AMPLITUDE MODULATION

Part 1

In class you have studied the theory of Amplitude Modulation. This lab gives you the opportunity to actually work on Amplitude Modulation and reinforce the theory taught in class. We also see how to use a balanced mixer to modulate a signal.

The equipment used for this lab is similar to that used in the previous lab: Agilent 33250A function generator and the Agilent 54621D oscilloscope.

Using the diagram above make the necessary connections.

Use the "utility" menu to place the function generator is in the “high Z” mode.

The Agilent 33250A function generator will modulate a message signal against a carrier internally.

- First adjust the carrier to a 100kHz sine wave of amplitude 200mV.
- Press the MOD button on the function generator and adjust the message frequency to 20kHz. The amplitude is set automatically.
- Adjust any modulation characteristics

We are going to observe the spectrum of the modulated wave.

- Press the MATH button
- Select FFT using the on screen menu
Adjust the sampling rate for the signal to approximately 2 MSa/s (MegaSamples per second) by adjusting the time scale knob. This will bring the spectrum into view.

Using the MORE FFT mode, adjust the center frequency to approximately 100 kHz and the span to approximately 200 kHz so that the graph is easily visible.
Measure the peak values for the impulses obtained after modulation. Record the peak values with modulation index set to 100% and then at 50%. Obtain a plot of the spectra.

Using the cursor tool, measure the frequency and the amplitude difference between the carrier and side bands.

Measure these values and discuss as to why we get such values.

**Double Side Band with Suppressed Carrier**

*Part 2*

Now we modulate the message signal, 20kHz sine wave that we used before, using a mixer. The mixer that we use is a *Mini-Circuits SRA-1 balanced mixer*.

The most popular application of balanced mixer modules is to convert an incoming RF signal to a lower frequency IF output in systems like receivers, spectrum analyzers, and radar front ends. In a double-balanced mixer the incoming RF signal (R) is combined with a high-level oscillator signal (L) and the desired IF sideband is selected at the output by appropriate filters. Four specially selected-selected Schottky-barrier diodes combined with two carefully balanced wideband transformers considerably reduce the amount of RF and LO signals appearing at the IF output; the more effective the balance, the stringent the demand on the IF filter requirements. In most models the R and L signals are transformer coupled while the IF (I) output is DC coupled; all three ports are isolated from each other. To achieve optimum isolation between the R and L signals, apply the RF signal to the R port and the Local Oscillator signal to the L port; for down converter service output is taken from the I port.

For most double-sideband suppressed carrier applications, the balanced mixer is used with the carrier signal $F_c$, applied to the R port and the modulating signal (message signal), $F_m$ applied to the IF port. In that configuration the output signal composed of the $F_m$ signal centered on the suppressed carrier $F_c$ is taken at the LO (L) port.
Connect the mixer are shown below.

The Agilent 33250A function generator provides the message signal, while the other function generator, Agilent 33120A serves as the carrier generator.

From the connection diagram we see that for the mixer, the carrier is connected to the L connection while the message is connected to R. The output is taken from I.

Use the same amplitude and frequency values for the carrier and the message signal that were used on the previous section of the experiment. The carrier is a 100kHz sine wave of amplitude 200mV and the message is a 20kHz sine wave of the same amplitude. This will enable you to compare the results obtained by this method with the results obtained earlier in the experiment.

Observe the spectrum of the output on the oscilloscope. Notice the amplitude of the carrier frequency. What we obtain is a Double side band suppressed carrier (DSB-SC) spectrum. Why is this modulation scheme desirable? Obtain a plot of the spectrum and include it with your report. Discuss the operation of the balanced mixer and describe how it creates the carrier suppression. For the report, draw the waveforms for this type of modulation technique. Does the envelope cross zero? Explain your answer.

After you finish, clean up the lab and put all the components including the co-ax cables in their respective positions and clean up the workbench. Make sure that your lab TA signs your datasheet before you leave the lab.
DATA SHEET

PART 1

Carrier frequency \( f_c \): 
Carrier amplitude: 

Message frequency \( f_m \): 

50% modulation index

Amplitude of Carrier from FFT (dB): 
Amplitude of message from FFT (dB): 

Difference in amplitude between carrier and message: 
Difference in freq \( f_c - f_m \): 

100% modulation index

Amplitude of Carrier from FFT: 
Amplitude of message from FFT: 

Difference in amplitude between carrier and message: 
Difference in freq \( f_c - f_m \): 

PART 2

Carrier frequency \( f_c \): 
Carrier amplitude: 

Message frequency \( f_m \): 

Amplitude of Carrier from FFT (dB): 
Amplitude of message from FFT (dB): 

Difference in amplitude between carrier and message: 
Difference in freq \( f_c - f_m \):