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Simulation and Analysis of a transmission system to compensate dispersion in an optical fiber by use chirp gratings

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ABSTRACT:
In this paper, the optical dispersion of communication system based on Fiber Bragg Grating (FBG) is compensate and implemented using Optisystem 7.0. The FBG components could be used to provide best transmission system due to the applicable and reliable characteristics such as low wastage , little bulk, low price, big compensation. This project is focusing on one design parameter against two performance parameters; variable distance length of the fiber with Signal power(dBm), with use FBG and without FBG.
Keywords- *Optical dispersion; Communication System, chirp gratings ; Fiber Bragg; Grating.*

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I. INTRODUCTION

Most important demands on optical fibers are a proper waveguiding in communication system. Due to low loss of optical power and low distortion of the transmitted optical signals.used in high speed data transmission. Although optical fiber communication has a lot of advantages, dispersion is the main performance limiting factor [1]. The FBG based devices have gain popularity in modern optical communication systems and fiber sensing fields. Design and optimize grating reflection or transmission spectra can flexibly by properly choosing the period,chirp, length,apodization function and index modulation amplitude for normal fiber gratings to meet the many applications [2]

Chromatic dispersion it is important parameter in optical fibers that permit anoptical pulse to spread when propagates over the fiber and spread more severely when the propagation for long distance thereforeincrease the data rate .With the increasing happen of high-bit-rate in optical communication system, In optical fibers compensation for chromatic dispersion has become a crucial issue. The chromatic dispersion has various methods to compensate have already been reported in high-speed optical systems, including a compensator using a pair of mode converters, dispersion compensated fibers (DCFs)),fiber gratings, like as fiber Bragg grating (FBG) [3–4].

By using the dispersion compensated fibers(DCF) as a non-liner effect, the dispersion compensator will be needs to be spliced with an present installed optical fiber network,due to the additional equipment caused by increasing the installation costs.Considerable attention in recent times by using of chirped fiber gratings as a dispersion compensator for several reasons simple fabrication,low—insertion loss, fiber compatibityandpassiveoperation.Dispersion compensator have high delta value as an efficient by using LPFGs fabricated which proposed for dispersion compensation [5].By using a high negative dispersion,a significant dispersion compensation will be achieved over a reasonable bandwidth that Based on choosing the refractive index modulation and length of the grating. The requirements of this device is the coupling of high order cladding mode, and produce highly prone to bend losses, when connected to a single mode fiber will be occurs a large power loss, small amount of dispersion compensation can be accomplished, when using unchirped gratings in a transmission mode for dispersion compensation due to give small bandwidth of the high dispersion region and there by heatedly limiting of the bandwidth-distance product[6-7].

Using chirped FBG as a reflective device therefore a dispersion compensator based on, increase the cost when additional optical components for example optical circulator are required .Therefore, extensive research has been conducted on dispersion compensators operating in a transmission mode.Outlet Suggestion a dispersive FBG and active of dispersion compensation in a transmission over signal optical fiber depend on propagating the signal through waveguide with different group velocities [4].

II. DISPERSION

The variation in the refractive index of a material with the frequency or wavelength of the radiation being propagated through this phenomenon which called dispersion[8],pulse broadening when light propagates through a optical fiber expressed in terms of the symbol Δt will be defined Dispersion,elements such as wavelength, core diameter,numerical aperture, refractive index profile,

The pulse broadening of laser line width will be cause poses a limitation on the extensive bandwidth of the fiber [9].

A. Chromatic dispersion

Chromatic dispersion is spreading in transmitted optical signal because the fact that propagated of light at different wavelengths and velocities through the fiber, an important and decisive factor the quality of transmitted optical signal will be limits of in high speed data in optical fiber communication system. [10].

All laser or LED light sources, the radiation more than one wavelength and have limit line widths.Because the propagation in optical fiber at different wavelengths and velocities,then the refraction index is a wavelength-dependent quantity.Chromatic dispersion often is related with wavelength dependence and expressed in units of nanoseconds or picoseconds per (km-nm). An optical fiber the total dispersion is a function of both the material composition and geometry of the waveguide [9] .

