Digital Design

Lecture 13: Decoders and Encoders

Decoder

A Decoder is a combinational circuit that converts binary information from ‘n’ input lines to 2^n output lines

n to m decoders where $m \leq 2^n$

The name decoder is also used in conjunction with other code converters (e.g. BCD to seven segment decoder)

Decoder

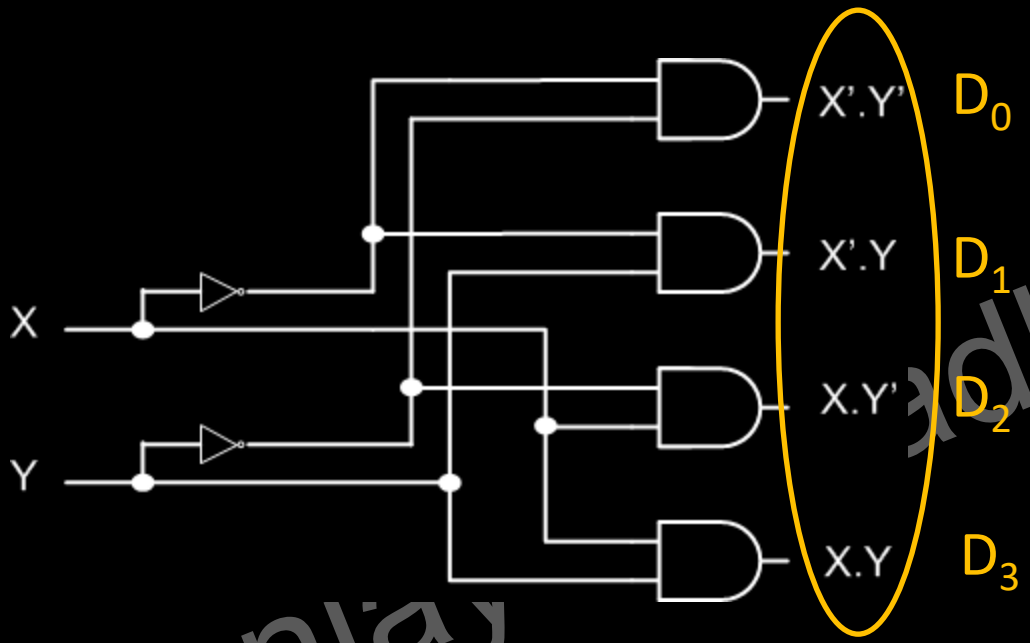
An Example: 2 to 4 Line Decoder

X	Y
0	0
0	1
1	0
1	1

D_0	D_1	D_2	D_3
1	0	0	0
0	1	0	0
0	0	1	0
0	0	0	1

Decoder

An Example: 2 to 4 Line Decoder



Minterms
(0, 1, 2, 3)

Minterm Generating circuit

Decoder

An Example: 2 to 4 Line Decoder with Enable

E	X	Y
1	0	0
1	0	1
1	1	0
1	1	1
0	X	X

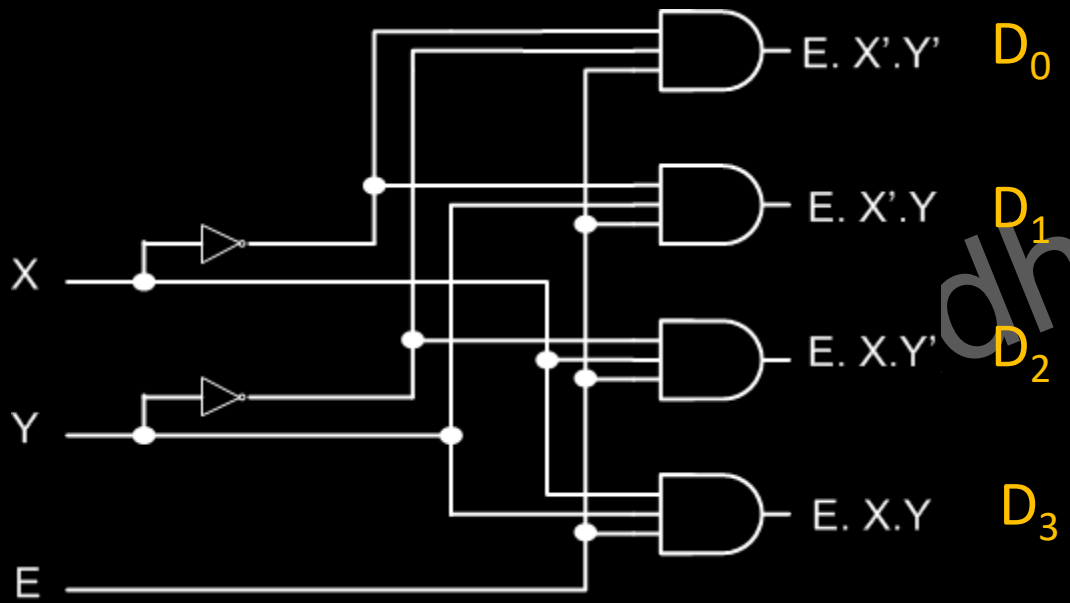
D_0	D_1	D_2	D_3
1	0	0	0
0	1	0	0
0	0	1	0
0	0	0	1
0	0	0	0

