Patient monitoring 101: Part-7

ECG lead detection in wearable devices

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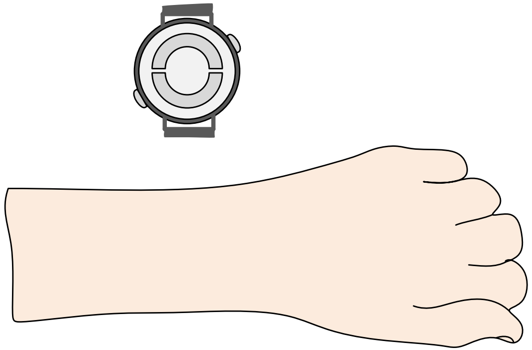
Agenda

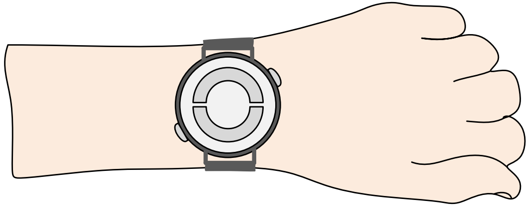
- **Overview of lead detection**
  - Need for leads on and leads off detection
- **DC lead detection**
  - Methods of biasing and detection
  - Design example
- **AC lead detection**
  - Signal chain for AC lead detection
  - Design example

