Bioelectric Amplifiers

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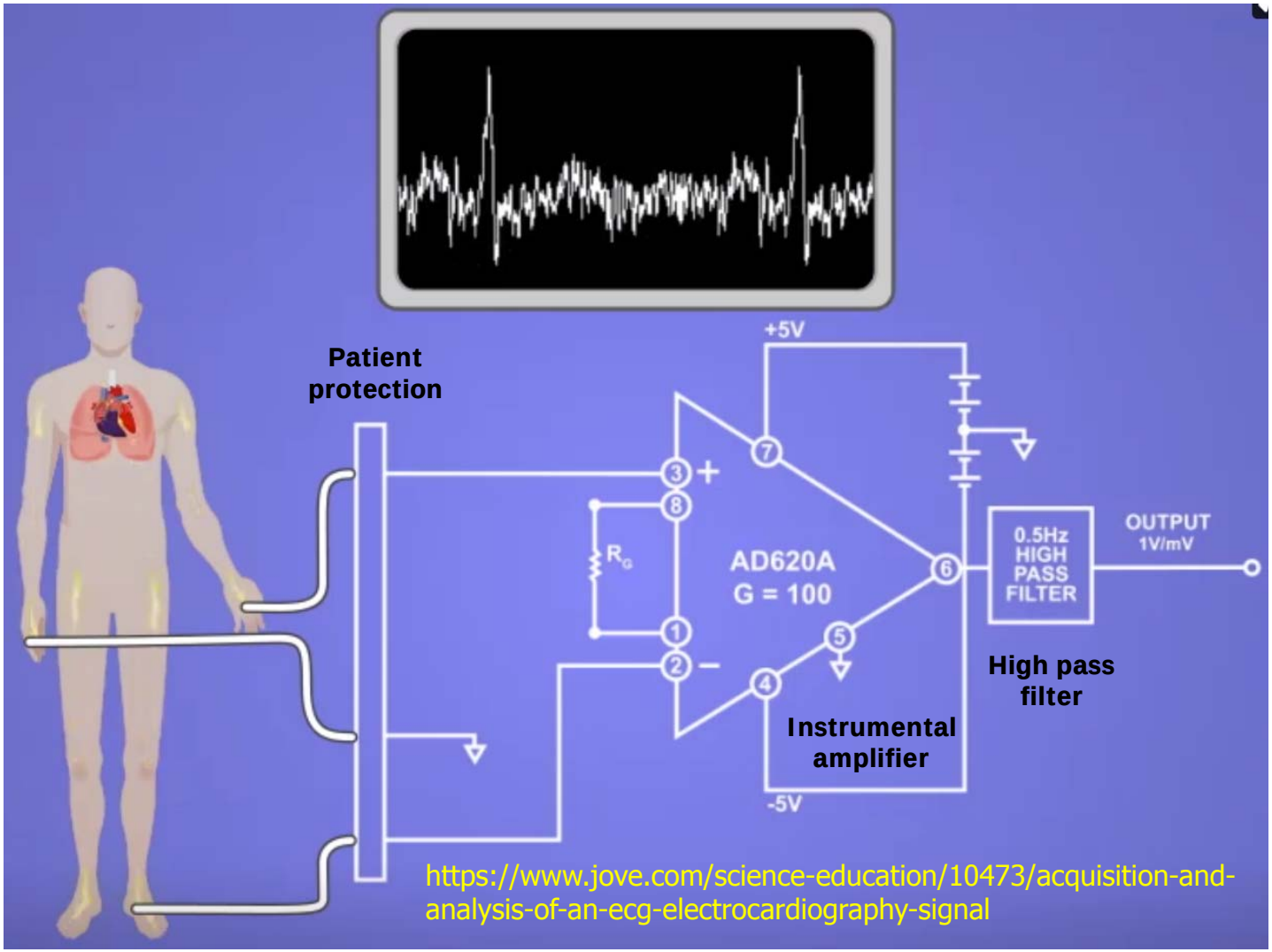
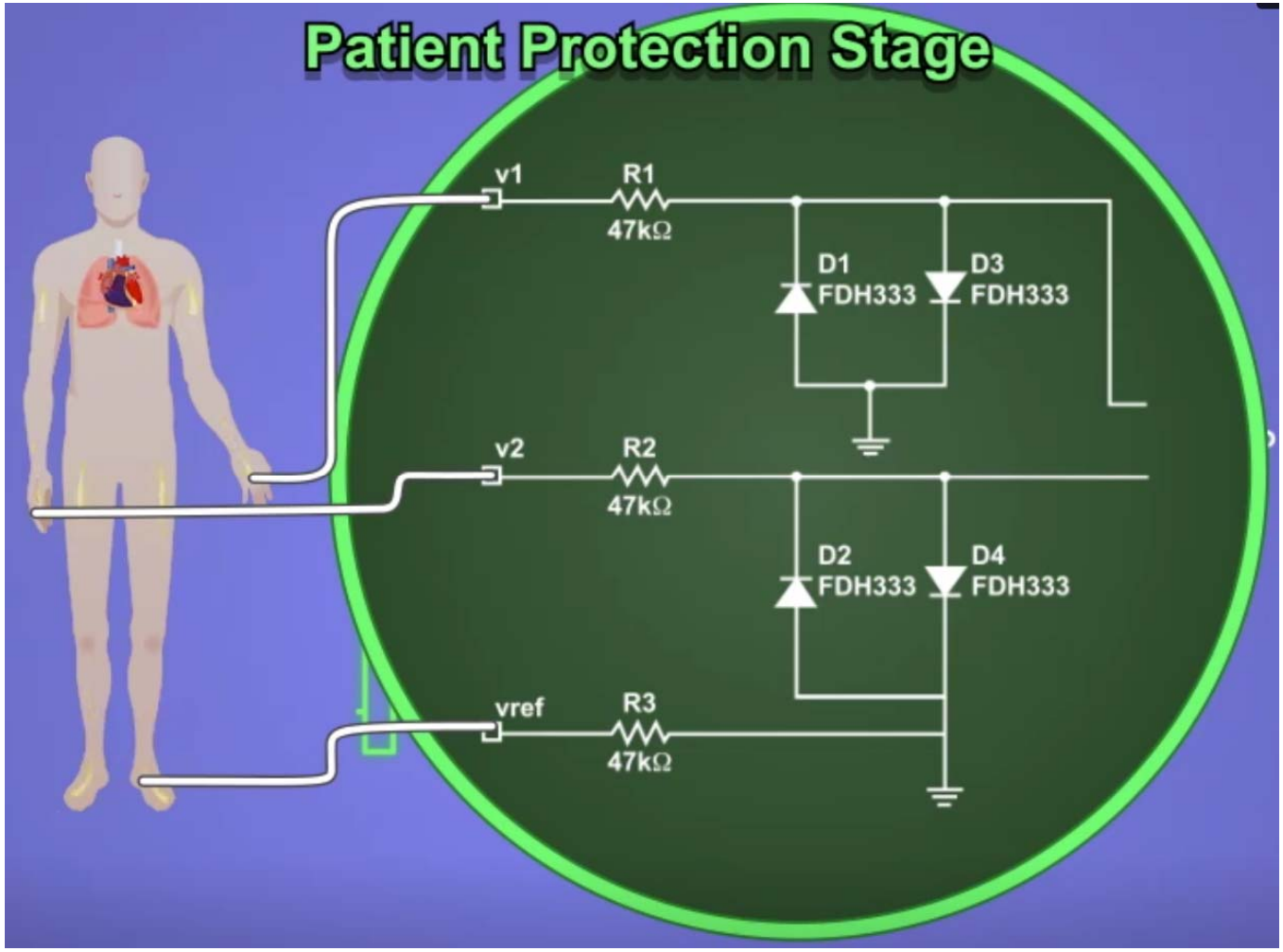
Acquisition and analysis of an ECG signal

