J COMPONENT REVIEW

Faculty –Sangeetha A

SLOT – B2

SENSE

Dispersion Compensation by using FBG and low pass Gaussian filter

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18BIS0147

Optical Communication and Networks

J - Component

ECE4005

AIM / OBJECTIVE

- FBG can be perceived as an ***optical block*** for some wavelengths; it reflects specific wavelengths only.

- Chirp is to form variations in grating periods along the grating and EDFA(Erbium Doped Fiber Amplifier) is to overcome attenuation.

- The net effect is a compression of the input pulse, which is then tailored to compensate for the chromatic dispersion accumulated along the fiber link, along with ***low pass Gaussian filter*** which helps in improving Q-factor of the performance and eye diagram.

- This technique requires very less space, has a minimal value of insertion value, is efficient with single-mode fiber and very cost-effective.

OVERVIEW

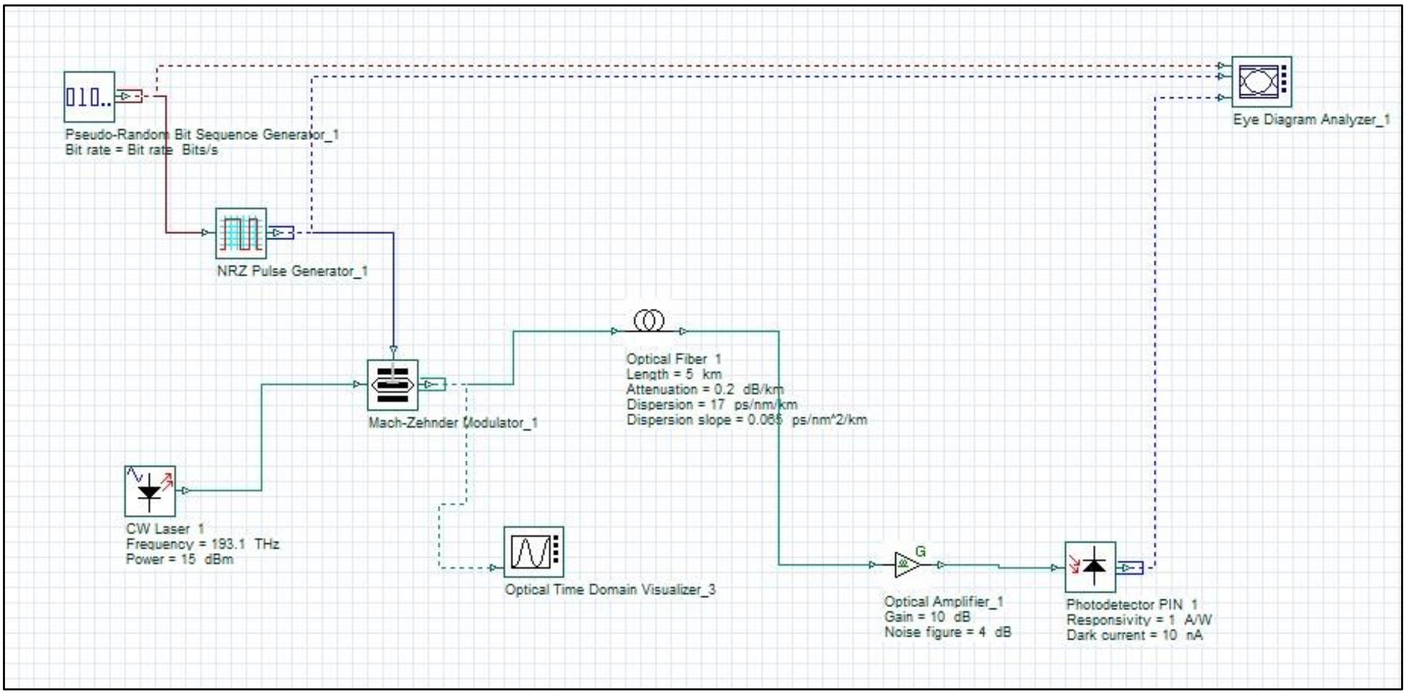
- The wavelength dependence of the optical fiber group index causes temporal-broadening of the pulses as they propagate, leading to chromatic dispersion, which affects the quality of data transmission & causes blurring of bit stream.
- Fiber Bragg Gratings (FBGs) are an alternative for dispersion-compensating fibers; it is a reflective device which contains an optical fiber that has a modulation of its core refractive index (RI) over a certain length.
- The grating reflects light propagating through the fiber when its wavelength corresponds to the modulation periodicity. The reflected wavelength is known as Bragg's wavelength.

