Patient monitoring 101: Part-3

Key considerations for designing electrocardiogram (ECG) front-end circuit

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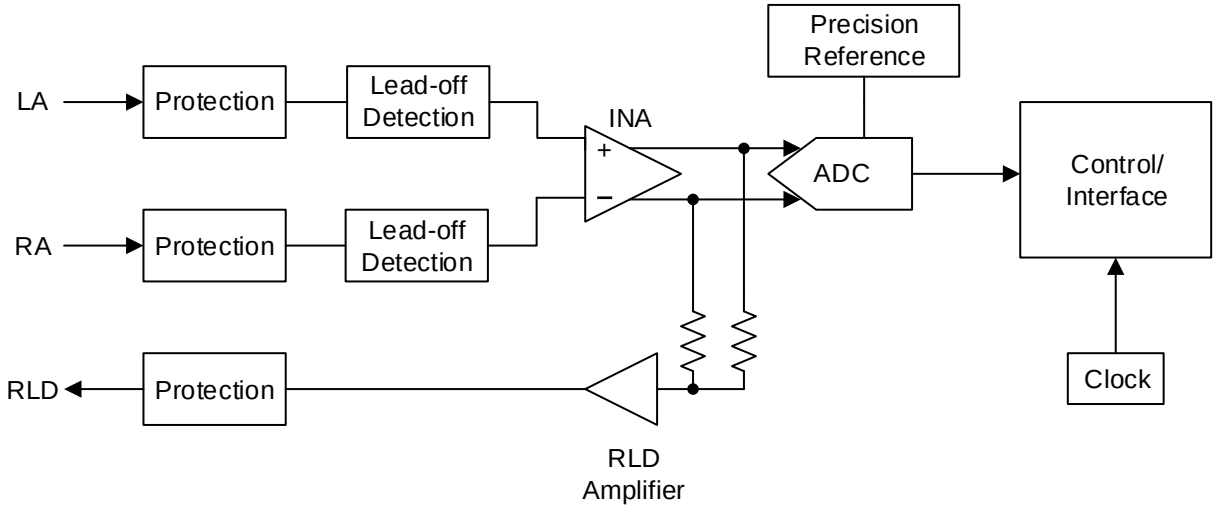
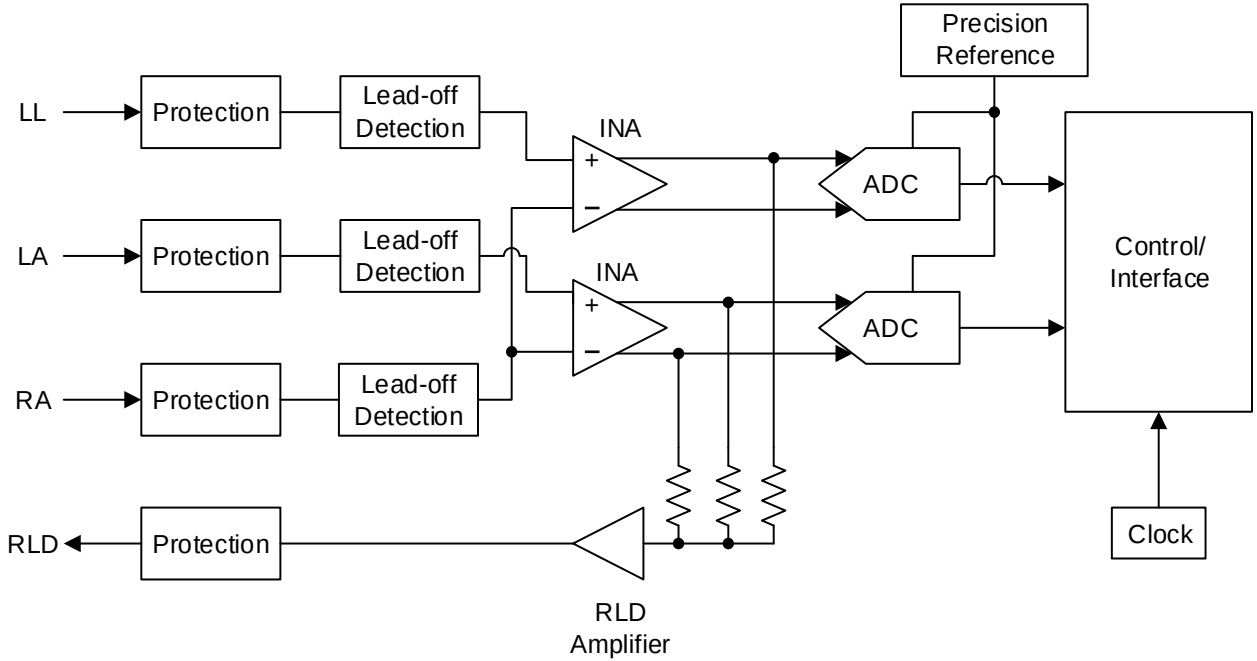
Typical ECG system