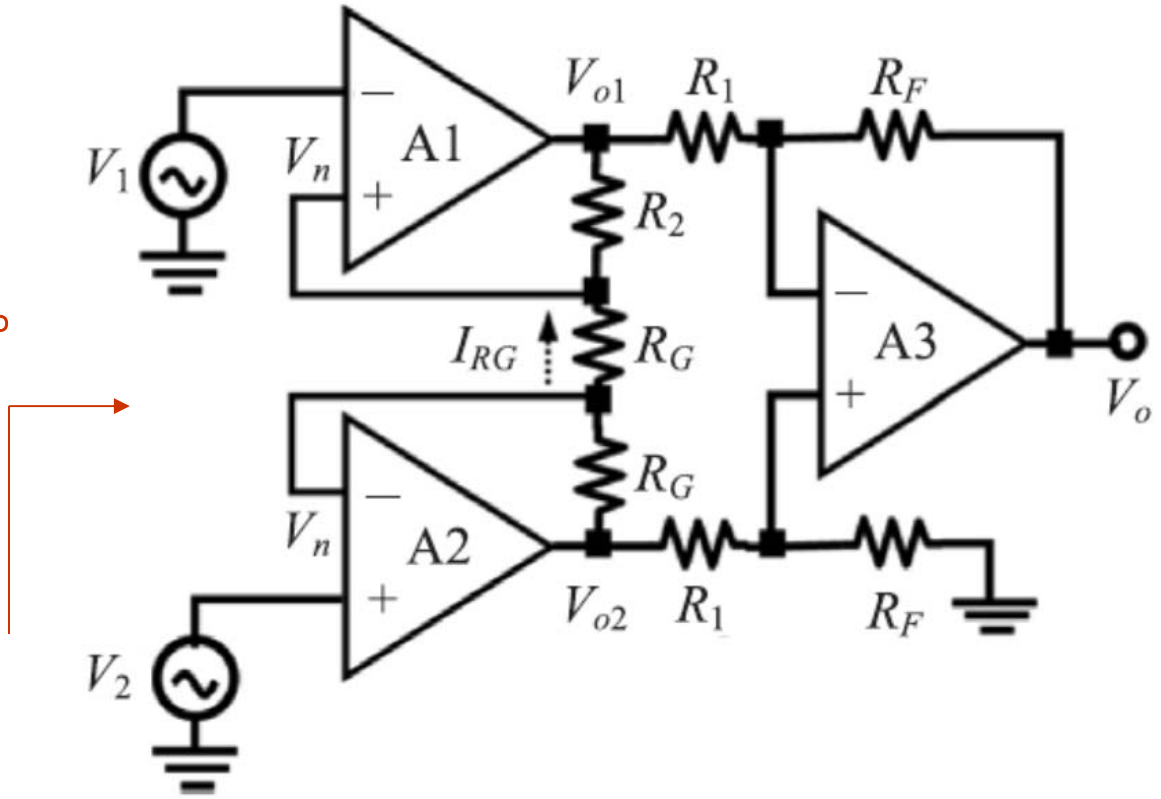


Patient protection stage



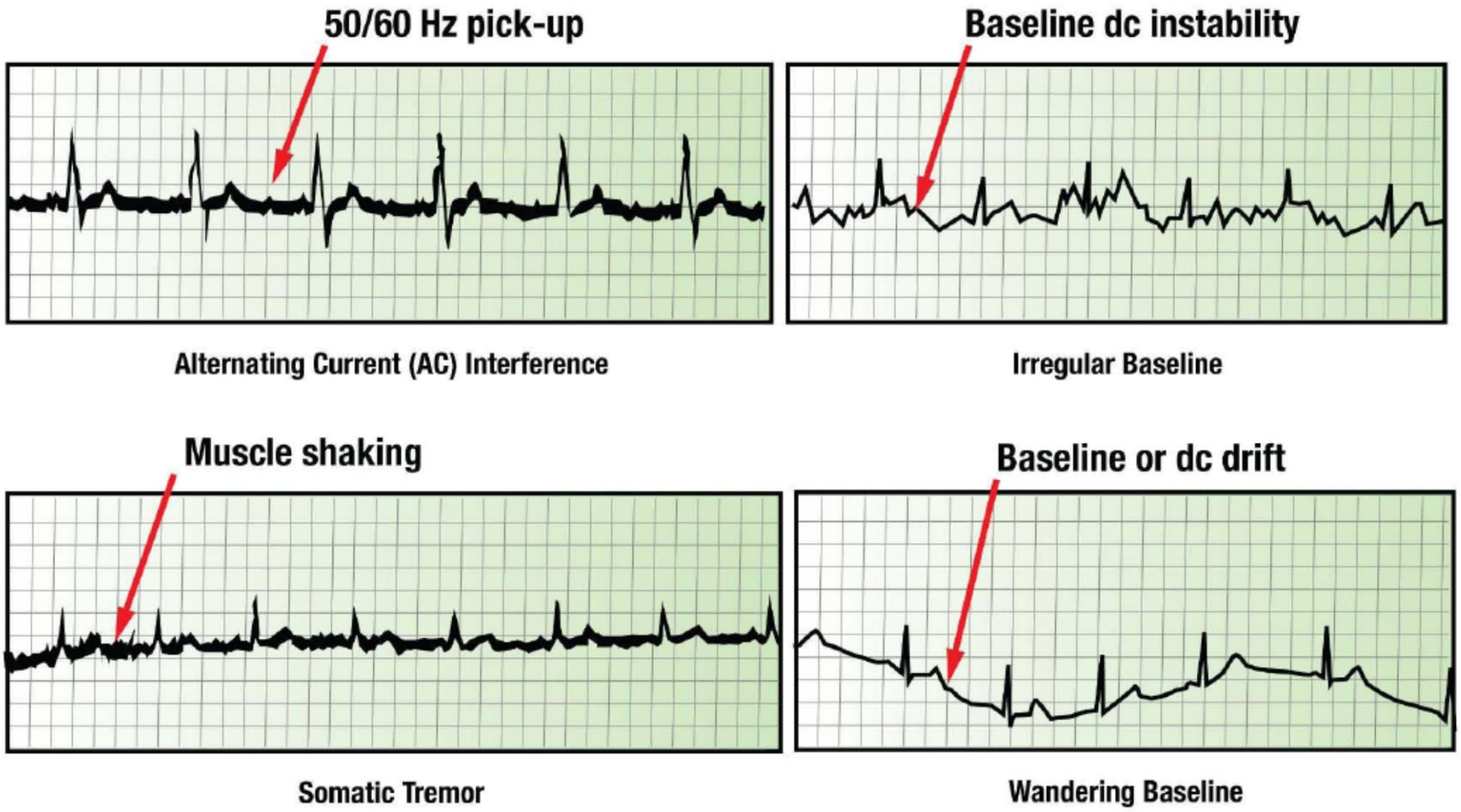
Instrumental amplifier (IA)

$R_{id} = \infty$



$$V_o = (R_F/R_1)\,(1+2R_2/R_G)\,(V_2-V_1)$$

