Pre-lab 6: The Oscillator Circuit

Name/NetID:

Teammate/NetID:

Section AB/BB:

0 1 2 3 4 5 6 7

8 9 A B C D E F

(circle one)

Integrated Circuits

In lab 2, we constructed several different circuits on a breadboard. Now imagine we need many circuits with the same basic mathematical function on the same breadboard. Building each circuit would require a great deal of effort and may not even fit very well on the breadboard. Now consider that the circuits we built before were very simple circuits. One solution to this problem is to package multiple copies of a circuit into one compact device known as an integrated circuit (IC).

ICs are built to be easily integrated into larger circuits and the packaging is designed for use with breadboards or printed circuit boards. ICs can contain a large variety of devices such as amplifiers, logic gates or even very large and complicated circuits known as a System on Chip (which integrates a completed computer system into a single chip).

The circuit contained in each IC is goes through a rigorous design process and tested under a wide range of conditions. Most ICs follow a few sets of universal standards, making it possible to wire them together and implement more complicated design. In general, there are three aspects of ICs that we are concerned with:

1) Chip orientation (pin numbering)
2) Circuit functionality and Schematic
3) Operation envelops and output characteristics.

The first of these points comes deals with a very common set of industry standards while the second two points differ from chip to chip. Let us begin with chip orientation and pin numbering. Below is an illustration of an IC in a dual in-line package (DIP) as seen from an oblique angle and from directly above.

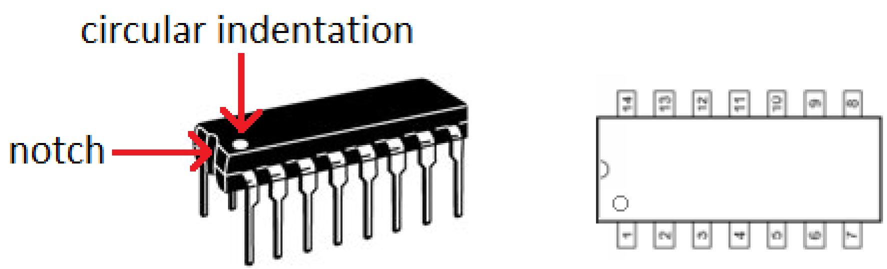


Figure 1: Two views of an IC "DIP" package showing the counter-clockwise pin numbering system.

Usually IC DIP chips have a semi-circle or notch on one side of chip body. Pin numbers always start counter-clock-wise from the notch, wrapping around the chip body and back up the other side. In some cases, a chip may have a small circular indent in one corner of the chip rather than (or, in addition to) a notch. In this case, the indent resides right next to pin 1 and the numbering proceeds in the same fashion.

In most case the chips will have to be powered to work properly. Most chips are powered by a $5\ V$ or $3\ V$ source, however some amplifiers will require $+12\ V$ and $-12\ V$ power. In most cases, the positive terminal of the power source (often called V_{dd}) will be wired to the highest numbered pin, N, and the negative terminal (GND) of the power source is connected to the lower left pin, numbered $N/2$.

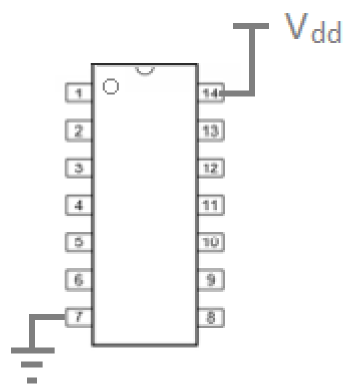
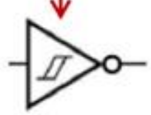


Figure 2: Typical "power and ground" configuration of a DIP package.

Although most chips found in the ECE 110 lab are powered in this way, not every IC follows this convention. Countless chips have been DAMAGED due to incorrect powering. Every IC (and virtually all circuit elements) come with a datasheet. The datasheet is a resource that attempts to list all important information on the internal circuit of an IC as well as its operational envelope. It is very important to check the datasheet for each IC for the correct pins and appropriate voltage level 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 from chip to chip so it is very important to learn to read and understand the information listed on a datasheet if you ever wish to use a device you haven't seen before.

