 0x67	CRC12 0x1f13	enum	
InitialState	initial state of encoder(use when ModeSelect=User defined): all 1's, all 0's	all 1's	enum	
Polynomial	generator polynomial in hex format; used when ModeSelect=User defined	0x1f13	int	(2, ∞)

Pin Inputs

Pin	Name	Description	Signal Type
1	D_in	input data	int

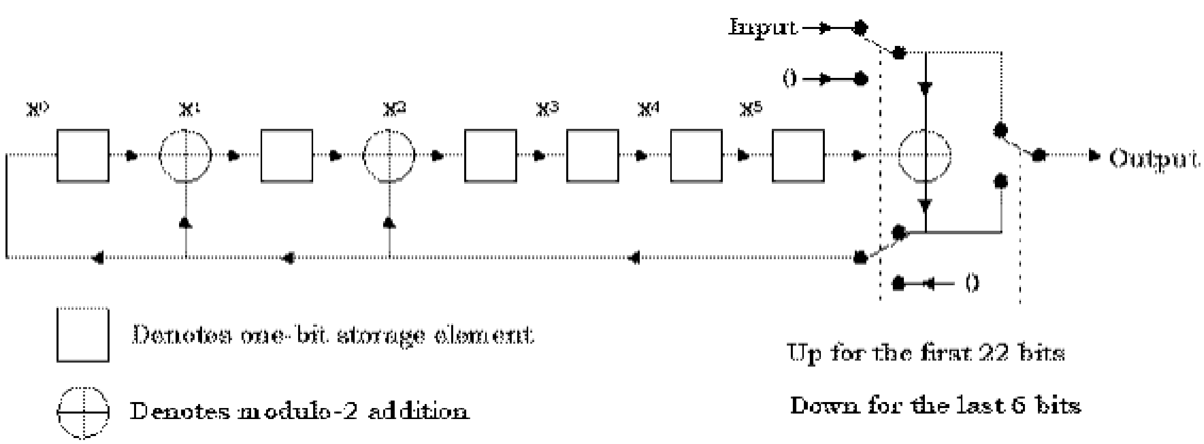
Pin Outputs

Pin	Name	Description	Signal Type
2	D_out	output data	int
3	FrmErr	quality indicator of output frame; 1 denotes frame error	int

Notes/Equations

1. This model is used to erase CRC bits from the input frame and check the quality of the input frame.
   Each firing, (InputFrameLen − CRCLength) D_out tokens and one FrmErr token are produced when InputFrameLen D_in tokens are consumed. CRCLength is the length of CRC bits in the input frame.
2. A frame quality indicator (a CRC) is used in many channels. This model calculates the frame quality indicator bits of the input frame (not including received CRC bits) and compares them with the received CRC bits. If they are the same, the frame is good and FrmErr output is 0; if it is a bad frame the FrmErr output is 1.
   - Generator polynomials for the frame quality indicator are:
     - g(x) = x16 + x15 + x14 + x11 + x6 + x5 + x2 + x + 1 for the 16-bit

frame quality indicator, where g(x) = 0x1c867 (hex format)
    - g(x) = x12 +x11 + x10 + x9 + x8 + x4 + x + 1 for the 12-bit frame quality indicator, where g(x) = 0x1f13 (hex format)
    - g(x) = x10 + x9 + x8 + x7 + x6 + x4 + x3 + 1 for the 10-bit frame quality indicator, where g(x) = 0x7d9 (hex format)
    - g(x) = x8 + x7 + x4 + x3 + x + 1 for the 8-bit frame quality indicator, where g(x) = 0x19b (hex format)
    - g(x) = x6 + x2 + x + 1(g(x) = 0x47) for the 6-bit frame quality indicator (RC = 2)
    - g(x) = x6 + x5 + x2 + x + 1(g(x) = 0x67) for the 6-bit frame quality indicator (2 ≤ RC ≤ 9)
  - The frame quality indicators are calculated according to the following procedure using the logic shown in the following figure (here g(x) = x6 + x2 + x + 1 is used).
    - Initially, all shift register elements are set to logical one and the switches are set in the up position.
    - The register is clocked a number of times equal to the number of reserved and information bits in the frame with those bits as input.
    - The switches are set in the down position so that the output is a modulo-2 addition with a 0 and successive shift register inputs are 0.
    - The register is clocked an additional number of times equal to the number of bits in the frame quality indicator (16, 12, 10, 8, or 6). These additional bits are the frame quality indicator bits.
3. To set generation functions, CRC code length, and the initial states of CRC encoder, set ModeSelect to *User defined* and the values of InitialState and Polynomial are valid. CRC code length (n) is determined by Polynomial, where 2n ≤ Polynomial ≤ 2n+1.

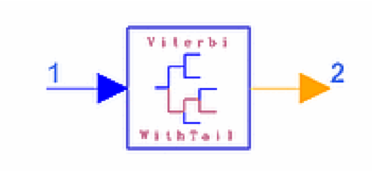


Frame Quality Indicator Calculation

References

1. TIA/EIA/IS-2000.2 (PN-4428), Physical Layer Standard for cdma2000 Spread Spectrum Systems, July 1999.

CDMA2K_DCC_WithTail



Description Viterbi decoder for convolutional code with tail
Library cdma2000, Channel Coding
Class SDFCDMA2K_DCC_WithTail
Derived From CDMA2K_ViterbiDecoder

Parameters

Name	Description	Default	Type	Range
ModeSelect	mode for setting parameters: Choose CCType from list, User defined	Choose CCType from list	enum	
CCType	convolutional code type; used when ModeSelect=Choose CCType from list: rate 1/2 K 9 g0 0753 g1 0561, rate 1/3 K 9 g0 0557 g1 0663 g2 0711, rate 1/4 K 9 g0 0765 g1 0671 g2 0513 g3 0473, rate 1/6 K 9 g0 0457 g1 0755 g2 0551 g3 0637 g4 0625 g5_0727	rate 1/2 K 9 g0 0753 g1 0561	enum	
ConstraintLength	constraint length of convolutional code; use when ModeSelect=User defined	9	int	
Polynomial	generator polynomial	0753 0561	int array	
OutputFrameLen	output frame length	96	int	[K, ∞)

Pin Inputs

Pin	Name	Description	Signal Type
1	D_in	input data	real

Pin Outputs

Pin	Name	Description	Signal Type
2	D_out	output decoded bits	int

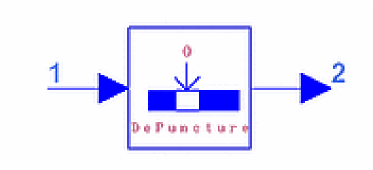
Notes/Equations

1. This model is used to decode the convolutional code frame by frame. The decoded frames are assumed to have K−1 tail bits.
   Each firing, if ModeSelect is
   - *Choose CCType from list*, OutputFrameLen tokens are produced when OutputFrameLen/rate input tokens are consumed
   - *User defined*, user input N generator functions, OutputFrameLen tokens are produced when OutputFrameLen×N tokens are consumed.

References

1. TIA/EIA/IS-2000.2 (PN-4428), Physical Layer Standard for cdma2000 Spread Spectrum Systems, July 1999.

CDMA2K_DePuncture



Description Zero inserter for de-punctured input stream
Library cdma2000, Channel Coding
Class SDFCDMA2K_DePuncture

Parameters

Name	Description	Default	Type	Range
ModeSelect	mode for setting parameters: Choose PuncturePattern from list, User defined	Choose PuncturePattern from list	enum	
PuncturePattern	puncture pattern; used when ModeSelect=Choose PuncturePattern from list: P 0, P 2 of 6 110101, P 1 of 5 11110, P 1 of 9 111111110, P 4 of 12 110110011011, P 2 of 18 111011111111111110, P 8 of 24 111010111011101011101010	P 2 of 6 110101	enum	
UserDefPattern	puncture pattern; used when ModeSelect=User defined	1 1 0 1 0 1	int array	0 or 1

Pin Inputs

Pin	Name	Description	Signal Type
1	D_in	input data	real

Pin Outputs

Pin	Name	Description	Signal Type
2	D_out	output data	real

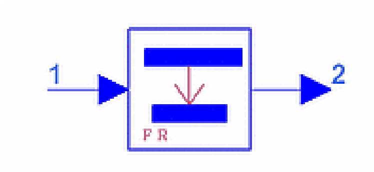
Notes/Equations

1. This model is used to depuncture symbols from the input frame for rate matching. Each firing, if ModeSelect is:
   - *Choose PuncturePattern from list* : if *P n of m 11, ... , 01* is selected, m D_out tokens are produced and (m-n) D_in tokens are consumed; if *P 0* is selected, puncturing will not be used, and 1 D_in token will be produced and 1 token will be consumed.
   - *User defined* , *UserDefPattern* is set as *11001, ... , 1* , and includes m bits and n 0s; then m D_out tokens are produced while (m-n) D_in tokens are consumed.

References

1. TIA/EIA/IS-2000.2 (PN-4428), Physical Layer Standard for cdma2000 Spread Spectrum Systems, July 1999.

CDMA2K_FR_RateDematch



Description Flexible and variable rate de-puncture and combine repeated bits
Library cdma2000, Channel Coding
Class SDFCDMA2K_FR_RateDematch

Parameters

Name	Description	Default	Type	Range
CodedFrmLen	number of specified encoded symbols per frame at encoder output	768	int	[1, 12288] for SR1;
AssignBitNumPerFrm	maximum assigned number of channel bits per frame after coding	768	int	[1, 12288] for SR1;
RadioConfig	radio configurations for forward and reverse link respectively: Forward RC3, Forward RC4, Forward RC5, Forward RC6, Forward RC7, Forward RC8, Forward RC9, Reverse RC3, Reverse RC4, Reverse RC5, Reverse RC6	Forward RC3	enum	
ChType	fundamental supplemental or dedicated control channel: FundamentalorSupplemental, DedicatedControl	FundamentalorSupplemental	enum	

Pin Inputs

Pin	Name	Description	Signal Type
1	D_in	input data	real

Pin Outputs

Pin	Name	Description	Signal Type
2	D_out	output data	real

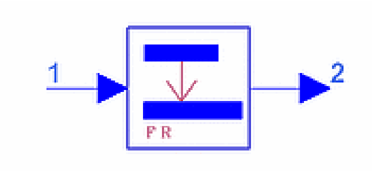
Notes/Equations

1. This model is used to de-match rates for fundamental, supplemental, or dedicated control channels in flexible rate situations. It depunctures the input symbols then averages the symbols for different interleaver sizes and data rates.

References

1. 3GPP2 C.S0002_A_1, "Physical Layer Standard for cdma2000 Spread Spectrum Systems Release A-Addendum 1," Oct. 27, 2000.

CDMA2K_FR_RateMatch



Description Flexible and variable rate repeat and puncture
Library cdma2000, Channel Coding
Class SDFCDMA2K_FR_RateMatch

Parameters

Name	Description	Default	Type	Range
CodedFrmLen	number of specified encoded symbols per frame at encoder output	768	int	[1, 12288] for SR1;
AssignBitNumPerFrm	maximum assigned number of channel bits per frame after coding	768	int	[1, 12288] for SR1;
RadioConfig	radio configurations for forward and reverse link respectively: Forward RC3, Forward RC4, Forward RC5, Forward RC6, Forward RC7, Forward RC8, Forward RC9, Reverse RC3, Reverse RC4, Reverse RC5, Reverse RC6	Forward RC3	enum	
ChType	fundamental supplemental or dedicated control channel: FundamentalorSupplemental, DedicatedControl	FundamentalorSupplemental	enum	

Pin Inputs

Pin	Name	Description	Signal Type
1	D_in	input data	real

Pin Outputs

Pin	Name	Description	Signal Type
2	D_out	output data	real

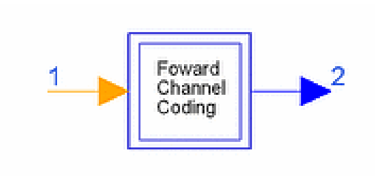
Notes/Equations

1. This model is used for flexible rate matching of fundamental, supplemental, or dedicated control channels. The input symbols are repeated and punctured for different interleaver sizes.
2. If the maximum assigned data rate matches one of the corresponding radio configuration data rates, the interleaver size for that data rate is used. Otherwise, the interleaver size of the next higher data rate is used.

References

1. 3GPP2 C.S0002_A_1, "Physical Layer Standard for cdma2000 Spread Spectrum Systems Release A-Addendum 1," Oct. 27, 2000.

CDMA2K_FwdChannelCoding



Description Forward link channel coding subnetwork
Library cdma2000, Channel Coding
Class SDFCDMA2K_FwdChannelCoding

Parameters

Name	Description	Default	Type	Range
DataRate	data rate in kbps	9.6	real	1.5, 2.7,4.8,9.6,19.2,38.4,76.8,153.6
RadioConfig	radio configuration for forward link respectively: Forward RC3, Forward RC4, Forward RC5	Forward RC3	enum	

Pin Inputs

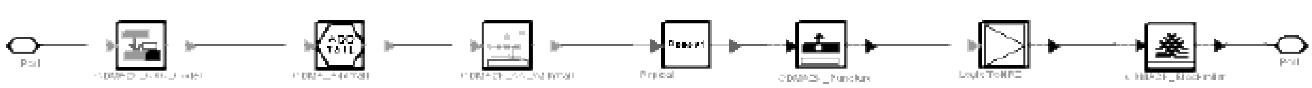
Pin	Name	Description	Signal Type
1	In	input data	int

Pin Outputs

Pin	Name	Description	Signal Type
2	Out	output data	real

Notes/Equations

1. This subnetwork performs forward channel coding. The schematic for this subnetwork is shown in the following figure.

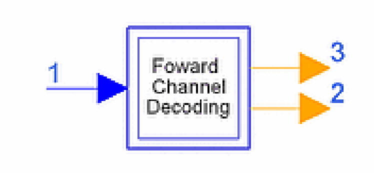


CDMA2K_FwdChannelCoding Subnetwork

References

1. 3GPP2 C.S0002_A_1, "Physical Layer Standard for cdma2000 Spread Spectrum Systems Release A-Addendum 1," Oct. 27, 2000

CDMA2K_FwdChannelDecoding



Description Forward link channel decoding subnetwork
Library cdma2000, Channel Coding
Class SDFCDMA2K_FwdChannelDecoding

Parameters

Name	Description	Default	Type	Range
DataRate	data rate in kbps	9.6	real	1.5, 2.7,4.8,9.6,19.2,38.4,76.8,153.6 for Forward RC3; 1.5,2.7,4.8,9.6,19.2,38.4,76.8,153.6,307.2 for Forward RC4; 1.8,3.6,7.2,14.4,28.8,57.6,115.2,230.4 for Forward RC5
RadioConfig	radio configuration for forward link: Forward RC3, Forward RC4, Forward RC5	Forward RC3	enum	

Pin Inputs

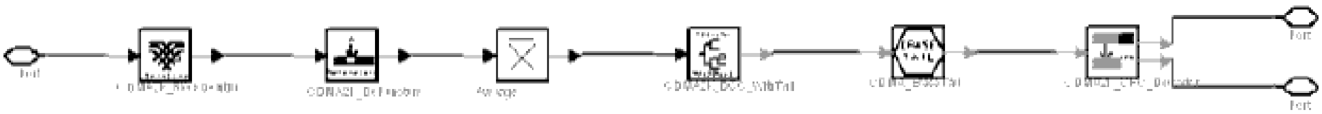
Pin	Name	Description	Signal Type
1	In	input data	real

Pin Outputs

Pin	Name	Description	Signal Type
2	Out	output data	int
3	QIB	quality indicator bits	int

Notes/Equations

1. This subnetwork performs forward channel decoding. The schematic for this subnetwork is shown in the following figure.

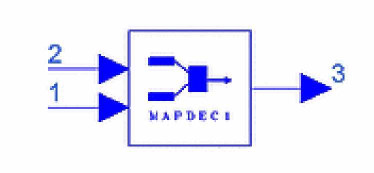


CDMA2K_FwdChannelDeCoding Subnetwork

References

1. 3GPP2 C.S0002_A_1, "Physical Layer Standard for cdma2000 Spread Spectrum Systems Release A-Addendum 1," Oct. 27, 2000

CDMA2K_MAPDecoder1



*

Description MAP decoder 1 for turbo decoder
Library cdma2000, Channel Coding
Class SDFCDMA2K_MAPDecoder1

Parameters

Name	Description	Default	Sym	Type	Range
BlockSize	number of particles in a block	378	L	int	(0, 65536]
ConstraintLength	constraint length of RSC encoder in turbo encoder	4	K	int	[3, 9]
Polynomial	generator polynomial	015 013 017		int array	

Pin Inputs

Pin	Name	Description	Signal Type
1	D_in	input data	real
2	InPri	input priori probability	real

Pin Outputs

Pin	Name	Description	Signal Type
3	Post	output a posteriori probability	real

Notes/Equations

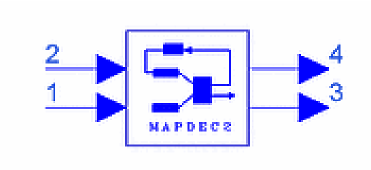
1. This model is used to decode turbo code with MAP algorithm (maximum a posterior). It is a modified BAHL et al. algorithm for RSC code. Two parallel concatenated MAP decoders are used. If the Polynomial has M components, then the turbo code rate will be 1/M.
   Each firing, L Post tokens are produced when L × M D_in tokens and M InPri tokens are consumed.

References

1. L. R. Bahl, J. Cocke, F. Jeinek and J. Raviv. "Optimal decoding of linear codes for minimizing symbol error rate," *IEEE Trans. Inform. Theory*, vol. IT-20. March 1974, pp. 248-287.

2. C. Berrou, A. Glavieux, and P. Thitiumjshima, "Near Shannon limit error correcting coding: Turbo codes," *IEEE International Conference on Communications*, May 1993, pp. 1064-1070.

CDMA2K_MAPDecoder2



Description MAP decoder 2 for turbo decoder
Library cdma2000, Channel Coding
Class SDFCDMA2K_MAPDecoder2

Parameters

Name	Description	Default	Sym	Type	Range
BlockSize	number of particles in a block	378	L	int	(0, 65536]
ConstraintLength	constraint length of RSC encoder in turbo encoder	4	K	int	[3, 9]
Polynomial	generator polynomial	015 013 017		int array	

Pin Inputs

Pin	Name	Description	Signal Type
1	Parity	input parity signal	real
2	InPri	input priori probability	real

Pin Outputs

Pin	Name	Description	Signal Type
3	Post	output a posterior probability	real
4	OutPri	output a priori probability to Decoder1	real

Notes/Equations

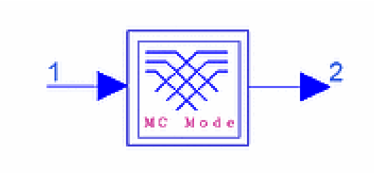
1. This model is used to decode turbo code with MAP algorithm (maximum a posteriori). It is a modified BAHL et al. algorithm for RSC codes. Two parallel concatenated MAP decoders constitute the decoder of turbo code. If Polynomial has M components, then the code rate of the component code of turbo code will be 1/M.
   Each firing, L Post tokens and L OutPri tokens are produced when $L \times (M - 1)$ Parity tokens and L InPri tokens are consumed.

References

1. L. R. Bahl, J. Cocke, F. Jeinek and J. Raviv. "Optimal decoding of linear codes for minimizing symbol error rate," *IEEE Trans. Inform. Theory*, vol. IT-20. March 1974, pp. 248-287.
2. C. Berrou, A. Glavieux, and P. Thitiumjshima, "Near Shannon limit error correcting

coding: Turbo codes," *IEEE International Conference on Communications*, May 1993, pp. 1064-1070.

CDMA2K_MCMode_DeIntlvr



Description Multi_Carrier Mode De-Interleaver
Library cdma2000, Channel Coding
Class SDFCDMA2K_MCMode_DeIntlvr

Parameters

Name	Description	Default	Sym	Type	Range
m	interleaver parameter 2^m *J = (1/3) input block size	4	m	int	[1, ∞)
J	interleaver parameter 2^m *J = (1/3) input block size	3	J	int	[1, ∞)

Pin Inputs

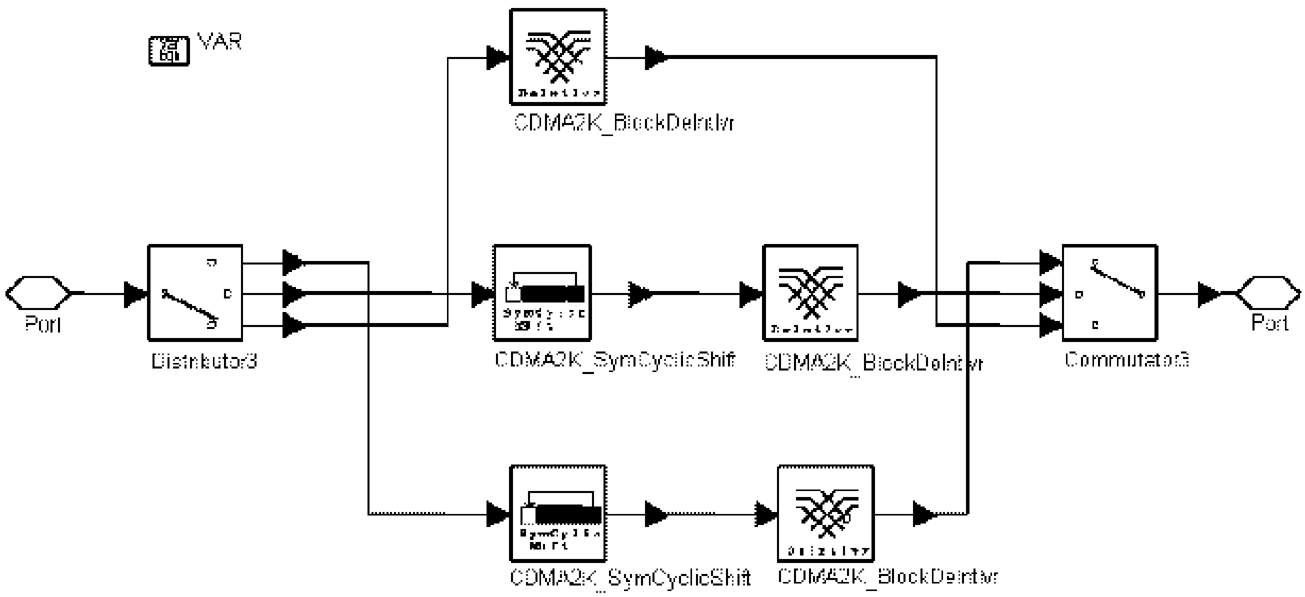
Pin	Name	Description	Signal Type
1	D_in	information symbols	real

Pin Outputs

Pin	Name	Description	Signal Type
2	D_out	de-interleaved symbols	real

Notes/Equations

1. This subnetwork is used to de-interleave the input symbols for forward link multi-carrier mode.
   3 × 2m × J D_out tokens are produced when 3 × 2m × J D_in tokens are consumed.
   This de-interleaving process is the reverse of the process used for CDMA2K_MCMode_Intlvr.
   The following figure shows the schematic for this subnetwork.

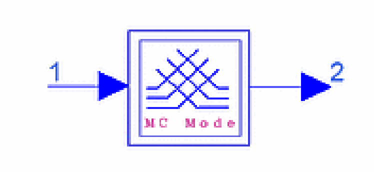


CDMA2K_MCMode_DeIntlvr Subnetwork

References

1. TIA/EIA/IS-2000.2 (PN-4428), Physical Layer Standard for cdma2000 Spread Spectrum Systems, July 1999.

CDMA2K_MCMode_Intlvr



Description Multi_Carrier Mode Interleaver
Library cdma2000, Channel Coding
Class SDFCDMA2K_MCMode_Intlvr

Parameters

Name	Description	Default	Sym	Type	Range
m	interleaver parameter 2m*J = (1/3) input block size	4	m	int	[1, ∞)
J	interleaver parameter 2m*J = (1/3) input block size	3	J	int	[1, ∞)

Pin Inputs

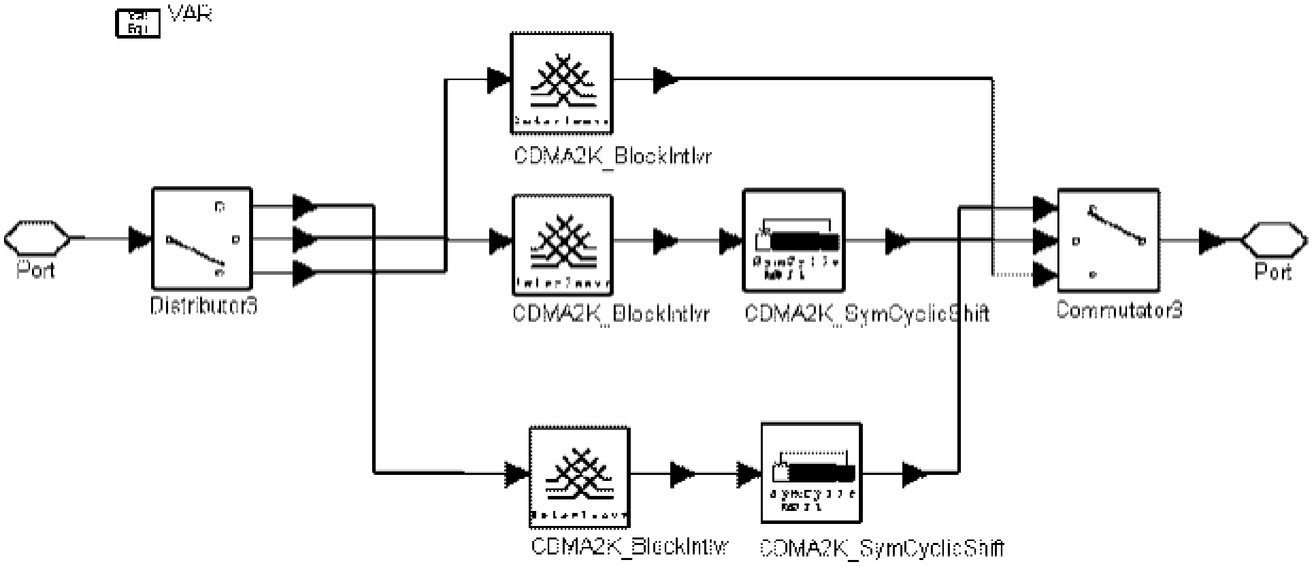
Pin	Name	Description	Signal Type
1	D_in	information symbols	real

Pin Outputs

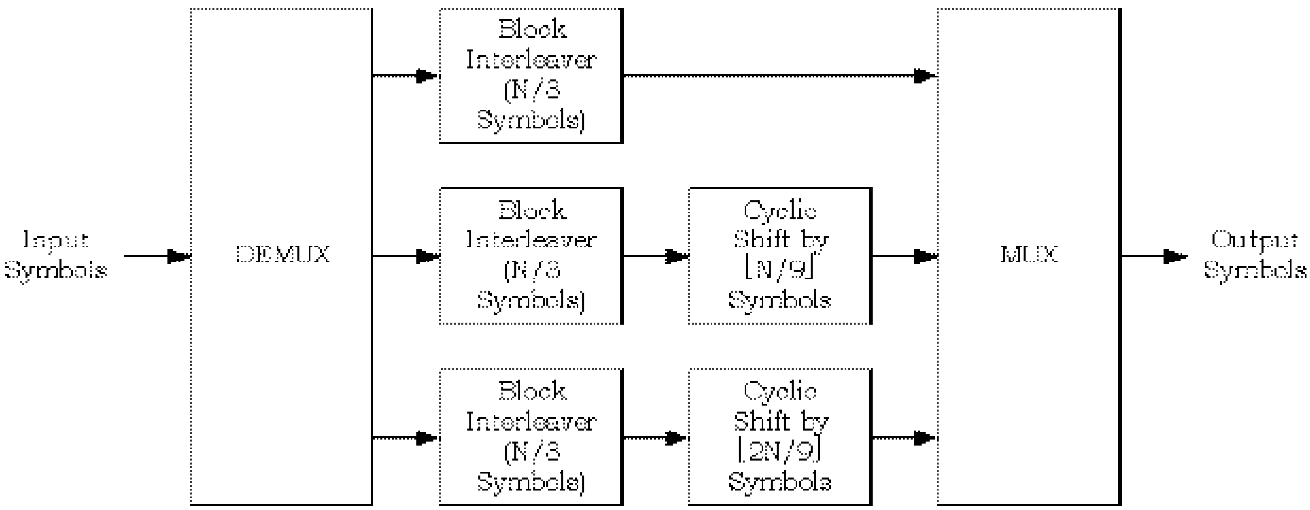
Pin	Name	Description	Signal Type
2	D_out	de-interleaved symbols	real

Notes/Equations

1. This subnetwork is used to interleave the input symbols for forward link multi-carrier (MC) mode.
   3 × 2m × J D_out tokens are produced when 3 × 2m × J D_in tokens are consumed.
   CDMA2K_MCMode_Intlvr Subnetwork shows the schematic for this subnetwork.
2. Multi-Carrier Mode Interleaver shows the structure of the interleaver. When MC mode is used in the forward link, the block interleaver demultiplexes its input symbols into three blocks. Each block is interleaved by CDMA2K_BlockIntlvr. The second block is cyclically shifted forward by N/9 symbols; the third block is cyclically shifted forward by 2N/9 symbols and the three interleaved blocks are multiplexed. For the second interleaver the cyclic shift is done by moving the first 8N/9 symbols to the end of the block and the last N/9 symbols to the start of the block. Here N= 3 × 2m × J.



CDMA2K_MCMode_Intlvr Subnetwork

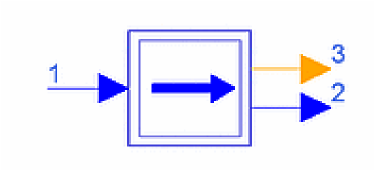


Multi-Carrier Mode Interleaver

References

1. TIA/EIA/IS-2000.2 (PN-4428), Physical Layer Standard for cdma2000 Spread Spectrum Systems, July 1999.

CDMA2K_OneWay



Description One Way Decoder with Constant Rate for Blind Detection
Library cdma2000, Channel Coding
Class SDFCDMA2K_OneWay

Parameters

Name	Description	Default	Type
RadioConfig	radio configuration: Fwd RC1, Fwd RC2, Fwd RC3, Fwd RC4, Fwd RC5, Fwd RC6, Fwd RC7, Fwd RC8, Fwd RC9, Rev RC3, Rev RC4, Rev RC5, Rev RC6	Fwd RC1	enum
DataRate	data rate: Full Rate, Half Rate, Rate1-4, Rate1-8	Full Rate	enum

Pin Inputs

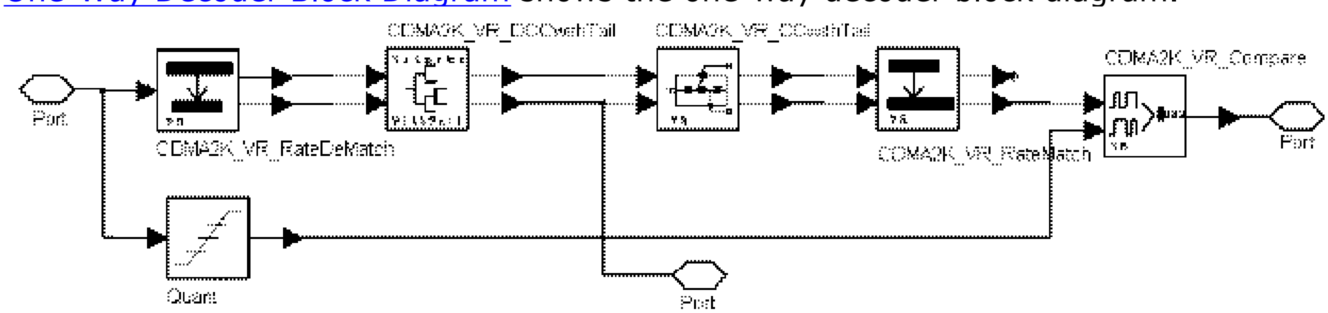
Pin	Name	Description	Signal Type
1	D_in	input data	real

Pin Outputs

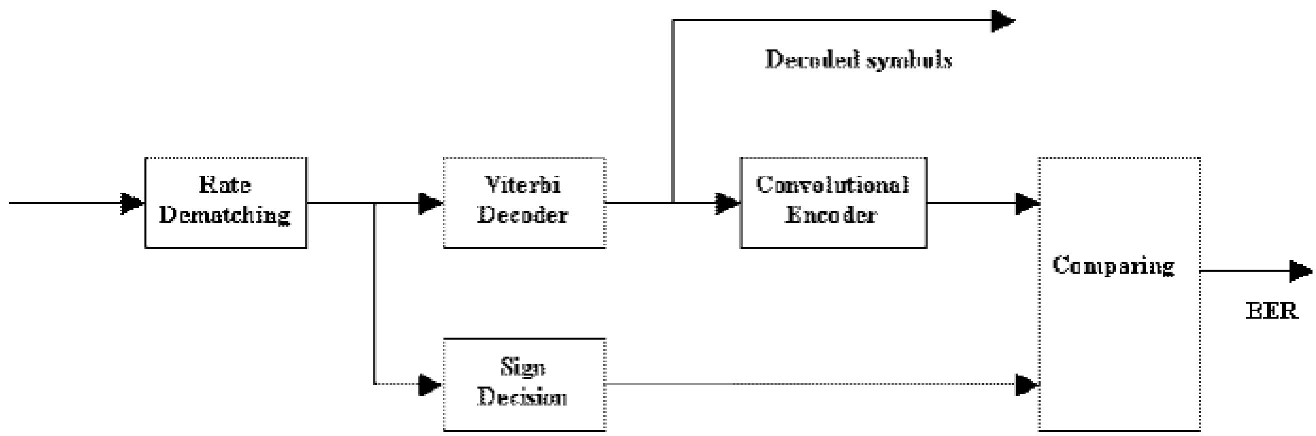
Pin	Name	Description	Signal Type
2	BER	error rate of this output frame	real
3	BitOut	decoded bits	int

Notes/Equations

1. This subnetwork is used to implement channel decoding according to the data rate and radio configuration specified. It includes averaging, depuncturing, Viterbi decoding, convolutional encoding, and BER measurement. CDMA2K_OneWay Subnetwork shows the schematic for this subnetwork.
2. Input data is from the Viterbi decoder with soft decision. Dematching and decoding are performed according to data rate; after decoding, data is encoded with the same code generator, and the results are compared with the data before decoding and BER is measured.
   One-Way Decoder Block Diagram shows the one-way decoder block diagram.



CDMA2K_OneWay Subnetwork

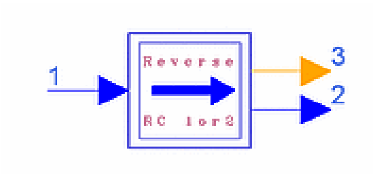


One-Way Decoder Block Diagram

References

1. TIA/EIA/IS-2000.2 (PN-4428), Physical Layer Standard for cdma2000 Spread Spectrum Systems, July 1999.

CDMA2K_OnewayRevRC1_2



Description One Way Decoder for Blind Decoder in Reverse Link RC1, RC2
Library cdma2000, Channel Coding
Class SDFCDMA2K_OnewayRevRC1_2

Parameters

Name	Description	Default	Type
RadioConfig	radio configuration: Rev RC1, Rev RC2	Rev RC1	enum
DataRate	data rate: Full Rate, Half Rate, Rate1_4, Rate1_8	Full Rate	enum

Pin Inputs

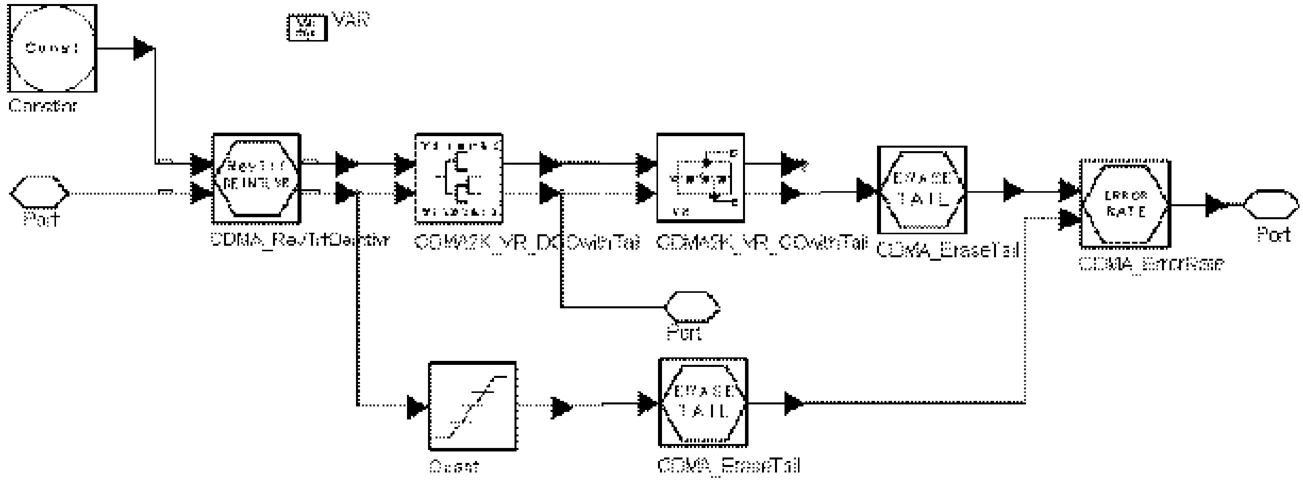
Pin	Name	Description	Signal Type
1	D_in	input data	real

Pin Outputs

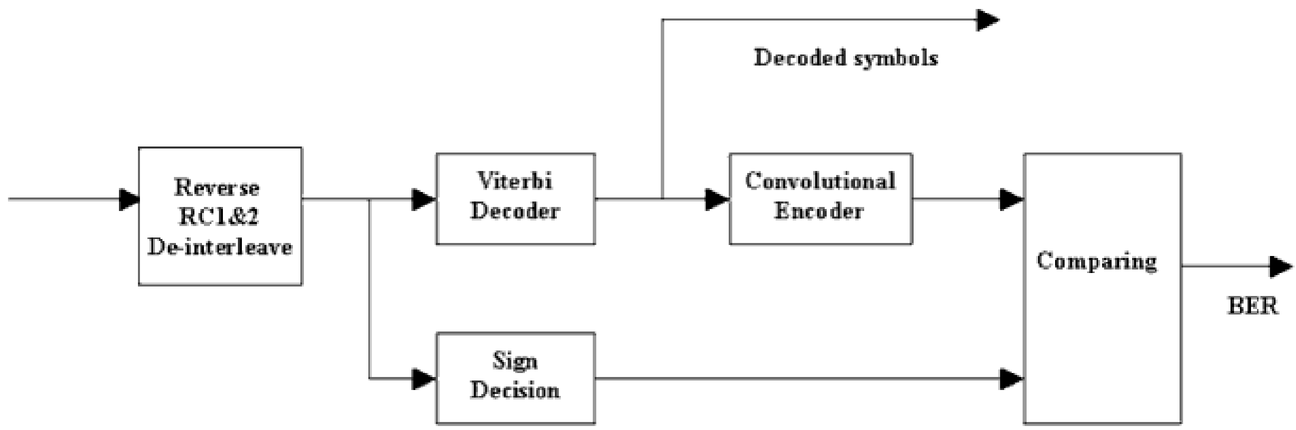
Pin	Name	Description	Signal Type
2	BER	error rate of this output frame	real
3	BitOut	decoded bits	int

Notes/Equations

1. This subnetwork is used to implement channel decoding for reverse RC1 or RC2. It includes Viterbi decoding, convolutional encoding, and BER measurement. CDMA2K_OnewayRevRC1_2 Structure shows the schematic for this subnetwork.
2. Input data is from the Viterbi decoder with soft decision. Rate dematching and decoding are performed according to data rate; after decoding data is encoded again with the same code generator; results are compared with the data before decoding and BER measurement.
   One-Way Decoder Block Diagram shows the one-way decoder block diagram.



CDMA2K_OnewayRevRC1_2 Structure

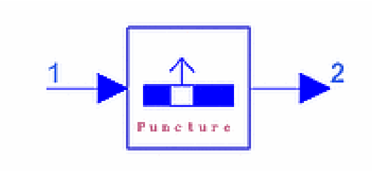


One-Way Decoder Block Diagram

References

1. TIA/EIA/IS-2000.2 (PN-4428), Physical Layer Standard for cdma2000 Spread Spectrum Systems, July 1999.

CDMA2K_Puncture



Description Symbol puncture for input stream
Library cdma2000, Channel Coding
Class SDFCDMA2K_Puncture

Parameters

Name	Description	Default	Type	Range
ModeSelect	mode for setting parameters: Choose PuncturePattern from list, User defined	Choose PuncturePattern from list	enum	
PuncturePattern	puncture pattern; used when ModeSelect=Choose PuncturePattern from list: P 2 of 6 110101, P 1 of 5 11110, P 1 of 9 111111110, P 4 of 12 110110011011, P 2 of 18 111011111111111110, P 8 of 24 111010111011101011101010	P 2 of 6 110101	enum	
UserDefPattern	puncture pattern; used when ModeSelect=User defined	1 1 0 1 0 1	int array	1 or 0

Pin Inputs

Pin	Name	Description	Signal Type
1	D_in	input data	real

Pin Outputs

Pin	Name	Description	Signal Type
2	D_out	output data	real

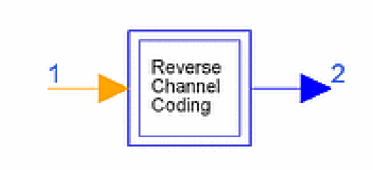
Notes/Equations

1. This model is used to puncture symbols from input frame for rate matching. Each firing, if ModeSelect is
   - *Choose PuncturePattern from list (P n of m 11, ..., 01* is selected) (m − n) D_out tokens are produced for m D_in tokens consumed.
   - *User defined*, UserDefPattern is set as *11001, ..., 1*, and includes m bits and n 0s. (m − n) D_out tokens are produced for m D_in tokens consumed.

References

1. TIA/EIA/IS-2000.2 (PN-4428), Physical Layer Standard for cdma2000 Spread Spectrum Systems, July 1999.

CDMA2K_RevChannelCoding



Description reverse link channel coding subnetwork
Library cdma2000, Channel Coding
Class SDFCDMA2K_RevChannelCoding

Parameters

Name	Description	Default	Type	Range
DataRate	data rate in kbps	9.6	real	1.5, 2.7,4.8,9.6,19.2,38.4,76.8,153.6,307.2 for Reverse RC3; 1.8,3.6,7.2,14.4,28.8,57.6,115.2,230.4 for Reverse RC4 1.5,2.7,4.8,9.6,19.2,38.4,76.8,153.6,307.2,614.4 for Reverse RC5; 1.8,3.6,7.2,14.4,28.8,57.6,115.2,230.4,460.8,1036.8 for Reverse RC6
RadioConfig	radio configuration for reverse link respectively: Reverse RC3, Reverse RC4, Reverse RC5, Reverse RC6	Reverse RC3	enum	

Pin Inputs

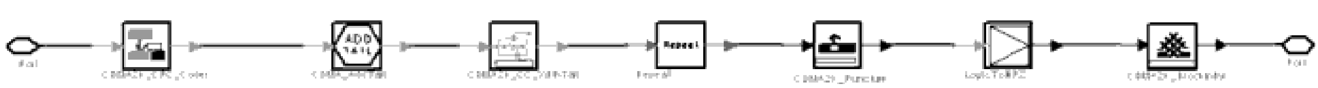
Pin	Name	Description	Signal Type
1	In	input data	int

Pin Outputs

Pin	Name	Description	Signal Type
2	Out	output data	complex

Notes/Equations

1. This subnetwork performs reverse channel coding. The schematic for this subnetwork is shown in the following figure.

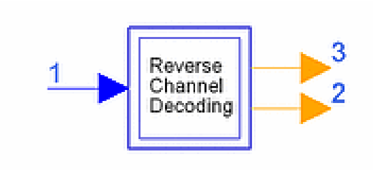


CDMA2K_RevChannelCoding Subnetwork

References

1. IS2000.2, "Physical Layer Standard for cdma2000 Spread Spectrum Systems," Nov., 1999.

CDMA2K_RevChannelDecoding



Description reverse link channel decoding subnetwork
Library cdma2000, Channel Coding
Class SDFCDMA2K_RevChannelDecoding

Parameters

Name	Description	Default	Type	Range
DataRate	data rate in kbps	9.6	real	1.5, 2.7,4.8,9.6,19.2,38.4,76.8,153.6,307.2 for Reverse RC3; 1.8,3.6,7.2,14.4,28.8,57.6,115.2,230.4 for Reverse RC4 1.5,2.7,4.8,9.6,19.2,38.4,76.8,153.6,307.2,614.4 for Reverse RC5; 1.8,3.6,7.2,14.4,28.8,57.6,115.2,230.4,460.8,1036.8 for Reverse RC6
RadioConfig	radio configuration for reverse link respectively: Reverse RC3, Reverse RC4, Reverse RC5, Reverse RC6	Reverse RC3	enum	

Pin Inputs

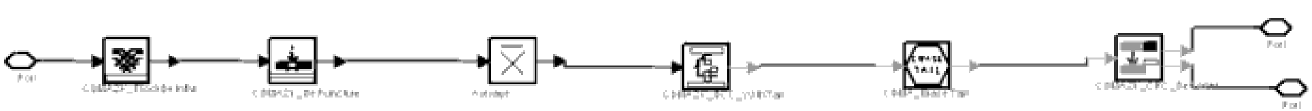
Pin	Name	Description	Signal Type
1	In	input data	real

Pin Outputs

Pin	Name	Description	Signal Type
2	Out	output data	int
3	QIB	quality indicator bits	int

Notes/Equations

1. This subnetwork performs perform reverse channel decoding. The schematic for this subnetwork is shown in the following figure.

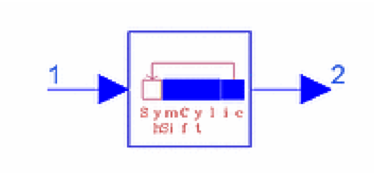


CDMA2K_RevChannelDeCoding Subnetwork

References

1. 3GPP2 C.S0002_A_1, "Physical Layer Standard for cdma2000 Spread Spectrum Systems Release A-Addendum 1," Oct. 27, 2000

CDMA2K_SymCyclicShift



Description Cyclic shifter for MC Mode interleaver
Library cdma2000, Channel Coding
Class SDFCDMA2K_SymCyclicShift

Parameters

Name	Description	Default	Type
BlockSize	number of particles in a block	576	int
CyclicFormat	cyclic shifter format	2 9	int array

Pin Inputs

Pin	Name	Description	Signal Type
1	D_in	input data	real

Pin Outputs

Pin	Name	Description	Signal Type
2	D_out	output data	real

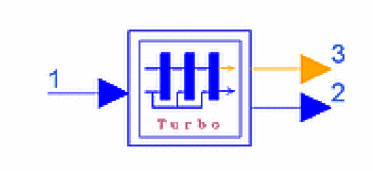
Notes/Equations

1. This model is used to cyclic shift symbols before interleaving by the multi-carrier mode interleaver.
   Each firing, BlockSize D_out tokens are produced when BlockSize D_in tokens are consumed.
2. If CyclicFormat is set as *n m*, the first (1− n/m) × BlockSize symbols are moved to the end of the block and the last n/m symbols are moved to the start of the block.

References

1. TIA/EIA/IS-2000.2 (PN-4428), Physical Layer Standard for cdma2000 Spread Spectrum Systems, July 1999.

CDMA2K_TurboDecoder



Description 4-Level Turbo Decoder
Library cdma2000, Channel Coding
Class SDFCDMA2K_TurboDecoder

Parameters

Name	Description	Default	Sym	Type	Range
OutputFrameLen	output frame length (not including 6 tail bits)	378	N	int	[256, ∞)
CodeRate	code rate of turbo encoder: rate 1/2, rate 1/3, rate 1/4	rate 1/2		enum	

Pin Inputs

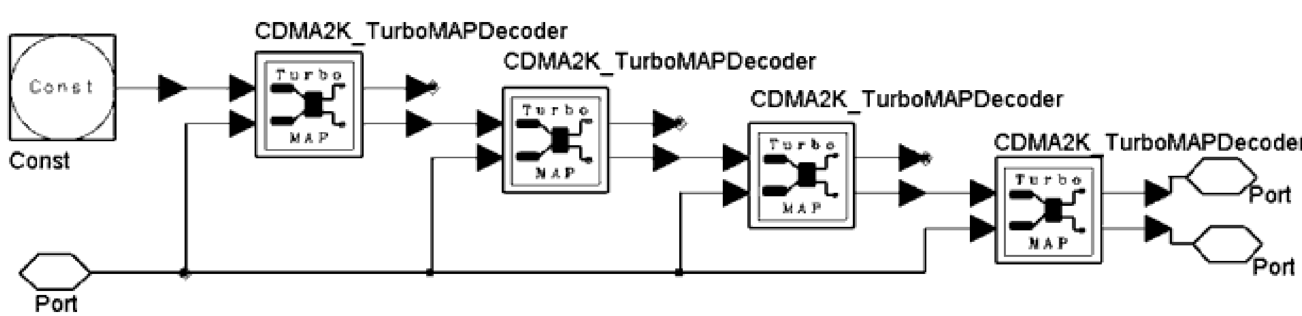
Pin	Name	Description	Signal Type
1	D_in	input data	real

Pin Outputs

Pin	Name	Description	Signal Type
2	PriOut	priori value for next decoder	real
3	BitOut	decoded bits	int

Notes/Equations

1. This subnetwork is used to implement 4-level iterative MAP decoding algorithm for turbo code.
   N PriOut and N BitOut tokens are produced when ((N + 6)/CodeRate) D_in tokens are consumed.
   The following figure shows the schematic for this subnetwork.

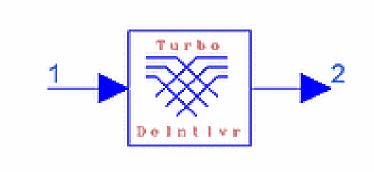


CDMA2K_TurboDecoder Subnetwork

References

1. L. R. Bahl, J. Cocke, F. Jeinek and J. Raviv. "Optimal decoding of linear codes for minimizing symbol error rate," *IEEE Trans. Inform. Theory*, vol. IT-20. March 1974, pp. 248-287.
2. C. Berrou, A. Glavieux, and P. Thitiumjshima, "Near Shannon limit error correcting coding: Turbo codes," *IEEE International Conference on Communications*, May 1993, pp. 1064-1070.
3. TIA/EIA/IS-2000.2 (PN-4428), Physical Layer Standard for cdma2000 Spread Spectrum Systems, July 1999.

CDMA2K_TurboDeIntlvr



Description De-interleaver for turbo code
Library cdma2000, Channel Coding
Class SDFCDMA2K_TurboDeIntlvr

Parameters

Name	Description	Default	Sym	Type	Range
BlockSize	number of particles in a block	378	Nturbo	int	[256, ∞)

Pin Inputs

Pin	Name	Description	Signal Type
1	D_in	input data	real

Pin Outputs

Pin	Name	Description	Signal Type
2	D_out	output data	real

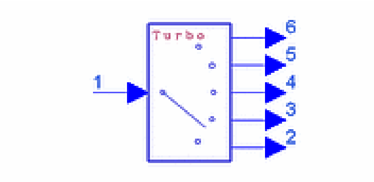
Notes/Equations

1. This model is used to de-interleave the input symbols for turbo code. Each firing, Nturbo output tokens are produced when Nturbo input tokens are consumed.
2. The turbo de-interleaver process is the reverse of that used in the CDMA2K_TurboIntlvr. Functionally, it is the same; the entire sequence of turbo interleaver input bits are written sequentially into an array at a sequence of addresses, and the entire sequence is read out from a sequence of addresses.

References

1. TIA/EIA/IS-2000.2 (PN-4428), Physical Layer Standard for cdma2000 Spread Spectrum Systems, July 1999.

CDMA2K_TurboDeMux



Description De-puncture and de-mux for turbo decoder
Library cdma2000, Channel Coding
Class SDFCDMA2K_TurboDeMux

Parameters

Name	Description	Default	Sym	Type	Range
BlockSize	number of particles in a block	768	N	int	[6/R, ∞)
CodeRate	code rate of turbo encoder: CodeRate1/2, CodeRate1/3, CodeRate1/4	CodeRate1/2	R	enum	

Pin Inputs

Pin	Name	Description	Signal Type
1	D_in	input data	real

Pin Outputs

Pin	Name	Description	Signal Type
2	C1_X	X output of decoder#1	real
3	C1_Y0	Y0 output of decoder#1	real
4	C1_Y1	Y1 output of decoder#1	real
5	C2_Y0	Y0 output of decoder#2	real
6	C2_Y1	Y1 output of decoder#2	real

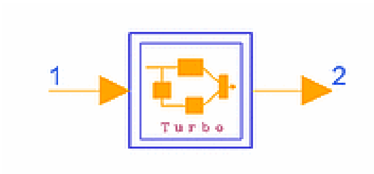
Notes/Equations

1. This model is used to demultiplex, depuncture or delete tail symbols for the turbo decoder.
   Each firing, $(N \times R - 6)$ output tokens are produced when N input tokens are consumed.
2. This model uses the reverse process described for CDMA2K_TurboMux, except 6 tail symbols are not included in each output symbol sequence. So the number of each output pin in each firing equals $(N \times R - 6)$.

References

1. TIA/EIA/IS-2000.2 (PN-4428), Physical Layer Standard for cdma2000 Spread Spectrum Systems, July 1999.

CDMA2K_TurboEncoder



Description Turbo Encoder
Library cdma2000, Channel Coding
Class SDFCDMA2K_TurboEncoder

Parameters

Name	Description	Default	Sym	Type	Range
InputFrameLen	input frame length including 6 tail bits	384	N	int	[262, ∞)
CodeRate	code rate of Turbo encoder: rate 1/2, rate 1/3, rate 1/4	rate 1/2		enum	

Pin Inputs

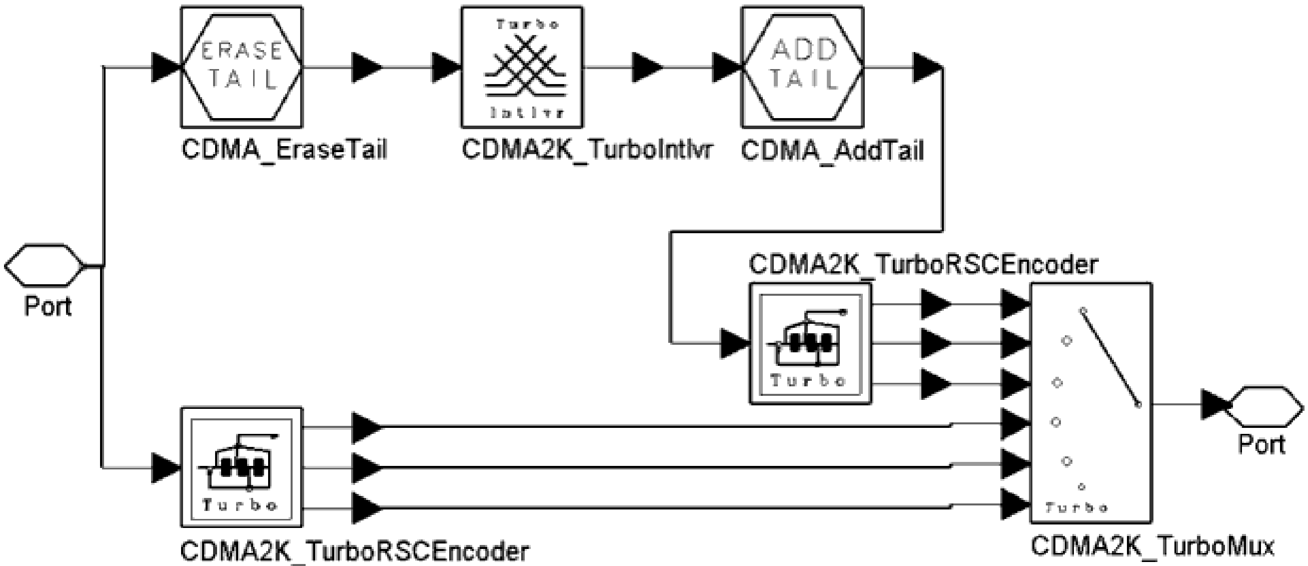
Pin	Name	Description	Signal Type
1	D_in	input data	int

Pin Outputs

Pin	Name	Description	Signal Type
2	D_Out	output data	int

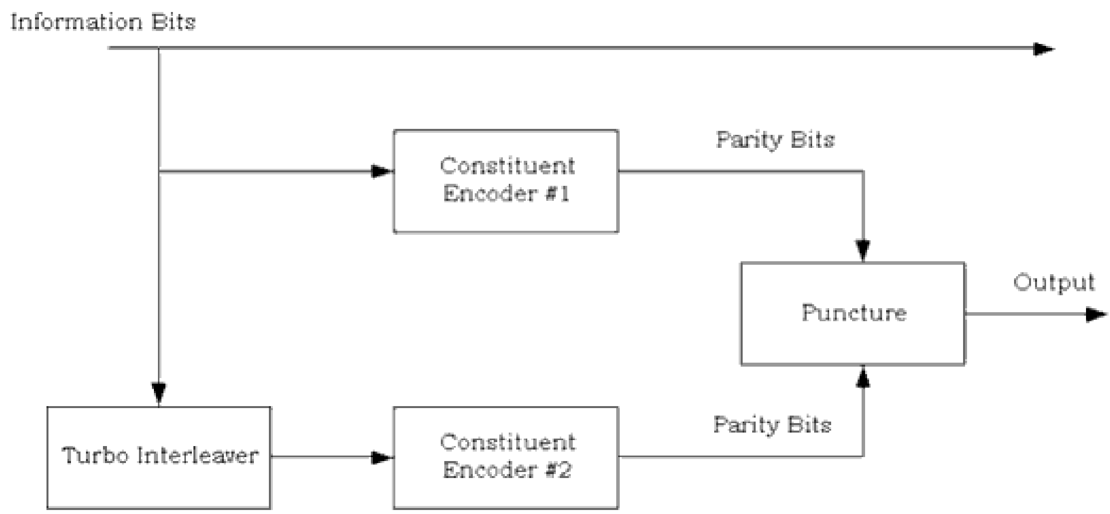
Notes/Equations

1. This subnetwork is a turbo encoder.
   (N/CodeRate) output tokens are produced when N input tokens are consumed.
   The following figure shows the schematic for this subnetwork.



CDMA2K_TurboEncoder Subnetwork

2. The turbo encoder uses two parallel concatenated RSC (recursive systematic convolutional) encoders with an interleaver before the second RSC encoder. The two recursive convolutional codes are named the constituent codes of the turbo code. The outputs of the constituent encoders are punctured and repeated to achieve the (Nturbo + 6)/R output symbols.
A common constituent code (RSC code) is used for turbo codes of rate 1/2, 1/3, and 1/4. The transfer function for the constituent code is
$$G(D) = [1, \frac{n_0(D)}{d(D)}, \frac{n_1(D)}{d(D)}, \frac{n_2(D)}{d(D)}]$$
where d(D) = 1 + D2 + D3, n0(D) = 1 + D + D3, and n1(D) = 1 + D + D2 + D3.
The turbo encoder generates an output symbol sequence that is shown in the following figure. Initially, the states of the constituent encoder registers are set to 0.

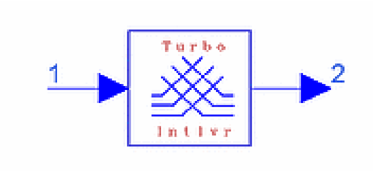


General Turbo Encoder

References

1. TIA/EIA/IS-2000.2 (PN-4428), Physical Layer Standard for cdma2000 Spread Spectrum Systems, July 1999.

CDMA2K_TurboIntlvr



Description Interleaver for turbo code
Library cdma2000, Channel Coding
Class SDFCDMA2K_TurboIntlvr

Parameters

Name	Description	Default	Sym	Type	Range
BlockSize	number of particles in a block	378	Nturbo	int	[256, ∞)

Pin Inputs

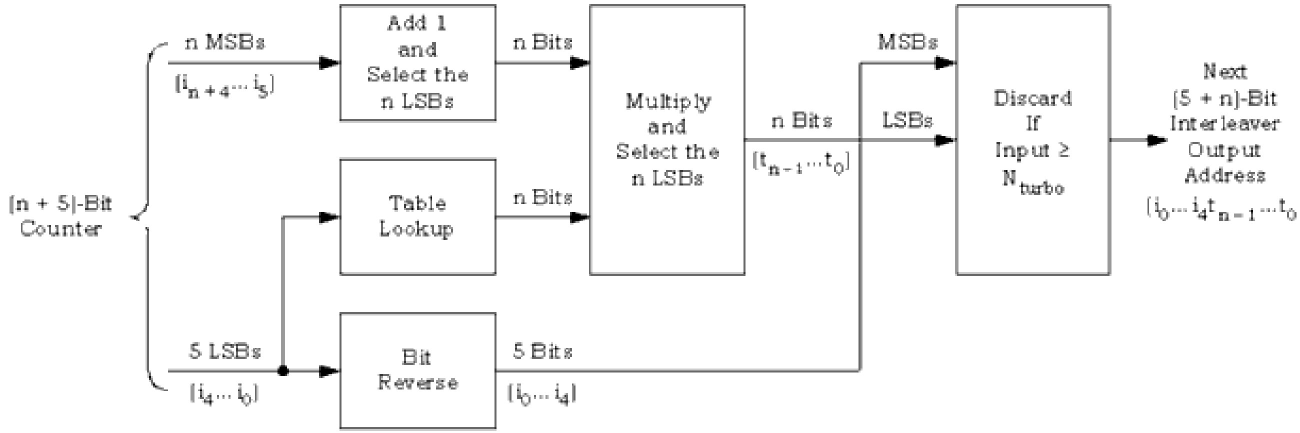
Pin	Name	Description	Signal Type
1	D_in	input data	real

Pin Outputs

Pin	Name	Description	Signal Type
2	D_out	output data	real

Notes/Equations

1. This model is used to interleave the input symbols for turbo code.
   Each firing, Nturbo output tokens are produced when Nturbo input tokens are consumed.
2. The entire sequence of turbo interleaver input bits are written sequentially into an array at a sequence of addresses; the entire sequence is then read out from a sequence of addresses that are defined as follows.
   Let the sequence of input addresses be from 0 to Nturbo - 1, where Nturbo is the number of symbols in the turbo interleaver. The sequence of interleaver output addresses must be equivalent to those generated by the following steps and illustrated in the following figure.



Turbo Interleaver Output Address Calculation

Step 1. Determine the turbo interleaver parameter n, where n is the smallest integer such that Nturbo ≤ 2^{n+5}. Refer to *Turbo Interleaver Parameters*.

Step 2. Initialize an (n + 5)-bit counter to 0.

Step 3. Extract the n most significant bits (MSBs) from the counter and add one to form a new value. Then, discard all except the n least significant bits (LSBs) of this value.

Step 4. Obtain the n-bit output of the lookup table (*Turbo Interleaver Lookup Table Definition*) with a read address equal to the five LSBs of the counter. (Note that this table depends on the value of n.)

Step 5. Multiply the values obtained in Steps 3 and 4, and discard all except the n LSBs.

Step 6. Bit-reverse the five LSBs of the counter.

Step 7. Form a tentative output address that has its MSBs equal to the value obtained in Step 6 and its LSBs equal to the value obtained in Step 5.

Step 8. Accept the tentative output address as an output address if it is less than Nturbo; otherwise, discard it.

Step 9. Increment the counter and repeat Steps 3 through 8 until all Nturbo interleaver output addresses are obtained.

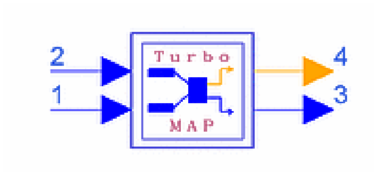
Turbo Interleaver Block Size Nturbo	Turbo Interleaver Parameter n
378	4
570	5
762	5
1,146	6
1,530	6
2,298	7
3,066	7
4,602	8
6,138	8
9,210	9
12,282	9
20,730	10

Table Index	n = 4	n = 5	n = 6	n = 7	n = 8	n = 9	n = 10
0	5	27	3	15	3	13	1
1	15	3	27	127	1	335	349
2	5	1	15	89	5	87	303
3	15	15	13	1	83	15	721
4	1	13	29	31	19	15	973
5	9	17	5	15	179	1	703
6	9	23	1	61	19	333	761
7	15	13	31	47	99	11	327
8	13	9	3	127	23	13	453
9	15	3	9	17	1	1	95
10	7	15	15	119	3	121	241
11	11	3	31	15	13	155	187
12	15	13	17	57	13	1	497
13	3	1	5	123	3	175	909
14	15	13	39	95	17	421	769
15	5	29	1	5	1	5	349
16	13	21	19	85	63	509	71
17	15	19	27	17	131	215	557
18	9	1	15	55	17	47	197
19	3	3	13	57	131	425	499
20	1	29	45	15	211	295	409
21	3	17	5	41	173	229	259
22	15	25	33	93	231	427	335
23	1	29	15	87	171	83	253
24	13	9	13	63	23	409	677
25	1	13	9	15	147	387	717
26	9	23	15	13	243	193	313
27	15	13	31	15	213	57	757
28	11	13	17	81	189	501	189
29	3	1	5	57	51	313	15
30	15	13	15	31	15	489	75
31	5	13	33	69	67	391	163

References

1. TIA/EIA/IS-2000.2 (PN-4428), Physical Layer Standard for cdma2000 Spread Spectrum Systems, July 1999.

CDMA2K_TurboMAPDecoder



Description MAP Decoder for Turbo Decoder
Library cdma2000, Channel Coding
Class SDFCDMA2K_TurboMAPDecoder

Parameters

Name	Description	Default	Sym	Type	Range
OutputFrameLen	output frame length (not including 6 tail bits)	378	N	int	[256, ∞)
CodeRate	code rate of turbo encoder: rate 1/2, rate 1/3, rate 1/4	rate 1/2	R	enum	

Pin Inputs

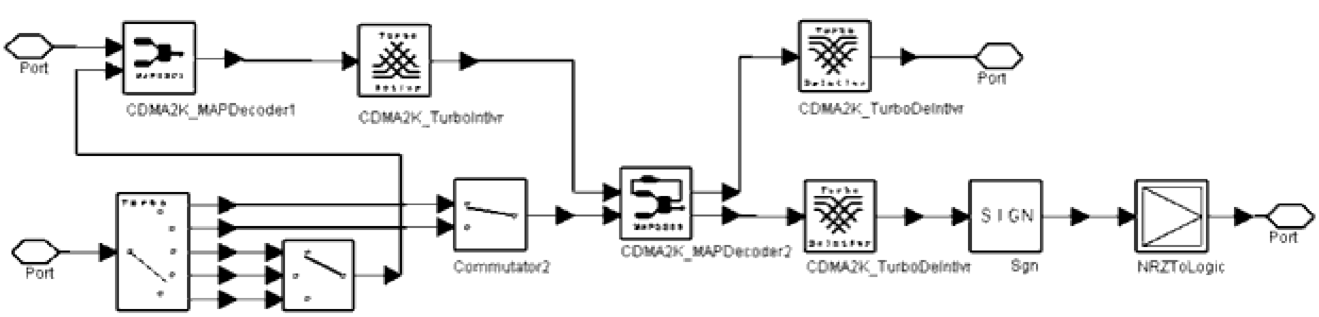
Pin	Name	Description	Signal Type
1	D_in	input data	real
2	PriIn	priori value	real

Pin Outputs

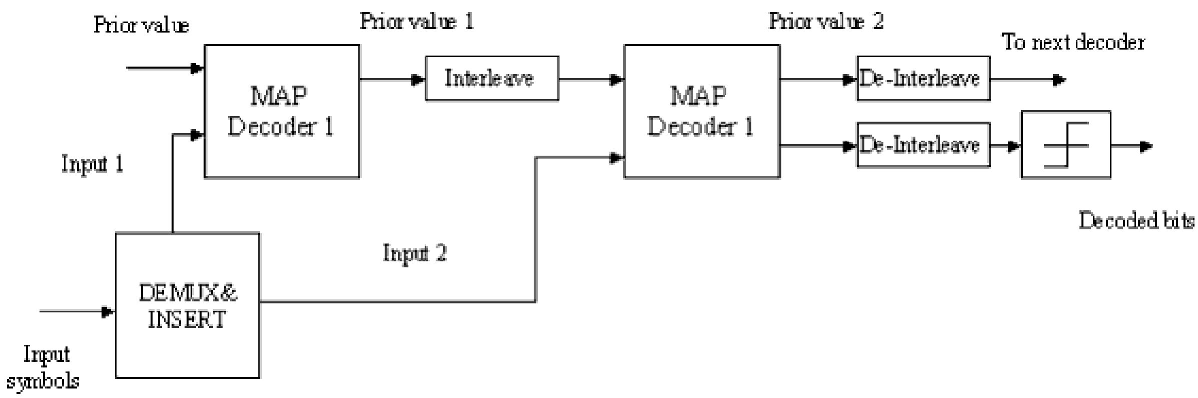
Pin	Name	Description	Signal Type
3	PriOut	priori value for next decoder	real
4	BitOut	decoded bits	int

Notes/Equations

1. This subnetwork is used to implement parallel concatenated MAP decoder for turbo code. It includes CDMA2K_MAPDecoder1, CDMA2K_MAPDecoder2, and Interleavers. The following figure shows the schematic for this subnetwork.
   N PriOut and N BitOut tokens are produced when ((N + 6)/R) D_in tokens and N PriIn tokens are consumed.
   Turbo Code Decoder (MAP) structure shows the turbo code decoder (MAP) structure.



CDMA2K_TurboMAPDecoder Subnetwork

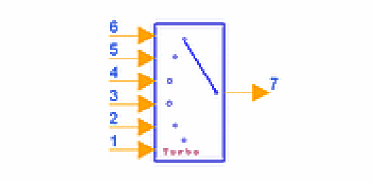


Turbo Code Decoder (MAP) structure

References

1. L. R. Bahl, J. Cocke, F. Jeinek and J. Raviv. "Optimal decoding of linear codes for minimizing symbol error rate," *IEEE Trans. Inform. Theory*, vol. IT-20. March 1974, pp. 248-287.
2. C. Berrou, A. Glavieux, and P. Thitiumjshima, "Near Shannon limit error correcting coding: Turbo codes," *IEEE International Conference on Communications*, May 1993, pp. 1064-1070.
3. TIA/EIA/IS-2000.2 (PN-4428), Physical Layer Standard for cdma2000 Spread Spectrum Systems, July 1999.

CDMA2K_TurboMux



Description Multiplexer for turbo code
Library cdma2000, Channel Coding
Class SDFCDMA2K_TurboMux

Parameters

Name	Description	Default	Sym	Type	Range
InputFrameLen	input frame length	384	N	int	[6/R, ∞)
CodeRate	code rate of turbo code: CodeRate1/2, CodeRate1/3, CodeRate1/4	CodeRate1/2	R	enum	

Pin Inputs

Pin	Name	Description	Signal Type
1	C1_X	X output of Encoder#1	int
2	C1_Y0	Y0 output of Encoder#1	int
3	C1_Y1	Y1 output of Encoder#1	int
4	C2_X	X output of Encoder#2	int
5	C2_Y0	Y0 output of Encoder#2	int
6	C2_Y1	Y1 output of Encoder#2	int

Pin Outputs

Pin	Name	Description	Signal Type
7	D_out	output data	int

Notes/Equations

1. This model is used to repeat, puncture, and multiplex the input symbols for turbo encoder.
   Each firing, N/R output tokens are produced when N of each input tokens are consumed.
2. The RSC encoder output symbol puncturing and repetition are specified in Puncturing Patterns for Data Bit Periods and Puncturing Patterns for Tail Bit Periods. Within a puncturing pattern, 0 means the symbol will be deleted and 1 means the symbol will be passed.
   For rate 1/2 turbo codes, the tail output symbols for each of the first three tail bit periods will be XY0, and the tail output symbols for each of the last three tail bit periods shall be X′Y′0.
   For rate 1/3 turbo codes, the tail output symbols for each of the first three tail bit periods will be XXY0, and the tail output symbols for each of the last three tail bit periods shall be X′X′Y′0.

For rate 1/4 turbo codes, the tail output symbols for each of the first three tail bit periods will be XXY0Y1, and the tail output symbols for each of the last three tail bit periods will be X′X′Y′0Y′.

Puncturing Patterns for Data Bit Periods

Output	Code Rate		
	1/2	**1/3**	**1/4**
X	11	11	11
Y0	10	11	11
Y1	00	00	10
X′	00	00	00
Y′0	01	11	01
Y′1	00	00	11
Note: For each rate, the puncturing table is read top to bottom, then left to right.			

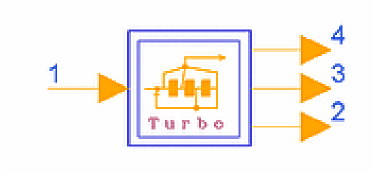
Puncturing Patterns for Tail Bit Periods

Output	Code Rate		
	1/2	**1/3**	**1/4**
X	111 000	111 000	111 000
Y0	111 000	111 000	111 000
Y1	000 000	000 000	111 000
X′	000 111	000 111	000 111
Y′0	000 111	000 111	000 111
Y′1	000 000	000 000	000 111
Note: For rate 1/2 turbo codes, the puncturing table will be read top to bottom, then left to right. For rate 1/3 and 1/4 turbo codes, the puncturing table will be read top to bottom repeating X and X′, then left to right.			

