Wrocław University of Science and Technology

FUNDAMENTALS OF TELECOMMUNICATION LABORATORY REPORT

FIBER OPTIC TRANSMISSION

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1) Introduction

In this laboratory report, we explore the intricacies of optical fiber transmission and the spectral characteristics of various light sources. Optical fibers, primarily made from silica due to its high mechanical strength and low propagation loss, serve as critical conduits for telecommunication, facilitating the transmission of information over considerable distances with minimal loss. The report examines how light propagates within these fibers under conditions of total internal reflection, a phenomenon essential for efficient light guidance. Additionally, we delve into the attenuation mechanisms within optical fibers, quantifying loss using specific formulas and observing how different fiber conditions affect propagation. The second part of the exercise focuses on utilizing a spectrometer to analyze the light emission spectra from diverse sources, enhancing our understanding of spectral properties in practical applications. This investigation not only deepens our comprehension of optical fiber dynamics but also underscores the broader implications of optical technologies in modern communications.

2) Exercises

5.2

Measured reference power the laser:

1550 nm / 8.44 dBm / 6.95 mW

5.3

DBm's	1 patchcords	2 patchcords	3 patchcords
1	7.60	7.27	6.55
2	7.59	7.28	6.56
3	7.59	7.27	6.56
4	7.58	7.27	6.55
Avg.	7.59	7.27	6.56
mW's	1 patchcords	2 patchcords	3 patchcords
1	5.75	5.34	4.53
2	5.74	5.35	4.52
3	5.75	5.34	4.52
4	5.74	5.35	4.53
Avg.	5.75	5.35	4.53

It is evident that with the increase in the number of patchcords, there is a corresponding rise in attenuation. This trend is anticipated, as each patchcord contributes additional losses through absorption, scattering, and reflection of the optical signal.

5.4

Attenuation (dB) = Pin (dB) - Pout (dB)

Given Values:

- Without splice, the previously measured attenuation is 7.59 dB (used as Pin).

- With splice, the output power measured is -9.15 dBm (Pout).

Calculation:

Attenuation with splice = 7.59 dB - (-9.15 dBm)

Attenuation with splice = 16.74 dB

This calculation shows that the total attenuation when the optical signal passes through a patchcord with a splice is 16.74 dB. This value demonstrates the impact of the splice on the optical signal compared to a standard patchcord connection.

5.5

	mW	dBm
1	3.80	5.88
2	3.82	5.82
3	3.96	5.92
4	4.05	6.08
5	4.05	6.08
6	4.06	6.09
7	4.05	6.09
8	4.06	6.10
9	4.04	6.08
10	4.06	6.09
Avg.	3.99	6.03

5.6

	mW	dBm
1	3.80	5.80
2	3.80	5.80
3	3.81	5.80
4	3.80	5.80
5	3.81	5.80
6	3.80	5.81
7	3.81	5.80
8	3.80	5.81
9	3.80	5.80
10	3.81	5.80
Avg.	3.81	5.80

It is noted that the attenuation in optical fibers increases with their length, a phenomenon consistent with established patterns in optical fiber communications. Longer fibers generally exhibit greater attenuation, a result of increased scattering, absorption, and the inherent imperfections present within the fiber material.

5.7

	mW	dBm
1	2.39	3.78
2	2.33	3.68
3	2.40	3.86
4	2.43	3.84
5	2.35	3.70
6	2.38	3.75
7	2.37	3.78
8	2.35	3.69
9	2.42	3.84
10	2.40	3.70
Avg.	2.38	3.77

