ENCODERS

An encoder is a digital circuit that performs the inverse operation of a decoder.

An encoder has 2^n (or fewer) input lines and n output lines.

The output lines, as an aggregate, generate the binary code corresponding to the input value.

An example of an encoder is the octal-to-binary encoder whose truth table is given.

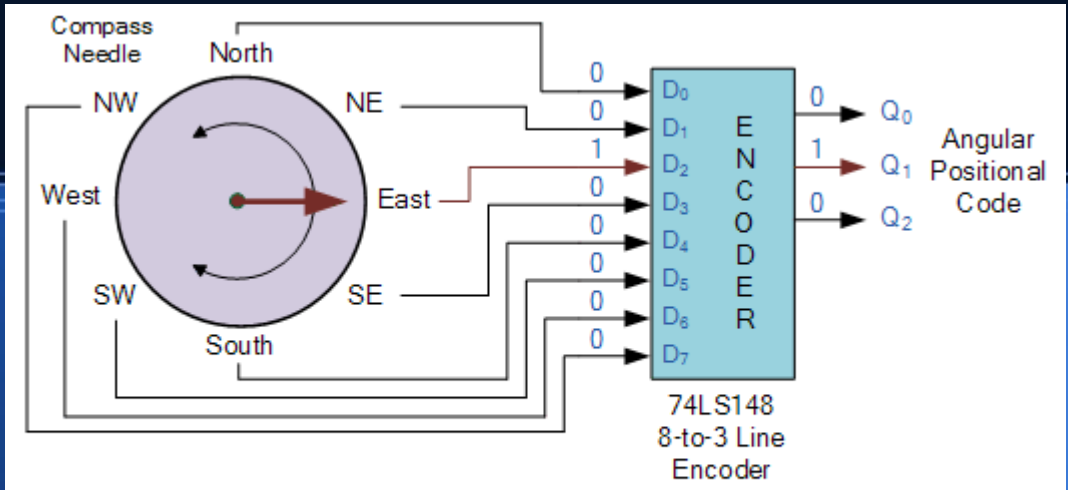
Truth Table of an Octal-to-Binary Encoder

Inputs								Outputs		
D_0	D_1	D_2	D_3	D_4	D_5	D_6	D_7	x	y	z
1	0	0	0	0	0	0	0	0	0	0
0	1	0	0	0	0	0	0	0	0	1
0	0	1	0	0	0	0	0	0	1	0
0	0	0	1	0	0	0	0	0	1	1
0	0	0	0	1	0	0	0	1	0	0
0	0	0	0	0	1	0	0	1	0	1
0	0	0	0	0	0	1	0	1	1	0
0	0	0	0	0	0	0	1	1	1	1

8 position to 3-bit output compass encoder

A common application is in magnetic positional control as used on ships navigation or for robotic arm positioning etc.

Here for example, the angular or rotary position of a compass is converted into a digital code by a 74LS148 8-to-3 line priority encoder and inputed to the systems computer to provide navigational data



Compass Direction	Binary Output		
	Q_0	Q_1	Q_2
North	0	0	0
North-East	0	0	1
East	0	1	0
South-East	0	1	1
South	1	0	0
South-West	1	0	1
West	1	1	0
North-West	1	1	1

The encoder can be implemented with OR gates whose inputs are determined directly from the truth table.

Output z is equal to 1 when the input octal digit is 1, 3, 5, or 7. Output y is 1 for octal digits 2, 3, 6, or 7, and output x is 1 for digits 4, 5, 6, or 7.

These conditions can be expressed by the following Boolean output functions:

$z = D1 + D3 + D5 + D7$

$y = D2 + D3 + D6 + D7$

$x = D4 + D5 + D6 + D7$

Inputs								Outputs		
D_0	D_1	D_2	D_3	D_4	D_5	D_6	D_7	x	y	z
1	0	0	0	0	0	0	0	0	0	0
0	1	0	0	0	0	0	0	0	0	1
0	0	1	0	0	0	0	0	0	1	0
0	0	0	1	0	0	0	0	0	1	1
0	0	0	0	1	0	0	0	1	0	0
0	0	0	0	0	1	0	0	1	0	1
0	0	0	0	0	0	1	0	1	1	0
0	0	0	0	0	0	0	1	1	1	1

The encoder has the limitation that only one input can be active at any given time.