References

1. TIA/EIA/IS-2000.2 (PN-4428), Physical Layer Standard for cdma2000 Spread Spectrum Systems, July 1999.

CDMA2K_TurboRSCEncoder



Description RSC Encoder
Library cdma2000, Channel Coding
Class SDFCDMA2K_TurboRSCEncoder

Parameters

Name	Description	Default	Sym	Type	Range
InputFrameLen	input frame length including 6 tail bits	384	N	real	[7, ∞)

Pin Inputs

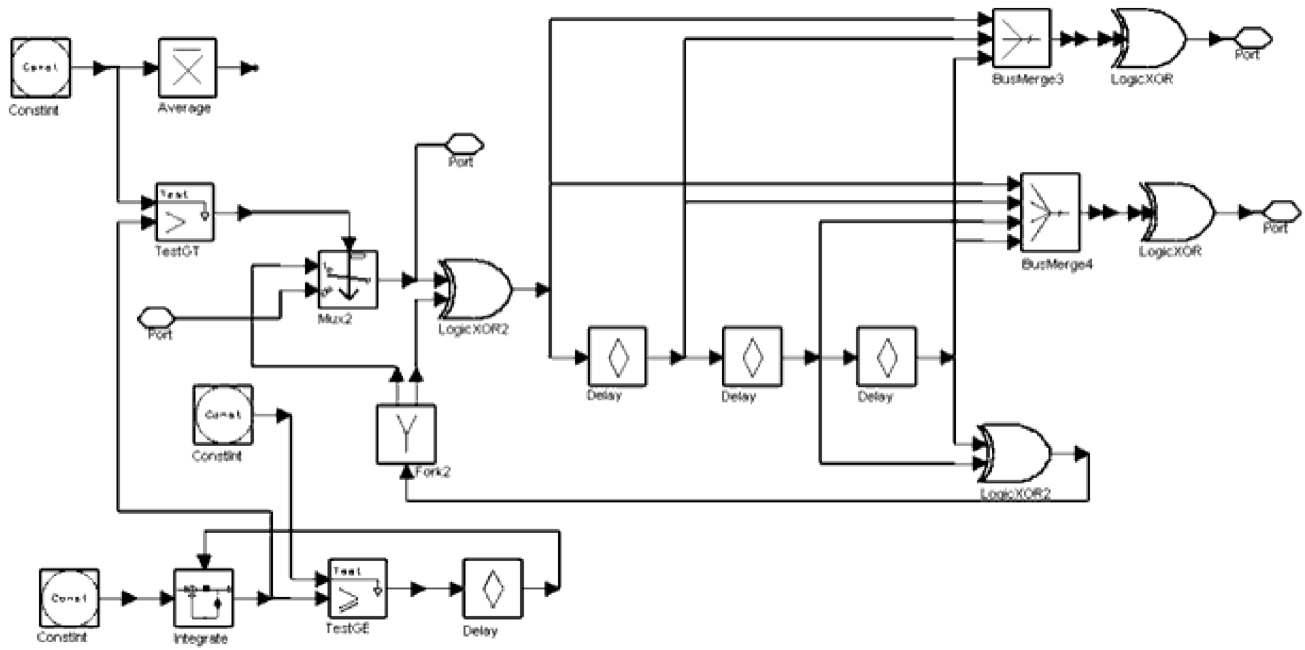
Pin	Name	Description	Signal Type
1	D_in	input data	int

Pin Outputs

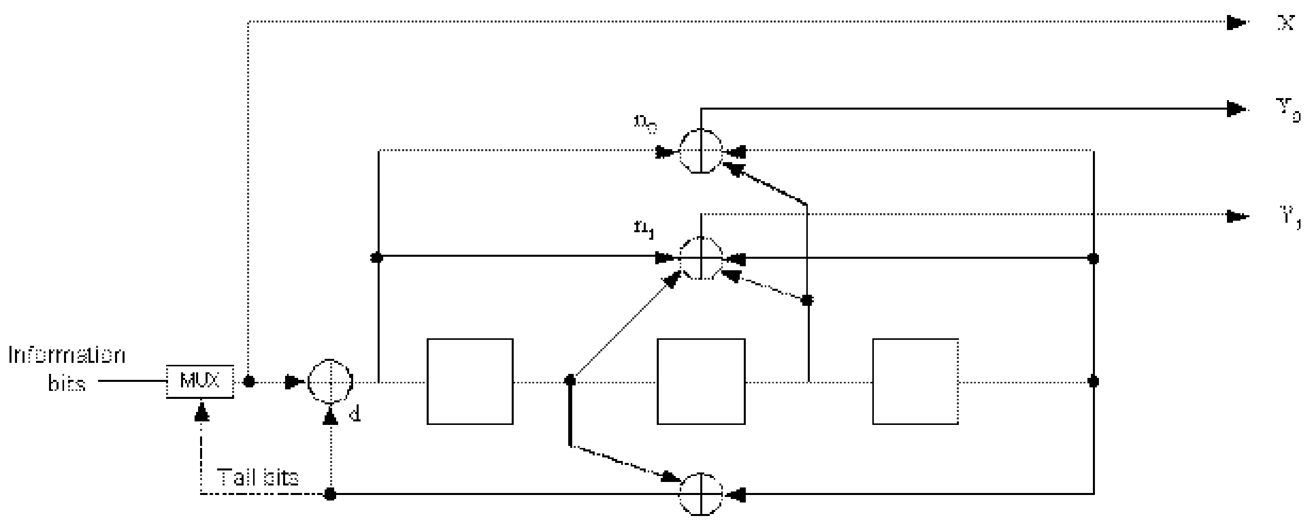
Pin	Name	Description	Signal Type
2	X_out	output data X	int
3	Y0_out	output data Y0	int
4	Y1_out	output data Y1	int

Notes/Equations

1. This subnetwork is used to implement the encoder for recursive systematic convolutional (RSC) code.
   N output tokens are produced when N input tokens are consumed.
   The following figure shows the schematic for this subnetwork.
2. The subnetwork is the constituent (RSC) encoder used in turbo encoder. The transfer function for the constituent code is
   $$G(D) = [1, \frac{n_0(D)}{d(D)}, \frac{n_1(D)}{d(D)}, \frac{n_2(D)}{d(D)}]$$
   where d(D) = 1 + D2 + D3, n0(D) = 1 + D + D3, and n1(D) = 1 + D + D2 + D3.
   The constituent encoder generates an output symbol sequence shown in Constituent Encoder. Initially, the states of the constituent encoder registers are set to 0.



CDMA2K_TurboRSCEncoder Subnetwork

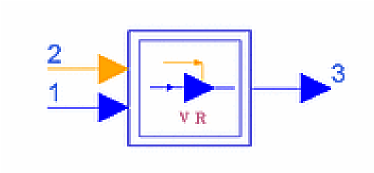


Constituent Encoder

References

1. TIA/EIA/IS-2000.2 (PN-4428), Physical Layer Standard for cdma2000 Spread Spectrum Systems, July 1999.

CDMA2K_VR_AmpAdjust



Description Input Symbol Amplitude Adjuster for Data Rate in Forward Channel
Library cdma2000, Channel Coding
Class SDFCDMA2K_VR_AmpAdjust

Parameters

Name	Description	Default	Sym	Type	Range
RadioConfig	radio configuration: RC3_4_6_7, otherRC	RC3_4_6_7		enum	
InputFrameLen	input frame length	384	M	int	[1, ∞)

Pin Inputs

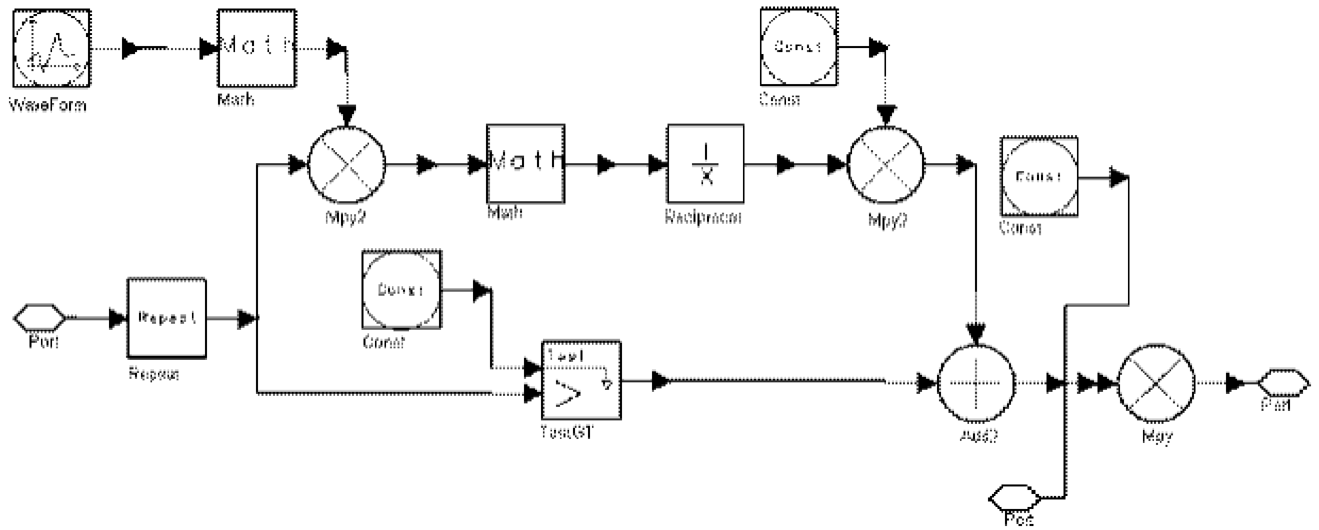
Pin	Name	Description	Signal Type
1	D_in	input symbols	real
2	rateI	data rate of current frame	int

Pin Outputs

Pin	Name	Description	Signal Type
3	D_out	output symbols	real

Notes/Equations

1. This subnetwork is used to adjust input symbol amplitude by data rate for continuous transmission in forward traffic channels.
   M D_out tokens are produced when M D_in tokens and one rateI token are consumed.
   The following figure shows the schematic for this subnetwork.



CDMA2K_VR_AmpAdjust Subnetwork

2. The modulation symbols that are transmitted at lower data rates will be transmitted using lower energy. Specifically, the energy per modulation symbol (Es) for the supported data rates must be:
   Es = Emax × R/Rmax
   where Emax is the energy per symbol at the maximum data rate for the forward fundamental channel with the associated radio configuration, R is the data rate, and Rmax is the maximum data rate for the forward fundamental channel for the associated radio configuration (that is, when transmitting a radio configuration 1 frame at 4800 bps, the symbols should have one-half the power of the symbols in a 9600 bps frame).
   Note that all symbols in an interleaver block are from the same frame; thus they are all transmitted at the same energy. The following table lists R/Rmax values according to radio configurations and data rates.

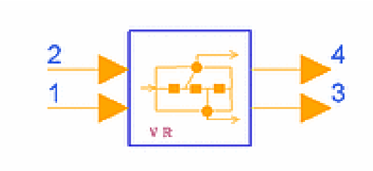
R/Rmax Values

Radio Configuration Type	rateI Value	Data Rate	R/Rmax Value
RC3RC4RC6RC7	0	9600 bps	1
	1	4800 bps	0.5
	2	2700 bps	0.28125
	3	1500 bps	0.15625
Other	0	9600 or 14400 bps	1
	1	4800 or 7200 bps	0.5
	2	2400 or 3600 bps	0.25
	3	1200 or 1800 bps	0.125

References

1. TIA/EIA/IS-2000.2 (PN-4428), Physical Layer Standard for cdma2000 Spread Spectrum Systems, July 1999.

CDMA2K_VR_CCwithTail



Description Variable data rate convolutional encoder with tail
Library cdma2000, Channel Coding
Class SDFCDMA2K_VR_CCwithTail
Derived From CDMA2K_VR_CC

Parameters

Name	Description	Default	Type
RadioConfig	radio configuration: Fwd RC1, Fwd RC2, Fwd RC3, Fwd RC4, Fwd RC5, Fwd RC6, Fwd RC7, Fwd RC8, Fwd RC9, Rev RC1, Rev RC2, Rev RC3, Rev RC4, Rev RC5, Rev RC6	Fwd RC1	enum

Pin Inputs

Pin	Name	Description	Signal Type
1	D_in	input data	int
2	rateI	data rate of input frame	int

Pin Outputs

Pin	Name	Description	Signal Type
3	D_out	output data	int
4	rateO	data rate of output frame	int

Notes/Equations

1. This model is used to convolutionally encode variable data rate input frames with tail bits for forward or reverse traffic channels.
   Each firing, N D_out tokens and one rateO token are produced when M D_in tokens and one rateI token are consumed. (N and M are defined in the following table.)
2. Convolutional encoder types for different radio configurations are listed in the following table.
   These rates are used:
   - rate 1/2 K 9 g0 0753 g1 0561, rate 1/3 K 9 g0 0557 g1 0663 g2 0711
   - rate 1/4 K 9 g0 0765 g1 0671 g2 0513 g3 0473
   - rate 1/6 K 9 g0 0457 g1 0755 g2 0551 g3 0637 g4 0625 g5_0727
     (rate means convolutional code rate, K means constraint length, g means generator functions)
3. Information is transmitted at data rates listed in Input Frame Formats for Various Radio Configurations. To easily implement in the SDF domain, the full rate frame length is selected as the length of block to be processed; padding bits are appended after the valid data for lower data rate frames in order to keep the block length constant.

Convolutional Type Used in Fundamental Channel

	Radio Configuration	CC Type	Maximum Input Frame Length (M)	Maximum Output Frame Length (N)
Reverse Traffic Fundamental Channel	RC1	R=1/3 K=9	192	576
	RC2	R=1/2 K=9	288	576
	RC3, RC5	R=1/4 K=9	192	768
	RC4, RC6	R=1/4 K=9	288	1152
Forward Traffic Fundamental Channel	RC1, RC4	R=1/2 K=9	192	384
	RC2, RC9	R=1/2 K=9	288	576
	RC3	R=1/4 K=9	192	768
	RC5, RC8	R=1/4 K=9	288	1152
	RC6	R=1/6 K=9	192	1152
	RC7	R=1/3 K=9	192	576

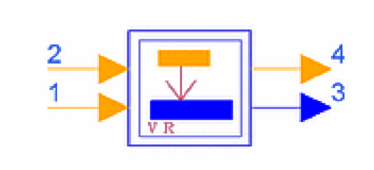
Input Frame Formats for Various Radio Configurations

Radio Configuration	Data Rate	Input Frame Length	Information Bits	Padding Bits
RC1	9600 bps	192	192	0
	4800 bps	192	96	96
	2400 bps	192	48	144
	1200 bps	192	24	168
RC2Forward Channel:RC5, RC8, RC9Reverse Channel:RC4, RC6	14400 bps	288	288	0
	7200 bps	288	144	144
	3600 bps	288	72	216
	1800 bps	288	36	252
Forward Channel:RC3, RC4, RC6, RC7Reverse Channel:RC3, RC5	9600 bps	192	192	0
	4800 bps	192	96	96
	2700 bps	192	54	138
	1500 bps	192	30	162

References

1. TIA/EIA/IS-2000.2 (PN-4428), Physical Layer Standard for cdma2000 Spread Spectrum Systems, July 1999.

CDMA2K_VR_Coding



Description Variable Data Rate Coder
Library cdma2000, Channel Coding
Class SDFCDMA2K_VR_Coding

Parameters

Name	Description	Default	Type
RadioConfig	radio configuration: Fwd RC1, Fwd RC2, Fwd RC3, Fwd RC4, Fwd RC5, Fwd RC6, Fwd RC7, Fwd RC8, Fwd RC9, Rev RC1, Rev RC2, Rev RC3, Rev RC4, Rev RC5, Rev RC6	Fwd RC1	enum

Pin Inputs

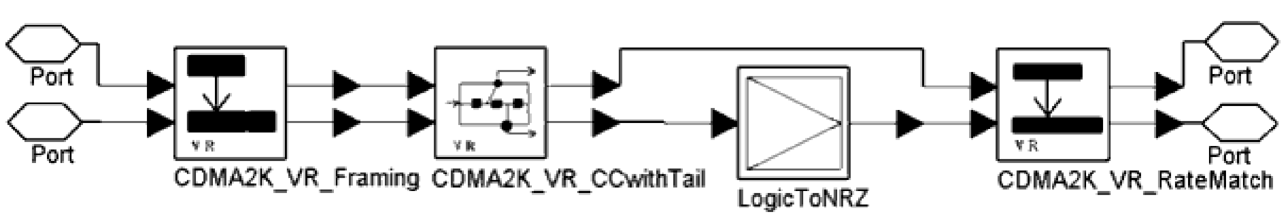
Pin	Name	Description	Signal Type
1	D_in	input symbols	int
2	rateI	data rate of input frame	int

Pin Outputs

Pin	Name	Description	Signal Type
3	D_out	output symbols	real
4	rateO	data rate of output frame	int

Notes/Equations

1. This subnetwork is used to perform channel coding for radio configurations of variable data rate. The following figure shows the schematic for this subnetwork, which includes framing, convolutional encoder and frame rate matching. Interleaving is not included.
   M D_out tokens and one rateO token are produced when N D_in tokens and one rateI token are consumed; refer to the following table.



CDMA2K_VR_Coding Subnetwork

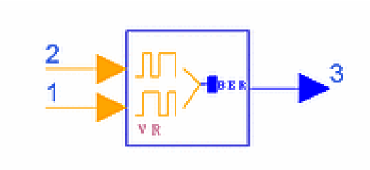
Frame Lengths

	Radio Configuration	Input Frame Length (N)	Output Frame Length (M)
Reverse Traffic Fundamental Channel	RC1	171	576
	RC2	267	576
	RC3	171	1536
	RC4	267	1536
	RC5	171	1536
	RC6	267	1536
Forward Traffic Fundamental Channel	RC1	171	384
	RC2	267	384
	RC3	171	768
	RC4	171	384
	RC5	267	768
	RC6	171	1152
	RC7	171	576
	RC8	267	1152
	RC9	267	576

References

1. TIA/EIA/IS-2000.2 (PN-4428), Physical Layer Standard for cdma2000 Spread Spectrum Systems, July 1999.

CDMA2K_VR_Compare



Description BER calculator for blind rate detection
Library cdma2000, Channel Coding
Class SDFCDMA2K_VR_Compare

Parameters

Name	Description	Default	Type
RadioConfig	radio Configuration: Fwd RC1, Fwd RC2, Fwd RC3, Fwd RC4, Fwd RC5, Fwd RC6, Fwd RC7, Fwd RC8, Fwd RC9, Rev RC1, Rev RC2, Rev RC3, Rev RC4, Rev RC5, Rev RC6	Fwd RC1	enum

Pin Inputs

Pin	Name	Description	Signal Type
1	input1	input 1	int
2	input2	input 2	int

Pin Outputs

Pin	Name	Description	Signal Type
3	BER	bit error rate	real

Notes/Equations

1. This model is used to measure the bit error rate for blind detection in variable data rate fundamental channels.
   Each firing, one BER token is produced when N input1 tokens and N input2 tokens are consumed. Input tokens based on RC type are listed in the following table.
2. For variable data rate transmission, blind detection is used to detect the data rate and decode the received symbols.
   The four-way decision is a common structure. The de-interleaved symbols are quantified by the sign of symbols.
   In the one-way decision, de-interleaved symbols are de-rate-matched, Viterbi decoded at one constant rate, such as full rate. The output bits of Viterbi decoder will be encoded and rate-matched again.
   By comparing the two, the BER of this data rate frame can be measured. The minimum BER data rate is chosen.

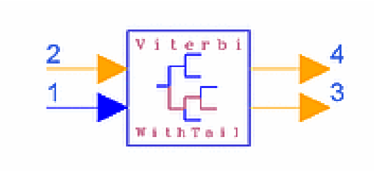
Input Frame Length

Radio Configuration	Input Frame Length (N)
Forward RC1, RC2, RC4	384
Reverse RC1, RC2; Forward RC7, RC9	576
Forward RC3, RC5	768
Forward RC6, RC8	1152
Reverse RC3, RC4, RC5, RC6	1536

References

1. TIA/EIA/IS-2000.2 (PN-4428), Physical Layer Standard for cdma2000 Spread Spectrum Systems, July 1999.

CDMA2K_VR_DCCwithTail



Description Variable data rate Viterbi decoder for convolutional code with tail
Library cdma2000, Channel Coding
Class SDFCDMA2K_VR_DCCwithTail
Derived From CDMA2K_VR_Viterbi

Parameters

Name	Description	Default	Type
RadioConfig	radio configuration: Fwd RC1, Fwd RC2, Fwd RC3, Fwd RC4, Fwd RC5, Fwd RC6, Fwd RC7, Fwd RC8, Fwd RC9, Rev RC1, Rev RC2, Rev RC3, Rev RC4, Rev RC5, Rev RC6	Fwd RC1	enum

Pin Inputs

Pin	Name	Description	Signal Type
1	D_in	input data	real
2	rateI	data rate of input frame	int

Pin Outputs

Pin	Name	Description	Signal Type
3	D_out	output data	int
4	rateO	data rate of output frame	int

Notes/Equations

1. This model is used to decode variable data rate input symbols for forward or reverse traffic channels. The Viterbi decoding algorithm is same as the algorithm used in CDMA2K_DCC_withTail.
   Each firing, N output tokens and one rateO token are produced when M input tokens and one rateI token are consumed. (N and M are defined in the following table.)
2. In forward or reverse fundamental channels, information is transmitted at various data rates. The convolutional encoder types based on RC type are listed in the following table.
   - These rates are used:
     - rate 1/2 K 9 g0 0753 g1 0561
     - rate 1/3 K 9 g0 0557 g1 0663 g2 0711
     - rate 1/4 K 9 g0 0765 g1 0671 g2 0513 g3 0473
     - rate 1/6 K 9 g0 0457 g1 0755n g2 0551 g3 0637 g4 0625 g5_0727 (rate=convolutional code rate, K=constraint length, g= generator functions).
   - To easily implement in the SDF domain, the full rate frame length is selected as the length of block to process; padding bits are appended after the valid data for

lower data rate frame in order to keep the block length constant. If

- rateI = 0, the input frame is full rate, all symbols in input frame are valid
- rateI = 1, the input frame is 1/2 rate, the first 0.5×M symbols in this frame are valid and the others are padding 0 bits
- rateI = 2, the input frame is 1/4 rate, the first 0.25×M symbols in this frame are valid and the others are padding 0 bits
- rateI = 2, the input frame is 1/8 rate, the first 0.125×M symbols in this frame are valid and the others are padding 0 bits

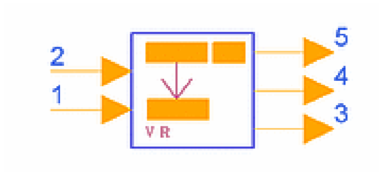
Convolutional Type Used in Fundamental Channels

	Radio Configuration	**CC Type**	**Maximum Input Frame Length (M)**	**Maximum Output Frame Length (N)**
Reverse Traffic Fundamental Channel	RC1	R=1/3 K=9	576	192
	RC2	R=1/2 K=9	576	288
	RC3 and RC5	R=1/4 K=9	768	192
	RC4 and RC6	R=1/4 K=9	1152	288
Forward Traffic Fundamental Channel	RC1 and RC4	R=1/2 K=9	384	192
	RC2 and RC9	R=1/2 K=9	576	288
	RC3	R=1/4 K=9	768	192
	RC5 and RC8	R=1/4 K=9	1152	288
	RC6	R=1/6 K=9	1152	192
	RC7	R=1/3 K=9	576	192

References

1. TIA/EIA/IS-2000.2 (PN-4428), Physical Layer Standard for cdma2000 Spread Spectrum Systems, July 1999.

CDMA2K_VR_DeFraming



Description Variable rate deframing for fundamental channel
Library cdma2000, Channel Coding
Class SDFCDMA2K_VR_DeFraming

Parameters

Name	Description	Default	Type
RadioConfig	radio configuration: Fwd RC1, Fwd RC2, Fwd RC3, Fwd RC4, Fwd RC5, Fwd RC6, Fwd RC7, Fwd RC8, Fwd RC9, Rev RC1, Rev RC2, Rev RC3, Rev RC4, Rev RC5, Rev RC6	Fwd RC1	enum

Pin Inputs

Pin	Name	Description	Signal Type
1	D_in	input data	int
2	rateI	data rate of input frame	int

Pin Outputs

Pin	Name	Description	Signal Type
3	D_out	output data	int
4	rateO	data rate of output frame	int
5	FrmErr	frame error indicator	int

Notes/Equations

1. This model is used to deframe forward or reverse fundamental channels and check frame quality by the CRC bits. It includes CRC decoding and erasing tail bits.
   Each firing, for
   - Rev RC1, RC3, RC5, or Fwd RC3, RC4, RC6, RC7,
     172 D_out tokens, one rateO and one FrmErr token are produced when 192 D_in tokens and one rateI token are consumed.
   - Rev RC2, RC4, RC6, or Fwd RC5, RC8, RC9,
     267 D_out tokens, one rateO, and one FrmErr token are produced when 288 input tokens and one rateI token are consumed.
     If the input frame has errors, FrmErr is 1; if the input frame does not have errors FrmErr is 0. If there are no CRC bits in the input frame, it is considered to not have errors.
2. In forward or reverse fundamental channels, information is transmitted at various data rates. To easily implement in the SDF domain, the full rate frame length is selected as the length of block to process; padding bits are appended after the valid data for lower data rate frame in order to keep the block length constant. Data rates

according to radio configuration are listed in the following tables.

Frame Structure of RC1 in Forward or Reverse Fundamental Channel

Index	Data Rate	Frame Length	Frame Structure		
			Information Bits per Frame	CRC Bits per Frame	Tail Bits
0	9600 bps	192	172	12	8
1	4800 bps	96	88	8	8
2	2400 bps	48	40	0	8
3	1200 bps	24	16	0	8

Frame Structure of RC2, RC4, RC6 in Reverse Fundamental Channel or RC2, RC5, RC8, RC9 in Forward Fundamental Channel

Index	Data Rate	Frame Length	Frame Structure			
			Reserved Bits per Frame	Information Bits per Frame	CRC Bits per Frame	Tail Bits
0	14400 bps	288	1 (value=0)	267	12	8
1	7200 bps	144	1 (value=0)	125	10	8
2	3600 bps	72	1 (value=0)	55	8	8
3	1800 bps	36	1 (value=0)	21	6	8

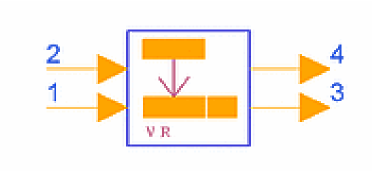
Frame Structure of RC3, RC5 in Reverse Fundamental Channel or RC3, RC4, RC6, RC7 in Forward Fundamental Channel

Index	Data Rate	Frame Length	Frame Structure		
			Information Bits per Frame	CRCBits per Frame	Tail Bits
0	9600 bps	192	172	12	8
1	4800 bps	96	88	8	8
2	2700 bps	54	40	6	8
3	1500 bps	30	16	6	8

References

1. TIA/EIA/IS-2000.2 (PN-4428), Physical Layer Standard for cdma2000 Spread Spectrum Systems, July 1999.

CDMA2K_VR_Framing



Description Variable rate framing for fundamental channel
Library cdma2000, Channel Coding
Class SDFCDMA2K_VR_Framing

Parameters

Name	Description	Default	Type
RadioConfig	radio configuration: Fwd RC1, Fwd RC2, Fwd RC3, Fwd RC4, Fwd RC5, Fwd RC6, Fwd RC7, Fwd RC8, Fwd RC9, Rev RC1, Rev RC2, Rev RC3, Rev RC4, Rev RC5, Rev RC6	Fwd RC1	enum

Pin Inputs

Pin	Name	Description	Signal Type
1	D_in	input data	int
2	rateI	data rate of input frame	int

Pin Outputs

Pin	Name	Description	Signal Type
3	D_out	output data	int
4	rateO	data rate of output frame	int

Notes/Equations

1. This model is used to frame forward or reverse fundamental channels. It includes CRC coder and adding 8 bits tail.
   Each firing, for
   - Rev RC1, RC3, RC5 or Fwd RC3, RC4, RC6, RC7,
     192 D_out tokens and one rateO token are produced when
     172 D_in tokens and one rateI token are consumed.
   - Rev RC2, RC4, RC6 or Fwd RC5, RC8, RC9,
     288 output tokens and one rateO token are produced when
     267 input tokens and one rateI token are consumed.
2. In forward or reverse fundamental channels, information is transmitted at various data rates. To easily implement in the SDF domain, the full rate frame length is selected as the length of block to process and is appended to the padding bits after the valid data for lower data rate frame in order to keep the block length constant. Data rates according to radio configuration are listed in the following tables.

Frame Structure of RC1 in Reverse or Forward Fundamental Channels

Index	Data Rate	Frame Length	Frame Structure		
			Information Bits per Frame	CRCBits per Frame	Tail Bits
0	9600 bps	192	172	12	8
1	4800 bps	96	88	8	8
2	2400 bps	48	40	0	8
3	1200 bps	24	16	0	8

Frame Structure of Rev RC2, RC4, RC6 or Fwd RC2, RC5, RC8, RC9

Index	Data Rate	Frame Length	Frame Structure			
			Reserved Bits per Frame	Information Bits per Frame	CRCBits per Frame	Tail Bits
0	14400 bps	288	1 (value=0)	267	12	8
1	7200 bps	144	1 (value=0)	125	10	8
2	3600 bps	72	1 (value=0)	55	8	8
3	1800 bps	36	1 (value=0)	21	6	8

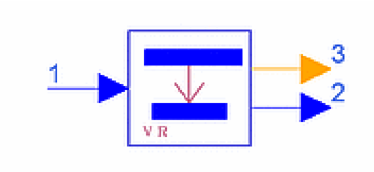
Frame Structure of Rev RC3, RC5 or Fwd RC3, RC4, RC6, RC7

Index	Data Rate	Frame Length	Frame Structure		
			Information Bits per Frame	CRCBits per Frame	Tail Bits
0	9600 bps	192	172	12	8
1	4800 bps	96	88	8	8
2	2700 bps	54	40	6	8
3	1500 bps	30	16	6	8

References

1. TIA/EIA/IS-2000.2 (PN-4428), Physical Layer Standard for cdma2000 Spread Spectrum Systems, July 1999.

CDMA2K_VR_RateDeMatch



Description Rate dematching
Library cdma2000, Channel Coding
Class SDFCDMA2K_VR_RateDeMatch

Parameters

Name	Description	Default	Type
RadioConfig	radio configuration: Fwd RC1, Fwd RC2, Fwd RC3, Fwd RC4, Fwd RC5, Fwd RC6, Fwd RC7, Fwd RC8, Fwd RC9, Rev RC1, Rev RC2, Rev RC3, Rev RC4, Rev RC5, Rev RC6	Fwd RC1	enum
DataRate	data rate of input frame: Full Rate, Half Rate, Rate 1_4, Rate 1_8	Full Rate	enum

Pin Inputs

Pin	Name	Description	Signal Type
1	D_in	input data	real

Pin Outputs

Pin	Name	Description	Signal Type
2	D_out	output data	real
3	rateO	data rate of output frame	int

Notes/Equations

1. This model is used to de-match rates for forward or reverse fundamental channels. It depunctures the input symbols then averages the symbols for different radio configurations and data rates.
   M D_out tokens and one rateO token are produced when N D_in tokens are consumed. (The following tables show radio configurations and input and output tokens for forward and reverse fundamental channels. Input frame length = M and output frame length = N.)
2. In forward or reverse fundamental channels, information is transmitted at various data rates. To easily implement in the SDF domain, the full rate frame length is selected as the length of block to process; padding bits are appended after the valid data for lower data rate frame in order to keep the block length constant. The following tables show rate de-matching of radio configurations for forward and reverse traffic fundamental channels.

Rate De-Matching of Radio Configurations in Forward Fundamental Channel

Radio Config.	Data Rate(bps)	Output Frame Length	Information Bits in Output Frame	Padding Bits in Output Frame	Repetition Factor	Puncture Deletion	Input Frame Length
RC1	9600	384	384	0	1	None	384
	4800	384	192	192	2	None	
	2400	384	96	288	4	None	
	1200	384	48	336	8	None	
RC2	14400	576	576	0	1	2 of 6	384
	7200	576	288	288	2	2 of 6	
	3600	576	144	432	4	2 of 6	
	1800	576	72	504	8	2 of 6	
RC3	9600	768	768	0	1	None	768
	4800	768	384	384	2	None	
	2700	768	216	552	4	1 of 9	
	1500	768	120	648	8	1 of 5	
RC4	9600	384	384	0	1	None	384
	4800	384	192	192	2	None	
	2700	384	108	276	4	1 of 9	
	1500	384	60	324	8	1 of 5	
RC5	14400	1152	1152	0	1	4 of 12	768
	7200	1152	576	576	2	4 of 12	
	3600	1152	288	864	4	4 of 12	
	1800	1152	144	1008	8	4 of 12	
RC6	9600	1152	1152	0	1	None	1152
	4800	1152	576	576	2	None	
	2700	1152	324	828	4	1 of 9	
	1500	1152	180	972	8	1 of 5	
RC7	9600	576	576	0	1	None	576
	4800	576	288	288	2	None	
	2700	576	162	414	4	1 of 9	
	1500	576	90	486	8	1 of 5	
RC8	14400	1152	1152	0	1	None	1152
	7200	1152	576	576	2	None	
	3600	1152	288	864	4	None	
	1800	1152	144	1008	8	None	
RC9	14400	576	576	0	1	None	576
	7200	576	288	288	2	None	
	3600	576	144	432	4	None	
	1800	576	72	504	8	None	

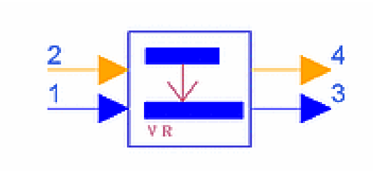
Rate De-Matching of Radio Configuration in Reverse Fundamental Channel

Radio Config.	Data Rate(bps)	Output Frame Length	Information Bits in Output Frame	Padding Bits in Output Frame	Repetition Factor	Puncture Deletion	Input Frame Length
RC1	9600	576	576	0	1	None	576
	4800	576	288	288	2	None	
	2400	576	144	432	4	None	
	1200	576	72	504	8	None	
RC2	14400	576	576	0	1	None	576
	7200	576	288	288	2	None	
	3600	576	144	432	4	None	
	1800	576	72	504	8	None	
RC3	9600	768	768	0	2	None	1536
	4800	768	384	384	4	None	
	2700	768	216	552	8	1 of 9	
	1500	768	120	648	16	1 of 5	
RC4	14400	1152	1152	0	2	8 of 24	1536
	7200	1152	576	576	4	8 of 24	
	3600	1152	288	864	8	8 of 24	
	1800	1152	144	1008	16	8 of 24	
RC5	9600	768	768	0	2	None	1536
	4800	768	384	384	4	None	
	2700	768	216	552	8	1 of 9	
	1500	768	120	648	16	1 of 5	
RC6	14400	1152	1152	0	2	8 of 24	1536
	7200	1152	576	576	4	8 of 24	
	3600	1152	288	864	8	8 of 24	
	1800	1152	144	1008	16	8 of 24	

References

1. TIA/EIA/IS-2000.2 (PN-4428), Physical Layer Standard for cdma2000 Spread Spectrum Systems, July 1999.

CDMA2K_VR_RateMatch



Description Rate matching for fundamental channel
Library cdma2000, Channel Coding
Class SDFCDMA2K_VR_RateMatch

Parameters

Name	Description	Default	Type
RadioConfig	radio Configuration: Fwd RC1, Fwd RC2, Fwd RC3, Fwd RC4, Fwd RC5, Fwd RC6, Fwd RC7, Fwd RC8, Fwd RC9, Rev RC1, Rev RC2, Rev RC3, Rev RC4, Rev RC5, Rev RC6	Fwd RC1	enum

Pin Inputs

Pin	Name	Description	Signal Type
1	D_in	input data	real
2	rateI	data rate of input frame	int

Pin Outputs

Pin	Name	Description	Signal Type
3	D_out	output data	real
4	rateO	data rate of output frame	int

Notes/Equations

1. This model is used to match rates for forward or reverse fundamental channels. It repeats input symbols then punctures the symbols for different radio configurations. Each firing, M D_out tokens and one rateO token are produced when N D_in tokens and one rateI token are consumed. (the following tables show radio configurations and input and output tokens. Input frame length = M; output frame length = N.)
2. In forward or reverse fundamental channels, information is transmitted at various data rates. To easily implement in the SDF domain, the full rate frame length is selected as the length of block to process; padding bits are appended after the valid data for lower data rate frame in order to keep the block length constant.
   The following tables show rate matching of radio configurations for forward and reverse traffic fundamental channels.

Rate Matching of Radio Configurations in Forward Fundamental Channel

Radio Config.	Data Rate(bps)	Input Frame Length	Information Bits	Padding Bits	Repetition Factor	Puncture Deletion	Output Frame Length
RC1	9600	384	384	0	1	None	384
	4800	384	192	192	2	None	
	2400	384	96	288	4	None	
	1200	384	48	336	8	None	
RC2	14400	576	576	0	1	2 of 6	384
	7200	576	288	288	2	2 of 6	
	3600	576	144	432	4	2 of 6	
	1800	576	72	504	8	2 of 6	
RC3	9600	768	768	0	1	None	768
	4800	768	384	384	2	None	
	2700	768	216	552	4	1 of 9	
	1500	768	120	648	8	1 of 5	
RC4	9600	384	384	0	1	None	384
	4800	384	192	192	2	None	
	2700	384	108	276	4	1 of 9	
	1500	384	60	324	8	1 of 5	
RC5	14400	1152	1152	0	1	4 of 12	768
	7200	1152	576	576	2	4 of 12	
	3600	1152	288	864	4	4 of 12	
	1800	1152	144	1008	8	4 of 12	
RC6	9600	1152	1152	0	1	None	1152
	4800	1152	576	576	2	None	
	2700	1152	324	828	4	1 of 9	
	1500	1152	180	972	8	1 of 5	
RC7	9600	576	576	0	1	None	576
	4800	576	288	288	2	None	
	2700	576	162	414	4	1 of 9	
	1500	576	90	486	8	1 of 5	
RC8	14400	1152	1152	0	1	None	1152
	7200	1152	576	576	2	None	
	3600	1152	288	864	4	None	
	1800	1152	144	1008	8	None	
RC9	14400	576	576	0	1	None	576
	7200	576	288	288	2	None	
	3600	576	144	432	4	None	
	1800	576	72	504	8	None	

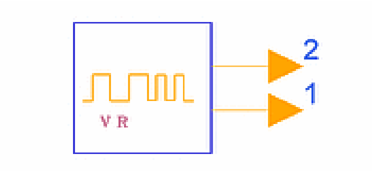
Rate Matching of Radio Configurations in Reverse Fundamental Channel

Radio Config.	Data Rate(bps)	Input Frame Length	Information Bits	Padding Bits	Repetition Factor	Puncture Deletion	Output Frame Length
RC1	9600	576	576	0	1	None	576
	4800	576	288	288	2	None	
	2400	576	144	432	4	None	
	1200	576	72	504	8	None	
RC2	14400	576	576	0	1	None	576
	7200	576	288	288	2	None	
	3600	576	144	432	4	None	
	1800	576	72	504	8	None	
RC3	9600	768	768	0	2	None	1536
	4800	768	384	384	4	None	
	2700	768	216	552	8	1 of 9	
	1500	768	120	648	16	1 of 5	
RC4	14400	1152	1152	0	2	8 of 24	1536
	7200	1152	576	576	4	8 of 24	
	3600	1152	288	864	8	8 of 24	
	1800	1152	144	1008	16	8 of 24	
RC5	9600	768	768	0	2	None	1536
	4800	768	384	384	4	None	
	2700	768	216	552	8	1 of 9	
	1500	768	120	648	16	1 of 5	
RC6	14400	1152	1152	0	2	8 of 24	1536
	7200	1152	576	576	4	8 of 24	
	3600	1152	288	864	8	8 of 24	
	1800	1152	144	1008	16	8 of 24	

References

1. TIA/EIA/IS-2000.2 (PN-4428), Physical Layer Standard for cdma2000 Spread Spectrum Systems, July 1999.

CDMA2K_VR_Src



Description Variable data rate source for fundamental channel
Library cdma2000, Channel Coding
Class SDFCDMA2K_VR_Src

Parameters

Name	Description	Default	Type
RadioConfig	radio configuration: Fwd RC1, Fwd RC2, Fwd RC3, Fwd RC4, Fwd RC5, Fwd RC6, Fwd RC7, Fwd RC8, Fwd RC9, Rev RC1, Rev RC2, Rev RC3, Rev RC4, Rev RC5, Rev RC6	Fwd RC1	enum
RateType	data rate type: Random, Constant full rate, Constant half rate, Constant rate 1_4, Constant rate 1_8	Random	enum

Pin Outputs

Pin	Name	Description	Signal Type
1	D_out	output data	int
2	rate	data rate of output frame	int

Notes/Equations

1. This model is used as a test source. It generates the data rate and fixed data rate source for fundamental channels. Each firing, 172 or 267 D_out tokens and one rate token are generated according to the radio configuration.
2. An output rate value of 0, 1, 2 or 3 denotes full rate, half rate, 1/4 rate, or 1/8 rate, respectively. The following table lists the output frame structure of the data rates.

Output Frame Structure

Output rateValue	Data Rate(bps)	Output Frame Length	Valid Bits	Padding Bits
0	9600	172	172	0
	14400	267	267	0
1	4800	172	80	91
	7200	267	125	142
2	2400, 2700	172	40	131
	3600	267	55	212
3	1200,1500	172	16	155
	1800	267	21	246

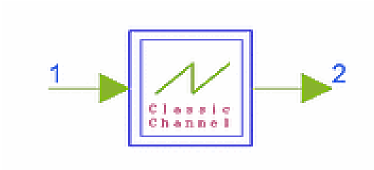
References

1. TIA/EIA/IS-2000.2 (PN-4428), Physical Layer Standard for cdma2000 Spread Spectrum Systems, July 1999.

Channel Components

- *CDMA2K ClassicChannel* (cdma2k)
- *CDMA2K ClassicSpec* (cdma2k)
- *CDMA2K Delay* (cdma2k)
- *CDMA2K FlatChannel* (cdma2k)
- *CDMA2K FlatSpec* (cdma2k)
- *CDMA2K FwdVectorChannel* (cdma2k)
- *CDMA2K Interpolation* (cdma2k)
- *CDMA2K RevVectorChannel* (cdma2k)

CDMA2K_ClassicChannel



Description Multi-Path Fading Channel with Classic Spectrum
Library cdma2000, Channel
Class SDFCDMA2K_ClassicChannel

Parameters

Name	Description	Default	Unit	Type	Range
SamplingRate	sampling rate	4915200		real	(0, ∞)
Dpath2	time delay of second tap relative to the first tap	310n	sec	real	(0, ∞)
Dpath3	time delay of third tap relative to the first tap	710n	sec	real	(0, ∞)
Dpath4	time delay of fourth tap relative to the first tap	1090n	sec	real	(0, ∞)
Dpath5	time delay of fifth tap relative to the first tap	1730n	sec	real	(0, ∞)
Dpath6	time delay of sixth tap relative to the first tap	2510n	sec	real	(0, ∞)
Gpath1_dB	average power of first tap relative to the strongest tap in dB	0		real	(∞, 0]
Gpath2_dB	average power of second tap relative to the strongest tap in dB	-1.0		real	(∞, 0]
Gpath3_dB	average power of third tap relative to the strongest tap in dB	-9.0		real	(∞, 0]
Gpath4_dB	average power of fourth tap relative to the strongest tap in dB	-10.0		real	(∞, 0]
Gpath5_dB	average power of fifth tap relative to the strongest tap in dB	-15.0		real	(∞, 0]
Gpath6_dB	average power of sixth tap relative to the strongest tap in dB	-20.0		real	(∞, 0]
Velocity	velocity of mobile station,km/hour	120		real	[0, 5000)
CarrierFrequency	carrier frequency	825M	Hz	real	(0, ∞)

Pin Inputs

Pin	Name	Description	Signal Type
1	SigIn	input signal	complex

Pin Outputs

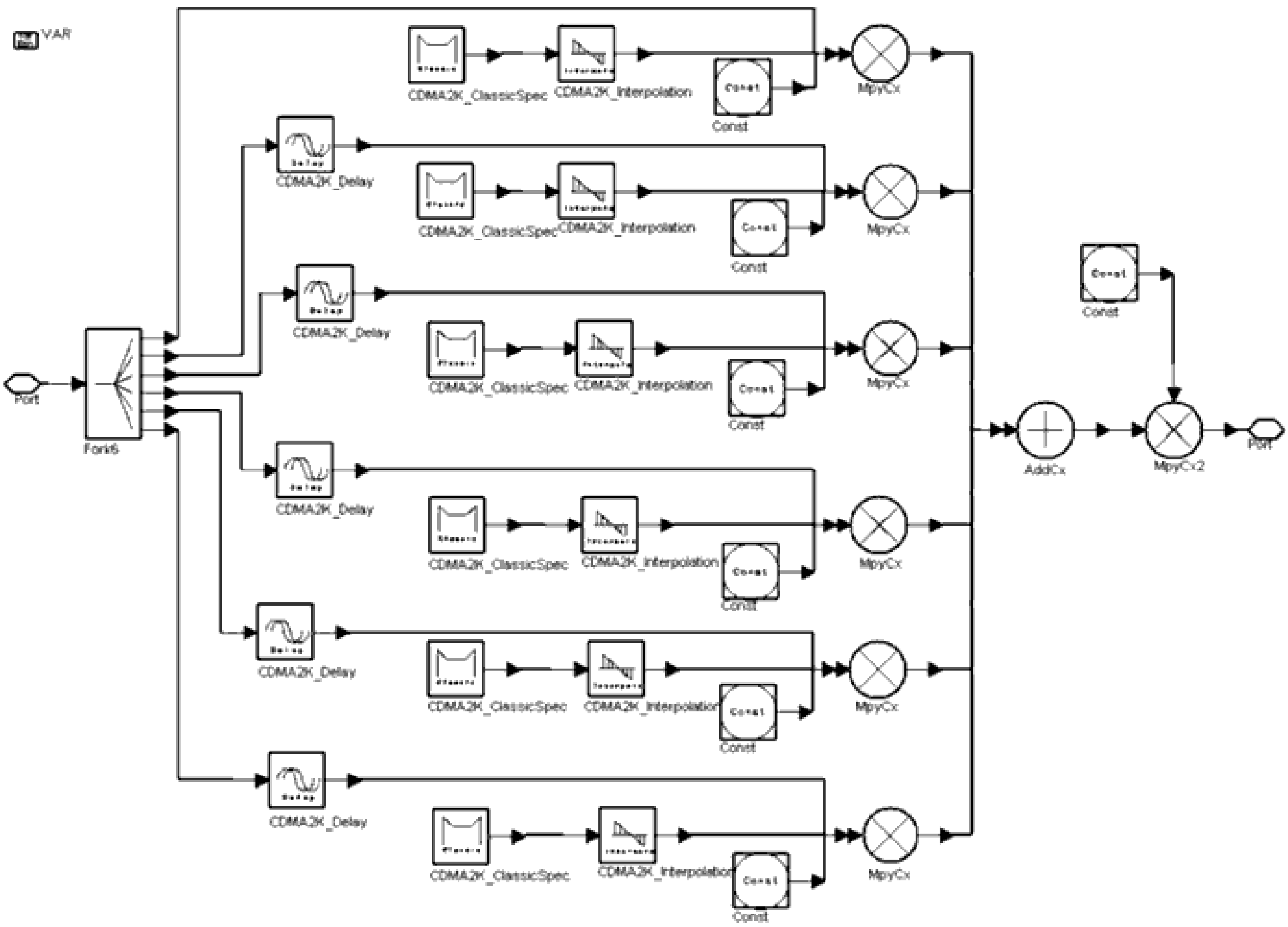
Pin	Name	Description	Signal Type
2	SigOut	output signal after passing channel	complex

Notes/Equations

1. This subnetwork is used to pass the input signal through a multipath Rayleigh fading channel based on a tapped-delay line model. The Doppler spectrum is classic. The maximum number of paths is 6. If Gpathi_dB(i=1, 2, ... , 6) is set to larger than 0,

then this tap is ignored. There is no path loss in this model.

The following figure shows the schematic for this subnetwork.

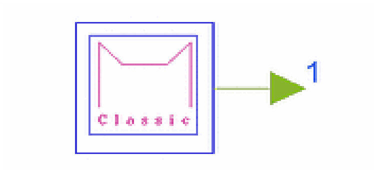


CDMA2K_ClassicChannel Subnetwork

References

1. TIA/EIA/IS2000.2, *Physical Layer Standard for cdma2000 Spread Spectrum Systems* , Apr., 1999.
2. TR 101 112 v3.2.0, *Universal Mobile Telecommunications System (UMTS); Selection procedures for the choice of radio transmission technologies of UMTS (UMTS 30.03 Version 3.2.0)* , ETSI.

CDMA2K_ClassicSpec



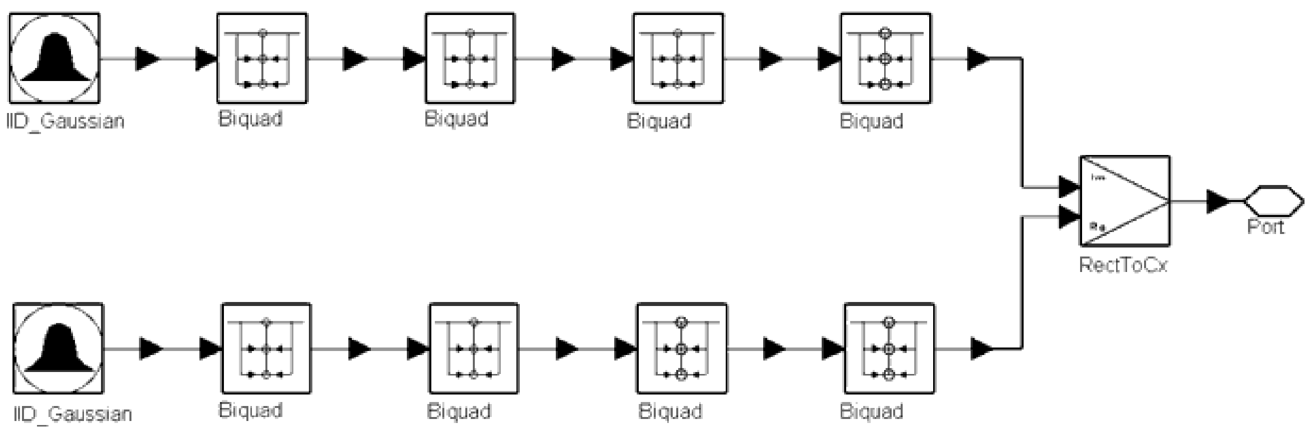
Description Classic Spectrum Generator
Library cdma2000, Channel
Class SDFCDMA2K_ClassicSpec

Pin Outputs

Pin	Name	Description	Signal Type
1	SigOut	output signal with classic spectrum	complex

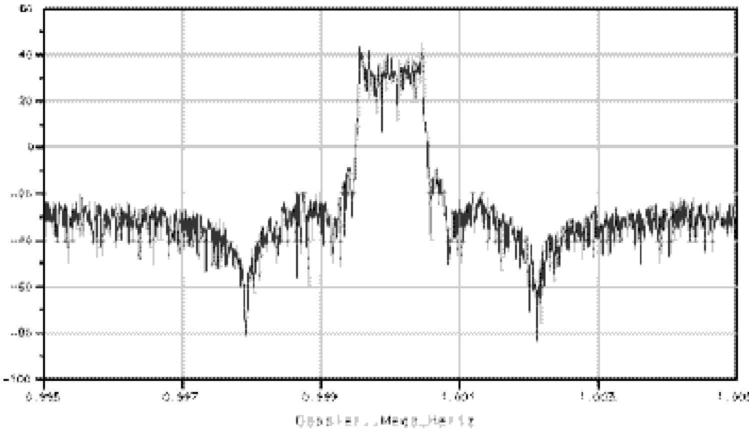
Notes/Equations

1. This subnetwork is a signal source that generates signals with classic Doppler spectrum. It is designed for use with CDMA2K_ClassicChannel.
   The following figure shows the schematic for this subnetwork.



CDMA2K_ClassicSpec Subnetwork

2. An IID_Gaussian component is used to obtain Gaussian distributed signals; power density is adjusted by a linear filter that is an 8-order IIR-filter that models the classic spectra (described in [1,3]).
   The following figure shows the spectrum of the output signals; carrier frequency=1 MHz.

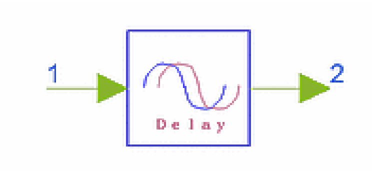


Output Signal with Classic Spectrum

References

1. H. Brehm, H. Stammler, W. Werner, "Design of a high flexible digital simulator for narrowband fading channels," *Signal Processing III: Theories and Applications* , I.T. Young et al. (ed.), Elsevier Science Publishers, 1986, pp.113-116.
2. S. A. Fechtel, "A Novel Approach to Modelling and Efficient Simulation of Frequency-Selective Fading Channels," *IEEE Trans. Sel. Areas Commun* . Vol. 11, No.3, April 1993, pp. 422-431.
3. R. Haeb, "Kohaerenter Empfang bei Datenuebertragung ueber nichtffrequentselective Schwundkanaele" (PhD thesis, Aachen University of Technology, 1988).

CDMA2K_Delay



Description Signal delay based on channel tapped-delay line model
Library cdma2000, Channel
Class SDFCDMA2K_Delay

Parameters

Name	Description	Default	Sym	Unit	Type	Range
SamplingRate	sampling rate	4915200	f_s		int	[1, ∞)
Delay	delay time	50n	τ	sec	real	(-∞, ∞)

Pin Inputs

Pin	Name	Description	Signal Type
1	SigIn	input signals	complex

Pin Outputs

Pin	Name	Description	Signal Type
2	SigOut	output signals after delay	complex

Notes/Equations

1. This model is used to delay the input signal by the time specified by Delay. It is used in channel impulse response model based on a tapped-delay line model.

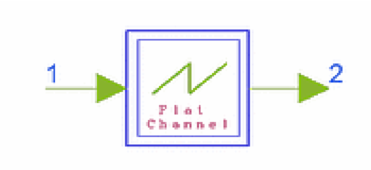
   Each firing, Max(64, int(f_s τ)+1) SigOut tokens are produced when

   Max(64, int(f_s τ)+1) SigIn tokens are consumed.

References

1. TIA/EIA/IS2000.2, *Physical Layer Standard for cdma2000 Spread Spectrum Systems* , Apr., 1999.
2. J. G. Proakis, *Digital Communications* , Third Edition, Publishing House of Electronics Industry.

CDMA2K_FlatChannel



Description Multi-Path Fading Channel with Flat Spectrum
Library cdma2000, Channel
Class SDFCDMA2K_FlatChannel

Parameters

Name	Description	Default	Unit	Type	Range
SamplingRate	sampling rate	4915200		real	(0, ∞)
Dpath2	time delay of second tap relative to the first tap	310n	sec	real	(0, ∞)
Dpath3	time delay of third tap relative to the first tap	710n	sec	real	(0, ∞)
Dpath4	time delay of fourth tap relative to the first tap	1090n	sec	real	(0, ∞)
Dpath5	time delay of fifth tap relative to the first tap	1730n	sec	real	(0, ∞)
Dpath6	time delay of sixth tap relative to the first tap	2510n	sec	real	(0, ∞)
Gpath1_dB	average power of first tap relative to the strongest tap in dB	0		real	(∞, 0]
Gpath2_dB	average power of second tap relative to the strongest tap in dB	-1.0		real	(∞, 0]
Gpath3_dB	average power of third tap relative to the strongest tap in dB	-9.0		real	(∞, 0]
Gpath4_dB	average power of fourth tap relative to the strongest tap in dB	-10.0		real	(∞, 0]
Gpath5_dB	average power of fifth tap relative to the strongest tap in dB	-15.0		real	(∞, 0]
Gpath6_dB	average power of sixth tap relative to the strongest tap in dB	-20.0		real	(∞, 0]
Velocity	velocity of mobile station, km/hour	120		real	[0, 5000)
CarrierFrequency	carrier frequency	825M	Hz	real	(0, ∞)

Pin Inputs

Pin	Name	Description	Signal Type
1	SigIn	input signal	complex

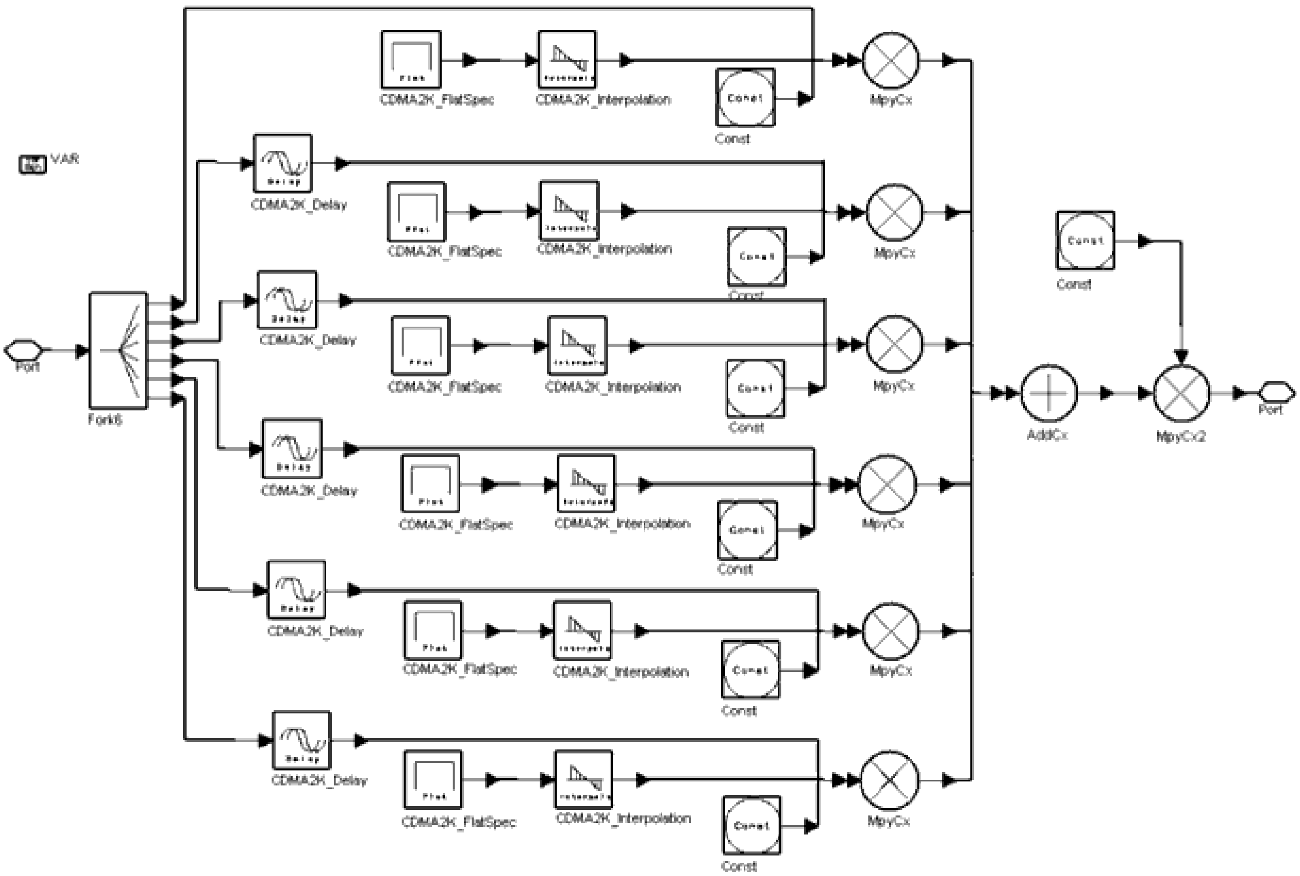
Pin Outputs

Pin	Name	Description	Signal Type
2	SigOut	output signal after passing channel	complex

Notes/Equations

1. This subnetwork is used to pass the input signal through a Rayleigh fading channel that is based on a tapped-delay line model. The Doppler spectrum is flat. The maximum number of paths is 6. If Gpathi_dB(i=1, 2, ... , 6) is set to larger than 0,

then this tap is ignored. There is no path loss in this model.
The following figure shows the schematic for this subnetwork.

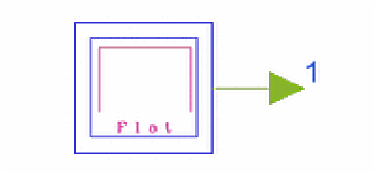


CDMA2K_FlatChannel Subnetwork

References

1. TIA/EIA/IS2000.2, *Physical Layer Standard for cdma2000 Spread Spectrum Systems* , Apr., 1999.
2. TR 101 112 v3.2.0, *Universal Mobile Telecommunications System (UMTS); Selection procedures for the choice of radio transmission technologies of UMTS (UMTS 30.03 Version 3.2.0), ETSI* .

CDMA2K_FlatSpec



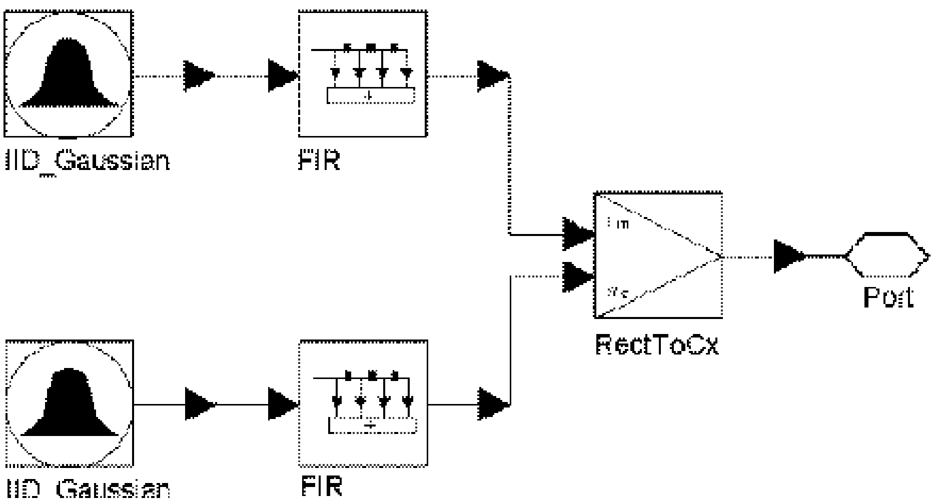
Description Flat Spectrum Generator
Library cdma2000, Channel
Class SDFCDMA2K_FlatSpec

Pin Outputs

Pin	Name	Description	Signal Type
1	SigOut	output signals	complex

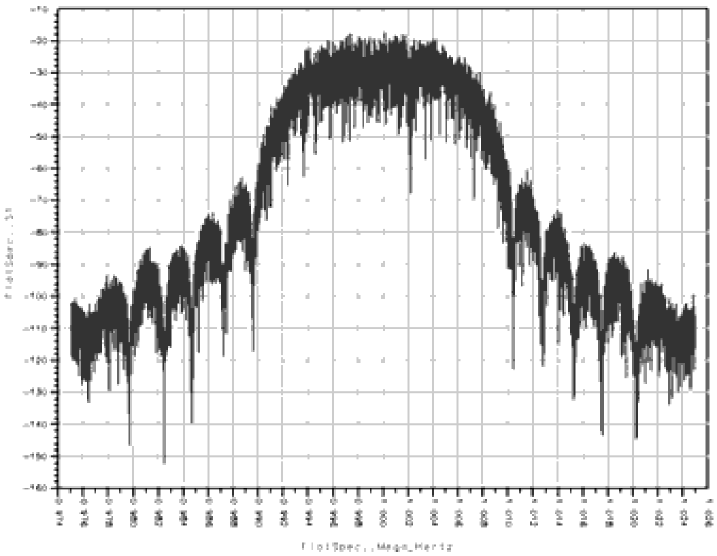
Notes/Equations

1. This subnetwork is a signal source that generates signals with a flat Doppler spectrum. It is designed for use with CDMA2K_FlatChannel.
   The following figure shows the schematic for this subnetwork.



CDMA2K_FlatSpec Subnetwork

2. An IID_Gaussian component is used to obtain Gaussian distributed signals; power density is adjusted by a 21-order Hanning window FIR-filter that models the flat Doppler spectrum.
   The following figure shows the output signal; carrier frequency=1 MHz.

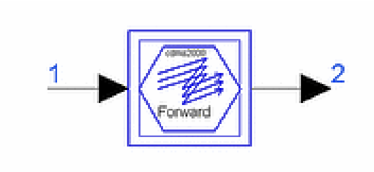


Output Signal Spectrum

References

1. H. Brehm, H. Stammler, W. Werner, "Design of a high flexible digital simulator for narrowband fading channels," *Signal Processing III: Theories and Applications*, I.T. Young et al. (ed.), Elsevier Science Publishers, 1986, pp.113-116.
2. S. A. Fechtel, "A Novel Approach to Modelling and Efficient Simulation of Frequency-Selective Fading Channels," *IEEE Trans. Sel. Areas Commun.,* Vol. 11, No.3, April 1993, pp. 422-431.
3. H. Zhenya, *Theories and Applications of Digital Signal Processing*, Published by postal publishing company of Chinese, 1987.

CDMA2K_FwdVectorChannel



Description Vector Propagation channel model for cdma2000 forward link
Library cdma2000, Channel
Class TSDFCDMA2K_FwdVectorChannel

Parameters

Name	Description	Default	Type	Range
Vx	X component of velocity vector	0.0	real	(1, ∞)
SpeedType	Velocity unit option: km/hr, miles/hr	km/hr	enum	
Type	CDMA Type Options: NoMultipath, OnePath, TwoPath, ThreePath	NoMultipath	enum	
Pathloss	Option for inclusion of large scale pathloss: No, Yes	No	enum	
Seed	integer number to randomize the channel output	1234567	int	[1, ∞]

Pin Inputs

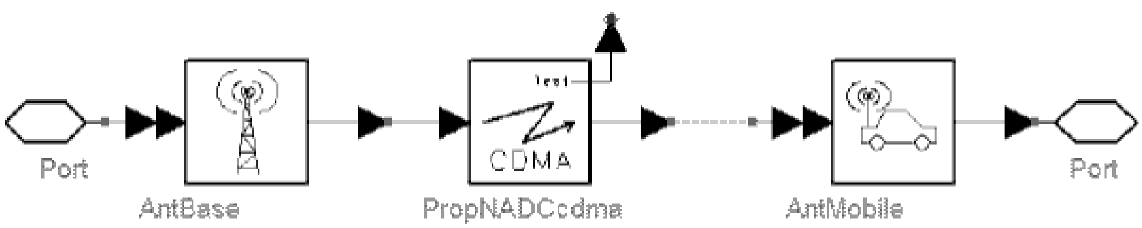
Pin	Name	Description	Signal Type
1	input	antenna input signal	timed

Pin Outputs

Pin	Name	Description	Signal Type
2	mout	antenna output signal	timed

Notes/Equations

1. This subnetwork is used to simulate multipath fading channel for cdma2000 forward link.
   The schematic for this subnetwork is shown in the following figure.



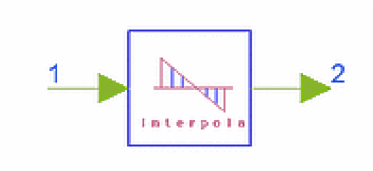
CDMA2K_FwdVectorChannel

References

References

1. 3GPP2 C.S0002_A_1, "Physical Layer Standard for cdma2000 Spread Spectrum Systems Release A-Addendum 1," Oct. 27, 2000.
2. 3GPP2 TSG-C Interim Plenary, "Recommended Minimum Performance Standards for cdma2000 Spread Spectrum Mobile Stations: Release A," Nov. 27, 2000.
3. 3GPP2 TSG-C4.1,"Recommended Minimum Performance Standards for cdma2000 Spread Spectrum Base Stations: Release A," Oct. 26, 2000.

CDMA2K_Interpolation



Description Lagrange interpolator
Library cdma2000, Channel
Class SDFCDMA2K_Interpolation

Parameters

Name	Description	Default	Sym	Type	Range
InterpolRate	interpolation rate	2	M	int	[1, ∞)
InterpolOrder	interpolation polynomial order	2	N	int	[2, ∞)
OutputSamples	output samples in each firing	6144	X	int	[M, ∞)

Pin Inputs

Pin	Name	Description	Signal Type
1	D_in	input data	complex

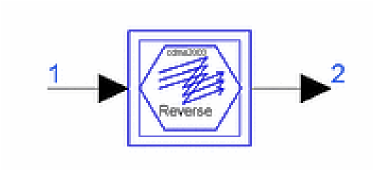
Pin Outputs

Pin	Name	Description	Signal Type
2	D_out	interpolated data	complex

Notes/Equations

1. This model is a Lagrange interpolator.
   Each firing, OutputSamples D_out tokens are produced when Round(OutputSamples/M) D_in tokens are consumed.

CDMA2K_RevVectorChannel



Description Vector Propagation channel model for cdma2000 reverse link
Library cdma2000, Channel
Class TSDFCDMA2K_RevVectorChannel

Parameters

Name	Description	Default	Type	Range
Vx	X component of velocity vector	0.0	real	(0, ∞)
SpeedType	Velocity unit option: km/hr, miles/hr	km/hr	enum	
Type	CDMA Type Options: NoMultipath, OnePath, TwoPath, ThreePath	NoMultipath	enum	
Pathloss	Option for inclusion of large scale pathloss: No, Yes	No	enum	
Seed	integer number to randomize the channel output	1234567	int	[1, 65535

Pin Inputs

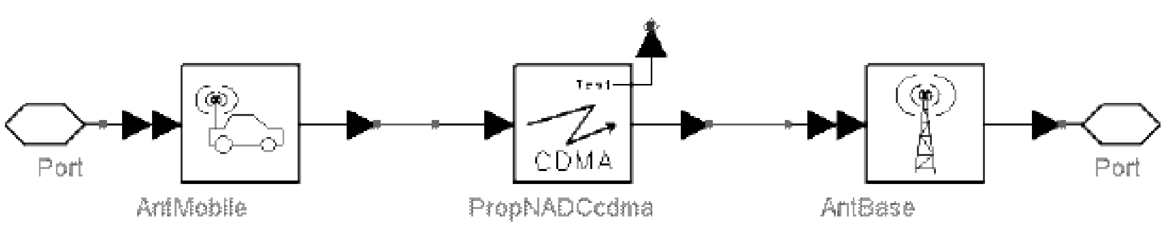
Pin	Name	Description	Signal Type
1	input	antenna input signal	timed

Pin Outputs

Pin	Name	Description	Signal Type
2	mout	antenna output signal	timed

Notes/Equations

1. This subnetwork is used to simulate multipath fading channel for cdma2000 reverse link.
   The schematic for this subnetwork is shown in the following figure.



CDMA2K_RevVectorChannel Subnetwork

References

1. 3GPP2 C.S0002_A_1, "Physical Layer Standard for cdma2000 Spread Spectrum Systems Release A-Addendum 1," Oct. 27, 2000.
2. 3GPP2 TSG-C Interim Plenary, "Recommended Minimum Performance Standards for cdma2000 Spread Spectrum Mobile Stations: Release A," Nov. 27, 2000.
3. 3GPP2 TSG-C4.1,"Recommended Minimum Performance Standards for cdma2000 Spread Spectrum Base Stations: Release A," Oct. 26, 2000.

Measurement Design Examples

Introduction

The CDMA2K_Measurement_wrk workspace shows examples for measuring forward and reverse link transmission as well as peak to average power performance of HPSK and QPSK. The following sections describe the designs and provide schematics and simulation results.

Forward Link SR1 Transmission Measurements

- DsnCDMA2K_FwdSR1Trans

Features

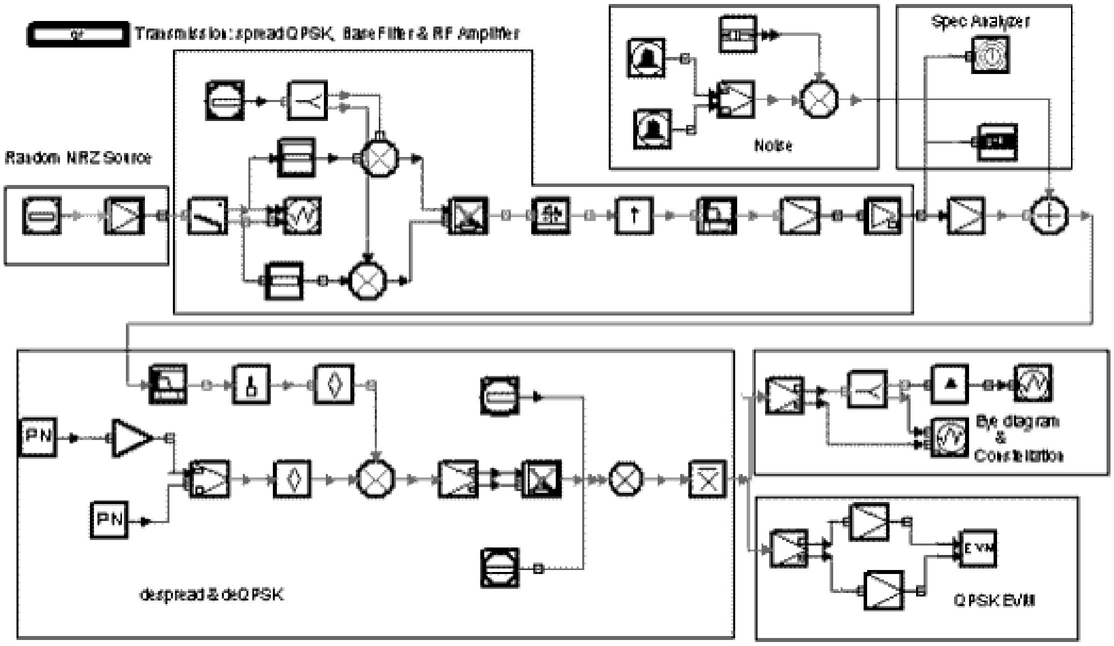
- Forward QPSK modulation
- Walsh modulator and Walsh rotation
- De-QPSK structure
- Demodulation and derotation
- 48-order baseband filter
- 1.2288 Mcps chip rate
- Non-linear RF amplifier
- Eye diagram and constellation display during simulation
- EVM and ACPR measurements

Description

DsnCDMA2K_FwdSR1Trans is an example design for measuring forward link SR1 transmissions. QPSK, Walsh modulator, Walsh rotator, baseband filter and non-linear RF amplifier are applied.

After De-QPSK, demodulation and derotation, the I way Eye diagram and received signal constellation are shown in real time.When the amplitude of white noise is adjusted, the eye diagram opening and constellation scattering changes can be viewed.

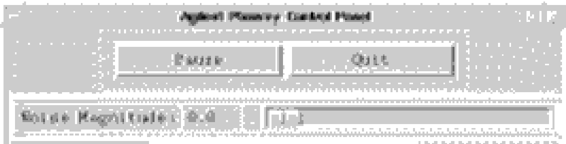
Schematic



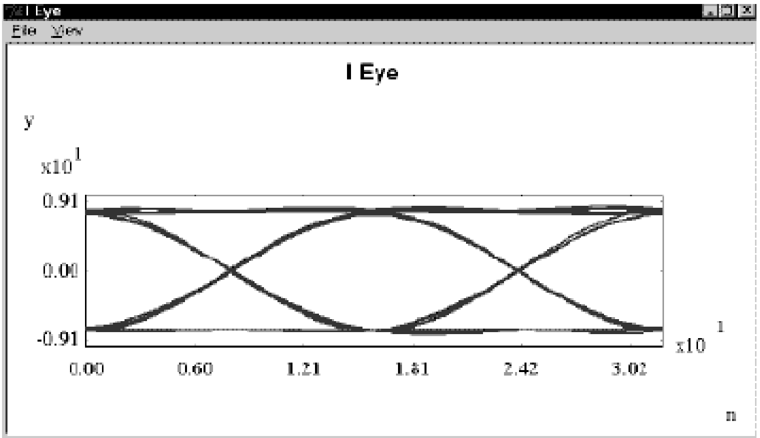
DsnCDMA2K_FwdSR1Trans

Notes

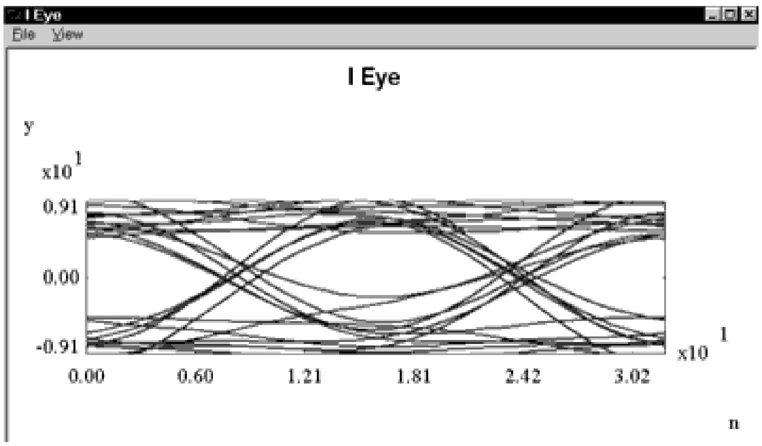
1. Channel coding and Rake receiver are not shown in this example.
2. During simulation, the Control Panel is displayed to allow noise magnitude adjustment. For EVM measurement, noise magnitude must remain constant before the Data collection is complete message is displayed.



