

Low Frequency Experimental Characterization of an FSO Channel: an Invitation*

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Abstract

In this note the authors prepare a free space optical channel of 18 cm propagation length and characterize its low frequency behavior.

We prepare an FSO communication system of roughly 18 cm propagation length. We use a red laser and a basic LDR. We characterize the FSO channel by transmitting randomly generated bits using Amplitude Modulation at different frequencies. We capture the gain between reception and transmission. We also capture the correlation between the transmitted waveform and the received waveform. This is done for:

1. Clear FSO
2. FSO with translucent ruler
3. FSO with translucent taped ruler
4. FSO with newspaper clipping

1 Results: Channel Characterization

1.1 Clear FSO

1.2 FSO with translucent ruler

1.3 FSO with translucent taped ruler

1.4 FSO with newspaper

The results are shown in Figures 1 through 4. The upper subplot shows correlation vs frequency and the lower subplot shows gain vs frequency.

*This document is also available in Hindi upon request to the corresponding author.

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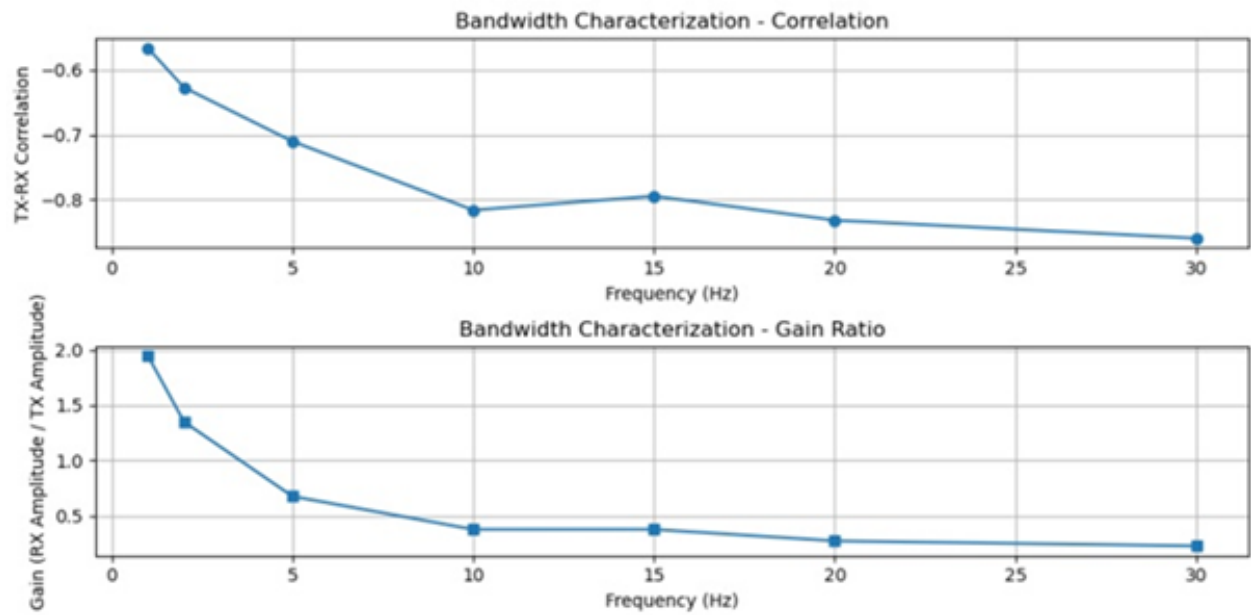


