Lab 1: Binary Numbers and Logic

1.1 General Lab Introduction

All relevant data, calculations, observations, and responses to questions in the lab handouts should be recorded in a lab notebook, which ideally should be a hardcover notebook containing quadrille paper. Prelab writeups are not required, although they might be useful. All material to be turned in should be included in the lab notebook. Label your notebook entries with the corresponding section number from the handout. The notebooks will be due a few days after the lab class, as specified by your T.A. There should be one student per lab station, and it is expected that all students become familiar with electronics techniques.

1.2 Goals of this Lab

An introduction to basic concepts of binary numbers and logic, and familiarization with some lab tools. We will be working with integrated circuit chips (ICs). Here are a few rules to follow:

- Always turn off the power on your prototyping board before inserting any ICs.
- Be careful to avoid reversing power connections. Typically we only need +5 V and 0 V (ground) connections for digital circuits. Ask your T.A. for help with setting up power busses on your prototype board if in doubt.
- We will primarily be using TTL circuitry. Do not connect TTL outputs together, as the resulting circuit will not work. Also, unconnected TTL inputs will usually "float" up to the high level. However, it is not good practice to count on this property, and "pull-up" resistors connected to +5 V should be used to maintain a high input.

1.3 Binary Generation and Translation

1.3.1

As a simple exercise in binary generation, connect four of the DIP (dual in-line package) switches to four LED logic indicators on your prototype board. Make each connection as shown in Fig. 1. The DIP switches are set up to choose either ground or open. The pull-up resistor should be in the range $\sim 100\,\Omega$ to $\sim 5k\,\Omega$, but the exact value should not be important. Check that the LEDs respond as expected to the switch positions. Verify that the four LEDs can be used to represent 16 digits numbered from decimal 0 to 15.

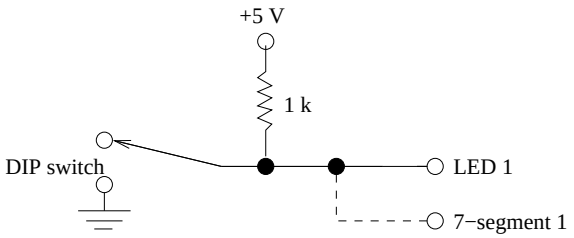

Figure 1: One of four DIP switch to logic LED connections. Also shown (dashed) is the connection to one input of the 7-segment circuit.

1.3.2

The four bits can be encoded and displayed as a decimal digit using the circuit sketched in Fig. 2. The 7-segment chip consists of seven LEDs which can be combined to display decimal digits. (The display is oriented correctly when the decimal point is at the bottom.) The 7447 IC is a binary (BCD) to 7-segment decoder (see attached description). These two chips have been conveniently wired up for us on separate small circuit boards. Connect up this circuit using your four bits as the inputs. Wire these inputs in parallel with the previously used logic LEDs, as shown for one of the four bits in Fig. 1, so that binary LEDs and decimal display can both be observed.

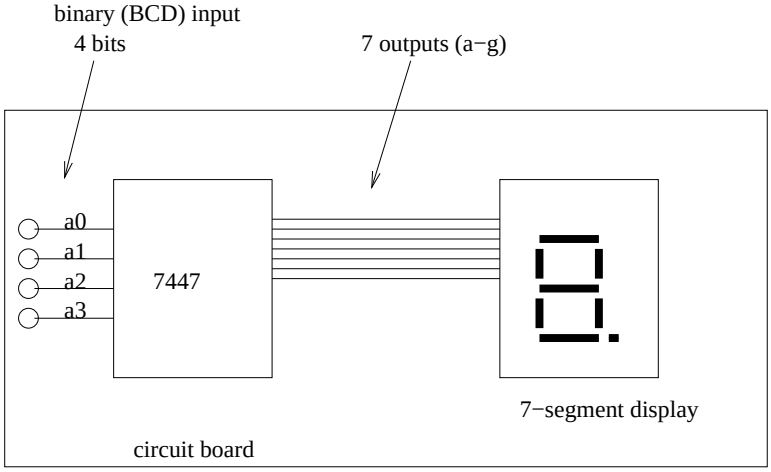

Figure 2: Conceptual schematic of the small 7-segment display boards.

Make a truth table as shown below. Cycle through all switch combinations and complete the table. What do you observe on the 7-segment display for binary inputs larger than 1001 ? Does it produce the hexadecimal digits A—F ?

Binary Number	Binary Display	Expected Decimal	Observed Decimal
0000 to 1111	off-off-off-off	0	?

1.4 Counters

We begin by establishing good TTL pulses generated by push button. Connect one of the debounced push buttons on your prototyping board to one of the inputs of a 7404 TTL inverter IC. See the attached sheet for the 7404 pin assignments. Note that the 7404 IC contains 6 independent inverters — we only need one here. Depending on whether the NC or NO button is used, one can now obtain a normally-low-goes-high pulse or a normally-high-goes-low pulse at the 7404 output.

1.4.1 Decade Counter

Wire up a 7490 decade counter IC as shown in Fig. 3 using your pulsed output from the 7404 as the input at pin 14 of the 7490. Connect the 4-bit output lines of the 7490 to your 7-segment display mini-board, as shown. Note the pin assignments. Also make parallel connections of these outputs to the binary LEDs. Pins 2 and 7 of the 7490 must be grounded, otherwise the counter is reset. Also, pins 1 and 12 must be connected together ("jumpered").

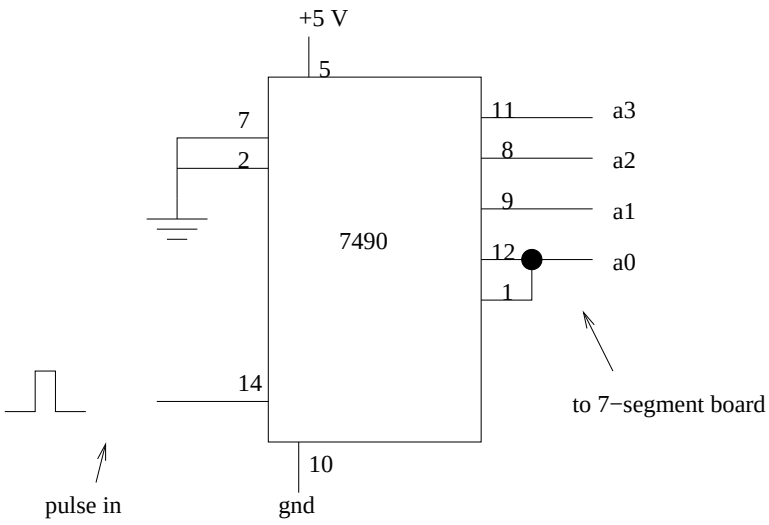

Figure 3: Wiring schematic for decimal counting and display.

For each button push, the displays should respond by counting. Cycle through the complete pattern several times. Simple decimal counting should be evident. Record a truth table for one cycle which indicates binary and decimal displays. Are all 4-bit combinations present?

Reset the counter by removing the pin 2 connection to ground. What happens?

1.4.2 Binary Counter

Replace the 7490 with a 7493 binary counter. The pin asignments are the same as the 7490. Repeat the steps above. This time, include in your truth table the state (on or off) of the individual 7-segment display "values" (a—g). How do the 7490 and 7493 differ?