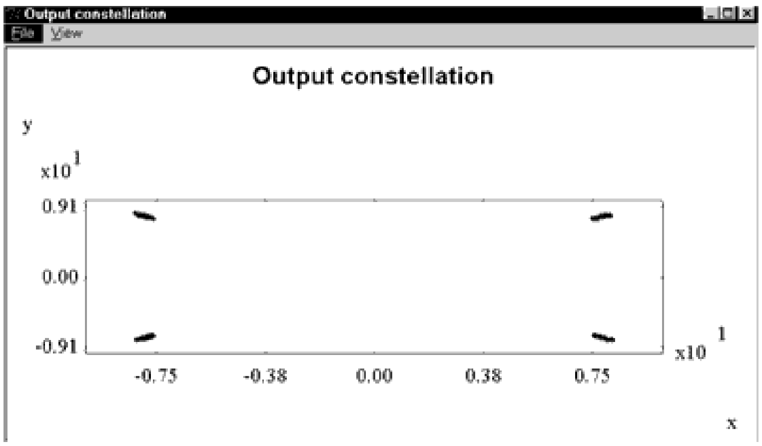
Simulation Results



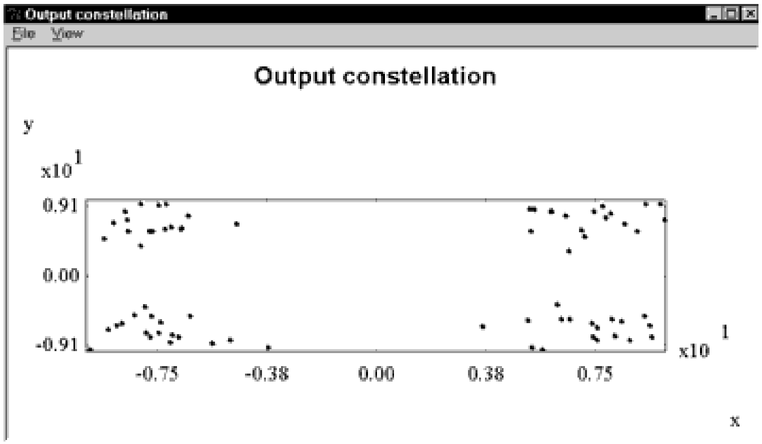
Eye Diagram (Noise Magnitude = 0)



Eye Diagram (Noise Magnitude = 5.3)

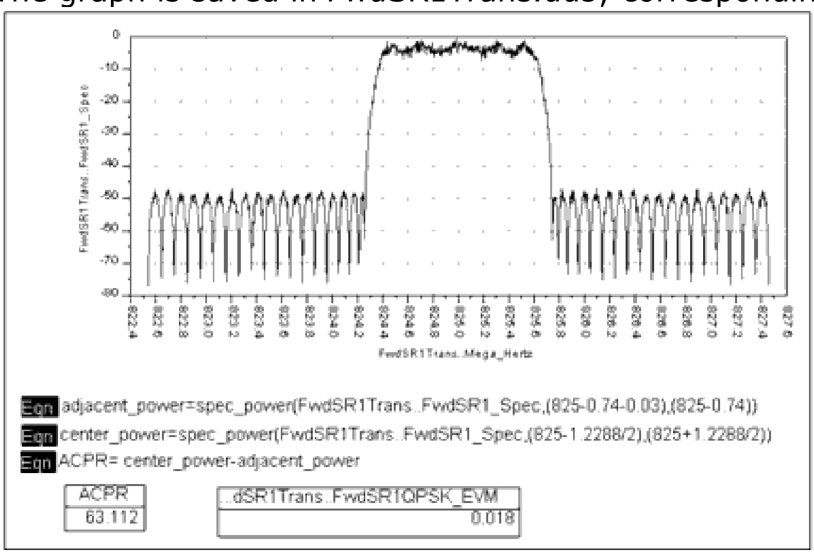


Constellation of Demodulated Signals (Noise Magnitude = 0)



Constellation of Demodulated Signals (Noise Magnitude = 5.3)

The following figure shows spectrum, ACPR and EVM values. Noise magnitude equals 0.5. The graph is saved in *FwdSR1Trans.dds*; corresponding data is saved in *FwdSR1Trans.ds*.



ACPR and EVM Performance

The following table shows EVM values based on different noise values.

EVM Values

EVM	Noise Magnitude Value
0.017	0
0.030	0.5
0.055	1
0.083	1.5

Benchmark

- Hardware platform: Pentium II 400 MHz, 256 MB memory
- Software platform: Windows NT 4.0 workstation, ADS 1.3
- Data points: data of 5 msec
- Simulation time: 73 seconds

Forward Link SR3 Transmission Measurements

CDMA2K_Measurement_wrk Design Name

- DsnCDMA2K_FwdSR3Trans

Features

- Forward QPSK modulation
- Walsh modulator and Walsh rotator
- De-QPSK structure
- Demodulation and derotation
- 108-order baseband filter
- 3.6864 Mcps chip rate
- Non-linear RF amplifier
- Eye diagram and constellation display during simulation
- EVM and ACPR measurements

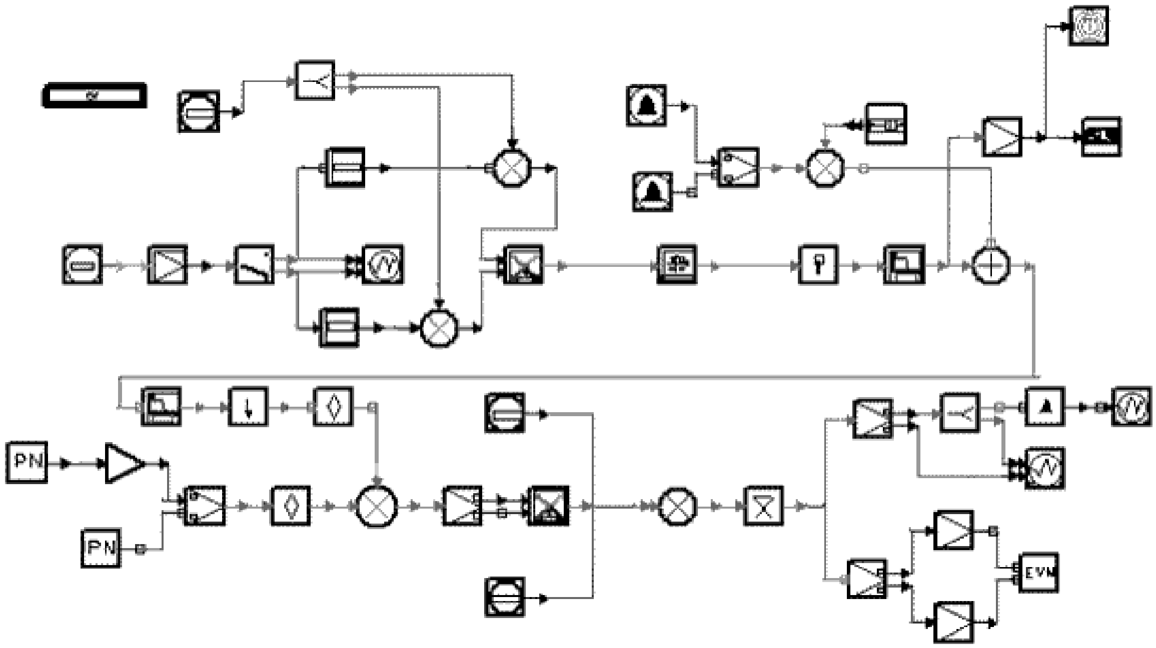
Description

DsnCDMA2K_FwdSR3Trans is an example design for measuring forward link SR3 transmissions. QPSK, Walsh modulator, Walsh rotator, baseband filter and non-linear RF amplifier are applied.

After De-QPSK, demodulation and derotation, the I way Eye diagram and received signal constellation are shown in real time. When the amplitude of white noise is adjusted, the eye diagram opening and constellation scattering changes can be viewed.

Schematic

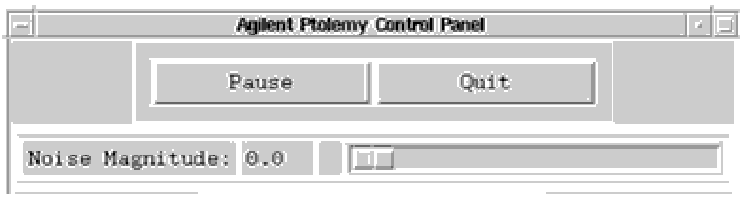
The schematic for this design is shown in the following figure.



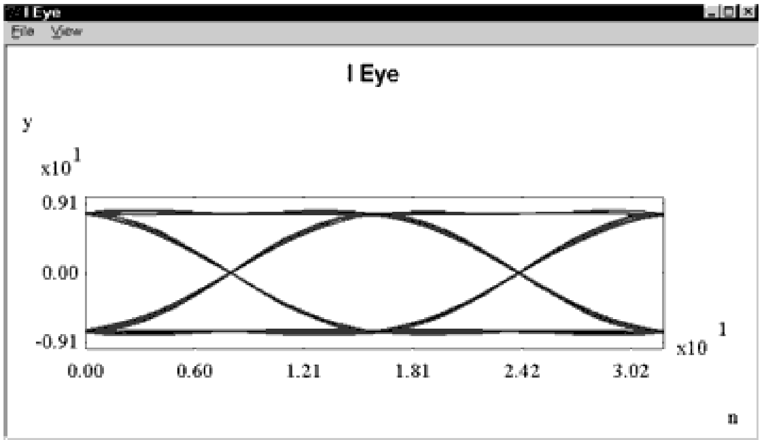
DsnCDMA2K_FwdSR3Trans

Notes

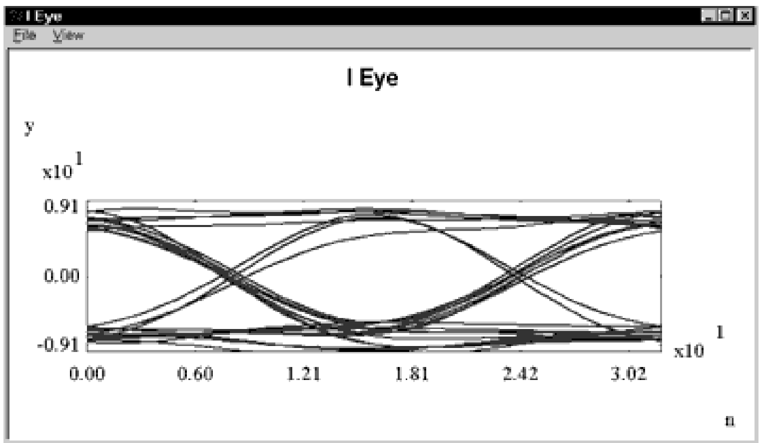
1. Channel coding and Rake receiver are not shown in this example.
2. During simulation, the Control Panel is displayed to allow noise magnitude adjustment. For EVM measurement, noise magnitude must remain constant the Data collection is complete message is displayed.



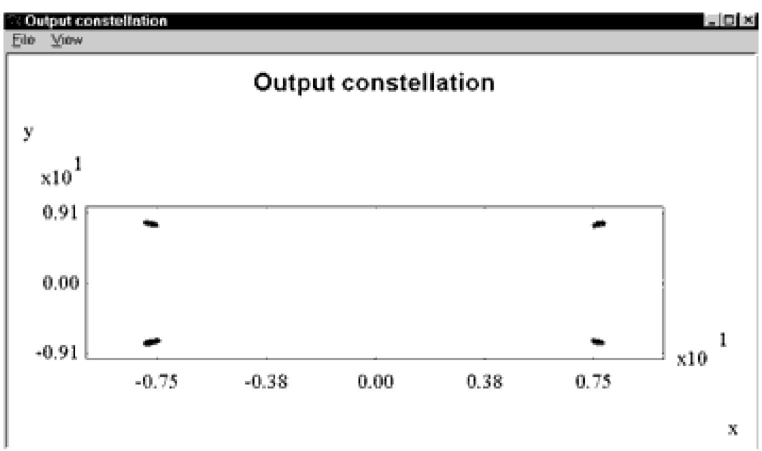
Simulation Results



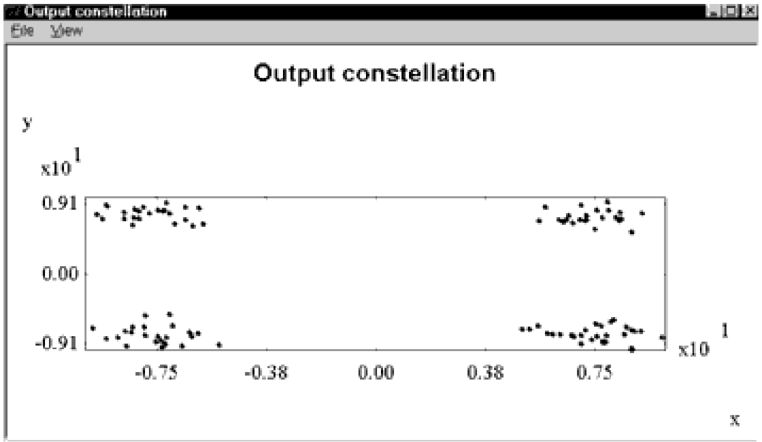
Eye Diagram (Noise Magnitude = 0)



Eye Diagram (Noise Magnitude = 4.5)

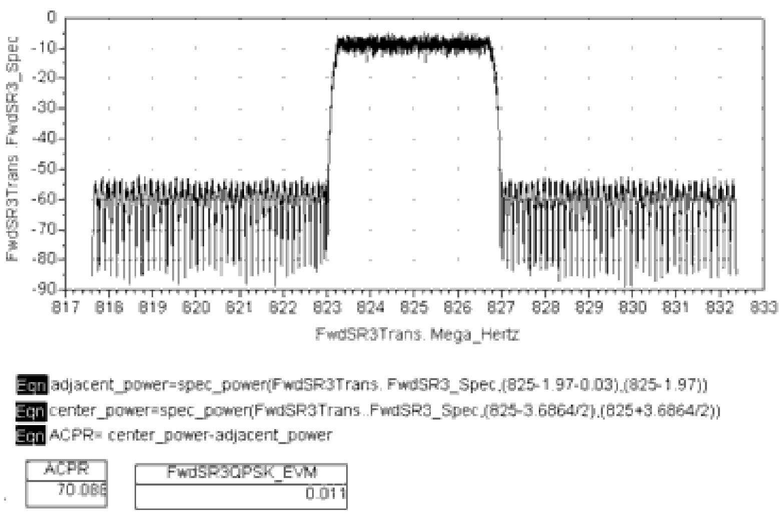


Constellation of Demodulated Signals (Noise Magnitude = 0)



Constellation of Demodulated Signals (Noise Magnitude =4.5)

The following figure shows the ACPR and EVM performance spectrum with a noise magnitude of 0. The graph is saved in *FwdSR3Trans.dds*; corresponding data is saved in *FwdSR3Trans.ds*.



ACPR and EVM Performance

The following table shows EVM values based on different noise values.

EVM Values

EVM	Noise Magnitude Value
0.011	0
0.021	0.5
0.037	1
0.055	1.5

Benchmark

- Hardware platform: Pentium II 400 MHz, 256 MB memory
- Software platform: Windows NT 4.0 workstation, ADS 1.3
- Data points: data of 2 msec
- Simulation time: 136 seconds

Reverse SR1 Transmission (HPSK) Measurements

CDMA2K_Measurement_wrk Design Name

- DsnCDMA2K_RevSR1Hpsk

Features

- Multi-code channel (HPSK channel)
- HPSK modulation and demodulation
- 48-order baseband filter
- 1.2288 Mcps chip rate
- Non-linear RF amplifier
- Eye diagram and constellation display during simulation
- EVM, ACPR, and CCDF measurements

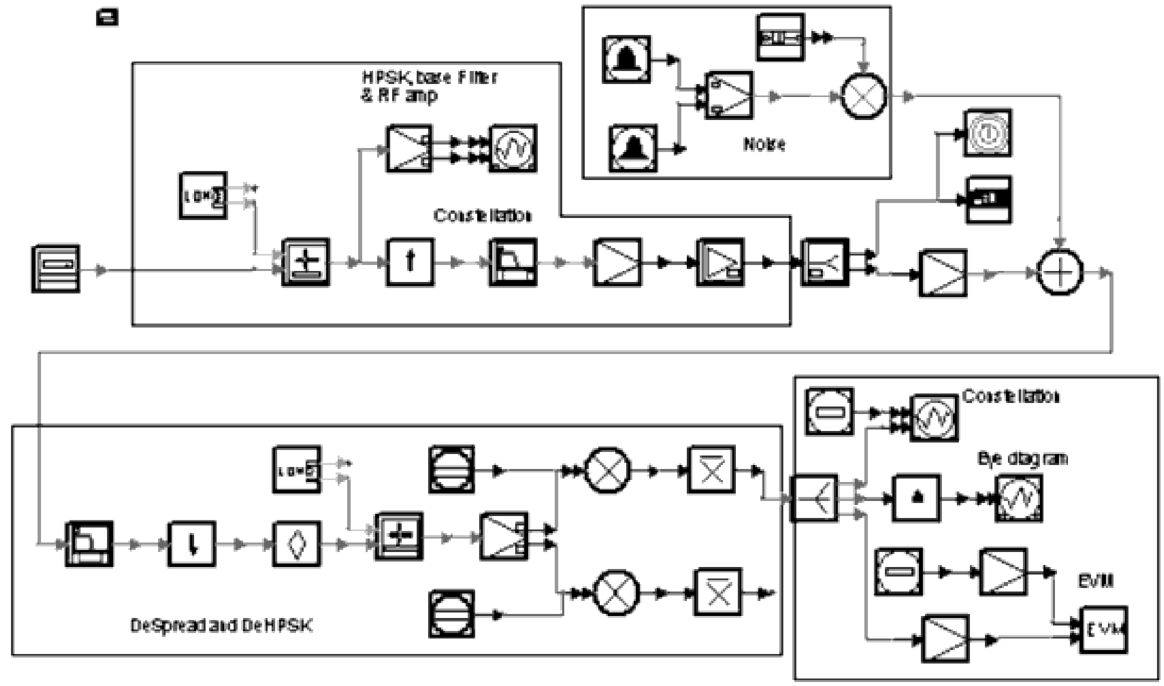
Description

DsnCDMA2K_RevSR1Hpsk is an example design for measuring reverse link SR1 transmissions. HPSK, baseband filter, and non-linear RF amplifier are applied.

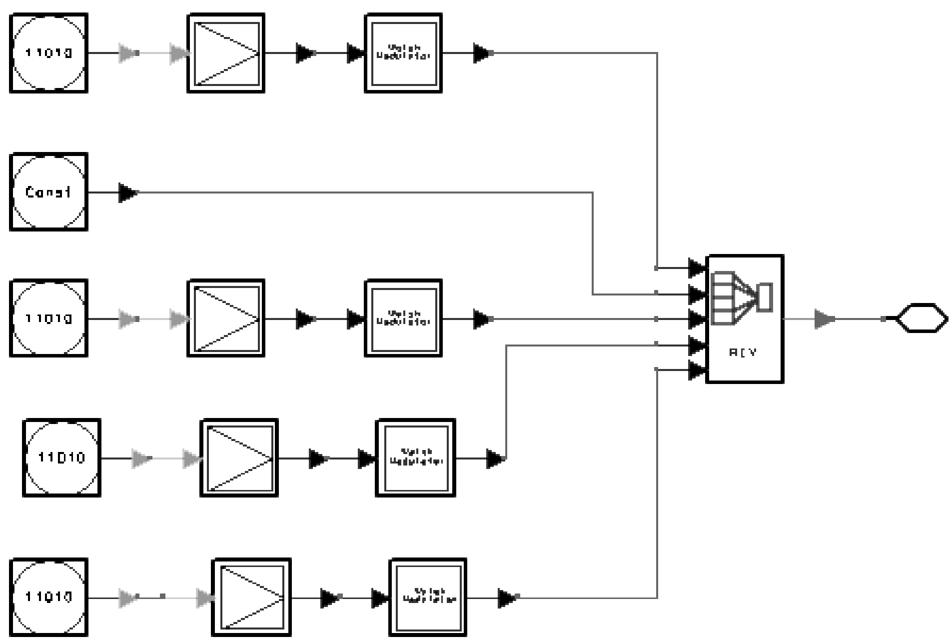
After HPSK demodulation, the I way Eye diagram and received signal constellation are displayed during simulation. White noise amplitude can be adjusted while observing the Eye diagram and constellation scattering.

In this example the Traffic Fundamental Channel signal with Walsh Code Index 5 are measured. For this code channel, the modulator method is HPSK. After demodulation, the constellation of this code channel is same as BPSK. So in EVM measurement and constellation showing, BPSK mode is referred as standard modulation type.

Schematics



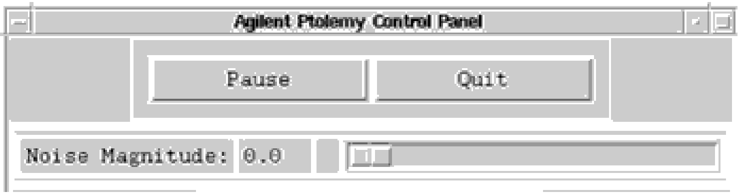
DsnCDMA2K_RevSR1Hpsk



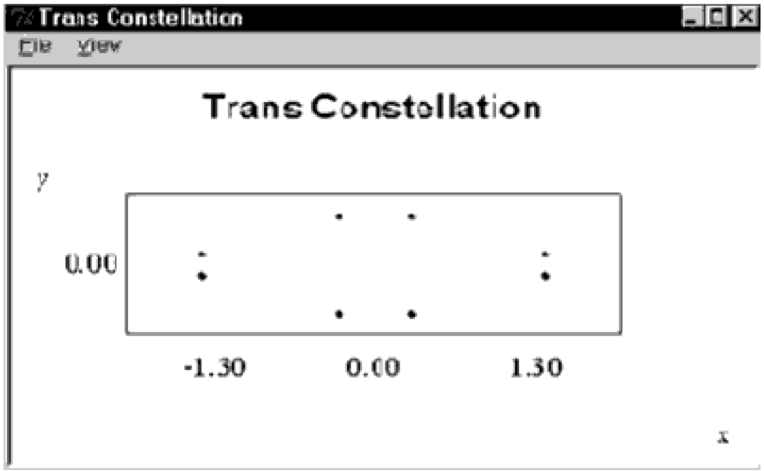
HPSK Channel

Notes

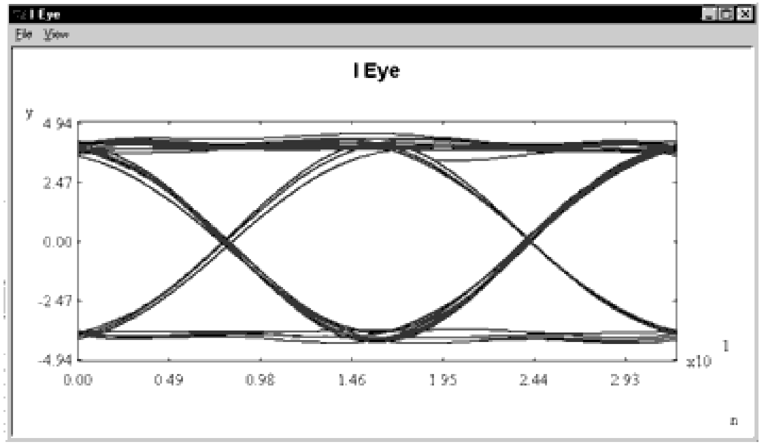
1. Channel coding and Rake receiver are not shown in this example.
2. In HPSK Channel subnetwork, various code channels are used. The Pilot Channel is constant logic 0, which equals NRZ 1. The output power of other code channels can be adjusted by Gain model. Here the fundamental channel uses Walsh Code index 5.
3. During simulation, the Control Panel is displayed to allow noise magnitude adjustment. For EVM measurement, noise magnitude must remain constant before the Data collection is complete message is displayed.



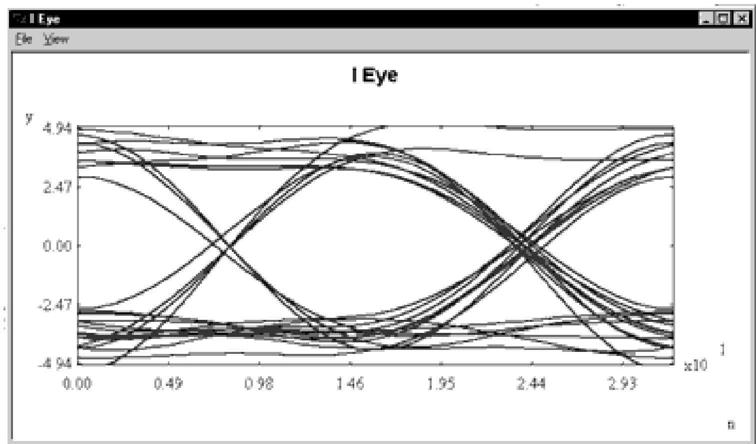
Simulation Results



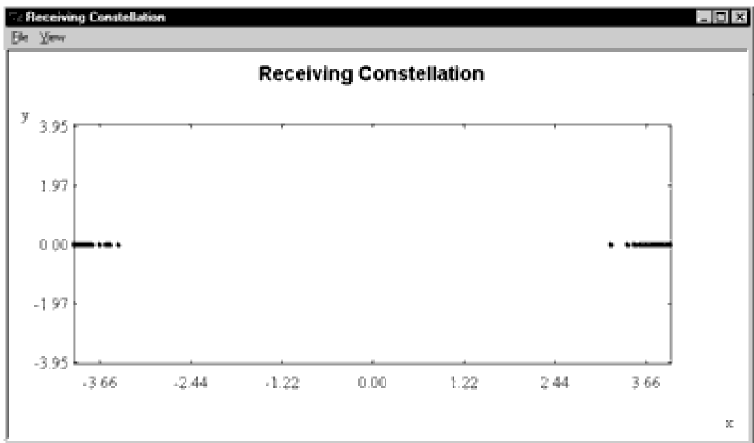
Transmission Constellation



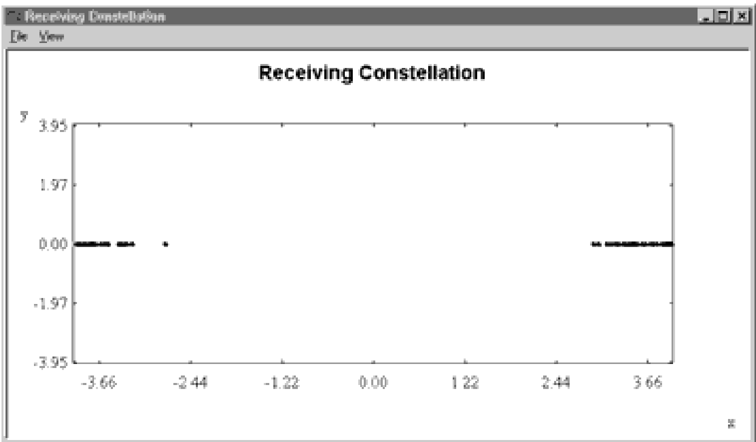
Eye diagram (Noise Magnitude = 0)



Eye Diagram (Noise Magnitude = 1.4)

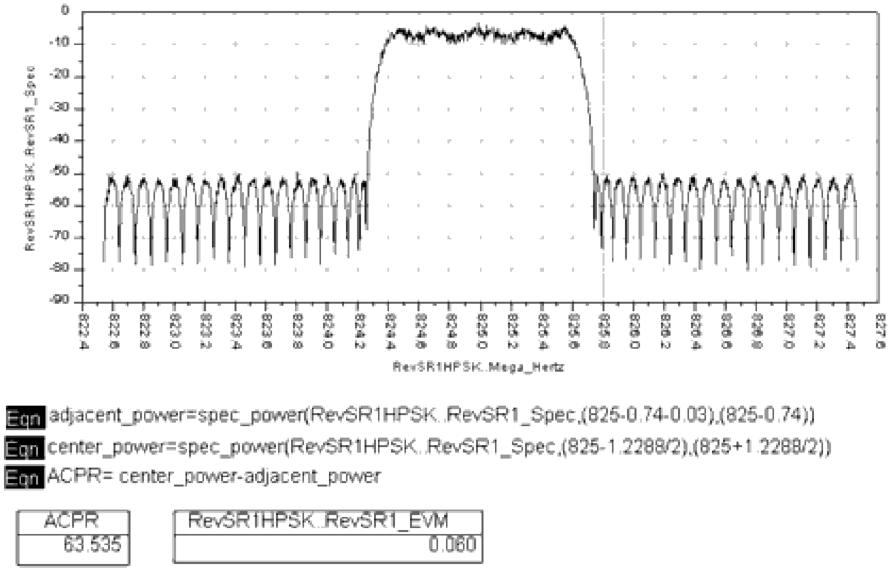


Constellation of Demodulated Signals (Noise Magnitude = 0)



Constellation of Demodulated Signals (Noise Magnitude = 1.4)

The following figure shows the ACPR and EVM performance spectrum with a noise magnitude of 0. The graph is saved in *RevSR1HPSK.dds*; corresponding data is saved in *RevSR1HPSK.ds*.



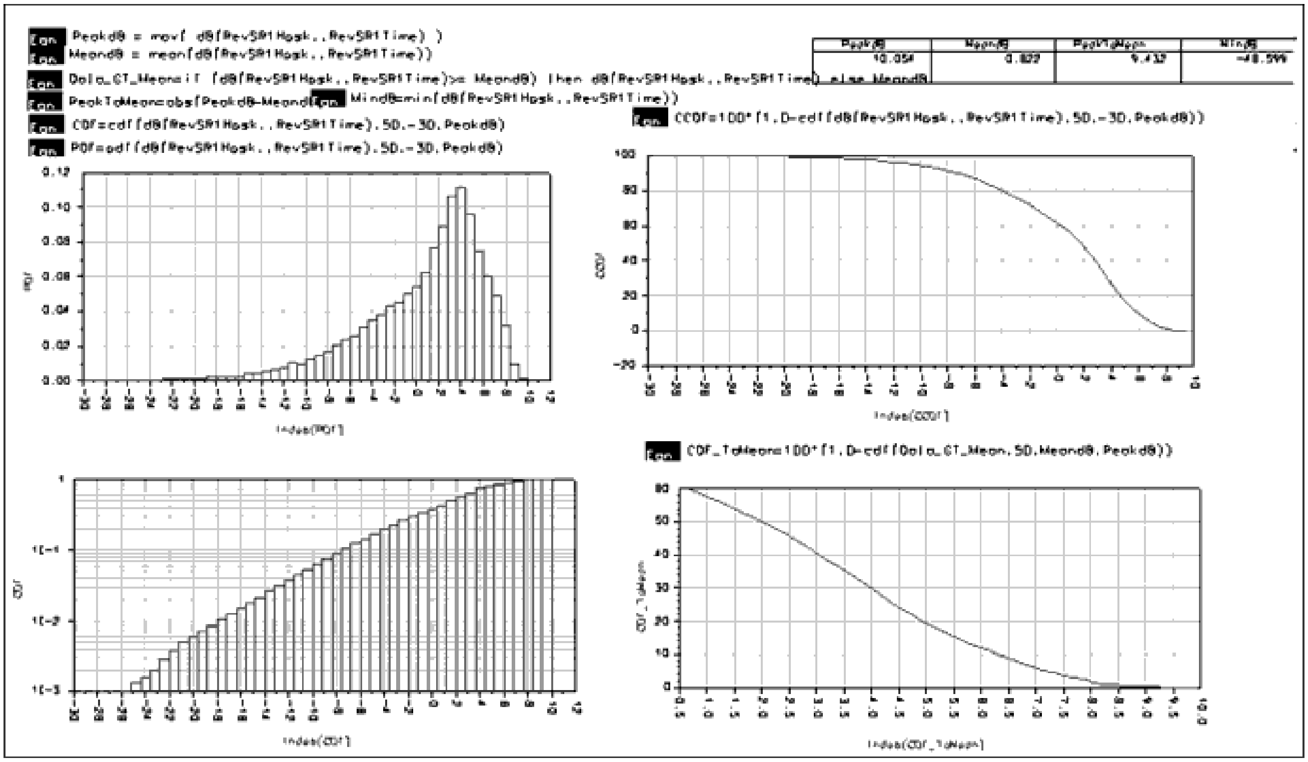
ACPR and EVM Performance

The following table shows EVM values based on different noise values.

EVM Values

EVM	Noise Magnitude Value
0.060	0
0.069	0.5
0.103	1

The following figure shows CCDF performance.



CCDF Performance

Benchmark

- Hardware platform: Pentium II 400 MHz, 256 MB memory
- Software platform: Windows NT 4.0 workstation, ADS 1.3
- Data points: data of 5 msec
- Simulation time: 193 seconds

Reverse SR3 Transmission (HPSK) Measurements

CDMA2K_Measurement_wrk Design Name

- DsnCDMA2K_RevSR3Hpsk

Features

- Multi-code channel (HPSK channel)
- HPSK modulation and demodulation
- 108-order baseband filter
- 3.6864 Mcps chip rate
- Non-linear RF amplifier
- Eye diagram and constellation display during simulation
- EVM, ACPR and CCDF measurements

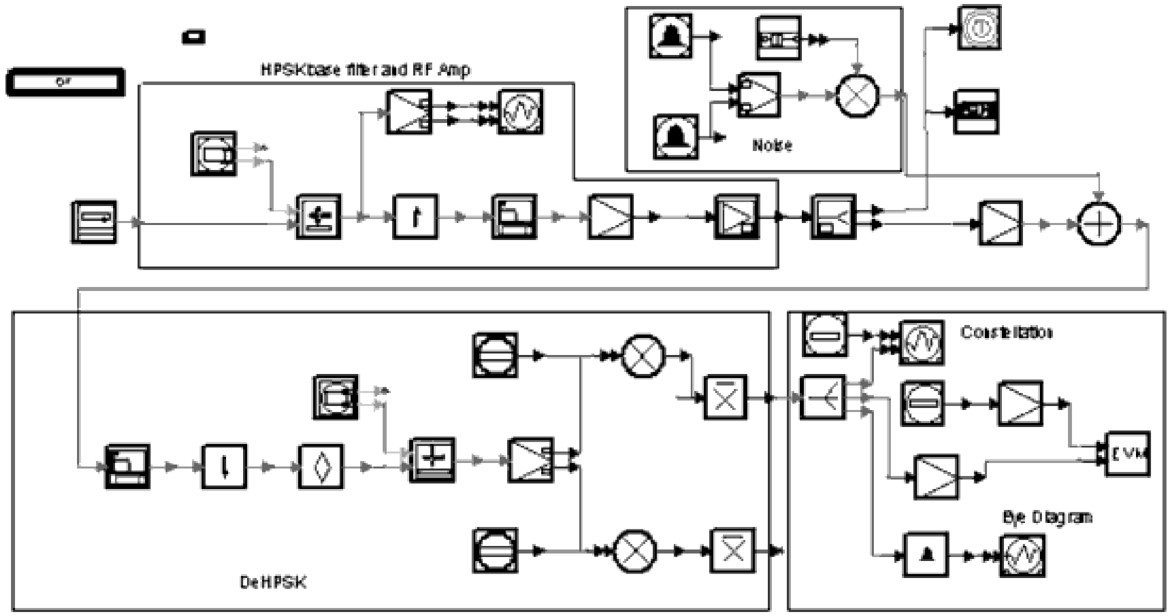
Description

DsnCDMA2K_RevSR3Hpsk is an example design for measuring reverse link SR3 transmissions. HPSK, baseband filter and non-linear RF amplifier are applied.

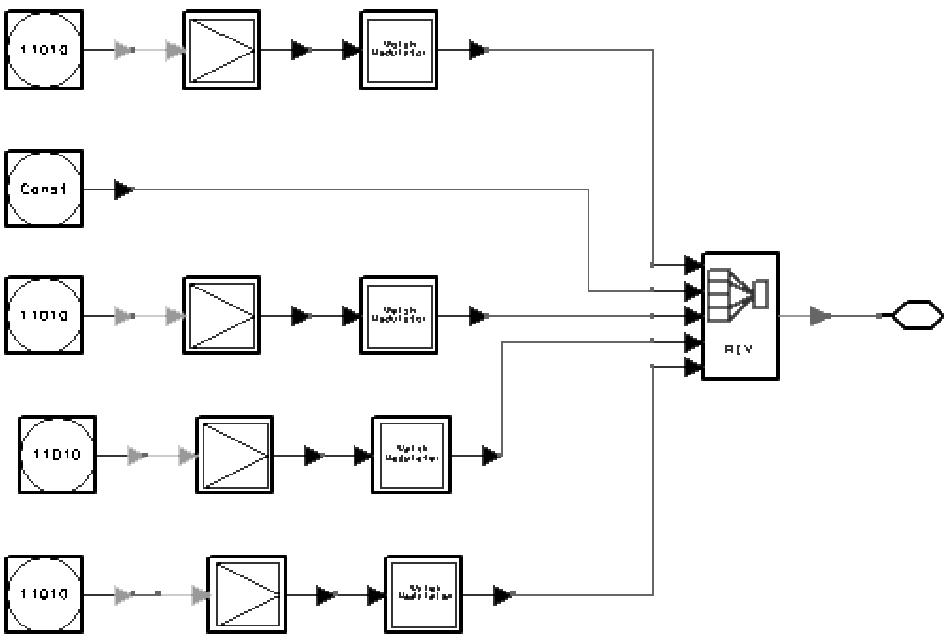
After HPSK demodulation, I way Eye diagram and received signal constellation are displayed during simulation. White noise amplitude can be adjusted while observing the Eye diagram and constellation scattering.

In this example the Traffic Fundamental Channel signal with Walsh Code Index 5 are measured. For this code channel, the modulator method is HPSK. After demodulation, the constellation of this code channel is same as BPSK. So in EVM measurement and constellation showing, BPSK mode is referred as standard modulation type.

Schematic



DsnCDMA2K_RevSR3Hpsk



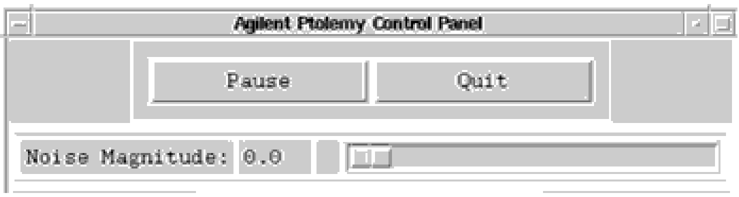
HPSK Channel

Notes

1. Channel coding and Rake receiver are not shown in this example.
2. In HPSK Channel subnetwork, various code channels are used. The pilot channel is constant logic 0, which equals NRZ 1. The output power of the code channels are

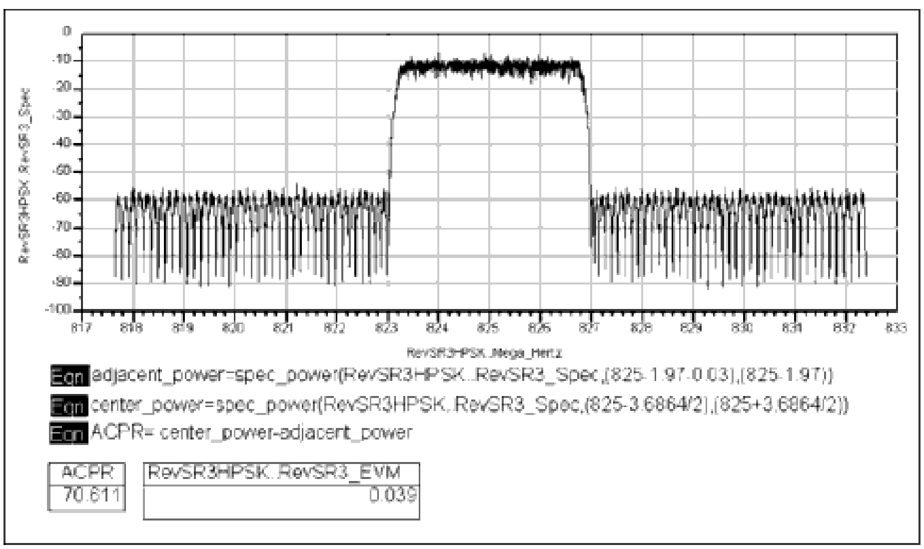
allocated according to the frame length, channel coding and its rate, etc. In this example, Walsh code W_{16}^{5} is used in fundamental channel.

3. During simulation, the Control Panel is displayed to allow noise magnitude adjustment. For EVM measurement, noise magnitude must remain constant before a Data collection is complete message is displayed.



Simulation Results

The following figure shows the ACPR and EVM performance spectrum. Noise magnitude equals 0.5. The graph is saved in *RevSR3HPSK.dds*; corresponding data is saved in *RevSR3HPSK.ds*.



ACPR and EVM Performance

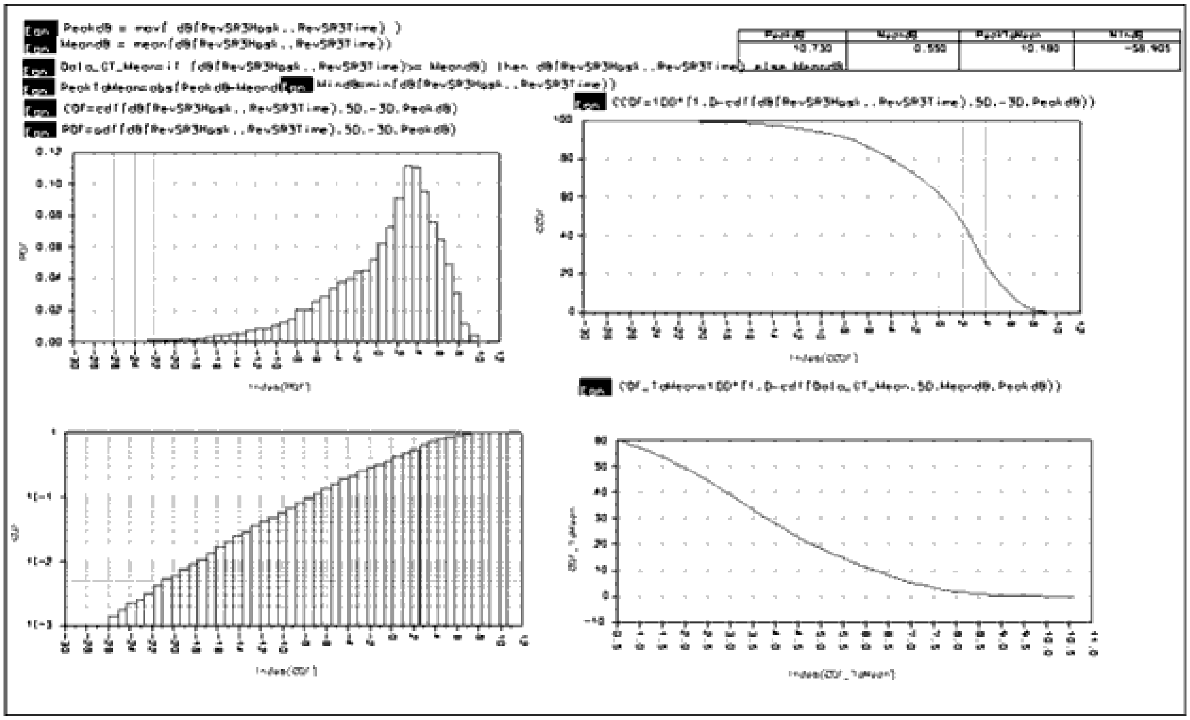
The following table shows EVM values based on different noise values.

EVM Values

EVM	Noise Magnitude Value
0.039	0
0.044	0.5
0.069	1
0.097	1.5

The following figure shows the CCDF performance; the graph is saved in *RevSR3CCDF.dds*

; the corresponding data is saved in *RevSR3CCDF.ds.*



CCDF Performance

Benchmark

- Hardware platform: Pentium II 400 MHz, 256 MB memory
- Software platform: Windows NT 4.0 workstation, ADS 1.3
- Data points: data of 2 msec
- Simulation time: 630 seconds

Peak to Average Power Ratio of HPSK and QPSK Modulation Measurements

CDMA2K_Measurement_wrk Design Name

- DsnCDMA2K_H_Q_PSK_PAPR

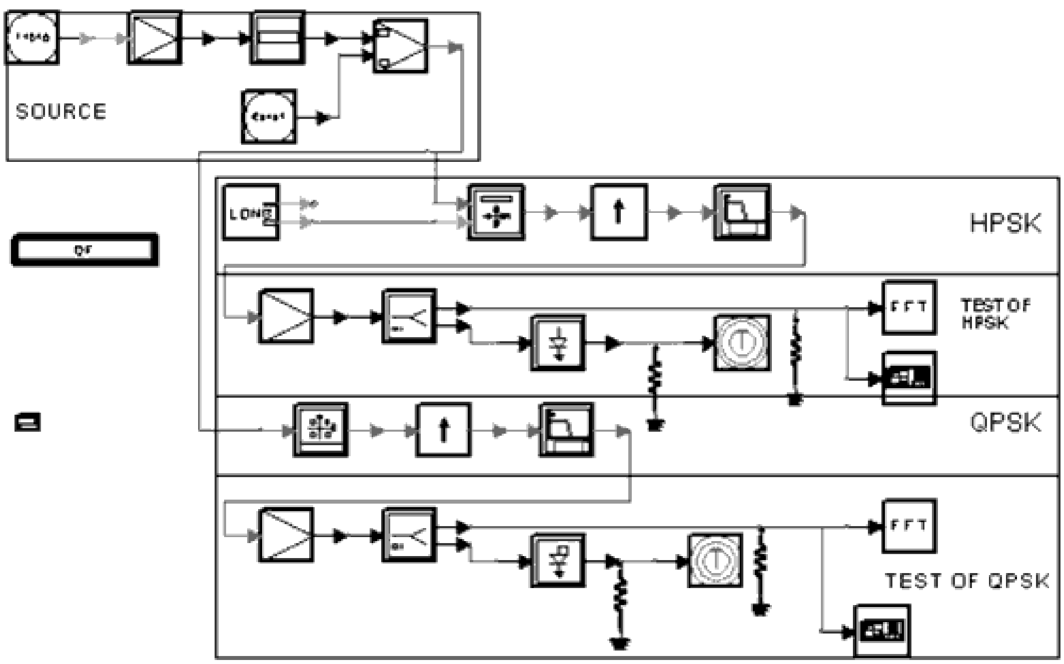
Features

- Reverse HPSK modulation
- Forward QPSK modulation
- Walsh modulator
- 48-order baseband filter
- Peak to average power ratio (PAPR) measurement
- CCDF measurement

Description

DsnCDMA2K_H_Q_PSK_PAPR is an example design to compare PAPR performance of HPSK and QPSK.

Schematic



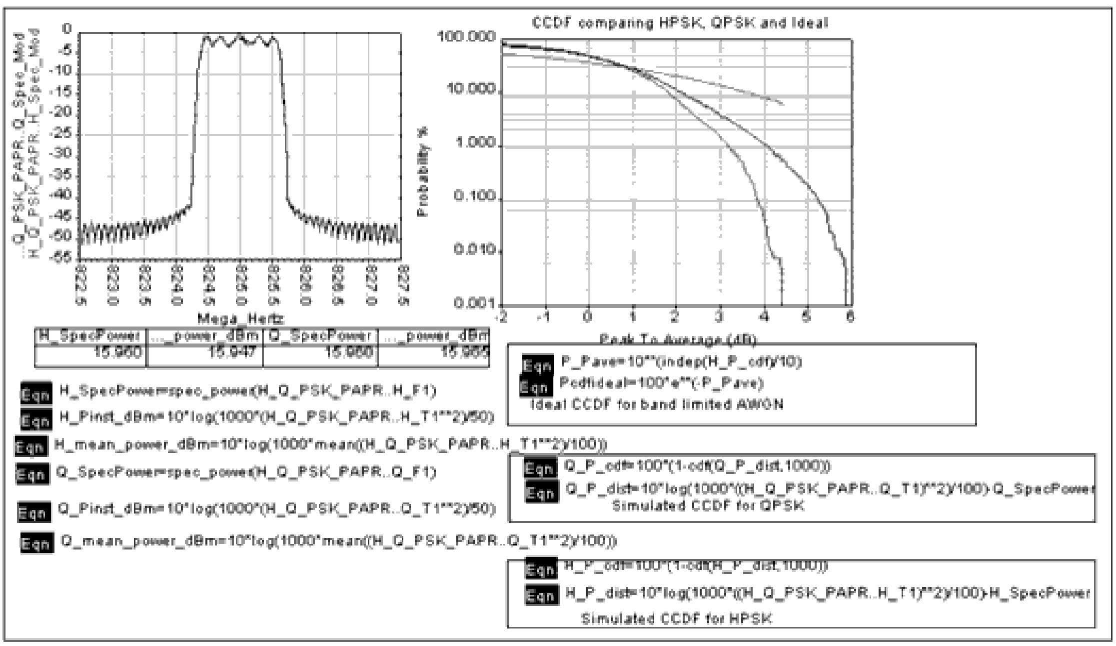
DsnCDMA2K_H_Q_PSK_PAPR

Notes

1. Channel coding and Rake receiver are not shown in this example.

Simulation Results

The following figure shows CCDF performance; the graph is saved in _H_Q_PSK_PAPR.dds_; corresponding data is saved in _H_Q_PSK_PAPR.ds._ According to the graph, for a probability of 0.01%, the PAPR of the HPSK signal is approximately 1.5dB lower than the signal with QPSK modulation.



CCDF Performance

Benchmark

- Hardware platform: Pentium II 400 MHz, 256 MB memory
- Software platform: Windows NT 4.0 workstation, ADS 1.3
- Data points: 64K
- Simulation time: 40 seconds

Mobile Station Receiver Design Examples for cdma2000-Compliant Design Library

Introduction

The MS_RX_wrk workspace shows cdma2000 mobile station receiver measurements, including receiver sensitivity and dynamic range, single-tone desensitization with and without TX leakage, intermodulation spurious response attenuation, adjacent channel selectivity, and reverse traffic channel demodulation performance. Designs for these measurements include:

- MS_RxAdjacentSelectivityRC3 for mobile station receiver adjacent channel selectivity
- MS_RxDemodRC4AWGN for forward traffic channel demodulation performance
- MS_RxDnmcRngRC3 for mobile station receiver sensitivity and dynamic range
- MS_RxIntermodulationRC3 for mobile station receiver intermodulation spurious response attenuation
- MS_RxSingleToneRC3 for mobile station receiver single-tone desensitization
- MS_RxTxLeakageRC3 for mobile station receiver single-tone desensitization with transmit leakage

Designs under this workspace consist of:

- BS signal source in baseband
  CDMA2K_FwdRCsrc provides the downlink signal source of different radio configurations and data rates.
- Transmit modulation and up-convertor
  The data source of base band output from CDMA2K_FwdRCsrc is up-converted to IF signal with CDMA2K_RF_Mod, then modulated into RF signal with RF_TX_IFin.
- Channel loss and interfering signal combination
  The transmitted RF signal is then attenuated by RF channel (GainRF model) and combined with interfering signals (modulated or continuous waveform) at given frequency offsets.
- Down-convertor and demodulation
  At the receiver side, the received signal is demodulated to be the baseband signal by RF_RX_IFout and CDMA2K_RF_Demod models.
- Mobile station receiver in baseband
  CDMA2K_FwdRCreceiver is used to demodulate and decode the received baseband signals.

Adjacent Channel Selectivity

- MS_RxAdjacentSelectivityRC3

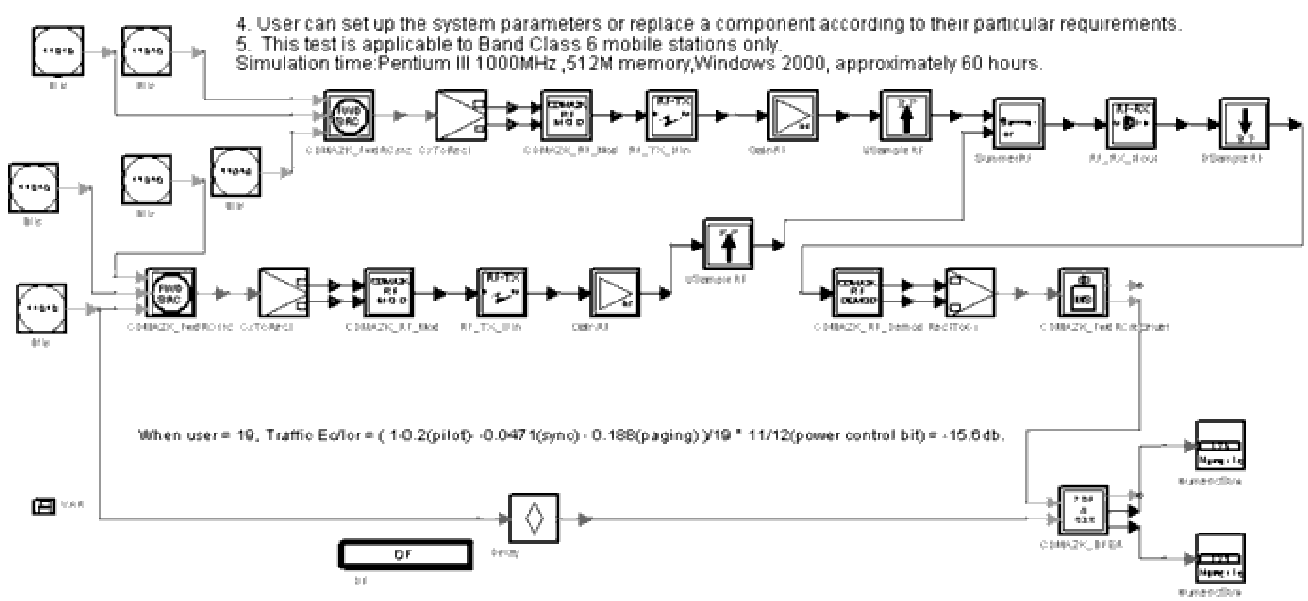
Features

- Forward pilot and fundamental channel
- Ec/Ior is −15.6 dB; Iorr is −101 dBm/1.23 MHz
- Ec/Ior can be changed by setting User in CDMA2K_FwdRCsrc
- Applies to band class 6 mobile stations only
- FER of fundamental channel measurement

Description

This example measures the receiver adjacent channel selectivity, as defined in section 3.5.4 of 3GPP2 C.S0011-A. FER is measured in the presence of another CDMA signal that is offset from the center frequency of the assigned channel by 2.5 MHz. RC3 is used as an example.

Schematic



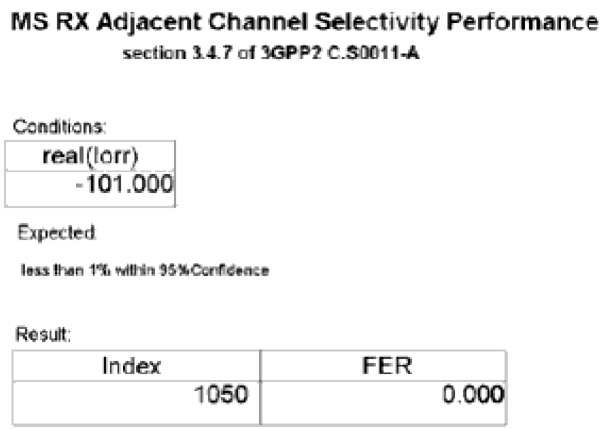
MS_RxAdjacentSelectivityRC3 Schematic

Notes

User can set up the system parameters or replace a component according to their particular requirements.

Simulation Results

Simulation results displayed in MS_RxAdjacentSelectivityRC3.dds are shown in the following figure.



Adjacent Channel Selectivity Performance

Benchmark

- Hardware Platform: Pentium III 1000 MHz, 512 Mb memory
- Software Platform: Windows NT 2000, ADS 1.5
- Data Points: 1050 frames
- Simulation Time: approximately 60 hours

Forward Traffic Channel Demodulation

- MS_RxDemodRC4AWGN

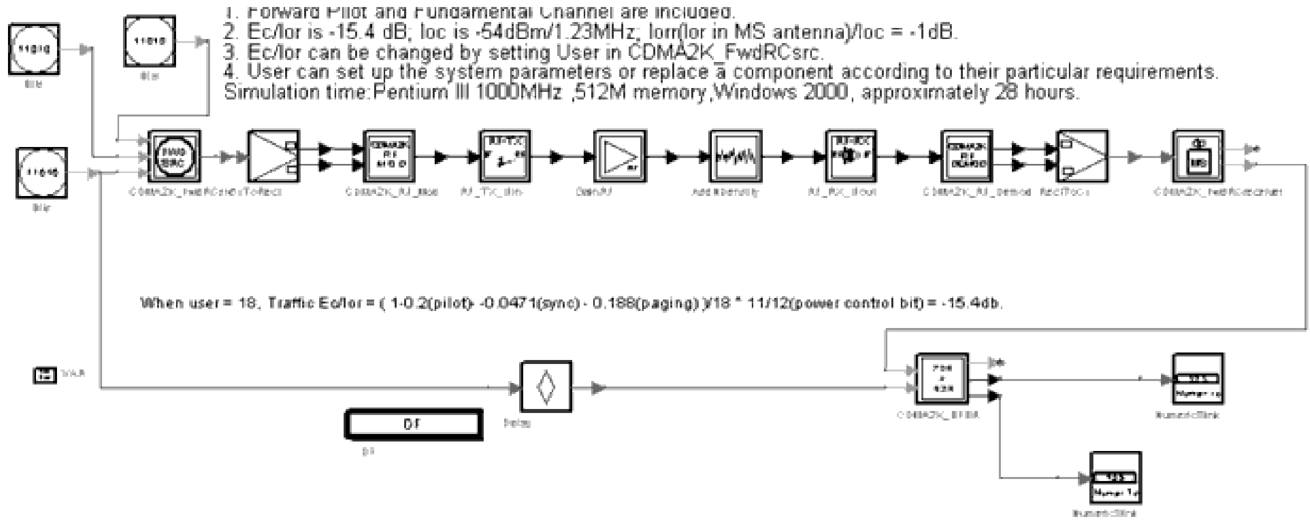
Features

- Forward pilot and fundamental channel
- Ec/Ior is −15.9 dB; Ioc is −54 dBm/1.23 MHz; Iorr (Ior in MS antenna)/Ioc = −1 dB
- Ec/Ior can be changed by setting User in CDMA2K_FwdRCsrc
- FER and BER of fundamental channel measurements

Description

This example verifies the demodulation performance of forward traffic channel under AWGN conditions, as defined in section 3.4.1 of 3GPP2 C.S0011-A. RC4 is used as an example.

Schematic



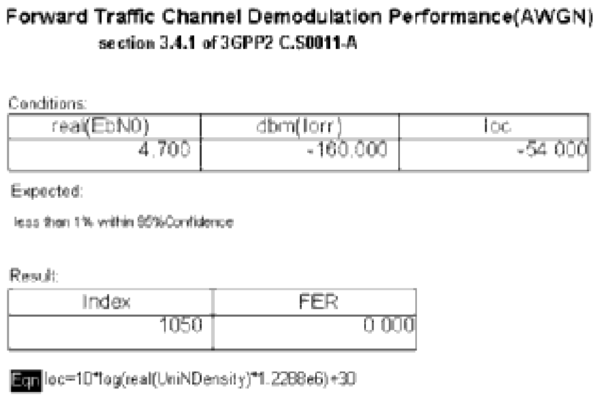
MS_RxDemodRC4AWGN Schematic

Notes

User can set up the system parameters or replace a component according to their particular requirements.

Simulation Results

Simulation results displayed in MS_RxDemodRC4AWGN.dds are shown in the following figure.


Forward Traffic Channel Demodulation Performance(AWGN)
section 3.4.1 of 3GPP2 C.S0011-A

Conditions:

real(EbN0)	dbm(Iorr)	Ioc
4.700	-160.000	-54.000

Expected:

less than 1% within 95%Confidence

Result:

Index	FER
1050	0.000

Eqn Ioc=10*log(real(UniNDensity)*1.2288e6)+30

Fundamental Channel

Benchmark

- Hardware Platform: Pentium III 1000 MHz, 512 Mb memory
- Software Platform: Windows 2000, ADS 1.5
- Data Points: 1050 frames
- Simulation Time: approximately 28 hours

Receiver Sensitivity and Dynamic Range

- MS_RxDnmcRngRC3

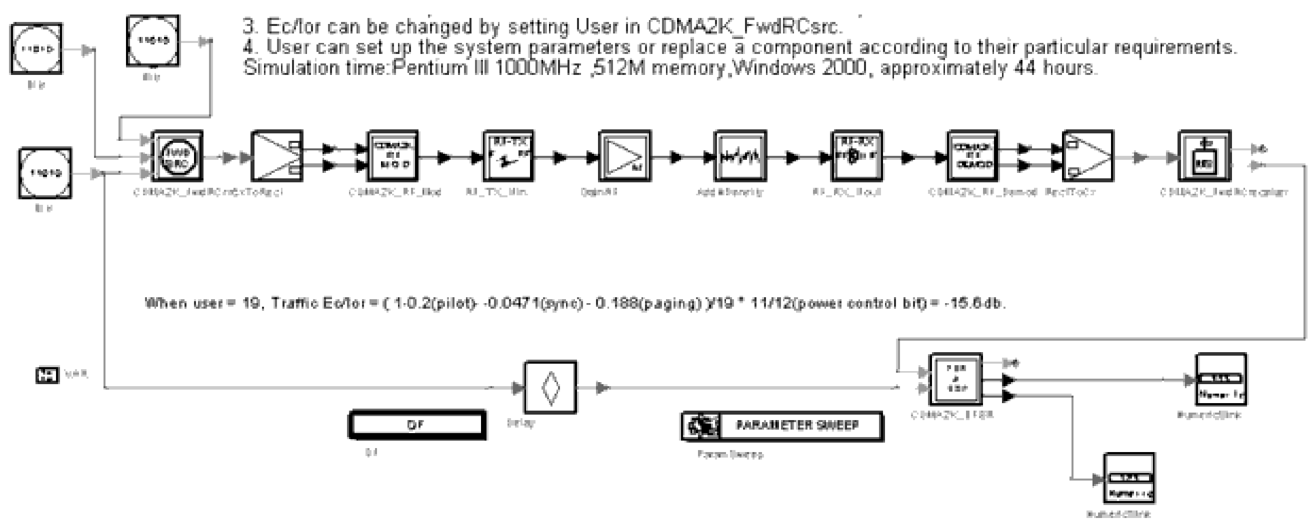
Features

- Forward Pilot and fundamental channel
- Ec/Ior is −15.6 dB; Iorr is −104 dBm/1.23 MHz or −25 dBm/1.23 MHz
- Ec/Ior can be changed by setting User in CDMA2K_FwdRCsrc.
- Dynamic range determined through parameter sweeping
- FER and BER of fundamental channel measurements

Description

This example verifies the receiver sensitivity and dynamic range, as defined in section 3.5.1 of 3GPP2 C.S0011-A. RC3 is used as an example.

Schematic



MS_RxDnmcRngRC3 Schematic

Notes

Both receiver sensitivity and dynamic range can be measured using this design. The dynamic range can be measured through changing the signal power at receiver side.

Simulation Results

Simulation results displayed in MS_RxDnmcRngRC3.dds are shown in the following figure.

MS Receiver Sensitivity and Dynamic Range

section 3.5.1 of 3GPP2 C.S0011-A

Conditions:

FER.DF.Iorr[0]	FER.DF.Iorr[1]
-104.000	-25.000

Expected:

less than 0.5% within 95%Confidence

Result:

Index	FER	
	Iorr=-104.000	Iorr=-25.000
949	0.000	0.000

Receiver Sensitivity and Dynamic Range Simulation Results

Benchmark

- Hardware Platform: Pentium II 400 MHz, 512 Mb memory
- Software Platform: Windows NT 4.0 Workstation, ADS 1.5
- Data Points: 1050 frames.
- Simulation Time: approximately 44 hours

Intermodulation Spurious Response Attenuation

- MS_RxIntermodulationRC3

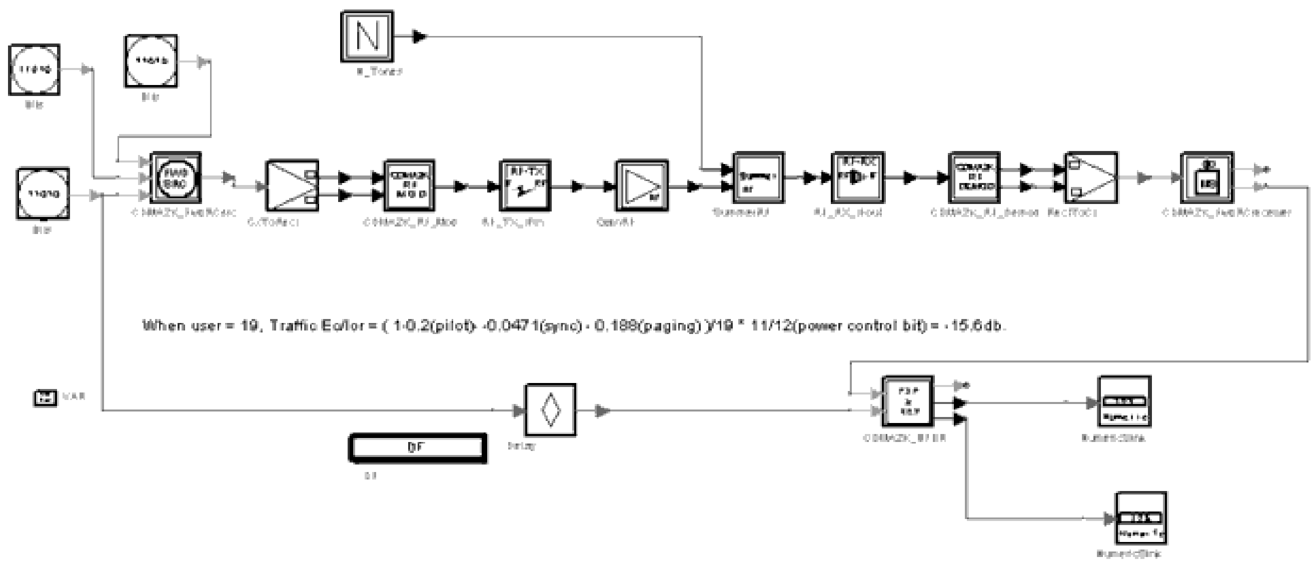
Features

- Forward pilot and fundamental channel
- Ec/Ior is −15.6 dB; Iorr is −101 dBm/1.23 MHz
- Ec/Ior can be changed by setting User in CDMA2K_FwdRCsrc
- FER and BER of fundamental channel measurements

Description

This example verifies a receiver's ability to receive a CDMA signal on its assigned channel frequency in the presence of two interfering CW tones, as defined in section 3.5.3 of 3GPP2 C.S0011-A. RC3 is used as an example.

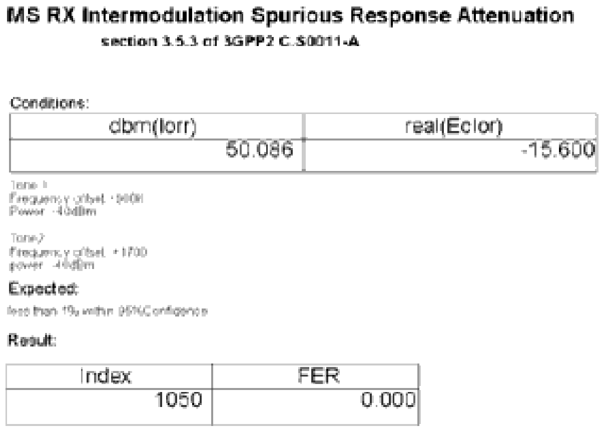
Schematic



MS_RxIntermodulationRC3 Schematic

Simulation Results

Simulation results displayed in MS_RxIntermodulationRC3.dds are shown in the following figure.



MS RX Intermodulation Spurious Response Attenuation

section 3.5.3 of 3GPP2 C.S0011-A

Conditions:

dbm(Iorr)	real(Ec/Ior)
50.086	-15.600

Tone 1
Frequency offset +900k
Power -40dBm

Tone2
Frequency offset +1700
power -40dBm

Expected:

less than 1% within 95%Confidence

Result:

Index	FER
1050	0.000

Intermodulation Spurious Response Attenuation Simulation Results

Benchmark

- Hardware Platform: Pentium III 1000 MHz, 512 Mb memory
- Software Platform: Windows 2000, ADS 1.5
- Data Points: 1050 frames.
- Simulation Time: approximately 23 hours

Single Tone Desensitization

- MS_RxSingleToneRC3

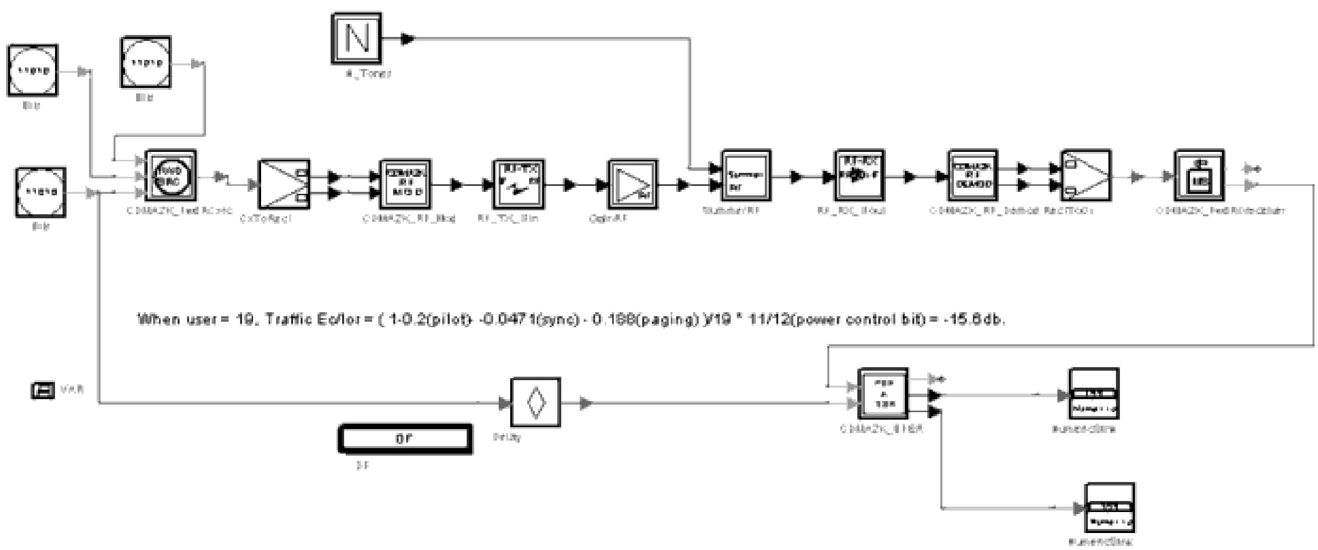
Features

- Forward Pilot and fundamental channel
- Ec/Ior is −15.6 dB; Iorr is −101 dBm/1.23 MHz
- Ec/Ior can be changed by setting User in CDMA2K_FwdRCsrc
- FER and BER of fundamental channel measurements

Description

This example verifies a receiver's ability to receive a CDMA signal at its assigned channel frequency in the presence of a single tone spaced at a given frequency offset from the center frequency of the assigned channel as defined in section 3.5.2 of 3GPP2 C.S0011-A. RC3 is used as an example.

Schematic



MS_RxSingleToneRC3 Schematic

Simulation Results

Simulation results displayed in MS_RxSingleToneRC3.dds are shown in the following figure.

MS RX Single Tone Desensitization

section 3.5.2 of 3GPP2 C.S0011-A

Conditions:

dbm(Iorr)
50.086

Ec/Ior = -15.6dB
Tone 1:
Frequency offset +900K
Power: -40dBm

Expected:

less than 1% within 95%Confidence

Result:

Index	FER
1050	0.000

Single-Tone Desensitization Simulation Results

Benchmark

- Hardware Platform: Pentium III 1000 MHz, 512 Mb memory
- Software Platform: Windows 2000, ADS 1.5
- Data Points: 1050 frames
- Simulation Time: approximately 23 hours

Single-Tone Desensitization with Transmit Leakage

- MS_RxTxLeakageRC3

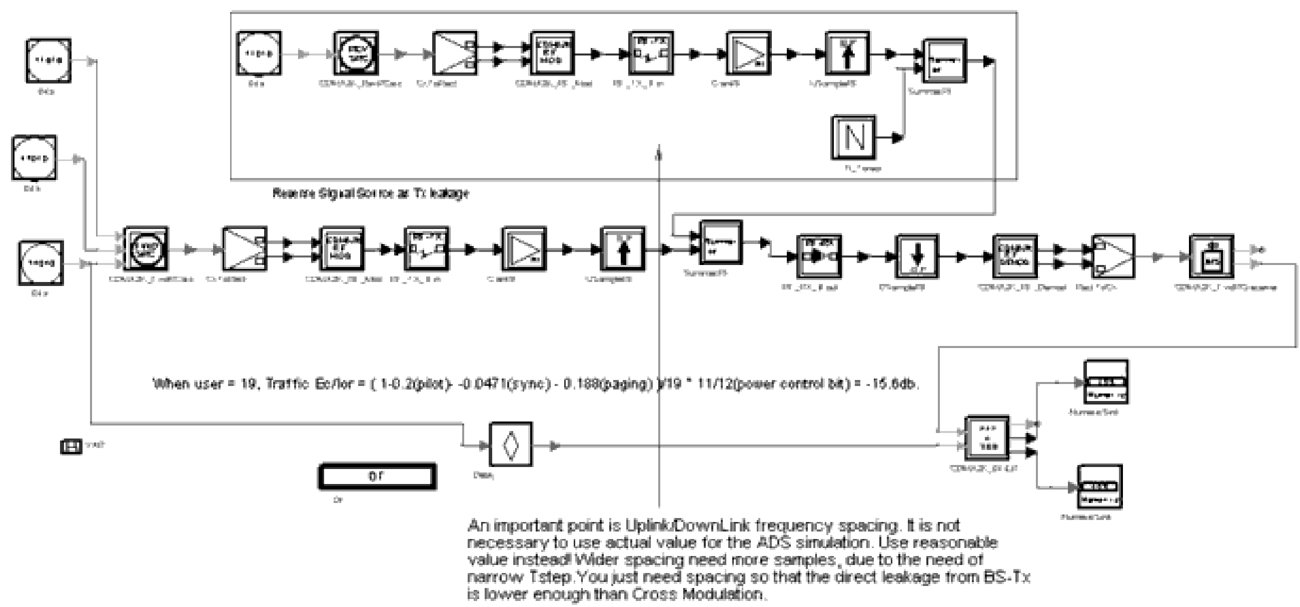
Features

- Forward Pilot and fundamental channel
- Ec/Ior is −15.6 dB; Iorr is −101 dBm/1.23 MHz
- Ec/Ior can be changed by setting User in CDMA2K_FwdRCsrc
- Reverse source used as transmit leakage of mobile station receiver and transmitted at approximately 20 dBm
- Isolation of duplexer is 100dBm
- FER and BER of fundamental channel measurements

Description

This example measures the receiver single-tone desensitization with transmit leakage. RC3 is used as an example.

Schematic



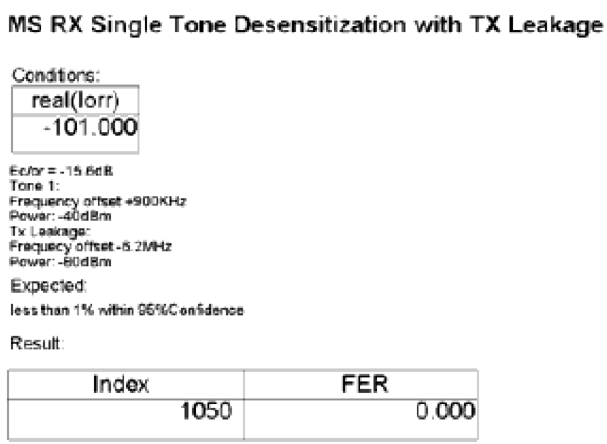
MS_RxTxLeakageRC3 Schematic

Notes

For uplink/downlink frequency spacing, use a reasonable value-it is not necessary to use the actual value for ADS simulation. Wider spacing requires more samples due to narrow Tstep. This spacing is necessary in order for the direct leakage from the base station transmitter to be lower than cross modulation.

Simulation Results

Simulation results displayed in MS_RxTxLeakageRC3.dds are shown in the following figure.



