EXERCISES OF
FUNDAMENTALS OF COMPUTER TECHNOLOGY

UNIT 5. MEMORY SYSTEM

Most of the exercises in this units deal with installing memory chips in a computer to increase its capacity, either in number of available addresses, in word size, or both.

Increasing memory capacity in number of addresses.

Example: In a CPU with an address bus of 14 bits, you are required to install a memory of 16Kx8 using chips of 8Kx8. Design the memory system.

-Check that the required amount of memory can be addressed with 14 bits: 2^{14} = 16K

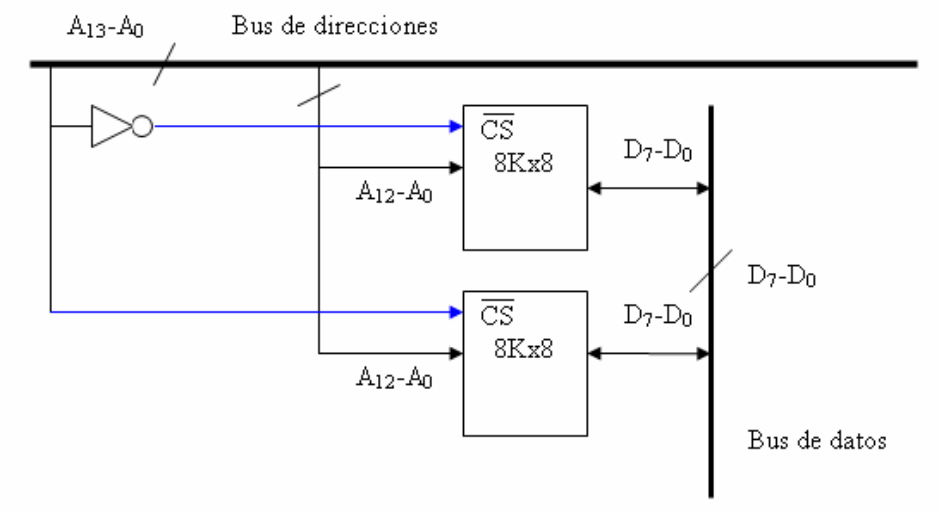
-Calculate how many 8Kx8 chips are needed: 16K/8K * 8/8 = 2 * 1 → 2 chips of 8Kx8

-Scheme of the memory map:

0 8K-1	Módulo 0 de 8Kx8
8K 16K-1	Módulo 0 de 8Kx8

Calculate addresses in each chip. As chips are of 8K we need the least 13 significant bits A_{12}-A_0 to select an address in each of them (2^{13} = 8K). The most significant bit A_{13} will be used to select the chip with the CS input. Both will share the same data bus with 8 lines. The memory map and the system design are

A_{13}	A_{12}	A_{11}	A_{10}	A_9	A_8	A_7	A_6	A_5	A_4	A_3	A_2	A_1	A_0	Módulo
1	1 … 0	1 … 0	1 … 0	1 … 0	1 … 0	1 … 0	1 … 0	1 … 0	1 … 0	1 … 0	1 … 0	1 … 0	1 … 0	Módulo 1
0	1 … 0	1 … 0	1 … 0	1 … 0	1 … 0	1 … 0	1 … 0	1 … 0	1 … 0	1 … 0	1 … 0	1 … 0	1 … 0	Módulo 0



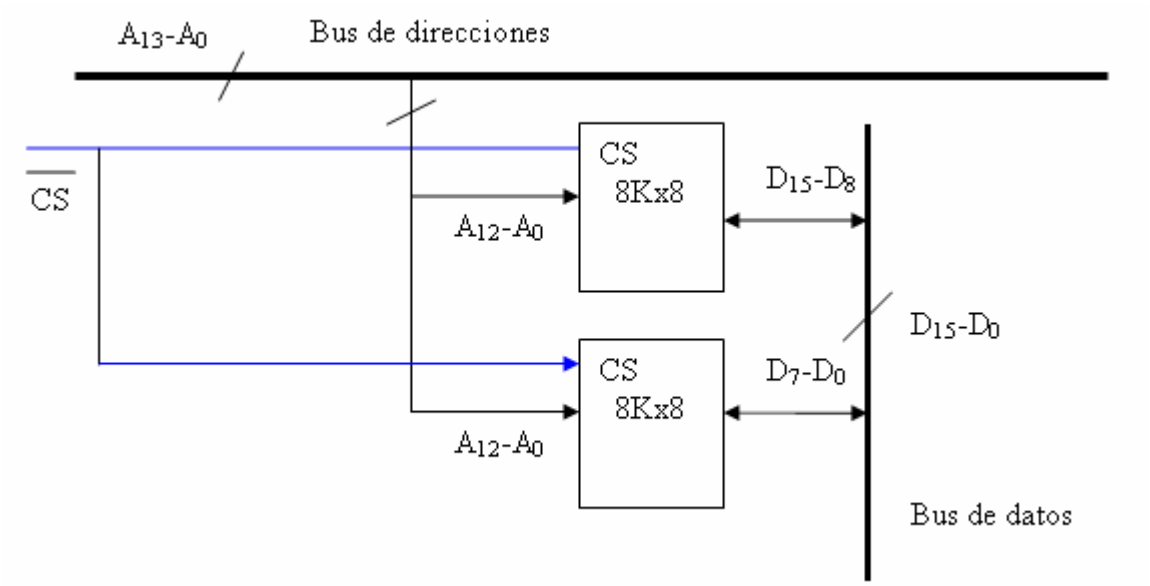
Increasing memory capacity in word size:

Example: In a CPU with an address bus of 14 bits, you are required to install a memory of 16Kx16 using chips of 8Kx8. Design the memory system.

