

CSE-3215

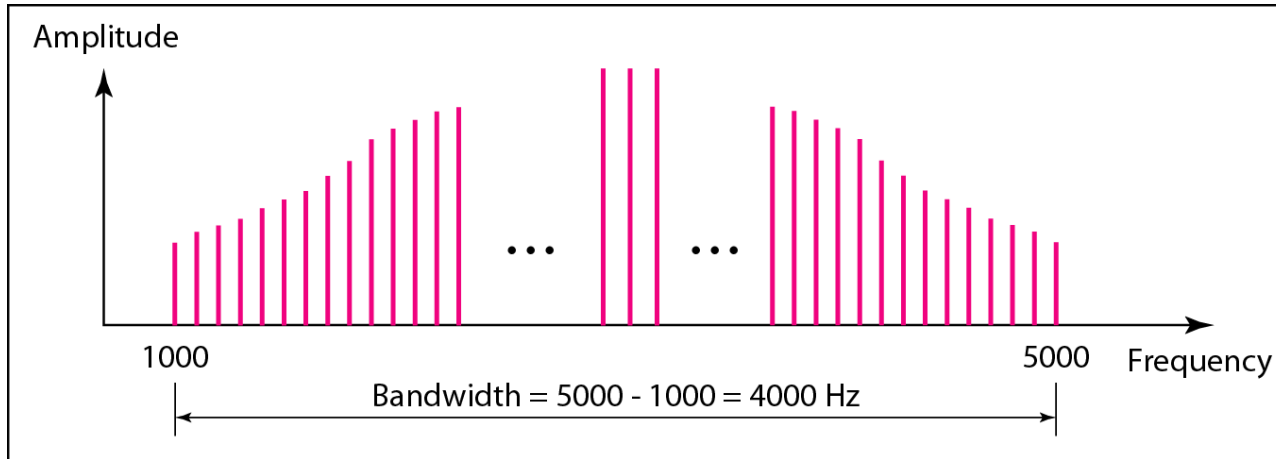
Data Communication

Lecture-11

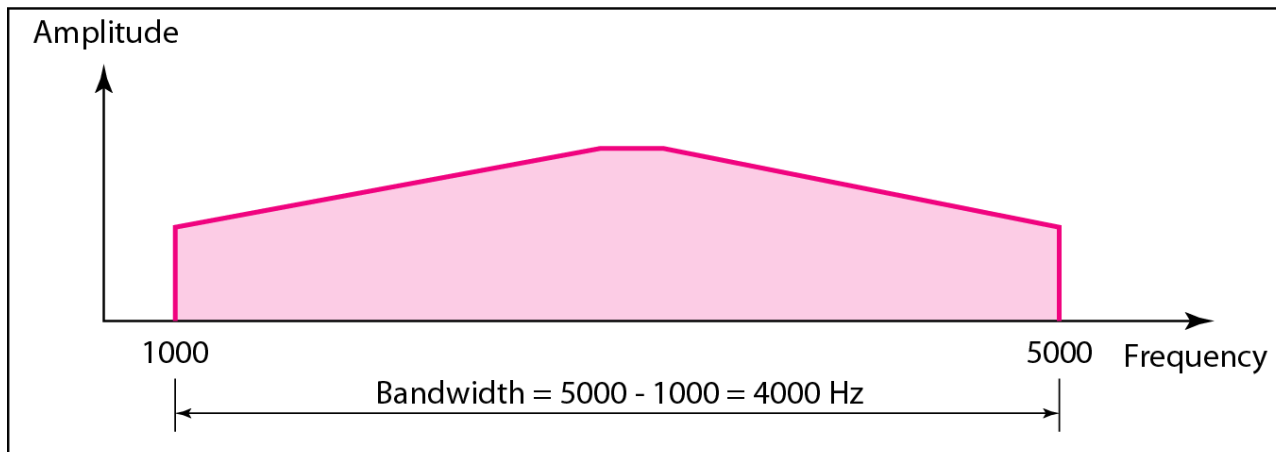
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a. Bandwidth of a periodic signal



b. Bandwidth of a nonperiodic signal

Figure-1: *The bandwidth of periodic and nonperiodic composite signals*

Note

The bandwidth of a composite signal is the difference between the highest and the lowest frequencies contained in that signal.

If a periodic signal is decomposed into five sine waves with frequencies of 100, 300, 500, 700, and 900 Hz, what is its bandwidth? Draw the spectrum, assuming all components have a maximum amplitude of 10 V.

Solution

Let f_h be the highest frequency, f_l the lowest frequency, and B the bandwidth. Then

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

The spectrum has only five spikes, at 100, 300, 500, 700, and 900 Hz (see Figure 2).