B. Fiber bragg grating

The exposure laterally core of a single optical fiber with intense ultraviolet light can be made Fiber Bragg Gratings. The increase refractive index of the fiber core and creating a fixed modulation index due to exposure pattern . Fiber Bragg gratings (FBG‟s) have been recognized as Important fiber-optic devices used for spectral filtering, dispersion compensation, wavelength tuning , and sensing in optical communication and optoelectronics [11]. A fiber Bragg grating (FBG) is a type of distributed Bragg reflector constructed in a short segment of optical fiber that reflects particular wavelengths of light and transmits all others. This is get through the establishment of regular variation in the refractive index of the fiber core, by creating a specific wavelength of dielectric mirror. [12]. Fig. 1 show the Fiber Bragg Grating structure, with refractive index profile and spectral response.

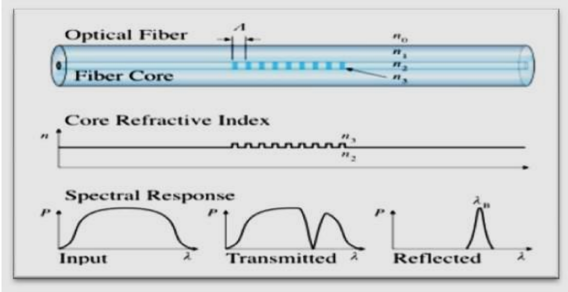


Figure 1. Fiber Bragg Grating structure, with refractive index profile and spectral response

The refractive index will typically alternate over a defined length. The reflected wavelength (λ_B), called the Bragg wavelength, is defined by the relationship,

$$\lambda_B = 2n_e\Lambda$$

where n_e is the effective refractive index of the grating in the fiber core and Λ is the grating period. The effective refractive index quantifies the velocity of propagating light as compared to its velocity in vacuum n_e .depends not only on the wavelength The propagating wave is reflected, if its wavelength equals Bragg resonance wavelength,
λ ,Bragg, shown in Fig. 2.
Bragg

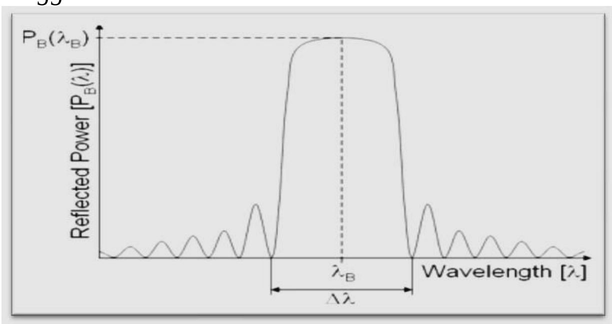


Figure 2. Graph for Reflected Power versus Wavelength

III. SYSTEM DESCRIPTION

The proposed block diagram to simulate transmission system with FBG and without FBG is shown in Fig. 3 (a) , and Fig. 3 (b) respectively. The function of Pseudo-random bit sequence generator (generating 10 Gbps) is to generate sequence random of bits (0 or 1) [13]. NRZ-pulse Generator produces the electrical data signal for modulation process [14]. Continuous Wave (CW) laser is operating at frequency 193.1 THz is applied to the system and it is modulated externally with non-return-zero (NRZ) pseudorandom binary sequence in a Mach–Zehnder modulator (Mach-Zehnder has extinction ratio of 30 dB). Signal flows through single mode optical fiber has parameter dispersion 16.5(ps/km/nm), dispersion slope is 0.075 (ps/nm2/km), attenuation index is 0.2(dB) and Length of fiber(5,15,25,50,100km). FBG is used to compensate the chromatic dispersion of optical fiber (working principle-the longer wavelengths are transmitted through the last part of grating and short wavelengths are reflected by the first part of grating, due to this results longer wavelength have to travel a longer distance, so they are delayed and allowing the shorter wavelength to catch up, and dispersion gets reduced).The function of erbium-doped fiber amplifier (EDFA) is to compensate the losses in optical transmission system. Function of photodetector is detection of light (photon) at the receiver. It directly converts light into current. Optical power meter is used to checking the received signal power level. Eye Diagram Analyzer is used for measure strength of power and noise signal.

IV. RESULTS AND DISCUSSIONS

This section describes comparison of eye diagram using dispersion compensation with FBG and without FBG of the signal propagating over different values of distances.

