Elektrostatikk / mikrofon

- Materiale fra
- Fraden 3.1 – Elektrostatikk
- Fraden 3.2 – Kapasitans
- Fraden 12.15 – Electret microphone
- Fraden 12.2 – Condencer microphone
- Brüel & Kjær (www.bk.dk)
- Fraden 3.10 – Desibel skalaen

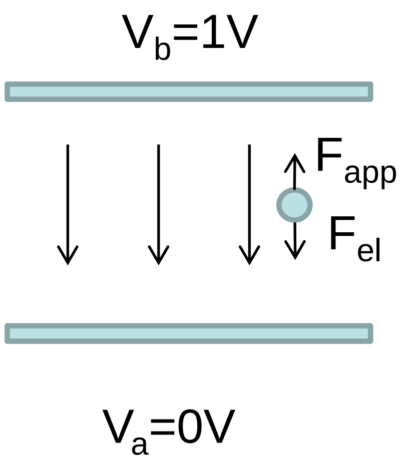
Elektrisk felt og spenning

$$\varepsilon_0 \oint \mathbf{E}\, ds = q\,,$$

$$\vec{F} = q\vec{E}$$

$$V_B - V_A = +\frac{W_{AB}}{q_0}. \qquad (3.14)$$

$$= \frac{1}{q}\int_A^B \vec{F}_{app} \cdot d\vec{r} = -\frac{1}{q}\int_A^B \vec{F}_{el} \cdot d\vec{r} = -\int_A^B \vec{E} \cdot d\vec{r}$$



