Calculation of Bends losses in single-mode fibers and The Critical Radius of Curvature by two light sources

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Abstract:

Bending effect was studied on reached signal through single mode fiber by two light sources (Infrared LED model IR333C-A with wavelength 940nm andpure red laser Diode model RLD63NZC5 with wavelength rate 635nm) , Measurements were conducted contacts Postal Service and the communication in Najaf the bending losses were calculated in addition to the critical radius of curvature. These results were compared to theoretical results to find out that both results were very close.

Keywords: single mode optical fiber, bending losses, critical bending.

حساب خسائر الانحناءات في الالياف البصرية احادية النمط و حساب نصف قطر الانحناء الحرج و لمصدريين ضوئيين

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الخلاصة:

دُرس في هذا البحث تأثير الانحناء على الاشارة الواصلة في حالة الليف البصري أحادي النمط Single Mode Fiber عن طريق مصدرين ضوئيين هما Infrared LED موديل IR333C-A و بطول موجي 940nm و المصدر الثاني Pure Red Laser Diode موديل RLD63NZC5 و بمعدل طول موجي 635nm اذ أُجريت القياسات في دائرة بريد واتصالات النجف الاشرف و حساب الخسائر في كل انحناء ، كما تم حساب نصف قطر الانحناء الحرج و بعد مقارنة النتائج مع النتائج النظرية وجد انهما متقاربان.

الكلمات المفتاحية: ...

1. Introduction

Optical fiber is one of the most important scientific achievements in the last century. it was found in the early sixties, and it made communications technology evolved dramatically [1,2]. Optical fibers are made from glass or plastic. Its diameter is similar to the diameter of a human hair, and optical fiber extends to long distances. The light is transmitted through the fiber carrying the signal that must betransferred. Its high capability to transfer signal, in addition to its low cost, weight, and size makes it

better than copper cables which makes it more convenient for a lot of different applications, including the micro-surgery operations, speculum operation, and industrial applications.[3,4]

Optical fibersuffering excessive bending losses during the transmission of the optical signal in the core due to escaping of light into cladding which leads to a defect in the mechanism of transmission[2].

a wavefront in the optical fiber must be perpendicular to the propagation direction .when there are bends in the fiber, the signal transmitted in core faster than in cladding, leading to a loss in the energy of signal transmitted through the optical fiber and to avoid that the speed of light must be increased in the cladding as shown in fig (1), the losses can be represented by Radiation attenuation coefficient as:

$$\alpha_r = C_1 \exp(-C_2 R) \dots\dots\dots\dots (1)$$

Where R is a radius of curvature C_1, $C_2$are constant.

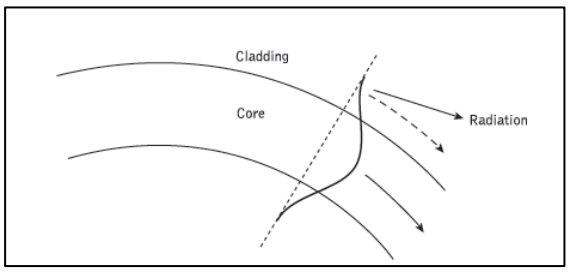

Figure (1) the effect of the bending on the transmission of radiation through the fiber

The Critical Radius of Curvature of Single-mode Fiber can be calculated by the equation (2):[3]

$$R_{cs} = \frac{20\lambda}{(n_1 - n_2)^{\frac{3}{2}}}\left(2.748 - 0.996\frac{\lambda}{\lambda_c}\right)^{-3} \dots (2)$$

Where λ_c the cutoff wavelength for the single-mode fiber[5,3].

The critical curvature of radius is directly proportional to the used wavelength i.e. smaller wavelength leads to smaller radius of curvature[2]

2. Experimental work

For the major importance and widely used of the single mode fiber,the study of bending losses and the calibration lossesare obtained. [6,7] , the calibration losses which are resulting from structure properties, manufacturing, connection points,and purity of the fiber [2].

The main descriptions of the used single mode fiber are:

1- Cutoff Wavelength (λ_{cc} =1260 nm).

2- Chromatic Dispersion (3 ps/[nm.km]) for Wavelength 1285nm and (22 ps/[nm.km]) for Wavelength (1322nm) .

After the connection between the transmitter and the receiver by single mode fiber (4 meter), data transmission (text massage, numbers and characters) can be obtained for two optical sources:

1- Infrared LED (IR333C-A) which has high density irradiation, greatest operation wavelength (940nm), viewing angle 20 ◦ and high reliability.

2- Pure Red Laser Diode (RLD63NZC5) which has average operation wavelength(635 nm), output power (5mw), operation voltage (2.2V) and operation current (33m A).

The losses practical measurements for different curvature radii and for the Infrared LED source are shown in table (1), and for pure red laser diode are shown

in table (2) by using power meter (CORNING OM-610).

