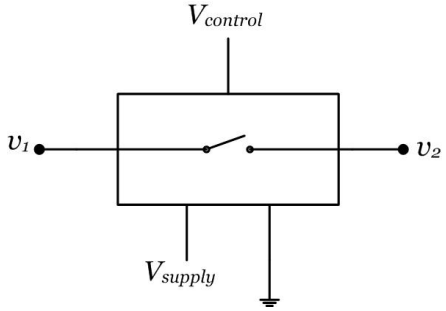
Elec Eng 2EI5
Design Project #2

Problem Definition

Design and build "ideal" voltage controlled switches. You are required to design two types of switches.

Switch Type 1

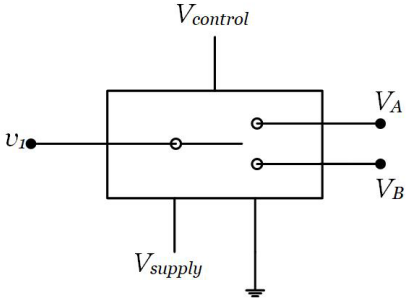


The operation of this switch is illustrated by the circuit schematic on the right.

The switch shown inside the box is whatever you design – it's not an off the shelf switch that you need to buy and it is definitely not one of the switches in your parts kit. **You** have to design a circuit that has an interface to the outside world made up of 5 wires:

a. One wire connects to ground.
b. One wire connects to a single supply voltage, V_{supply}. (See Design Constraints below).
c. One wire connects to a control signal. During testing, this signal is only allowed to have values 0 or +5V.
d. The remaining two wires v_1 and v_2 are what the switch is supposed to connect. If $V_{control}$ = 0V then the switch should be closed and ideally $v_1 = v_2$. If $V_{control}$ = +5V then the switch is open and ideally $i_1 = i_2 = 0$ where i_1 and i_2 are the currents into each of the two wires v_1 and v_2.

Switch Type 2



The operation of this switch is illustrated by the circuit schematic on the right.

The switch shown inside the box is whatever you design – it's not an off the shelf switch that you need to buy and it is definitely not one of the switches in your parts kit. **You** have to design a circuit that has an interface to the outside world made up of 6 wires:

a. One wire connects to ground.
b. One wire connects to a single supply voltage, V_{supply}. (See Design Constraints below).
c. One wire connects to a control signal. During testing, this signal is only allowed to have values 0 or +5V.
d. The remaining three wires v_1, V_A, and V_B are what the switch is supposed to connect. If $V_{control}$ = 0V then ideally $v_1 = V_A$. If $V_{control}$ = +5V then ideally $v_1 = V_B$.

Design Constraints

1. You are limited to the use of a single dc power supply. $V_{supply} \leq +5\text{V}$.
2. You are allowed the use of MOSFETs, diodes, resistors, and capacitors that are available in your component kits.
3. You have a single control voltage. The function of the control voltage is as described above for each type of switch.

Test Requirements

In this project, you will not only produce a design but you will also have to produce a convincing **test plan**. The operation of the switches as described in the Problem Definition is that of ideal switches. Nothing that you can build using real components will be ideal. Therefore you must understand how real switches behave, how this is different from ideal switches, what are the important performance metrics for switches, and how these performance metrics can be measured.

Just to give one example, ideal switches work for any voltage level. In your designs we are specifically limiting all voltages in the circuit to be $\leq 5\text{V}$. So this is a limitation. You may choose a design that doesn't even work all the way up to 5V. You'd then have to explain this limitation and justify your design choices. So one important metric might be the maximum voltage for which your switch can function. There are other non-idealities and each non-ideality can be assessed by one or more performance metrics.

Therefore, as part of your project, you must:

1. Describe the important properties of ideal switches and quantify non-idealities;
2. Specify parameters for your design to show how close to "ideal" it is; and
3. Take into account practical considerations such as cost and complexity.

Based on item 2 (your important design parameters) you need to specify tests that will be performed on your design. For example, if your claim is that your switch can operate for voltages up to 4V, then you need to show that with $V_{control}$ = 0V and $0 \leq v_1 \leq 4\text{V}$, you measure $v_2 \approx v_1$.

Report Requirements

1. Cover page.
2. Pages 1-2:
    a. (10 pts) Ideal switches: a description of the important properties of an ideal switch.
    b. (15 pts) Switch non-idealities:
        i. Qualitatively describe each non-ideality that is expected in a real switch.
        ii. Quantitatively state the behavior caused by each non-ideality.
    c. (20 pts) Test plan: For each non-ideality specified above, describe the experiment that you will use to determine the quantitative performance of your design. This includes:
        i. Values that you will set for $V_{control}$, V_{supply} and and v_1 .
        ii. Values that you will measure.
        iii. Values, if any, that you will calculate based on the measurement.

3. Page 3:
    a. (30 pts) Switch type 1:
        i. (10 pts) A circuit schematic of your design.
        ii. (7.5 pts) Measurements performed according to the test plan.
        iii. (7.5 pts) Theoretical explanation for the results obtained and comparison of the quantitative results with theory.
        iv. (5 pts) Design tradeoffs. What tradeoffs did you make in your design for performance, complexity, and cost?
4. Page 4:
    a. (15 pts) Switch type 2:
        i. (5 points) A circuit schematic of your design.
        ii. (5 points) Measurements performed according to the test plan.
        iii. (2.5 pts) Theoretical explanation for the results obtained and comparison of the quantitative results with theory.
        iv. (2.5 pts) Design tradeoffs. What tradeoffs did you make in your design for performance, complexity, and cost?

In addition to the above, 10 points will be assessed on presentation. This includes the layout of the report according to the above sections, quality of figures, neatness, and clarity of presentation in a professional style.