Feltfordeling

$$E = \frac{\lambda}{2\pi \varepsilon_0 r},$$

$$E = \frac{\sigma}{2\varepsilon_0},$$

$$E = \frac{1}{4\pi \varepsilon_0} \frac{q}{r^2},$$

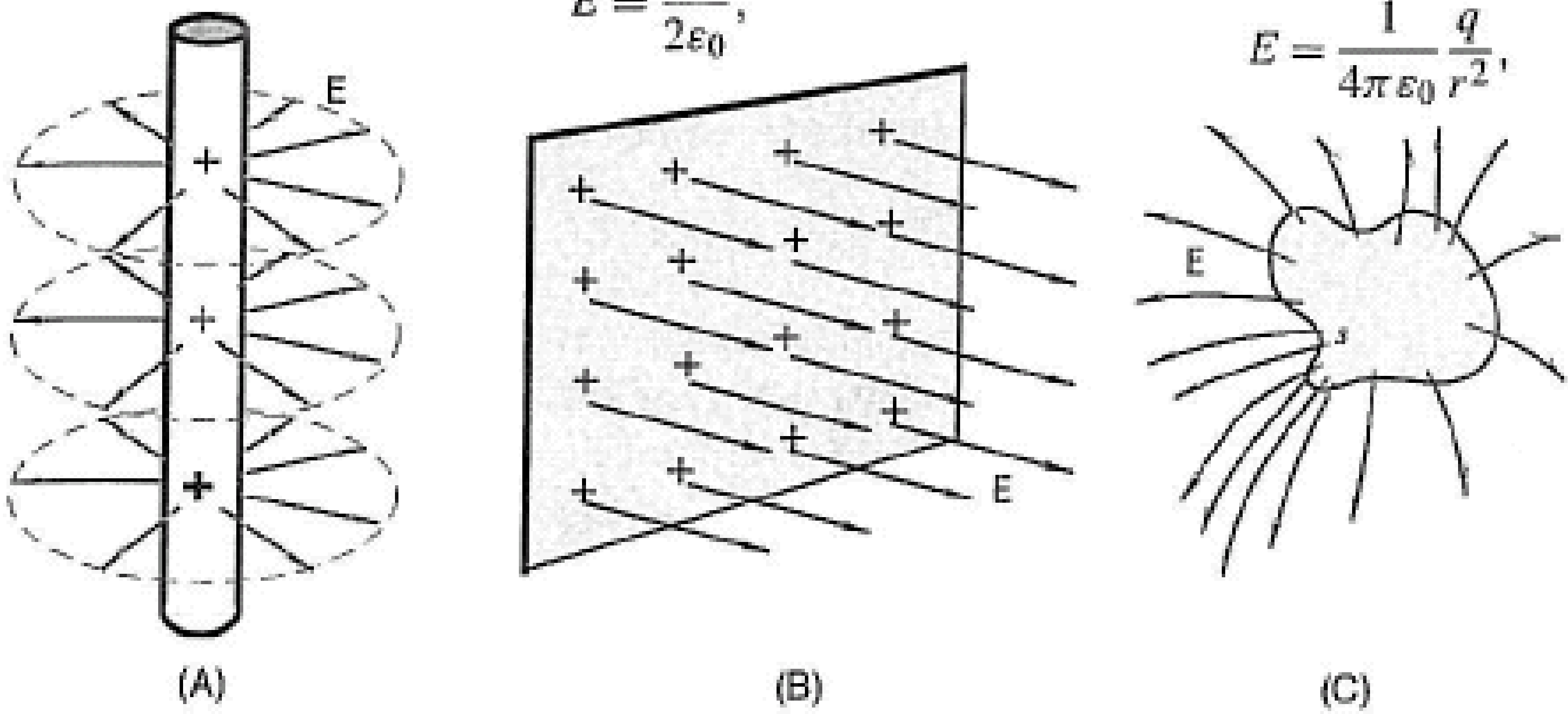
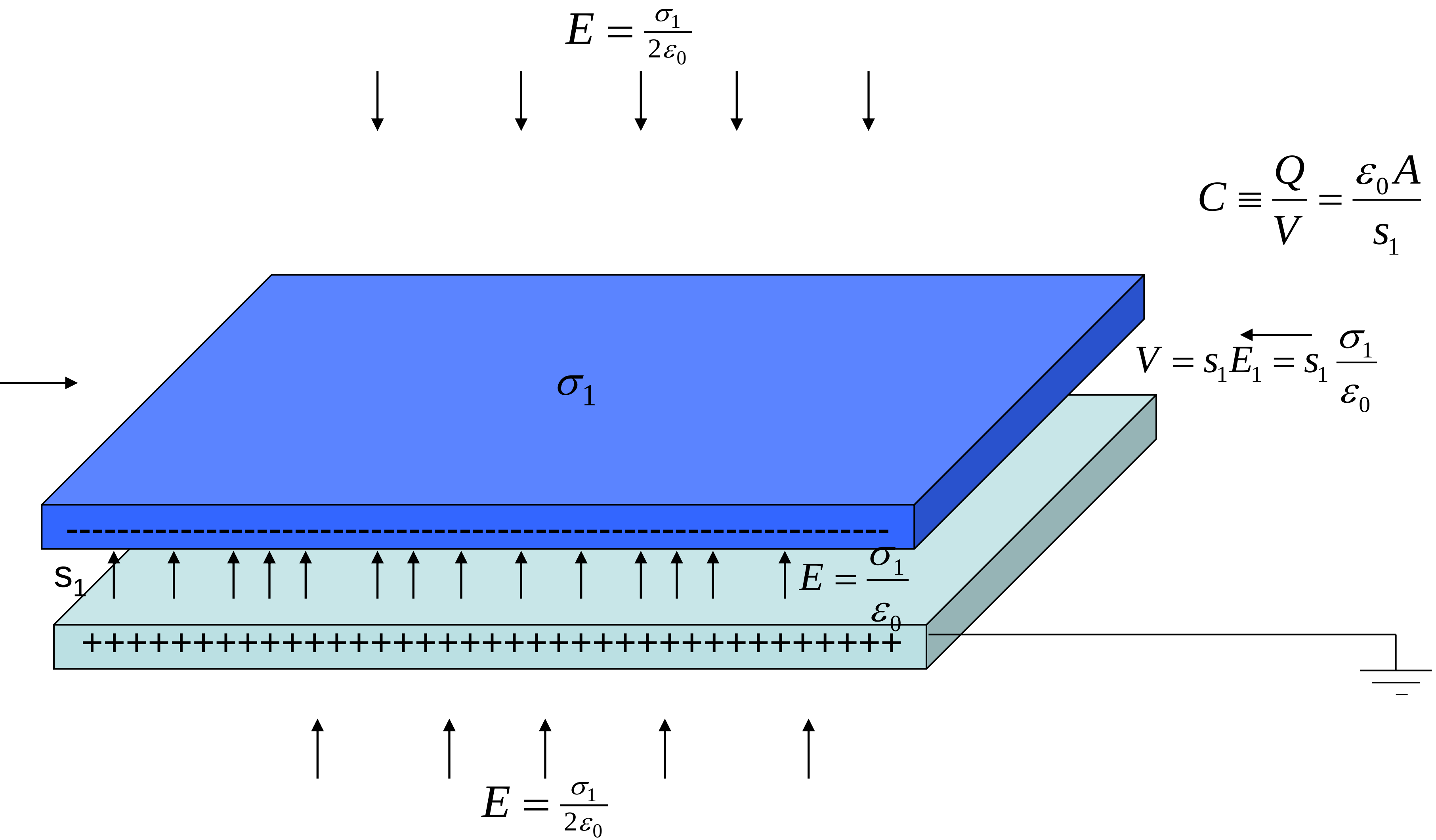


