

Expt 9 – Measurement of Opamp DC Parameters

Oct 8, 2021 (Friday)

EE 230 Analog Circuits Lab

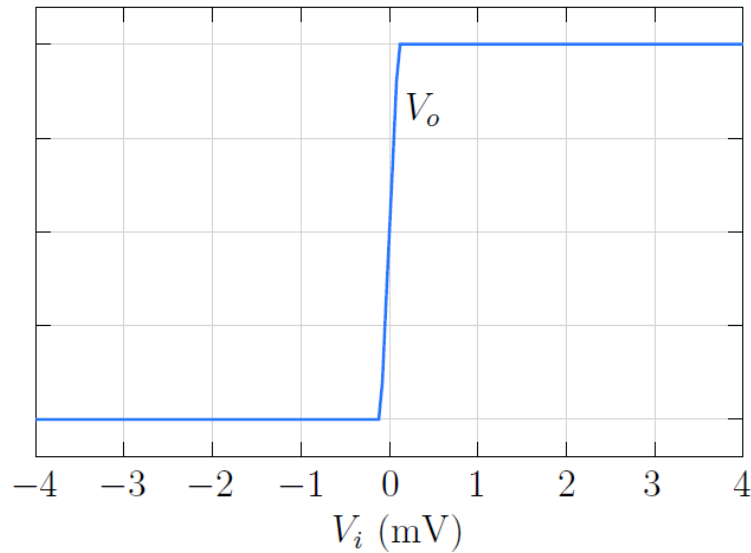
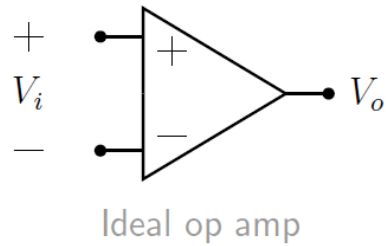
Joseph John

2021-22/I

Summary

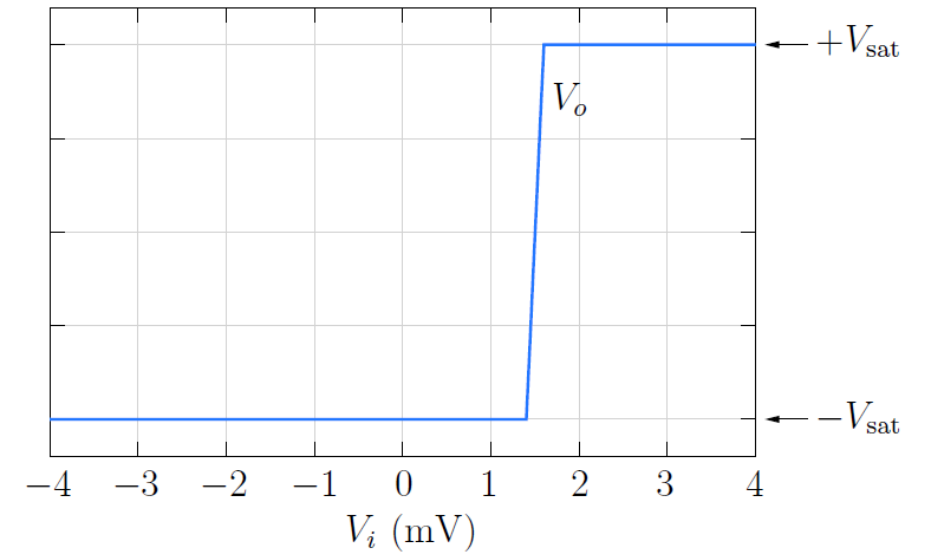
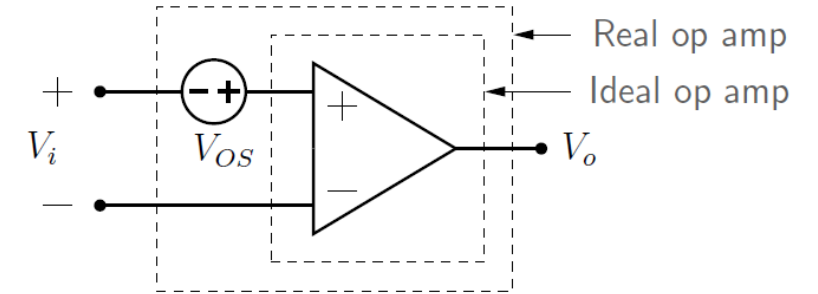
- Measurement of the Major Opamp DC Parameters
 - Input Offset Voltage, V_{OS}
 - Input Bias currents, I_B^+, I_B^-
 - Input Offset Current, I_{OS}
 - DC Open-loop Voltage gain, A_{OL}

