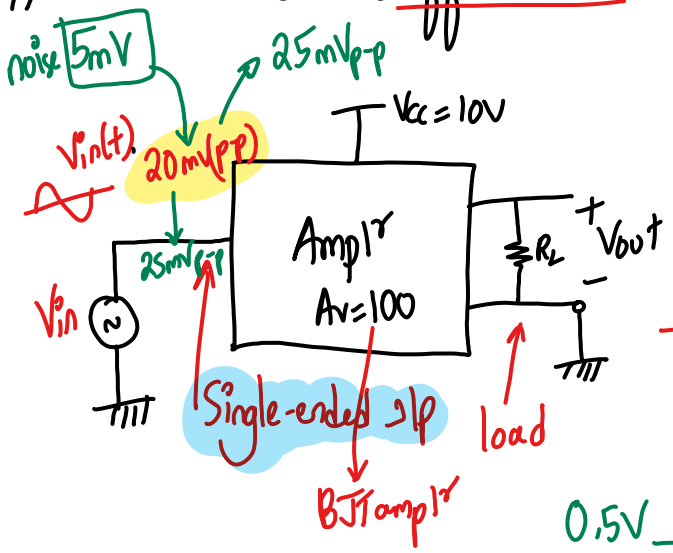
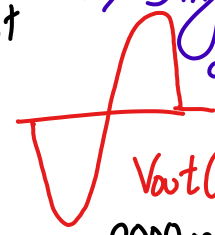
AEC lec 35 15/10/23

Module 5 : Differential amplifier



Why diffamp?

→ Single stage ampl'r

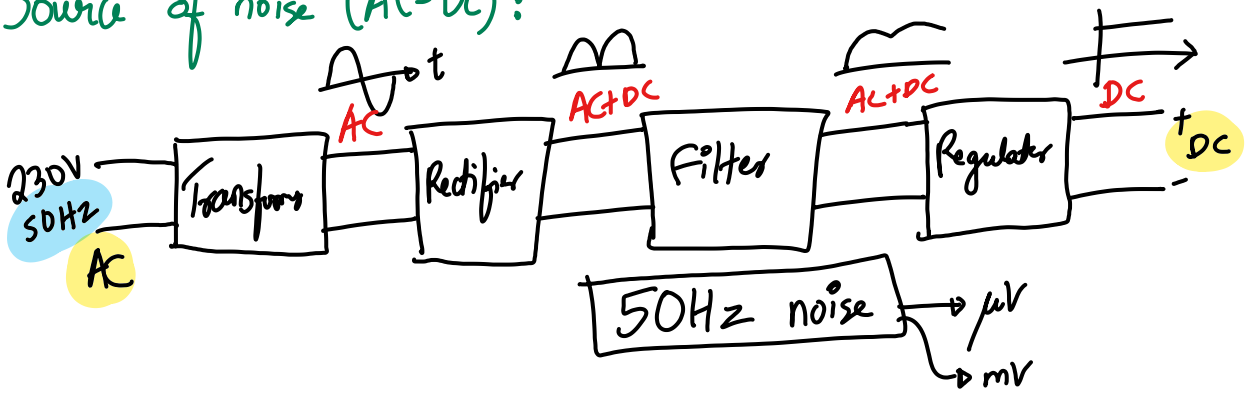


- BJT amplifier
  - CE CB CC
- MOSFET amplifier
  - CS CG CD

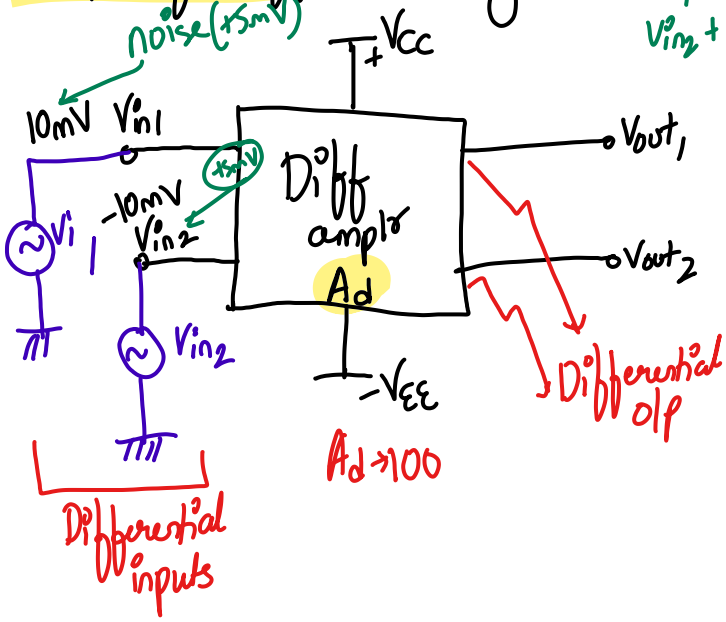
2000 mV = 2V

0.5V → (2.5V)(2500mV)