Single-Tone Desensitization with Transmit Leakage Simulation Results

Benchmark

- Hardware Platform: Pentium III 1000 MHz, 512 Mb memory
- Software Platform: Windows 2000, ADS 1.5
- Data Points: 1050 frames.
- Simulation Time: approximately 73 hours

Mobile Station Transmitter Design Examples for cdma2000-Compliant Design Library

Introduction

The MS_TX_wrk workspace shows cdma2000 mobile station transmitter measurement characteristics, including waveform quality (rho), mean power, code channel to reverse pilot channel output power accuracy, code domain power and conducted spurious emissions. Designs for these measurements include:

- MS_TxCDP_RC3 for code domain power
- MS_TxMeanPowerSR1 for mean power measurement of RF output
- MS_TxPowerAccuracy for measurement of code channel to reverse pilot channel output power accuracy
- MS_TxRhoRC3 for waveform quality measurement
- MS_TxSR1Spectrum for conducted spurious emissions measurement

Designs under this workspace consist of:

- MS signal source in baseband
  CDMA2K_RevRCsrc provides the uplink signal source of different Radio Configurations and data rates.
- Transmit modulation and up-convertor
  The data source of base band output from CDMA2K_RevRCsrc is up-converted to IF signal with CDMA2K_RF_Mod, then modulated into RF signal with RF_TX_IFin.
- Code domain power measurement
  CDMA2K_CDP is used to measure the code domain power.
- Mean power measurement
  CDMA2K_PwrMeasure is used to measure the mean power of input signal.
- Rho measurement
  CDMA2K_RevRhoWithRef is used to measure the waveform quality.

Code Domain Power

- MS_TxCDP_RC3

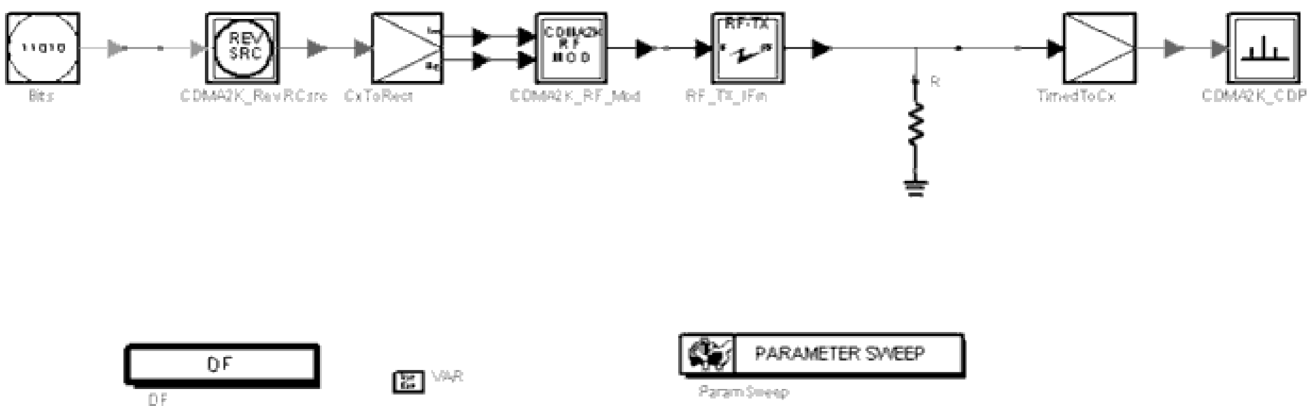
Features

- Walsh length is variable
- Reverse pilot and fundamental channels enabled
- Code domain powers for different Walsh length measurements

Description

This example measures the code domain power of RC3 for the reverse link, as defined in section 4.3.3 of 3GPP2 C.S0011-A.

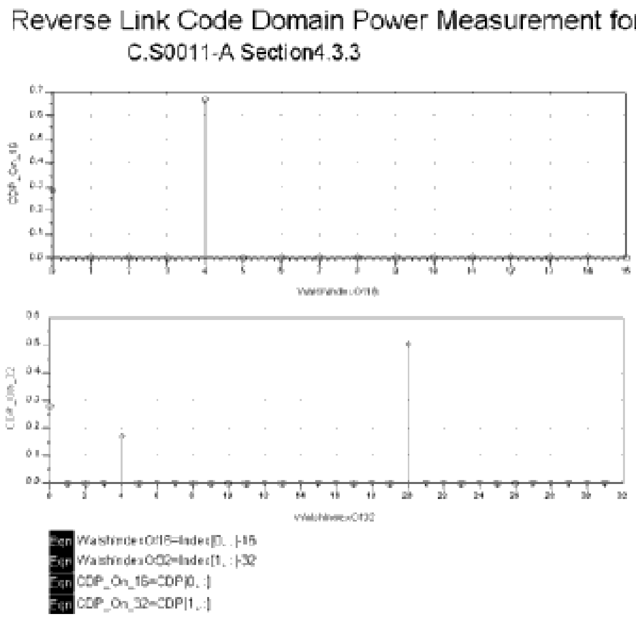
Schematic



MS_TxCDP_RC3 Schematic

Simulation Results

Simulation results displayed in MS_TxCDP_RC3.dds are shown in the following figure.



RC3 Reverse Link Code Domain Power Measurement

Benchmark

- Hardware Platform: Pentium II 400 MHz, 512 Mb memory
- Software Platform: Windows NT 4.0 Workstation, ADS 1.5
- Simulation Time: approximately 3 minutes

RF Output Mean Power

- MS_TxMeanPowerSR1

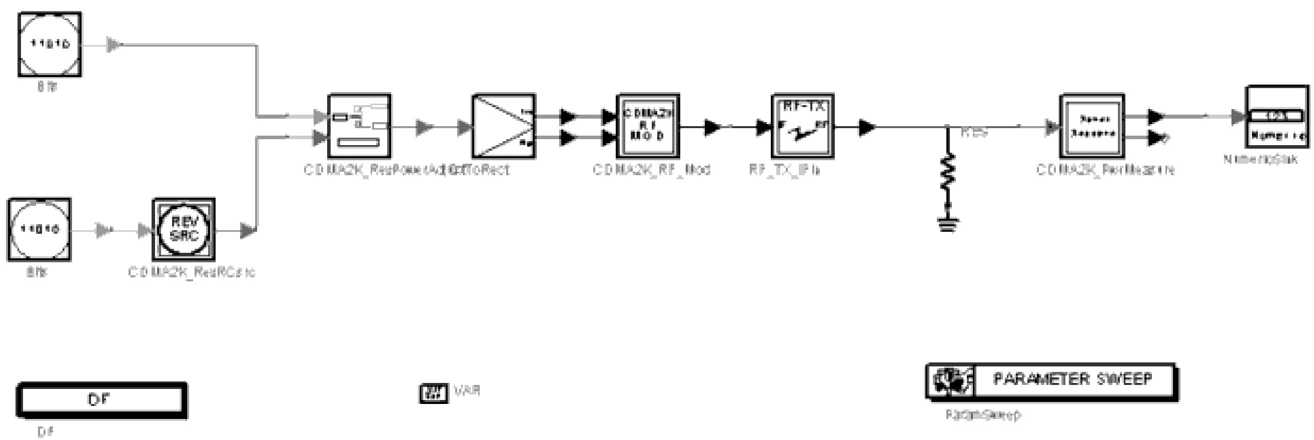
Features

- Maximum RF output power is obtained by sending continuous 0s as power control bits
- Minimum controlled output power is obtained by sending continuous 1s as power control bits
- Total transmit power measurement

Description

This example measures the mobile station transmit mean power as defined in sections 4.4.5 and 4.4.6 of 3GPP2 C.S0010-A.

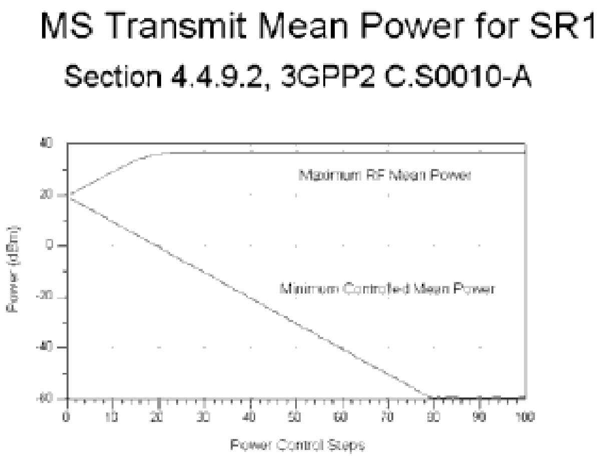
Schematic



MS_TxMeanPowerSR1 Schematic

Simulation Results

Simulation results displayed in MS_TxMeanPowerSR1.dds are shown in the following figure.



SR1 Mobile Station Transmit Mean Power

Benchmark

- Hardware Platform: Pentium II 400 MHz, 512 Mb memory
- Software Platform: Windows NT 4.0 Workstation, ADS 1.5
- Simulation Time: approximately 15 minutes

Code Channel Power Accuracy

- MS_TxPowerAccuracyRC3

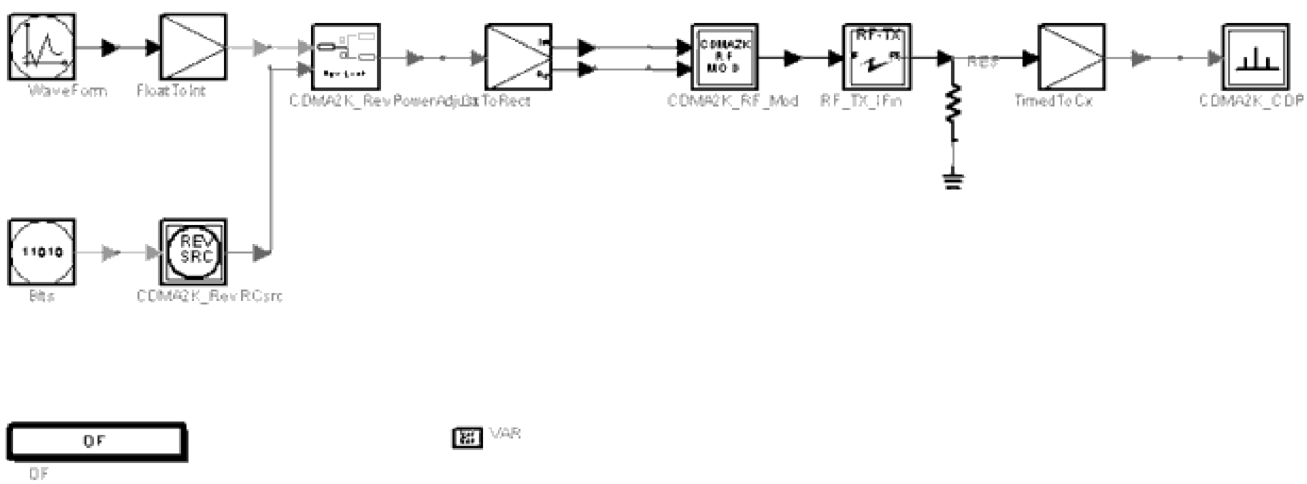
Features

- Sending alternating 0 and 1 power control bits to adjust reverse transmit power
- Reverse pilot channel power to traffic channel power ratio measurement

Description

This example measures the mobile station transmitter output at the antenna with a code domain power analyzer, as defined in section 4.4.9 3GPP2 C.S0010-A.

Schematic



MS_TxPowerAccuracyRC3 Schematic

Simulation Results

Simulation results displayed in MS_TxPowerAccuracyRC3.dds are shown in the following figure.

MS Code Channel Accuracy

Section 4.4.9.2,3GPP2 C.S0010-A.

LowerLimit_dB	TrafficToPilotRatio_dB	UpperLimit_dB
3.500	3.722	4.000

Eqn WalshLength=16

Eqn Pilot=CDP[0::WalshLength::WalshLength*int(CDP_GroupNum)-1]

Eqn Traffic=CDP[4::WalshLength::WalshLength*int(CDP_GroupNum)-1]

Eqn TrafficToPilotRatio_dB=10*log(mean(Traffic/Pilot))

Eqn UpperLimit_dB=3.75+0.25

Eqn LowerLimit_dB=3.75-0.25

Mobile Station Code Channel Accuracy

Benchmark

- Hardware Platform: Pentium II 400 MHz, 512 Mb memory
- Software Platform: Windows NT 4.0 Workstation, ADS 1.5
- Simulation Time: approximately 5 minutes

Waveform Quality

- MS_TxRhoRC3

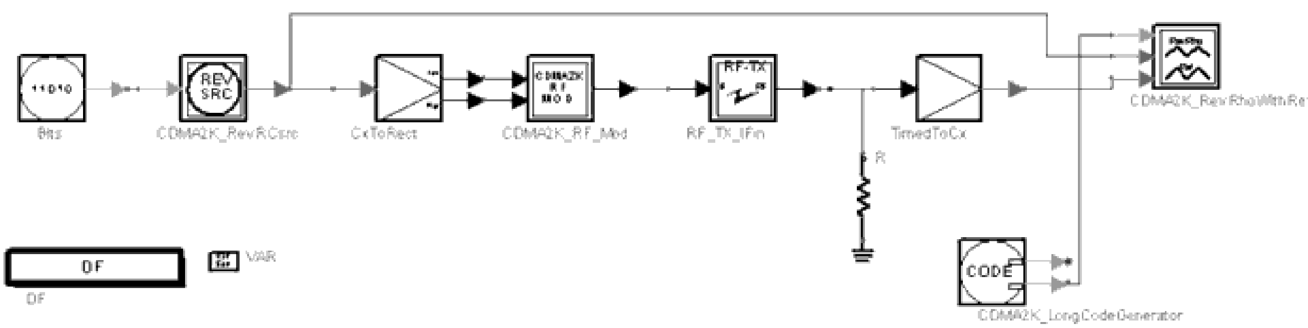
Features

- Reverse pilot channel and fundamental channel are transmitted
- Normalized correlated power (rho) measurement

Description

This example measures the normalized correlated power, rho, for the reverse link, as defined in section 4.2.2 of 3GPP2 C.S0011-A.

Schematic



MS_TxRhoRC3 Schematic

Simulation Results

Simulation results displayed in MS_TxRhoRC3.dds are shown in the following figure.

Rho Measurement for the Reverse Link of RC3

C.S0011-A Section4.2.2

Test results for frequency error in hertz and rho

Dlt_F	Rho
0.3844	0.9499

RC3 Reverse Link Measurement

Benchmark

- Hardware Platform: Pentium II 400 MHz, 512 Mb memory
- Software Platform: Windows NT 4.0 Workstation, ADS 1.5
- Simulation Time: approximately 2 minutes

Spurious Emissions

- MS_TxSR1Spectrum

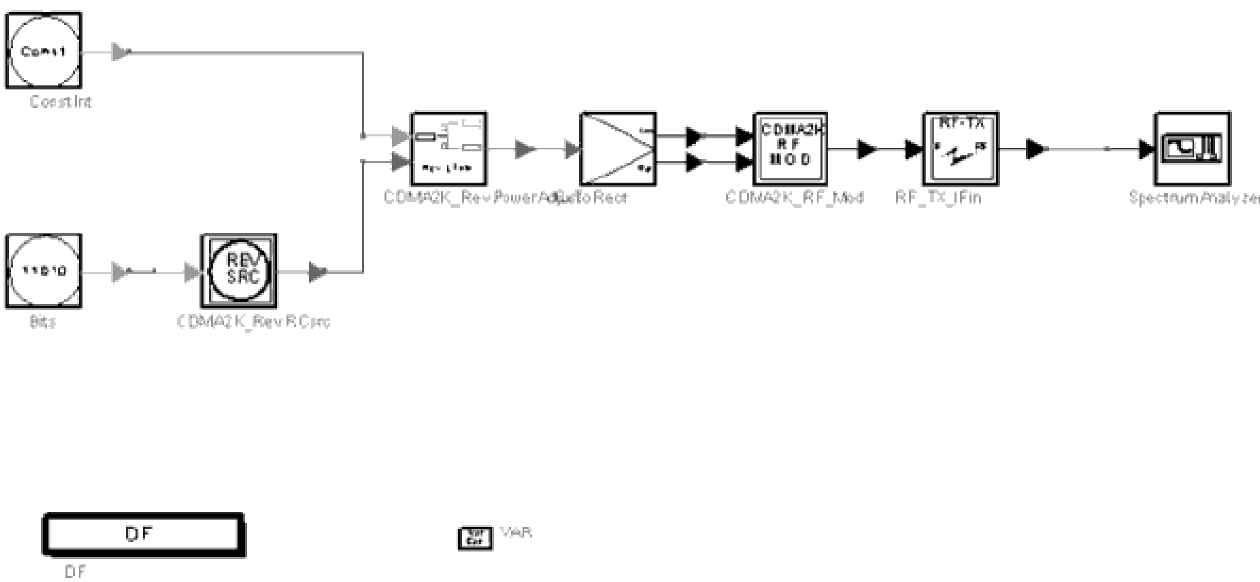
Features

- Continuous 0 power control bits sent to adjust mobile station transmit power
- Emission at frequencies outside assigned CDMA channel for SR1 is measured

Description

This example measures the emission at frequencies that are outside the assigned CDMA channel for SR1 as defined in section 4.5, 3GPP2 C.S0011-A.

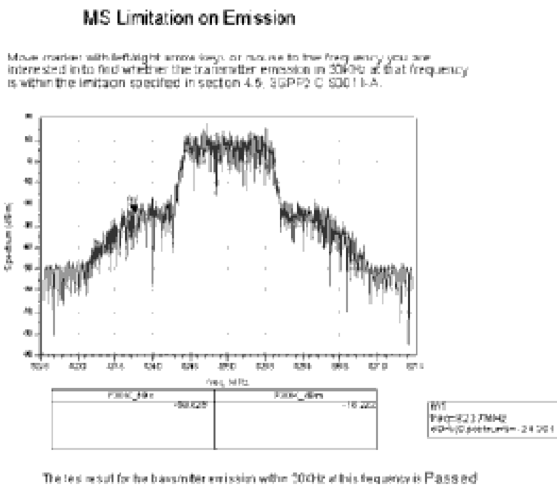
Schematic



MS_TxSR1Spectrum Schematic

Simulation Results

Simulation results displayed in MS_TxSR1Spectrum.dds are shown in the following figure.



Emission Measurements

Benchmark

- Hardware Platform: Pentium II 400 MHz, 512 Mb memory
- Software Platform: Windows NT 4.0 Workstation, ADS 1.5
- Simulation Time: approximately 3 minutes

Rake Design Examples

Introduction

The CDMA2K_Rake_wrk workspace shows examples for measuring forward and reverse link Rake receiver BER performance. The following sections describe the designs and provide schematics and simulation results.

BER of Forward Link Rake Receiver

- DsnCDMA2K_FwdRake

Features

- QPSK modulation
- 1.2288 Mcps chip rate
- AWGN and fading channel
- Rake receiver for forward traffic channel
- BER value
- Performance curve

Description

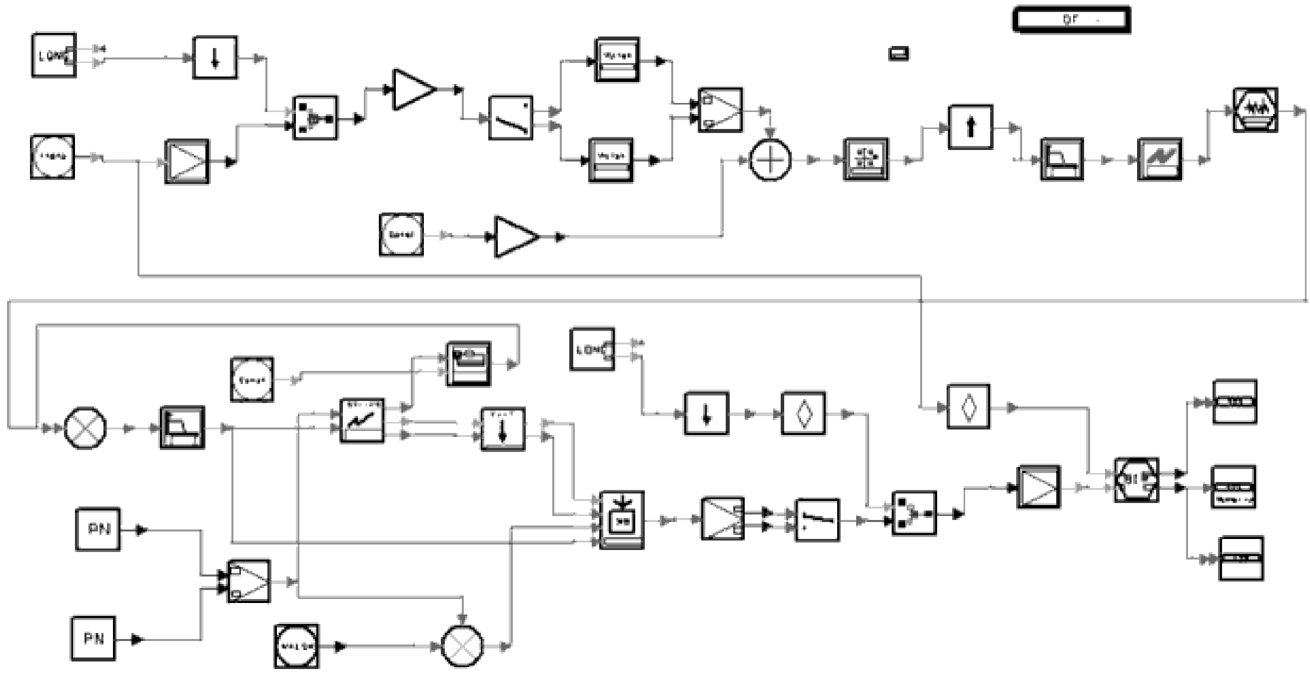
DsnCDMA2K_FwdRake is an example design for measuring forward link Rake receiver BER performance.

Schematic

The schematic for this design is shown in the following figure.

Specific parameter settings are

- WalshLength (CDMA2K_WalshModulator): **64**
- WalshCodeIndex (CDMA2K_WalshModulator): **6**
- SpreadRate (CDMA2K_BaseFilter): **SR1**
- FingerNum (CDMA2K_FwdChnlEstimate, CDMA2K_FwdCohReceiver): **3** (multipath fading channel), **1** (AWGN only)
- EstimateWindow (CDMA2K_FwdChnlEstimate, CDMA2K_FwdCohReceiver): **6**



DsnCDMA2K_FwdRake

Simulation Results

Note that noise is band limited and its bandwidth is 4 times the bandwidth of the baseband filter. When *Eb/Nt* is calculated, only the inband noise power is considered. For example, if noise power (2 × variance) is set as 100, the inband noise power is set as 25, the real noise power equals the measured noise power *P* N − 6 dB.

The following equation is from TIA/EIA/IS-98-A, pp. 1-12 to 1-14 (Reference [2]):

$$\frac{E_b}{N_t} = \frac{\dfrac{TrafficE_c}{TotalTransPowerSpecDensity} \times Processing(Gain)}{\dfrac{BandlimitedAWGNPowerSpecDensity(N_o)}{ReceivedPowerSpecDensity}}$$

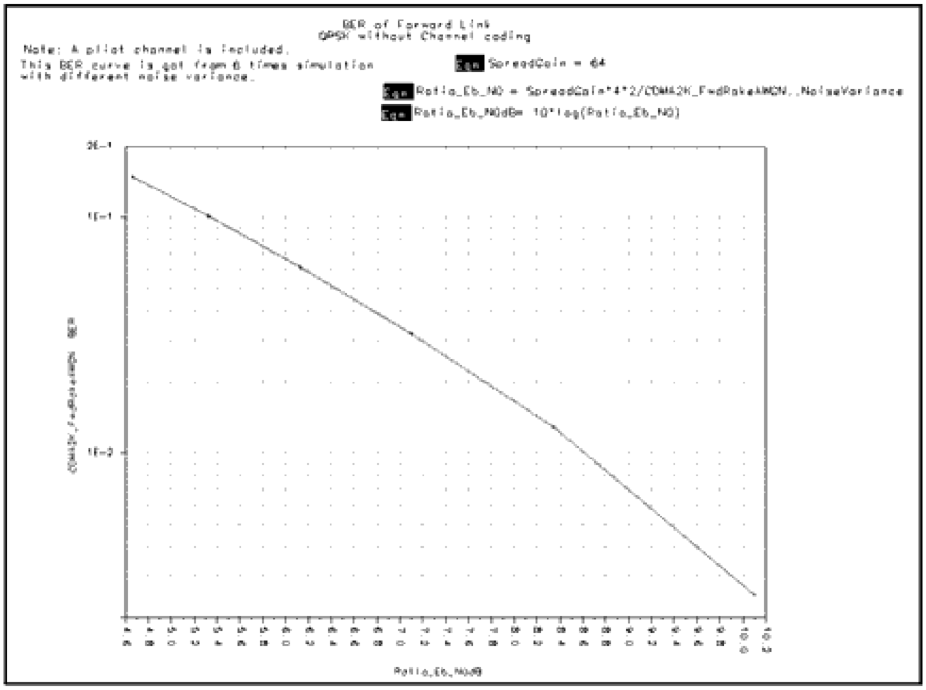
In this example, for AWGN channel, transmit power equals received power. For RC3 20 msec frames without channel coding, processing gain equals 64 (18.06 dB).

$$\frac{N_o}{2} = \sigma^2$$

Eb/Nt = dB(*Processing Gain*) − dB(N_o) + 6.

BER performance is shown in the following figure. The graph is saved in *FwdRake.dds;*

corresponding data is saved in *CDMA2K_FwdRakeAWGN.ds*.



BER to *Eb/Nt* Curve

Benchmark

- Hardware platform: Pentium II 400 MHz, 256 MB memory
- Software platform: Windows NT 4.0 Workstation, ADS 1.3
- Data points: 5000 symbols
- Simulation time: approximately 1 hour

Notes

TkShowValues is used in this example. BER and Tested frames are displayed during simulation; values are displayed in the *Ptolemy Control Panel* window. The user can control the number of bits to be tested; lower BER may result by testing more bits.

References

1. IS2000.2, *Physical Layer Standard for cdma2000 Spread Spectrum Systems*, April 1999.
2. TIA/EIA/IS-98-A, *Recommended Minimum Performance Standards for Dual-Mode Wideband Spread Spectrum Cellular Mobile Stations*, July 1996.

BER of Reverse Link Rake Receiver

- DsnCDMA2K_RevRake

Features

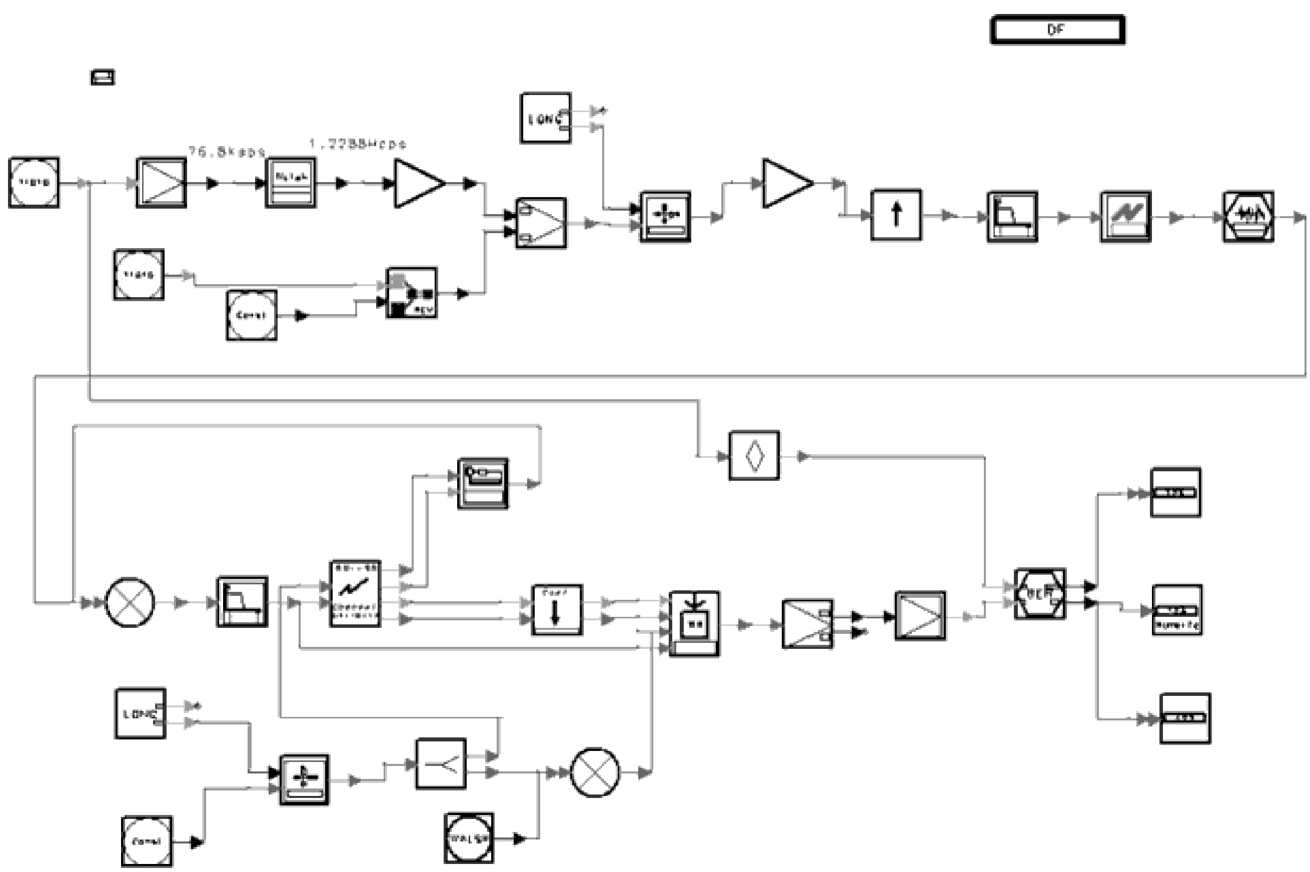
- HPSK modulation
- 1.2288 Mcps chip rate
- AWGN and fading channel
- Rake receiver for reverse traffic channel
- BER value
- Performance curve

Description

DsnCDMA2K_RevRake is an example design for measuring reverse link Rake receiver BER performance.

Schematic

The schematic for this design is shown in the following figure.



DsnCDMA2K_RevRake

Specific parameter settings are:

- WalshLength (CDMA2K_WalshModulator): **16**
- WalshCodeIndex (CDMA2K_WalshModulator): **6**
- SpreadRate (CDMA2K_BaseFilter, CDMA2K_RevChnlEstimate, CDMA2K_RevCohReceiver): **SR1**
- FingerNum (CDMA2K_RevChnlEstimate, CDMA2K_RevCohReceiver): **3** (Multipath fading channel), **1** (AWGN only)

Simulation Results

Note that noise is band limited, and its bandwidth is 4 times the bandwidth of the baseband filter. When *Eb/Nt* is calculated, only the inband noise power is considered. For example, if the noise power (2 × variance) is set as 100, then the inband noise power is set as 25, the real noise power equals the measured noise power *P* N − 6 dB.

The following equation is from TIA/EIA/IS-98-A, pp. 1-12 to 1-14 (Reference [2]):

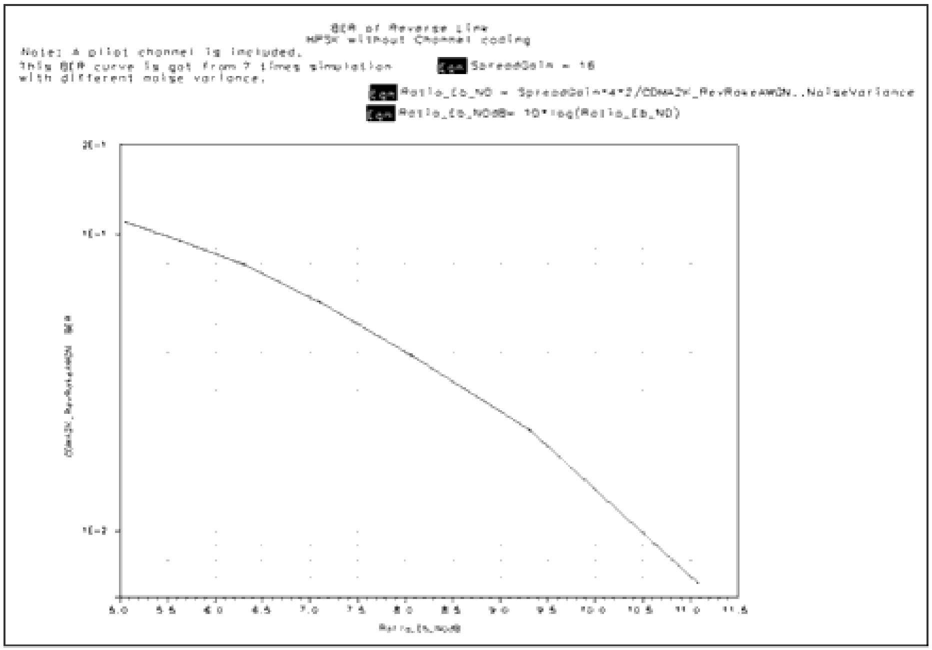
$$\frac{E_b}{N_t} = \frac{\dfrac{TrafficE_c}{TotalTransPowerSpecDensity} \times ProcessingGain}{\dfrac{BandlimitedAWGNPowerSpecDensity(N_o)}{ReceivedPowerSpecDensity}}$$

In this example, for AWGN channel, transmit power equals received power. For RC3 20 msec frames without channel coding, processing gain equals 16 (12.04 dB).

$$\frac{N_o}{2} = \sigma^2$$

Eb/Nt = dB(Processing Gain) − dB(*N* o) + 6.

BER performance is shown in the following figure. The graph is saved in *RevRake.dds*; corresponding data is saved in *CDMA2K_RevRakeAWGN.ds*.



BER to *Eb/Nt* Curve

Benchmark

- Hardware platform: Pentium II 400 MHz, 256 MB memory
- Software platform: Windows NT 4.0 Workstation, ADS 1.3
- Data points: 5000 symbols
- Simulation time: approximately 1 hour

Notes

TkShowValues is used in this example. BER and Tested frames are displayed during simulation; values are displayed in the *Ptolemy Control Panel* window. The user can control the number of bits to be tested; lower BER may result by testing more bits.

References

1. IS2000.2, *Physical Layer Standard for cdma2000 Spread Spectrum Systems*, April 1999.
2. TIA/EIA/IS-98-A, *Recommended Minimum Performance Standards for Dual-Mode Wideband Spread Spectrum Cellular Mobile Stations*, July 1996.

RC_TD Design Examples

Introduction

The CDMA2K_RC_TD_wrk workspace shows examples for measuring forward and reverse link RC3, including AWGN channel, and multipath fading channel BER and FER. The following sections describe the designs and provide schematics and simulation results.

BER and FER of Forward Link Radio Configuration 3

- DsnCDMA2K_FwdRC3AWGN
- DsnCDMA2K_FwdRC3DS

Features

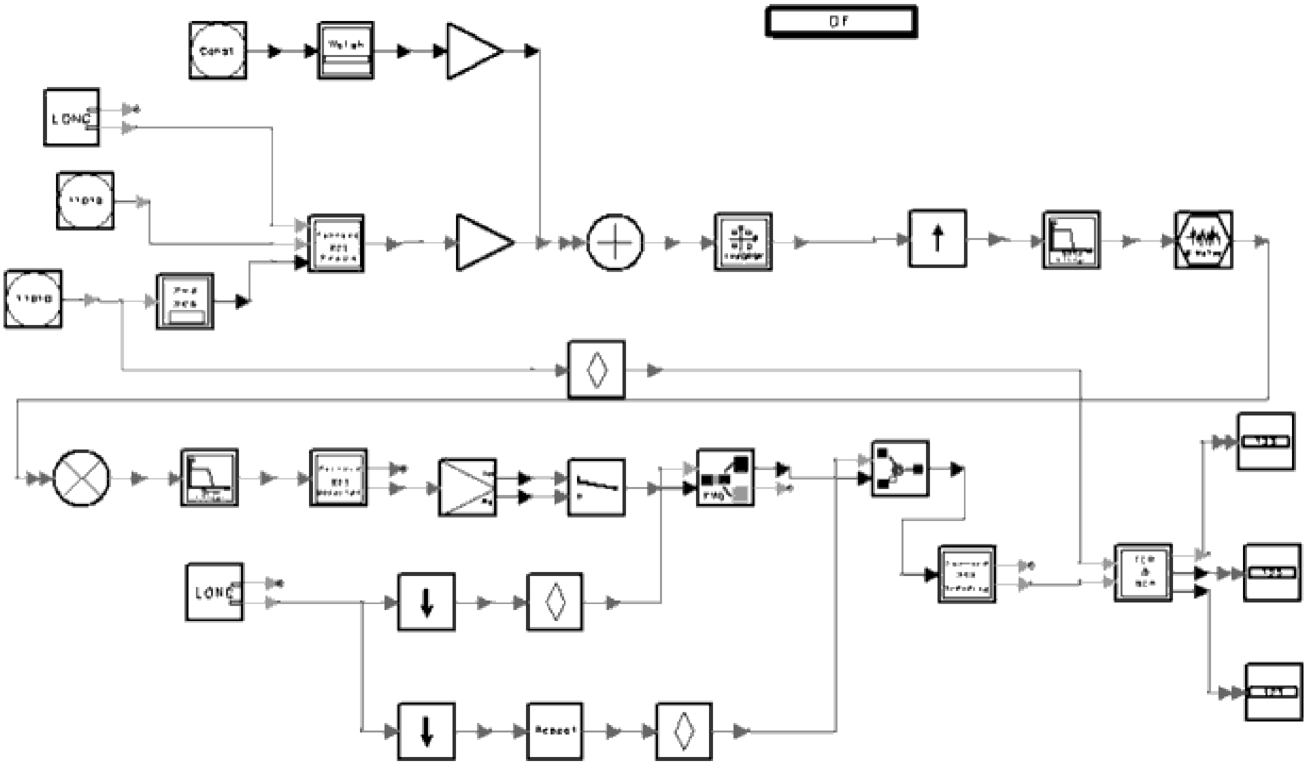
- Constant data rate 9600 bps and 20 μ frame
- Convolutional encoder and Viterbi decoder
- QPSK modulation
- 1.2288 Mcps chip rate
- AWGN channel and multipath fading channel
- Rake receiver for forward traffic channel
- BER and FER values
- Performance curve

Description

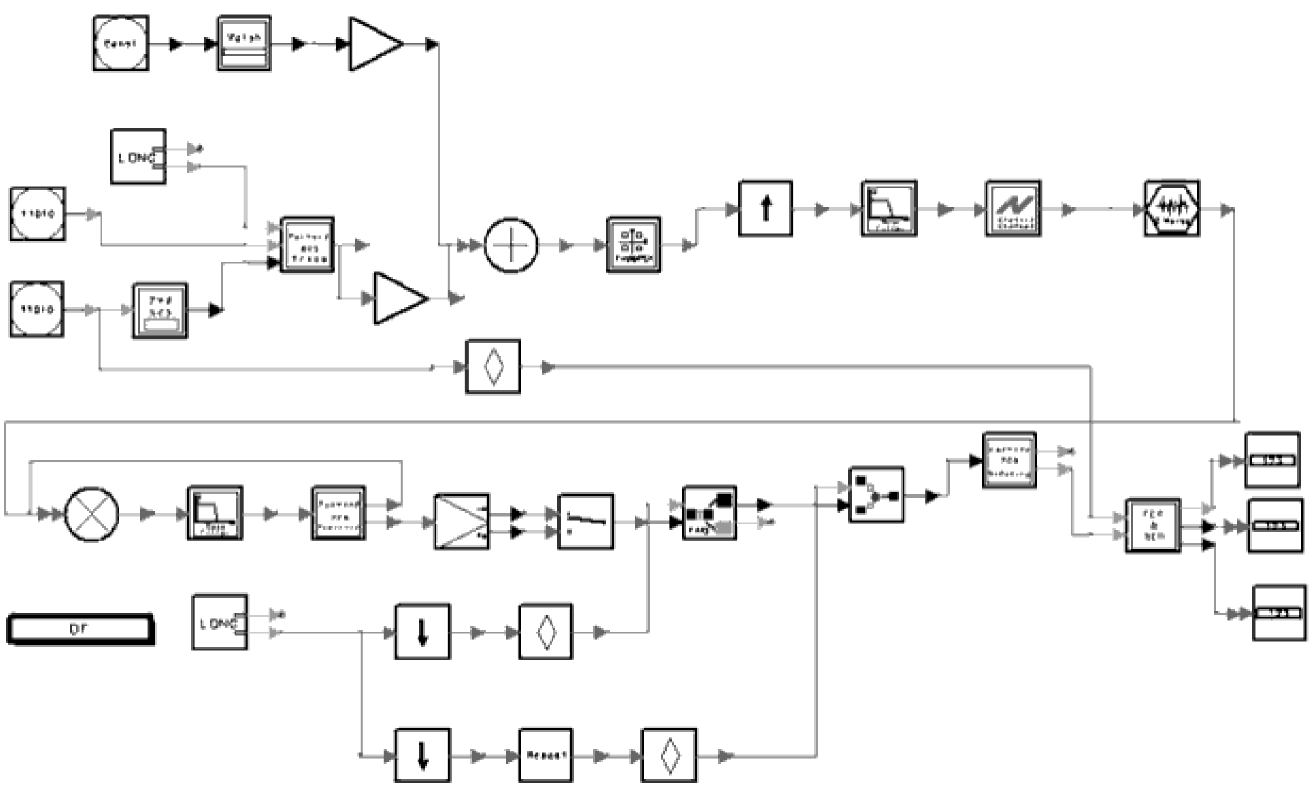
DsnCDMA2K_FwdRC3AWGN and *DsnCDMA2K_FwdRC3DS* example designs for measuring forward link RC3 in AWGN and multipath fading channel BER and FER performance, respectively.

Schematics

The schematics for *DsnCDMA2K_FwdRC3AWGN* and *DsnCDMA2K_FwdRC3DS* are shown in the following figures.



DsnCDMA2K_FwdRC3AWGN



DsnCDMA2K_FwdRC3DS

Subnetworks *FwdRC3_ChannelCoding*, *FwdRC3_Receiver*, *FwdRC3_ChannelDecoding* and *FwdRC3_Transmission* were designed for these examples.

- *FwdRC3_ChannelCoding* : channel coding includes CRC encoder, adding tail, convolutional encoder and interleaver.
  (Forward Fundamental Channel and Forward Supplemental Channel Structure for RC3 are given in Reference [1] figures 3.1.3.1.1.1-13.)
  Specific parameter settings for this subnetwork are
  - InputFrameLen (CDMA2K_CRC_Coder): **172**
  - CRCType (CDMA2K_CRC_Coder): **CRC12 0x1f13**
  - CCType (CDMA2K_CC_WithTail): **rate 1/4 K 9 g0 0765 g1 0671 g2 0513 g3 0473**
  - BlockRow_m and BlockColumn_J (CDMA2K_BlockIntlvr): **m=6**, **J=12**
  - IntlvrType (CDMA2K_BlockIntlvr): **Fwd_Backwards**
- *FwdRC3_ChannelDeCoding* : channel decoding includes de-interleaver, Viterbi decoder, CRC check and erasing tail.
  Specific parameter settings for this subnetwork are
  - InputFrameLen (CDMA2K_CRC_DeCoder): **184**
  - CRCType (CDMA2K_CRC_DeCoder): **CRC12 0x1f13**
  - CCType (CDMA2K_DCC_WithTail): **rate 1/4 K 9 g0 0765 g1 0671 g2 0513 g3 0473**
  - BlockRow_m and BlockColumn_J (CDMA2K_DeBlockIntlvr): **m=6**, **J=12**
  - IntlvrType (CDMA2K_BlockDeIntlvr): **Fwd_Backwards**
- *FwdRC3_Receiver* : Rake receiver for RC3 includes forward Rake and Walsh and PN function generators. It includes a TrafficIndex parameter (the Walsh function index used in the Traffic Channel) and a PilotType parameter with pilot or transmit diversity pilot options (Pilot is used for this example).
  Specific parameter settings for this subnetwork are
  - SpreadRate (CDMA2K_FwdRake): **SR1**
  - PilotWalshLen (CDMA2K_FwdRake): **128**
  - TrafficWalshLen (CDMA2K_FwdRake): **64**
  - FrameLength (CDMA2K_FwdRake): **384**
  - FingerNum (CDMA2K_FwdRake): **1** (AWGN), **3** (Multipath fading channel)
    (This parameter value must be checked before simulation.)
  - WalshLength (CDMA2K_VL_Walsh): **128** (for Pilot channel), **64** (for Traffic channel)
- *FwdRC3_Transmission* : transmission includes data scrambling, inserting PC bits, Walsh modulator and Walsh rotator.
  (Long Code Scrambling, Power Control, and Signal Point Mapping for Forward Traffic Channels with RC3, RC4, and RC5 are performed and shown in Ref [1] figures 3.1.3.1.1.1-16. I and Q Mapping (non-OTD mode) for SRate1 are performed and shown in Ref [1] figures 3.1.3.1.1.1-18.)
  Specific parameter settings for this subnetwork are
  - RadioConfig (CDMA2K_DataScrambling): **RC3 to RC9 Non OTD**
  - RadioConfig (CDMA2K_FwdPCBitPuncture): **RC3 Non OTD**
  - WalshLength (CDMA2K_WalshModulator): **64**

Simulation Results

A constant 9600 bps data rate frame is used as source. The ratio of traffic to pilot power is −8.3dB. The multipath channel model is Vehicular Test Environment, Channel A. The carrier frequency is 825 MHz; mobile speed is 120 km/hour.

Note that noise is band limited, and its bandwidth is 4 times the bandwidth of the baseband filter. When *Eb/Nt* is calculated, only the inband noise power is considered. For example if the noise power (2 × variance) is set as 100, the inband noise power is set as 25, the real noise power equals the measured noise power *PN* − 6 dB.

The following equation is from TIA/EIA/IS-98-A, pp. 1-12 to 1-14 (Reference [2]):

$$\frac{E_b}{N_t} = \frac{\dfrac{TrafficE_c}{TotalTransPowerSpecDensity} \times ProcessingGain}{\dfrac{BandlimitedAWGNPowerSpecDensity(N_o)}{ReceivedPowerSpecDensity}}$$

In this example, for AWGN channel, transmit power equals received power. For RC3 20μ frames without channel coding, processing gain equals 128 (21.1bdB).

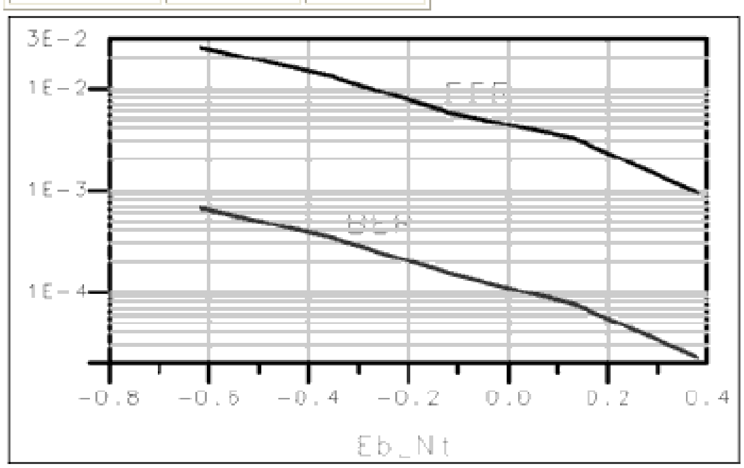
$$\frac{N_o}{2} = \sigma^2$$

Eb/Nt = dB(*Processing Gain*) - dB(*No*) + 6.

The fllowing table and figure show BER and FER performance for different *Eb/Nt* under AWGN.

AWGN BER and FER

Eb/Nt(dB)	BER	FER
−0.618	0.067%	2.5%
−0.358	0.03435%	1.32%
−0.118	0.0152%	0.57%
0.132	0.00765%	0.317%
0.382	0.00226%	0.0936%

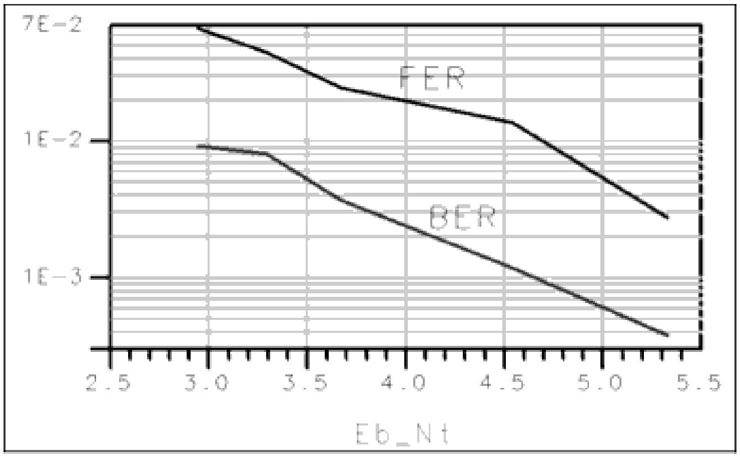


AWGN BER and FER to *Eb/Nt* Curve

The fllowing table and figure show BER and FER performance in different *Eb/Nt* in multipath fading channel.

Multipath Fading Channel BER and FER

Eb/Nt(dB)	BER	FER
2.94	0.93%	6.7%
3.29	1.61%	4.5%
3.67	0.372	2.45%
4.54	0.118%	1.37%
5.33	0.0375%	0.272%



Multipath Fading Channel BER and FER to *Eb/Nt* Curve

Benchmark

- Hardware platform: Pentium II 400 MHz, 256 Mb memory
- Software platform: Windows NT 4.0 Workstation, ADS 1.3
- Data points: 1000 frames
- Simulation time: approximately 10 hours for AWGN; 24 hours for multipath fading channel

Notes

TkShowValues is used in this example. FER, BER, and Tested frames are displayed during simulation; values are displayed in the *Ptolemy Control Panel* window. The user can control the number of bits to be tested; lower FER and BER may result by testing more bits.

References

1. IS2000.2, *Physical Layer Standard for cdma2000 Spread Spectrum Systems*, April 1999.
2. TIA/EIA/IS-98-A, *Recommended Minimum Performance Standards for Dual-Mode Wideband Spread Spectrum Cellular Mobile Stations*, July 1996.

BER and FER of Forward Link Radio Configuration 3 with OTD Mode

CDMA2K_RC_TD_wrk Design Name

- DsnCDMA2K_FwdRC3OTD

Features

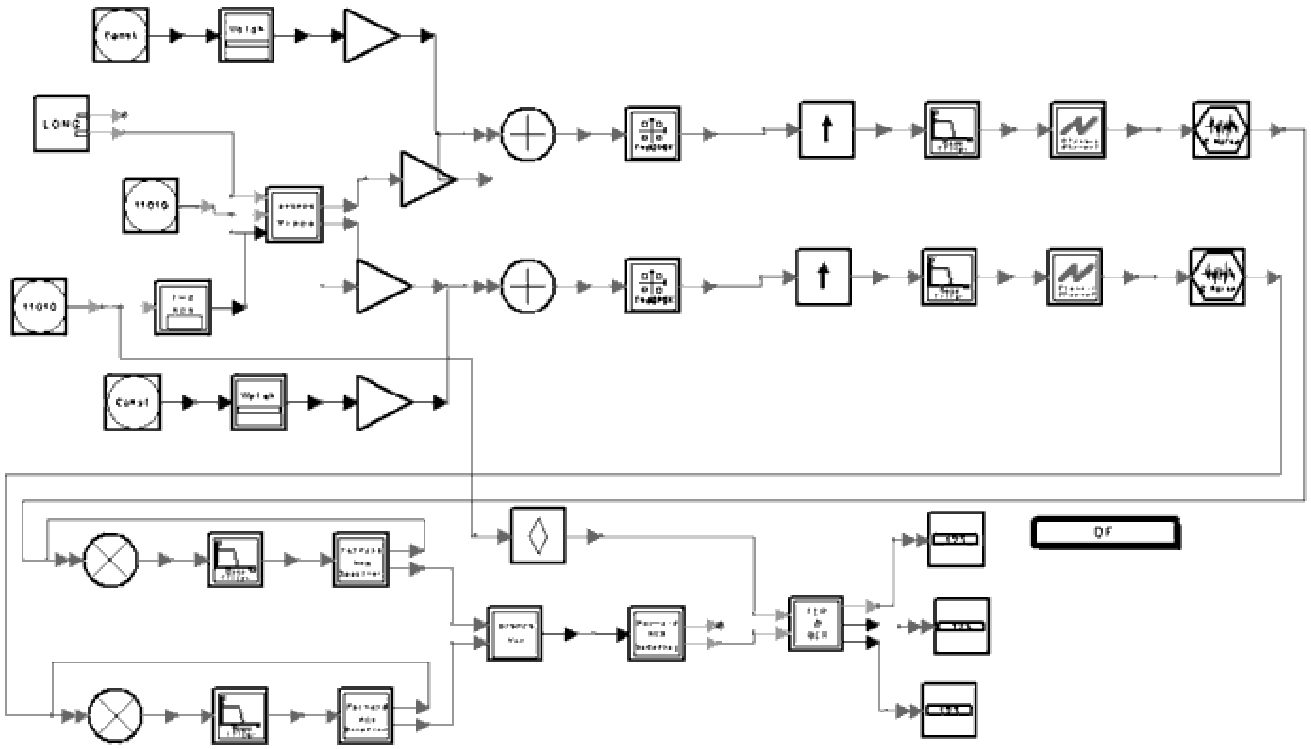
- Constant data rate 9600 bps and 20 µ frame
- Pilot and transmit diversity pilot channel
- Convolutional encoder and Viterbi decoder
- QPSK modulation
- 1.2288 Mcps chip rate
- Multipath fading channel
- Orthogonal transmission diversity
- Rake receiver for forward traffic channel
- BER and FER values
- Performance curve

Description

DsnCDMA2K_FwdRC3OTD is an example design for measuring forward link RC3 OTD mode in multipath fading channel BER and FER performance.

Schematic

The schematic for this design is shown in the following figure.



DsnCDMA2K_FwdRC3OTD

Subnetworks *FwdRC3_ChannelCoding*, *FwdRC3_ChannelDecoding*, *FwdRC3_Receiver*, *FwdRC3OTD_Multiplex and FwdRC3OTD_Transmission* were designed for this example.

- *FwdRC3_ChannelCoding* : channel coding includes CRC encoder, adding tail, convolutional encoder and interleaver.
  Specific parameter settings for this subnetwork are
  - InputFrameLen (CDMA2K_CRC_Coder): **172**
  - CRCType (CDMA2K_CRC_Coder): **CRC12 0x1f13**
  - CCType (CDMA2K_CC_WithTail): **rate 1/4 K 9 g0 0765 g1 0671 g2 0513 g3 0473**
  - BlockRow_m and BlockColumn_J (CDMA2K_BlockIntlvr): **m=6, J=12**
  - IntlvrType (CDMA2K_BlockIntlvr): **Fwd_Backwards**
- *FwdRC3_ChannelDeCoding* : channel decoding includes de-interleaver, Viterbi decoder, CRC check and erasing tail.
  Specific parameter settings for this subnetwork are
  - InputFrameLen (CDMA2K_CRC_DeCoder): **184**
  - CRCType (CDMA2K_CRC_DeCoder): **CRC12 0x1f13**
  - CCType (CDMA2K_DCC_WithTail): **rate 1/4 K 9 g0 0765 g1 0671 g2 0513 g3 0473**
  - BlockRow_m and BlockColumn_J (CDMA2K_BlockDeIntlvr): **m=6, J=12**
  - IntlvrType (CDMA2K_BlockDeIntlvr): **Fwd_Backwards**
- *FwdRC3OTD_Multiplex* : multiplexing the outputs of each Rake receiver.
- *FwdRC3_Receiver* : Rake receiver for RC3 includes forward Rake and Walsh and PN function generators. It includes a TrafficIndex parameter (the Walsh function index used in the Traffic Channel) and a PilotType parameter with pilot or transmit diversity pilot options (TDPilot is used for this example).

Specific parameter settings for this subnetwork are
- SpreadRate (CDMA2K_FwdRake): **SR1**
- PilotWalshLen (CDMA2K_FwdRake): **128**
- TrafficWalshLen (CDMA2K_FwdRake): **64**
- FrameLength (CDMA2K_FwdRake): **384**
- FingerNum (CDMA2K_FwdRake): *3

- (This parameter must be set to 3 before simulation.)
  - WalshLength (CDMA2K_VL_Walsh): **128** (for Pilot channel), **64** (for Traffic channel).
- *FwdRC3OTD_Transmission* : transmission includes data scrambling, inserting PC bits, Walsh modulator and Walsh rotator.
  Specific parameter settings for this subnetwork are
  - RadioConfig (CDMA2K_DataScrambling): **RC3 to RC9 OTD**
  - RadioConfig (CDMA2K_FwdPCBitPuncture): **RC3 OTD**
  - WalshLength (CDMA2K_WalshModulator): **64**

Simulation Results

In this example, constant 9600 bps data rate frame is used as source. The ratio of traffic power to pilot power is −11.3 dB. The multipath channel model is Vehicular Test Environment, Channel A. Carrier frequency is 825 MHz and mobile speed is 120 km/hour.

Note that noise is band limited, and its bandwidth is 4 times the bandwidth of the baseband filter. When *Eb/Nt* is calculated, only the inband noise power is used. For example, if noise power (2 × variance) is set as 100, then the inband noise power is set as 25, the real noise power equals the measured noise power *PN* − 6 dB.

The following equation is from TIA/EIA/IS-98-A, pp. 1-12 to 1-14 (Reference [2]):

$$\frac{E_b}{N_t} = \frac{\dfrac{TrafficE_c}{TotalTransPowerSpecDensity} \times ProcessingGain}{\dfrac{BandlimitedAWGNPowerSpecDensity(N_0)}{ReceivedPowerSpecDensity}}$$

In this example, for AWGN channel, transmit power equals received power. For RC3 20 μ frames, processing gain equals 128 (21.1 dB).

$$\frac{N_o}{2} = \sigma^2$$

Eb/Nt = dB(Processing Gain) - dB(N~o~) + 6.

Under the same channel condition, when FER=1%, the required *Eb/Nt* is approximately 4.7dB without OTD, and approximately 2.9dB with OTD. Performance is increased by 1.8dB with OTD when FER is 1%.

Benchmark

- Hardware platform: Pentium II 400 MHz, 256 Mb memory
- Software platform: Windows NT 4.0 workstation, Advanced Design System 1.3
- Data points: 1000 frames
- Simulation time: approximately 48 hours

Notes

TkShowValues is used in this example. FER, BER, and Tested frames are displayed during simulation; values are displayed in the *Ptolemy Control Panel* window. The user can control the number of bits to be tested; lower FER and BER may result by testing more bits.

References

1. IS2000.2, *Physical Layer Standard for cdma2000 Spread Spectrum Systems*, April 1999.
2. TIA/EIA/IS-98-A, *Recommended Minimum Performance Standards for Dual-Mode Wideband Spread Spectrum Cellular Mobile Stations*, July 1996.

BER and FER of Reverse Link Radio Configuration 3

CDMA2K_RC_TD_wrk Design Name

- DsnCDMA2K_RevRC3AWGN
- DsnCDMA2K_RevRC3Fade

Features

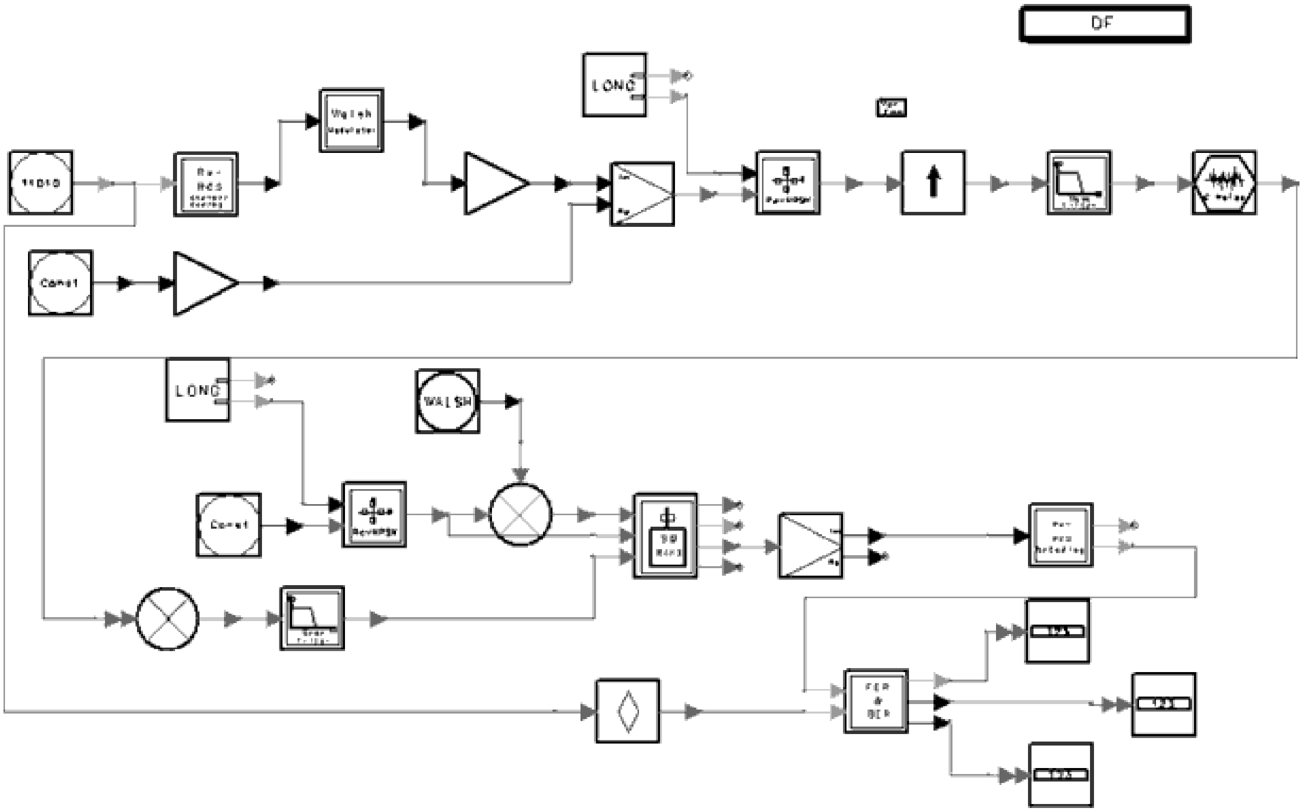
- Constant data rate 9600 bps and 20 μ frame
- 1/4 convolutional encoder and Viterbi decoder
- Pilot channel and one fundamental traffic channel
- HPSK modulation
- 1.2288 Mcps chip rate
- AWGN and multipath fading channel
- Rake receiver for reverse traffic channel
- BER and FER values
- Performance curve

Description

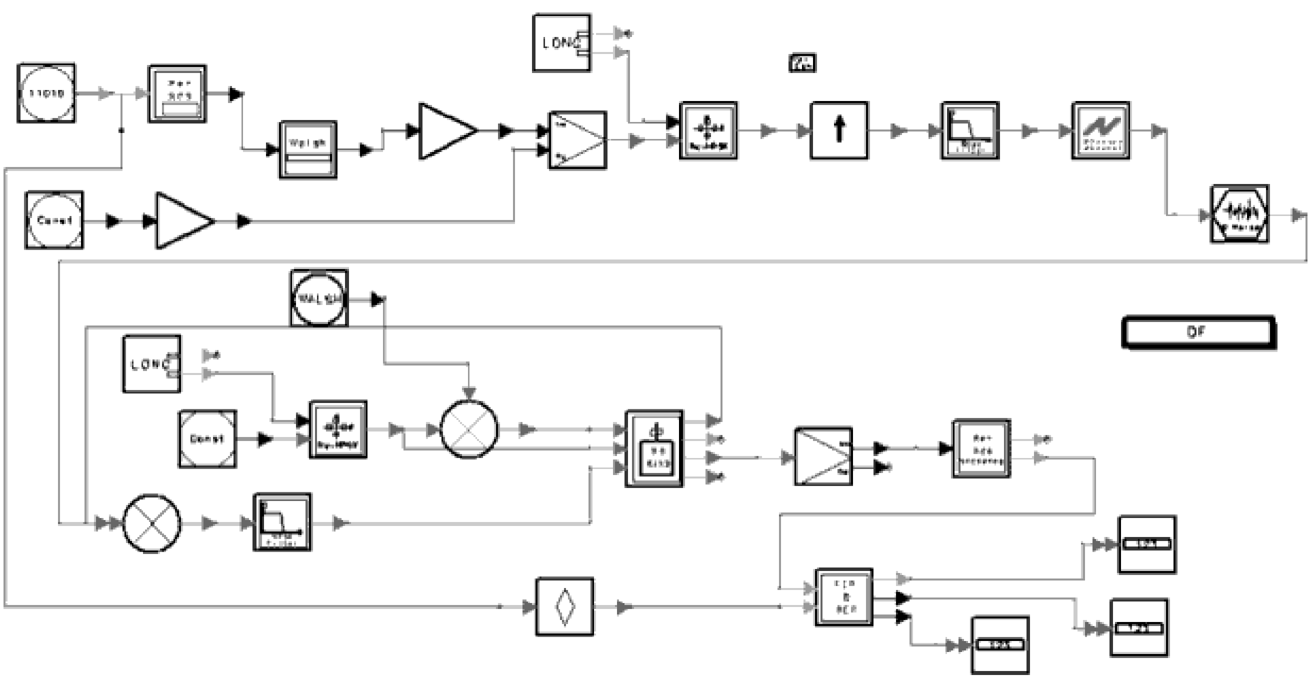
DsnCDMA2K_RevRC3AWGN and *DsnCDMA2K_RevRC3Fade* are example designs for measuring BER and FER performance of reverse link RC3 in AWGN and multipath fading channel, respectively.

Schematic

Schematics for *DsnCDMA2K_RevRC3AWGN* and *DsnCDMA2K_RevRC3Fade are* shown in the following figures.



DsnCDMA2K_RevRC3AWGN



DsnCDMA2K_RevRC3Fade

Subnetworks *RevRC3_ChannelCoding* and *RevRC3_ChannelDecoding* are designed for use in these examples.

- *RevRC3_ChannelCoding* : channel coding includes CRC encoder, adding tail, convolutional encoder, repeater and interleaver.
  Specific parameter settings for this subnetwork are
  - InputFrameLen (CDMA2K_CRC_Coder): **172**
  - CRCType (CDMA2K_CRC_Coder): **CRC12 0x1f13**
  - CCType (CDMA2K_CC_WithTail): **rate 1/4 K 9 g0 0765 g1 0671 g2 0513 g3 0473**
  - BlockRow_m and BlockColumn_J (CDMA2K_BlockIntlvr): **m=6**, **J=24**
  - IntlvrType (CDMA2K_BlockIntlvr): **BROIntlvr**
- *RevRC3_ChannelDeCoding* : channel decoding includes de-interleaver, average, Viterbi decoder, CRC check and erasing tail.
  Specific parameter settings for this subnetwork are
  - InputFrameLen (CDMA2K_CRC_DeCoder): **172**
  - CRCType (CDMA2K_CRC_DeCoder): **CRC12 0x1f13**
  - CCType (CDMA2K_DCC_WithTail): **rate 1/4 K 9 g0 0765 g1 0671 g2 0513 g3 0473**
  - BlockRow_m and BlockColumn_J (CDMA2K_BlockDeIntlvr): **m=6**, **J=24**
  - IntlvrType (CDMA2K_BlockDeIntlvr): **BROIntlvr**
    Specific parameter settings for CDMA2K_RevRake in these subnetworks are:
- SpreadRate: **SR1**
- TrafficWalshLen: **16**
- FrameLength: **1536**
- FingerNum: **1** (AWGN), **3** (multipath fading channel)

Simulation Results

In this example, constant 9600 bps data rate frame is used as source. The ratio of traffic power to pilot power is 3.75 dB. The multipath channel model is Vehicular Test Environment, Channel A. Carrier frequency is 825 MHz; mobile speed is 120 km/hour.

Note that noise is band limited, and its bandwidth is 4 times the bandwidth of the baseband filter. When *Eb/Nt* is calculated, only the inband noise power is used. For example, if the noise power (2 × variance) is set as 100, the inband noise power is set as 25, the real noise power equals the measured noise power *PN* − 6 dB.

The following equation is from TIA/EIA/IS-98-A, pp. 1-12 to 1-14 (Reference [2]):

$$\frac{E_b}{N_t} = \frac{\dfrac{TrafficE_c}{TotalTransPowerSpecDensity} \times ProcessingGain}{\dfrac{BandlimitedAWGNPowerSpecDensity(N_0)}{ReceivedPowerSpecDensity}}$$

In this example, for AWGN channel, transmit power equals received power. For RC3 20µ frames, processing gain equals 128 (21.1dB).

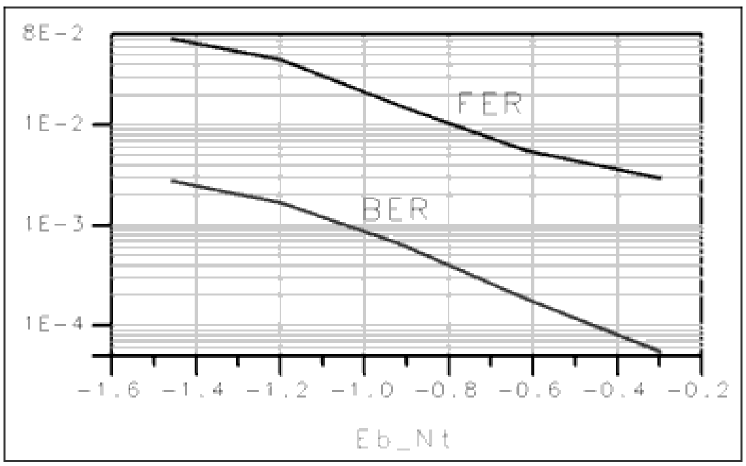
$$\frac{N_o}{2} = \sigma^2$$

Eb/Nt = dB(*Processing Gain*) - dB(*No*) + 6.

The following table and figure show BER and FER performance for different *Eb/Nt* under AWGN.

AWGN BER and FER

Eb/Nt(dB)	BER	FER
−1.46	0.276%	7.25%
−1.198	0.167%	4.496%
−0.918	6.661e-4	1.58%
−0.618	1.886e-4	0.562%
−0.296	5.4416e-5	0.295%

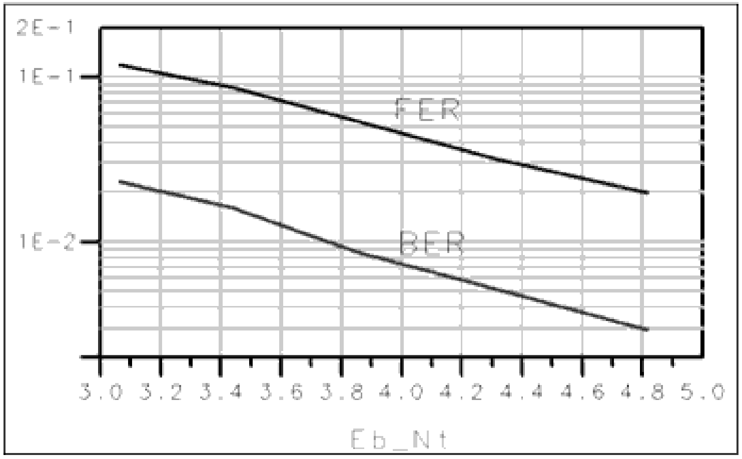


AWGN BER and FER to *Eb/Nt* Curve

The following table and figure show BER and FER performance for different *Eb/Nt* in multipath fading channel.

Fading Channel BER and FER

Eb/Nt(dB)	BER	FER
3.06	2.32%	11.85%
3.44	1.61%	8.7%
3.85	0.867	5.43%
4.31	0.518%	3.18%
4.82	0.29%	1.98%



Multipath Fading Channel BER and FER to *Eb/Nt* Curve

Benchmark

- Hardware platform: Pentium II 400 MHz, 256 Mb memory
- Software platform: Windows NT 4.0 workstation, ADS 1.3
- Data points: 1000 frames
- Simulation time: approximately 10 hours for AWGN; 24 hours for multipath fading channel

Notes

TkShowValues is used in this example. FER, BER, and Tested frames are displayed during simulation; values are displayed in the *Ptolemy Control Panel* window. The user can control the number of bits to be tested; lower FER and BER may result by testing more bits.

References

1. IS2000.2, *Physical Layer Standard for cdma2000 Spread Spectrum Systems*, April 1999.
2. TIA/EIA/IS-98-A, *Recommended Minimum Performance Standards for Dual-Mode Wideband Spread Spectrum Cellular Mobile Stations*, July 1996.
3. ETSI, TR 101 112, *Universal Mobile Telecommunications System (UMTS); Selection Procedures for the Choice of Radio Transmission Technologies of the UMTS* (UMTS 30.03 version 3.2.0), April 1998.

BER and FER AWGN of Forward Link Radio Configuration 6

CDMA2K_RC_TD_wrk Design Name

- DsnCDMA2K_FwdRC6AWGN

Features

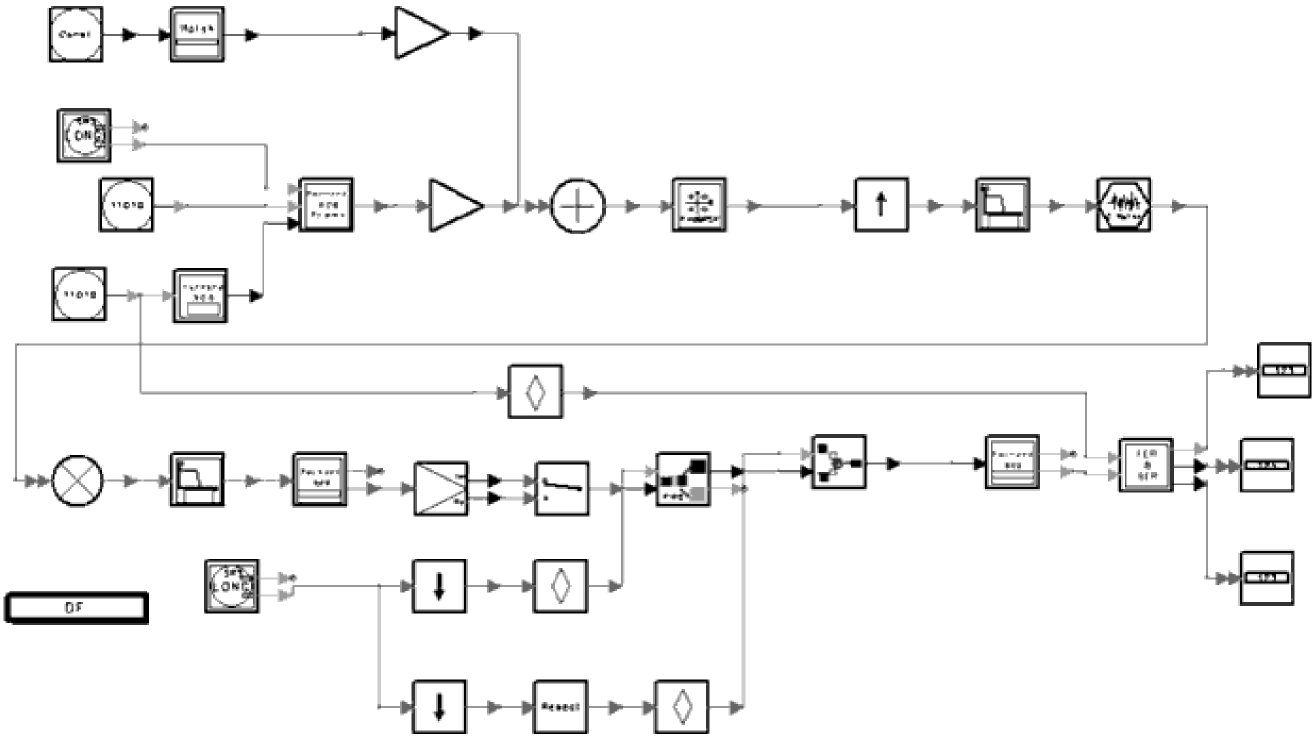
- Constant data rate 9600 bps and 20 μ frame
- Convolutional encoder and Viterbi decoder
- QPSK modulation
- 3.6864 Mcps chip rate
- AWGN channel
- Rake receiver for forward traffic channel
- BER and FER values
- Performance curve

Description

DsnCDMA2K_FwdRC6AWGN is an example designed for measuring BER and FER performance of forward link RC6 in AWGN channel.

