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High speed pulse generators with electro-optic modulators based on different bit sequence for the digital fiber optic communication links

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ABSTRACT

The paper outlines the simulation of various pulse generators for the enhancement of optical fiber access transmission networks within flow rate of 10 Gbps and transmission range of 100 km. The pulse generators are gaussian, hyperbolic secant, triangle, sine, raised cosine in the transmission stage. Proposed pulse generators are mixed with both electro-absorption modulator (EAM) and Mach-Zehnder modulator (MZM) for efficient transmission. We have compared the max. the quality factor with using proposed pulse generators against nonreturn to zero (NRZ) return to zero (RZ) pulse generators in the previous research works for different bit sequences. The signal power amplitude is tested for both optical fiber and PIN photodetector optical time-domain visualizer and RF spectrum analyzer by using in the optimum cases for different bit sequence. It is observed that proposed pulse generators/EAM have presented an efficient increase in Q-factor value compared with proposed pulse generators/MZM for different bit sequences.

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1. RELATED WORKS

They have studied the data error rate optimization using differential phase-shift keying modulation technique [1]. The bit error rate performance is studied for various fiber lengths and the number of optical amplifiers at wavelength of 1550 nm [2]. The study has outlined the point to point optical communications fiber links [3]. The system consists of multiple quantum well distributed feedback laser and its governing equations with nonreturn to zero code [4-7]. The fiber is modeled with neglecting the Kerr effects. The basic principles and characteristics of photodetection and the bit error rate against the sensibility of the detector [8-10]. They have presented the performance evaluation of optical fiber communication links [11]. The signal attenuation, bending loss, splices loss, Q-factor value and data error rate are examined for both single-mode and multimode optical fibers at wavelength of 1310 nm, 1550 nm [12]. The complete comparison between different communication channels is studied to ensure the optical fiber channel is the best over other communication channels for high bit rate transmission [13]. The non return to zero (NRZ) and return to zero (RZ) formats are used in performance analysis of long band optical systems at different transmission bit rates

[14]. The comparison between different formats (NRZ, RZ) is studied at different bit rates. RZ formats show better performance than NRZ at high transmission bit rates. At the wavelength value of 1625 nm and bit rate value of 35 Gbps, RZ formats give a bit error rate of 5.187 x 10-10 [15].

The bit error rate is enhanced in optical communication systems by using NRZ, RZ pulse generators with different optical modulation techniques [16-20]. NRZ/EAM, NRZ/MZM, RZ/EAM, and RZ/MZM are constructed by using optisystem simulation software in the presence of optical power variations from 15 dBm to 20 dBm in order to achieve the minimum BER values for different 4 bit sequence value of 1010, and 8 bit sequence value of 10101100 [21-25]. The Q-factor and BER values are investigated and stimulated in wavelength division multiplexing networks by using differential phase-shift keying modulation scheme [26-30]. The Q-factor and BER are studied against fiber length, gain, number of amplifiers and channel spacing. The trade-off operating parameters is tested to achieve optimized Q-factor and BER [31-36].

This study clarified the max. the quality factor can be enhanced with using triangle pulse generator/EAM for different bit sequences through the comparison with RZ/EAM. As well as the Q-factor is maximized with using hyperbolic Secant pulse generator/MZM through the comparison with NRZ/MZM for 8-bit sequence. Moreover, the Q-factor is maximized with using Gaussian pulse generator/MZM through the comparison with NRZ/MZM for 16-bit sequence.

2. MODEL DESCRIPTION AND RESEARCH METHOD

Figure 1 outlines the components of the proposed model: User-defined bit sequence generator generates a bit sequence of 4 bits (1010), 8 bits (10101100), and 16 bits (1100110011001100). The flow rate available up to 10 Gbps through the distance varies from 50 km to 100 km. Different electrical pulse generators are employed that are namely Gaussian, Triangle, Hyperbolic secant, Sine, and raised cosine pulses with the light signal that is generated from the continuous wave (CW) laser which is both injected to optical modulators.

