Lab 7: MOSFET Switch Design

GOAL

To understand how to build some circuits using MOSFET switches.

OBJECTIVES

To build and test MOSFET switches for the following circuits:

1) LED night light
2) High-side load switch for fan.

Fig. 0: From left to right: Photocell, small-signal MOSFET, power MOSFET, 12V brushless DC fan.

GENERAL GUIDELINES

The usual …

And

There is no lab report to hand in. Just demonstrate your circuits.

PARTS AND MATERIALS

- Lab kit (breadboard, wire stripper, wire)
- Oscilloscope, scope probes, multimeter
- Function generator, coaxial cable (with alligator clips), benchtop power supply
- Transistors: 2N7000 (2)
  IRF9520 (1)
- Resistors: **<u>Your lab kit should already have all/most of the resistors for this lab</u>**:
  330 ohm (orange/orange/brown) (1)
  1 kohm (brown/black/red) (1)
  33 kohm (orange/orange/orange) (1)
  100 kohm (brown/black/yellow) (1)
  1.0 Mohm (yellow/purple/green) (1)
- Photocell (1)
- Photocell cap (1)
- White LED (1)
- 12V DC fan (1)

PART 1: LED NIGHT LIGHT

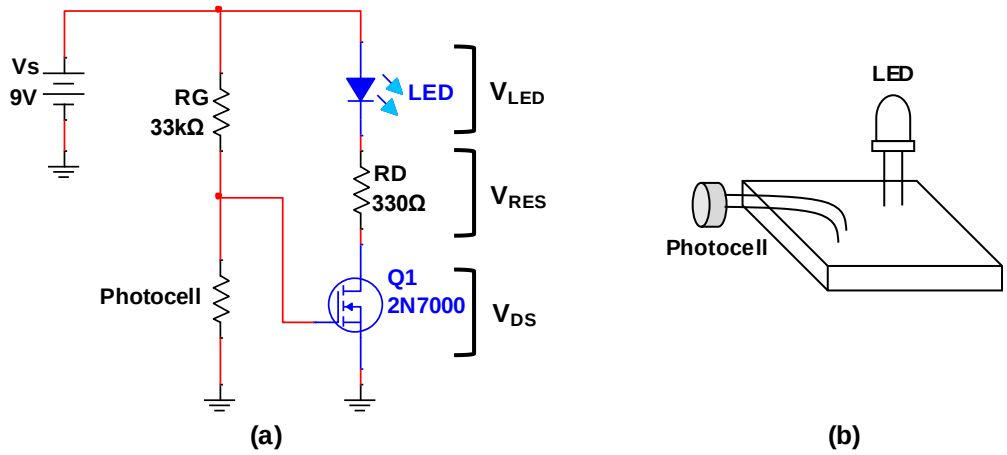

Fig. 1: (a) LED night light circuit. DO NOT CLIP the photocell leads. (b) Bend the photocell away from the LED.

- **Step 1a**: Build and test the circuit shown in Fig. 1a.
  - **Do NOT cram your circuit into a tiny area!**
  - See the course website for the 2N7000 pin diagram (data sheet).
  - The photocell is basically a resistor, so there is no "right" or "wrong" orientation.
    - **Do not clip the photocell leads! Bend the photocell to the side (see Fig. 1b).**
  - Wire the benchtop power supply to provide TWO outputs:
    - +9V is for the LED circuit. Set the max current of the power supply to 0.1A.
    - +12V is for the fan circuit. Set the max current to 3A.
  - The colored terminals on your breadboard should be the following:
    - RED terminal = +12V (use red wire on breadboard)
    - YELLOW terminal = +9V (use blue wire on breadboard)
    - GND terminal = GND (use black wire on breadboard)
  - The LED should turn on when you cover it with the black "photocell cap".
  - Use the multimeter to complete Table 1 (see Fig. 1a for locations of V_{DS}, V_{RES}, and V_{LED}).
    - You should get $V_{GATE} < 1V$ (bright), $V_{GATE} > 4V$ (dark), $V_{DS} < 200$ mV, $V_{RES} \approx 6V$, $V_{LED} \approx 3V$