Schematic

The schematic for this design is shown in the following figure.



DsnCDMA2K_FwdRC6AWGN

Subnetworks *FwdRC6_ChannelCoding*, *FwdRC6_ChannelDecoding*, and *FwdRC6_Receiver* were designed for use in this example.

- *FwdRC6_ChannelCoding* : channel coding includes CRC encoder, adding tail, convolutional encoder and interleaver.
  (As shown in Figure 3.1.3.1.1.2-11, Forward Fundamental Channel and Forward Supplemental Channel Structure for RC6 are given in Reference [1].)
  Specific parameter settings for this subnetwork are
  - InputFrameLen (CDMA2K_CRC_Coder): **172**
  - CRCType (CDMA2K_CRC_Coder): **CRC12 0x1f13**
  - CCType (CDMA2K_CC_WithTail): **rate 1/6 K 9**
  - BlockRow_m and BlockColumn_J (CDMA2K_BlockIntlvr): **m=6, J=18**
  - IntlvrType (CDMA2K_BlockIntlvr): **Fwd_Backwards**
- *FwdRC6_ChannelDeCoding* : channel decoding includes de-interleaver, Viterbi decoder, CRC check and erasing tail.
  Specific parameter settings for this subnetwork are
  - InputFrameLen (CDMA2K_CRC_DeCoder): **184**
  - CRCType (CDMA2K_CRC_DeCoder): **CRC12 0x1f13**
  - CCType (CDMA2K_DCC_WithTail): **rate 1/6 K 9**
  - BlockRow_m and BlockColumn_J (CDMA2K_DeBlockIntlvr): **m=6, J=18**
  - IntlvrType (CDMA2K_DeBlockIntlvr): **Fwd_Backwards**
- *FwdRC6_Receiver* : Rake receiver for RC6 includes forward Rake and Walsh and PN function generators. It includes a TrafficIndex parameter (the Walsh function index used in the Traffic Channel) and a PilotType parameter with pilot or transmit diversity pilot options (Pilot is used for this example).
  Specific parameter settings for this subnetwork are

    - SpreadRate (CDMA2K_FwdRake): **SR3**
    - PilotWalshLen (CDMA2K_FwdRake): **128**
    - TrafficWalshLen (CDMA2K_FwdRake): **128**
    - FrameLength (CDMA2K_FwdRake): **576**
    - FingerNum (CDMA2K_FwdRake): **1**
- *FwdRC6_Transmission* : transmission includes data scrambling, inserting PC bits, Walsh modulator and Walsh rotator.
  Specific parameter settings for this subnetwork are
    - RadioConfig (CDMA2K_DataScrambling): **RC3 to RC9 Non OTD**
    - RadioConfig (CDMA2K_FwdPCBitPuncture): **RC6 Non OTD**
    - WalshLength (CDMA2K_WalshModulator): **128**

Simulation Results

In this example, constant 9600 bps data rate frame is used as source. The ratio of traffic power to pilot power is −8.3dB.

Note that noise is band limited, and its bandwidth is 4 times the bandwidth of the baseband filter. When *Eb/Nt* is calculated, only the inband noise power is used. For example, if noise power (2 × variance) is set as 100, the inband noise power is set as 25, the real noise power equals the measured noise power *PN* − 6 dB.

The following equation is from TIA/EIA/IS-98-A, pp. 1-12 to 1-14 (Reference [2]):

$$\frac{E_b}{N_t} = \frac{\dfrac{TrafficE_c}{TotalTransPowerSpecDensity} \times Processing\,Gain}{\dfrac{BandlimitedAWGNPowerSpecDensity(N_0)}{ReceivedPowerSpecDensity}}$$

In this example, for AWGN channel, transmit power equals received power. For RC6 20 μ frames, processing gain equals to 384 (25.8 dB).

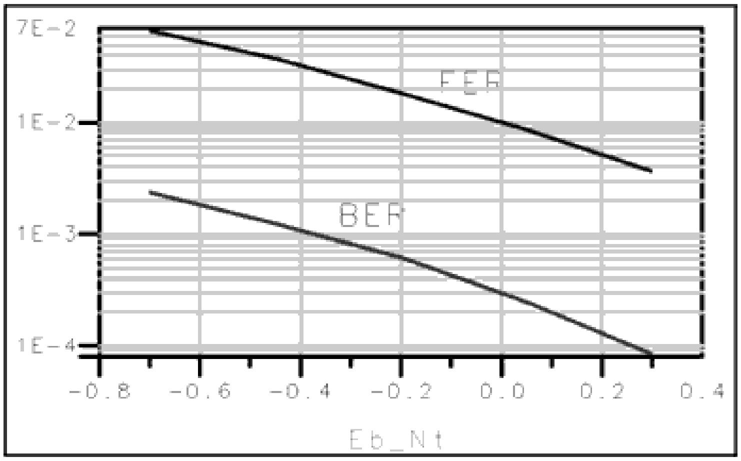
$$\frac{N_o}{2} = \sigma^2$$

Eb/Nt = dB(Processing Gain) − dB(N_o) + 6.

The following table and figure show BER and FER for different *Eb/Nt*.

BER and FER

Eb/Nt (dB)	BER	FER
-0.7	0.2353%	6.71%
-0.443	0.122%	3.68%
-0.193	0.061%	1.81%
0.057	0.02382%	0.855%
0.3	0.00844%	0.3686%



BER and FER

Benchmark

- Hardware platform: Pentium II 400 MHz, 256 Mb memory
- Software platform: Windows NT 4.0 workstation, ADS 1.3
- Data points: 1000 frames
- Simulation time: approximately 14 hours

Notes

TkShowValues is used in this example. FER, BER, and Tested frames are displayed during simulation; values are displayed in the *Ptolemy Control Panel* window. The user can control the number of bits to be tested; lower FER and BER may result by testing more bits.

References

1. IS2000.2, *Physical Layer Standard for cdma2000 Spread Spectrum Systems*, April 1999.
2. TIA/EIA/IS-98-A, *Recommended Minimum Performance Standards for Dual-Mode Wideband Spread Spectrum Cellular Mobile Stations*, July 1996.

BER and FER AWGN of Reverse Link Radio Configuration 6

CDMA2K_RC_TD_wrk Design Name

- DsnCDMA2K_RevRC6AWGN

Features

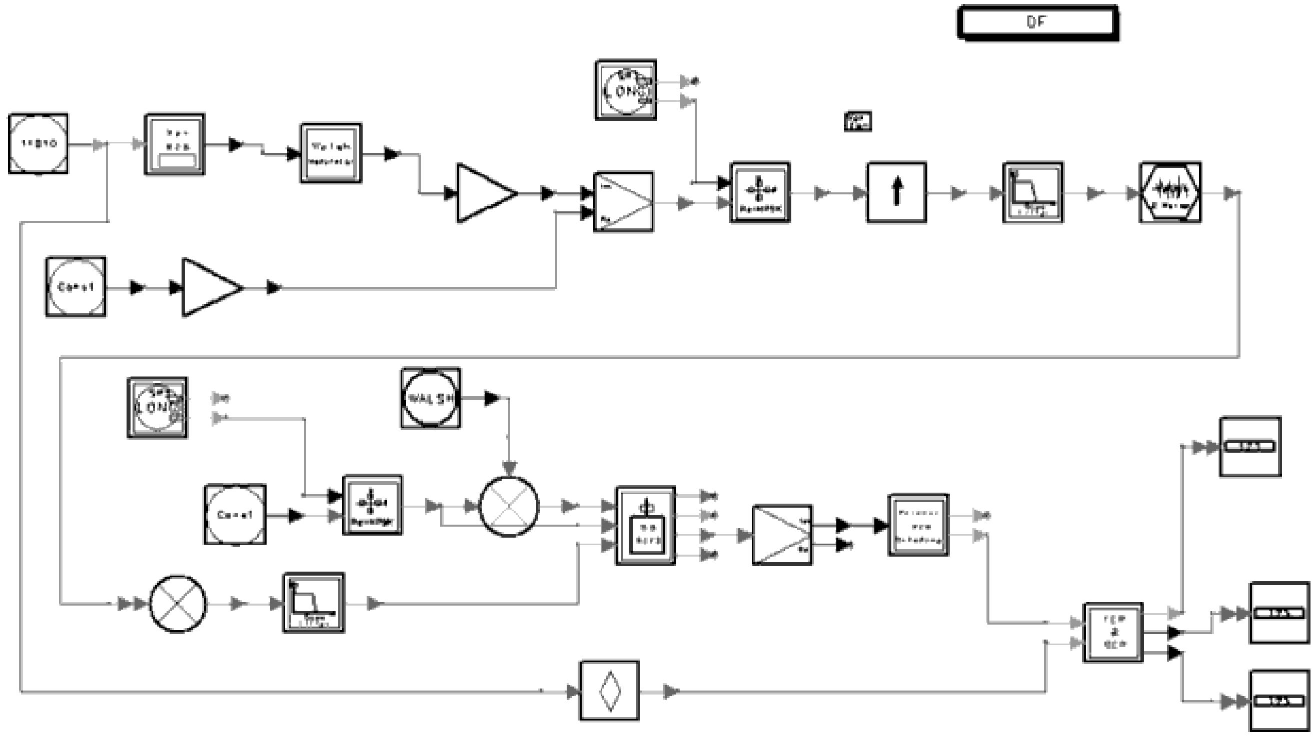
- Constant data rate 14400bps and 20 µ Frame
- 1/4 convolutional encoder and Viterbi decoder
- HPSK modulation
- 3.6864 Mcps chip rate
- AWGN channel
- Rake receiver for reverse traffic channel
- BER and FER values
- Performance curve

Description

DsnCDMA2K_RevRC6AWGN is an example design for measuring BER and FER performance of reverse linkRC6 in an AWGN channel.

Schematic

The schematic for this design is shown in the following figure.



DsnCDMA2K_RevRC6AWGN

Subnetworks *RevRC6_ChannelCoding* and *RevRC6_ChannelDecoding* were designed for this example.

- *RevRC6_ChannelCoding* : channel coding includes CRC encoder, adding tail, convolutional encoder, repeater and interleaver.
  Specific parameter settings for this subnetwork are
  - InputFrameLen (CDMA2K_CRC_Coder): **268**
  - CRCType (CDMA2K_CRC_Coder): **CRC12 0x1f13**
  - CCType (CDMA2K_CC_WithTail): **rate 1/4 K 9 g0 0765 g1 0671 g2 0513 g3 0473**
  - BlockRow_m and BlockColumn_J (CDMA2K_BlockIntlvr): **m=6, J=24**
  - IntlvrType (CDMA2K_BlockIntlvr): **BROIntlvr**
- *RevRC6_ChannelDeCoding* : channel decoding includes de-interleaver, average, Viterbi decoder, CRC check and erasing tail.
  Specific parameter settings for this subnetwork are
  - InputFrameLen (CDMA2K_CRC_DeCoder): **280**
  - CRCType (CDMA2K_CRC_DeCoder): **CRC12 0x1f13**
  - CCType (CDMA2K_DCC_WithTail): **rate 1/4 K 9 g0 0765 g1 0671 g2 0513 g3 0473**
  - BlockRow_m and BlockColumn_J (CDMA2K_BlockDeIntlvr): **m=6, J=24**
  - IntlvrType (CDMA2K_BlockDeIntlvr): **BROIntlvr**

Simulation Results

In this example, constant 14400 bps data rate frame is used as source. The ratio of traffic power to pilot power is 3.75 dB.

Note that noise is band limited, and its bandwidth is 4 times the bandwidth of the baseband filter. When *Eb/Nt* is calculated, only the inband noise power is used. For example, if the noise power (2 × variance) is set as 100, the inband noise power is set as 25, the real noise power equals the measured noise power *PN* − 6 dB.

The following equation is from TIA/EIA/IS-98-A, pp. 1-12 to 1-14 (Reference [2]):

$$\frac{E_b}{N_t} = \frac{\dfrac{TrafficE_c}{TotalTransPowerSpecDensity} \times ProcessingGain}{\dfrac{BandlimitedAWGNPowerSpecDensity(N_0)}{ReceivedPowerSpecDensity}}$$

In this example, for AWGN channel, transmit power equals received power. For RC6 20 µ frames, processing gain equals to 256 (24.1 dB).

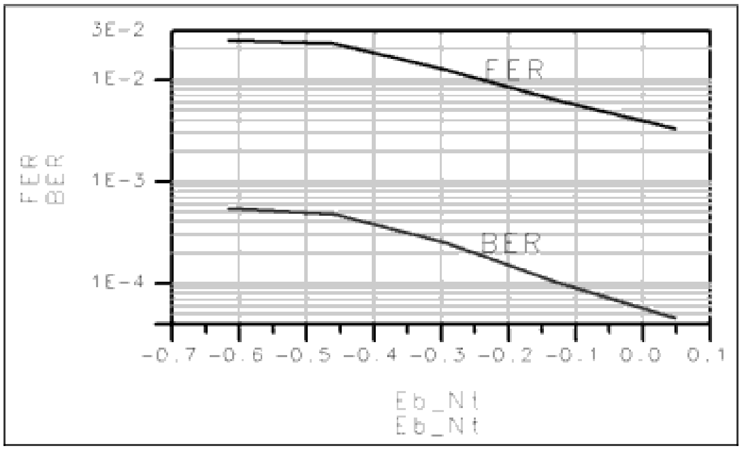
$$\frac{N_o}{2} = \sigma^2$$

Eb/Nt = dB(Processing Gain) − dB(N_o) + 6.

The following table and figure show BER and FER performances for different *Eb/Nt* values.

BER and FER Performance

Eb/Nt(dB)	BER	FER
-0.618	0.0548%	2.42%
-0.46	0.0483%	2.27%
-0.296	0.0254%	0.126%
-0.126	0.01%	0.621%
0.05	4.548e-5	0.33%



BER and FER to *Eb/Nt* Curve

Benchmark

- Hardware platform: Pentium II 400 MHz, 256 Mb memory
- Software platform: Windows NT 4.0 workstation, ADS 1.3
- Data points: 1540 frames
- Simulation time: approximately 16 hours

Notes

TkShowValues is used in this example. FER, BER, and Tested frames are displayed during simulation; values are displayed in the *Ptolemy Control Panel* window. The user can control the number of bits to be tested; lower FER and BER may result by testing more bits.

References

1. IS2000.2, *Physical Layer Standard for cdma2000 Spread Spectrum Systems*, April 1999.
2. TIA/EIA/IS-98-A, *Recommended Minimum Performance Standards for Dual-Mode Wideband Spread Spectrum Cellular Mobile Stations*, July 1996.

BER and FER of Forward Link Radio Configuration 8 with MC Mode

CDMA2K_RC_TD_wrk Design Name

- DsnCDMA2K_MCRC8

Features

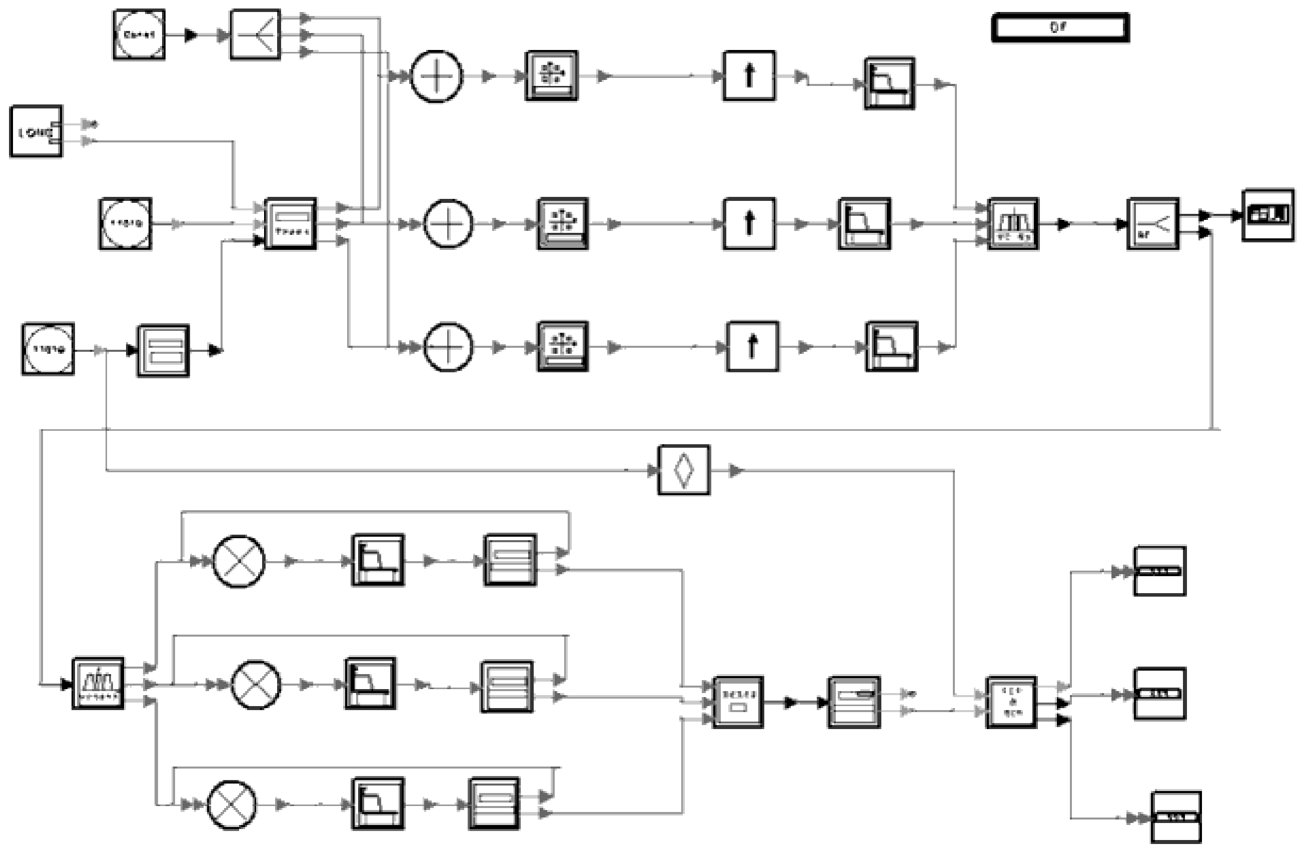
- Constant data rate 14400 bps and 20 μ frame
- Convolutional encoder and Viterbi decoder
- QPSK modulation
- Three carriers; each with 1.2288 Mcps chip rate
- Bandpass filters separate signals over different carriers
- Rake receiver for signal over each carrier
- BER and FER values

Description

DsnCDMA2K_MCRC8 is an example design for measuring BER and FER performance of forward link RC8 with multi-carrier mode.

Schematic

The schematic for this design is shown in the following figure.



DsnCDMA2K_MCRC8

Subnetworks *MCRC8_ChannelCoding*, *MCRC8_ChannelDecoding, MCRC8_Multiplex*, *MCRC8_Receiver,* and *MCRC8_Transmission* were designed for use in this example.

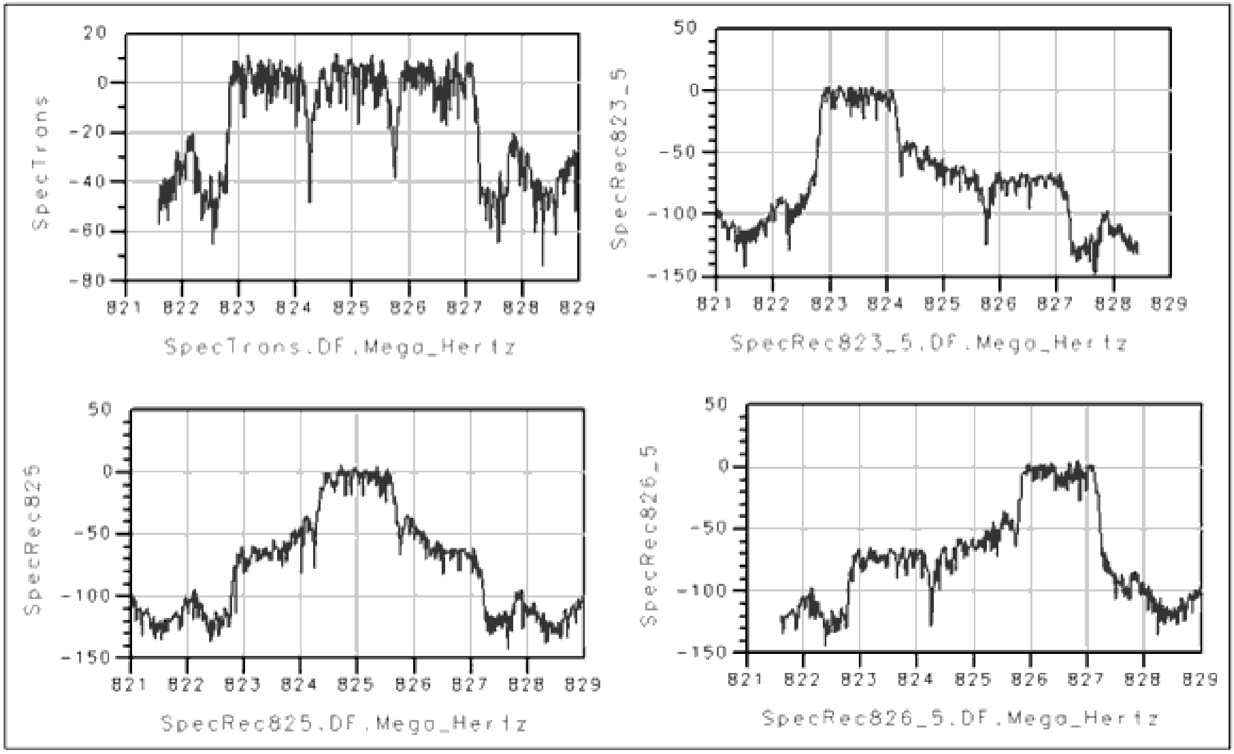
- *MCRC8_ChannelCoding* : channel coding includes CRC encoder, adding tail, convolutional encoder and interleaver.
  Specific parameter settings for this subnetwork are
  - InputFrameLen (CDMA2K_CRC_Coder): **268**
  - CRCType (CDMA2K_CRC_Coder): **CRC12 0x1f13**
  - CCType (CDMA2K_CC_WithTail): **rate 1/4 K 9**
  - BlockRow_m and BlockColumn_J (CDMA2K_MCMode_Intlvr): **m=6, J=6**
- *MCRC8_ChannelDeCoding* : channel decoding includes De-Interleaver, Viterbi decoder, Check CRC and erase tail.
  Specific parameter settings for this subnetwork are
  - InputFrameLen (CDMA2K_CRC_DeCoder): **280**
  - CRCType (CDMA2K_CRC_DeCoder): **CRC12 0x1f13**
  - CCType (CDMA2K_DCC_WithTail): **rate 1/4 K 9**
  - BlockRow_m and BlockColumn_J (CDMA2K_MCMode_DeIntlvr): **m=6, J=6**
- *MCRC8_Multiplex* : multiplexing the outputs of each Rake receiver on different carriers.
- *MCRC8_Receiver* : Rake receiver includes Forward Rake and Walsh and PN Function generators.
  Specific parameter settings for this subnetwork are
  - SpreadRate (CDMA2K_FwdRake): **SR1**

- PilotWalshLen (CDMA2K_FwdRake): **128**
- TrafficWalshLen (CDMA2K_FwdRake): **128**
- FrameLength (CDMA2K_FwdRake): **192**
- FingerNum (CDMA2K_FwdRake): **1**

- *MCRC8_Transmission* : transmitter includes data scrambling, PC bit puncture, Walsh modulator and Walsh rotation.
  Specific parameter settings for this subnetwork are
  - RadioConfig (CDMA2K_DataScrambling): **RC3 To RC9 MC**
  - RadioConfig (CDMA2K_FwdPCBitPuncture): **RC8 MC**
  - WalshLength (CDMA2K_WalshModulator): **128**

Simulation Results

The spectrums on the transmitter and on the receiver sides after bandpass filter are shown in the following figure. The first graph shows the transmitter side; the other graphs show the receiver side with center frequencies of 823.5, 825, and 826.5 MHz.



Spectrums of MC Transmitter and Receiver

Benchmark

- Hardware platform: Pentium II 400 MHz, 256 Mb memory
- Software platform: Windows NT 4.0 workstation, ADS 1.3
- Data points: data of 60 μ
- Simulation time: approximately 1 minutes

Notes

TkShowValues is used in this example. FER, BER, and Tested frames are displayed during simulation; values are displayed in the *Ptolemy Control Panel* window. The user can control the number of bits to be tested; lower FER and BER may result by testing more bits.

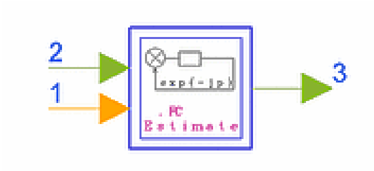
References

1. IS2000.2, *Physical Layer Standard for cdma2000 Spread Spectrum Systems*, April 1999.
2. TIA/EIA/IS-98-A, *Recommended Minimum Performance Standards for Dual-Mode Wideband Spread Spectrum Cellular Mobile Stations*, July 1996.

Receivers for cdma2000-Compliant Design Library

- *CDMA2K CarrierFreqEstimate* (cdma2k)
- *CDMA2K CoefDownSample* (cdma2k)
- *CDMA2K FwdChnlEstimate* (cdma2k)
- *CDMA2K FwdCohReceiver* (cdma2k)
- *CDMA2K FwdOTDreceiver* (cdma2k)
- *CDMA2K FwdRake* (cdma2k)
- *CDMA2K FwdRake U* (cdma2k)
- *CDMA2K FwdRCreceiver* (cdma2k)
- *CDMA2K FwdSTSreceiver* (cdma2k)
- *CDMA2K PhaseDetector* (cdma2k)
- *CDMA2K RevChnlEstimate* (cdma2k)
- *CDMA2K RevCohReceiver* (cdma2k)
- *CDMA2K RevDeHPSK* (cdma2k)
- *CDMA2K RevRake* (cdma2k)
- *CDMA2K RevRCreceiver* (cdma2k)

CDMA2K_CarrierFreqEstimate



Description Phase Estimator for Carrier Frequency
Library cdma2000, Receivers
Class SDFCDMA2K_CarrierFreqEstimate

Parameters

Name	Description	Default	Type	Range
Link	type of link: Forward link, Reverse link	Forward link	enum	
PhaseDetectRate	phase detection rate: PD3200, PD6400, PD9600, PD12800	PD3200	enum	†
SpreadRate	PN chip rate, multiple of 1.2288Mcps: SR1, SR3	SR1	enum	
SampleRate	number of samples per chip	4	int	[1, 32]††
G1	parameter to determine first lowpass filter gain	0.00036	real	(0, 0.0022]
G2	parameter to determine second lowpass filter gain	0.000025	real	(0, 0.002]
EstimateWindow	window size for estimating channel coefficients in terms of symbol (used when Link=Forward link)	6	int	[1, 50]
WalshLength	Walsh code length used for spreading (used when Link=Forward link)	64	int	[1, 256]
† When PhaseDetectRate is PD3200, PD6400, PD9600, PD12800, M is 1, 2, 3, 4, respectively, which is the gain of phase detector. G1 and G2 will be adjusted during applications.††SampleRate is defined as 4 in the cdma2000 standard.				

Pin Inputs

Pin	Name	Description	Signal Type
1	Pbit	pilot and power control bits	int
2	SigIn	input signal	complex

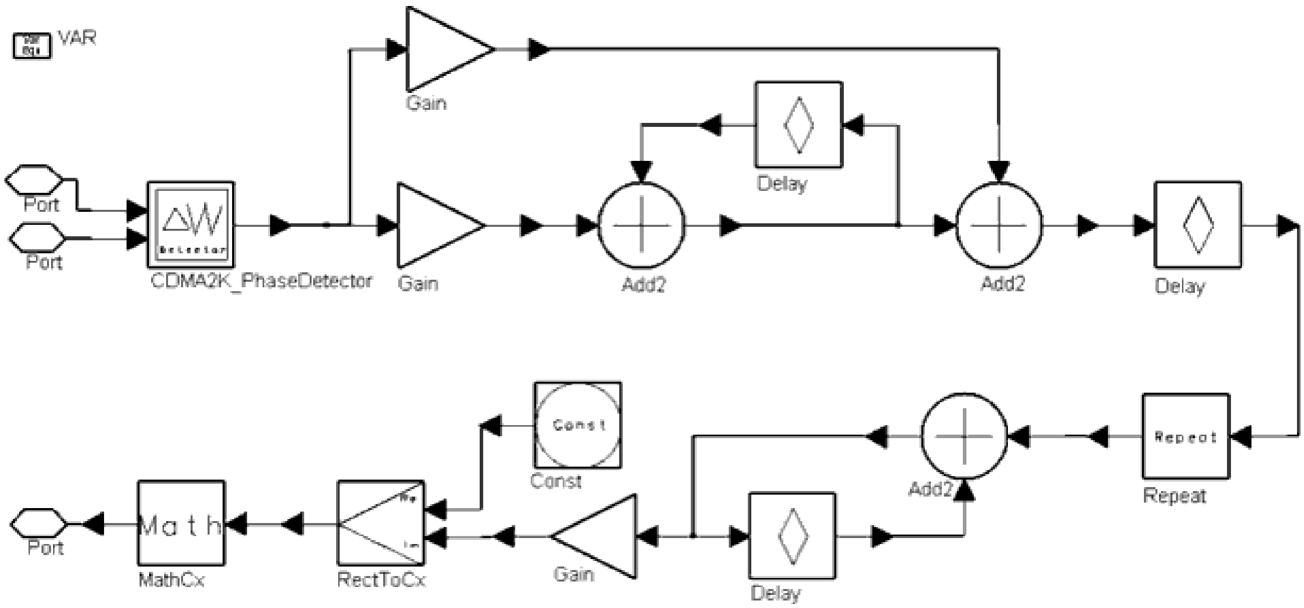
Pin Outputs

Pin	Name	Description	Signal Type
3	Phase	phase offset	complex

Notes/Equations

1. This subnetwork is used to estimate carrier frequency. It is a part of the automatic frequency control loop and includes a phase detector, lowpass filter, and numeric control oscillator. The input signal is received from the pilot signal after despreading and maximal ratio combination.

The following figure shows the schematic for this subnetwork.

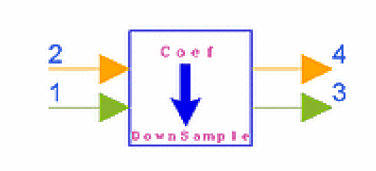


CDMA2K_CarrierFreqEstimate Subnetwork

References

1. L. Yan, "Research of Synchronization technique in Direction Sequence Spread Spectrum Communication System" (Ph.D. dissertation, March 1998).

CDMA2K_CoefDownSample



Description Down sample coefficients
Library cdma2000, Receivers
Class SDFCDMA2K_CoefDownSample

Parameters

Name	Description	Default	Type	Range
FingerNum	number of fingers in Rake receiver	3	int	[1, 5]
PhaseDetectRate	phase detection rate: PD3200, PD6400, PD9600, PD12800	PD3200	enum	

Pin Inputs

Pin	Name	Description	Signal Type
1	CoeIn	amplitude and phase of each selected path	complex
2	DlyIn	delay spread of each selected path in terms of sample	int

Pin Outputs

Pin	Name	Description	Signal Type
3	CoeOut	amplitude and phase of each selected path after down sampling	complex
4	DlyOut	delay spread of each selected path in terms of sample after down sampling	int

Notes/Equations

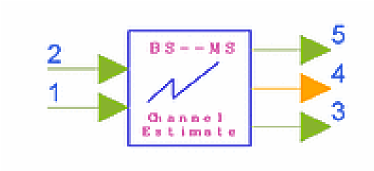
1. This model is used to down-sample the coefficients from the channel estimation model to meet coherent receiver model requirements. It is used as an interface between the channel estimation model and the coherent receiver model.
   Each firing, FingerNum CoeOut and DlyOut tokens are produced when FingerNum × M CoeIn and DlyIn tokens are consumed. When

   PhaseDetectRate=PD3200, M=1
   PhaseDetectRate=PD6400, M=2
   PhaseDetectRate=PD9600, M=3
   PhaseDetectRate=PD12800, M=4.

References

1. TIA/EIA/IS-2000.2 (PN-4428), Physical Layer Standard for cdma2000 Spread Spectrum Systems, July, 1999.

CDMA2K_FwdChnlEstimate



Description Forward channel estimator
Library cdma2000, Receivers
Class SDFCDMA2K_FwdChnlEstimate

Parameters

Name	Description	Default	Sym	Type	Range
MaxSearchPathNum	range for searching strongest paths	30		int	[F/4, F/4 + 100]
EstimateWindow	window size for estimating channel coefficients in terms of symbols	6	N	int	[1, 50]
FingerNum	number of Rake receiver fingers	3	K	int	[1, 5]
SampleRate	number of samples per chip	4	R	int	[1, 32] †
FilterOrder	filter order	48	F	int	[2, 150)
WalshLength	Walsh code length used for spreading	64	L	int	2^n, n=0,1,2,...,9
PhaseDetectRate	phase detection rate: PD3200, PD6400, PD9600, PD12800	PD3200		enum	
† SampleRate is defined as 4 in the cdma2000 standard.					

Pin Inputs

Pin	Name	Description	Signal Type
1	SigIn	received baseband signal.	complex
2	PNp	PN code used by pilot channel	complex

Pin Outputs

Pin	Name	Description	Signal Type
3	CoeOut	multipath channel coefficient for every finger.	complex
4	DlyOut	multipath delays for every finger.	int
5	Pilot	pilot signals after maximal ratio combination	complex

Notes/Equations

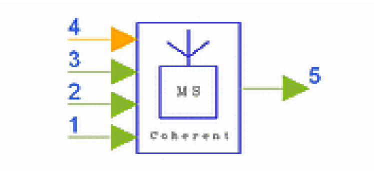
1. This model is used to estimate channel profile, including delay, strength and phase of multipath for forward link. This model combines channel estimating and multipath search.
   Since the Walsh function length for corresponding channel varies, WalshLength must

be set in advance. The received signal is sampled at SampleRate times the chip rate. The PNp input is a product of short PN code and Walsh function used by the pilot channel.
PhaseDetectRate is designed for the automatic frequency control function; this parameter works with, and must be consistent with, the PhaseDetectRate parameter in CDMA2K_CarrierFreqEstimate.
Each firing, K tokens of DlyOut, K tokens of CoeOut and one Pilot token are produced when N × L × R / (1+PhaseDetectRate) tokens of input SigIn and N × L / (1+PhaseDetectRate) tokens of input PNp are consumed.
Pilot outputs the pilot signal after maximal ratio combination for automatic frequency control. The algorithm of maximal ratio combination is the same as the algorithm used in CDMA2K_FwdCohReceiver.

References

1. F. Li, H. Xiao and J. Yang, "On Channel Estimation for Rake Receiver in a Mobile Multipath Fading Channel," *IEEE* 1994 CD-ROM.
2. U. Fawer, "A Coherent Spread-Spectrum Diversity-Receiver with AFC for Multipath Fading Channels," *IEEE Trans. on Comm* . Vol.42, 1994, pp. 1300-1311.
3. A. J. Viterbi, Principles of Spread Spectrum Communication, The Peoples Posts & Telecommunications Publishing, 1995.
4. TIA/EIA/IS-2000.2 (PN-4428), Physical Layer Standard for cdma2000 Spread Spectrum Systems, July, 1999.

CDMA2K_FwdCohReceiver



Description Forward coherent combiner
Library cdma2000, Receivers
Class SDFCDMA2K_FwdCohReceiver

Parameters

Name	Description	Default	Sym	Type	Range
EstimateWindow	window size for estimating channel coefficients in terms of symbols	6	N	int	[1, 50]
FingerNum	number of Rake receiver fingers	3	K	int	[1, 5]
SampleRate	number of samples per chip	4	R	int	[1, 32] †
FilterOrder	filter order	48		int	[2, 150)
WalshLength	Walsh code length used for spreading	64	L	int	2^n, n=0,1,2,...,9
† SampleRate is defined as 4 in the cdma2000 standard.					

Pin Inputs

Pin	Name	Description	Signal Type
1	SigIn	input received signal.	complex
2	PN	input complex PN code used by corresponding channel	complex
3	CoeIn	input multipath channel coefficients	complex
4	DlyIn	input multipath delays	int

Pin Outputs

Pin	Name	Description	Signal Type
5	SigOut	output signals	complex

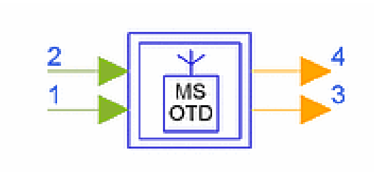
Notes/Equations

1. This model is used to implement coherent receiving with maximal ratio combining. The necessary coefficients for rake combining, such as multipath delay, channel phase, and attenuation are from the channel estimate model. All parameters of this model must be consistent with CDMA2K_FwdChnlEstimate.
   Each firing, N output tokens of SigOut are produced when N × L × R tokens of input SigIn, N × L tokens of input PN, K tokens of DlyIn, K tokens of CoeIn are consumed.

References

1. F. Li, H. Xiao and J. Yang, "On Channel Estimation for Rake Receiver in a Mobile Multipath Fading Channel," *IEEE* 1994 CD-ROM.
2. U. Fawer, "A Coherent Spread-Spectrum Diversity-Receiver with AFC for Multipath Fading Channels," *IEEE Trans. on Comm* . Vol.42, 1994, pp. 1300-1311.
3. A. J. Viterbi, Principles of Spread Spectrum Communication, The Peoples Posts & Telecommunications Publishing, 1995.
4. TIA/EIA/IS-2000.2 (PN-4428), Physical Layer Standard for cdma2000 Spread Spectrum Systems, July, 1999.

CDMA2K_FwdOTDreceiver



Description foward link OTD receiver subnetwork
Library cdma2000, Receivers
Class SDFCDMA2K_FwdOTDreceiver

Parameters

Name	Description	Default	Type	Range
DataRate	data rate in kbps	9.6	real	1.5, 2.7,4.8,9.6 for Forward RC3; and Forward RC4 1.8,3.6,7.2,14.4 for Forward RC5
RadioConfig	radio configuration for forward link: Forward RC3, Forward RC4, Forward RC5	Forward RC3	enum	
TrffcIndex1	traffic Walsh index for forward main antenna transmission	61	int	[2, 15] or [17, 31] or [33, 63] for Forward RC3 and RC5, [2, 15] or [17, 31] or [33, 63] or [65, 127] for Forward RC4
TrffcIndex2	traffic Walsh index for forward auxiliary antenna transmission	62	int	[2, 15] or [17, 31] or [33, 63] for Forward RC3 and RC5, [2, 15] or [17, 31] or [33, 63] or [65, 127] for Forward RC4
FingerNum	finger number of rake receiver	1	int	[1, 5]
OuterLoop	outer loop power control enable: ENABLE, DISABLE	DISABLE	enum	
SIR_Threshold	signal-to-interference ratio required	0	real	(-∞, ∞)

Pin Inputs

Pin	Name	Description	Signal Type
1	In1	input data from the main antenna	complex
2	In2	input data from the auxiliary antenna	complex

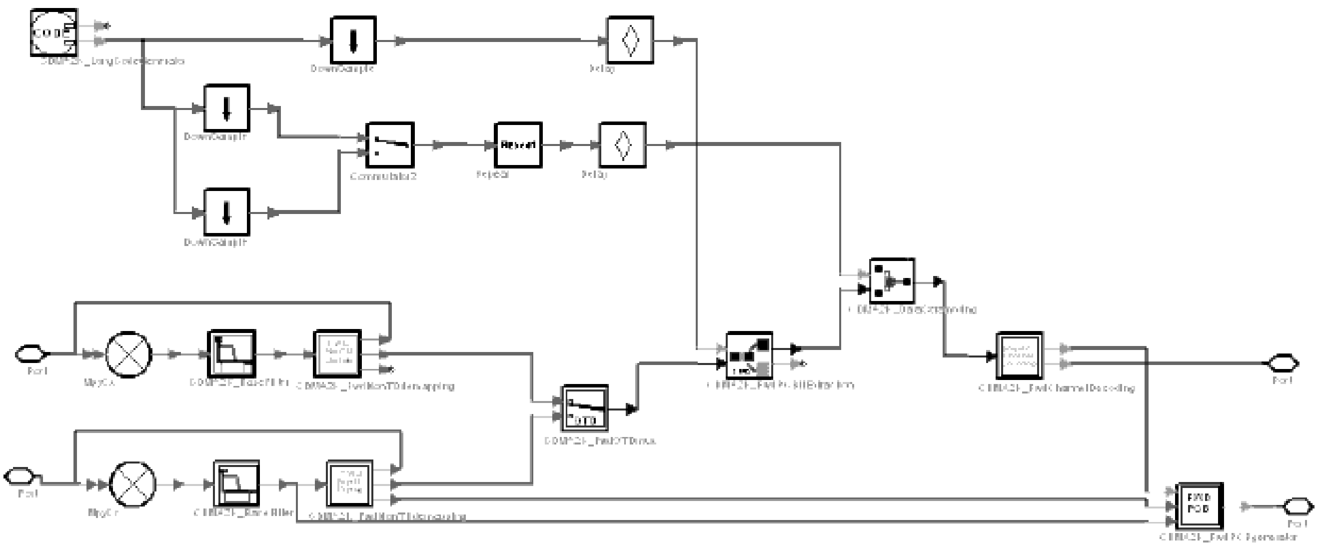
Pin Outputs

Pin	Name	Description	Signal Type
3	Out	output data	int
4	PCB	power control bits	int

Notes/Equations

1. The subnetwork provides forward link receiver for OTD mode. The schematic is

shown in the following figure.

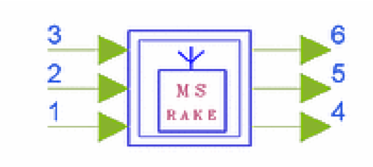


CDMA2K_FwdOTDreceiver Subnetwork

References

1. 3GPP2 C.S0002_A_1, "Physical Layer Standard for cdma2000 Spread Spectrum Systems Release A-Addendum 1," Oct. 27, 2000

CDMA2K_FwdRake



Description Forward Rake Receiver
Library cdma2000, Receivers
Class SDFCDMA2K_FwdRake

Parameters

Name	Description	Default	Sym	Type	Range
SpreadRate	PN chip rate, multiple of 1.2288 Mcps: SR1, SR3	SR1	SR	enum	
PilotWalshLen	Walsh code length for pilot channel (longer than traffic channel)	128		int	2^n, n=1,2,...,9 †
TrafficWalshLen	Walsh code length for traffic channel	64		int	2^n, n=1,2,...,9
FrameLength	frame length of output complex signals	192	L	int	[1, ∞)
FingerNum	number of fingers in Rake receiver	3	K	int	[1, 5]

† In general, the Walsh code used by the pilot channel is longer than the Walsh code used by the traffic channel.

Pin Inputs

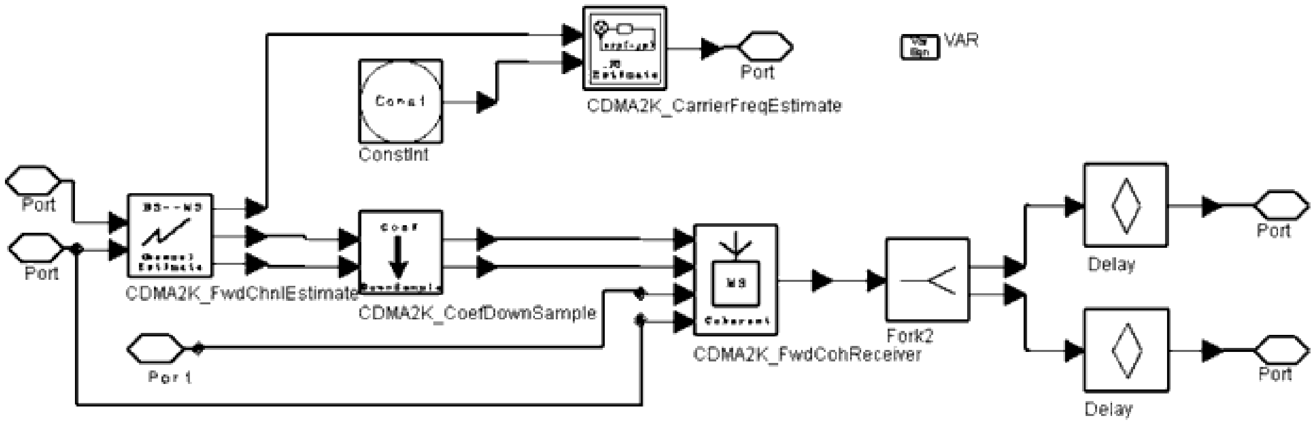
Pin	Name	Description	Signal Type
1	SigIn	received baseband signal	complex
2	Pilot	pilot channel PN code and Walsh code	complex
3	Trffc	traffic channel PN code and Walsh code	complex

Pin Outputs

Pin	Name	Description	Signal Type
4	D_PCG	signal for power control component	complex
5	SigOut	signal for decoder	complex
6	AFC	phase signal of automatic frequency control	complex

Notes/Equations

1. This subnetwork is used to implement coherent Rake receiving with maximal ratio combining. It includes channel estimator, coherent receiver, and automatic frequency recovery.
   The following figure shows the schematic for this subnetwork.

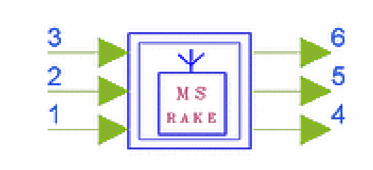


CDMA2K_FwdRake Subnetwork

References

1. F. Li, H. Xiao and J. Yang, "On Channel Estimation for Rake Receiver in a Mobile Multipath Fading Channel," *IEEE* 1994 CD-ROM.
2. U. Fawer, "A Coherent Spread-Spectrum Diversity-Receiver with AFC for Multipath Fading Channels," *IEEE Trans. on Comm* . Vol.42, 1994, pp. 1300-1311.
3. A. J. Viterbi, Principles of Spread Spectrum Communication, The Peoples Posts & Telecommunications Publishing, 1995.
4. TIA/EIA/IS-2000.2 (PN-4428), Physical Layer Standard for cdma2000 Spread Spectrum Systems, July 1999.

CDMA2K_FwdRake_U



Description Forward Rake receiver, spec. 3GPP2 C.S0002-A-1, Oct. 2000.
Library cdma2000, Receivers
Class SDFCDMA2K_FwdRake_U

Parameters

Name	Description	Default	Sym	Type	Range
SpreadRate	PN chip rate, multiple of 1.2288 Mcps: SR1, SR3	SR1		enum	
PilotWalshLen	Walsh code length for pilot channel (longer than traffic channel)	128		int	2^n, n=1,2,...,9 †
TrafficWalshLen	Walsh code length for traffic channel	64		int	2^n, n=1,2,...,9
FrameLength	frame length of output complex signals	192	L	int	[48 * PilotWalshLen/TrafficWalshLen, ∞)
FingerNum	number of fingers in Rake receiver	3	K	int	[1, 5]
† In general, the Walsh code used by the pilot channel is longer than the Walsh code used by the traffic channel.					

Pin Inputs

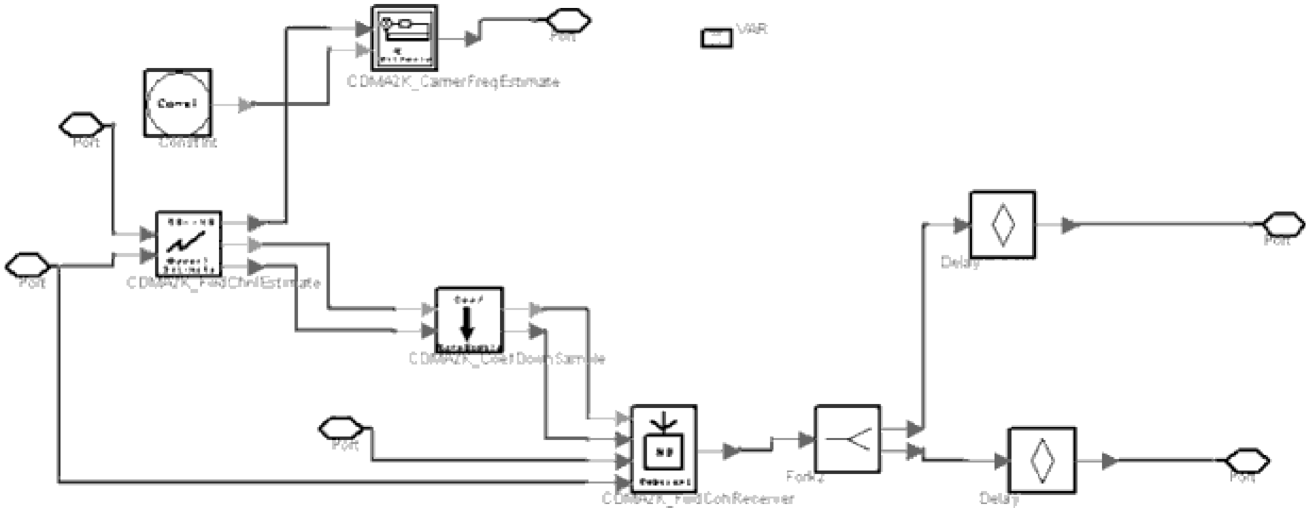
Pin	Name	Description	Signal Type
1	SigIn	received baseband signal	complex
2	Pilot	pilot channel PN code and Walsh code	complex
3	Trffc	traffic channel PN code and Walsh code	complex

Pin Outputs

Pin	Name	Description	Signal Type
4	D_PCG	signal for power control component	complex
5	SigOut	signal for decoder	complex
6	AFC	phase signal of automatic frequency control	complex

Notes/Equations

1. This subnetwork implements coherent Rake receiving with maximal ratio combining (MRC). The schematic is shown in the following figure; it consists of a channel estimator, coherent receiver, and automatic frequency recovery.

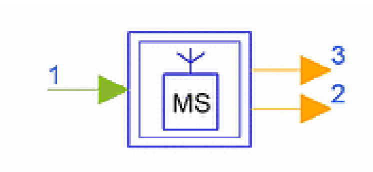


Structure of CDMA2K_FwdRake

References

1. Fu Li and Heng Xiao and Jin Yang, "On Channel Estimation for Rake Receiver in a mobile multipath fading channel," IEEE 1994 CD-ROM
2. Urs Fawer, "A Coherent Spread-Spectrum Diversity-Receiver with AFC for Multipath Fading Channels," IEEE Trans. on Comm. Vol.42, pp1300-1311, 1994.
3. A. J. Viterbi, "Principles of Spread Spectrum Communication," The Peoples Posts & Telecommunications Publishing, 1995.
4. 3GPP2 C.S0002_A_1, "Physical Layer Standard for cdma2000 Spread Spectrum Systems Release A-Addendum 1," Oct. 27, 2000.

CDMA2K_FwdRCreceiver



Description Foward link receiver subnetwork for different radio configuration
Library cdma2000, Receivers
Class SDFCDMA2K_FwdRCreceiver

Parameters

Name	Description	Default	Type	Range
DataRate	data rate in kbps	9.6	real	1.5, 2.7,4.8,9.6 for Forward RC3; and Forward RC4 1.8,3.6,7.2,14.4 for Forward RC5
RadioConfig	radio configuration for forward link: Forward RC3, Forward RC4, Forward RC5	Forward RC3	enum	
TrffcIndex	traffic Walsh index	61	int	[2, 15] or [17, 31] or [33, 63] for Forward RC3 and RC5, [2, 15] or [17, 31] or [33, 63] or [65, 127] for Forward RC4
FingerNum	finger number of rake receiver	1	int	[1, 5]
OuterLoop	outer loop power control enable: ENABLE, DISABLE	DISABLE	enum	
SIR_Threshold	signal-to-interference ratio required	0	real	(-∞, ∞)

Pin Inputs

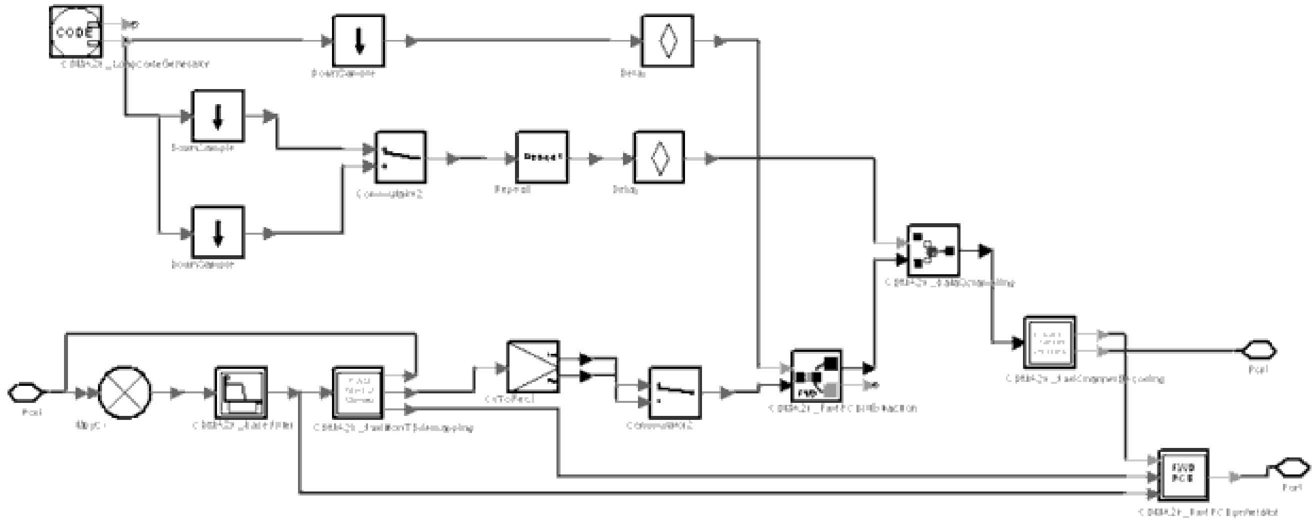
Pin	Name	Description	Signal Type
1	In	input data	complex

Pin Outputs

Pin	Name	Description	Signal Type
2	Out	output data	int
3	PCB	power control bits	int

Notes/Equations

1. This subnetwork provides forward link receiver for different radio configurations and data rates. The schematic is shown in the following figure.

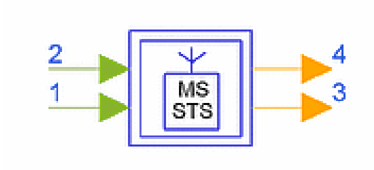


CDMA2K_FwdRCreceiver Subnetwork

References

1. 3GPP2 C.S0002_A_1, "Physical Layer Standard for cdma2000 Spread Spectrum Systems Release A-Addendum 1," Oct. 27, 2000

CDMA2K_FwdSTSreceiver



Description Foward link STS receiver subnetwork
Library cdma2000, Receivers
Class SDFCDMA2K_FwdSTSreceiver

Parameters

Name	Description	Default	Type	Range
DataRate	data rate in kbps	9.6	real	1.5, 2.7,4.8,9.6 for Forward RC3; and Forward RC4 1.8,3.6,7.2,14.4 for Forward RC5
RadioConfig	radio configuration for forward link: Forward RC3, Forward RC4, Forward RC5	Forward RC3	enum	
TrffcIndex1	traffic Walsh index for forward main antenna transmission	61	int	[2, 15] or [17, 31] or [33, 63] for Forward RC3 and RC5, [2, 15] or [17, 31] or [33, 63] or [65, 127] for Forward RC4
TrffcIndex2	traffic Walsh index for forward auxiliary antenna transmission	62	int	[2, 15] or [17, 31] or [33, 63] for Forward RC3 and RC5, [2, 15] or [17, 31] or [33, 63] or [65, 127] for Forward RC4
FingerNum	finger number of rake receiver	1	int	[1, 5]
OuterLoop	outer loop power control enable: ENABLE, DISABLE	DISABLE	enum	
SIR_Threshold	signal-to-interference ratio required	0	real	(-∞, ∞)

Pin Inputs

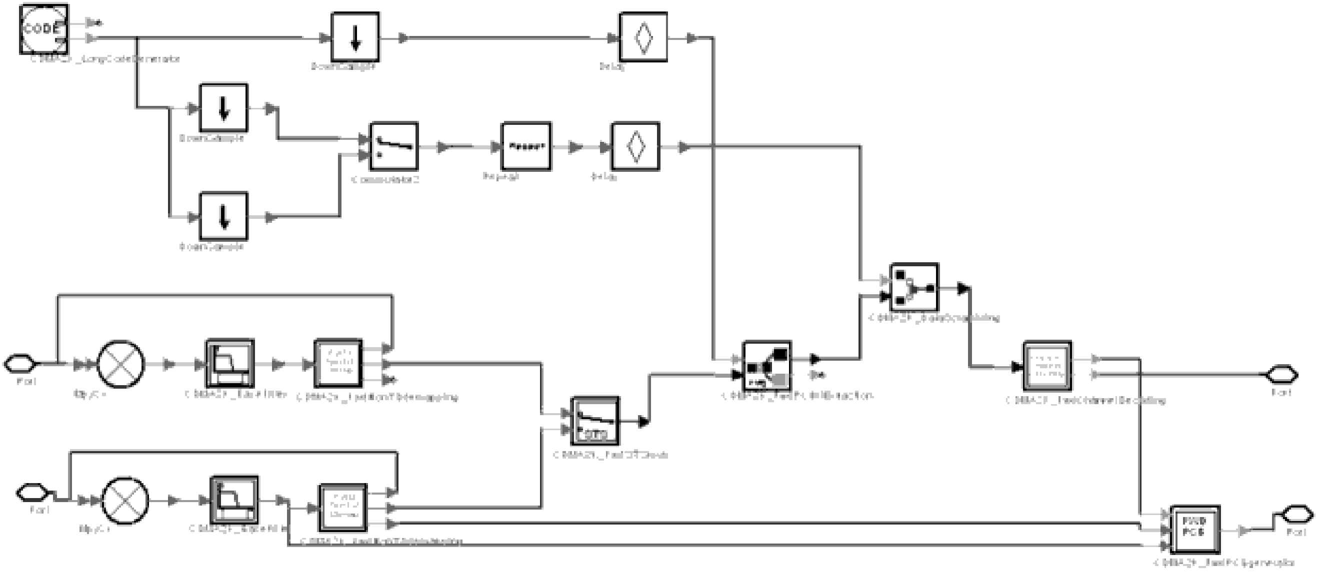
Pin	Name	Description	Signal Type
1	In1	input data from the main antenna	complex
2	In2	input data from the auxiliary antenna	complex

Pin Outputs

Pin	Name	Description	Signal Type
3	Out	output data	int
4	PCB	power control bits	int

Notes/Equations

1. This subnetwork provides forward link receiver for STS mode. The schematic is shown in the following figure.

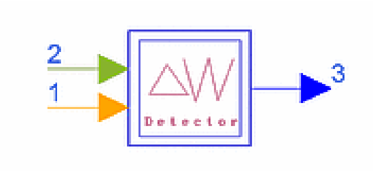


CDMA2K_FwdSTSreceiver Subnetwork

References

1. 3GPP2 C.S0002_A_1, "Physical Layer Standard for cdma2000 Spread Spectrum Systems Release A-Addendum 1," Oct. 27, 2000.

CDMA2K_PhaseDetector



Description Phase Detector
Library cdma2000, Receivers
Class SDFCDMA2K_PhaseDetector

Pin Inputs

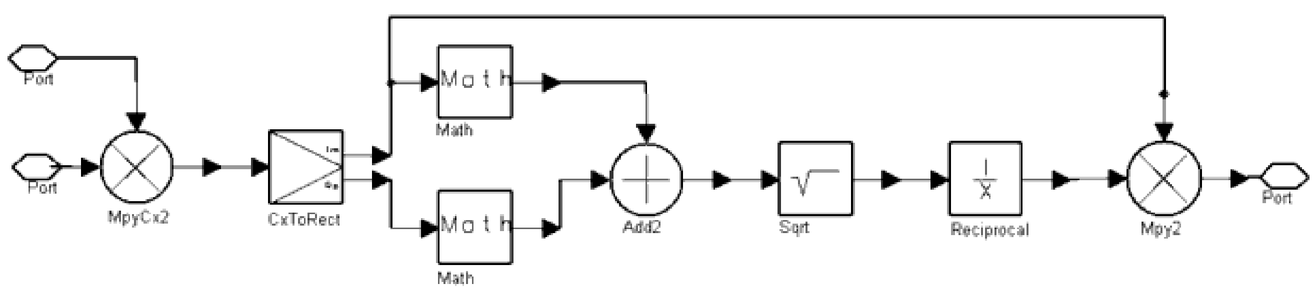
Pin	Name	Description	Signal Type
1	Pilot	input signal	int
2	SigIn	input signal	complex

Pin Outputs

Pin	Name	Description	Signal Type
3	Phase	phase offset detected by phase detector	real

Notes/Equations

1. This subnetwork is used to detect the phase offset caused by Doppler shift. It is a part of the automatic frequency control loop. The signal detects the phase offset from the pilot signal after despreading and maximal ratio combination.
   Each firing, 1 Phase token is produced when 1 SigIn token and 1 Pbit token are consumed.
   The following figure shows the schematic for this subnetwork.

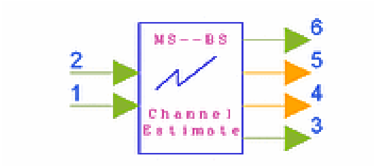


CDMA2K_PhaseDetector Subnetwork

References

1. L. Yan, "Research of Synchronization Tecnique in Direct Sequence Spread Spectrum Communication System" (Ph.D. dissertation, March 1998).

CDMA2K_RevChnlEstimate



Description Reverse link channel estimator
Library cdma2000, Receivers
Class SDFCDMA2K_RevChnlEstimate

Parameters

Name	Description	Default	Sym	Type	Range
MaxSearchPathNum	range for searching strongest paths	30		int	[F/4, F/4 +100]
SampleRate	number of samples per chip	4		int	[1, 32] †
FilterOrder	filter order	48	F	int	[2, 50] for SR1, [2, 150] for SR3
FingerNum	number of fingers in Rake receiver	3		int	[1, 5]
SpreadRate	PN chip rate, multiple of 1.2288 Mcps: SR1, SR3	SR1		enum	
PhaseDetectRate	phase detection rate: PD3200, PD6400, PD9600, PD12800	PD3200		enum	
† SampleRate is defined as 4 in the cdma2000 standard.					

Pin Inputs

Pin	Name	Description	Signal Type
1	SigIn	received signal	complex
2	PNp	pilot channel PN code	complex

Pin Outputs

Pin	Name	Description	Signal Type
3	CoeOut	amplitude and phase of each selected path	complex
4	DlyOut	delay spread of each selected path in terms of sample	int
5	PCBit	pilot and power control bits	int
6	SigOut	output signal after maximal ratio combination	complex

Notes/Equations

1. This model is used to estimate channel profile, including delay spread and strength and phase of multipath. This information is derived from the pilot channel signal. Each firing, FingerNum CoeOut, FingerNum DlyOut, 1PCbit, and 1 SigOut tokens are produced when 384 × SampleRate × SpreadRate / M SigIn tokens, 384 × SpreadRate / M PNp tokens are consumed. Here SampleRate is 4 and the default

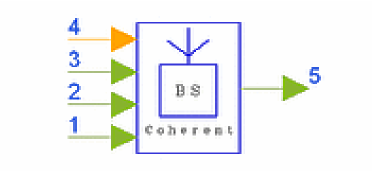
value of SpreadRate is SR1. M is determined by PhaseDetectRate; when

PhaseDetectRate=3.2k, M=1
PhaseDetectRate=6.4k, M=2
PhaseDetectRate=9.6k, M=3
PhaseDetectRate=12.8k, M=4.

References

1. TIA/EIA/IS-2000.2 (PN-4428), Physical Layer Standard for cdma2000 Spread Spectrum Systems, July, 1999.
2. L. Yan, "Research of Synchronization Tecnique in Direct Sequence Spread Spectrum Communication System" (Ph.D. dissertation, March 1998).

CDMA2K_RevCohReceiver



Description Reverse link Rake receiver
Library cdma2000, Receivers
Class SDFCDMA2K_RevCohReceiver

Parameters

Name	Description	Default	Sym	Type	Range
MaxSearchPathNum	range for searching strongest paths	30		int	[11, 100]
SampleRate	number of samples per chip	4		int	[1, 32] †
FingerNum	number of fingers in Rake receiver	3		int	[1, 5]
WalshLength	Walsh code length used for spreading	16	L	int	2^n, n=0,1,2,...,9
SpreadRate	PN chip rate, multiple of 1.2288 Mcps: SR1, SR3	SR1		enum	
† SampleRate is defined as 4 in the cdma2000 standard.					

Pin Inputs

Pin	Name	Description	Signal Type
1	SigIn	received signal	complex
2	PN	PN code used by corresponding channel	complex
3	CoeIn	amplitude and phase of each selected path	complex
4	DlyIn	delay spread of each selected path in terms of sample	int

Pin Outputs

Pin	Name	Description	Signal Type
5	SigOut	output signal after maximal ratio combination	complex

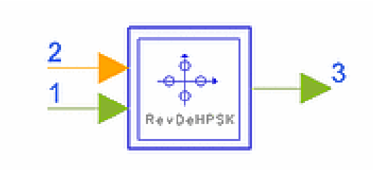
Notes/Equations

1. This model is used to fulfill maximal ratio combining by collecting the energy of the receiving arms. The phases and attenuation factors of those paths are the inputs of this model.
   Each firing, 384/WalshLength × SpreadRate SigOut tokens are produced when 384 × SampleRate × SpreadRate SigIn tokens, 384 × SpreadRate PN tokens, FingerNum CoeIn, FingerNum DlyIn, are consumed. Here SampleRate is 4 and the default value of SpreadRate is SR1.

References

1. TIA/EIA/IS-2000.2 (PN-4428), Physical Layer Standard for cdma2000 Spread Spectrum Systems, July, 1999.

CDMA2K_RevDeHPSK



Description HPSK demodulation for reverse link
Library cdma2000, Receivers
Class SDFCDMA2K_RevDeHPSK

Parameters

Name	Description	Default	Type	Range
PN_Offset	offset of PN code	0	int	[0, 511]
TransDelay	used to delay long PN code to compensate filter delay	16	int	[0, 511] †
I_PhaseCodeType	type of I-phase PN code: SR1 I phase, SR3 I phase	SR1 I phase	enum	
Q_PhaseCodeType	type of Q-phase PN code: SR1 Q phase, SR3 Q phase	SR1 Q phase	enum	
Q_Phase	sign of sine: Sine, Minus Sine	Minus Sine	enum	
† TransDelay is a multiple of Walsh length.				

Pin Inputs

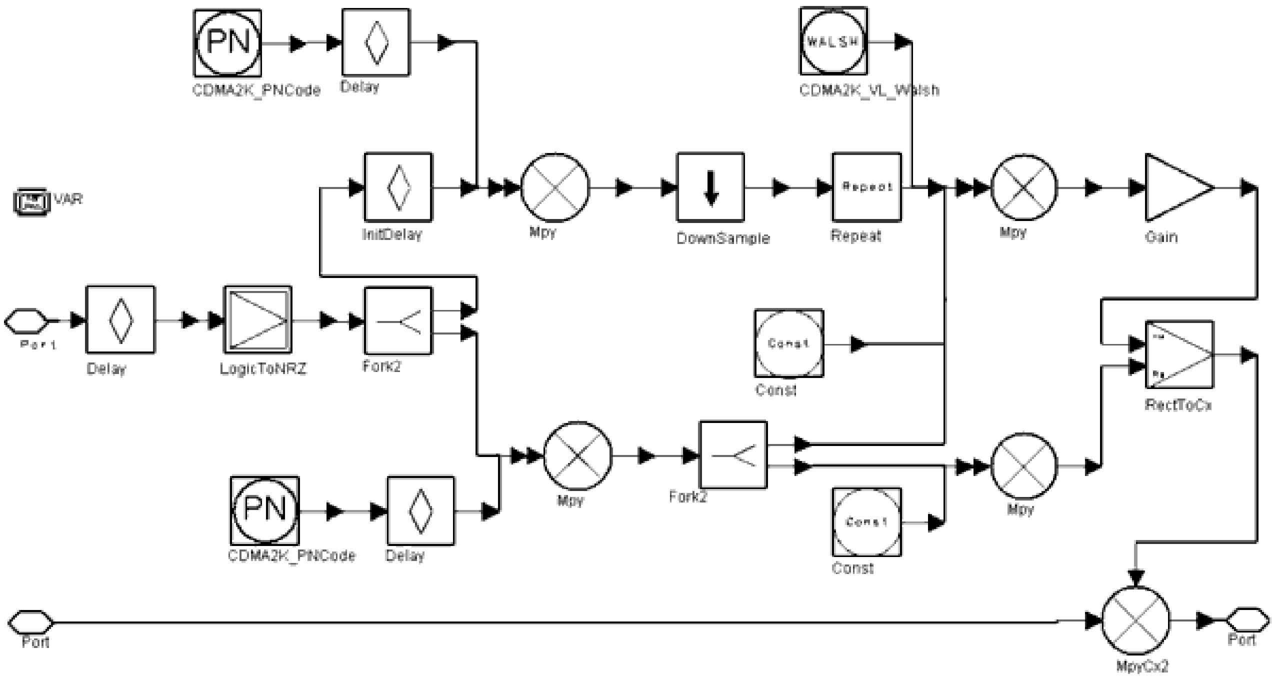
Pin	Name	Description	Signal Type
1	D_in	input data	complex
2	LgCode	long PN code	int

Pin Outputs

Pin	Name	Description	Signal Type
3	D_out	data after demodulation	complex

Notes/Equations

1. This subnetwork is used to implement HPSK demodulation for the reverse link. The following figure shows the schematic for this subnetwork.

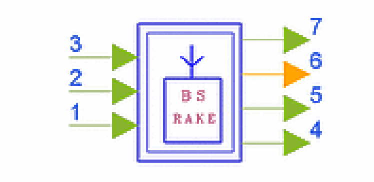


CDMA2K_RevDeHPSK Subnetwork

References

1. TIA/EIA/IS-2000.2 (PN-4428), Physical Layer Standard for cdma2000 Spread Spectrum Systems, July 1999.

CDMA2K_RevRake



Description Reverse Rake Receiver
Library cdma2000, Receivers
Class SDFCDMA2K_RevRake

Parameters

Name	Description	Default	Sym	Type	Range
SpreadRate	PN chip rate, multiple of 1.2288 Mcps: SR1, SR3	SR1	SR	enum	
TrafficWalshLen	Walsh code length for traffic channel	16		int	2^n , n=1,2,...,9
FrameLength	frame length of output complex signals	384	L	int	[1, ∞)
FingerNum	number of fingers in Rake receiver	3	K	int	[1, 5]

Pin Inputs

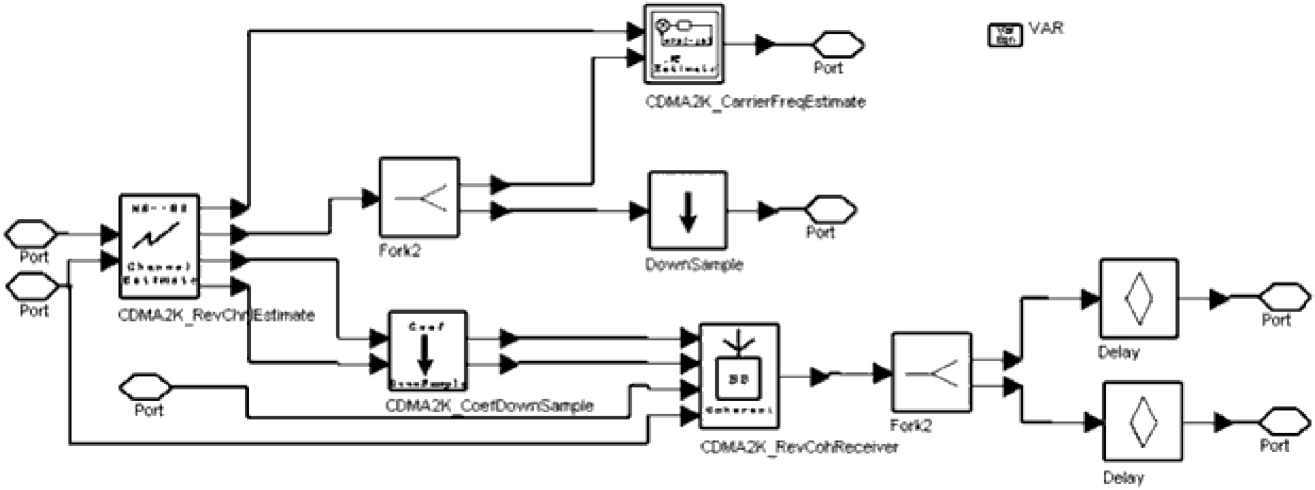
Pin	Name	Description	Signal Type
1	SigIn	received baseband signal	complex
2	Pilot	pilot channel PN code and Walsh code	complex
3	Trffc	traffic channel PN code and Walsh code	complex

Pin Outputs

Pin	Name	Description	Signal Type
4	D_PCG	signal for power control component	complex
5	SigOut	decision signal	complex
6	PCBit	power control bits	int
7	AFC	phase signal of automatic frequency control	complex

Notes/Equations

1. This subnetwork is used to implement coherent Rake receiver with maximal ratio combining. It consists of channel estimator, coherent receiver, and automatic frequency recovery.
   Each firing, 384 × SpreadRate/TrafficWalshLen output tokens at SigOut and D_PCG and 384 × SpreadRate × 4 output tokens at AFC are produced when 384 × SpreadRate × 4 SigIn tokens, 384 × SpreadRate Pilot and Trffc tokens are consumed.
   The following figure shows the schematic for this subnetwork.

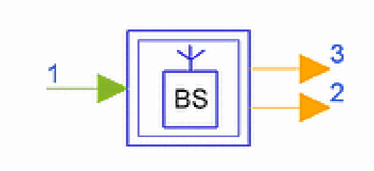


CDMA2K_RevRake Subnetwork

References

1. F. Li, H. Xiao and J. Yang, "On Channel Estimation for Rake Receiver in a Mobile Multipath Fading Channel," *IEEE* 1994 CD-ROM.
2. U. Fawer, "A Coherent Spread-Spectrum Diversity-Receiver with AFC for Multipath Fading Channels," *IEEE Trans. on Comm* . Vol.42, 1994, pp. 1300-1311.
3. A. J. Viterbi, Principles of Spread Spectrum Communication, The Peoples Posts & Telecommunications Publishing, 1995.
4. TIA/EIA/IS-2000.2 (PN-4428), Physical Layer Standard for cdma2000 Spread Spectrum Systems, July 1999.

