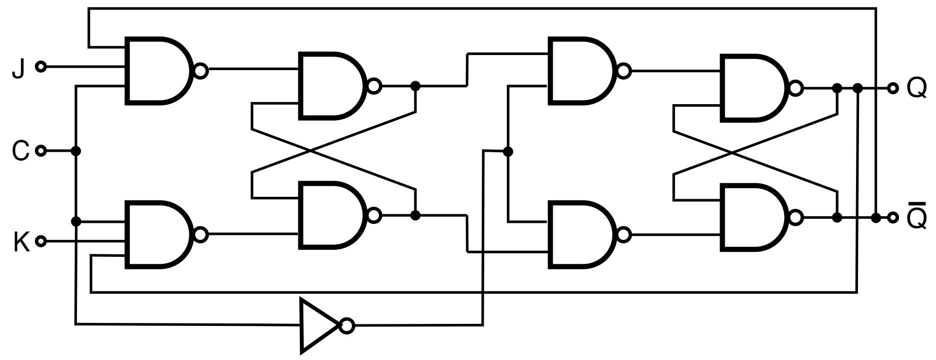
Introduction to Computer Science Module: CH-232
Constructor University Date: 2023-11-10
Dr. Jürgen Schönwälder Due: 2023-11-17

Problem Sheet #10

Problem 10.1: *JK flip-flops* (1+1+1+1 = 4 points)

JK flip-flops, also colloquially known as jump/kill flip-flops, augment the behaviour of SR flip-flops. (The letters J and K were presumably picked by Eldred Nelson in a patent application.) The sequential digital circuit shown below presents the design of a JK flip-flop based on two SR NAND latches.



Assume the circuit's output is $Q = 0$, that the inputs are $J = 0$ and $K = 0$, and that the clock input is $C = 0$. (You can make use of the fact that we already know how an SR NAND latch behaves.)

a) Suppose J transitions to 1 and C transitions to 1 soon after. Create a copy of the drawing and indicate for each line whether it carries a 0 or a 1.

b) Some time later, C transitions back to 0 and soon after J transitions to 0 as well. Create another copy of the drawing and indicate for each line whether it carries a 0 or a 1.

c) Some time later, J and K both transition to 1 and C transitions to 1 soon after. Create another copy of the drawing and indicate for each line whether it carries a 0 or a 1.

d) Finally, C transitions back to 0 and soon after J and K both transition to 0 as well. Create another copy of the drawing and indicate for each line whether it carries a 0 or a 1.

Problem 10.2: *assembler programming* (1+2+2+1 = 6 points)

The following program has been written for the simple central processing unit introduced in class. The table below shows the initial content of the 16 memory cells. The first column denotes the memory address while the second column shows the memory content in hexadecimal notation.

Cell	Hex	Binary	Assembler	Description
0	2e			
1	b0			
2	d4			
3	e0			
4	2f			
5	6f			
6	4f			
7	2e			
8	91			
9	4e			
10	cb			
11	00			
12	00			
13	00			
14	06			
15	01			

a) Convert the machine code given in hexadecimal notation into binary notation.

b) Write down the assembly code for the machine code. Add meaningful descriptions.

c) The program leaves a result in memory cell 15 when it halts. What is the value? Explain how the program works, either in words or by providing an equivalent program code in a higher level imperative language.

d) What happens if the value stored in memory cell 14 is changed to 10 before execution starts? Explain.