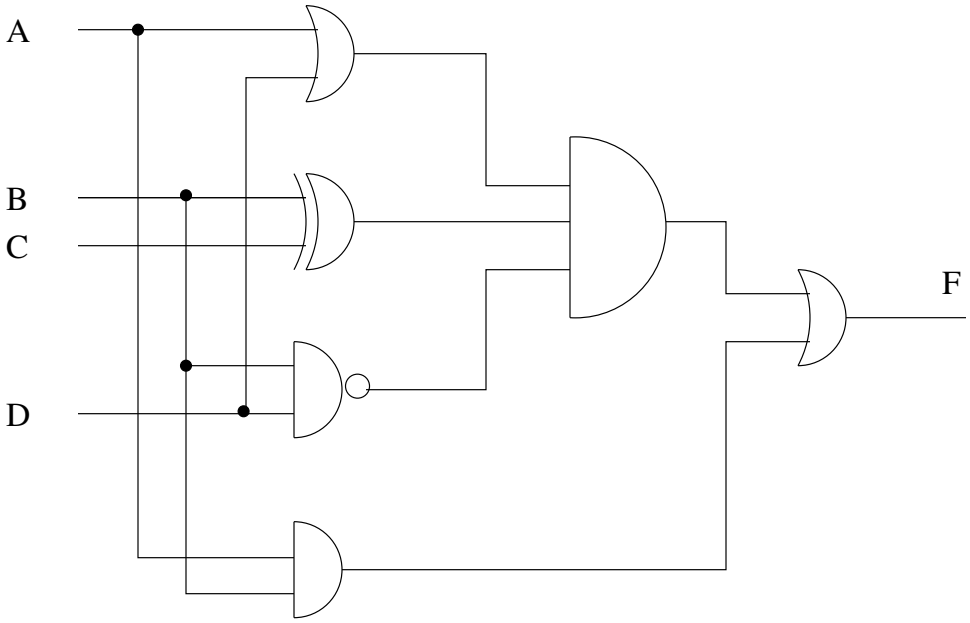
Massachusetts Institute of Technology
Department of Electrical Engineering and Computer Science
6.111 – Introductory Digital Systems Laboratory

Problem Set 2

Issued: September 11, 2002
Due: September 18, 2002

Problem 1: Fun with Combinational Logic

(a) Write the equation for output F in the circuit shown below. Using boolean algebra, simplify the equation until it is expressed in sums of products. The expression does not have to be minimal.



(b) Build a truth table for the output F, using A as the most significant bit and D as the least significant bit.

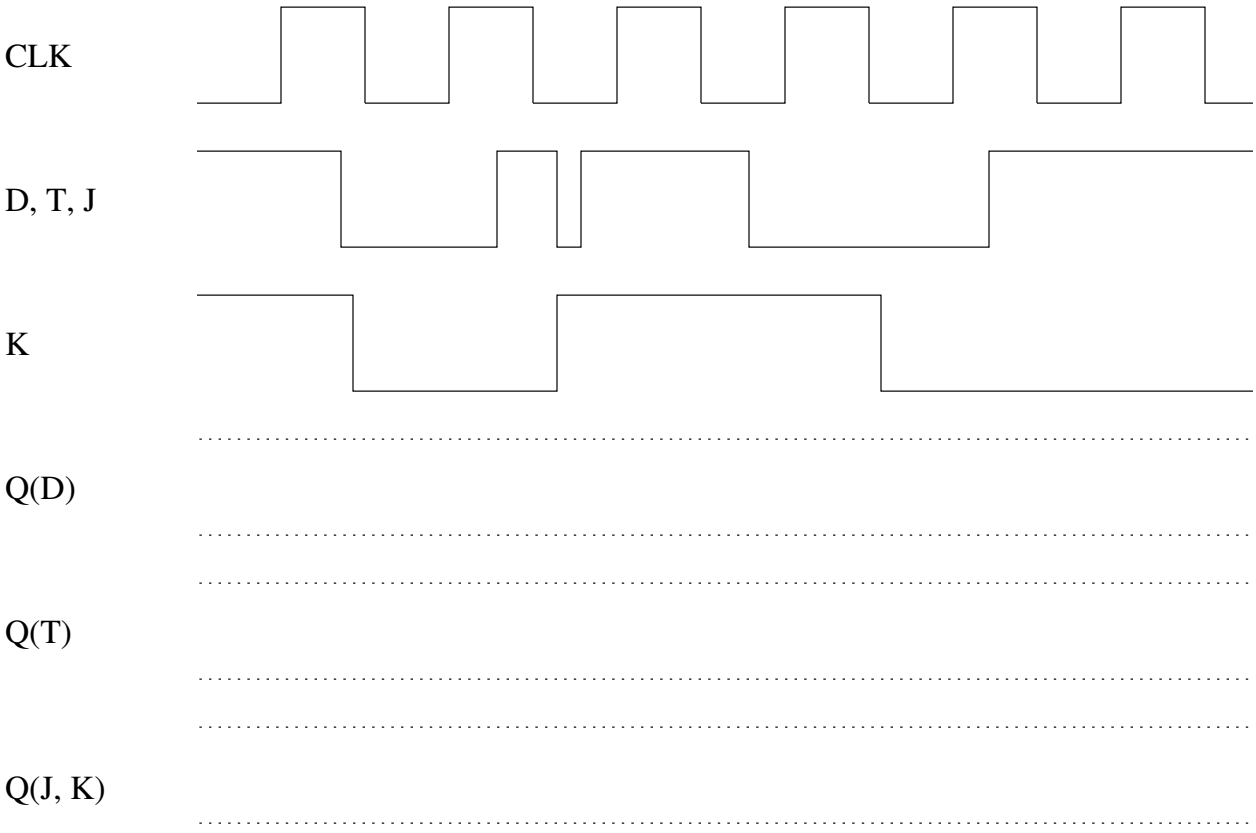
(c) Show the Karnaugh map for the circuit. Use the K-map to find a minimal sum of products expression.

(d) Is the MSP expression from (c) free from static hazards? If there are hazards, write a new expression that is hazard free.

(e) Use the truth table from (b) and implement the function F using an 8-to-1 multiplexor. Use A, B, C for the control leads with A acting as the most significant bit. The function can be generated by tying the remaining inputs to the mux to D, /D, 0, or 1. Label your diagram carefully, making sure that every input lead of the mux is connected with some input signal.

Problem 2: Thou shall know his Flip-Flops

Using the following timing diagram, draw the output Q (assume that Q starts at 0) for a positive-edge triggered D flip-flop, a negative-edge triggered T flip-flop, and a positive-edge triggered JK flip-flop.



Problem 3: Counters are Crucial

(a) The ’163 is a synchronous counter while a ’393 is a ripple counter. What does this mean? Comment on their differences (design, performance, area, etc.).

(b) There are multiple ways to create an 8-bit counter from two ’163 chips. One might think to wire the RCO of the first counter into the clock input of the next counter, but it is a bad way of cascading two counters. Why? What is a better way of cascading two ’163 counters?

(c) /ENT and /ENP on the ’163s are not the same. What is the difference?

(d) You have been hired by MIT to count the number of students in a classroom. Since the room is small, there is a maximum of 26 students in the class. Design a counter circuit which you can use to keep track of the number of people in the classroom. The circuit needs an output that tells how many students are in the class, as well as an output that alerts you when a maximum of 26 students enter the classroom. Draw a wiring diagram for the implementation of your circuit.