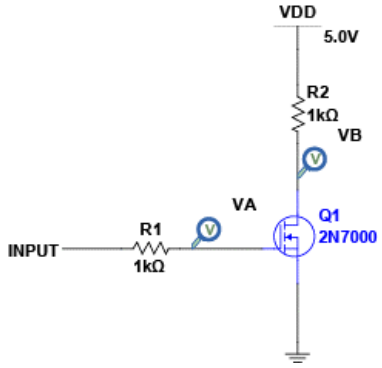
Problem Set #4, EE part

Issue date: Nov. 18, 2021; Deadline: 23:59, Dec. 9, 2021

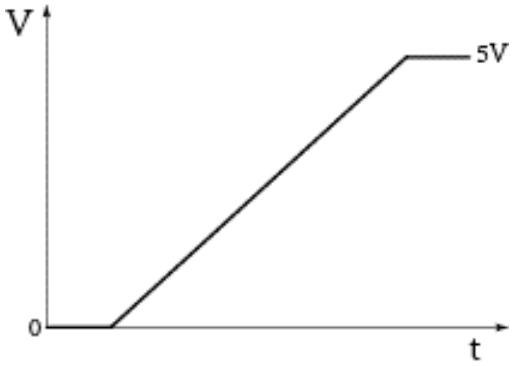
Student Name: _____ Student No.: _____

1. *Transistor circuit*

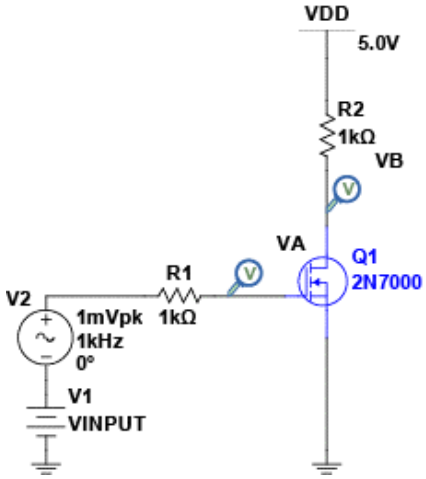
A MOSFET amplification circuit is given below. The datasheet of NMOS 2N7000 can be found here: https://www.findic.com/doc/browser/mQGwOXDQp?doc_id=53694047#locale=zh-CN



- If the input voltage rises from 0 to 5V very slowly, please guess and sketch the waveform of V_A and V_B, and explain the reason (For example, why does the output voltage change when the input voltage reaches a certain value). (5')



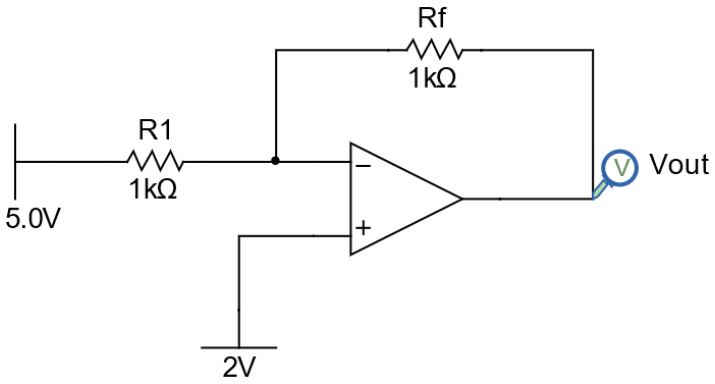
- Build the circuit in Multisim, use 'DC sweep' or 'transient' simulation to validate your guess. (5')
- Find the input value, when $V_B \approx 2.5V$ based on your result in the last question. Then apply an AC voltage (1mV peak voltage) on the DC input. Find the output waveform of V_B, and calculate the voltage gain (neglecting the DC offset, only consider the AC) of this circuit based on your simulation data. (10')



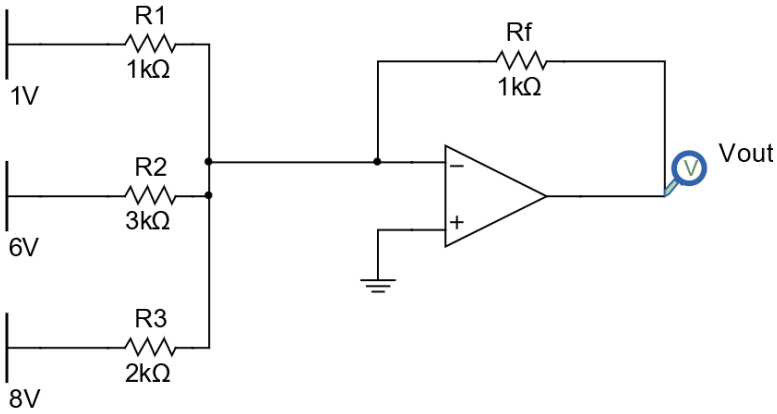
2. ***Operational amplifier***

Virtual ground is an important method to analyze the circuits with operational amplifiers. (link: https://baike.baidu.com/item/虚短). Based on the method of virtual ground, please analyze the output voltage of following circuits. Simulation is not needed in this question, but the procedure of your calculation is necessary.

- Circuit #1 (10')



- Circuit #2 (10')



3. ***Analog-to-digital converter (ADC)***

- Build a 2-bit flash analog-to-digital converter (ADC) in Multisim, the function should confirm to the rule in the following table. Please write down your procedures of design, including your design thought, the simplifications of

digital circuit, and the final simulation. (40')

Input voltage	digital output
0<Vin<1	11
1<Vin<2	10
2<Vin<3	01
3<Vin<4	00

Hints: 1. The ADC example can be found in the slides of lecture #6. 2. Ideal comparator can be found in Analog/ANALOG_VIRTUAL/COMPARATOR_IDEAL

4. *MCU development*

- To realize the traffic light, the effect is that the red light is on for 5 seconds, then the yellow light for 2 seconds, and finally the green light for 4 seconds. Each light needs to flash in a period of 1 second. Add a touch pin, when touched by hand anytime, resetting the whole system, and the response time does not exceed 1 second. (20')

(It is recommended that using the TouchPad function of esp32.)
(Annotate each line of your code and take a clear picture. In addition, take a clear picture of the hardware connection part. Make sure your student ID card is shown in two pictures.)
(Make sure you submit your code in addition to two pictures.)

** When capturing circuit schematics and simulation results, taking a screenshot is recommended. Please refrain from using your phones to take a photo of the screen.*
** Please submit the softcopy of your solutions to the problems on gradescope. When uploading to gradescope, please select all corresponding pages related to each question.*
** Please use English.*
** All flow charts and codes should be enclosed in your solutions.*
** Discussion on methodology is allowed, yet, the assignment should be done individually. Plagiarism, once found, grades zero for the whole homework assignment!!*