

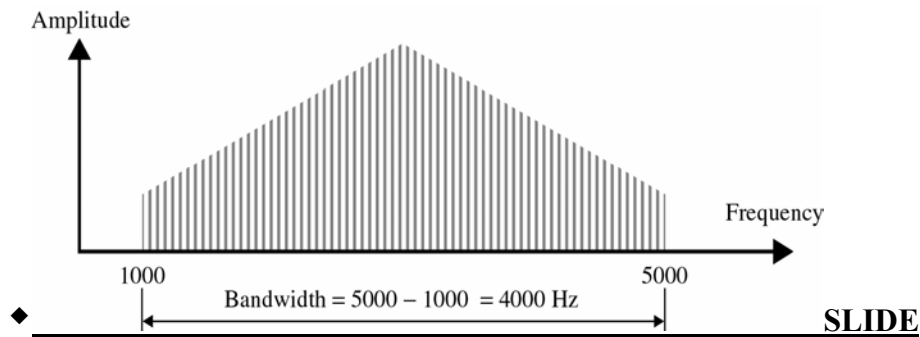
LECTURE #13

Frequency Spectrum / Bandwidth

- **Frequency Spectrum:** of a signal is the collection of all the component frequencies it contains
- It is shown using a Frequency domain graph
- **Bandwidth:** of a signal is the width of the frequency spectrum
- In other words ,Bandwidth refers to the range of the component frequencies and Frequency Spectrum refers to the elements within that range

How to calculate Bandwidth?

- To calculate Bandwidth, subtract the lowest frequency from the highest frequency

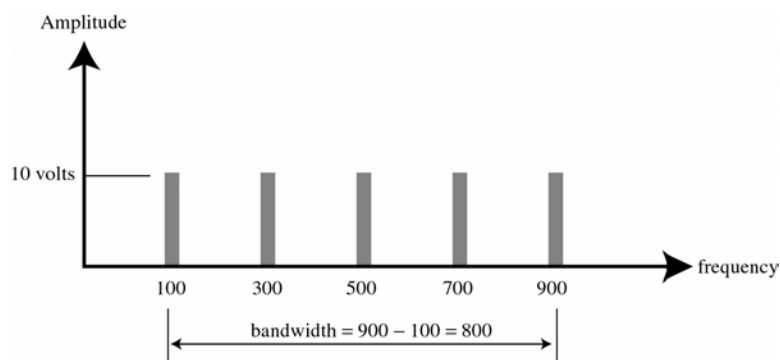


Example 4.8

If a periodic signal is decomposed into five sine waves with frequencies 100, 300, 500, 700, and 900 Hz, what is the Bandwidth?

Solution

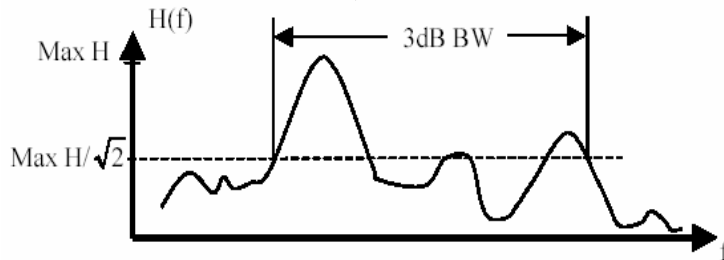
$$B = f_h - f_l = 900 - 100 = 800 \text{ Hz}$$



❖ Other Definitions of Bandwidth

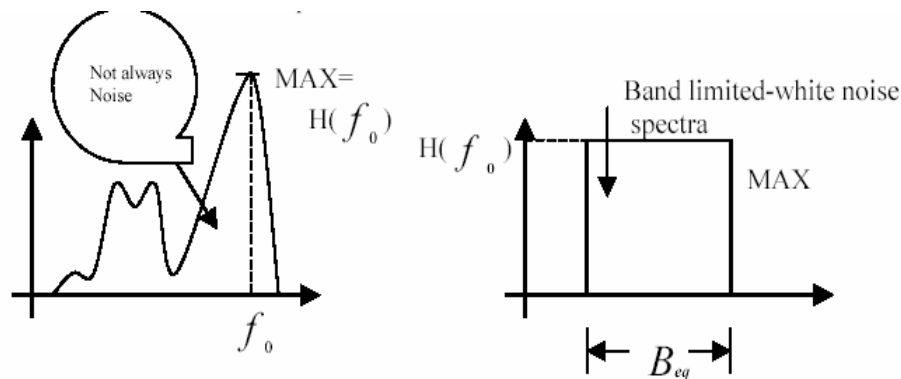
➤ 3 dB Bandwidth or Half Power Bandwidth

For the magnitude spectra of $|H(f)|$, the range of the spectrum that does not fall lower than $\frac{1}{\sqrt{2}}$ times the max. $|H(f)|$



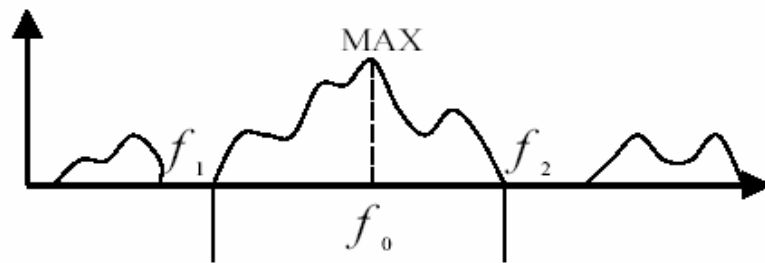
➤ Equivalent Noise Bandwidth

The width of a fictitious rectangular spectrum created to have the same power in the rectangular band as the power of the signal in positive frequencies



