

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

6.091 Hands-On Introduction to EE Lab Skills

Laboratory No. 4 Digital Circuits

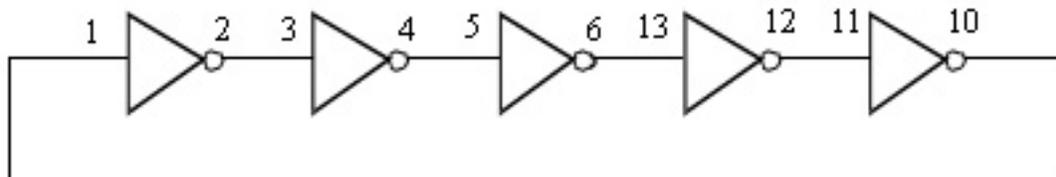
IAP 2008

1 Objective

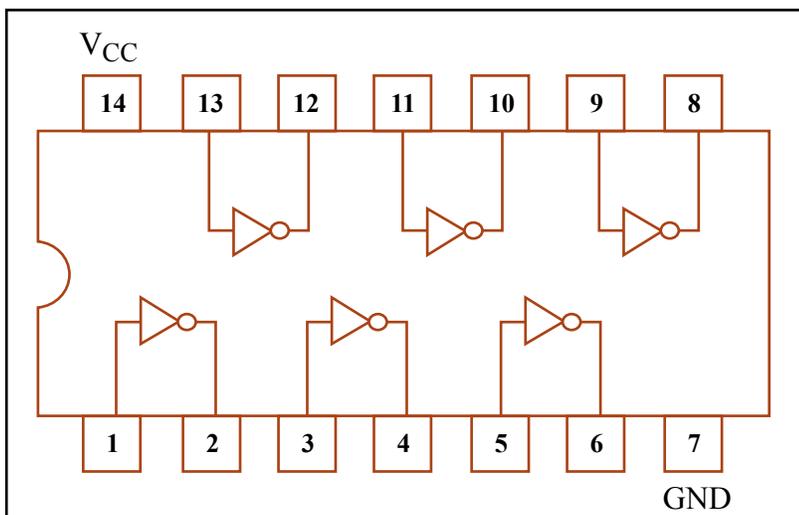
In this laboratory, you will become familiar with basic digital logic, design and implementation through the use of LSTTL (Low power Schottky Transistor Transistor Logic) and HCT (High-speed CMOS with TTL compatible inputs). You will also use a 68 channel logic analyzer. Please get a bag of parts from the LA. Return the bag with the parts when your exercise is completed.

1.1 Ring Oscillator

Digital circuits have finite propagation delays. Typically the delays are on the order of 10 ns per gate. In this exercise you will construct a ring oscillator – much like a dog chasing its tail.

1.1.1 Exercise – Ring Oscillator

Wire up the above circuit using a 74LS04. Note that power ($V_{cc} = 5V$) and ground are not shown but need to be attached. Use the BK Precision bench power supply which has a fixed 5 volt supply. The IC pin out for the 74LS04 is shown below:

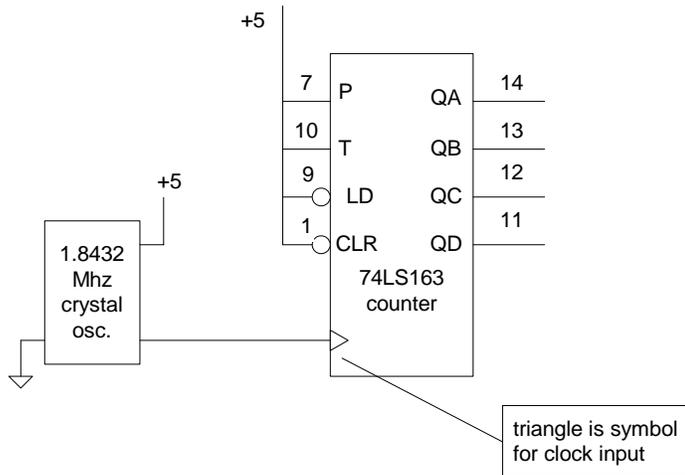


Using the oscilloscope, take a look at the output and describe what is happening. What is the period of the waveform? Would an even number of inverters work?

