



## Introduction

- Optical communication systems are essential in modern telecommunications due to their high bandwidth, low attenuation, and immunity to electromagnetic interference.
- This project analyzes a simplified optical communication link based on intensity modulation and direct detection (IM-DD), including an LED source, optical fiber, and photodiode receiver.
- The objective is to understand how optical losses, nonlinearity, and bandwidth limitations affect signal transmission.
- This work combines numerical simulation with a designed experimental implementation, which will be carried out to validate the system behavior.

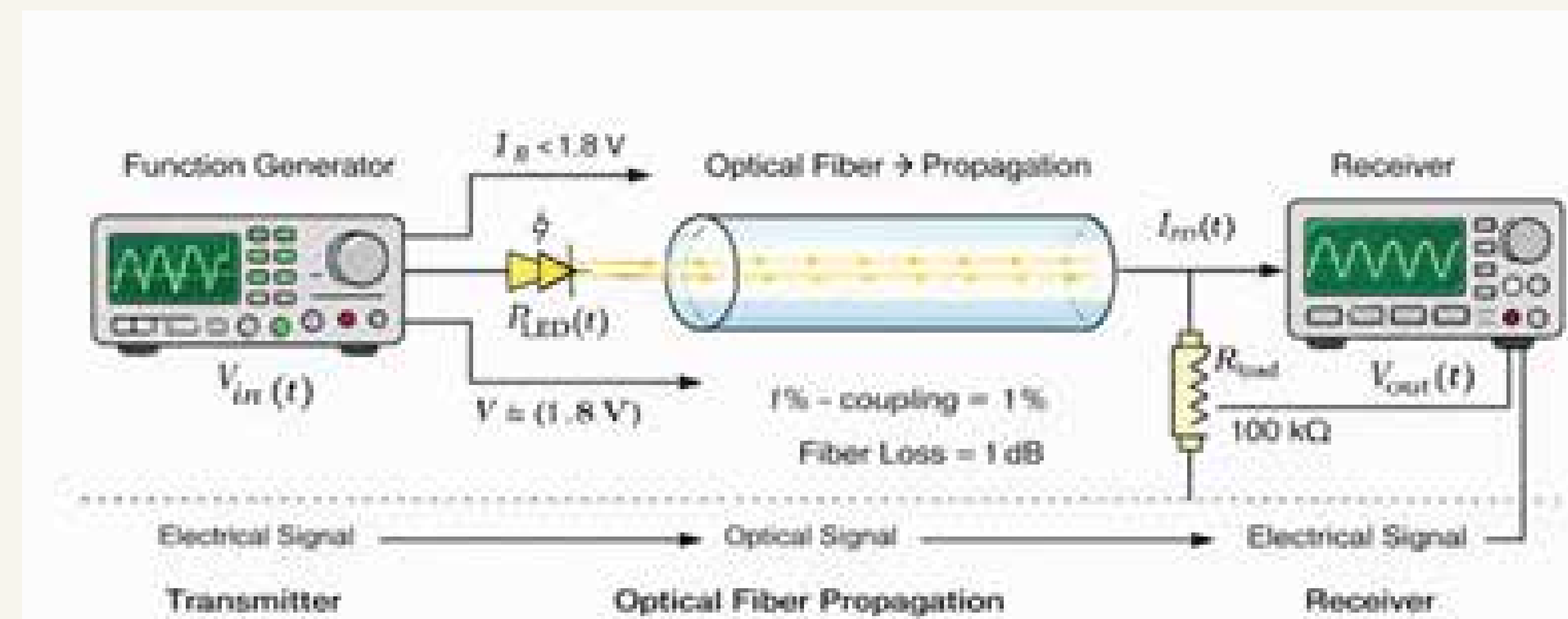
## Methodology

- The system was modeled in MATLAB to simulate an optical communication link including an LED source, optical fiber, and photodiode detector.
- The model incorporates realistic parameters such as coupling efficiency (1%), fiber attenuation (1 dB), LED threshold voltage (1.8 V), and photodiode responsivity (0.4 A/W).
- A sinusoidal input signal with DC offset was used to ensure proper LED operation.
- The simulation serves as a basis for a planned physical implementation of the system to validate the obtained results.