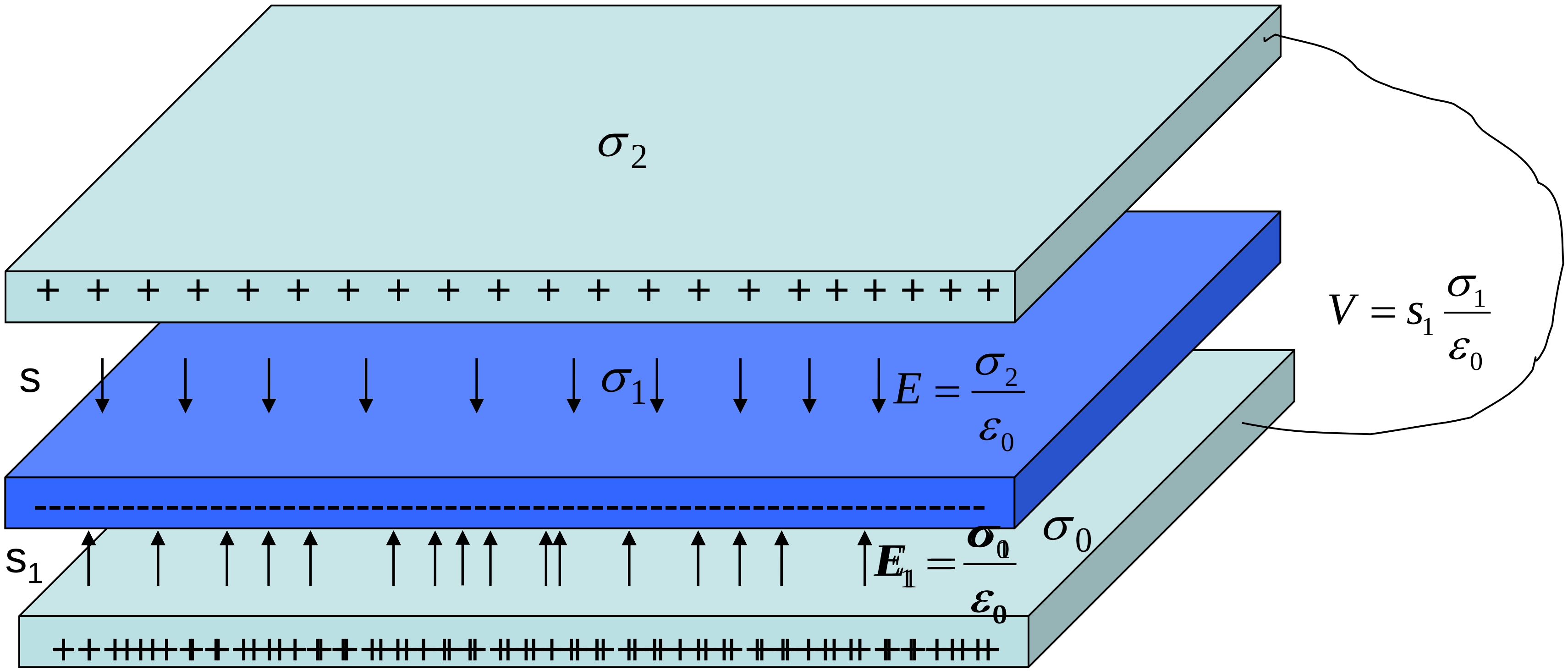
Fig. 3.2. Electric field around an infinite line (A) and near an infinite sheet (B). A pointed conductor concentrates an electric field (C).

