EE230 : Analog Circuits Lab

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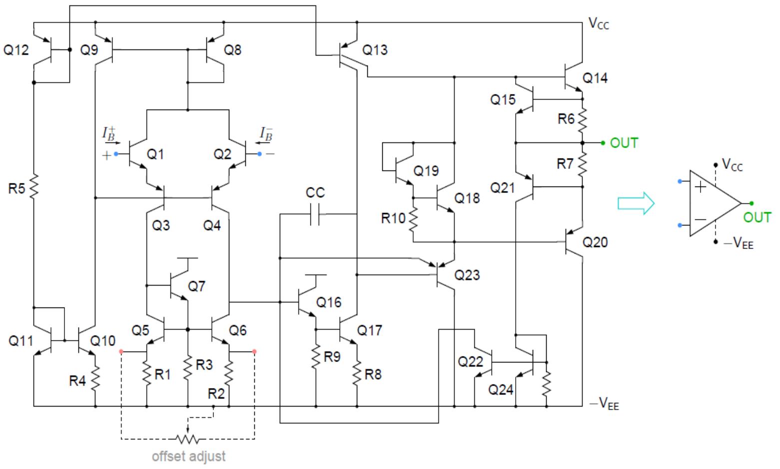
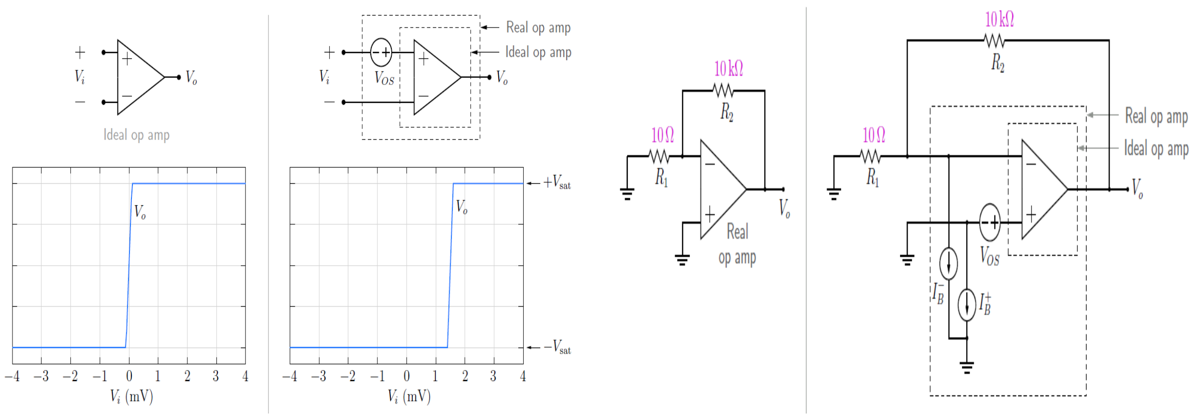
Experiment 9 : Measurement of Opamp DC Parameters

October 9, 2021



Internal Circuit of OpAmp 741

Input offset voltage



In reality, there are always some small differences between the transistors.
As a result of this mismatch, the Vo versus Vi relationship of a real OpAmp exhibits a shift along the Vi axis.
For Op Amp 741, the offset voltage is typically in the range -5mV to +5mV.

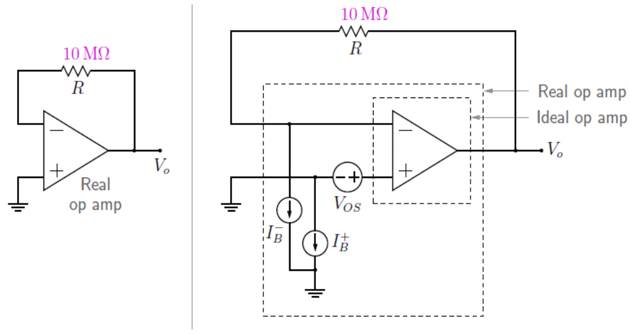
$$V_{OS} = \frac{V_o}{1 + R_2/R_1} = \frac{V_o}{R_2/R_1}$$

