ELEC 464 : MICROCOMPUTER SYSTEM DESIGN
FALL 1995

Assignment 5 - Solutions

Question 1

For each of the memory areas we first find the decoding pattern. The remaining questions can be answered by inspection.

(a)

device	addresses	memory size		bits
		width	bytes	decoded
RAM1	0000 0000 XXXX XXXX XXXX XXXX	16	64k	8
RAM2	0000 0001 XXXX XXXX XXXX XXXX	16	64k	8
IO_1	1110 0000 0000 0000 000X XXXX	5	32	19
IO_2	1110 0000 0000 0000 001X XXXX	5	32	19

```
RAM1 = !A23 & !A22 & !A21 & !A20 & !A19 & !A18 & !A17 &
        !A16 ;

RAM2 = !A23 & !A22 & !A21 & !A20 & !A19 & !A18 & !A17 &
        A16 ;

IO_1 = A23 & A22 & A21 & !A20 & !A19 & !A18 & !A17 &
        !A16 & !A15 & !A14 & !A13 & !A12 & !A11 & !A10
        & !A09 & !A08 & !A07 & !A06 & !A05 ;

IO_2 = A23 & A22 & A21 & !A20 & !A19 & !A18 & !A17 &
        !A16 & !A15 & !A14 & !A13 & !A12 & !A11 & !A10
        & !A09 & !A08 & !A07 & !A06 & A05 ;
```

(b)

device	addresses	memory size		bits
		width	bytes	decoded
ROM1	0000 0000 00XX XXXX XXXX XXXX	14	16k	10
ROM2	0000 0000 01XX XXXX XXXX XXXX	14	16k	10
ROM3	0000 0000 10XX XXXX XXXX XXXX	14	16k	10
RAM	0000 01XX XXXX XXXX XXXX XXXX	18	256k	6
IO	0000 1000 0000 0000 XXXX XXXX	8	256	16

```
ROM1 = !A23 & !A22 & !A21 & !A20 & !A19 & !A18 & !A17 &
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        !A16 & !A15 & !A14 ;

ROM2 = !A23 & !A22 & !A21 & !A20 & !A19 & !A18 & !A17 &
        !A16 & !A15 & A14 ;

ROM3 = !A23 & !A22 & !A21 & !A20 & !A19 & !A18 & !A17 &
        !A16 & A15 & !A14 ;

RAM = !A23 & !A22 & !A21 & !A20 & !A19 & A18 ;

IO = !A23 & !A22 & !A21 & !A20 & A19 & !A18 & !A17 &
      !A16 & !A15 & !A14 & !A13 & !A12 & !A11 & !A10 &
      !A09 & !A08 ;
```
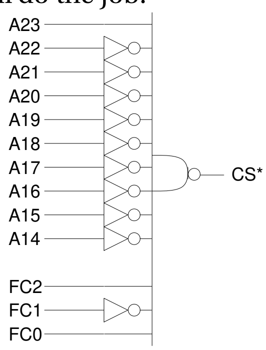

Question 2

The 16kB memory area requires 14 bits for addressing within the chips and to select one of the two devices. The remaining $24 - 14 = 10$ pins must be decoded. The decoded address pattern is 1000 0000 00XX XXXX XXXX XXXX. To ensure that the memory is only accessed in supervisor data mode (supervisor stack is supervisor data (r/w memory), see section 4.1 for a more detailed description) the function code bits should be FC2,FC1, FC0 $= 101$.

The following circuit will do the job:



Question 3

One reason not to put address decoders on the microprocessor is to increase the amount of addressable memory for a given number of pins. The amount of addressable memory only grows linearly with the number of chip selects whereas it grows as a power of 2 of the number of address pins. For a fixed number of pins we can address more memory by using the available outputs for address bits instead of chip selects. Note that it is always possible to use address bits as enables although this leads to a discontinuous memory map.

Another reason to use an external memory decoder is to increase the flexibility of the decoding function. For example, an external memory decoder can be designed to use the function code outputs, add memory protection, generate BERR* for missing memory areas, or add a different number of wait states for different memory areas. A built-in decoder might not provide all of these features.

On the other hand, reducing the chip count can reduce the overall system cost so some microcontrollers (e.g. the Motorola 68000-based 68300 series) do include built-in memory decoders. Although they have limited functionality, it's often sufficient for simple systems.