

S-72.3340 Simulation Problems (Spring 2007)

Simulation 1

This simulation setup is used to study the performance of a fixed optical add-drop multiplexer (OADM) based on array waveguide gratings (AWGs). The OADM is used to add/drop a single channel at an intermediary site of an 8 channel DWDM (100 GHz spacing) linear add/drop link. The use of DWDM instead of CWDM means that the system is intolerant to frequency offsets (frequency or wavelength drifting) of the transmitters from their original values. These offsets result in imperfect filtering and crosstalk isolation of channels in the OADM.

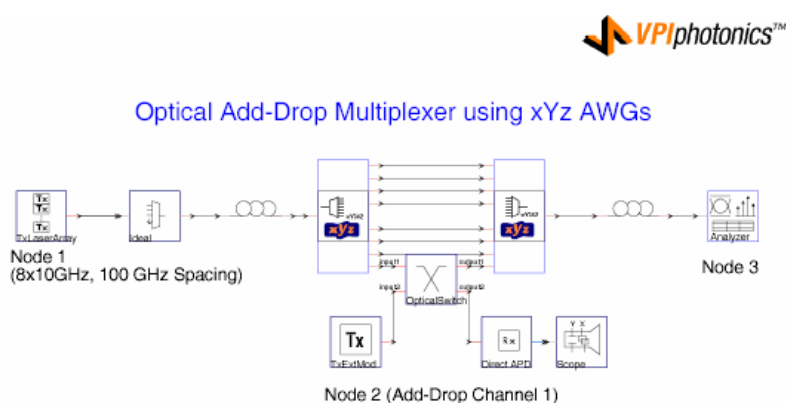


Figure 1 Screenshot of Simulation 1

Exercise

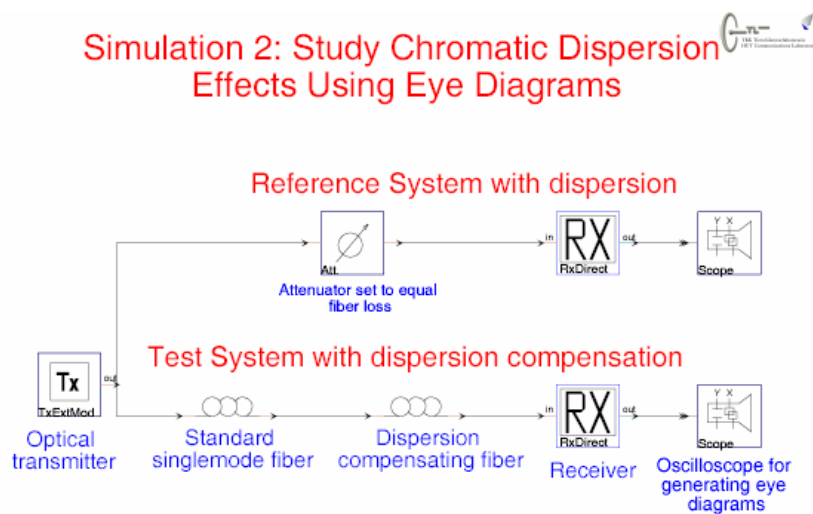
Run the simulation for the using the following settings:

- Frequency offset = 0 Hz
- Length of first fiber span Length1 = 50 km
- Length of second fiber span Length2 = 25 km

Note the eye opening from the eye diagram of the drop channel. Repeat the simulation, this time with frequency offset = 10 GHz. Note the change in the eye diagram of the drop channel. Assuming that the initial simulation with transmitters with a 0 Hz offset is the reference system, what is the eye opening penalty due to the 10 GHz frequency offset in the second simulation? (*Hints: For improved accuracy of measuring the eye opening you could use the horizontal markers [H & I] that you can create from the right hand panel of the eye diagram window.*)

Simulation 2

This simulation highlights the advantages of dispersion compensation in reducing penalties due to chromatic dispersion. An optical data signal with wavelength 1552.52 nm (193.1 THz frequency) is transmitted over 110 km of standard singlemode fiber (SMF). The chromatic dispersion coefficient of the SMF at a wavelength 1552.52 nm is 17 ps/nm-km. To compensate for dispersion the output of the SMF is fed into a dispersion compensating fiber (DCF) with a dispersion coefficient of -100 ps/nm-km at 1552.52 nm. The effectiveness of dispersion compensation is observed by comparing eye diagrams of the test system and the back-to-back reference system (with no dispersion).



Exercises

Run the simulation with the parameter slider set to $x=0$ to see the eye diagram for the test system when **no** DCF is used (DCF length is 0 km). Note the difference in quality between the resulting eye diagrams of the test and reference systems. Now repeat the simulation with the parameter slider set to $x=1$ to see the change in the quality eye diagram due to the use of a DCF (DCF is now set to a suitable length) in the test system.

- Deduce the data signal's line rate from the eye diagram of the reference system.
- What is the eye opening penalty for case when the DCF is not used in the test system? What is the reduction in the eye opening penalty when the DCF used for dispersion compensation?
- Evaluate the length of the DCF that was used in this simulation for dispersion compensation.