CDMA2K_RevRCreceiver



Description Reverse link reciever subnetwork for different radio configuation
Library cdma2000, Receivers
Class SDFCDMA2K_RevRCreceiver

Parameters

Name	Description	Default	Type	Range
DataRate	data rate in kbps	9.6	real	1.5, 2.7,4.8,9.6 for Reverse RC3; 1.8,3.6,7.2,14.4 for Reverse RC4
RadioConfig	radio configuration for reverse link respectively: Reverse RC3, Reverse RC4	Reverse RC3	enum	
FingerNum	finger number of rake receiver	1	int	[1, 5]
OuterLoop	outer loop power control enable: ENABLE, DISABLE	DISABLE	enum	
SIR_Threshold	signal-to-interference ratio required	0	real	(-∞, ∞)

Pin Inputs

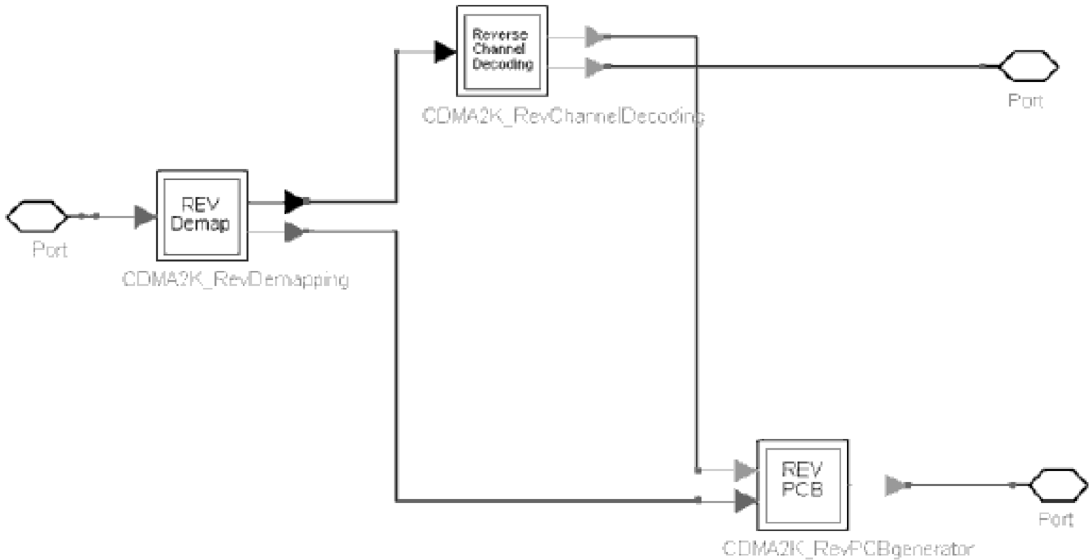
Pin	Name	Description	Signal Type
1	In	input data	complex

Pin Outputs

Pin	Name	Description	Signal Type
2	Out	output data	int
3	PCB	power control bits	int

Notes/Equations

1. The subnetwork provides reverse link receiver for different radio configurations and data rates. The schematic is shown in the following figure.



CDMA2K_RevRCreceiver Subnetwork

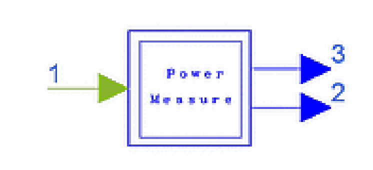
References

1. 3GPP2 C.S0002_A_1, "Physical Layer Standard for cdma2000 Spread Spectrum Systems Release A-Addendum 1," Oct. 27, 2000.

RF Subsystems for cdma2000-Compliant Design Library

- *CDMA2K PwrMeasure* (cdma2k)
- *CDMA2K RF Demod* (cdma2k)
- *CDMA2K RF Mod* (cdma2k)

CDMA2K_PwrMeasure



Description Average signal power measurement
Library cdma2000, RF Subsystems
Class SDFCDMA2K_PwrMeasure

Parameters

Name	Description	Default	Unit	Type	Range
BlockSize	number of particles in a block	16		int	[1, ∞]
SignalType	type of signal: Baseband signal, RF signal	Baseband signal		enum	
RefR	reference resistance	50.0	Ohm	real	(0, ∞)

Pin Inputs

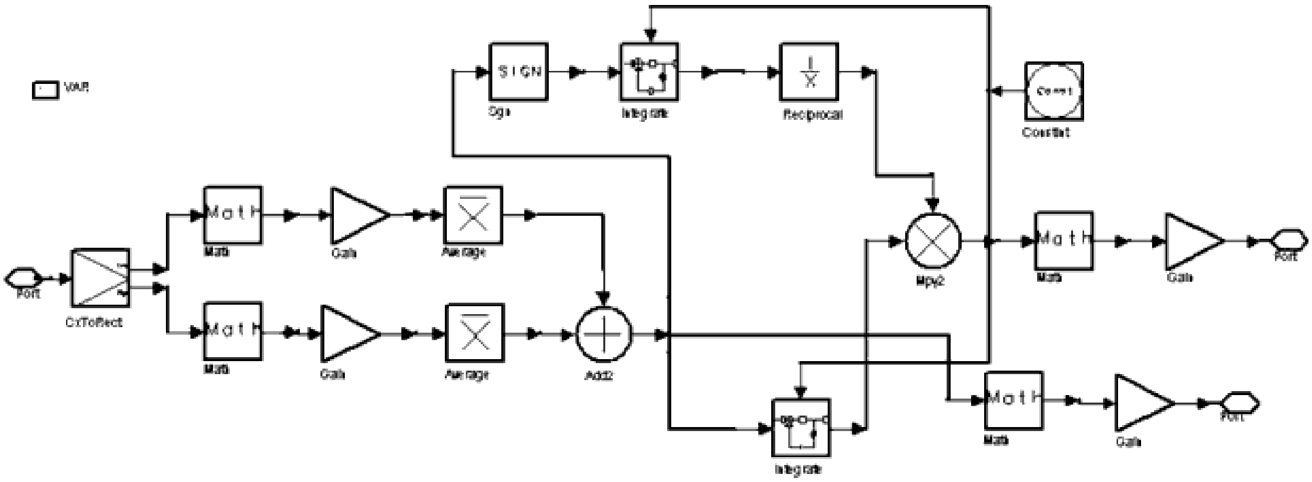
Pin	Name	Description	Signal Type
1	SigIn	input signal	complex

Pin Outputs

Pin	Name	Description	Signal Type
2	Ave_P	average power of input signals	real
3	BlockP	average power of input signal in a block	real

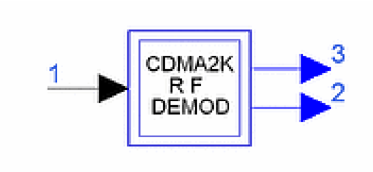
Notes/Equations

1. This subnetwork measures the mean power (in dBm) of the input signal. Users must set the SignalType and RefR values properly to result in a valid dBm value. This model does not have any associated input resistance. RefR is for use in calculation of the dBm power value.
   The schematic for this subnetwork is shown in the following figure.



CDMA2K_PwrMeasure Subnetwork

CDMA2K_RF_Demod



Description RF Demodulator
Library cdma2000, RF Subsystems
Class TSDFCDMA2K_RF_Demod

Parameters

Name	Description	Default	Unit	Type	Range
FCarrier	carrier frequency	70e6	Hz	real	(0, ∞)
Phase	demodulator reference phase in degrees	0.0	deg	real	(-∞, ∞)
VRef	reference voltage for output calibration	1.0	V	real	(0, ∞)
RIn	input resistance	DefaultRIn	Ohm	real	(0, ∞)

Pin Inputs

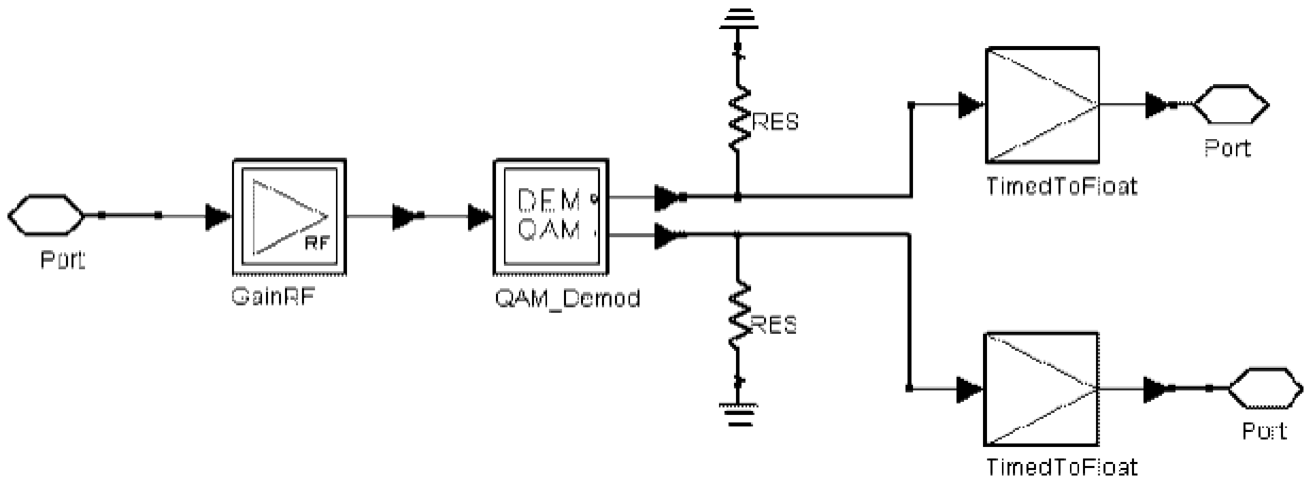
Pin	Name	Description	Signal Type
1	RF_in	RF input	timed

Pin Outputs

Pin	Name	Description	Signal Type
2	Re_Out	real part of baseband output	real
3	Im_Out	imaginary part of baseband output	real

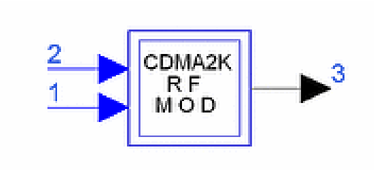
Notes/Equations

1. The schematic for this subnetwork is shown in the following figure.
   The input to the demodulator is an RF signal. Output signals are the baseband I and Q components of the input RF signal. For each input one sample is consumed and one output sample is produced.



CDMA2K_RF_Demod Subnetwork

CDMA2K_RF_Mod



Description RF Modulator
Library cdma2000, RF Subsystems
Class TSDFCDMA2K_RF_Mod

Parameters

Name	Description	Default	Unit	Type	Range
FCarrier	carrier frequency	70e6	Hz	real	(0, ∞)
Power	RF output power	0.01	W	real	
VRef	reference voltage for output power calibration	1.0	V	real	(0, ∞)
PhasePolarity	if set to Invert, Q channel signal is inverted: Normal, Invert	Normal		enum	
I_OriginOffset	I origin offset in percent with respect to output rms value	0.0		real	(-∞, ∞)
Q_OriginOffset	Q origin offset in percent with respect to output rms value	0.0		real	(-∞, ∞)
IQ_Rotation	IQ_Rotation in degrees	0.0		real	(-∞, ∞)
FrequencyError	frequency error	0.0	Hz	real	(-∞, ∞)
GainImbalance	gain imbalance in dB; Q channel has the gain imbalance applied to it	0.0		real	(-∞, ∞)
PhaseImbalance	phase imbalance in degrees; Q channel has the phase imbalance applied to it	0.0		real	(-∞, ∞)
NDensity	additive noise density in dBm per Hz	-173.975		real	(-∞, ∞)
ROut	output resistance	DefaultROut	Ohm	real	
TStep	time step	203.45e-9	sec	real	(0, ∞)

Pin Inputs

Pin	Name	Description	Signal Type
1	Re_In	real part of baseband input	real
2	Im_In	imaginary part of baseband input	real

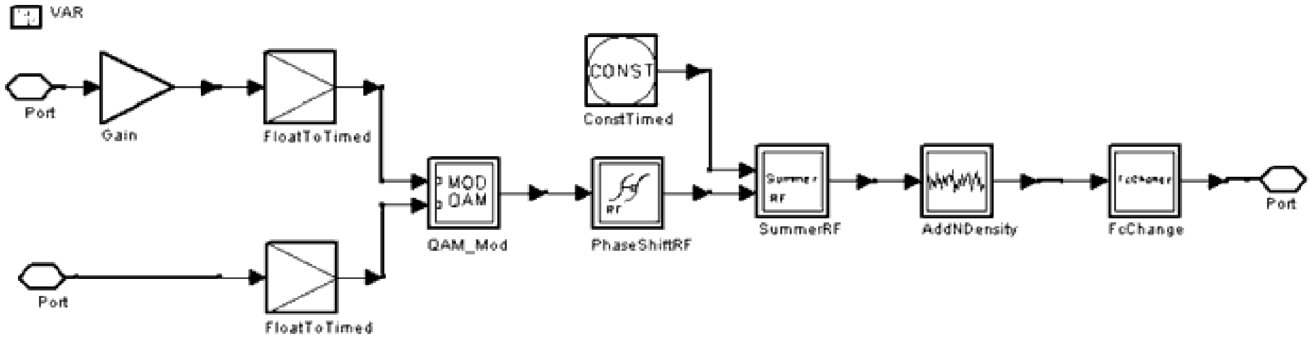
Pin Outputs

Pin	Name	Description	Signal Type
3	RF_out	RF output	timed

Notes/Equations

1. The schematic for this subnetwork is shown in the following figure. Inputs are the I

and Q waveform of the baseband signal. Input signals are used to modulate the in-phase and quadrature-phase carriers of a QAM modulator. For each input sample consumed, one output sample is produced.



CDMA2K_RF_Mod Subnetwork

Signal Source Design Examples for cdma2000-Compliant Design Library

Introduction

The SignalSource_wrk workspace shows cdma2000 signal source measurement characteristics, including transmit power spectrum and the waveform quality of the forward pilot source, transmit power spectrum and CCDF of the forward source, transmit power spectrum, rho and CCDF of the reverse source. Designs for these measurements include:

- BS_PilotSrc for the measurement of transmit power spectrum and waveform quality of the forward pilot source
- BS_SR1Src for the measurement of transmit power spectrum and CCDF of the forward source
- MS_SR1Src for the measurement of transmit power spectrum, rho and CCDF of the reverse source

Transmit Power Spectrum and Waveform Quality of Forward Pilot Source

- BS_PilotSrc

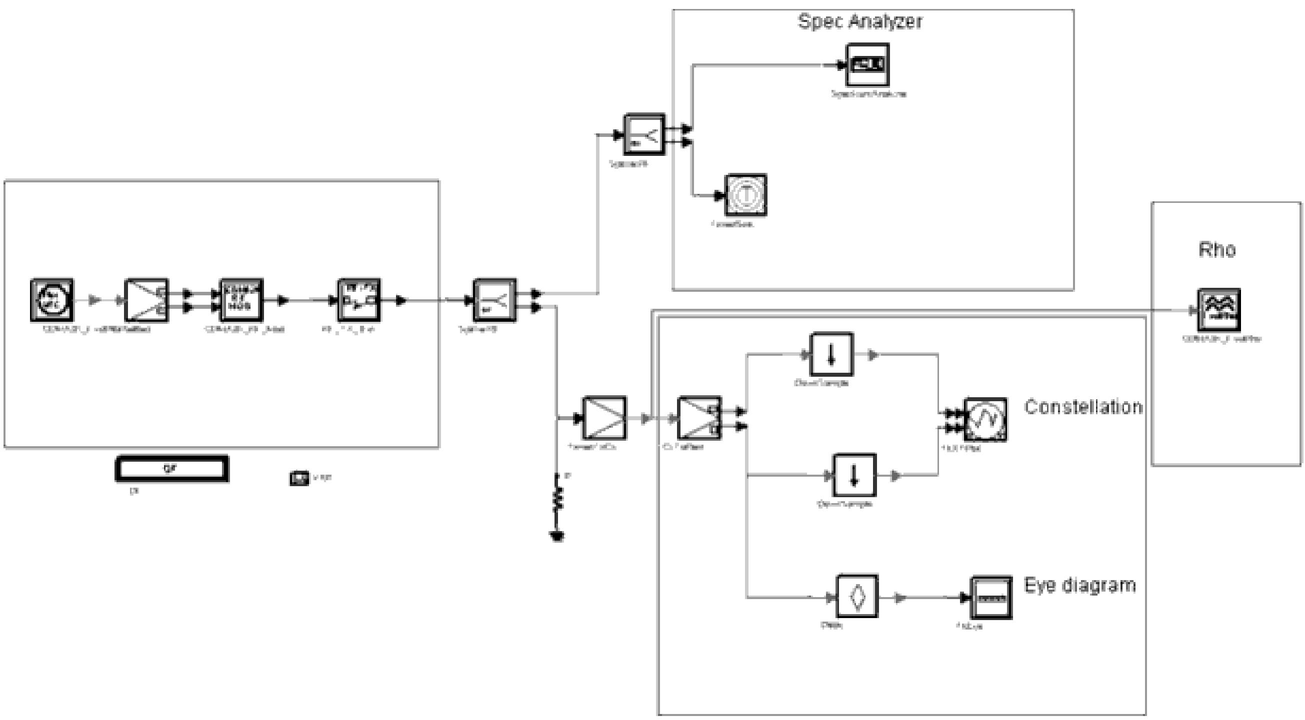
Features

- Forward pilot channel
- Eye diagram and constellation display during simulation
- Transmit spectrum and waveform quality measurements

Description

This example measures the transmit power spectrum and waveform quality of the forward pilot source. The eye diagram and constellations are displayed during simulation.

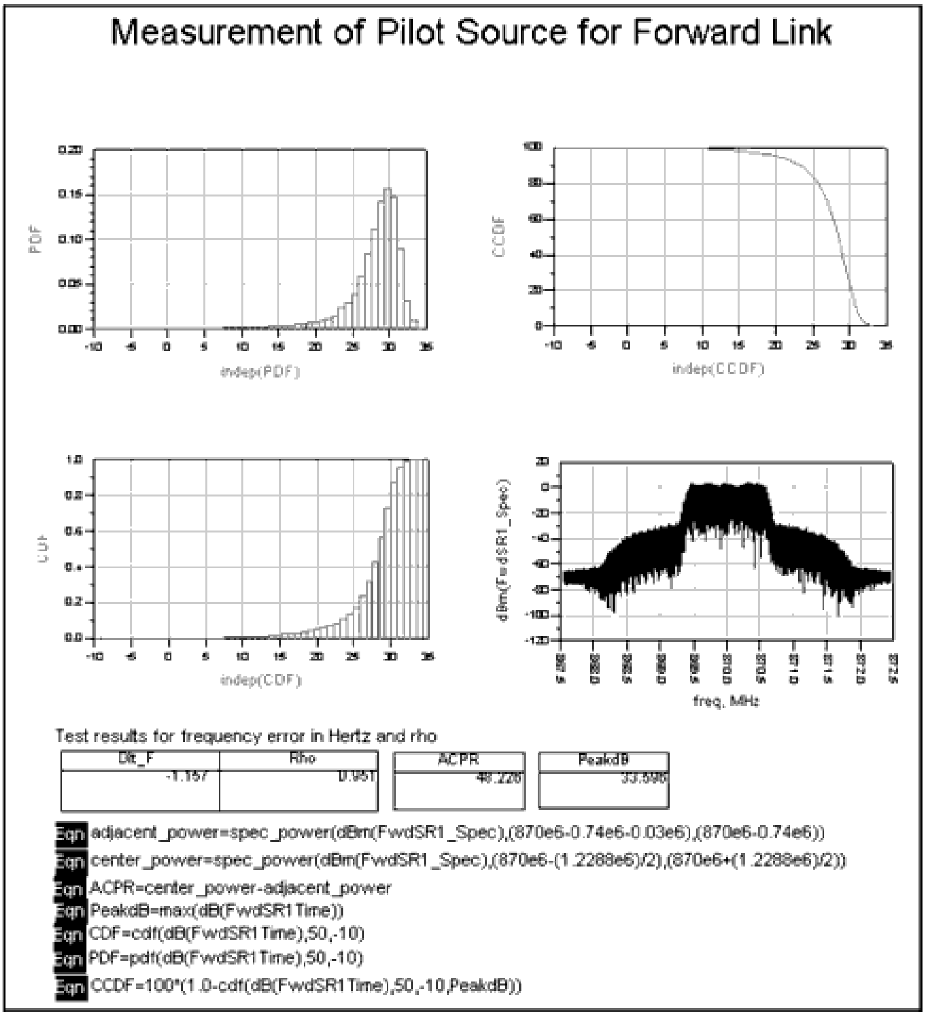
Schematic



BS_PilotSrc Schematic

Simulation Results

Simulation results displayed in BS_PilotSrc.dds are shown in the following figure.



Forward Link Pilot Source Simulation Results

Benchmark

- Hardware Platform: Pentium II 400 MHz, 512 Mb memory
- Software Platform: Windows NT 4.0 Workstation, ADS 1.5
- Simulation Time: approximately 3 minutes

Transmit Power Spectrum and CCDF of Forward Source

- BS_SR1Src

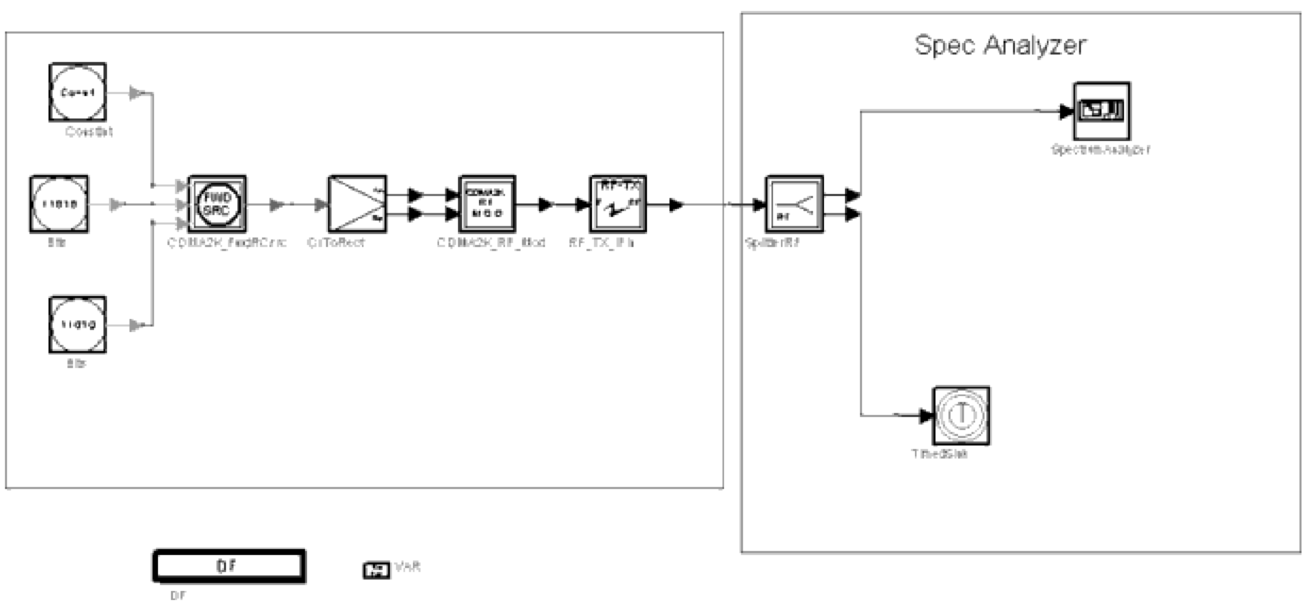
Features

- Forward pilot channel and fundamental channel
- Multiple users
- ACPR and CCDF measurements

Description

This example measures the transmit power spectrum of the forward source. The ACPR and CCDF values are diplayed in the .dds file.

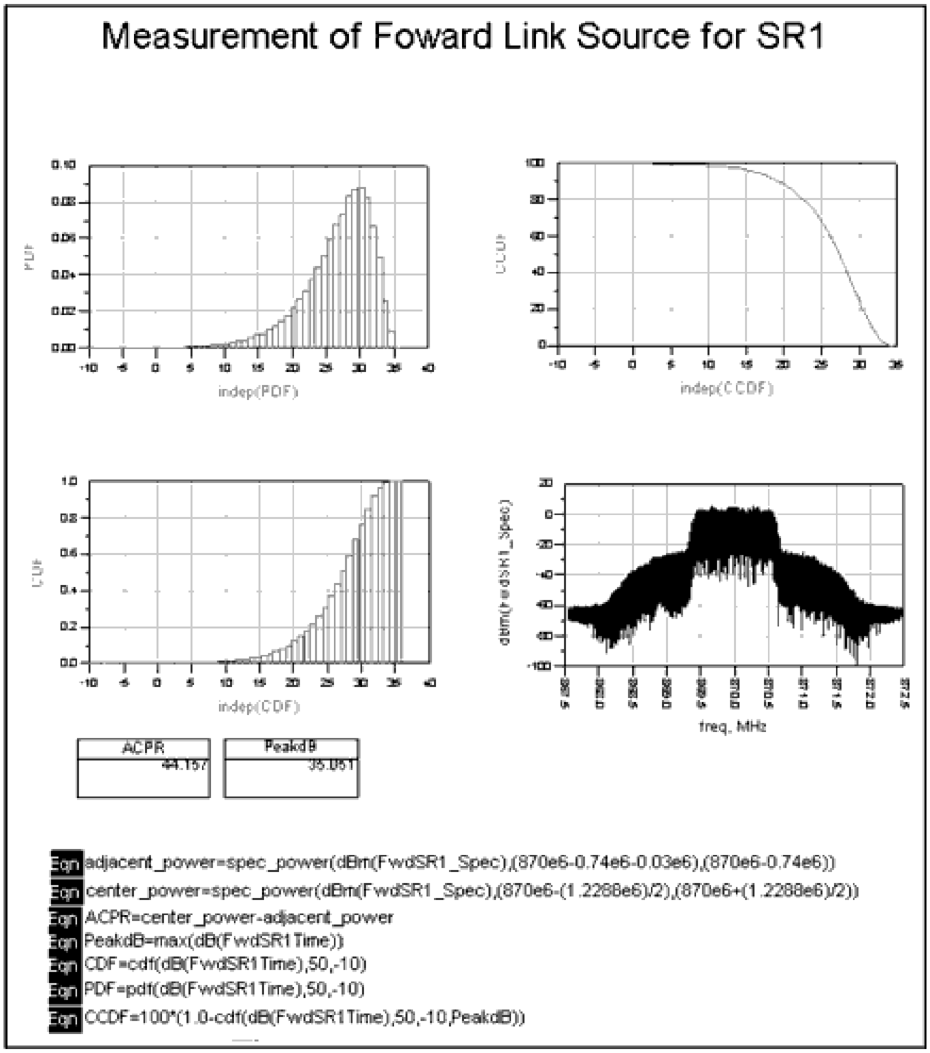
Schematic



BS_SR1Src Schematic

Simulation Results

Simulation results displayed in BS_SR1Src.dds are shown in the following figure.



SR1 Forward Link Source Simulation Results

Benchmark

- Hardware Platform: Pentium II 400 MHz, 512 Mb memory
- Software Platform: Windows NT 4.0 Workstation, ADS 1.5
- Simulation Time: approximately 3 minutes

Transmit Power Spectrum, Rho and CCDF of Reverse Source

- MS_SR1Src

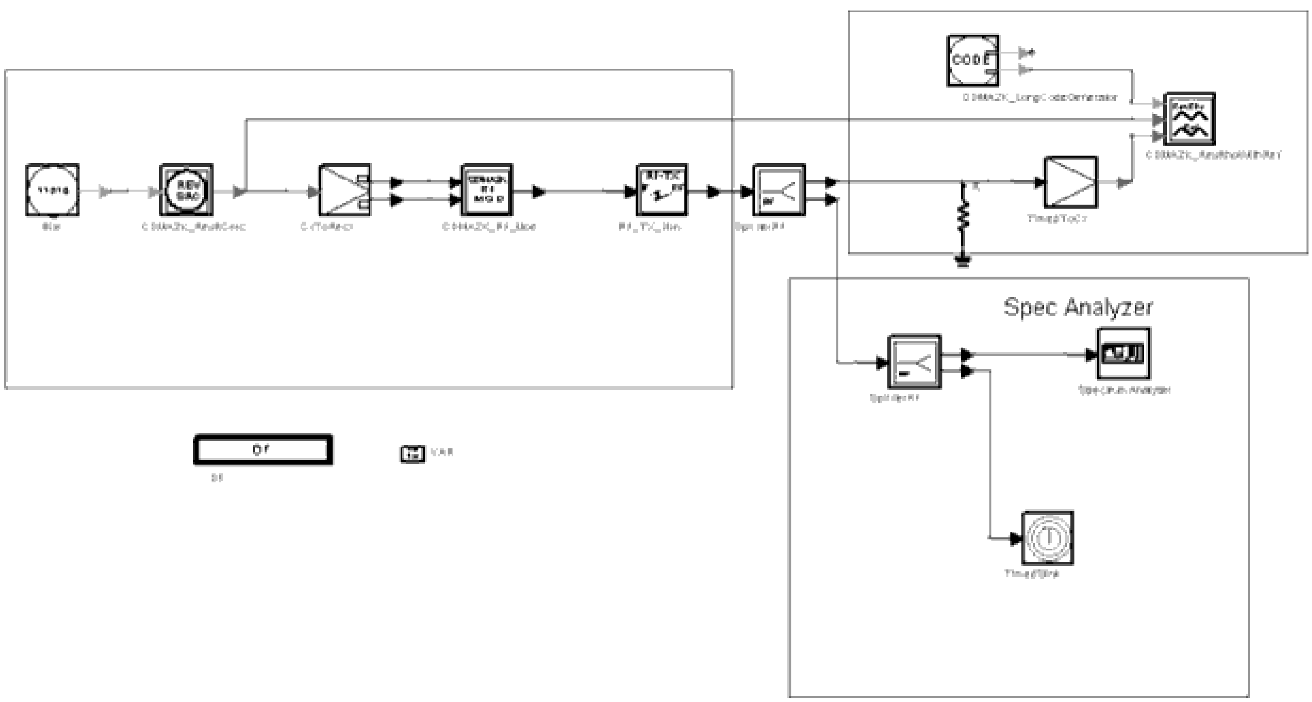
Features

- Reverse pilot channel and fundamental channel
- Transmit power spectrum and waveform quality measurements
- ACPR and CCDF measurements

Description

This example measures the transmit power spectrum and waveform quality (Rho) of the reverse link source. The ACPR and CCDF values are displayed in the .dds file.

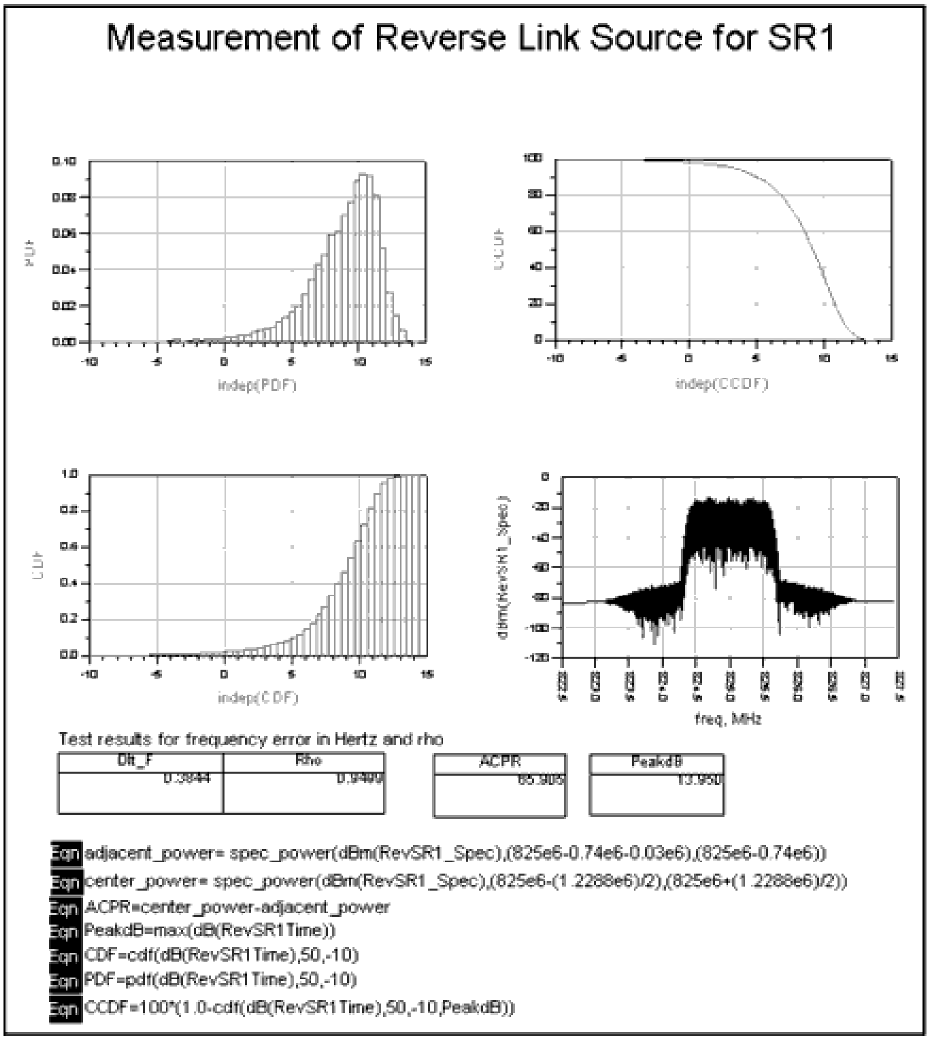
Schematic



MS_SR1Src Schematic

Simulation Results

Simulation results displayed in MS_SR1Src.dds are shown in the following figure.



SR1 Reverse Link Source Measurement

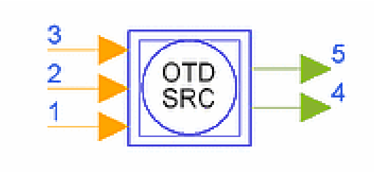
Benchmark

- Hardware Platform: Pentium II 400 MHz, 512 Mb memory
- Software Platform: Windows NT 4.0 Workstation, ADS 1.5
- Simulation Time: approximately 4 minutes

Signal Sources for cdma2000-Compliant Design Library

- *CDMA2K FwdOTDsrc* (cdma2k)
- *CDMA2K FwdPilotSrc* (cdma2k)
- *CDMA2K FwdRCsrc* (cdma2k)
- *CDMA2K FwdSTSsrc* (cdma2k)
- *CDMA2K RevRCsrc* (cdma2k)

CDMA2K_FwdOTDsrc



Description foward link OTD signal source subnetwork
Library cdma2000, Signal Sources
Class SDFCDMA2K_FwdOTDsrc

Parameters

Name	Description	Default	Type	Range
DataRate	data rate in kbps	9.6	real	1.5, 2.7,4.8,9.6 for Forward RC3; and Forward RC4 1.8,3.6,7.2,14.4 for Forward RC5
RadioConfig	radio configuration for forward link: Forward RC3, Forward RC4, Forward RC5	Forward RC3	enum	
PowerControl	enable the power control: Yes, No	No	enum	
User	total user number	21	int	[6, N-3-(N/64)/2] †
TrffcIndex1	traffic Walsh index for forward main antenna transmission	61	int	[2, 15] or [33, 63] for Forward RC3 and RC5, [2, 15] or [33, 63] or [65, 127] for Forward RC4
TrffcIndex2	traffic Walsh index for forward auxiliary antenna transmission	62	int	[2, 15] or [33, 63] for Forward RC3 and RC5, [2, 15] or [33, 63] or [65, 127] for Forward RC4
† N is the Walsh length: N=64 for Forward RC3 and RC5; N=128 for Forward RC4.				

Pin Inputs

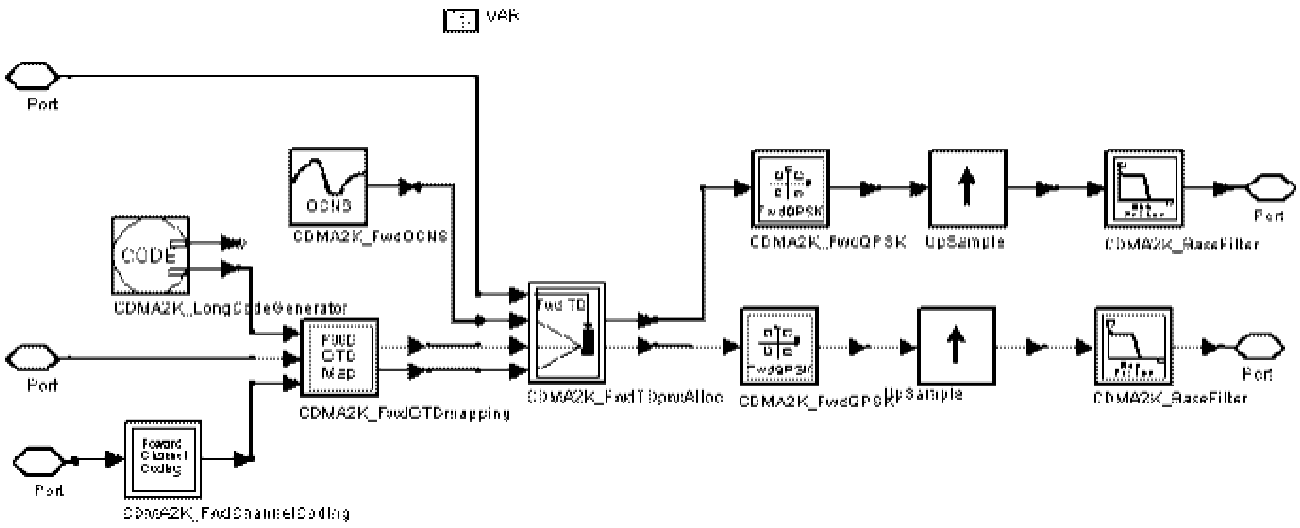
Pin	Name	Description	Signal Type
1	In	input data	int
2	PC_in	power control bits added into the radio frame to control the reverse transmission power	int
3	PC	power control bits for forward link transmission	int

Pin Outputs

Pin	Name	Description	Signal Type
4	Out1	output data for forward main antenna transmission	complex
5	Out2	output data for forward auxiliary antenna transmission	complex

Notes/Equations

1. This subnetwork provides forward link OTD signal source for different radio configurations and data rates. The schematic is shown in the following figure.

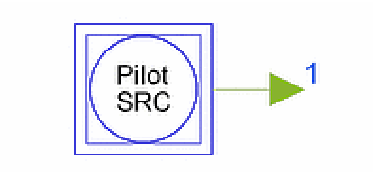


CDMA2K_FwdOTDsrc Subnetwork

References

1. 3GPP2 C.S0002_A_1, "Physical Layer Standard for cdma2000 Spread Spectrum Systems Release A-Addendum 1," Oct. 27, 2000

CDMA2K_FwdPilotSrc



Description foward link pilot signal source subnetwork
Library cdma2000, Signal Sources
Class SDFCDMA2K_FwdPilotSrc

Parameters

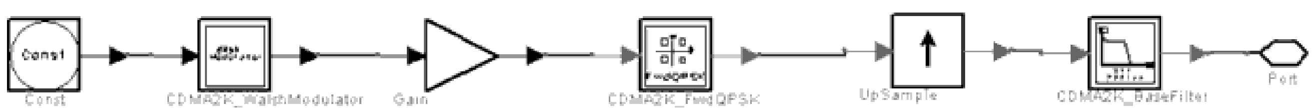
Name	Description	Default	Type
PilotGain	pilot gain	2.6	real

Pin Outputs

Pin	Name	Description	Signal Type
1	Out	output data	complex

Notes/Equations

1. This subnetwork produces the forward pilot signal. The schematic is shown in the following figure.

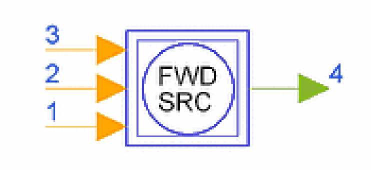


CDMA2K_FwdPilotSrc Subnetwork

References

1. 3GPP2 C.S0002_A_1, "Physical Layer Standard for cdma2000 Spread Spectrum Systems Release A-Addendum 1," Oct. 27, 2000

CDMA2K_FwdRCsrc



Description Foward link singal source subnetwork for different radio configuration
Library cdma2000, Signal Sources
Class SDFCDMA2K_FwdRCsrc

Parameters

Name	Description	Default	Type	Range
DataRate	data rate in kbps	9.6	real	1.5, 2.7,4.8,9.6 for Forward RC3 and Forward RC4 1.8,3.6,7.2,14.4 for Forward RC5
RadioConfig	radio configuration for forward link: Forward RC3, Forward RC4, Forward RC5	Forward RC3	enum	
PowerControl	enable the power control: Yes, No	No	enum	
User	total user number	21	int	[6, N-3-(N/64)] †
TrffcIndex	traffic Walsh index	61	int	[2, 15] or [33, 63] for Forward RC3 and RC5, [2, 15] or [33, 63] [65, 127] for Forward RC4
†N is the Walsh length: N=64 for Forward RC3 and RC5; N=128 for Forward RC4.				

Pin Inputs

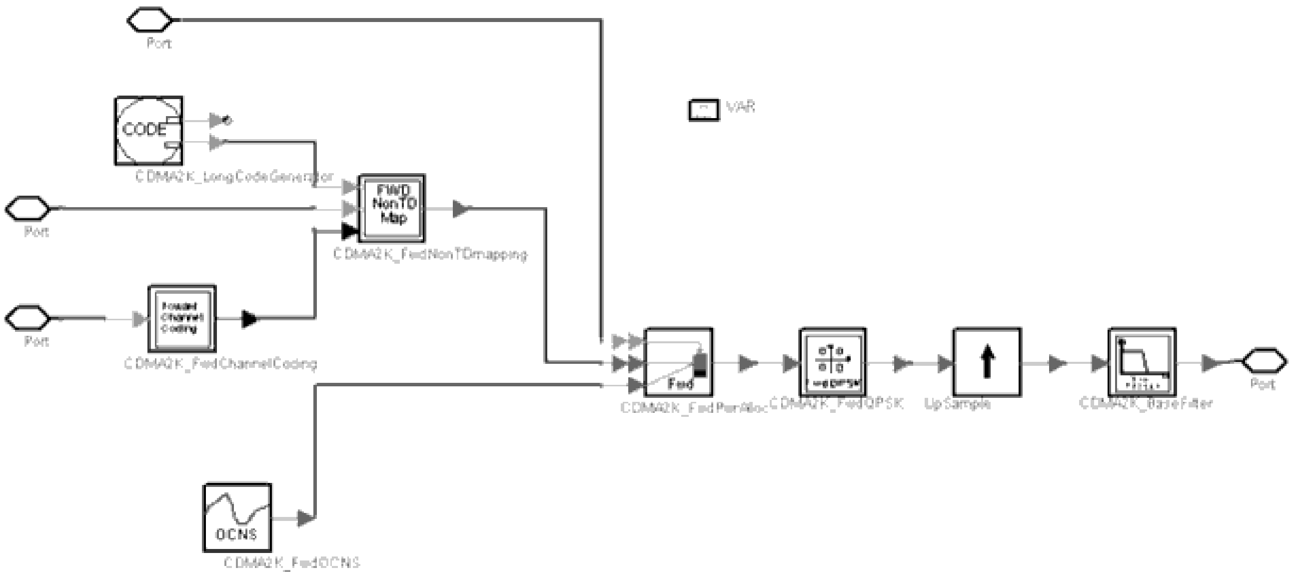
Pin	Name	Description	Signal Type
1	In	input data	int
2	PC_in	power control bits added into the radio frame to control the reverse transmission power	int
3	PC	power control for forward transmission	int

Pin Outputs

Pin	Name	Description	Signal Type
4	Out	output data	complex

Notes/Equations

1. This subnetwork provides the forward link signal source for different radio configurations and data rates. The schematic is shown in the following figure].

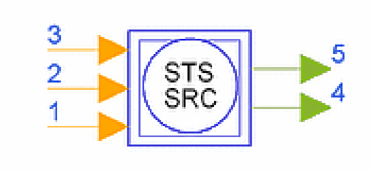


CDMA2K_FwdRCsrc Subnetwork

References

1. 3GPP2 C.S0002_A_1, "Physical Layer Standard for cdma2000 Spread Spectrum Systems Release A-Addendum 1," Oct. 27, 2000

CDMA2K_FwdSTSsrc



Description foward link STS singal source subnetwork
Library cdma2000, Signal Sources
Class SDFCDMA2K_FwdSTSsrc

Parameters

Name	Description	Default	Type	Range
DataRate	data rate in kbps	9.6	real	1.5, 2.7,4.8,9.6 for Forward RC3; and Forward RC4 1.8,3.6,7.2,14.4 for Forward RC5
RadioConfig	radio configuration for forward link: Forward RC3, Forward RC4, Forward RC5	Forward RC3	enum	
PowerControl	enable the power control: Yes, No	No	enum	
User	total user number	21	int	[6, N-3-(N/64)/2] †
TrffcIndex1	traffic Walsh index for forward transmission from main antenna	61	int	[2, 15] or [33, 63] for Forward RC3 and RC5, [2, 15] or [33, 63] or [65, 127] for Forward RC4
TrffcIndex2	traffic Walsh index for forward transmission from auxiliary antenna	62	int	[2, 15] or [33, 63] for Forward RC3 and RC5, [2, 15] or [33, 63] or [65, 127] for Forward RC4
† N is the Walsh length: N=64 for Forward RC3 and RC5; N=128 for Forward RC4.				

Pin Inputs

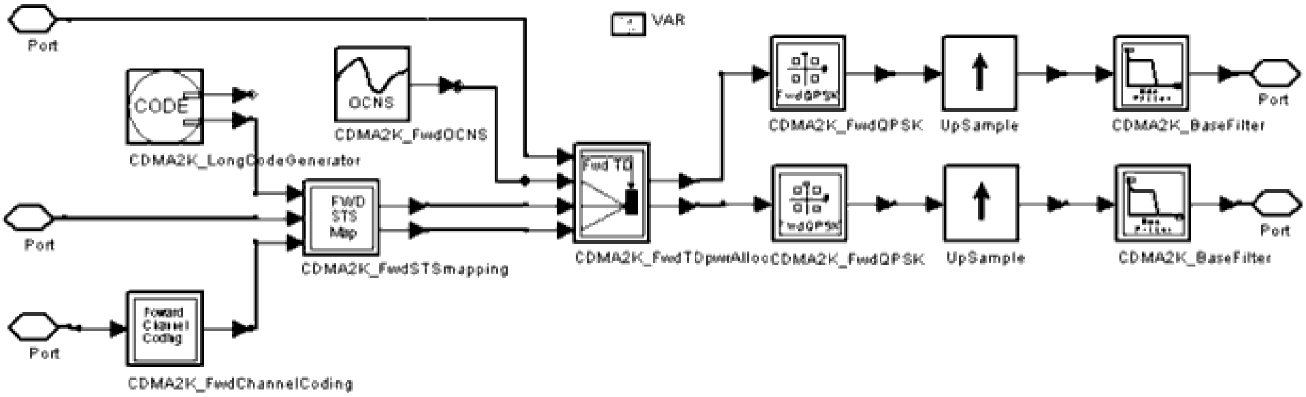
Pin	Name	Description	Signal Type
1	In	input data	int
2	PC_in	power control bits added into the radio frame to control the reverse transmission power	int
3	PC	power control bits for forward link transmission	int

Pin Outputs

Pin	Name	Description	Signal Type
4	Out1	output data for forward main antenna transmission	complex
5	Out2	output data for forward auxiliary antenna transmission	complex

Notes/Equations

1. This subnetwork provides the forward link STS signal source for different radio configurations and data rates. The schematic is shown in the following figure.

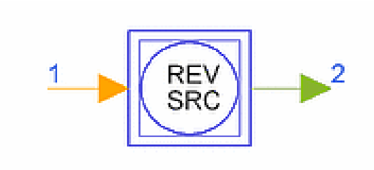


CDMA2K_FwdSTSsrc Subnetwork

References

1. 3GPP2 C.S0002_A_1, "Physical Layer Standard for cdma2000 Spread Spectrum Systems Release A-Addendum 1," Oct. 27, 2000.

CDMA2K_RevRCsrc



Description Reverse link channel signal source subnetwork for different radio configuration
Library cdma2000, Signal Sources
Class SDFCDMA2K_RevRCsrc

Parameters

Name	Description	Default	Type	Range
DataRate	data rate in kbps	9.6	real	1.5, 2.7,4.8,9.6 for Reverse RC3; 1.8,3.6,7.2,14.4 for Reverse RC4
RadioConfig	radio configuration for reverse link respectively: Reverse RC3, Reverse RC4	Reverse RC3	enum	

Pin Inputs

Pin	Name	Description	Signal Type
1	In	input data	int

Pin Outputs

Pin	Name	Description	Signal Type
2	Out	output data	complex

Notes/Equations

1. This subnetwork provides the reverse link signal source for different radio configurations and data rates. The schematic is shown in the following figure.

CDMA2K_RevRCsrc Subnetwork

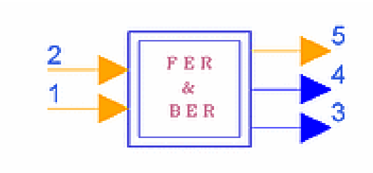
References

1. 3GPP2 C.S0002_A_1, "Physical Layer Standard for cdma2000 Spread Spectrum Systems Release A-Addendum 1," Oct. 27, 2000.

Test Measurement for cdma2000-Compliant Design Library

- *CDMA2K BFER* (cdma2k)
- *CDMA2K CDP* (cdma2k)
- *CDMA2K FwdMultiUserSrc* (cdma2k)
- *CDMA2K FwdOCNS* (cdma2k)
- *CDMA2K FwdRho* (cdma2k)
- *CDMA2K MC DownConv* (cdma2k)
- *CDMA2K MC UpConv* (cdma2k)
- *CDMA2K RevRhoWithRef* (cdma2k)

CDMA2K_BFER



Description BER and FER Measurement
Library cdma2000, Test
Class SDFCDMA2K_BFER

Parameters

Name	Description	Default	Type	Range
IgnoreNum	number of initially ignored firings	0	int	[0, ∞)
InputFrameLen	input frame length	172	int	[1, ∞)

Pin Inputs

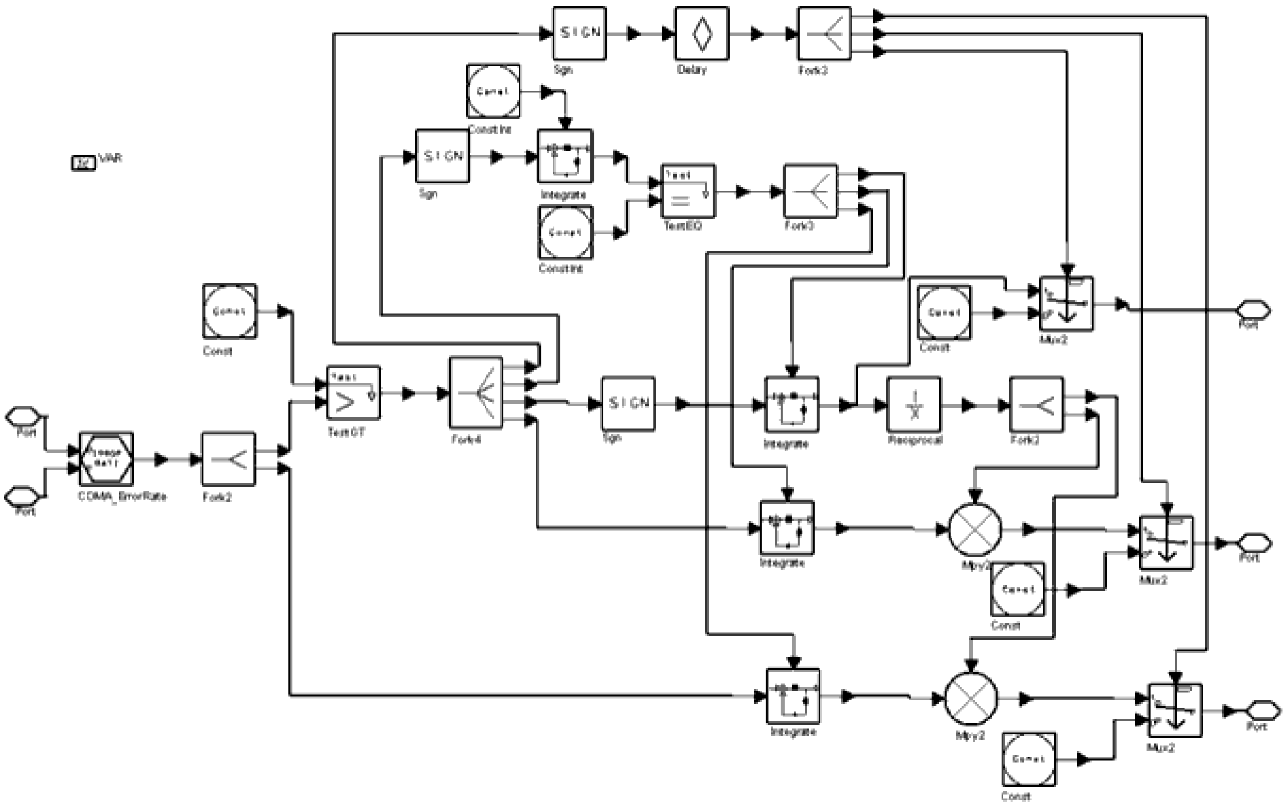
Pin	Name	Description	Signal Type
1	input1	input data 1	int
2	input2	input data 2	int

Pin Outputs

Pin	Name	Description	Signal Type
3	BER	bit error rate	real
4	FER	frame error rate	real
5	FrmNum	number of frames	int

Notes/Equations

1. This subnetwork is used to measure BER and FER during simulation. One BER, FER and FrmNum output tokens are produced for each set of InputFrameLen tokens consumed.
   The following figure shows the schematic for this subnetwork.



CDMA2K_BFER Subnetwork

2. BER and FER are measured based on the following equations.

$$FER = \frac{number\ of\ error\ frames}{total\ frames}$$

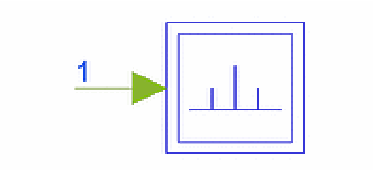
$$BER = \frac{number\ of\ error\ bits}{total\ bits} = \frac{number\ of\ error\ bits}{total\ frames \times InputFrameLen}$$

3. The two input received signals are at one sample per bit. The *DsnCDMA2K_FwdRC3AWGN* design demonstrates the use of this subnetwork in the *Examples CDMA2K/CDMA2K_BER_wrk.*
4. One input signal is the test signal at the receiver output bit stream that typically includes the system delay and errors. Another input signal is the reference signal typically a delayed copy of the data bits from the transmitter. The InputFrameLen is typically set to the same value as was set in the transmitter CDMA2K_CRC_Coder component.
   The user is responsible for synchronizing the bit alignment for the signals at both inputs. The reference signal should have a delay (typically by use of a Delay component) inserted before its input pin with delay set to an integral multiple of InputFrameLen bits. The integer multiple of InputFrameLen bits to use is dependent on the number of frames delayed in the test path.

References

1. TIA/EIA/IS-2000.2 (PN-4428), Physical Layer Standard for cdma2000 Spread Spectrum Systems, July 1999.

CDMA2K_CDP



Description Code domain power measurement
Library cdma2000, Test
Class SDFCDMA2K_CDP

Parameters

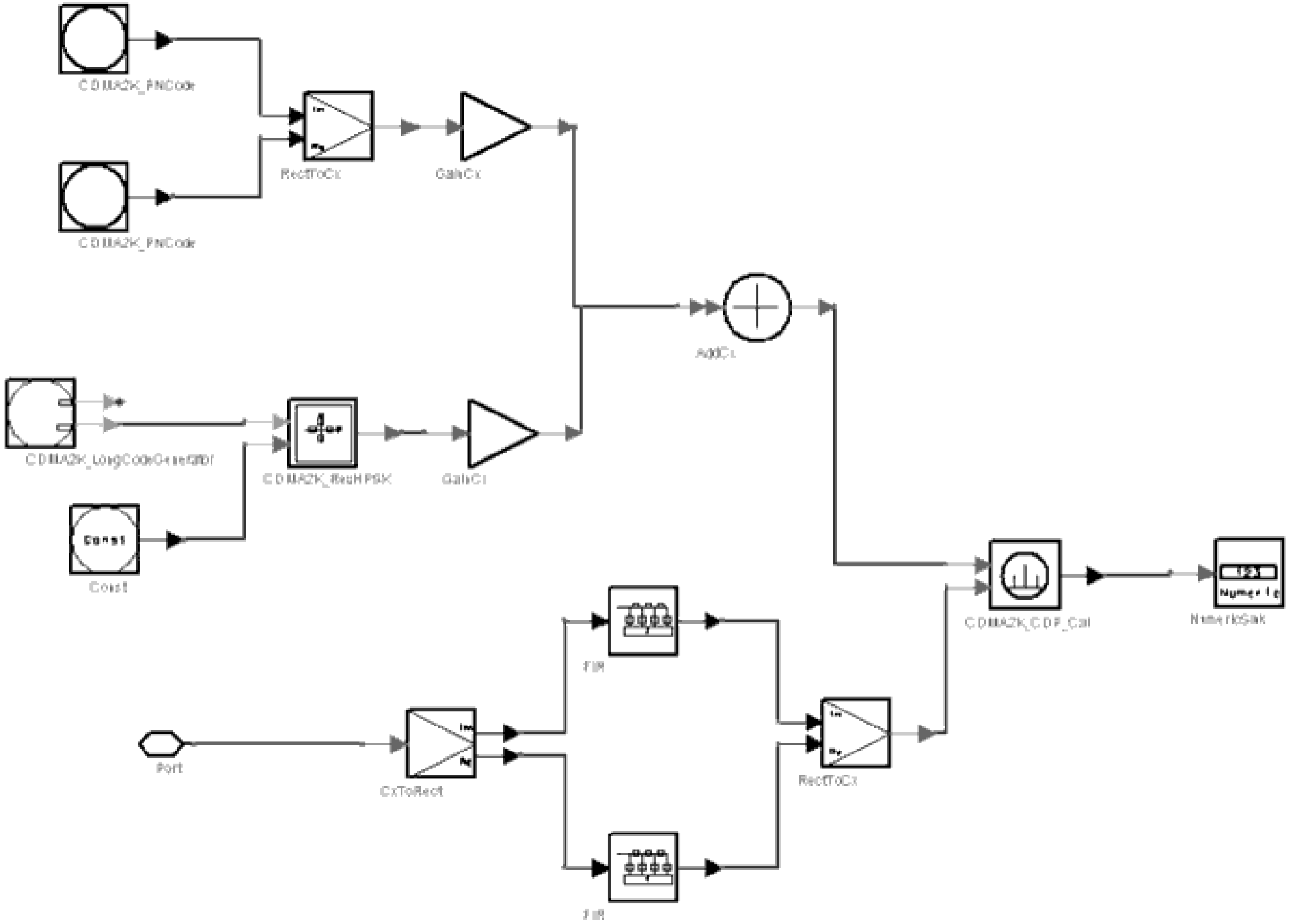
Name	Description	Default	Sym	Type	Range
WalshLength	Walsh code length used for spreading	128	N	int	2^n, n=0,1,2,...,9
TestLength	number of Walsh periods for measurement	48	LN	int	[1, ∞)
SampleRate	number of samples per chip	4	R	int	[1, ∞)
Link	type of link: Forward link, Reverse link	Forward link		enum	
CDP_GroupNum	number of output CDP groups	1	CDP_Num	int	[1, ∞]

Pin Inputs

Pin	Name	Description	Signal Type
1	SigIn	received baseband signal	complex

Notes/Equations

1. This subnetwork is used to measure code domain power. This measurement is available for cdma2000 SR1 systems only. The schematic for this subnetwork is shown in the following figure.
   Because the Walsh function length for the corresponding channel varies, it is necessary to set the WalshLength parameter in advance. TestLength is the length in terms of Walsh intervals for measurement. The received signal is sampled at SampleRate × chip rate. The SigIn input is the received complex envelope.
   Each firing, N × CDP_Num tokens of CDP are collected by NumericSink when N × (CDP_Num+1)LN × R tokens of the SigIn input are consumed.



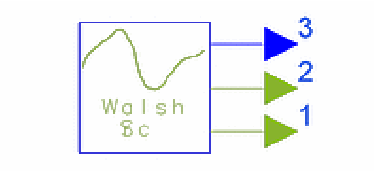
CDMA2K_CDP Subnetwork

2. The SigIn input is at SampleRate samples per chip. The cdma2000 SR1 chip rate is 1.2288 Mcps. The *MS_TxCDP_RC3* design demonstrates the use of this subnetwork in the *Examples CDMA2K/MS_TX_wrk*.

References

1. 3GPP2 C.S0002_A_1, "Physical Layer Standard for cdma2000 Spread Spectrum Systems Release A-Addendum 1," Oct. 27, 2000.
2. 3GPP2 TSG-C Interim Plenary, "Recommended Minimum Performance Standards for cdma2000 Spread Spectrum Mobile Stations: Release A," Nov. 27, 2000.
3. 3GPP2 TSG-C4.1, "Recommended Minimum Performance Standards for cdma2000 Spread Spectrum Base Stations: Release A," Oct. 26, 2000.

CDMA2K_FwdMultiUserSrc



Description Multiuser data source for forward link
Library cdma2000, Test
Class SDFCDMA2K_FwdMultiUserSrc

Parameters

Name	Description	Default	Sym	Type	Range
WalshLength	length of Walsh code	64	N	int	2^n, n=0,1,2,...,11
UserNumber	user number for forward link	6	M	int	[1, N-1]
UserIndex	index of user to be tested; (= Walsh code index of the user)	1		int	[1, M]
PilotPowerRatio	pilot channel power to total power ratio	0.20		real	(0, 1)

Pin Outputs

Pin	Name	Description	Signal Type
1	D_out	traffic channel data and pilot Channel data, the power of which is normalized	complex
2	T_out	traffic channel data, the power of which is not normalized	complex
3	NRZout	data of the given traffic channel before Walsh modulation (NRZ)	real

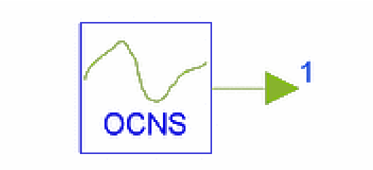
Notes/Equations

1. This model is used to generate multiuser data for forward link.
   Each firing, N tokens of D_out, N tokens of T_out, and two tokens of NRZout are produced.
2. The data of D_out is the sum of data from the pilot and traffic channels. The power ratio of the pilot is set by PilotPowerRatio; the power ratio of each traffic channel is set to the same value in the initialization. The power of D_out is normalized.
3. The data of T_out is the sum of the traffic channels.

References

1. TIA/EIA/IS-2000.2 (PN-4428), Physical Layer Standard for cdma2000 Spread Spectrum Systems, July 1999.

CDMA2K_FwdOCNS



Description Orthogonal channel noise simulator
Library cdma2000, Test
Class SDFCDMA2K_FwdOCNS

Parameters

Name	Description	Default	Sym	Type	Range
TransmitDiversity	transmit diversity enable: NON_TD, TD	NON_TD		enum	
WalshLength	length of Walsh code	64	N	int	2^n, n=6,...,11
OrthogonalChNum	number of the orthogonal channel to form the noise, in TD mode, it will be double of number of orthogonal users	29		int	
TestChIdx	the Walsh index for traffic channel(s) to be tested	61		int array	

Pin Outputs

Pin	Name	Description	Signal Type
1	output	orthoganal channel noise	complex

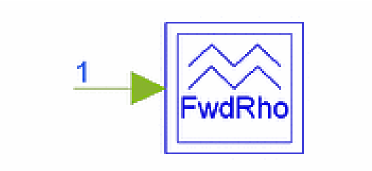
Notes/Equations

1. This model is the orthogonal channel noise simulator for forward link. Each firing, if TransmitDiversity = NON_TD, N output tokens are produced; if TransmitDiversity = TD, 2N output tokens are produced.
2. The indexes of walsh code used as orthogonal channels can be all channels except the channels used by pilot channel(!cdma2k-06-5-09.gif!), paging channel(!cdma2k-06-5-10.gif!), Sync channel(!cdma2k-06-5-11.gif!), TD pilot channel(!cdma2k-06-5-12.gif!) and code channel defined by parameter TestChIdx. Code channels W_{64k}^{N}, where N > 64 and k is an integer such that $0 \le 64k < N$, cannot be used. User cannot set the orthogonal index directly. The index will be sequentially selected from the accessible index. For example, if test channel index is 4 and 7, orthogonal channel number is 10, then the indexes used by orthogonal will be 2,3,5,6,8,9,10,11,12,13.
3. If TransmitDiversity= TD mode, each user occupies two walsh channels, so the orthogonal number must be twice of the number of users. And, the number of test channel indexes must be even.

References

1. 3GPP2 C.S0002_A_1, "Physical Layer Standard for cdma2000 Spread Spectrum Systems Release A-Addendum 1," Oct. 27, 2000.
2. 3GPP2 TSG-C Interim Plenary, "Recommended Minimum Performance Standards for cdma2000 Spread Spectrum Mobile Stations: Release A," Nov. 27, 2000.
3. 3GPP2 TSG-C4.1,"Recommended Minimum Performance Standards for cdma2000 Spread Spectrum Base Stations: Release A," Oct. 26, 2000.

CDMA2K_FwdRho



Description Rho meter for forward link
Library cdma2000, Test
Class SDFCDMA2K_FwdRho

Parameters

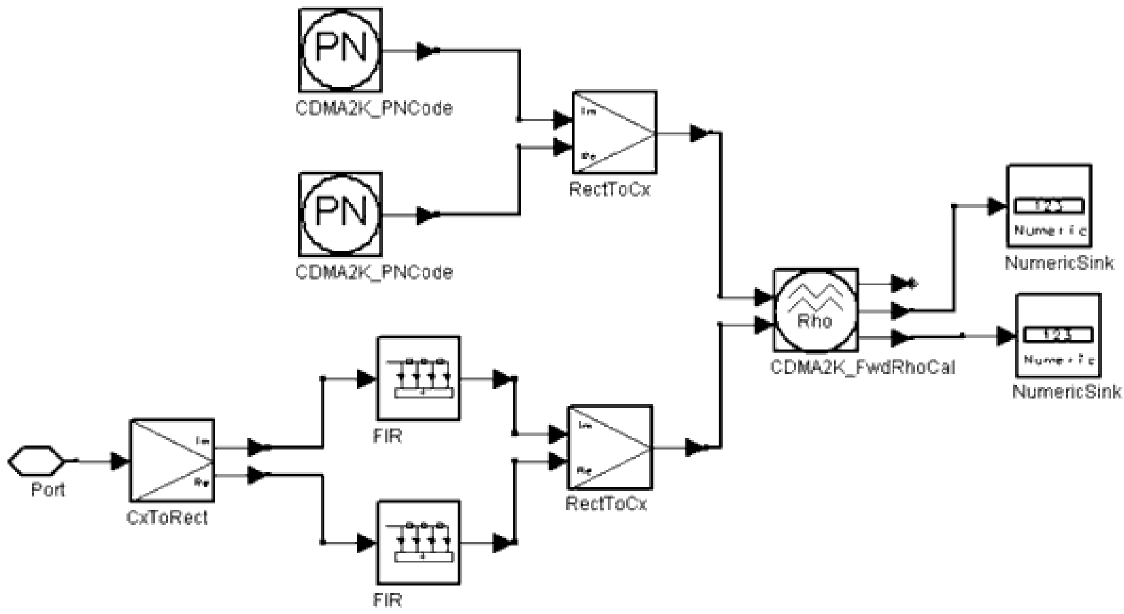
Name	Description	Default	Sym	Type	Range
WalshLengthMax	maximum Walsh code length used for spreading	128	N	int	2^n, n=0,1,2,...,9
TestLength	number of Walsh periods for measurement	48	LN	int	[1, ∞)
SampleRate	number of samples per chip	4	R	int	[1, ∞)

Pin Inputs

Pin	Name	Description	Signal Type
1	SigIn	received baseband signal	complex

Notes/Equations

1. This subnetwork is used to measure waveform quality, including rho and frequency error for a forward link. This measurement is available for cdma2000 SR1 systems only. The schematic is shown in the following figure.
   Because the walsh function length for the corresponding channel varies, it is necessary to set the WalshLengthMax parameter in advance. TestLength is the length in terms of walsh intervals for measurement. The received signal is sampled at SampleRate times the chip rate. The SigIn input is the received complex envelope. Each firing, 1 token of Rho and 1 token of Dlt_F are collected by two NumericSink components when 6 × N × LN × R tokens of SigIn are consumed.
   For measurement accuracy, set TestLength large enough (according to reference [3] N × LN should be at least one power control group, in chips).
2. The SigIn input is at SampleRate samples per chip. The cdma2000 SR1 chip rate is 1.2288 Mcps. The *BS_PilotSrc* design demonstrates the use of this subnetwork in the *Examples CDMA2K/SignalSource_wrk* .

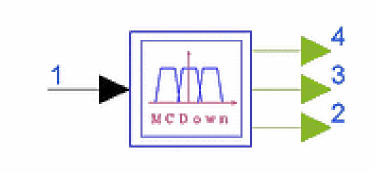


CDMA2K_FwdRho Subnetwork

References

1. 3GPP2 C.S0002_A_1, "Physical Layer Standard for cdma2000 Spread Spectrum Systems Release A-Addendum 1," Oct. 27, 2000.
2. 3GPP2 TSG-C Interim Plenary, "Recommended Minimum Performance Standards for cdma2000 Spread Spectrum Mobile Stations: Release A," Nov. 27, 2000.
3. 3GPP2 TSG-C4.1,"Recommended Minimum Performance Standards for cdma2000 Spread Spectrum Base Stations: Release A," Oct. 26, 2000.

CDMA2K_MC_DownConv



Description Down-Converter for Multi-Carrier Mode
Library cdma2000, Test
Class TSDFCDMA2K_MC_DownConv

Parameters

Name	Description	Default	Unit	Type
MiddleCF	middle carrier frequency of multi-carrier mode	825M	Hz	real

Pin Inputs

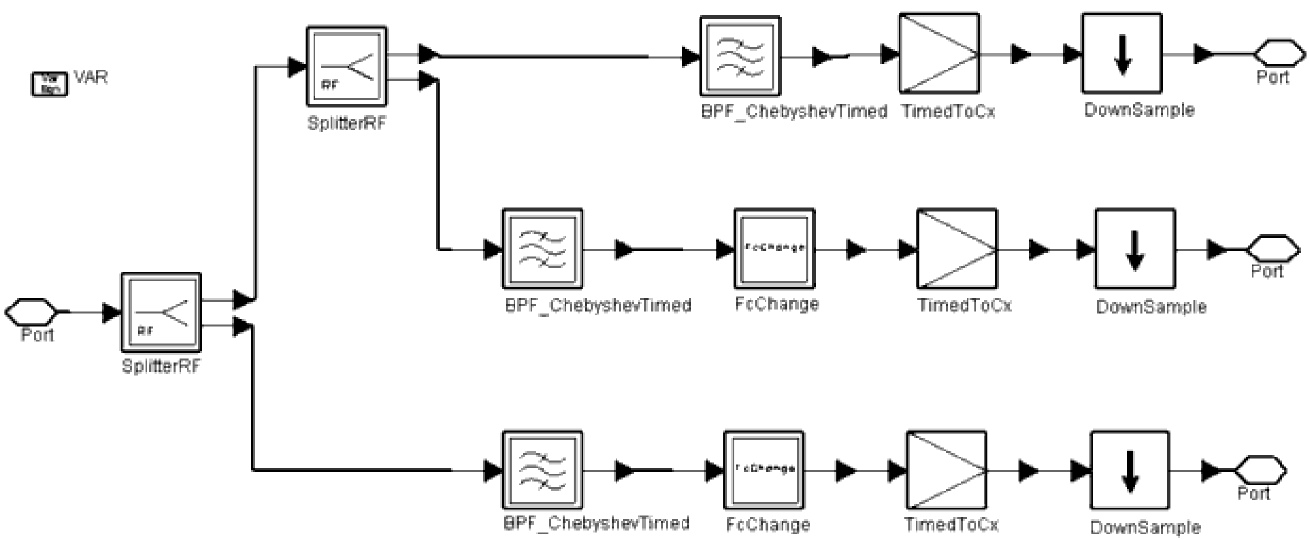
Pin	Name	Description	Signal Type
1	RFIn	input signal	timed

Pin Outputs

Pin	Name	Description	Signal Type
2	out1	signal down-converted from(MiddleCF Hz - 1.5 MHz)	complex
3	out2	signal down-converted from MiddleCF Hz	complex
4	out3	signal down-converted from(MiddleCF Hz + 1.5 MHz)	complex

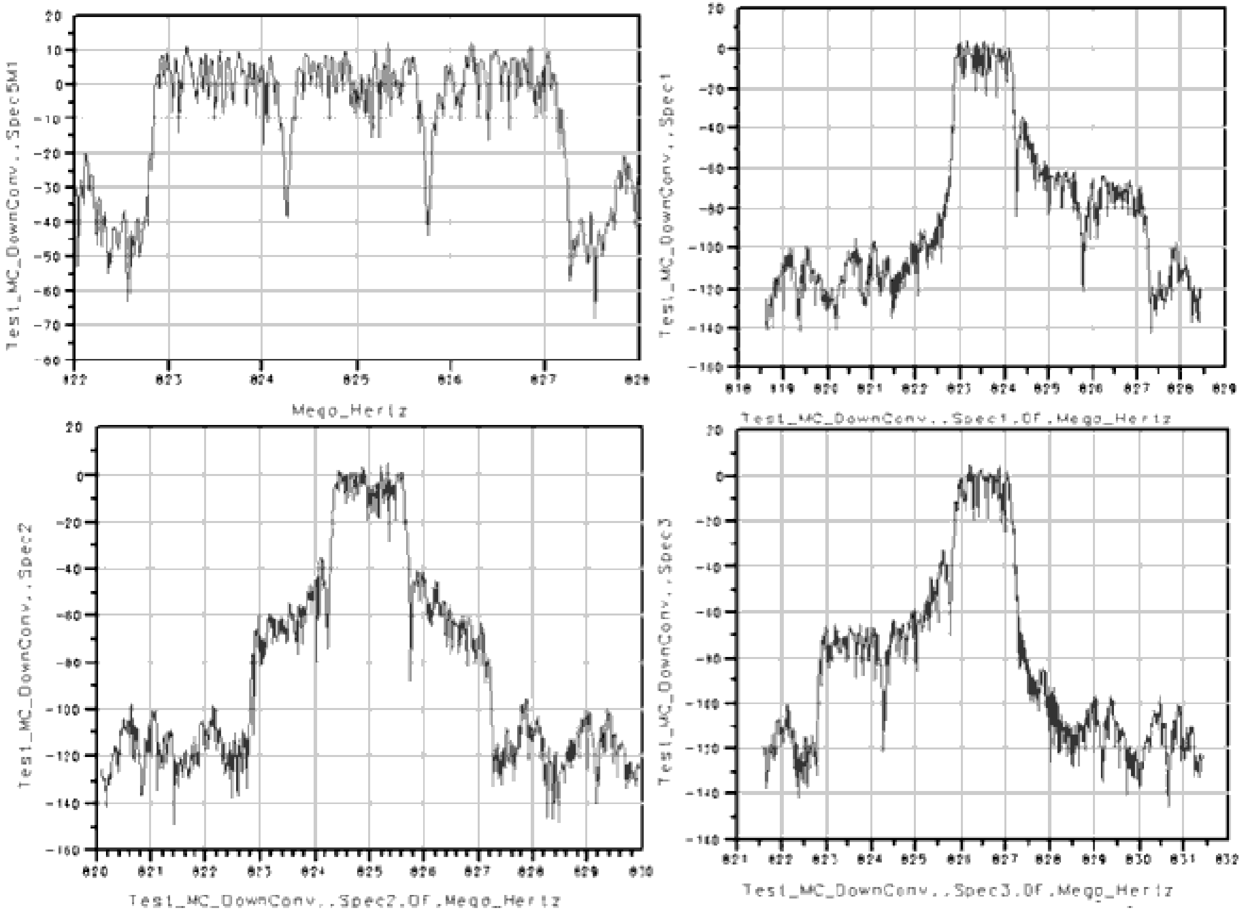
Notes/Equations

1. This subnetwork is a down-converter for the multi-carrier mode; each output is a 1.25 MHz bandwidth.
   The following figure shows the schematic for this subnetwork.



CDMA2K_MC_DownConv Subnetwork

The following figure shows the output spectrum of this subnetwork. Here fc=825 MHz. The spectrum analyzer is connected with the output pin of FcChange or Filter in the third output.

