Agilent Technologies

Advanced Design System 2011.01

Feburary 2011
CMMB Design Library

Acknowledgments

7-zip - 7-Zip Copyright: Copyright (C) 1999-2009 Igor Pavlov. Licenses for files are: 7z.dll: GNU LGPL + unRAR restriction, All other files: GNU LGPL. 7-zip License: This library is free software; you can redistribute it and/or modify it under the terms of the GNU Lesser General Public License as published by the Free Software Foundation; either version 2.1 of the License, or (at your option) any later version. This library is distributed in the hope that it will be useful,but WITHOUT ANY WARRANTY; without even the implied warranty of MERCHANTABILITY or FITNESS FOR A PARTICULAR PURPOSE. See the GNU Lesser General Public License for more details. You should have received a copy of the GNU Lesser General Public License along with this library; if not, write to the Free Software Foundation, Inc., 59 Temple Place, Suite 330, Boston, MA 02111-1307 USA. unRAR copyright: The decompression engine for RAR archives was developed using source code of unRAR program.All copyrights to original unRAR code are owned by Alexander Roshal. unRAR License: The unRAR sources cannot be used to re-create the RAR compression algorithm, which is proprietary. Distribution of modified unRAR sources in separate form or as a part of other software is permitted, provided that it is clearly stated in the documentation and source comments that the code may not be used to develop a RAR (WinRAR) compatible archiver. 7-zip Availability: http://www.7-zip.org/

AMD Version 2.2 - AMD Notice: The AMD code was modified. Used by permission. AMD copyright: AMD Version 2.2, Copyright © 2007 by Timothy A. Davis, Patrick R. Amestoy, and Iain S. Duff. All Rights Reserved. AMD License: Your use or distribution of AMD or any modified version of AMD implies that you agree to this License. This library is free software; you can redistribute it and/or modify it under the terms of the GNU Lesser General Public License as published by the Free Software Foundation; either version 2.1 of the License, or (at your option) any later version. This library is distributed in the hope that it will be useful, but WITHOUT ANY WARRANTY; without even the implied warranty of MERCHANTABILITY or FITNESS FOR A PARTICULAR PURPOSE. See the GNU Lesser General Public License for more details. You should have received a copy of the GNU Lesser General Public License along with this library; if not, write to the Free Software Foundation, Inc., 51 Franklin St, Fifth Floor, Boston, MA 02110-1301 USA Permission is hereby granted to use or copy this program under the terms of the GNU LGPL, provided that the Copyright, this License, and the Availability of the original version is retained on all copies.User documentation of any code that uses this code or any modified version of this code must cite the Copyright, this License, the Availability note, and "Used by permission." Permission to modify the code and to distribute modified code is granted, provided the Copyright, this License, and the Availability note are retained, and a notice that the code was modified is included. AMD Availability: http://www.cise.ufl.edu/research/sparse/amd

UMFPACK 5.0.2 - UMFPACK Notice: The UMFPACK code was modified. Used by permission. UMFPACK Copyright: UMFPACK Copyright © 1995-2006 by Timothy A. Davis. All Rights Reserved. UMFPACK License: Your use or distribution of UMFPACK or any modified version of UMFPACK implies that you agree to this License. This library is free software; you can redistribute it and/or modify it under the terms of the GNU Lesser General Public License as published by the Free Software Foundation; either version 2.1 of the License, or (at your option) any later version. This library is distributed in the hope that it will be useful, but WITHOUT ANY WARRANTY; without even the implied warranty of MERCHANTABILITY or FITNESS FOR A PARTICULAR PURPOSE. See the GNU Lesser General Public License for more details. You should have received a copy of the GNU Lesser General Public License along with this library; if not, write to the Free Software Foundation, Inc., 51 Franklin St, Fifth Floor, Boston, MA 02110-1301 USA Permission is hereby granted to use or copy this program under the terms of the GNU LGPL, provided that the Copyright, this License, and the Availability of the original version is retained on all copies. User documentation of any code that uses this code or any modified version of this code must cite the Copyright, this

License, the Availability note, and "Used by permission." Permission to modify the code and to distribute modified code is granted, provided the Copyright, this License, and the Availability note are retained, and a notice that the code was modified is included. UMFPACK Availability: http://www.cise.ufl.edu/research/sparse/umfpack UMFPACK (including versions 2.2.1 and earlier, in FORTRAN) is available at http://www.cise.ufl.edu/research/sparse . MA38 is available in the Harwell Subroutine Library. This version of UMFPACK includes a modified form of COLAMD Version 2.0, originally released on Jan. 31, 2000, also available at http://www.cise.ufl.edu/research/sparse . COLAMD V2.0 is also incorporated as a built-in function in MATLAB version 6.1, by The MathWorks, Inc. http://www.mathworks.com . COLAMD V1.0 appears as a column-preordering in SuperLU (SuperLU is available at http://www.netlib.org). UMFPACK v4.0 is a built-in routine in MATLAB 6.5. UMFPACK v4.3 is a built-in routine in MATLAB 7.1.

Qt Version 4.6.3 - Qt Notice: The Qt code was modified. Used by permission. Qt copyright: Qt Version 4.6.3, Copyright (c) 2010 by Nokia Corporation. All Rights Reserved. Qt License: Your use or distribution of Qt or any modified version of Qt implies that you agree to this License. This library is free software; you can redistribute it and/or modify it under the
terms of the GNU Lesser General Public License as published by the Free Software Foundation; either version 2.1 of the License, or (at your option) any later version. This library is distributed in the hope that it will be useful,
but WITHOUT ANY WARRANTY; without even the implied warranty of MERCHANTABILITY or FITNESS FOR A PARTICULAR PURPOSE. See the GNU Lesser General Public License for more details. You should have received a copy of the GNU Lesser General Public License along with this library; if not, write to the Free Software Foundation, Inc., 51 Franklin St, Fifth Floor, Boston, MA 02110-1301 USA Permission is hereby granted to use or copy this program under the terms of the GNU LGPL, provided that the Copyright, this License, and the Availability of the original version is retained on all copies.User
documentation of any code that uses this code or any modified version of this code must cite the Copyright, this License, the Availability note, and "Used by permission." Permission to modify the code and to distribute modified code is granted, provided the Copyright, this License, and the Availability note are retained, and a notice that the code was modified is included. Qt Availability: http://www.qtsoftware.com/downloads Patches Applied to Qt can be found in the installation at:
$HPEESOF_DIR/prod/licenses/thirdparty/qt/patches. You may also contact Brian Buchanan at Agilent Inc. at brian_buchanan@agilent.com for more information.

The HiSIM_HV source code, and all copyrights, trade secrets or other intellectual property rights in and to the source code, is owned by Hiroshima University and/or STARC.

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.

Warranty The material contained in this document is provided "as is", and is subject to being changed, without notice, in future editions. Further, to the maximum extent permitted by applicable law, Agilent disclaims all warranties, either express or implied, with regard to this documentation and any information contained herein, including but not limited to the implied warranties of merchantability and fitness for a particular purpose. Agilent shall not be liable for errors or for incidental or consequential damages in connection with the furnishing, use, or performance of this document or of any

information contained herein. Should Agilent and the user have a separate written agreement with warranty terms covering the material in this document that conflict with these terms, the warranty terms in the separate agreement shall control.

Technology Licenses The hardware and/or software described in this document are furnished under a license and may be used or copied only in accordance with the terms of such license. Portions of this product include the SystemC software licensed under Open Source terms, which are available for download at http://systemc.org/ . This software is redistributed by Agilent. The Contributors of the SystemC software provide this software "as is" and offer no warranty of any kind, express or implied, including without limitation warranties or conditions or title and non-infringement, and implied warranties or conditions merchantability and fitness for a particular purpose. Contributors shall not be liable for any damages of any kind including without limitation direct, indirect, special, incidental and consequential damages, such as lost profits. Any provisions that differ from this disclaimer are offered by Agilent only.

Restricted Rights Legend U.S. Government Restricted Rights. Software and technical data rights granted to the federal government include only those rights customarily provided to end user customers. Agilent provides this customary commercial license in Software and technical data pursuant to FAR 12.211 (Technical Data) and 12.212 (Computer Software) and, for the Department of Defense, DFARS 252.227-7015 (Technical Data - Commercial Items) and DFARS 227.7202-3 (Rights in Commercial Computer Software or Computer Software Documentation).

About CMMB Design Library

Introduction

The CMMB wireless library complies with Mobile Multimedia Broadcasting specification (GY/T 220.1-2006). This design library is intended to help designers on signal pattern compliance with specification.

Top Level Models

Top-level baseband signal sources and RF signal sources for CMMB transmitter are provided. Various signal patterns can be generated with these top-level models by setting their parameters. The functionalities are as follows:

- 2 bandwidth modes, B_f=8MHz and B_f=2MHz
- 3 constellation mapping modes, BPSK, QPSK and 16QAM
- signalling information
- TxID and 2 synchronization signal

Test Benches

The CMMB Wireless Library provides test benches for CMMB transmitter measurements. One workspace (CMMB_Tx_wrk) is provided.

CMMB_Tx_wrk:
This workspace provides transmitter measurements, including waveform, CCDF, spectrum and EVM.

- CMMB_CCDF_Spectrum: A demo for CMMB transmitter CCDF and spectrum measurements
- CMMB_Tx_EVM: A demo for CMMB transmitter evm measurements

References

1. "Mobile Multimedia Broadcasting Part1: Framing Structure, Channel Coding and Modulation for Broadcasting Channel", GY/T 220.1-2006, Oct. 24 2006.

