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Sources, Modulated-DSP-Based

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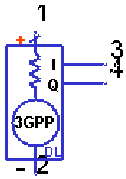
Contents

Chapter 1: Sources, Modulated-DSP-Based

3GPPFDD_DnLink (3GPP FDD Downlink Signal Source)

Symbol



Parameters

Name	Description	Default	Sym	Unit	Type	Range
Num	Port number for S-parameter and HB noise figure analysis	1			int	[1, ∞)
R	Source resistance	50 Ohm		Ohm	real	(0, ∞)
Temp	Temperature			Celsius	real	[-273.15, ∞)
Noise	Enable thermal noise? NO, YES	YES			enum	
MaxTimeStep	Expression showing how TStep is related to the other source parameters	1/3.84 MHz/SamplesPerChip			string	
FCarrier	Carrier frequency	2140 MHz		Hz	real	(0, ∞)
Power	Power	dbmtow(43.0)		W	real	[0, ∞)
MirrorSpectrum	Mirror spectrum about carrier? NO, YES	NO			enum	
GainImbalance	Gain imbalance, Q vs I	0.0		dB	real	(-∞, ∞)
PhaseImbalance	Phase imbalance, Q vs I	0.0		deg	real	(-∞, ∞)
I_OriginOffset	I origin offset (percent)	0.0			real	(-∞, ∞)
Q_OriginOffset	Q origin offset (percent)	0.0			real	(-∞, ∞)
IQ_Rotation	IQ rotation	0.0		deg	real	(-∞, ∞)
SamplesPerChip	Samples per chip	8	S		int	[2, 32]
RRC_FilterLength	RRC filter length (chips)	16			int	[2, 128]

Name	Description	Default	Sym	Unit	Type	Range
SpecVersion	Specification version: Version 03_00, Version 12_00, Version 03_02	Version 12_00			enum	
SourceType	Source type: TestModel1_16DPCHs, TestModel1_32DPCHs, TestModel1_64DPCHs, TestModel2, TestModel3_16DPCHs, TestModel3_32DPCHs, TestModel4	TestModel1_16DPCHs			enum	

Pin Outputs

Pin	Name	Description	Signal Type
1	RF	RF output	timed
2	Minus	Ground	timed
3	I	I symbols	real
4	Q	Q symbols	real

Notes/Equations

1. This 3GPP FDD signal source generates a downlink RF signal of 3GPP FDD test models. The RF signal has a chip rate of 3.84 MHz. The downlink is from the base station to the user equipment.

   To use this source, RF carrier frequency (FCarrier) and power (Power) must be set.

   RF impairments can be introduced by setting the R, Temp, Noise, MirrorSpectrum, GainImbalance, PhaseImbalance, I_OriginOffset, Q_OriginOffset, and IQ_Rotation parameters.

   3GPP FDD signal characteristics can be specified by setting the RRC_FilterLength, SpecVersion, and SourceType parameters.

   The maximum Circuit Envelope simulation time allowed is 1/3.84 MHz/SamplesPerChip. If the actual Circuit Envelope simulation time step is greater than this maximum allowed, the simulation will stop and display an error message.

2. An example (3GPPFDD_DnLink_test.dsn) demonstrating the use of this signal source is available under /examples/WCDMA3G/RF_Verification_prj.

3. This signal source includes a DSP section, RF modulator, and RF output resistance as illustrated in Figure 1-1.

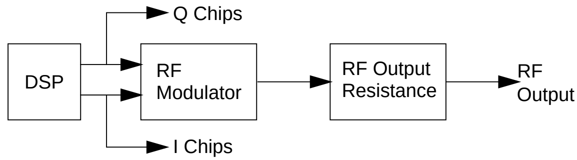


Figure 1-1. Signal Source Block Diagram

The R, Temp and Noise parameters are used by the RF output resistance. The FCarrier, Power, MirrorSpectrum, GainImbalance, PhaseImbalance, I_OriginOffset, Q_OriginOffset, and IQ_Rotation parameters are used by the RF modulator. The remaining signal source parameters are used by the DSP block.

The RF output from the signal source is at the frequency specified (FCarrier), with the specified source resistance (R) and with power (Power) delivered into a matched load of resistance R. The RF signal has additive Gaussian noise power set by the resistor temperature (Temp) (when Noise=yes).

The I and Q outputs are baseband outputs with zero source resistance and contain the unfiltered I and Q chips available at the RF modulator input. Because the I and Q outputs are from the inputs to the RF modulator, the RF output signal has a time delay relative to the I and Q chips. This RF time delay (RF_Delay) is related to the RRC_FilterLength parameter value.

RF_Delay = RRC_FilterLength/(3.84e6)/2 sec

4. This 3GPP FDD downlink signal source model is compatible with Agilent E4438C ESG Vector Signal Generator, Option 400 (3GPP W-CDMA Firmware Option for the E4438C ESG Vector Signal Generator).

   Details regarding Agilent E4438C ESG for 3GPP FDD are included at the website **http://www.agilent.com/find/esg**

5. Regarding the 3GPP downlink signal frame structure, one frame has a time duration of 10 msec and consists of 15 slots. Each slot contains 2560 chips. Each chip is an RF signal symbol.

   There is only one type of downlink dedicated physical channel, the downlink Dedicated Physical Channel (downlink DPCH).

Within one downlink DPCH, dedicated data generated at Layer 2 and above, i.e. the dedicated transport channel (DCH), is transmitted in time-multiplex with control information generated at Layer 1. The Layer 1 control information consists of known pilot bits to support channel estimation for coherent detection, transmit power-control (TPC) commands, and an optional transport-format combination indicator (TFCI). The TFCI informs the receiver about the instantaneous transport format combination of the transport channels mapped to the simultaneously transmitted downlink DPCH radio frame.

The downlink DPCH can therefore be seen as a time multiplex of a downlink DPDCH (Data1 and Data2) and a downlink DPCCH (TPC, TFCI, and Pilot).

The frame and slot structure of the downlink DPCH is illustrated in Figure 1-2. (Table 1-5 and Table 1-6 provide more information about each field.)

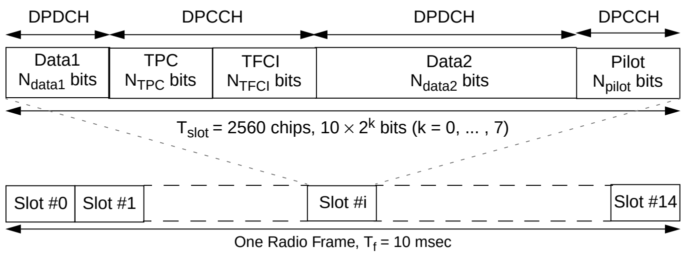


Figure 1-2. 3GPP FDD Downlink Frame and Slot Structure

6. Parameter Details

- Num defines the circuit port number for S-parameter and Harmonic Balance noise figure analysis only (it is not used for other circuit analysis).
- R is the RF output source resistance.
- Temp is the RF output source resistance temperature in Celsius and sets the noise density in the RF output signal to (k(Temp+273.15)) Watts/Hz, where k is Boltzmann's constant.
- Noise, when set to NO disables the Temp and effectively sets it to -273.15^{o}C (0 Kelvin). When set to YES, the noise density due to Temp is enabled.
- FCarrier is the RF output signal frequency.
- Power is the RF output signal power delivered into a matched load of resistance R.

- MirrorSpectrum is used to mirror the RF_out signal spectrum about the carrier. This is equivalent to conjugating the complex RF envelope voltage.

  Depending on the configuration and number of mixers in an RF transmitter, the RF output signal from hardware RF generators can be inverted. If such an RF signal is desired, set MirrorSpectrum to YES.

- GainImbalance, PhaseImbalance, I_OriginOffset, Q_OriginOffset, and IQ_Rotation are used to add certain impairments to the ideal output RF signal. Impairments are added in the order described here.

  The unimpaired RF I and Q envelope voltages have gain and phase imbalance applied. The RF is given by:

$$V_{RF}(t) = A\left(V_I(t)\cos(\omega_c t) - gV_Q(t)\sin\left(\omega_c t + \frac{\phi\pi}{180}\right)\right)$$

  where A is a scaling factor based on the Power and R parameters specified by the user, $V_I(t)$ is the in-phase RF envelope, $V_Q(t)$ is the quadrature phase RF envelope, g is the gain imbalance

$$g = 10^{\frac{GainImbalance}{20}}$$

  and, ϕ (in degrees) is the phase imbalance.

  Next, the signal $V_{RF}(t)$ is rotated by IQ_Rotation degrees. The I_OriginOffset and Q_OriginOffset are then applied to the rotated signal. Note that the amounts specified are percentages with respect to the output rms voltage. The output rms voltage is given by sqrt(2 R Power).

- SamplesPerChip is used to set the number of samples in a chip.

  The default value is set to 8 to display settings according to the 3GPP standard. It can be set to a larger value for a simulation frequency bandwidth wider than 8×3.84 MHz. It can be set to a smaller value for faster simulation; however, this will result in lower signal fidelity. If SamplesPerChip = 8, the simulation RF bandwidth is larger than the signal bandwidth by a factor of 8 (e.g., simulation RF bandwidth = 8×3.84 MHz).

- RRC_FilterLength is used to set root raised-cosine (RRC) filter length in number of chips.

The default value is set to 16 to transmit a 3GPP FDD downlink signal in time and frequency domains based on the 3GPP standard defined in [4]. It can be set to a smaller value for faster simulation times; however, this will result in lower signal fidelity.

- SpecVersion is used to specify the 3GPP specification versions (2000-03, 2000-12 and 2002-03).
- SourceType is used to specify the type of baseband signal that can be generated by this source based on the test model as defined in [5].

TestModel1_16DPCHs, **TestModel1_32DPCHs**, **TestModel1_64DPCHs.** Table 1-1 lists the active channels of Test Model 1, which tests spectrum emission mask, ACLR, spurious emissions, transmit intermodulation, and base station maximum output power.

TestModel2. Table 1-2 lists the active channels in Test Model 2, which tests output power dynamics.

TestModel3_16DPCHs, **TestModel3_32DPCHs.** Table 1-3 lists the active channels of Test Model 3, which tests peak code domain error.

TestModel4. Table 1-4 lists the active channels of Test Model 4, which tests EVM.

Table 1-1. Test Model 1 Active Channels

Type	Number of Channels	Fraction of Power (%)	Level Setting (dB)	Channelization Code	Timing Offset ($x256T_{chip}$)
PCCPCH+SCH	1	10	-10	1	0
Primary CPICH	1	10	-10	0	0
PICH	1	1.6	-18	16	120
SCCPCH containing PCH (SF=256)†	1	1.6	-18	3	0
DPCH (SF=128)††	16/32/64	76.8 total	see [5]	see [5]	see [5]

† SCCPCH containing PCH is not included in versions 2000-03 and 2000-12 [5].
†† Refer to Table 1-5 for DPCH structure.

Table 1-2. Test Model 2 Active Channels

Type	Number of Channels	Fraction of Power (%)	Level Setting (dB)	Channelization Code	Timing Offset (x256T_{chip})
PCCPCH+SCH	1	10	-10	1	0
Primary CPICH	1	10	-10	0	0
PICH	1	5	-13	16	120
S-CCPCH containing PCH (SF=256)	1	5	-13	3	0
DPCH (SF=128)††	3	2 x 10,1 x 50	2 x –10, 1 x –3	24, 72, 120	1, 7, 2

† SCCPCH containing PCH is not included in versions 2000-03 and 2000-12 [5].
†† Refer to Table 1-5 for DPCH structure.

