



Lab 2 — AM Modulation

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Objective

1. Illustrate the concept of an amplitude modulated (AM) waveform.
2. Learn to observe the output of the Agilent 33120A Arbitrary Waveform Generator on the Agilent 54645A Oscilloscope
3. Learn to perform the following tasks in Agilent VEE:
 - Use a control panel for the Agilent 33120A Arbitrary Waveform Generator
 - Add inputs for AM-FREQ, AM-DEPTH
 - Remotely control the carrier frequency, modulation frequency, and modulation index of the waveform generator.
 - Modulate the waveform generator with an external voice waveform.
4. Build a simple AM radio transmitter that broadcasts in the range 550 kHz to 1600 kHz. This frequency range can be received by an ordinary AM transistor radio.

Equipment

- Agilent VEE software package
- Agilent 33120A 15 MHz Function/Arbitrary Waveform Generator
(Replacement model: Agilent 33220A Function / Arbitrary Waveform Generator)
- Agilent 54645A Deep Memory Oscilloscope
(Replacement model: Agilent DSO5012A 5000 Series Oscilloscope)
- Agilent E3631A DC Power Supply

Part I:

Controlling the Generator Manually

After signing out a cable box, perform the following tasks. Be prepared to explain or discuss with instructors those concepts marked with an asterisk (*).

1. Turn on the arbitrary waveform generator (Agilent 33120A) and oscilloscope.
2. Connect a coaxial cable from the OUTPUT of the waveform generator to the channel 1 input of the Agilent 54645A oscilloscope.
3. Connect a second cable from the SYNC output of the waveform generator to the External Trigger input of the oscilloscope.
 - * Can you explain why this "sync" connection is necessary?
4. Push the Source button on the scope (located within the TRIGGER group of controls.) Choose Ext by pressing the appropriate button under the display. This setting will synchronize the pattern on the oscilloscope with the AM modulation envelope. An AM waveform is easier to see if the scope is synchronized to the modulating signal, rather than to the carrier.



5. Now push button [1] (located within the VERTICAL group of controls.) Make sure the following settings are in chosen:
[1]on [Coupling]DC [BW Limit]off [Invert]off [Vernier]off [Probe]1
*Can you explain the meanings of these settings?
6. Push the Autoscale button on the scope. You should see a sinusoidal waveform on the screen. The waveform that you see is a plot the voltage produced by the waveform generator as a function of time. The number in the upper left-hand corner of the screen indicates the vertical scale of the plot in volts per large (1 cm) division. The number at the top of the screen about two-thirds of the way from the left indicates the horizontal scale of the plot in seconds per division (or milliseconds, microseconds, or nanoseconds per division.)
7. Push the Time button on the scope (at the top, within the "Measure" group.) Choose [Freq] and compare the scope frequency reading with the frequency display on the waveform generator. * What are the frequency and amplitude of the voltage produced by the waveform generator?

Controlling the Waveform Generator in Agilent VEE

8. Turn on your computer, then start the Agilent-VEE program. Bring up a control panel for the function (arbitrary waveform) generator (under I/O; Instrument manager.) Make sure your function generator control panel displays the following settings:

Function: Sinusoid
User Name: (doesn't matter)
Frequency: 1k or 1000
Amplitude: 5
Offset: 0
Duty Cycle: 50
Load: Infinity

If any setting is incorrect, click on its box and choose the correct setting from the menu. Now click on the "Main Panel" bar and choose "Modulation Panel" from the menu. Make sure your modulation control panel displays the following settings:

Function: Sinusoid
User Name: (doesn't matter)
Frequency: 500
% Depth: 50
Source: Internal
AM State: ON

If any setting is incorrect, double click on its box and choose the correct setting from the menu. Push the Autoscale button on the scope, then turn the Time/Div knob counterclockwise until you see an amplitude modulated waveform on the scope.

9. Experiment with different values of the Function, Frequency, and %_Depth settings on the function generator control panel and note the changes on the waveform displayed by the oscilloscope.

Creating an AM Radio Transmitter

10. You will now control the settings of the Agilent 33120A function generator from Agilent-VEE by adding software control inputs. Add an input terminal for FREQ to the control panel, and connect to it the data output of a real slider. Set the limits of your real slider to



550k minimum and 1600k maximum, and set its increment value (the value by which the setting changes when you click on the up or down arrows) to 10k. (Recall that the suffix "k", or "kilo", denotes multiplication by 1000.) The increment setting is called "Detents" under the "Properties" selection available from the upper left hand pull down menu of the slider box. Double click on the title bar of this slider and label it "Carrier Frequency."

- Make sure that your slider is set to "auto execute."
- Set the slider to different values and observe the frequency of the waveform generator. What changes are evident in the scope display?

