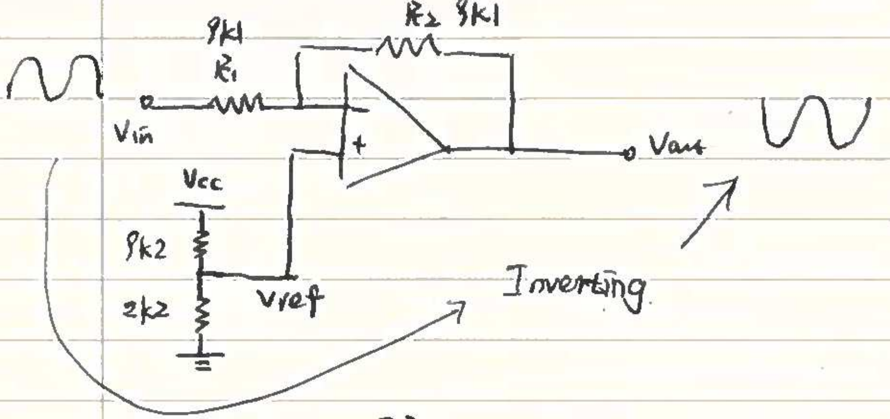
Problem 1: Op-Amp stable operation should maintain gain > 1 (simulation error)
Solution: upgrade sense resistor value.
Afterwards, we can use differential amplifier to amplify voltage across small value sense resistor
One of these allegro sensors is recommended for my circuit:
https://www.allegromicro.com/en/products/sense/current-sensor-ics/zero-to-fifty-amp-integrated-conductor-sensor-ics
Main task:
Study performance of Op-Amp LM741 and FDS9926A dual N-channel MOSFET for building test circuit.
The frequency chosen is 1KHz, which is suitable for LM741 (with around 200KHz bandwidth product)
FDS9926A: spice model found from
https://www.onsemi.com/design/resources/technical-documentation?rpn=FDS9926A#ZHQ9TW9kZWxzO3N3PUZEUzk5MjZBO3N0PXR5cGU7c2Q9ZGVzYzs=

(Review in 07/16 and here are some comments after experiments)

Solved: LM741is a rail to rail operational amplifier - if it used as an amplifier - we need to consider amplification - ≥ 1 gain
Obviously, we want signal that control gate voltage of MOSFET stay as much stable as it can from the feedback loop. If there is a gain in amplifier that is bigger than 1, it amplifies the oscillation in the loop, which can not make the circuit stable at operation.
Another reason that amplifier should not be used here, since LM741 is -&+ power supply, the feedback also need inverse response, therefore negative gain will cause negative output in this case. An offset voltage is needed to inverse the negative output to positive.
Solution: Using LM324 single power supply as a comparator to compare set reference voltage with sensing voltage across the Rs, then give a positive output to turn on MOSFET.

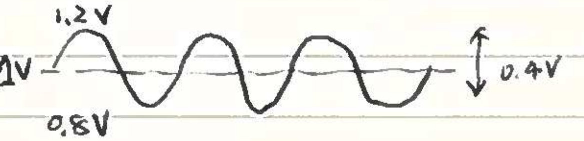
-> How to add this part into my essay - how to explain why amplifier is a bad idea in this circuit & how to explain why LM324 is better than LM741 in comparator usage?
In the dissertation, it would be better to add basic introduction to operational amplifier.
And explain my attempts and why i chose to try this way & what i found is important & How it affect the choice later
-> Explore:
1, For feedback loop, why we choose op amp as a comparator in our circuit?
2, For op amp selection, which features are important? Is single supply and dual supply really matters? Will it affect the performance as a comparator?

The same structure



$V_{ref} = 5 \times \frac{2.2}{9.2+2.2} \approx 0.965$

V_{in} = sine wave →

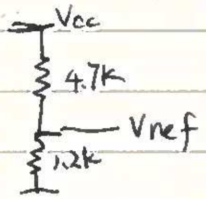


freq = 322.2 kHz

V_{out} = 1.8 ~ 2V sine   freq = 322.6 kHz

↕ 0.2V

$V_{output\ offset}$ = 1.9V → ≈ 2 × 0.965 = 1.930V



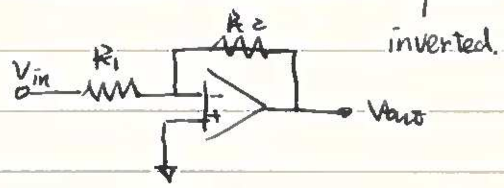
V_{ref} = 1V

V_{in} = 1V offset 0.4mV amplitude

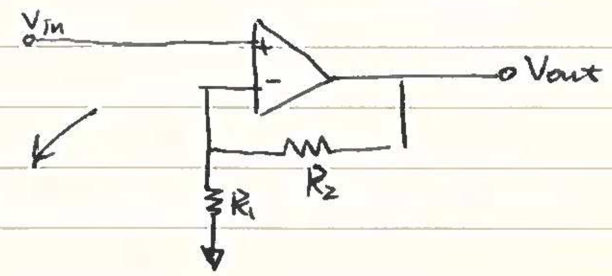
V_{out} = 1.9V offset 0.2mV amplitude

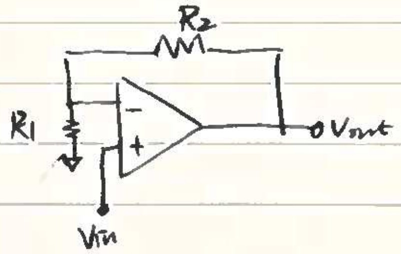
★ Gain caculated wrong: for inverting amplifier $A_V = -\frac{R_2}{R_1}$