$$\boldsymbol{\lambda_b = 2\eta_{eff}\Lambda}$$

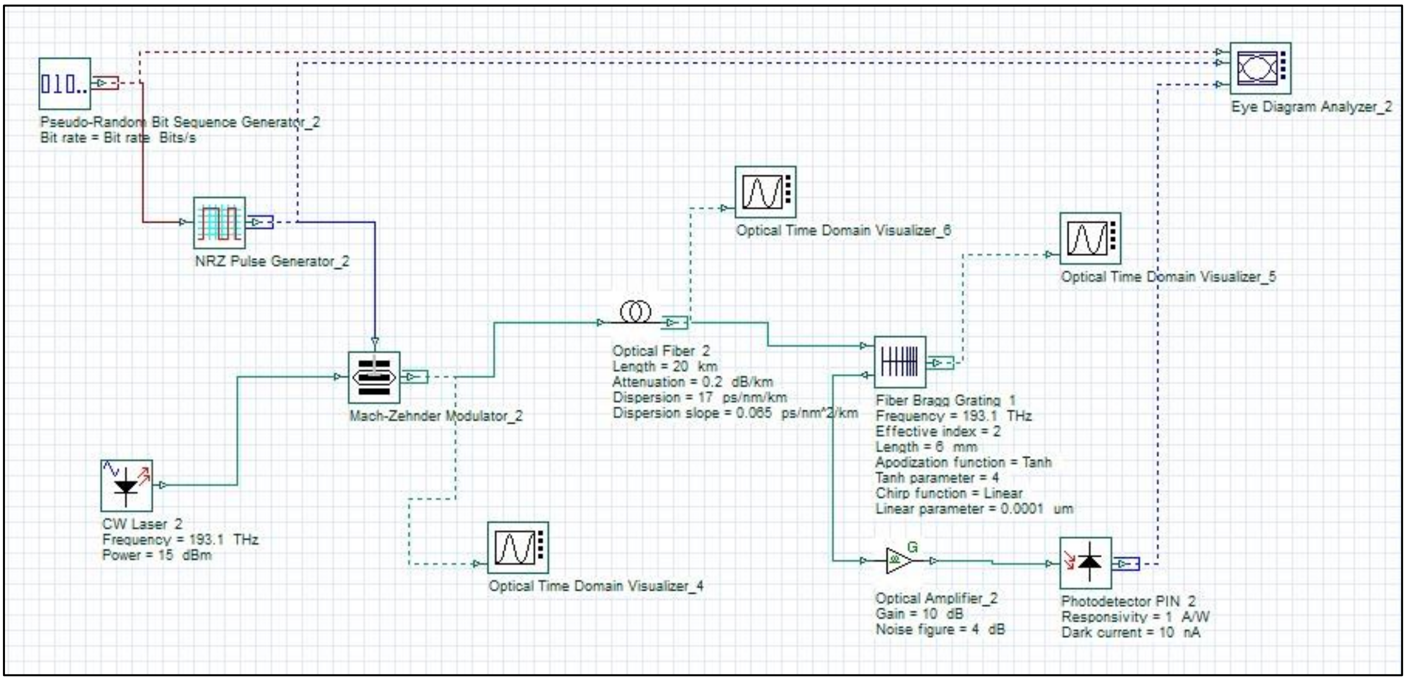
(η_{eff} - effective RI, Λ- grating period)

