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Lab 11

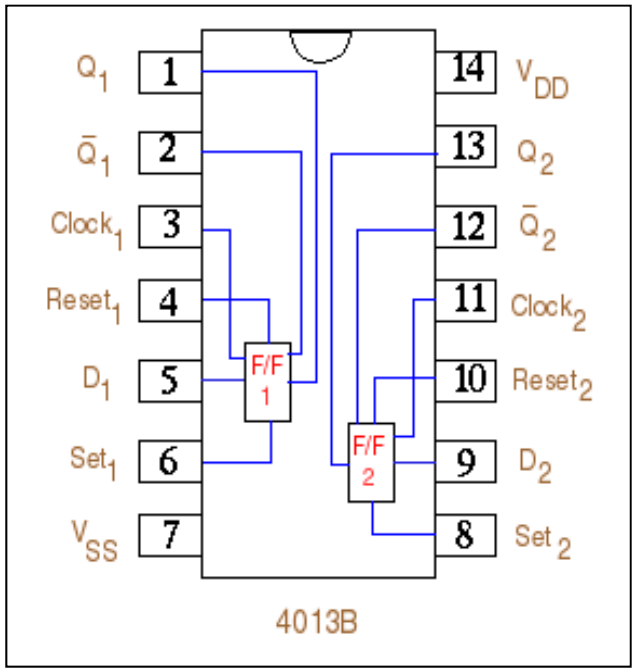
1. The CMOS 4013 flip-flop contains TWO flips in one package. The schematic (last page) shows these two flips in all three circuits.

2. We will be using the +5 volt power supply for our circuits today, although as we noted before, the CMOS series of circuits will work quite nicely on +3 to +18 volt power supplies (it is the only logic family that works over this extended range).

3. While the schematic of a logic circuit does NOT normally show the supply voltage, the +5 supply should be connected to Vdd (pin 14) and Vss (pin 7) should go to ground.

4. Unused INPUT pins (Cl, D, R, and S) should be grounded. NEVER, NEVER ground a Q or /Q output.

5. The "debounced switches" on the trainer (lower left hand side) are already connected to +5 and ground internally. You can use them for the switches in the circuit diagram (last page) with no additional connections. You may use either the Q or the /Q outputs of the switches, but I much prefer to use the Q connectors (up is logic high, down is logic low).



See the schematic diagrams of these three circuits on Page 3.

6. **CIRCUIT 1.**

a. Connect both S (pin 6) and R (pin 4) to ground on flip 1. Ground all inputs (S-pin 8, R-pin 10, D-pin 9, and Cl-pin 11) on flip 2.

b. The upper switch controls the data. The lower switch controls the clock. Place both switches down so that logic low is on both clock (pin 3) and data (pin 5) of flip 1 (check with an oscilloscope).

c. Connect the Q (pin 1) to logic indicator 1 on the trainer. Connect the /Q (pin 2) to logic indicator 2.

d. One of the logic indicators should be lit and the other one should be dark.

e. The data line should be low (check with an oscilloscope). Toggle the clock line high and then back to low. The Q light should be dark and the /Q line should be lit. Toggle the data line several times and notice that the lights do not change.

f. Now bring the data line high and toggle the clock low to high and back to low. Note that the Q light is now lit and the /Q line is dark. Toggle the data line several times and notice that the lights do not change.

7. CIRCUIT 2.

a. Disconnect the D line (pin 9) and Cl line (pin 11) of flip 2. Connect the D line of flip 2 to the Q output of flip 1. Connect the Cl line of flip 2 to the Cl line of flip 1.

b. Connect the Q output (pin 13) of flip 2 to logic indicator 3. Connect the /Q output (pin 12) of flip to to logic indicator 4.

c. Use the data switch to input alternate zeroes and ones into the data line of flip 1 and notice how the outputs of flip 1 and flip 2 change.

8. CIRCUIT 3.

a. Connect the /Q output of flip 1 to the D input of flip 1. Similarly, connect the /Q output of flip 2 to the D input of flip 2.

b. Connect the Q output of flip 1 to the Cl input of flip 2. Connect the Cl input of flip 1 to the "TTL" output of the trainer's function generator. Set the function generator for an approximate frequency of 1000 Hz. (1 kHz.).