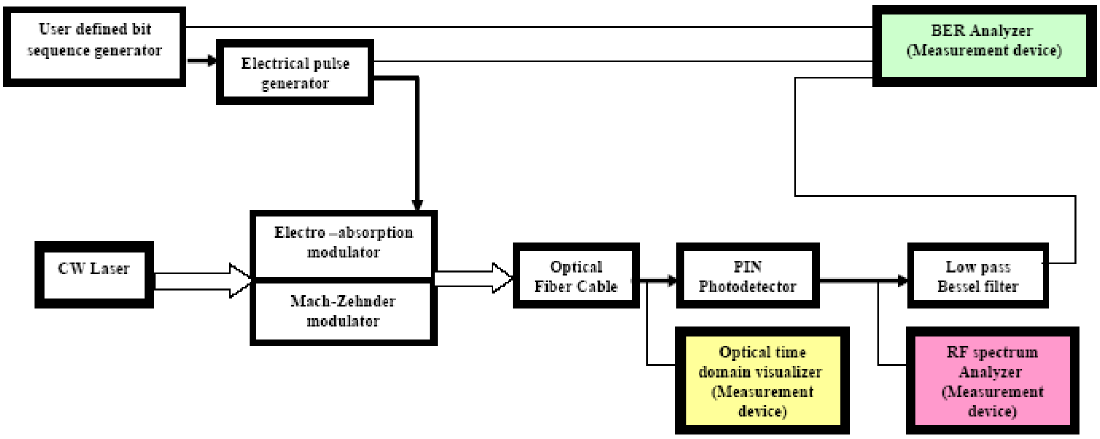

Figure 1. Proposed simulation model

The light signal is forward to fiber cable and then to PIN photodetector where electrical form can be detected. The electrical signal is fed to low pass Bessel filter which is used to remove the ripples from the signal. Both electro-absorption and Mach-Zehnder modulators are used to modulate the electrical and optical signals together. Bit error rate (BER) tests the max Q-factor value and min BER value.

3. PERFORMANCE ANALYSIS WITH DISCUSSIONS

We have numerically simulated the different electrical signal pulse generators for high performance of optical access transmission networks. The efficient employment of different electrical pulse generators with optical modulators are done using optisystem simulation program version 13. The system is built to measure the quality factor based on the efficient coupling between the electrical pulse generator and optical modulators. Based on the clarified parameters in Table 1. The obtained results are assured below:

Figure 2 shows the max. the quality factor with bit period for electrical triangle signal pulse generator with electro-absorption modulator based on 4-bit sequence value of 1010 at a transmission distance of 50 km and flow rate of 10 Gbps. It is found that the max Q-factor reaches to 105.013 and bit error rate tends to zero. RF power spectrum after PIN photodetector for triangle pulse generator with electroabsorption modulator based on 4 bits sequence value of 1010 at transmission distance value of 50 km and flow rate of 10 Gbps is reported in Figure 3. the max signal power amplitude reaches to -16.9349 dBm, and its min value of -103.995 dBm. Optical time domain visualizer after optical fiber length of 50 km for triangle pulse generator with electroabsorption modulator based on 4 bits sequence value of 1010 at transmission distance value of 50 km and flow rate of 10 Gbps is shown in Figure 4. the max signal power amplitude reaches to 14.114 mW and its min value reaches to -0.67209 mW. The bit error rate analyzer for triangle pulse generator with electroabsorption modulator based on eight bits sequence value of 10101100 at transmission distance value of 50 km and flow rate value of 10 Gbps is shown in Figure 5. Max. Q-factor reaches to 72.4073 and bit error rate tends to zero. RF power spectrum after PIN photodetector for triangle pulse generator with electro-absorption modulator based on 8 bits sequence value of 10101100 at distance value of 50 km and bit rate value of 10 Gbps is reported in Figure 6. the max signal power amplitude reaches to -17.2276 dBm, while its minimum value reaches to -103.942 dBm. As well as the optical time-domain visualizer after optical fiber length of 50 km for triangle pulse generator with electro-absorption modulator based on eight bits sequence value of 10101100 at flow rate value of 10 Gbps is reported in Figure 7. The max signal power amplitude reaches to 14.904 mW, while its minimum value reaches to -0.70792 mW.

Table 1. Variables for the study [13]

Components	Parameter description	Value/Unit
The user-defined bit sequence generator	Bit sequence	1010, 10101100, 1100110011001100
Gaussian pulse generator	Amplitude	1 a.u.
Triangle pulse generator	Bias	c0 a.u.
Hyperbolic Secant pulse generator	Width	0.5 bit
Cosine pulse generator	Position	0 bit
Sine pulse generator	Order	1
	Frequency	193.1 THz
CW Laser	Power	20 dBm
	Linewidth	10 MHz
	Extinction ratio	30 dB
Mach-Zehnder modulator	Symmetry factor	-1
	Modulation index	0.95
Electroabsorption modulator	Chirp factor	0
	Reference wavelength	1550 nm
	Range	50 km-100 km
ptical fiber	Attenuation	0.2 dB /km
	Dispersion	16.75 ps/nm/km
	Differential group delay	0.2 ps/km
	Responsitivity	1 A/W
PIN photodetector	Dark current	10 nA
	Insertion loss	0 dB
Low Pass Bessel Filter	Depth	100 dB
	Order	4

