BE87 FRESHMAN SEMINAR

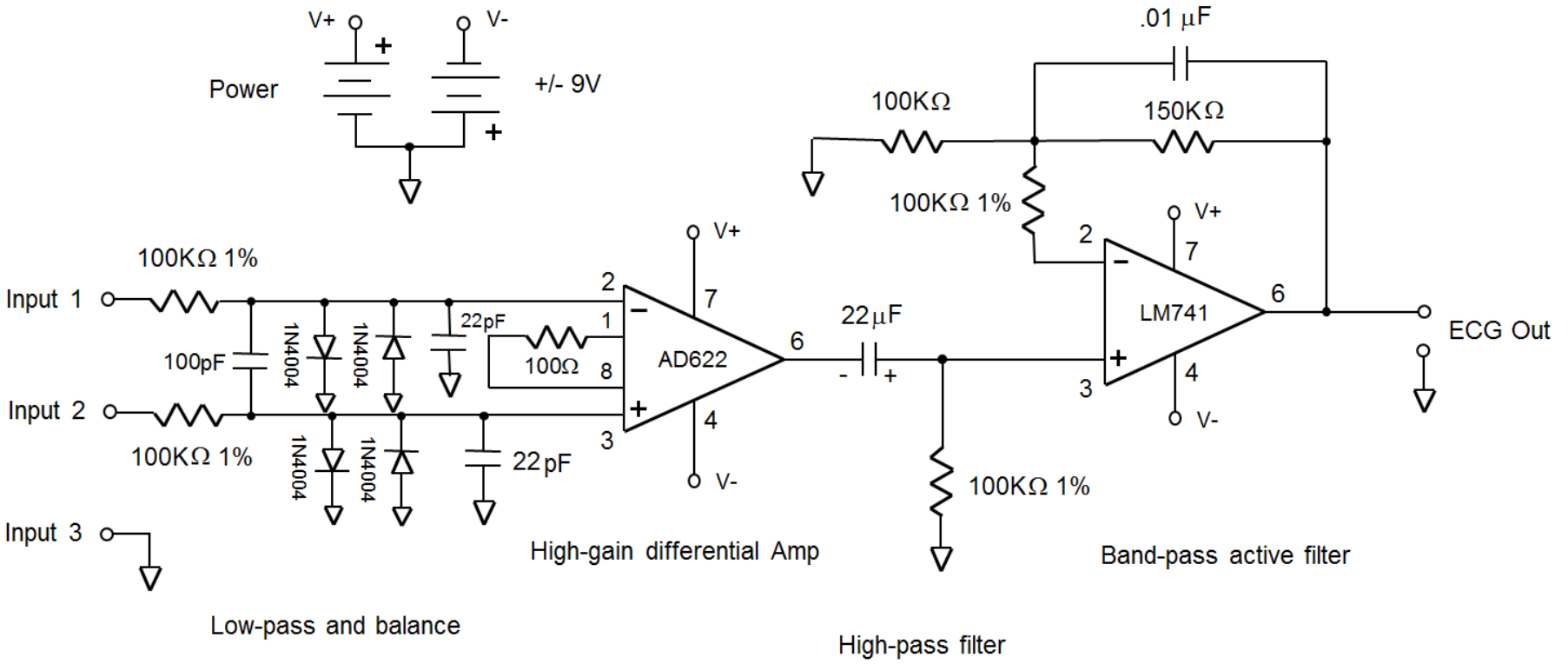
WEEK 3: ECG AMPLIFIER DESIGN

- Electronic circuit for amplifying a biopotential
- Functions of the circuit, parts summary
- Discrete components in the design

GOALS FOR THIS LAB

- Review schematic design and function
- Label your tool box and component boxes
- Locate and organize electronic components:
  - Find resistors, capacitors, IC's, etc., place in plastic bag
- Verify other components: breadboard with BNC-type connectors, ECG input wires, breadboard prototyping wires, batteries, battery holders
- Create a parts list (with images or drawings) of your parts

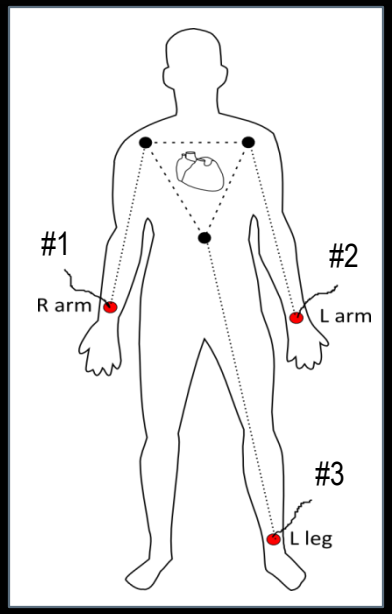
ECG AMPLIFIER SCHEMATIC DESIGN



Note: the triangles ⏚ connected to components denote a connection to “ground” or a common wire.

