EE 215 Homework #1 Solution

1. Memory space (15 pts total, 3 pts each)
   What is the largest memory space that can be addressed by processors having the following number of address bits? For this problem, assume that each byte of memory has a unique address.
   a. 4 bits
   b. 16 bits
   c. 22 bits
   d. 25 bits
   e. 32 bits

Solution:

The number of addressable location is 2 raised to the power of the number of address bits. Since each location contains a byte of data, the results are in bytes. Remember that 1K=1024 and $1\text{M} = 1\text{K} \times 1\text{K}$

a. $2^4 = 16$ bytes

b. $2^{16} = 65{,}536$ bytes $= 64$ KB

c. $2^{22} = 4{,}194{,}304$ bytes $= 4$ MB

d. $2^{25} = 33{,}554{,}432$ bytes $= 32$ MB

e. $2^{32} = 4{,}294{,}967{,}296$ bytes $= 4$ GB

2. Memory space (15 pts total, 3 pts each)
   What is the number of bits needed for addressing these memories? For this problem, assume that each byte of memory has a unique address (byte addressable).

Solution:

The number of addressable locations is 2 raised to the power of the number of address bits. Since each location contains a byte of data, the results are in bytes. Some numbers to remember are $2^{11} = 1{,}024 = 1$ kB,

$2^{20} = 1{,}048{,}576 = 1$ MB,

$2^{30} = 1{,}073{,}741{,}824 = 1$ GB.

a. 2 KB (Arduino's SRAM for runtime data)

$2^{11} = 2048\ Bytes$, requires 11 address bits.

b. 32 KB (the Arduino's Flash memory for bootloader and sketch)

$2^{15} = 32768\ Bytes$, requires 15 address bits.

c. 512 MB (Raspberry Pi RAM)

$2^{29} = 536870912\ Bytes$, requires 29 address bits.

d. 4 GB (Motorola 68020)

$2^{32} = 4{,}294{,}967{,}296\ Bytes\ =\ 4\ GB$, requires 32 address bits.

e. 32 GB (max memory size for micro SD for Raspberry Pi)

$2^{35} =\ 34{,}359{,}738{,}368\ Bytes$, requires 35 address bits.

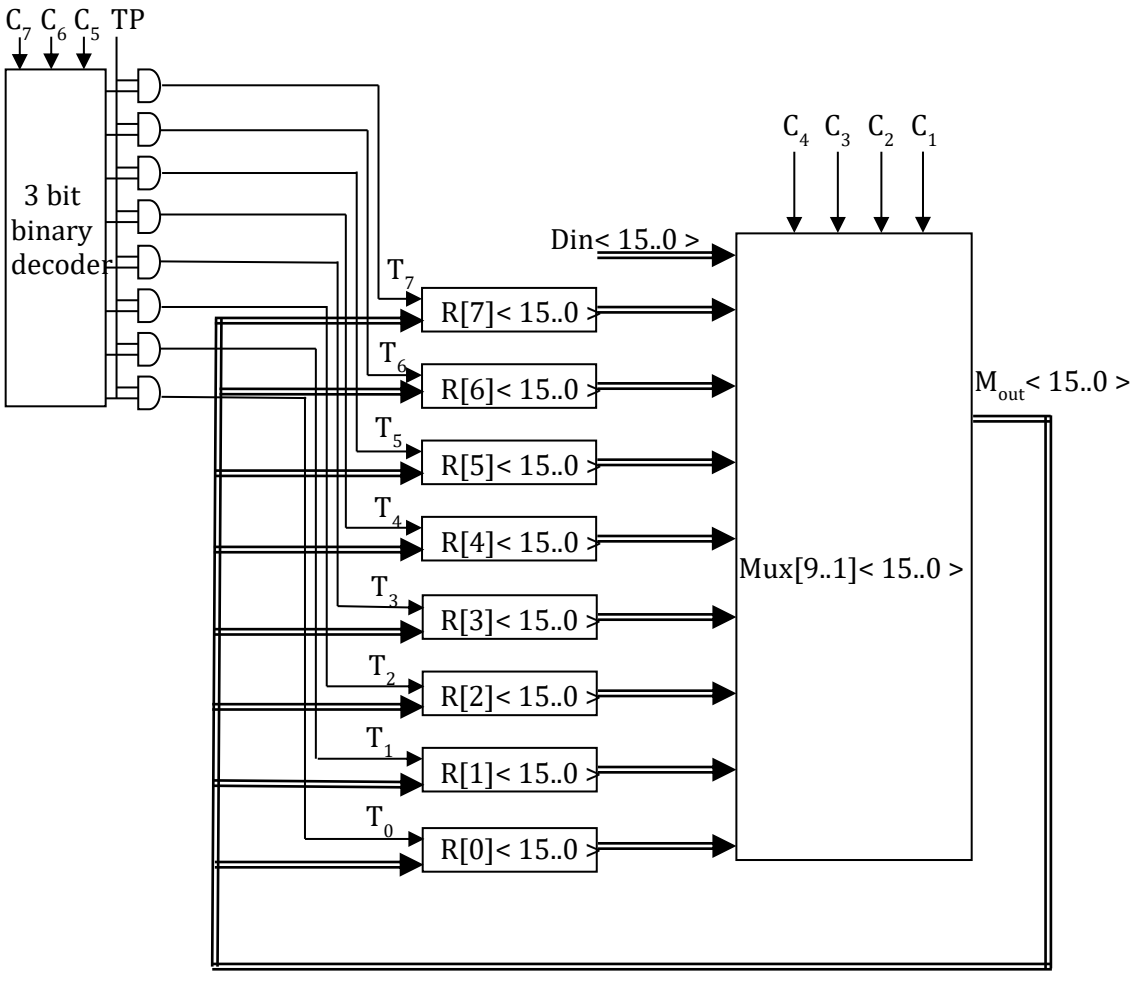
3. (20 pts total, 5 pts each)
For the following control signals, $C_3C_2C_1$ are used to select source register R[0]-R[7], and C_4 is used for D_{in} selection. If $C_4 = 1$, MUX output is D_{in}. $C_7C_6C_5$ are used for 3 bit binary decoder to select destination register.

1) (3 pts) If $C_7C_6C_5C_4C_3C_2C_1 = 1011100$, describe the corresponding register transfer.

2) (3 pts) If $C_7C_6C_5C_4C_3C_2C_1 = 1110111$, describe the corresponding register transfer.

3) (3 pts) If we want $R[0] \leftarrow R[2]$, what control signals should be used?

4) (3 pts) If we want $R[3] \leftarrow D_{in}$, what control signals should be used?



Solution:

1) R[5]<15..0> ⟵ Din< 15..0 >
2) R[7]<15..0> ⟵ R[7]<15..0>
3) $C_7C_6C_5C_4C_3C_2C_1 = 000\ 0010$
4) $C_7C_6C_5C_4C_3C_2C_1 = 011\ 1XXX$

4. New words. (20 pts total, 5 pts each).
Define these words in one or two sentences.

Solution:

a. register

A register is a storage location for data in the central processing unit (CPU). It typically has a size of 8,16, or 32 bits. [Functions like a row of D-flip flops with clock lines tied together.]

b. microprocessor

An integrated circuit with only a CPU. It is modular, needs peripherals, has an operating system, and typically has clock speeds in GHz.

c. microcontroller

An integrated circuit with CPU, memory, peripherals together. It has no operating system, and typically has clock speeds in MHz.

d. machine code

Machine code is a computer program written in numerical language instructions that can be executed directly by a computer's central processing unit (CPU).