Input bias currents

The transistors of the input stage of OpAmp 741 draw small but non-zero base currents I_B+ and I_B-. Due to mismatches, I_B+ and I_B- are not the same.
The average of the two currents is called the input bias current I_B, and the difference between the two is called the input offset current I_{OS}

$$I_B = \frac{I_B^+ + I_B^-}{2} \qquad I_{OS} = |I_B^+ - I_B^-|$$

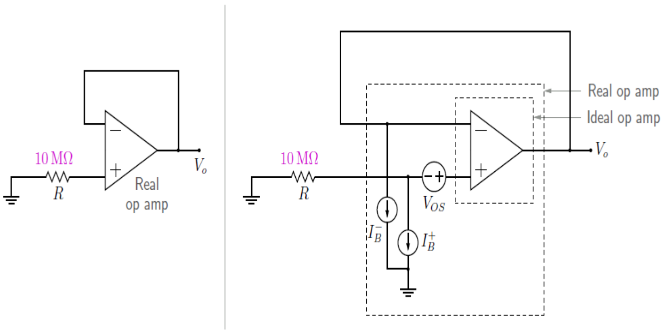
For Op Amp 741, IB is typically 100 nA, and IOS is 10 nA at 25 ◦C.



I_B^- **:** Since the OpAmp is ideal, we have V =V+ =Vos, and the output voltage is,

$$V_o = V - + I_B^- R = V_{OS} + I_B^- R$$

$$\implies I_B^- \approx V_o/R \quad \text{For large values of R}$$

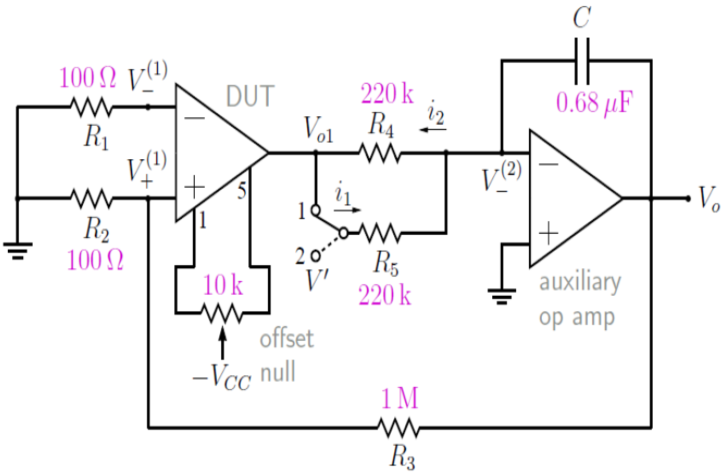


I_B^+ **:** Since the OpAmp is ideal, we have V =V+ =Vos, and the output voltage is,

$$V_o = V + + I_B^+ R = V_{OS} + I_B^+ R$$

$$\implies I_B^+ \approx V_o/R \quad \text{For large values of R}$$

Measurement of dc open loop gain



One of the most important features of an OpAmp is a high open-loop gain A_{OL} which is typically in the range 10^5 to 10^6. With a large gain of 10^5 or more, the OpAmp is likely to be driven to saturation on account of the input offset voltage Vos which is typically in the range -5mV to +5mV for OpAmp 741.

$$V_{o1} = [V_o.R_2/(R_2+R_3)].A_{OL} \approx [V_o.(R_2/R_3)].A_{OL}$$

$$V_{o1} = V_-^{(2)} - i_2 R_4 = 0 - \frac{V' R_4}{R_5} = -V'$$

$$\frac{R_2}{R_2+R_3}(V_o^B - V_o^A) * A_{OL} = -V'$$

Comparison

Following is a table comparing the Input offset voltage (V_{OS}), Input bias current (I_B), Input offset current (I_{OS}) and the DC open loop gain (A_{OL}) of UA741, TL084 and LM324.
Values in the table are the typical values at 25^oC

Parameter	UA741	TL084	LM324
V_{OS}	1mV	3mV	3mV
I_B	80nA	20pA	20nA
I_{OS}	20nA	5pA	2nA
A_{OL}	200V/mV	200V/mV	100V/mV

References

1) Lecture Slides
2) Sedra-Smith