Input Offset Voltage, V_{OS}

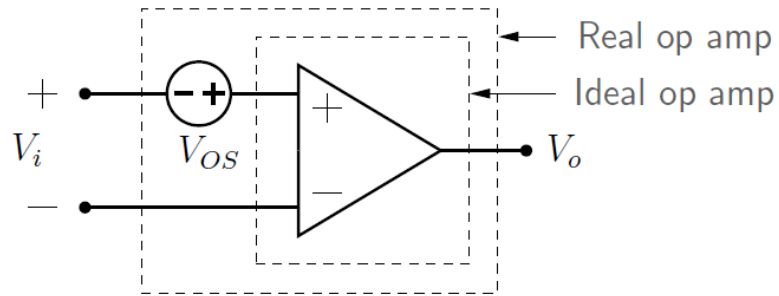


V_{OS} (typ -5 to +5mV)

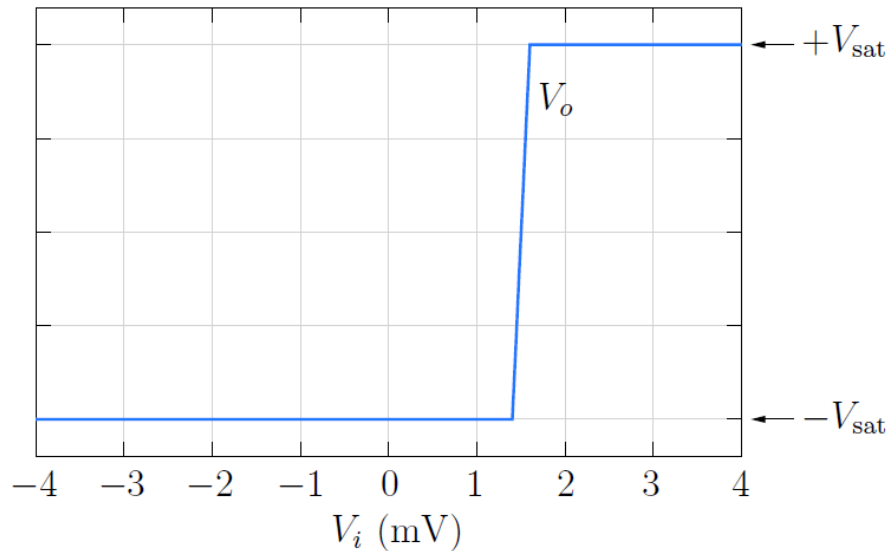
- V_{OS} – the amount input voltage to be applied to make $V_o = 0$
- Due to device parameter mismatches



