

Technology

Macro-Microphony – clearly explained

Wherever inductors, capacitors and resistors are at work, conductors lie very close to each other. The music signal flows through them as alternating current; their magnetic and electric fields interact. These fields exert forces – in the inductor via the Lorentz force, in the capacitor via an electric field between the foils. That's where the story of macro-microphony begins: windings and foils are set into mechanical vibration. This motion is small (from micrometres up to millimetres), but it has a double effect – as mechanical energy loss and as microphonic modulation of the signal.

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Why forces arise at all Inductor
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Two consequences – both
audible

What about resistors?

Conclusion

Glossary – short & helpful

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Why forces arise at all

Inductor (magnetic field & Lorentz force). Current in a conductor creates a magnetic field. When conductors lie close and parallel, their fields push the conductors sideways. This lateral force is the Lorentz force – roughly described by $\mathbf{F} \approx \mathbf{I} \cdot \mathbf{L} \times \mathbf{B}$: current (I) over conductor length (L) in a magnetic field (B). The more current and the tighter the winding, the more strongly the field forces "pluck" at the conductors.

Capacitor (electrical field). Between the metal plates there is an electrical field that pulls the foils together. You can see the relationship in $\mathbf{C} = \epsilon \cdot \mathbf{A} / \mathbf{d}$: the capacitance (C) increases as the distance (d) becomes smaller. If the foils move even minimally, the capacitance "breathes" with them.

Two consequences – both audible

(1) Mechanical losses.

Part of the useful electrical energy ends up as motion and heat instead of accelerating the loudspeaker diaphragm. Audible result: less fine detail, slowed attack, weaker microdynamics.

(2) Microphonic modulation.

Motion in the structure changes electrical parameters over time:

- In the capacitor, the foil spacing fluctuates → **C(t)** (capacitance becomes a function of time).
- In the inductor the motion of the conductors in the magnetic field generates an induced voltage: $\mathbf{u}_{\text{ind}} \approx \mathbf{B} \cdot \mathbf{I} \cdot \mathbf{v}$ – magnetic field (B), effective conductor length (I), velocity of motion (v).

This is the same principle as in a dynamic microphone (movingcoil). The capacitor behaves analogously to a condenser microphone: when **d** "breathes", **C(t)** modulates the signal.

Sum of these effects: fine noise, crackle, distortion and small resonance combs are picked up microphonically and added to the music signal. They overlay the original signal, mask details, blur spatial cues and make sibilants sound unnaturally prominent.

What about resistors?

Simple Wirewound resistors contain a small inductor of their own (the wire is wound into a coil). Here too, field forces can excite motion; the principle is the same as in an inductor – just weaker. Film / metalfilm resistors show small resistance changes under mechanical stress (piezoresistive effects) – in practice usually much smaller, but measurable in sensitive test setups.

Conclusion

Macro-Microphony is applied field and solidstate physics on the micro to millimetre scale. Wherever currents, fields and elastic structures meet, forces, energy losses and microphonic interference voltages arise.

Anyone who thinks of components not only electrically but electromechanically can extract more music from identical schematics – with a blacker background, crisper transients, a more stable soundstage and more natural sibilants.

"Crossover transition region – why small modulations have a big impact".

Our goal: The component stays still – the music speaks.

Glossary – short & helpful

- **Lorentz force:** Force on a currentcarrying conductor in a magnetic field (experienced in an inductor as "side pressure" between conductors).
- **Capacitance C / C(t):** Storage capability of a capacitor; **C(t)** means it changes over time when the foil spacing "breathes".
- **Inductance L / L(t):** "Inertia" of current in an inductor; **L(t):** minimal timevariation caused by conductor motion.
- **u_ind:** Induced voltage generated by the motion of conducting parts in a magnetic field (principle of the dynamic microphone).
- **Eigenmode:** Preferred mode of vibration / natural resonance of a component (often in the audio band → can couple into the signal)