CMMB_CCDF_Spectrum Design Examples

The CMMB_Tx_wrk workspace shows base station transmitter measurement characteristics including complementary cumulative distribution function (CCDF), spectrum and EVM.

- Designs for CCDF and spectrum measurements include:
  - **CMMB_CCDF_Spectrum**
- Variables used in these designs are listed in the **Variable parameter** table detailed below:

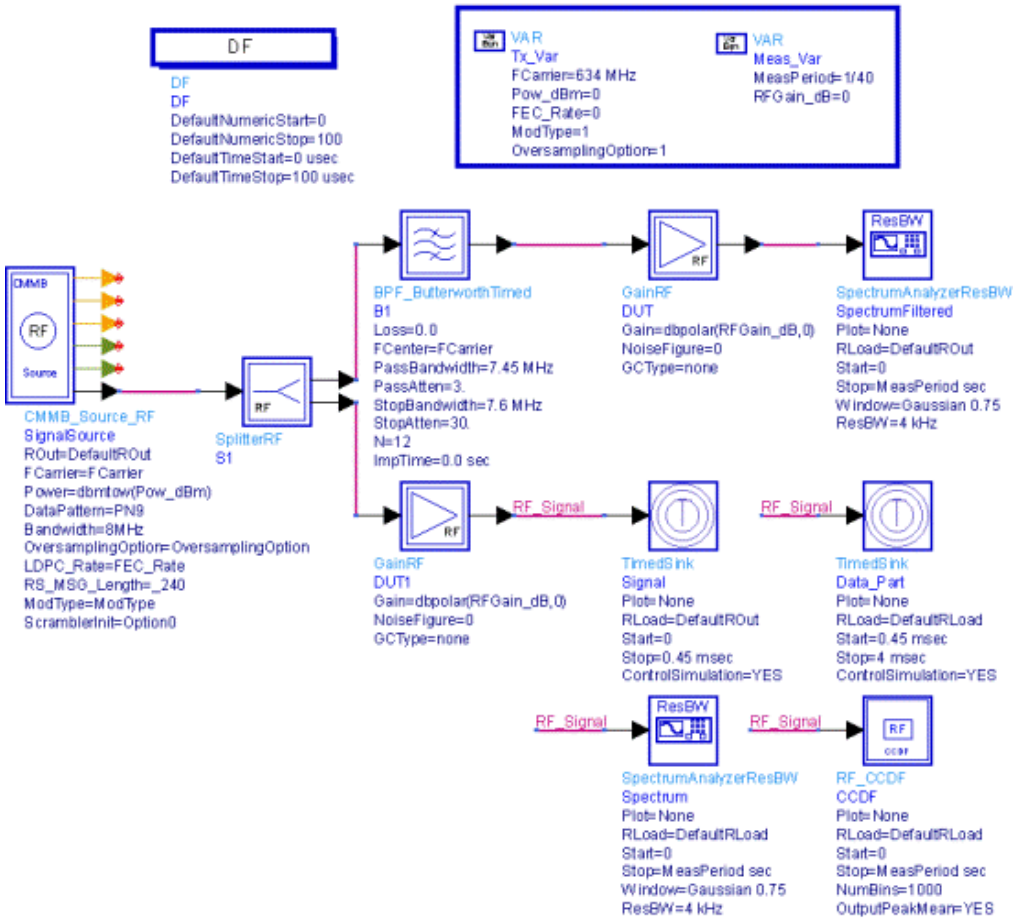
Parameter Name	Description	Default Value
FCarrier	carrier frequency	634MHz
Bandwidth	transmit bandwidth	8MHz
Start	start time for data recording	DefaultTimeStart will inherit from the DF Controller
Pow_dBm	specifies the transmitter power, in dBm	0
ModType	modulation format for each time slot	BPSK
OversamplingOption	oversampling ration	x2

Features:

- Waveform, Spectrum, CCDF, Power, and etc

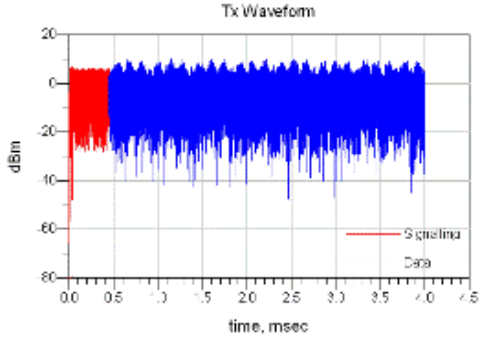
Description:
This design measures the waveform, CCDF and spectrum of the base station transmitter. The schematic for this design is shown below:

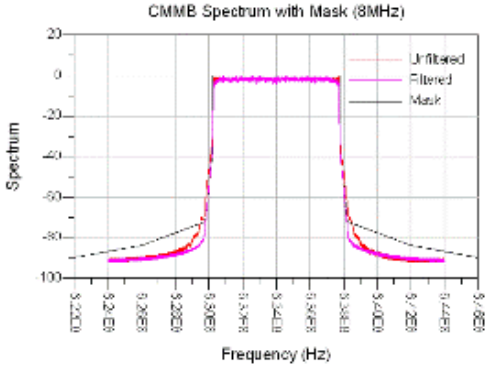
CMMB_CCDF_Spectrum.dsn



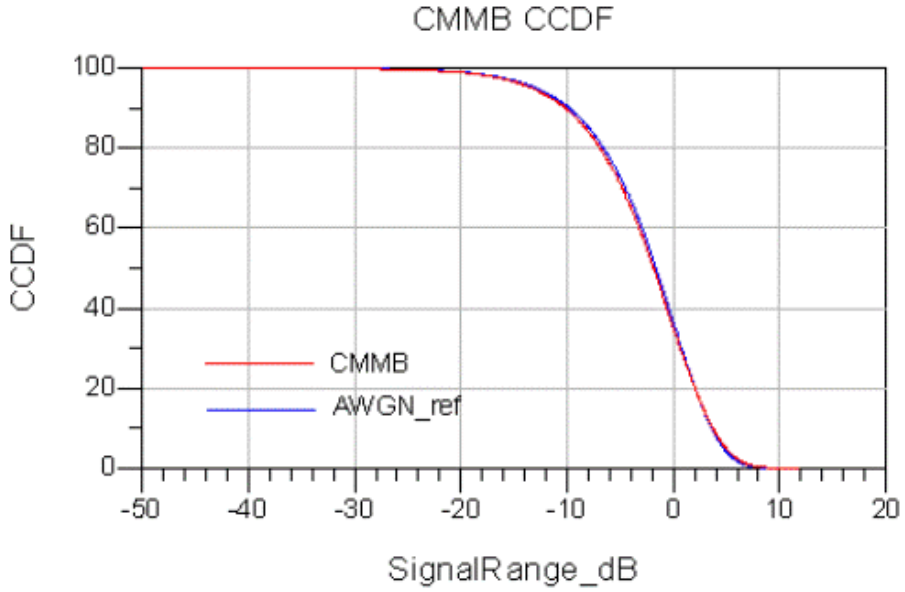
Simulation Results:

1. The waveform and spectrum measurement results are shown below:





2. The CCDF and power measurement results are shown below:



MeanPower_dBm	PeakPower_dBm	Peak_to_Avg_dB
-0.16527924	8.84049486	9.00577410

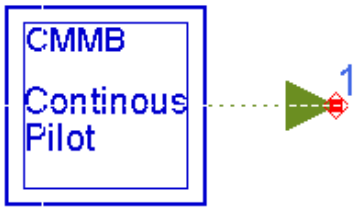
Benchmark:

- Hardware Platform: Xeon 5130 2 GHz, 4 GB memory
- Software Platform: Windows xp, ADS 2009u1
- Data Points: 1 slot, i.e. signalling and 53 OFDM symbols
- Simulation Time: approximately 30 seconds.

References

1. "Mobile Multimedia Broadcasting Part1: Framing Structure, Channel Coding and Modulation for Broadcasting Channel"", GY/T 220.1-2006, Oct. 24 2006.

CMMB_ContinuousPilot



Description: CMMB continuous pilot
Library: CMMB, Source

Parameters

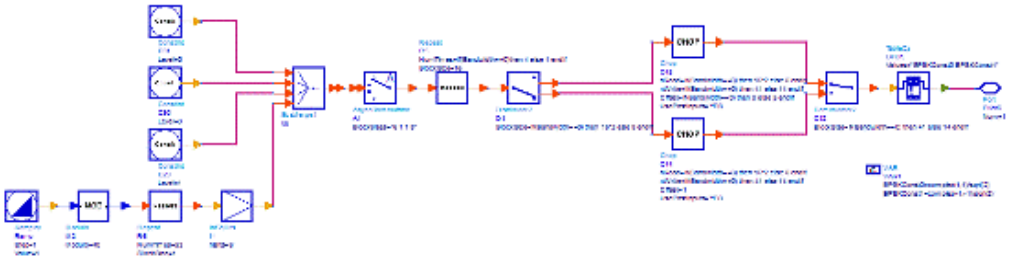
Name	Description	Default	Type
Bandwidth	Bandwidth: _8MHz, _2MHz	_8MHz	enum

Pin Outputs

Pin	Name	Description	Signal Type
1	PilotC	Continuous Pilot	complex

Notes/Equations

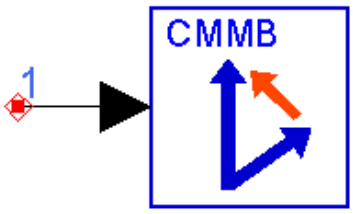
1. Every OFDM symbol has continual pilots for channel estimation. In 8MHz mode, there are 82 pilots while in 2MHz mode, there are 28 pilots. Pilot sub-carriers are BPSK modulated with system information for the first 16 bits and all "zeros" for the rest bits.
   The schematic is shown as below.