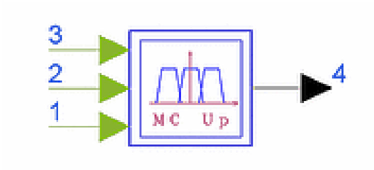


Input and Output Spectrums of CDMA2K_MC_DownConv

References

1. TIA/EIA/IS-2000.2 (PN-4428), Physical Layer Standard for cdma2000 Spread Spectrum Systems, July 1999.

CDMA2K_MC_UpConv



Description Up-Converter for Multi-Carrier Mode
Library cdma2000, Test
Class TSDFCDMA2K_MC_UpConv

Parameters

Name	Description	Default	Unit	Type
MiddleCF	middle carrier frequency of multi-carrier mode	825M	Hz	real

Pin Inputs

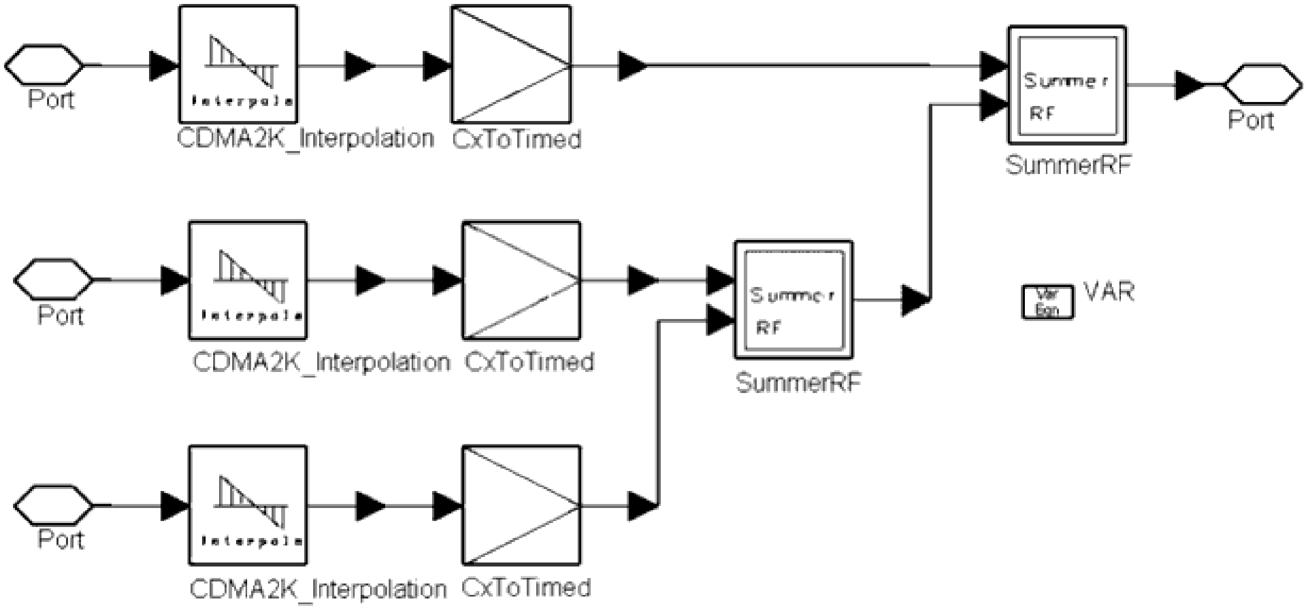
Pin	Name	Description	Signal Type
1	input1	input to be converted to(MiddleCF Hz - 1.5 MHz)	complex
2	input2	input to be converted to MiddleCF Hz	complex
3	input3	input to be converted to(MiddleCF Hz + 1.5 MHz)	complex

Pin Outputs

Pin	Name	Description	Signal Type
4	RFOut	signal with 5MHz bandwidth	timed

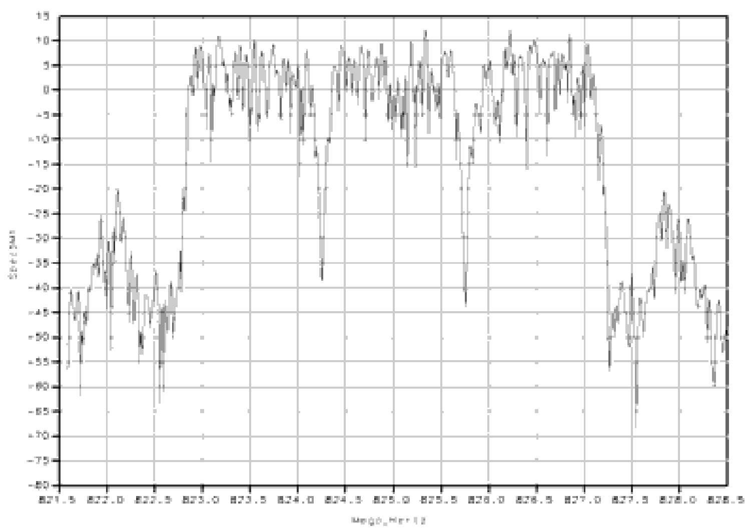
Notes/Equations

1. This subnetwork is an up-converter for the multi-carrier mode, each input will be 1.25 MHz bandwidth and output signals will be 5 MHz.
   The following figure shows this subnetwork.



CDMA2K_MC_UpConv Subnetwork

The following figure shows the output spectrum of this subnetwork. Here fc = 825 MHz.

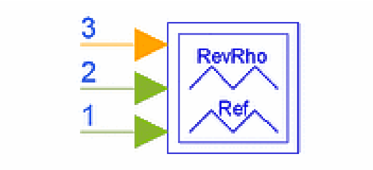


Output Spectrum of CDMA2K_MC_UpConv

References

1. TIA/EIA/IS-2000.2 (PN-4428), Physical Layer Standard for cdma2000 Spread Spectrum Systems, July 1999.

CDMA2K_RevRhoWithRef



Description Rho meter with reference input for reverse link
Library cdma2000, Test
Class SDFCDMA2K_RevRhoWithRef

Parameters

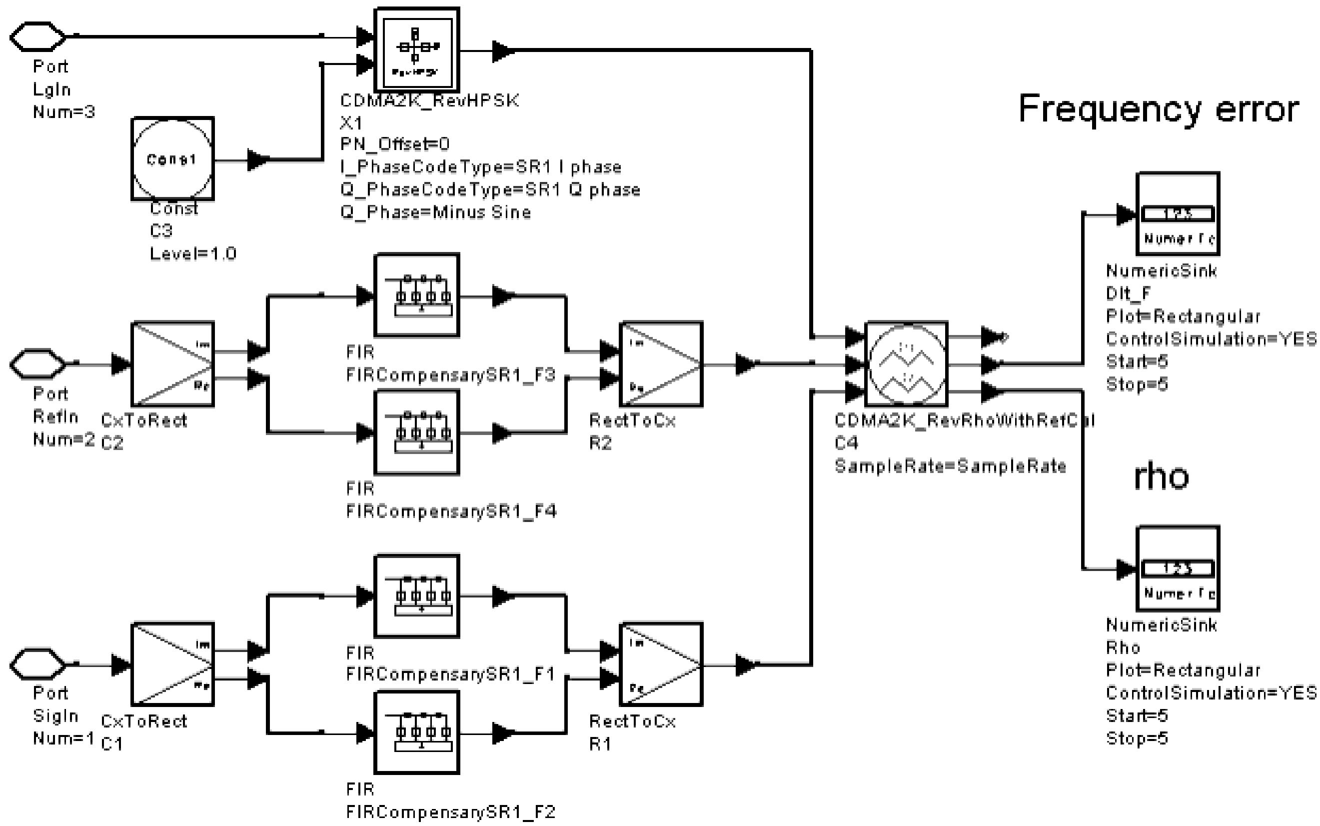
Name	Description	Default	Sym	Type	Range
SampleRate	number of samples per chip	4	R	int	[1, ∞)

Pin Inputs

Pin	Name	Description	Signal Type
1	SigIn	received baseband signal	complex
2	RefIn	reference signals for waveform quality measurement	complex
3	LgIn	long code	int

Notes/Equations

1. This subnetwork measures cdma2000 SR1 waveform quality, including rho and frequency error for reverse link with reference input. This measurement is available for cdma2000 SR1 systems only. The measurement output values are Rho and Dlt_F. The schematic for this subnetwork is shown in the following figure.



CDMA2K_RevRhoWithRef Subnetwork

The MS_TxRhoRC3 design (in the *Examples* > *CDMA2K* > *MS_TX_wrk* directory) demonstrates the use of this subnetwork.
The received signal is sampled at SampleRate times the chip rate. The cdma2000 SR1 chip rate is 1.2288 Mcps. The SigIn input denotes the received signal complex envelope; RefIn is the reference complex signal; LgIn is the long code input and should be set to the same long code as used in the generation of the RefIn signal. For measurement recording, 1 value of Rho and 1 value of Dlt_F (frequency error) are collected by NumericSink components. For this one value, the number of SigIn and RefIn tokens consumed is $6 \times 96 \times 32 \times R$, and the number of LgIn tokens consumed is $6 \times 96 \times 32$. Per the cdma2000 specification, the Rho measurement is performed on a signal segment with duration greater than or equal to 500 mSec. For the purpose of the Agilent CDMA2000 Design Library, Rho measurements are made for 96 × 32 chips (96 × 32 × R samples) which represents a 2.5 μ duration. The CDMA2K_RevRhoWithRefCal collects signals for 6 of these time durations and outputs the Rho and Dlt_F values for only the 6th time duration interval.

2. The SampleRate default value is 4, which is compliant with the cdma2000 specification. The compensatory filters (shown as FIR filters) in this subnetwork are designed based on this default value. The following discussion is based on SampleRate = 4.
3. This subnetwork includes auto-synchronization for the SigIn and RefIn signals. Typically the SigIn signal has a delay relative to the RefIn signal and synchronization is required. Auto-synchronization is achieved when the SigIn delay is from 0 to 49.4 μ, i.e., 243 samples or 60.75 chips (chip rate = 1.2288 Mcps, SampleRate = 4). It is common in communication systems for a delay to be introduced in the signal path.

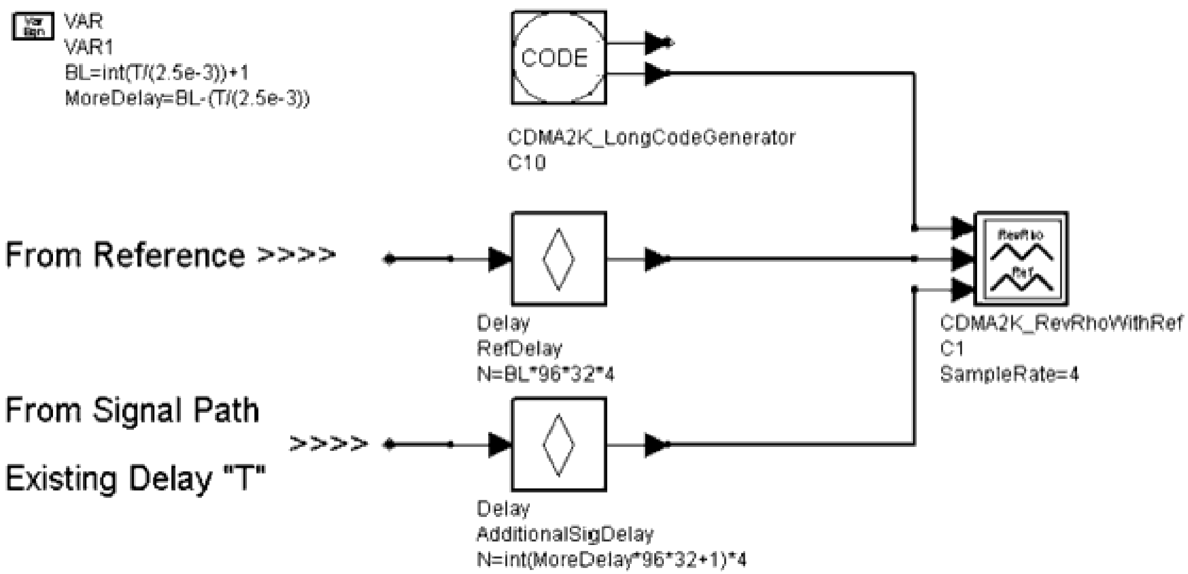
If the signal delay (SigIn pin 1) is less than 49.4 mSec (relative to the reference - RefIn pin 2), this subnetwork will work correctly without any special adjustment. This subnetwork will not work with negative delay (SigIn relative to RefIn). If the input to RefIn lags behind the input to SigIn, improper Rho and Dlt_F values will result.

If the delay of SigIn relative to RefIn is greater than 49.4 mSec (i.e., 243 samples or 60.75 chips), the synchronization between SigIn and RefIn must be achieved with additional external components. For this case, the user must insert appropriate delay components into the RefIn, SigIn and LgIn paths. For this case, the user must know the existing delay in the signal path and call this T sec. The user must perform separate calibration simulations to determine this value T (that calibration is not discussed here); the following discussion assumes the user knows the T sec value.

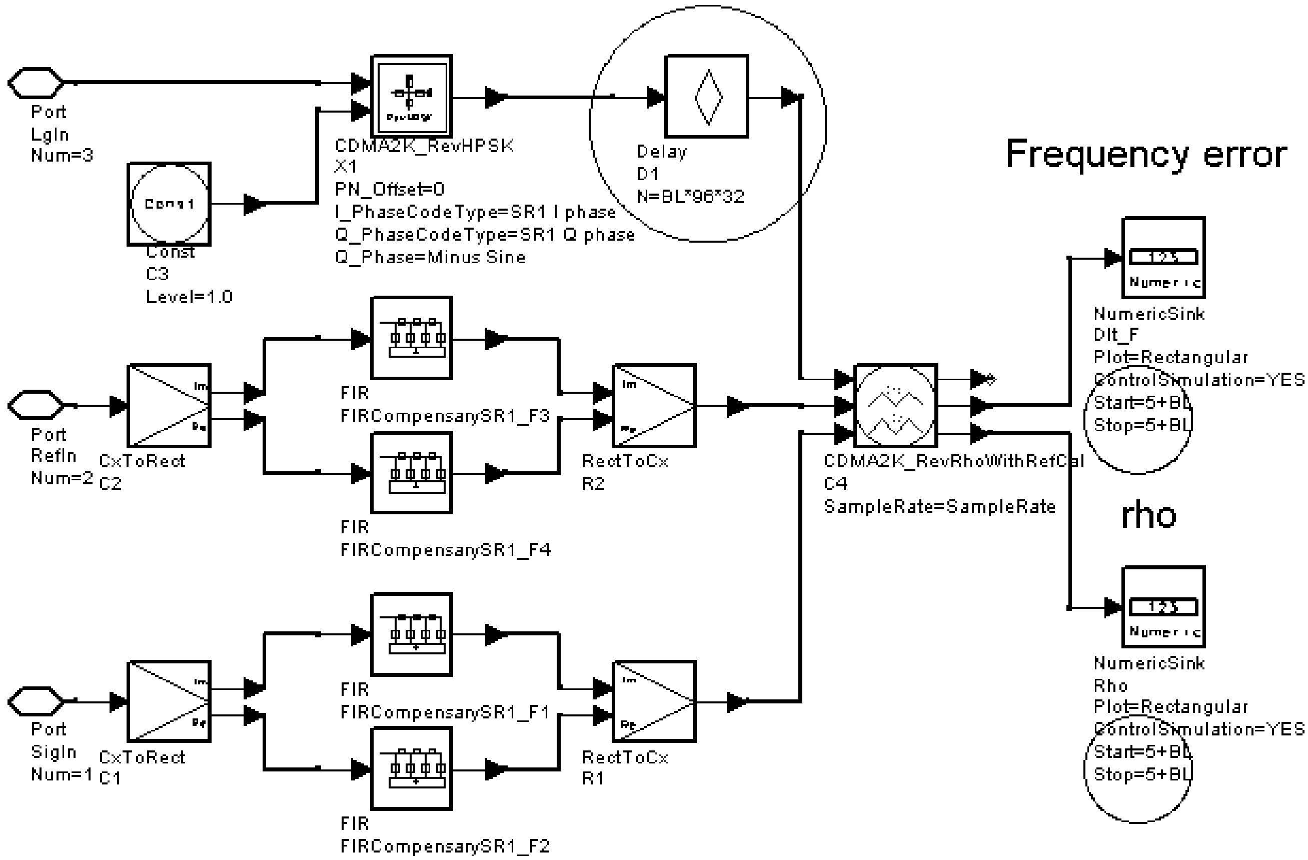
From the figure above, Rho and Dlt_F measurements are made using CDMA2K_RevRhoWithRefCal. The Rho and Dlt_F are measured for each 2.5 mSec duration ($96 \times 32 \times R$ samples). Therefore, the delay to be inserted in the RefIn path should be $BL \times 96 \times 32 \times R$ samples ($BL \times 2.5$ mSec) and LgIn path should be $BL \times 96 \times 32$ chips. BL is an integer ≥ 0. Let the delay to be inserted in the SigIn path be M sec. The total SigIn path delay inclusive of the original SigIn path delay of T will be (M sec + T sec). The user will select M to result in a relative delay, δ, of SigIn to RefIn inputs to CDMA2K_RevRhoWithRef that is within the autosynchronization delay range 0 ≤ δ ≤ 49.4 μ. M is thus selected such that 0 ≤ (M sec + T sec) − ($BL \times 2.5$ mSec) ≤ 49.4 μ.

The above two delays (for M sec and BL × 2.5 μ) can be inserted in the signal and reference paths respectively outside the CDMA2K_RevRhoWithRef subnetwork. However, the delay for the PN code ($BL \times 96 \times 32$ samples) must be inserted within the CDMA2K_RevRhoWithRef subnetwork itself. In the time domain, the PN code delay should be the same as the reference path, i.e., $BL \times 2.5$ mSec. Note that this is $BL \times 96 \times 32$ chips in the numeric domain.

The following figures illustrate how delay can be inserted when the existing signal delay is T sec. Although the numeric domain Delay is used for demonstration, it can be easily replaced by the time domain delay, DelayRF for example.



Delay Inserted Outside the CDMA2K_RevRhoWithRef Subnetwork



Delay Inserted Inside the CDMA2K_RevRhoWithRef Subnetwork

References

1. 3GPP2 C.S0002_A_1, "Physical Layer Standard for cdma2000 Spread Spectrum Systems Release A-Addendum 1," Oct. 27, 2000.
2. 3GPP2 TSG-C Interim Plenary, "Recommended Minimum Performance Standards for cdma2000 Spread Spectrum Mobile Stations: Release A," Nov. 27, 2000.
3. 3GPP2 TSG-C4.1,"Recommended Minimum Performance Standards for cdma2000 Spread Spectrum Base Stations: Release A," Oct. 26, 2000.

TPC Design Examples

Introduction

The CDMA2K_TPC_wrk workspace shows examples for measuring forward and reverse link transmission power. The following sections describe the designs and provide schematics and simulation results.

Power Control of Forward Link Radio Configuration 3

- DsnCDMA2K_FwdPC

Features

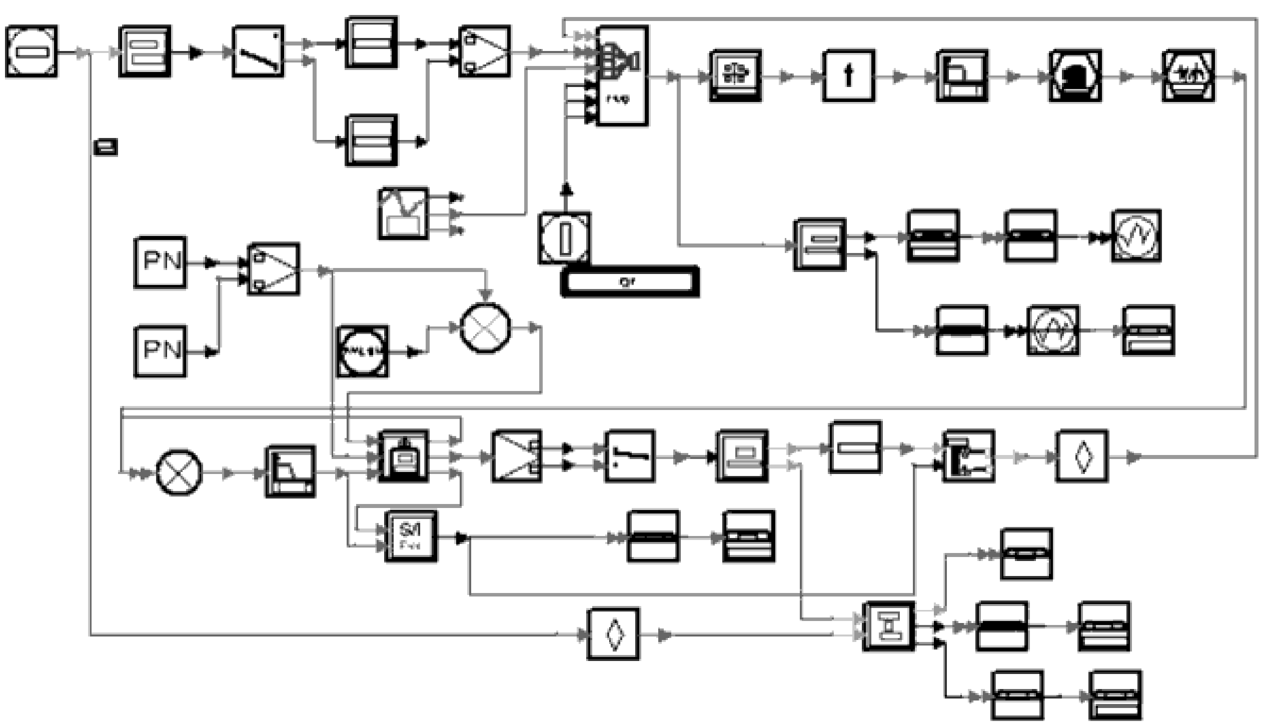
- Constant data rate 9600 bps
- Convolutional encoder and Viterbi decoder
- QPSK modulation
- 1.2288 Mcps chip rate
- Multipath fading channel
- Rake receiver for forward traffic channel
- Power control for forward traffic channel
- BER and FER values
- Performance curve

Description

DsnCDMA2K_FwdPC is an example designed for measuring BER and FER performance of forward link RC3 in a multipath fading channel.

Schematic

The schematic for this design is shown in the following figure.



DsnCDMA2K_FwdPC

Subnetworks *FwdPC_ChannelCoding* and *FwdPC_ChannelDecoding* were designed for use in this example.

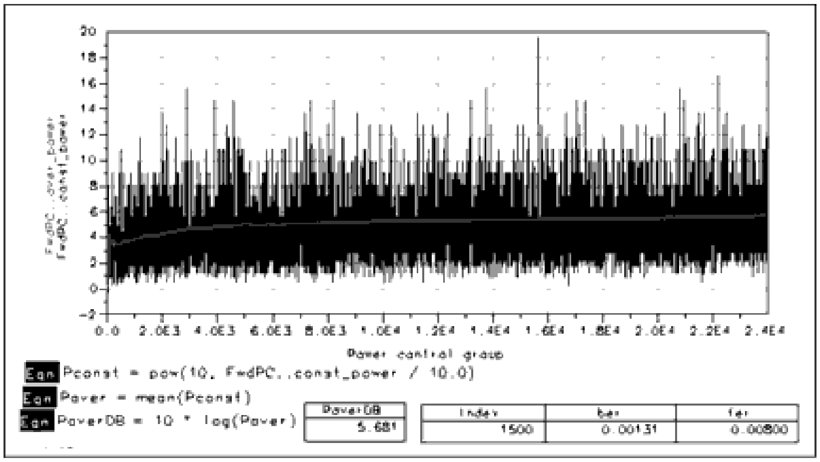
- *FwdPC_ChannelCoding* : channel coding includes CRC encoder, add tail, convolutional encoder and interleaver.
  Specific parameter settings for this subnetwork are
  - InputFrameLen (CDMA2K_CRC_Coder): **172**
  - CRCType (CDMA2K_CRC_Coder): **CRC12 0x1f13**
  - CCType (CDMA2K_CC_WithTail): **rate 1/4 K 9 g0 0765 g1 0671 g2 0513 g3 0473**
  - BlockRow_m and BlockColumn_J (CDMA2K_BlockIntlvr): **m=6, J=12**
  - IntlvrType (CDMA2K_BlockIntlvr): **Fwd_Backwards**
- *FwdPC_ChannelDeCoding* : channel decoding includes de-interleaver, Viterbi decoder, CRC check and erasing tail.
  Specific parameter settings for this subnetwork are
  - InputFrameLen (CDMA2K_CRC_DeCoder): **184**
  - CRCType (CDMA2K_CRC_DeCoder): **CRC12 0x1f13**
  - CCType (CDMA2K_DCC_WithTail): **rate 1/4 K 9 g0 0765 g1 0671 g2 0513 g3 0473**
  - BlockRow_m and BlockColumn_J (CDMA2K_BlockDeIntlvr): **m=6, J=12**
  - IntlvrType (CDMA2K_BlockDeIntlvr): **Fwd_Backwards**

Simulation Conditions

- Multipath fading channel: no pathloss, three path
- Gaussian noise variance: 5
- Active user number: 30
- Power-controlled user number: 1
- Power adjustment step: 1 dB
- SIR threshold in receiver is 0 dB
- FER threshold is 0.007

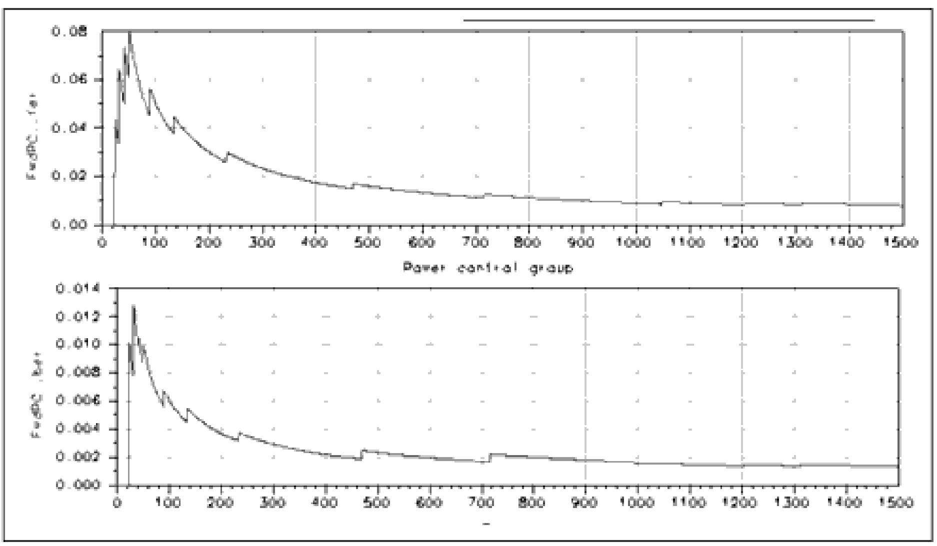
Simulation Results

The output power is shown in the following figure. The graph is saved in FwdPC.dds; corresponding data is saved in *FwdPC.ds.*



Power Control and Average Power

The BER and FER are shown in the following figure. The graph is saved in FwdPC.dds; corresponding data is saved in *FwdPC.ds.*



BER and FER

Benchmark

- Hardware platform: Pentium II 400 MHz, 256 Mb memory
- Software platform: Windows NT 4.0 workstation, ADS 1.3
- Data points: 1500 frames
- Simulation time: 28 hours

References

1. IS2000.2, *Physical Layer Standard for cdma2000 Spread Spectrum Systems*, April 1999.
2. TIA/EIA/IS-98-A, *Recommended Minimum Performance Standards for Dual-Mode Wideband Spread Spectrum Cellular Mobile Stations*, July 1996.

Power Control of Reverse Link Radio Configuration 3

- DsnCDMA2K_RevPC

Features

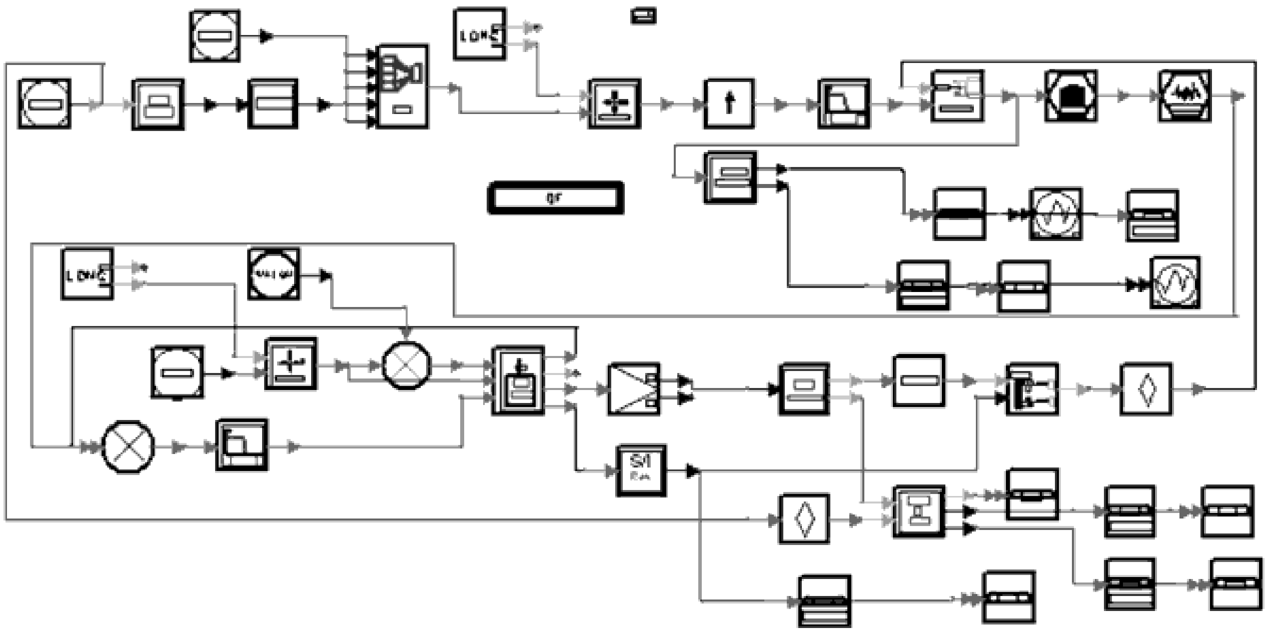
- Constant data rate 9600 bps
- Convolutional encoder and Viterbi decoder
- Reverse HPSK modulation
- 1.2288 Mcps chip rate
- Multipath fading channel
- Rake receiver for reverse traffic channel
- Power control for reverse traffic channel
- BER and FER values
- Performance curve

Description

DsnCDMA2K_RevPC is a design example for measuring BER and FER performance under power control of reverse link RC3 in a multipath fading channel.

Schematic

The schematic for this design is shown in the following figure.



DsnCDMA2K_RevPC

DsnCDMA2K_RevPC

Subnetworks *RevPC_ChannelCoding*, *RevPC_Receiver* and *RevPC_ChannelDecoding* were designed for use in this example.

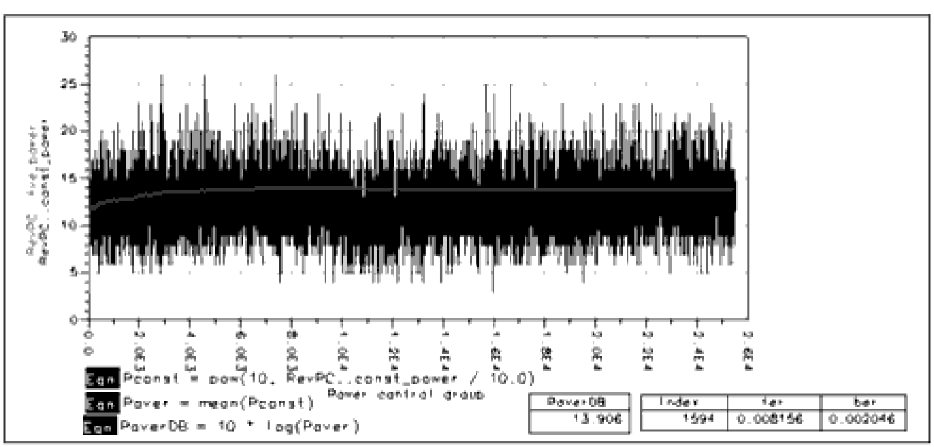
- *RevPC_ChannelCoding* : channel coding includes CRC encoder, adding tail, convolutional encoder and interleaver.
  Specific parameter settings for this subnetwork are
  - InputFrameLen (CDMA2K_CRC_Coder): **172**
  - CRCType (CDMA2K_CRC_Coder): **CRC12 0x1f13**
  - CCType (CDMA2K_CC_WithTail): **rate 1/4 K 9 g0 0765 g1 0671 g2 0513 g3 0473**
  - BlockRow_m and BlockColumn_J: (CDMA2K_BlockIntlvr): **m=6, J=24**
  - IntlvrType: (CDMA2K_BlockIntlvr): **BroIntlvr**
- *RevPC_ChannelDeCoding* : channel decoding includes de-interleaver, Viterbi decoder, CRC check and erasing tail.
  Specific parameter settings for this subnetwork are
  - InputFrameLen (CDMA2K_CRC_DeCoder): **184**
  - CRCType (CDMA2K_CRC_DeCoder): **CRC12 0x1f13**
  - CCType (CDMA2K_DCC_WithTail): **rate 1/4 K 9 g0 0765 g1 0671 g2 0513 g3 0473**
  - BlockRow_m and BlockColumn_J: (CDMA2K_BlockDeIntlvr): **m=6, J=24**
  - IntlvrType: (CDMA2K_BlockDeIntlvr): **BroIntlvr**

Simulation Conditions

- Multipath fading channel: no pathloss, three path
- Gaussian noise variance: 200
- Power adjustment step: 1bdB
- SIR threshold in receiver is 0bdB
- FER threshold is 0.007

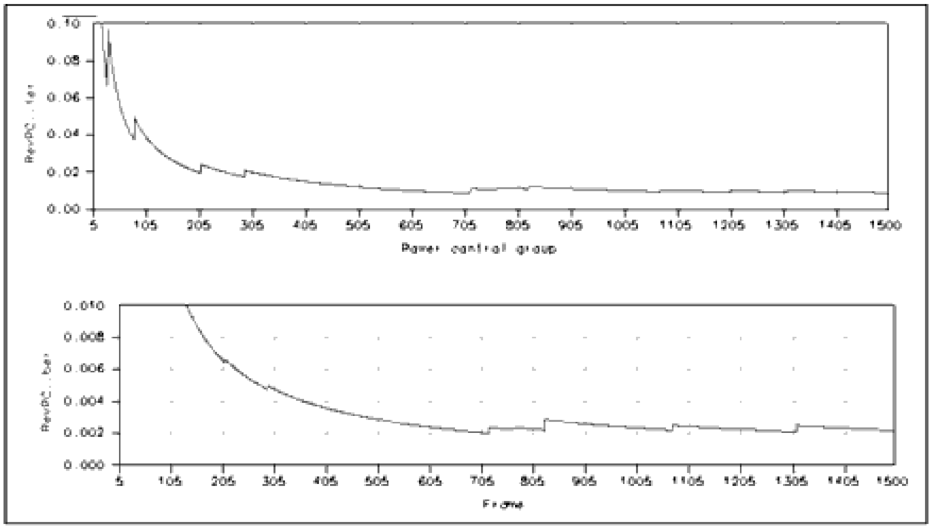
Simulation Results

Output power is shown in the following figure. The graph is saved in RevPC.dds; corresponding data is saved in *RevPC.ds.*



Power Control and Average Power

BER and FER are shown in the following figure. The graph is saved in RevPC.dds; corresponding data is saved in *RevPC.ds*.



BER and FER

Benchmark

- Hardware platform: Pentium II 400 MHz, 256 Mb memory
- Software platform: Windows NT 4.0 workstation, ADS 1.3
- Data points: 1500 frames
- Simulation time: 28 hours

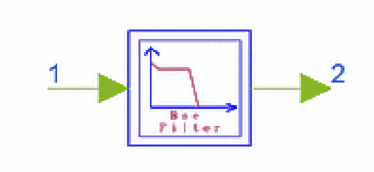
References

1. IS2000.2, *Physical Layer Standard for cdma2000 Spread Spectrum Systems*, April 1999.
2. TIA/EIA/IS-98-A, *Recommended Minimum Performance Standards for Dual-Mode Wideband Spread Spectrum Cellular Mobile Stations*, July 1996.

Transmission

- *CDMA2K BaseFilter* (cdma2k)
- *CDMA2K BSTX* (cdma2k)
- *CDMA2K DataScrambling* (cdma2k)
- *CDMA2K DataScrambling U* (cdma2k)
- *CDMA2K FIR* (cdma2k)
- *CDMA2K FwdPCBitExtraction* (cdma2k)
- *CDMA2K FwdPCBitExtraction U* (cdma2k)
- *CDMA2K FwdPCBitPuncture* (cdma2k)
- *CDMA2K FwdPCBitPuncture U* (cdma2k)
- *CDMA2K FwdPowerAllocation* (cdma2k)
- *CDMA2K FwdPwrAlloc* (cdma2k)
- *CDMA2K FwdQPSK* (cdma2k)
- *CDMA2K FwdSIREstimate* (cdma2k)
- *CDMA2K FwdTDpwrAlloc* (cdma2k)
- *CDMA2K LongCodeGenerator* (cdma2k)
- *CDMA2K MSTX* (cdma2k)
- *CDMA2K PCBgenerator* (cdma2k)
- *CDMA2K PNCode* (cdma2k)
- *CDMA2K PNCode U* (cdma2k)
- *CDMA2K PowerControl* (cdma2k)
- *CDMA2K QuasiOrthMask* (cdma2k)
- *CDMA2K QuasiOrthMask U* (cdma2k)
- *CDMA2K RevHPSK* (cdma2k)
- *CDMA2K RevPCBitPuncture* (cdma2k)
- *CDMA2K RevPowerAdjust* (cdma2k)
- *CDMA2K RevPowerAllocation* (cdma2k)
- *CDMA2K RevPowerAllocation U* (cdma2k)
- *CDMA2K RevSIREstimate* (cdma2k)
- *CDMA2K SR3LongCode* (cdma2k)
- *CDMA2K SyncChSARSublayer* (cdma2k)
- *CDMA2K SyncChSource* (cdma2k)
- *CDMA2K SyncChUtilitySublayer* (cdma2k)
- *CDMA2K VL Walsh* (cdma2k)
- *CDMA2K WalshModulator* (cdma2k)
- *CDMA2K WalshRotateFunction* (cdma2k)

CDMA2K_BaseFilter



Description Complex FIR Baseband Filter
Library cdma2000, Transmission
Class SDFCDMA2K_BaseFilter

Parameters

Name	Description	Default	Type
SpreadRate	PN chip rate,multiple of 1.2288 Mcps: SR1, SR3	SR1	enum

Pin Inputs

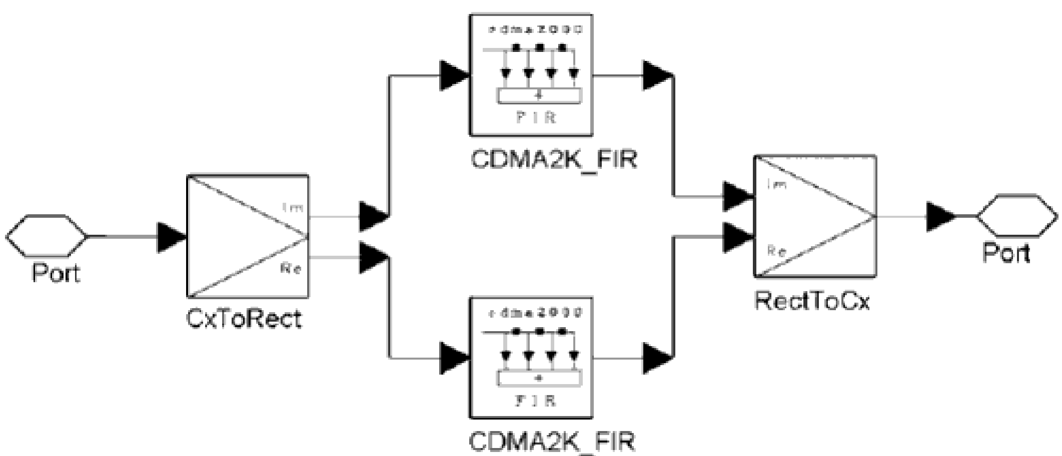
Pin	Name	Description	Signal Type
1	SigIn	input signal	complex

Pin Outputs

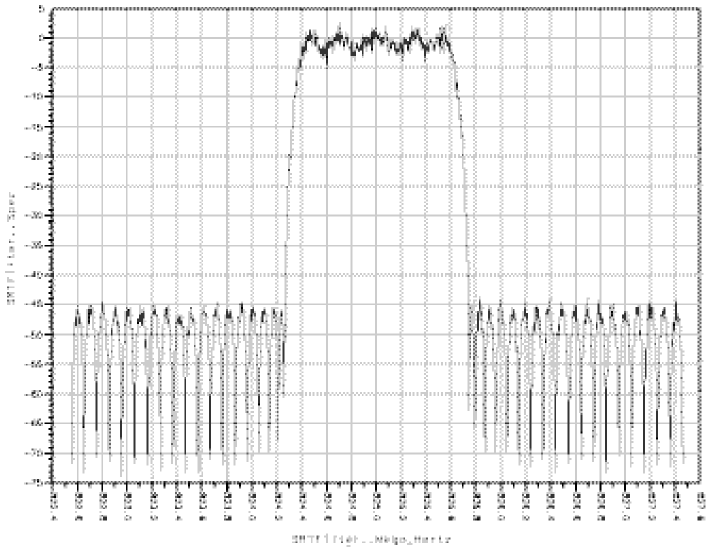
Pin	Name	Description	Signal Type
2	SigOut	output signal	complex

Notes/Equations

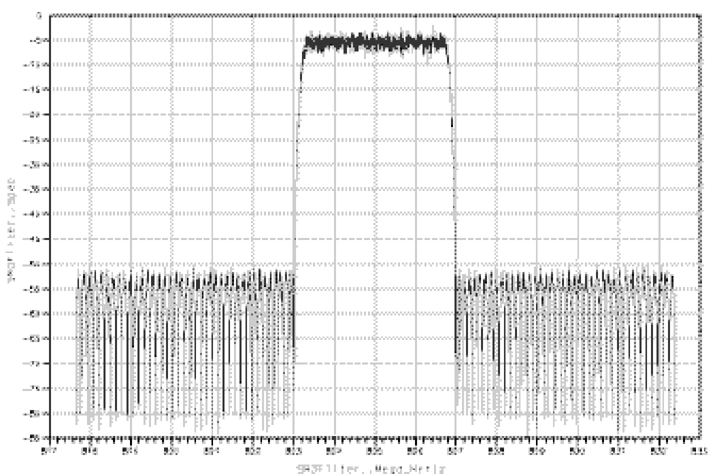
1. This subnetwork is used as a baseband filter. The I and Q impulses are applied to the inputs of the I and Q baseband filters.
   The following figure shows the schematic for this subnetwork.
   The first plot shows the spectrum of the SR1 filter; The second plot shows the spectrum of the SR3 filter.



CDMA2K_BaseFilter Subnetwork



SR1 Filter Spectrum

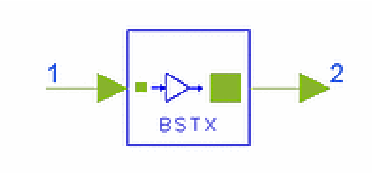


SR3 Filter Spectrum

References

1. TIA/EIA/IS-2000.2 (PN-4428), Physical Layer Standard for cdma2000 Spread Spectrum Systems, July 1999.

CDMA2K_BSTX



Description Base station transmitter
Library cdma2000, Transmission
Class SDFCDMA2K_BSTX

Parameters

Name	Description	Default	Unit	Type	Range
BS_Power	base station transmission power	10.0	W	real	(0, ∞)

Pin Inputs

Pin	Name	Description	Signal Type
1	D_in	input data	complex

Pin Outputs

Pin	Name	Description	Signal Type
2	D_out	output data	complex

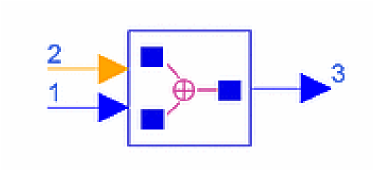
Notes/Equations

1. This model is used to allocate real base station power for data transmission. Each firing, 1 D_out token is produced when 1 D_in token is consumed.

References

1. TIA/EIA/IS-2000.2 (PN-4428), Physical Layer Standard for cdma2000 Spread Spectrum Systems, July 1999.

CDMA2K_DataScrambling



Description Data scrambler and descramblerfor forward link
Library cdma2000, Transmission
Class SDFCDMA2K_DataScrambling

Parameters

Name	Description	Default	Type
RadioConfig	radio configuration: RC1 To RC2, RC3 To RC9 Non OTD, RC3 To RC9 OTD, RC3 To RC9 MC	RC1 To RC2	enum

Pin Inputs

Pin	Name	Description	Signal Type
1	D_in	input data	real
2	LgCode	long code bits after decimation	int

Pin Outputs

Pin	Name	Description	Signal Type
3	D_out	output data	real

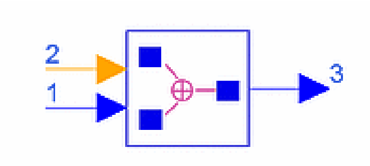
Notes/Equations

1. This model is used to implement long code data scrambling and descrambling. Each firing,
   - for RC1 To RC2, 1 D_out token is produced when 1 D_in and 1 LgCode tokens are consumed
   - for RC3 To RC9 Non OTD mode, 2 D_out tokens are produced when 2 D_in and 2 LgCode tokens are consumed
   - for RC3 To RC9 OTD, 4 D_out tokens are produced when 4 D_in and 4 LgCode tokens are consumed
   - for RC3 To RC9 MC mode, 6 D_out tokens are produced when 6 D_in and 6 LgCode tokens are consumed.

References

1. TIA/EIA/IS-2000.2 (PN-4428), Physical Layer Standard for cdma2000 Spread Spectrum Systems, July 1999.

CDMA2K_DataScrambling_U



Description Data scrambler and descrambler for forward link, spec. 3GPP2 C.S0002-A-1, Oct. 2000.
Library cdma2000, Transmission
Class SDFCDMA2K_DataScrambling_U

Parameters

Name	Description	Default	Type
RadioConfig	radio configuration: RC1 To RC2, RC3 To RC5 Non TD, RC3 To RC5 TD, RC6 To RC9 MC	RC1 To RC2	enum

Pin Inputs

Pin	Name	Description	Signal Type
1	D_in	input data	real
2	LgCode	long code bits after decimation	int

Pin Outputs

Pin	Name	Description	Signal Type
3	D_out	output data	real

Notes/Equations

1. This model is used to implement long code data scrambling and descrambling. Each firing,
   - for *RC1 To RC2*, 1 D_out tokens are produced when 1 D_in and 1 LgCode tokens are consumed
   - for *RC3 To RC5 Non TD*, 2 D_out tokens are produced when 2 D_in and 2 LgCode tokens are consumed
   - for *RC3 To RC5 TD*, 4 D_out tokens are produced when 4 D_in and 4 LgCode tokens are consumed
   - for *RC6 To RC9 MC*, 6 D_out tokens are produced when 6 D_in and 6 LgCode tokens are consumed
2. Data scrambling is accomplished as follows.
   - for *RC1 To RC2*, data scrambling is performed by the modulo-2 addition of the modulation symbol with the binary value of the long code PN chips. This PN sequence is the equivalent of the long code operating at 1.2288 $\times$ N MHZ, where N is the chip rate / 1.2288 Mcps. Only the first output of every M chips is used, M is the decimation rate equal to the chip rate divided by the modulation symbol rate.
   - for *RC3 To RC5*, data scrambling is performed in groups of 2M modulation symbols, where M is 1 for *Non TD* modes and 2 for *TD* mode. Modulo-2 addition

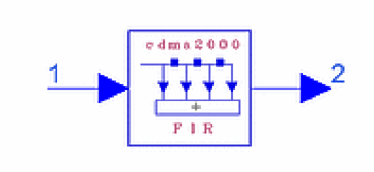
is performed on the modulation symbols with the binary value of the long code PN chips that is valid at the start of the 2M modulation symbol for the first M modulation symbols of each group, and is valid just prior to the start of the 2M modulation symbol for the second M modulation symbols.

- for *RC6 To RC9*, data scrambling is performed in groups of 2M modulation symbols, where M is 3 for *MC* mode. Modulo-2 addition is performed on the modulation symbols with the binary value of the long code PN chips that is valid at the start of the 2M modulation symbol for the first M modulation symbols of each group, and is valid just prior to the start of the 2M modulation symbol for the second M modulation symbols.

References

1. 3GPP2 C.S0002_A_1, "Physical Layer Standard for cdma2000 Spread Spectrum Systems Release A-Addendum 1," Oct. 27, 2000.

CDMA2K_FIR



Description FIR baseband filter
Library cdma2000, Transmission
Class SDFCDMA2K_FIR

Parameters

Name	Description	Default	Type
SpreadRate	PN chip rate; multiple of 1.2288 Mcps: SR1, SR3	SR1	enum

Pin Inputs

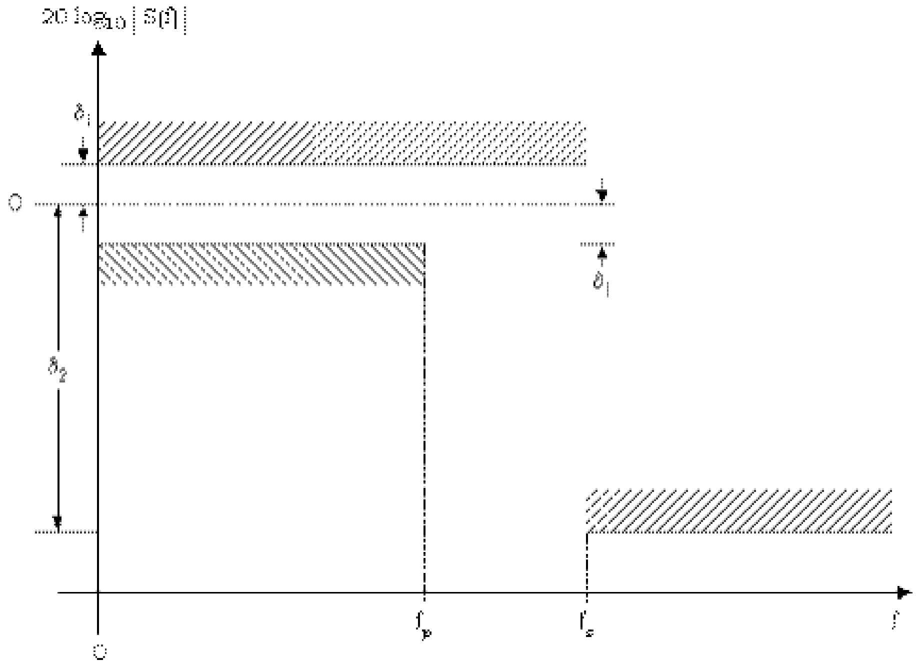
Pin	Name	Description	Signal Type
1	D_in	input data	real

Pin Outputs

Pin	Name	Description	Signal Type
2	D_out	output data	real

Notes/Equations

1. This model is used as a 48-order FIR filter for SR1, or as a 108-order FIR filter for SR3.
2. The baseband filters have a frequency response S(f) that satisfies the limits given in the following figure. Specifically, the normalized frequency response of the filter must be contained within ±!cdma2k-07-06-09.gif! in the passband $0 \le f \le f_p$, and must be ≤ -δ_2 in the stopband $f \ge f_s$.
   - for SR1 the numerical values for the parameters are δ_1 = 1.5 dB, δ_2 = 40 dB, fp = 590 kHz, and fs = 740 kHz.
   - for SR3 the numerical values for the parameters are δ_1 = 1.5 dB, δ_2 = 40 dB, fp = 1.7164 MHz, and fs = 1.97 MHz.



Baseband Filter Frequency Response Limits

Let s(t) be the impulse response of the baseband filter. Then s(t) should satisfy the following equation:

$$MeanSquaredError = \sum_{k=0}^{\infty} [\alpha S(kT_s - \tau) - h(k)]^2 \leq 0.03$$

where the constants α and τ are used to minimize the mean squared error. The constant Ts is equal to 203.451... / N ns, where N is the chip rate/1.2288 Mcps. Ts equals one quarter of the duration of a PN chip.

- for SR1 the values of the coefficients h(k), for k < 48, are given in Table 2.1.3.1.13.1-1 (Ref. [1]), h(k) = 0 for k ≥ 48. Note that h(k) = h(47 − k).
- for SR3 the values of the coefficients h(k), for k < 108, are given in Table 2.1.3.1.13.2-1.(Ref. [1]), h(k) = 0 for k≥ 108. Note that h(k) = h(107 − k).

The coefficients of h(k) are given in the following tables.

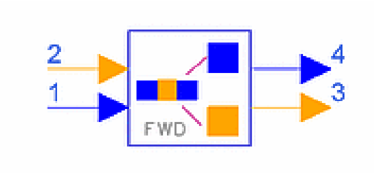
k	h[k]	k	h[k]
0,47	-0.025288315	12,37	0.007874526
1,46	-0.034167931	13,34	0.084368728
2,45	-0.035752323	14,33	0.126869306
3,44	-0.016733702	15,34	0.094528345
4,43	0.021602514	16,31	-0.012839661
5,42	0.064938487	17,30	-0.143477028
6,41	0.091002137	18,29	-0.211829088
7,40	0.081894974	19,28	-0.140513128
8,39	0.037071157	20,27	0.094601918
9,38	-0.021998074	21,26	0.441387140
10,37	-0.060716277	22,25	0.785875640
11,36	-0.051178658	23,24	1.0
k	**h(k)**	**k**	**h(k)**
0, 107	0.005907324	27, 80	0.036864993
1, 106	0.021114345	28, 79	0.032225981
2, 105	0.017930022	29, 78	0.007370446
3, 104	0.019703955	30, 77	-0.025081919
4, 103	0.011747086	31, 76	-0.046339352
5, 102	0.001239201	32, 75	-0.042011421
6, 101	-0.00892579	33, 74	-0.011379513
7, 100	-0.01333914	34, 73	0.030401507
8, 99	-0.00986819	35, 72	0.059332552
9, 98	-0.00019046	36, 71	0.055879297
10, 97	0.01034771	37, 70	0.017393708
11, 96	0.015531711	38, 69	-0.037885556
12, 95	0.011756251	39, 68	-0.078639005
13, 94	0.000409244	40, 67	-0.077310571
14, 93	-0.01243954	41, 66	-0.027229017
15, 92	-0.01916985	42, 65	0.049780118
16, 91	-0.01500653	43, 64	0.111330557
17, 90	-0.00124565	44, 63	0.115580285
18, 89	0.014862732	45, 62	0.046037444
19, 88	0.023810108	46, 61	-0.073329573
20, 87	0.019342903	47, 60	-0.182125302
21, 86	0.002612151	48, 59	-0.20734917
22, 85	-0.01766272	49, 58	-0.097600349
23, 84	-0.02958801	50, 57	0.148424686
24, 83	-0.02493396	51, 56	0.473501031
25, 82	-0.00457532	52, 55	0.779445702
26, 81	0.020992966	53, 54	0.964512513

References

1. TIA/EIA/IS-2000.2 (PN-4428), Physical Layer Standard for cdma2000 Spread

Spectrum Systems, July 1999.

CDMA2K_FwdPCBitExtraction



Description Power control bit extractor for forward link
Library cdma2000, Transmission
Class SDFCDMA2K_FwdPCBitExtraction

Parameters

Name	Description	Default	Type
RadioConfig	radio configuration: RC1, RC2, RC3 Non OTD, RC3 OTD, RC4, RC5 Non OTD, RC5 OTD, RC6 DS Non OTD, RC6 DS OTD, RC6 MC, RC7 DS, RC7 MC, RC8 DS Non OTD, RC8 DS OTD, RC8 MC, RC9 DS, RC9 MC	RC1	enum

Pin Inputs

Pin	Name	Description	Signal Type
1	D_in	input data	real
2	LgCode	long code bits after decimation	int

Pin Outputs

Pin	Name	Description	Signal Type
3	PCBit	power control bit	int
4	D_out	data after extracting power control bit and de-scrambling	real

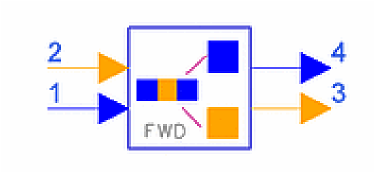
Notes/Equations

1. This model is used to extract power control bits from decoded traffic bits and replace PCBit with 0. This model processes one power control group as a block.
   Each firing,
   - for RC1, RC2, RC4:
     24 D_out tokens and 1 PCBit token are produced when
     24 D_in tokens and 24 LgCode tokens are consumed.
   - for RC3 Non OTD, RC3 OTD, RC5 Non OTD, RC5 OTD:
     48 D_out tokens and 1 PCBit token are produced when
     48 D_in tokens and 48 LgCode tokens are consumed.
   - for RC6 DS Non OTD, RC6 DS OTD, RC6 MC, RC8 DS Non OTD, RC8 DS OTD, RC8 MC:
     72 D_out tokens and 1 PCBit token are produced when
     72 D_in tokens and 72 LgCode tokens are consumed.
   - for RC7 DS, RC7 MC, RC9 DS, RC9 MC:
     36 D_out tokens and 1 PCBit token are produced when
     36 D_in tokens and 36 LgCode tokens are consumed.

References

1. TIA/EIA/IS-2000.2 (PN-4428), Physical Layer Standard for cdma2000 Spread Spectrum Systems, July 1999.

CDMA2K_FwdPCBitExtraction_U



Description Power control bit extractor for forward link, spec. 3GPP2 C.S0002-A-1, Oct. 2000.
Library cdma2000, Transmission
Class SDFCDMA2K_FwdPCBitExtraction_U

Parameters

Name	Description	Default	Type
RadioConfig	radio configuration: RC1, RC2, RC3 Non TD, RC3 TD, RC4, RC5 Non TD, RC5 TD, RC6, RC7, RC8, RC9	RC1	enum

Pin Inputs

Pin	Name	Description	Signal Type
1	D_in	input data	real
2	LgCode	long code bits after decimation	int

Pin Outputs

Pin	Name	Description	Signal Type
3	PCBit	power control bit	int
4	D_out	data after extracting power control bit and de-scrambling	real

Notes/Equations

1. This model is used to extract power control bit from decoded traffic bits and replace power control bit with 0. This model processes one power control group as a block. Each firing,
   - for *RC1, RC2, RC4*, 24 D_out tokens and 1 PCBit token are produced when 24 D_in tokens and 24 LgCode tokens are consumed.
   - for *RC3 Non TD, RC3 TD, RC5 Non TD, RC5 TD*, 48 D_out tokens and 1 PCBit token are produced when 48 D_in tokens and 48 LgCode tokens are consumed.
   - for *RC6* and *RC8*: 72 D_out tokens and 1 PCBit token are produced when 72 D_in tokens and 72 LgCode tokens are consumed.
   - for *RC7* and *RC9*: 36 D_out tokens and 1 PCBit token are produced when 36 D_in tokens and 36 LgCode tokens are consumed.
   The model extracts the power control bit at every power control group and sends it to the mobile station power controller, then replaces the power control bits with 0.
   As shown in the following table, 1, 2, 3, 4 or 6 analogy values will be combined into one integer type power control bit at the position indicated by the long code of last power control group. The power control bit starting position can be

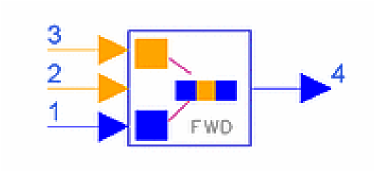
derived from the long code value.

Radio Configuration	Punctured Modulation Symbols	Starting Symbol Positions	Scrambling Bits (MSB -> LSB)
1	2	0, 1, ..., 15	23, 22, 21, 20
2	1	0, 1, ..., 15	23, 22, 21, 20
3 (non-TD)	4	0, 2, ..., 30	47, 46, 45, 44
3 (TD)	4	0, 4, ..., 28	47, 46, 45
4	2	0, 2, ..., 14	23, 22, 21
5 (non-TD)	4	0, 2, ..., 30	47, 46, 45, 44
5 (TD)	4	0, 4, ..., 28	47, 46, 45
6	6	0, 6, ..., 42	71, 70, 69
7	3	0, 3, ..., 21	35, 34, 33
8	6	0, 6, ..., 42	71, 70, 69
9	3	0, 3, ..., 21	35, 34, 33

References

1. 3GPP2 C.S0002_A_1, "Physical Layer Standard for cdma2000 Spread Spectrum Systems Release A-Addendum 1," Oct. 27, 2000.

CDMA2K_FwdPCBitPuncture



Description Forward power control bit puncture
Library cdma2000, Transmission
Class SDFCDMA2K_FwdPCBitPuncture

Parameters

Name	Description	Default	Type
RadioConfig	radio configuration: RC1, RC2, RC3 Non OTD, RC3 OTD, RC4, RC5 Non OTD, RC5 OTD, RC6 DS Non OTD, RC6 DS OTD, RC6 MC, RC7 DS, RC7 MC, RC8 DS Non OTD, RC8 DS OTD, RC8 MC, RC9 DS, RC9 MC	RC1	enum

Pin Inputs

Pin	Name	Description	Signal Type
1	D_in	input data	real
2	PCBit	power contol bit from measurement part	int
3	LgCode	long code bits after decimation	int

Pin Outputs

Pin	Name	Description	Signal Type
4	D_out	output data	real

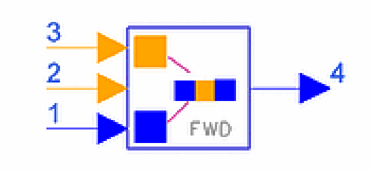
Notes/Equations

1. This model is used by the forward link to insert power control bits into one power control group.
   Each firing,
   - for RC1, RC2, RC4:
     24 D_out tokens are produced when
     24 D_in tokens, 24 LgCode and 1 PCBit tokens are consumed.
   - for RC3 Non OTD, RC3 OTD, RC5 Non OTD, RC5 OTD:
     48 D_out tokens are produced when
     48 D_in, 48 LgCode, and 1 PCBit tokens are consumed.
   - for RC6 DS Non OTD, RC6 DS OTD, RC6 MC, RC8 DS Non OTD, RC8 DS OTD, RC8 MC:
     72 D_out tokens are produced
     when 72 D_in, 72 LgCode, and 1 PCBit tokens are consumed.
   - for RC7 DS, RC7 MC, RC9 DS, RC9 MC:
     36 D_out tokens are produced when
     36 D_in tokens, 36 LgCode and 1 PCBit tokens are consumed.

References

1. TIA/EIA/IS-2000.2 (PN-4428), Physical Layer Standard for cdma2000 Spread Spectrum Systems, July 1999.

CDMA2K_FwdPCBitPuncture_U



Description Forward power control bit puncture, spec. 3GPP2 C.S0002-A-1, Oct. 2000.
Library cdma2000, Transmission
Class SDFCDMA2K_FwdPCBitPuncture_U

Parameters

Name	Description	Default	Type
RadioConfig	radio configuration: RC1, RC2, RC3 Non TD, RC3 TD, RC4, RC5 Non TD, RC5 TD, RC6, RC7, RC8, RC9	RC1	enum

Pin Inputs

Pin	Name	Description	Signal Type
1	D_in	input data	real
2	PCBit	power contol bit from measurement part	int
3	LgCode	long code bits after decimation	int

Pin Outputs

Pin	Name	Description	Signal Type
4	D_out	output data	real

Notes/Equations

1. This model is used by forward link to insert power control bits into one power control group.
   Each firing,
   - for *RC1*, *RC2*, *RC4*, 24 D_out tokens are produced when 24 D_in tokens, 24 LgCode tokens, and 1 PCBit token are consumed.
   - for *RC3 Non OTD*, *RC3 OTD*, *RC5 Non OTD*, *RC5 OTD*, 48 D_out tokens are produced when 48 D_in tokens, 48 LgCode tokens, and 1 PCBit token are consumed.
   - for *RC6*, *RC8*: 72 D_out tokens are produced when 72 D_in tokens, 72 LgCode tokens, and 1 PCBit token are consumed.
   - for *RC7*, *RC9*: 36 D_out tokens are produced when 36 D_in tokens, 36 LgCode tokens, and 1 PCBit token are consumed.
     As shown in the following table, 1, 2, 3, 4 or 6 information bits are replaced with power control bit (with the same value) at the position indicated by the long code of last power control group. The power control bit initial (first bit) position can be derived from the long code value.

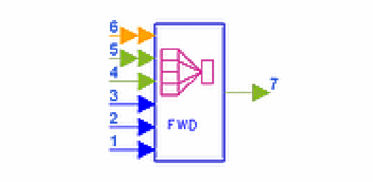
     An n-bit (n = 3 or 4) binary number with values 0 through $2n^{-1}$ formed by the scrambling bits as shown in the following table will be used to determine the power control bit starting position by indexing the list in the following table.

Radio Configuration	Punctured Modulation Symbols	Starting Symbol Positions	Scrambling Bits (MSB -> LSB)
1	2	0, 1,..., 15	23, 22, 21, 20
2	1	0, 1,..., 15	23, 22, 21, 20
3 (non-TD)	4	0, 2,..., 30	47, 46, 45, 44
3 (TD)	4	0, 4,..., 28	47, 46, 45
4	2	0, 2,..., 14	23, 22, 21
5 (non-TD)	4	0, 2,..., 30	47, 46, 45, 44
5 (TD)	4	0, 4,..., 28	47, 46, 45
6	6	0, 6,..., 42	71, 70, 69
7	3	0, 3,..., 21	35, 34, 33
8	6	0, 6,..., 42	71, 70, 69
9	3	0, 3,..., 21	35, 34, 33

References

1. 3GPP2 C.S0002_A_1, "Physical Layer Standard for cdma2000 Spread Spectrum Systems Release A-Addendum 1," Oct. 27, 2000.

CDMA2K_FwdPowerAllocation



Description Power allocator for base station channels
Library cdma2000, Transmission
Class SDFCDMA2K_FwdPowerAllocation

Parameters

Name	Description	Default	Sym	Type	Range
PilotPowerRatio	pilot channel power to total power ratio	0.2		real	(0, 1) †
SyncPowerRatio	sync channel power to total power ratio	0.025		real	[0, 1)
PagingPowerRatio	paging channel power to total power ratio	0.063		real	[0, 1)
WalshLength	length of Walsh code	64	N	int	2^n, n=1,...,11
PermitdActiveUr	number of users in forward link	30		int	[6, N-3-(N/64)] if TransmitDiversity = NON_TD; [6, N-3-(N/64)/2] if TransmitDiversity = TD
PowerControl	enable the power control: Yes, No	Yes		enum	
TrafficAdjustStep	traffic channel power adjust step	1		real	(0, ∞)
BlockSize	number of particles in a block	1536		int	[1, ∞)
IgnoreNum	number of initially ignored firings	1		int	[0, ∞)
†The sum of PilotPowerRatio, SyncPowerRatio, and PagingPowerRatio must be < 1 if TransmitDiversity = NON_TD.					

Pin Inputs

Pin	Name	Description	Signal Type
1	Pilot	Pilot Channel data	real
2	Sync	Sync Channel data	real
3	Paging	Paging Channel data	real
4	MoreUr	other user data	complex
5	UrData	Traffic Channel data of users for testing	multiple complex
6	PCBit	power control bit	multiple int

Pin Outputs

Pin	Name	Description	Signal Type
7	D_out	output data	complex

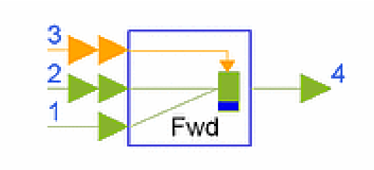
Notes/Equations

1. This model is used to allocate power to the forward transmission link (such as pilot channel, sync channel, paging channel, variable number of forward traffic channels) for testing and other traffic channels added as multi-user interference. This model also adjusts the traffic channel power ratio with the step of TrafficAdjustStep according to PCBit when PowerControl = Yes.
   The traffic channel data for different users and PCBit for these channels are multiple inputs; ADS automatically detects the connected traffic users then calculates the corresponding power ratio. Other traffic channel data added for multi-user interference can be input through pin MoreUr.
   During simulation, the AWGN signal can be used as multi-user data. If the number of more users is n, and power of one user is P, then multi-user power data will be n × P. Note that the sum of the number of more users and the number of users for testing will be less than the number set by PermitdActiveUr.
   Each firing, BlockSize D_out tokens are produced when BlockSize Pilot, BlockSize Sync, BlockSize Paging, BlockSize UrData, BlockSize MoreUr, and 1 PCBit tokens are consumed.

References

1. TIA/EIA/IS-2000.2 (PN-4428), Physical Layer Standard for cdma2000 Spread Spectrum Systems, July 1999.

CDMA2K_FwdPwrAlloc



Description Power allocator for base station channels
Library cdma2000, Transmission
Class SDFCDMA2K_FwdPwrAlloc

Parameters

Name	Description	Default	Sym	Type	Range
TransmitDiversity	transmit diversity enable: NON_TD, TD	NON_TD		enum	
PilotPowerRatio	pilot channel power to total power ratio	0.2		real	(0, 1) †
SyncPowerRatio	sync channel power to total power ratio	0.025		real	[0, 1)
PagingPowerRatio	paging channel power to total power ratio	0.063		real	[0, 1)
TDPilotPowerRatio	transmit diversity pilot channel power to total power ratio	0.2		real	(0, 1) if TransmitDiversity=TD
WalshLength	length of Walsh code	64	N	int	2^n, n=6,...,11
PermitdActiveUr	number of permitted active users in forward link	30		int	[6, N-3-(N/64)] if TransmitDiversity = NON_TD; [6, (N-3-(N/64))/2] if TransmitDiversity = TD
OrthogonalChNum	number of the orthogonal channel to form the noise, in TD mode, it will be double of number of orthogonal users	29		int	[0, PermitdActiveUr-sizeof(UrData)] if TransmitDiversity=NON_TD; [0, 2×PermitdActiveUr-1]
PowerControl	enable the power control: Yes, No	Yes		enum	
TrafficAdjustStep	traffic channel power adjust step	1		real	(0, ∞)
IgnoreNum	number of initially ignored firings	1		int	[0, ∞)

† The sum of PilotPowerRatio, SyncPowerRatio, and PagingPowerRatio must be < 1 if TransmitDiversity = NON_TD; the sum of PilotPowerRatio, SyncPowerRatio, PagingPowerRatio, and TDPilotPowerRatio must be < 1 if TransmitDiversity =TD.

Pin Inputs

Pin	Name	Description	Signal Type
1	OCN_Ur	user data as orthogonal channel noise	complex
2	UrData	Traffic Channel data of users for testing	multiple complex
3	PCBit	power control bit	multiple int

Pin Outputs

Pin	Name	Description	Signal Type
4	D_out	output data	complex

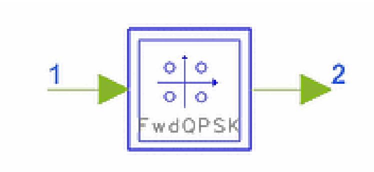
Notes/Equations

1. This model is used to allocate power ratio to the forward transmission link (including pilot channel, transmit diversity pilot channel, sync channel, paging channel, variable number of forward traffic channels concerned and other traffic channels not concerned) and adjust the traffic channel power ratio with the step of TrafficAdjustStep according to PCBit when PowerControl = Yes.
   Traffic channel data for different users and PCBit for these channels are multiple inputs; ADS can automatically detect the connected traffic users. Orthogonal channel data added for multi-user interference can be imported through pin OCN_Ur. If the number of users is n, and the power of one user is P, then multi-user power data will be n × P. Note that the sum of the number of OCN users and the number of users for the test will be less than the number set by the PermitdActiveUr parameter.
   - Each firing,
     - if TransmitDiversity = *NON_TD*, 1536 D_out tokens are produced when 1536 UrData tokens, 1536 OCN_Ur tokens, and 1 PCBit token are consumed;
     - if TransmitDiversity = *TD*, 3072 D_out tokens are produced when 3072 UrData tokens, 3072 OCN_Ur tokens and 1 PCBit token are consumed.
   - D_out can be determined by:
     $CombinedSignalPower = \Sigma(EachChannel \times RelativeRatio)$
     Each traffic channel, as well as the channels simulated as signal of OCN_Ur, are assumed to have the same power initially. Then if PCBit is 0 the base station will increase the corresponding traffic channel power ratio at a TrafficAdjustStep value, otherwise the base station will decrease it at a TrafficAdjustStep value. At the same time, the ratio between power of pilot channel and average power of all traffic channels remains a constant value- the pilot channel power will not be changed when traffic channel powers are changed.

References

1. 3GPP2 C.S0002_A_1, "Physical Layer Standard for cdma2000 Spread Spectrum Systems Release A-Addendum 1," Oct. 27, 2000.
2. 3GPP2 TSG-C Interim Plenary, "Recommended Minimum Performance Standards for cdma2000 Spread Spectrum Mobile Stations: Release A," Nov. 27, 2000.
3. 3GPP2 TSG-C4.1,"Recommended Minimum Performance Standards for cdma2000 Spread Spectrum Base Stations: Release A," Oct. 26, 2000.

CDMA2K_FwdQPSK



Description QPSK Modulator for Base Station Channels
Library cdma2000, Transmission
Class SDFCDMA2K_FwdQPSK

Parameters

Name	Description	Default	Type	Range
PN_Offset	offset of PN code	0	int	[0, 512)
I_PhaseCodeType	type of I-phase PN code: SR1 I phase, SR3 I phase	SR1 I phase	enum	
Q_PhaseCodeType	type of Q-phase PN code: SR1 Q phase, SR3 Q phase	SR1 Q phase	enum	
Q_Phase	sign of sine: Sine, Minus Sine	Minus Sine	enum	

Pin Inputs

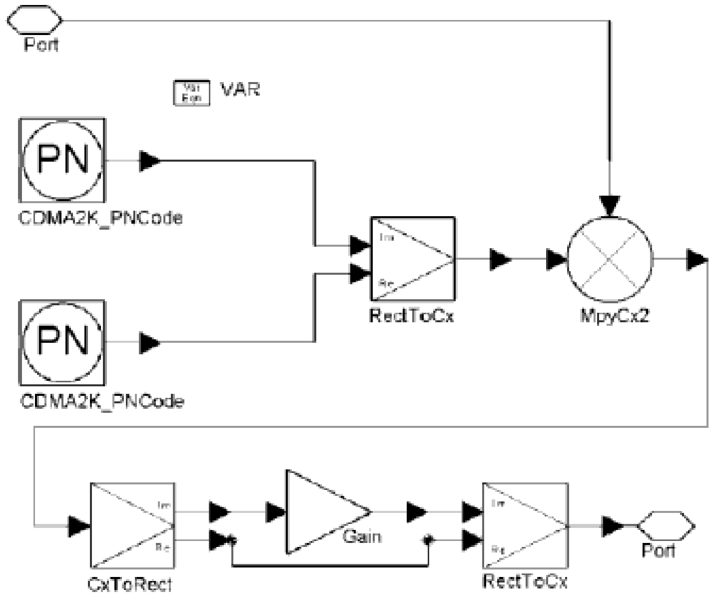
Pin	Name	Description	Signal Type
1	D_in	input data	complex

Pin Outputs

Pin	Name	Description	Signal Type
2	D_out	output data	complex

Notes/Equations

1. This subnetwork is used to implement forward QPSK modulation. Input data is spread by I- and Q-phase PN codes.
   The following figure shows the schematic for this subnetwork.