Decoder with enable pin is also called as Demultiplexer

X and Y – Select Lines E- Input line

Decoder

An Example: 2 to 4 Line Decoder with Enable



Decoder

An Example: 3 to 8 Line Decoder

X	Y	Z
0	0	0
0	0	1
0	1	0
0	1	1
1	0	0
1	0	1
1	1	0
1	1	1

D_0	D_1	D_2	D_3	D_4	D_5	D_6	D_7
1	0	0	0	0	0	0	0
0	1	0	0	0	0	0	0
0	0	1	0	0	0	0	0
0	0	0	1	0	0	0	0
0	0	0	0	1	0	0	0
0	0	0	0	0	1	0	0
0	0	0	0	0	0	1	0
0	0	0	0	0	0	0	1

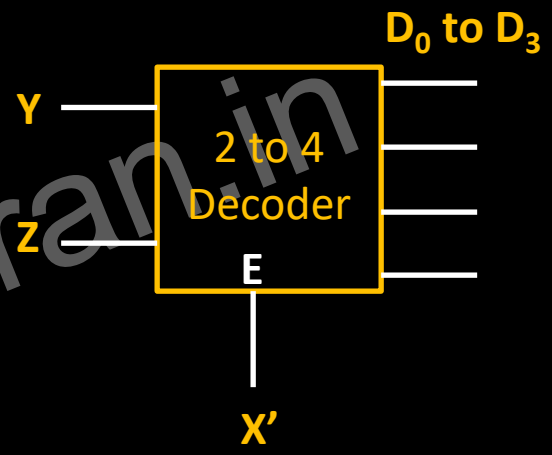
Direct Implementation – Home Assignment

Decoder

Can you implement a 3 to 8 decoder using two 2 to 4 decoders with enable pin

X	Y	Z
0	0	0
0	0	1
0	1	0
0	1	1
1	0	0
1	0	1
1	1	0
1	1	1

D_0	D_1	D_2	D_3	D_4	D_5	D_6	D_7
1	0	0	0	0	0	0	0
0	1	0	0	0	0	0	0
0	0	1	0	0	0	0	0
0	0	0	1	0	0	0	0
0	0	0	0	1	0	0	0
0	0	0	0	0	1	0	0
0	0	0	0	0	0	1	0
0	0	0	0	0	0	0	1

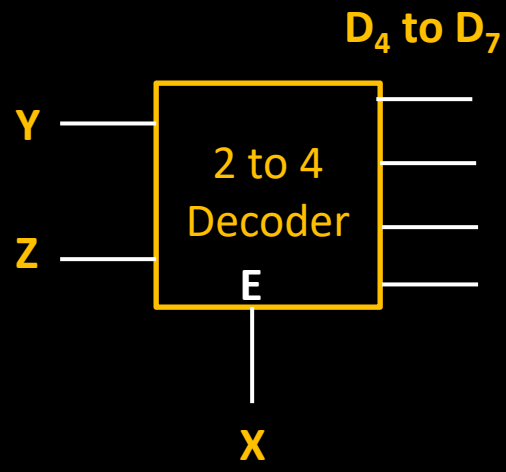


Decoder

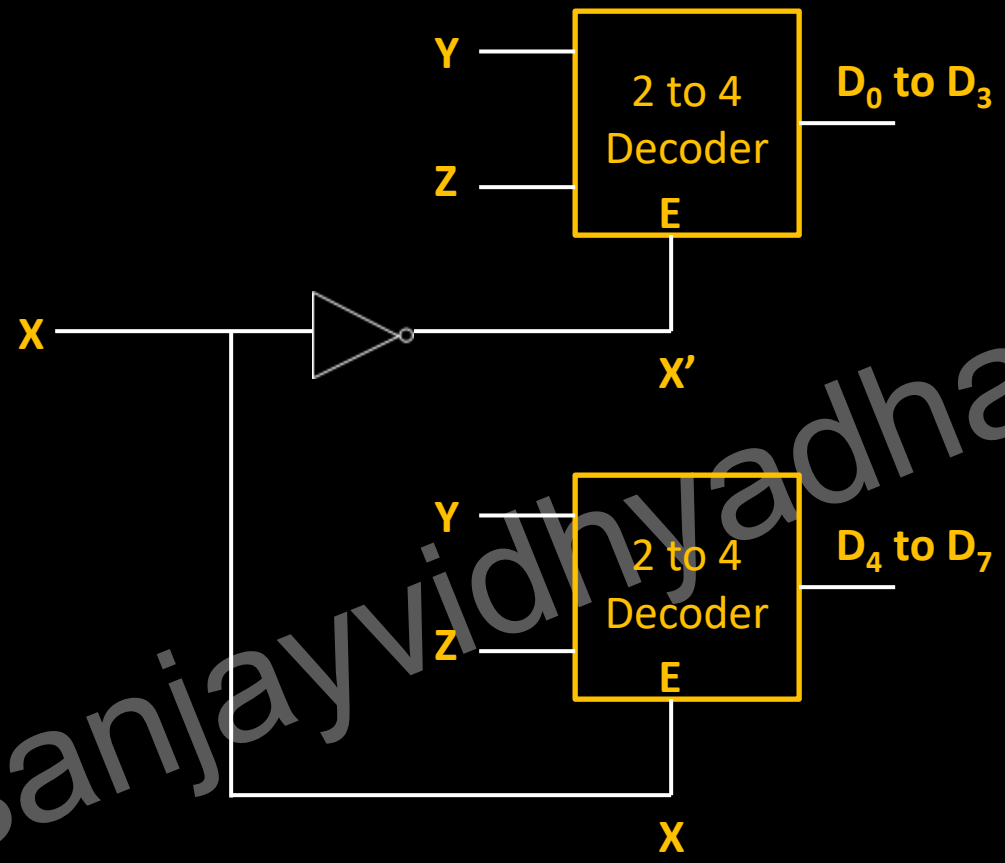
Can implement a 3 to 8 decoder using two 2 to 4 decoders with enable pin