Artifacts or noises in ECG measurement

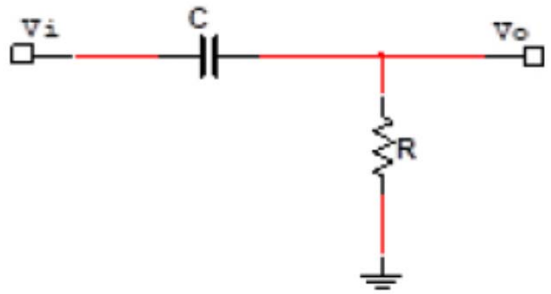


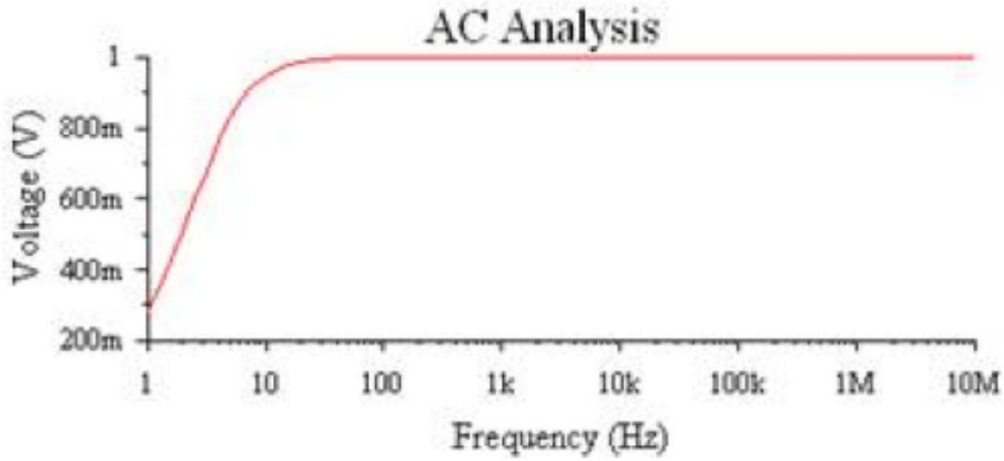
Matthew Hann, Analog Fundamentals of the ECG Signal Chain, Texas Instruments

