Digital Logic and Design - Handwritten Style Notes

1. Half Adder

A Half Adder is a combinational circuit that adds two single-bit binary numbers (A and B). It has two outputs:
- Sum: A XOR B
- Carry: A * B

Truth Table:

A	B	Sum	Carry
0	0	0	0
0	1	1	0
1	0	1	0
1	1	0	1

Used in: Basic binary addition.

2. Full Adder

A Full Adder is a digital circuit that adds three binary bits: A, B, and Cin (carry in). It produces:
- Sum = A XOR B XOR Cin
- Carry = (A*B) + (B*Cin) + (A*Cin)

Truth Table:

A	B	Cin	Sum	Carry
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

Used in: Multi-bit binary adders.

3. Encoder

An Encoder is a digital circuit that converts 2^n input lines into n output lines. It performs the reverse operation of a Decoder.

Example: 4-to-2 Encoder
Inputs: D0, D1, D2, D3
Outputs: A, B

Truth Table:

D0	D1	D2	D3	A	B
0	0	0	1	1	1
0	0	1	0	1	0
0	1	0	0	0	1
1	0	0	0	0	0

Used in: Keyboards, Priority Encoders.

4. Decoder

A Decoder is a circuit that converts n input lines to 2^n output lines. It is used to activate one unique output line based on the input combination.

Example: 2-to-4 Decoder
Inputs: A, B
Outputs: Y0, Y1, Y2, Y3

Truth Table:

A	B	Outputs
0	0	Y0 = 1

0 1 | Y1 = 1
1 0 | Y2 = 1
1 1 | Y3 = 1

Used in: Memory address decoding, I/O selection.

5. Multiplexer (MUX)

A Multiplexer selects one of many input signals and forwards it to a single output line. It uses selection lines to choose the input.

Example: 4-to-1 MUX
Inputs: I0, I1, I2, I3
Select lines: S0, S1
Output: Y

Y = (I0 AND ~S1 AND ~S0) + (I1 AND ~S1 AND S0) + (I2 AND S1 AND ~S0) + (I3 AND S1 AND S0)

Used in: Data routing, Communication systems.

6. De-Multiplexer (DEMUX)

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A De-Multiplexer takes a single input and routes it to one of several output lines. It is the reverse of a Multiplexer.

Example: 1-to-4 DEMUX
Inputs: Data (D), Select Lines (S0, S1)
Outputs: Y0, Y1, Y2, Y3

Y0 = D AND NOT(S1) AND NOT(S0)

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Y1 = D AND NOT(S1) AND S0

Y2 = D AND S1 AND NOT(S0)

Y3 = D AND S1 AND S0

Used in: Data distribution, Memory writing, Communication channels.