X	Y	Z
0	0	0
0	0	1
0	1	0
0	1	1
1	0	0
1	0	1
1	1	0
1	1	1

D_0	D_1	D_2	D_3	D_4	D_5	D_6	D_7
1	0	0	0	0	0	0	0
0	1	0	0	0	0	0	0
0	0	1	0	0	0	0	0
0	0	0	1	0	0	0	0
0	0	0	0	1	0	0	0
0	0	0	0	0	1	0	0
0	0	0	0	0	0	1	0
0	0	0	0	0	0	0	1



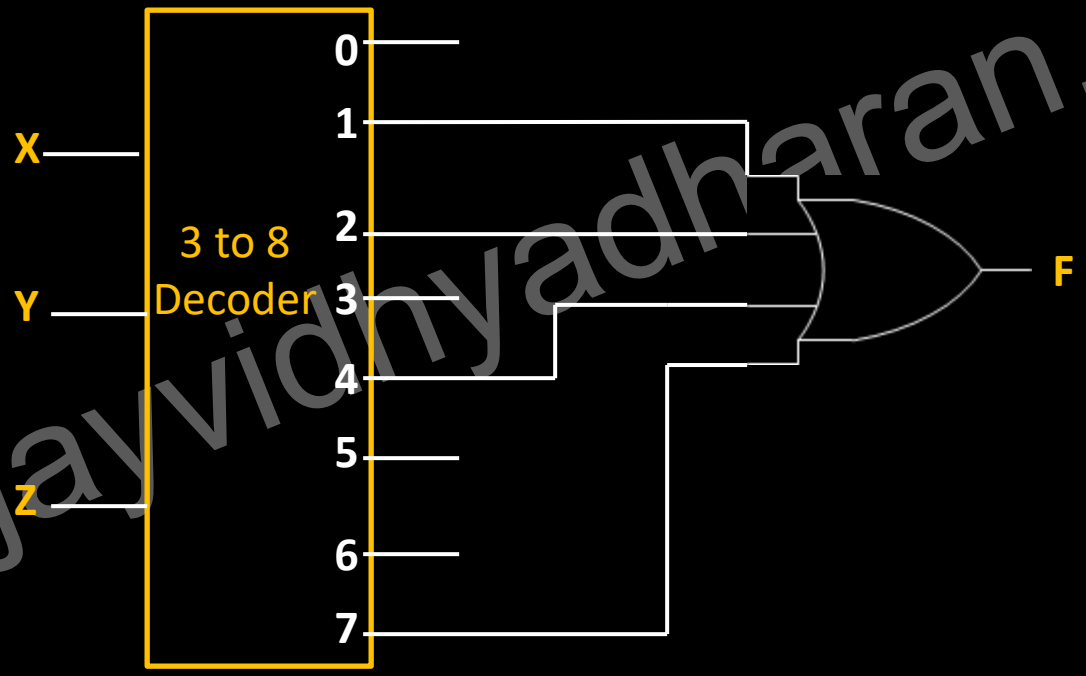
Decoder



Decoder

Implementing function using Decoders

$F = \sum (1, 2, 4, 7) = X'Y'Z + X'YZ' + XY'Z' + XYZ$



Encoder

Encoder - combinational circuit that performs inverse operation of decoder

Has 2^n or fewer input lines and n output lines

An Example:

$X = D_2 + D_3$

$Y = D_1 + D_3$

D_0	D_1	D_2	D_3
1	0	0	0
0	1	0	0
0	0	1	0
0	0	0	1

X	Y
0	0
0	1
1	0
1	1

Encoder

$X = D_2 + D_3$

$Y = D_1 + D_3$

D_0	D_1	D_2	D_3
1	0	0	0
0	1	0	0
0	0	1	0
0	0	0	1

X	Y
0	0
0	1
1	0
1	1

Limitations:

If two ones appear i.e. if D_1 and D_2 are '1' then both X and Y will be '1' resulting in output 11

If all the inputs are zeros then output is 00 – which indicates that D_0 is 1

Priority Encoder

If two ones appear i.e. if D_1 and D_2 are '1' then both X and Y will be '1' resulting in output 11

Encoder circuits must establish input priority

E.g. If high priority is given to inputs with higher subscripts
If both D_1 and D_2 are '1' then resulting o/p should be 10

Priority Encoder

If all the inputs are zeros then output is 00 – which indicates that D_0 is 1

This ambiguity can be resolved by providing one more output.