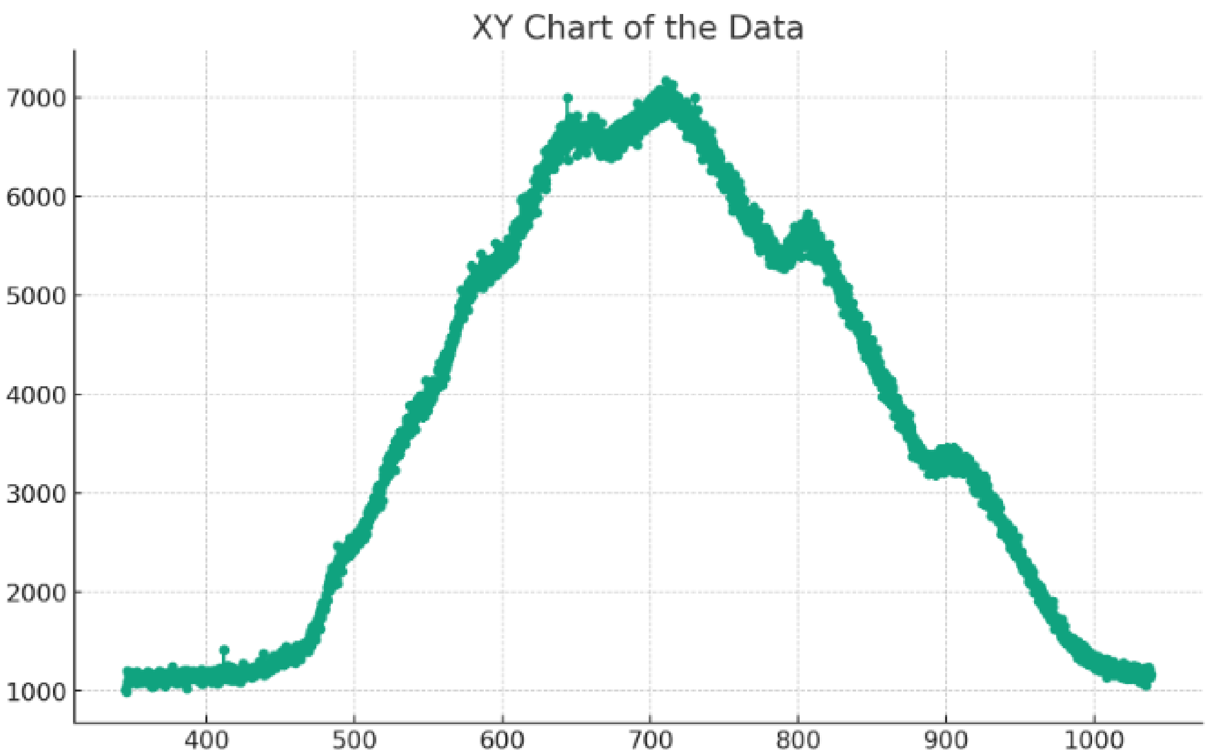
The observed attenuation of 3.77 dB when combining the 6.3 km and 8.5 km fiber segments exceeds the sum of their individual attenuations, indicating a cumulative loss greater than expected. This increase in attenuation at the junction point may be attributed to factors such as experimental inaccuracies, mismatches in fiber types, or suboptimal connection quality.

5.8

In the realm of optical fiber communications, the various elements such as splices, connectors, and fiber lengths significantly influence signal loss, thereby affecting overall network efficacy. Connectors and patchcords, while providing essential flexibility, inherently contribute to attenuation. This effect tends to compound with the number of connections used, making them ideal for scenarios requiring temporary or frequent reconfigurations within fiber networks. On the other hand, splices play a pivotal role in expanding network reach by joining fiber segments. They typically offer lower insertion losses and robust mechanical integrity, yet their efficiency can be compromised by poor craftsmanship, leading to increased signal degradation. Extended fiber lengths facilitate broader network coverage but also accumulate greater attenuation, which challenges the maintenance of signal integrity and often necessitates the integration of signal amplifiers. A thorough comprehension of each component's benefits and drawbacks is crucial for the strategic design and optimization of durable and efficient optical fiber networks.

