

Electret Microphone

Laboratory Outline

An electret microphone with proper **biasing** produces a response from ordinary sounds often measured only in millivolts. These voltages will need to be **amplified** for typical sound applications like detection (did someone clap?), equalization (pump up the bass!), or even transmission over short distances (tiny signal + tiny noises = significant noise interference). The electret microphone's output voltage should be amplified right after the microphone to both preserve the best integrity, that is the lowest-noise version of the signal and allow for further electronics operations at voltage levels typical of other basic electronic devices like diodes and transistors.

The microphone in Figure 1 is like the one in your electronics kit. It has two leads (wires, see arrows) which exit the microphone's capsule (the "can"). Close examination of the can in the photo shows the negative lead has metallic connections (circled) to the can of the mic capsule...therefore, you should be careful not to let other component leads touch the can or you would short those nodes.

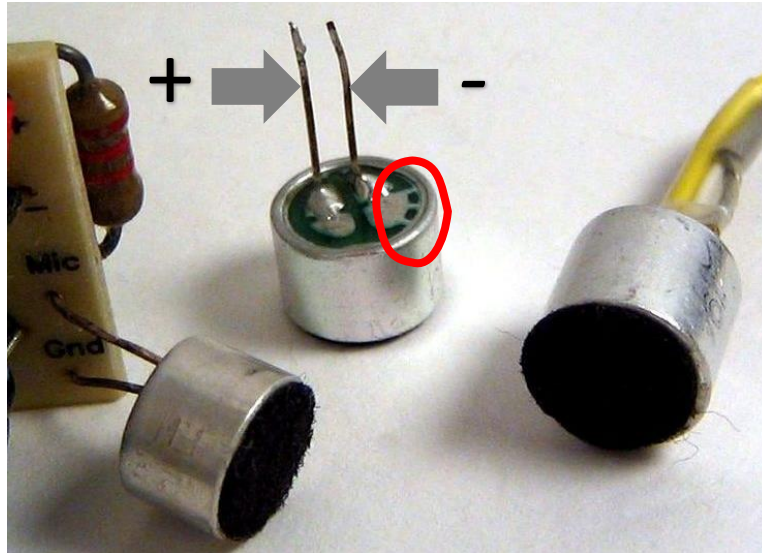


Figure 1: A photo and a model of the inner operation of the electret microphone capsule. Photo credit: https://upload.wikimedia.org/wikipedia/commons/5/57/Electret_condenser_microphone_capsules.jpg

In electronics, **biasing** usually refers to a fixed DC voltage or current applied to a terminal of an electronic component such as a diode, transistor, or vacuum tube in a circuit in which AC signals are also present, to establish proper operating conditions for the component. -

Wikipedia

<https://en.wikipedia.org/wiki/Biasing>

Prerequisites

- Breadboarding experience.
- Use of an oscilloscope.
- Thevenin-equivalent circuit theory.

Parts Needed

- (1) electret microphone capsule,
- (1) battery or voltage source, preferably near 9 volts,
- A device (smartphone?) with a loudspeaker to play a 1 kHz tone,
- Other components:
 - (1) $0.1 \mu F$ or $1 \mu F$ ceramic capacitor (choose the largest ceramic/yellow capacitor from your kit),
 - (2) $2.2 k\Omega$ resistor,
 - (1) $1 k\Omega$ resistor,
 - (1) $10 k\Omega$ resistor

Learning Objectives

- To gain practical experience in circuit building and use of a microphone.
- To improve oscilloscope skills.
- To apply Thevenin modelling to a microphone circuit.

Resources

Datasheet: <https://media.digikey.com/pdf/Data%20Sheets/Soberton%20PDFs/EM-9745P-46.pdf>

Electret microphones: <https://mynewmicrophone.com/the-complete-guide-to-electret-condenser-microphones/>

AC coupling capacitor: <http://www.learningaboutelectronics.com/Articles/What-is-a-coupling-capacitor>

From these resources, we can discover quite a bit about the microphone sensor we will be using.