Extra Output indicates whether at least one input is equal to 1

Priority Encoder

D_0	D_1	D_2	D_3
1	0	0	0
0	1	0	0
0	0	1	0
0	0	0	1

X	Y
0	0
0	1
1	0
1	1

Encoder

$X = D_2 + D_3$

$Y = D_1 + D_3$

D_0	D_1	D_2	D_3
1	0	0	0
X	1	0	0
X	X	1	0
X	X	X	1
0	0	0	0

X	Y	V
0	0	1
0	1	1
1	0	1
1	1	1
X	X	0

Priority Encoder

$X = D_2 + D_3$

$Y = D_1D_2' + D_3$

$V = D_0 + D_1 + D_2 + D_3$

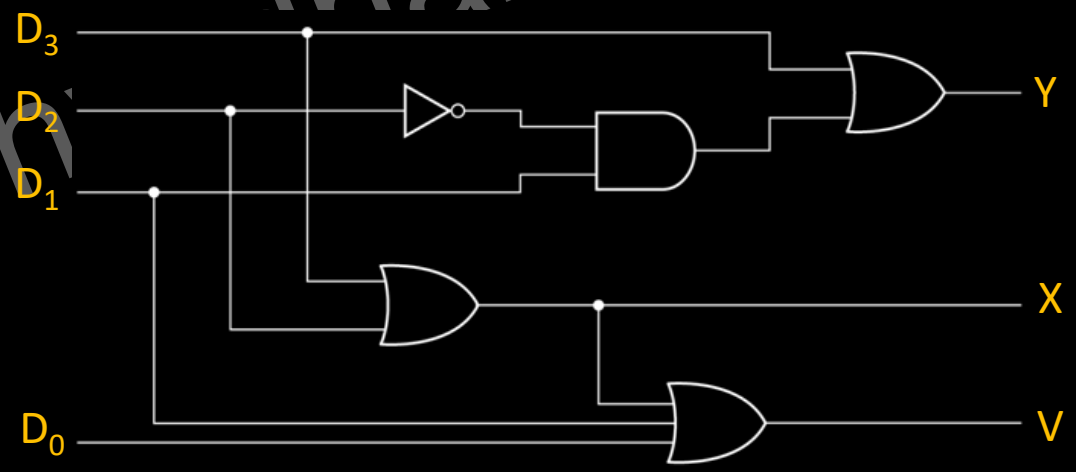
Priority Encoder

Priority Encoder

