24. 222 Digital Logic

Laboratory 6
Sequential Circuits I: Flip-flops and Shift Registers

1. Introduction

In this lab you will become familiar with basic sequential circuits, consisting of flip-flops and shift registers. You will examine some applications of shift registers.

2. Momentary "1" and "0"

In some applications, it is necessary to provide the circuit with a momentary "1" or "0" at the start up. This can be used to cause an initial load or clear input signal for a circuit. A momentary input can be produced by using an RC circuit as shown in Fig. 1. It takes about 5*RC* for the capacitor to charge, thus, the values of *R* and *C* should be chosen so that this time is much greater than the clock pulse period. The voltage waveform of the circuit shown in Fig. 1 is plotted in Fig.2.

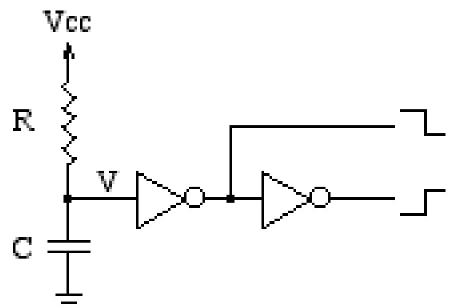

Fig. 1. Power-up momentary "1" or "0".

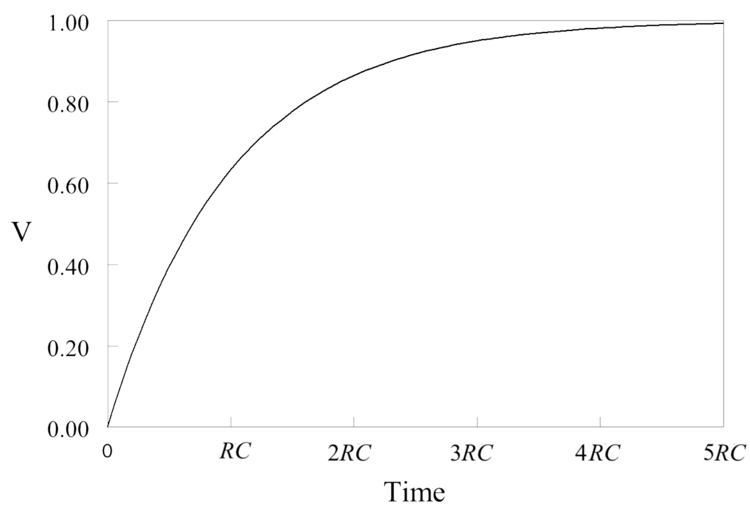

Fig. 2. The waveform of V (see Fig. 1).

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Answer Sheet

Name(s):	Student number(s):	Section: Group:

1. Operation of the D flip-flop

Connect a D type flip-flop as shown in Fig. 3, and observe the clock pulse on CH1, and the D flip-flop's output Q on CH2 of the oscilloscope (with the time base set at 1s or any other appropriate time). By running the oscilloscope in the single-sweep mode and toggling the various switches, try to capture the best image that reveals which, if any, of the inputs are synchronized with the clock pulse. If an input is synchronized with the clock, determine if synchronization occurs with the zero-to-one transition of the clock pulse or the one-to-zero transition? Plot the images on this page.

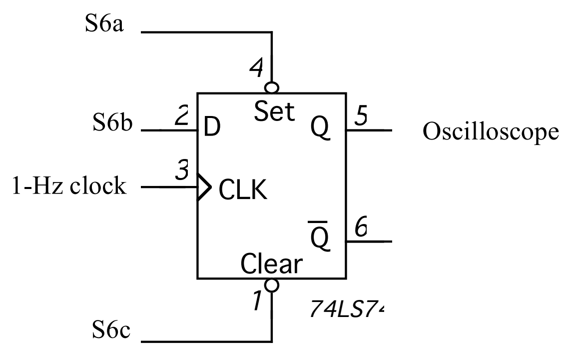

Fig. 3. The circuit for the operation of the D flip-flop.

Show the captured images to the TAs.

2. A 4-bit Bi-directional Universal Shift Register: 74194

The 74194 is a universal 4-bit shift register. Using the 74194 data sheet, explain the function of this chip in the space below.