If two inputs are active simultaneously, the output produces an undefined combination.

For example, if D3 and D6 are 1 simultaneously, the output of the encoder will be 111 because all three outputs are equal to 1.

The output 111 does not represent either binary 3 or binary 6.

To resolve this ambiguity, encoder circuits must establish an input priority to ensure that only one input is encoded.

If we establish a higher priority for inputs with higher subscript numbers, and if both D3 and D6 are 1 at the same time, the output will be 110 because D6 has higher priority than D3.

Another ambiguity in the octal-to-binary encoder is that an output with all 0's is generated when all the inputs are 0; but this output is the same as when D0 is equal to 1.

The discrepancy can be resolved by providing one more output to indicate whether at least one input is equal to 1.

Priority Encoder

A priority encoder is an encoder circuit that includes the priority function.

The operation of the priority encoder is such that if two or more inputs are equal to 1 at the same time, the input having the highest priority will take precedence.

They are often used to control interrupt requests by acting on the highest priority request.

The truth table of a four-input priority encoder.

Inputs				Outputs		
D_0	D_1	D_2	D_3	x	y	V
0	0	0	0	X	X	0
1	0	0	0	0	0	1
X	1	0	0	0	1	1
X	X	1	0	1	0	1
X	X	X	1	1	1	1

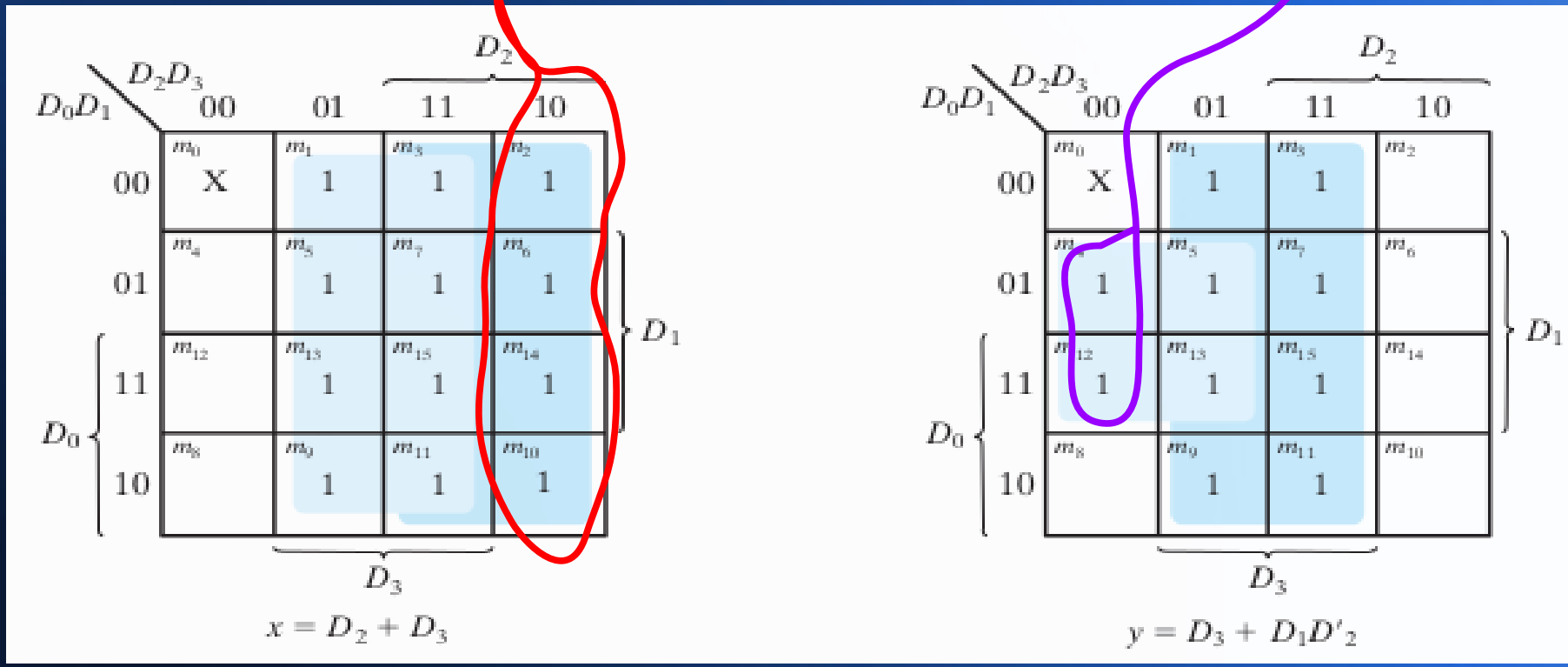
In addition to the two outputs x and y, the circuit has a third output designated by V; this is a valid bit indicator that is set to 1 when one or more inputs are equal to 1. If all inputs are 0, there is no valid input and V is equal to 0.

