

## Computer simulation technique for teaching basic communication and signaling system

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**ABSTRACT:** Theoretical concepts of communication system will be better understood when computer simulations are used as a teaching aid in line with experimental works. In this paper, MATLAB is employed as a demonstration tool for easy understanding of basic Amplitude Modulation Technique with its behavioural pattern analyzed. To achieve this, the building blocks of amplitude modulation characteristics were coded in terms of their modulation index, carrier amplitude, carrier frequency and modulating frequency. The MATLAB software was used to develop a true replica of the experimental data.

**Keywords:** MATLAB, Modulation Index, Carrier wave, true-replica.

### I. INTRODUCTION

In the Akanu Ibiam federal polytechnic today, we have experienced that students gain a better understanding of theoretical concept of communication system because of the application of experimental works using communication equipment. These equipment in some cases require high grade of professionalism for meaningful experimental works therefore, making experiments to be trained personnel driven sessions rather than students interactive learning sessions. (Z. GHASSEML OOOY and R. SAATCHI, 1999). Also the cost of providing some of the equipment are so prohibitive (cost wise) that no polytechnic, can easily afford them. MATLAB as a high-performance language for mathematics and technical computing comes to the rescue by integrating computation, visualization, and programming in cheap and easy-to-use environment where problems and solutions are expressed in familiar mathematical notations. (Brian R, Ronald L, Jonathan M, 2001),(MATLAB, 2007).

The authors advocate the integration of MATLAB tools as part of experimental works for teaching of communication systems. This is because the results obtained using MATLAB compare favourably with experimental results. The use of Multisim and Matlab/Simulink as instructional tools to teach circuit theory, power analysis and electronics at an introductory level was introduced in this polytechnic two years ago. The success rate in examinations shows that students' ability to understand the behavior of power and electronics circuits was immensely increased by this innovation.

### II. AMPLITUDE MODULATION (AM) CONCEPT

In amplitude modulation, a carrier signal of high frequency is varied by a modulating voltage of lower frequency, as illustrated in figure 1. In this system, the amplitude of the carrier is made proportional to the instantaneous amplitude of the voltage. Figure 2 shows the mathematical relationships that resulted in AM modulation.

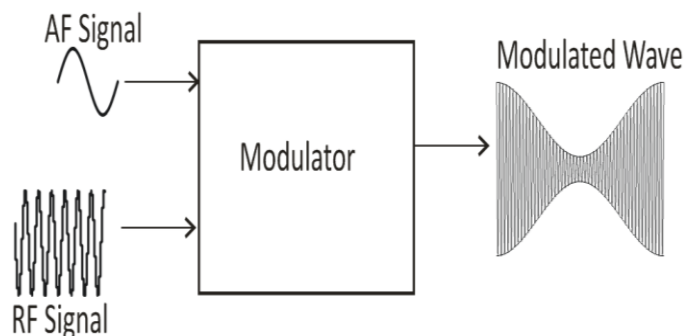


Figure 1: AM Analogy

Mathematically, The carrier voltage is shown in eq1 while eq2 illustrates the modulating voltage with the modulation index given as eq3. The modulation index shows depth of the modulating wave ( $V_m$ ) over the

carrier wave ( $V_c$ ). This figure ranges between 0 and 1, Over-modulation occurs when it exceeds 1 resulting in signal distortion because the amplifier is driven beyond set capacity.

$$v_c = V_c \sin \omega_c t \text{ ----- eq1}$$

$$v_m = V_m \sin \omega_m t \text{ ----- eq2}$$

$$m = \frac{V_m}{V_c} \text{ ----- eq3}$$

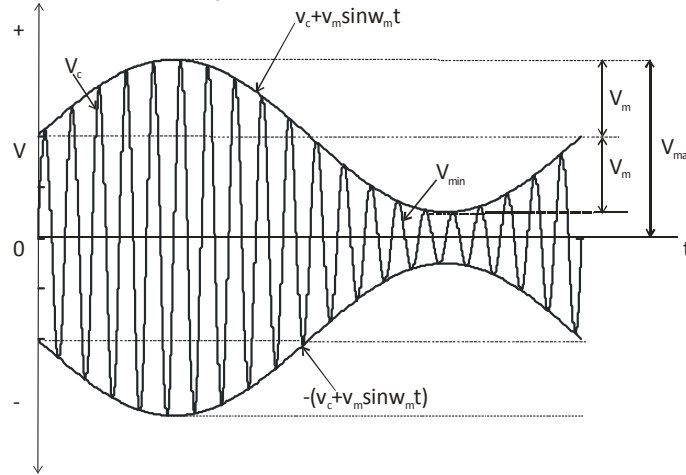
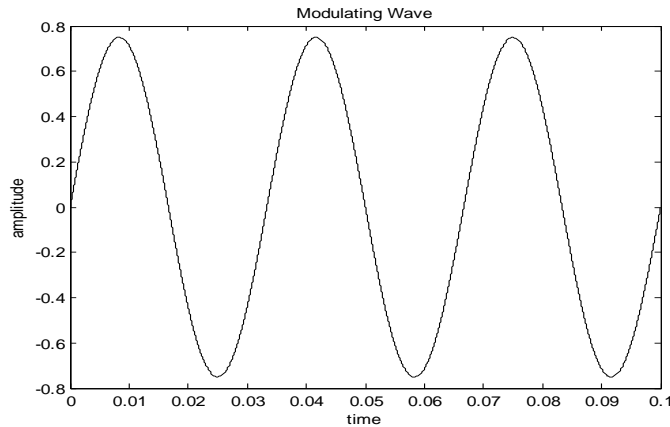


