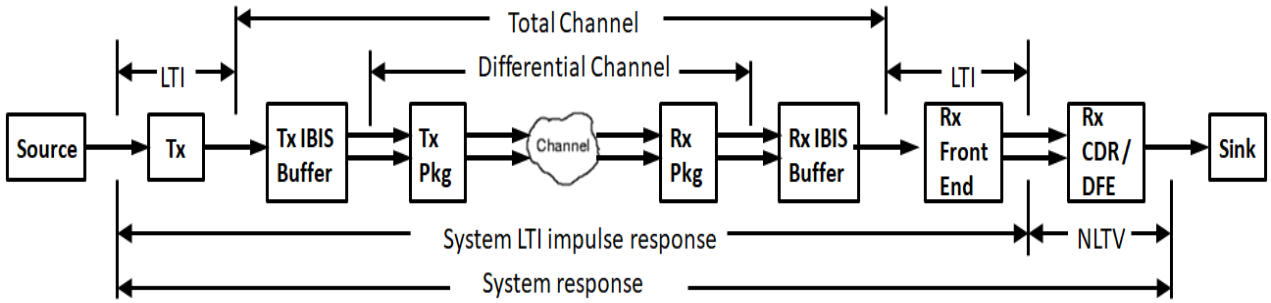
Subject: Clock and Data Recovery Bang Bang Model

Author: John Baprawski; John Baprawski Inc. (JB)

Date: Jan 3, 2019

This paper discusses features on the web site: **https://www.serdesdesign.com**

A SerDes system for a single channel has the typical structure shown in this figure.



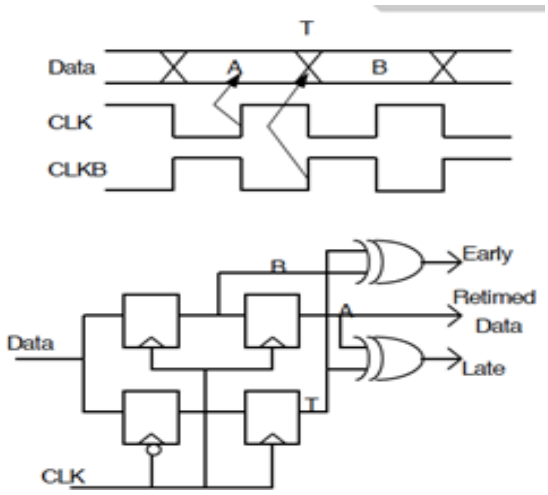
See details in **About the SerDes System Single Channel Tool...**

This document discussed the Clock and Data Recovery (CDR) model of the Bang-Bang type available from JB for use in creating custom IBIS-AMI models. The CDR is typically used in a Rx model.

CDR model using a Bang-Bang (BB) architecture

A Clock and Data Recovery (CDR) model based on a bang-bang type of phase detector is a CDR model that is IP belonging to JB. This CDR performance is specified by defining its observed jitter transfer function (OJTF) corner frequency (Fc in Hz). For this CDR model, this Fc value is limited such that (BitRate/2)*0.0001 <= Fc <= (BitRate/2)*0.01. For BitRate = 25 Gbps, then the range for Fc is 1.25 MHz to 125 MHz.

This CDR is based on an industry standard bang-bang phase detector approach shown here.



For details, see discussion on the web such as:

https://en.wikibooks.org/wiki/Clock_and_Data_Recovery/Structures_and_types_of_CDRs/The_CDR_phase_comparator#The_classic_bang-bang_phase_detector

The phase detector detects data transitions and data states to determine whether the CDR clock is early or late and adjusts the CDR clock timing accordingly. This phase detector is strongly nonlinear and does not have a simple theoretical analysis.

The Observed Jitter Transfer Function (OJTF) corner frequency (OJTF Fc) is used as a CDR specification.

The phase response of a system which uses a CDR to generate its reference clock is the observed jitter transfer function, OJTF, which is related to the JTF in the frequency domain as OJTF(f) = 1 - JTF(f) (phase matters).

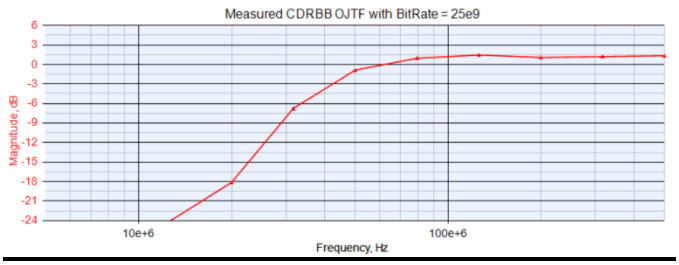
The OJTF has a high pass frequency response. Jitter significantly below the corner frequency, OJTF Fc, is not observed.

OTJF gives the amount of jitter which is tracked and therefore not observed at the output of the CDR as a function of the jitter rate applied to the input. OJTF is typically the quantity measured when evaluating the CDR jitter characteristic.

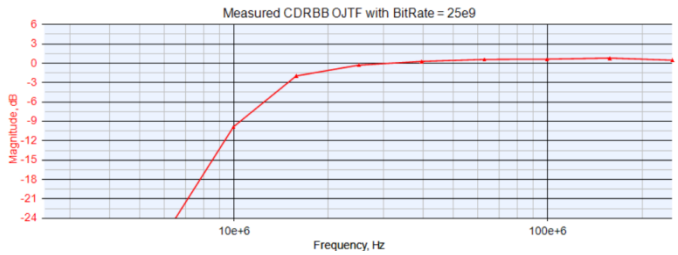
Measured CDR BB OJTF

Using a bit rate of 25 Gbps, the following plots show the measured OJTF for various OJTF Fc values.

CDRBB OJTF = 40 MHz



CDRBB OJTF = 15 MHz



Conclusion

A Clock and Data Recovery (CDR) model that is IP belonging to John Baprawski Inc. was discussed in this report. The CDR is based on a bang-bang type of nonlinear phase detector.

The CDR has a user specified Observed Jitter Transfer Function corner frequency (OJTF Fc).

The phase response of a system which uses a CDR to generate its reference clock is the observed jitter transfer function, OJTF, which is related to the JTF in the frequency domain as OJTF(f) = 1 - JTF(f).

Typical measured OJTF characteristics for this CDR model was shown.

This CDR model has successfully been used by JB to create custom IBIS-AMI models based on customer requirements.