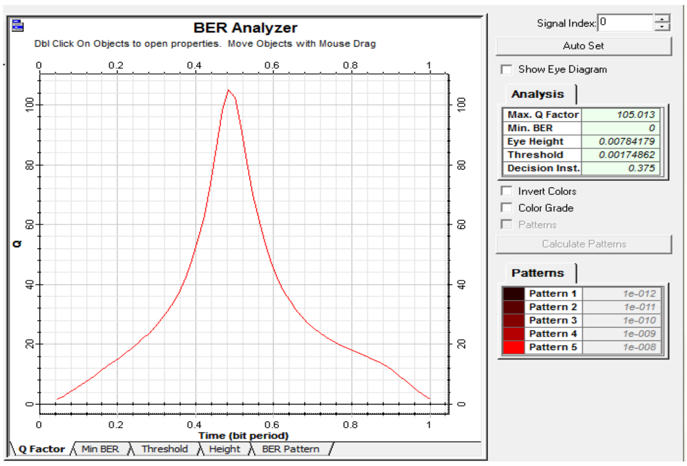

Figure 2. Bit error rate analyzer for triangle pulse generator with electroabsorption modulator based on four bits sequence value of 1010 at transmission distance value of 50 km

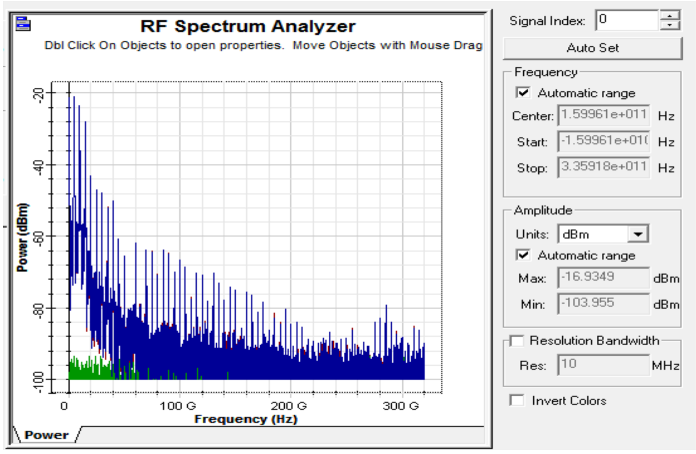

Figure 3. RF power spectrum after PIN photodetector for triangle pulse generator with electroabsorption modulator based on four bits sequence value of 1010 at transmission distance value of 50 km

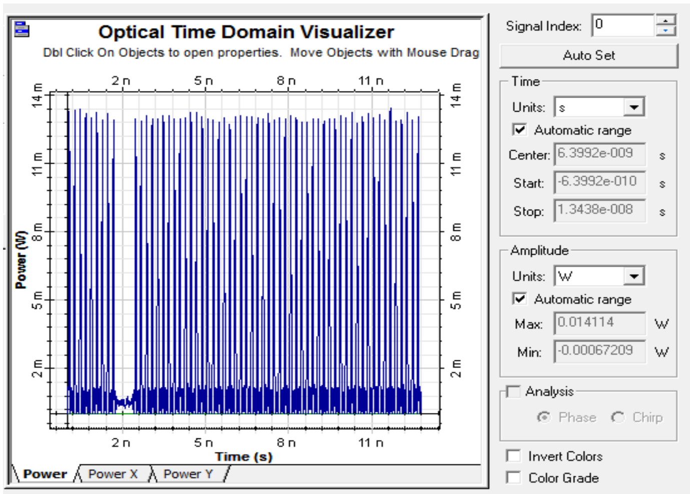

Figure 4. Optical time domain visualizer after optical fiber length of 50 km for triangle pulse generator with electroabsorption modulator based on four bits sequence value of 1010 at the bit rate value of 10 Gbps