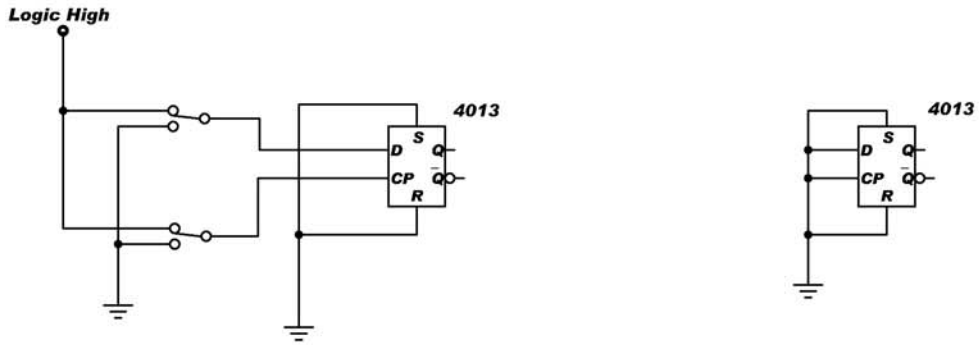
c. Use a dual-trace oscilloscope and observe the relationship between the clock, the Q output of flip 1 and the flip output of Q2.

This is a "digital divider". The frequency of the clock is divided by two at Q1 and divided by four at Q2.

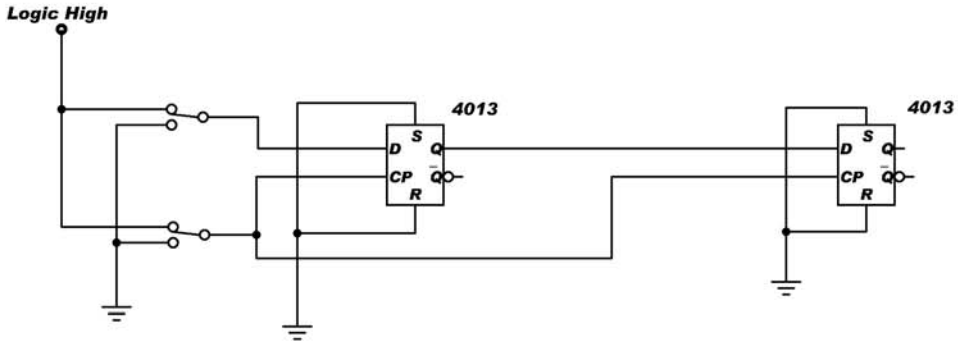
If you will recall, I said a way, way long time ago that the only difference between musical instruments is the amount of harmonics and their relationships to one another in the instrument sound. If you will notice, these outputs are all harmonics of one another, as a harmonic is simply an integer multiple of a fundamental frequency. If we call Q2 the fundamental, then the frequency at Q1 is the second harmonic and the clock is the fourth harmonic.

If we continue to chain flips together like this, we can get harmonics out as far as you wish, and by getting a precise amount of a given harmonic we can "synthesize" any instrument you wish. The same note sounded, for example, by a piccolo is going to be rich in the higher harmonics (higher frequencies) while synthesizing a guitar will be richer in the lower harmonics.

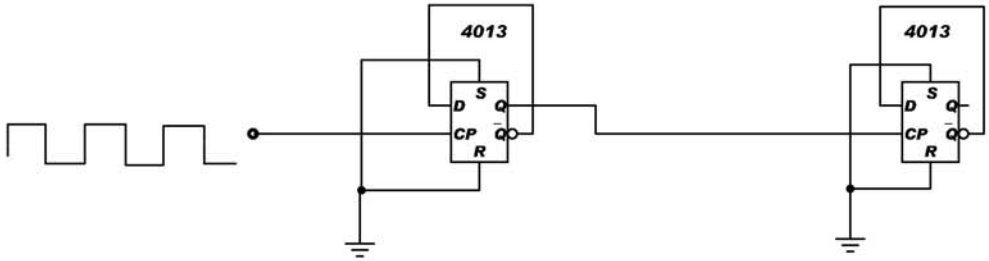
Circuit 1



Circuit 2



Circuit 3



Flip-Flop Lab	
Rev A	ID CIE-01 Lab 11
Date: 18 Nov 08	Page: 1 of 1