Variable Modulus Decade Counter With Display

Object

To construct a circuit that counts modulo 7 and displays its count on a seven-segment LED readout.

Parts

(1) 7404 hex inverter
(1) 7447 BCD to 7 segment decoder/driver
(1) 7476 dual JK flip-flop
(1) 7485 4-bit comparator
(1) 74176 presettable BCD counter
(1) TIL312 or MAN71A common anode red 7-segment display
(7) 330 ohm resistors

Study sections

Computer Systems, Fourth Edition, Jones and Bartlett Publishers: Section 10.4, Combinational Devices; Section 11.1, Latches and Clocked Flip-Flops, Section 11.3 Computer Subsystems.

General information

A variable modulus counter is a counter that will count to a predetermined number and then reset itself to start a new count. A conventional binary or BCD (binary coded decimal) counter may be connected to perform variable modulus counting in a number of ways. One way is to gate the output so that the count following the highest number of the sequence resets the counter to zero.

In the experiment you will use a BCD counter to implement a variable modulus counter. The procedure consists of constructing and testing the counter, drawing timing diagrams, and explaining the operation of the circuit using the timing diagrams, logic diagrams, and data sheets for the integrated circuits being used.

Procedure

There are two types of 7-segment displays—common cathode and common anode. With a common cathode display, one end of each LED segment is connected to ground and the other end is connected to the output of a decoder/driver. When the decoder/driver puts +5V on the other end of the segment, current flows from power to ground through the segment and it lights up. The TIL312 display is common anode. With a common anode display, one end of each LED segment is connected to +5V, as shown by pins 3 and 14 on the 7-segment display in Figure 1. When the 7447 puts 0V on the other end of the segment (through pins 13, 12, 11, 10, 9, 15, 14), current flows from power to ground through the segment and it lights up. When you describe the operation of the circuit remember that a low output (*not* a high output) from the 7447 lights the segment.

One electrical component that is not in previous labs is the 330 ohm resistor that is placed between the decoder/driver and the 7-segment display. The purpose of the resistor is to limit the current that is allowed to pass through the LEDs of the display. The 7447 decoder/driver supplies a +5V or 0V signal to drive the 7-segment display. When it supplies +5V to a segment both ends of the segment are at +5V, there is no voltage difference between them, no current flows, and the segment does not light up. When it supplies 0V, there is a 5V difference between it and the common anode, so current flows and the segment lights up. The resistance of the LED in that case is extremely small, and if a resistor was not in the circuit the current would be so large as to blow out the LED segment. Each LED segment can handle up to about 25 milliamperes continuously without blowing out. If you are familiar with Ohm's Law, you know that V=IR is the relation between voltage V, current I, and resistance R. Substituting 5V for the voltage, 330 ohms for the resistance and solving for current gives I = 5/330 = 15 milliamperes, well below the threshold for damaging the display. Current-limiting resistors for driving LEDs are typically 330 ohms.

Caution: Because the leads of the resistors are bare, you must be careful to not let them touch each other.