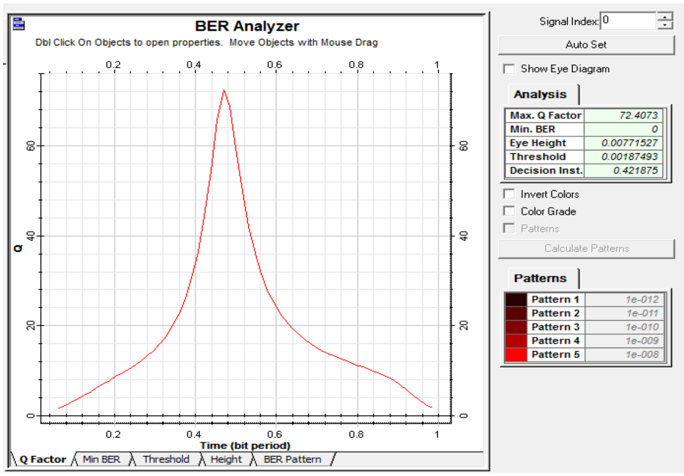

Figure 5. Bit error rate analyzer for triangle pulse generator with electroabsorption modulator based on eight bits sequence value of 10101100 at transmission distance value of 50 km

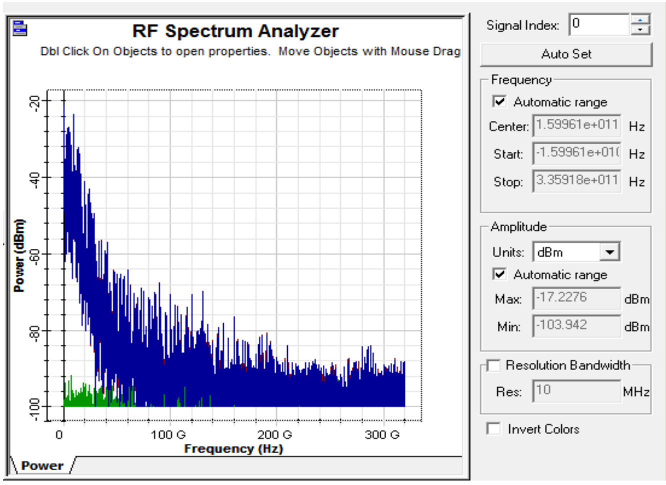

Figure 6. RF power spectrum after PIN photodetector for triangle pulse generator with electroabsorption modulator based on eight bits sequence value of 10101100 at transmission distance value of 50 km

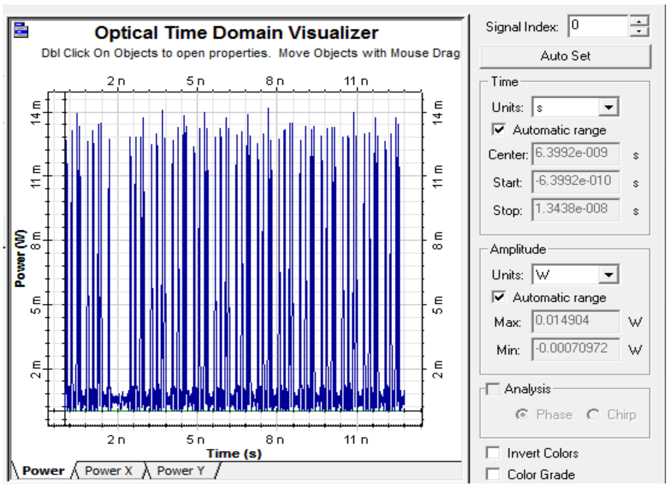

Figure 7. Optical time domain visualizer after optical fiber length of 50 km for triangle pulse generator with electroabsorption modulator based on eight bits sequence value of 10101100 at flow rate value of 10 Gbps

Figure 8 outlines the bit error rate analyzer for triangle pulse generator with electroabsorption modulator based on 16 bits sequence value of 1100110011001100 at transmission distance value of 50 km and a flow rate of 10 Gbps. It is observed that the max Q-factor reaches to 70.5091, and bit error rate tends to zero. RF power spectrum after PIN photodetector for triangle pulse generator with electroabsorption modulator based on 16 bits sequence value of 1100110011001100 at transmission distance value of 50 km and flow rate of 10 Gbps is outlined in Figure 9. It is indicated that maximum signal power amplitude reaches to -17.106 dBm, and its minimum value reaches to -103.947 dBm.

The time-domain visualizer after optical fiber length of 50 km for triangle pulse generator with electroabsorption modulator based on sixteen bits sequence value of 1100110011001100 at bit rate value of 10 Gbps is shown in Figure 10. It is evident that the max signal power amplitude reaches to 14.837 mW, and its minimum value is -0.70654 mW. Figures 11-13 outline the maximum quality factor against transmission distance variations for different proposed pulse generators/EAM based on different bit sequence values. The negative dramatic effects on the increase of the transmission distance on the maximum signal quality factor. Triangle pulse generator presents the max. Q-factor in compared to either proposed pulse generators or RZ pulse generator [9] for different bit sequence. RF power spectrum after PIN photodetector for Hyperbolic Secant pulse generator with Mach-Zehnder modulator based on 8 bits sequence value of 10101100 at transmission distance value of 50 km and flow rate of 10 Gbps is shown in Figure 14. It is found that maximum signal power amplitude reaches to -14.1828 dBm and its min value is -104.087 dBm.