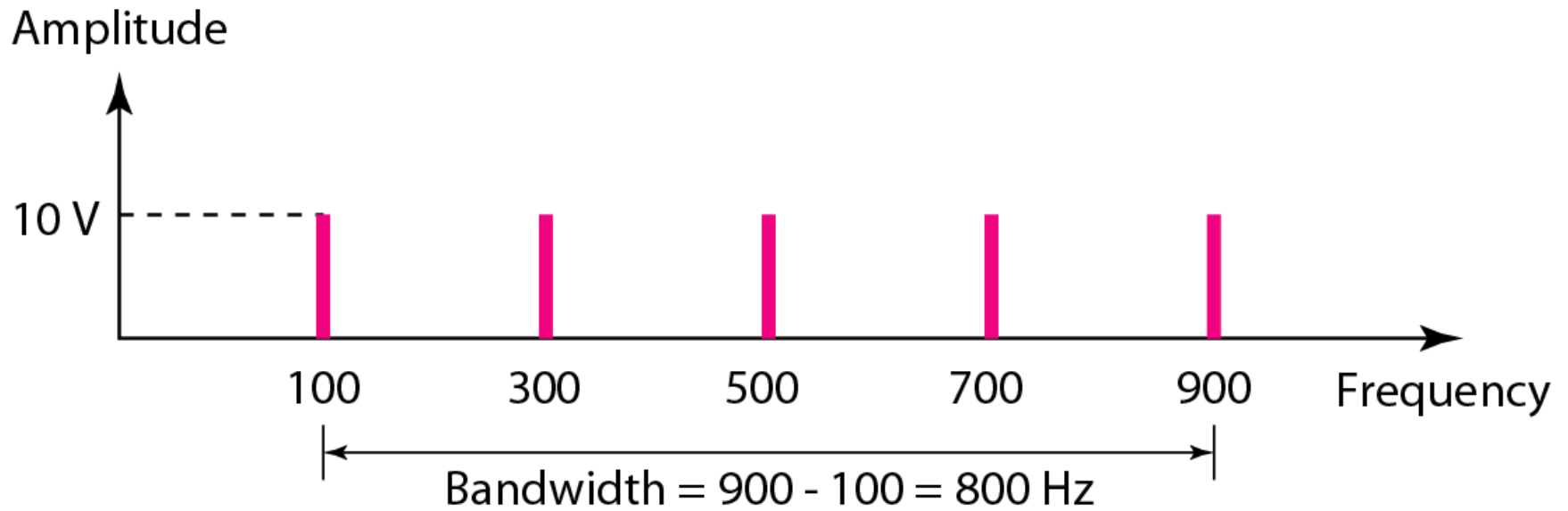


Figure 2: *The bandwidth for previous example*

A periodic signal has a bandwidth of 20 Hz. The highest frequency is 60 Hz. What is the lowest frequency? Draw the spectrum if the signal contains all frequencies of the same amplitude.

Solution

Let f_h be the highest frequency, f_l the lowest frequency, and B the bandwidth. Then

$$B = f_h - f_l \Rightarrow 20 = 60 - f_l \Rightarrow f_l = 60 - 20 = 40 \text{ Hz}$$

The spectrum contains all integer frequencies. We show this by a series of spikes (see Figure 3).

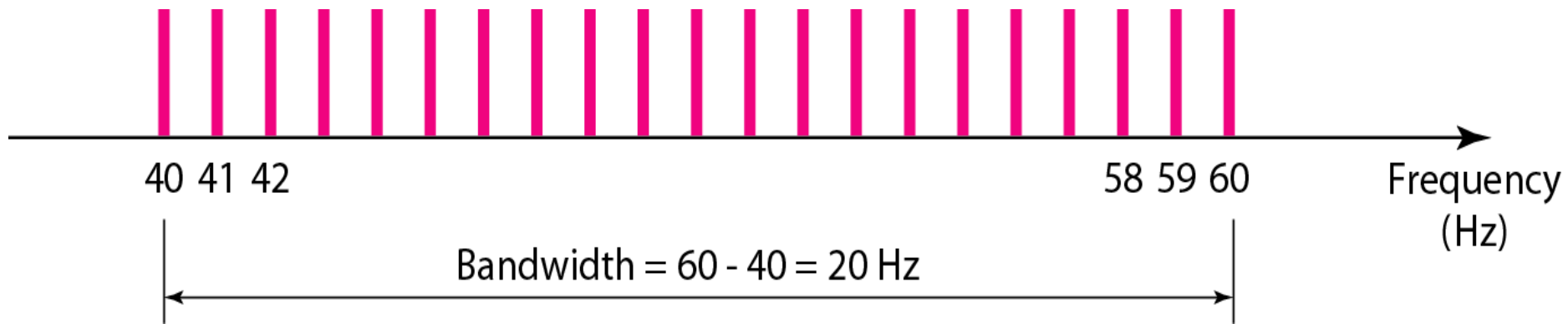


Figure 3: *The bandwidth for previous example*

A nonperiodic composite signal has a bandwidth of 200 kHz, with a middle frequency of 140 kHz and peak amplitude of 20 V. The two extreme frequencies have an amplitude of 0. Draw the frequency domain of the signal.