BLOCK DIAGRAM

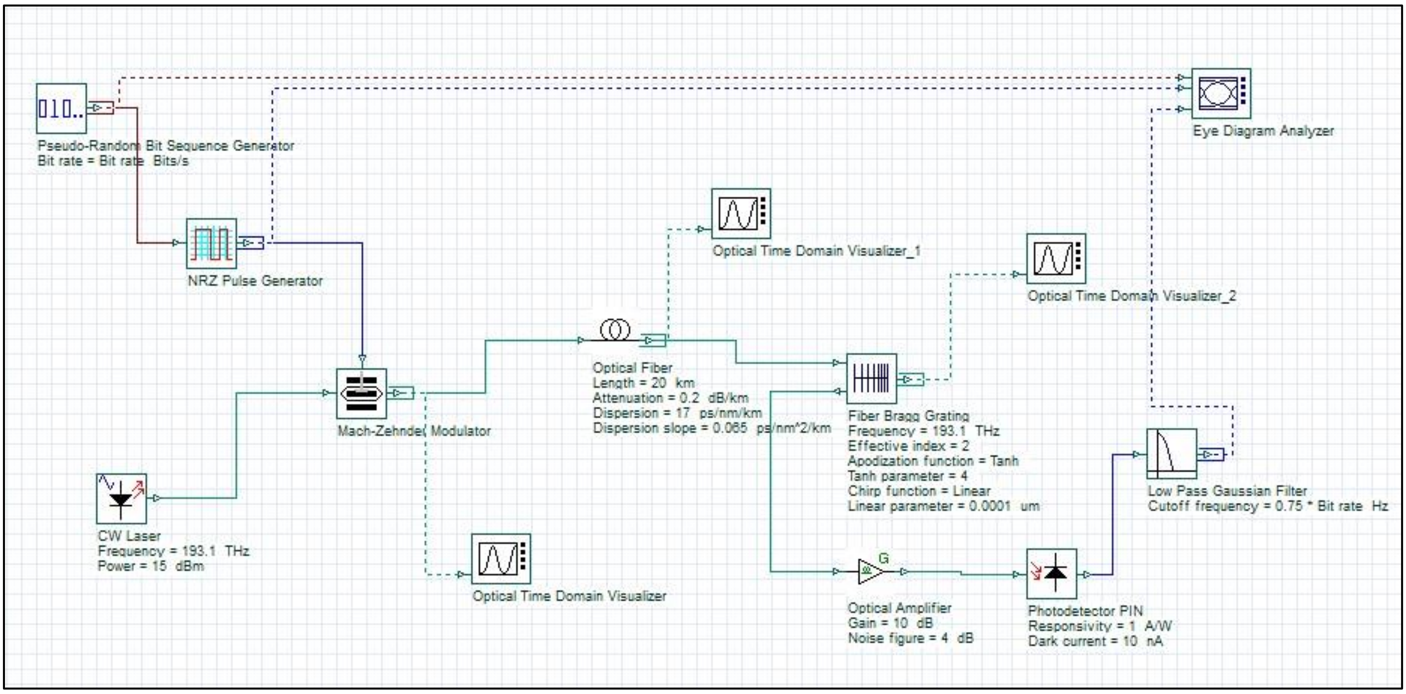
Pre FBG:



With FBG:



Proposed model (FBG & low pass Gaussian filter):



WORKING OF THE BLOCK DIAGRAM:

- The continuous wave laser is operated at 193.1 THz frequency.
- CW lase power is set to 15 dBm.
- The pulse is intensity-modulated with pseudo-random bit sequence generator (bit rate – 10 Gbps)
- Signal is encoded by a pulse generator, then combined at MZ Modulator with 30 dB of extinction ratio.
- Optical fiber is set to 0.2 dB/km attenuation, 17 ps/nm/km dispersion and 0.065 ps/nm^2/km dispersion slope.
- Length of the grating used is 6 mm.
- Superlative performance of FBG is given by Tanh apodization (Tanh) and chirp function (linear).
- Overall link is operated at 1550 nm wavelength.
- At receiver, amplification is required to overcome fiber loss and amplify the signal, so its passed through EDFA (10 dB gain, 4 dB noise) before PIN Photodiode (1 A/W responsivity).

- Low pass Gaussian filter is embedded in the electrical part of the system, and its cut-off frequency is set at 0.75*bit-rate.
- BER, eye diagram and Q-factor are analyzed from the eye diagram analyzer.

