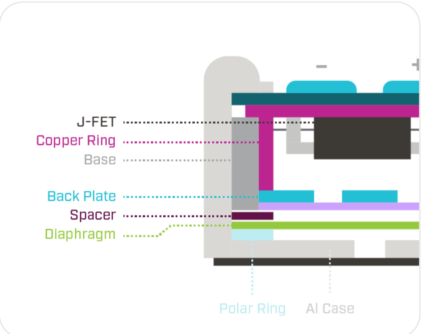
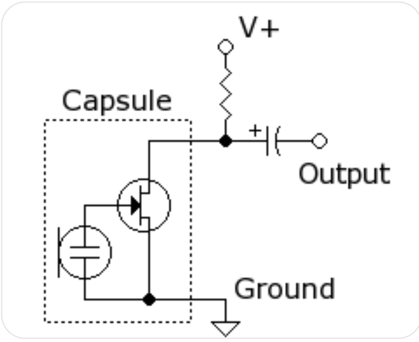
how does an electret microphone work

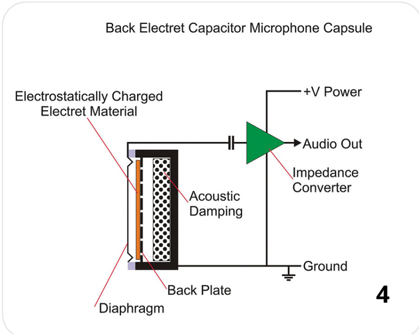
An **electret microphone** is a type of condenser (capacitor) microphone that uses a **permanently charged material** instead of requiring an external high-voltage polarization supply.

Here's how it works:

1️⃣ Basic Structure







An electret mic capsule contains:

- **Diaphragm** – a very thin, flexible membrane
- **Backplate** – a rigid metal plate behind the diaphragm
- **Electret material** – a permanently charged dielectric (usually embedded in or attached to the diaphragm or backplate)
- **Built-in FET transistor** – acts as an impedance converter

Together, the diaphragm and backplate form a **capacitor**.

2️⃣ The Key Idea: A Moving Capacitor

A capacitor's capacitance depends on:

- The area of the plates
- The distance between them

When sound waves hit the diaphragm:

- The diaphragm vibrates

- The distance between diaphragm and backplate changes
- The capacitance changes

Because the electret material holds a **permanent electric charge**, these capacitance changes produce a changing voltage — which is your **audio signal**.

3️⃣ Why It's Called "Electret"

An **electret** is like the electrical equivalent of a magnet:

- A magnet has a permanent magnetic field
- An electret has a permanent electric field

This eliminates the need for the high external polarization voltage required by traditional condenser microphones.

4️⃣ The Role of the FET (Important!)

The raw signal from the capsule has:

- Very **high impedance**
- Very **low current**

So electret microphones include a tiny built-in **Field Effect Transistor (FET)** that:

- Buffers the signal
- Lowers the output impedance
- Makes it usable by mixers, sound cards, and amplifiers

This is why electret mics still require **power (usually 1.5–10V)** — not to charge the capsule, but to power the FET.

5️⃣ Simple Step-by-Step Summary

1. Sound waves hit the diaphragm
2. Diaphragm moves
3. Capacitance changes
4. Voltage changes (due to permanent charge)
5. FET buffers the signal
6. Audio output is produced

6️⃣ Why They’re So Common

Electret microphones are used in:

- Smartphones
- Laptops
- Lavalier mics
- Headsets
- Cheap USB microphones

Because they are:

- Small
- Inexpensive

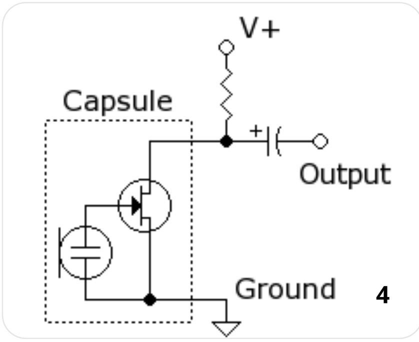
- Sensitive
- Reliable
- Low power

If you'd like, I can also explain how they compare to dynamic microphones or traditional condenser microphones.

can you explain physical details and metric for small elecetret microphone

Here are the **physical details and typical metrics** for a common small electret microphone capsule (the kind used in headsets, lav mics, laptops, and small electronics).

