EXPERIMENT #1: BINARY AND DECIMAL NUMBERS

OBJECTIVES:

- Demonstrate the count sequence of binary, Binary Coded Decimal (BCD), and Hexadecimal numbers.
- Observe timing diagrams on the oscilloscope.

Equipment and ICs:

- Mini-Lab ML-2001 lab station
- IC type 7493 4-bit ripple counter
- IC type 5082-7340 Hex display with integral decoder
- Dual–trace oscilloscope

Introduction:

All digital information is represented in the form of binary digits (0, 1) each known as a *bit*. For an n-bit binary number, the maximum possible combinations of binary numbers are 2^n. The Hexadecimal number system has 16 discrete values (0 to 9, A to F). The Hexadecimal numbers are just a compact way of representing binary numbers. The following table shows the 4-bit binary numbers and the corresponding Hexadecimal numbers. It also shows the BCD numbers.

4-bit Binary	Hexadecimal	BCD	Decimal Equivalent
0000	0	0000	0
0001	1	0001	1
0010	2	0010	2
0011	3	0011	3
0100	4	0100	4
0101	5	0101	5
0110	6	0110	6
0111	7	0111	7
1000	8	1000	8
1001	9	1001	9
1010	A		10
1011	B		11
1100	C		12
1101	D		13
1110	E		14
1111	F		15

Note: The BCD (Binary Coded Decimal) numbers only go from 0000 to 1001 since there are only 10 decimal numbers from 0 to 9. The rest of the binary number combinations from 1010 to 1111 are **NOT** BCD numbers.

Part 1: Binary and Hexadecimal Count Sequence
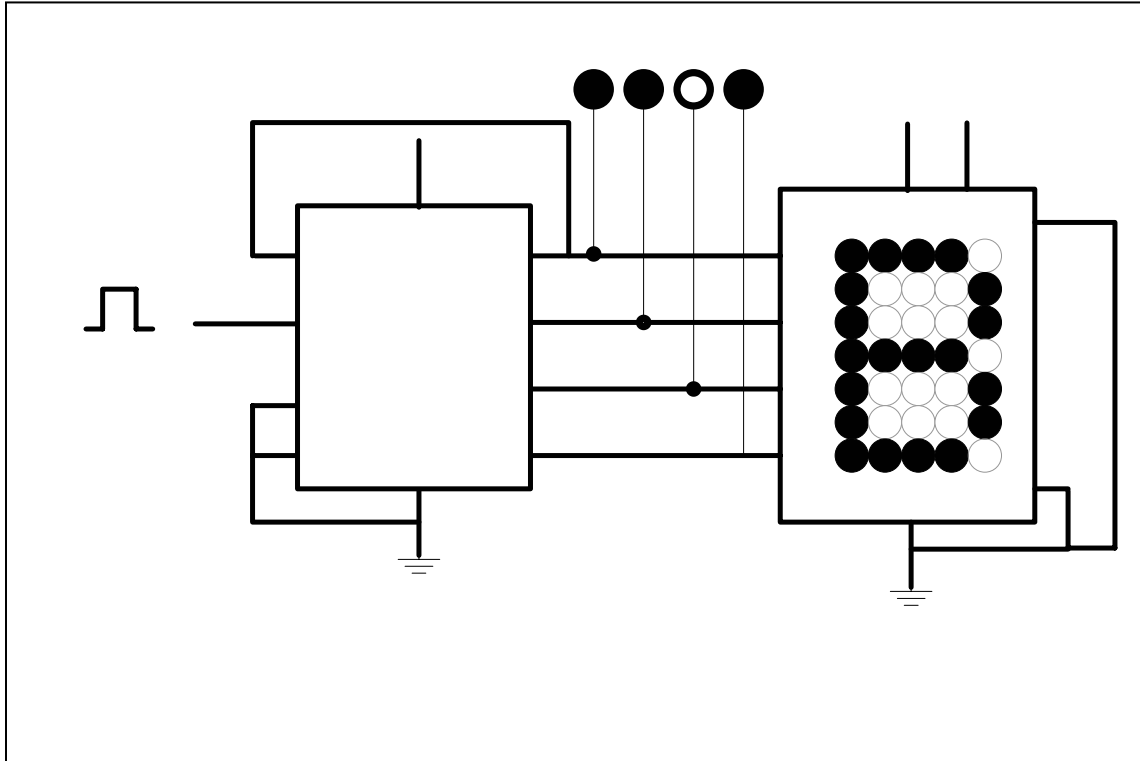
Circuit Description:

- IC **7493** is a 4-bit counter that can be connected to count in Binary or BCD. Here it is connected to count in binary (from 0000 through 1111). Pulses are applied at the input of the IC which cause the IC to increment its output value by 1. The outputs of this counter are connected to the inputs of IC PROM. The outputs are also connected to four indicator lamps on the proto-board. Q_A is the least significant bit and Q_D is the most significant bit of the 4-bit BCD digit.
- IC **TIL 311** is a Hexadecimal display which displays the hexadecimal equivalent of the 4-bit binary input. Pins 6, 9, & 11 are "No Connections".
- The 4 Indicator Lamps show the binary value of the 4-bit binary number.
- IC **TIL 311** shows the hexadecimal equivalent of the 4-bit binary number.
- The input to IC 7493 may be applied from a push-button pulser or a clock generator on the proto-board.

2

1

Pre-lab Work:

Review the count sequence of 4-bit binary numbers, and the description of the circuit above. You are not expected, at this stage, to know the details of how each device in the circuit works. The **Circuit Description** given above should be sufficient for you.

Lab Work:

1. Connect the circuit shown above on the proto-board. All connects should be made with the power supply in the off position.

    a. Connect input (pin 14) of IC 7493 to a pulser-button on the proto-board
    b. Connect the 4 outputs of IC 7493 to four indicator lamps (or LEDs) on the proto-board. Q_A is the least significant bit and Q_D is the most significant bit of the 4-bit BCD digit produced at the output.

2. Turn the power on and observe the four indicator lamps, and the Hex display.

    a. The 4-bit number in the lamps is incremented by one for every pulse generated by pushing the pulser-switch PS1 following the sequence 0000, 0001, …., 1010, 1011, 1100, 1101, 1110, 1111, 0000, 0001, …..
    b. The Hex display (IC 7340) shows the hexadecimal equivalent of the 4-bit number appearing in the indicator lamps following the sequence 0, 1, 2, …, A, B, C, D, E, F, 0, 1, …, F, …

3. Disconnect the input of the counter at pin 14 from pulser-switch PS1 and connect it to TTL clock output of the function generator. Set frequency selector to "Time 1" (1 Hz). This will provide an automatic binary count.

4. Record your observations in the form of a table showing the 4-bit binary number and its hexadecimal equivalent for each binary digit.

5. Increase the frequency of the clock to 10 kHz.

6. Connect clock output to Channel 1 of the oscilloscope. Connect the output of Q_A to Channel 2. Observe the clock pulses and Q_A and record their timing waveforms.

7. Connect Q_A to Channel 1 of the oscilloscope and Q_B to Channel 2, and record their timing waveforms.

8. Repeat Step 7 with Q_B connected to Channel 1 and Q_C connected to Channel 2.

9. Repeat Step 7 with Q_C connected to Channel 1 and Q_D connected to Channel 2.

10. Sketch the timing relationship of the clock and the four outputs in one composite diagram showing atleast 16 clock cycles.