Solution

The lowest frequency must be at 40 kHz and the highest at 240 kHz. *Figure 4* shows the frequency domain and the bandwidth.

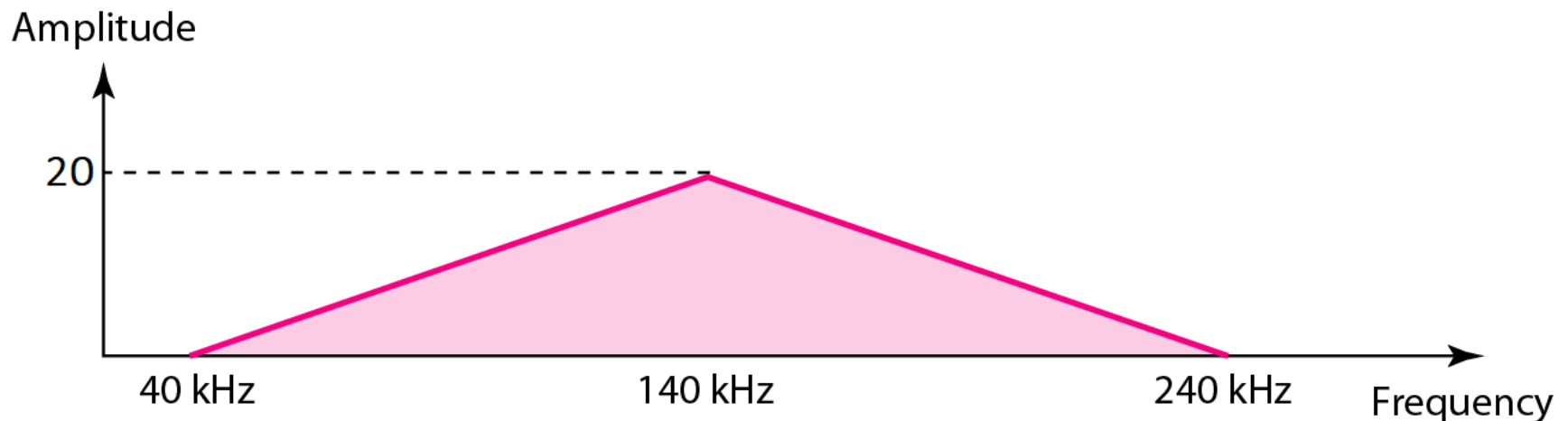


Figure 4 *The bandwidth for previous example*

Some Examples of Non-periodic Composite Signal

- An example of a nonperiodic composite signal is the signal propagated by an AM radio station. In the United States, each AM radio station is assigned a 10-kHz bandwidth. The total bandwidth dedicated to AM radio ranges from 530 to 1700 kHz. We will show the rationale behind this 10-kHz bandwidth in Chapter 5.
- Another example of a nonperiodic composite signal is the signal propagated by an FM radio station. In the United States, each FM radio station is assigned a 200-kHz bandwidth. The total bandwidth dedicated to FM radio ranges from 88 to 108 MHz. We will show the rationale behind this 200-kHz bandwidth in Chapter 5.
- Another example of a nonperiodic composite signal is the signal received by an old-fashioned analog black-and-white TV. A TV screen is made up of pixels. If we assume a resolution of 525×700 , we have 367,500 pixels per screen. If we scan the screen 30 times per second, this is $367,500 \times 30 = 11,025,000$ pixels per second. The worst-case scenario is alternating black and white pixels. We can send 2 pixels per cycle. Therefore, we need $11,025,000 / 2 = 5,512,500$ cycles per second, or Hz. The bandwidth needed is 5.5125 MHz