References

1. "Mobile Multimedia Broadcasting Part1: Framing Structure, Channel Coding and Modulation for Broadcasting Channel", GY/T 220.1-2006, Oct. 24 2006.

CMMB_EVM



Description: CMMB EVM measurement
Library: CMMB, Measurement

Parameters

Name	Description	Default	Unit	Type	Range
RLoad	load resistance. DefaultRLoad will inherit from the DF controller.	DefaultRLoad	Ohm	real	(0,∞)
RTemp	physical temperature, in degrees C, of load resistance. DefaultRTemp will inherit from the DF controller.	DefaultRTemp	Celsius	real	[-273.15,∞)
FCarrier	carrier frequency	634 MHz	Hz	real	(0,∞)
MirrorSpectrum	mirror frequency or not: NO, YES	NO		enum	
Bandwidth	bandwidth: _8MHz, _2MHz	_8MHz		enum	
Start	start time for data recording. DefaultTimeStart will inherit from the DF Controller.	DefaultTimeStart	sec	real	[0,∞)
numSlots	specifies the slot number to calculate the EVM	1		int	[0,+∞)
numSyms	this parameter indicate the number of ofdm symbols to analyze (1~53) in each slot	53		int	[1,53]
modFormatsV	modulation format for each time slot, 0 for BPSK, 1 for QPSK, 2 for 16QAM	0		int array	

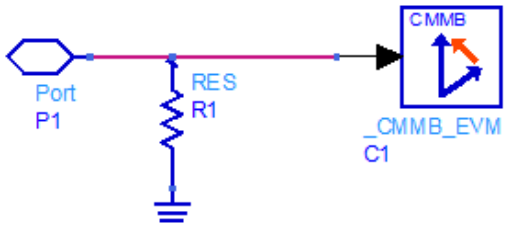
Pin Inputs

Pin	Name	Description	Signal Type
1	input	input signal	timed

Notes/Equations

1. This subnetwork model is used to measure EVM for CMMB transmitter as defined in Reference [1]. It can be used to measure EVM of a set of slots and a set of OFDM symbols within a slot. The input signal must be a timed RF (complex envelope) signal. The schematic for this subnetwork is shown below.

CMMB_EVM Schematic



2. The measurement methods include EVM, MER, Magnitude Error, Phase Error, Frequency Error, Quad Error, Amplitude Imbalance, etc.
   - EVM:
     EVM(Error Vector Magnitude) is a modulation quality metric widely used in digital communications systems and wireless industry. It is a measure of the difference between the reference waveform and the measured waveform. This difference is called the error vector. The EVM result is defined as the square root of the ratio of the mean error vector power to the mean reference power expressed as a %:

$$EVM = \frac{\sqrt{\frac{1}{N}\sum_{j=1}^{N}(\delta I_j^2 + \delta Q_j^2)}}{S_{rms}} \times 100\%$$

     Where N is the number of total points in the measurement samples. S_{rms} is calculated in the following way

$$S_{rms} = \sqrt{\frac{1}{N}\sum_{j=1}^{N}(I_j^2 + Q_j^2)}$$

     The representations of other definitions are expressed in Figure 1

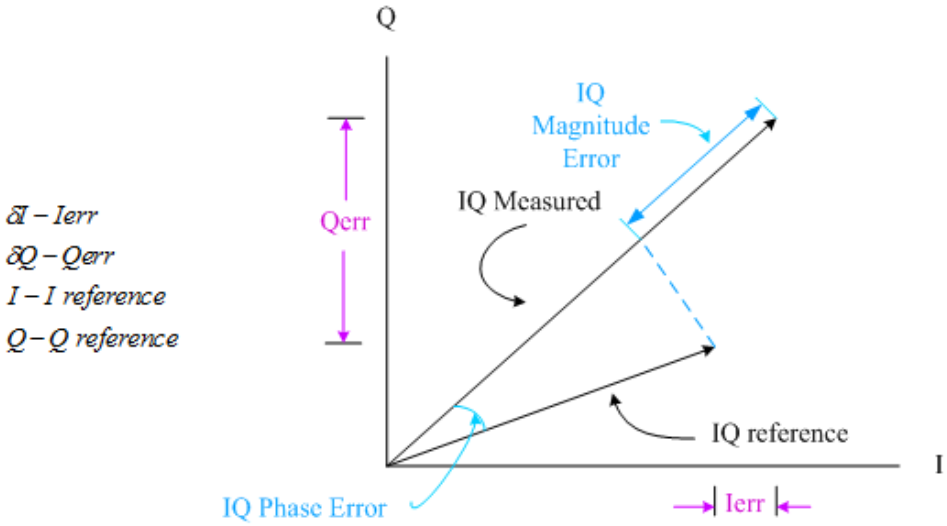


Figure 1: Digital Demodulation Error

- MER:
  MER(Modulation Error Ratio) is a power ratio expressed in dB of the sum of the squares of the magnitude of the ideal symbol vectors to the sum of the squares of the magnitudes of the symbol error vectors.
  The formula of MER is shown below:

$$MER = 10\log_{10}\left[\frac{\sum_{j=1}^{N}(I_j^2 + Q_j^2)}{\sum_{j=1}^{N}(\delta I_j^2 + \delta Q_j^2)}\right] dB$$

  N is the number of total points in the measurement samples. The representations of other definitions are expressed in Figure 1.
- Magnitude Error:
  Magnitude Error is the difference in amplitude between the I/Q measured signal and the I/Q reference signal.
  Figure 1 shows the magnitude error.
- Phase Error:
  Phase error is the difference in phase, between the I/Q reference signal and the I/Q measured signal for composite signal.
  Figure 1 shows the phase error.
- Frequency Error:
  Frequency Error shows the signal carrier frequency-error relative to the analyzer's center frequency. This parameter is displayed in Hz and is the amount of frequency shift, from the analyzer's center frequency, that the analyzer must perform to achieve carrier lock.
  Errors in RF frequency, LO frequency, or digitizer clock rate could all appear as carrier frequency error.
- Quad Error:
  Quad Err (Quadrature Skew Error) indicates the orthogonal error between the I and Q signals.
  Ideally, I and Q should be orthogonal (90 degrees apart). A quadrature skew error of 3 degrees means I and Q are 93 degrees apart. A quadrature skew error of -3 degrees means I and Q are 87 degrees apart.
- Amplitude Imbalance:
  Amplitude Imbalance is another form of IQ Gain Imbalance. It's calculated from the formula: AI = 20lg(v_I / v_Q) dB.

where v_I and v_Q represent I and Q gain respectively.

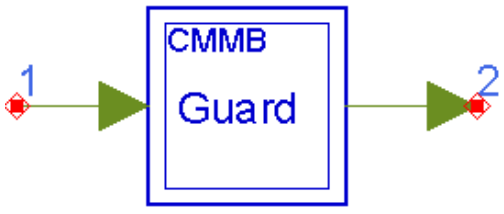
- Timing Skew:
  Timing Skew indicates the skew changes between the I and Q signals in microsecond. A positive value means that the I signal delays relative to the Q signal and a negative value means that the Q signal delays relative to the I signal.

3. The available results from this measurement comprise of
   - Avg_EVM_rms_percent: overall rms EVM in % for all of the slots and OFDM symbols determined by the parameter numSlots and numSyms.
   - EVM_rms_percent: average rms EVM for each slot in %
   - DataEVM_rms_percent: average rms data EVM for each slot in %
   - ContPilotEVM_rms_percent: average rms continual pilot EVM for each slot in %
   - ScatPilotEVM_rms_percent: average rms scattered pilot EVM for each slot in %
   - EVMPk_rms_percent: the peak rms EVM in % for each slot
   - EvmPerSubcarrV_rms_percent: rms EVM in % for each subcarrier with the length of N_v * numSlots. (N_v is the subcarrier number for each OFDM symbol)
   - PkEVMSubcarIndex: the subcarrier index of the peak EVM for each slot
   - MER: average MER for each slot
   - DataMER: average data MER for each slot
   - ContPilotMER: average continual pilot MER for each slot
   - ScatPilotMER: average scattered pilot MER for each slot
   - MERPk: the peak MER for each slot
   - MERPerSubcarrV: MER for each subcarrier with the length of N_v * numSlots. (N_v is the subcarrier number for each OFDM symbol)
   - PkMERSubcarIndex: the subcarrier index of the peak MER for each slot
   - ErrPwr: Sum of error vector power for each timeslot
   - Refwr: Sum of reference vector power for each timeslot
   - FreError: calculated frequency error
   - IQGainImb: IQ imbalance
   - IQQuadErr: Quadrature error
   - MagE: overall MagError for each TS
   - peakMagE: peak MagError for each TS
   - peakMagEIndex: peak MagError subcarrier index for each TS
   - PhaseE: PhaseError for each TS
   - peakPhaseE: peak PhaseError for each TS
   - peakPhaseEIndex: peak PhaseError subcarrier index for each TS
   - TxIDNum: TxID number (Region Index or Transmitter Index)

References

1. "Mobile Multimedia Broadcasting Part1: Framing Structure, Channel Coding and Modulation for Broadcasting Channel", GY/T 220.1-2006, Oct. 24 2006.