Part 2: BCD Count Sequence
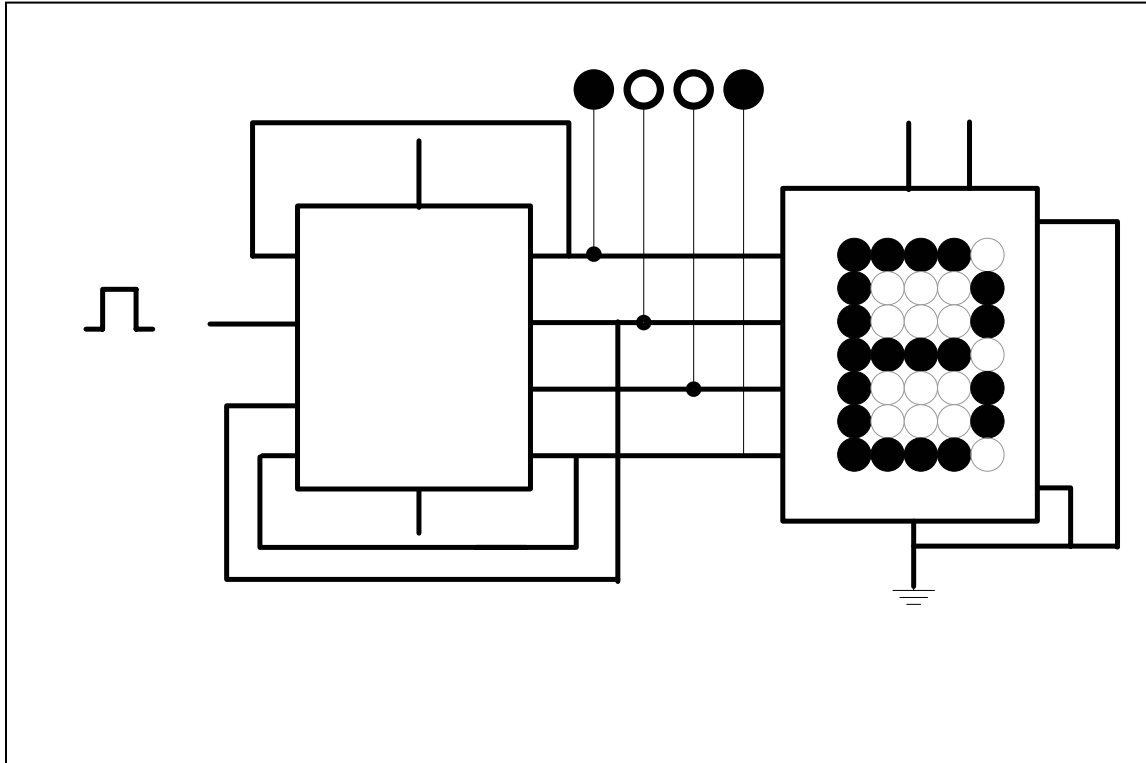
Circuit Description:

- IC **7493** is a 4-bit counter that can be connected to count in Binary or BCD. Here it is connected to count in BCD (from 0000 through 1001). Pulses are applied at the input of the IC which causes the IC to increment its output value by 1. The outputs of this counter are connected to the inputs of IC 7447. The outputs are also connected to four indicator lamps on the proto-board. Q_A is the least significant bit and Q_D is the most significant bit of the 4-bit BCD digit.
- IC **TIL 311** is a Hexadecimal display which displays the hexadecimal equivalent of the 4-bit binary input. Pins 6, 9, & 11 are "No Connections"
- The 4 Indicator Lamps show the binary value of the 4-bit binary number.
- IC **TIL 311** shows the hexadecimal equivalent of the 4-bit binary number.
- The input to IC 7493 may be applied from from a push-button pulser or a clock generator on the proto-board.

1

14

Input pulse

2

3

Pre-lab Work:

Review the count sequence of BCD numbers, and the description of the circuit above. You are not expected, at this stage, to know the details of how each device in the circuit works. The **Circuit Description** above should be sufficient for you.

Lab Work:

1. Connect the circuit shown above on the proto-board. All connects should be made with the power supply in the off position.

    a. Connect input (pin 14) of IC 7493 to a pulser-button on the proto-board
    b. Connect the 4 outputs of IC 7493 to four indicator lamps (or LEDs) on the proto-board. Q_A is the least significant bit and Q_D is the most significant bit of the 4-bit BCD digit produced at the output.

2. Turn the power on and observe the four indicator lamps, and the seven-segment display.

    a. The 4-bit number in the lamps is incremented by one for every pulse generated by pushing the pulser-switch PS1 following the sequence 0000, 0001, …., 1001, 0000, 0001, …..
    b. The seven-segment display shows the decimal equivalent of the 4-bit number appearing in the indicator lamps following the sequence 0, 1, 2, …, 9, 0, 1, …

3. Disconnect the input of the counter at pin 14 from pulser-switch PS1 and connect it to TTL clock output of the function generator. Set frequency selector to "Time 1" (1 Hz). This will provide an automatic binary count.

4. Record your observations in the form of a table showing the 4-bit binary number and its decimal equivalent for each BCD digit.

5. Increase the frequency of the clock to 10 kHz.

6. Connect clock output to Channel 1 of the oscilloscope. Connect the output of Q_A to Channel 2. Observe the clock pulses and Q_A and record their timing waveforms.

7. Connect Q_A to Channel 1 of the oscilloscope and Q_B to Channel 2, and record their timing waveforms.

8. Repeat Step 7 with Q_B connected to Channel 1 and Q_C connected to Channel 2.

9. Repeat Step 7 with Q_C connected to Channel 1 and Q_D connected to Channel 2.

10. Sketch the timing relationship of the clock and the four outputs in one composite diagram having at least 10 clock cycles.