User's Guide
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User's Guide
DS1xxDF410 IBIS-AMI Model

Version 7
March 2024

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1 Document Revision History

Revision	Editor	Comment	Date
1	Casey Morrison	Initial creation of User's Guide.	28-Nov-2012
2	Casey Morrison	Corrected [Retimer Pin] to [Repeater Pin] in Section 5.	19-Dec-2012
3	Casey Morrison	Updated default value for RX_Config. Updated file names for model files.	28-Feb-2013
4	Casey Morrison	Added instructions for configuring the model as a DS1xxRT410 device by disabling the DFE.	19-Apr-2013
5	Casey Morrison	New revision of the model. There is now a separate model for the DS1xxRT410 devices.	30-Sep-2013
6	A0283200	Updated this user's guide for the map between AMI de-emphasis parameter settings and datasheet registers on page 8.	17-Jan-2017
7	A0489615	Updated for public release.	5-Mar-2024

2 Overview

This document is a User's Guide for the DS1xxDF410 quad-channel advanced retimer IBIS-AMI model. Table 1 below lists pertinent information related to the delivered model.

Table 1: Model information

Item	Value/Comment
TI device models included	*DS1xxDF410 Quad-Channel Advanced Retimers with DFE:* DS100DF410, DS110DF410, DS125DF410
IBIS version	Compliant to IBIS version 5.0. *Note: The concept of a "retimer" in the context of IBIS-AMI had not been standardized at the time this document was written. However, several EDA vendors have anticipated the standardization of retimer models and included this feature in their tools (Agilent ADS and SiSoft QCD to name a few).*
Supported platforms	• 32-bit Windows • 64-bit Windows • 64-bit Linux
Release package files	TI_DS1xxDF410_IBIS_AMI_v2 | +-- Example_Projects | | | +-- TI_DS1xxDF410_ADS_Project_Quick_Guide.pdf | +-- Agilent_ADS_2013.06.7zap | +-- Model | +-- TI_DS1xxDF410_IBIS_AMI_User_Guide.pdf +-- ds125df410.ibs +-- ds110df410.ibs +-- ds100df410.ibs +-- DS1xxDF410_Tx_9_2013.ami +-- DS1xxDF410_Rx_9_2013.ami +-- DS1xxDF410_Tx_9_2013.dll +-- DS1xxDF410_Rx_9_2013.dll +-- DS1xxDF410_Tx_9_2013_x64.dll +-- DS1xxDF410_Rx_9_2013_x64.dll +-- DS1xxDF410_Tx_9_2013_x64.s0 +-- DS1xxDF410_Rx_9_2013_x64.so +-- llp48_pkg.s4p

3 Receiver Model Parameters

The DS1xxDF410 receiver model includes the following model-specific parameters:

1. **EQ_Level**: This parameter sets the Retimer's input equalization setting. Note that this parameter is normally self-adaptive, however if CTLEAdapt is set to 0, then this setting determines the Retimer's CTLE value. The settings range from lowest equalization (0) to highest equalization (31).

Model EQ_Level setting	Register (Hex)	Bits 7:6 (CTLE Stage 0)	Bits 5:4 (CTLE Stage 1)	Bits 3:2 (CTLE Stage 2)	Bits 1:0 (CTLE Stage 3)	CTLE Boost String	CTLE Adaptation Index
0	40	0	0	0	0	0000	0
1	41	0	0	0	1	0001	1
2	42	0	0	1	0	0010	2
3	43	0	1	0	0	0100	3
4	44	1	0	0	0	1000	4
5	45	0	0	2	0	0020	5
6	46	0	0	0	2	0002	6
7	47	2	0	0	0	2000	7
8	48	0	0	0	3	0003	8
9	49	0	0	3	0	0030	9
10	4A	0	3	0	0	0300	10
11	4B	1	0	0	1	1001	11
12	4C	1	1	0	0	1100	12
13	4D	3	0	0	0	3000	13
14	4E	1	2	0	0	1200	14
15	4F	2	1	0	0	2100	15
16	50	2	0	2	0	2020	16
17	51	2	0	0	2	2002	17
18	52	2	2	0	0	2200	18
19	53	1	0	1	2	1012	19
20	54	1	1	0	2	1102	20
21	55	2	0	3	0	2030	21
22	56	2	3	0	0	2300	22
23	57	3	0	2	0	3020	23
24	58	1	1	1	3	1113	24
25	59	1	1	3	1	1131	25
26	5A	1	2	2	1	1221	26
27	5B	1	3	1	1	1311	27
28	5C	3	1	1	1	3111	28
29	5D	2	1	2	1	2121	29
30	5E	2	1	1	2	2112	30
31	5F	2	2	1	1	2211	31

2. **Rx_config**: This parameter controls the output of the receiver model's AMI_GetWave function.

Model Rx_config setting	Description
0	Receiver model outputs retimed data for normal operation. Retimed data is data at the output of the decision slicer, therefore it swings between +1 and -1.
1	(Default) Receiver model's output is the output of the DFE summing node, which includes the CTLE and DFE equalization, but does not include retiming. This is similar to the "Raw" mode of operation in the silicon. This will allow the user to evaluate the margin on the post-equalized signal within the receiver.

3. **DFEAdapt**: This parameter controls the behavior of the DFE adaption.

Model DFEAdapt setting	Description
0	User-specified values for C1, C2, ..., C5 are used for the DFE, and the DFE does not auto-adapt.
1	(Default) DFE will auto-adapt to the optimum values.

4. **CTLEAdapt**: This parameter controls the behavior of the CTLE adaption.