Table 1-3. Test Model 3 Active Channels

Type	Number of Channels	Fraction of Power (%) 16/32	Level Settings (dB) 16/32	Channelization Code	Timing Offset (x256T_{chip})
PCCPCH+SCH	1	12.6/7.9	-9 / -11	1	0
Primary CPICH	1	12.6/7.9	-9 / -11	0	0
PICH	1	5/1.6	-13 / -18	16	120
SCCPCH containing PCH (SF=256) †	1	5/1.6	-13 / -18	3	0
DPCH (SF=256)††	16/32	63,7/80,4 total	see Reference [5]	see Reference [5]	see Reference [5]

† SCCPCH containing PCH is not included in versions 2000-03 and 2000-12 [5]
†† Refer to Table 1-6 for DPCH structure.

Table 1-4. Test Model 4 Active Channels

Type	Number of Channels	Fraction of Power (%) 16/32	Level Settings (dB) 16/32	Channelization Code	Timing Offset (x256T_{chip})
PCCPCH+SCH when Primary CPICH is disabled	1	50 to 1.6	-3 to -18	1	0
PCCPCH+SCH when Primary CPICH is enabled	1	25 to 0.8	-6 to -21	1	0
Primary CPICH†	1	25 to 0.8	-6 to -21	0	0

† Primary CPICH is optional; it is not included in versions 2000-03 and 2000-12 [5]

Table 1-5. DPCH Structure for Test Model 1 and Test Model 2

Slot Format No.	Channel Bit Rate (kbps)	Channel Symbol Rate (kbps)	SF	Bits / Slot	DPDCH Bits / Slot		DPCCH Bits / Slot		
					N_{Data1}	N_{Data2}	N_{TFCI}	N_{TPC}	N_{pilot}
10	60	30	128	40	6	24	0	2	8

Table 1-6. DPCH Structure for Test Model 3

Slot Format No.	Channel Bit Rate (kbps)	Channel Symbol Rate (kbps)	SF	Bits / Slot	DPDCH Bits / Slot		DPCCH Bits / Slot		
					N_{Data1}	N_{Data2}	N_{TFCI}	N_{TPC}	N_{pilot}
6	30	15	256	20	2	8	0	2	8

7. Use with Circuit Analyses

   The full features of this model are used with Circuit Envelope simulations; for other circuit simulations, it defaults to a simpler model.

   Signal output noise is based on Temp and Noise parameters and included in the RF output I and Q waveforms for Circuit Envelope (Env) analysis.

References

[1] 3GPP Technical Specification TS 25.211, “Physical channels and mapping of transport channels onto physical channels (FDD)” Release 1999.

http://www.3gpp.org/ftp/Specs/2002-03/R1999/25_series/25211-3a0.zip

[2] 3GPP Technical Specification TS 25.212, “Multiplexing and Channel Coding (FDD)” Release 1999.

http://www.3gpp.org/ftp/Specs/2002-03/R1999/25_series/25212-390.zip

[3] 3GPP Technical Specification TS 25.213, “Spreading and modulation (FDD)” Release 1999.

http://www.3gpp.org/ftp/Specs/2002-03/R1999/25_series/25213-370.zip

[4] 3GPP Technical Specification TS 25.104, “UTRA (BS) FDD; Radio transmission and Reception” Release 1999.

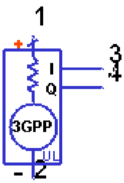
http://www.3gpp.org/ftp/Specs/2002-03/R1999/25_series/25104-3a0.zip

[5] 3GPP Technical Specification TS 25.141, “Base station conformance testing (FDD)” Release 1999.

http://www.3gpp.org/ftp/Specs/2002-03/R1999/25_series/25141-390.zip

3GPPFDD_UpLink (3GPP FDD Uplink Signal Source)

Symbol



Parameters

Name	Description	Default	Sym	Unit	Type	Range
Num	Port number for S-parameter and HB noise figure analysis	1			int	[1, ∞)
R	Source resistance	50 Ohm		Ohm	real	(0, ∞)
Temp	Temperature			Celsius	real	[-273.15, ∞)
Noise	Enable thermal noise? NO, YES	YES			enum	
MaxTimeStep	Expression showing how TStep is related to the other source parameters	1/3.84 MHz/SamplesPerChip			string	
FCarrier	Carrier frequency	1950 MHz		Hz	real	(0, ∞)
Power	Power	dbmtow(24.0)		W	real	[0, ∞)
MirrorSpectrum	Mirror spectrum about carrier? NO, YES	NO			enum	
GainImbalance	Gain imbalance, Q vs I (dB)	0.0		dB	real	(-∞, ∞)
PhaseImbalance	Phase imbalance, Q vs I	0.0		deg	real	(-∞, ∞)
I_OriginOffset	I origin offset (percent)	0.0			real	(-∞, ∞)
Q_OriginOffset	Q origin offset (percent)	0.0			real	(-∞, ∞)
IQ_Rotation	IQ rotation	0.0		deg	real	(-∞, ∞)
SamplesPerChip	Samples per chip	8	S		int	[2, 32]
RRC_FilterLength	RRC filter length (chips)	16			int	[2, 128]
SpecVersion	Specification version: Version 03_00, Version 12_00, Version 03_02	Version 12_00			enum	
SourceType	Source type: UL_12_2, UL_768	UL_12_2			enum	

Pin Outputs

Pin	Name	Description	Signal Type
1	RF	RF output	timed
2	Minus	Ground	timed
3	I	I symbols	real
4	Q	Q symbols	real

Notes/Equations

1. This 3GPP FDD uplink signal source generates a 12.2 and 768 kbps uplink RF signal with one dedicated transport channel (DTCH) and one dedicated control channel (DCCH). The RF signal has a chip rate of 3.84 MHz. The uplink is from the user equipment to the base station.

   To use this source, RF carrier frequency (FCarrier) and power (Power) must be set.

   RF impairments can be introduced by setting the R, Temp, Noise, MirrorSpectrum, GainImbalance, PhaseImbalance, I_OriginOffset, Q_OriginOffset, and IQ_Rotation parameters.

   3GPP FDD signal characteristics can be specified by setting the RRC_FilterLength, SpecVersion, and SourceType parameters.

   The maximum Circuit Envelope simulation time allowed is 1/3.84 MHz/SamplesPerChip. If the actual simulation Circuit Envelope simulation time step is greater than this maximum allowed, the simulation will stop and display an error message.

2. An example (3GPPFDD_UpLink_test.dsn) demonstrating the use of this signal source is available under /examples/WCDMA3G/RF_Verification_prj.

3. This signal source includes a DSP block, an RF modulator, and RF output resistance as illustrated in Figure 1-3.

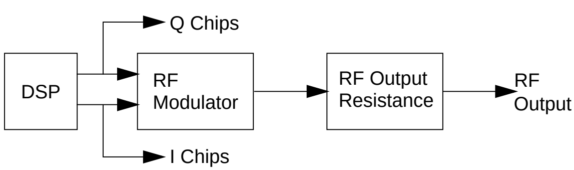


Figure 1-3. Signal Source Block Diagram

The R, Temp and Noise parameters are used by the RF output resistance. The FCarrier, Power, MirrorSpectrum, GainImbalance, PhaseImbalance, I_OriginOffset, Q_OriginOffset, and IQ_Rotation parameters are used by the RF modulator. The remaining signal source parameters are used by the DSP block.

The RF output from the signal source is at the frequency specified (FCarrier), with the specified source resistance (R) and with power (Power) delivered into a matched load of resistance R. The RF signal has additive Gaussian noise power set by the resistor temperature (Temp) (when Noise=yes).

The I and Q outputs are baseband outputs with zero source resistance and contain the unfiltered I and Q chips available at the RF modulator input. Because the I And Q outputs are from the RF modulator inputs, the RF output signal has a time delay relative to the I and Q chips. This RF time delay (RF_Delay) is related to the RRC_FilterLength parameter value.

RF_Delay = RRC_FilterLength/(3.84e6)/2 sec.

4. This 3GPP FDD downlink signal source model is compatible with Agilent E4438C ESG Vector Signal Generator, Option 400 (3GPP W-CDMA Firmware Option for the E4438C ESG Vector Signal Generator).

   Details regarding Agilent E4438C ESG for 3GPP FDD are included at the website **http://www.agilent.com/find/esg**

5. Regarding the 3GPP uplink signal frame structure, one frame has a time duration of 10 msec and consists of 15 slots. Each slot corresponds to one power control period and contains 2560 chips.

   There are two types of uplink dedicated physical channels - uplink Dedicated Physical Data Channel (uplink DPDCH) and uplink Dedicated Physical Control Channel (uplink DPCCH). These channels are I/Q code multiplexed within each radio frame.

   Uplink DPDCH is used to carry the DCH transport channel. There may be zero, one, or several uplink DPDCHs on each radio link.

   Uplink DPCCH is used to carry control information generated at Layer 1. The Layer 1 control information consists of known pilot bits to support channel estimation for coherent detection, transmit power-control (TPC) commands, feedback information (FBI), and an optional transport-format combination indicator (TFCI). The TFCI informs the receiver about the instantaneous transport format combination of the transport channels mapped to the simultaneously transmitted uplink DPDCH radio frame. There is only one uplink DPCCH on each radio link.

The frame structure of the uplink dedicated physical channels is illustrated in Figure 1-4. Table 1-8, Table 1-9, Table 1-12, and Table 1-13 provide more information about each field.

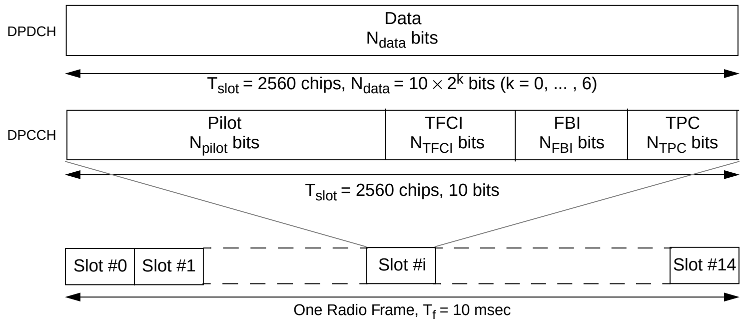


Figure 1-4. 12.2 kbps Uplink Channel Frame Structure

6. Parameter Details

- Num defines the circuit port number for S-parameter and Harmonic Balance noise figure analysis only (it is not used for other circuit analysis).
- R is the RF output source resistance.
- Temp is the RF output source resistance temperature in Celsius and sets the noise density in the RF output signal to (k(Temp+273.15)) Watts/Hz, where k is Boltzmann’s constant.
- Noise, when set to NO disables the Temp and effectively sets it to -273.15^{o}C (0 Kelvin). When set to YES, the noise density due to Temp is enabled.
- FCarrier is the RF output signal frequency.
- Power is the RF output signal power delivered into a matched load of resistance R.
- MirrorSpectrum is used to mirror the RF_out signal spectrum about the carrier. This is equivalent to conjugating the complex RF envelope voltage.

  Depending on the configuration and number of mixers in an RF transmitter, the RF output signal from hardware RF generators can be inverted. If such an RF signal is desired, set MirrorSpectrum to YES.

- GainImbalance, PhaseImbalance, I_OriginOffset, Q_OriginOffset, and IQ_Rotation are used to add certain impairments to the ideal output RF signal. Impairments are added in the order described here.

  The unimpaired RF I and Q envelope voltages have gain and phase imbalance applied. The RF is given by:

  $$V_{RF}(t) = A\left(V_I(t)\cos(\omega_c t) - gV_Q(t)\sin\left(\omega_c t + \frac{\phi\pi}{180}\right)\right)$$

  where A is a scaling factor based on the Power and R parameters specified by the user, $V_I(t)$ is the in-phase RF envelope, $V_Q(t)$ is the quadrature phase RF envelope, g is the gain imbalance

  $$g = 10^{\frac{GainImbalance}{20}}$$

  and, ϕ (in degrees) is the phase imbalance.