Figure 1: Clear FSO

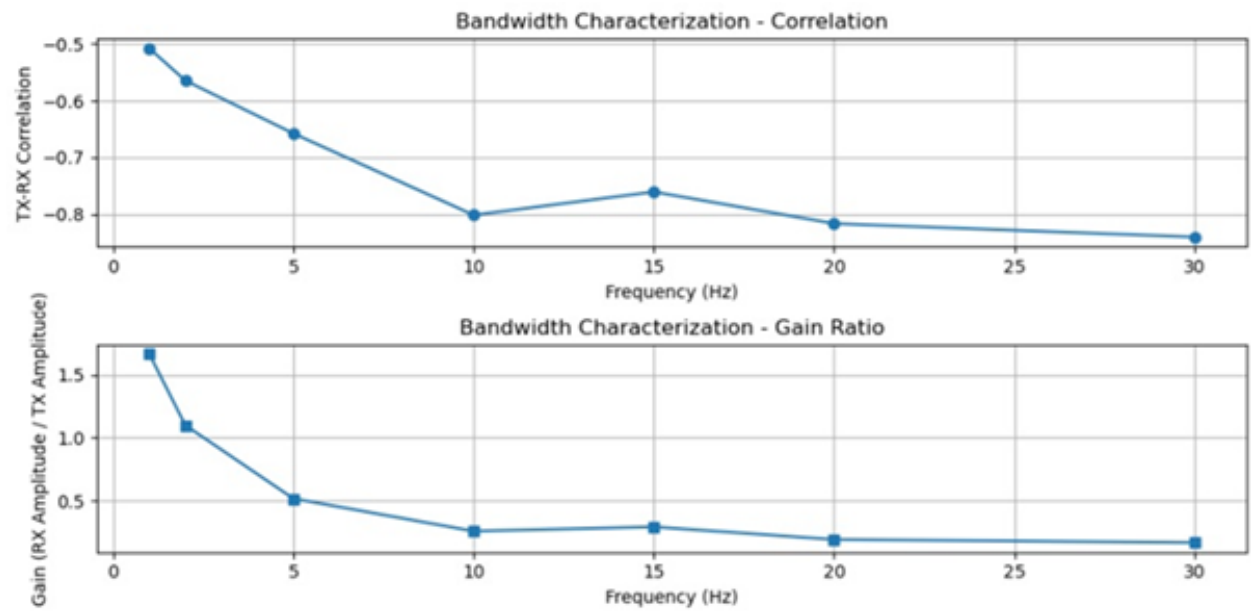


Figure 2: Translucent ruler

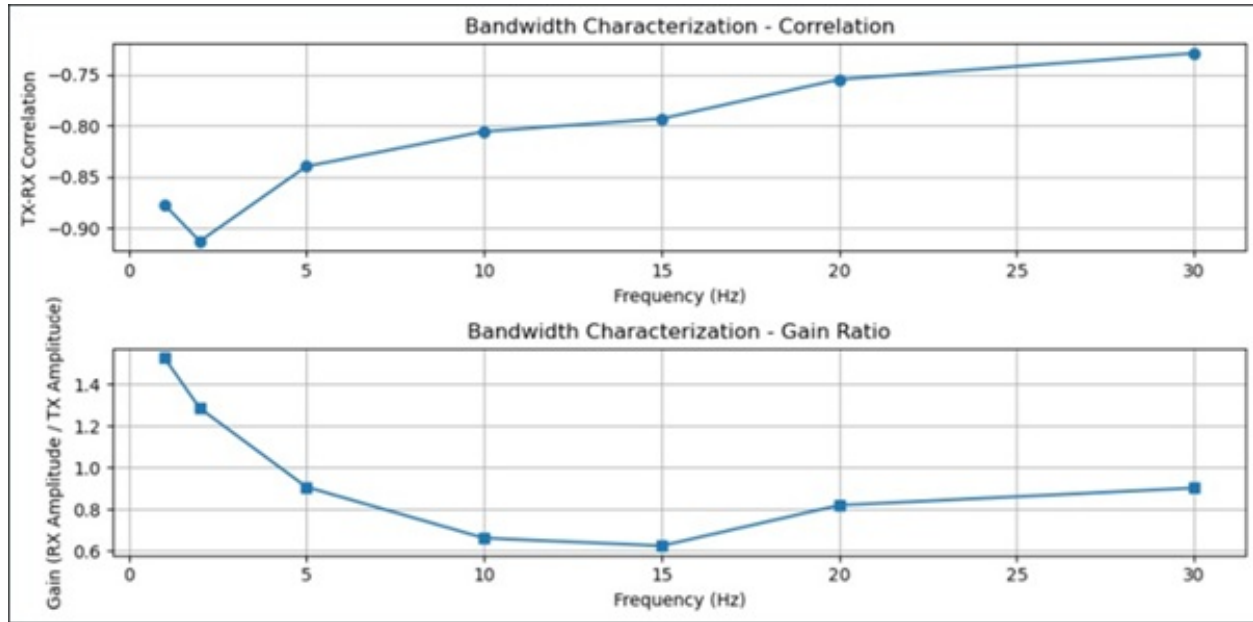


Figure 3: Translucent taped ruler

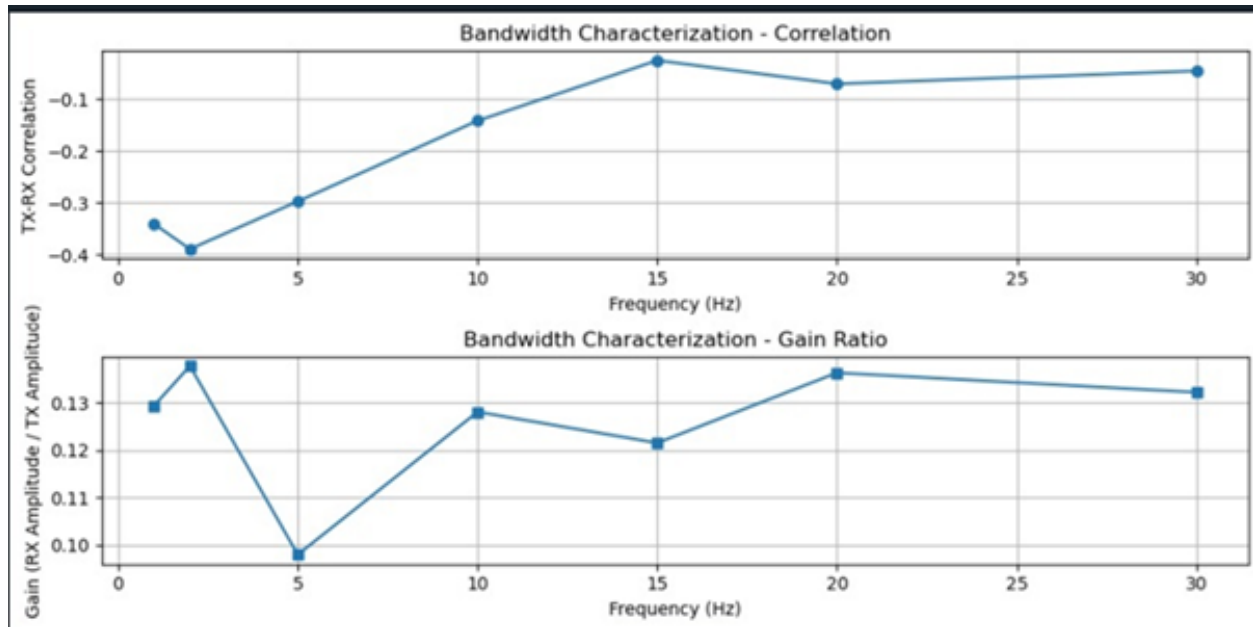


Figure 4: FSO with newspaper