Overview of lead detection

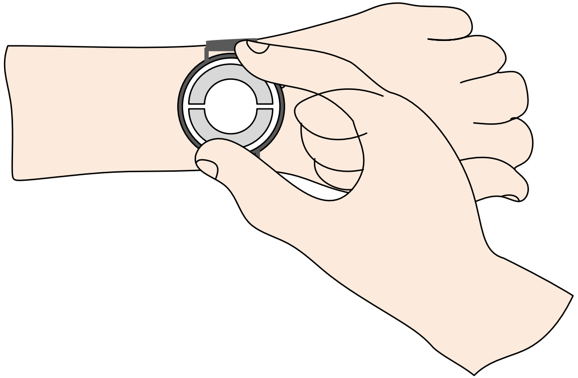
All leads off



Wrist leads on

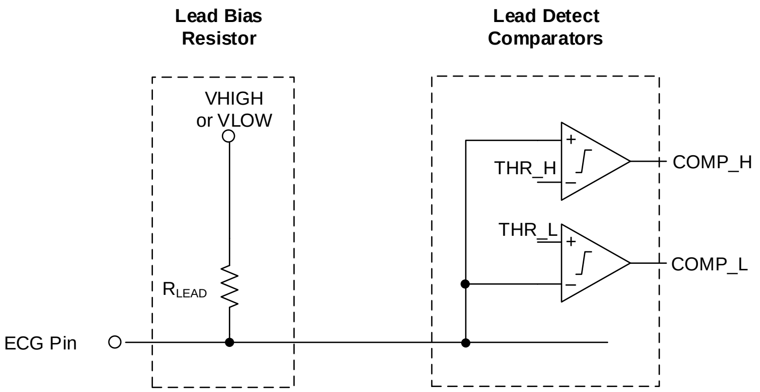


All leads on

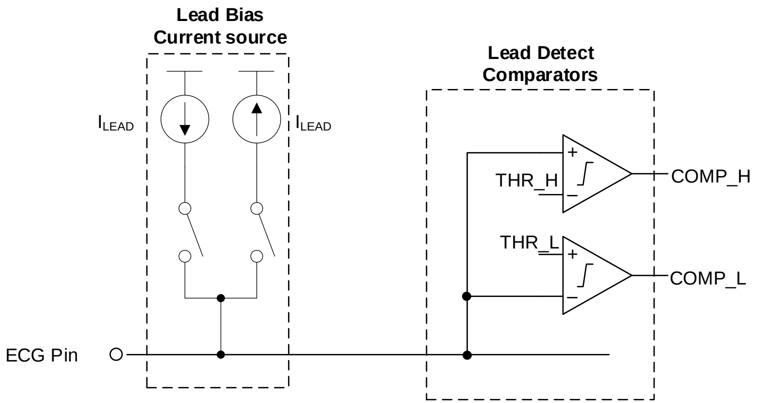