-Check that the required amount of memory can be addressed with 14 bits: 2^{14} = 16K

-Calc. how many 8Kx8 chips are needed: 16K/16K * 16/8 = 1 * 2 → 2 chips of 16Kx8

Now the CPU accesses the same address in both chips at the same time, providing each of them half of the total 16 bits to be sent to the data bus when reading a position. The system design is now



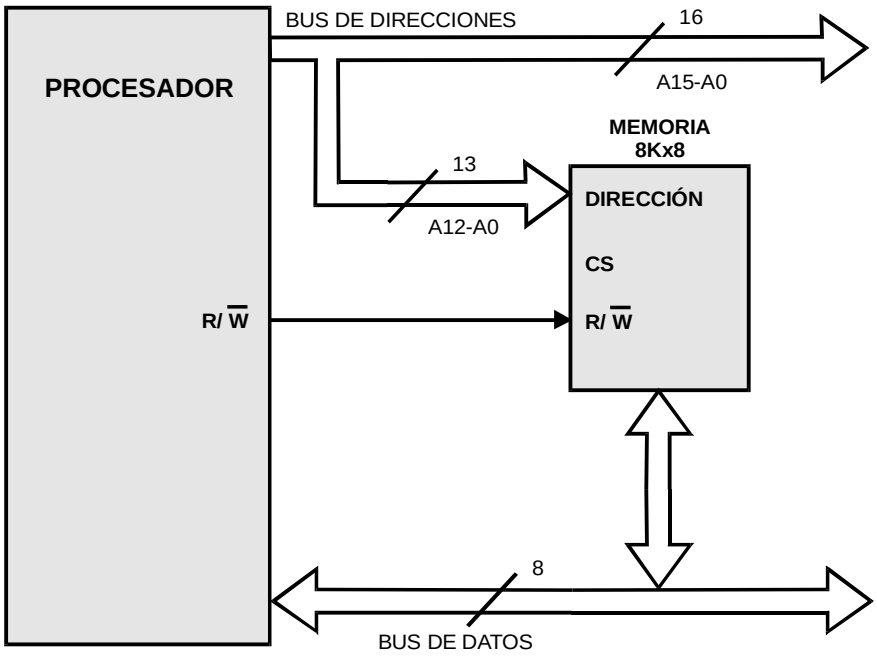
Increasing memory capacity in number of addresses and in word size

In the following exercises the two cases shown above can be combined to increase the amount of available memory both in number of addresses and in word size.

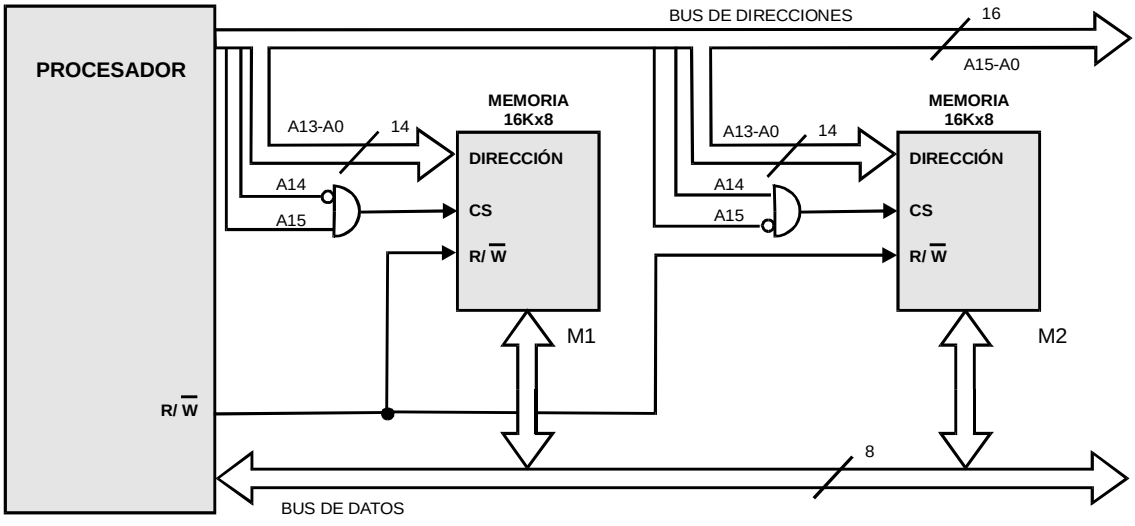
EXERCISES UNIT 5

1. In a CPU with 8 bits in the data bus and 10 bits in the address bus it is required to install two memory chips of 256x8. One must be in the lowest part of the map (ie. it must contain the first 256 addresses), and the other one in the highest part. Design the memory system.