Notes:

Abstract Symbol



Part Number

HEF40106B

Hex inverting Schmitt trigger

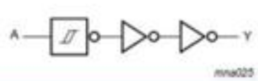
Rev. 7 — 21 November 2011 Product data sheet

General description

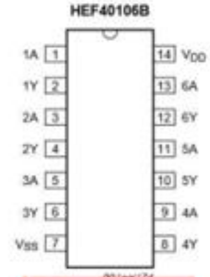
The HEF40106B provides six inverting buffers. Each input has a Schmitt trigger circuit. The inverting buffer switches at different points for positive-going and negative-going signals. The difference between the positive voltage (V_{T+}) and the negative voltage (V_{T-}) is defined as hysteresis voltage (V_H).

Applications

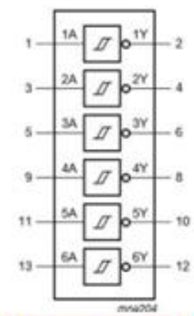
- Wave and pulse shapers
- Astable multivibrators
- Monostable multivibrators



Logic diagram (one inverting buffer)



Pin configuration



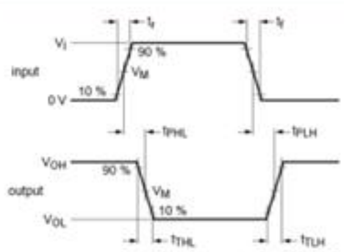
Functional diagram

Pin description

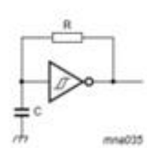
Symbol	Pin	Description
1A to 6A	1, 3, 5, 9, 11, 13	input
1Y to 6Y	2, 4, 6, 8, 10, 12	output
V_{DD}	14	supply voltage
V_{SS}	7	ground (0 V)

Limiting values

Symbol	Parameter	Conditions	Min	Max	Unit
V_{DD}	supply voltage		−0.5	+18	V
V_I	input voltage		−0.5	V_{DD} + 0.5	V
T_{stg}	storage temperature		−65	+150	°C
T_{amb}	ambient temperature		−40	+125	°C



Waveforms



Astable multivibrator

Notes:

Comment: Datasheets are scary at first, but don't worry. They likely contain a lot of details that don't look familiar to you...at least, not yet. Luckily, most engineers grow in knowledge at the same rate in which those other mysterious parameters become necessary for their design! Look around and make a note of what you can understand. A week later, look again and many more details might make sense!

Datasheets provide a general overview, physical description, circuit schematic, features, limitations, and applications of packaged circuit devices.

The above data sheet is for an IC that integrates 6 special inverters. The actual functionality of this inverter is not our concern right now. Instead, we would like to learn the IC input and output characteristics from the data sheet. The part number for most devices can be found often as a 4 or 5 digit number in the center of the full part number. In this case, "40106 Schmitt trigger datasheet" provides a good criterion for an Internet search engine. Most datasheets can be found online for free.

Spend some time investigating the datasheet for the 40106 inverter. An excerpt of the datasheet is listed in the figure above but you'll need to find the entire datasheet to answer all the questions listed. Although this datasheet (and most others) will contain more information that you need or can understand, it's important for you to learn to find key information amid what seems like chaos. See if you can find the answers to the following questions.

Question 1: Are there limitations on the voltage that may be supplied to pin 14? Explain how you know.

Question 2: There are limitations to the voltage that might be applied to each inverter input. Explain.

Question 3: Are there limitations to the storage and operating temperature? Explain how you know.

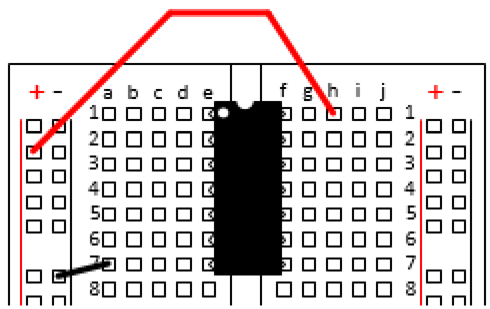
Question 4: *Think about it*…What do you suppose may happen if these limitations are exceeded?