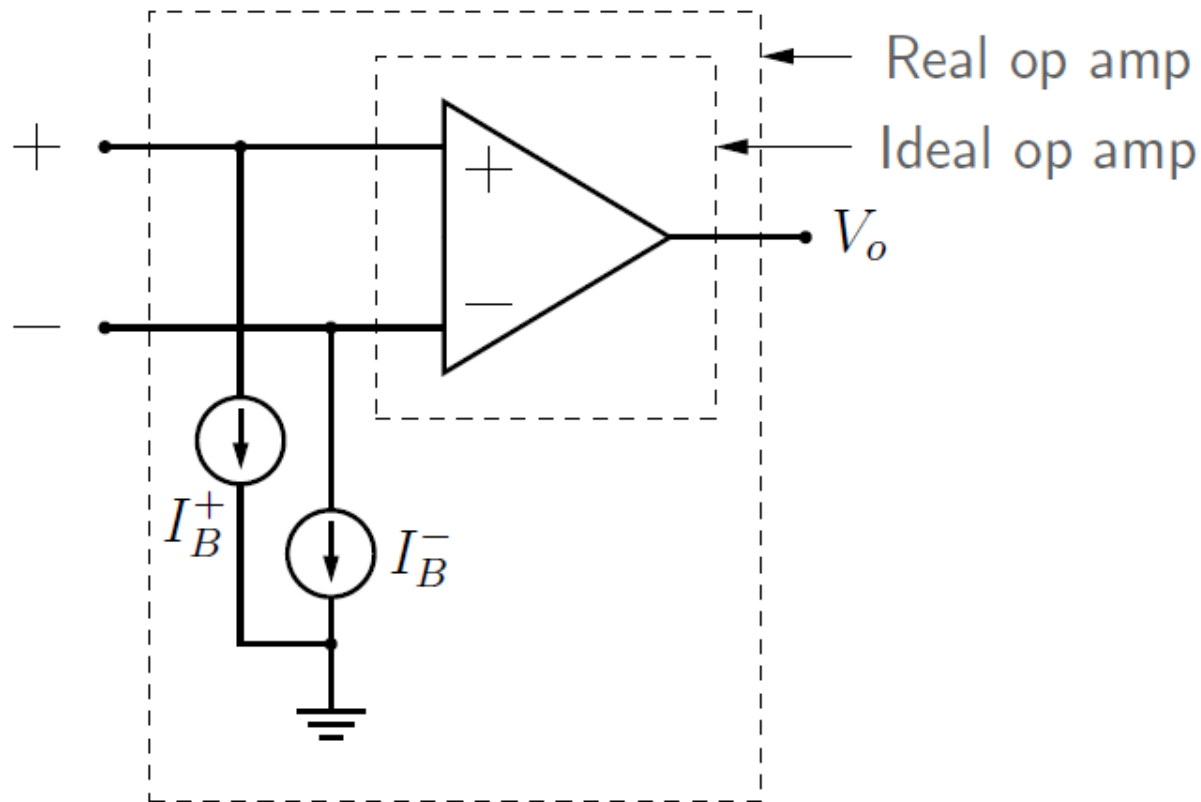
Input Offset Voltage, V_{OS}



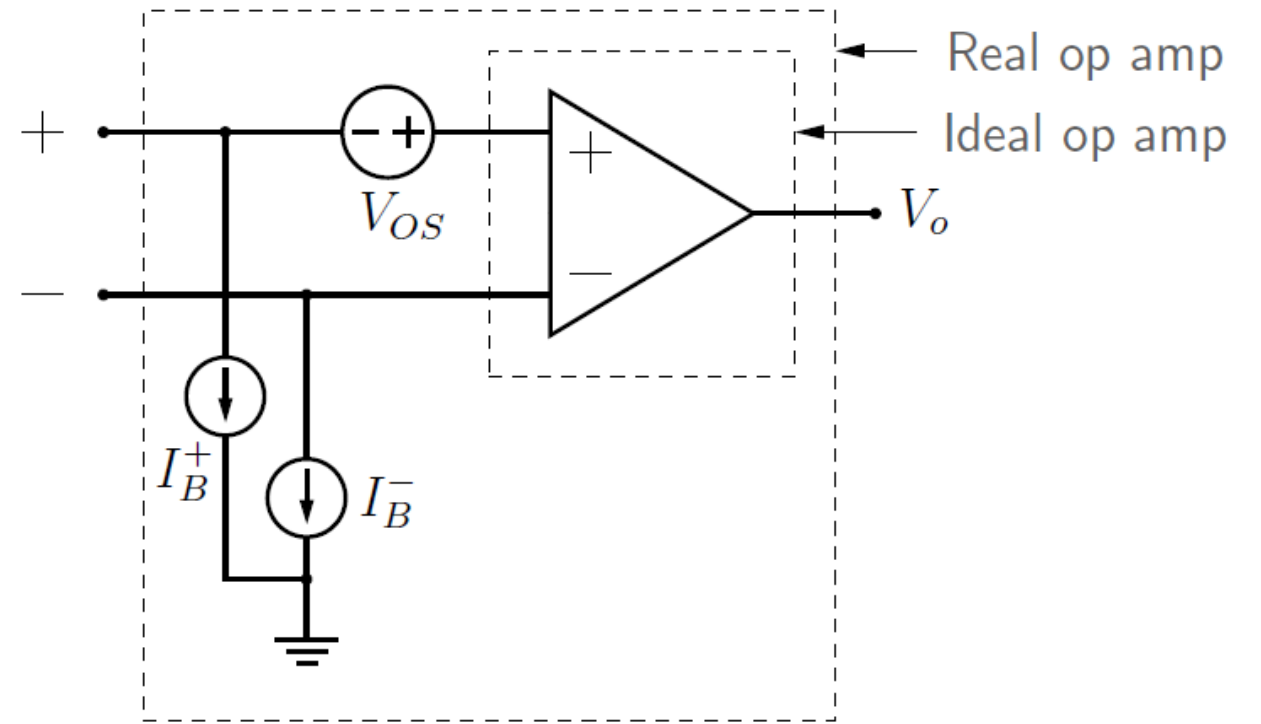
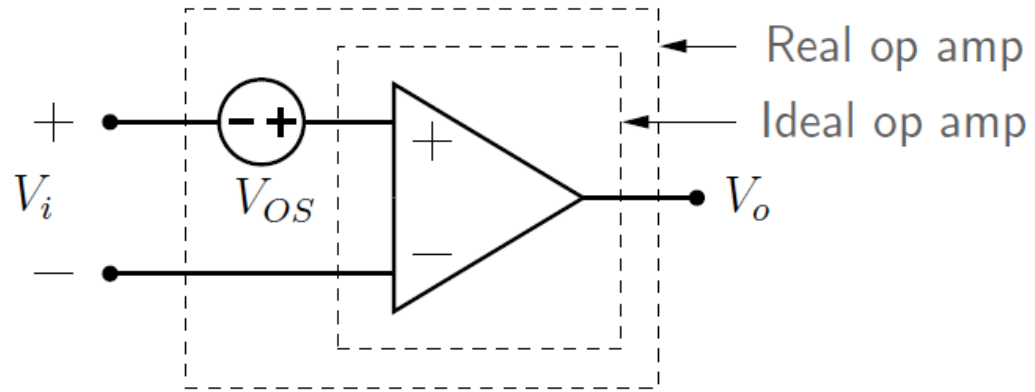
- External input voltage that must be applied to make V_o go to zero
- This external source balances out the input offset voltage of the op amp.