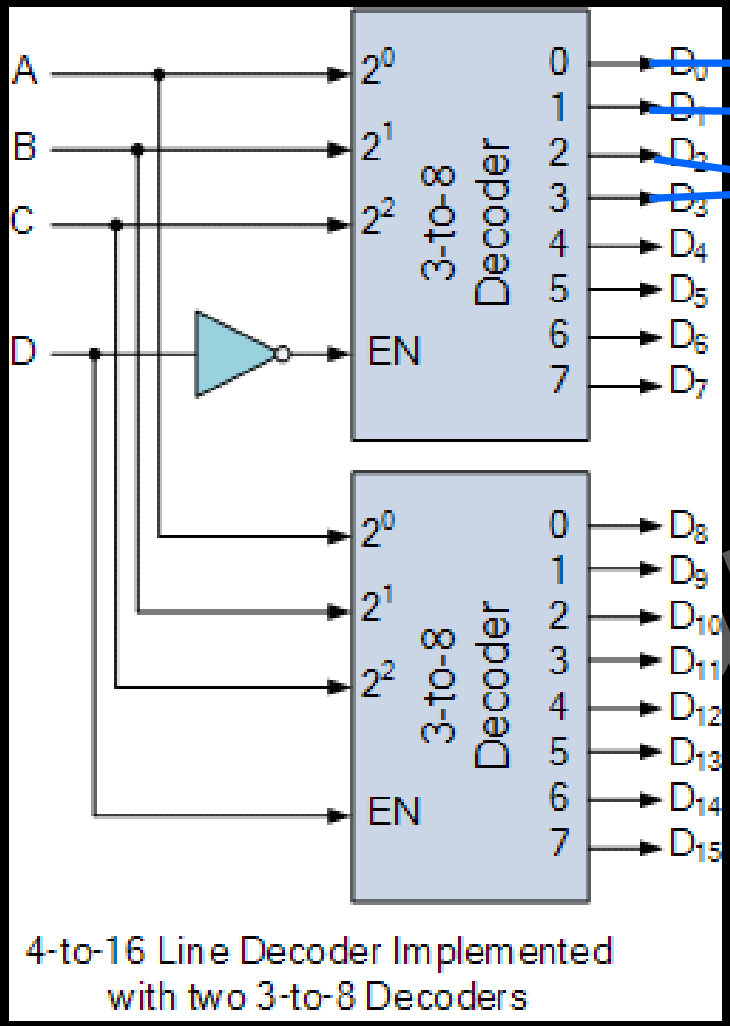
$X = D_2 + D_3$

$Y = D_1D_2' + D_3$

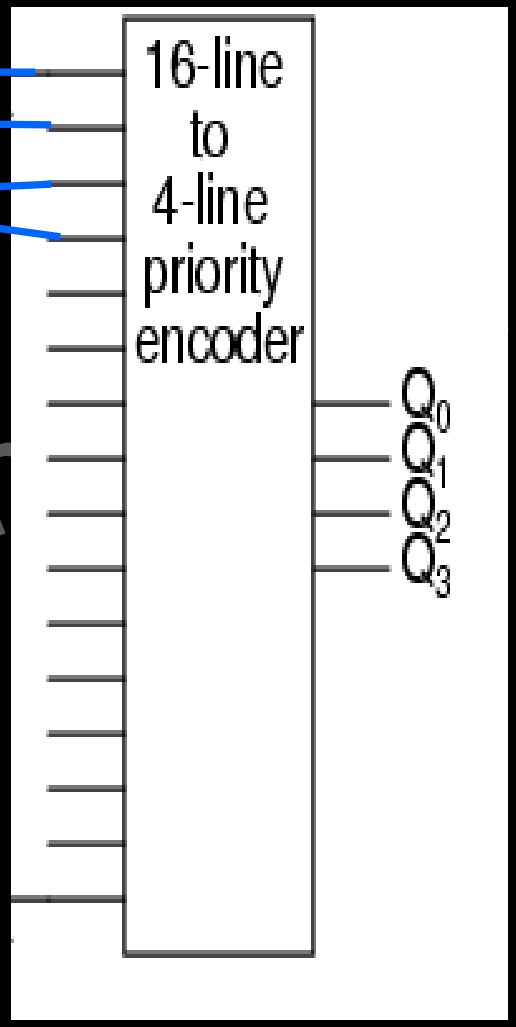
$V = D_0 + D_1 + D_2 + D_3$



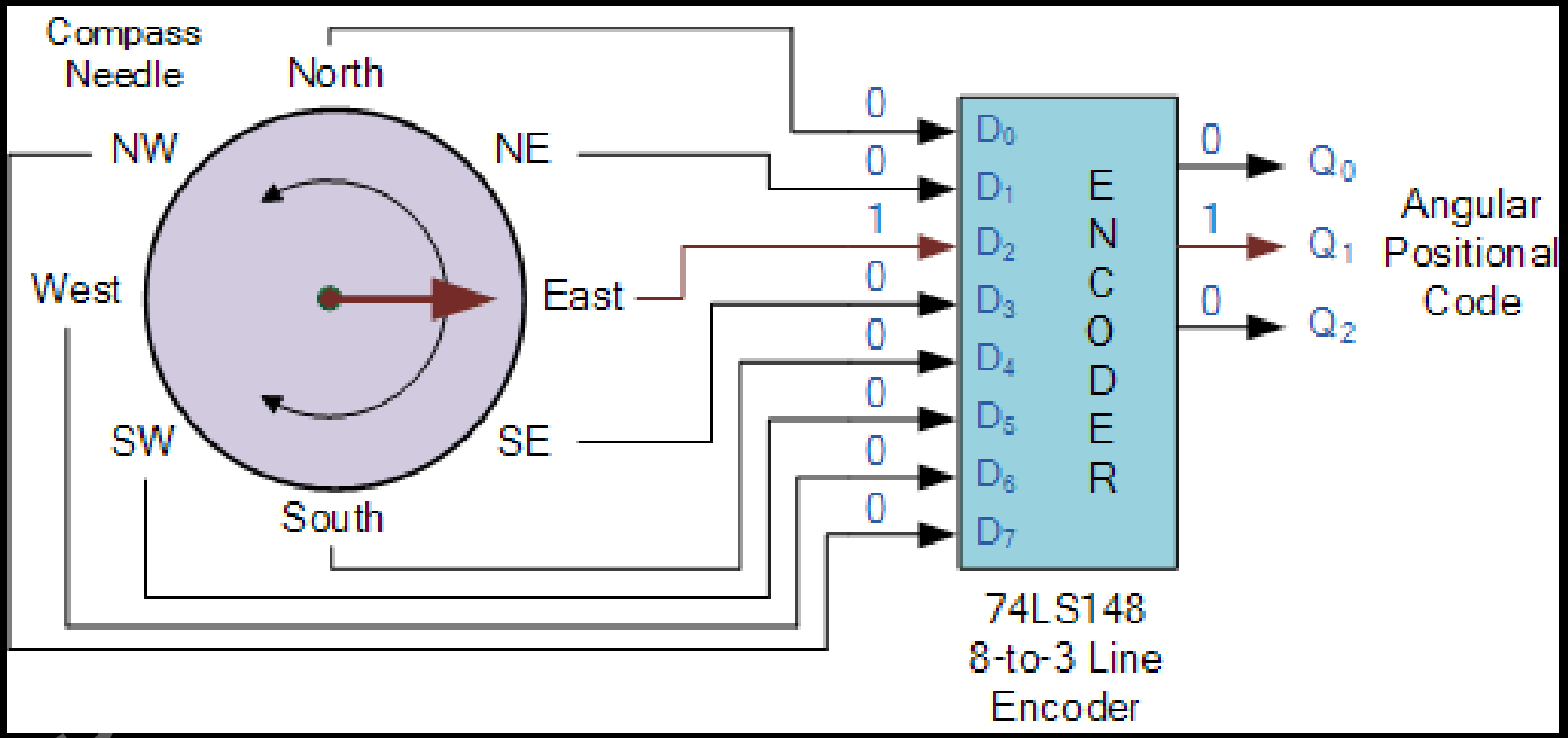
Binary to Gray Using Encoder-Decoder