  Next, the signal $V_{RF}(t)$ is rotated by IQ_Rotation degrees. The I_OriginOffset and Q_OriginOffset are then applied to the rotated signal. Note that the amounts specified are percentages with respect to the output rms voltage. The output rms voltage is given by sqrt(2 R Power).

- SamplesPerChip is used to set the number of samples in a chip.

  The default value is set to 8 to display settings according to the 3GPP standard. It can be set to a larger value for a simulation frequency bandwidth wider than 8×3.84 MHz. It can be set to a smaller value for faster simulation times; however, this will result in lower signal fidelity. If SamplesPerChip = 8, the simulation RF bandwidth is larger than the signal bandwidth by a factor of 8 (e.g., simulation RF bandwidth = 8×3.84 MHz).

- RRC_FilterLength is used to set root raised-cosine (RRC) filter length in chips.

  The default value is set to 16 to transmit a 3GPP FDD uplink signal in time and frequency domains based on the 3GPP standard [4]. It can be set to a smaller value for faster simulation times; however, this will result in lower signal fidelity.

- SpecVersion is used to specify the 3GPP specification versions (2000-03, 2000-12 and 2002-03).

- SourceType is used to specify the type of baseband signal. Reference measurement channels (RMC) 12.2 and 768 kbps as defined in [4] and [5] are available.

  Basic parameters of 12.2 kbps RMC (SourceType = UL_12_2) are listed in Table 1-7 through Table 1-10.

  Basic parameters of 768 kbps RMC (SourceType = UL_768) are listed in Table 1-11 through Table 1-14.

Table 1-7. Uplink 12.2 kbps Reference Measurement Channel, Physical Parameters

Parameter	Unit	Level
Information bit rate	kbps	12.2
DPDCH	kbps	60
DPCCH	kbps	15
DPCCH Slot Format		0
DPCCH/DPDCH power ratio	dB	-5.46
TFCI		On
Repetition	%	23

Table 1-8. Uplink 12.2 kbps Reference Measurement Channel, DPDCH Fields

Channel Bit Rate (kbps)	Channel Symbol Rate (ksps)	SF	Bits / Frame	Bits / Slot	N_{data}
60	60	64	600	40	40

Table 1-9. Uplink 12.2 kbps Reference Measurement Channel, DPCCH Fields

Channel Bit Rate (kbps)	Channel Symbol Rate (ksps)	SF	Bits / Frame	Bits / Slot	N_{pilot}	N_{TPC}	N_{TFCI}	N_{FBI}
15	15	256	150	10	6	2	2	0

Table 1-10. Uplink 12.2 kbps Reference Measurement Channel, Transport Channel Parameters

Parameter	DTCH	DCCH
Transport Channel Number	1	2
Transport Block Size	244	100
Transport Block Set Size	244	100
Transmission Time Interval	20 ms	40 ms
Type of Error Protection	Convolution Coding	Convolution Coding
Coding Rate	1/3	1/3
Rate Matching attribute	256	256
Size of CRC	16	12

Table 1-11. Uplink 768 kbps Reference Measurement Channel, Physical Parameters

Parameter	Unit	Level
Information bit rate	kbps	2*384
$DPDCH_1$	kbps	960
$DPDCH_2$	kbps	960
DPCCH	kbps	15
DPCCH Slot Format		0
DPCCH/DPDCH power ratio	dB	-11.48
TFCI		On
Puncturing	%	18

Table 1-12. Uplink 768 kbps Reference Measurement Channel, Transport Channel Parameters

Parameter	DTCH	DCCH
Transport Channel Number	1	2
Transport Block Size	3840	100
Transport Block Set Size	7680	100
Transmission Time Interval	10 ms	40 ms
Type of Error Protection	Turbo Coding	Convolution Coding
Coding Rate	1/3	1/3
Rate Matching attribute	256	256
Size of CRC	16	12

Table 1-13. Uplink 768 kbps Reference Measurement Channel, DPDCH Fields†

Channel Bit Rate (kbps)	Channel Symbol Rate (ksps)	SF	Bits / Frame	Bits / Slot	N_{data}
960	960	4	9600	640	640

† There are two DPDCHs in uplink 768 kbps RMC.

Table 1-14. Uplink 768 kbps Reference Measurement Channel, DPCCH Fields

Channel Bit Rate (kbps)	Channel Symbol Rate (ksps)	SF	Bits / Frame	Bits / Slot	N_{pilot}	N_{TPC}	N_{TFCI}	N_{FBI}
15	15	256	150	10	6	2	2	0

7. Use with Circuit Analyses

The full features of this model are used with Circuit Envelope simulations; for other circuit simulations, it defaults to a simpler model.

Signal output noise is based on Temp and Noise parameters and included in the RF output I and Q waveforms for Circuit Envelope (Env) analysis.

References

[1] 3GPP Technical Specification TS 25.211, "Physical channels and mapping of transport channels onto physical channels (FDD)" Release 1999.

http://www.3gpp.org/ftp/Specs/2002-03/R1999/25_series/25211-3a0.zip

[2] 3GPP Technical Specification TS 25.212, "Multiplexing and Channel Coding (FDD)" Release 1999.

http://www.3gpp.org/ftp/Specs/2002-03/R1999/25_series/25212-390.zip

[3] 3GPP Technical Specification TS 25.213, "Spreading and modulation (FDD)" Release 1999.

http://www.3gpp.org/ftp/Specs/2002-03/R1999/25_series/25213-370.zip

[4] 3GPP Technical Specification TS 25.101, "UE Radio Transmission and Reception (FDD)" Release 1999.

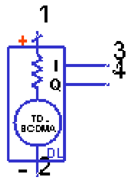
http://www.3gpp.org/ftp/Specs/2002-03/R1999/25_series/25101-3a0.zip

[5] 3GPP Technical Specification TS 25.104, “BS Radio transmission and (FDD)” Release 1999.

http://www.3gpp.org/ftp/Specs/2002-03/R1999/25_series/25104-3a0.zip

TDSCDMA_DnLink (TDSCDMA Downlink Signal Source)

Symbol



Parameters

Name	Description	Default	Sym	Unit	Type	Range
Num	Port number for S-parameter and HB noise figure analysis	1			int	[1, ∞)
R	Source resistance	50 Ohm		Ohm	real	(0, ∞)
Temp	Temperature			Celsius	real	[-273.15, ∞)
Noise	Enable thermal noise? NO, YES	YES			enum	
MaxTimeStep	Expression showing how TStep is related to the other source parameters	1/1.28 MHz/SamplesPer Chip			string	
FCarrier	Carrier frequency	1900 MHz		Hz	real	(0, ∞)
Power	Power	0.01		W	real	[0, ∞)
MirrorSpectrum	Mirror spectrum about carrier? NO, YES	NO			enum	
GainImbalance	Gain imbalance, Q vs I	0.0		dB	real	(-∞, ∞)
PhaseImbalance	Phase imbalance, Q vs I	0.0		deg	real	(-∞, ∞)
I_OriginOffset	I origin offset (percent)	0.0			real	(-∞, ∞)
Q_OriginOffset	Q origin offset (percent)	0.0			real	(-∞, ∞)
IQ_Rotation	IQ rotation	0.0		deg	real	(-∞, ∞)
SamplesPerChip	Samples per chip	8	S		int	[2, 32]
RRC_FilterLength	RRC filter length (chips)	12			int	[2, 128]
ModPhase	Modulation phase quadruples: S1, S2	S1			enum	
MidambleAllocScheme	Midamble allocation scheme: UE_Specific, Common, Default	Common			enum	
BasicMidambleID	Basic midamble index	0			int	[0, 127]

Name	Description	Default	Sym	Unit	Type	Range
MidambleID1	1st DPCH midamble index	1			int	[1, K]
MidambleID2	2nd DPCH midamble index	2			int	[1, K]
MaxMidambleShift	Max midamble shift	16	K		int	{2, 4, 6, 8, 10, 12, 14, 16}
SpreadCode1	1st DPCH spread code index	1			int	[1, 16]
SpreadCode2	2nd DPCH spread code index	2			int	[1, 16]
DwPCH_Gain	DwPCH gain	1			int	(0, ∞)
DownlinkPilotCode	Downlink pilot code index	0			int	[0, 31]
ActiveTimeslot	Slot index: TS0, TS2, TS3, TS4, TS5, TS6	TS6			enum	

Pin Outputs

Pin	Name	Description	Signal Type
1	RF	RF output	timed
2	Minus	Ground	timed
3	I	I symbols	real
4	Q	Q symbols	real

Notes/Equations

1. This TD-SCDMA signal source generates a 12.2 kbps downlink RF signal with two dedicated physical channels (DPCH) and one downlink pilot channel (DwPCH). The RF signal has a chip rate of 1.28 MHz. The downlink is from the base station to the user equipment.

   To use this source, RF carrier frequency (FCarrier) and power (Power) must be set.

   RF impairments can be introduced by setting the R, Temp, Noise, MirrorSpectrum, GainImbalance, PhaseImbalance, I_OriginOffset, Q_OriginOffset, and IQ_Rotation parameters.

   TD-SCDMA signal characteristics can be specified by setting the RRC_FilterLength, ModPhase, MidambleAllocScheme, BasicMidambleID, MidambleID1, MidambleID2, MaxMidambleShift, SpreadCode1, SpreadCode2, DwPCH_Gain, DownlinkPilotCode, and ActiveTimeslot parameters.

The maximum Circuit Envelope simulation time allowed is 1/1.28 MHz/SamplesPerChip. If the actual simulation Circuit Envelope simulation time step is greater than this maximum allowed, the simulation will stop and display an error message.

2. An example (TDSCDMA_DnLink_test.dsn) demonstrating the use of this signal source is available under /examples/TDSCDMA/RF_Verification_prj.

3. This signal source includes a DSP section, RF modulator, and RF output resistance as illustrated in Figure 1-5.

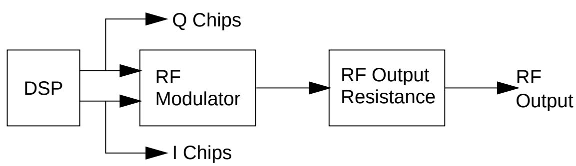


Figure 1-5. Signal Source Block Diagram

The R, Temp and Noise parameters are used by the RF output resistance. The FCarrier, Power, MirrorSpectrum, GainImbalance, PhaseImbalance, I_OriginOffset, Q_OriginOffset, and IQ_Rotation parameters are used by the RF modulator. The remaining signal source parameters are used by the DSP block.

The RF output from the signal source is at the frequency specified (FCarrier), with the specified source resistance (R) and with power (Power) delivered into a matched load of resistance R. The RF signal has additive Gaussian noise power set by the resistor temperature (Temp) (when Noise=yes).

The I and Q outputs are baseband outputs with zero source resistance and contain the unfiltered I and Q chips available at the RF modulator input. Because the I And Q outputs are from the inputs to the RF modulator, the RF output signal has a time delay relative to the I and Q chips. This RF time delay (RF_Delay) is related to parameter value for RRC_FilterLength.

RF_Delay = RRC_FilterLength/(1.28e6)/2 sec.

4. The RF power delivered into a matched load with resistance R is the average power delivered in the subframe time slot specified by ActiveTimeslot (this is not the average frame power, which is less).

Figure 1-6 shows the RF envelope for an output RF signal with 30 dBm power delivered in time slot 6 (ActiveTimeSlot = TS6).