CMMB_GI



Description: CMMB Guard Interval

Library: CMMB, Source

Parameters

Name	Description	Default	Type
Bandwidth	Bandwidth: _8MHz, _2MHz	_8MHz	enum
OversamplingOption	Oversampling ratio (x1 is meaningless): x1, x2, x4	x2	enum
SymbolType	OFDM symbol type (Data , Sync or TxID) selection: Data, Sync, TxID	Data	enum

Pin Inputs

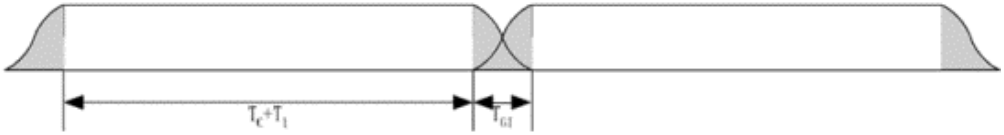
Pin	Name	Description	Signal Type
1	in	output	complex

Pin Outputs

Pin	Name	Description	Signal Type
2	out	output	complex

Notes/Equations

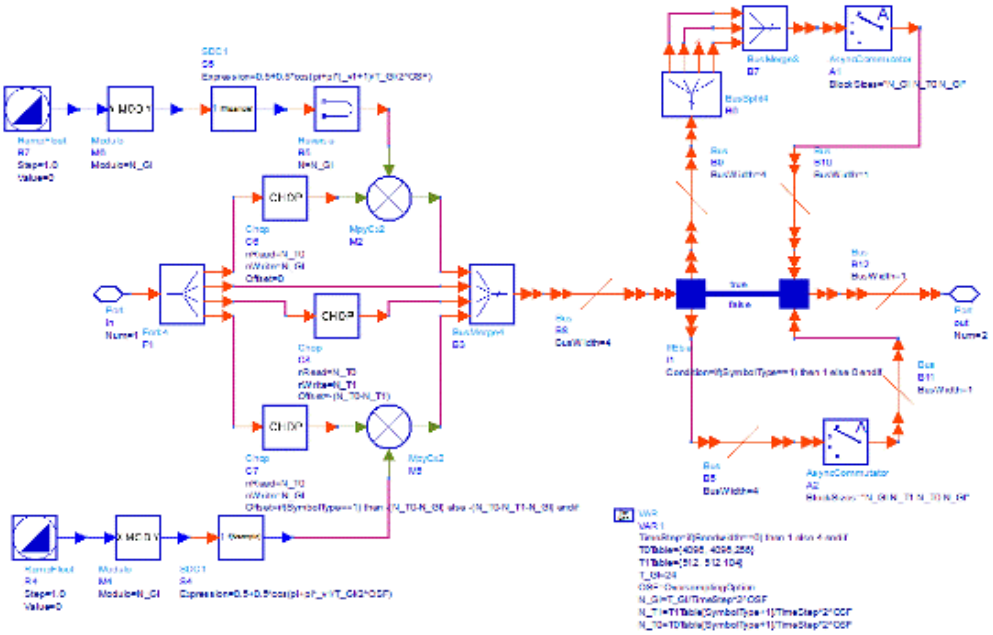
1. This subnetwork is used to add the cyclic prefix and guard intervals for each OFDM symbol. There is no GI between two synchronization OFDM symbols. While for data and TxID symbols, there is a 2.4us guard interval overlapped between consecutive OFDM symbols. The guard intervals are windowed with a cosine function. The diagram is shown below.



T_1 is the data length, T_0 is the cyclic prefix length and T_{GI} is the guard interval length. The window function is defined as below.

$$w(t)=\begin{cases}0.5+0.5\cos(\pi+\pi t/T_{GI}), & 0\le t\le T_{GI}\\ 1, & T_{GI}<t<(T_0+T_1)+T_{GI}\\ 0.5+0.5\cos(\pi+\pi(T_0+T_1-t)/T_{GI}), & (T_0+T_1)+T_{GI}\le t\le(T_0+T_1)+2T_{GI}\end{cases}$$

The schematic is shown as below.



References

1. "Mobile Multimedia Broadcasting Part1: Framing Structure, Channel Coding and Modulation for Broadcasting Channel", GY/T 220.1-2006, Oct. 24 2006.

CMMB_LDPC_Encoder

Description: CMMBLDPC Encoder
Library: CMMB, Channel Coding

Parameters

Name	Description	Default	Type
LDPC_Rate	LDPCcode rate: Half, ThreeFourth	Half	enum

Pin Inputs

Pin	Name	Description	Signal Type
1	Input	bitsto be encoded	int

Pin Outputs

Pin	Name	Description	Signal Type
2	Output	encoded bits	int

Notes/Equations

1. This model is used to encode the Reed-Solomon encoded and byte interleaved bytes (LSB first) with the LDPC parity check matrix defined in [1].
2. LDPC encoding parameters

Code Rate	Information Length K	Codeword Length N
1/2	4608 bits	9216 bits
3/4	6912 bits	9216 bits

3. The LDPC output codeword $\mathbf{C}=\{c_0,c_1, ..., c_{N-1}\}$ consits of information bits $\mathbf{S}=\{s_0,s_1, ..., s_{K-1}\}$ and parity check bits $\mathbf{P}=\{p_0,p_1, ..., p_{K-1}\}$ as shown below

   for 0<=i<N-K,
   $c_{COL\_ORDER[i]} = p_i$
   for N-K<=i<N,
   $c_{COL\_ORDER[i]} = s_{i-(N-K)}$

   where COL_ORDER[i] is the codeword bits mapping vector defined in Annex C in [1].
4. The encoding is implemented in the following steps based on the parity check equation $\mathbf{H} \times \mathbf{C}^T = \mathbf{0}^T$
   - Reorder columns of **H** (defined in [1]) with

     $\mathbf{H_{sys}}[::,i] = \mathbf{H}[::,COL\_ORDER[i]]$

where $\mathbf{H_{sys}}$ is the parity check matrix in system code form, and $\mathbf{H_{sys}}[::,i]$ is the i^{th} column. $\mathbf{H_{sys}}$ satisfies equation $\mathbf{H_{sys}} \times \mathbf{C_{sys}}^T = \mathbf{0}^T$, $\mathbf{C_{sys}} = [\mathbf{P},\mathbf{S}]$ is the codeword in system code form.

- Rewrite $\mathbf{H_{sys}}$ as $[\mathbf{H_p},\mathbf{H_s}]$, where $\mathbf{H_p}$ is (N-K) x (N-K) and $\mathbf{H_s}$ is (N-K) x K, and resolve equation $[\mathbf{H_p},\mathbf{H_s}] \times [\mathbf{P},\mathbf{S}]^T = \mathbf{0}^T$, i.e.

$$\mathbf{H_p} \times \mathbf{P}^T = \mathbf{H_s} \times \mathbf{S}^T$$

in Galois Field (2) to obtain **P** and then $\mathbf{C_{sys}}$.

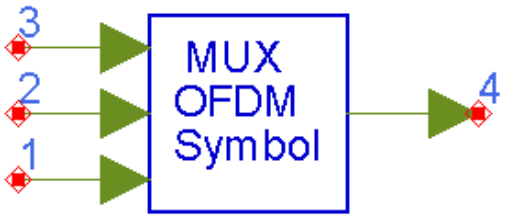
- Reorder $\mathbf{C_{sys}}$ with equation

$$\mathbf{C}[\text{COL\_ORDER}[i]] = \mathbf{C_{sys}}[i]$$

References

1. "Mobile Multimedia Broadcasting Part1: Framing Structure, Channel Coding and Modulation for Broadcasting Channel", GY/T 220.1-2006, Oct. 24 2006.

CMMB_MuxOFDMSym



Description: CMMB OFDM symbol multiplexer
Library: CMMB, Source

Parameters

Name	Description	Default	Type
Bandwidth	Bandwidth: _8MHz, _2MHz	_8MHz	enum

Pin Inputs

Pin	Name	Description	Signal Type
1	Data	data input	complex
2	PilotC	Continuous pilot	complex
3	PilotS	Scattered pilot	complex

Pin Outputs

Pin	Name	Description	Signal Type
4	Out	OFDM symbol output	complex

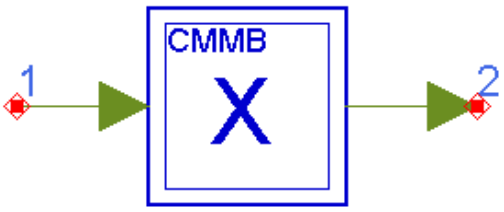
Notes/Equations

1. This model is used to insert continual pilots and scattered pilots to the data sub-carriers to form an OFDM symbol.

References

1. "Mobile Multimedia Broadcasting Part1: Framing Structure, Channel Coding and Modulation for Broadcasting Channel", GY/T 220.1-2006, Oct. 24 2006.