11. Now add input terminals for AM_FREQ and AM_DEPTH to the function generator control panel. These controls set the frequency of the modulation envelope and the percentage of modulation (%_Depth), respectively. Connect a real slider to the AM_FREQ input and an integer slider to the AM_DEPTH input, setting the slider limits as follows:

- 200 to 5000 for AM_FREQ
- 0 to 100 for AM_DEPTH. Label the title bars of these sliders "AM Frequency" and "Percent Modulation"

12. Your waveform generator will function as an AM transmitter if you add a simple antenna. Find a BNC type coaxial T-connector in your cable box, and insert it at the signal output of the waveform generator. A cable from one arm of the tee should connect the waveform generator to the Agilent 54645A oscilloscope. Connect a coax cable terminated in "alligator" clips to the other arm of the tee, and connect a single free wire lead (not a coax cable) to the red alligator clip. This single lead forms your transmitter's antenna.
*Why must you use the red clip and not the black clip?

13. Set your carrier frequency to the value assigned to you by the TA. Your uniquely assigned frequency will be one on which no local AM radio station transmits. If modulate your signal at an audible frequency with at least a 10% modulation index (AM_DEPTH), you should be able to tune it in on your radio.

* Experiment with different values of modulation frequency and depth, and different types of modulation envelope. (Do not use anything but a sine wave for your carrier or you may cause interference with your classmates' radio reception.)

*How far can you broadcast your signal? Can you do anything to your antenna to extend your broadcast range?

**Save your Agilent-VEE program for Part II.

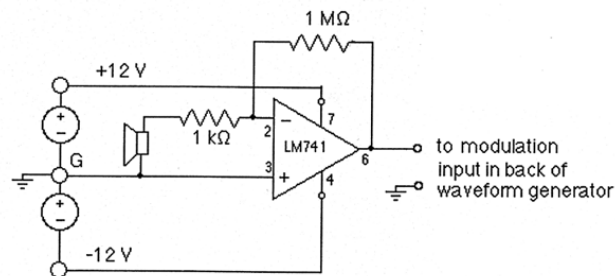


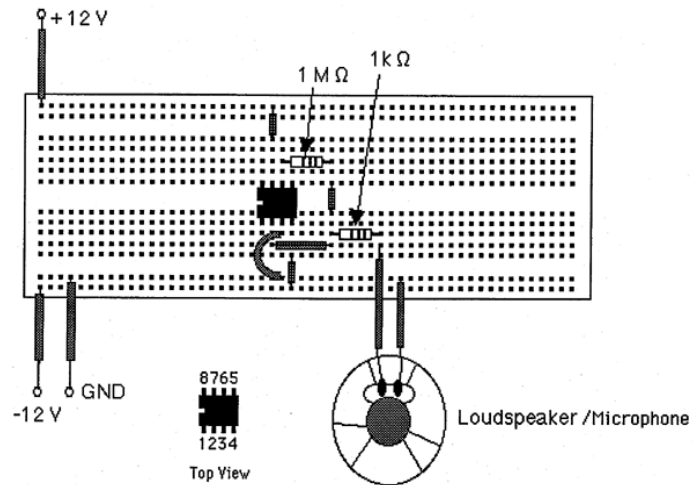
Part II:

Using a Voice Waveform to AM Modulate the Carrier

In this part of the experiment, you will use your own voice as the AM modulation signal for your am transmitter.

1. On the Agilent 33120A Waveform Generator control panel, set Source to "Both". This setting will allow the waveform generator to accept as AM modulation signals both the internal settings derived from the control panel and any arbitrary signal that you send it via a BNC connector in the rear (this feature will be explained in step #3 below.)
 2. For this part of the experiment, disconnect the line from the SYNC output of the waveform generator to the EXT TRIGGER input of the oscilloscope. Instead, set the scope Trigger Source to channel [1]. Your speech-modulated waveform will be easier to see if the scope is synchronized to the carrier, rather than to the modulating signal.
 3. You will now use an external speech signal to modulate the amplitude of your carrier. Your modulation signal will be derived from your own voice, then sent to the waveform generator by way of the BNC connector located on the rear panel of the arbitrary waveform generator. As a microphone, you will use the small loudspeaker contained in your lab kit. The voltage output of this "microphone" represents your speech waveform. The signal it produces in response to normal human speech is about 5 μV peak, and the waveform generator operates best with an external modulation signal in the 5-V range. Hence you will have to build an electronic circuit that amplifies your speech signal by about 106.
- 1) If you have not already done so as part of your homework, construct the circuit shown below using the parts in your lab kit. The integrated circuit is an LM741 general purpose amplifier. Note that a 1-k* resistor has the color code brn-blk-red, and 1-M* resistor has the code brn-blk-grn. Consult with your instructor if you are not sure how to use the connection breadboard.





5. Your amplifier needs to be powered by +12V and -12V dc voltage sources in order to operate. Turn on the Agilent E3631A DC power supply and set the sources to +12 V and -12 V. With the output off, connect these voltage outputs to your circuit at the points shown. Be sure to connect the ground lead as well. Use a cable to connect the output of the amplifier to Channel 2 of the scope.
6. Ask an instructor to check your wiring, then turn on the circuit and set the scope to view Channel 2. Speak into the microphone and observe your waveform on the scope.
7. Now use another T-connector to connect your speech output to the external modulation terminal on the back of the waveform generator. Set the scope to display both Channel 1 and Channel 2 at the same time.
8. Set your Agilent-VEE control panel AM-SOURCE to "External". Talk into your microphone and observe what happens to your carrier. Can you hear your voice over your radio?

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