6.2

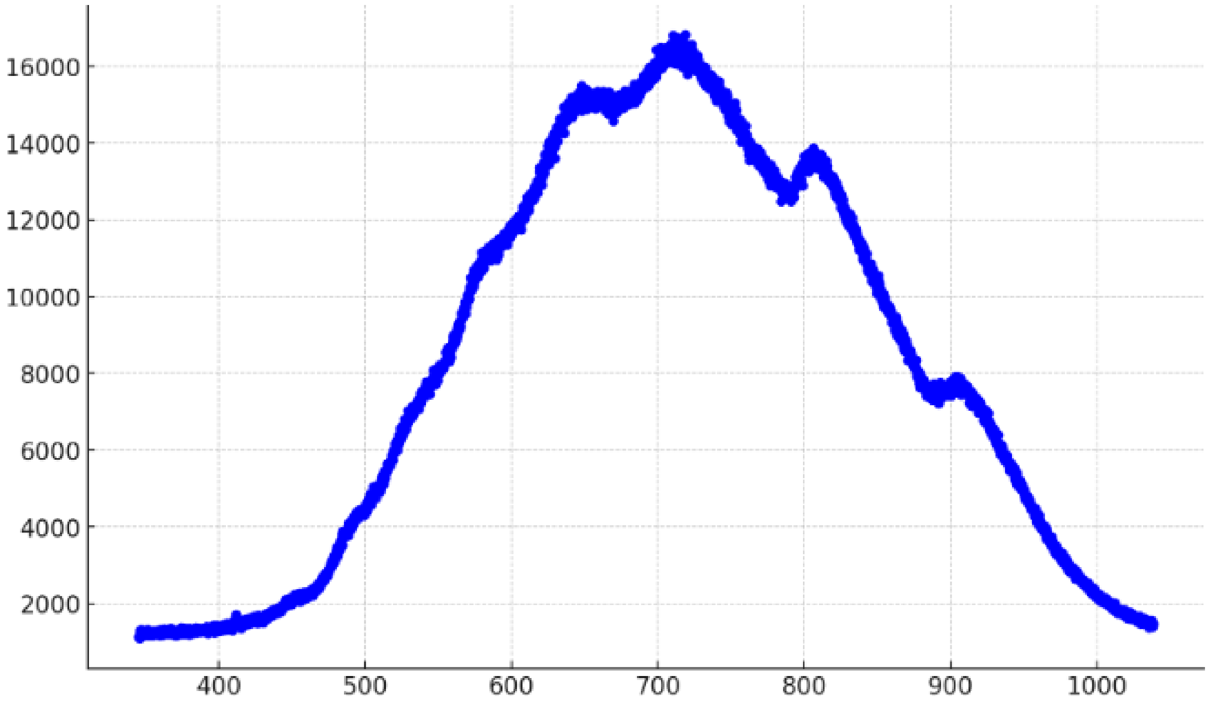
First bulb



The central wavelength of the peak in your data is approximately 710.39 nm, and the Full Width at Half Maximum (FWHM) is approximately 338.85 nm.

The spectral characteristics of your bulb, including a broad and smooth spectrum with a central wavelength around 710.39 nm and a Full Width at Half Maximum (FWHM) of 338.85 nm, strongly suggest it's a tungsten incandescent bulb. Tungsten bulbs emit a continuous spectrum due to blackbody radiation from the heated filament, prominently featuring longer wavelengths in the red and infrared regions. This broad spectrum and the deep red central wavelength align well with the typical output of tungsten bulbs, known for their warm, inviting light and a color temperature that leans toward the warmer end of the spectrum, making them a favorite for cozy indoor lighting.