The other two outputs are not inspected when V equals 0 and are specified as don't-care conditions. Note that whereas X's in output columns represent don't-care conditions, the X's in the input columns are useful for representing a truth table in condensed form.

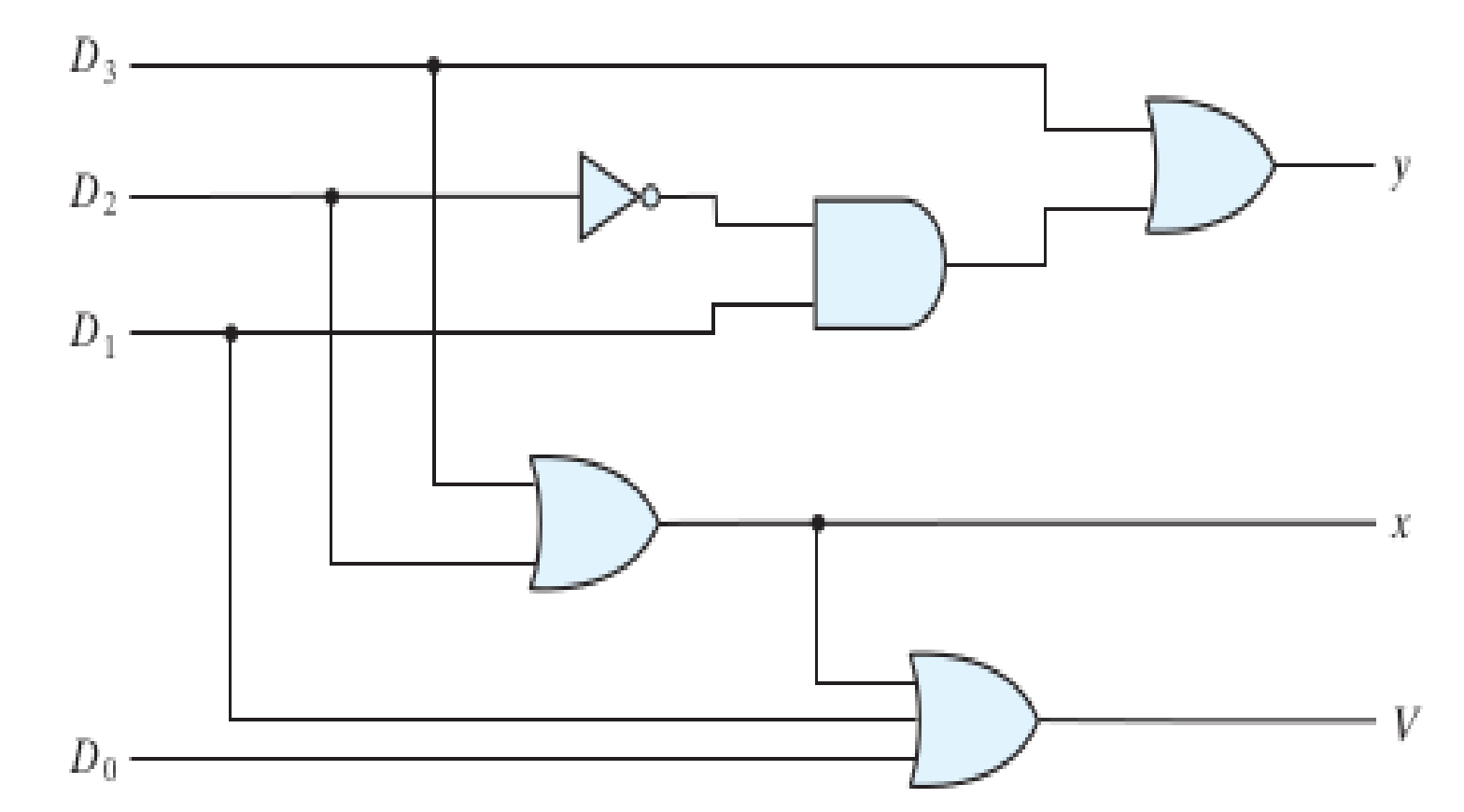
Instead of listing all 16 minterms of four variables, the truth table uses an X to represent either 1 or 0. For example, X100 represents the two minterms 0100 and 1100