Table I: Multimeter measurements for LED night light (RG = 33 kohm)

Ambient = Bright	Ambient = Dark			
V_{GATE}	V_{GATE}	V_{DS}	V_{RES}	V_{LED}

- **Step 1b**: Test your circuit with two different values for R_G.
    - The purpose of this step is to see the different effects of using incorrect values for R_G.
    - Replace the 33 kohm resistor with R_G = 1 kohm:
        - Is the LED always on or always off in bright and dark conditions?
        - Make the necessary multimeter measurements to complete the first row of Table 2.
            - You should get V_{GATE} > 5V for both bright and dark.
    - Replace the 1 kohm resistor with R_G = 1.0 Mohm:
        - Is the LED always on or always off in bright and dark conditions?
        - Make the necessary multimeter measurements to complete the second row of Table 2.
            - You should get V_{GATE} < 2V for both bright and dark.

Table II: Multimeter measurements with different RG

R_G	V_{GATE} (bright)	V_{GATE} (dark)
1 kohm		
4.7 Mohm		

(see next page for Part 2)

PART 2: HIGH-SIDE LOAD SWITCH FOR 12V FAN

- Step 2a: Build and test the circuit shown in Fig. 2.
  - **Do NOT cram your circuit into a tiny area!**
  - The IRF9520 pin diagram is on its data sheet (course website).
  - The control signal is the Agilent function generator with the following settings:
    - HighZ output
    - Configure a 5V DC signal (Press "Utility", select "DC ON", then enter "Offset = 5 VDC").
    - Keep the "Output" button turned ON.

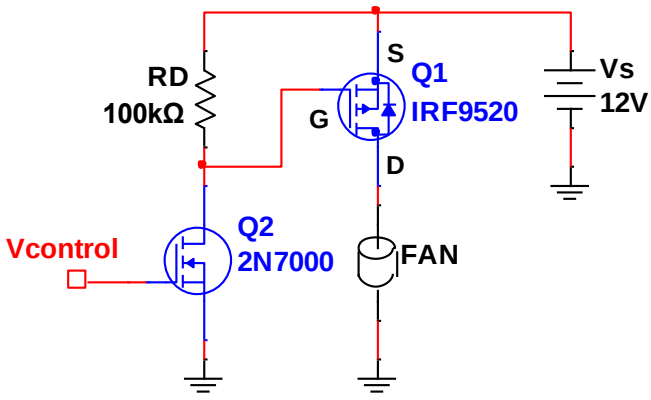

Fig. 2: High-side load switch for 12V fan. Q2 is a logic-level shifter while Q1 is the power MOSFET switch.

  - **Your circuit works properly when the fan turns on (Offset = 5VDC) and off (Offset = 0V).**
    - Remember to avoid getting blown away by the fan.
  - Use the multimeter to complete Table 3. See Fig. 2 for the gate (G), source (S), and drain (D) locations of Q1.
    - V_{SD} is the voltage between the source and drain of Q1.
    - When the fan is ON, you should get $V_{G1} < 20$ mV, $V_{SD} < 400$ mV, $I_D \approx 700$ mA.
    - When the fan is OFF, you should get $V_{G1} \approx 12$V and $V_{SD} \approx 12$V.
    - Use the appropriate multimeter range to get accurate measurements.

Table III: Multimeter measurements for fan switch.

Fan State	V_{GATE} (Q1)	V_{SD} (Q1)	I_D (Q1)
ON			
OFF			----------

PART 3: CIRCUIT DEMOS

- LED night light
  - Show your completed Table 1 and 2.
  - Show that your LED properly turns on when the photocell is in darkness.
- Fan switch (Hedrick will NOT reset the function generator. Nice! ☺)
  - Show your completed Table 3.
  - Show that your fan properly turns on (Offset = 5V) and off (Offset = 0V).

(End of Lab 7)