ECE3204 Lecture 2

Review:
- KVL/KCL
- Nodal Analysis
- Superposition
- Thevenin

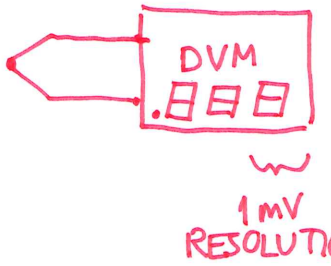
Transducers

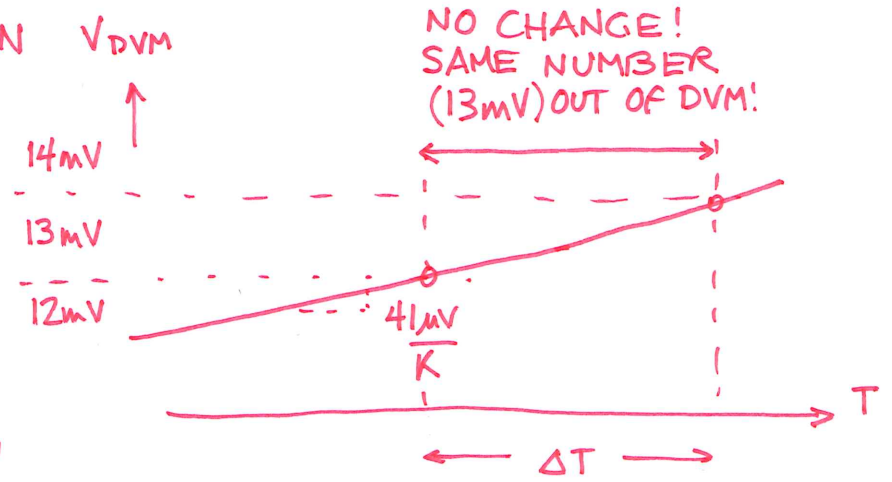
Why Amplify?

Ideal Op-Amp

① SIGNAL GAIN

THERMOCOUPLE



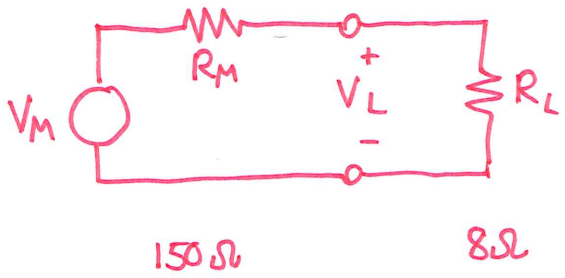


$$\frac{41\,\mu V}{K} = \frac{1mV}{\Delta T} \Rightarrow \Delta T = \frac{1mV}{41\mu V/K} = 24\,K$$

SCALE SIGNAL RANGE TO MATCH MEASUREMENT

② POWER GAIN

CONNECT MICROPHONE TO SPEAKER



WHAT V_L FROM V_M?

FROM VOLTAGE DIVIDER:

$$V_L = V_M\left(\frac{R_L}{R_M + R_L}\right)$$

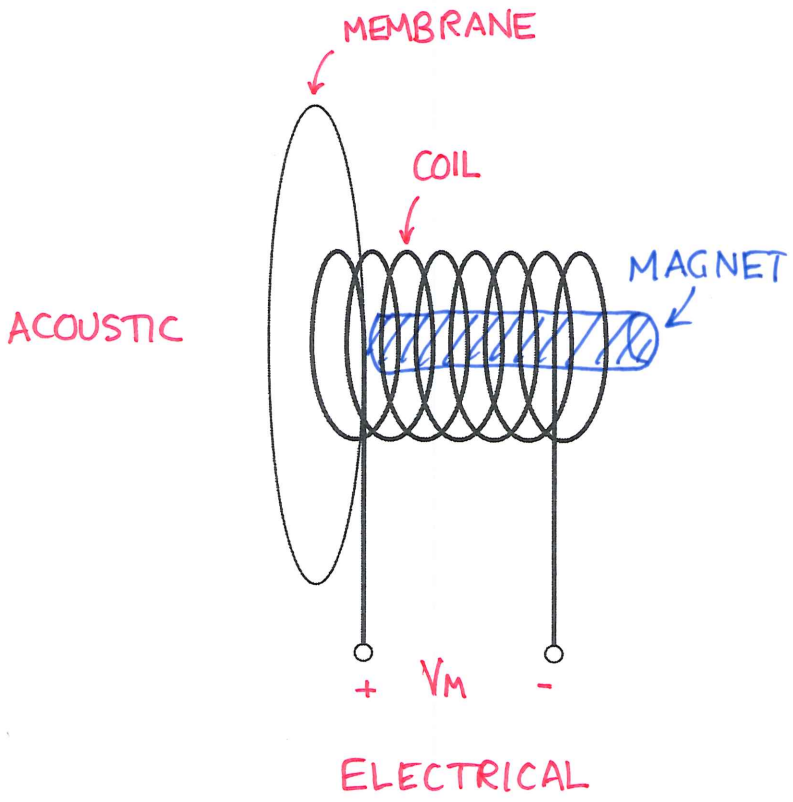
$$= V_M\underbrace{\left(\frac{8\Omega}{150\Omega + 8\Omega}\right)}_{0.05}$$