FUNCTIONS OF THE CIRCUIT

- Input: ECG signal from a human subject
  - 3 wire/electrode inputs: differential signal is amplified (Inputs #1 and #2), relative to a common reference (ground, input #3)

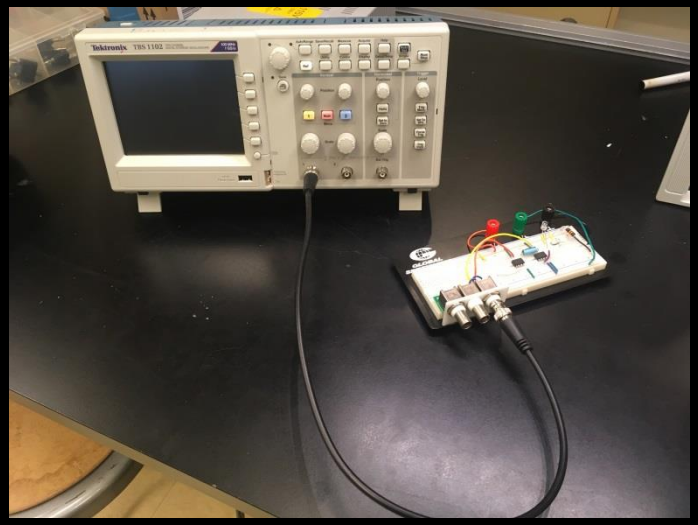


• Limb wires/electrodes connect to amplifier

ECG wires connect to amplifier circuit to human subject with stick-on skin electrodes

FUNCTIONS OF THE CIRCUIT (CON'T)

- Output: Amplified ECG to "BNC" connecter (part of the bread board)
  - Output can be viewed on an oscilloscope or computer acquisition system

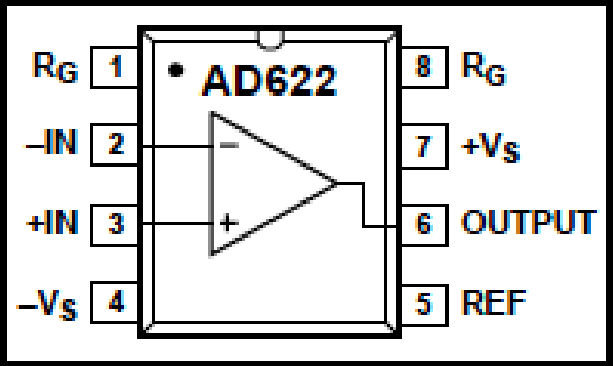


Bread-boarded circuit using the BNC connector, via a co-axial cable, to the input of the oscilloscope

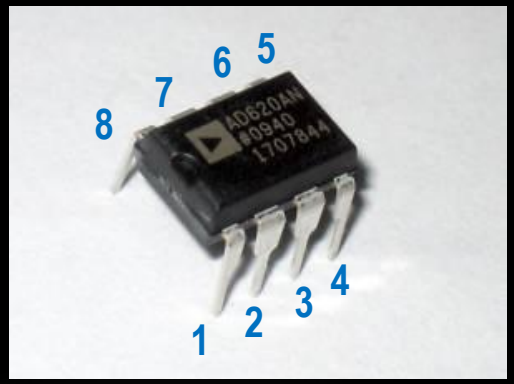
BNC type "twist and lock" connector

FUNCTIONS OF THE CIRCUIT (CON'T)

- Main amplification
  - Voltage on the skin is in the millivolt range
  - Use the AD622 "differential" amplifier to boost signal to volt range
  - Amplifies the difference between the 2 inputs (-IN and +IN): will reject noise common to both inputs
  - Resistor between R_G pins sets amplification. R = 100 Ω is for gain of ~500 (Out = 500 x In)



Pins on an 8-pin IC



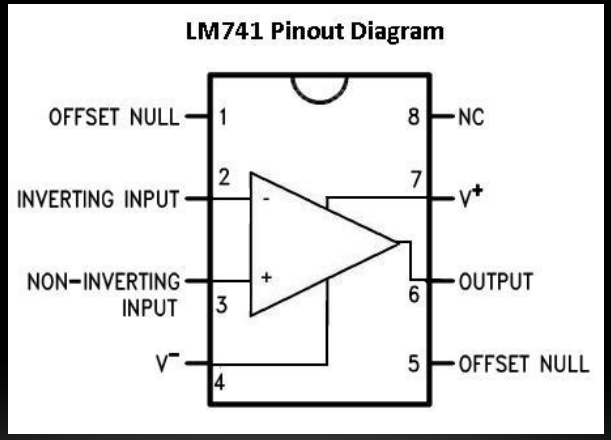
Pin functions
1 - Gain resistor
2 - Input #1
3 - Input #2
4 - Negative supply (-9V)
5 - no connections
6 - Amplified output
7 - Positive supply (+9V)
8 - Gain resistor

FUNCTIONS OF THE CIRCUIT (CON'T)

- Filters
  - Input filters: Low-pass (passes low frequencies, cuts out higher frequencies)
  - R-C combination at each input: 100K Ω resistor with a 22 pico-farad capacitor
  - High pass filter: passes high frequency, filters out very low frequencies
  - R-C combination at AD622 output: 100K Ω resistor with a 22 micro-farad capacitor
  - Active "band-pass" filter: filters around 60 Hz, which is frequency of household AC voltage/current. Major source of nose.
  - LM741 amplifier with 100K Ω, 150K Ω, 0.01 μF.