Notes:

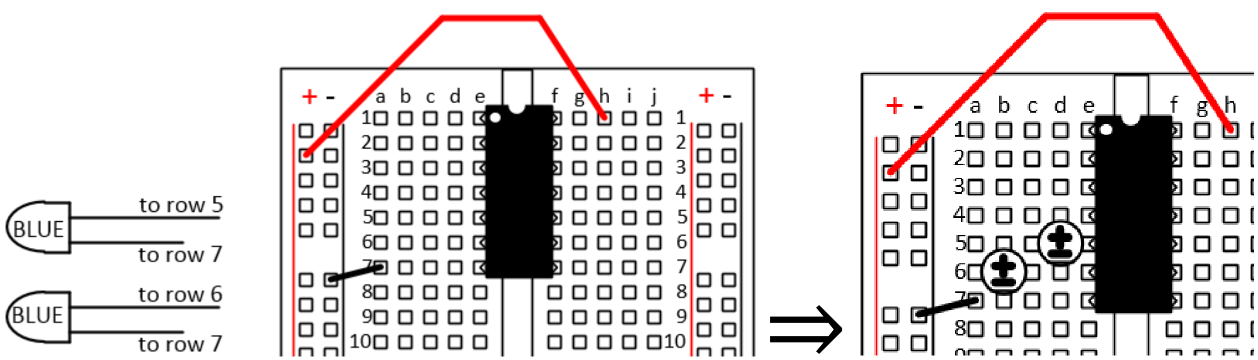
So what does can you use a “Hex Inverting Schmitt Trigger” for? You will see something far more amazing in the lab procedure, but here we will have you build a small circuit that demonstrates the inverting operation. An electronic inverter outputs a “logical” voltage signal that is the opposite of the logical voltage at its input. That is, if the input voltage is low (say, 0 volts), the output-to-ground voltage is high (say, 3.3 volts). If the input voltage is high, the output voltage is low.

Build the following circuit. Follow the instructions carefully using the correct voltages and the blue LEDs so that you do not damage any of the parts.

Step 1. Insert the HEF40106B Schmitt Trigger Inverter into the breadboard and connect the power and ground as shown:

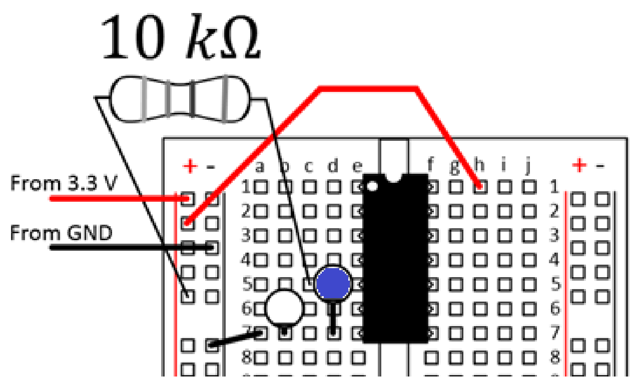


Step 2. Insert two blue-colored LEDs into the breadboard taking care to insert the shorter wire into row 7, the circuit “ground”.

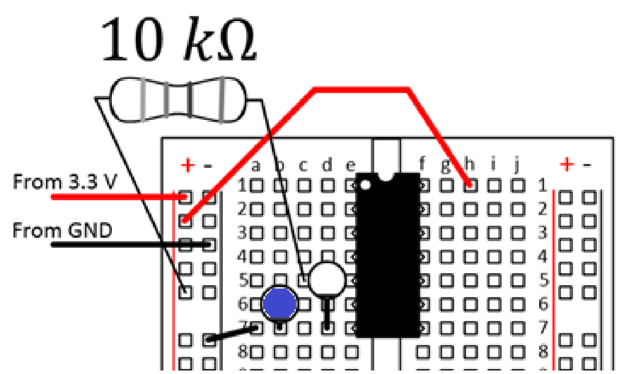


Notes:

Step 3. Provide power from your microprocessor (Arduino/RedBoard). Use the 3.3 volt output for the positive and one of the two GND ports for the negative. Connect a $10\ k\Omega$ resistor from pin 5 to the 3.3-volt source. The LED connected to pin 5 should illuminate while the output stays low.



Step 4. Change the connection of the $10\ k\Omega$ resistor so that it connects pin 5 to the GND. The LED connected to pin 6 should illuminate as the output goes high. Note that the input (as illustrated by the dim LED connected to pin 5) is low.



Question 5: Describe an application where a light should come on when power is lost.

Question 6: Bring your breadboard to lab and show your TA. Your TA can sign below after checking your circuit.

TA:____

Notes:

Warning: Do you remember laboratory exercise 1 where you might have used a current-limiting resistor to prevent burning up the LED? Here, we get away without using one by choosing a blue LED (higher voltage required to illuminate) and using a lower voltage supply (3.3 V instead of 5, 7 or 9 volts).

If you make a mistake and smell something burning, disconnect your power, but **DO NOT TOUCH YOUR CIRCUIT** until it has had time to cool.