INPUT SPECIFICATIONS

Pseudo-Random Bit Sequence Generator	CW Laser	NRZ Pulse Generator	Mach-Zehnder Modulator	Optical Fiber
▪ Bit rate = Bit rate Bits/s	▪ Frequency = 193.1 THz ▪ Power = 15 dBm	▪ Rectangle shape = Exponential ▪ Amplitude = 1 a.u. ▪ Rise time = Fall time = 0.05 bit	▪ Extinction ratio = 30 dB ▪ Symmetry factor = -1	▪ Reference wavelength = 1550 nm ▪ Length = 30 km ▪ Attenuation = 0.2 dB/km ▪ Dispersion = 17 ps/nm/km ▪ Dispersion slope = 0.065 ps/nm²/km

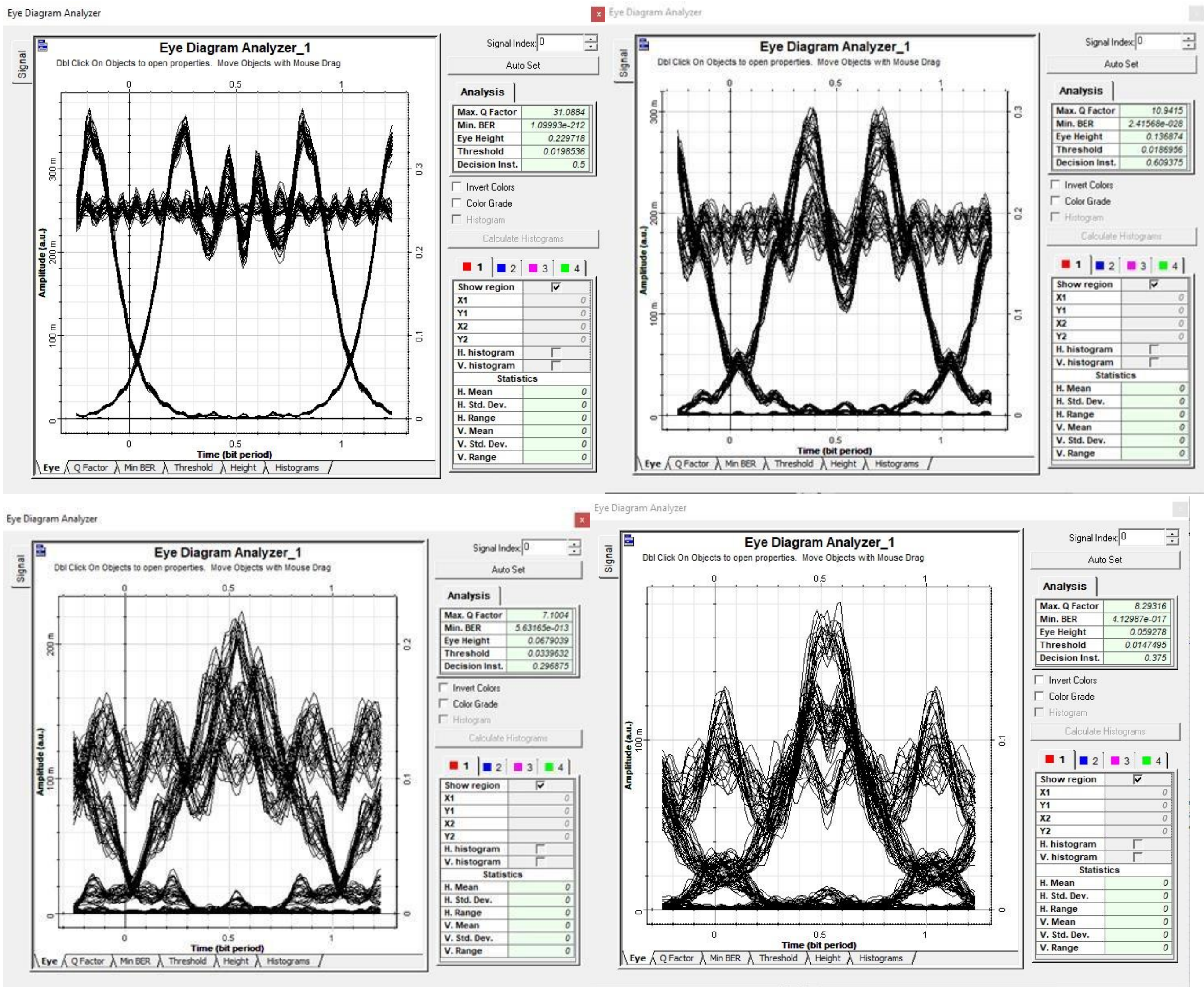
Finer Bragg Grating	Optical Amplifier	Photodetector PIN	Low Pass Gaussian Filter
▪ Frequency = 193.1 THz ▪ Effective Index = 2 ▪ Length = 6 mm ▪ Apodization function = Tanh ▪ Tanh parameter = 4 ▪ Chirp function = linear ▪ Linear parameter = 0.0001 um	▪ Operation mode = Gain control ▪ Gain = 10 dB ▪ Noise figure = 4 dB	▪ Responsivity = 1 A/W ▪ Dark current = 10 nA	▪ Cutoff frequency = 0.75 * Bit rate Hz