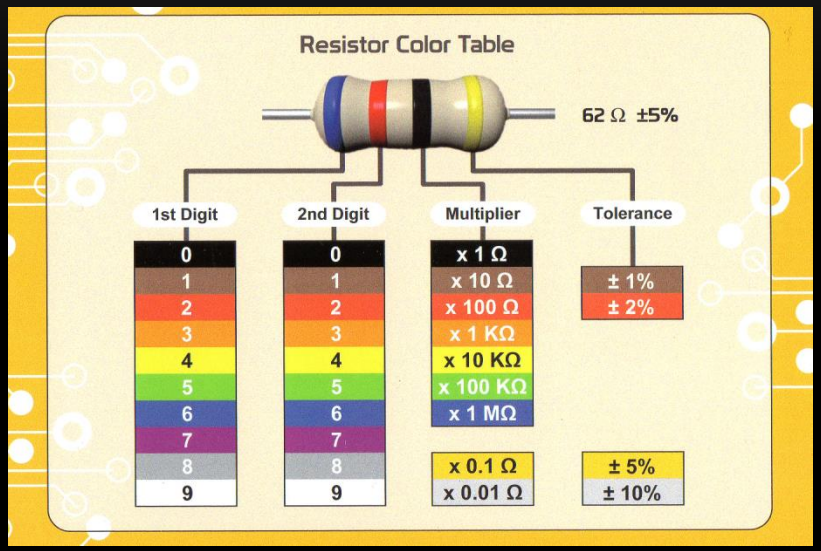
LM 741: BASIC OPERATIONAL AMPLIFIER

- Basic amplifier used in many applications
  - Here, connected as the 60 Hz filter
  - Same pin order as the AD620
  - Same +/- 9V supplies on pins 4/7
  - Same input pins (2 and 3), and output pin (6)
  - Pins 1, 5, 8 not used in our configuration



RESISTORS

- Standard resistors use a 4-stripe “color code” for resistance value
  - First 2 bands are digits of the value, times the multiplier band. 4th band is tolerance



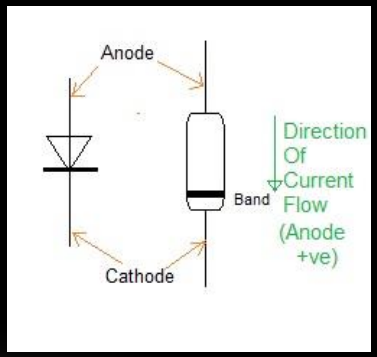
- 100K Ω = Brown, Black, Yellow code. Tolerance is typically gold (5%) or sliver (10%)
- 150K Ω = Brown, Green, Yellow; 100 Ω = Brown, Black, Brown
- “Precision” resistors, i.e. 1% tolerance, have value printed or 5-stripe code; precision = brown (1%)

CAPACITORS

- Many shapes and sizes. Some are polarized (electrolytic) with a labeled polarity.
- Capacitors use various codes for values. Mostly printed value is in “pico-Farads”
  - 1000 pico-farad (pF) = 1 nF = .001 μF
  - Small caps use 3 digits: First 2 digits x multiplier 10ⁿ, n= 3rd digit. i.e. “103” = 10x10³= 10000 pf (=.01 μ F)
  - 22 pF can also be written as “22” or “22K”, where K denotes the tolerance code (if only 2 digits, no multiplier).
  - Larger values of capacitance require the polarized capacitor type, with positive and negative ends. Most 22 μF’s are polarized (note polarity in schematic).

DIODES

- Diodes are a 1-way gate for current flow (current rectifier).
  - Small threshold for current flow (<1 V)
  - Therefore, is voltage is >1V, current will flow along arrow in schematic (anode to cathode)
  - Here, use for safety: any voltage >1 volt on subject will flow through diode, not through the user!
  - Each pair protects against both positive and negative voltages.
  - Since ECG voltage is much less than 1V, it is not affected by diodes in normal operation



CREATE PARTS LIST WITH PICTURES IF NEEDED (SHOULD MATCH PARTS IN YOUR BAG!)

Sample (Partial) Parts List for ECG Amplifier

Resistors:

(1) 100 Ohm

(4) 100K Ohm 1%

Capacitors:

(1) 100 pF

(1) 22uF

Semiconductors

(4) 1N4004 Diodes

(1) AD622 Chip

(1) LM741 Chip

WEEK 3 TOPICS FOR FINAL REPORT

- Schematic diagram of the electronic amplifier circuit.
- Text description of the circuit functions, including 2 8-pin amplifiers.
- Table of electronic components needed for the design, with images/pictures!
- Include listing of additional parts such as bread board, batteries, etc.