High pass filter: reduce DC voltage and baseline wandering

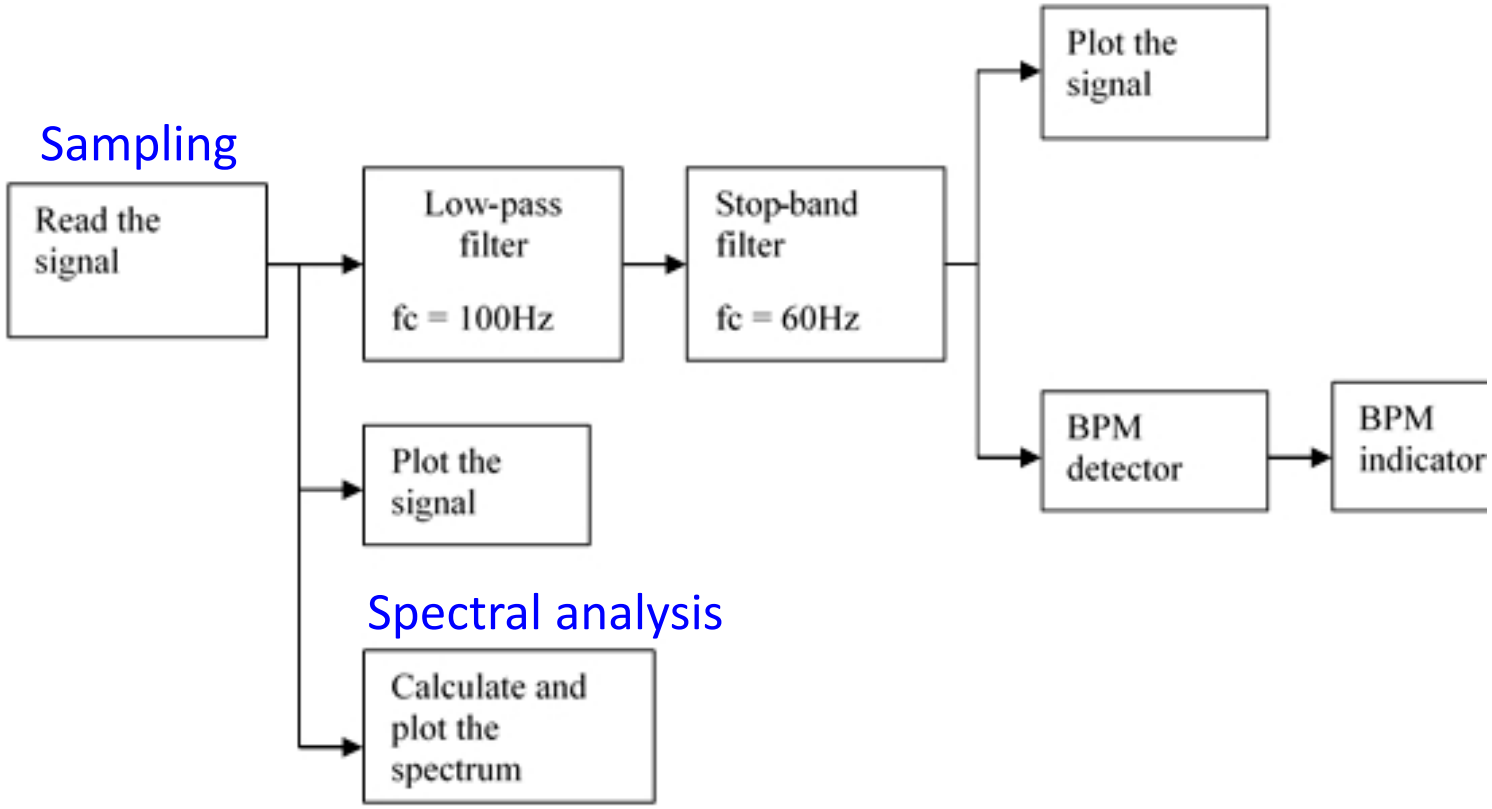
$$f_c = \frac{1}{2\pi RC}, \omega_c = 2\pi f_c$$