CMMB_Oversample



Description: CMMB oversample component in frequency domain
Library: CMMB, Source

Parameters

Name	Description	Default	Type
Bandwidth	Bandwidth: _8MHz, _2MHz	_8MHz	enum
OversamplingOption	Oversampling ratio (x1 is meaningless): x1, x2, x4	x2	enum
SymbolType	OFDM symbol type (Data, Sync or TxID) selection: Data, Sync, TxID	Data	enum

Pin Inputs

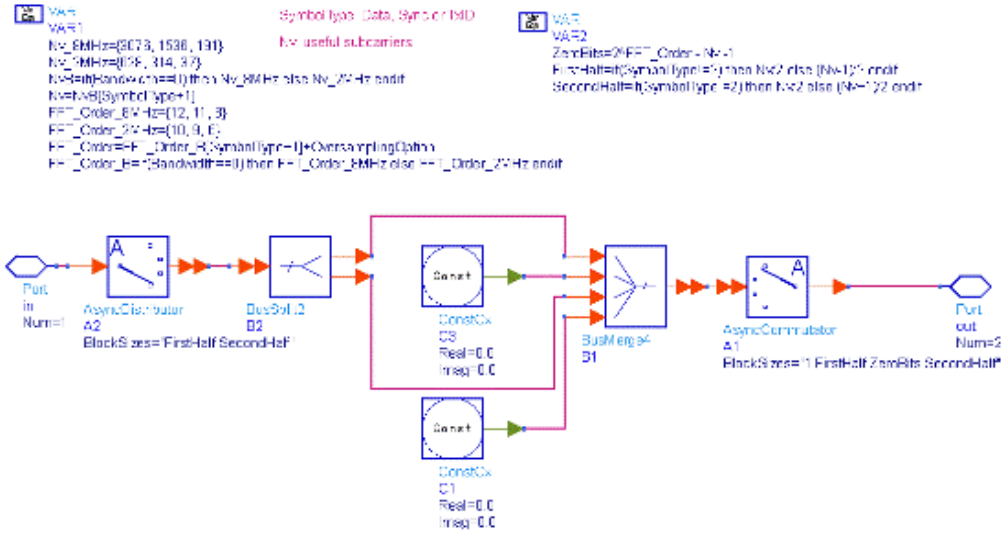
Pin	Name	Description	Signal Type
1	in	output	complex

Pin Outputs

Pin	Name	Description	Signal Type
2	out	output	complex

Notes/Equations

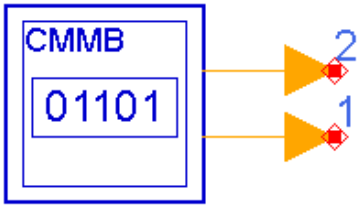
1. The model is used to load transmission data into the IFFT buffer in frequency domain. The schematic is shown as below.



References

1. "Mobile Multimedia Broadcasting Part1: Framing Structure, Channel Coding and Modulation for Broadcasting Channel", GY/T 220.1-2006, Oct. 24 2006.

CMMB_Scrambler



Description: CMMB scrambler for TS bits
Library: CMMB, Source

Parameters

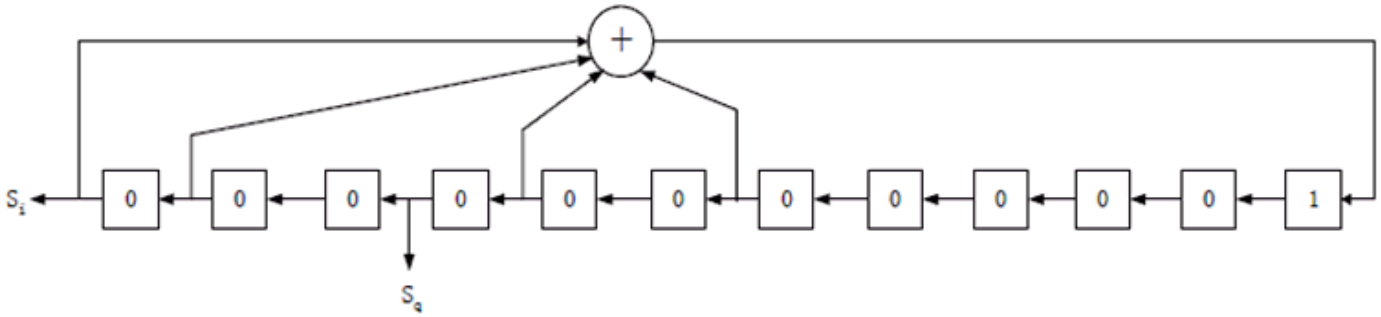
Name	Description	Default	Type	Range
ScramblerInit	Scrambler initial value: Option0, Option1, Option2, Option3, Option4, Option5, Option6, Option7	Option0	enum	
Period	Scrambler period	1000	int	[0,∞)

Pin Outputs

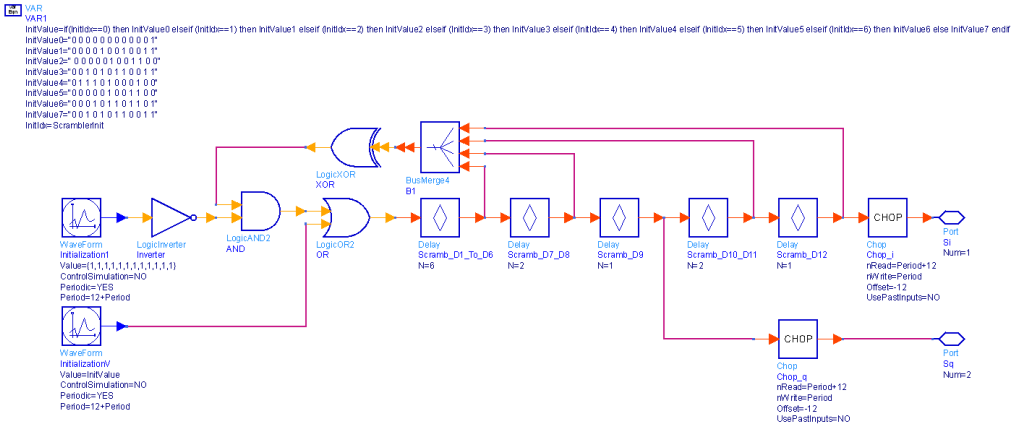
Pin	Name	Description	Signal Type
1	Si	TS bits (MSB of Byte first)	int
2	Sq	Scrambled TS bits	int

Notes/Equations

1. This subnetwork is used to generate a scrambler that is applied to all the data and pilots sub-carriers. It is implemented by linear feedback shift registers, which has 8 different initial values. The LFSR diagram is shown below.



The schematic is shown as below.

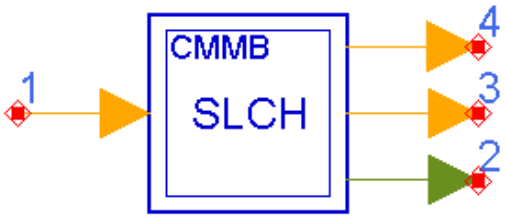


References

1. "Mobile Multimedia Broadcasting Part1: Framing Structure, Channel Coding and

Modulation for Broadcasting Channel", GY/T 220.1-2006, Oct. 24 2006.

CMMB_SLCH



Description: CMMB SLCH
Library: CMMB, Source

Parameters

Name	Description	Default	Type
Bandwidth	Bandwidth: _8MHz, _2MHz	_8MHz	enum
LDPC_Rate	LDPC code rate: Half, ThreeFourth	Half	enum
RS_MSG_Length	RS message length: _240, _224, _192, _176	_240	enum
ModType	Modulation type: BPSK, QPSK, _16QAM	BPSK	enum
Interleaving	Interleaving mode: Mode_1, Mode_2, Mode_3	Mode_1	enum

Pin Inputs

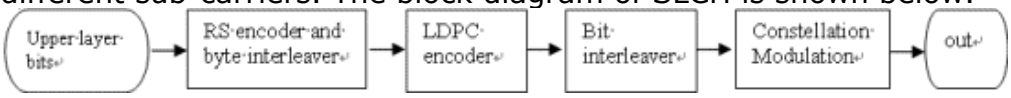
Pin	Name	Description	Signal Type
1	in	output	int

Pin Outputs

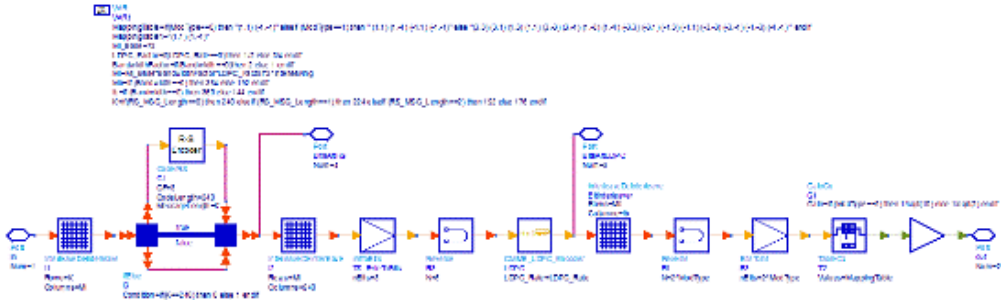
Pin	Name	Description	Signal Type
2	out	output	complex
3	BitsAftLDPC	LDPC encoded bits	int
4	BitsAftRS	RS encoded bits	int

Notes/Equations

1. Coding and modulation schemes are applied to different physical logical channel independently. The information bits stream are byte interleaved first and encoded by RS encoder, then LDPC encoder is used to improve the system robustness. After bit interleaving and constellation modulation, the encoded symbols are mapped to different sub-carriers. The block diagram of SLCH is shown below.