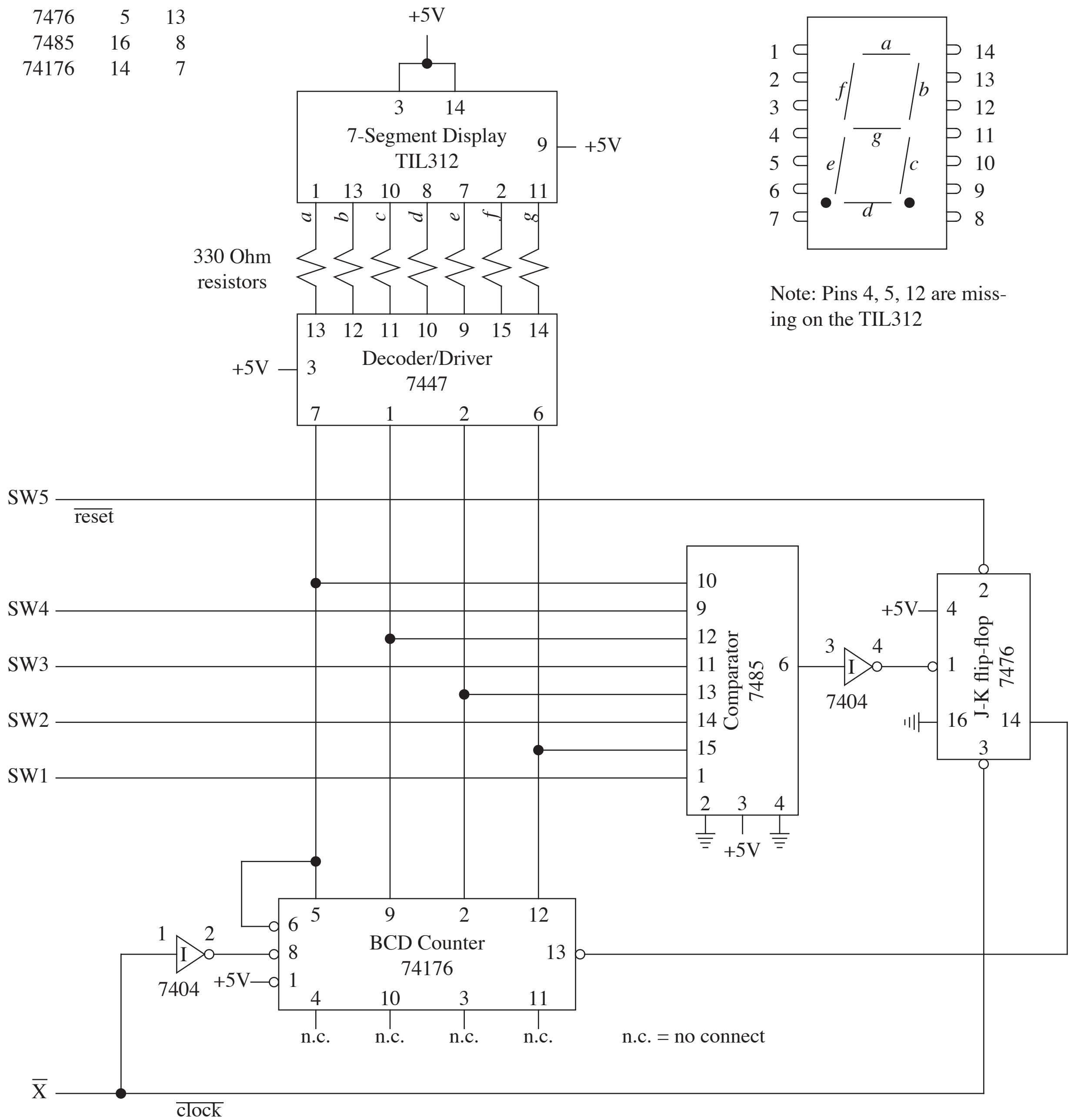
Construct the circuit shown in Figure 1. Set the switches SW1 (MSB) through SW4 (LSB) to a binary number between 1 and 9. Reset the circuit by switching SW5 off then back on. The readout should show 0. Repeatedly switch the debounced X switch. The readout should count the modulo which has been set into the switches. Set SW1 through SW4 to some other numbers and verify that the circuit works for other modulo counts.

Demonstrate operation of the circuit to your instructor. Complete the timing diagram of Figure 2. Note that the count is modulo 7.

