



Lab 4 — Building an Analog AM Modulator

By: Mark Horenstein
Associate Professor
Dept. of Electrical and Computer Engineering
Boston University
Boston, Massachusetts
USA

Objective

1. Illustrate the concept of a carrier that is amplitude modulated by a speech waveform.
2. Construct a microphone amplifier from basic electronic parts.

Equipment

- Agilent VEE software package
- Agilent 33120A 15 MHz Function/Arbitrary Waveform Generator
- Agilent 54645A Deep Memory Oscilloscope
- Agilent E3631A DC Power Supply

Introduction

In this lab, we again will use the Agilent 33120A Arbitrary Waveform Generator as an AM transmitter broadcasting in the 530 kHz to 1.6 MHz AM radio band. In previous labs, the modulating signal consisted of a regular sinusoid or other periodic waveforms. In this lab, you will use your own human speech to modulate the carrier.

To Do:

After turning on your computer, sign out a cable box, then perform the following tasks:

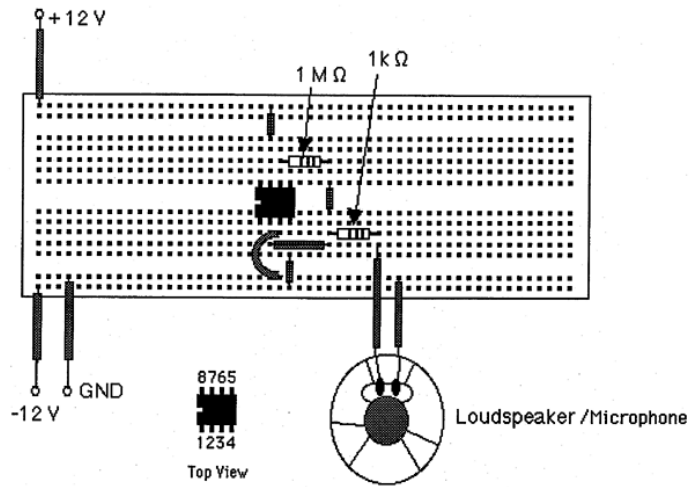
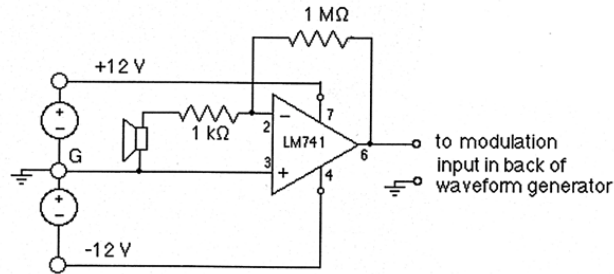
1. Start Agilent-VEE, turn on the Agilent 33120A arbitrary waveform generator and turn on the Agilent 54645A oscilloscope.
2. Connect a coaxial cable from the OUTPUT of the waveform generator to the channel 1 input of the oscilloscope using a T-connector. As in the previous AM experiment, connect a broadcast antenna to the other side of the Tee.
3. For this experiment, do not connect an external trigger signal from the SYNC output of the waveform generator. 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.
4. Bring up a control panel in Agilent-VEE for the function (arbitrary waveform) generator. Set the carrier to your assigned frequency.
5. Make sure that AM SOURCE is set to "Both". Click on Main Panel, and choose Modulation Panel from the menu. If the Amplitude Panel does not appear, click on the Frequency Panel and choose Amplitude Panel from the menu. Choose a 1 kHz sinusoidal waveform for modulation at 50% to 100%, then tune in your signal on your radio. Leave the receiver on this frequency setting for the rest of the experiment.
6. Turn the Time/Div knob on the scope counterclockwise until about three or so cycles of the sinusoidal modulation envelope are visible. You can adjust the Time/Div knob as needed throughout the remainder of this experiment to properly observe the waveform.
7. Push Autoscale on the scope, then turn the Delay knob (located within the HORIZONTAL group of controls) counterclockwise until the little "zero" marker at the top center of the graph moves to the far left hand corner of the display. This setting places the origin of the graph at the far left and will make the speech modulated waveform easier to see on the scope.



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 $5 \mu\text{V}$ 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.

- Construct the circuit shown below using the parts in your lab kit. The integrated circuit is an LM741 general purpose amplifier.

Note that $1 \text{ k}^* = \text{brn-blk-red}$ and $1 \text{ M}^* = \text{brn-blk-grn}$. Consult with your instructor if you are not sure how to use the connection breadboard.



- 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.
- 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 Agilent 54645A oscilloscope.
- 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.
- 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?