ECE 124 digital circuits and systems
Assignment #7

Q1: A bi-directional shift register can shift both left-to-right and right-to-left. Design a bi-directional shift register than also has a parallel-load capability.

Q2: Design a 4-bit synchronous binary counter that also has a parallel load capability. Use T flip-flops.

Q3: Design a 3-bit up/down counter using T flip-flops. The counter should have one control input called $\overline{up}/down$. If $\overline{up}/down = 0$, then the circuit should behave as an up counter. If $\overline{up}/down = 1$, then the circuit should behave as an down counter.

Q4: Repeat Problem 3 using D flip-flops.

Q5: Consider the circuit shown below in Figure 5. What is the count sequence for this circuit?

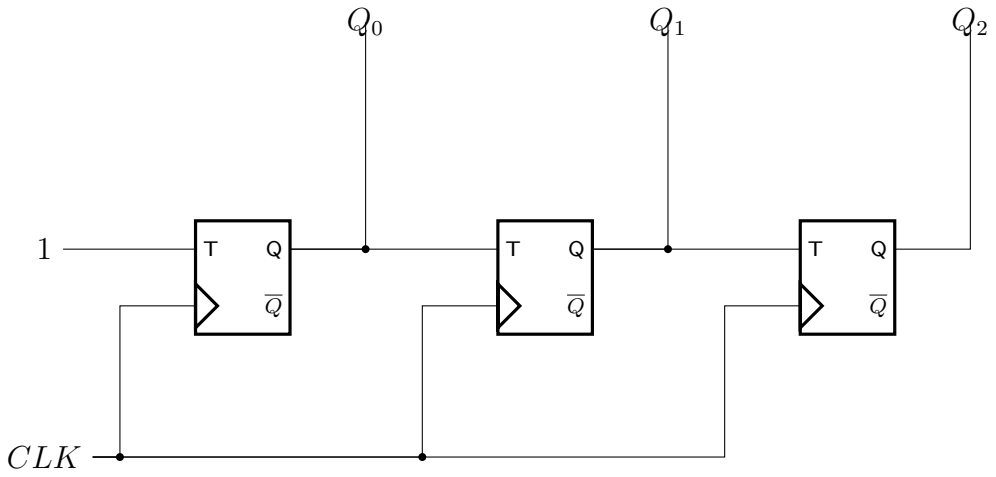


Figure 1: Circuit for Problem 5.

Q6: Consider the circuit shown in Figure 6 which implements a 4-bit counter with a parallel-load capability. Assume that each flip-flop has a setup time of $3ns$, a hold time of $1ns$ and a clock-to-output time of $1ns$. Further assume that each AND gate, XOR gate and 2-to-1 MUX has a propagation delay of $1ns$. What is the maximum frequency for which the circuit will operate correctly?

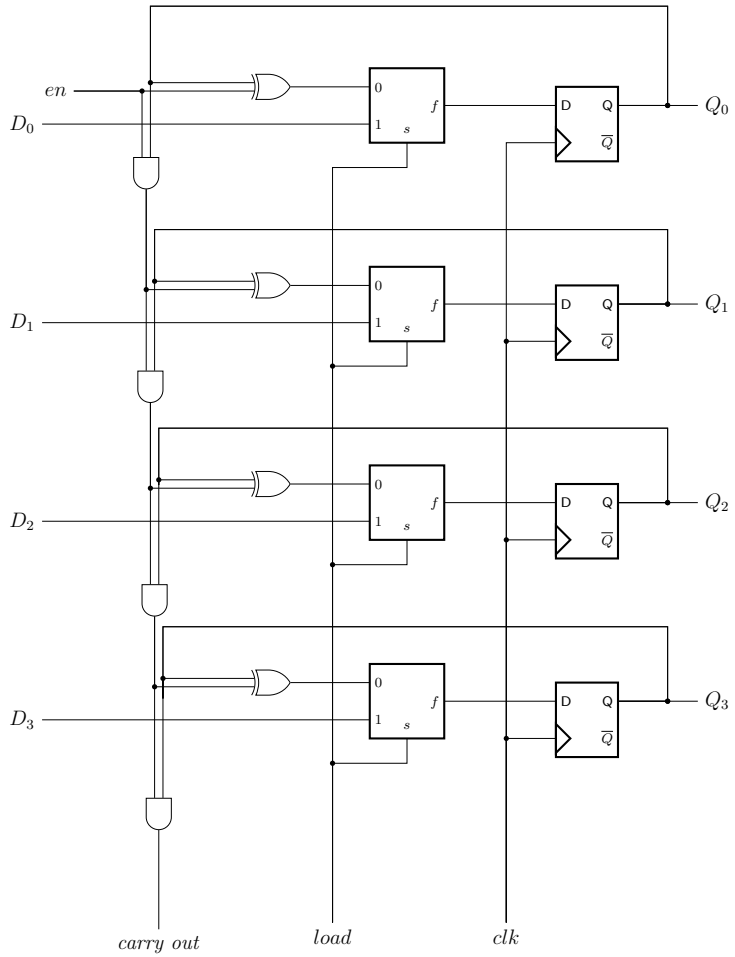
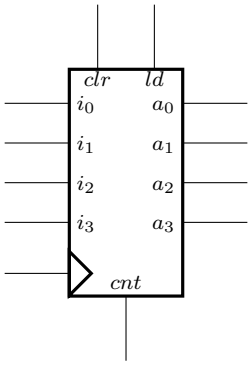


Figure 2: Circuit for problem 6.

Q7: Shown below is a symbol for a 4-bit binary up-counter which also has the ability to be cleared or load new data. The operation of the counter is described in the table below. When in count mode, the circuit will count from 0000 $\rightarrow$ 0001 $\rightarrow$ 0010 $\rightarrow$ 0011 $\rightarrow \cdots \rightarrow$ 1111 and repeats. Note that the counting or loading of data is synchronous with the rising clock edge while the clear is asynchronous.

clr	*ld*	*cnt*	*clk*	Function
0	X	X	X	Output to zero
1	1	X	$\uparrow$	Parallel load
1	0	1	$\uparrow$	Count
1	0	0	$\uparrow$	Hold



Design a module-10 counter using this 4-bit binary counter and any other additional logic; that is, design a counter which counts 0000 $\rightarrow$ 0001 $\rightarrow$ 0010 $\rightarrow$ 0011 $\rightarrow \cdots \rightarrow$ 1001 and repeats.

Q8: Assume you are given two of the 4-bit binary counters from Problem 7. Construct a circuit using two of these 4-binary counters along with any additional logic required to count from binary 4 to binary 99 and repeat.

Q9: Design a 3-bit binary counter that counts in the following sequence: 000 $\rightarrow$ 001 $\rightarrow$ 010 $\rightarrow$ 111 $\rightarrow$ 110 and repeats. Design 3 different circuits; one that uses D flip-flops, one that uses T flip-flops and one that uses JK flip-flops.