Figure 1

	+5V	Gnd
7404	14	7
7447	16	8
7476	5	13
7485	16	8
74176	14	7

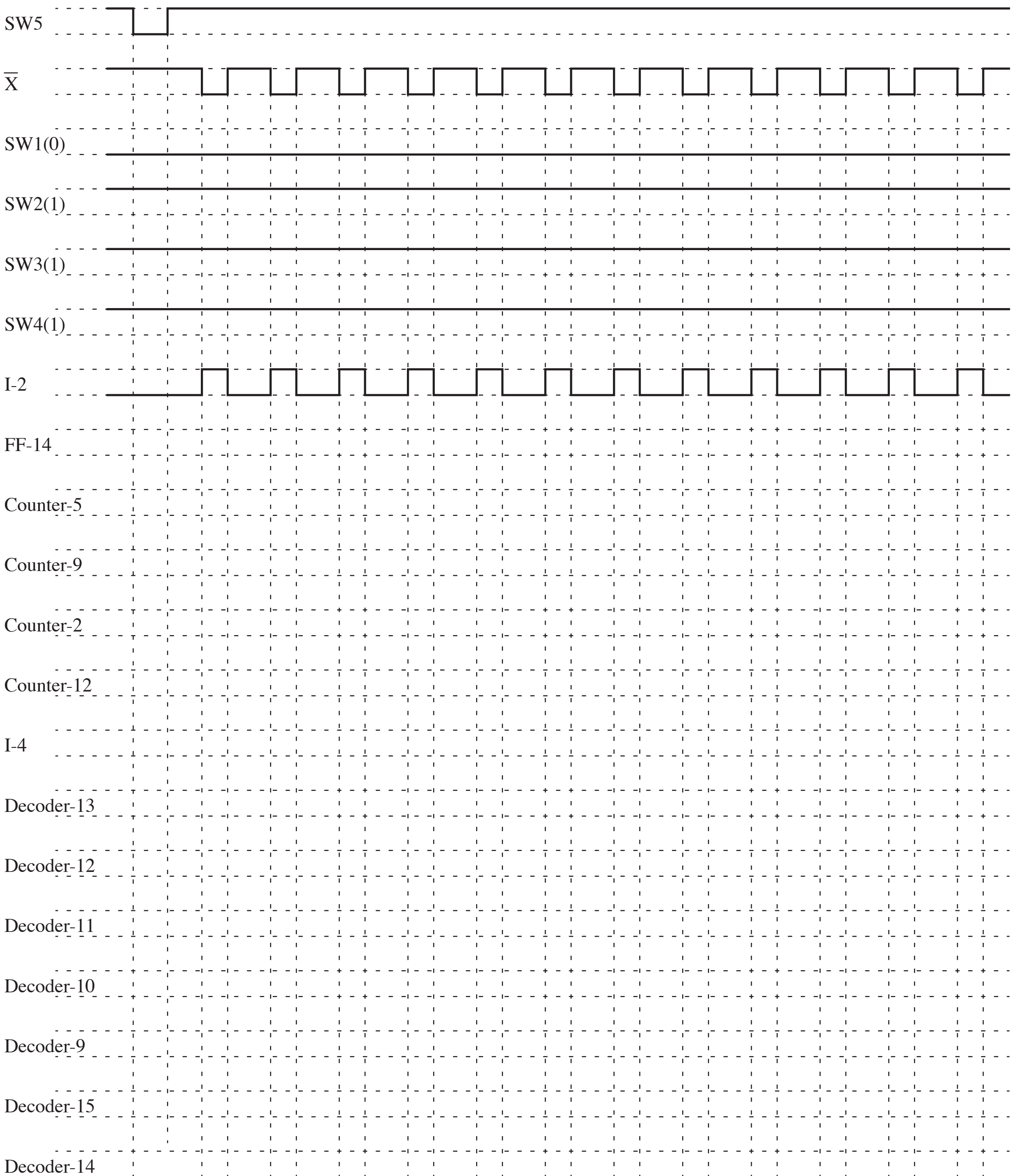
TIL312 7-Segment Display Pinout



Note: Pins 4, 5, 12 are missing on the TIL312

Instructor verification: ___________________

Figure 2


SW5
$\overline{X}$
SW1(0)
SW2(1)
SW3(1)
SW4(1)
I-2
FF-14
Counter-5
Counter-9
Counter-2
Counter-12
I-4
Decoder-13
Decoder-12
Decoder-11
Decoder-10
Decoder-9
Decoder-15
Decoder-14

Questions

Answer the following questions using the information furnished by your timing diagram, and in the data sheets for the individual ICs.

An accurate description of the details of the circuit will count for half of your grade in this lab. Be thorough.

1. Why does the Decoder-14 line start high, while all the other Decoder lines start low?

2. Why is pin 5 of the counter connected to pin 6?

3. What is the purpose of pin 13 of the counter? Is it asserted high or asserted low?

4. What is connected to pin 13 of the counter? When is it asserted?

5. Does I-4 appear to change on your timing diagram? _________ Explain the relationship between I-4 and FF-14. Describe the modulo operation of the circuit.

6. Why is the clock connected to pin 3 of the flip-flop as well as to the counter?

7. Explain the action of the reset switch (SW5).