Block diagram – 1 Lead



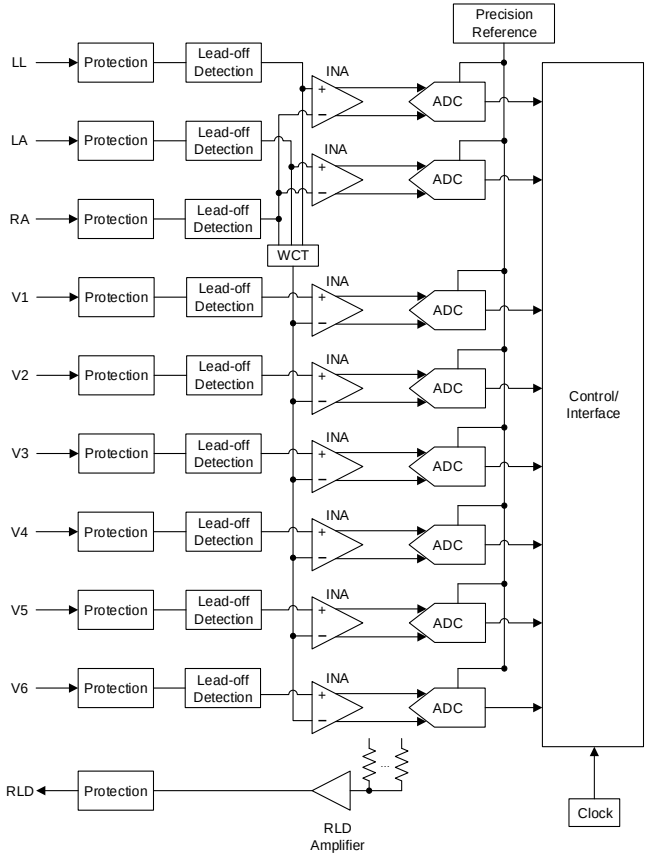
Typical ECG system

Block diagram – 3 Leads



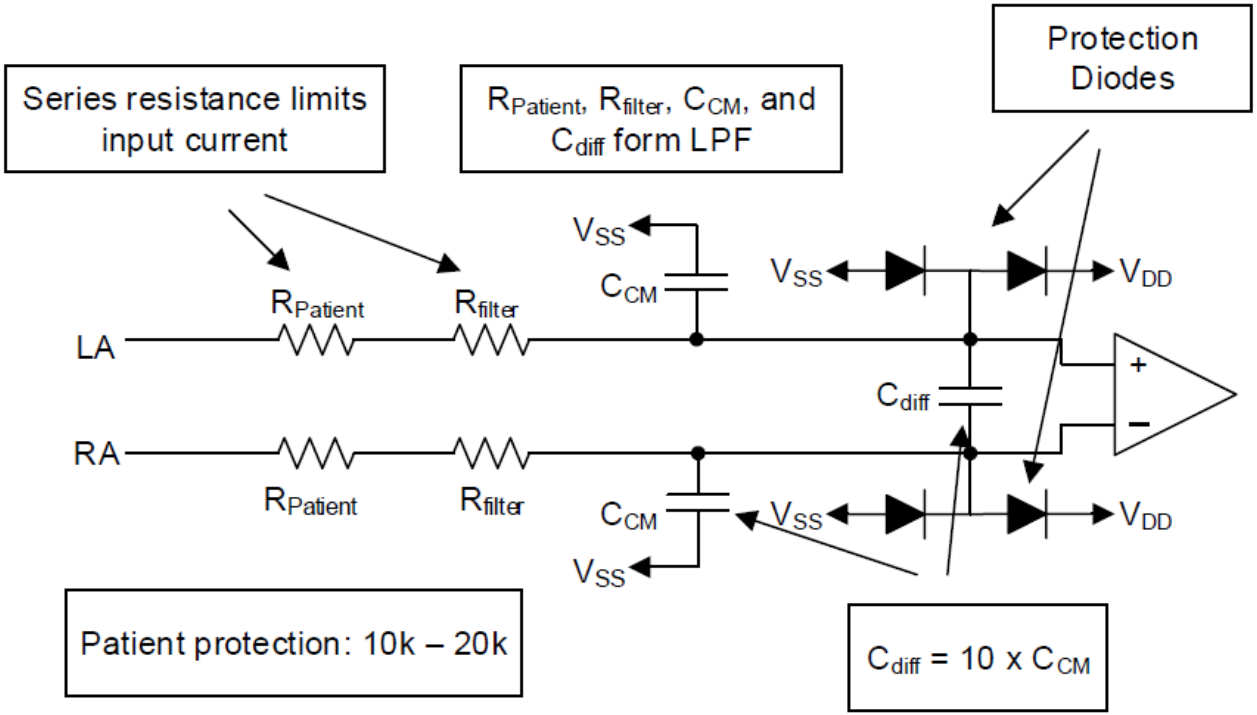
Typical ECG system

Block diagram – 12 Leads