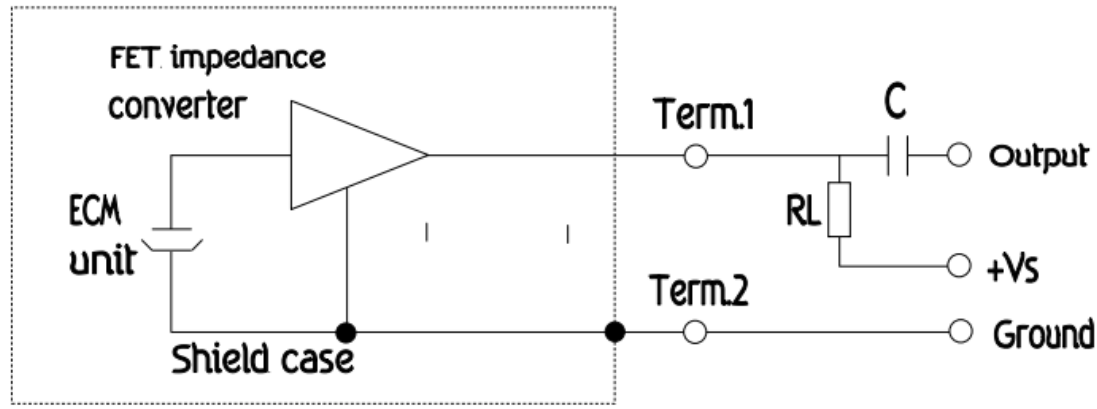


Figure 2: Schematic of the microphone and typical use configuration.

Figure 2 shows the typical way to configure the microphone for use. The physical content of the microphone capsule is shown inside the dotted box. External to the capsule, a resistor provides bias to the internal “FET impedance converter” of the capsule while an [AC-coupling capacitor](#) removes the DC component before sending a zero-mean microphone signal to the next component of your design. By “zero-mean” we mean that the signal will vary above and below the ground reference evenly such that its average voltage is zero.

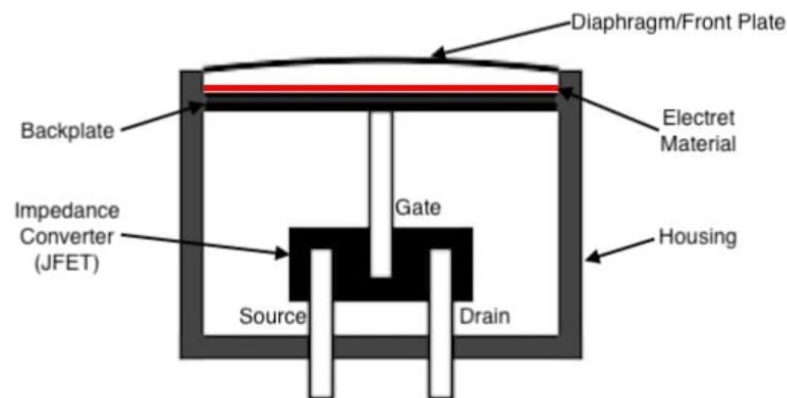


Figure 3: A physical diagram of the electret microphone capsule (canister). Click for [Source](#).

The physical diagram of Figure 3 provides some insight into the simplicity and construction of the microphone capsule. The “magic” (if there is any magic) is in the electret material used. If interested in the history of locking electrical dipoles into a material for the purpose of building simple, long-lasting microphones, you can read more about at <https://mynewmicrophone.com/the-complete-guide-to-electret-condenser-microphones/>.

Next, let’s turn that microphone capsule on its side and blend it with the necessary biasing resistor and the AC coupling capacitor (see Figure 4, top left).