- **Input offset voltage** (V_{OS}) must be of equal magnitude and of opposite polarity to the voltage we applied externally.



Input Bias currents, I_B^+ and I_B^-

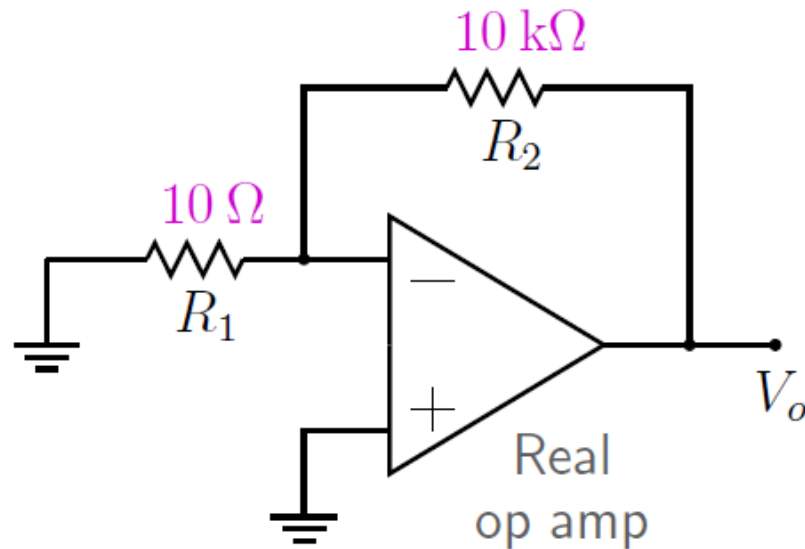


- Due to the non-zero base currents in BJT Opamps (such as UA741 and LM324)
 - nA range
- Due to the non-zero base currents in JFET-input Opamps (such as TL084)
 - pA range