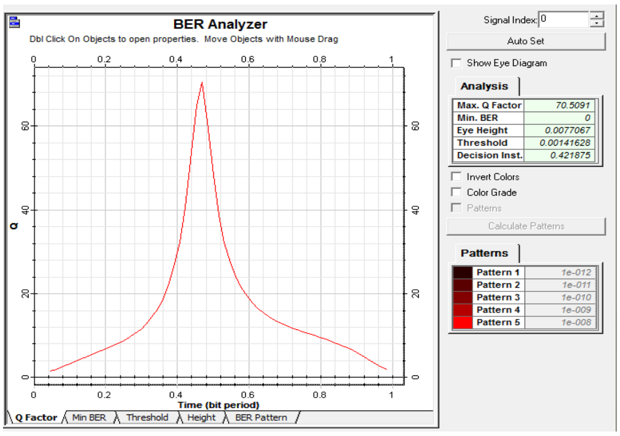

Figure 8. Bit error rate analyzer for triangle pulse generator with electroabsorption modulator based on 16 bits sequence value of 1100110011001100 at transmission distance value of 50 km

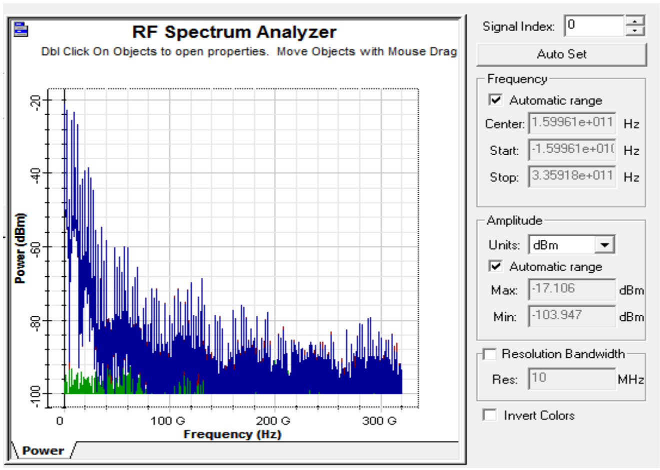

Figure 9. RF power spectrum after PIN photodetector for triangle pulse generator with electroabsorption modulator based on 16 bits sequence value of 1100110011001100 at transmission distance value of 50 km

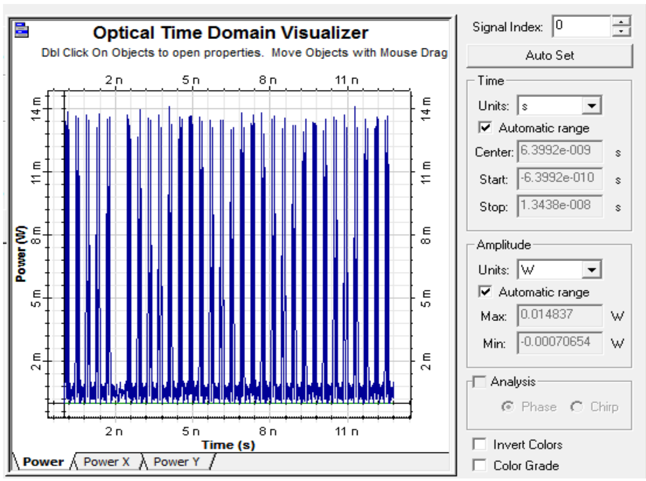

Figure 10. Optical time domain visualizer after optical fiber length of 50 km for triangle pulse generator with electroabsorption modulator based on 16 bits sequence value of 1100110011001100 at flow rate value of 10 Gbps

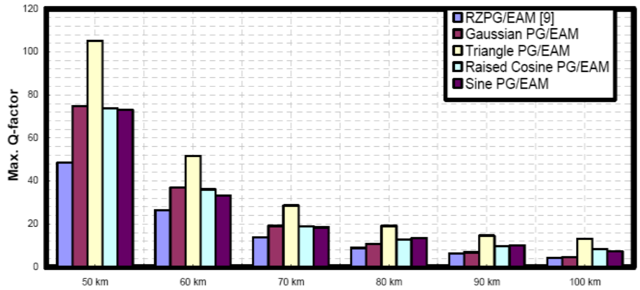

Figure 11. Maximum quality factor versus propagation distance for various proposed pulse generators/EAM based on 4 bits sequence value of 1010

