S-72.3340 Optical Networks

Exercise 3

1) Various protocols (Fiber Channel, ESCON, FICON etc.) have been proposed for implementation of Storage Area Networks (SANs) over fiber infrastructure. Consider an ESCON fiber link operating at a data rate of 17 MBytes/s. The sender transmits a block of data and waits for an acknowledgement before sending the next block of data. Compute the throughput (in KByte/s) on the link for the following sets of parameters:

   a) Block size of 1 KByte, link length of 1 km.
   b) Block size of 1 KByte, link length of 10 km.
   c) Block size of 1 KByte, link length of 100 km.
   d) Block size of 4 KByte, link length of 10 km.
   e) Block size of 4 KByte, link length of 100 km.

   Assume that the speed of light in the fiber is 2×10^5 km/s.

Assuming the block size is B KBytes, the transmission time of a block is $1000B/17$ μs.

After transmitting each block, the transmitter must for a one round-trip propagation delay for the ACK before transmitting the next block (assuming there are no errors.) The propagation time is 5 μs per km, so that for a link of length l, the round-trip propagation time is $10l$ s. Thus, the throughput γ is

$$\gamma = \frac{1000B/17}{1000B/17 + 10l}$$

a) $\gamma = 0.855$ (or 0.855×17 MBytes/s $= 14.535$ MBytes/s)

b) $\gamma = 0.370$

c) $\gamma = 0.056$

d) $\gamma = 0.702$

e) $\gamma = 0.190$

Note that the throughput worsens with increasing propagation delay, due to increased waiting time between transmission of successive blocks. The throughput increases if the block size is increased, for the same propagation delay, since more data is transmitted for the same waiting time.

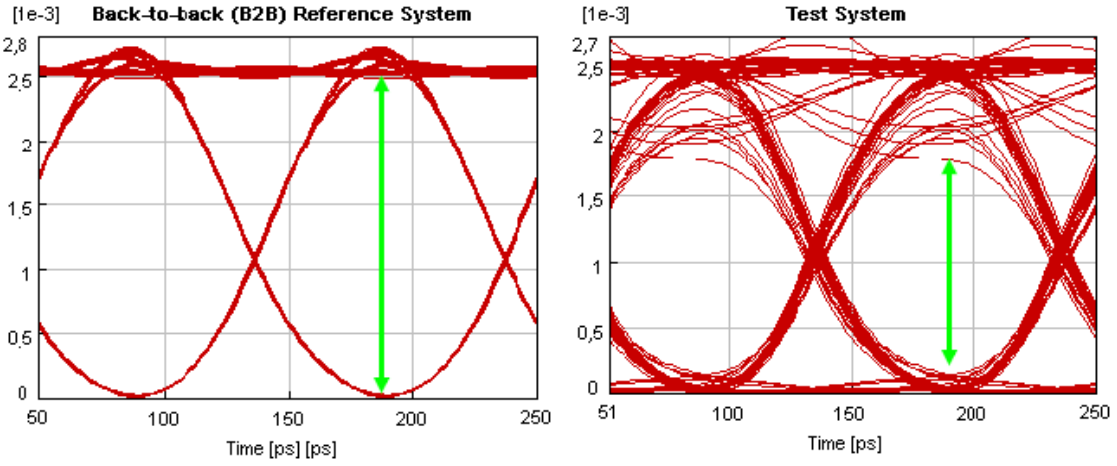
2) A 4 channel (each 10 Gbit/s) DWDM signal is transported over 10 km of dispersion-shifted fiber (DSF). The back-to-back reference eye diagram and the eye diagram of the test signal impaired by the DSF are shown in Figure 1a. The received signal is further impaired when the DSF link length is increased to 25 km (see Figure 1b).

a) What is the eye opening penalty for the two different cases (when DSF length is 10 km and 25 km)?

When L=10 km, EOP= $-10\times\log_{10}(1.6\times10^{-3}/2.5\times10^{-3})$ dB Þ 1.94 dB

When L=10 km, EOP= $-10\times\log_{10}(0.48\times10^{-3}/1.25\times10^{-3})$ dB Þ 4.2 dB

b) What is the reason for the increase in eye opening penalty with the increase in DSF link length? The effect of fiber nonlinear impairments (mostly four-wave mixing for DSF) increases or accumulates along the length of the fiber.



(a) B2B reference [left] and 10 km DSF [right]

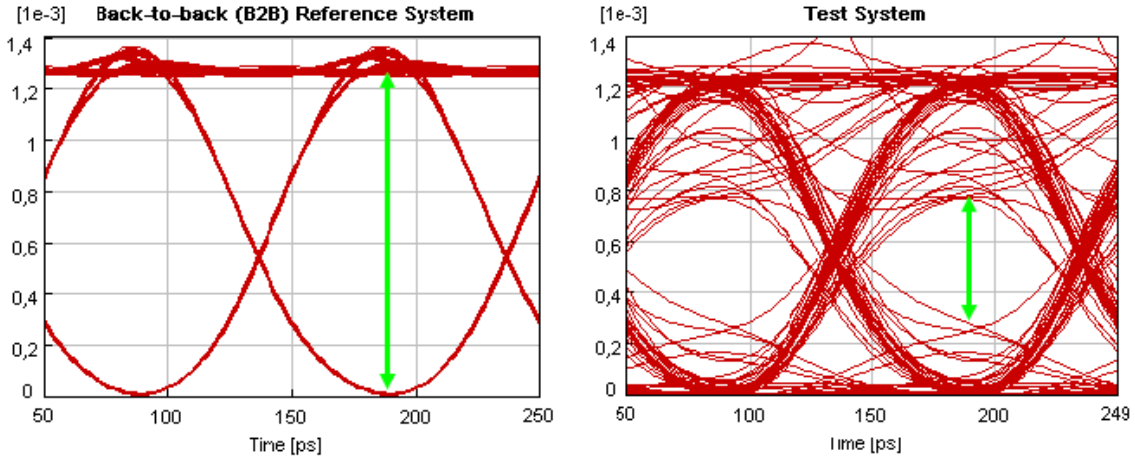


Figure 1 Eye diagrams for back-to-back and DSF links.