IBIS AMI Modeling of Retimer and Performance Analysis of Retimer based Active Serial Links

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Overview

- Retimer implementation and simulation flows based on IBIS-AMI Standard 5.2
- General Retimer topology
- Jitter transfer analysis by using Retimer AMI model
- Full link analysis by using IBIS-AMI models



Background

- Repeaters, including redrivers and retimers, are increasingly applied in high-speed interconnects to compensate loss
- Redriver restores the signal with equalization and preemphasis
- Retimer employs clock-data-recovery (CDR) to sample the equalized signal and recover the digital signal
- Retimer can track and filter jitters in the incoming signal and fully compensate the upstream channel loss



Existing Redriver AMI Modeling Methodology

110

 Redriver is modeled by two back-to-back Rx and Tx IBIS-AMI models





Existing IBIS-AMI Redriver Simulation Flow

222



• Redriver Tx is continuously driven by redriver Rx's analog output signal

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• Inefficient to model recovered clocks and digital signal in retimer



Retimer Rx model must implement AMI_GetWave function, and the function must return clock times.



Simulator samples retimer Rx Getwave's output signal at 0.5UI after each clock time returned by Rx, generates the digital stimulus that drives retimer Tx







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Jitter Transfer Analysis

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EveDiff Probe	Fred Eve Probe
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Tx_AMI CHANNEL: RX_EVM_PATH Tx_AMI1 I_4 I_10 BitRate=12 Gbps JitterName[1]=Tx_Dj JitterName[2]=Tx_Rj JitterName[2]=Tx_Rj ChannelSim JitterName[4]=Tx_Sj ChannelSim JitterValue[1]=0.0 ChannelSim1 JitterValue[2]=0.0 NumberOfBits=2000000	ReTimer_AMI RETIMER_TXTERM_TX_EVM_PATH Rx_AMI ReTimer_AMI1 L_14 L_16 IbisFile="C1System_Modeling/IBIS_AMI/DS110DF1610ids110df1610_ami_v1p02ids110df1640_HS" DisFile="C1System_Modeling/IBIS_AMI/LS10DF1610ids110df1610_ami_v1p02ids110df1640_HS" ComponentName="ds110df1610" DisFile="C1System_Modeling/IBIS_AMI/LS10DF1610ids110df1610_ami_v1p02ids110df1640_HS" PinNameIN="2p" ComponentName="ibis_50ohm" ModelNameIN="ds110df1610_rx" PinName="ibis_50ohm" SetAIIDataIN=yes ModelNamie="ibis_50ohm_irx" DataTypeSelectorIN=Typ DataTypeSelector=Typ
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Tx_AMI CHANNEL RX_EVM_PATH Tx_AMI1 I_4 I_0 BitRate=12 Gbps JitterName[1]=Tx_D] Image: ChannelSim JitterName[2]=Tx_Ri Image: ChannelSim Image: ChannelSim JitterName[4]=Tx_Si_Frequency ChannelSim Image: ChannelSim JitterValue[4]=0.0 NumberOfBits=2000000 Image: ChannelSim JitterValue[3]=0.1 ToleranceMode=Auto JitterValue[4]=0.166 JitterType[1]=UI M ode=Bit-by-bit	ReTimer_AMI RETIMER_TXTERM_TX_EVM_PATH Rx_AMI ReTimer_AMI1 L_14 L_16 IbisFile="C1System_Modeling\IBIS_AMI/DS110DF1610\ds110df1610_ami_v1p02\ds110df1640_lbs" IbisFile="C1System_Modeling\IBIS_AMI/LS110DF1610\ds110df1610_ami_v1p02\ds110df1640_lbs" ComponentName="ds110df1610" IbisFile="C1System_Modeling\IBIS_AMI/LS110DF1610\ds110df1610_ami_v1p02\ds110df1640_lbs" ComponentName="lbis_50ohm" PinNameIN="2p" ComponentName="lbis_50ohm" PinName="lbis_50ohm" M odelNameIN="ds110df1610_nd" ModelName="lbis_50ohm" PinName="lbis_50ohm" DataTypeSelectorIN=Typ SetAIIData=yes DataTypeSelector=Typ UsePkgIN=yes UsePkg=yes ModelNameOUT="lp"
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Tx_AMI CHANNEL: RX_EVM_PATH Tx_AMI1 I_4 I_10 BitRate=12 Gbps JitterName[1]=Tx_D] Image: ChannelSim JitterName[2]=Tx_Rj Image: ChannelSim Image: ChannelSim JitterName[4]=Tx_Sj_Frequency ChannelSim Image: ChannelSim JitterName[3]=0.0 NumberOfBits=2000000 Image: ChannelSim JitterValue[3]=0.1 ToleranceMode=Auto EnforcePassivity=rio JitterType[1]=Uf M ode=Bit-by-bit JitterType[3]=Ul JitterType[4]=Float JitterType[4]=Float Image: ChannelSim	ReTimer_AMI RETIMER_TXTERM_TX_EVM_PATH Rx_AMI ReTimer_AMI1 L_14 L_16 IbisFile="C1System_Modeling/IBIS_AMI/DS110DF1610/ds110df1610_ami_v1p02/ds110df1640/lbs" IbisFile="C1System_Modeling/IBIS_AMI/LCS110df1610_ami_v1p02/ds110df1640/lbs" ComponentName="ds110df1610" IbisFile="C1System_Modeling/IBIS_AMI/LCS110DF1610/ds110df1610_ami_v1p02/ds110df1640/lbs" IbisFile="C1System_Modeling/IBIS_AMI/LCS100/lbs" ComponentName="ds110df1610" IbisFile="C1System_Modeling/IBIS_AMI/LCS100/lbs" IbisFile="C1System_Modeling/IBIS_AMI/LCS100/lbs" PinNameIN="2p" ModelNameIN="bis_500hm" IbisFile="C1System_Modeling/IBIS_AMI/LCS100/lbs" ModelNameIN="ds110df1610_nx" SetAIIDataIN=yes SetAIIData="yes" DataTypeSelectorIN=Typ UsePkgIN=yes DataTypeSelector=Typ UsePkgIN=yes DataTupeSelectorUT="tp" UsePkg=yes ModelNameOUT="ds110df1610_tx" SetAIIDataOUT=yes DataTypeSelectorOUT=Typ UsePkgOUT=yes DataTypeSelectorOUT=Typ UsePkgOUT=yes
Tx_AMI CHANNEL: Rx_EVM_PATH Tx_AMI1 I_4 I_10 BitRate=12 Gbps JitterName[1]=Tx_D] Image: ChannelSim JitterName[2]=Tx_Rj Image: ChannelSim JitterName[4]=Tx_Sj_Frequency ChannelSim JitterName[4]=Tx_Sj_Frequency ChannelSim JitterName[4]=Tx_Sj_Frequency ChannelSim JitterName[4]=Tx_Sj_Frequency ChannelSim1 JitterValue[4]=0.0 NumberOfBits=2000000 JitterValue[3]=0.1 Toleranc eMode=Auto JitterValue[4]=0.1e6 Eriforc eP assivity=rio JitterType[1]=UI M ode=Bit-by-bit JitterType[3]=UI JitterType[4]=Float	ReTimer_AMI RETIMER_TXTERM_TX_EVM_PATH Rx_AMI ReTimer_AMI1 L_14 L_16 IbisFile="C1System_Modeling\IBIS_AMI\DS110DF1610\ds110df1610_ami_v1p02\ds110df1640_MS" IbisFile="C1System_Modeling\IBIS_AMI\k ComponentName="ds110df1610" IbisFile="C1System_Modeling\IBIS_AMI\k ComponentName="ibis_500hm" PinNameIN="2p" ModelNameIN="ds110df1610_nx" PinName="2p" ModelNameIN="ds110df1610_nx" SetAIIDataIN=yes SetAIIData=yes DataTypeSelectorIN=Typ DataTypeSelector=Typ UsePkgIN=yes VisePkgIN=yes DataTypeSelectorOUT="tp" UsePkg=yes ModelNameOUT="ds110df1610_tx" SetAIIDataQUT=yes DataTypeSelectorOUT=Typ UsePkg0UT=yes DataTypeSelectorOUT=Typ UsePkg0UT=yes

