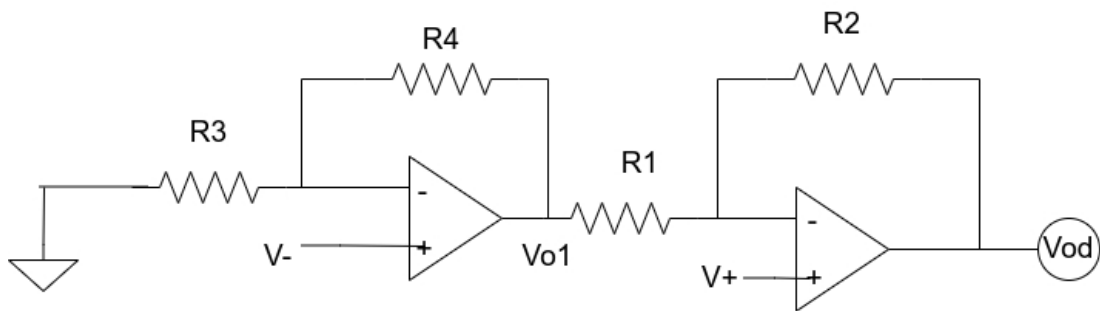


# Hardware design EEG Amplifier circuit

## 1. Instrumentation stage

Need to use Instrumentation stage instead of simple amplifier

- a) High CMRR
- b) Low bias current input - High input impedance
- c) Low Noise and drifts



Applying nodal analysis as R3, R4 joining node

$$\frac{V(-)}{R3} + \frac{V(-) - Vo1}{R4} = 0$$

$$(R4 + R3) * V(-) = R3 * Vo1$$

Applying nodal analysis as R1, R2 joining node

$$\frac{V(+) - Vo1}{R1} + \frac{V(+) - Vod}{R2} = 0$$

$$(R1 + R2) * V(+) = R1 * Vod + R2 * Vo1$$

Now  $R4 = R1 = 10k$  and  $R2 = R3 = 1k$ , Replacing  $Vo1$  with  $V(-)$  from above equation

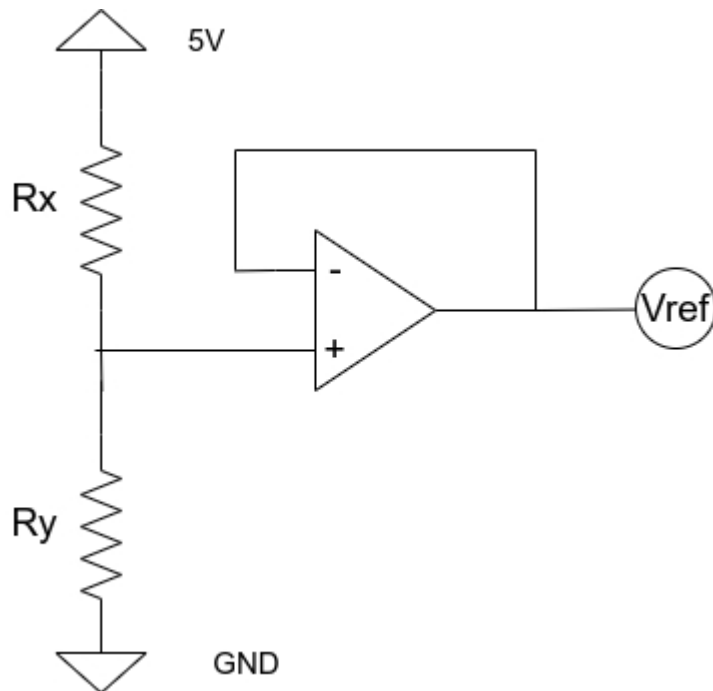
$$Vod = (V(+) - V(-)) * (1 + \frac{R1}{R2})$$