2. In the computing system shown in the figure it is required that the 8Kx8 memory chip stores the lowest addresses in the map. Design the circuit to connect the necessary lines of the address bus to the chip select of the memory.



3. In the memory system shown in the figure, calculate the addresses that memory chips M1 and M2 store.



4. In a CPU with 16 bits in the data bus and 20 bits in the address bus it is required to install a memory system with the following characteristics:

- 256 Kwords (256 K x 16) of ROM memory.
- 512 Kwords (512 K x 16) of RAM memory.

Design the memory system allocating RAM memory in the lowest part of the map followed by ROM in the next positions. Use the minimum number of the following available chips

ROM chips	RAM chips
64 K x 8	128 K x 1
128 K x 1	256 K x 8
128 K x 8	

5. In a CPU with 16 bits in the data bus and 20 bits in the address bus it is required to install a memory system with the following characteristics:

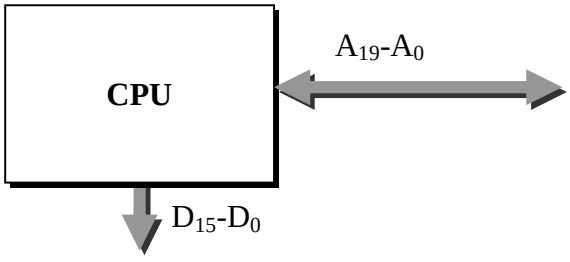
- 256 Kwords (256 K x 16) of ROM memory.
- 512 Kwords (512 K x 16) of RAM memory.

Design the memory system allocating RAM memory in the lowest addresses of the map and ROM in the highest ones. Use the minimum number of the following available chips:

ROM chips	RAM chips
64 K x 8	128 K x 1
128 K x 1	256 K x 8
128 K x 16	256 K x 16

6. In the CPU shown in the figure it is required to install a memory system with the following characteristics:

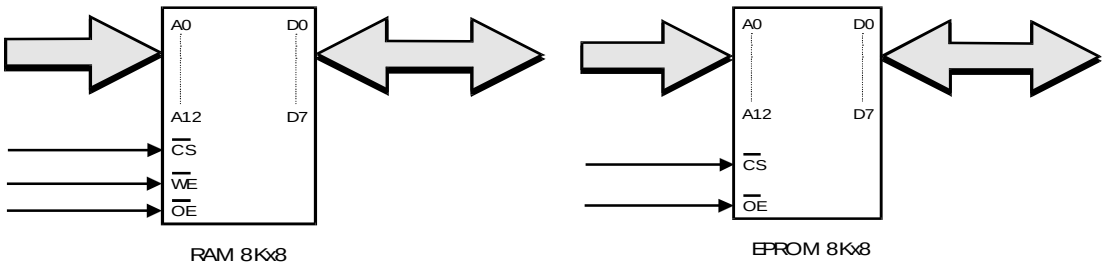
- 128 Kwords (128K x 16) of ROM memory
- 768 Kwords (640K x 16) of RAM memory.



Design the memory system allocating RAM memory in the lowest addresses of the map and ROM in the highest ones. Use the minimum number of the following available chips:

ROM chips	RAM chips
64 k x 8	128 k x 1
128 k x 1	256 k x 8
128 k x 16	256 k x 16

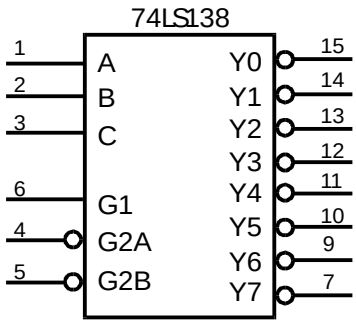
7. In a CPU with 16 bits in the data bus and 16 bits in the address bus it is required to install 16 Kwords of RAM memory and 8 Kwords of EPROM memory. The following chips are available:



The address range for each type of memory must be:

	Firs address	Last address
RAM	2000h	5FFFh
EPROM	8000h	9FFFh

a) Design the memory system using the necessary logic gates
b) Design the memory system using the 3 to 8 decoder 74138 of the figure



Inputs					Outputs							
Enable		Select										
G1	G2 (Note 1)	C	B	A	YO	Y1	Y2	Y3	Y4	Y5	Y6	Y7
X	H	X	X	X	H	H	H	H	H	H	H	H
L	X	X	X	X	H	H	H	H	H	H	H	H
H	L	L	L	L	L	H	H	H	H	H	H	H
H	L	L	L	H	H	L	H	H	H	H	H	H
H	L	L	H	L	H	H	L	H	H	H	H	H
H	L	L	H	H	H	H	H	L	H	H	H	H
H	L	H	L	L	H	H	H	H	L	H	H	H
H	L	H	L	H	H	H	H	H	H	L	H	H
H	L	H	H	L	H	H	H	H	H	H	L	H
H	L	H	H	H	H	H	H	H	H	H	H	L

Nota 1: G2 = G2A + G2B