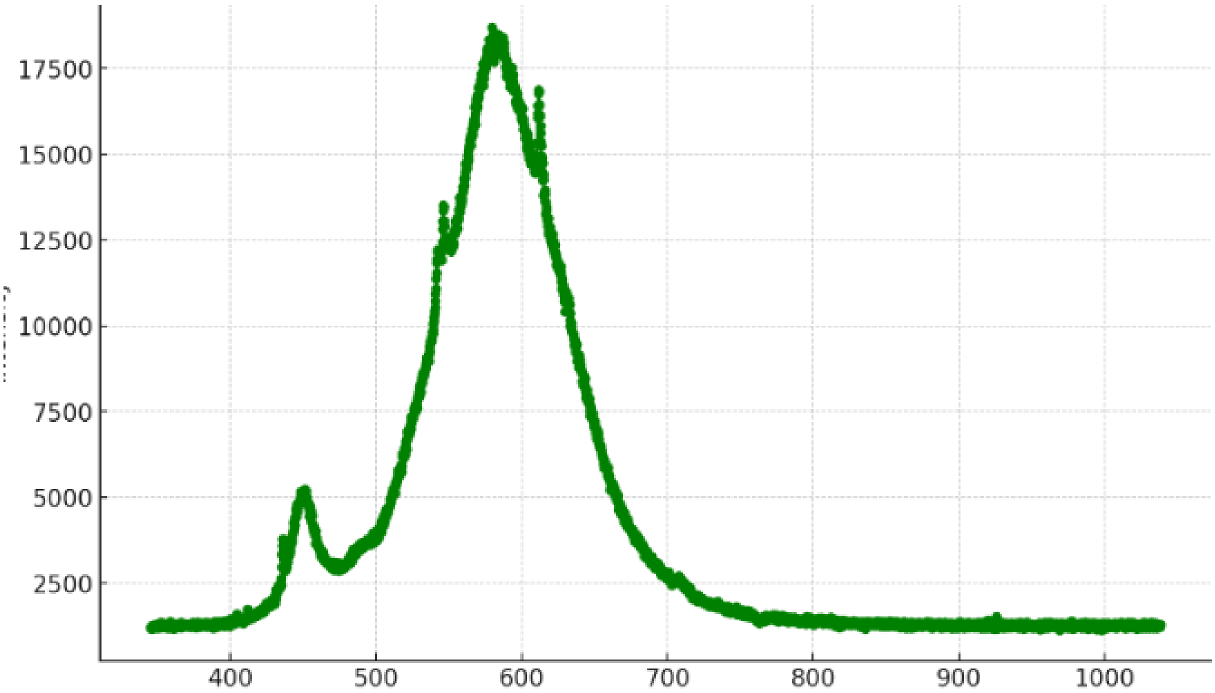
Second Bulb



The central wavelength for this dataset is approximately 718.84 nm, and the Full Width at Half Maximum (FWHM) is about 313.52 nm.

The spectral characteristics of this bulb, with a central wavelength of approximately 718.84 nm and a Full Width at Half Maximum (FWHM) of about 313.52 nm, suggest it could be a Halogen Incandescent Bulb. Halogen bulbs generally produce a cooler, slightly whiter light than traditional tungsten bulbs due to a higher filament temperature, which shifts the peak of their emission towards the visible spectrum while maintaining a broad continuous spectrum. This results in a spectrum that's similar to tungsten incandescent bulbs but with improved efficiency and brightness, as indicated by the shape and intensity distribution of the spectrum.