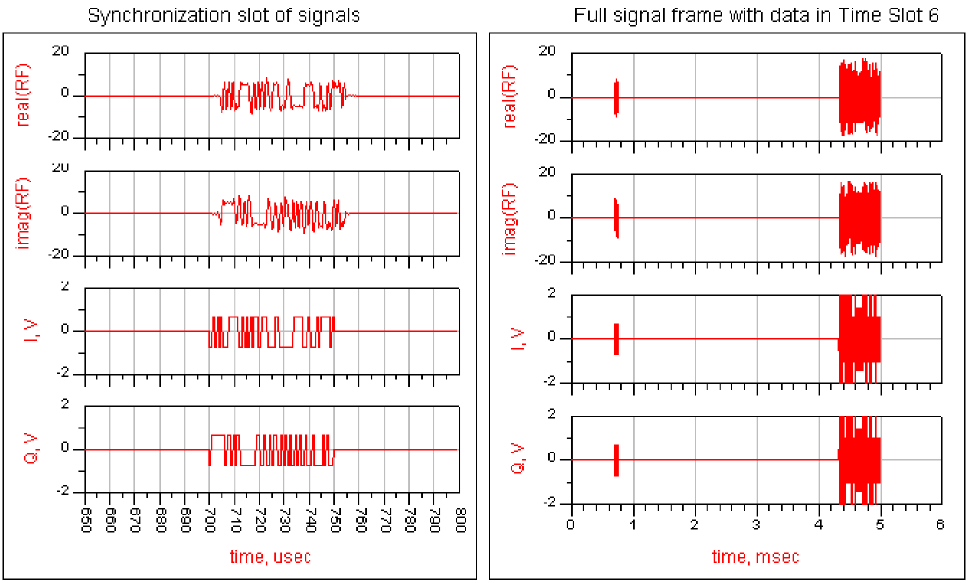


Figure 1-6. TD-SCDMA Downlink Source

5. This TD-SCDMA downlink signal source model is compatible with Agilent Signal Studio software option 411 for transmission test.

   Details regarding Signal Studio for TD-SCDMA are included at the website **http://www.agilent.com/find/signalstudio**

Note There are two standards for TD-SCDMA systems: the international standard is called the 3GPP NTDD standard; the China national standard is called the TD-SCDMA TSM standard. This partially-coded TD-SCDMA signal source in ADS is based on the 3GPP NTDD standard. The Agilent TD-SCDMA signal studio signal source is based on the TD-SCDMA TSM standard. For TD-SCDMA transmission tests, this partially-coded TD-SCDMA signal source in ADS is compatible with the Agilent Signal Studio signal source.

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6. Regarding the TD-SCDMA signal frame structure, one frame consists of two subframes. Each subframe consists of 7 time slots (TS), and one downlink pilot time slot (DwPTS), one guard period (GP) and one uplink pilot time slot (UpPTS). Each time slot can transmit DPCH signals. One subframe is

composed of 6400 chips. Because the chip rate is 1.28 MHz, the subframe has a 5 msec duration. The subframe structure is illustrated in Figure 1-7.

For example, two DPCH signals in DPCH1 and DPCH2 are transmitted in TS0 as illustrated in Figure 1-7. The first DPCH bits are modulated by QPSK and Spread by Walsh code of length 16 then transmitted in the slot. The DPCH1 signal is comprised of 88 coded information bits ($88 \times 16/2$ chips) and 144 chips for midamble sequence plus 16 chips for GP. The DPCH2 signal, with the same modulation and spread scheme as DPCH1, is composed of 76 coded information bits ($76 \times 16/2$ chips), 8 bits ($8 \times 16/2$ chips) for transport format combination indicator (TFCI), 144 chips for midamble sequence, 4 bits ($4 \times 16/2$ chips) for transmitter power control and synchronization shift (TPC and SS) plus 16 chips for GP. The total chips for the subframe is composed of 7 time slots plus 96 chips for DwPTS, 96 chips for GP and 160 chips for UpPTS and summarized as $(88 \times 8+144+16) \times 7+160+96 \times 2=6400$ chips.

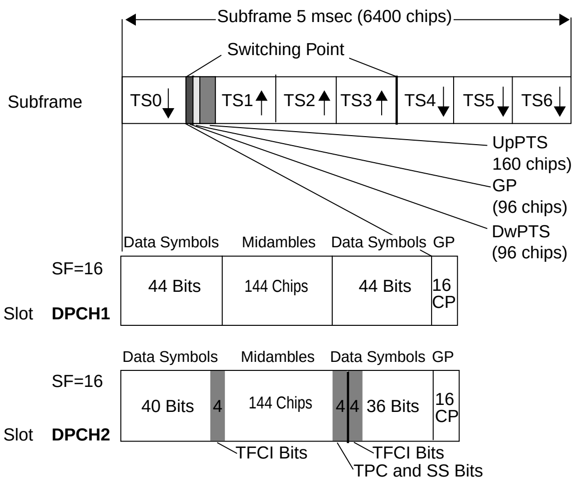


Figure 1-7. Subframe Structure of 12.2 kbps DL Channel

7. Parameter Details

- Num defines the circuit port number for S-parameter and Harmonic Balance noise figure analysis only (it is not used for other circuit analysis).
- R is the RF output source resistance.
- Temp is the RF output source resistance temperature in Celsius and sets the noise density in the RF output signal to (k(Temp+273.15)) Watts/Hz, where k is Boltzmann's constant.
- Noise, when set to NO, disables Temp and effectively sets it to -273.15^{o}C (0 Kelvin); when set to YES, the noise density due to Temp is enabled.
- FCarrier is the RF output signal frequency.
- Power is the RF output signal power. The Power of the signal is defined as the average power delivered in the subframe time slot specified by ActiveTimeslot. Refer to note 4 for details.
- MirrorSpectrum is used to mirror the RF_out signal spectrum about the carrier. This is equivalent to conjugating the complex RF envelope voltage.

  Depending on the configuration and number of mixers in an RF transmitter, the RF output signal from hardware RF generators can be inverted. If such an RF signal is desired, set this parameter to YES.
- GainImbalance, PhaseImbalance, I_OriginOffset, Q_OriginOffset, and IQ_Rotation are used to add certain impairments to the ideal output RF signal. Impairments are added in the order described here.

  The unimpaired RF I and Q envelope voltages have gain and phase imbalance applied. The RF is given by:

$$V_{RF}(t) = A\left(V_I(t)\cos(\omega_c t) - gV_Q(t)\sin\left(\omega_c t + \frac{\phi\pi}{180}\right)\right)$$

  where A is a scaling factor based on the Power and R parameters specified by the user, $V_I(t)$ is the in-phase RF envelope, $V_Q(t)$ is the quadrature phase RF envelope, g is the gain imbalance

$$g = 10^{\frac{GainImbalance}{20}}$$

  and, ϕ (in degrees) is the phase imbalance.

Next, the signal $V_{RF}(t)$ is rotated by IQ_Rotation degrees. The I_OriginOffset and Q_OriginOffset are then applied to the rotated signal. Note that the amounts specified are percentages with respect to the output rms voltage. The output rms voltage is given by sqrt(2 R Power).

- SamplesPerChip sets the number of samples in a chip.

  The default value is set to 8 to display settings according to the 3GPP NTDD. It can be set to a larger value for a simulation frequency bandwidth wider than 8×1.28 MHz. It can be set to a smaller value for faster simulation; however, this will result in lower signal fidelity. If SamplesPerChip = 8, the simulation RF bandwidth is larger than the signal bandwidth by a factor of 8 (e.g., simulation RF bandwidth = 8×1.28 MHz).

- RRC_FilterLength is used to set root raised-cosine (RRC) filter length in number of chips.

  The default value is set to 12 to transmit TD-SCDMA downlink signals in time and frequency domains based on the 3GPP NTDD standard [1] - [3]. It can be set to a smaller value for faster simulation; however, this will result in lower signal fidelity.

- ModPhase is used to select the phase quadruples of DwPTS for various phase rotation patterns. In Signal Studio, the Rotation Phase parameter is used to select the phase quadruples.

  There are two different phase quadruples, S1 and S2 specified by 3GPP NTDD standard [3], as described in Table 1-15. A quadruple always starts with an even signal frame number.

Table 1-15. Phase Modulation Sequences

Name	Phase Quadruple	Description
S1	135, 45, 225, 135	A P-CCPCH is present in the next 4 sub-frames
S2	315, 225, 315, 45	A P-CCPCH is not present in the next 4 sub-frames

- MidambleAllocScheme is used to select the midamble allocation scheme. There are three midamble allocation schemes based on the 3GPP NTDD standard [1], [2].

  UE specific midamble allocation a UE specific midamble for uplink and downlink is explicitly assigned by higher layers

Default midamble allocation the midamble for uplink and downlink is assigned by layer 1 depending on associated channelization code.

Common midamble allocation the midamble for downlink is allocated by layer 1 depending on the number of channelization codes currently present in the downlink time slot.

To set MidambleAllocScheme parameter based on the 3GPP NTDD standard [1], related parameters must be set as stated here:

if **MidambleAllocScheme=UE_Specific**, the BasicMidambleID, MaxMidambleShift and MidambleID parameters are used to specify which midamble is exported.

if **MidambleAllocScheme=Common**, only the BasicMidambleID, MaxMidambleShift are used to specify which midamble is exported; the MidambleID parameter is ignored.

if **MidambleAllocScheme=Default**, only the BasicMidambleID, MaxMidambleShift are used to specify which midamble is exported, the MidambleID parameter is ignored.

- BasicMidambleID sets the basic midamble code ID. The basic midamble code is used for training sequences for uplink and downlink channel estimation, power measurements and maintaining uplink synchronization. There are 128 different sequences; BasicMidambleID can be set from 0 to 127.

  In Signal Studio, Basic Midamble ID code has the same meaning as this parameter.

- MaxMidambleShift is the maximum number of different midamble shifts in a cell that can be determined by maximum users in the cell for the current time slot.

- MidambleID1 and MidambleID2 set the indices of midambles for the first and second DPCH, respectively. Midambles of different users active in the same cell and the same time slot are cyclically shifted versions of one basic midamble code.

  Let P = 128, the length of basic midamble and K=MaxMidambleShift, then

  $W = \left\lfloor \frac{P}{K} \right\rfloor$, is the shift between midambles and $\lfloor x \rfloor$ denotes the largest number less or equal to x. The MidambleID range is from 1 to MaxMidambleShift.

MidambleID and MaxMidambleShift together correspond to parameter of Midamble Offset in Signal Studio for Timeslot setup. Midamble Offset = MidambleID $\times$ W.

- SpreadCode1 and SpreadCode2 set spread code indices for the first and second DPCH, respectively. For this signal source, the spreading factor is 16.

  In Signal Studio, channelization code for time slot setup has the same meaning as SpreadCode1 and SpreadCode2.

- DwPCH_Gain sets the gain of DwPCH relative to DPCH.

  In Signal Studio, there are dialog boxes with dB unit for each DwPCH to set the gain of DwPCH relative to DPCH.

- DownlinkPilotCode sets the downlink pilot synchronization sequence (SYNC-DL). Downlink pilot synchronization is used for DL synchronization and cell initial search. There are 32 different SYNC-DL code groups, which are used to distinguish base stations.

  DwPTS has 64 chips of a complex SYNC_DL sequence $\underline{s} = (\underline{s}_1, \underline{s}_2, \ldots, \underline{s}_{64})$ and 32 chips of guard period. To generate the complex SYNC_DL code, the basic SYNC_DL code $s = (s_1, s_2, \ldots, s_{64})$ is used. There are 32 different basic SYNC_DL codes for the whole system. The relation between s and $\underline{s}$ is given by:

  $$\underline{s}_i = (j)^i s_i \text{ where } v_i \in \{1, -1\}, i = 1, \ldots, 64$$

  Therefore, the elements $\underline{s}_i$ of $\underline{s}$ are alternating real and imaginary.