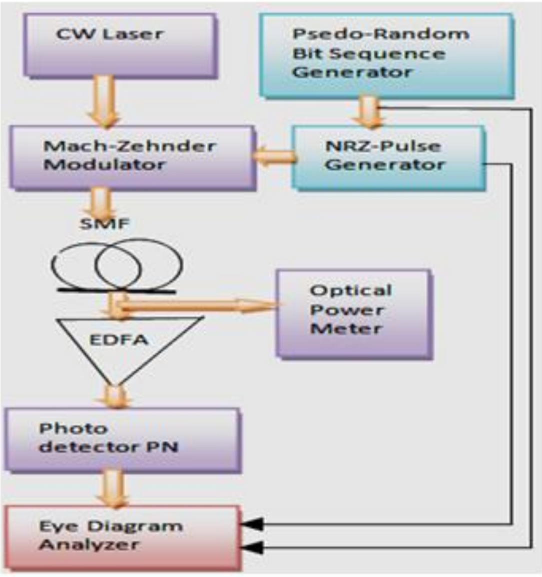


Figure 3. A block diagram of transmission system using FBG

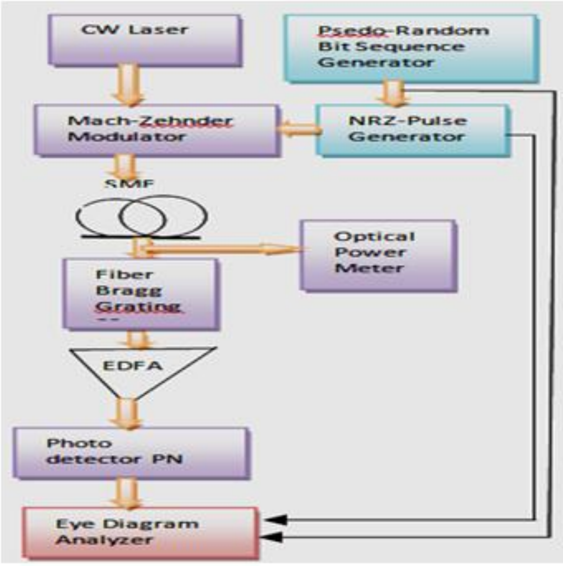


Figure 4. A block diagram of transmission system without using FBG

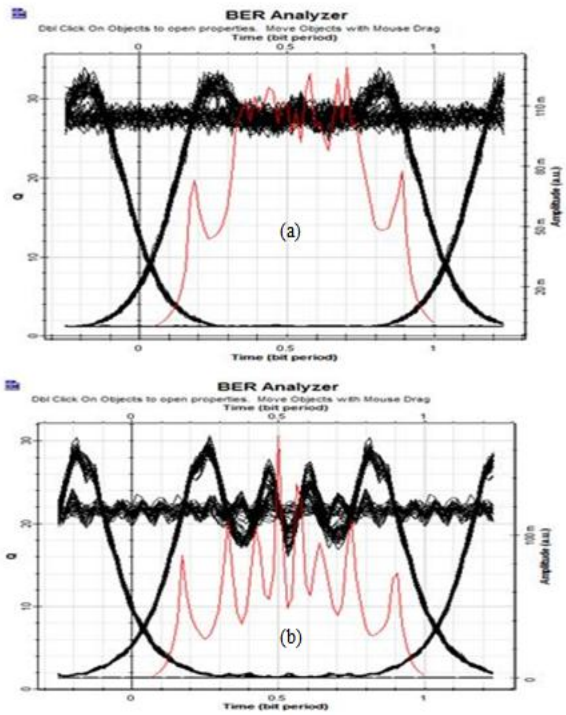


Figure 5. For optical fiber of length 5 km at bit rate of 10 Gbps (a) Eye diagram with using FBG (b) Eye diagram without using FBG