$$\frac{V_o}{V_i} = \frac{1}{1 - j\frac{\omega_c}{\omega}}$$



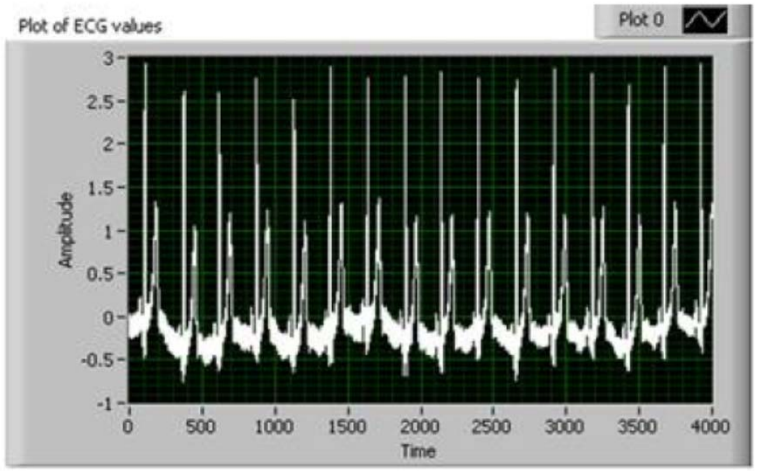


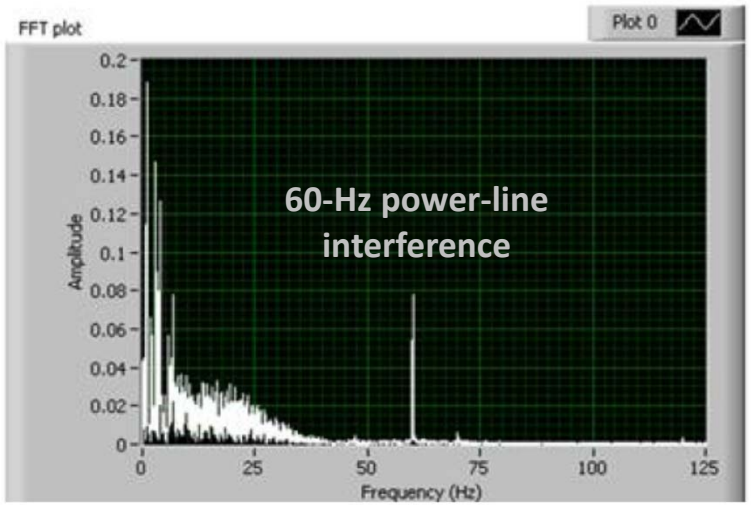
ECG analysis on Labview software



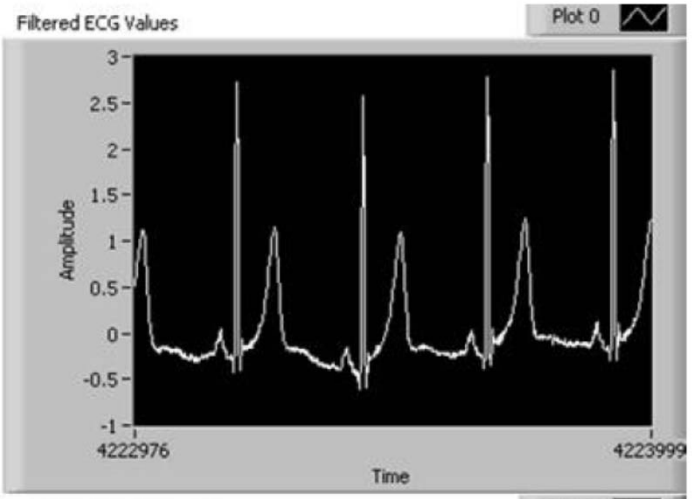
ECG filtering

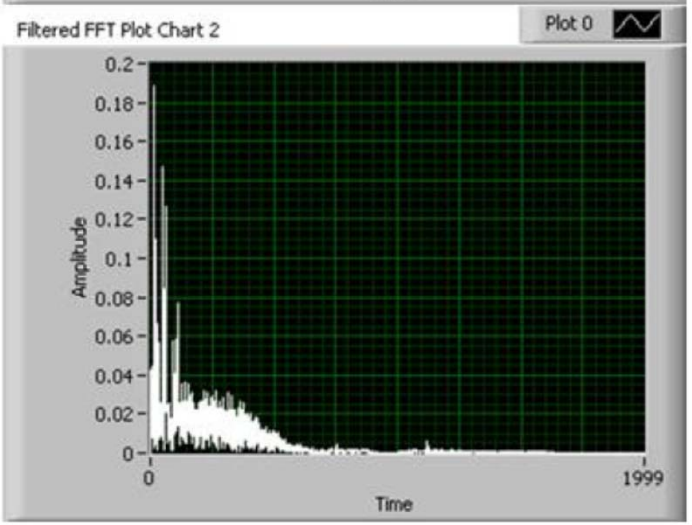
ECG signal before filtering