Retimer Tracks Low-frequency Jitter



time, psec Retimer Rx CDR tracks SJ in clock times





Tracked SJ is passed to downstream channel



Retimer Filters High-frequency Jitter



SJ is rejected

100

120

140

80

SJ at retimer

input

80

time, psec

Retimer Tx

output

100

120

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160

180

140

160

180

Simulated and Silicon Measured Jitter Transfer Curve



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Active Link Analysis Using AMI Model

- We first analyze a channel w/o retimer at 12Gbps data rate
- IL=30dB
- ICR=34dB
- BER target is 1e-12





Link Performance w/o Retimer



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Using Retimer to Improve System Performance



Insertion Loss and ICR of the System



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Link Performance with Retimer









Link Performance with Retimer (cont'd)





Inside Receiver - Timing Bathtub



• Eye is open at 1e-12 BER

 Retimer increases system tolerances to IL and ICR by 10dB and 19dB, respectively

Simulation and Silicon Measurement Correlations



Simulation and Silicon Measurement Correlations (cont'd)



Simulation and Silicon Measurement Correlations (cont'd)





Eye captured by EyeScope inside SerDes



At 1e-12 BER, measured eye height=70mV and width=25ps



- We presented a novel IBIS-AMI modeling approach for developing and simulating Retimer models
- Retimer is shown to be a promising candidate to extend the reach of high-speed serial links
- Retimer AMI model can be used to predict jitter and link performance to ensure first pass manufacture success