Combined effect of V_{OS} and bias currents

Measurement of V_{OS}

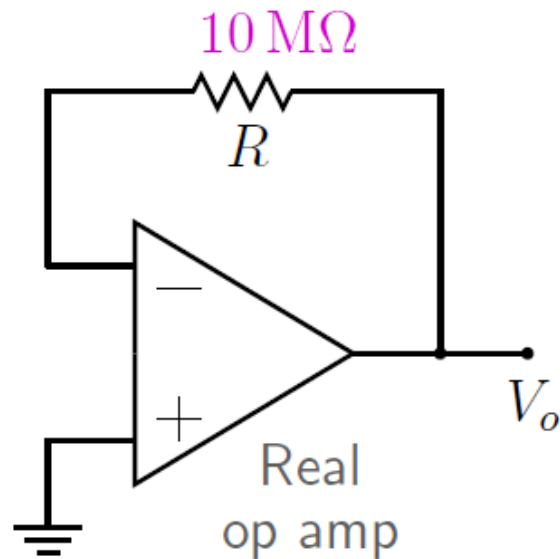


741 Opamp

- $V_o = 0.39\ \text{V}$
- $V_{OS} = 0.39\ \text{mV}$

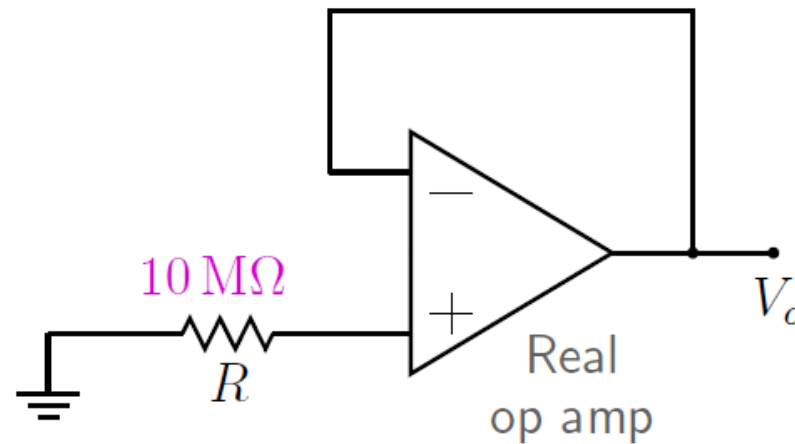
- Effect of bias currents negligible
 - Small (R_1 and R_2)
- Opamp amplifier configuration, with high gain
- Offset voltage gets amplified
- $V_{OS} = V_o / [1 + (R_2/R_1)]$
 $\approx V_o / (R_2/R_1)$

Measurements of Input Bias Currents: I_{B+} and I_{B-}



741 Opamp

- $V_o = 0.28 \text{ V}$
- $I_{B-} = 28 \text{ nA}$



741 Opamp

- $V_o = -0.34 \text{ V}$
- $I_{B+} = 34 \text{ nA}$

- Effect of V_{os} negligible
- Drops due to bias currents much higher than due to V_{os}
- Bias current direction?