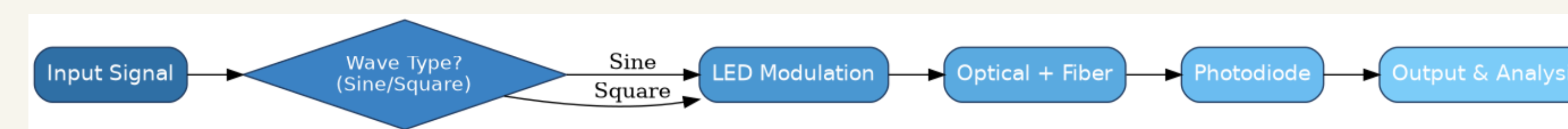
## System Parameters

- LED threshold voltage: 1.8 V
- Coupling efficiency: 1%
- Fiber attenuation: 1 dB
- Photodiode responsivity: 0.4 A/W
- Load resistance: 100 k $\Omega$
- LED bandwidth: 200 kHz.

## System Overview



Schematic of the optical communication link including LED source, optical fiber propagation, and photodiode detection.



Flowchart of the system simulation.

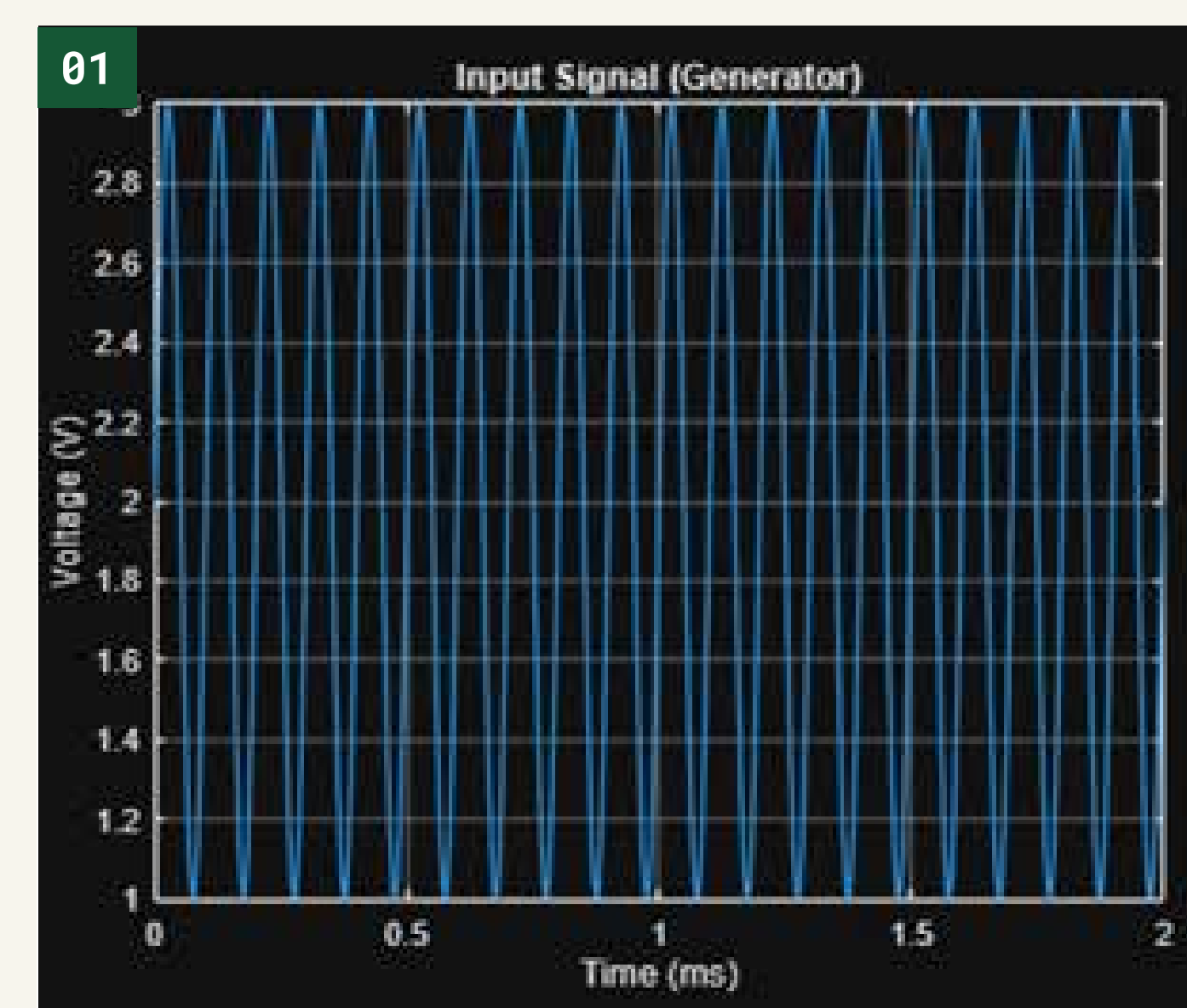
## Results

- Simulation results show significant signal attenuation due to low coupling efficiency and fiber losses.
- The received optical power is reduced to the microwatt range, producing output voltages in the order of millivolts.
- The system preserves the general shape of the transmitted signal but introduces nonlinear distortion due to the LED threshold voltage. Additionally, the system behaves as a first-order low-pass filter with a bandwidth of approximately 200 kHz, indicating that the LED is the dominant limiting component.