AVOID VOLTAGE DROP ACROSS SOURCE RESISTANCE

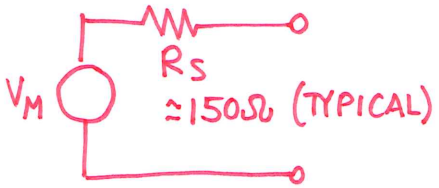
DRIVE ALL OF SIGNAL TO R_L

ECE3204: Transducers

MICROPHONE



Equivalent Circuit Model:



HOW BIG?

~10mV pk

HOW FAST?

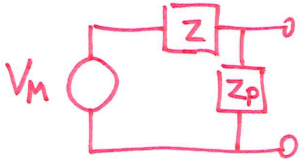
AUDIO: 20 Hz – 20 KHz

ULTRASOUND

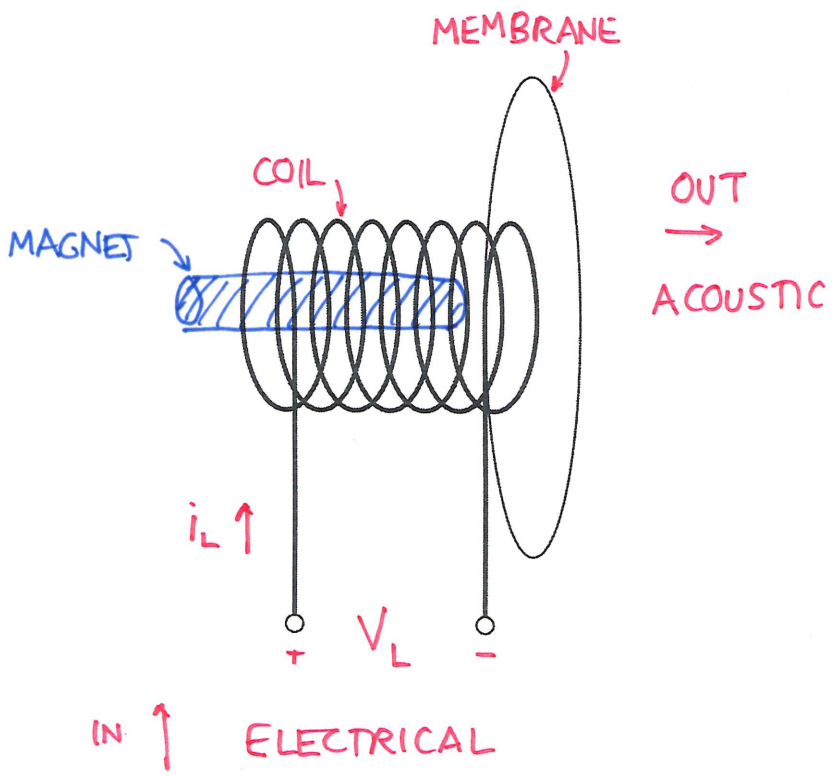
UP TO 1 MHz

CAPACITIVE, PIEZOELECTRIC

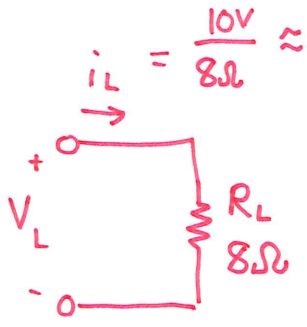
SAME MODEL



SPEAKER



Equivalent Circuit Model:



AMPLIFIER DRIVING R_L MUST BE ABLE TO PROVIDE i_L

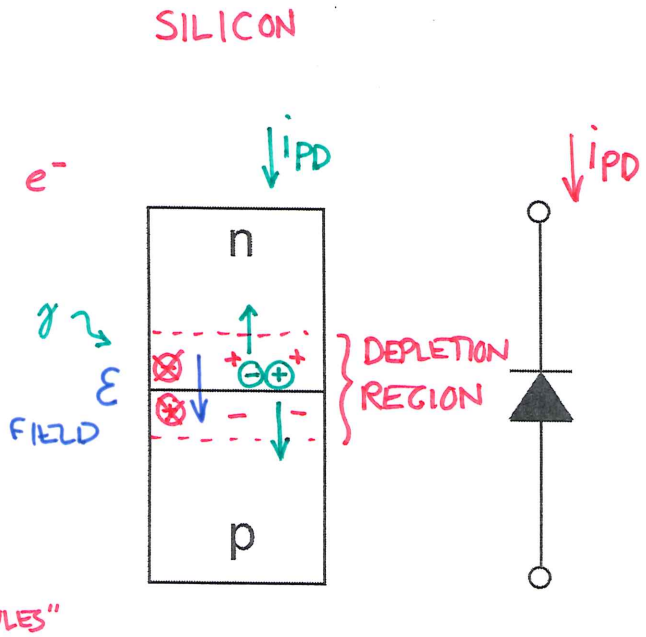
HOW BIG? DEPENDS ON POWER

10V rms IN: $P_L = \frac{V_L^2}{R_L} = \frac{(10V)^2}{8\Omega} \approx 12\,W$

HOW FAST?

AUDIO 20 Hz - 20 kHz

PHOTODIODE



LIGHT ENERGY PHOTON γ

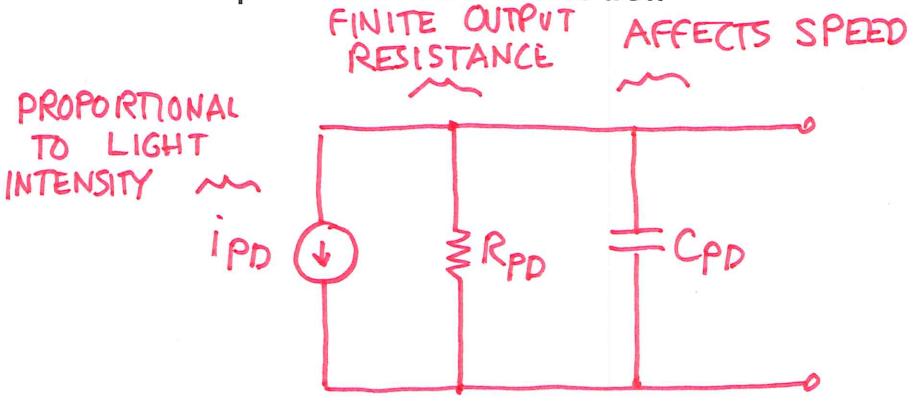
CREATE e^- HOLE PAIR

SEPARATED BY $\mathcal{E}$ FIELD

$\Rightarrow$ CURRENT i_{PD}

MORE PHOTONS $\rightarrow$ MORE i_{PD}

Equivalent Circuit Model:

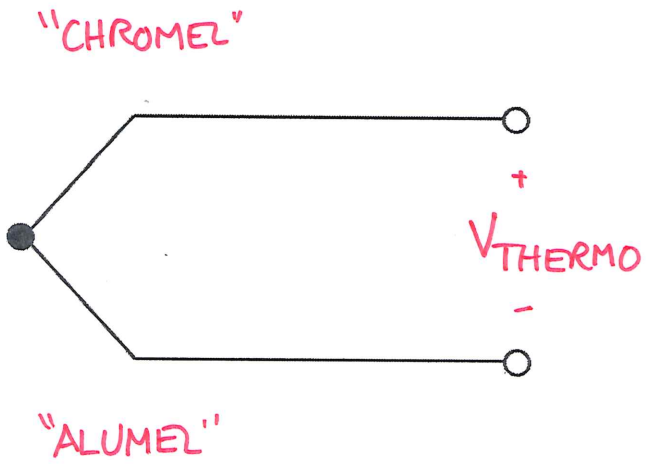


	SOLAR PANEL	OXYGEN SENSOR	OPTICAL DATA COMM
HOW BIG?	10 A	1nA	1μA
HOW FAST?	1 sec $\downarrow$ 1 day	1-100 Hz	GHz

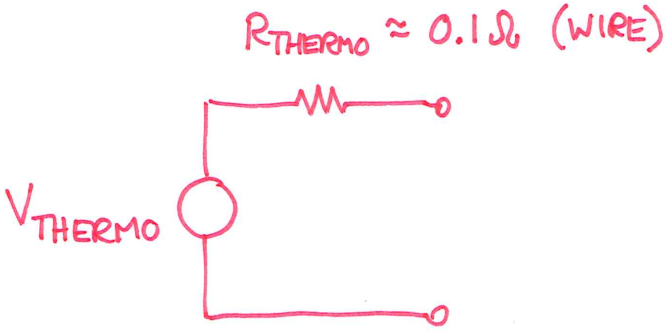
C_{PD} NOT MUCH OF A PROBLEM!

