Experiment 10: Introduction to AM Communications

Purpose and Discussion

The purpose of this simulation is to demonstrate the characteristics and operation of amplitude modulation. The desire for humans to communicate with each other is increasingly prevalent as we move into the global communication platform of the 21st century. In fact, the most astounding technological advances that took place in the 20th century were in the field of communications, with RF communications demanding its share of the marketplace.

Amplitude modulation (AM) communication is a method by which voice and music is combined or modulated with a high frequency radio signal and transmitted via a transmission medium before it is demodulated by a receiver. Amplitude modulation is the process which is responsible for the combining of the audio or message signal with the high frequency carrier before transmission takes place. Audio information requires a carrier frequency of some kind for two reasons. The range of hearing of the human ear is 20 - 20 kHz, relatively low in frequency. Information being transmitted in the audio range would require a far longer antenna than that of a high frequency carrier. This is due to the requirement that antenna length should be one half of the frequency wavelength. Since wavelength = c/f_c, a 2 kHz signal would require an antenna length of $c/2f_c = 3 \times 10^5 /2(2 \times 10^3) = 75$ km. which of course is not a realistic length. If this same 2 kHz signal were to be combined with a high frequency carrier of 1050 kHz, the antenna length would be reduced significantly. This would factor out in terms of cost of transmission.

The second reason why a carrier is used is discovered when separation of information is required at the receiver. When you tune your radio in order to select a station of choice, it is the carrier signal that provides the separation of information. Strict communication guidelines prevent overlapping of information through use of assigned high frequency carrier frequencies with tight bandwidths of 10 kHz for AM transmission. Assuming the information is a pure sinusoidal 2 kHz signal, the modulation process results in a lower sideband of $f_c - f_m$, f_c and upper sideband of $f_c + f_m$ resulting in the carrier frequency surrounded by an upper and lower sideband. This results in 3 spectral lines at the output of the AM modulator. With a 10 kHz bandwidth restriction, each sideband is limited to 5 kHz. This means that in practical terms, the bandwidth of the voice or music is limited to 5 kHz.

Multisim provides an AM modulator which we will use to produce a modulated signal from a low frequency message signal f_m and a high frequency carrier f_c. We will observe the modulated output in both time and frequency domains.

Parts

AM Modulator

Test Equipment

- Oscilloscope
- Spectrum Analyzer

Formulae

Lower Sideband

$$f_{lower} = f_c - f_m$$

Equation 10-1

Upper Sideband

$$f_{upper} = f_c + f_m$$

Equation 10-2

Procedure

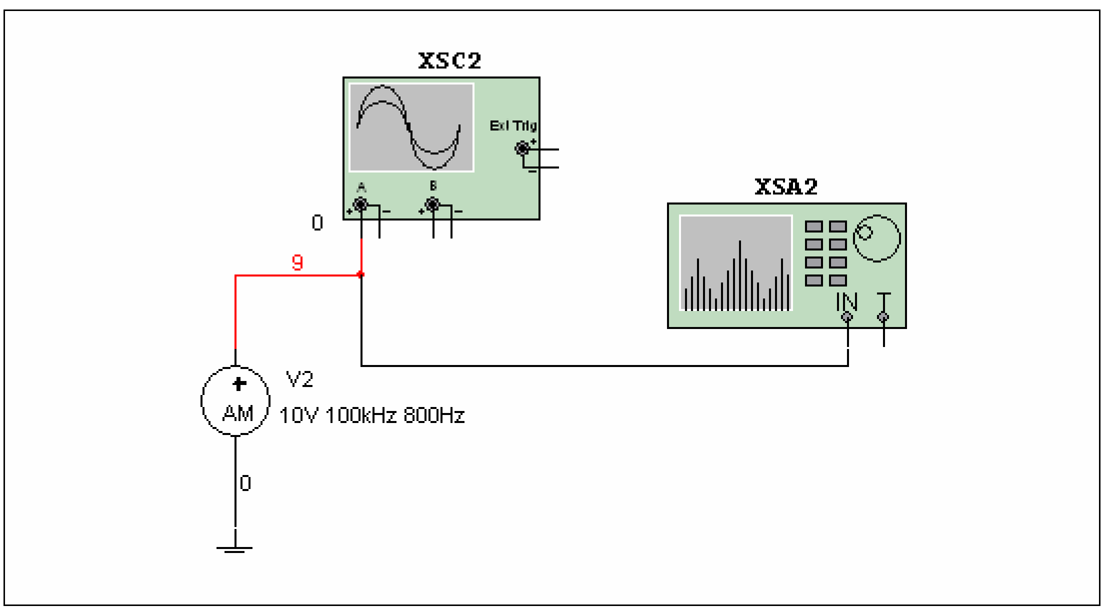

Figure 10-1 AM Modulator Example

1. Connect the circuit illustrated in Figure 10-1.
2. Double-click the AM Modulator. Select Carrier Amplitude = 10 V, Carrier Frequency = 100 kHz, Modulating Frequency = 800 Hz and Modulation Index = 0.6.