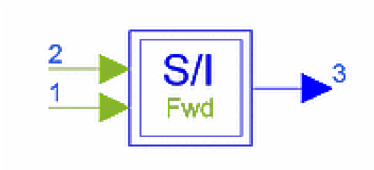


CDMA2K_FwdQPSK Subnetwork

References

1. TIA/EIA/IS-2000.2 (PN-4428), Physical Layer Standard for cdma2000 Spread Spectrum Systems, July 1999.

CDMA2K_FwdSIREstimate



Description SIR Estimator for Forward Link
Library cdma2000, Transmission
Class SDFCDMA2K_FwdSIREstimate

Parameters

Name	Description	Default	Sym	Type	Range
SpreadRate	PN chip rate, multiple of 1.2288 Mcps: SR1, SR3	SR1		enum	
WalshLength	length of Walsh code	64	N	int	2^n, n=1,...,11
PilotGain	pilot gain	1.0		real	(0, ∞)

Pin Inputs

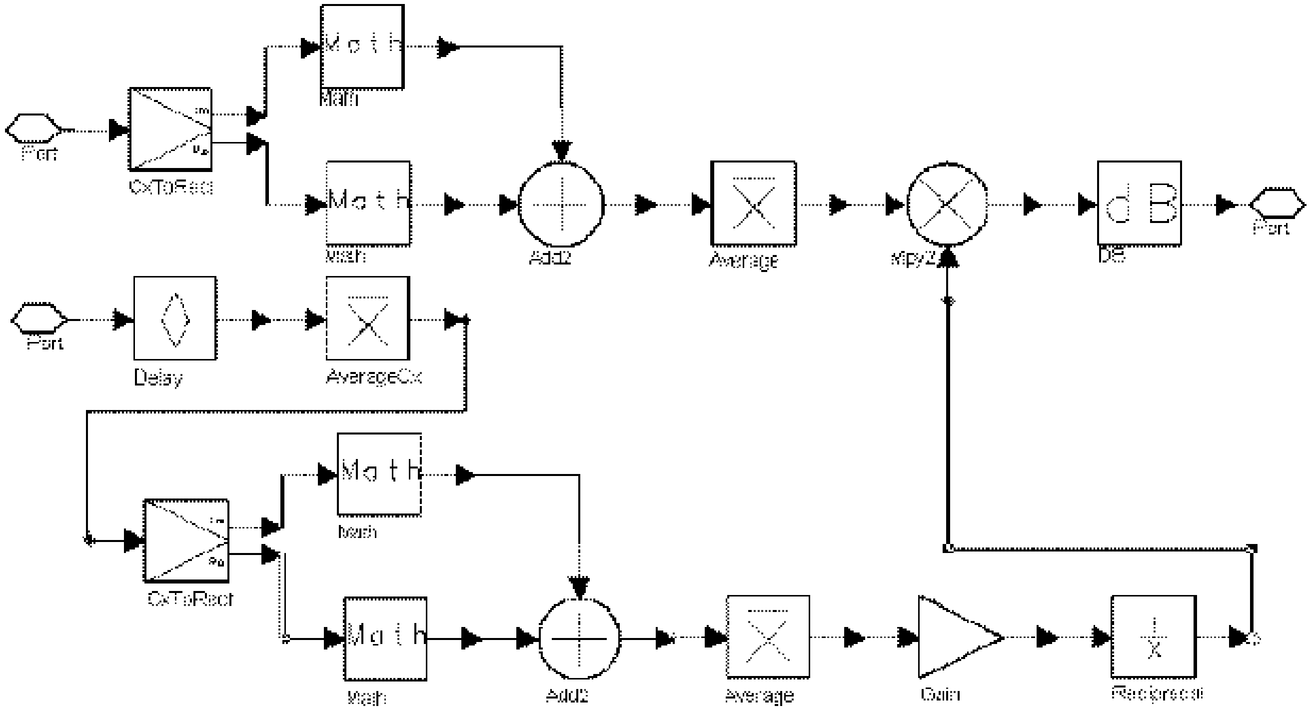
Pin	Name	Description	Signal Type
1	SigIn	signal from filter of receiving end	complex
2	D_in	data from Rake receiver	complex

Pin Outputs

Pin	Name	Description	Signal Type
3	SIR	signal-to-interference ratio	real

Notes/Equations

1. This subnetwork is used to estimate the signal-to-interference ratio for forward link. The following figure shows the schematic for this subnetwork.
   D_in data from the Rake receiver is considered as the signal; SigIn data from the receiving filter is used to calculate noise power; SIR is the power ratio of the two.

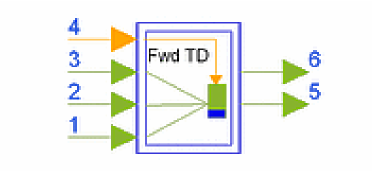


CDMA2K_FwdSIREstimate Subnetwork

References

1. TIA/EIA/IS-2000.2 (PN-4428), Physical Layer Standard for cdma2000 Spread Spectrum Systems, July 1999.

CDMA2K_FwdTDpwrAlloc



Description Power allocator for base station channels in transmit diversity mode
Library cdma2000, Transmission
Class SDFCDMA2K_FwdTDpwrAlloc

Parameters

Name	Description	Default	Sym	Type	Range
PilotPowerRatio	pilot channel power to total power ratio	0.2		real	(0, 1) †
SyncPowerRatio	sync channel power to total power ratio	0.0471		real	[0, 1)
PagingPowerRatio	paging channel power to total power ratio	0.1882		real	[0, 1)
TDPilotPowerRatio	transmit diversity pilot channel power to total power ratio	0.2		real	[0, 1)
WalshLength	length of Walsh code	64	N	int	2^n, n=6,...,11
PermitdActiveUr	number of permitted active users in forward link	6		int	[6, (N - 3 - (N/64))/2]
OrthogonalChNum	number of the orthogonal channel to form the noise, in TD mode, it will be double of number of orthogonal users	10		int	[0, 2 * (PermitdActiveUr-1)]
PowerControl	enable the power control: Yes, No	Yes		enum	
TrafficAdjustStep	traffic channel power adjust step	1.0		real	(0, ∞)

† The sum of PilotPowerRatio, SyncPowerRatio, PagingPowerRatio, and TDPilotPowerRatio must be < 1.

Pin Inputs

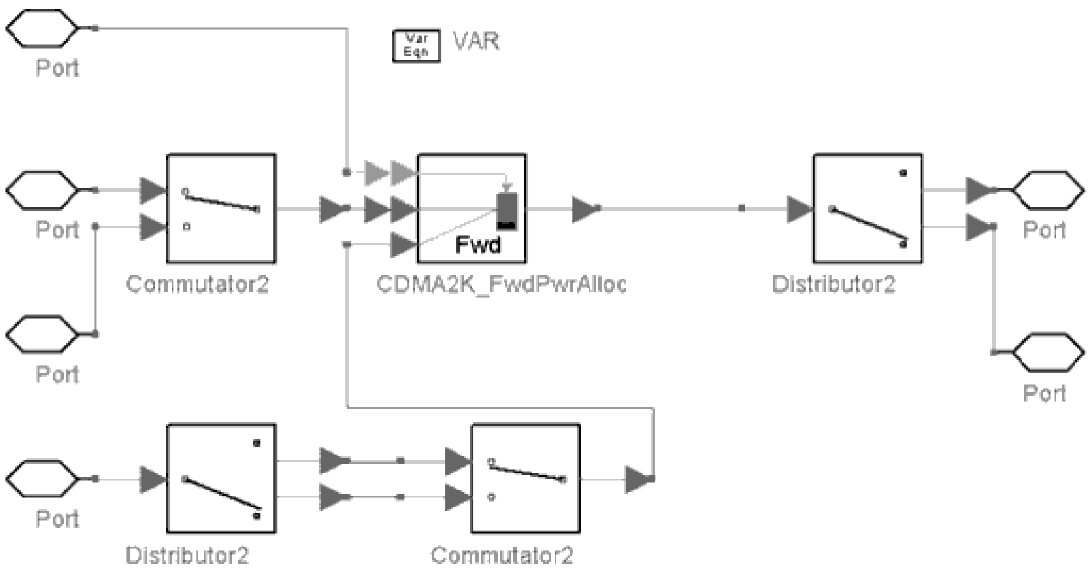
Pin	Name	Description	Signal Type
1	MainIn	traffic channel data of user for testing that is associated with the transmit diversity pilot channel	complex
2	TDin	traffic channel data of user for testing that is associated with the transmit diversity pilot channel	complex
3	OCN_Ur	user data as orthogonal channel noise	complex
4	PCBit	power control bit	int

Pin Outputs

Pin	Name	Description	Signal Type
5	MainOut	output data of user for testing that is associated with the transmit diversity pilot channel	complex
6	TDout	output data of user for testing that is associated with the transmit diversity pilot channel	complex

Notes/Equations

1. This subnetwork is used to allocate power ratio to the forward transmission link (including pilot channel, transmit diversity pilot, sync channel, paging channel, variable number of forward traffic channels concerned and other traffic channels not concerned) and adjust the traffic channel power ratio with the step of TrafficAdjustStep according to PCBit when PowerControl = Yes.
   The schematic for this subnetwork is shown in the following figure.

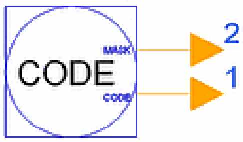


CDMA2K_FwdTDpwrAlloc Subnetwork

References

1. 3GPP2 C.S0002_A_1, "Physical Layer Standard for cdma2000 Spread Spectrum Systems Release A-Addendum 1," Oct. 27, 2000.
2. 3GPP2 TSG-C Interim Plenary, "Recommended Minimum Performance Standards for cdma2000 Spread Spectrum Mobile Stations: Release A," Nov. 27, 2000.
3. 3GPP2 TSG-C4.1,"Recommended Minimum Performance Standards for cdma2000 Spread Spectrum Base Stations: Release A," Oct. 26, 2000.

CDMA2K_LongCodeGenerator



Description Long code generator
Library cdma2000, Transmission
Class SDFCDMA2K_LongCodeGenerator

Parameters

Name	Description	Default	Type	Range
ChannelType	type of channel: Access Channel, Reverse Traffic Channel RC1 To RC2, Enhanced Access Channel Header, Reverse Common Control Channel Reservation, Reverse Traffic Channel RC3 To RC6, Paging Channel, Broadcast Channel, Common Power Control Channel, Common Assignment Channel, Forward Common Control Channel, Forward Traffic Channel	Access Channel	enum	
CodeChannelIndex	code channel index	0	int	[0, 7]
ACN	access channel number	0	int	[0, 31]
PCN	paging channel number	0	int	[0, 7]
BASE_ID	base station identification	0	int	[0, 65535]
PILOT_PN	pilot PN code offset index for the forward channel	0	int	[0, 511]
ESN1	first 16-bit electronic serial number	0	int	[0, 65535]
ESN2	last 16-bit electronic serial number	0	int	[0, 65535]
EACN	enhanced access channel number	0	int	[0, 31]
FCCCN	forward common control channel number	0	int	[0, 7]
RCCCN	reverse common control channel number	0	int	[0, 31]
SLOT_OFFSET	slot offset for enhanced access channel	0	int	[0, 511]
BCN	broadcast channel number	0	int	[0, 7]
CPCCN	common power control channel number	0	int	[0, 3]
CACN	common assignment channel number	0	int	[0, 7]

Pin Outputs

Pin	Name	Description	Signal Type
1	LgCode	long code	int
2	T_Mask	mask value for test	int

Notes/Equations

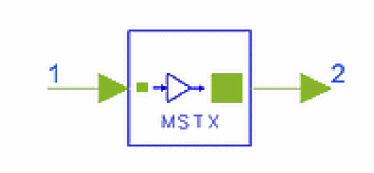
1. This model is used to generate m-sequence bits with the period of 2^{42-1} bit long. The

output is the sequence of logic value 0 or 1. The initial register status is:
{00,0000000000,0000000000,0000000000,0000000001}
(from the 42nd register to the first one) and shift 41 times.
There are 11 kinds of masks in IS-2000, each PN chip of the long code is generated by the modulo-2 inner product of a 42-bit mask and the 42-bit state vector of the sequence generator.
While mask 0 is not supported by this model, a ConstInt component (Numeric Sources library) with Level=0 can be used as a substitute.
Each firing, 1 LgCode and 42 T_Mask tokens are produced.

References

1. TIA/EIA/IS-2000.2 (PN-4428), Physical Layer Standard for cdma2000 Spread Spectrum Systems, July 1999.

CDMA2K_MSTX



Description Mobile station transmitter
Library cdma2000, Transmission
Class SDFCDMA2K_MSTX

Parameters

Name	Description	Default	Unit	Type	Range
MS_Power	output power of mobile station	0.2	W	real	(0, ∞)

Pin Inputs

Pin	Name	Description	Signal Type
1	D_in	input data	complex

Pin Outputs

Pin	Name	Description	Signal Type
2	D_out	output Data	complex

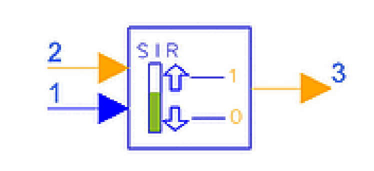
Notes/Equations

1. This model is used to allocate real transmission power for a mobile station. Each firing, 1 D_out token is produced when 1 D_in and 1 PCBit tokens are consumed.

References

1. TIA/EIA/IS-2000.2 (PN-4428), Physical Layer Standard for cdma2000 Spread Spectrum Systems, July 1999.

CDMA2K_PCBgenerator



Description Power control bit generator
Library cdma2000, Transmission
Class SDFCDMA2K_PCBgenerator

Parameters

Name	Description	Default	Type	Range
OuterLoop	outer loop power control enable: ENABLE, DISABLE	DISABLE	enum	
SIR_Threshold	signal-to-interference ratio required	0	real	(-∞, ∞)
SIR_AdjustStep	signal-to-interference ratio adjustment	1.0 0.2 0.1 0.02	real array	(0, ∞)
FER_Threshold	minimum frame error rate required	0.007	real	[0, 1)
IgnoreNum	number of initially ignored firings	1	int	[1, ∞)

Pin Inputs

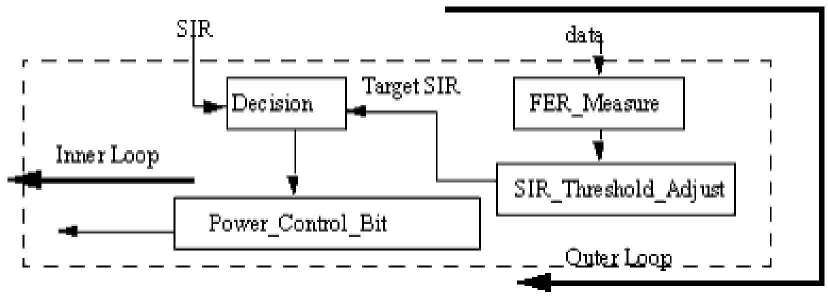
Pin	Name	Description	Signal Type
1	SIR	signal interference ratio	real
2	FrmErr	frame error indicator of current frame	int

Pin Outputs

Pin	Name	Description	Signal Type
3	PCBit	Power Control Bit	int

Notes/Equations

1. This model is used to generate the power control bit.
   Each firing, 1 PCBit token is produced when 1 SIR token and 1 FrmErr token are consumed.
   As shown in the following figure, the closed loop power control includes an inner and an outer loop.

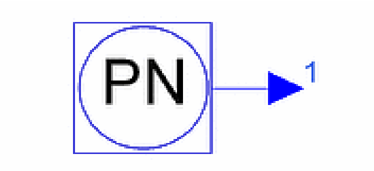


Power Control Block Diagram

References

1. 3GPP2 C.S0002_A_1, "Physical Layer Standard for cdma2000 Spread Spectrum Systems Release A-Addendum 1," Oct. 27, 2000.
2. 3GPP2 TSG-C Interim Plenary, "Recommended Minimum Performance Standards for cdma2000 Spread Spectrum Mobile Stations: Release A," Nov. 27, 2000.
3. 3GPP2 TSG-C4.1,"Recommended Minimum Performance Standards for cdma2000 Spread Spectrum Base Stations: Release A," Oct. 26, 2000.

CDMA2K_PNCode



Description PN code generator
Library cdma2000, Transmission
Class SDFCDMA2K_PNCode

Parameters

Name	Description	Default	Type	Range
PN_Offset	base station PN code offset	0	int	[0, 512)
CodeType	type of PN code: SR1 I phase, SR1 Q phase, SR3 I phase, SR3 Q phase	SR1 I phase	enum	

Pin Outputs

Pin	Name	Description	Signal Type
1	PNCode	PN code	real

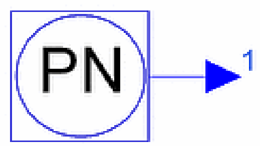
Notes/Equations

1. This model is used to generate pseudo noise code.
   Each firing, 1 PNCode token is produced.

References

1. TIA/EIA/IS-2000.2 (PN-4428), Physical Layer Standard for cdma2000 Spread Spectrum Systems, July 1999.

CDMA2K_PNCode_U



Description PN code generator, spec. 3GPP2 C.S0002-A-1, Oct. 2000.
Library cdma2000, Transmission
Class SDFCDMA2K_PNCode_U

Parameters

Name	Description	Default	Type	Range
PN_Offset	base station PN code offset	0	int	[0, 512)
CodeType	type of PN code: SR1 I phase, SR1 Q phase, SR3 I phase, SR3 Q phase	SR1 I phase	enum	

Pin Outputs

Pin	Name	Description	Signal Type
1	PNCode	PN code	real

Notes/Equations

1. This model is used to generate pseudo noise (PN) code.
   Each firing, 1 PNCode token is produced.
   - For *SR1 I phase* (Forward SR1 I phase, Forward MC SR3 I phase and Reverse SR1 I phase), PN code is a 2^{15-1} bits M-sequence inserted by another 0, the polynomial is:
     $$P_I(x) = x^{15} + x^{13} + x^9 + x^8 + x^7 + x^5 + 1$$
     The maximum length linear feedback shift register sequence {i(n)} based on the above polynomials are of length 2^{15-1} and can be generated by the following linear recursions:
     $$i(n) = i(n-15) \oplus i(n-10) \oplus i(n-8) \oplus i(n-7) \oplus i(n-6) \oplus i(n-2)$$
     where additions are modulo-2. In order to obtain the I sequences of period 2^{15}, a 0 is inserted in {i(n)} after 14 consecutive 0 outputs.
   - For ** *SR1 Q phase* (Forward SR1 Q phase, Forward MC SR3 Q phase and Reverse SR1 Q phase), PN code is a 2^{15-1} bits M-sequence inserted by another 0, the polynomial is:
     $$P_Q(x) = x^{15} + x^{12} + x^{11} + x^{10} + x^6 + x^5 + x^4 + x^3 + 1$$
     The maximum length linear feedback shift register sequence {q(n)} based on the above polynomials are 2^{15-1} and can be generated by the following linear recursions:
     $$q(n) = q(n-15) \oplus q(n-12) \oplus q(n-11) \oplus q(n-10) \oplus q(n-9) \oplus q(n-5) \oplus q(n-4) \oplus q(n-3)$$

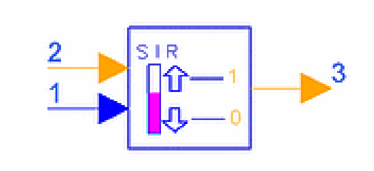
where additions are modulo-2. In order to obtain the I sequences of period 2 ,
a 0 is inserted in {q(n)} after 14 consecutive 0 outputs.

- For *SR3 I phase* (Forward DS SR3) and SR3 Q phase (Forward DS SR3), PN codes are both truncated M-sequence of length 2^{20-1} bits and truncating after 3×2^{15} chips, the polynomial is:
  $$P(x) = x^{20} + x^{9} + x^{5} + x^{3} + 1$$
  The maximum length linear feedback shift register sequence {b(n)} based on the above polynomials are 2^{20-1} and can be generated by the following linear recursions:
  $$b(n) = b(n-20) \oplus b(n-17) \oplus b(n-15) \oplus b(n-11)$$
  where additions are modulo-2. The I and Q PN sequences are both formed from this maximal length sequence of 2^{20-1} using different starting positions and truncating the sequence after 3×2^{15} chips.
  The starting position of the I PN sequence is such that the first chip is the 1 after the 19 consecutive 0s. The starting position of the Q PN sequence is the starting position of the I PN sequence delayed by 2^{19} chips.
  The mobile station will align the I and Q PN sequences such that the first 20 chips of the I and Q PN sequences on every even second mark as referenced to the transmit time reference are '1000 0000 0001 0001 0100' and '1001 0000 0010 0100 0101'.

References

1. 3GPP2 C.S0002_A_1, "Physical Layer Standard for cdma2000 Spread Spectrum Systems Release A-Addendum 1," Oct. 27, 2000.

CDMA2K_PowerControl



Description Power controller
Library cdma2000, Transmission
Class SDFCDMA2K_PowerControl

Parameters

Name	Description	Default	Type	Range
SIR_Threshold	signal-to-interference ratio required	0	real	[0, ∞)
SIR_AdjustStep	signal-to-interference ratio adjustment	1.0 0.2 0.1 0.02	real array	
FER_Threshold	minimum frame error rate required	0.007	real	[0, 1)
IgnoreNum	number of initially ignored firings	1	int	[0, ∞)

Pin Inputs

Pin	Name	Description	Signal Type
1	SIR	signal interference ratio	real
2	FrmErr	frame error indicator of current frame	int

Pin Outputs

Pin	Name	Description	Signal Type
3	PCBit	Power Control Bit	int

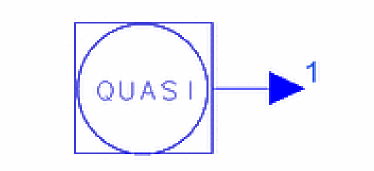
Notes/Equations

1. This model is used to generate the power control bit.
   Each firing, 1 PCBit token is produced when 1 SIR token and 1 FrmErr token are consumed.

References

1. TIA/EIA/IS-2000.2 (PN-4428), Physical Layer Standard for cdma2000 Spread Spectrum Systems, July 1999.

CDMA2K_QuasiOrthMask



Description Quasi-orthogonal mask generator
Library cdma2000, Transmission
Class SDFCDMA2K_QuasiOrthMask

Parameters

Name	Description	Default	Type
SpreadRate	PN chip rate; multiple of 1.2288 Mcps: SR1, SR3 MC, SR3 DS	SR1	enum
FunctionIndex	quasi-orthogonal function index: Function 0, Function 1, Function 2, Function 3	Function 0	enum

Pin Outputs

Pin	Name	Description	Signal Type
1	D_out	quasi-orthogonal mask symbol	real

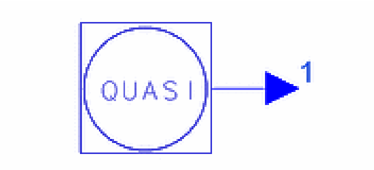
Notes/Equation

1. This model is used to generate quasi-orthogonal mask symbol.
   Each firing, 4 D_out tokens are produced.

References

1. TIA/EIA/IS-2000.2 (PN-4428), Physical Layer Standard for cdma2000 Spread Spectrum Systems, July 1999.

CDMA2K_QuasiOrthMask_U



Description Quasi-orthogonal mask generator, spec. 3GPP2 C.S0002-A-1, Oct. 2000.
Library cdma2000, Transmission
Class SDFCDMA2K_QuasiOrthMask_U

Parameters

Name	Description	Default	Type
FunctionIndex	quasi-orthogonal function index: Function 0, Function 1, Function 2, Function 3	Function 0	enum

Pin Outputs

Pin	Name	Description	Signal Type
1	D_out	quasi-orthogonal mask symbol	real

Notes/Equation

1. This model is used to generate quasi-orthogonal mask symbol. Each firing, 4 D_out tokens are produced.
2. Repeated sequence +1 and -1 should be output which correspond to the sign multiplier quasi-orthogonal function mask value of 0 and 1.

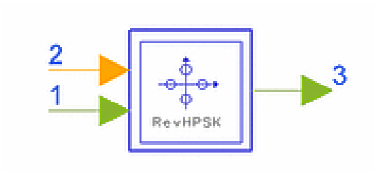
Masking Functions for Quasi-Orthogonal Functions for SR1 and SR3 MC Mode

Function	Binary Representation of Quasi-Orthogonal Mask
0	00000000000000000000000000000000 00000000000000000000000000000000
1	7228d7724eebebb1eb4eb1ebd78d8d28 278282d81b41be1b411b1bbe7dd8277d
2	114b1e4444e14beeee4be144bbe1b4ee dd872d77882d78dd2287d277772d87dd
3	1724bd71b28118d48ebddb172b187eb2 e7d4b27ebd8ee82481b22be7dbe871bd

References

1. 3GPP2 C.S0002_A_1, "Physical Layer Standard for cdma2000 Spread Spectrum Systems Release A-Addendum 1," Oct. 27, 2000.

CDMA2K_RevHPSK



Description HPSK Modulation for Mobile Station Channels
Library cdma2000, Transmission
Class SDFCDMA2K_RevHPSK

Parameters

Name	Description	Default	Type	Range
PN_Offset	offset of PN code	0	int	[0, 512)
I_PhaseCodeType	type of I-phase PN code: SR1 I phase, SR3 I phase	SR1 I phase	enum	
Q_PhaseCodeType	type of Q-phase PN code: SR1 Q phase, SR3 Q phase	SR1 Q phase	enum	
Q_Phase	sign of sine: Sine, Minus Sine	Minus Sine	enum	

Pin Inputs

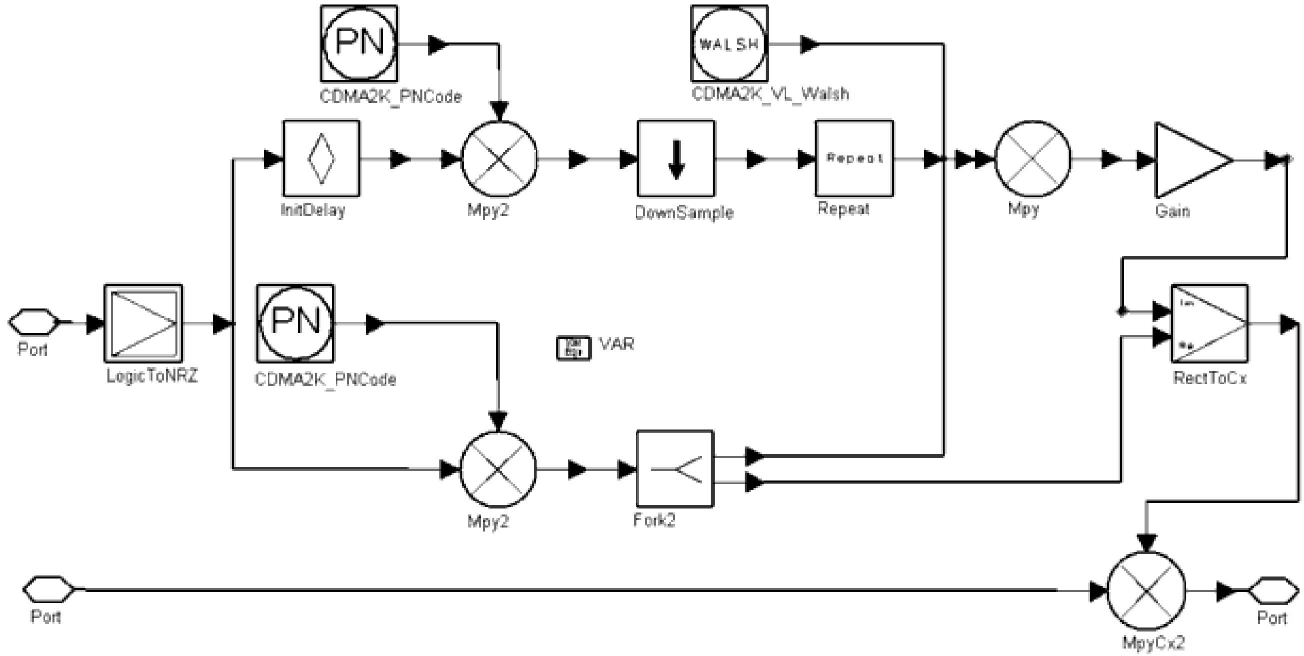
Pin	Name	Description	Signal Type
1	D_in	input data	complex
2	LgCode	long code	int

Pin Outputs

Pin	Name	Description	Signal Type
3	D_out	data after modulation	complex

Notes/Equations

1. This subnetwork is used to implement reverse HPSK modulation. The following figure shows the schematic for this subnetwork.

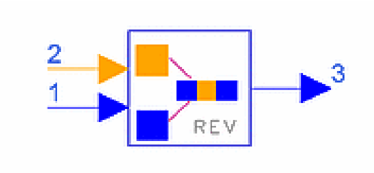


CDMA2K_RevHPSK Subnetwork

References

1. TIA/EIA/IS-2000.2 (PN-4428), Physical Layer Standard for cdma2000 Spread Spectrum Systems, July 1999.

CDMA2K_RevPCBitPuncture



Description Reverse power control bit puncture
Library cdma2000, Transmission
Class SDFCDMA2K_RevPCBitPuncture

Parameters

Name	Description	Default	Type
SpreadRate	PN chip rate; multiple of 1.2288 Mcps: SR1, SR3	SR1	enum

Pin Inputs

Pin	Name	Description	Signal Type
1	D_in	input data	real
2	PCBit	power contol bit	int

Pin Outputs

Pin	Name	Description	Signal Type
3	D_out	output data	real

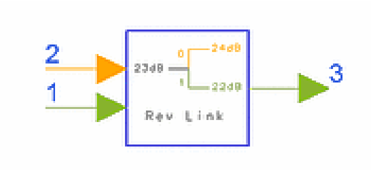
Notes/Equations

1. This model is used by the reverse pilot channel to insert power control bits into each power control group.
   Each firing,
   - for SR1, 1536 D_out tokens are produced when 1536 D_in and 1 PCBit tokens are consumed
   - for SR3, 1536×3 D_out tokens are produced when 1536 × 3 D_in and 1 PCBit tokens are consumed

References

1. TIA/EIA/IS-2000.2 (PN-4428), Physical Layer Standard for cdma2000 Spread Spectrum Systems, July 1999.

CDMA2K_RevPowerAdjust



Description Power adjuster for mobile station channels
Library cdma2000, Transmission
Class SDFCDMA2K_RevPowerAdjust

Parameters

Name	Description	Default	Type	Range
TrafficAdjustStep	power adjust step	1	real	0.25, 0.5, 1
BlockSize	number of particles in a block	6144	int	[1, ∞)
IgnoreNum	number of initially ignored firings	1	int	[0, ∞)

Pin Inputs

Pin	Name	Description	Signal Type
1	D_in	input data	complex
2	PCBit	power control bits	int

Pin Outputs

Pin	Name	Description	Signal Type
3	D_out	output data	complex

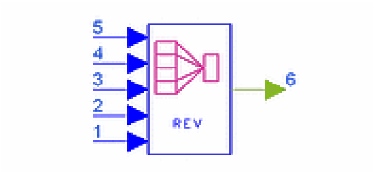
Notes/Equations

1. This model is used to adjust the reverse channel power with TrafficAdjustStep based on PCBit. A 0 power control bit implies an increase in transmit power; a 1 power control bit implies a decrease in transmit power.
   Each firing, BlockSize D_out tokens are produced when BlockSize D_in, and 1 PCBit tokens are consumed.

References

1. TIA/EIA/IS-2000.2 (PN-4428), Physical Layer Standard for cdma2000 Spread Spectrum Systems, July 1999.

CDMA2K_RevPowerAllocation



Description Relative power allocator for reverse channel
Library cdma2000, Transmission
Class SDFCDMA2K_RevPowerAllocation

Parameters

Name	Description	Default	Unit	Type	Range
PilotPower	power of pilot channel	1.0		real	(0, ∞)
ChannelEnable	enable or disable the channels RFC, RSC1, RSC2, RDCC and REAC_RCCC	1 0 0 0 0		int array	{0, 1}
DataRate	data rate of channels RFC, RSC1, RSC2, RDCC and REAC_RCCC; used when ChannelEnable=1	9600 9600 9600 9600 9600		int array	data rate for each channel defined in cdma2000 specification
FrameLength	frame length of channels RFC, RSC1, RSC2, RDCC and REAC_RCCC; used when ChannelEnable=1	20 20 20 20 20	sec	int array	{5, 20}
Coding	code used in RSC1 and RSC2; used when ChannelEnable=1: Convolutional Convolutional, Convolutional Turbo, Turbo Convolutional, Turbo Turbo	Convolutional Convolutional		enum	
RadioConfig	radio configuration: RC3, RC4, RC5, RC6	RC3		enum	

Pin Inputs

Pin	Name	Description	Signal Type
1	S1_EA_CC	reverse common control, enhanced access, or supplemental channel 1 data	real
2	RFC	reverse fundamental channel data	real
3	RDCC	reverse dedicated control channel data	real
4	RPC	reverse pilot channel data	real
5	RSC2	reverse supplemental chennal 2 data	real

Pin Outputs

Pin	Name	Description	Signal Type
6	SigOut	output data	complex

Notes/Equations

1. This model is used to allocate relative power for the reverse link (including reverse pilot channel, reverse fundamental channel, reverse supplemental channels, reverse dedicated control channel, enhanced access channel and reverse common control channels).

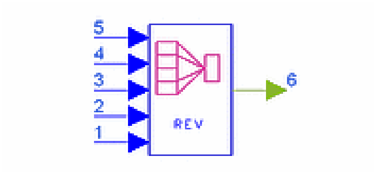
According to [1], when the reverse common control channel or enhanced access channel is used, the only additional channel is the reverse pilot channel. Binary signals from five inputs are represented as ±1, with the mapping +1 for 0 and −1 for 1, unused channels are represented with a 0 value.
Each firing, 1 Sigout token is produced when 1 S1_EA_CC, 1 RFC, 1 RDCC, 1 RPC and 1 RSC2 tokens are consumed.

2. This model does not support 10/40/80 msec frame length. CDMA2K_RevPowerAllocation_U is a more general model based on updated specifications that can be used for 5/10/20/40/80 msec frame length.

References

1. TIA/EIA/IS-2000.2 (PN-4428), Physical Layer Standard for cdma2000 Spread Spectrum Systems, July 1999.

CDMA2K_RevPowerAllocation_U



Description Relative power allocator for reverse channel, spec. 3GPP2 C.S0002-A-1, Oct. 2000.
Library cdma2000, Transmission
Class SDFCDMA2K_RevPowerAllocation_U

Parameters

Name	Description	Default	Unit	Type	Range
PilotPower	power of pilot channel	1.0		real	(0, ∞)
ChannelEnable	enable or disable the channels RFC, RSC1, RSC2, RDCC and REAC_RCCC	1 0 0 0 0		int array	{0, 1}
DataRate	data rate of channels RFC, RSC1, RSC2, RDCC and REAC_RCCC; used when ChannelEnable=1	9600 9600 9600 9600 9600		int array	refer to table below
FrameLength	frame length of channels RFC, RSC1, RSC2, RDCC and REAC_RCCC; used when ChannelEnable=1	20 20 20 20 20	sec	int array	refer to table below
Coding	code used in RSC1 and RSC2; used when ChannelEnable=1: Convolutional Convolutional, Convolutional Turbo, Turbo Convolutional, Turbo Turbo	Convolutional Convolutional		enum	
RadioConfig	radio configuration: RC3, RC4, RC5, RC6	RC3		enum	
FlexDataRate	radio config: Enable, Disable	Disable		enum	

Pin Inputs

Pin	Name	Description	Signal Type
1	S1_EA_CC	reverse common control, enhanced access, or supplemental channel 1 data	real
2	RFC	reverse fundamental channel data	real
3	RDCC	reverse dedicated control channel data	real
4	RPC	reverse pilot channel data	real
5	RSC2	reverse supplemental chennal 2 data	real

Pin Outputs

Pin	Name	Description	Signal Type
6	SigOut	output data	complex

Notes/Equations

1. This model is used to allocate relative power for the reverse link (including reverse pilot, reverse fundamental, reverse supplemental, reverse dedicated control, enhanced access, and reverse common control channels). According to standard [1],

when the reverse common control or enhanced access channel is used, the only additional channel is the reverse pilot channel. The binary signal from five inputs are represented, mapping +1 for 0 and -1 for 1; unused channels are represented with zero value.
Each firing, 1 Sigout token is produced when 1 S1EACC token, 1 RFC token, 1 RDCC token, 1 RPC token, and 1 RSC2 token are consumed.
2. Forward link data rates are given in the following table.

Forward Link Data Rates (bps)

	FrameLength (ms)	RC3	RC4	RC5	RC6
RFC	5	9600	9600	9600	9600
	20	1500, 2700, 4800, 9600	1800, 3600, 7200, 14400	1500, 2700, 4800, 9600	1800, 3600, 7200, 14400
RSC1	20	1500, 2700, 4800, 9600, 19200, 38400, 76800, 153600, 307200	1800, 3600, 7200, 14400, 28800, 57600, 115200, 230400	1500, 2700, 4800, 9600, 19200, 38400, 76800, 153600, 307200, 614400	1800, 3600, 7200, 14400, 28800, 57600, 115200, 230400, 460800, 1036800
	40	1350, 2400, 4800, 9600, 19200, 38400, 76800, 153600	1800, 3600, 7200, 14400, 28800, 57600, 115200	1350, 2400, 4800, 9600, 19200, 38400, 76800, 153600, 307200	1800, 3600, 7200, 14400, 28800, 57600, 115200, 230400, 518400
	80	1200, 2400, 4800, 9600, 19200, 38400, 76800	1800, 3600, 7200, 14400, 28800, 57600	1200, 2400, 4800, 9600, 19200, 38400, 76800, 153600	1800, 3600, 7200, 14400, 28800, 57600, 115200, 259200
RSC2	20	1500, 2700, 4800, 9600, 19200, 38400, 76800	1800, 3600, 7200, 14400, 28800, 57600, 115200	1500, 2700, 4800, 9600, 19200, 38400, 76800, 153600, 307200	1800, 3600, 7200, 14400, 28800, 57600, 115200, 230400
	40	1350, 2400, 4800, 9600, 19200, 38400, 76800, 153600, 307200	1800, 3600, 7200, 14400, 28800, 57600, 115200	1500, 2700, 4800, 9600, 19200, 38400, 76800, 153600, 307200	1800, 3600, 7200, 14400, 28800, 57600, 115200, 230400, 518400
	80	1200, 2400, 4800, 9600, 19200, 38400, 76800	1800, 3600, 7200, 14400, 28800, 57600	1200, 2400, 4800, 9600, 19200, 38400, 76800, 153600	1800, 3600, 7200, 14400, 28800, 57600, 115200, 259200
RDCC	5	9600	9600	9600	9600
	20	9600	14400	9600	14400
REAC_RCCC	5	9600, 38400			
	10	19200, 38400			
	20	9600, 19200, 38400			

3. ChannelEnable options are RFC, RSC1, RSC2, RDCC and REAC_RCCC. Reverse pilot channel is always active; it cannot be disabled.
4. The mobile station will set the output power of the reverse fundamental, reverse supplemental, and the reverse dedicated control channels relative to the output

power of the reverse pilot channel. The mobile station will transmit each of the reverse fundamental, reverse supplemental, and reverse dedicated control channels at an output power given by
mean code channel output power (dBm) =

mean pilot channel output power (dBm)
+ 0.125 × (Nominal_Attribute_Gain[Rate, Frame Duration, Coding]
+ Attribute_Adjustment_Gain[Rate, Frame Duration, Coding]
+ Reverse_Channel_Adjustment_Gain[Channel]
- Multiple_Channel_Adjustment_Gain[Channel]
+ RLGAIN_TRAFFIC_PILOTs
+ RLGAIN_SCH_PILOT[Channel]s).

where Channel identifies the fundamental, the dedicated control, and each supplemental channel.
The mobile station will maintain a reverse link nominal attribute gain table containing the nominal reverse fundamental, reverse supplemental, or reverse dedicated control channel power relative to the reverse pilot channel power for each transmission rate, frame duration, and coding rate supported by the mobile station. The mobile station will use the values given in the following table.

Reverse Link Nominal Attribute Gain Table

Data Rate (bps)	**Frame Length (ms)**	**Coding**	**Nominal Attribute Gain**	**Pilot Reference Level**	**Target Error Rate**
1200	80	Convolutional	-56	0	0.05
1350	40	Convolutional	-54	0	0.05
1500	20	Convolutional	-47	0	0.01
1800	20	Convolutional	-42	3	0.01
1800	40 or 80	Convolutional	-45	3	0.05
2400	40 or 80	Convolutional	-30	0	0.05
2700	20	Convolutional	-22	0	0.01
3600	20	Convolutional	-13	3	0.01
3600	40 or 80	Convolutional	-17	3	0.05
4800	20	Convolutional	-2	0	0.01
4800	40 or 80	Convolutional	-3	0	0.05
7200	20	Convolutional	15	3	0.01
7200	40 or 80	Convolutional	10	3	0.05
9600	20	Convolutional	30	0	0.01
9600	40 or 80	Convolutional	24	0	0.05
9600 (RC 3 and 5)	5	Convolutional	58	0	0.01
9600 (RC 4 and 6)	5	Convolutional	54	3	0.01
14400	20	Convolutional	44	3	0.01
14400	40 or 80	Convolutional	40	3	0.05
19200	20, 40 or 80	Convolutional	50	1	0.05
28800	20, 40 or 80	Convolutional	56	11	0.05
38400	20, 40 or 80	Convolutional	60	11	0.05
57600	20, 40 or 80	Convolutional	72	18	0.05

76800	20, 40 or 80	Convolutional	72	21	0.05
115200	20, 40 or 80	Convolutional	80	32	0.05
153600	20, 40 or 80	Convolutional	84	36	0.05
230400	20 or 40	Convolutional	88	46	0.05
259200	80	Convolutional	96	50	0.05
307200	20 or 40	Convolutional	96	54	0.05
460800	20	Convolutional	104	61	0.05
518400	40	Convolutional	104	64	0.05
614400	20	Convolutional	112	68	0.05
1036800	20	Convolutional	128	83	0.05
4800	80	Turbo	2	0	0.05
7200	80	Turbo	24	0	0.05
9600	40 or 80	Turbo	34	0	0.05
14400	40 or 80	Turbo	42	0	0.05
19200	20, 40 or 80	Turbo	44	2	0.05
28800	20, 40 or 80	Turbo	52	9	0.05
38400	20, 40 or 80	Turbo	56	10	0.05
57600	20, 40 or 80	Turbo	64	19	0.05
76800	20, 40 or 80	Turbo	68	19	0.05
115200	20, 40 or 80	Turbo	76	29	0.05
153600	20, 40 or 80	Turbo	76	33	0.05
230400	20 or 40	Turbo	88	39	0.05
259200	80	Turbo	88	48	0.05
307200	20 or 40	Turbo	88	50	0.05
460800	20	Turbo	104	54	0.05
518400	40	Turbo	108	56	0.05
614400	20	Turbo	112	58	0.05
1036800	20	Turbo	125	78	0.05

The mobile station will maintain a reverse link attribute adjustment gain table containing an offset relative to the reverse pilot channel power for each transmission rate, frame duration, and coding rate supported by the mobile station. The mobile station will initialize each entry in this table to 0. The mobile station will maintain a reverse channel adjustment gain table containing an offset relative to the reverse pilot channel power for each reverse link code channel supported by the mobile station. The mobile station will initialize each entry in this table to 0.
The adjustment RLGAIN_SCH_PILOT[Channel]s is valid for the reverse supplemental channel.
If the mobile station is transmitting on only one code channel in addition to the reverse pilot channel, the mobile station will set Multiple_Channel_Adjustment_Gain[Channel] to 0 for all code channels.
If the mobile station is transmitting on two or more code channels in addition to the reverse pilot channel, the mobile station will set Multiple_Channel_Adjustment_Gain[Channel] for each channel as follows:

- let Max_Channel identify the code channel with the highest Pilot_Reference_Level among the code channels on which the mobile station is transmitting.
- set Multiple_Channel_Adjustment_Gain[Max_Channel] to 0.

- for all other code channels, set Multiple_Channel_Adjustment_Gain [Channel] to Pilot_Reference_Level[Max_Channel] - Pilot_Reference_Level[Channel].

5. The mobile station will set the output power of the enhanced access channel header, the enhanced access channel data, and the reverse common control channel data relative to the output power of the reverse pilot channel. The mobile station will transmit the enhanced access channel header, enhanced access channel data, and reverse common control channel data at an output power given by
mean code channel output power (dBm) =

   mean pilot channel output power (dBm)
   + 0.125 × (Nominal_Reverse_Common_Channel_Attribute_Gain [Rate, Frame Duration])
   + 0.125 × RLGAIN_COMMON_PILOT s.

   The mobile station will maintain a nominal reverse common channel attribute gain table containing the relative header gain for the enhanced access channel header, and the relative data gain for the enhanced access channel data and reverse common channel data for each transmission rate and frame duration supported by the mobile station. The mobile station will use the values given in the following table.

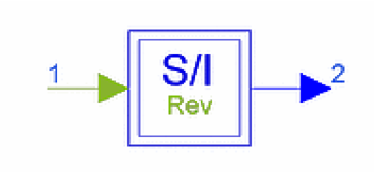
Nominal Reverse Common Channel Attribute Gain Table

Data Rate (bps)	Frame Length (ms)	Nominal Reverse Common Channel Attribute Gain
9600	5(Header)	50
9600	20	30
19200	10	64
19200	20	50
38400	5	88
38400	10	80
38400	20	72

References

1. 3GPP2 C.S0002_A_1, "Physical Layer Standard for cdma2000 Spread Spectrum Systems Release A-Addendum 1," Oct. 27, 2000.

CDMA2K_RevSIREstimate



Description SIR Estimator for Reverse Link
Library cdma2000, Transmission
Class SDFCDMA2K_RevSIREstimate

Parameters

Name	Description	Default	Sym	Type	Range
SpreadRate	PN chip rate, multiple of 1.2288 Mcps: SR1, SR3	SR1		enum	
WalshLength	length of Walsh code	16	N	int	2^n, n=1,...,11

Pin Inputs

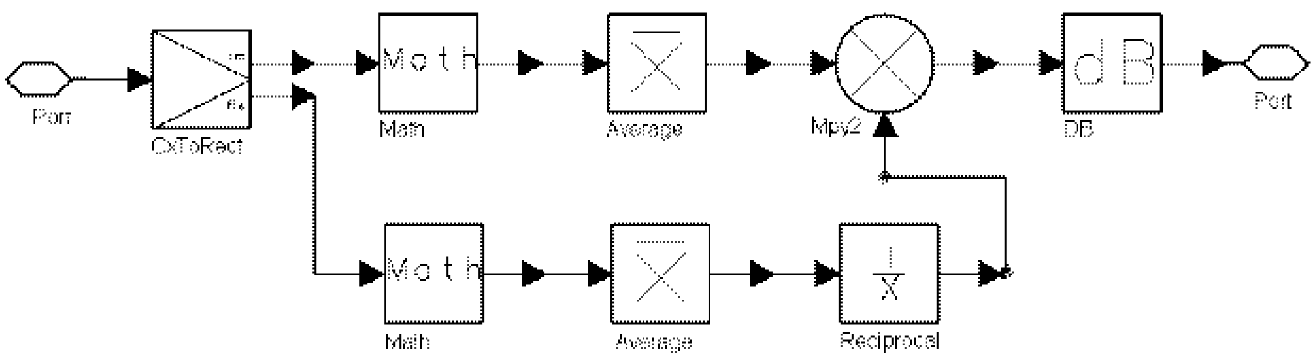
Pin	Name	Description	Signal Type
1	D_in	data from Rake receiver	complex

Pin Outputs

Pin	Name	Description	Signal Type
2	SIR	signal interference ratio	real

Notes/Equations

1. This subnetwork is used to estimate the signal-to-interference ratio for the reverse link.
   The following figure shows the schematic for this subnetwork.

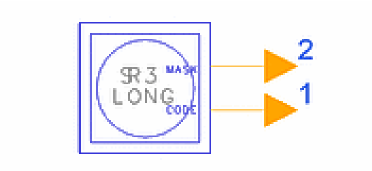


CDMA2K_RevSIREstimate Subnetwork

References

1. TIA/EIA/IS-2000.2 (PN-4428), Physical Layer Standard for cdma2000 Spread Spectrum Systems, July 1999.

CDMA2K_SR3LongCode



Description Long Code Generator for Spreading Rate 3
Library cdma2000, Transmission
Class SDFCDMA2K_SR3LongCode

Parameters

Name	Description	Default	Type	Range
ChannelType	type of channel: Access Channel, Reverse Traffic Channel RC1 To RC2, Enhanced Access Channel Header, Reverse Common Control Channel Reservation, Reverse Traffic Channel RC3 To RC6, Paging Channel, Broadcast Channel, Common Power Control Channel, Common Assignment Channel, Forward Common Control Channel, Forward Traffic Channel	Access Channel	enum	
CodeChannelIndex	code channel index	0	int	[0, 7]
ACN	access channel number	0	int	[0, 31]
PCN	paging channel number	0	int	[0, 7]
BASE_ID	base station identification	0	int	[0, 65535]
PILOT_PN	pilot PN code offset index for the forward channel	0	int	[0, 511]
ESN1	first 16-bit electronic serial number	0	int	[0, 65535]
ESN2	last 16-bit electronic serial number	0	int	[0, 65535]
EACN	enhanced access channel number	0	int	[0, 31]
FCCCN	forward common control channel number	0	int	[0, 7]
RCCCN	reverse common control channel number	0	int	[0, 31]
SLOT_OFFSET	slot offset for enhanced access channel	0	int	[0, 511]
BCN	broadcast channel number	0	int	[0, 7]
CPCCN	common power control channel number	0	int	[0, 3]
CACN	common assignment channel number	0	int	[0, 7]

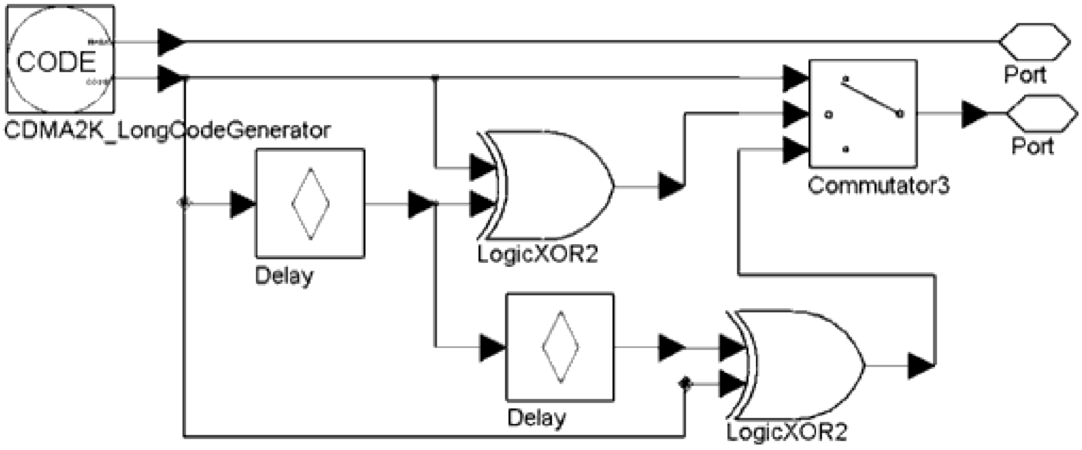
Pin Outputs

Pin	Name	Description	Signal Type
1	LgCode	long code	int
2	T_Mask	mask value for test	int

Notes/Equations

1. This subnetwork is used to generate the long code for spreading rate 3.

This subnetwork is shown in the following figure.

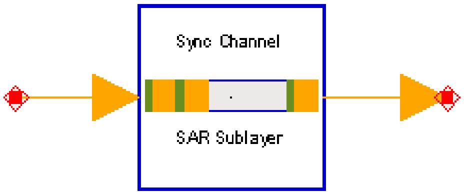


CDMA2K_SR3LongCode Subnetwork

References

1. TIA/EIA/IS-2000.2 (PN-4428), Physical Layer Standard for cdma2000 Spread Spectrum Systems, July 1999.

CDMA2K_SyncChSARSublayer



Description:Sync channel Segmentation and Reassembly (SAR) Sublayer process, add MSG_LENGTH, CRC and segment into fragments and add SOM bit
Library: cdma2k Transmission
Class: SDFCDMA2K_SyncChSARSublayer

Pin Inputs

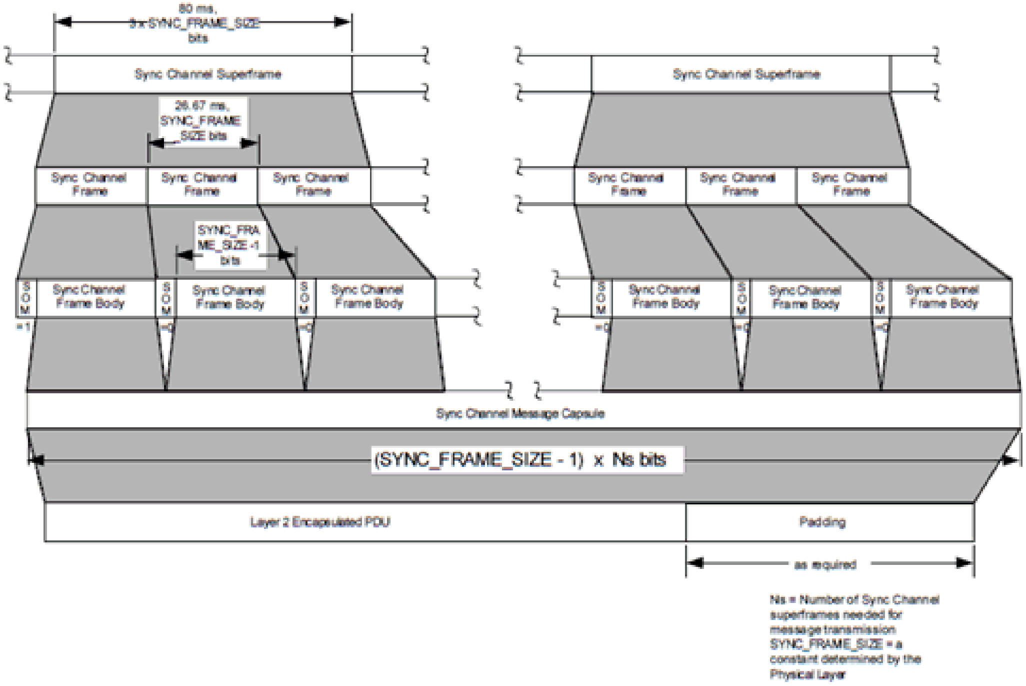
Pin	Name	Description	Signal Type
1	UtilityPDU_In	the Sync channel message	int

Pin Outputs

Pin	Name	Description	Signal Type
2	SuperFrame_Out	the PDU after the Sync channel Utility Sublayer process	int

Notes/Equations

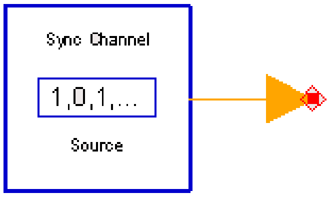
1. This model is to perform the segmentation and reassembly (SAR) sublayer process.
2. Each firing, 186 tokens are consumed at the input and 288 tokens are produced at the output.
3. In this model, a 8bits “MSG_LENGTH” is added in the front and a 30bits CRC result is added in the end. Then the length becomes 186+8+30=224bits. The value of the “MSG_LENGTH” should be 224/8 = 28D.
4. After that, 55 zeros will be padded at the end to fulfill 3 super frames. The length becomes 224+55=279 bits.
5. Then the total 279bits are segmented into 9 frames, each contain 31 bits. A Start of Message filed (SOA) 1 bit is added in the front of each frame. The first frame SOA is 1, others are 0. The length becomes (31+1)*9=288bits.
6. One super frame contains three frames, so there are 3 super frames in the Sync channel, each contains 96 bits and the length of a super frame is 80 ms.
7. The whole process is demonstrated as below.



References

1. 33GPP2 C.S0004-0, “Signaling Link Access Control (LAC) Standard for cdma2000 Spread Spectrum Systems,” July 1999.

CDMA2K_SyncChSource



Description: Sync channel source generation
Library: cdma2000, Transmission
Class: SDFCDMA2K_SyncChSource

Parameters

Name	Description	Default	Unit	Type	Range
P_REV	Protocol revision level, length is 8 bits	6	None	int	0-255
MIN_P_REV	Minimum protocol revision level, lenght is 8 bits	6	None	Integer	0-255
SID	System ID, length is 15 bits	331	None	int	0-32767
NID	Network ID, length is 16 bits	1	None	Integer	0-65535
PILOT_PN	PN Offset for the cell in units of 64 PN chips, length is 9 bits	12	None	Integer	0-511
SYS_TIME_Mode	the mode to set the Init_SYS_TIME parameter, Hex Array will let you input a hex array into the Init_SYS_TIME, the order is MSB--LSB, while the Date & Time mode will let to input a decimal array with the order of month,day,year,hour,minute,second,millisecond	Hex Array		enum	
Init_SYS_TIME	the System Time as of four Sync Channel superframes (320 ms) after the end of the last superframe containing any part of this Sync Channel Message, minus the pilot PN sequence offset, in units of 80 ms, length is 36 bits	0X02, 0X4F, 0X3B, 0X97, 0XBB		int array	0-255
LTM_OFF	Offset of local time from System Time, lenght is 6 bits	0	None	Integer	0-63
DAYLT	Daylight savings time indicator, lenght is 1 bits	0	None	Integer	0-1
PRAT	Paging Channel data rate, lenght is 2 bits	0	None	Integer	0-3
CDMA_FREQ	Frequency assignment, length is 11 bits	525	None	Integer	0-2047
EXT_CDMA_FREQ	Extended frequency assignment, length is 11 bits	525	None	Integer	0-2047
LP_SEC	The number of leap seconds that have occurred since the start of System Time, lenght is 8 bits	0	None	int	0-255

Pin Outputs

Pin	Name	Description	Signal Type
1	Message_Out	the Sync channel message output	int

Notes/Equations

1. This model is to generate the synchronization channel source.
2. Each firing, 173 bits are produced at the output.
3. There are 13 message content items in the Sync Channel, in which 11 items are

constant and could be set by the customer. I listed the 12 items as below and you can find 11 of them in the parameter list of the CDMA2K_SyncChSource model (except the "SYS_TIME" and "LC_STATE").

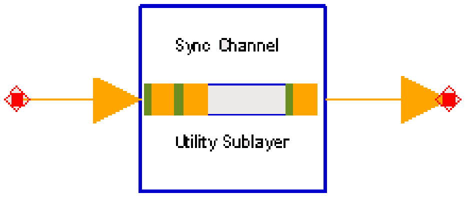
Field	Length (bits)
P_REV	8
MIN_P_REV	8
SID	15
NID	16
PILOT_PN	9
LC_STATE	42
SYS_TIME	36
LP_SEC	8
LTM_OFF	6
DAYLT	1
PRAT	2
CDMA_FREQ	11
EXT_CDMA_FREQ	11

4. Customers can set the initial system time and the software starts running in this system time and generate the follow system times. Each complete sync channel length is 240ms (3 super frames) and transmits continuously, so each "SYS_TIME" update is 240ms, that means the "SYS_TIME" will plus 3 (the "SYS_TIME" value is in the unit of 80ms).
5. There are two modes to set the initial system time.
   - When the parameter "SYS_TIME_Mode" is set to 1 (the label is "Date & TIME"), then customers can input an int array with the length of 7 into the parameter "Init_SYS_TIME". The meaning of the array is {month, day, year, hour, minute, second, millisecond}. For example, if the int array is {2, 27, 2005, 11, 33, 29, 840}, the initial system time is Feb. 27 2005 11:33:29.840. (Please make sure the initial system time could be divided by 80ms or it will send out an error message.)
   - When the parameter "SYS_TIME_Mode" is set to 0 (the label is "Hex Array"), then customers can input a hex value array with the length of 5 into the parameter "Init_SYS_TIME". The array is actually a hex value with the order of MSB—LSB. It represents the absolute system time in the unit of 80 ms from the Jan. 6 1980 00:00:00 (It is the starting of the system time). For example, if the hex array is {0X02, 0X4F, 0X3B, 0X97, 0XBB}, it mean the 36 bits "SYS_TIME" content will be filled with {0010 0100 1111 0011 1011 1001 0111 1011 1011} = 9919240123D. It also means the system time is Feb. 27 2005 11:33:29.840. Because the time between Jan. 6 1980 00:00:00 to Feb. 27 2005 11:33:29.840 is 9919240123*80ms.
6. The "LC_STATE" is auto calculated based on the corresponding "SYS_TIME".

References

1. 3GPP2 C.S0005-0, "Upper Layer (Layer 3) Signaling Standard for cdma2000 Spread Spectrum Systems," July 1999.

CDMA2K_SyncChUtilitySublayer



Description:Sync channel Utility Sublayer process
Library:cdma2000, Transmission
Class:SDFCDMA2K_SyncChUtilitySublayer

Pin Inputs

Pin	Name	Description	Signal Type
1	SDU_In	the Sync channel message	int

Pin Outputs

Pin	Name	Description	Signal Type
2	PDU_Out	the PDU after the Sync channel Utility Sublayer process	int

Notes/Equations

1. This model is to perform the utility sublayer process.
2. Each firing, 173 tokens are consumed at input and 186 tokens are produced at output.
3. In this model, a 8bits “MSG_TYPE” (00000001) will be added in the front of the input message and 5 0s will be padded in the end to meet the total length is 8k+2 bits. The output of this model is 173+8+5=186 bits.

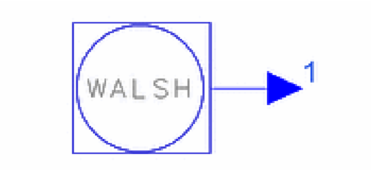
Field	Length (bits)
MSG_TYPE	8

Sync Channel Message	SCHM	00000001	sync

References

1. 33GPP2 C.S0004-0, “Signaling Link Access Control (LAC) Standard for cdma2000 Spread Spectrum Systems,” July 1999.

CDMA2K_VL_Walsh



Description Variable length Walsh code generator
Library cdma2000, Transmission
Class SDFCDMA2K_VL_Walsh

Parameters

Name	Description	Default	Sym	Type	Range
WalshLength	length of Walsh code	64	N	int	2^n, n=1,...,11
WalshCodeIndex	index of Walsh code	0		int	[0, 2^n - 1], n=1,...,11

Pin Outputs

Pin	Name	Description	Signal Type
1	Walsh	Walsh code	real

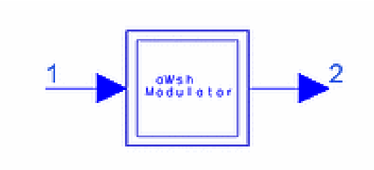
Notes/Equation

1. This model is used to generate a variable length Walsh code symbol. Each firing, 1 token is produced.

References

1. TIA/EIA/IS-2000.2 (PN-4428), Physical Layer Standard for cdma2000 Spread Spectrum Systems, July 1999.

CDMA2K_WalshModulator



Description Walsh Modulator
Library cdma2000, Transmission
Class SDFCDMA2K_WalshModulator

Parameters

Name	Description	Default	Sym	Type	Range
WalshLength	length of Walsh code	64	N	int	2^n, n=1,...,11
WalshCodeIndex	index of Walsh code	0		int	[0, N-1]

Pin Inputs

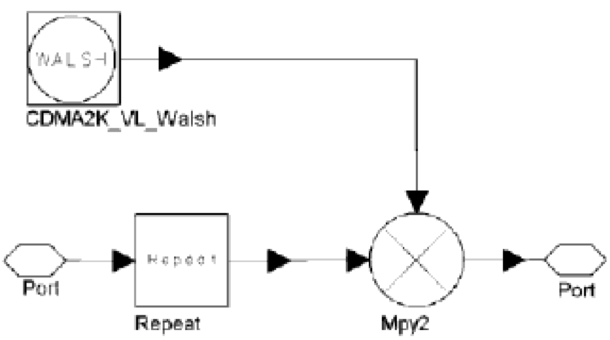
Pin	Name	Description	Signal Type
1	D_in	input data	real

Pin Outputs

Pin	Name	Description	Signal Type
2	D_out	output data	real

Notes/Equation

1. This subnetwork is used to spread input data to WalshLength bits with the Walsh code sequence of corresponding length and index.
   The following figure shows the schematic for this subnetwork.

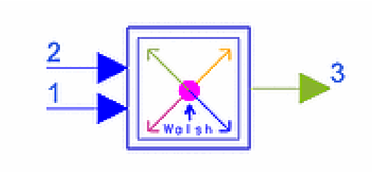


CDMA2K_WalshModulator Subnetwork

References

1. TIA/EIA/IS-2000.2 (PN-4428), Physical Layer Standard for cdma2000 Spread Spectrum Systems, July 1999.

CDMA2K_WalshRotateFunction



Description Walsh Rotate Function
Library cdma2000, Transmission
Class SDFCDMA2K_WalshRotateFunction

Parameters

Name	Description	Default	Type	Range
WalshLength	length of Walsh code	256	int	2^n, n=1,...,11
WalshCodeIndex	index of Walsh code	0	int	[0, N-1]
RotateType	type of rotate: Rotate, DeRotate	Rotate	enum	

Pin Inputs

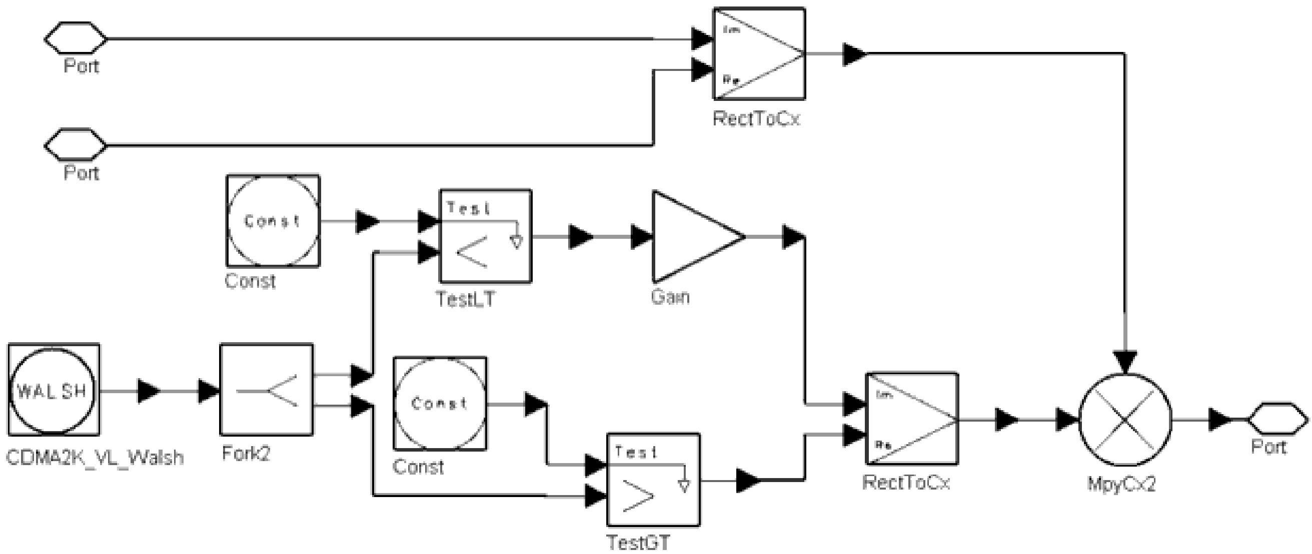
Pin	Name	Description	Signal Type
1	I_Data	data of in-phase path	real
2	Q_Data	data of quadrature-phase path	real

Pin Outputs

Pin	Name	Description	Signal Type
3	D_out	output data	complex

Notes/Equation

1. This subnetwork is used to implement non-zero rotate enable Walsh function. The following figure shows the schematic for this subnetwork.



CDMA2K_WalshRotateFunction Subnetwork

References

1. TIA/EIA/IS-2000.2 (PN-4428), Physical Layer Standard for cdma2000 Spread Spectrum Systems, July 1999.

Turbo Code Design Examples

Introduction

The CDMA2K_TurboCode_wrk shows examples for measuring turbo decoder BER performance. The following sections describe the designs and provide schematics and simulation results.

BER of Turbo Decoder (MAP)

- DsnCDMA2K_TurboCode

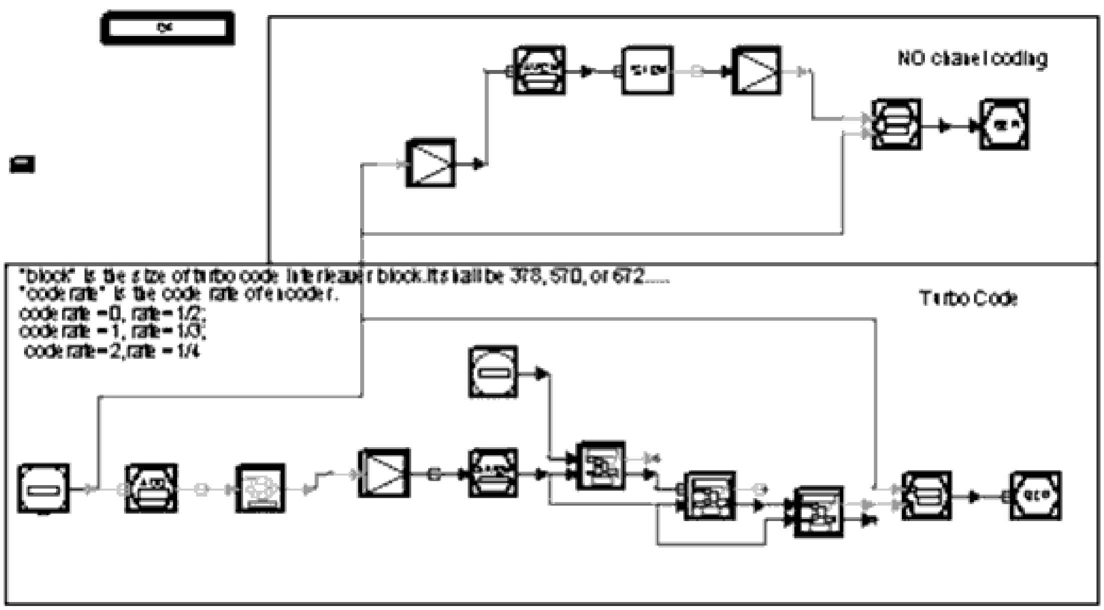
Features

- MAP algorithm
- 3-level MAP decoder
- BER curve
- Comparison of performance with and without turbo coder

Description

The Monte Carlo method is used to estimate the BER performance of the turbo code in AWGN channel. The BER performance without channel coding is measured and compared during the same simulation.

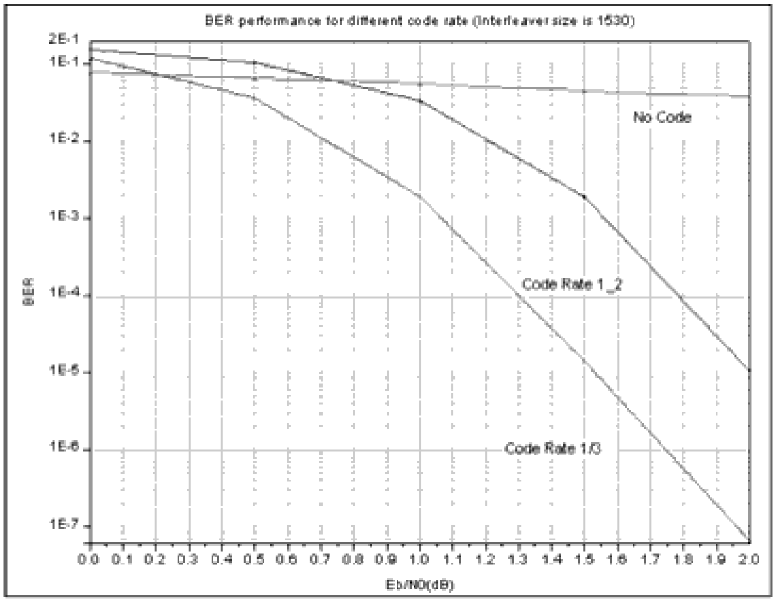
Schematic



DsnCDMA2K_TurboCode

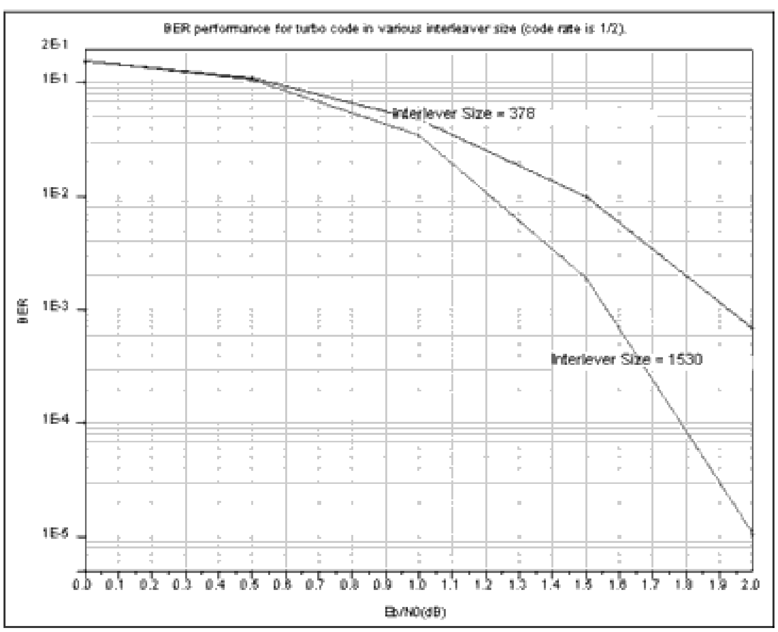
Simulation Results

The following figure shows BER performance with 1/2, 1/3 and 1/4 code rates, turbo code interleaver size is 1530, and *Eb/No* is 0 to 2 dB. The graph is saved in TurboCodeRate.dds; corresponding data is saved in TurboCodeResult1.ds.



BER Performance with Different Code Rates, Interleaver size of 1530

The following figure shows BER performance with a code rate of 1/2, turbo code interleaver sizes 378 and 1530, and *Eb/No* is 0 to 2 dB. The graph is in TurboIntlvrSize.dds; corresponding data is saved in TurboCodeResult.ds.



BER Performance with Code Rate of 1/2, Interleaver Sizes 378 and 1530

Benchmark

- Hardware platform: Pentium II 400 MHz, 256 Mb memory
- Software platform: Windows NT 4.0 Workstation, ADS 1.3
- Data points: 100,000 frames
- Simulation time: approximately 10 hours

Notes

The CDMA_AWGN_Ch and CDMA_BER_Sink models are used to obtain BER values based on *Eb/No* in one simulation. When the Monte Carlo method is used to estimate the BER, more symbols are used for higher *Eb/No* than are used for lower *Eb/No* to get the same reliability. For example, if four values are needed in one curve, to save simulation time the test can be done in two steps: test for low SNR and test for high SNR.