Comparison: Measured V_{OS} , I_B , and I_{OS}

	TL081	LM324
V_{OS}	0.18 mV	-12.82 mV
I_{B+}	20 pA	10.94 nA
I_{B-}	30 pA	10.9 nA
I_B	25 pA	10.92 nA
I_{OS}	10 pA	0.04 nA

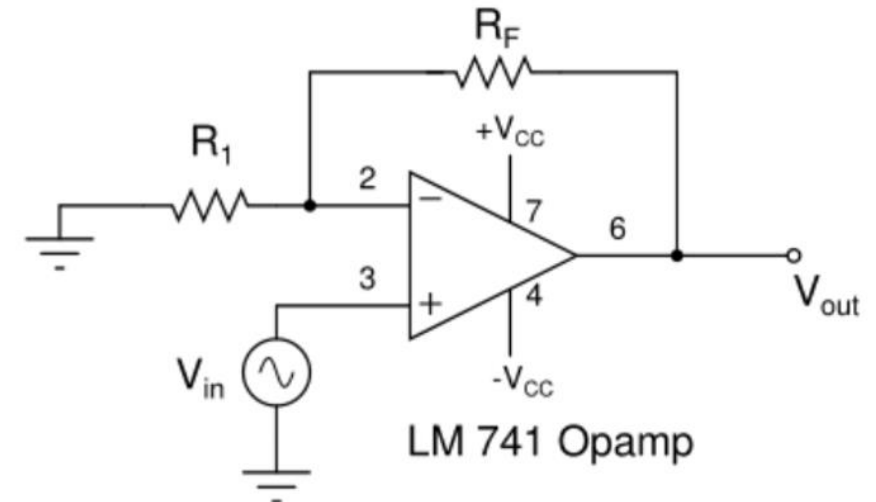
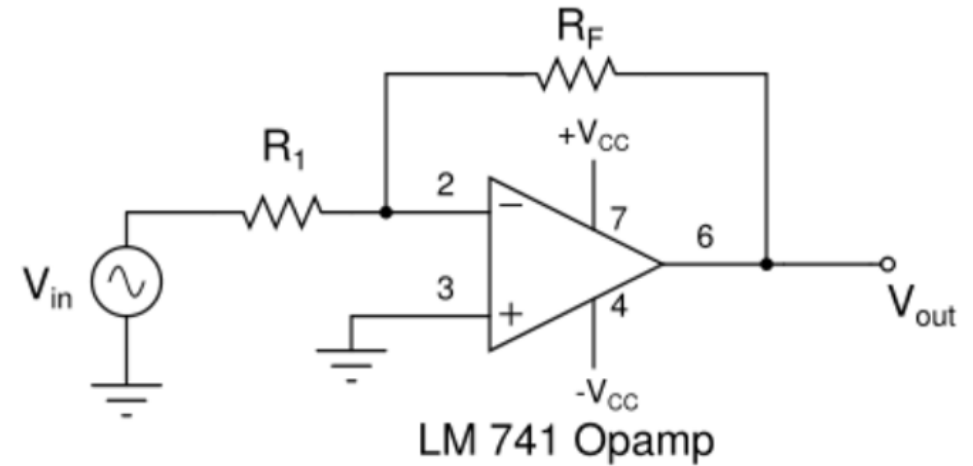
- TL081
 - JFET input Opamp
- LM324
 - BJT input Opamp

Input Bias Current (I_B) and Input Offset Current, (I_{OS})

- $I_B = (I_{B+} \text{ and } I_{B-})/2$
- $I_{OS} = |I_{B+} - I_{B-}|$
- How to reduce the effect of I_B ?
- How to reduce the effect of I_{OS} ?