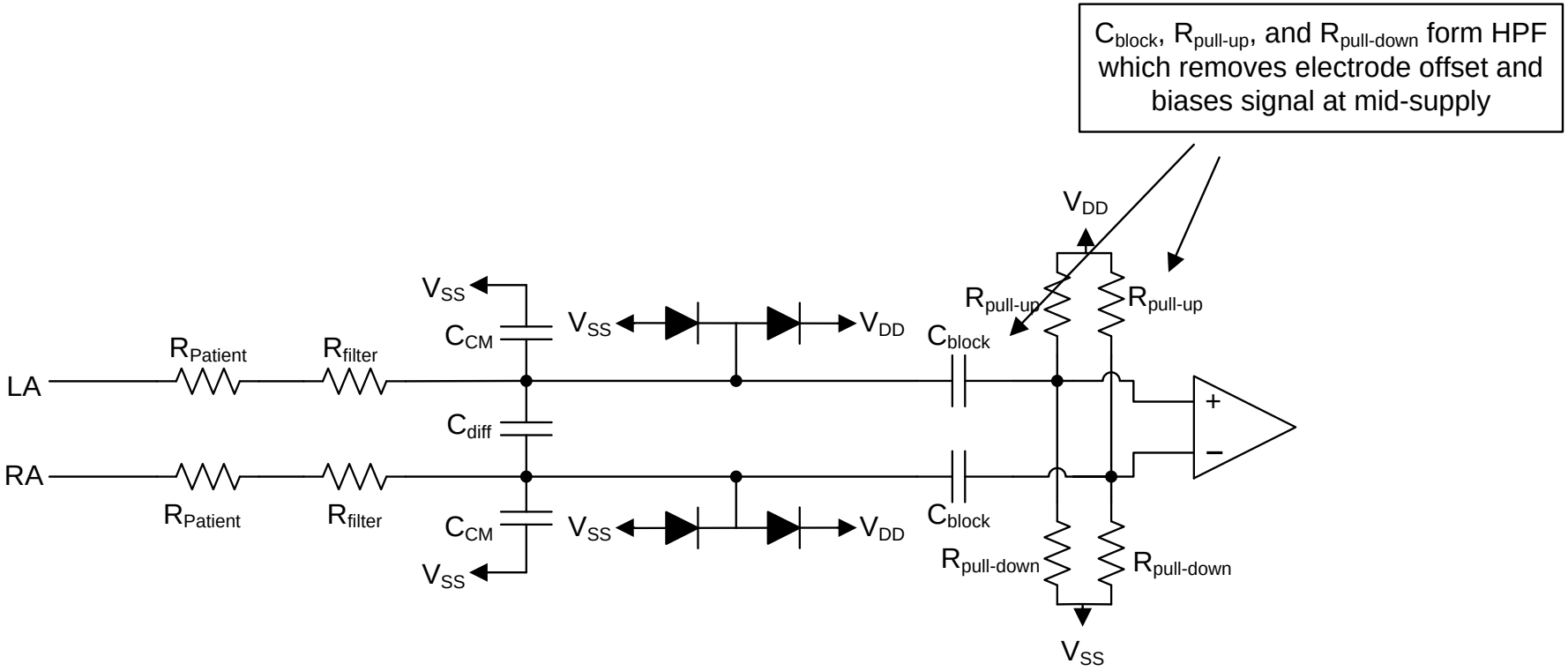
Input filtering and protection

Example: Lead I



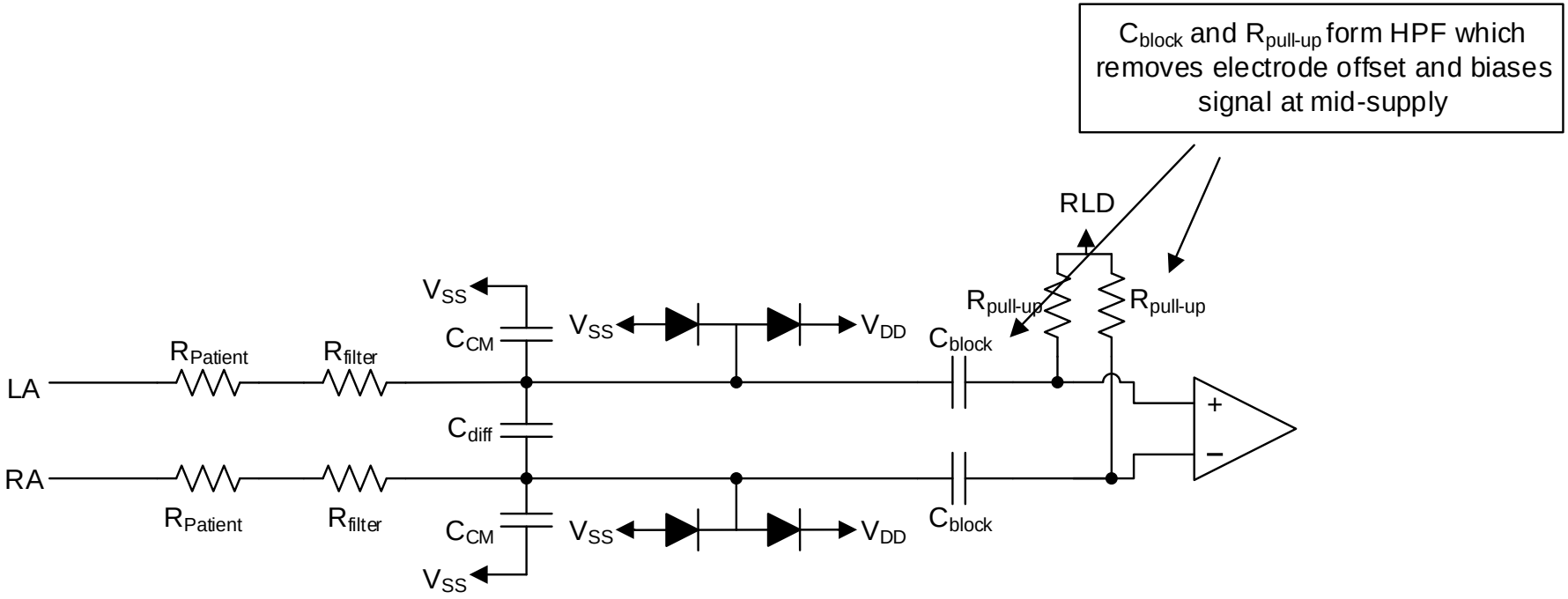
Input filtering and protection

Example: Lead I, AC-coupled



Input filtering and protection

Example: Lead I, AC-coupled

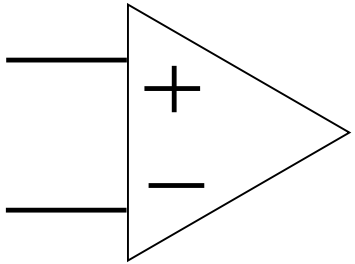


INA front end

Key features

Important

- Input Bias Current
- Input Impedance
- Input Current Noise
- Input Voltage Noise
- Power Consumption
- DC/AC CMRR

