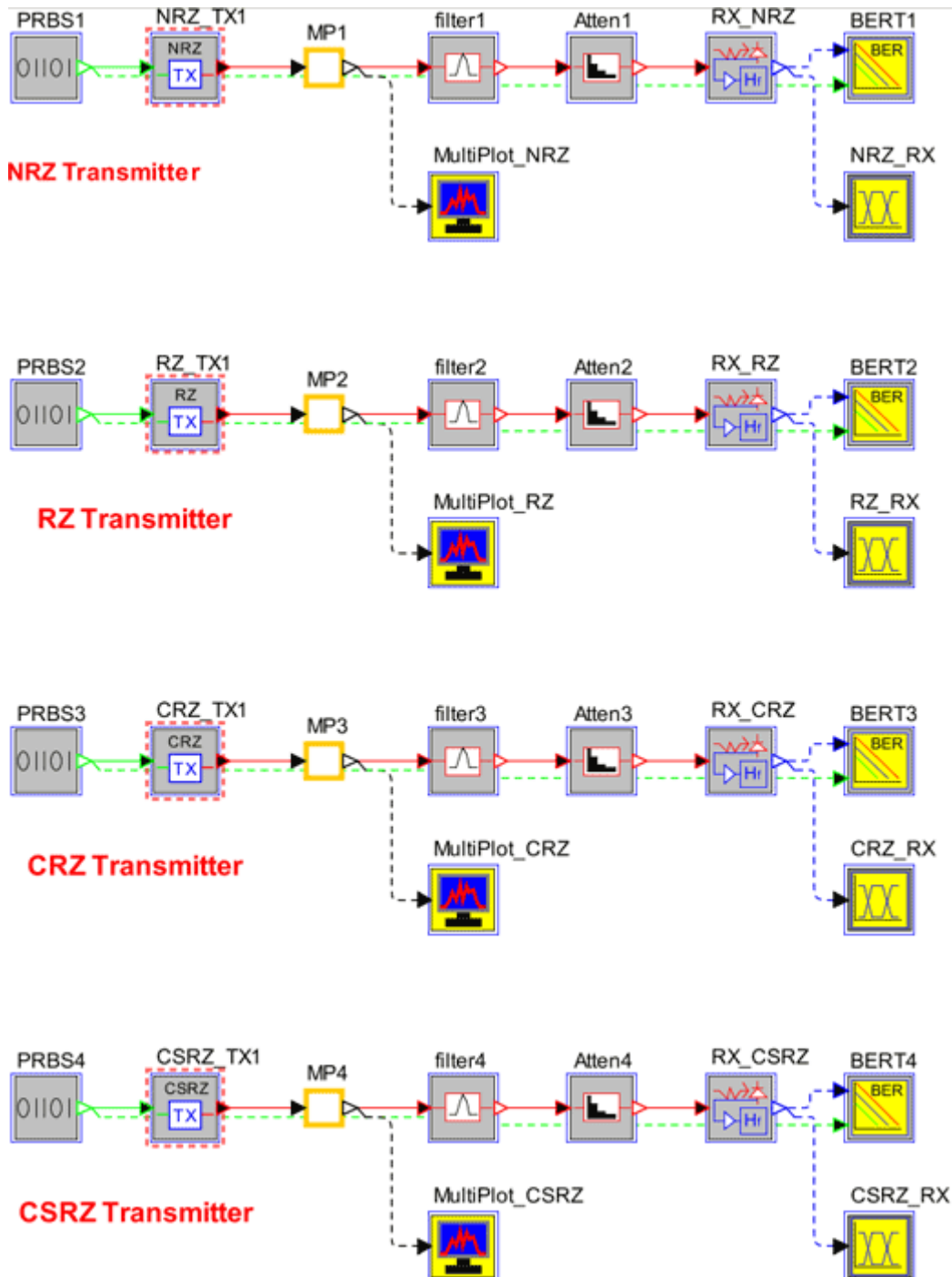


## NRZ, RZ, CRZ and CSRZ Modulation

Tools Used: OptSim

In this example we demonstrate two most used modulation formats in optical communications - nonreturn-to-zero (NRZ) and return-to-zero (RZ) - as well as two additional variants of RZ format chirped RZ (CRZ) and carrier-suppressed RZ (CSRZ). The setup is shown below:



Each link consists of PRBS generator, transmitter, optical filter, attenuator, receiver, and BER tester. Transmitters represented as compound components blocks, i.e. combination of blocks. For example, NRZ transmitter combines CW Laser source, Electrical signal generator (NRZ driver), external Mach-Zehnder modulator, and attenuator. The following parameters of transmitter can be set: power,

wavelength, extinction ratio, rise/fall time, RIN, etc. In case of RZ transmitter the electrical signal generator generate RZ signal with raised cosine shape and given duty cycle. In CRZ transmitter we add a chirp to RZ optical by applying a phase modulation. And finally in case of CSRZ transmitter the RZ optical signal after Mach-Zehnder modulator goes through phase modulator driven by analog sine wave generator at frequency equal to half of the bit rate. That will introduce a pi phase shift between any two adjacent bits and the spectrum will be modified such that the central peak at the carrier frequency is suppressed.

Figure below shows transmitter optical spectrum for different modulation formats. One can observe the central peak suppression in case of CSRZ.