SIMULATION (OBSERVATIONS)

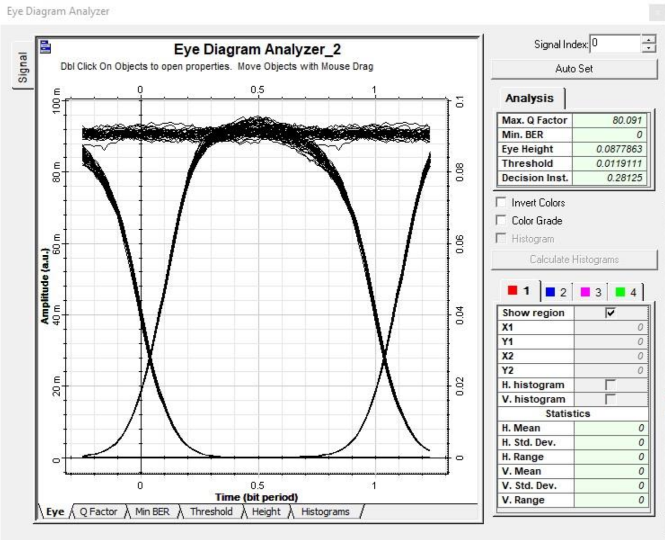
At 15 dBm power

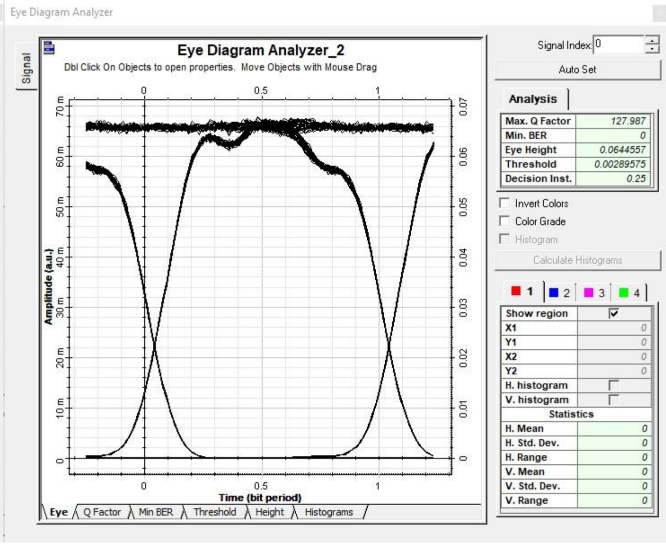
LENGTH	Pre-FBG Q Factor	With FBG Q Factor	Proposed Model Q Factor
5	34.2893	84.4064	65.1098
10	13.6513	136.426	52.0135
12	12.3968	126.227	48.2502
15	12.1037	98.2009	46.3994
17	7.29989	82.3134	48.1701
20	7.55758	65.8313	48.5117
22	7.47481	55.3719	49.2005
25	6.32228	45.6143	50.5517
30	9.20872	21.6975	46.6339