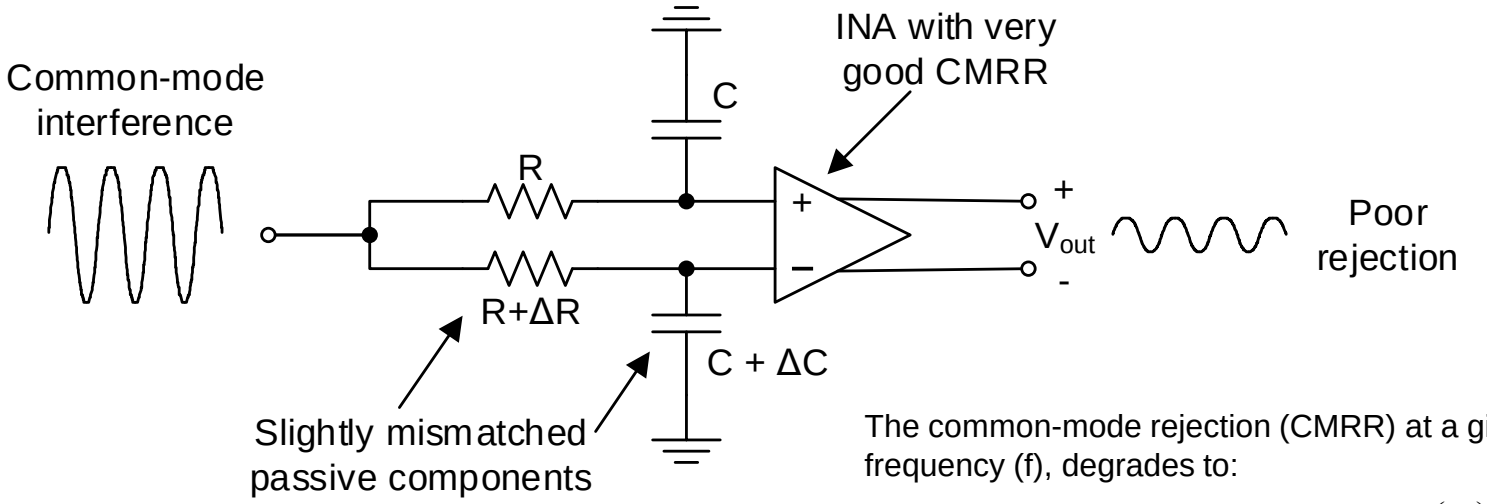


Less Important

- Input Offset Voltage
- Input Offset Voltage Drift
- Gain Error
- Nonlinearity
- PSRR

DC errors such as offset error are small compared to the offsets introduced by the **skin-electrode** contacts

Common-mode rejection in ECG front end



The common-mode rejection (CMRR) at a given frequency (f), degrades to:

$$CMRR = 20 \times \log_{10}\left(\frac{\Delta R}{R} + \frac{\Delta C}{C}\right) + 20 \times \log_{10}\left(\frac{f}{f_C}\right)$$

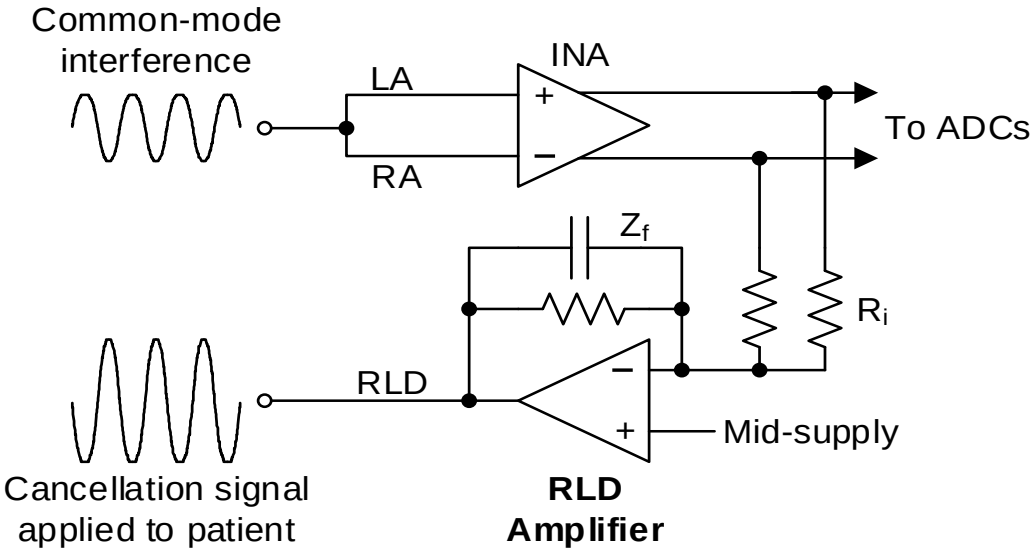
where f_C is the designed filter cutoff.

