Lab Note 4: Sensing Part 1 Extra Reading

Appendix A: Electronics Glossary

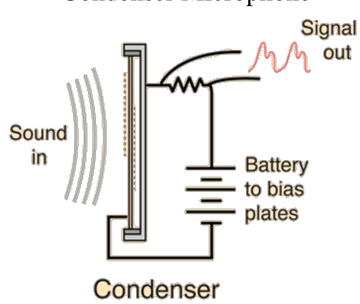
In this appendix, we will elaborate upon terms and components we mentioned in the main note whose explanations are too long to fit comfortably in a footnote. **PLEASE NOTE: this material is NOT IN SCOPE, so do not panic if it seems complex.** It is just here to give some additional background to the lab if you would like some.

- **Electret microphone:** First, we will address the term "electret," and then we will discuss how the electret's properties are exploited to make a microphone.

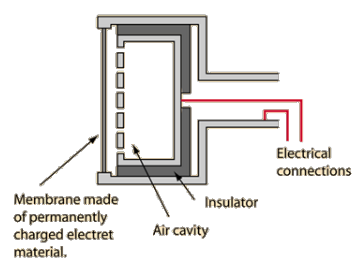
  An electret is a permanently[1] charged material (usually a piece of plastic). The term "electret" comes from the fact that an electret is the electrostatic equivalent of a permanent magnet: while in a permanent magnet, the magnetic field is generated by the natural alignment of the electrons' spins within the atoms of the material, the electrostatic field generated by the electret is created either by embedding additional negative charges within the material or by melting a suitable dielectric material and cooling it inside a strong electric field: while the material is liquid, the polar molecules (dipoles) align themselves with the electric field so that when the material cools, they are "frozen" in position, producing a dipole electret with a permanent electrostatic alignment or "bias". Just as there exist natural magnets, there also exist natural electrets: for example, quartz is a naturally-occurring electret.

  The electret microphone is a variation of the condenser microphone. A condenser microphone is essentially a sound-sensitive capacitor: it consists of a pair of charged plates (one flexible, one rigid) that can be forced closer by variation in air pressure. A sound wave is a pressure wave, so when the sound wave hits the flexible plate, it is pushed back toward the rigid plate, thereby changing the capacitance (recall, from physics, that the capacitance C of a parallel plate capacitor is given by the equation $C = \frac{\kappa \varepsilon_0 A}{d}$, where d is the distance between the plates, A is the area of one plate (assuming both plates have the same area), ε_0 is the permittivity of free space, and κ is the dielectric constant of the material between the plates.) and therefore the voltage between the plates.

  Condenser Microphone

  Electret Microphone

  While the condenser microphone requires an external voltage source to charge the diaphragm (the flexible plate), the electret microphone does not (because the electret has a permanent charge). In traditional electret microphones, the diaphragm is replaced by the electret, but this makes the diaphragm heavier and therefore less sensitive to sound waves, so most modern electret microphones attach the electret to the conductive backplate instead. Most electret microphones have a small transistor amplifier built into their packages, and this amplifier (like an op-amp) needs to be powered to work, so even though electret microphones do not require active biasing, most of them are still active components.

References

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[1] Technically, quasi-permanently: see the Wikipedia article on electrets for more explanation.

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