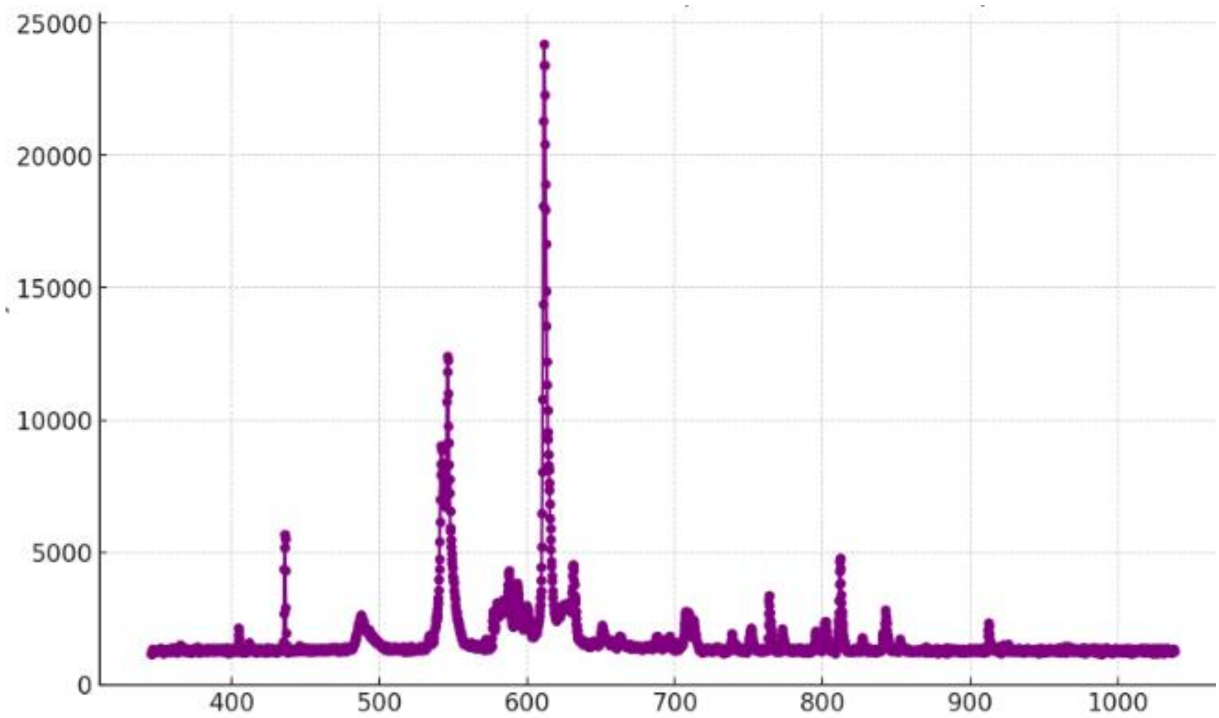
Third Bulb



The central wavelength for this dataset is approximately 579.28 nm, and the Full Width at Half Maximum (FWHM) is about 100.12 nm.

Considering this spectral profile, it suggests that the bulb is an LED. LED bulbs typically show narrow emission peaks due to the use of specific semiconductor materials that emit light at distinct wavelengths. The relatively narrow FWHM indicates a sharp emission peak, which is characteristic of LED bulbs, differing from the broader spectra of incandescent and fluorescent bulbs. Additionally, the central wavelength within the visible spectrum aligns with common LED colors, further supporting this identification.