3. Results and Discussion:

The calibration losses almost equals to (-44.66 db) for infrared LED and (-38.03 db) for pure red laser diode.Table(1) and figure (2) show the infrared LED (940nm) bending losses through the single mode optical fiber, where practically by decrease the radius of curvature ,the output power is decreased but at certain value of curvature (critical radius=0.27mm) the output power is cut off, while by using equation (2) the theoretical (critical radius=0.24mm).

table (2) and figure (3) show the pure red laser diode bending losses through the same mode of fiber for different curvature radii, where the practical critical radius of curvature is (0.2mm) and the theoretical radius is (0.122mm).so that for both sources it has been noted that, if the wavelength increase to be the infrared rage, the critical radius of curvature will be high and that support the relation (2).

Figure (4) illustrates the differences in the results between both light sources. When measured results were compared with the calculated results using equation (2), the calculated and the measured results were very close. However, small difference was found because of many factors such as the optical fiber properties and the calibration losses between the light sources and the fiber.

Table (1)bending losses forinfrared LED source in single mode optical fiber.

Ser	Rmm	Loss
1	0.5	-62.33
2	1	-57.1
3	2	-52.43
4	6	-50.75
5	10	-49.38
6	15	-47.5

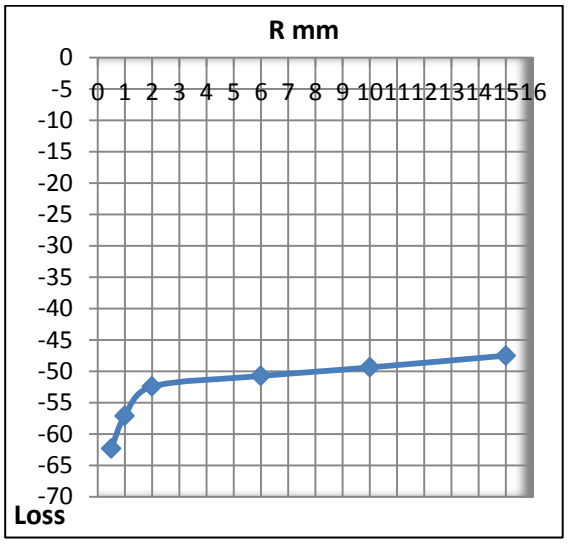

figure (2) bending losses forInfrared LED source insingle mod optical fiber

Table (2)bending losses forpure red laser diodesource in single mode optical fiber

Ser	Rmm	Loss
1	0.5	-52.02
2	1	-47.22
3	2	-44.18
4	6	42.72
5	10	-41.05
6	15	-38.15

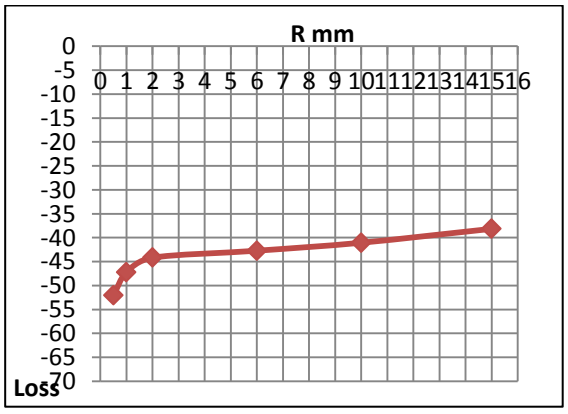

figure (3) bending losses for pure red laser diode source in single mod optical fiber

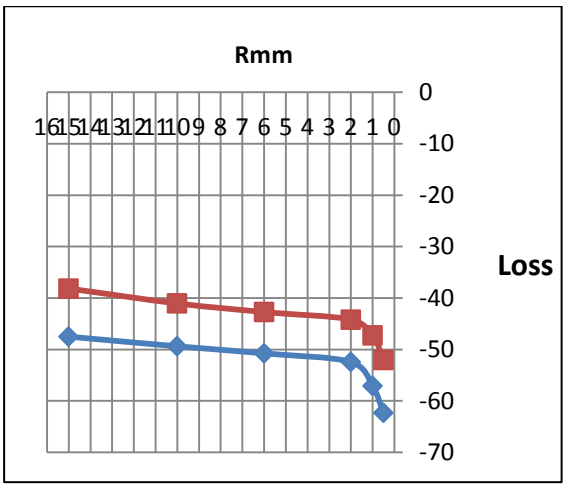

figure (3)bending losses for both sources (635nm) Pure Red Laser Diode (940nm)

4. Conclusions

1- In this paper the investigation of equation (2)is obtained when the wavelength was increased to reach the infrared range, the critical radius of curvature will be high.

2- An entire signal from Infrared LED (940nm) light source was cut when the critical radius was (Rcs= 0.244 mm).

3- An entire signal from pure red laser diode (635nm) light source was cut when the critical radius was (Rcs= 0.24 mm).

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