741 Opamp Measurements

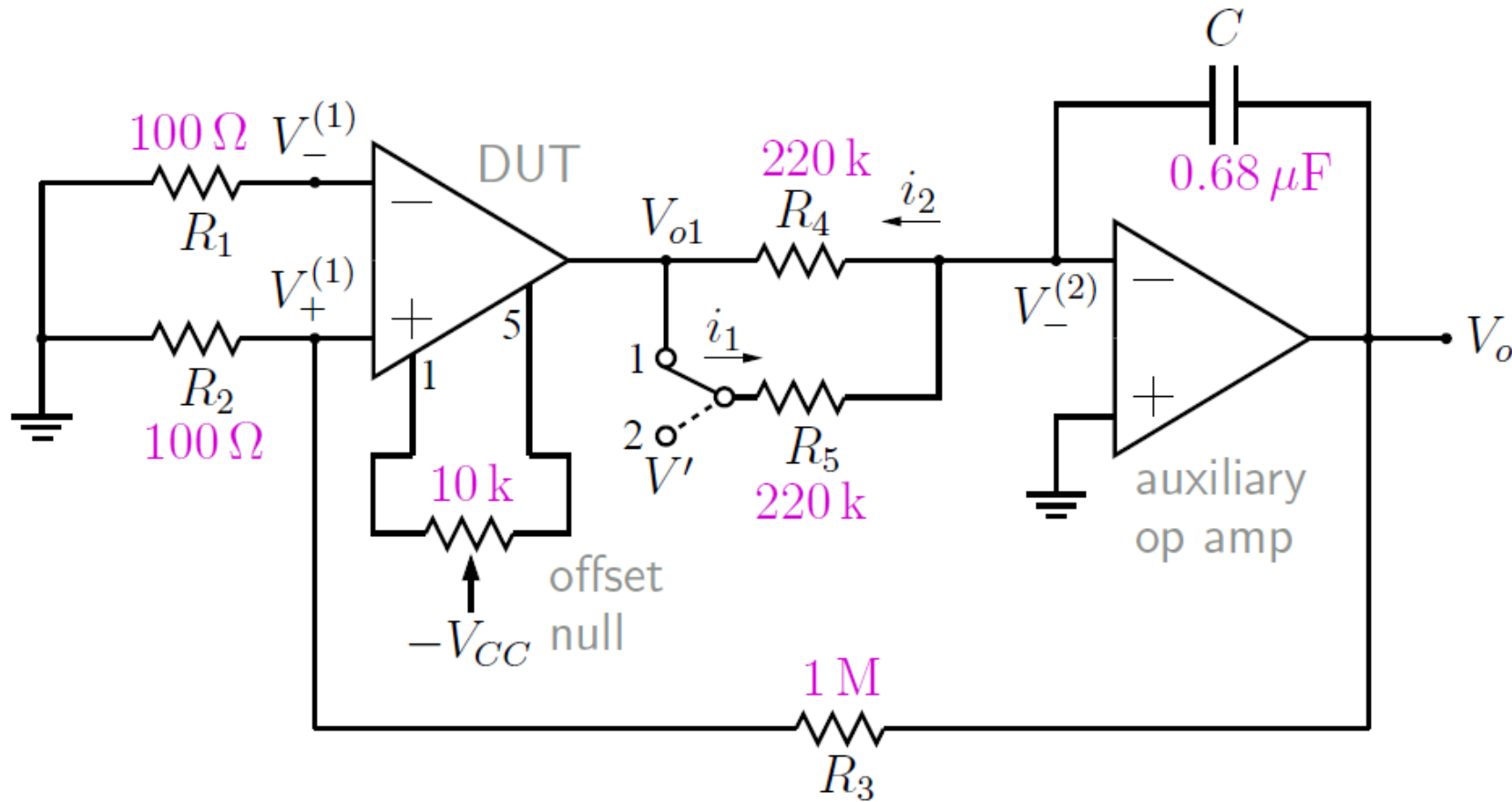
- $I_B = (34 + 28)/2 = 31 \text{ nA}$
- $I_{OS} = |34 - 28| = 6 \text{ nA}$