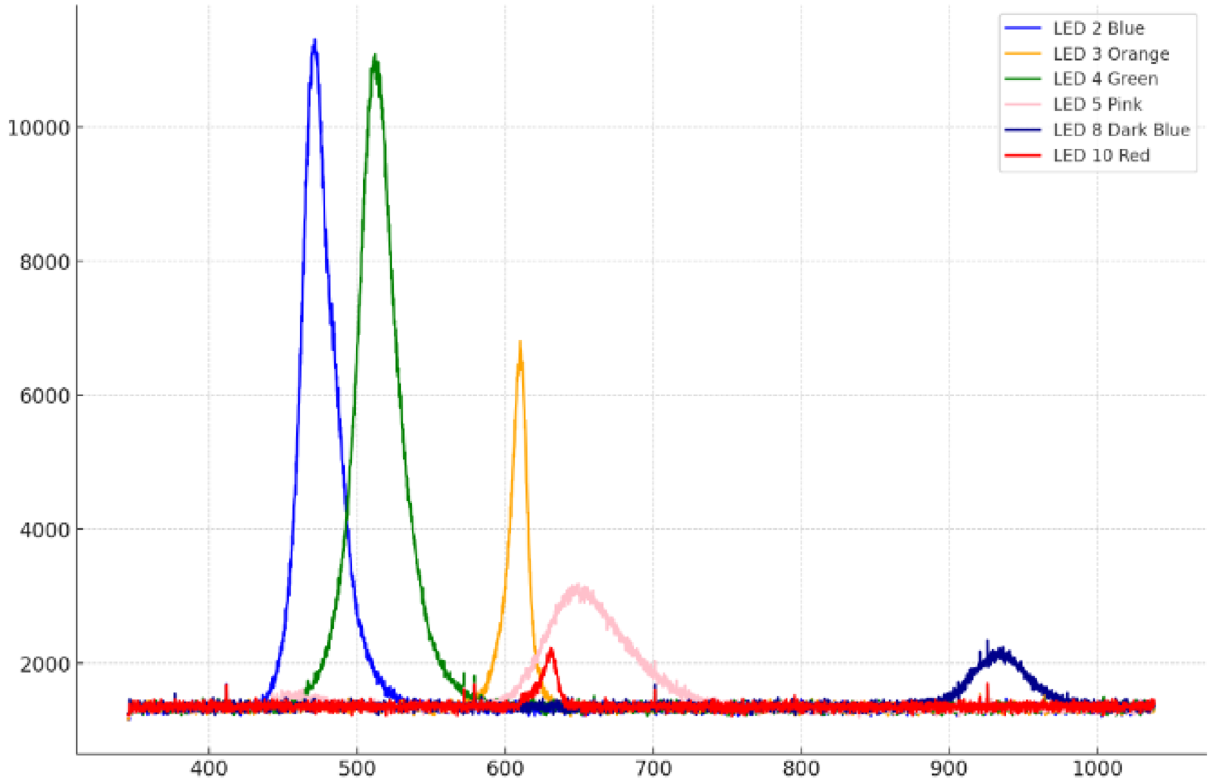
Fourth Bulb



The central wavelength for this dataset is approximately 611.49 nm, and the Full Width at Half Maximum (FWHM) is about 3.0 nm.

These findings indicate the bulb is likely a fluorescent type. Fluorescent bulbs characteristically display sharp emission lines across the spectrum due to the gases and phosphors used inside the bulb. This sharpness and narrow FWHM, along with specific peaks at certain wavelengths rather than a broad spectrum, align well with the emission properties of fluorescent lighting technology.

LED Lights



LED 2 Blue: Central Wavelength = 471.27 nm, FWHM = 27.66 nm

LED 3 Orange: Central Wavelength = 610.09 nm, FWHM = 16.03 nm

LED 4 Green: Central Wavelength = 512.11 nm, FWHM = 33.11 nm

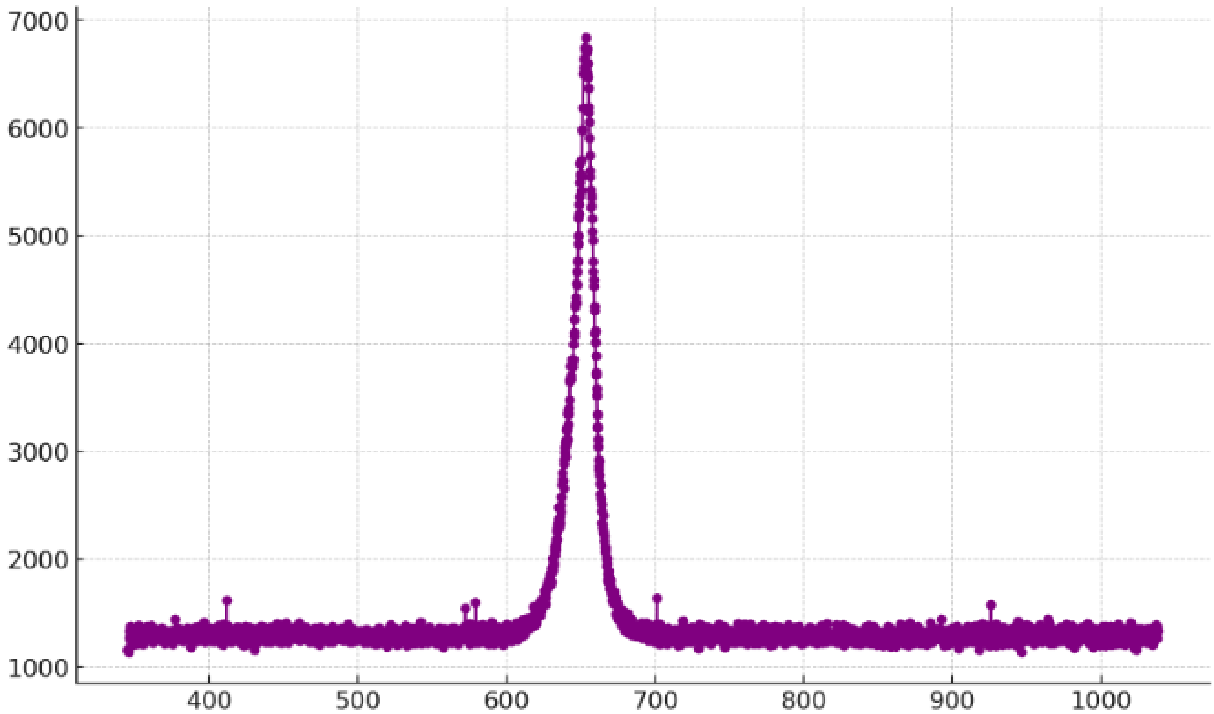
LED 5 Pink: Central Wavelength = 649.44 nm, FWHM = 108.73 nm