THERMOCOUPLE

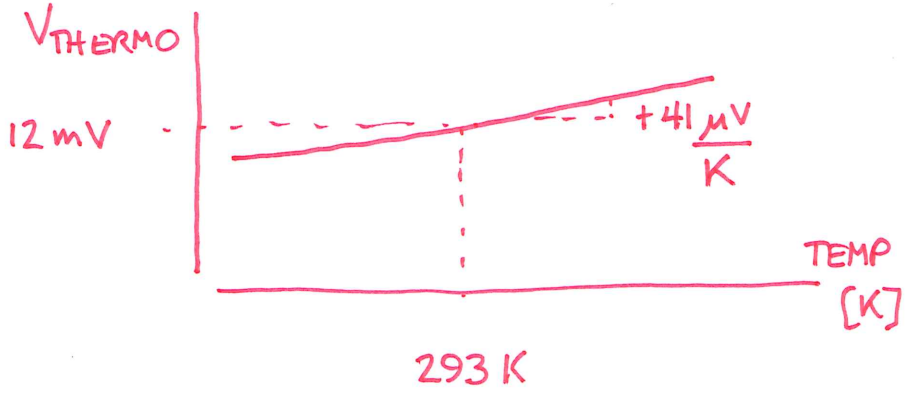
DIFFERENT MATERIALS



Equivalent Circuit Model:



HOW BIG? NOT VERY BIG!

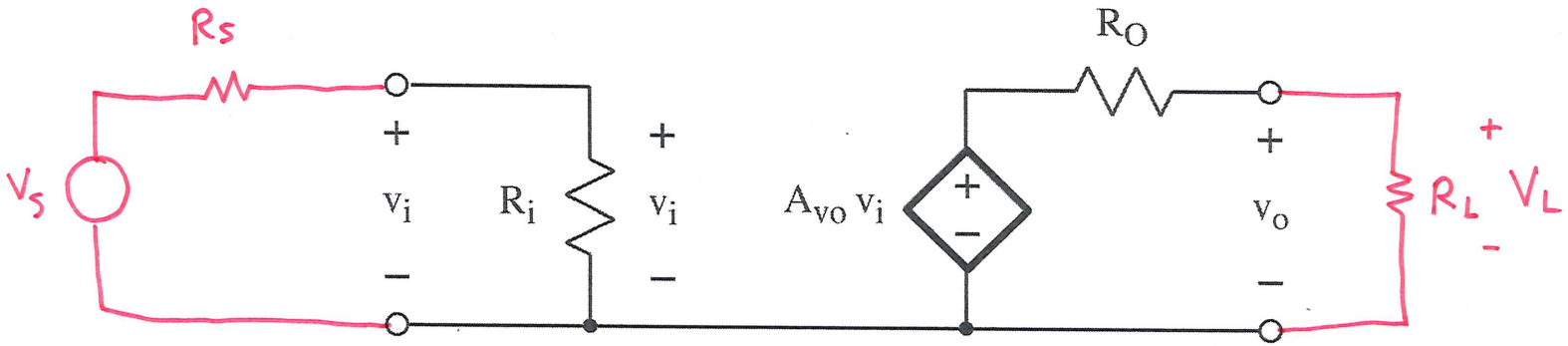


GENERAL AMPLIFIER MODEL

INPUT RESISTANCE R_i

OPEN-CIRCUIT VOLTAGE GAIN A_{VO}

OUTPUT RESISTANCE R_O



DEPENDENT SOURCE

$$V_i = V_s\left(\frac{R_i}{R_s + R_i}\right)$$

$$V_L = A_{VO}\, V_i\left(\frac{R_L}{R_o + R_L}\right)$$

$$V_L = V_s\underbrace{\left(\frac{R_i}{R_s + R_i}\right)}_{\to 1} A_{Vo}\underbrace{\left(\frac{R_L}{R_o + R_L}\right)}_{\to 1}$$

$R_i \gg R_s$ $\qquad$ $R_o \ll R_L$

IDEAL: $\quad R_i \to \infty \qquad R_o \to 0$