Method of DC lead biasing and detection

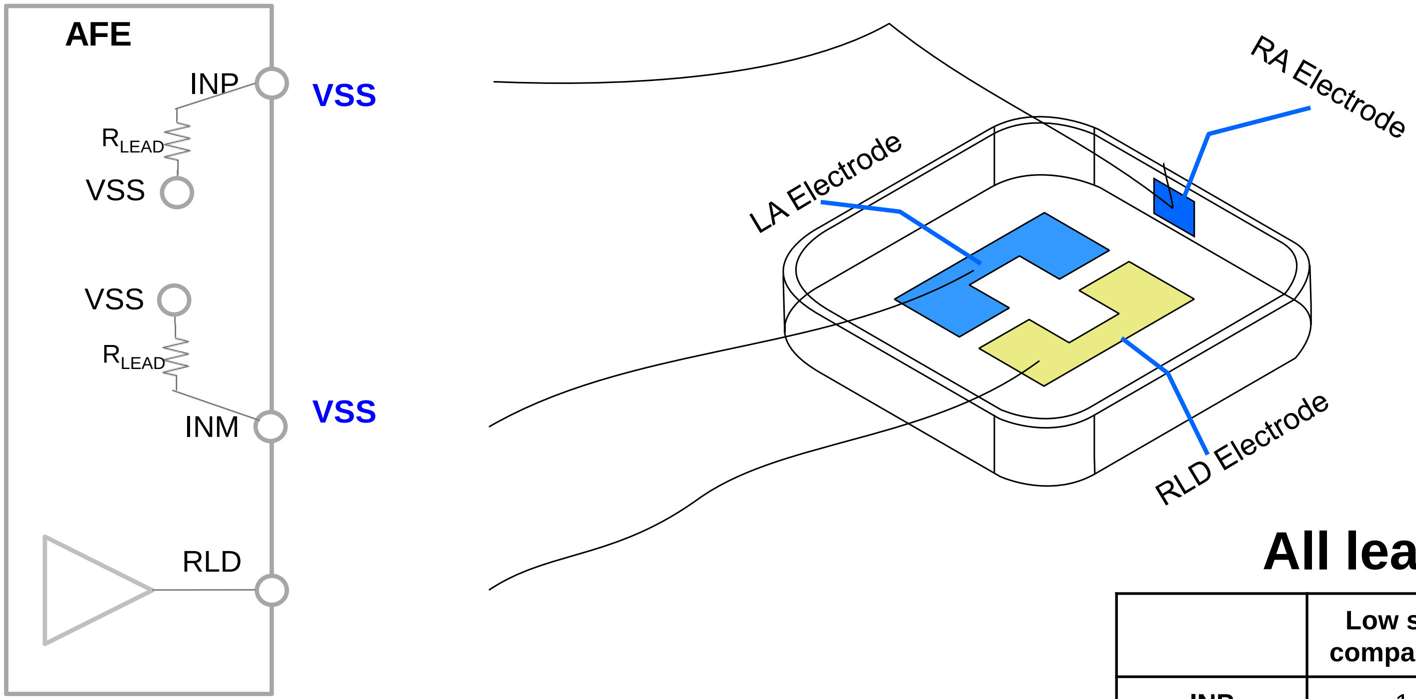
Lead biasing using resistors



Lead biasing using current sources



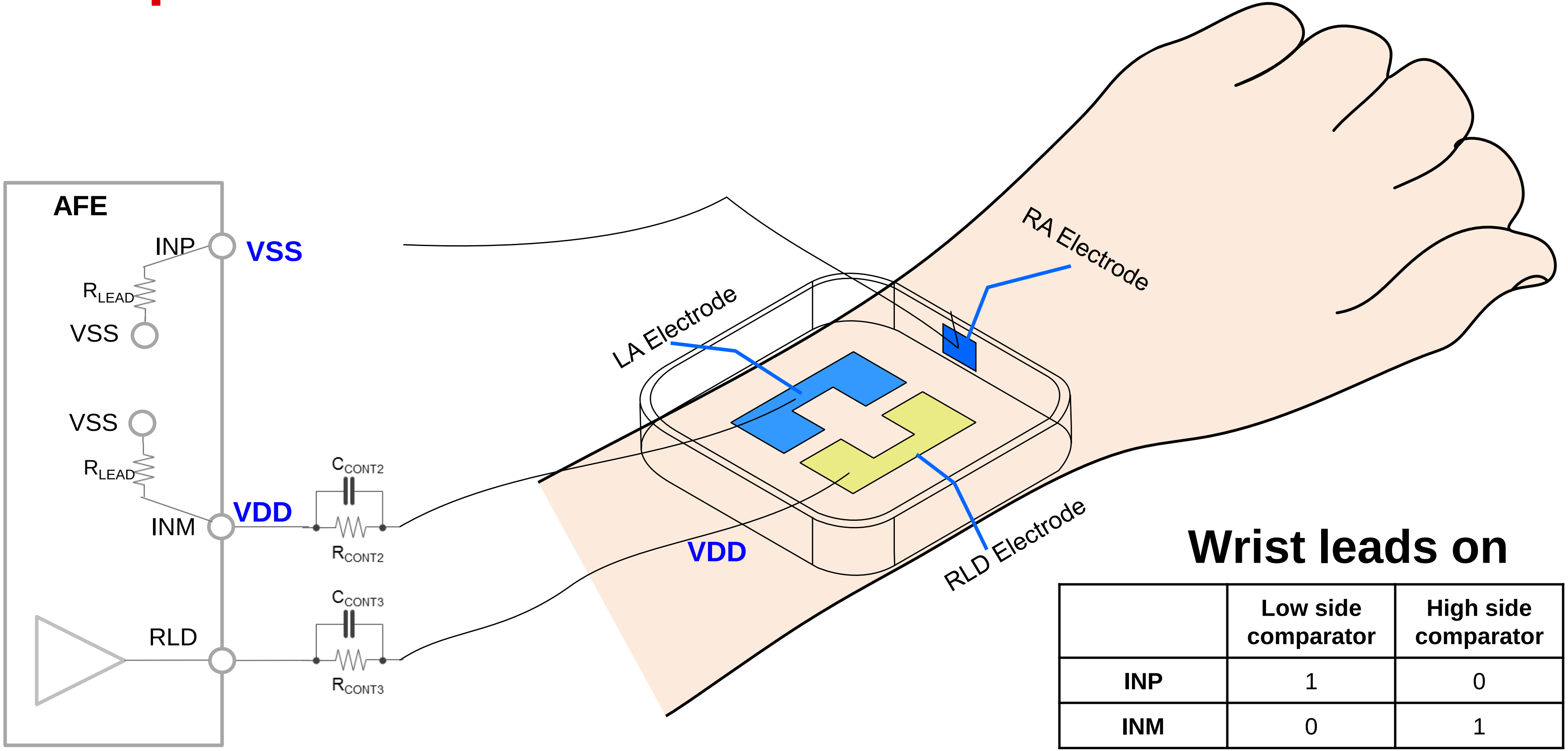
Principle of lead detection – All leads off