Charged plates



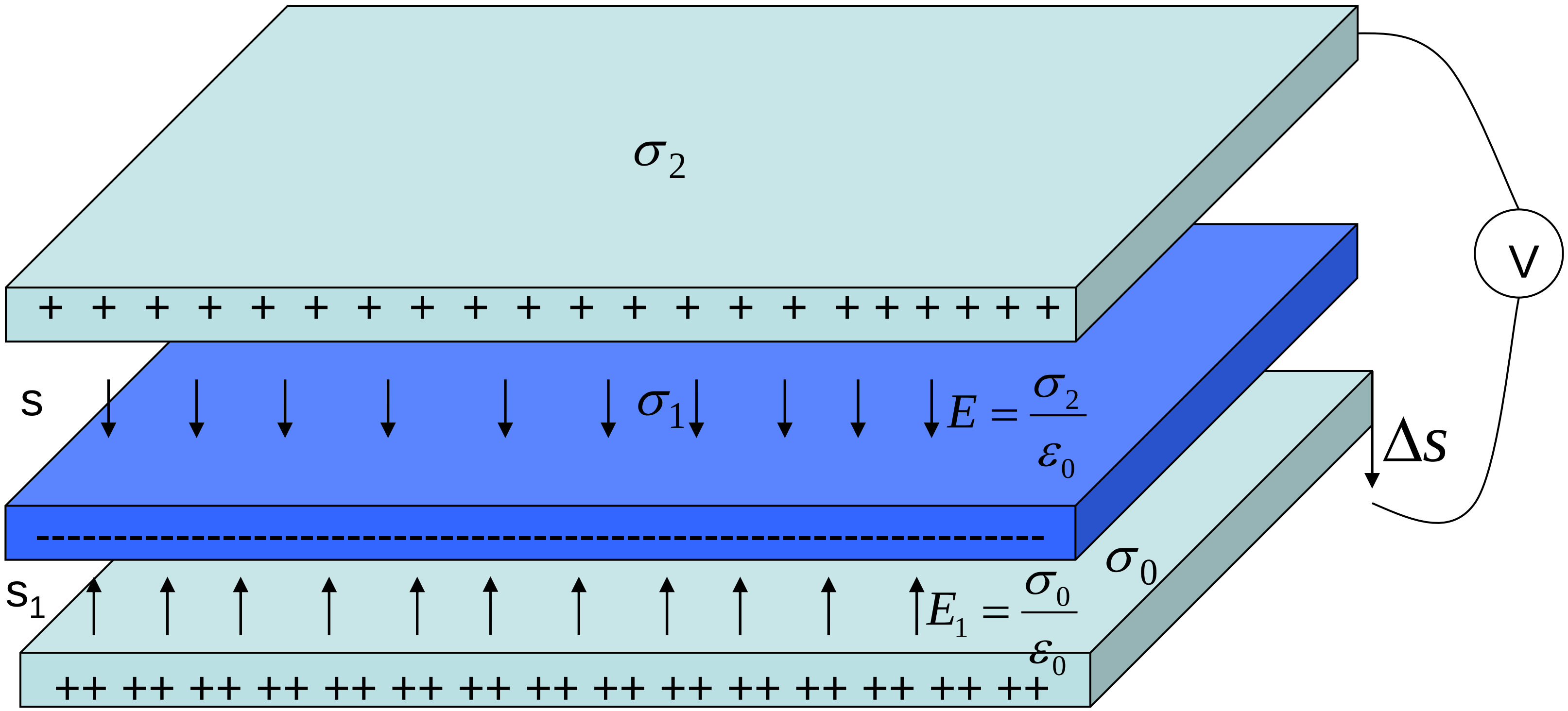
Adding a third plate

$$E_1 s_1 = Es \quad \Rightarrow \quad E_1 = \frac{\sigma_0 s}{\varepsilon_0 (s + s_1)}$$



Disconnecting and moving the plate

$$E_1 s_1 = E s \quad \Rightarrow \quad E_1 = \frac{\sigma_0 s}{\varepsilon_0 (s + s_1)}$$

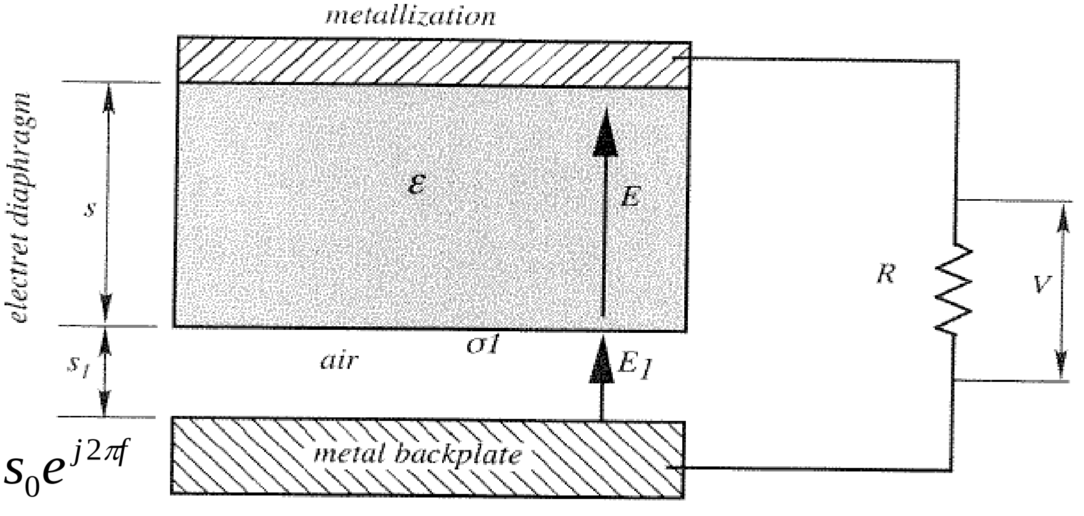


$$\frac{\sigma_0}{\varepsilon_0 (s + s_1)} \Delta s$$

(12.2)

