Chapter 3

Common Digital Components

Integrated Circuits

- Integrated circuit (IC) is the basic building block of digital circuits.
- it is a small silicon semiconductor crystal, called a *chip*.
- As the technology of ICs has improved, the number of gates that can be put in a single chip has increased.

Small-scale integration (SSI)

devices contain several (usually less than 10) independent gates in a single package.

Cont…

Medium-scale integration (MSI)

devices contain approximately 10 to 200 gates in a single package.

E.g To form decoders, adders, and registers.

Large-scale integration (LSI)

devices contain between 200 and a few thousands gates in a single package.

Eg. processors, memory chips, and programmable modules.

Cont…

Very-large-scale integration (VLSI)

devices contain thousands of gates in a single package.

E.g large memory arrays and complex microcomputer chips.

Classification of digital integrated circuit

- Digital integrated circuits are also classified based on the specific circuit technology to which they belong.
- The most popular logic families of integrated circuits are:
  - TTL Transistor-transistor logic
  - ECL Emitter-coupled logic
  - MOS Metal-oxide semiconductor
  - CMOS Complementary metal-oxide semiconductor

Multiplexers

- Multiplexer is a combinational circuit that receives binary information from one of 2^n input data & directs to one output.
- The multiplexer connects multiple inputs to a single output.

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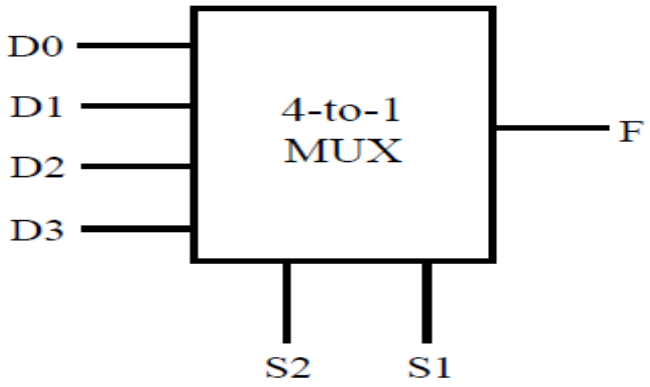

S2	S1	F
0	0	D0
0	1	D1
1	0	D2
1	1	D3

Block diagram & Truth table of a 4-to-1 multiplexer

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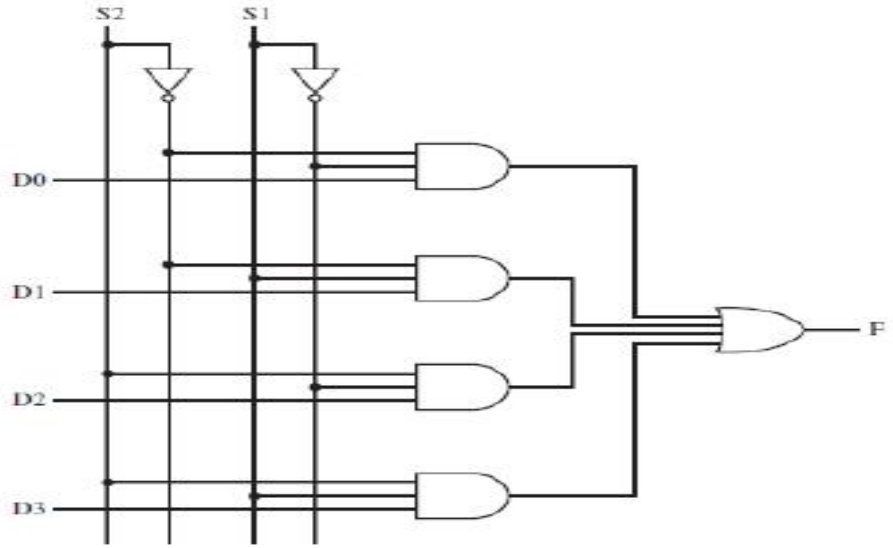

An implementation of a 4-to-1 multiplexer using AND, OR, and NOT gates

Cont…

- Multiplexers are used in digital circuits to *control* signal and data routing.
- An example is the loading of the program counter (PC).

Demultiplexer

- The De multiplexer performs the inverse function of a multiplexer.
- It connects a single input to one of several outputs.

Decoders

- A decoder is a combinational circuit with a number of output lines, only one of which is selected at any time, depending on the pattern of input lines.
- In general, a decoder has n inputs and 2^n outputs.
- Decoders find many uses in digital computers. Ex. address decoding.
- The other is binary-to- octal conversion.