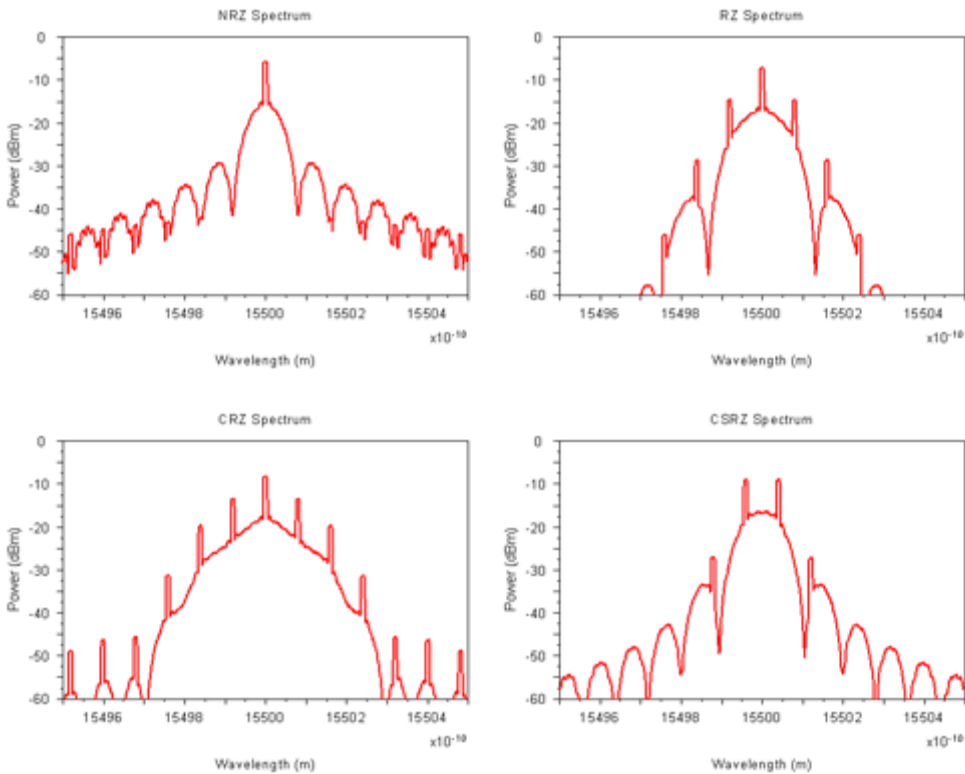
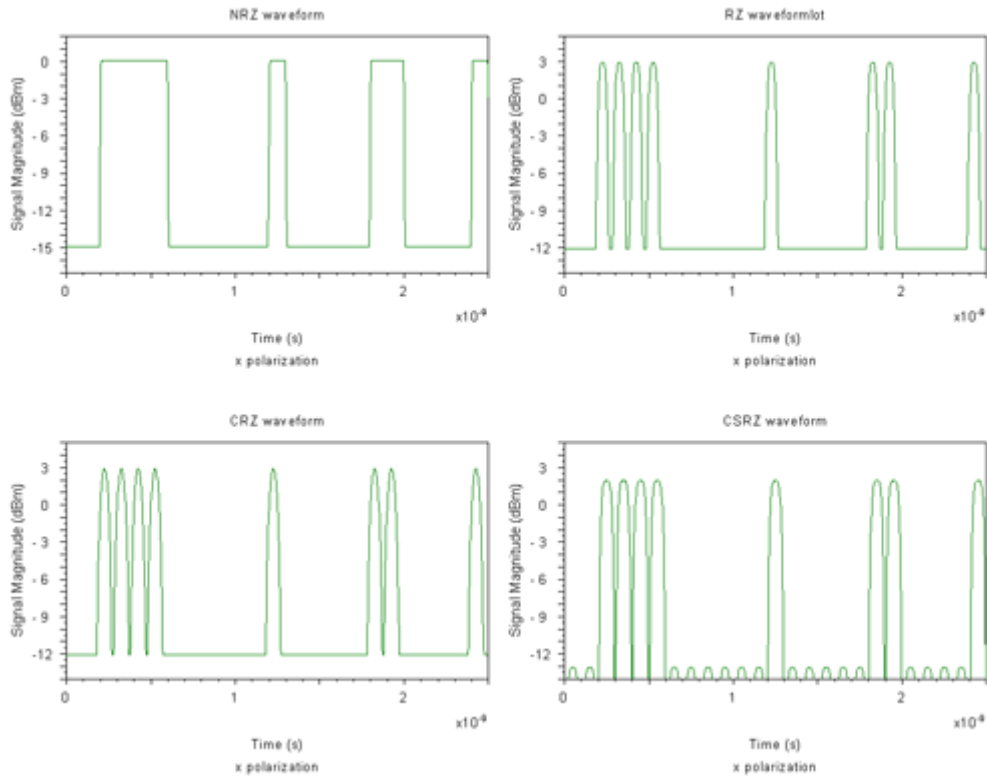


Figure below gives corresponding signal waveforms. In case of NRZ format, the optical pulse representing each 1 bit occupies the entire bit slot and does not drop to zero between two or more successive 1 bits. In the RZ format, each optical pulse representing 1 bit is chosen to be shorter than the bit slot, and its amplitude returns to zero before the bit duration is over. The ratio of the pulse width to bit duration is referred to as the duty cycle of the RZ bit stream.



Finally, figure below shows receiver eye diagrams for each of modulation formats.