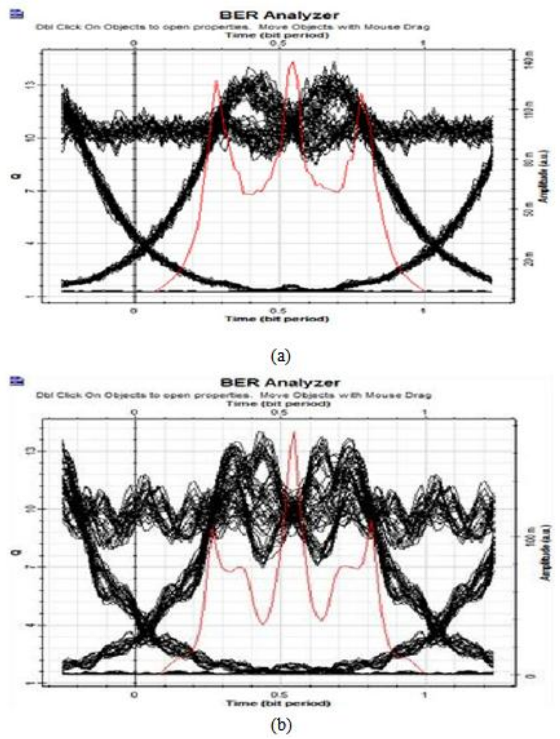


Figure 6. For optical fiber of length 15 km at bit rate of 10 Gbps (a) Eye diagram with using FBG (b) Eye diagram without using FBG.

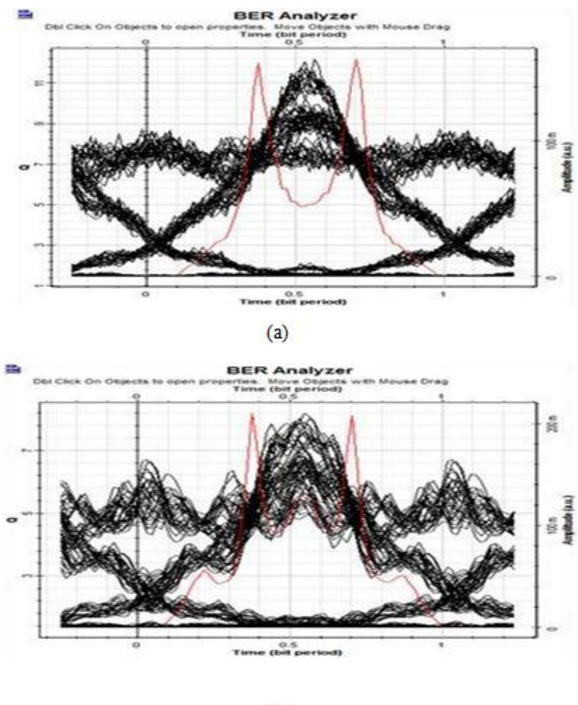


Figure 7. For optical fiber of length 25 km at bit rate of 10 Gbps (a) Eye diagram with using FBG (b) Eye diagram without using FBG..

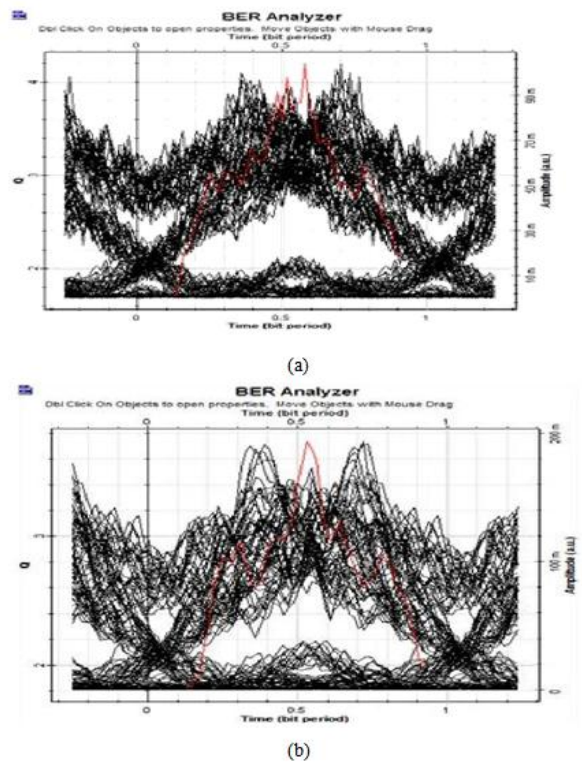


Figure 8. For optical fiber of length 50 km at bit rate of 10 Gbps (a) Eye diagram with using FBG (b) Eye diagram without using FBG.