(The oscilloscope in the 6.111 lab is slightly different from the one previously used.)

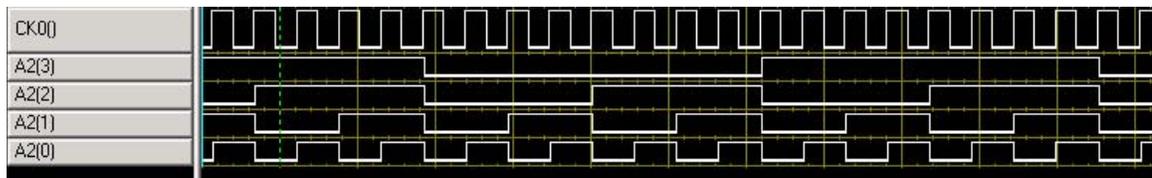
1.2 4 Bit Synchronous Counter

Counters are very commonly used in digital circuits. When each bit of the counter is clocked by the same signal, the counter is called synchronous. Wire up the crystal oscillator and counter. Power and ground is shown for the crystal because it is not a standard integrated circuit. Power and ground for the 74LS163 counter is not shown.



Look at the output of the crystal oscillator. Now look at QA, QB, QC, and QD. What is the relationship between the Q outputs? Which is the MSB (most significant bit)? Attached the logic analyzer “flying leads” to QA, QB, QC, and QD. QA should go to logic analyzer A2(0), QB to A2(1), etc.

You should be able to view the counter in graphical expanded mode, decimal mode, and hexadecimal mode. The counter should increment to 15 and then start at zero again.

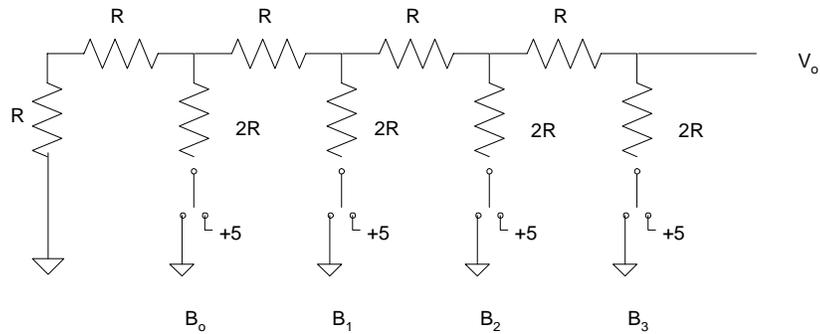


Using the vertical bars on the logical analyzer, measure the period of the clock. Similar to an oscilloscope, you can also select a trigger point. Try to set the trigger so that the display triggers when the count is 7 (binary: 0111).

If you have a USB drive, you can save a copy of the image using the PRINT SCREEN function and the PAINT program.

1.3 Digital to Analog (DA) Conversion

In lab 1, you built a R-2R ladder to perform a digital to analog conversion.



In place of the switches, you will now drive the R-2R ladder with the output of the counter. Note that B_0 is the least significant bit and the output is

$$V_o = \frac{1}{2} \left[B_3 + \frac{1}{2} B_2 + \frac{1}{2^2} B_1 + \frac{1}{2^3} B_0 \right]$$

In order to drive R-2R ladder to +5 and ground, you will need to buffer the output of the counter with a 74HC08. This IC is configured as a AND gate but we will use it as a buffer.