↑ inverted

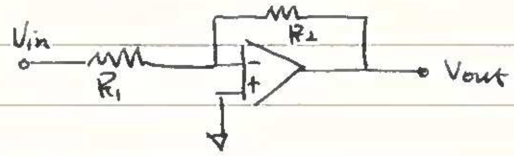


for non-inverting amplifier: $A_V = 1 + \frac{R_2}{R_1}$





Verification by simplest circuit

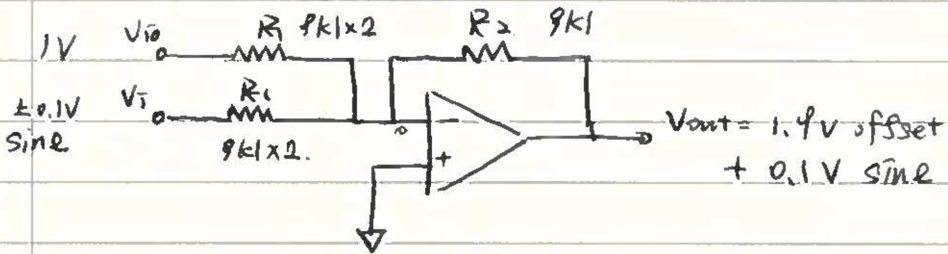


$R_2 = R_1 = 9k1$

V_{in} = 1V offset with ±0.1V amplitude   0.9 ~ 1.1V

V_{out} = 1.8V ~ 2V → 1.9 offset with ±0.1V amplitude

V_{in} with offset



$$\frac{V_{out} - V_-}{R_2} = \frac{0 - V_{io}}{R_1}$$

$$V_{out} = -\frac{V_{io}}{R_1} \times R_2$$

$$\frac{V_{out}}{V_{io}} = -\frac{R_2}{R_1} = -\frac{9k1 \times 2}{9k1} = -2$$

inverting but for offset → No effect for inverting

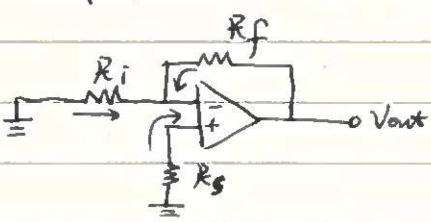
$V_{out\_offset} = 1.9V$ $V_{io\_} = 1V$? 1.9 gain rather than 2

why

⇒ If op-amp input is DC

lets put V_{in} = 1V_DC ⇒ $V_{out} = 1.9V$

⇒ Amplification for DC input.



bais current → Ri & Rs doesn't match

current different at V- & V+

① Ri & Rs matched

→ current V- & V+ identical

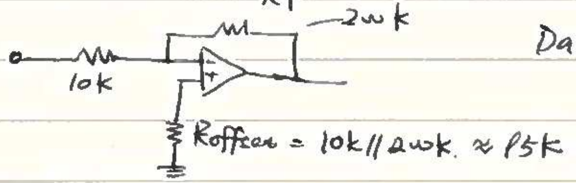
Rs = Ri parallel with Rf → DC offset

Input offset → V_{os}; offset current → I_{os}

$$V_{out\_offset} = A_n \times V_{os} + I_{os} \times R_f$$

A_n: noise gain

$$A_n = 1 + \frac{R_f}{R_i}$$



Datasheet: $V_{os} = 5\,mV \rightarrow$ LM741: 15mV.

$I_{os} = 0.1\,\mu A \rightarrow$ 80~500nA

$$\rightarrow A_v = -\frac{R_f}{R_i} = -20$$

$$A_n = 1 + \frac{R_f}{R_i} = 21$$

$$V_{outoffset} = \underbrace{21 \times 5mV}_{} + \underbrace{0.1\mu A \times 200k}_{}$$

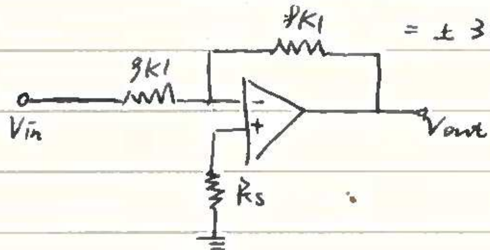
$$= 105mV + 20mV$$

$$= \pm 125mV$$

In my case: $V_{outoffset} = 2 \times 15mV + (80 \sim 500nA) \times 9k1$

$$= 30mV + 4.5mV$$

$$= \pm 34.5mV$$



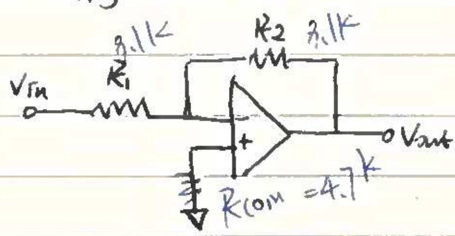
$$I_{offset} = \frac{1V}{9k1} = \frac{1}{9k1}\,A$$

I output offset input.

$$\Rightarrow V_{offset} = \frac{1}{9k1} \times R_f$$

$$= 1V$$

Power supply should be double sided → ±15V



$A_v = -\frac{R_2}{R_1} = -1$ gain

$V_{in} = \pm 0.5V$ sine wave with 333.3kHz

$V_{out} = \pm 0.3V$ sine wave.

1.5MHz Bandwidth_typical.