All leads off

	Low side comparator	High side comparator
INP	1	0
INM	1	0

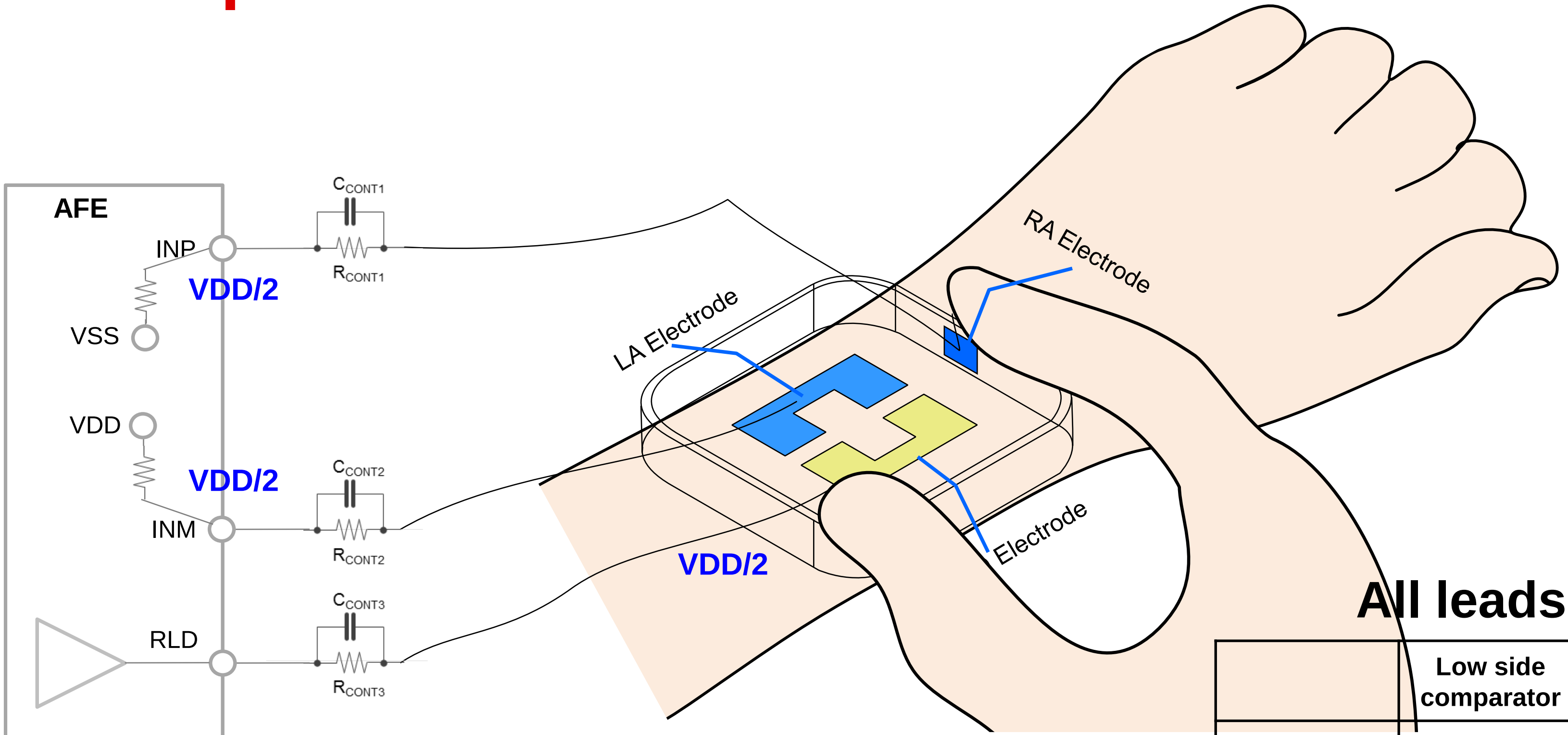
Principle of lead detection – Wrist leads on



Wrist leads on

	Low side comparator	High side comparator
INP	1	0
INM	0	1

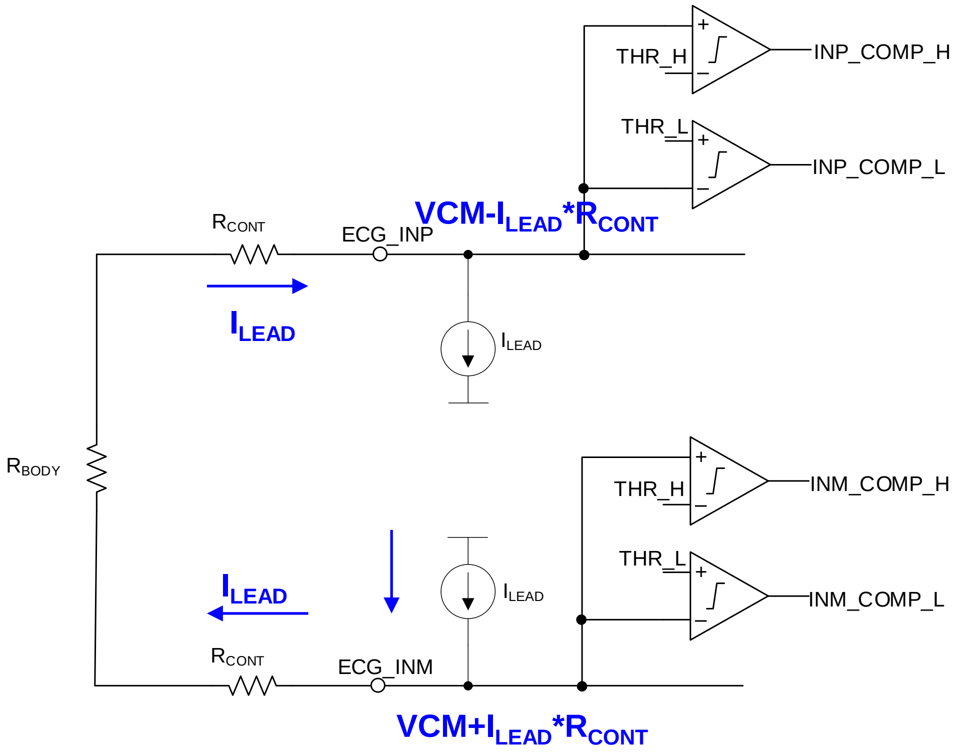
Principle of lead detection - All leads on