Source of noise (AC-DC):



Concept of Differential s/g:



$V_{out} = V_{out_1} - V_{out_2}$

$V_{out} = A_d (V_{in_1} - V_{in_2})$

$V_{out} = A_d \left(V_{in_1} + V_{noise} - (V_{in_2} + V_{noise}) \right)$

$V_{out} = A_d (V_{in_1} - V_{in_2})$

$V_{out} = 100(10mV - (-10mV))$

$V_{out} = 2V$

(AC) ↳ noise free o/p

1) Differential i/p voltage (V_d or V_{id}):

If inputs (V_{in_1} & V_{in_2}) applied to the differential amplr are such that there exist either amplitude or phase difference betn them → such inputs are called as "differential i/p"

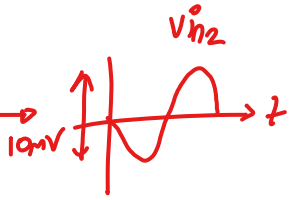
$$V_d = V_{id} = V_{in_d} = V_{in_1} - V_{in_2}$$

eg $V_{in_1} = 40mV$, $V_{in_2} = 20mV$ → $V_{id} = V_d = 20mV$ (amplitude difference)

eg $V_{in_1} = 10mV \angle 0°$, $V_{in_2} = 10mV$ @ $180°$ phase (phase difference) $= -10mV$

$V_{id} = 10mV - (-10mV)$

$V_{id} = 20mV$



2. Differential mode gain (A_d or A_{V_d})

The gain with which differential amplifier amplifies the differential inputs signal (V_{id} or V_d) is known as "Differential mode gain"

$$A_d = \frac{V_{out_1} - V_{out_2}}{(V_{in_1} - V_{in_2})} = \frac{V_{out_d}}{V_{in_d}} = \frac{V_{od}}{V_{id}}$$

($V_{out_1} - V_{out_2}$: differential o/p voltage (V_{out_1} w.r.t V_{out_2}))

$(V_{in_1} - V_{in_2})$: $100\mu V$, $50\mu V$, V_{id}

Ideally: $A_d : \infty$

Practically: A_d → very high

Diff amplr → ECG – low mV; EEG – low mV or μV

3. Common mode input voltage : (V_{icm} or V_{cm})

If inputs (V_{in_1}, V_{in_2}) applied to diffampl^r are of same magnitude & phase → then such i/p's are known as 'Common-mode input voltage'

$$V_{cm} = \frac{V_{in_1} + V_{in_2}}{2}$$

$V_{in_1} = 10\mu V$, $V_{in_2} = 10\mu V$

$V_{cm} = \frac{10\mu V + 10\mu V}{2} = 10\mu V$

eg $V_{in_1} = 1V$, $V_{in_2} = 1V$ (same magnitude) → $V_{cm} = \frac{1+1}{2} = 1V$ $\quad V_{cm} \neq 0$

4. Common mode gain (A_{cm} or A_{vcm})

The gain with which the diffampl^r amplifies the common-mode s/g is called "Common-mode gain"

$$A_{cm} = \frac{V_{out}}{V_{cm}} = \frac{V_{outcm}}{V_{cm}}$$

V_{outcm} → V_{out} due to common-mode component of o/p

V_{cm} : noise → Reject ?

Ideally, $A_{cm} \to 0$

Practically, A_{cm} → very low (< 1)

5. CMRR (Common mode rejection ratio):

- It is the ability of diffampl^r to amplify differential mode signal & reject common-mode signal
- It is the ratio of differential mode gain (A_d) to the common-mode gain (A_{cm})