  In Signal Studio, SYNC Code is used to set the downlink pilot code.

- ActiveTimeslot is used to select which slot signal in the subframe will be transmitted.

8. Use with Circuit Analyses

   The full features of this model are used with Circuit Envelope simulations; for other circuit simulations, it defaults to a simpler model.

   Signal output noise is based on Temp and Noise parameters and included in the RF output I and Q waveforms for Circuit Envelope (Env) analysis.

References

[1] 3GPP TS 25.221, *3rd Generation Partnership Project; Technical Specification Group Radio Access Network; Physical channels and mapping of transport channels onto physical channels (TDD) (Release 4)*, version 4.5.0, Dec., 2001.

http://www.3gpp.org/ftp/Specs/2001-12/Rel-4/25_series/25221-430.zip

[2] 3GPP TS 25.223, *3rd Generation Partnership Project; Technical Specification Group Radio Access Network; Spreading and modulation (TDD) (Release 4)*, version 4.3.0, Dec., 2001.

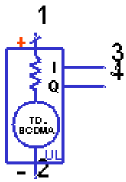
http://www.3gpp.org/ftp/Specs/2001-12/Rel-4/25_series/25223-430.zip

[3] 3GPP TS 25.105, *3rd Generation Partnership Project; Technical Specification Group Radio Access Network; BS Radio transmission and Reception (TDD) (Release 4)*, version 4.5.0, June 2002.

http://www.3gpp.org/ftp/Specs/2002-06/Rel-4/25_series/25105-450.zip

TDSCDMA_UpLink (TDSCDMA Uplink Signal Source)

Symbol



Parameters

Name	Description	Default	Sym	Unit	Type	Range
Num	Port number for S-parameter and HB noise figure analysis	1			int	[1, ∞)
R	Source resistance	50 Ohm		Ohm	real	(0, ∞)
Temp	Temperature			Celsius	real	[-273.15, ∞)
Noise	Enable thermal noise? NO, YES	YES			enum	
MaxTimeStep	Expression showing how TStep is related to the other source parameters	1/1.28 MHz/SamplesPerChip			string	
FCarrier	Carrier frequency	1900 MHz		Hz	real	(0, ∞)
Power	Power	0.01		W	real	[0, ∞)
MirrorSpectrum	Mirror spectrum about carrier? NO, YES	NO			enum	
GainImbalance	Gain imbalance, Q vs I	0.0		dB	real	(-∞, ∞)
PhaseImbalance	Phase imbalance, Q vs I	0.0		deg	real	(-∞, ∞)
I_OriginOffset	I origin offset (percent)	0.0			real	(-∞, ∞)
Q_OriginOffset	Q origin offset (percent)	0.0			real	(-∞, ∞)
IQ_Rotation	IQ rotation	0.0		deg	real	(-∞, ∞)
SamplesPerChip	Samples per chip	8	S		int	[2, 32]
RRC_FilterLength	RRC filter length (chips)	12			int	[2, 128]
MidambleAllocScheme	Midamble allocation scheme: UE_Specific, Common, Default	Common			enum	
BasicMidambleID	Basic midamble index	0			int	[0, 127]
MidambleID	Midamble index	1			int	[1, K]

Name	Description	Default	Sym	Unit	Type	Range
MaxMidambleShift	Max midamble shift	16	K		int	{2, 4, 6, 8, 10, 12, 14, 16}
SpreadCode	Spread code index	1			int	[1, 8]
ActiveTimeslot	Slot index: TS1, TS2, TS3, TS4, TS5, TS6	TS2			enum	

Pin Outputs

Pin	Name	Description	Signal Type
1	RF	RF output	timed
2	Minus	Ground	timed
3	I	I symbols	real
4	Q	Q symbols	real

Notes/Equations

1. This TD-SCDMA signal source generates a 12.2 kbps uplink RF signal with one dedicated physical channel (DPCH) and one uplink pilot channel (UpPCH). The index of the basic synchronization code is set to 0 in the UpPCH. The RF signal has a chip rate of 1.28 MHz. The uplink is from the user equipment to the base station.

   To use this source, RF carrier frequency (FCarrier) and power (Power) must be set.

   RF impairments can be introduced by setting the R, Temp, Noise, MirrorSpectrum, GainImbalance, PhaseImbalance, I_OriginOffset, Q_OriginOffset, and IQ_Rotation parameters.

   TD-SCDMA signal characteristics can be specified by setting the RRC_FilterLength, MidambleAllocScheme, BasicMidambleID, MidambleID, MaxMidambleShift, SpreadCode, and ActiveTimeslot parameters.

   The maximum Circuit Envelope simulation time allowed is 1/1.28 MHz/SamplesPerChip. If the Circuit Envelope simulation time step is greater than the maximum allowed, the simulation will stop and an error message will be displayed.

2. An example (TDSCDMA_UpLink_test.dsn) demonstrating the use of this signal source is available under /examples/TDSCDMA/RF_Verification_prj.

3. This signal source includes a DSP section, RF modulator, and RF output resistance as illustrated in Figure 1-8.

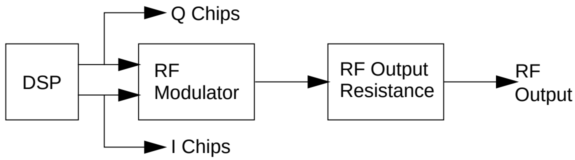


Figure 1-8. Signal Source Block Diagram

The R, Temp and Noise parameters are used by the RF output resistance. The FCarrier, Power, MirrorSpectrum, GainImbalance, PhaseImbalance, I_OriginOffset, Q_OriginOffset, and IQ_Rotation parameters are used by the RF modulator. The remaining signal source parameters are used by the DSP block.

The RF output from the signal source is at the frequency specified (FCarrier), with the specified source resistance (R) and with power (Power) delivered into a matched load of resistance R. The RF signal has additive Gaussian noise power set by the resistor temperature (Temp) (when Noise=yes).

The I and Q outputs are baseband outputs with zero source resistance and contain the unfiltered I and Q chips available at the RF modulator input. Because the I And Q outputs are from the inputs to the RF modulator, the RF output signal has a time delay relative to the I and Q chips. This RF time delay (RF_Delay) is related to parameter value for RRC_FilterLength.

RF_Delay = RRC_FilterLength/(1.28e6)/2sec.

4. The RF power delivered into a matched load with resistance R is the average power delivered in the subframe time slot specified by parameter ActiveTimeslot. This is not the average subframe power (which is less).

Figure 1-9 shows the RF envelope for one subframe with 10 dBm RF power delivered in time slot 2 (ActiveTimeslot = TS2).

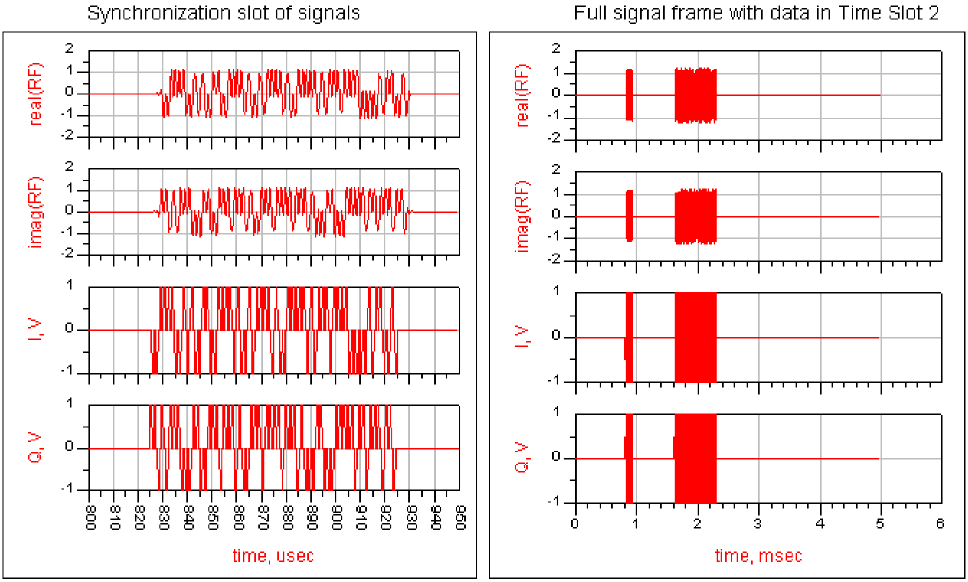


Figure 1-9. TD-SCDMA Uplink Source

5. This TD-SCDMA uplink signal source model is compatible with Agilent Signal Studio software option 411 for transmission test.

   Details regarding Signal Studio for TD-SCDMA are included at the website **http://www.agilent.com/find/signalstudio**

Note There are two standards for TD-SCDMA systems: the international standard is called the 3GPP NTDD standard; the China national standard is called the TD-SCDMA TSM standard. This partially-coded TD-SCDMA signal source in ADS is based on the 3GPP NTDD standard. The Agilent TD-SCDMA signal studio signal source is based on the TD-SCDMA TSM standard. For TD-SCDMA transmission tests, this partially-coded TD-SCDMA signal source in ADS is compatible with the Agilent Signal Studio signal source.

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6. Regarding the TD-SCDMA signal frame structure, one frame consists of two subframes. Each subframe consists of 7 time slots (TS), and one downlink pilot time slot (DwPTS), one guard period (GP) and one uplink pilot time slot (UpPTS). Each time slot can transmit DPCH signals. One subframe is

composed of 6400 chips. Because the chip rate is 1.28 MHz, the subframe has a 5msec duration. The subframe structure is illustrated in Figure 1-10.

For example, one DPCH signal is transmitted in TS2 as illustrated in Figure 1-10. The DPCH bits are modulated by QPSK and spread by Walsh code of length 8 then transmitted in the slot. The DPCH signal is composed of 164 coded information bits ($164 \times 8/2$ chips), 8 bits ($8 \times 8/2$ chips) for transport format combination indicator (TFCI), 144 chips for midamble sequence, 2 bits ($2 \times 8/2$ chips) for transmitter power control and 2 bits ($2 \times 8/2$ chips) reserved (TPC and Reserved) plus 16 chips for GP. The total chips for the subframe is composed of 7 time slots plus 96 chips for DwPTS, 96 chips for GP and 160 chips for UpPTS and summarized as
$(164 \times 4+8 \times 4+144+2 \times 4+2 \times 4+16) \times 7+160+96 \times 2=6400$ chips.

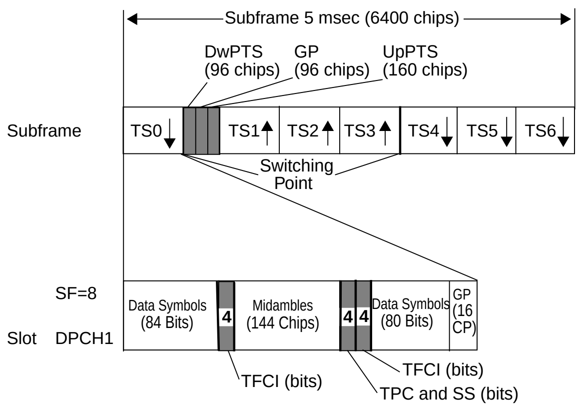


Figure 1-10. 12.2 kbps Uplink Channel of Subframe Structure

7. Parameter Details

- Num defines the circuit port number for S-parameter and Harmonic Balance noise figure analysis only (it is not used for other circuit analysis).
- R is the RF output source resistance.
- Temp is the RF output source resistance temperature in Celsius and sets the noise density in the RF output signal to (k(Temp+273.15)) Watts/Hz, where k is Boltzmann's constant.
- Noise, when set to NO disables the Temp and effectively sets it to -273.15^{o}C (0 Kelvin). When set to YES, the noise density due to Temp is enabled.