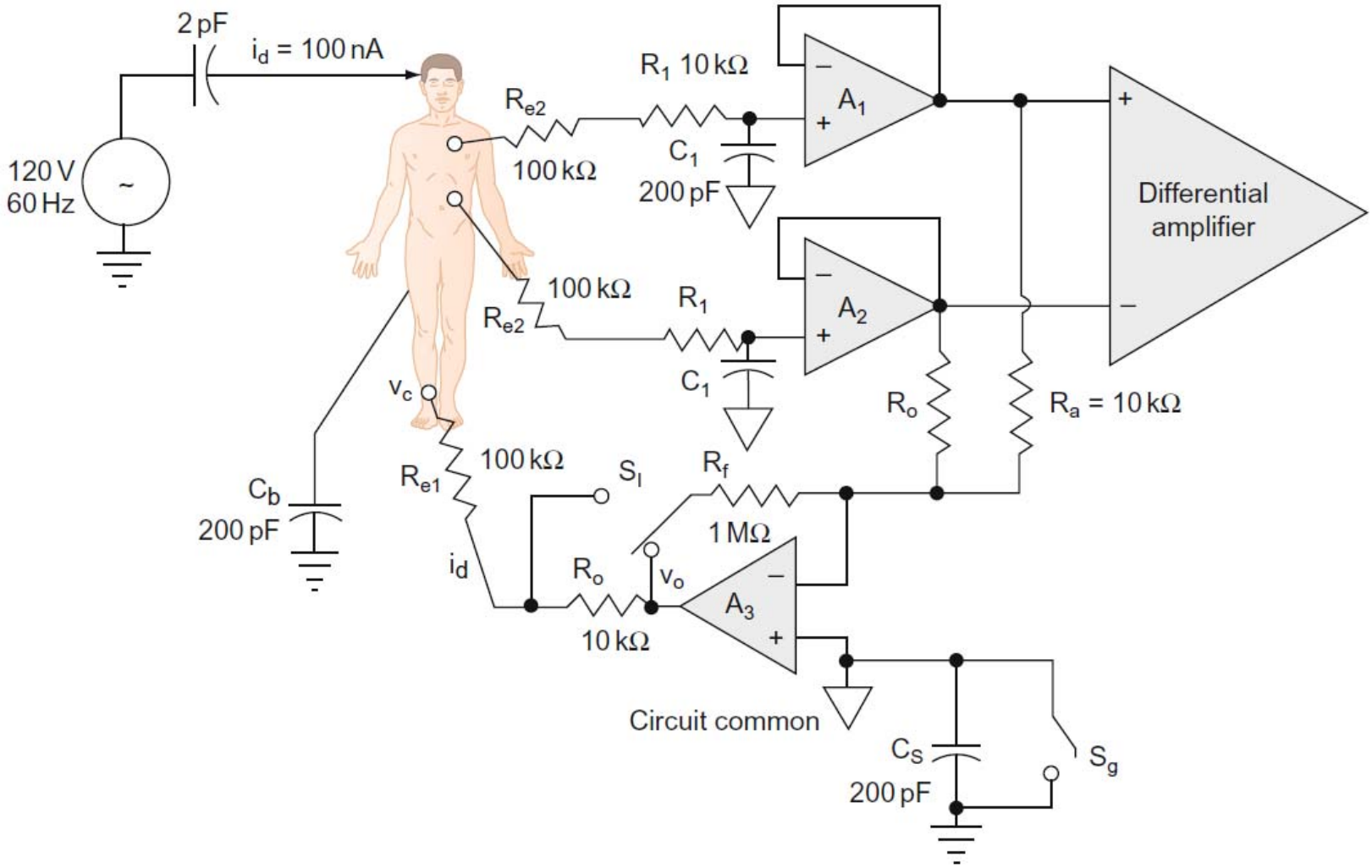


Filtered ECG signal

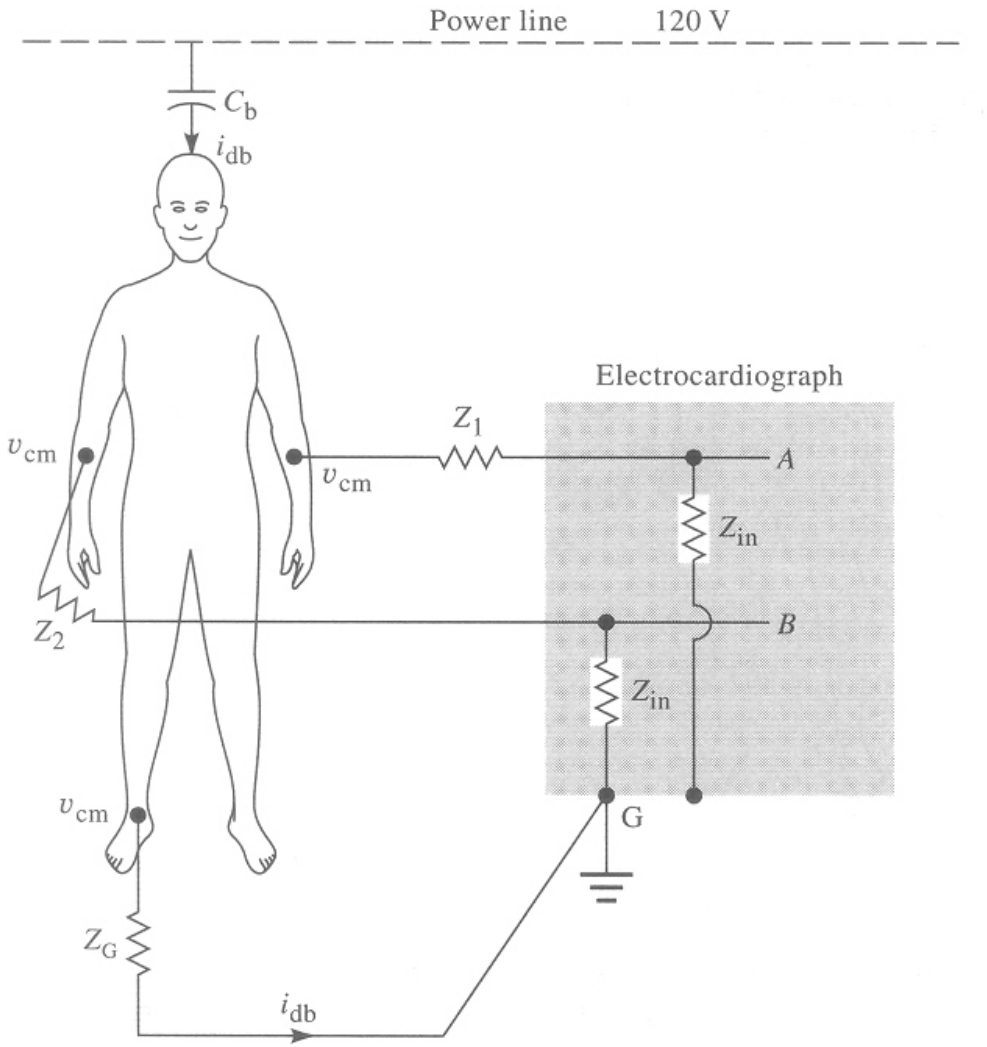




ECG amplifier



Common-mode voltage by power-line interference



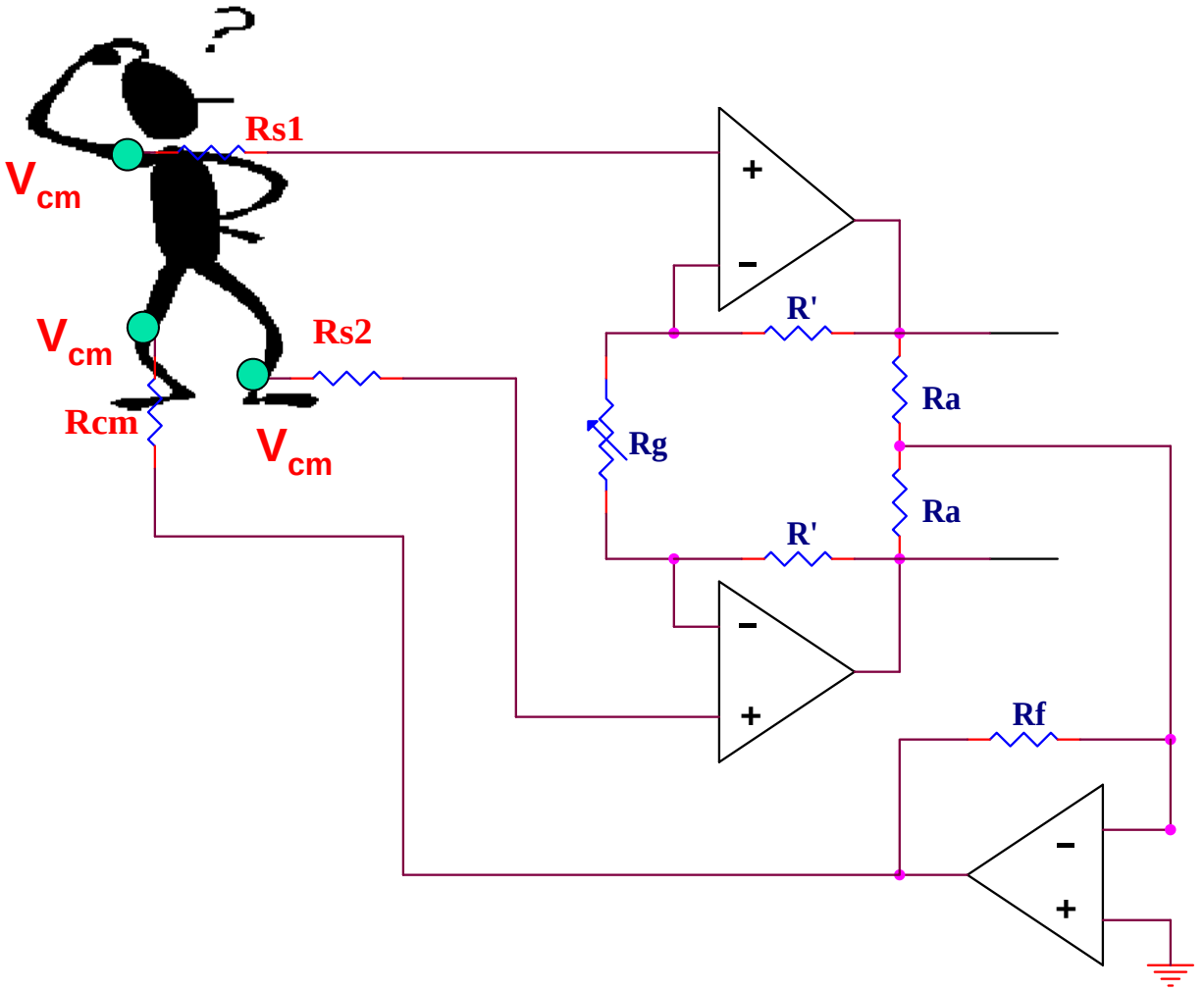
$$v_{cm} = i_{db} Z_G$$

Typical value

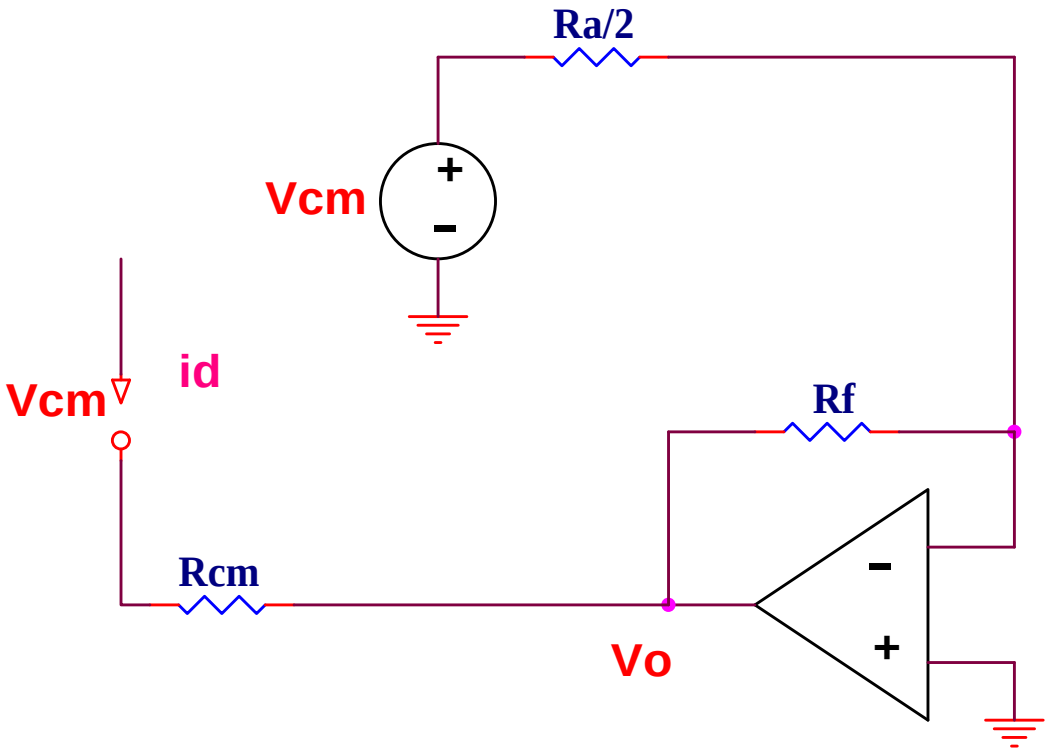
v_{cm} = (0.2 μA) (50 kΩ)

= 10 mV

Driven-right-leg circuit



Driven-right-leg circuit (cont.)



$$\frac{V_{cm}}{R_a/2}+\frac{V_o}{R_f}=0$$

$$\Rightarrow\ V_o=-\frac{2R_f}{R_a}V_{cm}$$

$$-\frac{2R_f}{R_a}V_{cm}=V_{cm}-i_dR_{cm}$$

$$\Rightarrow\ V_{cm}=\frac{i_dR_{cm}}{1+2R_f/R_a}$$

Driven-right-leg circuit (cont.)