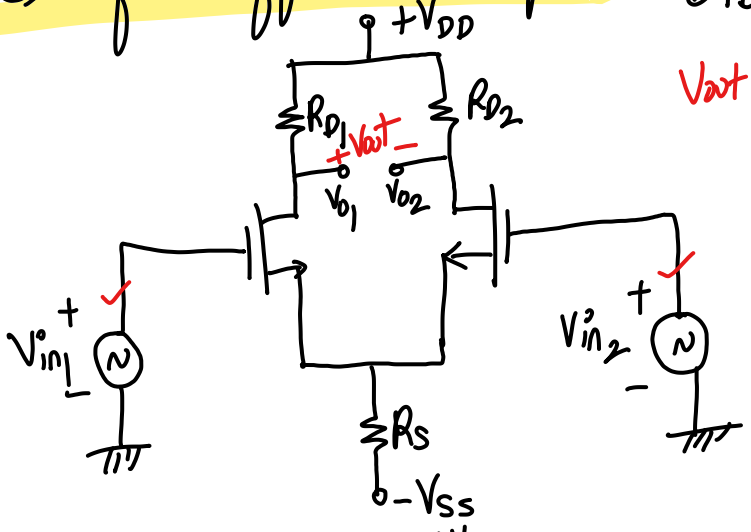
- $CMRR = \frac{A_d}{A_{cm}}$

- $CMRR_{dB} = 20 \log_{10}\left(\frac{A_d}{A_{cm}}\right)$ eg 80dB

Ideally → $CMRR = \frac{A_d \to \infty}{A_{cm} \to 0} \to CMRR \to \infty$

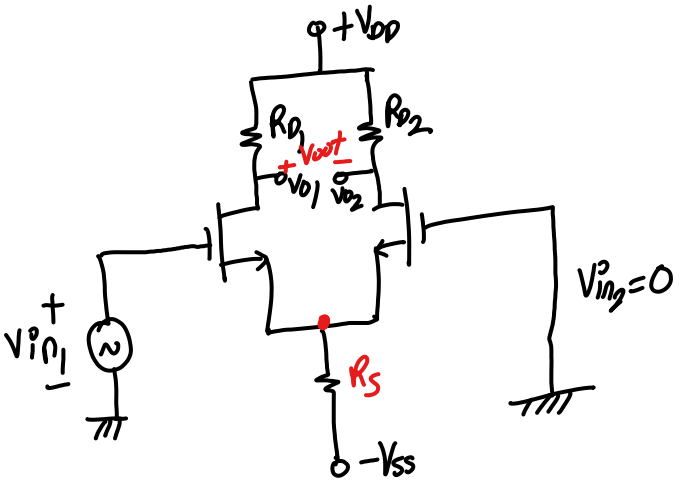
Practically → CMRR → very high

Types of Differential amplr: DIBO, DIUO, SIBO, SIUO



$V_{out} = V_{o1} - V_{o2}$

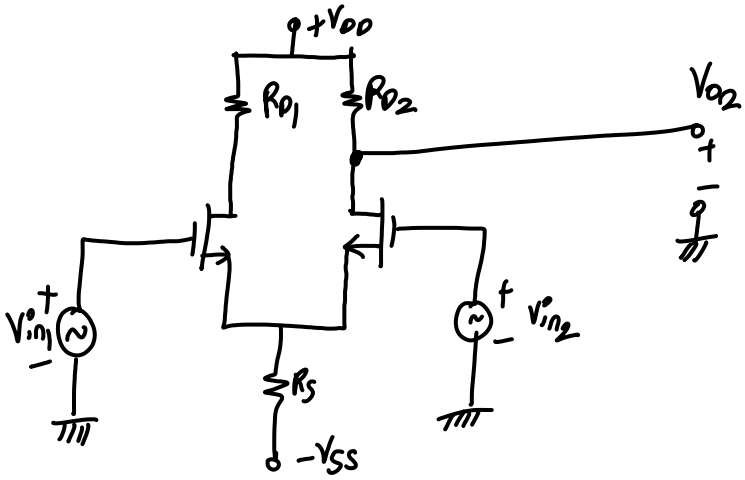
Dual i/p balanced o/p Differential amplr (DIBO)



SIBO (Single o/p balanced o/p diff amplr

$V_{out} = V_{o1} - V_{o2}$

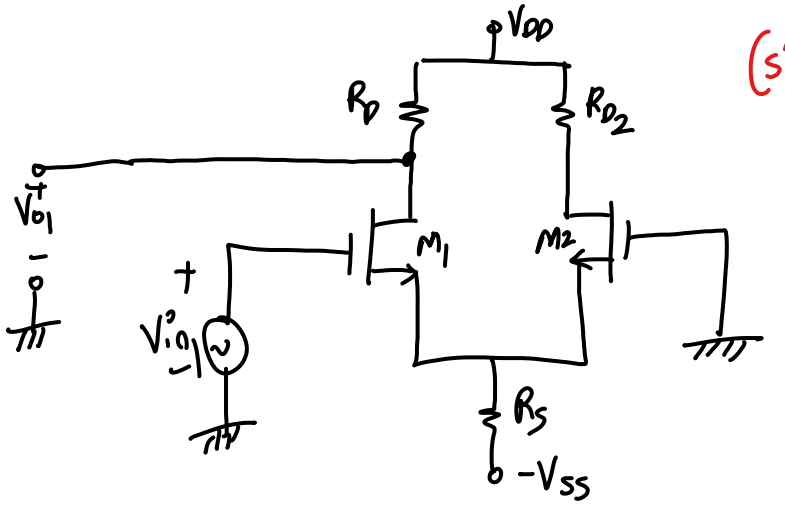
$V_{ind} = V_{in1}$



DIVO
(Dual i/p unbalanced o/p Opamp)

$V_{out} = V_{o2}$ or V_{o1}

o/p measured w.r.t gnd



SIVO
(single i/p unbalanced o/p diff. amplr)

$V_{out} = V_{o1}$ or V_{o2}

$V_{in_d} = V_{in_1}$ or V_{in_2}

—x—