Photonic Systems Laboratory

Photonic Systems and Technologies – Lab 3
Modulation

1. Topics covered

- External modulation of the optical signal using electroabsorption and Mach-Zehnder Modulators.

2. Laboratory simulations

Part 1 – Electro-absorption modulator

a. Open the setup Tx2_01. The schematic includes a simple set-up where an ideal laser (**LaserCW**) produces CW light that is then passed through an electro-absorption modulator (**ModulatorEA),** driven by an electrical sinusoidal signal. Both the input and output signals are analyzed by means of a **SignalAnalyzer** (Scope). The SignalAnalyzer can be used to view the signal both in the time domain (i.e. as a scope), and in the optical frequency domain (i.e. as an OSA). Moreover, signal phase or chirp can be displayed. Run the model, varying the linewidth of the laser (0, 1, 10, 100 MHz).

Question 1: Describe the behavior of the signal in time and frequency domain. Evaluate the modulation frequency.

Question 2: The EAM is driven by a sinusoidal wave, so why doesn't the modulated signal only acquire two modulation side peaks?

Question 3: A real EAM will induce chirp. Set the chirp parameter in the EAM from 0 to 0.1. What happens to the optical signal phase and chirp?

Question 4: Change the modulation index of the modulator (e.g. 0, 0.5 0.99) and see the effect on the output signal (time and frequency domains). How would you define the modulation index?

Part 2 – Electro-optical Mach-Zehnder modulator (MZM)

b. Open the setup Tx2_03, and run it. The schematic includes a simple set-up where an ideal laser (**LaserCW**) produces CW light that is then passed through a Mach-Zehnder modulator (**ModulatorMZ**), driven by an electrical sinusoidal signal.

Question 5: Change the ***SymmetryFactor*** from 0 (use values between -1 and 1). What happens?

Question 6: The symmetry factor k describes how symmetrically the two arms of the MZM are modulated, i.e. (for $|\Delta\Phi_2| \le |\Delta\Phi_1|$, where $\Delta\Phi_{1,2}$ are phase-shifts in the arms):

$$k = \frac{\Delta\Phi_2}{\Delta\Phi_1}.$$

Which symmetry factor causes ideal intensity modulation (no phase distortions)?

c. Open setup Tx2_05. The schematic represents the setup for generating RZ signals. First MZM forms NRZ signal with virtually rectangular pulse shape (5ps rise time). The second MZM, driven with a sine voltage (***FuncSineEl***) acts as pulse carver.

Question: for 33%, and 50% RZ signals, what full-width at half maximum (FWHM) of the optical pulses in the time domain should you have ?

Referring to the transmission function of the MZM, investigated in the previous schematic and information given in the Lecture 3 about RZ generation, set right bias voltage (***DC_Source_vtms2***), RF amplitude voltage and clock frequency (***FuncSineEl_vtms1***) to generate 33%, 50% RZ signals.
In addition a 67 % RZ signal can be generated by biasing at the null point (T(V) =0), a clock frequency of B/2 and a since with 2Vπ _peak to peak voltage.

Have in mind that identical RF and bias voltages are applied to the MZM arms via ***Fork*** components, which do not split the signals, but creates identical copies. Therefore, the voltage values you set at DC and RF sources should be divided by 2 (e.g. if you need V_π voltage at DC source, the value $V_\pi/2$ should be set).

For 33% and 50% RZ additional phase shift of sine signal of 90 deg is required.

Question 8: Specify parameters ***FuncSineEl_vtms1.Amplitude***, ***FuncSineEl_vtms1.Frequency*** and ***DC_Source_vtms2.Amplitude***, required to obtain 33%, 50% RZ OOK modulation formats. Check that parameters are selected properly, by measuring the full-width at half maximum (FWHM) of the optical pulses you obtain and comparing to your expected values.

Question 9: Check the spectra of RZ signals. Describe the spectra. What is the main difference between them?