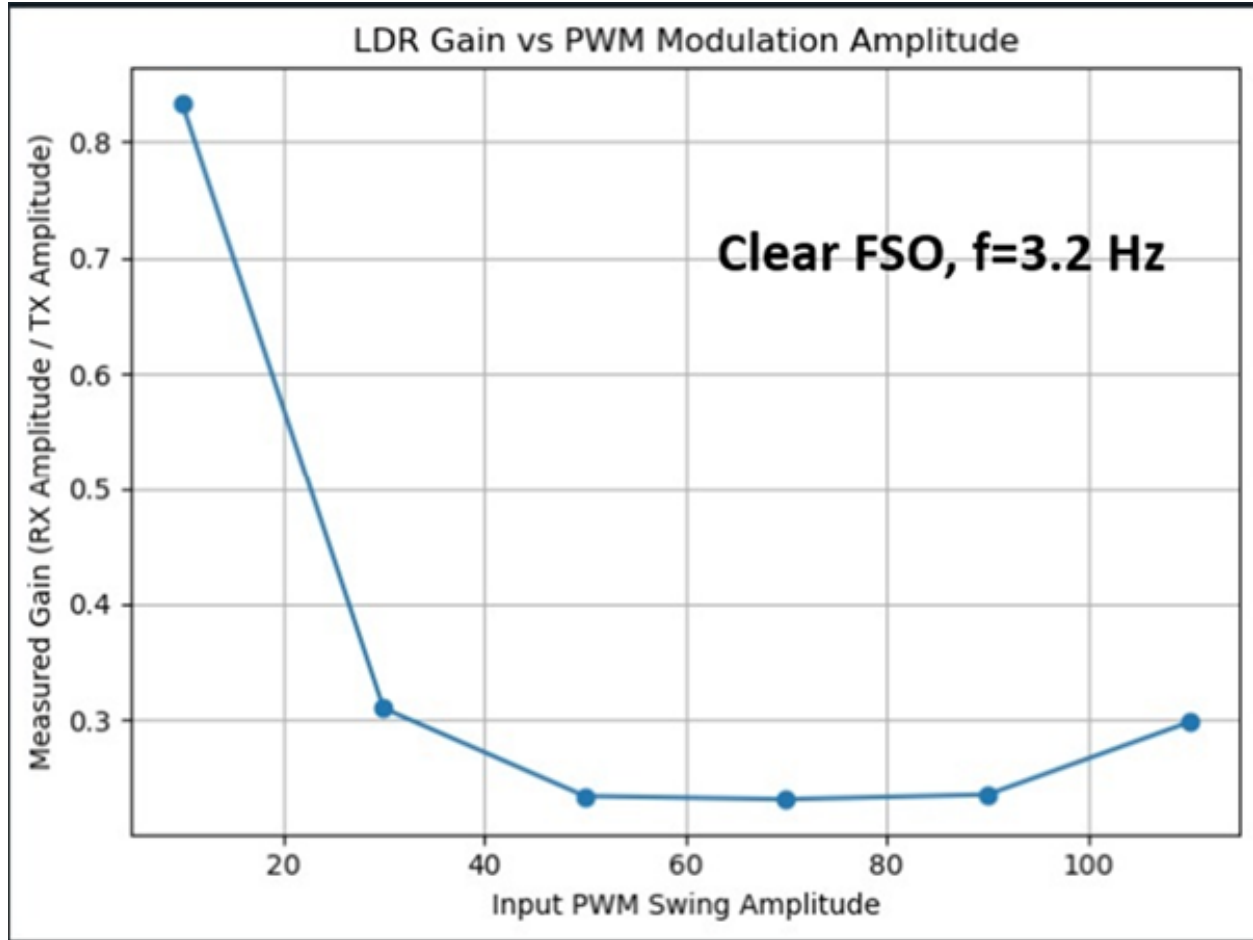


Figure 5: Clear FSO

2 Results: LDR Characterization

2.1 Clear FSO

Observing that the clear FSO has unity gain at 3.2 Hz, we transmit at this frequency, various amplitudes and record the received amplitudes. This helps us determine the LDR characteristics. Please see Figure 5.

2.2 FSO with Translucent Ruler

In this case, unity gain is at 2.4 Hz approximately. The shape of the response is roughly preserved. Please see Figure 6.

