

Supplement to Chapter 6 of *The Science of Digital Media* – Digital Video Data Representation and Communication

Mathematical Modeling Worksheet – Digital Video Data Representation and Communication > Amplitude Modulation¹

Introduction:

Amplitude modulation is one of three basic modulation methods that can be used to transmit either analog or digital data. In amplitude modulation, the amplitude of the carrier wave is changed in a way that encodes information – for example, image data for a video transmission.

Mathematically, amplitude modulation involves the multiplication of sinusoidal functions. The carrier signal has a frequency f_c . The data signal may be a complex function that can be decomposed into simple frequency components. It can be shown that in amplitude modulation, each frequency component f_d in the data signal creates upper and lower sidebands, one at frequency $f_c + f_d$ and one at frequency $f_c - f_d$.

Exercise 1

Graph the function $\cos(2\pi \cdot 3 \cdot x) \cdot (1.0 + \cos(2\pi \cdot 2 \cdot x))$. Notice that the frequency of the first cosine function is 3 cycles per unit and the frequency of the second is 2 cycles per unit. We don't need to worry about what the units are for this exercise.

Graph the function $\cos(2\pi \cdot 3 \cdot x) + 1/2 \cdot \cos(2\pi \cdot (3+2) \cdot x) + 1/2 \cdot \cos(2\pi \cdot (3-2) \cdot x)$

Question 1

How do the two graphs compare?

Question 2

What do each of the three terms in the function $\cos(2\pi \cdot 3 \cdot x) + 1/2 \cdot \cos(2\pi \cdot (3+2) \cdot x) + 1/2 \cdot \cos(2\pi \cdot (3-2) \cdot x)$ represent in the context of amplitude modulation?

Exercise 2

Now try this with a more complex data signal. Create a data signal that has three frequency components. Do this by adding three cosine functions and graphing the result: $0.5 \cdot \cos(2\pi \cdot 4 \cdot x)$, $2 \cdot \cos(2\pi \cdot 2 \cdot x)$, and $1.5 \cdot \cos(2\pi \cdot 1.5 \cdot x)$.

Modulate a carrier signal that has a frequency of 5 cycles per units using this data signal. Do the modulation by multiplying the carrier signal function f_1 times the data signal function f_2 to get the modulated function f_3 , as in $f_3 = f_1 \cdot (1.0 + f_2)$.

¹This material is based on work supported by the National Science Foundation under Grant No. DUE-0340969. This worksheet was written by Dr. Jennifer Burg (burg@wfu.edu).

Graph both the carrier signal and the modulated carrier signal.

Question 3

What frequency components do you expect in the modulated signal, based on your knowledge of amplitude modulation?

Create a function by adding your frequency components and graph it.

Question 4

How does this graph compare to the graph of the modulated signal?

Please give us feedback so that we can continue to refine the curriculum material:

1. What concepts were the most difficult for you in this worksheet?

2. What particular explanations or types of explanations did you find most effective in this worksheet?

3. Rate the helpfulness of the text and worksheet in explaining the concepts. Circle the response.

chapter in *The Science of Digital Media*
very helpful helpful a little helpful not helpful at all

completing the worksheet exercise
very helpful helpful a little helpful not helpful at all

4. What suggestions do you have for adding to or improving this worksheet?