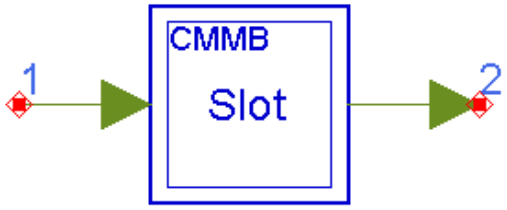
The schematic is shown as below.



References

1. "Mobile Multimedia Broadcasting Part1: Framing Structure, Channel Coding and Modulation for Broadcasting Channel", GY/T 220.1-2006, Oct. 24 2006.

CMMB_Slot



Description: CMMB slot generation
Library: CMMB, Source

Parameters

Name	Description	Default	Type	Range
Bandwidth	Bandwidth: _8MHz, _2MHz	_8MHz	enum	
OversamplingOption	Oversampling ratio (x1 is meaningless): x1, x2, x4	x2	enum	
ScramblerInit	Scrambler initial value: Option0, Option1, Option2, Option3, Option4, Option5, Option6, Option7	Option0	enum	
TxID	Tx ID	0	int	[0,127]
RegionID	Region ID	0	int	[0,127]

Pin Inputs

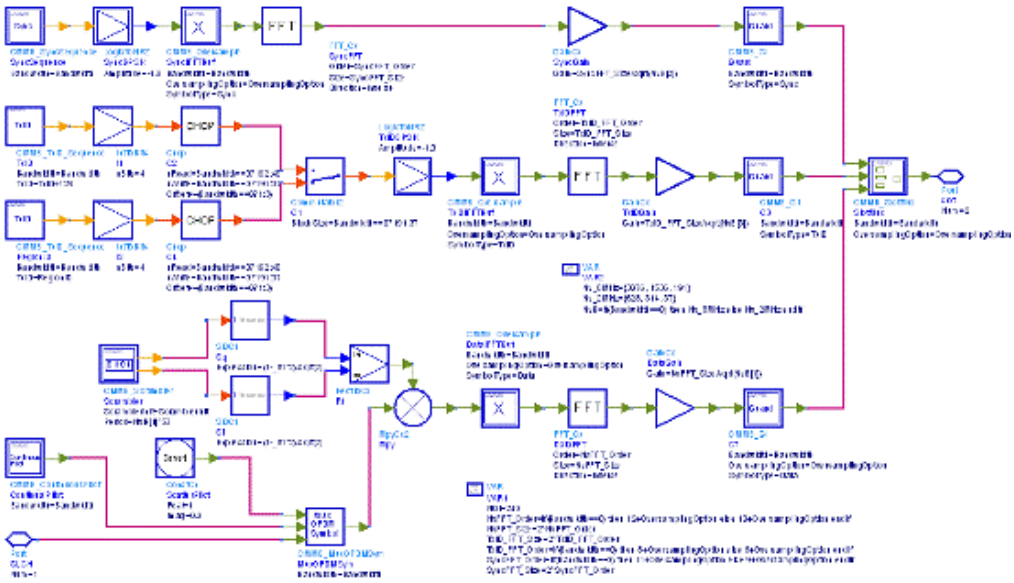
Pin	Name	Description	Signal Type
1	SLCH	SLCH	complex

Pin Outputs

Pin	Name	Description	Signal Type
2	slot	slot output	complex

Notes/Equations

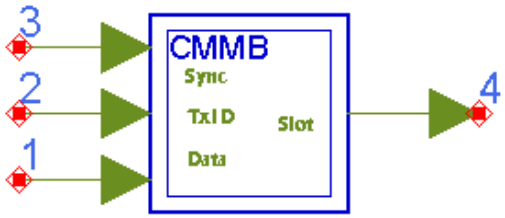
1. This subnetwork is used to generate a CMMB slot by multiplexing TxID signal, Sync signal and Data together. The data parts in the frequency domain are the input, while the whole slot in time domain are the output. The frequency domain signals are converted to time domain by FFT model with guard period and cyclic prefix added. The schematic is shown as below.



References

1. "Mobile Multimedia Broadcasting Part1: Framing Structure, Channel Coding and Modulation for Broadcasting Channel", GY/T 220.1-2006, Oct. 24 2006.

CMMB_SlotMux



Description: CMMB Slot Mux
Library: CMMB, Source

Parameters

Name	Description	Default	Type
Bandwidth	LDPC code rate: _8MHz, _2MHz	_8MHz	enum
OversamplingOption	Oversampling ratio (x1 is meaningless): x1, x2, x4	x2	enum

Pin Inputs

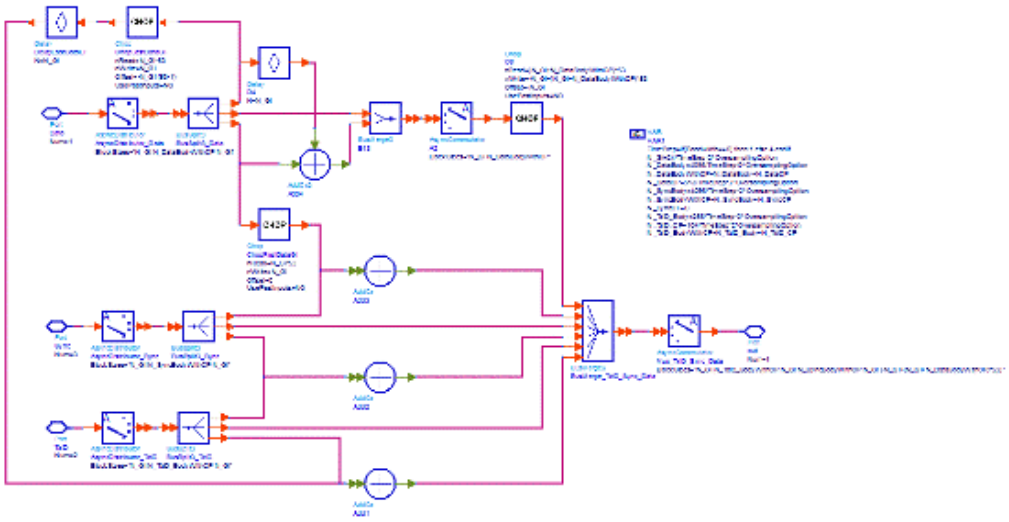
Pin	Name	Description	Signal Type
1	body	output	complex
2	TxID	output	complex
3	sync	output	complex

Pin Outputs

Pin	Name	Description	Signal Type
4	out	output	complex

Notes/Equations

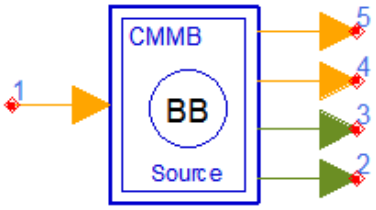
1. This subnetwork is used to multiplex data, TXID and synchronization OFDM symbols together to generate a whole slot.
   The schematic is shown as below.



References

1. "Mobile Multimedia Broadcasting Part1: Framing Structure, Channel Coding and Modulation for Broadcasting Channel", GY/T 220.1-2006, Oct. 24 2006.

CMMB_Source



Description: CMMB baseband signal source
Library: CMMB, Source

Parameters

Name	Description	Default	Type
Bandwidth	Bandwidth: _8MHz, _2MHz	_8MHz	enum
OversamplingOption	Oversampling ratio (x1 is meaningless): x1, x2, x4	x2	enum
LDPC_Rate	LDPC code rate: Half, ThreeFourth	Half	enum
RS_MSG_Length	RS message length: _240, _224, _192, _176	_240	enum
ModType	Modulation type: BPSK, QPSK, _16QAM	BPSK	enum
ScramblerInit	Scrambler initial value: Option0, Option1, Option2, Option3, Option4, Option5, Option6, Option7	Option0	enum
Interleaving	Interleaving mode: Mode_1, Mode_2, Mode_3	Mode_1	enum

Pin Inputs

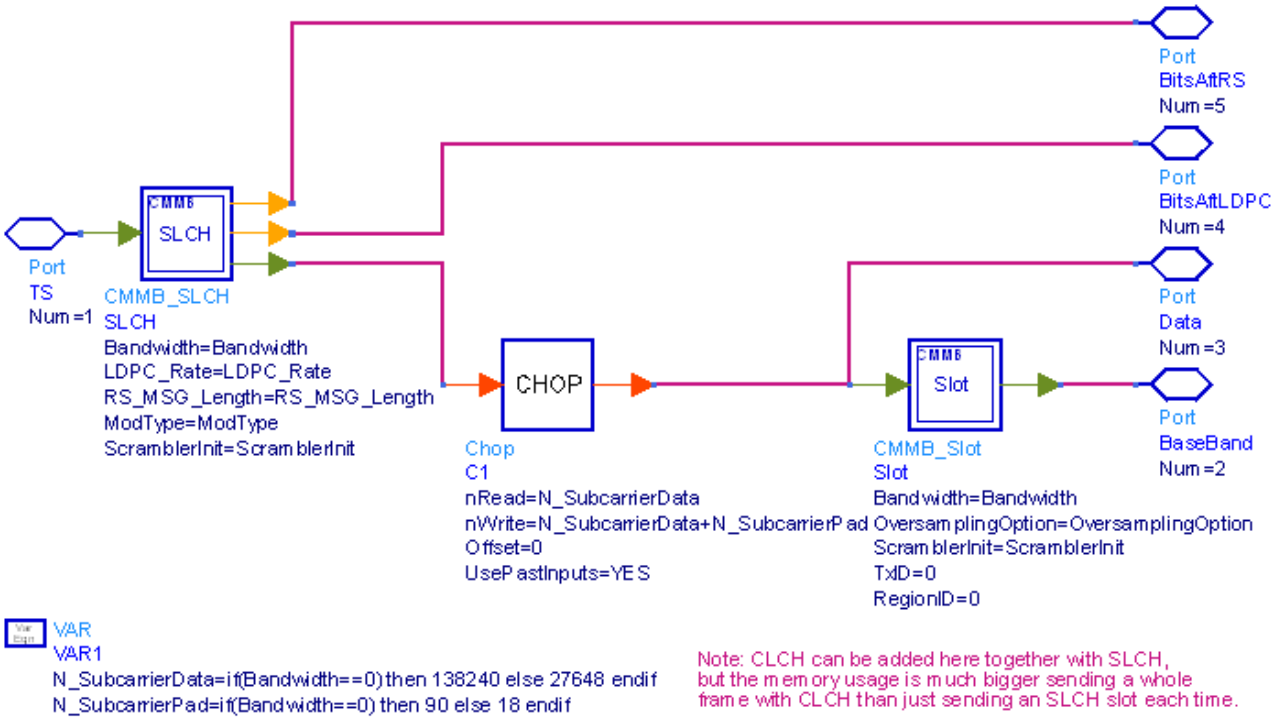
Pin	Name	Description	Signal Type
1	TS	Transport Stream in bit	int