Simulation 3

This simulation is used to evaluate the power penalty due to intrachannel crosstalk. The BER performance of a reference system with no crosstalk is compared to a test system with a single crosstalk component at a level X_{talk_dB} below the desired signal. These two systems are compared visually using BER versus Received Optical Power plots, whereby the power penalty due to intrachannel crosstalk could be deduced. The points in the plot are created using variable optical attenuators before the receiver to obtain different received powers measurements which in turn varies the BER.

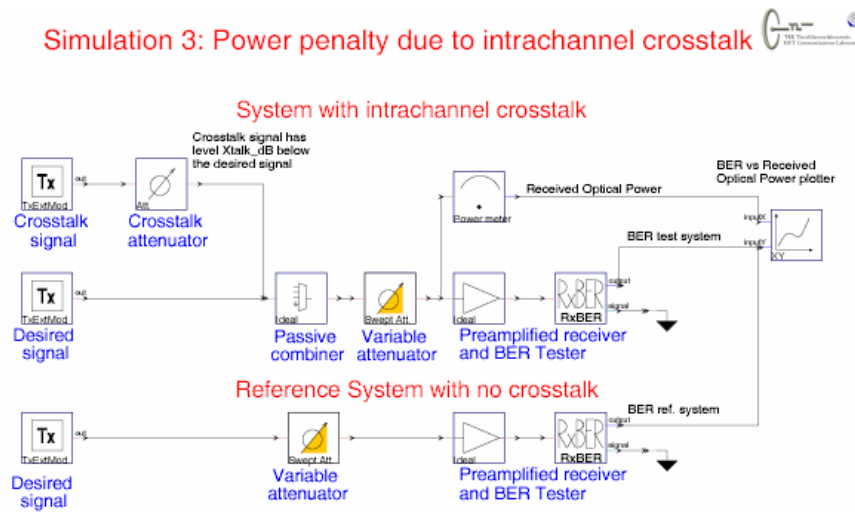


Figure 3 Screenshot of Simulation 3

Exercise

Run the simulation using a default $X_{talk_dB} = 20$ dB and note the difference in performance between the reference and test system. Use the parameter slider to reduce X_{talk_dB} to 17 dB and repeat the simulation. Note the change in the difference performance. Once again reduce X_{talk_dB} to 14 dB and note how performance of the test system deteriorates even further.

What is the intrachannel crosstalk power penalty (considered a $BER = 10^{-13}$ requirement) for the three different cases when X_{talk_dB} is 20 dB, 17 dB and 14 dB.

Simulation 4

This simulation setup is for measuring the loss introduced by various devices in a WDM link. The simulated system is a 4 channel WDM system with the channels;

- Channel 1 (1553.73 nm)
- Channel 2 (1552.92 nm)
- Channel 3 (1552.12 nm)
- Channel 4 (1551.31 nm)

An optical spectrum analyzers monitor signal at the output ports of the multiplexer, fiber and demultiplexer to observe the power losses incurred by the WDM signal after each respective device.

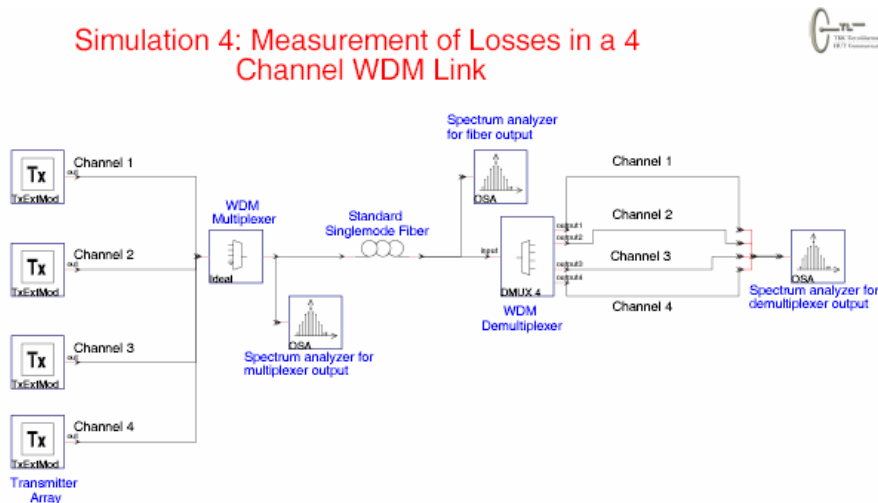


Figure 4 Screenshot of Simulation 4

Exercises

Run the simulation and note the WDM signal spectrum after each device. The spectra are plotted in units of dBm for power (y-axis) and nm for wavelength (x-axis). To obtain more accurate readings maximize the plots, and use horizontal and vertical markers for the power and wavelength measurements respectively.

- Assuming that the transmitted power of each channel is 0 dBm, estimate the insertion loss of the multiplexer using the spectrum plot of the signal obtained at the multiplexer output.
- Compare the spectrum plots at the output of the multiplexer and fiber. What is the loss attributed to fiber attenuation? If the attenuation coefficient of the fiber is 0.25 dB/km, how long is the fiber?

- The power of each channel at the destination is shown by the spectrum plot obtained at the output of the demultiplexer. If the receiver sensitivity is -27 dBm for each channel's receiver, how much gain should be applied to each channel to ensure reliable recovery of transmitted data?