Feeding a load

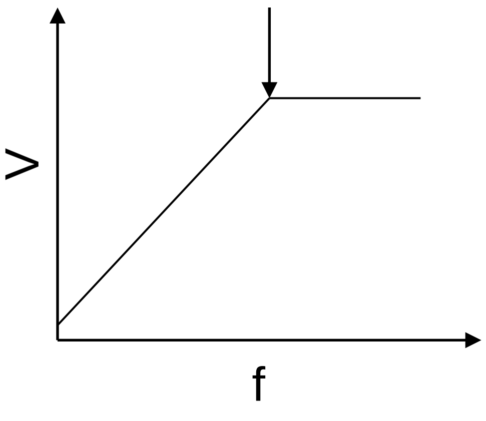
$$V = \frac{s\,\Delta s}{\varepsilon_0 (s + \varepsilon s_1)} \frac{2\pi f RC}{\sqrt{1 + (2\pi f RC)^2}}, \qquad (12.3)$$



$$\Delta s = s_0 e^{j2\pi f}$$

Fig. 12.6. General structure of an electret microphone. The thicknesses of layers are exagge for clarity. (After Ref. [9].)

$$f = \frac{1}{2\pi RC}$$



Construction

Stabil:

Billig (mobiltelefoner etc):

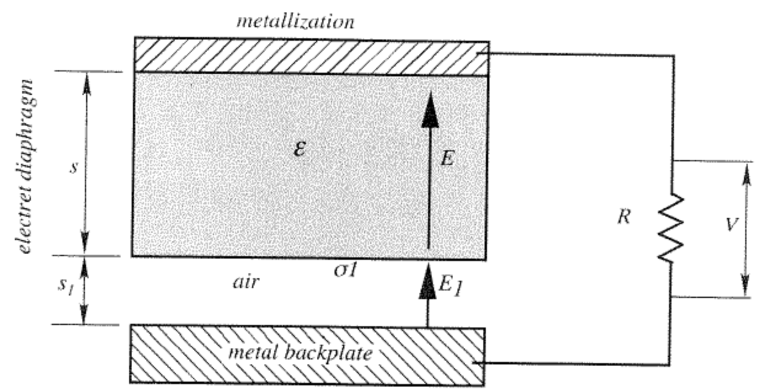
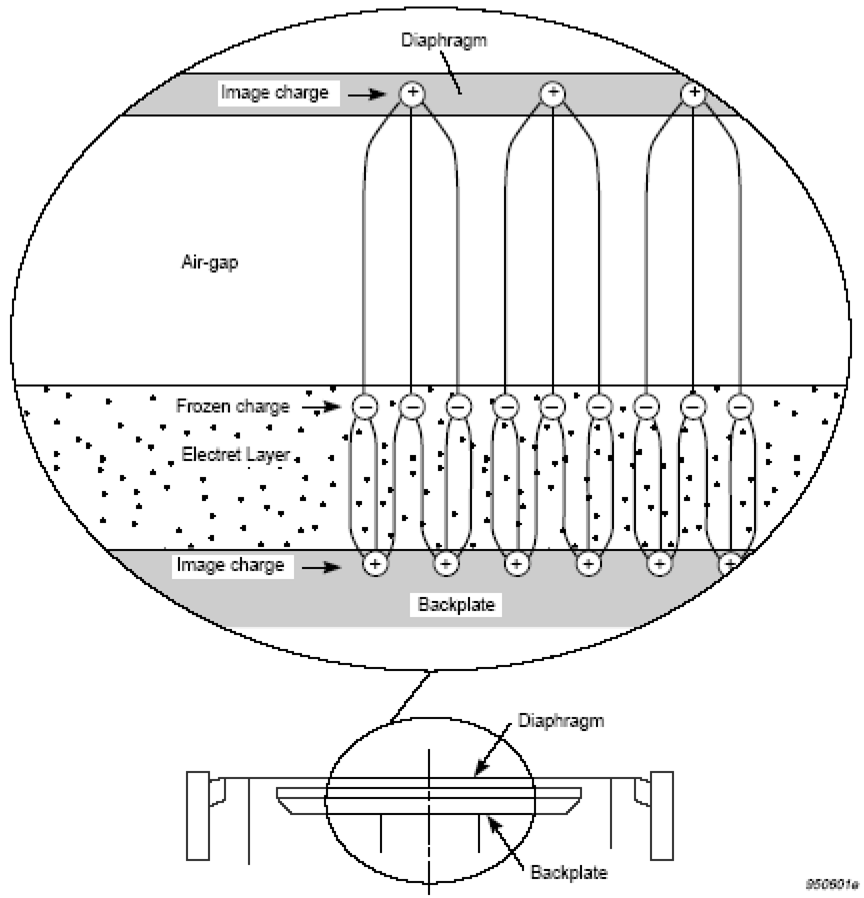


Fig. 12.6. General structure of an electret microphone. The thicknesses of layers are exagge for clarity. (After Ref. [9].)