- FCarrier is the RF output signal frequency.
- Power is the RF output signal power. The Power of the signal is defined as the average power delivered in the subframe time slot specified by parameter ActiveTimeslot. See note 4 for details.
- MirrorSpectrum is used to mirror the RF_out signal spectrum about the carrier. This is equivalent to conjugating the complex RF envelope voltage.

  Depending on the configuration and number of mixers in an RF transmitter, the RF output signal from hardware RF generators can be inverted. If such an RF signal is desired, set this parameter to YES.
- GainImbalance, PhaseImbalance, I_OriginOffset, Q_OriginOffset, and IQ_Rotation are used to add certain impairments to the ideal output RF signal. Impairments are added in the order described here.

  The unimpaired RF I and Q envelope voltages have gain and phase imbalance applied. The RF is given by:

$$V_{RF}(t) = A\left(V_I(t)\cos(\omega_c t) - gV_Q(t)\sin\left(\omega_c t + \frac{\phi\pi}{180}\right)\right)$$

  where A is a scaling factor based on the Power and R parameters specified by the user, $V_I(t)$ is the in-phase RF envelope, $V_Q(t)$ is the quadrature phase RF envelope, g is the gain imbalance

$$g = 10^{\frac{GainImbalance}{20}}$$

  and, ϕ (in degrees) is the phase imbalance.

  Next, the signal $V_{RF}(t)$ is rotated by IQ_Rotation degrees. The I_OriginOffset and Q_OriginOffset are then applied to the rotated signal. Note that the amounts specified are percentages with respect to the output rms voltage. The output rms voltage is given by sqrt(2 R Power).
- SamplesPerChip sets the number of samples in a chip.

  The default value is set to 8 to display settings according to the 3GPP NTDD. It can be set to a larger value for a simulation frequency bandwidth wider than 8×1.28 MHz. It can be set to a smaller value for faster simulation; however, this will result in lower signal fidelity. If SamplesPerChip = 8, the simulation RF bandwidth is larger than the signal bandwidth by a factor of 8 (e.g., simulation RF bandwidth = 8×3.84 MHz)

- RRC_FilterLength shows root raised-cosine (RRC) filter length in chips.

  The default value of this parameter is set to 12 to transmit TD-SCDMA downlink signals in time and frequency domains based on the 3GPP NTDD standard [1-3]. It can be set to a smaller value for faster simulation; however, this will result in lower signal fidelity.

- MidambleAllocScheme is used to select the midamble allocation scheme. There are three midamble allocation schemes based on the 3GPP NTDD standard [1,2].

  UE specific midamble allocation: a UE specific midamble for uplink and downlink is explicitly assigned by higher layers

  Default midamble allocation: the midamble for uplink and downlink is assigned by layer 1 depending on associated channelization code.

  Common midamble allocation: the midamble for downlink is allocated by layer 1 depending on the number of channelization codes currently present in the downlink time slot.

  To set the MidambleAllocScheme parameter based on the 3GPP NTDD standard [1], related parameters must be set as stated here:

  if **MidambleAllocScheme=UE_Specific**, the BasicMidambleID, MaxMidambleShift and MidambleID parameters are used to specify which midamble is exported.

  if **MidambleAllocScheme=Common**, only the BasicMidambleID, MaxMidambleShift are used to specify which midamble is exported; the MidambleID parameter is ignored.

  if **MidambleAllocScheme=Default**, only the BasicMidambleID, MaxMidambleShift are used to specify which midamble is exported, the MidambleID parameter is ignored.

- BasicMidambleID sets the basic midamble code ID. The basic midamble code is used for training sequences for uplink and downlink channel estimation, power measurements and maintaining uplink synchronization. There are 128 different sequences; BasicMidambleID can be set from 0 to 127. In Signal Studio, Basic Midamble ID code has the same meaning as this parameter.

- MaxMidambleShift is the maximum number of different midamble shifts in a cell that can be determined by maximum users in the cell for the current time slot.

- MidambleID sets the index of midambles for DPCH. Midambles of different users active in the same cell and the same time slot are cyclically shifted versions of one basic midamble code.

  Let P = 128, the length of basic midamble and K=MaxMidambleShift, then

  $W = \left\lfloor \frac{P}{K} \right\rfloor$, is the shift between midambles and $\lfloor x \rfloor$ denotes the largest number less than or equal to x. MidambleID range is from 1 to MaxMidambleShift.

  MidambleID and MaxMidambleShift together correspond to the Midamble Offset parameter in Signal Studio for Timeslot setup. Midamble Offset = MidambleID $\times$ W.

- SpreadCode sets the spread code index for the DPCH. For this signal source, the spreading factor is 8.

  In Signal Studio, Channelization code for Time slot setup has the same meaning of SpreadCode.

- ActiveTimeslot parameter is used to select which slot signal in the subframe will be transmitted.

8. Use with Circuit Analyses

   The full features of this model are used with Circuit Envelope simulations; for other circuit simulations, it defaults to a simpler model.

   Signal output noise is based on Temp and Noise parameters and included in the RF output I and Q waveforms for Circuit Envelope (Env) analysis.

References

[1] 3GPP TS 25.221, *3rd Generation Partnership Project; Technical Specification Group Radio Access Network; Physical channels and mapping of transport channels onto physical channels (TDD) (Release 4)*, version 4.5.0, Dec., 2001.

http://www.3gpp.org/ftp/Specs/2001-12/Rel-4/25_series/25221-430.zip

[2] 3GPP TS 25.223, *3rd Generation Partnership Project; Technical Specification Group Radio Access Network; Spreading and modulation (TDD) (Release 4)*, version 4.3.0, Dec., 2001.

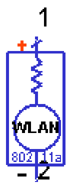
http://www.3gpp.org/ftp/Specs/2001-12/Rel-4/25_series/25223-430.zip

[3] 3GPP TS 25.102, *3rd Generation Partnership Project; Technical Specification Group Radio Access Network; UE Radio transmission and Reception (TDD) (Release 4)*, version 4.5.0, June 2002.

http://www.3gpp.org/ftp/Specs/2002-06/Rel-4/25_series/25102-450.zip

WLAN_802_11a (WLAN 80211a Signal Source)

Symbol



Parameters

Name	Description	Default	Sym	Unit	Type	Range
Num	Port number for S-parameter and HB noise figure analysis	1			int	[1, ∞)
R	Source resistance	50 Ohm		Ohm	real	(0, ∞)
Temp	Temperature			Celsius	real	[-273.15, ∞)
Noise	Enable thermal noise? NO, YES	YES			enum	
MaxTimeStep	Expression showing how TStep is related to the other source parameters	1/Bandwidth/2^OversamplingOption			string	
FCarrier	Carrier frequency: CH1_2412.0M, CH3_2422.0M, CH5_2432.0M, CH6_2437.0M, CH7_2442.0M, CH9_2452.0M, CH11_2462.0M, CH13_2472.0M, CH36_5180.0M, CH40_5200.0M, CH44_5220.0M, CH48_5240.0M, CH52_5260.0M, CH56_5280.0M, CH60_5300.0M, CH64_5320.0M, CH149_5745.0M, CH153_5765.0M, CH157_5785.0M, CH161_5805.0M	CH1_2412.0M		Hz	real enum	(0, ∞)
Power	Power	0.04		W	real	[0, ∞)
MirrorSpectrum	Mirror spectrum about carrier? NO, YES	NO			enum	
GainImbalance	Gain imbalance, Q vs I	0.0		dB	real	(-∞, ∞)

Name	Description	Default	Sym	Unit	Type	Range
PhaseImbalance	Phase imbalance, Q vs I	0.0		deg	real	$(-\infty, \infty)$
I_OriginOffset	I origin offset (percent)	0.0			real	$(-\infty, \infty)$
Q_OriginOffset	Q origin offset (percent)	0.0			real	$(-\infty, \infty)$
IQ_Rotation	IQ rotation	0.0		deg	real	$(-\infty, \infty)$
OversamplingOption	Oversampling ratio option: Option 0 for Ratio 1, Option 1 for Ratio 2, Option 2 for Ratio 4, Option 3 for Ratio 8, Option 4 for Ratio 16, Option 5 for Ratio 32	Option 2 for Ratio 4	S		enum	
DataRate	Data rate (Mbps): Mbps_6, Mbps_9, Mbps_12, Mbps_18, Mbps_24, Mbps_27, Mbps_36, Mbps_48, Mbps_54	Mbps_54	R		enum	
Bandwidth	Bandwidth	20 MHz	B	Hz	real	$(0, \infty)$
IdleInterval	Burst idle interval	4.0 usec	I	sec	real	[0, 1000usec]
DataType	Payload data type: PN9, PN15, FIX4, _4_1_4_0, _8_1_8_0, _16_1_16_0, _32_1_32_0, _64_1_64_0	PN9			enum	
DataLength	Data length (bytes per burst)	100	L		int	[1, 4095]
GuardInterval	Guard interval (frac FFT size)	0.25			real	[0, 1]

Pin Outputs

Pin	Name	Description	Signal Type
1	RF	RF output	timed
2	Minus	Ground	timed

Notes/Equations

1. This WLAN signal source generates an IEEE 802.11a and 802.11g OFDM RF signal.

   To use this source, RF carrier frequency (FCarrier) and power (Power) must be set.

RF impairments can be introduced by setting the R, Temp, Noise, MirrorSpectrum, GainImbalance, PhaseImbalance, I_OriginOffset, Q_OriginOffset, and IQ_Rotation parameters.

802.11a/g signal characteristics can be specified by setting the OversamplingOption, DataRate, Bandwidth, IdleInterval, DataType, DataLength, and GuardInterval parameters.

The maximum Circuit Envelope simulation time allowed is 1/Bandwidth/Ratio where Ratio = $2^{OversamplingOption}$. If the actual simulation Circuit Envelope simulation time step is greater than this maximum allowed, the simulation will stop and display an error message.

2. An example (WLAN_802_11a_test.dsn) demonstrating the use of this signal source is available under /examples/WLAN/RF_Verification_prj.

3. This signal source includes a DSP section, RF modulator, and RF output resistance as illustrated in Figure 1-11.

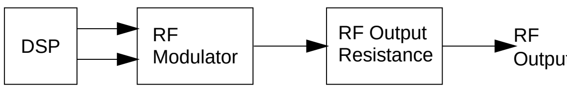


Figure 1-11. Signal Source Block Diagram

The R, Temp and Noise parameters are used by the RF output resistance. The FCarrier, Power, MirrorSpectrum, GainImbalance, PhaseImbalance, I_OriginOffset, Q_OriginOffset, and IQ_Rotation parameters are used by the RF modulator. The remaining signal source parameters are used by the DSP block.

The RF output from the signal source is at the frequency specified (FCarrier), with the specified source resistance (R) and with power (Power) delivered into a matched load of resistance R. The RF signal has additive Gaussian noise power set by the resistor temperature (Temp) (when Noise=yes).

4. This WLAN 802.11a signal source model is compatible with the Agilent Signal Studio Software for 802.11 WLAN Agilent E4438C ESG Vector Signal Generator Option 417 for transmitter test.

Details regarding Signal Studio for WLAN 802.11 are included at the website **http://www.agilent.com/find/signalstudio**

5. Regarding the WLAN 802.11a/g signal burst structure, one burst consists of four parts. Each burst is separated by an IdleInterval and is composed of the Short Preamble, Long Preamble, SIGNAL and DATA fields.