The RLD amplifier

Purpose of RLD amplifier is to:

- Bias the patient to the proper voltage range
- Cancel common-mode interference

$$\text{RLD Amp Output} = -\frac{Z_f}{R_i}(\text{RA} + \text{LA})$$



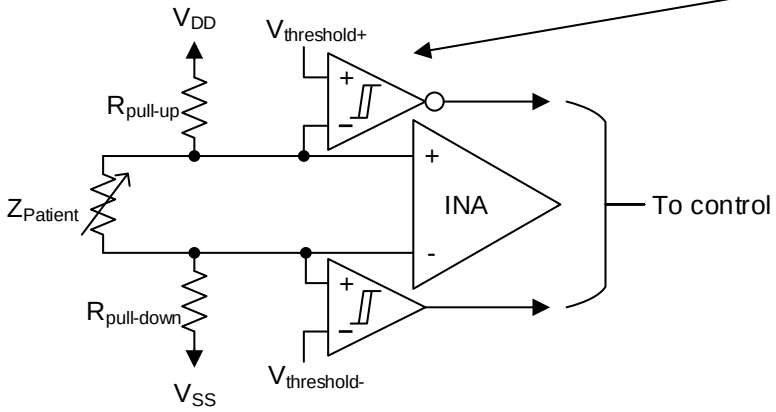
SBAA188: *Improving Common-Mode Rejection Using the Right-Leg Drive Amplifier*