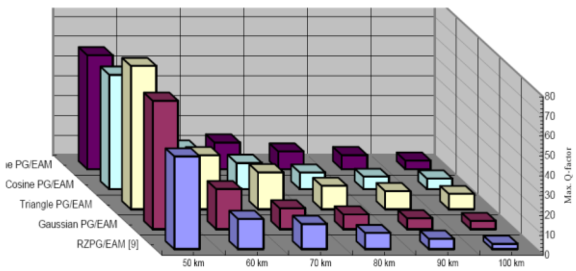

Figure 12. Maximum quality factor with transmission distance for different proposed pulse generators/EAM based on 8 bits sequence value of 10101100

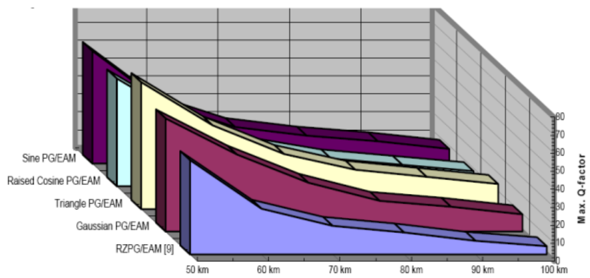

Figure 13. Maximum quality factor with propagation distance for different proposed pulse generators/EAM based on 16 bits sequence value of 1100110011001100

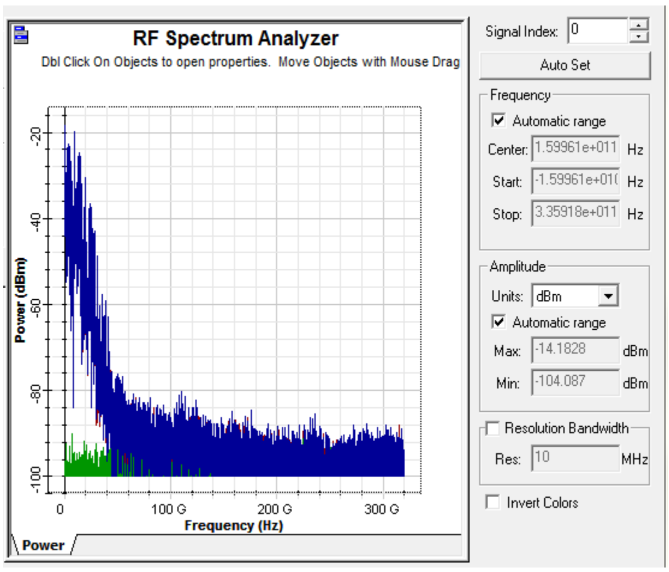

Figure 14. RF power spectrum after PIN photodetector for Hyperbolic Secant pulse generator with Mach-Zehnder modulator based on 8 bits sequence value of 10101100 at transmission distance value of 50 km

The time-domain visualizer after optical fiber length of 50 km for Hyperbolic Secant pulse generator with Mach-Zehnder modulator based on 8 bits sequence value of 10101100 at flow rate value of 10 Gbps is outlined n Figure 15. Maximum signal power amplitude reaches to 27.892 mW and its minimum value is -1.3282 mW. As well as the RF power spectrum after PIN photodetector for Gaussian pulse generator with Mach-Zehnder modulator based on sixteen bits sequence value of 1100110011001100 at transmission distance value of 50 km and flow rate of 10 Gbps is reported in Figure 16. The max signal power amplitude reaches to -

14.3078 dBm and its minimum value reaches to -104.081 dBm. Moreover, the time-domain visualizer after optical fiber length of 50 km for Gaussian pulse generator with Mach-Zehnder modulator based on sixteen bits sequence value of 1100110011001100 at flow rate value of 10 Gbps is reported in Figure 17.

It is found that the max power amplitude reaches to 25.673 dBm and its minimum value reaches to -1.2225 dBm. Figures 18 and19 show the variations of max signal quality factor versus distance variations for different proposed pulse generators/MZM based on both 8-bit sequence value of 10101100 and 16-bit sequence value of 1100110011001100. The dramatic negative effects of the increase of transmission distance on the maximum Q-factor value. It is evident that hyperbolic secant pulse generator/MZM has outlined the maximum signal quality factor in compared with either proposed pulse generators or NRZ PG/MZM [9] for 8-bit sequence value of 10101100. In addition to Gaussian pulse generator/MZM outlines the quality factor with either proposed pulse generators or NRZ PG/MZM [9] for 16-bit sequence value of 1100110011001100.