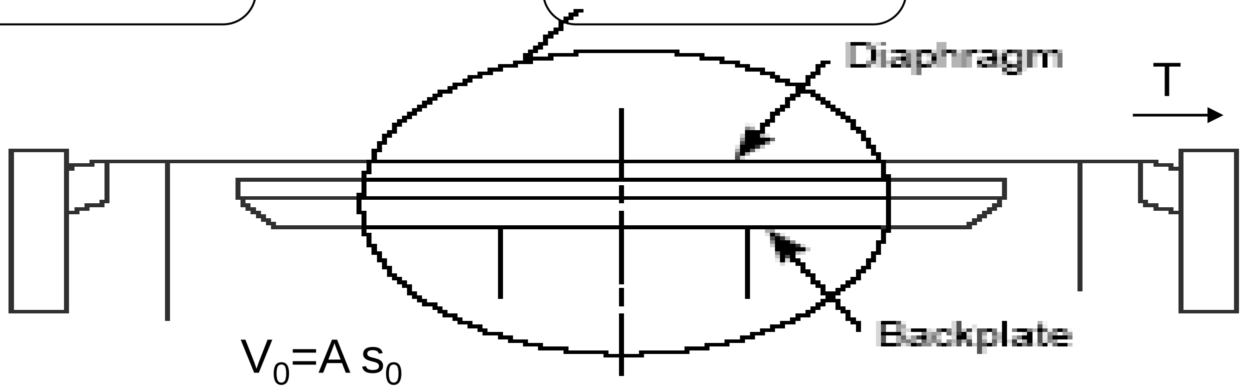
Brüel og Kjær

Sensitivity

$$\Delta s = \frac{\Delta p}{(\gamma p_0/s_0) + (8\pi T/A)}, \qquad (12.4)$$

Compression of air

Membrane tension

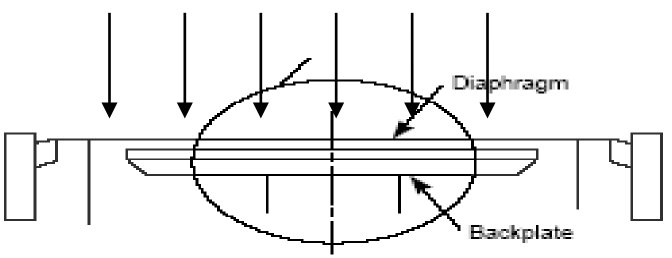


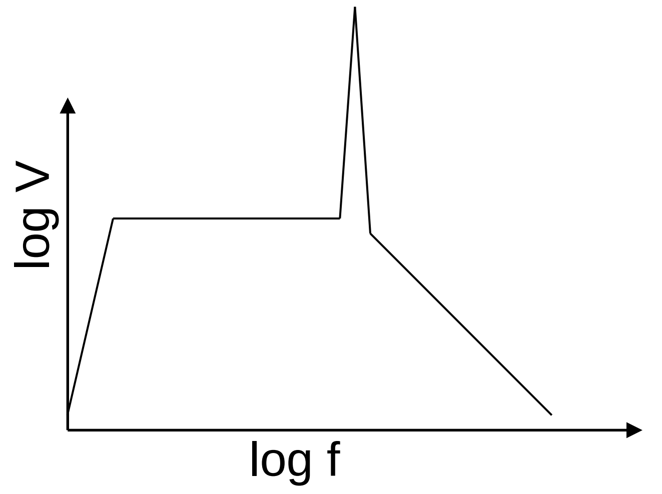
Frequency response

Low tension only

$$fr = \frac{1}{2\pi}\sqrt{\frac{p_0}{s_0 M}}. \qquad (12.6)$$

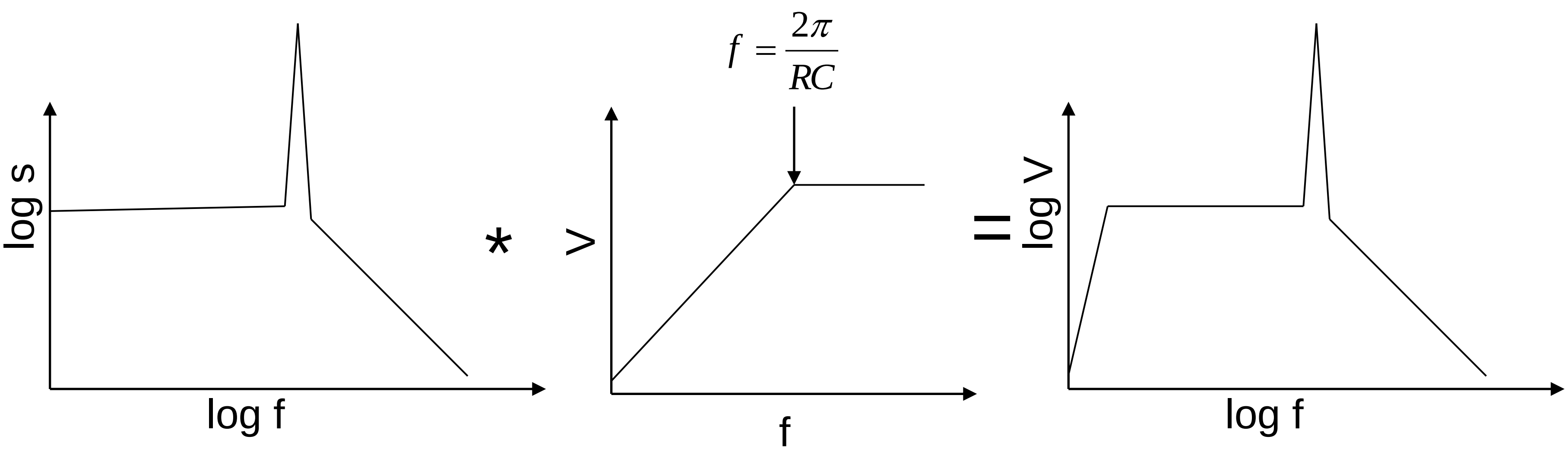
$$\Delta p = s_0 e^{j2\pi f}$$





Transfer functions

$$f r = \frac{1}{2\pi}\sqrt{\frac{p_0}{s_0 M}}.$$



Pressure ⇒ Displacement Displacement ⇒ Voltage Pressure ⇒ Voltage

Response examples

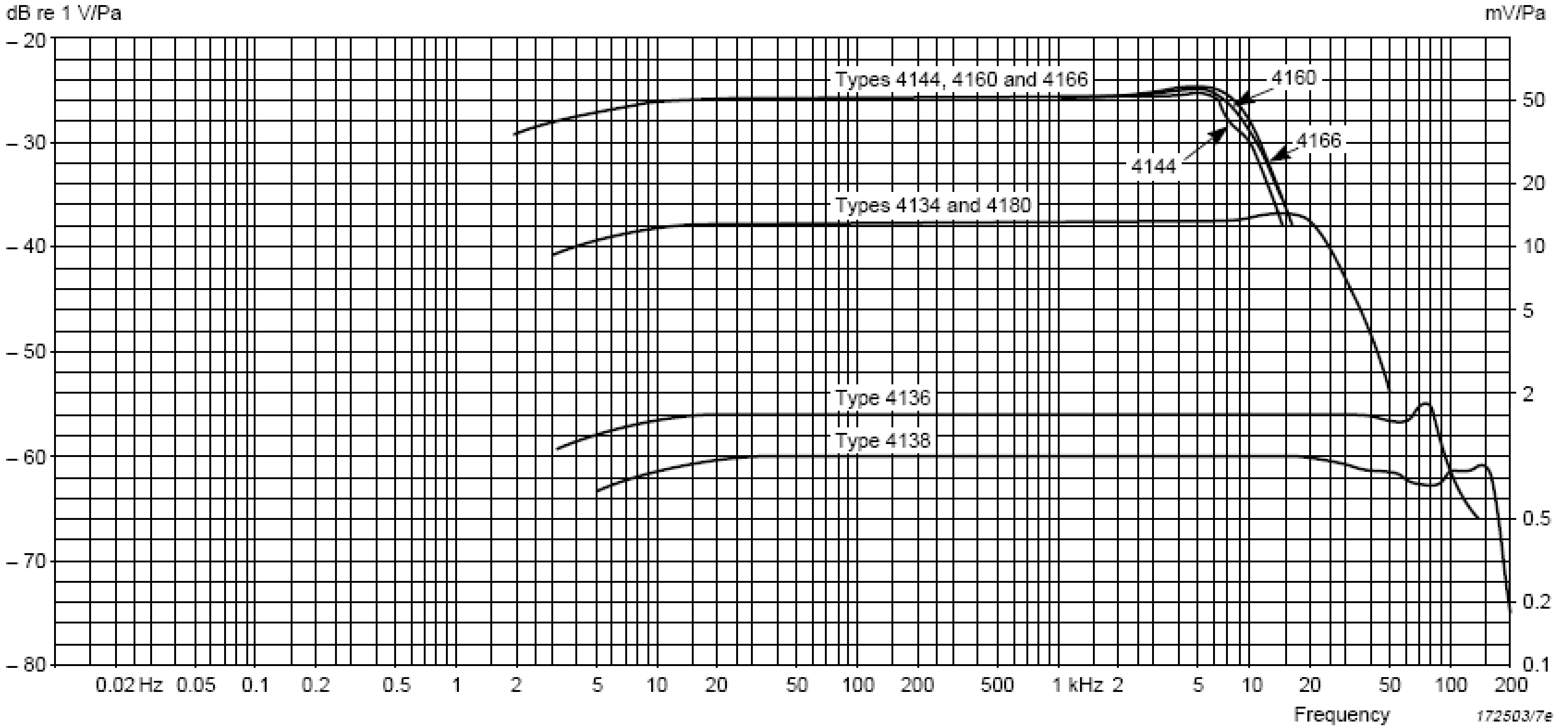


Fig. 7 Typical frequency responses of the different pressure response microphones recorded by means of the electrostatic actuator method

http://www.bksv.com/pdf/Bp0100.pdf

Electret microphones