Pin Outputs

Pin	Name	Description	Signal Type
2	BaseBand	CMMB baseband signal	complex
3	Data	signal after spatial mapping and before IFFT	complex
4	BitsAftLDPC	LDPC encoded bits	int
5	BitsAftRS	RS encoded bits	int

Notes/Equations

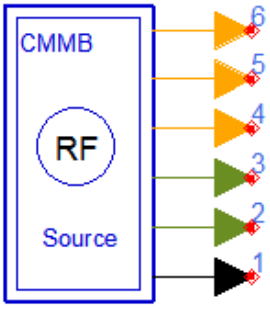
1. This subnetwork is used as a CMMB baseband signal source. It implements physical layer of CMMB specifications, including frame structure, partially channel coding, modulations and some instruction information. CMMB logical channel provides configurable transfer media for upper layer service, and it supports different modulation and coding scheme for different service based on different environment and quality of service. CMMB has two bandwidth choices, 8MHz or 2MHz.
   CMMB physical logical channel includes one CLCH (control logical channel) and N SLCHs (service logical channel), N is between 1 and 39. Currently, the CMMB library only supports SLCHs for the convenience of RF verifications.
   The schematic is shown below.



References

1. "Mobile Multimedia Broadcasting Part1: Framing Structure, Channel Coding and Modulation for Broadcasting Channel", GY/T 220.1-2006, Oct. 24 2006.

CMMB_Source_RF



Description: CMMB RF signal source
Library: CMMB, Source

Parameters

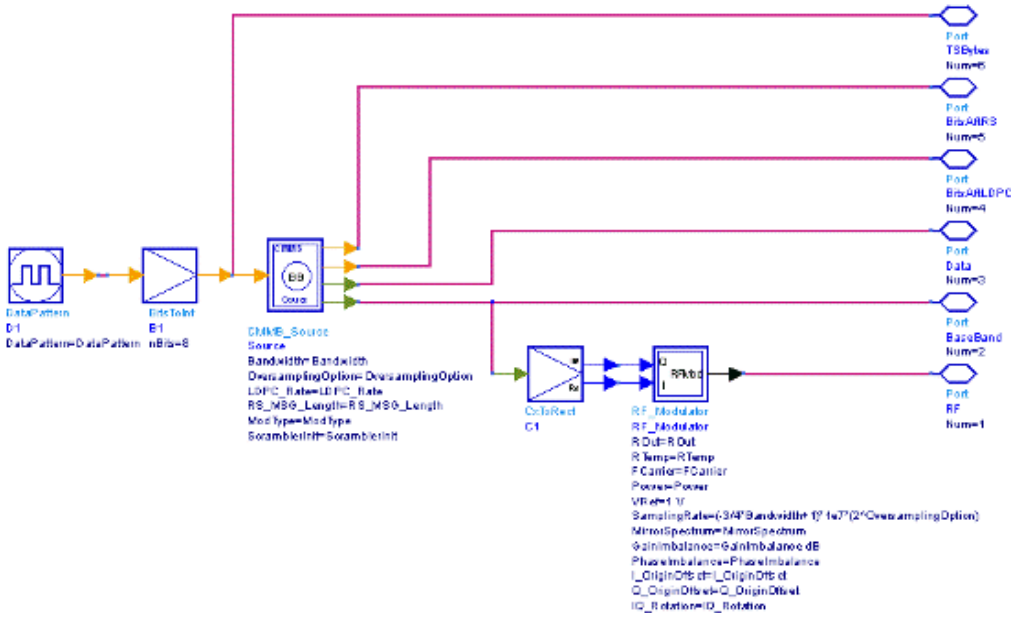
Name	Description	Default	Unit	Type	Range
ROut	Output resistance	DefaultROut	Ohm	real	(0,∞)
RTemp	Temperature, in degrees C	-273.15	Celsius	real	[-273.15,∞)
FCarrier	Carrier frequency	634 MHz	Hz	real	(0,∞)
Power	Output power of modulator	0.01	W	real	[0,∞)
MirrorSpectrum	Indication of mirror spectrum about carrier: NO, YES	NO		enum	
GainImbalance	Gain imbalance in dB, Q channel relative to I channel	0.0		real	(-∞,∞)
PhaseImbalance	Phase imbalance in degrees, Q channel relative to I channel	0.0		real	(-∞,∞)
I_OriginOffset	I origin offset in percent with respect to output rms voltage	0.0		real	(-∞,∞)
Q_OriginOffset	Q origin offset in percent with respect to output rms voltage	0.0		real	(-∞,∞)
IQ_Rotation	IQ rotation in degrees	0.0		real	(-∞,∞)
DataPattern	Data pattern: 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	
Bandwidth	Bandwidth: _8MHz, _2MHz	_8MHz		enum	
OversamplingOption	Oversampling ratio (x1 is meaningless): x1, x2, x4	x2		enum	
LDPC_Rate	LDPC code rate: Half, ThreeFourth	Half		enum	
RS_MSG_Length	RS message length: _240, _224, _192, _176	_240		enum	
ModType	Modulation type: BPSK, QPSK, _16QAM	BPSK		enum	
ScramblerInit	Scrambler initial value: Option0, Option1, Option2, Option3, Option4, Option5, Option6, Option7	Option0		enum	
Interleaving	Interleaving mode: Mode_1, Mode_2, Mode_3	Mode_1		enum	

Pin Outputs

Pin	Name	Description	Signal Type
1	RF	CMMB RF signal	timed
2	BaseBand	CMMB baseband signal	complex
3	Data	signal after spatial mapping and before IFFT	complex
4	BitsAftLDPC	LDPC encoded bits	int
5	BitsAftRS	RS encoded bits	int
6	TSBytes	original Transport Stream bytes	int

Notes/Equations

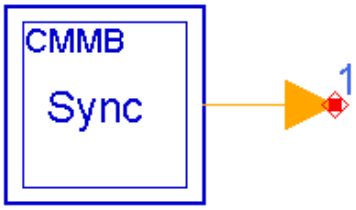
1. This subnetwork is used as RF CMMB signal source. Baseband CMMB signal source is modulated by a RF modulator to RF signals. RF impairments such as gain imbalance can be easily added by setting subnetwork RF parameters.
   The schematic is shown as below.



References

1. "Mobile Multimedia Broadcasting Part1: Framing Structure, Channel Coding and Modulation for Broadcasting Channel", GY/T 220.1-2006, Oct. 24 2006.

CMMB_SyncSequence



Description: CMMB synchronization sequence
Library: CMMB, Source

Parameters

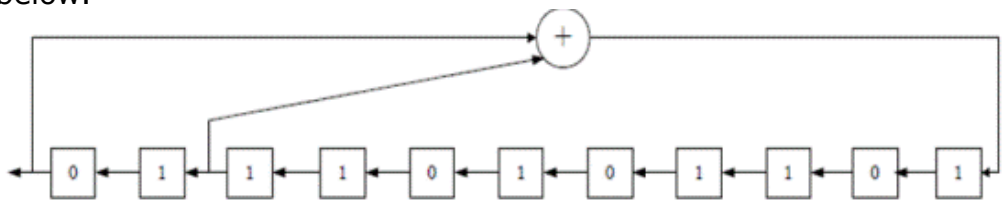
Name	Description	Default	Type
Bandwidth	Bandwidth: _8MHz, _2MHz	_8MHz	enum

Pin Outputs

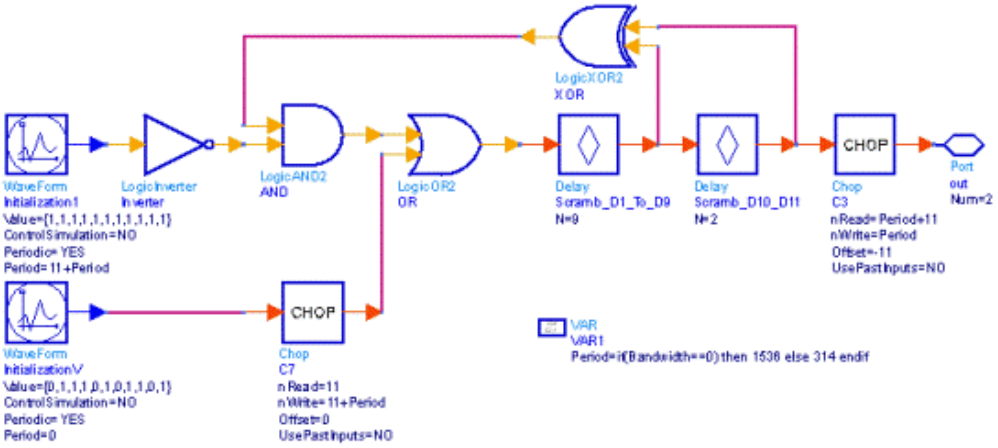
Pin	Name	Description	Signal Type
1	out	output	int

Notes/Equations

1. This subnetwork is used to generate synchronization sequence, which is the output of a LFSR (Linear Feedback Shift Register). The generation polynomial is X^11+X^9+1, and the initial value for the register is 01110101101. The LFSR diagram is shown below.