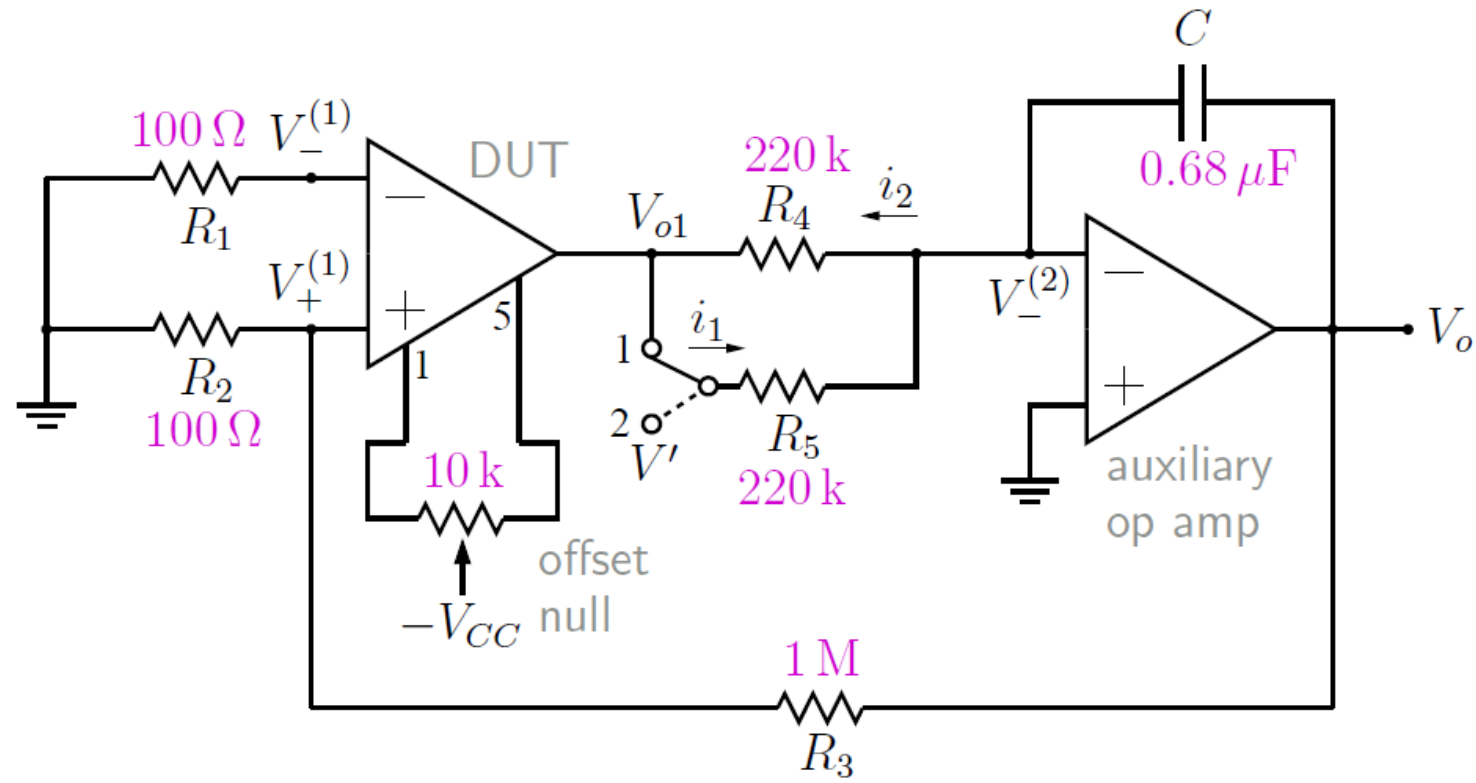
Implications of V_{OS} , I_B and I_{OS}

- Signal inputs should be at least tens of mV (for general purpose Opamps)
- Choose resistor values carefully
- Choose medium range resistor values – neither too high, nor too low

DC Open-loop Voltage gain, A_{OL}



- Servo mode
- DUT and Aux Opamp together working in –ve feedback



V'	V_{o1}	V_o	A_{oL}
1.2 V	- 1.2 V	0.12 V	10^5
3.15 V	-3.15 V	0.175 V	2×10^5
2.1 V	- 2.1 V	0.175 V	1.2×10^5

Announcements

- Oct 15 (Fri) – Holiday
- Oct 22 (Fri) – Exp 10 and Quiz 10
- Oct 29 (Fri) – Endsem Exam
 - 2 hour (2:00 – 4:30pm) – in two slots of 1 hour each
- Midsem and Quiz 7 and Quiz 8 Corrections
 - By Oct 15, 16 (at least Midsem + Quiz 7)
- Nov 5 (Fri) – No Lab !!