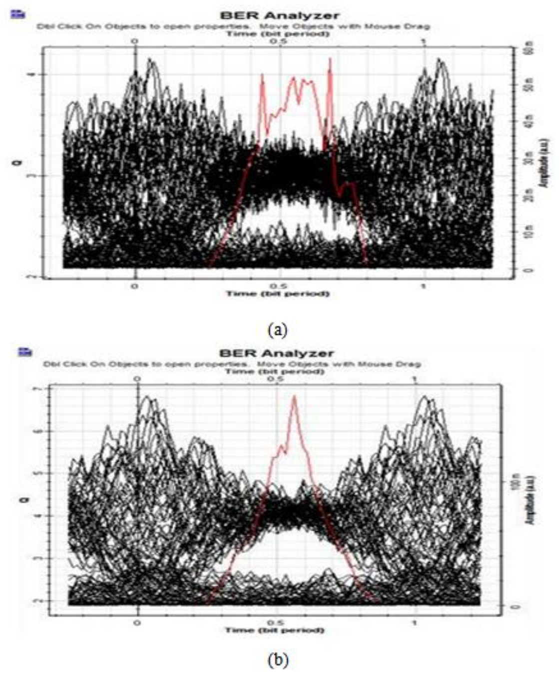
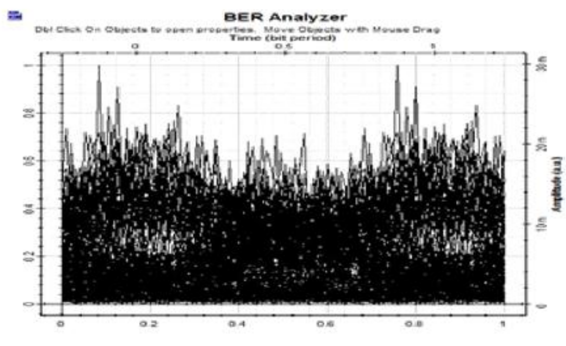
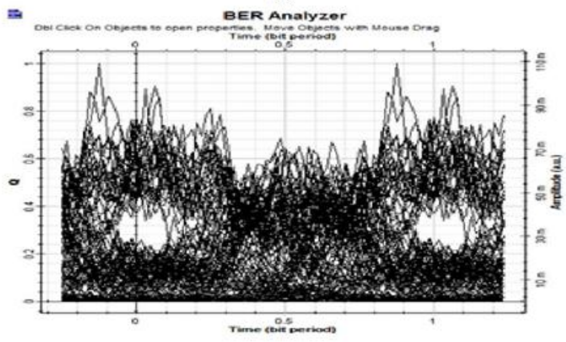


Figure 9. For optical fiber of length 75 km at bit rate of 10 Gbps (a) Eye diagram with using FBG (b) Eye diagram without using FBG.

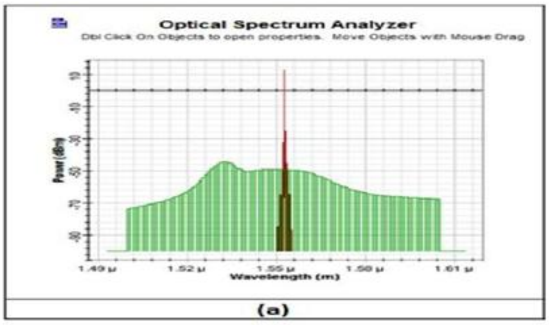


(a)

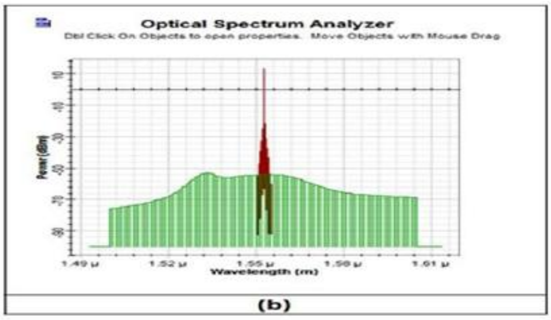


(b)

Figure 10. For optical fiber of length 100 km at bit rate of 10 Gbps (a) Eye diagram with using FBG (b) Eye diagram without using FBG.

