Experiment 6

**Submission Template**

# The following should be included in your experimental checklist. Everything should be labeled and easy to find. Credit will be deducted for poor labeling or unclear presentation. ALL PLOTS SHOULD INDICATE WHICH TRACE CORRESPONDS TO THE SIGNAL AT WHICH POINT AND ALL KEY FEATURES SHOULD BE LABELED.

**Hand written schematics are required for physically built circuits, ONLY.**

# Part A – Transistor Switches (20 pts)

A.1 *LTspice* DC sweep of transistor circuit with cutoff and saturation indicated. (3 pt)

***Double Click on picture placeholder to add plots/tables!***



A.2.*LTspice* DC sweep of transistor circuit with voltage divided. (3 pt)



A.3. *LTspice* plot of normalized currents with active region marked. (3 pt)



Answer PART A questions:

1. Draw a simplified circuit diagram for plot A.1 above that includes just V2, R2 and a simple switch to represent the transistor. (2 pt)

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1. For your simplified circuit, when the switch is open (OFF), how much voltage will there be at Vc? When the switch is closed (ON), how much voltage will be at Vc? (2 pt)

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3. What is a typical voltage across R3 in plot A.2 above when the switch is OFF? What is a typical voltage across R3 in plot 2 above when the switch is ON? (2 pt)

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4. Why do you think that the values in the previous question 3 make sense? (2 pt)

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5. For what range of input voltages did the transistor act like a current amplifier? (Where was there a direct relationship between base current and the current from collector to emitter?) About what was the amplification? (3 pt)

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**Part B – Comparators and Schmitt Triggers (20 points)**

B.1. *LTspice* transient for the comparator with 0V reference voltage. (1 pt)



B. 2. *LTspice* transient for the comparator with 1V reference voltage. (1 pt)



B. 3. *LTspice* transient for Schmitt trigger with 0V reference voltage. (1 pt)



B. 4. *LTspice* transient for Schmitt trigger with 1V reference voltage. (1 pt)



B. 5. *LTspice* plot of Vout as a function of Vin, this is called a hysteresis plot. (1 pt)



Answer the following questions:

1. At what input voltage level does the comparator in plot B.1. above switch states? (1 pt)

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1. At what input voltage level does the comparator in plot B.2. above switch states? (1 pt)

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1. What are the switching thresholds of the input for the Schmitt trigger in plot B.3 above? What is the hysteresis? (3 pt)

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1. Use a voltage divider to prove that the values in the previous question B.3. make sense. (2 pt)

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1. What are the switching thresholds of the input for the Schmitt trigger in plot B.4 above? What is the hysteresis? (3 pt)

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1. Use a voltage divider to prove that the values in the previous question B-5 make sense. (2 pt)

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1. Discuss the hysteresis plot, B.5, Vout vs Vin. Does it show the expected voltages were the output changes? Why are there 2 possible values of Vout for certain values of Vin? (3 pt)

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**Part C – Digital Switching (20 points)**

C1-1. *LTspice* transient of Schmitt trigger and inverter without noise, V2=0. (1 pt)



C1-2. *LTspice* transient of Schmitt trigger and inverter in the presence of noise. V2=0.2V (1 pt)



C2. *LTspice* transient of Schmitt trigger and inverter switching transistors with transition points marked. (1 pt)



Answer the following questions:

1. From plot C1-1, what input voltage causes a change in the output voltage? (2 pt)

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1. How do the values you found for the operating region of the inverter compare to the values of VIH and VIL you found on the spec sheet for the device? (2 pt)

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1. From plot C1-1, at what input voltage level does the Schmitt trigger switch from low to high? At what input voltage level does the Schmitt trigger switch from high to low? What is the hysteresis? (2 pt)

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1. How do the values you found for the thresholds and hysteresis of the Schmitt trigger compare to the values of VT+, VT-, and hysteresisyou found on the spec sheet for the device? (2 pt)

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1. From plot C1-2, describe the effects of the noise on both the inverter (7404) and the Schmitt Trigger (7414). Does the Schmitt Trigger offer advantages of input signals with substantial noise? (2 pt)

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1. From plot C2, at what input voltage does the transistor switch close and open when using the inverter? (2 pt)

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1. From plot C2, at what input voltage does the transistor switch close and open when using the Schmitt trigger? (2 pt)

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1. What effect did changing the values of the resistors R1, R2, R4 and R5 have on the output voltage? Why? (2 pt)

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9. Why do you think the Schmitt trigger is preferable to an inverter in the presence of noise? (1 pt)

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**Part D – Relay Circuit (12 points)**

D.1. Table of data points A, B, C & D (2 pts).



D.2 The voltages vs time at points A & B, A & C, A & D for the Inverter (3 pts).



Answer the following questions:

1. At what input voltage did the Inverter trigger toggle the LED as you increased the voltage? (3 pt)

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1. At what input voltage did the Inverter trigger toggle the LED as you decreased the voltage? (3 pt)

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1. Is the range found in questions 1 and 2 consistent with your *LTspice* results? (1 pt)

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**List group member *responsibilities*. (0 to -4pts)** Note that this is a list of *responsibilities*, not a list of what each partner did. It is very important that you divide the responsibility for each aspect of the experiment so that it is clear who will make sure that it is completed. Responsibilities include, but are not limited to, reading the full write up before the first class; collecting all information and writing the report; building circuits and collecting data (i.e. doing the experiment); setting up and running the simulations; comparing the theory, experiment and simulation to develop the practical model of whatever system is being addressed, etc.

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**Summary/Overview** (0 to -10 pts) There are two parts to this section, both of which require revisiting everything done on this experiment and addressing broad issues. Grading for this section works a bit differently in that the overall report grade will be reduced if the responses are not satisfactory.

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***Experiment 6***

***Checklist w/ Signatures for Main Concepts***

INSERT SIGNED COPY OF CHECKLIST BELOW (OR ADD SCANNED PDF VERSION)



***Experiment 6***

***Hand Drawn Schematics***

INSERT HAND DRAWN SCHEMATICS FOR ALL CIRCUITS BUILT

