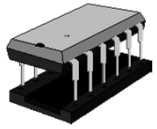
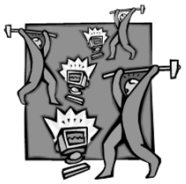
Chip design and use





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- https://www.doc.ic.ac.uk/~eedwards/compsys

Learning Outcomes

- At the end of this lecture you should
  - Understand how gates can be integrated onto chips (ICs)
  - Know the basic chip sizes – SSI, MSI, LSI, VLSI
  - Comprehend how circuits can be used for data selection/movement
  - Understand multiplexers, decoders and arithmetic logical units
  - See how basic memory units can be integrated to make memory chips
  - Have a grasp of how a microprocessor could be put together

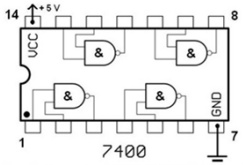
Integrated Circuits

- All ICs (chips) are made up of logic gates
- These are square pieces of silicon onto which logic gates have been deposited
- Generally two rows of pins enable connection onto a larger circuit

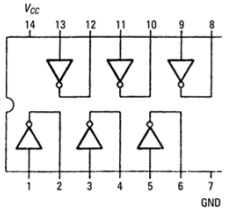
IC - sizes

Name	Abbreviation	Number of Gates
Small Scale Integrated	SSI	1-10
Medium Scale Integrated	MSI	10-100
Large Scale Integrated	LSI	100-100,000
Very Large Scale Integrated	VLSI	>100,000

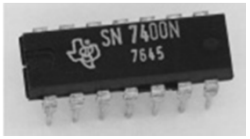
Example SSI Chips



7400 - Nand Gates

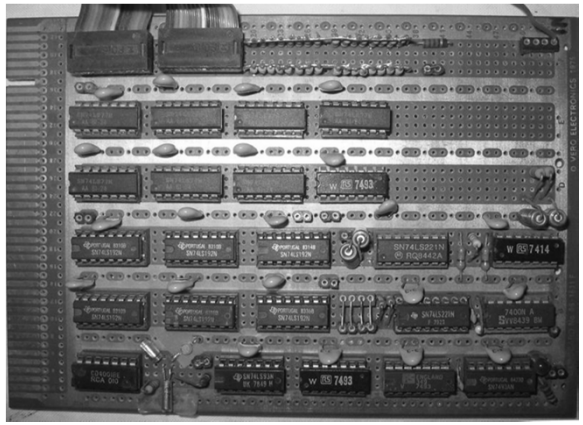


7404 – hex inverter

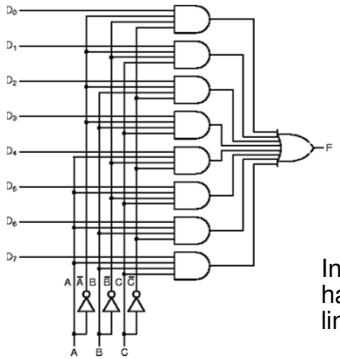


The 7400 TTL series

Example Circuit with SSI/MSI Chips



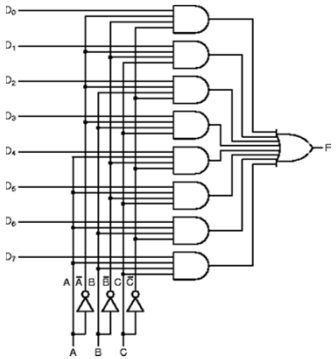
MSI Chips – the multiplexer



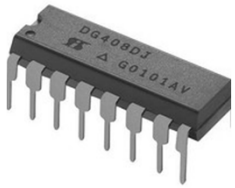
The 3 inputs A,B,C select which of the input lines is copied through to the output, f

In general, a multiplexer has 2^n inputs and n control lines and one output

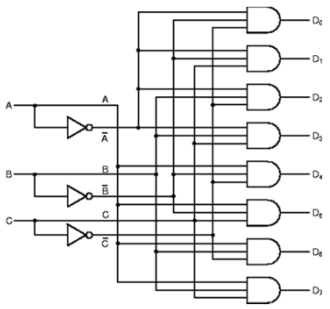
MSI Chips – the multiplexer



Fits nicely into a 14-pin package (with ground and +5V)



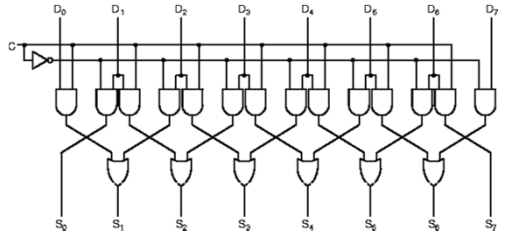
MSI Chips - Decoder



A decoder has n inputs and 2^n outputs. Only one output is 1 – the one selected by the n-bit binary input number – the rest are zero.