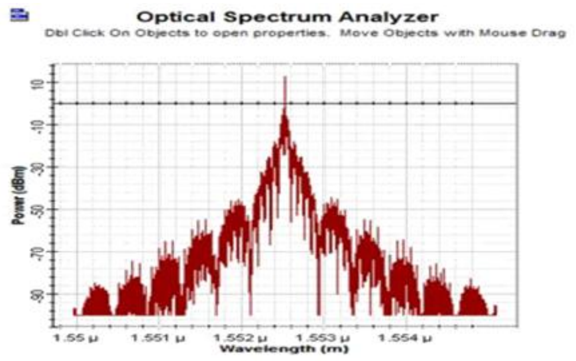


(a)

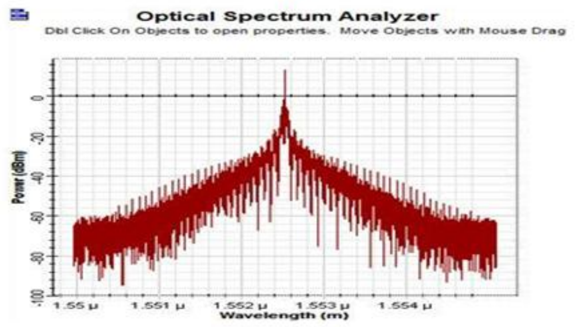


(b)

Figure 11. The output sampled power readings are measured by Optical power meter for fiber length 25km. (a) with using FBG (b) without using FBG



(a)



(b)

Figure 12. The output (signal and noise) power readings are measured by Optical power meter for fiber length 25km. (a) with using FBG (b) without using FBG.

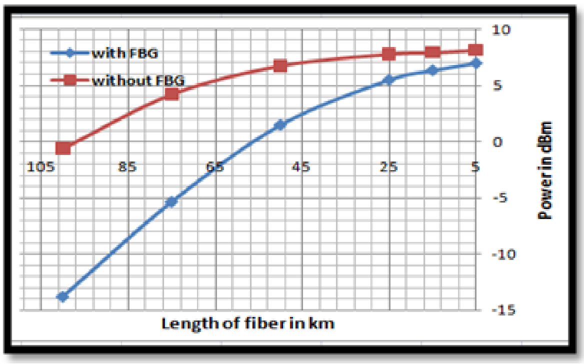


Figure 13. A graph showing length of fibervs total power using FBG and without FBG

Table I: Parameters of length of fiber and power without FBG

Length of the fiber (km)	Power(dBm)
5	8.13
15	7.93
25	7.79
50	6.75
75	4.213
100	-0.612

Table II: Parameters of length of fiber and power with FBG

Length of the fiber (km)	Power(dBm)
5	6.95
15	6.3134
25	5.4635
50	1.4634
75	-5.361
100	-13.78

Results through the use of optical dispersion compensation. Where when comparing the shapes of eye diagram from Fig. 5 to Fig. 10. For different distances using an a single mode optical fiber is found that using the optical dispersion compensation give much better results by reducing the ratio of error rate, note that the error rate increases with the length of optical fiber.

The Fig. 11 shows the optical spectrum analyzer reading before and after using the optical dispersion compensation for sampled signal while Fig. 12 shows the optical spectrum analyzer reading for the signal and noise together, and through these forms, will be found that the results are better when using the optical dispersion compensation. Note that read spectrum analyzer conducted on optical fiber length of 25 km.

Fig. 13 shows the relationship between power (dBm) and the length of optical fiber (km) which calculated from table 1and table2 ,before and after using the dispersion compensation and note by the results that the power decrease with increase the length of optical fiber and through curves conclude that when use the compensation dispersion will be need the minimum power at the end of the fiber optic, it is very important to reduce the dispersion and also reduce the cost of optical fiber.

V. CONCLUSION

The chromatic dispersion in optical fiber which be need compensated to get best result and improvement the quality of the fiber. By adding the chirp FBG in the transmission system it helps to reduce the losses and minimizes the cost of the system. The effect of dispersion at different optical fiber lengths are explained in this project. These effects are show by the help of eye diagrams drawn at the different values of fiber lengths. From the result have also shown with the help of graph comparing both the techniques one without using FBG and second using FBG. It can also be seen that when chirp FBG is added to the system total output power also decrease.

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