- The Short Preamble field consists of 10 short preambles (8 µsec).
- The Long Preamble field consists of 2 long preambles (8 µsec). The two preamble fields combined compose the PLCP Preamble that has a constant time duration (16 µsec) for all source parameter settings.
- The SIGNAL field includes 802.11a/g bursts of information (such as data rate, payload data, and length).
- The DATA field contains the payload data.

Channel coding, interleaving, mapping and IFFT processes are also included in SIGNAL and DATA parts generation. The SIGNAL field and each individual Data field (part of the overall DATA field) have a time duration defined as the OFDM_SymbolTime and includes a GuardInterval. OFDM_SymbolTime depends on the Bandwidth (=64/Bandwidth).

The burst structure is illustrated in Figure 1-12 and Figure 1-13. In these figures, PLCP means *physical layer convergence procedure*, PSDU means *PLCP service data units*, GI means *guard interval*; GI is set to 0.25 and Bandwidth is set to 20 MHz (resulting in OFDM_SymbolTime = 4 µsec).

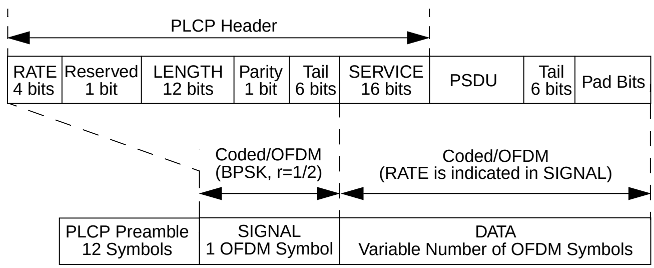


Figure 1-12. 802.11a/g Burst Format

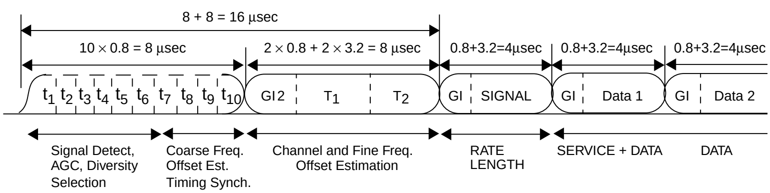


Figure 1-13. OFDM Training Structure

6. Parameter Details

- Num defines the circuit port number for S-parameter and Harmonic Balance noise figure analysis only (it is not used for other circuit analysis).
- R is the RF output source resistance.
- Temp is the RF output source resistance temperature in Celsius and sets the noise density in the RF output signal to (k(Temp+273.15)) Watts/Hz, where k is Boltzmann's constant.
- Noise, when set to NO disables the Temp and effectively sets it to -273.15^{o}C (0 Kelvin). When set to YES, the noise density due to Temp is enabled.
- FCarrier is the RF output signal frequency.
- Power is the RF output signal power. The Power of the signal is defined as the average burst power and excludes the idle interval time intervals.
- MirrorSpectrum is used to mirror the RF_out signal spectrum about the carrier. This is equivalent to conjugating the complex RF envelope voltage.

  Depending on the configuration and number of mixers in an RF transmitter, the RF output signal from hardware RF generators can be inverted. If such an RF signal is desired, set this parameter to YES.
- The GainImbalance, PhaseImbalance, I_OriginOffset, Q_OriginOffset, and IQ_Rotation parameters are used to add certain impairments to the ideal output RF signal. Impairments are added in the order described here.

  The unimpaired RF I and Q envelope voltages have gain and phase imbalance applied. The RF is given by:

$$V_{RF}(t) = A\left(V_I(t)\cos(\omega_c t) - gV_Q(t)\sin\left(\omega_c t + \frac{\phi\pi}{180}\right)\right)$$

  where A is a scaling factor based on the Power and R parameters specified by the user, $V_I(t)$ is the in-phase RF envelope, $V_Q(t)$ is the quadrature phase RF envelope, g is the gain imbalance

$$g = 10^{\frac{GainImbalance}{20}}$$

  and, ϕ (in degrees) is the phase imbalance.

Next, the signal $V_{RF}(t)$ is rotated by IQ_Rotation degrees. The I_OriginOffset and Q_OriginOffset are then applied to the rotated signal. Note that the amounts specified are percentages with respect to the output rms voltage. The output rms voltage is given by sqrt(2 R Power).

- Bandwidth is used to determine the actual bandwidth of WLAN system and also is used to calculate the sampling rate and time step per sample. The default value is 20 MHz, which is defined in 802.11a/g specification. Bandwidth can be set to 40 MHz in order to double the rate for the 802.11a/g turbo mode.
- OversamplingOption sets the oversampling ratio of 802.11a/g RF signal source. Options from 0 to 5 result in oversampling ratio 2, 4, 8, 16, 32 where oversampling ratio = $2^{\text{OversamplingOption}}$. If OversamplingOption = 2, the oversampling ratio = 2^2 = 4 and the simulation RF bandwidth is larger than the signal bandwidth by a factor of 4 (e.g. for Bandwidth=20 MHz, the simulation RF bandwidth = 20 MHz $\times$ 4 = 80 MHz).
- DataRate specifies the data rate: 6, 9, 12, 18, 24, 27, 36, 48 and 54 Mbps are available in this source. All data rates except 27 Mbps are defined in the 802.11a/g specification; 27 Mbps is from HIPERLAN/2 [2].

Table 1-16 lists key parameters of 802.11a/g.

Table 1-16. Rate-Dependent Values

Data Rate (Mbps)	Modulation	Coding Rate (R)	Coded Bits per Subcarrier (N_{BPSC})	Coded Bits per OFDM Symbol (N_{CBPS})	Data Bits per OFDM Symbol (N_{DBPS})
6	BPSK	1/2	1	48	24
9	BPSK	3/4	1	48	36
12	QPSK	1/2	2	96	48
18	QPSK	3/4	2	96	72
24	16-QAM	1/2	4	192	96
27	16-QAM	9/16	4	192	108
36	16-QAM	3/4	4	192	144
48	64-QAM	2/3	6	288	192
54	64-QAM	3/4	6	288	216

- IdleInterval specifies the idle interval between two consecutive bursts when generating a 802.11a signal source.

- For DataType:

  if PN9 is selected, a 511-bit pseudo-random test pattern is generated according to CCITT Recommendation O.153.

  if PN15 is selected, a 32767-bit pseudo-random test pattern is generated according to CCITT Recommendation O.151.

  if FIX4 is selected, a zero-stream is generated.

  if x_1_x_0 is selected (where x equals 4, 8, 16, 32, or 64) a periodic bit stream is generated, with the period being 2 x. In one period, the first x bits are 1s and the second x bits are 0s.

- DataLength is used to set the number of data bytes in a frame (or burst). There are 8 bits per byte.
- GuardInterval is used to set cyclic prefix in an OFDM symbol. The value range of GuardInterval is [0.0,1.0]. The cyclic prefix is a fractional ratio of the IFFT length. 802.11a/g defines GuardInterval=1/4 (0.8 µsec) and HIPERLAN/2 defines two GuardIntervals (1/8 and 1/4).

7. Use with Circuit Analyses

   The full features of this model are used with Circuit Envelope simulations; for other circuit simulations, it defaults to a simpler model.

   Signal output noise is based on Temp and Noise parameters and included in the RF output I and Q waveforms for Circuit Envelope (Env) analysis.

References

[1] IEEE Standard 802.11a-1999, “Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) specifications: High-speed Physical Layer in the 5 GHz Band,” 1999.

http://standards.ieee.org/getieee802/download/802.11a-1999.pdf

[2] ETSI TS 101 475 v1.1.1, “Broadband Radio Access Networks (BRAN); HIPERLAN Type 2; Physical (PHY) layer,” November 2000.

[3] IEEE P802.11G-2003, “Part II: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) specifications Amendment 4: Further Higher Data Rate Extension in the 2.4 GHz Band,” April 2003.

http://standards.ieee.org/getieee802/download/802.11g-2003.pdf

[4] CCITT, Recommendation O.151(10/92).

[5] CCITT, Recommendation O.153(10/92).

WLAN Links

European Radiocommunications Office: http://www.ero.dk.

U.S. Frequency Allocations Chart: http://www.ntia.doc.gov/osmhome.

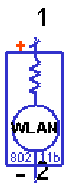
IEEE 802.11b Compliance Organization: http://www.wi-fi.org.

HomeRF Resource Center: http://www.homerf.org.

IEEE 802.11 Working Group: http://grouper.ieee.org/groups/802/11/index.html.

WLAN_802_11b (WLAN 80211b Signal Source)

Symbol



Parameters

Name	Description	Default	Sym	Unit	Type	Range
Num	Port number for S-parameter and HB noise figure analysis	1			int	[1, ∞)
R	Source resistance	50 Ohm		Ohm	real	(0, ∞)
Temp	Temperature			Celsius	real	[-273.15, ∞)
Noise	Enable thermal noise? NO, YES	YES			enum	
MaxTimeStep	Expression showing how TStep is related to the other source parameters	1/11 MHz/OversamplingRatio			string	
FCarrier	Carrier frequency: CH1_2412.0M, CH3_2422.0M, CH5_2432.0M, CH6_2437.0M, CH7_2442.0M, CH9_2452.0M, CH11_2462.0M, CH13_2472.0M	CH1_2412.0M		Hz	real enum	
Power	Power	0.04		W	real	[0, ∞)
MirrorSpectrum	Mirror spectrum about carrier? NO, YES	NO			enum	
GainImbalance	Gain imbalance, Q vs I	0.0		dB	real	(-∞, ∞)
PhaseImbalance	Phase imbalance, Q vs I	0.0		deg	real	(-∞, ∞)
I_OriginOffset	I origin offset (percent)	0.0			real	(-∞, ∞)
Q_OriginOffset	Q origin offset (percent)	0.0			real	(-∞, ∞)
IQ_Rotation	IQ rotation	0.0		deg	real	(-∞, ∞)
OversamplingRatio	Oversampling ratio	2	S		int	[2, 9]

Name	Description	Default	Sym	Unit	Type	Range
DataRate	Data rate (Mbps): Mbps_1, Mbps_2, Mbps_5.5, Mbps_11	Mbps_11	R		enum	
Modulation	Modulation format: CCK, PBCC	CCK			enum	
PreambleFormat	Preamble/header format: Long, Short	Long	H		enum	
ClkLockedFlag	Lock header clock? NO, YES	YES			enum	
PwrRamp	RF power ramp shape: None, Linear, Cosine	None	P		enum	
IdleInterval	Burst idle interval	10.0 usec	I	sec	real	[0, 1000usec]
FilterType	Shaping filter type: NoneFilter, Gaussian, Root Cosine, Ideal Lowpass	Gaussian			enum	
RRC_Alpha	RRC roll-off factor	0.2			real	(0.0, 1.0]
GaussianFilter_bT	Gaussian filter bT coefficient	0.3			real	(0.0, 1.0]
FilterLength	Filter length (chips)	6			int	[1, 200]
DataType	Payload data type: PN9, PN15, FIX4, _4_1_4_0, _8_1_8_0, _16_1_16_0, _32_1_32_0, _64_1_64_0	PN9			enum	
DataLength	Data length (bytes per burst)	100	L		int	[1, 2312]

Pin Outputs

Pin	Name	Description	Signal Type
1	RF	RF output	timed
2	Minus	Ground	timed

Notes/Equations

1. This WLAN signal source generates an IEEE 802.11b and 802.11g DSSS/CCK/PBCC RF signal.

   To use this source, RF carrier frequency (FCarrier) and power (Power) must be set.

   RF impairments can be introduced by setting the R, Temp, Noise, MirrorSpectrum, GainImbalance, PhaseImbalance, I_OriginOffset, Q_OriginOffset, and IQ_Rotation parameters.