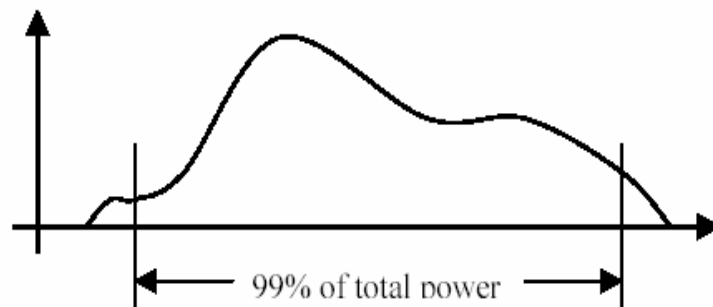
➤ Null-to-Null Bandwidth or Zero Crossing Bandwidth

If the maximum frequency in a spectrum is f_o , the first null above and below f_o will be f_1 and f_2 , where $|f_1 - f_2|$ is the Null-to-Null Bandwidth



➤ **Power Bandwidth**

Frequency Band in which 99% of the total power resides



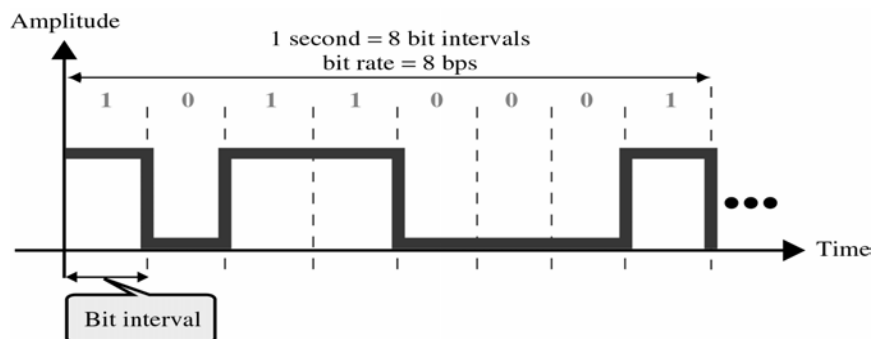
❖ **Digital Signals**

In addition to being represented by Analog Signals, data can also be represented by a Digital signal

❖ **Bit Interval and Bit Rate**

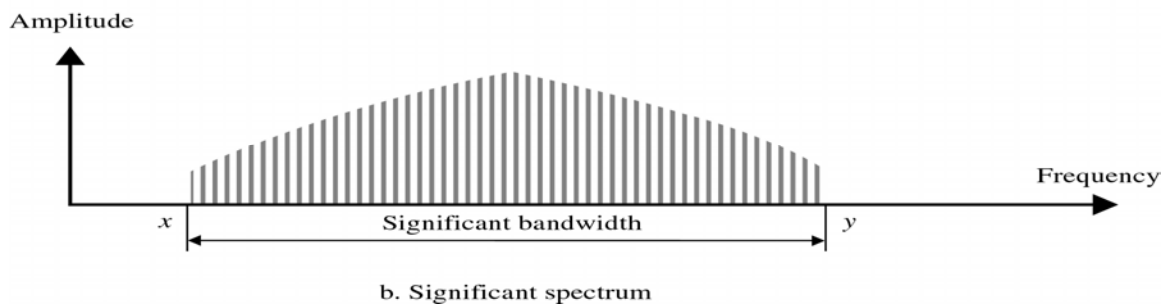
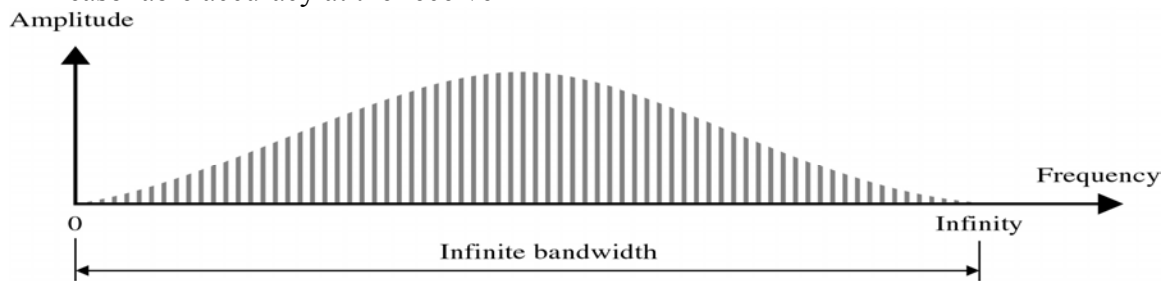
Most digital signals are aperiodic and thus Period and Frequency are not the appropriate terms to describe them

- Bit Interval (seconds)
 - ✓ Time required to send one single bit
- Bit Rate (bps)
 - ✓ Number of bits sent per second



Frequency Spectrum of a Digital Signal

- Frequency spectrum of a digital signal contains an infinite number of frequencies with different amplitudes
- Ideally we want to send all the components but if we send only those components whose amplitudes are significant, we can still recreate the digital signal with reasonable accuracy at the receiver



Summary

- ◆ Frequency Spectrum and Bandwidth
- ◆ Other Definitions of Bandwidth
- ◆ Digital Signals

Reading Sections

- ◆ Section 4.4, 4.5, 4.6 “Data Communications and Networking” 2nd Edition by Behrouz A. Forouzan