CASPER Memo 25: Optimum XAUI Implementation Parameters

July 31, 2008

1 Summary of Findings

For BEE2 to BEE2 communication using a copper cable of length less than or equal to 3 meters, the recommended implementation parameters are pre-emphasis = 3 and differential swing = 800 mV. For iBOB to BEE2 communication using a 3 meter cable, the recommended implementation parameters are pre-emphasis = 3 and differential swing = 600mV.

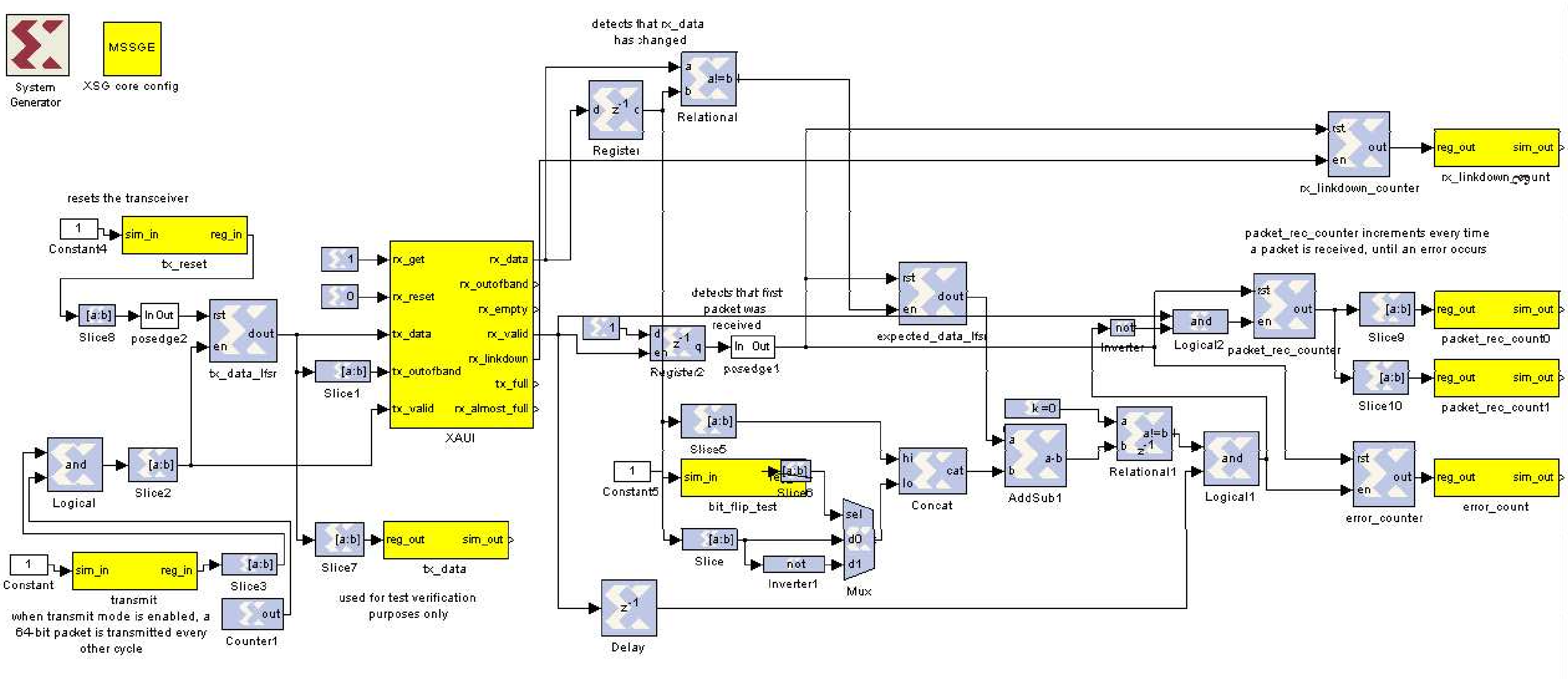
2 Background

The XAUI Transceiver block found in the CASPER library has two implementatin parameters (pre-emphasis and differential swing) that determine the properties of the physical layer communication scheme used by the transceiver. The purpose of the pre-emphasis setting is to boost transmission power for high frequency data since noise attenuation in copper cables is directly proportional to frequency. The possible pre-emphasis settings for the CASPER block are 0,1,2, and 3, where 0 has no pre-emphasis and 3 is the maximum pre-emphasis. The purpose of the differential swing setting is to define the minimum difference in transmission voltage between constellation points in the communication scheme. The possible differential swing settings are 400, 500, 600, 700, and 800, with the units of mV.