LED 8 Dark Blue: Central Wavelength = 925.72 nm, FWHM = 319.71 nm

LED 10 Red: Central Wavelength = 630.63 nm, FWHM = 185.34 nm

The central wavelengths of the LEDs, as calculated, align well with the expected ranges for their respective emitted colors, demonstrating the typical characteristics of LED technology. For instance, LEDs designed to emit blue light often show central wavelengths in the shorter end of the visible spectrum, while those intended for red light appear towards the longer end. This correlation between the designated color and the observed central wavelength highlights the precision with which these devices are manufactured to target specific portions of the spectrum. Moreover, LEDs typically exhibit narrow Full Width at Half Maximum (FWHM) values, indicating a sharp and focused emission peak. This narrow FWHM is crucial for applications that require specific color purity and efficiency, such as in lighting, signal lights, and electronic displays. The narrow emission profile also contributes to the energy efficiency of LEDs, as it ensures that most of the power used is converted into light at the desired wavelength, with minimal spread into other colors. This spectral accuracy and efficiency are key advantages of LED technology over more traditional light sources like incandescent or fluorescent bulbs, which emit broader spectra.

Laser



The central wavelength of the laser data is approximately 653.57 nm, and the Full Width at Half Maximum (FWHM) is about 18.91 nm.

The calculated Full Width at Half Maximum (FWHM) and central wavelength data indicate a relatively narrow emission range, which is characteristic of laser sources. Lasers are engineered to produce light at very specific and narrow wavelengths, achieving high intensities with minimal spectral dispersion. This precise control over wavelength and narrow emission profile is essential for numerous applications that rely on lasers, including optical communications, medical procedures, cutting and machining processes, and scientific research.

The narrow emission not only allows for targeted energy delivery in applications like laser surgery and materials processing but also enhances the efficiency of systems where precise wavelength control is necessary, such as in spectroscopy or holography. Moreover, this property of lasers to emit coherent light with minimal spread in wavelength leads to high beam quality and the ability to focus energy into very small areas, a critical feature in both industrial and research settings.

3) Conclusion

In conclusion, the laboratory exercises provided a comprehensive overview and practical experience with optical fiber communications and the spectral analysis of various light sources. Through the experiments, we observed firsthand the remarkable properties of optical fibers, including their low attenuation rates and high capacity for data transmission, which make them invaluable in modern telecommunication systems. The ability of silica fibers to maintain low loss over considerable distances and under varying conditions was particularly demonstrated in the attenuation tests, which emphasized the importance of meticulous setup and maintenance to optimize performance.

Furthermore, the spectral analysis segment of the lab offered insightful comparisons among different light sources—tungsten incandescent, halogen incandescent, LEDs, and fluorescent lights. By examining their spectral characteristics, we could distinguish between these sources based on the shapes of their emission spectra and parameters such as central wavelength and FWHM. This part of the lab not only reinforced the theoretical principles of light emission and spectrum analysis but also highlighted the practical applications of these concepts in identifying and utilizing different lighting technologies.

Overall, the exercises underscored the synergy between theoretical knowledge and practical application in the field of telecommunications and optical studies. This lab effectively bridged the gap between understanding fundamental optical principles and applying these principles in real-world scenarios, preparing us for further studies and professional work in optical technologies.