Optical Communication Experiment 1

Bandwidth measurement of an optical fiber link

1. OBJECTIVES

- ☑ To determine the bandwidth of an optical fiber link through frequency response measurement
- ☑ To determine the bandwidth of an optical fiber link through system rise-time measurement

2. MATERIALS NEEDED

- ☑ Variable DC Power Supply
- ☑ Optical fiber system kit
- ☑ Oscilloscope
- ☑ Function generator
- ☑ Semi-log scale graph paper

3. INTRODUCTION

A complete optical fiber system may be assembled using three components: optical source, optical detector and an optical fiber. In order to ensure that the assembled system meets the desired system performance, both the power budget and rise-time budget must be satisfied.

The power budget is to ensure that there is sufficient power available throughout the link to meet application demands. The rise-time budget is to ensure that the link operate fast enough to meet the bandwidth requirements of the application.

The system bandwidth is determined by the rise-time of the light source, detector and the optical fiber.

The system rise-time t_r is related to the system bandwidth as follows: $\tau_r = 0.35 / BW$

In this experiment, you will determine the bandwidth of an optical fiber link by measuring the system frequency response & rise-time.

4. PROCEDURES & RESULTS

Part 1: Frequency Response Measurement

1. The optical fiber system kit provides a printed circuit board with a piece of Plastic Fiber as the optical link between the optical transmitter and receiver.

2. Connect the Function Generator to the optical transmitter Input. Set the Function Generator to Sinewave, amplitude of 35 mV.

3. Connect the optical receiver Output to Channel 1 of the oscilloscope.

4. Switch on the DC power supply and set the supply voltage to 9V. Connect it to the optical fiber system kit power DC supply points.

5. Set the frequency of the Function Generator to 1.0 KHz. Press MEASURE and observe the output signal Vpp value on the oscilloscope Channel 1 as you slowly increase the frequency of the sinewave from 1 to 100 kHz, until you observe the output sinewave has reaches a maximum value and is undistorted.

6. Now slowly adjust the maximum signal amplitude by turning the Variable Resistor Knob (on the optical fiber system kit) such that Channel 1 is showing an undistorted sine wave with maximum signal level exactly at 6.0 Vpp.

7. **Now maintain the setting on the input signal amplitude and use this level throughout the whole experiment**.

There are TWO methods which can be used to estimate the bandwidth of the optical link.

METHOD 1

8. Vary the input signal frequency on the function generator from 100 Hz to 100 KHz. **Channel 1 should display undistorted sinewave output signal throughout the measurements.** Complete the following table:

Input Signal Frequency (Hz)	**Output Signal Level (Volt pp)**	**Input Signal Frequency (Hz)**	**Output Signal Level (Volt pp)**
100		4,000	
200		5,000	
300		10,000	
400		15,000	
500		16,000	
700		18,000	
800		20,000	
900		30,000	
1,000		50,000	
2,000		75,000	
3,000		100,000	

10. Plot the output signal level (in linear vertical scale) vs input frequency (in horizontal log scale) on a semi-log scale graph paper.

11. From the graph determine the bandwidth of the optical link using the 3 dB voltage point which is 0.707 of the maximum output signal level. Record the results.

Voltage at 3dB point $V_{3dB} = 0.707 x V_{max}$	
Frequency $F_{(low)}$	
Frequency $F_{(high)}$	
Bandwidth, BW $= F_{(high)} - F_{(low)}$	

METHOD 2

12. Increase the frequency of the sine wave from 1.0 KHz until the output voltage level of undistorted sine wave reached the **maximum (6.0 Vpp).** Record the frequency at V_{max}.

13. Continue to increase the frequency at the Function Generator until the output signal voltage Vpp is equal to the voltage at the 3dB point i.e. Vpp = V_{3dB} . Record the frequency value as $F_{(high)}$.

14. Now DECREASE the frequency at the Function Generator until the output sinewave signal reaches V_{3dB} value again. Record the frequency as $F_{(low)}$.

Frequency at V_{max}	
Frequency $F_{(low)}$	
Frequency $F_{(high)}$	
Bandwidth, BW $= F_{(high)} - F_{(low)}$	

Part 2 : Rise-Time Measurement

1. Use the same setup in Part 1. Change the Function Generator to “Square-wave” and set the frequency to 9 KHz.

2. Observe the output waveform on Channel 1. Measure the system rise-time on the oscilloscope. (Note: rise-time is defined as the time it takes for the output voltage to go from 10% to 90% of its maximum value).

System rise-time τ_r	
Bandwidth BW = $0.35 / \tau_r$	

5. DISCUSSION

1. From the graph, observe the frequency response at input signal operating frequencies below 50Hz and above 50 KHz. What is the characteristics of the optical fiber link?

2. Compare the system bandwidth measured using method 1 and method 2. Comment on the results.

3. Does the system bandwidth calculated from the rise-time measurement agree with the system bandwidth using the frequency response measurement? Explain why.

4. List down the 3 optical components used in the optical fiber link.

5. Suggest 4 ways to improve on the system bandwidth of the optical link.

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