Digital Signal

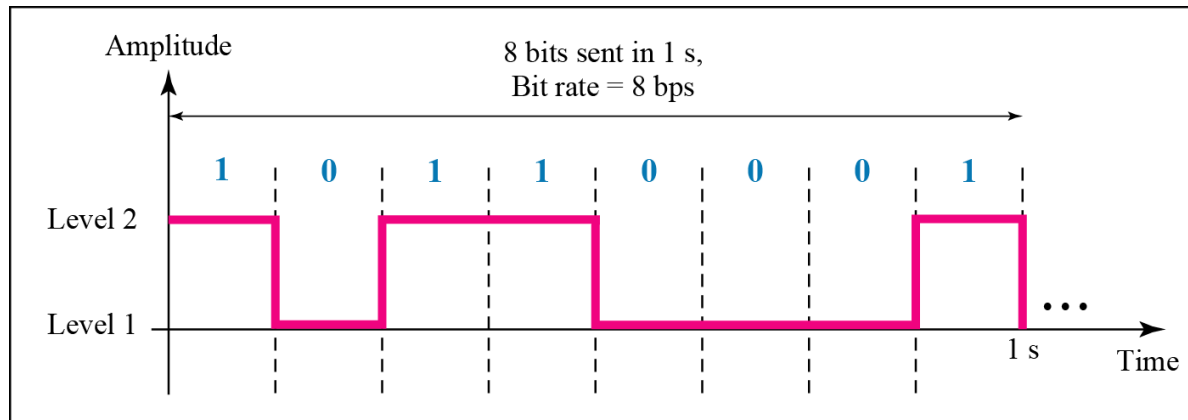
In addition to being represented by an analog signal, information can also be represented by a **digital signal**. For example, a 1 can be encoded as a positive voltage and a 0 as zero voltage. A digital signal can have more than two levels. In this case, we can send more than 1 bit for each level.

Topics to be discussed in this section:

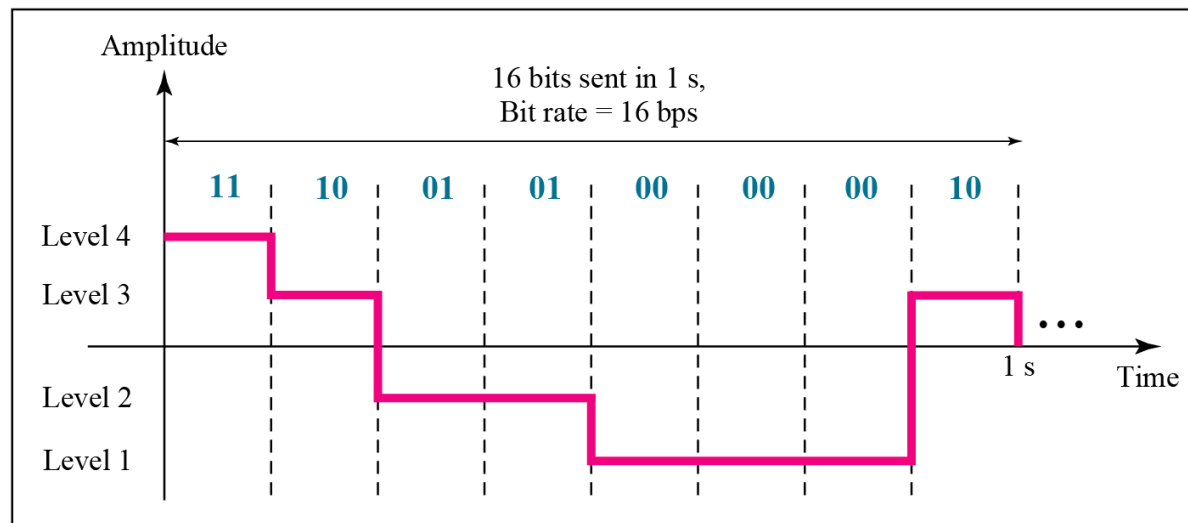
Bit Rate

Baud Rate

Levels of a Signal



a. A digital signal with two levels



b. A digital signal with four levels

Figure 5: *Two digital signals: one with two signal levels and the other with four signal levels*

Some Examples

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A digital signal has eight levels. How many bits are needed per level? We calculate the number of bits from the formula

$$\text{Number of bits per level} = \log_2 8 = 3$$

Each signal level is represented by 3 bits.

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A digital signal has nine levels. How many bits are needed per level? We calculate the number of bits by using the formula. Each signal level is represented by 3.17 bits. However, this answer is not realistic. The number of bits sent per level needs to be an integer. For this example, 4 bits can represent one level.

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Assume we need to download text documents at the rate of 100 pages per minute. What is the required bit rate of the channel? (A page is an average of 24 lines with 80 characters in each line)

Solution

A page is an average of 24 lines with 80 characters in each line. If we assume that one character requires 8 bits, the bit rate is

$$100 \times 24 \times 80 \times 8 = 1,636,000 \text{ bps} = 1.636 \text{ Mbps}$$

That's all for today

Thank You