Now as  $R1/R2 = 10$ ,  $Vod = 11 * (V+ - V-)$

## 2. Reference building stage

Need for reference voltage with

- a) Voltage isolation
- b) High input impedance
- c) Stable reference



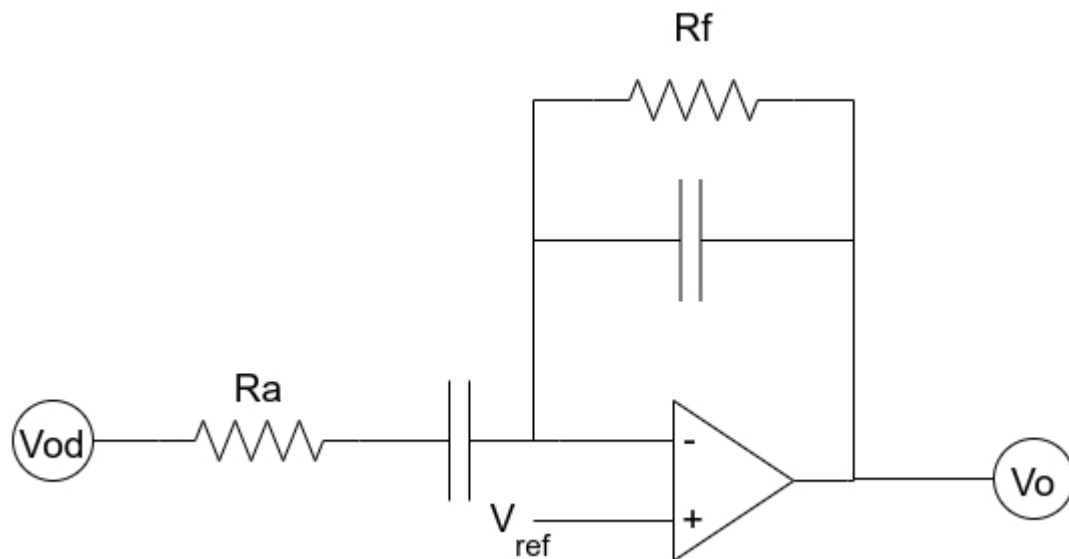
Here  $R_x = R_y = 10k$

Hence with Unity gain  $V_{ref} = 2.5\text{ V}$

We need 2.5V reference as our signal is differential and can go in negative but bias is not negative hence we can get clipped signal

### 3. Amplification stage

This stage will give gain and hence required here



Here capacitor in series of  $R_a$  will block dc signal to flow, Parallel cap to  $R_f$  is to filter higher frequencies

Applying nodal at  $R_f$  and  $R_a$  joint

$$\frac{V_{ref} - V_d}{R_a} + \frac{V_{ref} - V_o}{R_f} = 0$$

$$V_o = (V_{ref} * \frac{R_f + R_a}{R_a}) - (V_{in} * \frac{R_f}{R_a})$$

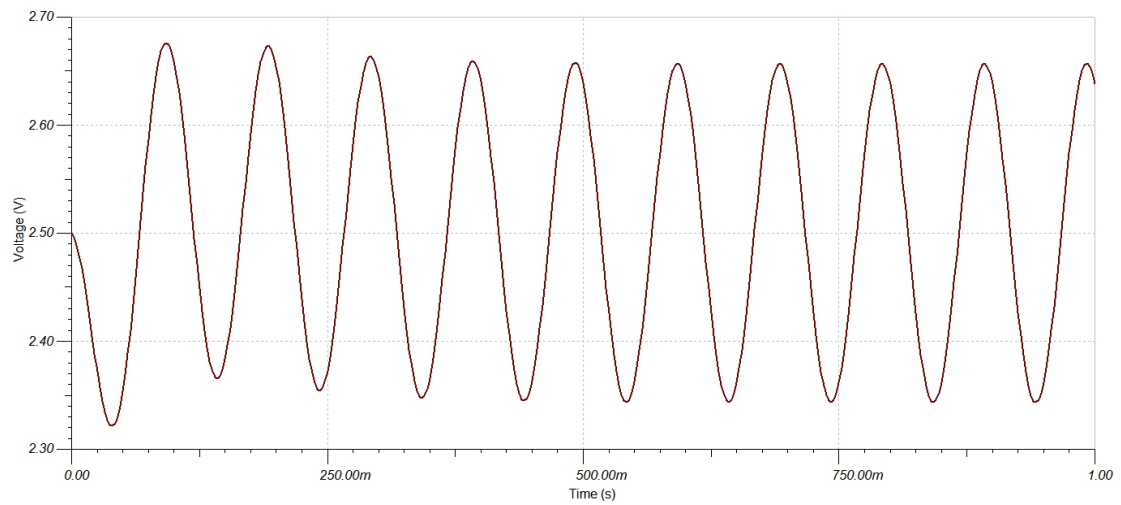
$V_{ref}$  term shall be 0 as there's already a capacitor blocking DC voltages

$$V_o = - V_{in} * \frac{R_f}{R_a}$$

To get 1000 gain value of  $R_f = 1M$ ,  $R_a = 1k$

We won't get 1000x but low as capacitor is there in parallel with  $R_f$  and with reduce value it'll give more gain but it'll reduce the filtering of higher frequency

For 1mV input at 10Hz output getting is 300x -> 300mV



For 10mV input at 10Hz we are getting 3V which is 300x output with change in shape which happens because of opamp saturation to bias which is 5v, Normally this won't happen as max brain signal voltage will be less than mV