Typical 6 mm Electret Microphone Capsule



The most common size is **Ø6 mm × 2.2 mm** (sometimes 2.7 mm thick).

1️⃣ Physical Dimensions

🔹 Common Sizes

Diameter	Thickness	Typical Use
4 mm	1.5–2.0 mm	ultra-compact devices

Diameter	Thickness	Typical Use
6 mm	2.2–2.7 mm	most common size
9.7 mm	4–6 mm	higher sensitivity / studio style

🔹 **Diaphragm**

- Material: **Metallized PET (Mylar)**
- Thickness: **2–6 µm**
- Diameter (6 mm capsule): ~5 mm active area

🔹 **Backplate**

- Metal (usually brass or aluminum)
- Has tiny acoustic holes

2️⃣ Electrical Characteristics (Typical 6 mm Capsule)

Parameter	Typical Value
Operating voltage	**1.5 – 10 V** (2 V typical)
Current consumption	**0.1 – 0.8 mA**
Output impedance	**1–2.2 kΩ**
Sensitivity	**–44 dBV/Pa** (common)
Frequency response	**20 Hz – 20 kHz** (usable 100 Hz–10 kHz typical)
Max SPL	**100–120 dB SPL**
Signal-to-noise ratio	**58–70 dB**
Self-noise	**24–36 dBA**

3️⃣ What –44 dBV/Pa Actually Means

Sound pressure reference:

- 1 Pa = 94 dB SPL

If sensitivity = −44 dBV:

$$10^{-44/20} \approx 6.3\,mV$$

So at **94 dB SPL**, the mic outputs about:

👉 **6.3 mV RMS**

At normal speech (~70 dB SPL):
👉 Around **1 mV RMS**

4️⃣ Internal FET Details

Inside the capsule is a tiny **JFET**:

- Usually common-source configuration
- Drain connected to V+ through resistor
- Source is output
- Bias resistor typically **2.2 kΩ**

Typical bias circuit:

```
Vcc (2V–5V)
    |
   2.2kΩ
    |
    +---- Audio Out
    |
   Mic
    |
   GND
```

5️⃣ Acoustic Characteristics

Polar Pattern

Most small capsules are:

- **Omnidirectional** (pressure type)

Cardioid versions exist but require rear acoustic ports.

Resonance

Typical diaphragm resonance:

- 8–15 kHz

This causes a slight treble boost.

6️⃣ Mechanical Construction Layers (Front to Back)

1. Protective metal mesh
2. Diaphragm (charged electret film)
3. Air gap (~20–50 µm)
4. Backplate
5. Insulating spacer
6. JFET transistor
7. Metal housing (ground)

7️⃣ Why Small Capsules Have Limited Bass

Because they are pressure microphones:

- Small diaphragm area
- Limited low-frequency displacement
- Often roll off below 100 Hz

Large 9.7 mm capsules capture bass better.

8️⃣ Comparison of Sizes

Feature	4 mm	6 mm	9.7 mm
Sensitivity	Lower	Medium	Higher
Noise	Higher	Medium	Lower
Bass response	Weak	Moderate	Good

Feature	4 mm	6 mm	9.7 mm
Cost	Low	Low	Moderate

9️⃣ Practical Design Notes

If you're designing with one:

- Use **2.2 kΩ bias resistor** for 3–5 V systems
- Add **1–10 µF coupling capacitor**
- Keep leads short (high impedance)
- Shield cable to reduce noise

If you'd like, I can also:

- Derive the capacitor equation with real numbers
- Show how to calculate gain for an amplifier stage
- Compare electret vs MEMS microphone specs
- Help you select one for a specific project

What are you building?