Recently we began testing XAUI communication links between CASPER hardware with the goal of finding the optimum implementation parameters (pre-emphasis and swing) for the XAUI transceiver block provided in the CASPER library. Although it is expected that maximum signal-to-noise ratio (SNR) can be obtained by maximizing both the pre-emphasis and the swing of the transceiver, the varying quality of signal integrity and signal power across devices ensures the existence of local optima in pre-emphasis settings.

3 Testing Model

Tests were conducted using 1 meter and 3 meter copper cables manufactured by GORE. Experimentally it has been found that optical cables yield better performance but are more expensive and less flexible. Each of the 15 different combinations of pre-emphasis were tested by transmitting 64 bits of data generated by a linear feedback shift register (LFSR) every other cycle over the CX4 link. On the receiving end of the data, there was another LFSR with the same seed value as the transmission data generator. The core of the design is synchronizing the two LFSRs such that they can be compared to determine when an error has occurred. The Simulink diagram for the design is show below:



System Generator
MSSGE
XSG core config
resets the transceiver
Constant4
tx_reset
Slice8
posedge2
tx_data_lfsr
Logical
Slice2
Constant
transmit
Slice3
Counter1
when transmit mode is enabled, a 64-bit packet is transmitted every other cycle
Slice1
Slice7
tx_data
used for test verification purposes only
rx_get
rx_reset
tx_data
tx_outofband
tx_valid
rx_data
rx_outofband
rx_empty
rx_valid
rx_linkdown
tx_full
rx_almost_full
XAUI
detects that rx_data has changed
Register
Relational
detects that first packet was received
Register2
posedge1
expected_data_lfsr
Slice5
Constant5
bit_flip_test
Slice6
Slice
Inverter1
Mux
Concat
AddSub1
k=0
Relational1
Delay
Inverter
Logical2
Logical1
packet_rec_counter
packet_rec_counter increments every time a packet is received, until an error occurs
Slice9
Slice10
packet_rec_count0
packet_rec_count1
error_counter
error_count
rx_linkdown_counter
rx_linkdown_count

Settings that appeared to result in no errors were validated using the "bit flip test" register, which intentionally generates errors by flipping the least significant bit of every 64-bit packet received. This ensures that a zero error count value is due to correct transmission rather than nothing being received. The onboard clock was used for the test on both the iBOB and the BEE2, which is rated at 100 MHz. The data rate then is

$$\frac{64 \text{ bits}}{\text{packet}} \cdot \frac{1 \text{ packet}}{2 \text{ cycles}} \cdot \frac{100 * 10^6 \text{ cycles}}{\text{sec}} = 3.2 \text{ Gbps}$$

One can infer the difference between errors due to bit-flips and errors due to packet loss by the way the error counter increments. In the first case (bit flip errors), the error counter will increment only once, whereas packet loss results in a continuous stream of errors since the design has no resynchronization ability.

4 Results

For BEE2 to BEE2 communication, the test showed high packet loss if the pre-emphasis setting was less than 3, resulting in immediate failure of the link test. Using a 1 meter cable, the test indicates that any differential swing setting coupled with a pre-emphasis setting of 3 functioned properly. Using a 3 meter cable, however, the test model indicates that if the pre-emphasis is less than 3 and the differential swing is less than 600 mV, one or more packets is lost almost instantly. The recommended settings for BEE2 to BEE2 transmission are a pre-emphasis of 3 and a differential swing of 800 mV; CASPER memo 13 shows that this setting meets the error rate constraint for the XAUI transmission protocol.

For iBOB to BEE2 communication using a 3 meter cable, the test showed almost 100% packet loss when a pre-emphasis of 0 or 1 was used. The settings that did not result in immediate packet loss had a pre-emphasis of 3 and a differential swing of 500/600/700/800 mV. In the span of hours, all of these settings also dropped packets. Transmission using a pre-emphasis of 3 and a differential swing of 600 mV lasted the longest during the test, but since the test was only run once, this result is statistically incomprehensive. Using a 3 meter cable for iBOB to BEE2 communication will require periodic resynchronization logic, as well as header data in each packet to watch for packet loss.