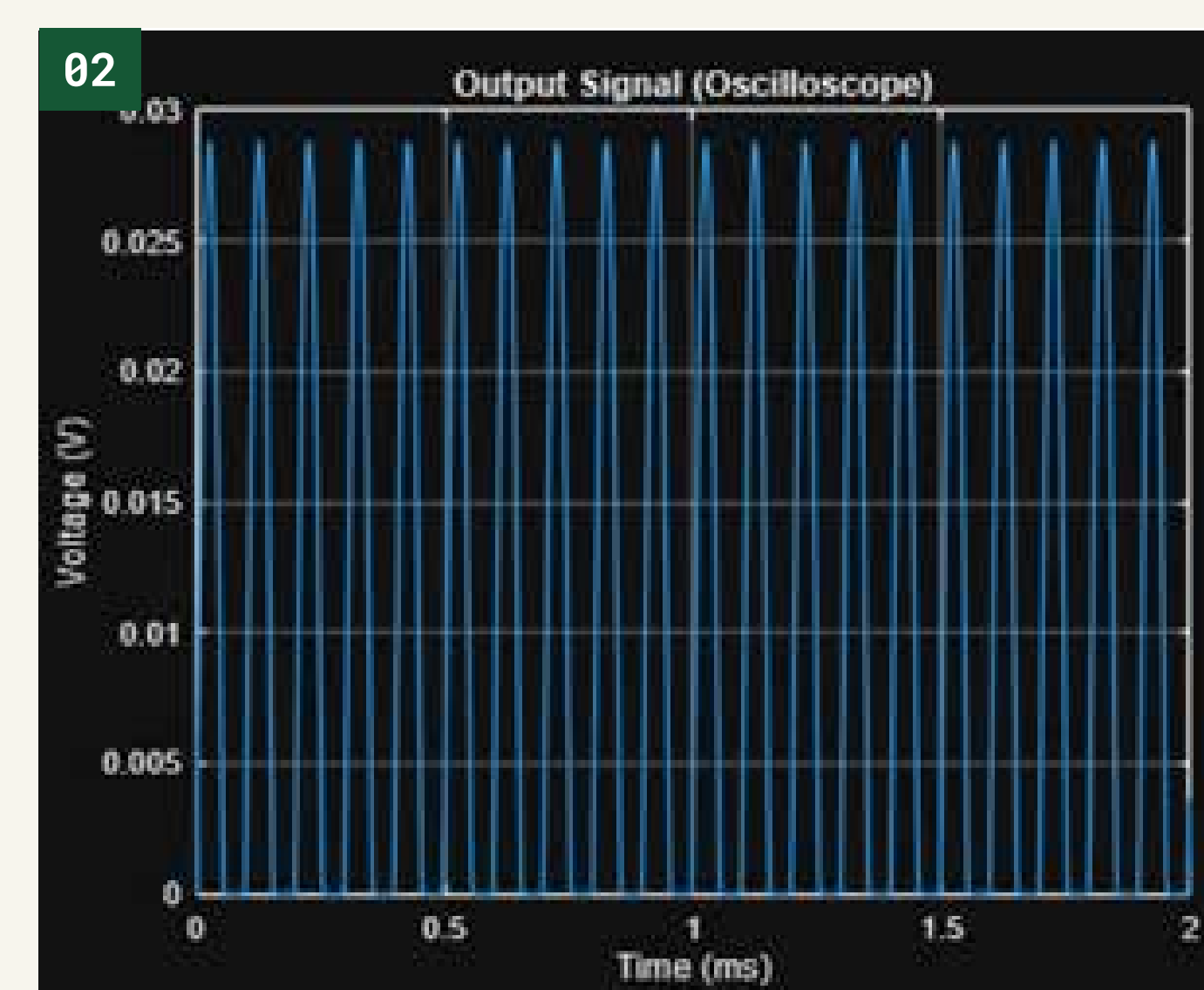
## Conclusions

- The simulation demonstrates that optical communication links are strongly influenced by attenuation, nonlinearity, and bandwidth limitations.
- The system behaves as a low-pass filter, with the LED as the main bandwidth-limiting element.
- Despite its simplicity, the model accurately represents real optical communication behavior and highlights key engineering trade-offs between performance and system design.
- Future work will focus on experimental implementation to validate the simulated results and analyze real-world deviations.