Maps for a priority encoder

Inputs				Outputs		
D_0	D_1	D_2	D_3	x	y	V
0	0	0	0	X	X	0
1	0	0	0	0	0	1
X	1	0	0	0	1	1
X	X	1	0	1	0	1
X	X	X	1	1	1	1

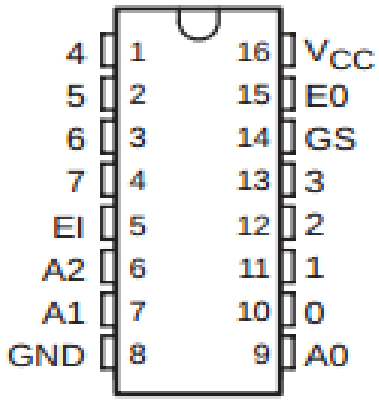


Four-input priority encoder

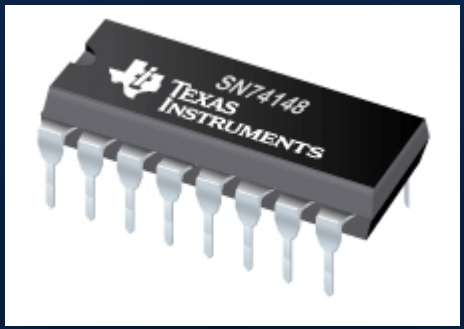


The condition for output V is an OR function of all the input variables.