Model CTLEAdapt setting	Description
0	User-specified values for EQ_Level are used for the CTLE, and the CTLE does not auto-adapt.
1	(Default) CTLE will auto-adapt to the optimum values.

5. **DFETap1 through DFETap5**: These parameters are used to adjust the DFE tap values. Note that these parameters are normally self-adaptive, however if
   DFEAdapt is set to 0, then these setting determine the Retimer's DFE value.

Model DFTap1:DFETap5 Setting	Description
0	(Default) DFETap1 takes on integer values between -32 and 32. DFETap2:DFETap5 take on integer values between -16 and 16. The LSB for each tap is 8mV.

6. **EOM_window**: This parameter controls the number of bits used for each eye opening monitor (EOM) computation.

Model EOM_window Setting	Description
2000	(Default) 2000 bits used for each EOM computation.

7. **Factor**: Reserved parameter.

Model Factor Setting	Description
1	(Default) Reserved parameter.

8. **VCO_Sensitivity**: Reserved parameter.

Model VCO_Sensitivity Setting	Description
800e6	(Default) Reserved parameter.

4 Transmitter Model Parameters

The DS1xxDF410 transmitter model includes the following model-specific parameters:

1. **DE**: This parameter sets the driver de-emphasis level setting in combination with the DE_range parameter. Refer to the table below for the different de-emphasis options.

2. **DE_range**: This parameter sets the driver de-emphasis level setting in combination with the DE parameter. Refer to the table below for the different deemphasis options.

Model DE Setting	Model DE_range setting
0	X
1	1
1	0
2	1
2	0
3	1
3	0
4	1
4	0
5	1
5	0
6	1
6	0
7	1
7	0

Table 13. Driver De-Emphasis Settings

REGISTER 0x15, Bit 2, dvr_dem[2]	REGISTER 0x15, Bit 1, drv_dem[1]	REGISTER 15, Bit 0, drv_dem[0]	REGISTER 0x15, Bit 6, drv_dem_range	DE-EMPHASIS SETTING (dB)
0	0	0	X	0.0
0	0	1	1	–0.9
0	0	1	0	–1.5
0	1	0	1	–2.0
0	1	0	0	–2.8
0	1	1	1	–3.3
0	1	1	0	–3.5
1	0	0	1	–3.9
1	0	0	0	–4.5
1	0	1	1	–5.0
1	0	1	0	–5.6
1	1	0	1	–6.0
1	1	0	0	–7.5
1	1	1	1	–9.0
1	1	1	0	–12.0

3. **VOD**: This parameter sets the driver output voltage setting. There are eight VOD settings implemented in the model as shown in the table below.

Model VOD_Level setting	**Output amplitude value**
0	0.6 Vppd
1	0.7 Vppd
2	0.8 Vppd
3	0.9 Vppd
4	1.0 Vppd
5	1.1 Vppd
6	1.2 Vppd
7	1.3 Vppd

5 Model Usage Tips

The following are general tips for using the DS1xxDF410 IBIS-AMI model.

1. ***Samples-per-bit:*** For accuracy reasons, it is highly recommended that the simulator be configured to produce 32 samples per bit or higher for 10Gbps simulations. The maximum suggested samples per bit is 256.

2. ***Number of bits to simulate:*** In order to give the CTLE and DFE sufficient data and time to adapt, the first 400,000 bits of a simulation are ignored (Ignore_Bits). This model can be configured such that the CTLE/DFE adapts or takes on fixed values. When not adapting, the Ignore_Bits time can be reduced to just 50,000 bits minimum.

   The number of bits required for the CTLE+DFE adaption can be computed by the formula:

Minimum ignore bits = CDR_lock + NEyeComputations * (EOM_window + 1000),

   Where CDR_lock is the initial delay for CDR lock (5000 bits), NEyeComputations is the number of eye computations, EOM_window is the parameter which determines the number of bits required for each EYE computation (default value is 2000), and 1000 is the delay from the CTLE/DFE coefficient change to the start of eye computation. In a very unlikely worst-case scenario, NEyeComputations can approach ~130, but in most cases it will be much less.

3. ***Note on [Repeater Pin]:*** The [Repeater Pin] key word in the IBIS file is used to define the Rx input pin and Tx output pin pairs which form retimers. At the time this document was written, this was not yet part of the official IBIS standard and hence the IBIS parser throws an 'Invalid Keyword: Repeater_Pin' and 'Data for unknown keyword' errors upon encountering the [Repeater Pin] keyword. Please ignore these errors as the model runs fine in most EDA tools (SiSoft QCD and Agilent ADS to name a few). In fact, the [Repeater Pin] definition is necessary to simulate 'Retimer' models in SiSoft QCD. If the model needs to be run in other tools which do not support this keyword (like Mentor Graphics Hyperlynx), the [Repeater Pin] definition can be deleted without any change in the functionality of the model.

4. ***Log files***: Each simulation will produce two log files:

   a. ***Adapt.txt***: Records the adaption steps and the final values to which the CTLE settles. The number of eye computations required for adaption is

also recorded at the end. Note that if this file is already present, any subsequent simulations will append to this file.

b. ***EOM.txt***: This file contains the raw eye measurement data as a 64x64 matrix, measured at the output of the DFE summation node. Note that if this file is already present, any subsequent simulations will append to this file.

The location of these log files depends on the simulator being used. For example, in Agilent ADS, these log files will be placed in the *<project>/data/* directory. In SiSoft QCD, these log files can be found in the *<project>/interfaces/serdes/pre_sims/ideal_models/default.ssm/qcd/* directory.