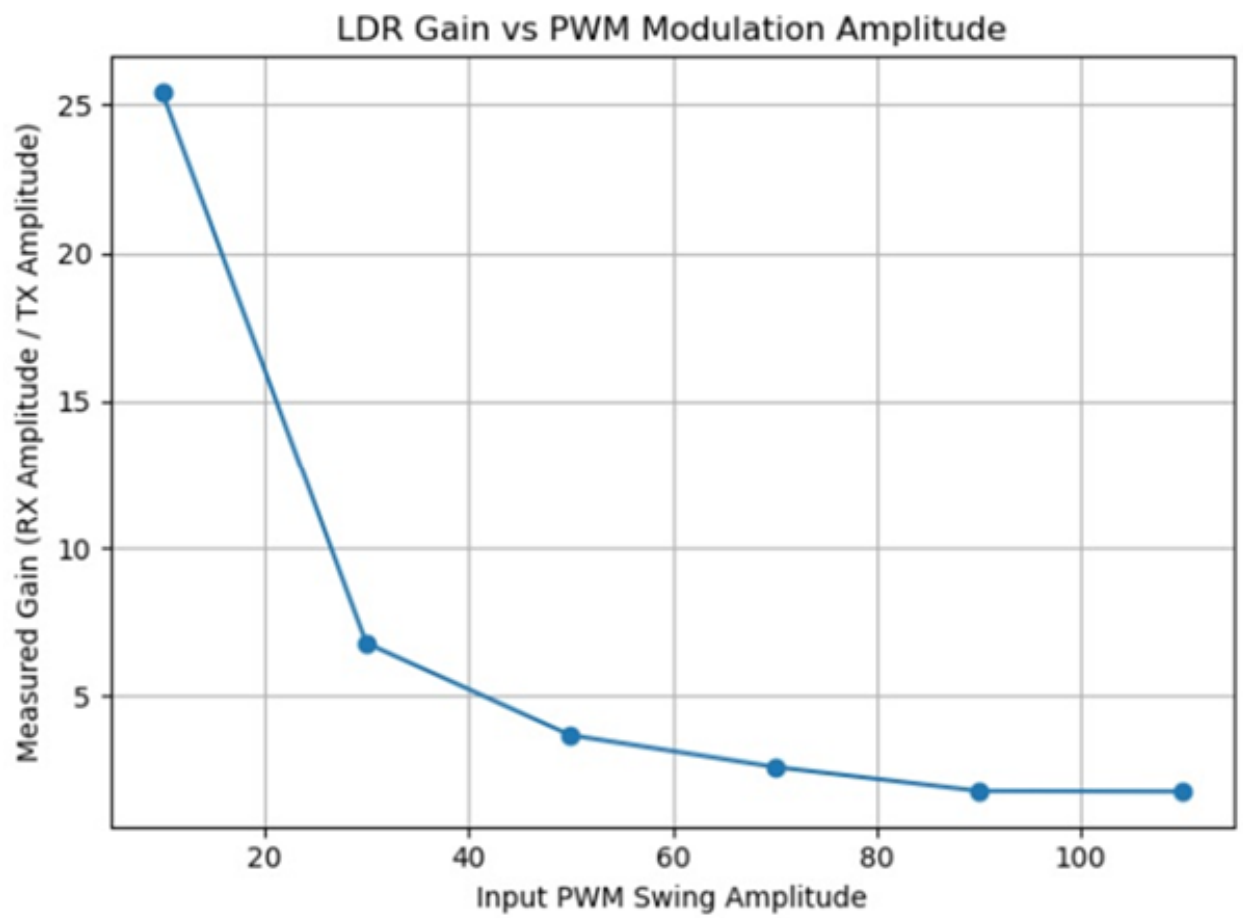


Figure 6: Translucent ruler

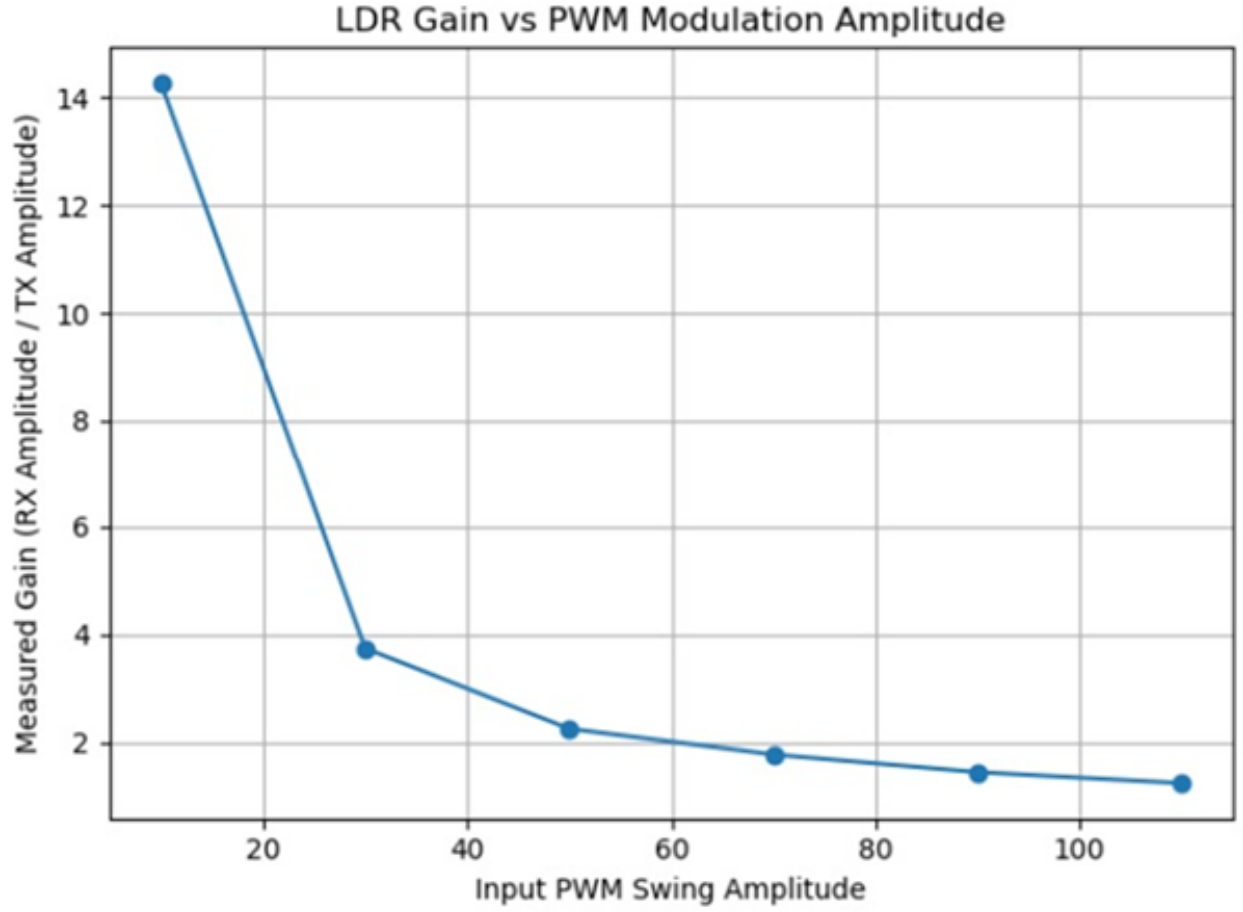


Figure 7: Translucent taped ruler

2.3 FSO with Translucent Taped Ruler

Unity gain is at 4 Hz. Please see Figure 7.

2.4 FSO with Newspaper

This case doesn't have a unity gain point. Thus it is not used to verify LDR response features.