Using a 74194 IC and any necessary basic gates or flip-flops, design a circuit to generate the light chaser patterns shown on the course web page. Use LEDs as the outputs. Draw the schematic of your circuit in the space below. If you need power-up momentary "1" or "0" use the circuit shown in Fig. 1 (with R = 10 kΩ and C = 10 μF). (*Hint:* load a specific input to the shift register at the power up and shift it. For example, for pattern #1 load "0001" into the shift register and shift it left, feeding the left-hand-side data as the serial input of the shift register.)

Verify your designs using Max+plus.

Pattern #1

Pattern #2

Pattern #3

Pattern #4 (optional)

3. Multi-digit Seven-segment Display

LTC-4727JR is a common-cathode quadruple-digit seven-segment display (4×SSD). In this package, all SSDs have common input pins (*i.e.*, all "a" segments are connected to a single pin, etc.), however, only the digit whose common-cathode is grounded is turned on . To display a 4-digit number on this display, the SSDs should be turned on one at a time. If this procedure is repeated at a high frequency, all the SSDs appear to be on.

In this part you will design a circuit to show the last two digits of both group member's student numbers (4 digits in total). The block diagram of the circuit is shown below, in Fig. 4.

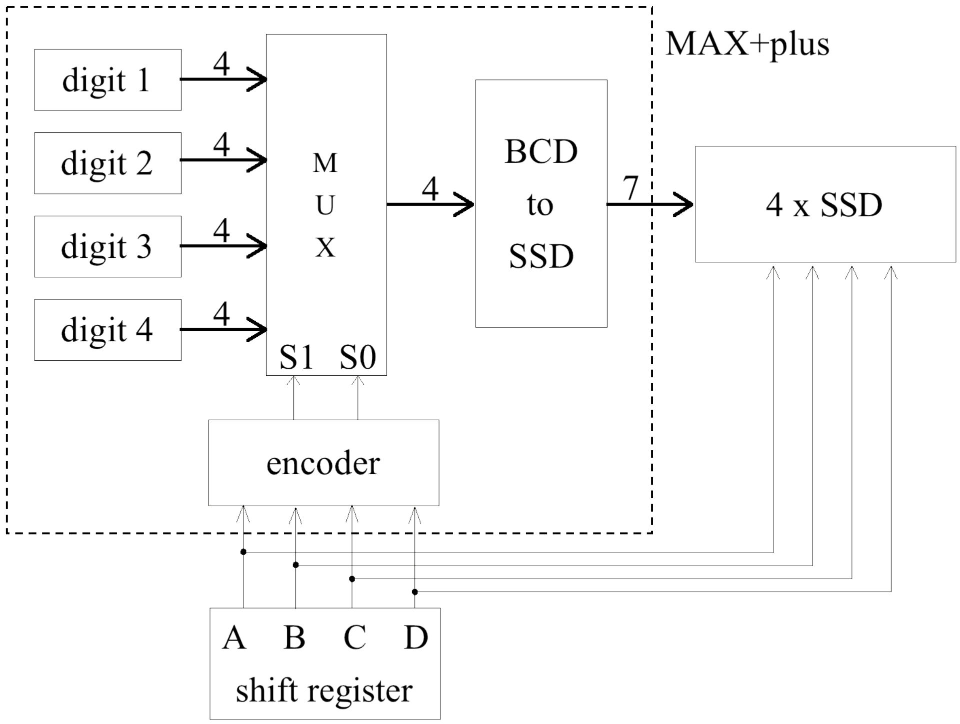

Fig. 4. Block diagram of the 4×SSD circuit. The numbers on the lines show the parallel data lines.

The shift register is loaded with "1110" at the start up. Receiving "1110" as the input, the encoder tells the multiplexer to provide the 4×SSD with the first digit and at the same time the shift register output enables one of the digits on the 4×SSD. The loaded pattern ("1110") is rotated and the second digit is shown on the next digit of the 4×SSD, and so on. Complete the truth table of the encoder and show it to the TAs. The encoder needs to be implemented using basic gates. Draw the schematic of your circuit on a separate page. Except for the shift register (74194), the 4×SSD (LTC-4727JR), NOT gate (7404), and the SSD series resistance (4116R), the rest of the circuit is implemented using MAX+plus. Now, apply the 1-Hz and 1-kHz clock pulses to the circuit and show the result of your implementation to the TAs. What's the difference?

Encoder Truth Table

A	B	C	D	S1	S0
1	1	1	0		
1	1	0	1		
1	0	1	1		
0	1	1	1		