Useful in transmitting line selection with fewer wires (e.g. selecting a memory chip)

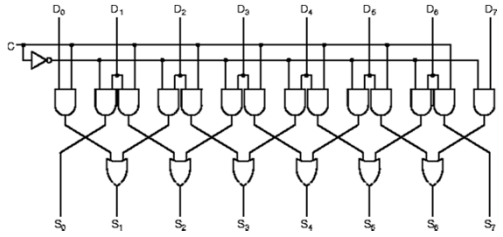
MSI Chips – calculations



The shifter. With c=0 shift left, c=1 shift right

(remember that shift operations multiply or divide by 2)

MSI Chips – calculations



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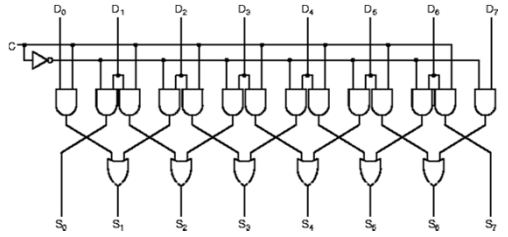
MSI Chips – calculations



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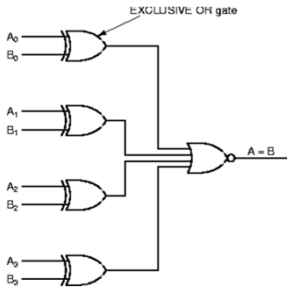
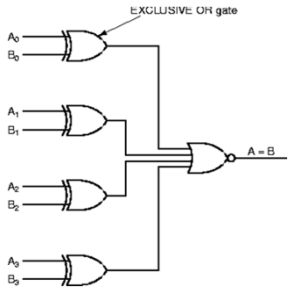
MSI Chips - Calculations



The comparator returns 1 if the two n-bit inputs A and B are equal, 0 otherwise

MSI Chips - Calculations

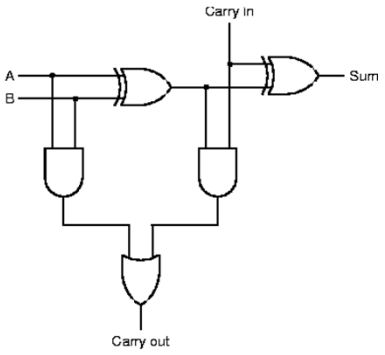


The comparator returns 1 if the two n-bit inputs A and B are equal, 0 otherwise

MSI Chips – calculations – remember the full adder?

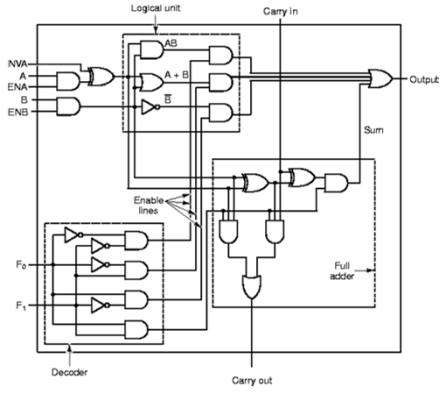
A	B	Carry in	Sum	Carry out
0	0	0	0	0
0	0	1	1	0
0	1	0	1	0
0	1	1	0	1
1	0	0	1	0
1	0	1	0	1
1	1	0	0	1
1	1	1	1	1

(a)



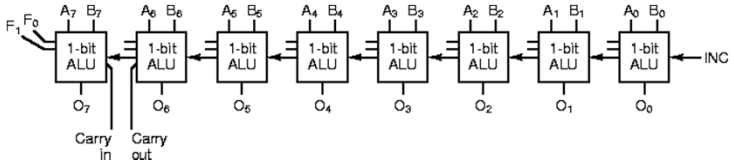
(b)

The Arithmetic Logical Unit (ALU)



The ALU is able to perform multiple functions. Depending on the input to the decoder (F0,F1) one of four functions is selected – A and B, A or B, not B, arithmetic A+B.