4-to-16 Line Decoder Implemented with two 3-to-8 Decoders

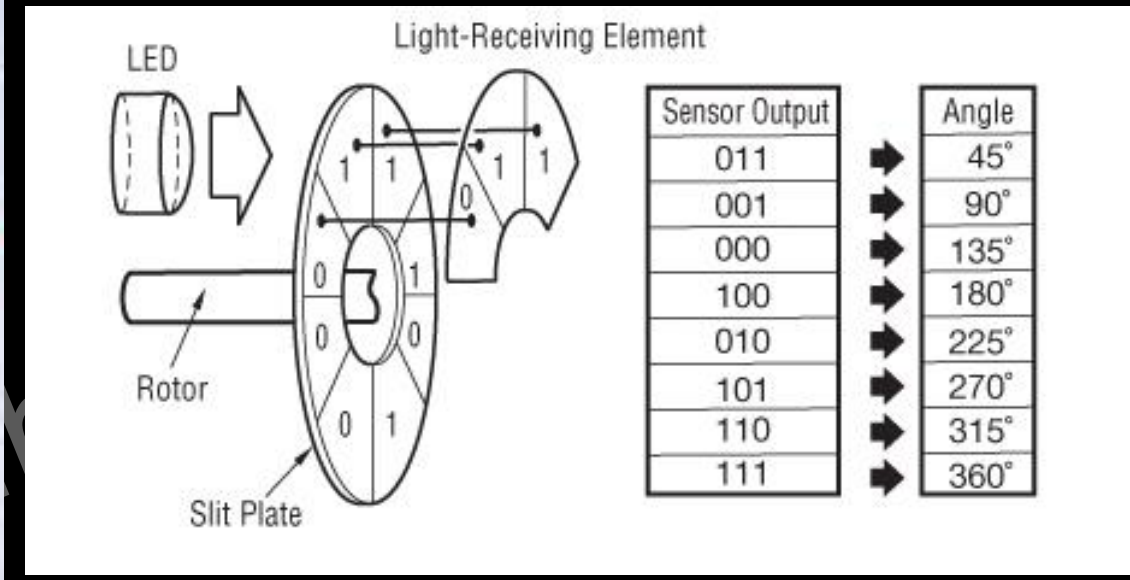


Encoder Applications



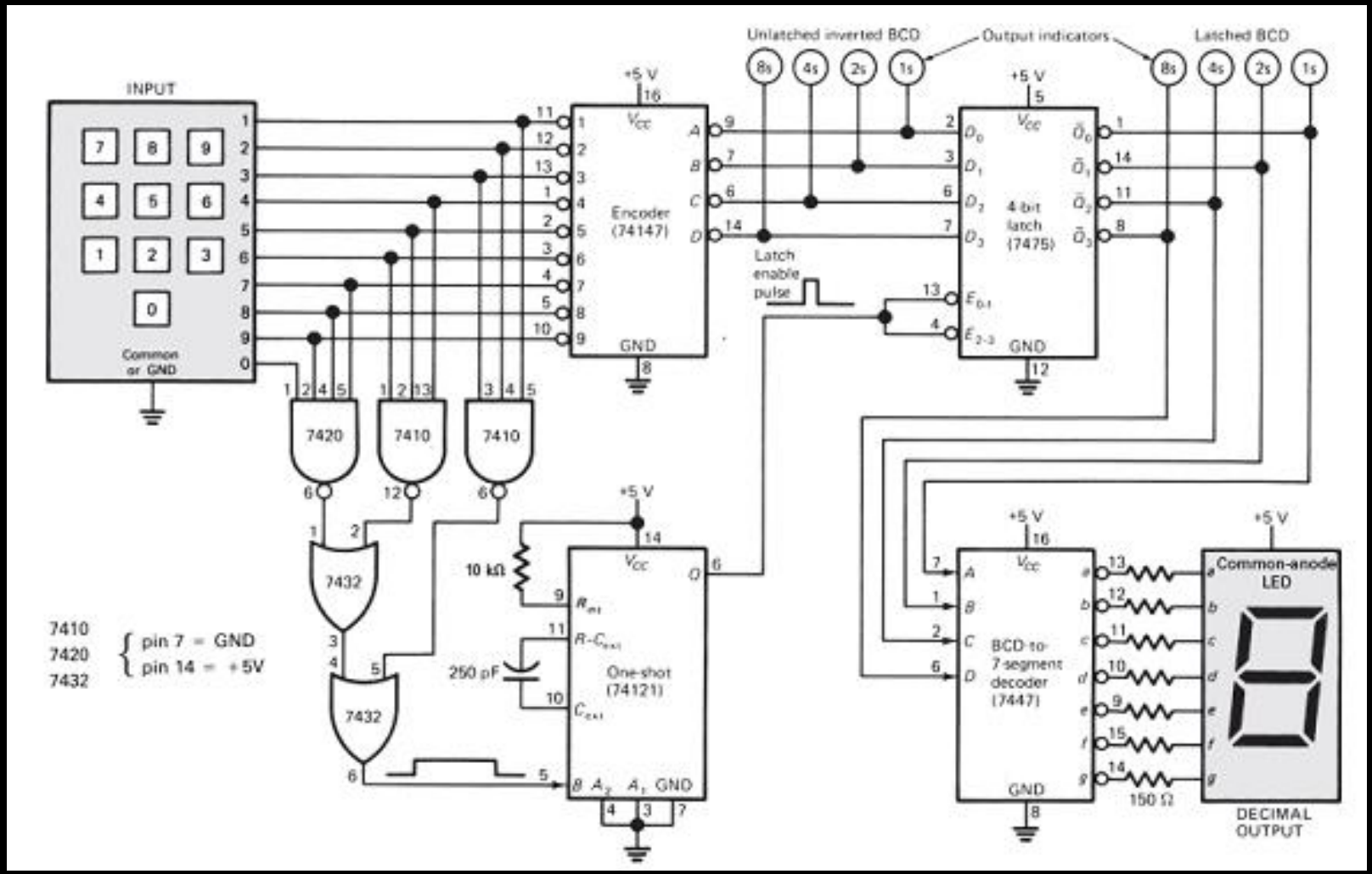
Encoder Applications

Encoder Applications

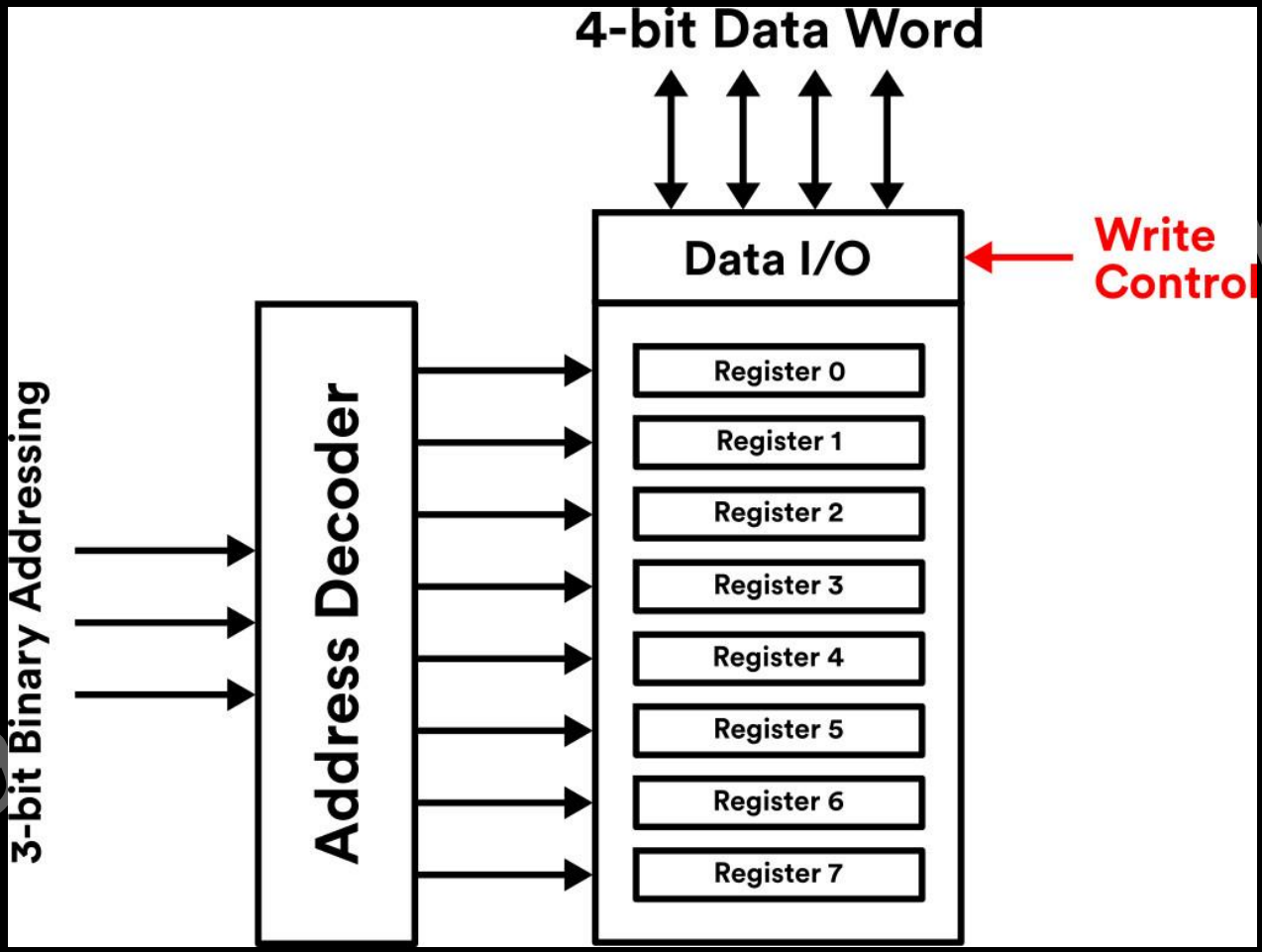