- Are passive
  - Can harvest energy
- No DC response (S(f=0)=0)
- Two main variants:
  - Electret diaphragm
    - Cheap
    - Stiffness dominated by back volume
  - Electret backplate
    - Stable
    - Stiffness dominated by membrane tension
- Can be used in reverse

  -> Electrostatic loudspeakers

  Are linear (p~V)

dB scale

$$\Pi = 20\log_{10}\left(\frac{p}{p_0}\right),$$

20 µPa

$$\beta = 10\log_{10}\left(\frac{I}{I_0}\right)$$

10^{-12}W/m^2

$$I_0 = \frac{{p_0}^2}{Z}$$

Acoustic Impedance of Air: $415\ \frac{Pa}{m/s}$

Table 3.3. Sound Levels (β) Referenced to I_0 at 1000 Hz

Sound Source	dB	
Rocket engine at 50 m	200	2 bar
Supersonic boom	160	
Hydraulic press at 1 m	130	
Threshold of pain	120	
10-W Hi-Fi speaker at 3 m	110	
Unmuffled motorcycle	110	
Rock-n-roll band	100	2 Pa
Subway train at 5 m	100	
Pneumatic drill at 3 m	90	
Niagara Falls	85	
Heavy traffic	80	
Automobiles at 5 m	75	
Dishwashers	70	
Conversation at 1 m	60	
Accounting office	50	
City street (no traffic)	30	
Whisper at 1 m	20	
Rustle of leaves	10	
Threshold of hearing	0	20 µPa

Kondensator mikrofon

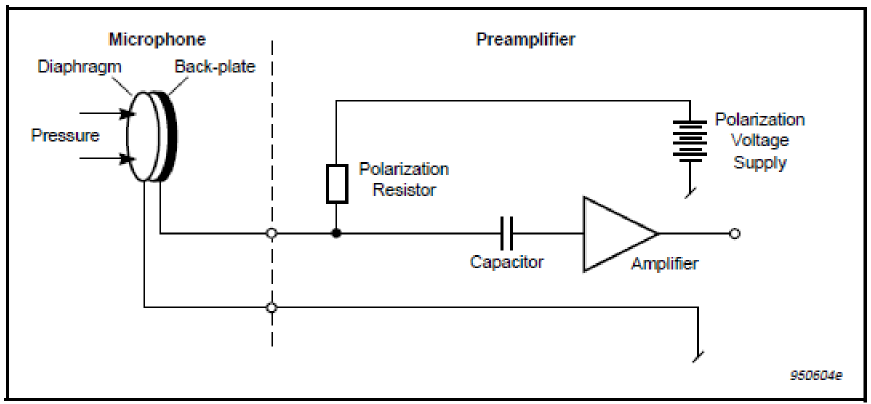
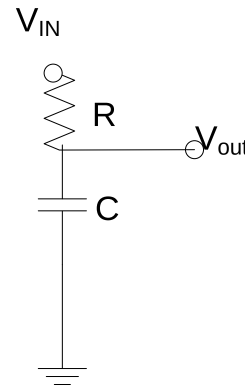


Fig. 2.3 Capacitive Transduction Principle. The constant electrical charge used for polarization is supplied from an external source



Over knekkfrekvensen $\frac{1}{2\pi RC}$

er ladningen: $Q_0 = \frac{V_{in}}{C_0}$

Spenningen ut blir da:

$$V_{out} = Q_0 C = \frac{V_{in}}{C_0} C = V_{in} \frac{C}{C_0}$$

Kondensator målemikrofon

- Omtrent samme konstruksjon som en elektret mikrofon med elektret bakplate

+ Bedre stabilitet fordi den ikke mister ladning

- Trenger spenningskilde