DC lead-off detection

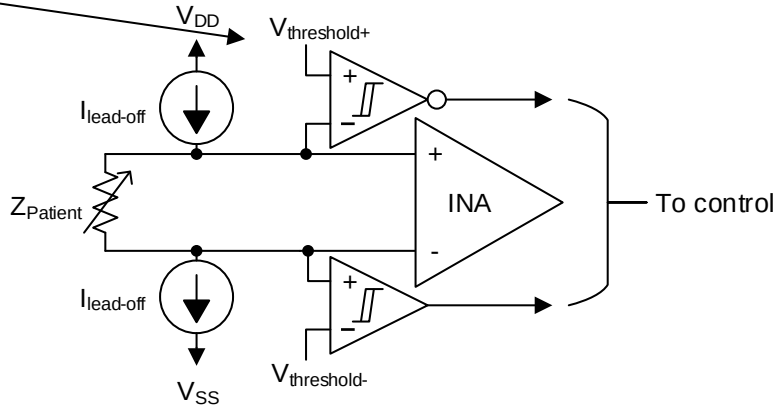
Detect if *electrode* is disconnected

If $Z_{patient}$ is high (electrode off), comparators will trigger

Pull-up/down method

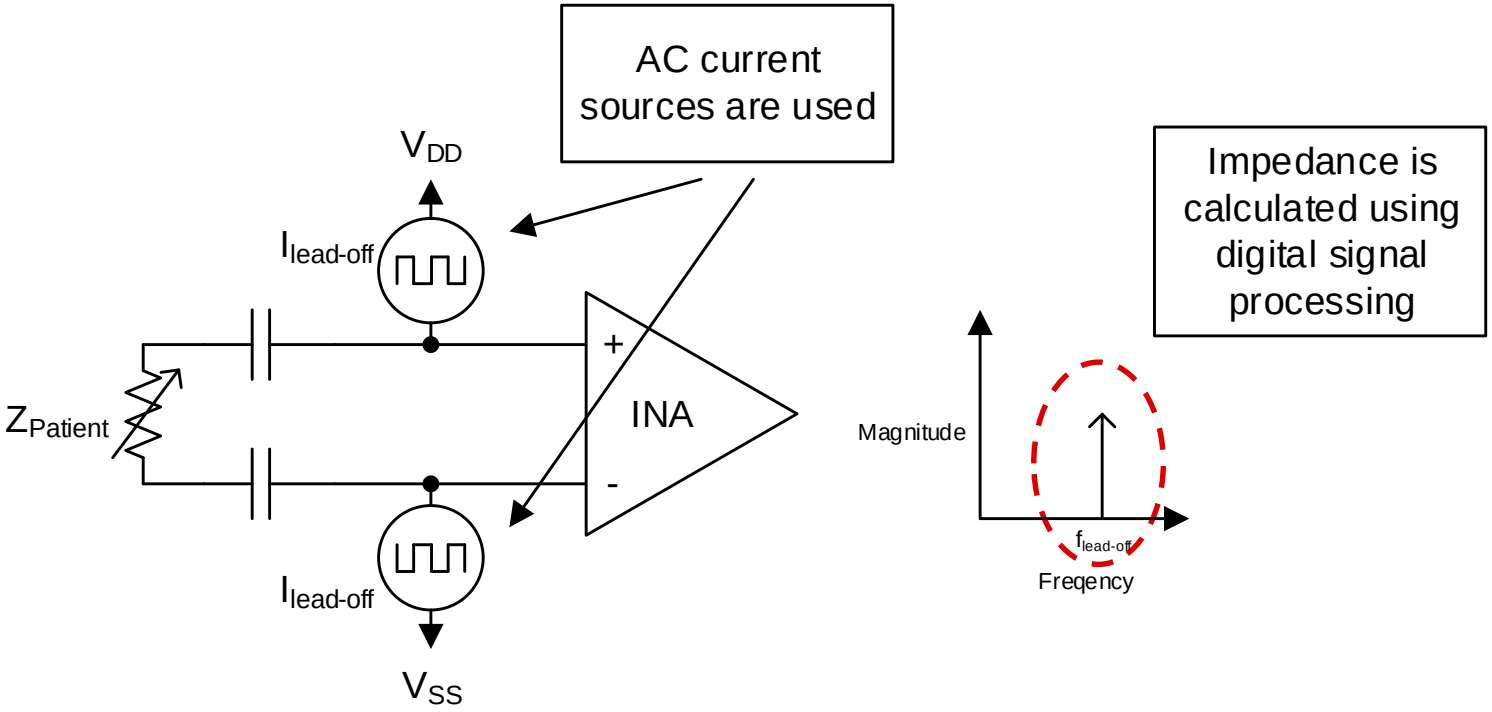


Excitation current source method



AC lead-off detection

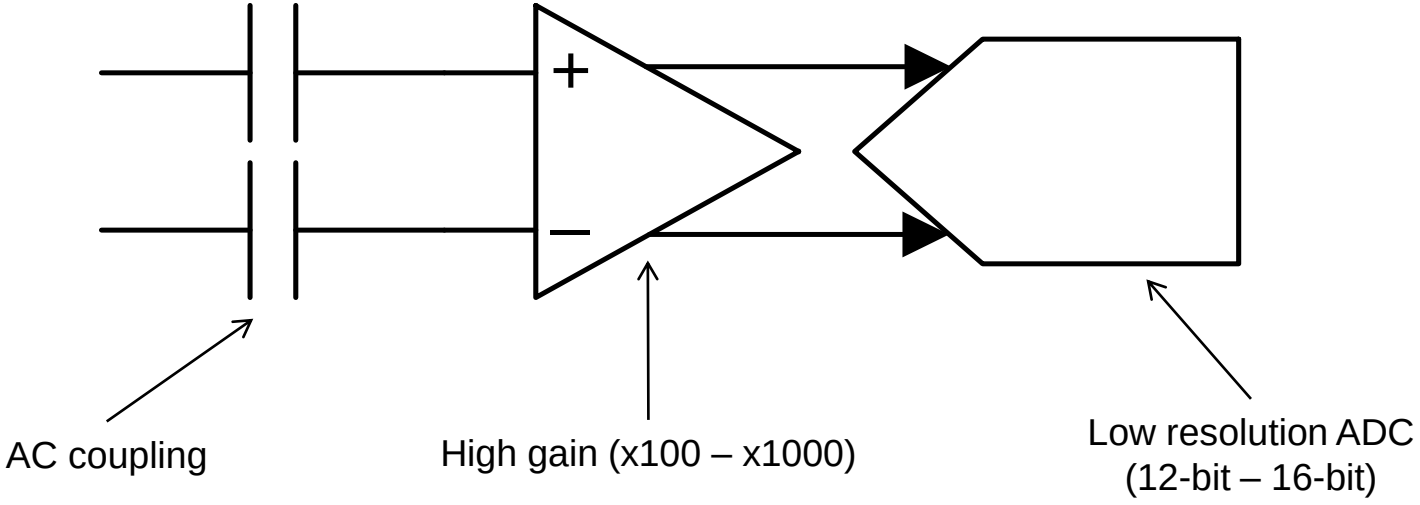
Detect if *lead* is disconnected: AC coupled front end



Data converter for ECG

Resolution requirements

Legacy ECG systems



Data converter for ECG

Resolution requirements

New ECG systems