

## Elec Eng 2EI5

### Design Project #2

#### Problem Definition

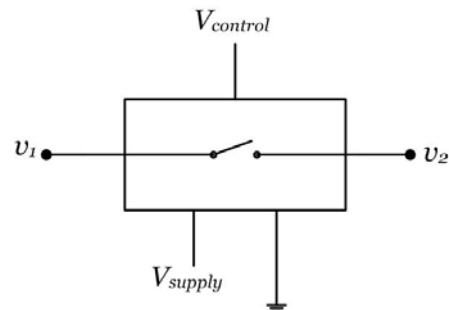
Design and build “ideal” voltage controlled switches. You are required to design two types of switches.

##### 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:

- One wire connects to ground.
- One wire connects to a single supply voltage,  $V_{supply}$ . (See Design Constraints below).
- One wire connects to a control signal. During testing, this signal is only allowed to have values 0 or +5V.
- 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  $v_2$ .

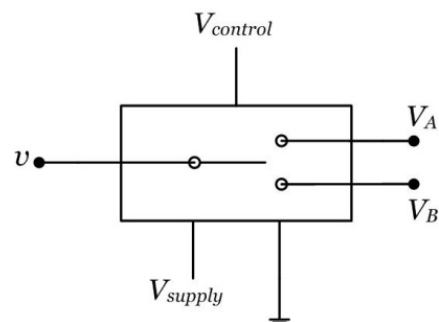


##### Switch Type 2

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:

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



### ***Design Constraints***

1. You are limited to the use of a single dc power supply.  $V_{supply} \leq +5V$ .
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 can these performance metrics 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  $\leq 5V$ . 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;
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  $v_1 = +4V$ , you measure  $v_2 = +4V$ .

### ***Report Requirements***

Your submitted report should not exceed five pages. You are allowed:

1. A maximum of 3 pages of discussion; and
2. A maximum of 2 page of figures (circuit diagram, simulation results, etc.); and

Your discussion pages should include:

1. A quantitative description of the operation of an ideal switch.
2. The circuit topology that you selected for each type of switch.
3. The main non-idealities that your design has. For each non-ideality:
  - a. Justify using a design that has this non-ideality. I.e. explain benefit of using this design despite this particular non-ideality instead of alternate designs.
  - b. Quantify the performance of your design in theory.

- c. Specify how you can measure the performance of your design.
- 4. Simulations
  - a. What simulations did you choose to perform?
  - b. What Spice models did you have to use and how did you obtain parameters for those models?
- 5. Measurement
  - a. What are the important specifications for your design?
  - b. Using your test plan (items mentioned in 1c above) report measurements on your circuit and compare the results with what you expected from hand calculations and Spice simulations.

### ***Marking***

A rubric for marking will be published on Avenue. Please check it for more guidance.