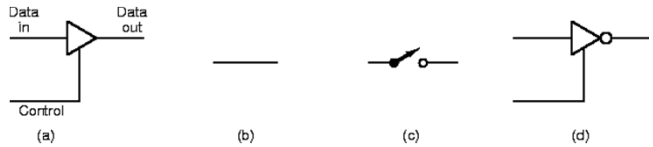
8-bit ALU



We can link together 1-bit ALUs to form a multi-byte ALU (sometimes known as bit-slice circuits)

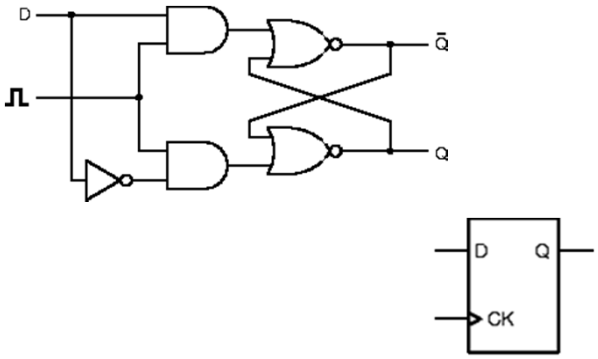
Extra not – tri-state buffers

The output is equal to the input if the control line is 1, otherwise it is disconnected.

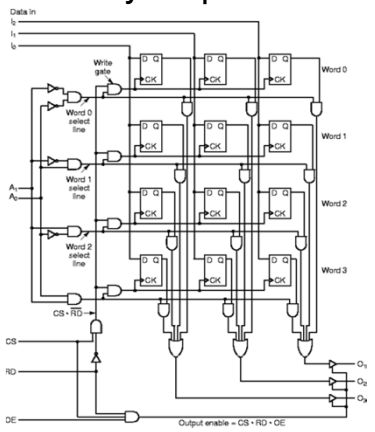


Tri-state buffer (a) non-inverting, (b) effect when control is 1, (c) effect when control is 0 and (d) inverting version

Memory – the D-type latch



Memory chips



The memory chip shown here comprises 12 D-latches in a 4x3 configuration.

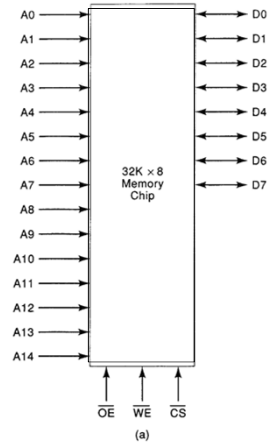
The 3 bit data will be read or written to one of the four words selcted by the input lines A_0/A_1.

A_0/A_1 are the address lines and I_n/O_n are the input/output data lines

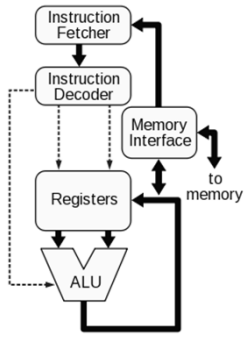
Memory Chips

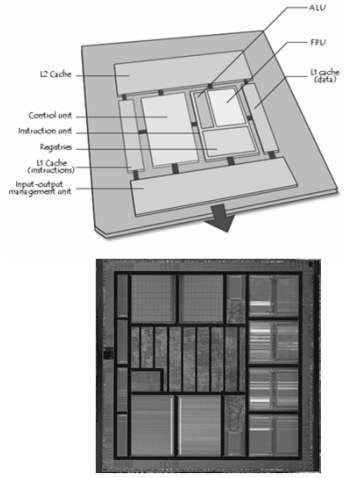
- In fact, input and output are never used at the same time.
- Chips use the same pins for input and output

Larger memory chips – potential layouts



CPU design - VLSI





CPUs consist of millions of gates – basic structure is as above.

Summary

- Have shown how gates can be integrated onto chips
- Shown examples of SSI, MSI chips
- Comprehend how circuits can be used for data selection/movement (multiplexers/decoders)
- Understand multiplexers, decoders and arithmetic logical units
- See how basic memory units can be integrated to make memory chips
- Described how addressing can work at the electronic level
- Hopefuly this gives a feel for how a VLSI microprocessor could be put together

This lecture - feedback

- The pace of the lecture was:

A. much too fast B. too fast C. about right D. too slow E. much too slow

- The learning objectives were met:

A. Fully B. Mostly C. Partially D. Slightly E. Not at all