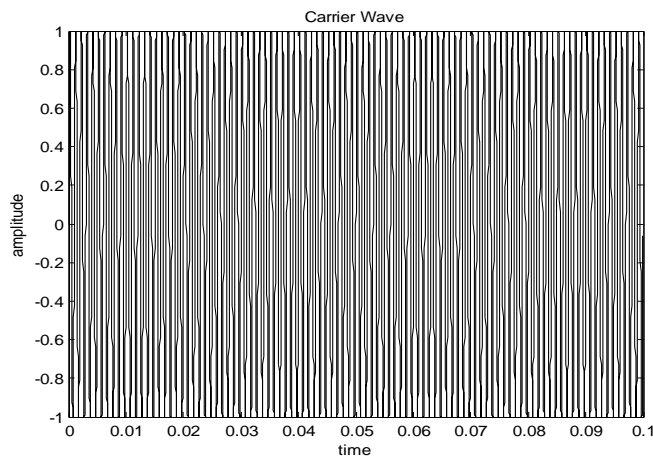
Figure 2: Modulated AM Wave

### III. MATLAB STUDY OF AMPLITUDE MODULATION

We have tried to illustrate most experimental conditions of AM using MATLAB. Shown in figure 3 are the resulting waveforms, code declarations and mathematical computation of basic amplitude modulation characteristics.

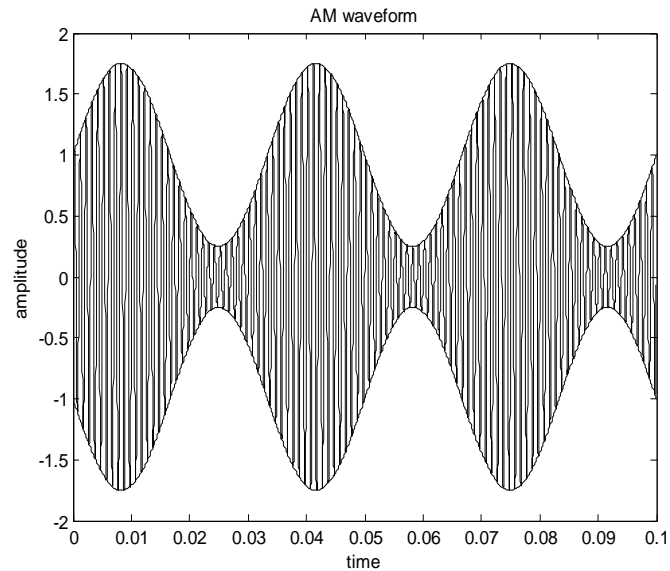


(a)



(b)

Figure 3: (a) Modulating wave. (b) Carrier Wave



(c)

```

Editor - C:\Documents and Settings\USER.USER-8D994E82B2\My
File Edit Text Go Cell Tools Debug Desktop Window Help
[Icons]
Zoom: 1.0 x
1 - fm=30;% Modulating frequency
2 - fc=1000;% Carrier Frequency
3 - vm=0.75;% Modulating amplitude
4 - vc=1;% Carrier amplitude
5 - m=vm/vc;%Modulation index
6 - wc=2*pi*fc;
7 - wm=2*pi*fm;
8 - V1=vc+vm*sin(wm*t);
9 - V2=-(vc+vm*sin(wm*t));
10 - Vm=vm*sin(wm*t);
11 - Vc=vc*sin(wc*t);
12 - Vam=(1+m*sin(wm*t)).*(sin(wc*t));% Modulated wave
13 - % Plotting the waveforms
14 - figure;
15 - plot(t,Vam,'k');
16 - hold on
17 - plot(t,V1,'k');
18 - plot(t,V2,'k');
19 - title('AM waveform time-domain');
20 - xlabel('time'), ylabel('amplitude');
21 - figure;
22 - plot(t,Vc,'k');
23 - title('Carrier Wave');
24 - xlabel('time'), ylabel('amplitude');
25 - figure;
26 - plot(t,Vm,'k');
27 - title('Intelligent Wave');
28 - xlabel('time'), ylabel('amplitude');
    
```

(d)

Figure 3 (c) MATLAB Code (d) Modulated Wave

The effect of modulation index is shown in figure 4 with different modulation indexes. The resulting AM signal with 100% modulation index and the MATLAB code are shown in figure 4a and 4b. The spectrum consists of 1000Hz carrier frequency with 30Hz modulating frequency. This result condition is replicated in 30% modulation except for changes in the modulating and carrier amplitude as shown in figure 4c and 4d.