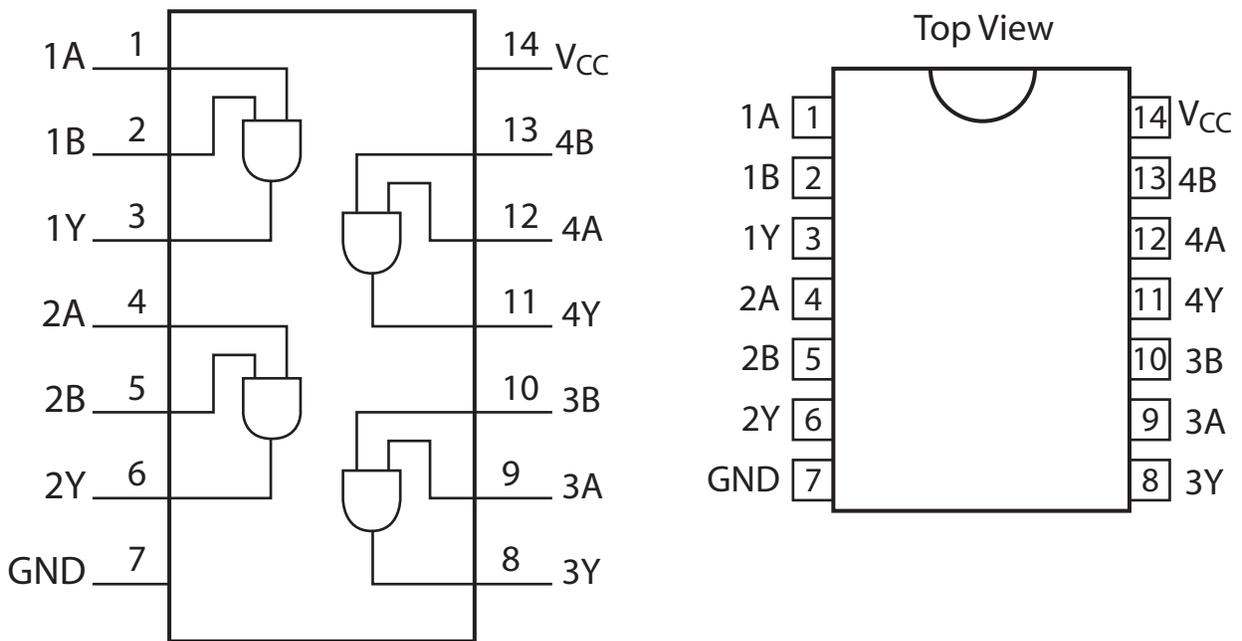
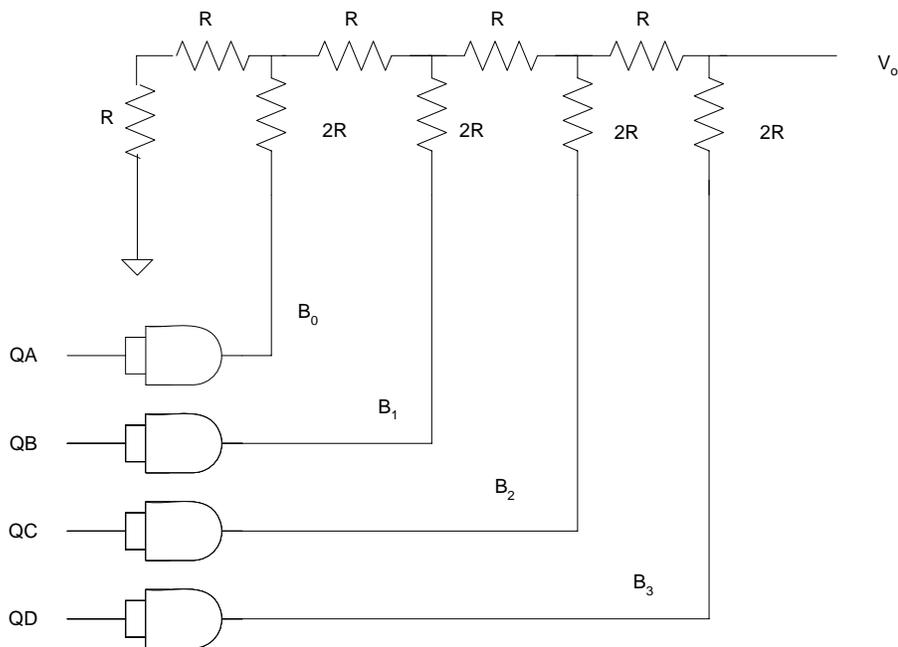


Figure by MIT OpenCourseWare.

If you successfully wired up this circuit you should see a 0-5V ramp. Notice the discrete quantum jumps. Place a 100pf capacitor on the output. How does the waveform change? Most of our personal electronics and computers are digital in nature. Audio is generated by DAC, digital to analog converters. Music CD players have 16 bit DAC. We will discuss this in more detail in lecture 5.