3 Results: PDF Characterization

Assuming there is no fading coefficient (which should be relaxed), we move to characterize the noise pdf. We transmit a fixed value and study the values

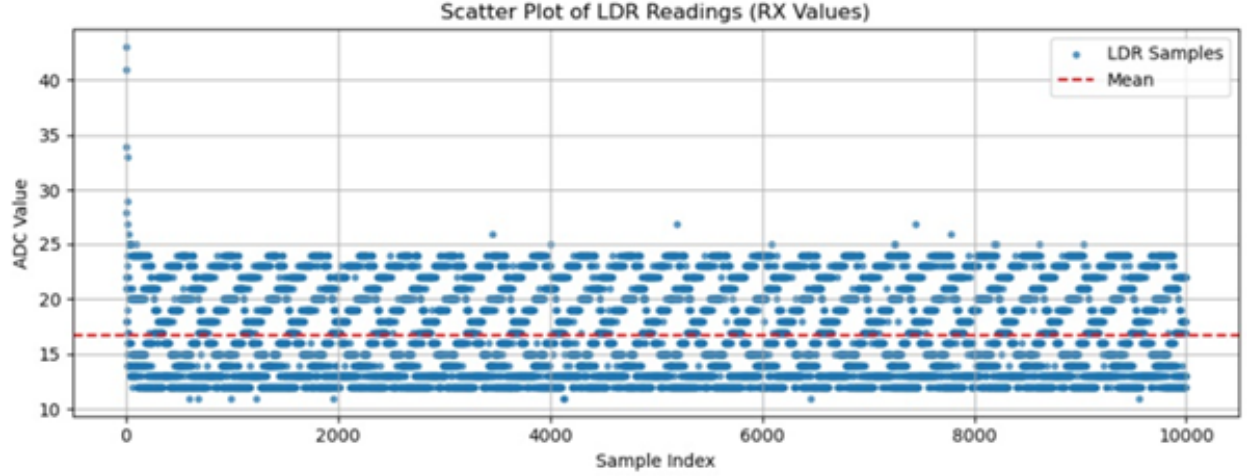


Figure 8: PDF characterization

obtained, and draw their histogram. Please see Figure 8.

4 Outlook

4.1 Avenues to Collaborate with Industry

FSO channel research is actively pursued at Intel Labs India, a leading global R&D firm. The following excerpt, provided by an LLM, summarizes their work: Intel Labs India is actively researching and developing integrated photonics, including free-space optical communication (FSOC) technologies, for high-speed data transmission in data centers and beyond, focusing on optical I/O chiplets and interconnects [1, 2, 3]. Their key areas of research are [1, 3]:

- **Optical Compute Interconnect (OCI) Chiplet:** Intel has developed an OCI chiplet, a fully integrated optical I/O solution, to enable high-speed data transmission and address the growing demands of AI infrastructure [1, 3].
- **Integrated Photonics for Data Center Interconnects:** Intel Labs has a research center dedicated to accelerating optical I/O technology innovation, focusing on photonics technology and devices, CMOS circuits, link architecture, package integration, and fiber coupling [2].
- **300 mm Hybrid Silicon Photonics Platform:** Intel is using a 300 mm hybrid silicon photonics platform to manufacture production optical transceivers in volume [1].
- **Focus on High-Speed, Low-Latency Communication:** Intel's research aims to increase communication bandwidth between compute silicon in data cen-

ters and across networks, addressing the need for high-speed, low-latency data transmission [1, 4].

- **Hybrid FSO/RF Solutions:** Intel explores the integration of FSO with radio frequency, millimeter-wave, and Terahertz technologies to enhance reliability and coverage, offering hybrid solutions that can overcome the challenges of FSO links [4].
- **Addressing Challenges of FSO:** Intel’s research acknowledges the challenges of FSO, such as atmospheric turbulence, weather-induced signal degradation, and alignment issues, and explores mitigation strategies like adaptive optics, modulation schemes, and error correction codes [4].

4.2 Future work

Apart from higher frequency characterization, which requires a different experimental setup, we will also modify the light’s wavelength. It is hoped that more enthusiasts and researchers in India will take to FSO research given the low cost nature of our experimental demonstration.

5 References

- [1] <https://www.intc.com/news-events/press-releases/detail/1555/intel-labs-announces-integrated-photonics-research>
- [2] <https://www.intel.com/content/www/us/en/research/integrated-photonics.html>
- [3] <https://newsroom.intel.com/artificial-intelligence/intel-unveils-first-integrated-optical-io-chiplet>
- [4] <https://www.mdpi.com/1424-8220/24/24/8036>