3. Double-click the Oscilloscope to view its display. Set the time base to 1 ms/Div and Channel A to 10 V/Div. Select Auto triggering and DC coupling.
4. Double-click the Spectrum Analyzer to view its display. Select *Set Span* and select *Span* = 10 kHz, *Center* = 100 kHz and *Amplitude* = LIN. Press *Enter*.
5. Start the simulation and draw the envelope complete with the carrier in the Data section of this experiment. Measure the modulating and carrier frequencies and verify the results with that of the AM modulator.
6. Double-click the Spectrum Analyzer. Observe the spectrum and use the red vertical marker to measure the frequency of the upper and lower sidebands as well as that of the carrier frequency. Record your results in the Data section of the lab. Verify your results with theoretical values.

Expected Outcome

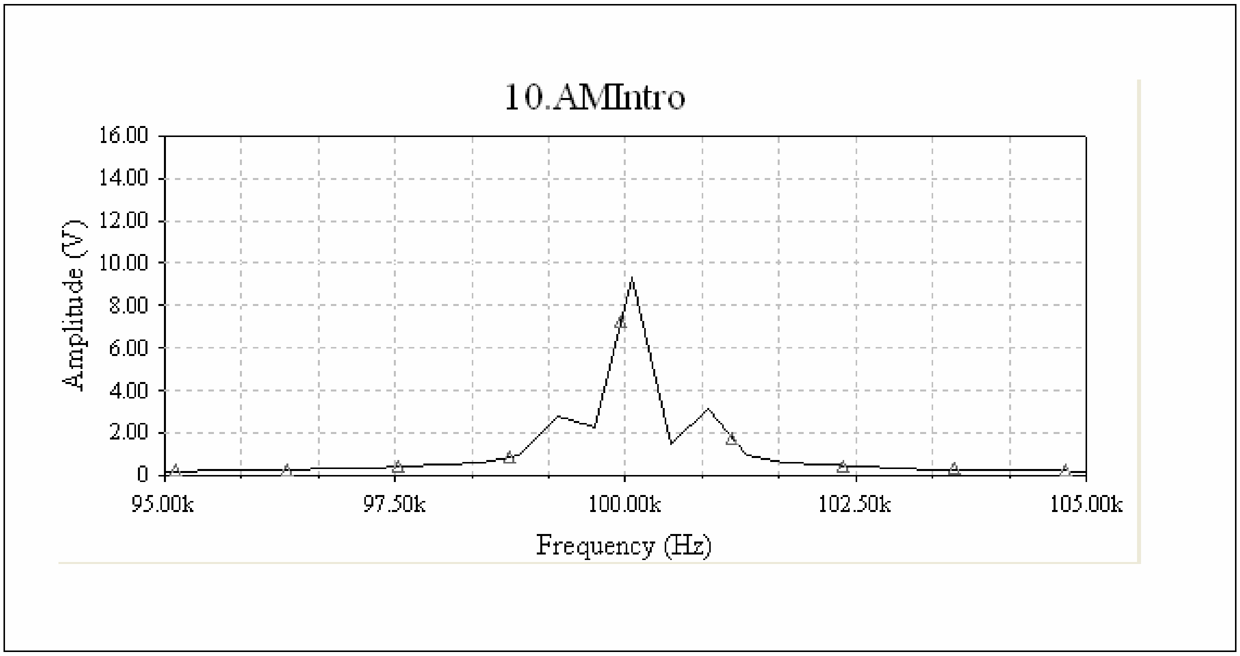

Figure 10-2 Frequency Spectrum of an AM Signal

Data for Experiment 10

Time versus Amplitude Sketch

	Measured Value	**Calculated Value**
f_{lower}		
f_{upper}		

Table 10-1

Additional Challenge

Double-click on the AM modulator to change the Carrier Frequency to 200 kHz, the Modulating Frequency to 500 Hz and the Modulation Index to 1. Run the simulation and observe the results in both time and frequency domains. Change the Modulation Index to 1.2 and observe the results on the Oscilloscope.