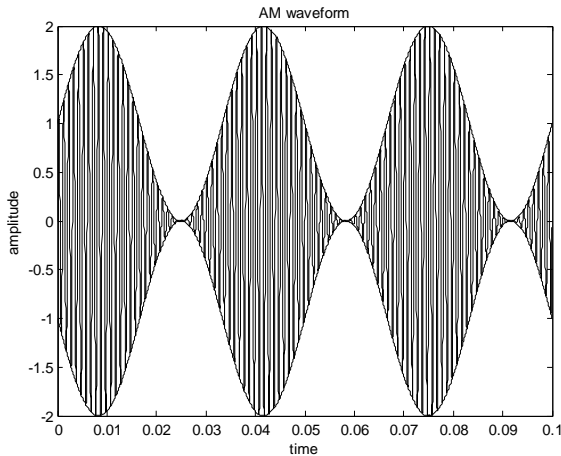


Figure 4a: 100% Modulation index

```

1 - fm = 30;% Modulating frequency
2 - fc = 1000;% Carrier Frequency
3 - vm = 0.3;% Modulating amplitude
4 - vc = 1;% Carrier amplitude
5 - m = vm/vc;% Modulation index
6 - interval = 0.001;
7 - t = 0:0.00001:0.09999;
8 - % x-axis:Time(second)
9 - % y-axis:Voltage(volt)
    
```

Figure 4b: Sample code for 100% Modulation

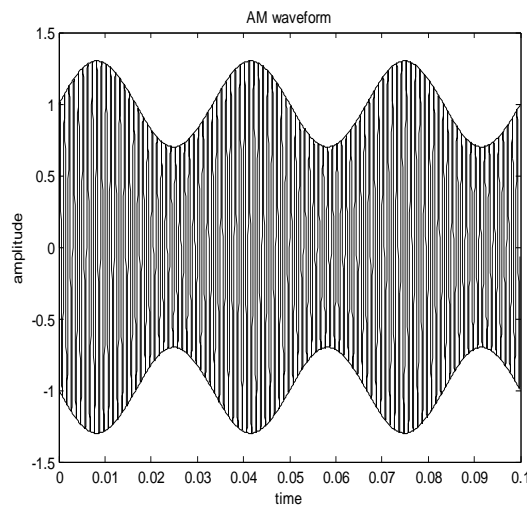


Figure 4c: 30% Modulation

```

1 - fm = 30;% Modulating frequency
2 - fc = 1000;% Carrier Frequency
3 - vm = 1;% Modulating amplitude
4 - vc = 1;% Carrier amplitude
5 - m = vm/vc;% Modulation index
6 - interval = 0.001;
7 - t = 0:0.00001:0.09999;
8 - % x-axis:Time(second)
9 - % y-axis:Voltage(volt)
    
```

Figure 4d: Sample code for 30% Modulation

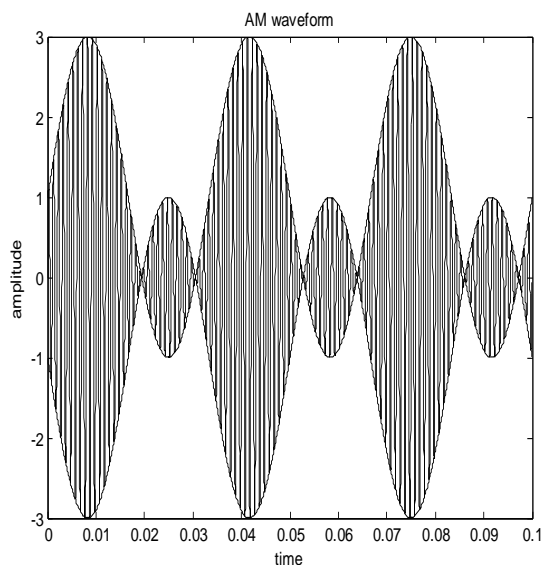


Figure 4e: 200% Over-modulation

```

1 - fm = 30;% Modulating frequency
2 - fc = 1000;% Carrier Frequency
3 - vm = 2;% Modulating amplitude
4 - vc = 1;% Carrier amplitude
5 - m = vm/vc;% Modulation index
6 - interval = 0.001;
7 - t = 0:0.00001:0.09999;
8 - % x-axis:Time(second)
9 - % y-axis:Voltage(volt)
    
```

Figure 4f: Sample code for 200% Over-Modulation

When the modulation index ( $m$ ) is greater than one, over-modulation occurs which leads to signal distortion as shown in figure 4c. (UNESCO-NBTE, 2008).

#### **IV. CONCLUSION**

In this paper, the authors have used MATLAB programming language to demonstrate how amplitude modulation can be simulated and studied outside the laboratory. This approach is very useful for teaching and learning of communication systems and other related areas. From the case study, the effectiveness of Matlab on more complex for teaching and research cannot be over-emphasized. The processes used here could very profitably be employed in the analysis of any signaling system.

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