802.11b/g signal characteristics an be specified by setting the OversamplingRatio, DataRate, Modulation, PreambleFormat, ClkLockedFlag, PwrRamp, IdleInterval, FilterType, RRC_Alpha, GaussianFilter_bT, FilterLength, DataType, and DataLength parameters.

The maximum Circuit Envelope simulation time allowed is 1/11 MHz/OversamplingRatio. If the actual simulation Circuit Envelope simulation time step is greater than the maximum allowed, the simulation will stop and an error message will be displayed.

2. An example (WLAN_802_11b_test.dsn) demonstrating the use of this signal source is available under /examples/WLAN/RF_Verification_prj.
3. This signal source includes a DSP section, RF modulator, and RF output resistance as illustrated in Figure 1-14.

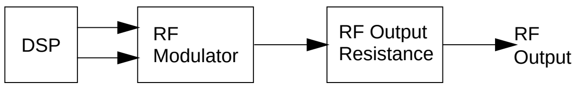


Figure 1-14. Signal Source Block Diagram

The R, Temp and Noise parameters are used by the RF output resistance. The FCarrier, Power, MirrorSpectrum, GainImbalance, PhaseImbalance, I_OriginOffset, Q_OriginOffset, and IQ_Rotation parameters are used by the RF modulator. The remaining signal source parameters are used by the DSP block.

The RF output from the signal source is at the frequency specified (FCarrier), with the specified source resistance (R) and with power (Power) delivered into a matched load of resistance R. The RF signal has additive Gaussian noise power set by the resistor temperature (Temp) (when Noise=yes).

4. This WLAN 802.11b signal source model is compatible with the Agilent Signal Studio Software for 802.11 WLAN Agilent E4438C ESG Vector Signal Generator Option 417 for transmitter test.

Details regarding Signal Studio for WLAN 802.11 are included at the website **http://www.agilent.com/find/signalstudio**.

5. The 802.11b baseband signal source frame structure is illustrated in Figure 1-15 and Figure 1-16. Each frame is separated by an IdleInterval; one 802.11b frame consists of PLCP Preamble, PLCP Header and Data (PSDU) parts. (PPDU means *physical layer protocol data units*; SFD means *start frame*

delimiter; CRC means *cyclic redundancy code*; PLCP means *physical layer convergence procedure*; PSDU means *PLCP service data units*.)

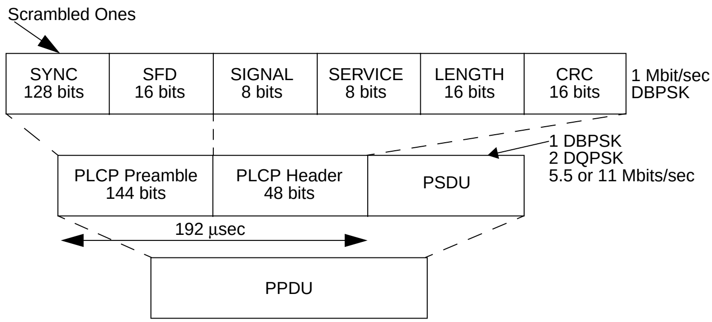


Figure 1-15. Long PLCP frame format

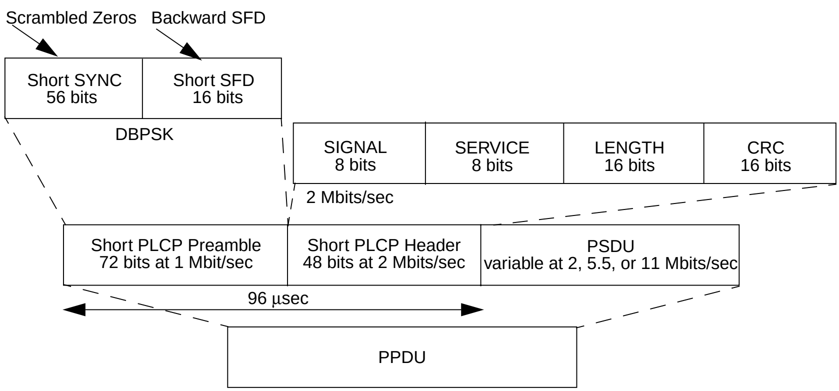


Figure 1-16. Short PLCP Frame Format

6. Parameter Details

- Num defines the circuit port number for S-parameter and Harmonic Balance noise figure analysis only (it is not used for other circuit analysis).
- R is the RF output source resistance.
- Temp is the RF output source resistance temperature in Celsius and sets the noise density in the RF output signal to (k(Temp+273.15)) Watts/Hz, where k is Boltzmann's constant.
- Noise, when set to NO disables the Temp and effectively sets it to -273.15^{o}C (0 Kelvin). When set to YES, the noise density due to Temp is enabled.

- FCarrier is the RF output signal frequency.
- Power is the RF output signal power. The Power of the signal is defined as the average frame power and excludes the idle interval time intervals.
- MirrorSpectrum is used to mirror the RF_out signal spectrum about the carrier. This is equivalent to conjugating the complex RF envelope voltage.

  Depending on the configuration and number of mixers in an RF transmitter, the RF output signal from hardware RF generators can be inverted. If such an RF signal is desired, set MirrorSpectrum to YES.
- GainImbalance, PhaseImbalance, I_OriginOffset, Q_OriginOffset, and IQ_Rotation are used to add certain impairments to the ideal output RF signal. Impairments are added in the order described here.

  The unimpaired RF I and Q envelope voltages have gain and phase imbalance applied. The RF is given by:

$$V_{RF}(t) = A\left(V_I(t)\cos(\omega_c t) - gV_Q(t)\sin\left(\omega_c t + \frac{\phi\pi}{180}\right)\right)$$

  where A is a scaling factor based on the Power and R parameters specified by the user, $V_I(t)$ is the in-phase RF envelope, $V_Q(t)$ is the quadrature phase RF envelope, g is the gain imbalance

$$g = 10^{\frac{GainImbalance}{20}}$$

  and, ϕ (in degrees) is the phase imbalance.

  Next, the signal $V_{RF}(t)$ is rotated by IQ_Rotation degrees. The I_OriginOffset and Q_OriginOffset are then applied to the rotated signal. Note that the amounts specified are percentages with respect to the output rms voltage. The output rms voltage is given by sqrt(2 R Power).
- OversamplingRatio sets the oversampling ratio of 802.11b RF signal source. There are eight oversampling ratios (2, 3, 4, 5, 6, 7, 8, 9) supported by this source. If OversamplingRatio = 4, the simulation RF bandwidth is larger than the signal bandwidth by a factor of 4 (e.g. for Bandwidth=11 MHz, the simulation RF bandwidth = 11 MHz $\times$ 4 = 44 MHz).
- DataRate specifies the data rate; 1, 2, 5.5, and 11 Mbps can be implemented in this source. All data rates are defined in 802.11b specification.

Modulation is defined as CCK or PBCC, which are two modulation formats in 802.11b. This DataRate parameter is useless for 1 Mbps and 2 Mbps data rates. For 5.5 Mbps and 11 Mbps data rates, the two different modulation formats available are CCK and PBCC.

- PreambleFormat is used to set the format of the framed signal preamble/header sections; refer to Figure 1-15 and Figure 1-16.
- ClkLockedFlag is used to toggle the clock locked flag in the header. This is Bit 2 in the Service field of the PPDU frame. This bit is used to indicate to the receiver if the carrier and the symbol clock use the same local oscillator. If ClkLockedFlag=YES, this bit is set to 1; if ClkLockedFlag=NO, this bit is set to 0.
- PwrRamp is used to select shape of the RF burst in framed mode. Selects the power up/down ramp type as none, linear, or cosine. Cosine ramp gives least amount of out-of-channel interference. None starts transmitting the signal at full power, and is the simplest power ramp to implement. The linear ramp shapes the burst in a linear fashion. The length (in microseconds) of the power up/down ramp is set to 2 μsec when PwrRamp is not none.
- IdleInterval sets an idle duration time between two consecutive bursts when generating the 802.11b signal source.
- FilterType can be used to specify that a baseband filter is applied to reduce the transmitted bandwidth, thereby increasing spectral efficiency. The 802.11b specification does not indicate the type of filter to be used, but the transmitted signal must meet the spectral mask requirements. Four options for baseband filtering are available:

None (no filter)

Gaussian The Gaussian filter does not have zero ISI. Wireless system architects must determine how much of the ISI can be tolerated in a system and combine that with noise and interference. The Gaussian filter is Gaussian-shaped in time and frequency domains, and it does not ring as root cosine filters do.

The effects of this filter in the time domain are relatively short and each symbol interacts significantly (or causes ISI) with only the preceding and succeeding symbols. This reduces the tendency for particular sequences of symbols to interact which makes amplifiers easier to build and more efficient.

Root Cosine (also referred to as square root raised-cosine) These filters have the property that their impulse response rings at the symbol rate. Adjacent symbols do not interfere with each other at the symbol times because the response equals zero at all symbol times except the center (desired) one.

Root cosine filters heavily filter the signal without blurring the symbols together at the symbol times. This is important for transmitting information without errors caused by ISI. Note that ISI exists at all times except at the symbol (decision) times.

Ideal Low Pass In the frequency domain, this filter appears as a lowpass, rectangular filter with very steep cut-off characteristics. The passband is set to equal the symbol rate of the signal. Due to a finite number of coefficients, the filter has a predefined length and is not truly *ideal*. The resulting ripple in the cut-off band is effectively minimized with a Hamming window. A symbol length of 32 or greater is recommended for this filter.

- RRC_Alpha is used to set the sharpness of a root cosine filter when FilterType=Root Cosine.
- GaussianFilter_bT is the Gaussian filter coefficient. B is the 3 dB bandwidth of the filter; T is the duration of the symbol period. BT determines the extent of the filtering of the signal. Common values for BT are 0.3 to 0.5.
- FilterLength is used to set the number of symbol periods to be used in the calculation of the symbol.
- For DataType:

  if PN9 is selected, a 511-bit pseudo-random test pattern is generated according to CCITT Recommendation O.153

  if PN15 is selected, a 32767-bit pseudo-random test pattern is generated according to CCITT Recommendation O.151

  if FIX4 is selected, a zero-stream is generated

  if x_1_x_0 is selected, where x equals 4, 8, 16, 32, or 64, a periodic bit stream is generated, with the period being 2 x. In one period, the first x bits are 1s and the second x bits are 0s.
- DataLength is used to set the number of data bytes in a frame.

7. Use with Circuit Analyses

The full features of this model are used with Circuit Envelope simulations; for other circuit simulations, it defaults to a simpler model.

Signal output noise is based on Temp and Noise parameters and included in the RF output I and Q waveforms for Circuit Envelope (Env) analysis.

References

[1] IEEE Standard 802.11b-1999, "Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) specifications: High-speed Physical Layer Extension in the 2.4 GHz Band," 1999.

http://standards.ieee.org/getieee802/download/802.11b-1999.pdf

[2] IEEE P802.11g/D8.2, "Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) specifications: Further Higher Data Rate Extension in the 2.4 GHz Band," April 2003.

http://standards.ieee.org/getieee802/download/802.11g-2003.pdf

[3] CCITT, Recommendation O.151(10/92).

[4] CCITT, Recommendation O.153(10/92).

WLAN Links

European Radiocommunications Office: http://www.ero.dk.

U.S. Frequency Allocations Chart: http://www.ntia.doc.gov/osmhome.

IEEE 802.11b Compliance Organization: http://www.wi-fi.org.

HomeRF Resource Center: http://www.homerf.org.

IEEE 802.11 Working Group: http://grouper.ieee.org/groups/802/11/index.html

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