<EX> i_d = 0.2 μA. A worst-case electrode resistance R_{cm} = 100 kΩ, R_a and R_f are selected as 25 kΩ and 5 MΩ respectively. Find V_{cm}.

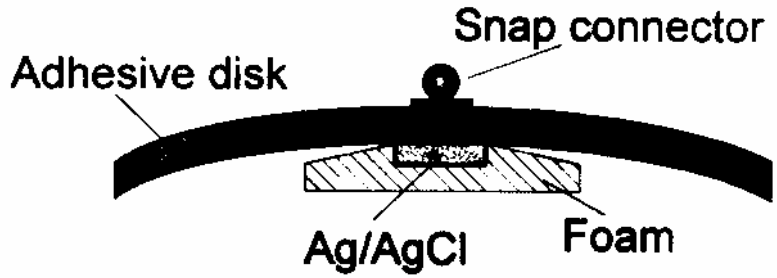
$$V_{cm} = \frac{100k\Omega \times 0.2\mu A}{1 + 2 \times 5M\Omega / 25k\Omega} = 50\mu V$$

If no right-leg-driven circuit

$$V_{cm} = i_d \times R_{cm} = 100k\Omega \times 0.2\mu A = 20mV$$

ECG electrodes

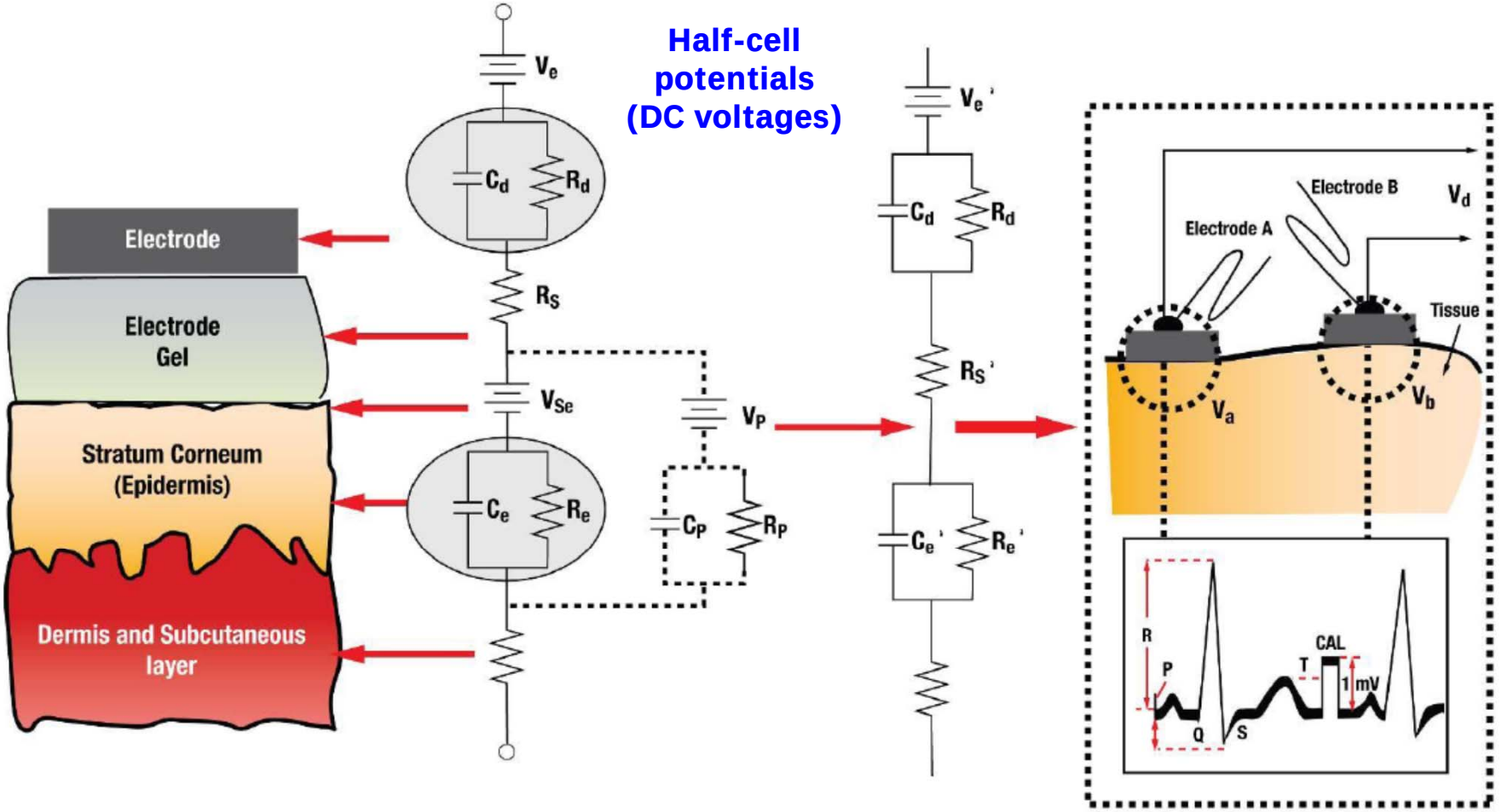
Typical ECG electrode



ECG tab electrode

A base of polyester film is covered with a Ag/AgCl coating

Electrode-tissue interface



Q/A: Can half-ell potentials be reduced through an instrumental amplifier?

Matthew Hann, Analog Fundamentals of the ECG Signal Chain, Texas Instruments

Reference

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