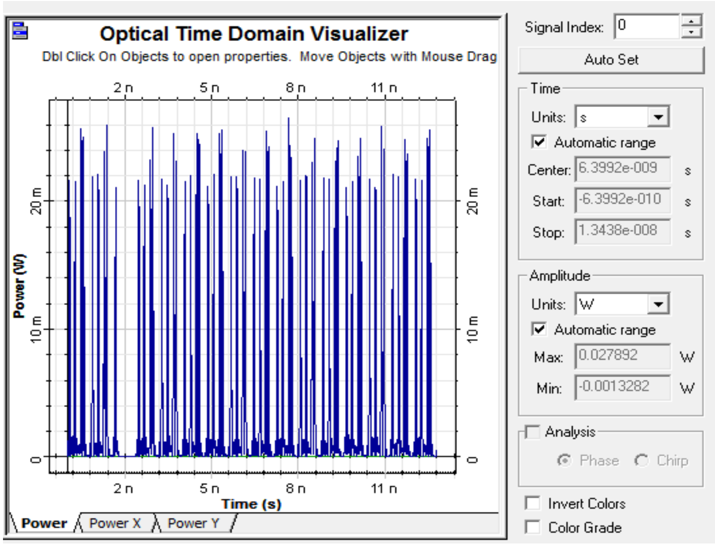

Figure 15. Optical time domain visualizer after optical fiber length of 50 km for Hyperbolic Secant pulse generator with Mach-Zehnder modulator based on 8 bits sequence value of 10101100 at flow rate value of 10 Gbps

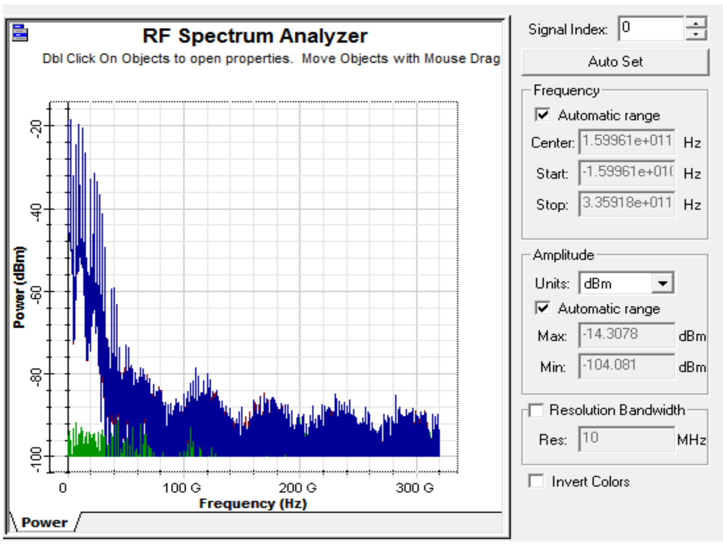

Figure 16. RF power spectrum after PIN photodetector for Gaussian pulse generator with Mach-Zehnder modulator based on 16 bits sequence value of 1100110011001100 at transmission distance value of 50 km

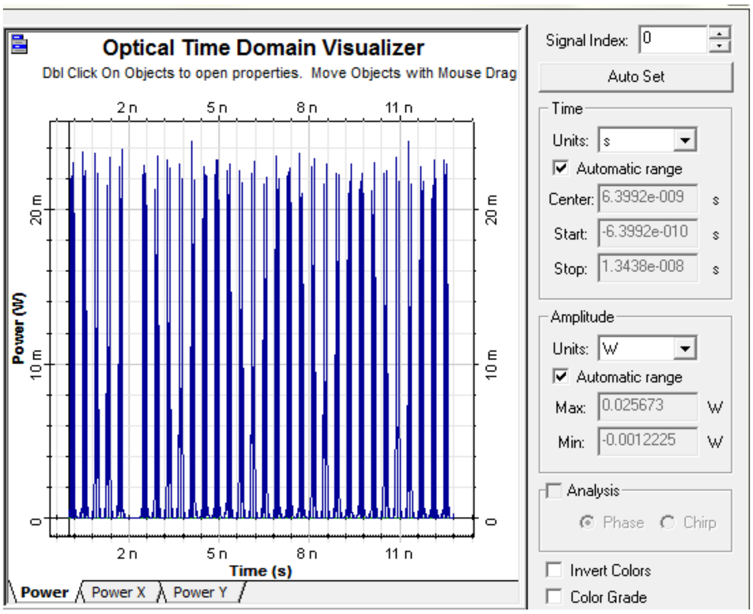

Figure 17. Optical time domain visualizer after optical fiber length of 50 km for Gaussian pulse generator with Mach-Zehnder modulator based on 16 bits sequence value of 1100110011001100 at flow rate value of 10 Gbps

