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Module 7F: Schmitt Trigger IV

Section AB/BB:

0 1 2 3 4 5 6 7

8 9 A B C D E F

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Laboratory Outline

In this module, you will use current-voltage measurements to characterize the Schmitt-trigger inverter.

An inverter outputs a logical voltage signal that is the opposite of the logical voltage at its input. That is, if the input voltage is low (referenced to the supply battery's negative post, 0 volts), the output-to-ground voltage is high (near the value of the battery's voltage). If the input voltage is high, the output voltage is low.

The Schmitt-trigger inverter is a special type of inverter with a hysteresis. That is to say, the determination of whether is the input is high or low is not determined by a simple threshold of the input voltage. Instead, it depends on the past. If the output of the inverter is a logical high, the input must rise above a certain voltage V_p before the output will fall low. If the output of the inverter is logical low, the input must fall below a different voltage value, V_n, before it will rise high. For a normal inverter, $V_p \approx V_n$. For the Schmitt-trigger inverter, $V_p > V_n$ by a significant amount.

Today, we will not only characterize the values of V_p and V_n, but we will also characterize the circuit behavior of the Schmitt-trigger inverter as viewed looking into its input side as well as looking back into its output side.

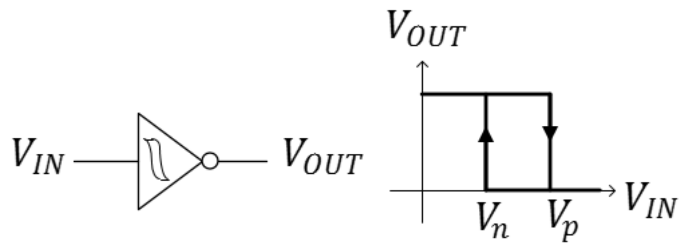


***Figure 1**: The input/output relationship of the Schmitt trigger from Texas Instruments, the TI 40106.*

Prerequisites

- Practical experience placing an IC on a breadboard and reading a datasheet.

Parts Needed

- The 40106 Schmitt-trigger inverter

Notes:

- A variable-voltage supply
- A fixed-voltage supply (battery)
- A $100\ \Omega$ and a $10\ k\Omega$ resistor

At Home: Study the Datasheet

Every IC (and nearly all circuit elements) come with a datasheet. The datasheet is a resource that list some important information on the internal circuitry of an IC, its operational envelope, and physical limitations. Datasheets provide a general overview, physical description, circuit schematic, features, limitations, and applications of packaged circuit devices. It is very important to check the datasheet for each IC for the correct pins and allowable voltage levels before using that IC. The datasheet generally contains all the information necessary for implementing a device in a circuit and gives the user an idea of what limitations the device might have in terms of voltage, current or temperature tolerances. These characteristics vary across models so it is very important to learn to read and understand the information listed on a datasheet when encountering a new device.

In this case, “40106 Schmitt trigger datasheet” provides a good criterion for an Internet search engine. Most datasheets can be found online for free.

In the Laboratory: Analysis

Insert the Schmitt-trigger inverter onto your breadboard and connect the NiMH rechargeable battery to provide “power and ground” to the chip.

Question 1: Use the oscilloscope to measure the voltage of the battery as it supplies power to the IC.

Connect the power supply between ground and the input of one of the 6 inverters available on your IC. You will only characterize this one inverter.

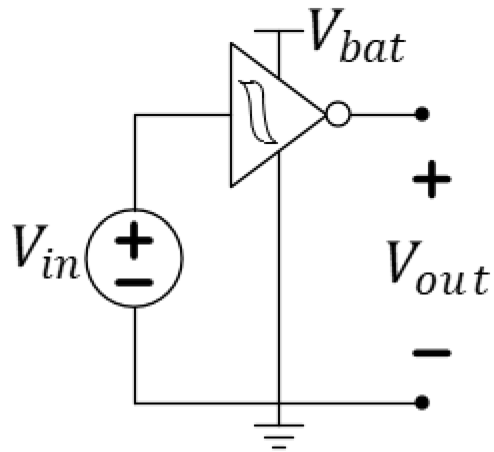


Figure 1: *Using a power supply for V_{in} and voltmeter to measure V_{out}, you will find the positive- and negative-going voltages.*

Place the voltmeter probe between ground and the output of the same inverter. Turn on the power supply's output and slowly adjust the voltage V_{in} until the output of the inverter goes low.

Question 2: Record this voltage, V_p.

Question 3: Write V_p as a fraction of the open circuit battery voltage. That is find α_p such that $V_p = \alpha_p V_{bat}$.

Slowly reduce the voltage of the power supply until the output of the inverter goes low.

Question 4: Record this voltage, V_n.

Notes:

Notes:

Question 5: Write V_n as a fraction of the open circuit battery voltage. That is find α_n such that $V_n = \alpha_n V_{bat}$.

Set the power supply voltage such that $V_{in} = V_{bat}$. You will need to use the **+25 V port** of the supply, but do not turn the voltage above V_{bat}.