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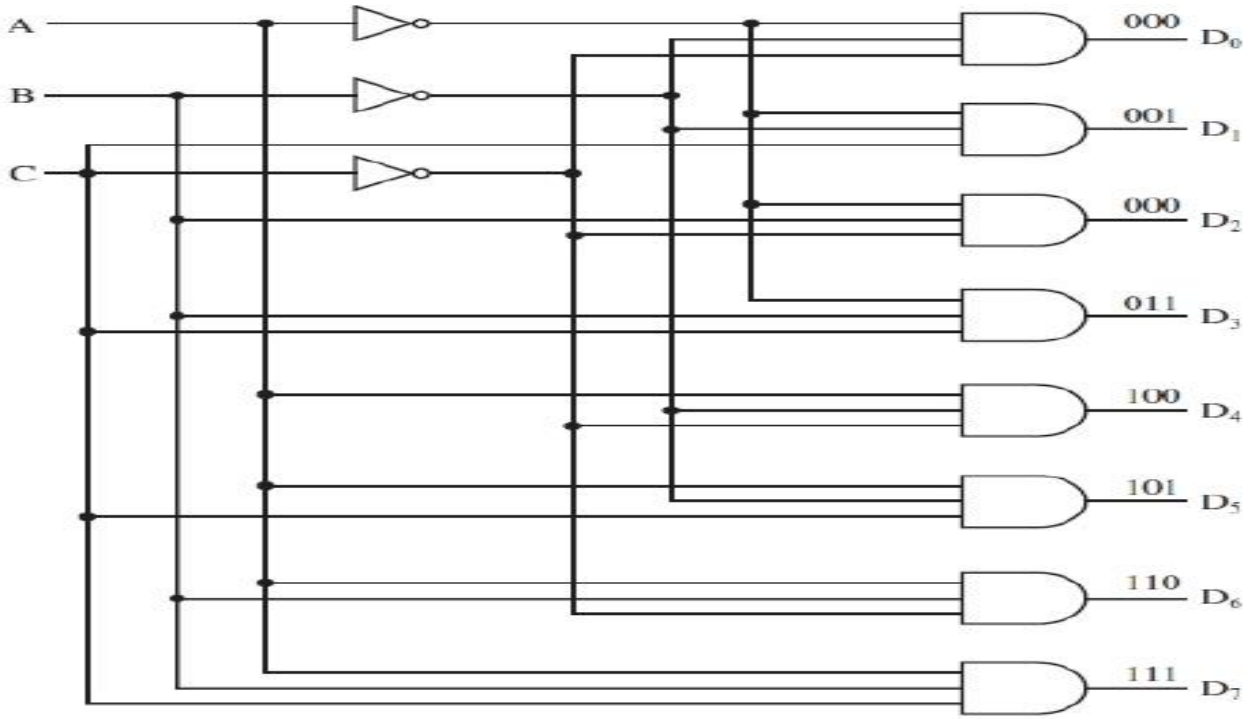

Decoder with 3 inputs and $2^3 = 8$ outputs

Encoders

- An encoder is a digital circuit that performs the inverse operation of a decoder.
- An encoder has 2^n (or less) input lines and n output lines. The output lines generate the binary code corresponding to the input value.
- An ex. of an encoder is the octal-to-binary encoder.

Inputs								Outputs		
D_7	D_6	D_5	D_4	D_3	D_2	D_1	D_0	A_2	A_1	A_0
0	0	0	0	0	0	0	1	0	0	0
0	0	0	0	0	0	1	0	0	0	1
0	0	0	0	0	1	0	0	0	1	0
0	0	0	0	1	0	0	0	0	1	1
0	0	0	1	0	0	0	0	1	0	0
0	0	1	0	0	0	0	0	1	0	1
0	1	0	0	0	0	0	0	1	1	0
1	0	0	0	0	0	0	0	1	1	1

Registers

- A register is a group of flip-flops with each flip- flop capable of storing one bit of information.
- It is a digital circuit used within the CPU to store one or more bits of data.
- Two basic types of registers are commonly used: parallel registers and shift registers.

Parallel Registers

- consists of a set of 1-bit memories that can be read or written simultaneously. Is used to store data.
- e.g The 8-bit register- D Flip-Flops

Shift Register

- A shift register accepts and/or transfers information serially.
- Data are input only to the leftmost flip-flop
- they can be used within the ALU to perform logical shift and rotate functions.

Binary Counters

- Another useful category of sequential circuit is the counter.
- A counter is a register whose value is easily incremented by 1 modulo the capacity of the register; that is, after the maximum value is achieved the next increment sets the counter value to 0.
- Thus, a register made up of n flip-flops can count up to 2^n-1.
- An example of a counter in the CPU is the program counter.

Memory Units

- memory units are, the amount of data that can be stored in the storage unit. This storage capacity is expressed in terms of Bytes.
- is a collection of storage cells together with associated circuits needed to transfer information in and out of storage.
- The memory stores binary information in groups of bits called words.

the main memory storage units

- Bit (Binary Digit)
- Nibble
- Byte
- Word

RAM-(Random Access Memory

- is the internal memory of the CPU for storing data, program, and program result.
- In RAM the memory cells can be accessed for information transfer from any desired random location
- The two operations that a RAM can perform are the **write** and **read** operations.
- The write signal specifies a *transfer-in* operation and the read signal specifies a *transfer-out* operation.

Cont…

- Communication between a memory and its environment is achieved through data input and output lines, address selection lines, and control lines that specify the direction of transfer.

Steps of transferring a new word to be stored into memory

- Are:

1. Apply the binary address of the desired word into the address line.

2. Apply the data bits that must be stored in memory into the data input lines.

3. Activate the write input.

- The steps that must be taken to transferring a stored word out of memory are :

1. Apply the binary address of the desired word into the address lines.

2. Activate the read input.

ROM (Read-Only Memory)

- A ROM is a memory unit that performs only the read operation.
- This implies that the binary information stored in a ROM is permanent and was created during the fabrication process.
- Thus, a given input to the ROM (address lines) always produces the same output (data lines).