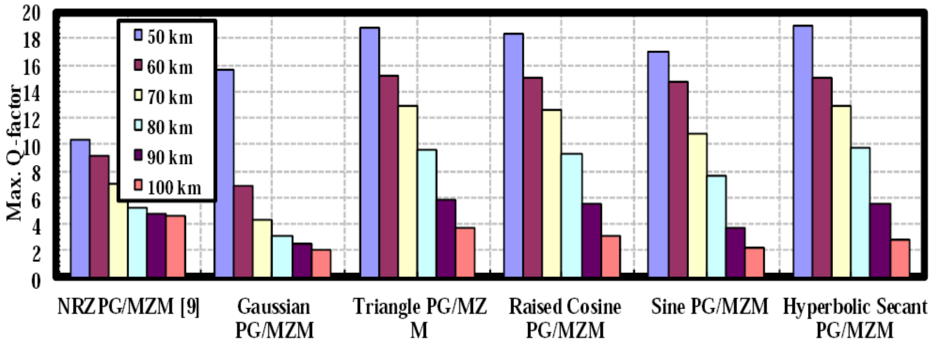

Figure 18. Max signal quality with transmission distance variations for different proposed pulse generators/MZM based on 8 bits sequence value of 10101100

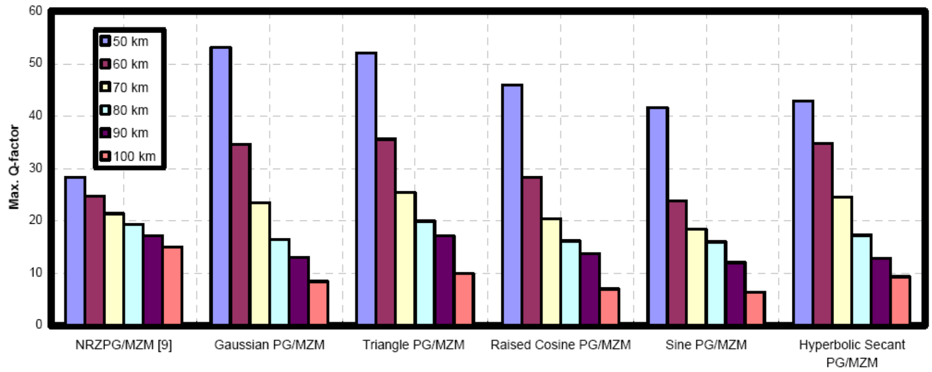

Figure 19. Maximum signal quality factor against transmission distance for different proposed pulse generators/MZM based on 16 bits sequence value of 1100110011001100

4. CONCLUSION

In summary, the efficient coupling between proposed electrical pulse signal generators and optical modulators is suggested in optical access transmission networks. The max quality factor is degraded with the increase of distance based on the numerical simulation. The max. Q-factor value and max. optical signal power is estimated for proposed pulse generators with different optical modulators. Percentage enhancement ratio in max. Q-factor value and max. optical signal power is also estimated in compared with previous pulse generators. It is found that triangle pulse generator/EAM has outlined better both max. Q-factor value, percentage enhancement ratio in max. Q-factor and percentage enhancement ratio in max. optical signal power than either proposed pulse generators/EAM or RZPG/EAM for different bit sequence. As well as hyperbolic-secant PG/MZM has presented better both maxi. Q-factor value, percentage enhancement ratio in max. Q-factor, and percentage enhancement ratio in max. optical signal power than either proposed pulse generators/MZM or NRZPG/MZM for 8-bit sequence. Also, Gaussian PG/MZM has outlined better both max. Q-factor value, percentage enhancement ratio in max. Q-factor and percentage enhancement ratio in max. optical signal power than either proposed pulse generators/MZM or NRZPG/MZM for 16-bit sequence. Therefore it is recommended to use triangle PG/EAM for different bit sequence instead of RZPG/EAM, Hyperbolic-secant PG/MZM instead of NRZPG/MZM for 8-bit sequence, and Gaussian PG/MZM instead of NRZPG/MZM for 16-bit sequence for high-speed transmission networks.

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