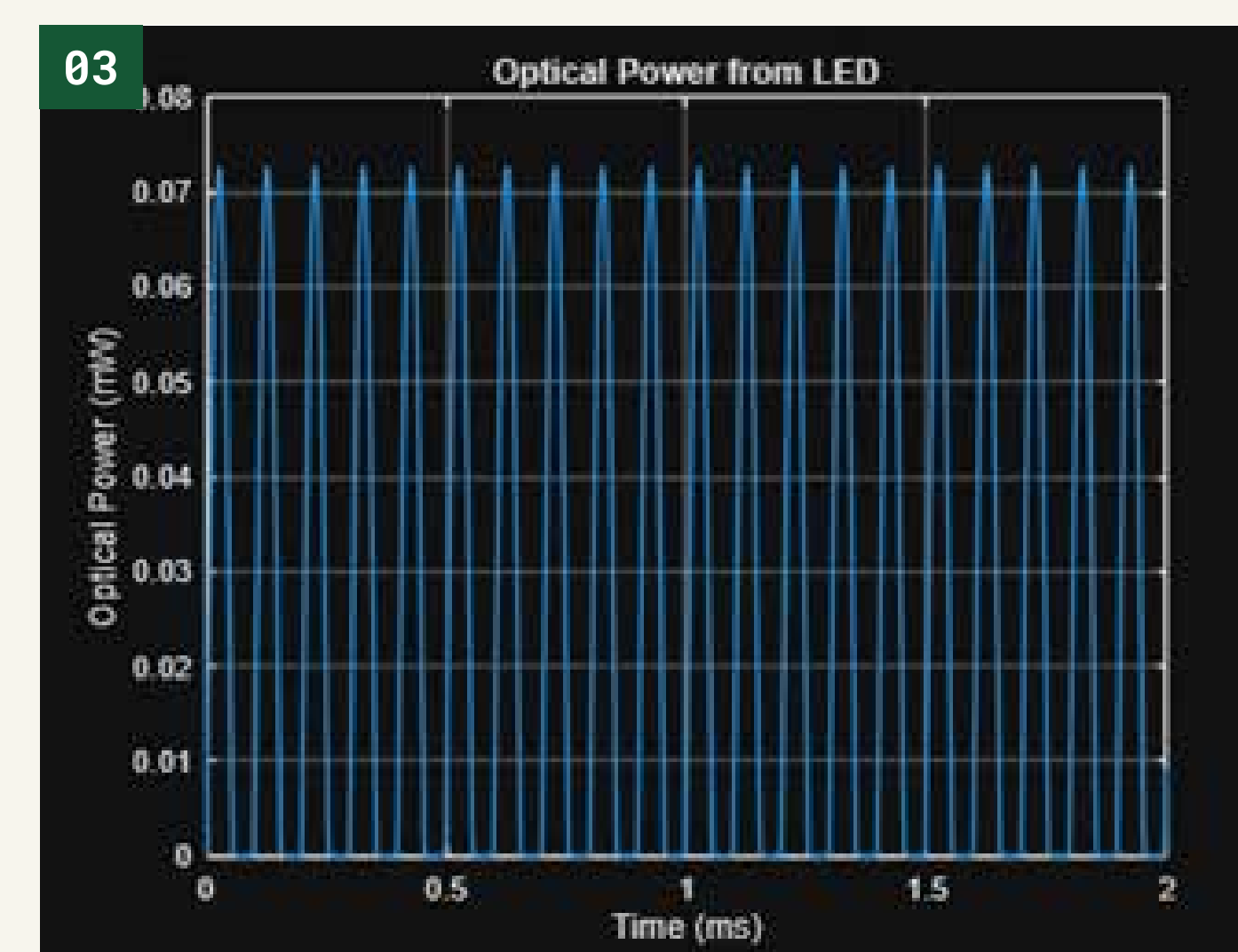
## Time Domain Analysis



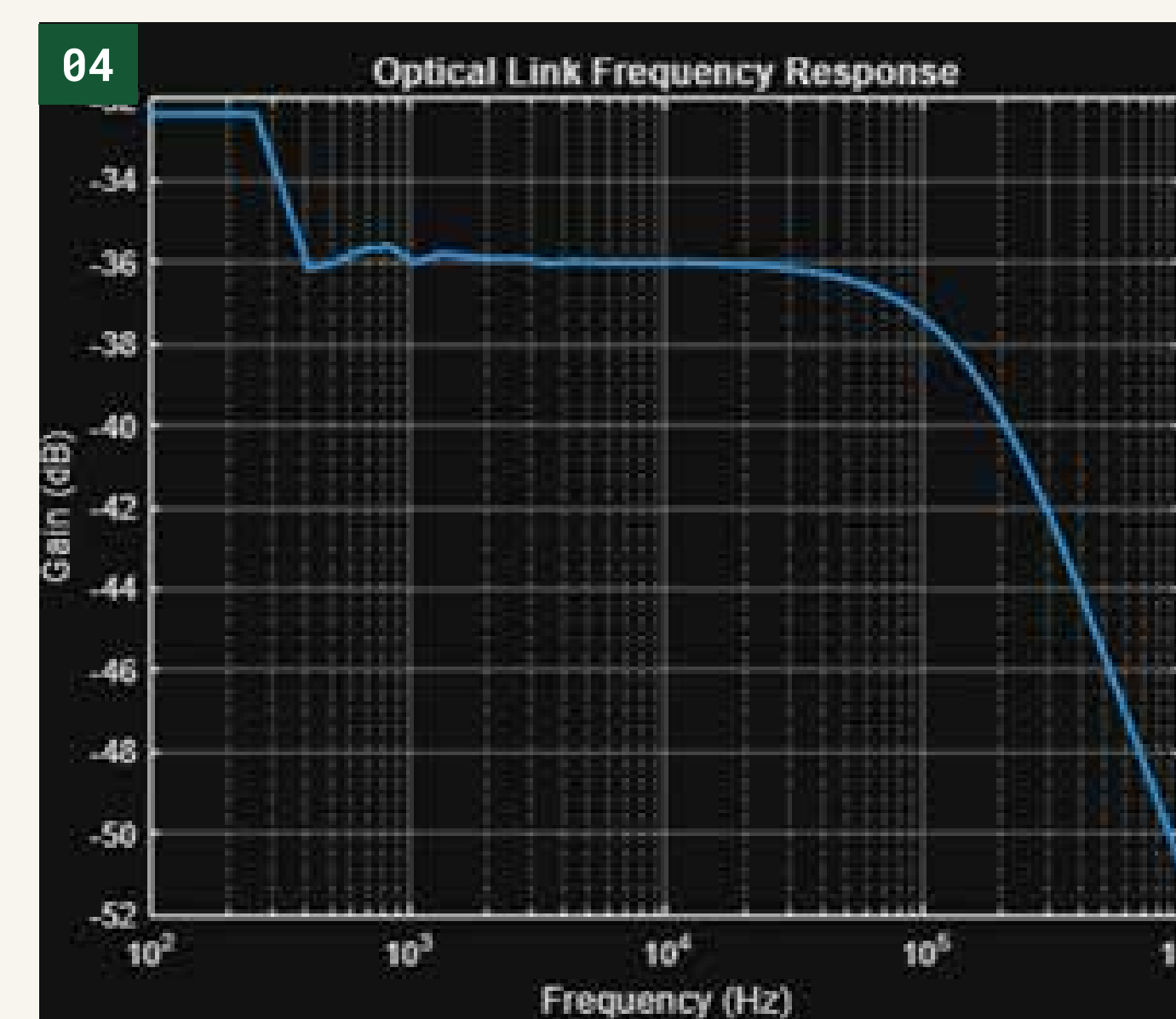
Output electrical signal after optical transmission and detection, showing significant attenuation and preservation of waveform shape.



Output electrical signal after optical transmission and photodetection, showing significant attenuation and preservation of the signal waveform.



Optical power emitted by the LED as a function of time, showing nonlinear behavior due to the threshold voltage and intensity modulation of the input signal.



Frequency response of the optical link showing low-pass behavior with a bandwidth limitation of approximately 200 kHz.

## References

- [1] G. P. Agrawal, Fiber-Optic Communication Systems, 2010.
- [2] J. M. Senior, Optical Fiber Communications, 2009.
- [3] B. E. A. Saleh, Fundamentals of Photonics, 2007.
- [4] G. Keiser, Optical Fiber Communications, 2013.

## Acknowledgments

- [1] This work was conducted under the supervision of Prof. Edward Song at the University of New Hampshire.
- [2] Special thanks to Yago Martinez for his help with the poster design.