

QUESTION 2b

DIGITAL CIRCUIT DESIGN

Which button was pressed first?

Design a system with 2 digital inputs (a, b) and 2 digital outputs (x, y).

Initially both outputs are 0.

If input a goes from 0 to 1 first, then x is set to 1 (and stays there forever), y stays at 0.

If input b goes from 0 to 1 first, then y is set to 1 (and stays there forever), x stays at 0.



(a) Design a circuit with this functionality using only flip-flops and logic gates.

a

b

The diagram shows two D flip-flop symbols, one for output x and one for output y. Each flip-flop has a D input, a clock input (indicated by a triangle), a Q output, and a Q-bar output. The top flip-flop is labeled 'x' and the bottom one is labeled 'y'.

QUESTION 3 *ASSEMBLY LANGUAGE*

(a) Execute the following Atmel Assembly program and enter all register values in hex.

- Note that constants with prefix '0x' are hex numbers, constants with prefix '0b' are binary numbers, and constants without a prefix are decimal numbers.

; REGISTER Commands

LDI R30, 0x30

LDI R31, 0x31

AND R30, R31 R30 = _____ (hex);

COM R30 R30 = _____ (hex);

NEG R30 R30 = _____ (hex);

LDI R30, 0xFE

LDI R31, 0x12

ADD R30, R31 R30 = _____ (hex);

SUBI R30, 0x0D R30 = _____ (hex);

LSR R30 R30 = _____ (hex);

; MEMORY Commands

temp: .DB 0x20 ; assume address of temp is **0x1234**

LDS R16, temp

INC R16

STS temp, R16 temp = _____ (hex)

LDI XL, _____ ; load "temp" address (low byte)

LDI XH, _____ ; load "temp" address (high byte)

LD R20, X R20 = _____ (hex)

X = _____ (hex)

QUESTION 4

ARCHITECTURE

(1.5+1.5+3 = 6 points)

Consider a CPU with 8-bit data bus and 16-bit address bus.

We want to connect the following components with continuous addresses starting at 0:

- ROM with 32 KB (32K x 8 bits)
- RAM with 16 KB (16K x 8 bits)
- Output Latch with 1 Byte (1 x 8 bits)

(a) Define the address spaces (from first to last address):

ROM from 0x **0000** to 0x _____

RAM from 0x _____ to 0x _____

Latch from 0x _____ to 0x _____

(b) Define bus lines for each memory component:

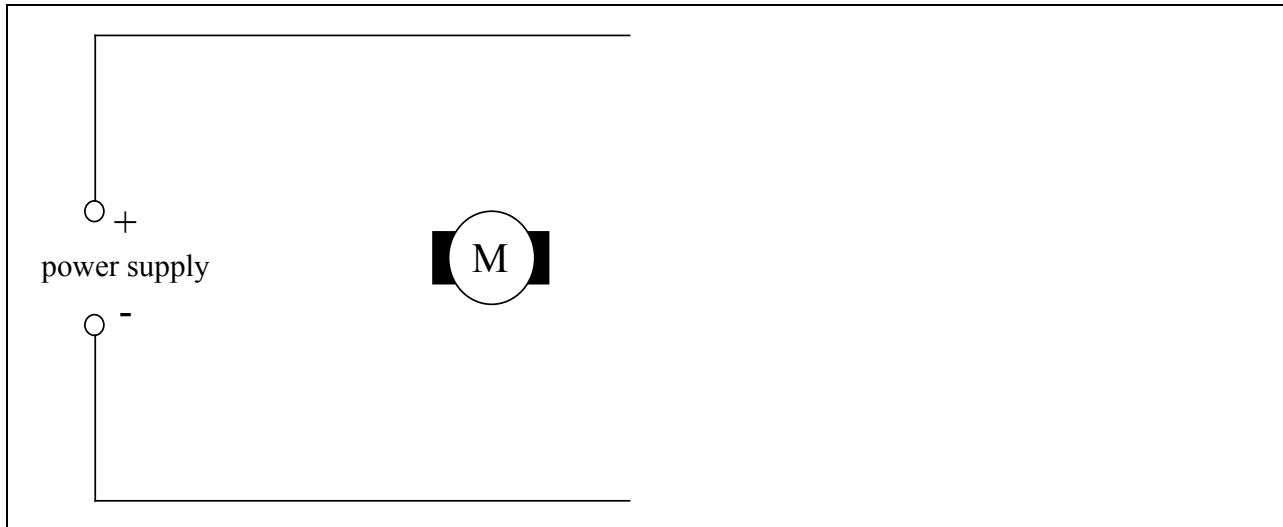
ROM chip has _____ address lines and _____ data lines

RAM chip has _____ address lines and _____ data lines

Latch chip has _____ address lines and _____ data lines

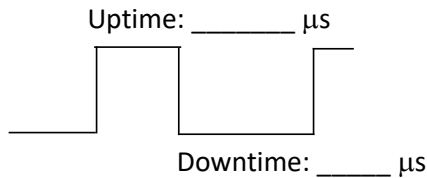
QUESTION 5 *Actuators*

(a) Connect the motor in the diagram below to the power supply, creating a H-bridge with 4 switches.



(b) A motor should run at 20% max speed by using PWM at 100 Hz.

- Enter the timing values in the diagram below.



(c) Complete this program to generate a specified motor speed by using PWM.

- Assume the motor enable line is connected to pin 1.
- Assume I/O lines have already been initialized.
- There is no encoder feedback.
- Run the while-loop at roughly 100 Hz.
- Use `usleep(microsec)` to sleep for the given number of microseconds.

```
void setPWM(int ratio) // ratio is between 0 and 100
{
    while(1)
    {

    }
}
```