Sensor Output	Angle
011	45°
001	90°
000	135°
100	180°
010	225°
101	270°
110	315°
111	360°

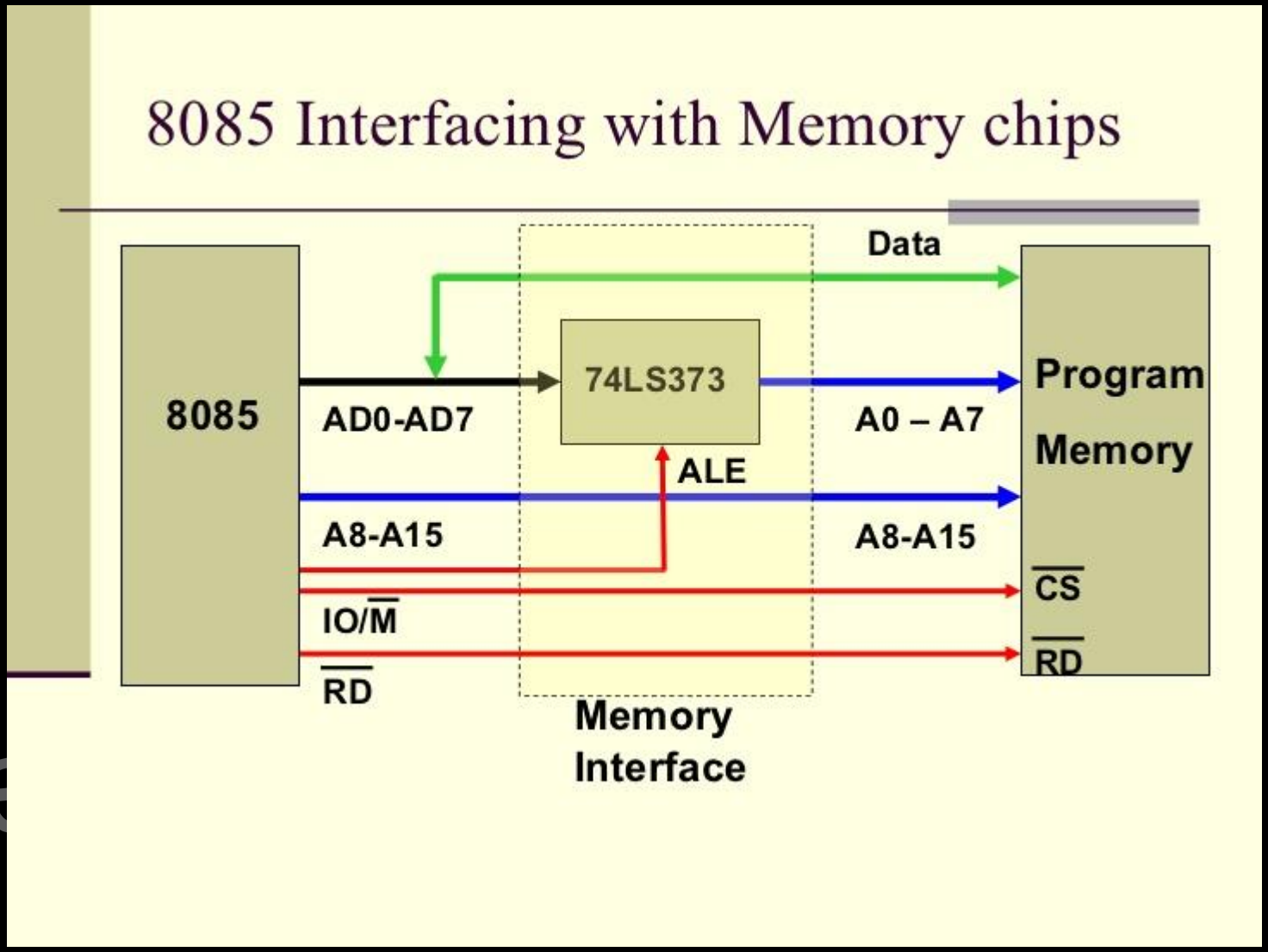
Encoder Applications



Decoder Applications



Decoder Applications



Thank You