All leads on

	Low side comparator	High side comparator
INP	0	0
INM	0	0

DC lead detection – Design example



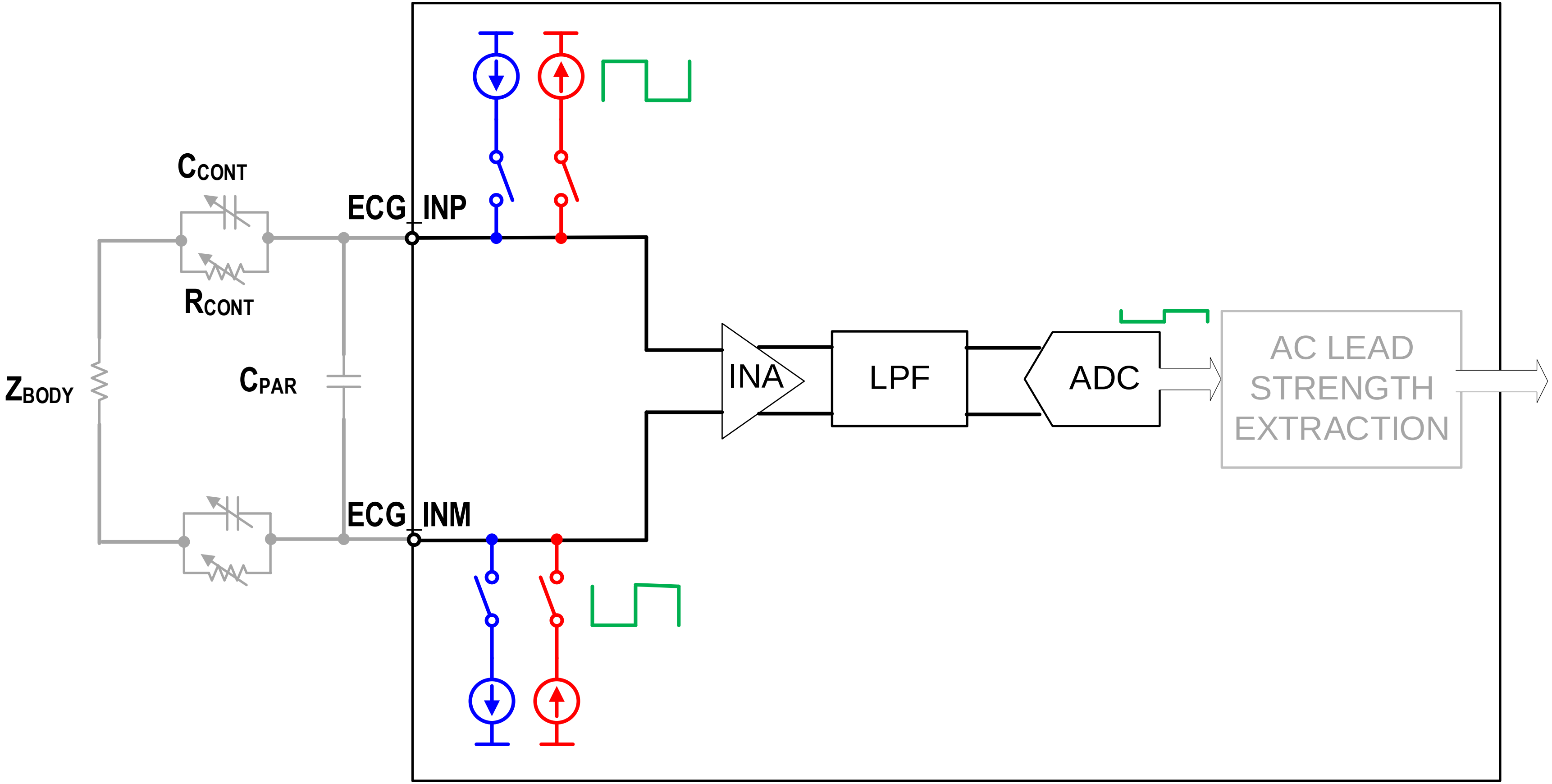
Example.