The schematic is shown as below.



References

1. "Mobile Multimedia Broadcasting Part1: Framing Structure, Channel Coding and Modulation for Broadcasting Channel", GY/T 220.1-2006, Oct. 24 2006.

CMMB_Tx_EVM Design Examples

The CMMB_Tx_wrk workspace shows base station transmitter measurement characteristics including complementary cumulative distribution function (CCDF), spectrum and EVM.

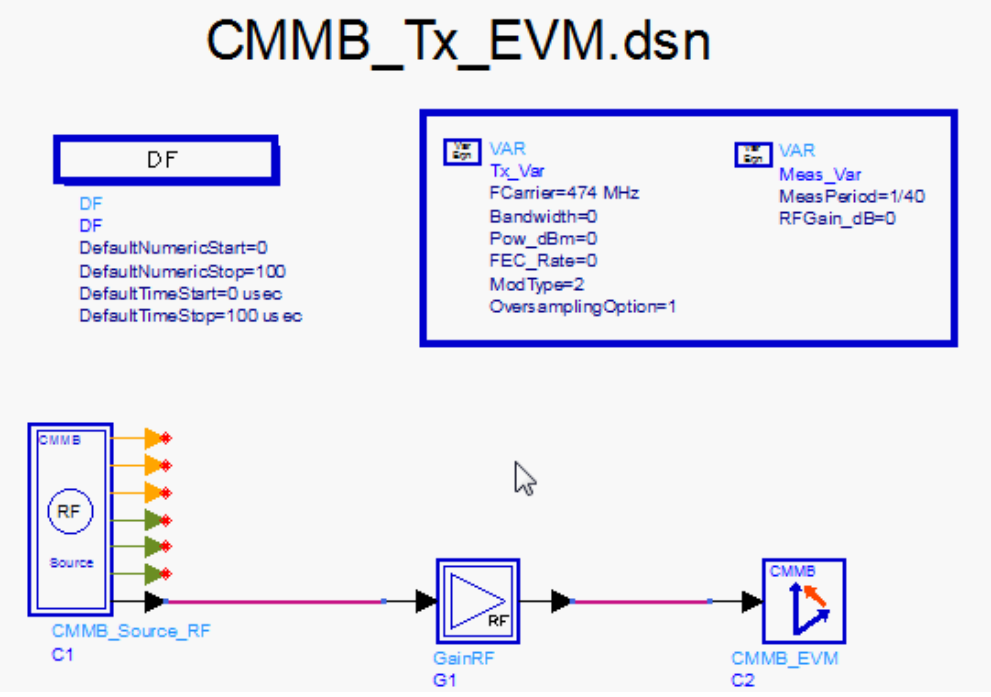
- Designs for EVM measurements include:
  - **CMMB_Tx_EVM**
- Variables used in these designs are listed in the **Variable parameter** table detailed below:

Parameter Name	Description	Default Value
FCarrier	carrier frequency	634MHz
MirrorSpectrum	mirror frequency or not	NO
Bandwidth	transmit bandwidth	8MHz
Start	start time for data recording	DefaultTimeStart will inherit from the DF Controller
numSlots	specifies the slot number to calculate the EVM	1
numSyms	this parameter indicate the number of ofdm symbols to analyze (1~53) in each slot	53
modFormatsV	modulation format for each time slot	BPSK

Features:

- EVM, MER, Magnitude Error, Phase Error, Frequency Error, Quad Error, Amplitude Imbalance, etc

Description:
This design measures the error vector magnitude (EVM) of the base station transmitter. EVM is the difference between the measured waveform and the theoretical modulated waveform and shows modulation accuracy. Please refer *CMMB EVM* (cmmb) for the detailed measurement method. The schematic for this design is shown below:



Simulation Results:

1. The measurement result is shown below:

Average EVM for all of the slots

Index	Avg_EVM_rms_percent
0	0.069

EVMs Per Slot

Slot	ContPilotEVM_rms_percent	DataEVM_rms_percent	EVM_rms_percent	ScatPilotEVM_rms_percent
0	0.080	0.068	0.069	0.079
1	0.082	0.068	0.069	0.079
2	0.081	0.066	0.068	0.078

MERs Per Slot

Slot	ContPilotMER	DataMER	MER	ScatPilotMER
0	61.988	63.400	63.220	62.026
1	61.714	63.392	63.211	62.072
2	61.857	63.574	63.386	62.204

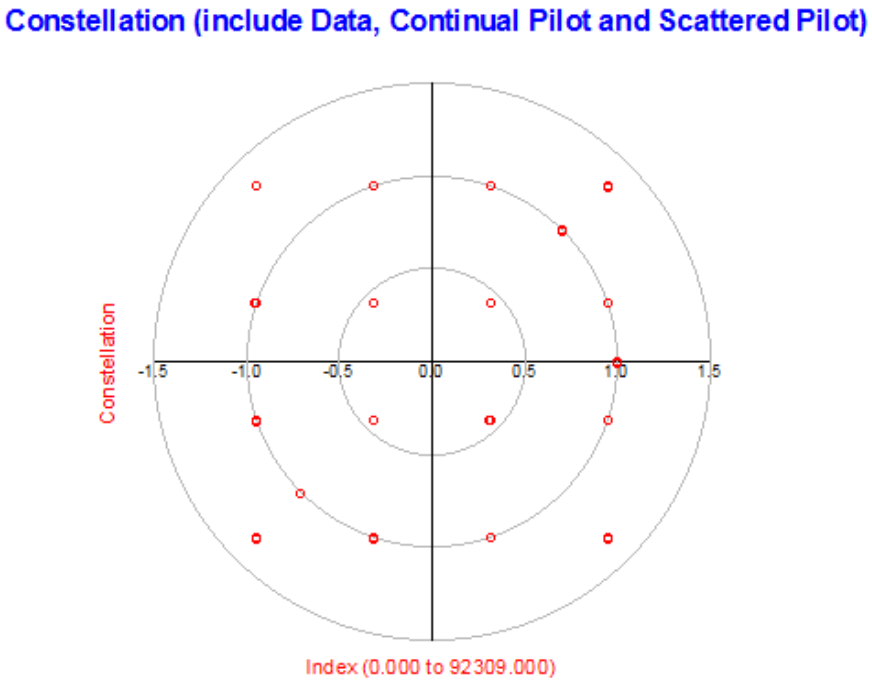
Error Power and Signal Power

Slot	ErrPwr	RefPwr
0	0.020	41160.578
1	0.020	41175.828
2	0.019	41191.078

Other measurements

Slot	FreError	IQGainImb	IQQuadErr	MagE	PhaseE	TxIDNum
0	4.525E-4	1.101E-4	0.001	0.059	0.034	128.000
1	-5.769E-4	2.882E-4	-0.001	0.058	0.034	0.000
2	-4.920E-4	1.769E-4	-0.001	0.057	0.033	128.000

2. The received constellations are shown below (include data, continual pilot and scattered pilot constellations):



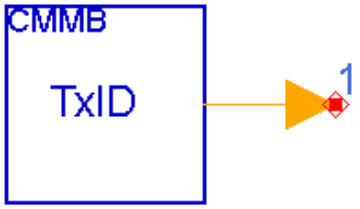
Benchmark:

- Hardware Platform: Xeon 5130 2 GHz, 4 GB memory
- Software Platform: Windows xp, ADS 2009u1
- Data Points: 3 slots, 10 OFDM symbols per slot
- Simulation Time: approximately 54 seconds.

References

1. "Mobile Multimedia Broadcasting Part1: Framing Structure, Channel Coding and Modulation for Broadcasting Channel"", GY/T 220.1-2006, Oct. 24 2006.

CMMB_TxID_Sequence



Description: CMMB TxID sequence
Library: CMMB, Source

Parameters

Name	Description	Default	Type	Range
Bandwidth	Bandwidth: _8MHz, _2MHz	_8MHz	enum	
TxID	Tx ID	0	int	[0,255]

Pin Outputs

Pin	Name	Description	Signal Type
1	Out	output	int

Notes/Equations

1. The transmitter identifier sequence is a pseudo random sequence for the receiver to identify the ID of transmitter and region. The sequence length is 191 for 8MHz mode and 37 for 2MHz mode. There are total 256 sequences, where the first 128 sequences are the region identifier sent in the even slots and the last 128 sequences are transmitter identifier sent in odd slots.

References

1. "Mobile Multimedia Broadcasting Part1: Framing Structure, Channel Coding and Modulation for Broadcasting Channel", GY/T 220.1-2006, Oct. 24 2006.