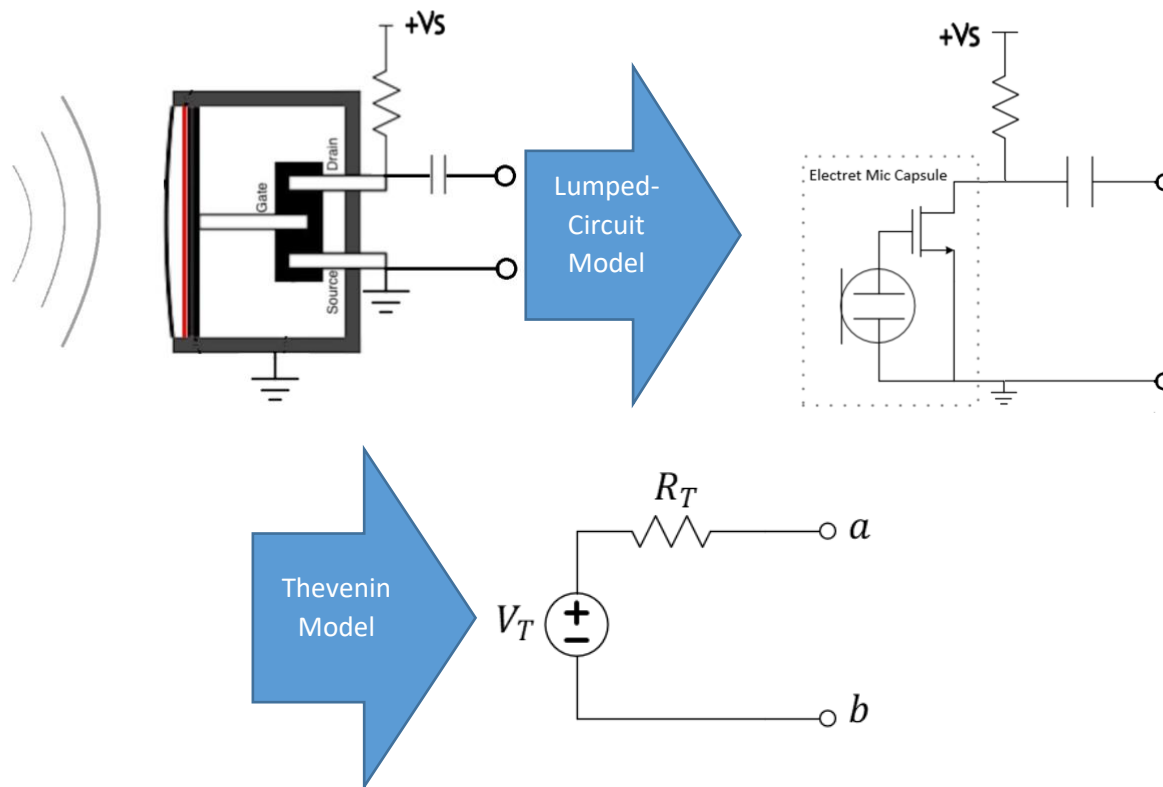


Figure 4: A mixed-physical diagram, full-circuit schematic, and Thevenin-equivalent model of the microphone circuit you will build and test.

Replacing the microphone capsule with our own circuit models for the electret diaphragm (a type of capacitor) and a transistor (we imagine that our nMOS transistor is a reasonable approximation appropriate at the ECE 110 level), we get the “lumped-circuit model” schematic of the top-right figure in Figure 4. Remember that the FET is *inside* the microphone capsule...you will only need to add the biasing resistor and a capacitor to complete a basic microphone sensor circuit. Finally, for purposes of predicting how the microphone circuit will interact with another circuit, we will explore the Thevenin-equivalent model of this microphone circuit (see bottom of Figure 4).

Build

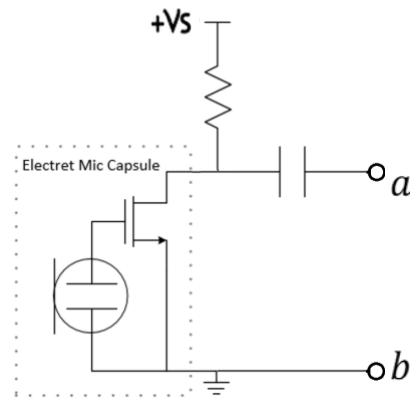


Figure 5: Your circuit build.

Use a $2.2\text{ k}\Omega$ resistor to connect the non-ground pin (the drain of the FET internal to the microphone capsule) to the power rail of your breadboard. Connect the ground pin to the negative power rail. Do not attach your power supply to the rails yet.

For the AC coupling capacitor, use the largest value ceramic/yellow capacitor from your electronics kit. This should be either $0.1\ \mu\text{F}$ or $1\ \mu\text{F}$ depending on when your kit was assembled. Either ceramic capacitor should work fine, but you should **not** use an electrolytic capacitor (blue capacitor) for this. Record your values here:

Question 1: $R = \underline{\hspace{2cm}}\text{ k}\Omega$ (*measured value*) $\approx 2.2\text{ k}\Omega$; $C = \underline{\hspace{2cm}}\ \mu\text{F}$ (*nominal value*)

Attach channel 1 of your oscilloscope between the open end of the capacitor and the ground rail of your breadboard (between nodes **a** and **b** of Figure 5.). Be sure that the oscilloscope is started in the default mode. Then, adjust the vertical axis of channel 1 to be about 5 mV per division.

Connect the battery to the power rails to energize the microphone capsule. Can you detect the sound of a clap on the oscilloscope as a sudden disruption in the voltage signal? You can try whistling (a nearly-sinusoidal acoustic wave) or playing a 1 kHz tone from your cell phone if your hands get tired. If you cannot find the voltage signal, after some trial and error plus adjustment of your oscilloscope, then you should disconnect your battery, return your oscilloscope to the default mode, and seek TA assistance.