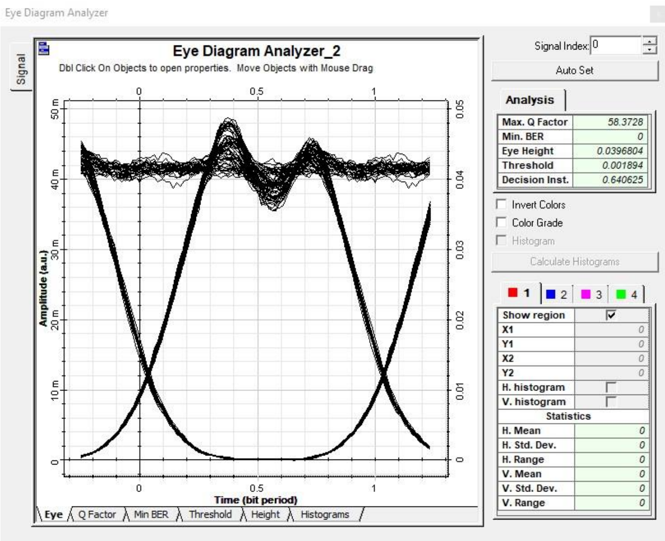
Eye diagrams of different fiber lengths without FBG

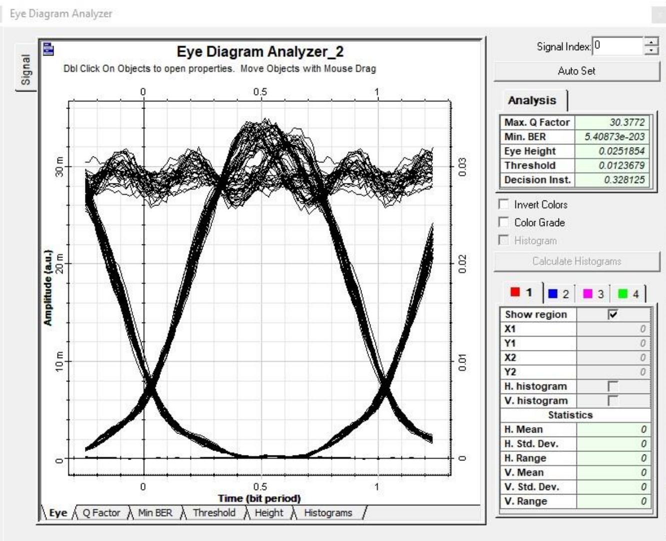


Eye diagrams of different fiber lengths after using FBG:

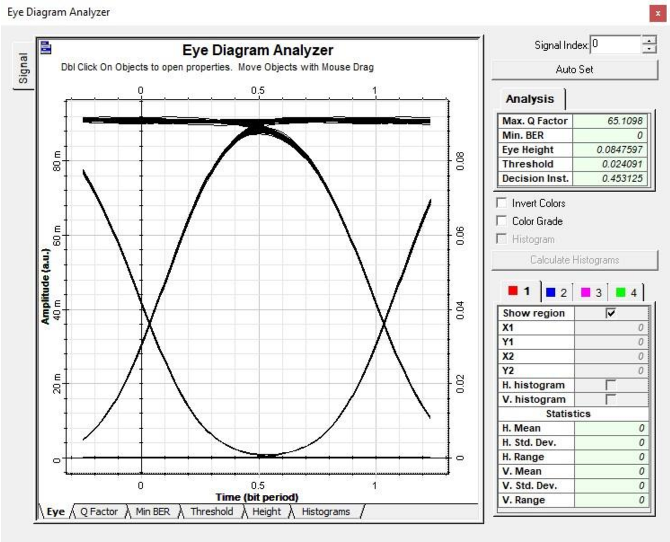


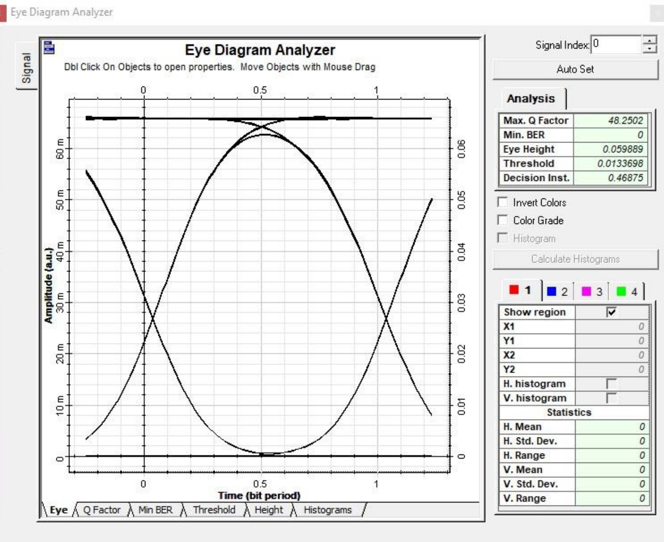


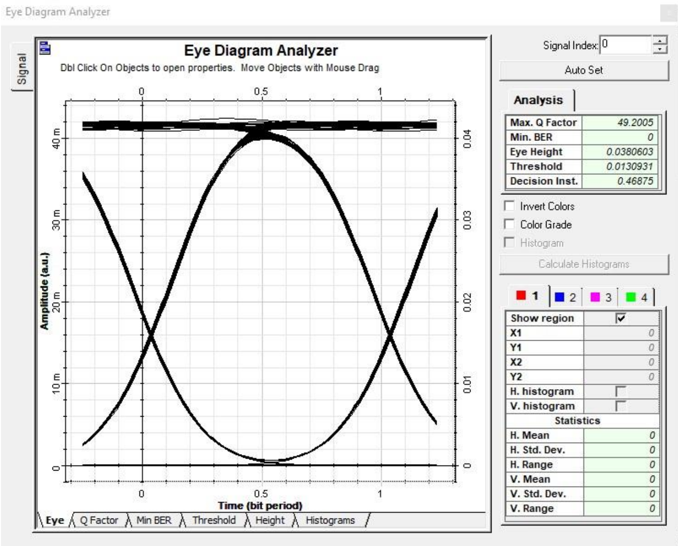


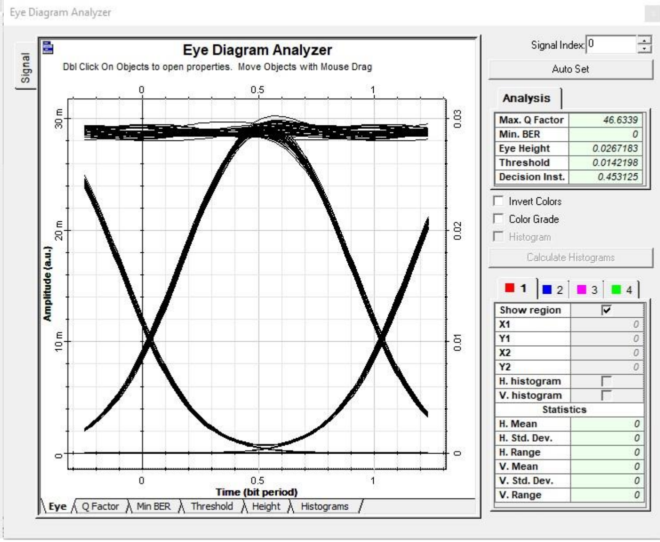


Eye diagrams of different fiber lengths after using FBG and low pass Gaussian filter:









CONCLUSIONS DERIVED FROM THE SIMULATIONS

From the eye diagrams we can see that,

- According to different lengths of optical fiber, the eye diagram is higher and the signal quality is better when we implement FBG and low pass Gaussian filter to the system.

- For the eye diagrams of the systems without FBG and with FBG, Q factor decreases as the distance increases and the eye diagram also becomes more chaotic with the increase in distance.
- The FBG with low pass Gaussian filter system offers improved max. Q factor and wide eye opening (clearer eye diagram) of the system, and is superior to the compensating dispersion compensation technique.

To demonstrate the validity of the proposed method, we examine the effect of variation in input power:

At 15 km length of optical fiber

Power (dBm)	Pre-FBG Q Factor	With FBG Q Factor	Proposed Model Q Factor
1	12.1629	32.8777	51.9587
5	12.4361	50.1661	53.3149
10	12.5536	78.9224	52.3631
15	12.1037	98.2009	46.3994
20			