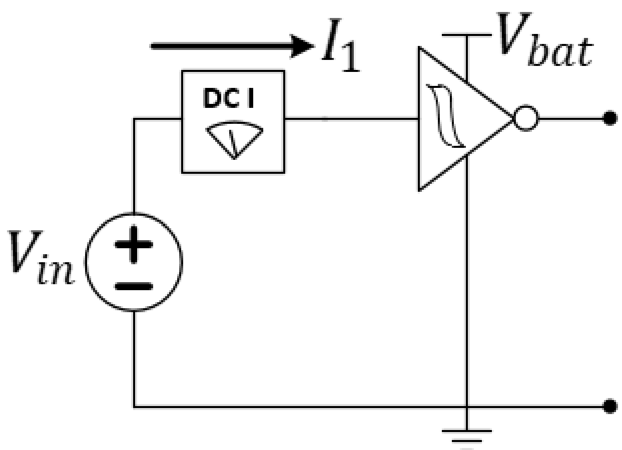
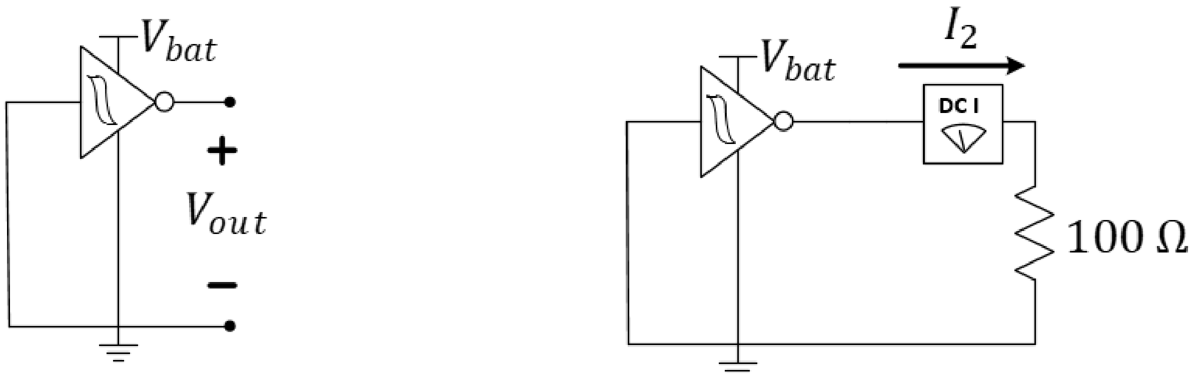


Figure 2: *Estimating the input resistance of the inverter. Set* $V_{in} = V_{bat}$.

Question 6: Measure the current that flows into the inverter's input, I_1.

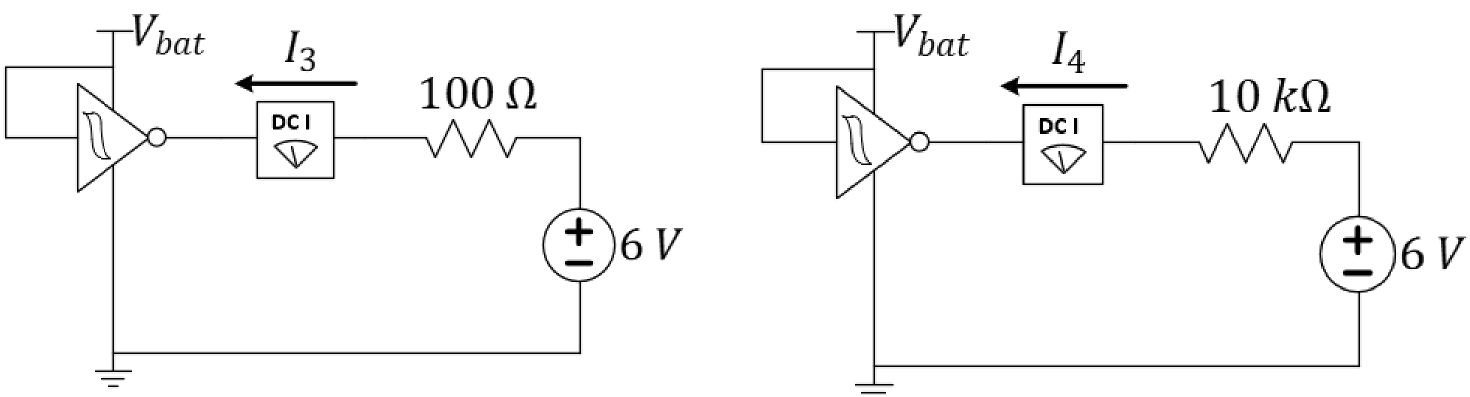
Question 7: Use I_1 to estimate the input resistance of the inverter.



(a) *(b)*

Figure 3: *Modeling the output of the inverter when the input is low.*

Question 8: Use the open circuit voltage and the current I_2 (of Figure 3) to determine a Thevenin model for the inverter output when the input is "tied low". Show your work.



(a) *(b)*

Figure 4: *Estimating the resistance of the inverter when looking into the output and the input is high.*

Notes:

Notes:

Question 9: Use the previous measurements to determine a Thevenin model for the inverter output when the input is "tied high". Show your work.

Back at Home: Drawing Conclusions

Question 10: Summarize your findings regarding the model of the input of the inverter.

Question 11: Summarize your findings regarding the models of the output of the inverter.

Learning Objectives

- To characterize the positive-going voltage and negative-going voltage of the Schmitt-trigger inverter.
- To find resistive and Thevenin-equivalent models to the input and output ports, respectively, of the 40106 inverter.

Learn More!

If you liked this module, you might like ***Explore More!*: The Amplifier**. There, we will learn to convert the "squashed" triangular waveform of our oscillator into a full-range waveform. Having the ability to adjust the gain and offset of a waveform is useful for things like microphone signals.