Acoustic measurement is the measuring of sound waves
What is it used for???

- Product design, production test, machine performance and process control, microphones.
- Ex: cars and modifying things so the car sounds the way they want it.
- Or limit excess noise that machines make.

The Microphone

One of them most common for devices for acoustic measurement is the "Microphone" which is a transducer that converts sound into an electrical signal and usually is then amplified through a speaker. Microphones are even used in ultrasonic sensors.
Condenser Microphones

- Electrostatic type transducer
- Narrow, precise range of measurement due to small diaphragm
- A thin membrane, often steel, aluminum, or metallized glass, separated a small distance from a plate

Hydrophone

- It is basically an underwater microphone. It is used to record or listen to the sounds under water.
- Most hydrophones are based on a piezoelectric transducer that generates an electric potential when subjected to a pressure change
- Sound in water travels about 4.3 times faster and exerts about 60 times more pressure.
• Converts sound waves to electrical voltage due to pressure change.
• WW1: used to locate submarines by using the echoes of sound.
• Now: Mostly used to locate marine life and other things underwater.

Accelerometers
• Accelerometers measure the speed that an object is going by measuring the vibrations that the object is making.
• Accelerometers are used to detect and monitor vibration in rotating machinery.
• Can be found in tablet computers, digital cameras, drones, and other type of technology.
Electrostatic Transducers

- Modeled as a set of capacitor plates
- Output voltage is AC
- Produces or receives sound waves
- i.e. vibrating objects such as crystals, ceramic, etc.

Moving-coil Transducers

- Coil moving through a magnetic field
- Output voltage is AC
- Produces or receives sound waves
- i.e. electromechanical conversion such as a moving coil, moving armature, etc.
Specific Devices

- Moving-coil loudspeaker
- Condenser microphone
- Pressure-gradient microphone
- Carbon microphone

**Moving-coil Loudspeaker**

- Diaphragm significantly larger than moving-coil improves efficiency at lower frequencies
- Smaller dome better disperses high frequencies
Other Devices

**Pressure-gradient**
- Measures pressure within and outside a piston, and subtracts the difference
- The difference is modeled as a wave function

**Carbon Microphone**
- High electrical output
- Low cost
- Durability
- Low fidelity
- Measures variations in resistance in a pocket of packed carbon granules beneath a membrane

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**Design Considerations**

- **Diffraction**
  - Low diffraction angles of incoming sound waves increases the high-frequency response by up to 6 dB
  - Solved by engineered optimal diaphragm angle and/or minimizing diameter of the diaphragm.
    - At 20 kHz this is \( r_d \leq 0.3 \text{cm} \)

- **Phase interference**
  - Pressure differences across the surface of the diaphragm cause interfering waves
  - Solved by minimizing the diameter of the diaphragm
    - At 20 kHz this is \( r_d \leq 0.2 \text{cm} \)
Design Considerations

- **Sensitivities**
  - Sensitivity is ratio of voltage to pressure expressed on a log scale
    - \( M_L = 20 \log \left( \frac{M}{M_{ref}} \right) \) where \( M \) is the sensitivity, \( M_{ref} \) is the reference (usually 1 V/Pa), and \( M_L \) is the scaled range (sensitivity)
  - Not unlike scaling for other sensors
- **Optimization:**
  - For sensitivity:
    - Large diaphragm area
    - High polarization voltage
    - Small interelectrode spacing
    - Low stiffness

Analysis

This is an example of the FFT of a sound wave
Sources


• https://en.wikipedia.org/wiki/Acoustical_measurements_and_instrumentation