VDD = 1.8V
VCM = 0.9V
I_{LEAD} = 30 nA
THR_H = VCM+0.6V = 1.5V
THR_L = VCM-0.6V = 0.3V

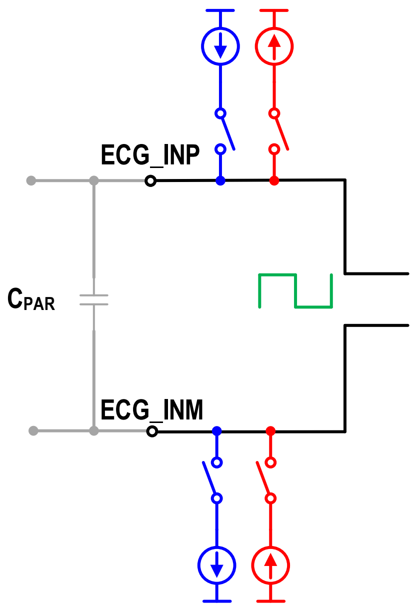
When **R_{CONT} > 20 MΩ:**
I_{LEAD}*R_{CONT} > 0.6V
INP_COMP_L = 1
INM_COMP_H = 1

R_{CONT} = 20 MΩ represents the threshold between leads on and leads off

AC lead detection - Concept



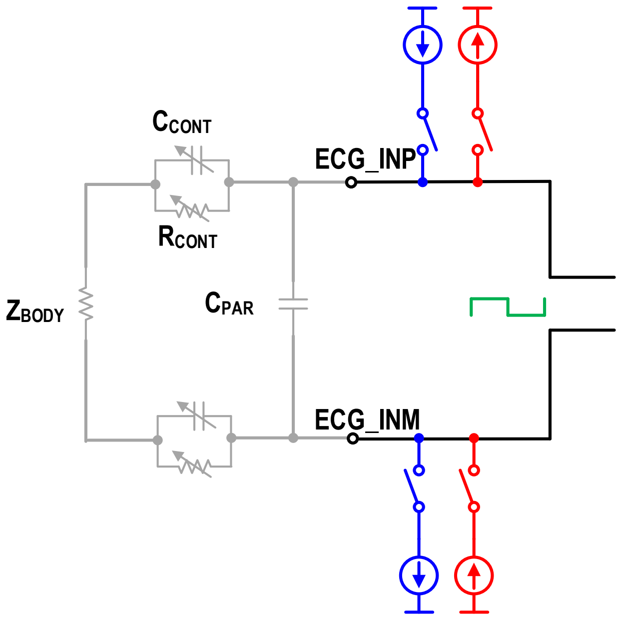
AC lead detection – Design example



Leads off:

F_{AC_LEAD} = 1 kHz
C_{PAR} = 50 pF
I_{LEAD} = 10 nA

Z_{PAR} = 3 MΩ
V_{AC_LEAD} = 30 mV



Leads on:

$2*Z_{CONT}$ = 100 kΩ

Z_{TOTAL} ~ 100 kΩ
V_{AC_LEAD} ~ 1 mV

Summary

- **Lead detection is an important function in an ECG signal acquisition system**
  - Allows changing the signal acquisition mode based on whether leads are ON or OFF
  - Can help alert the user to make better contact with the electrodes

- **DC lead detection**
  - DC lead detection comprises lead biasing using either resistors or current sources
  - The transition between leads on and leads off happens at a threshold value of electrode contact resistance : this threshold is dependent on the lead bias resistance or current source value and the detection threshold

- **AC lead detection**
  - AC lead detection can be realized through AC/ switching current sources at the leads
  - The signal strength at the AC switching frequency appearing at the ECG signal chain output can be used to determine the contact impedance of the lead

TEXAS INSTRUMENTS