74148 8-line to 3-line priority encoder



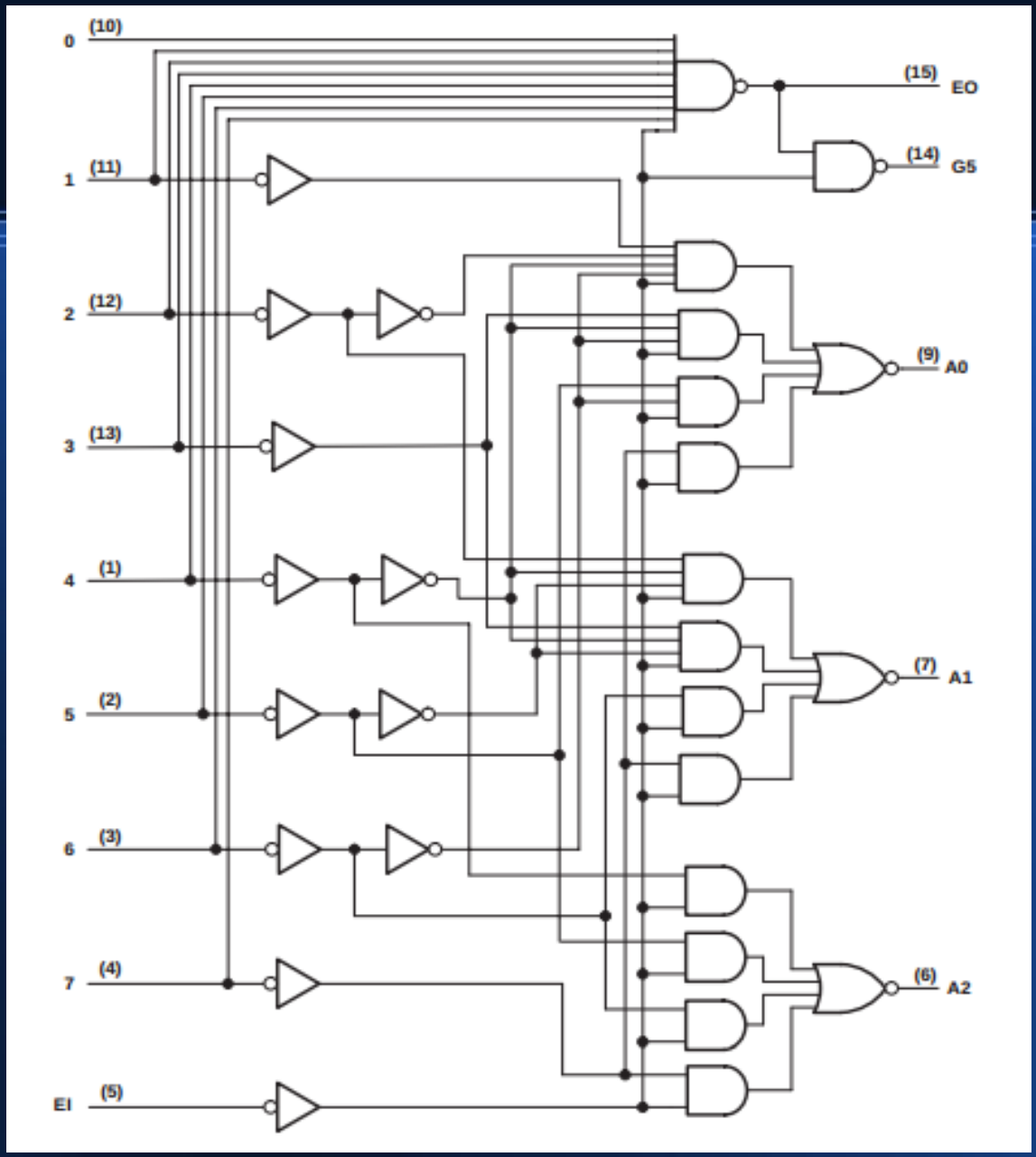
SN54LS148 . . . FK PACKAGE
(TOP VIEW)



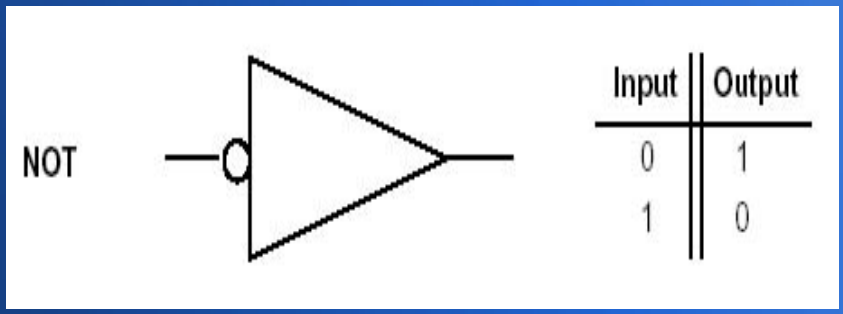
FUNCTION TABLE – '148, 'LS148

INPUTS									OUTPUTS				
EI	0	1	2	3	4	5	6	7	A2	A1	A0	GS	EO
H	X	X	X	X	X	X	X	X	H	H	H	H	H
L	H	H	H	H	H	H	H	H	H	H	H	H	L
L	X	X	X	X	X	X	X	L	L	L	L	L	H
L	X	X	X	X	X	X	L	H	L	L	H	L	H
L	X	X	X	X	X	L	H	H	L	H	L	L	H
L	X	X	X	X	L	H	H	H	L	H	H	L	H
L	X	X	X	L	H	H	H	H	H	L	L	L	H
L	X	X	L	H	H	H	H	H	H	L	H	L	H
L	X	L	H	H	H	H	H	H	H	H	L	L	H
L	L	H	H	H	H	H	H	H	H	H	H	L	H

H = high logic level, L = low logic level, X = irrelevant

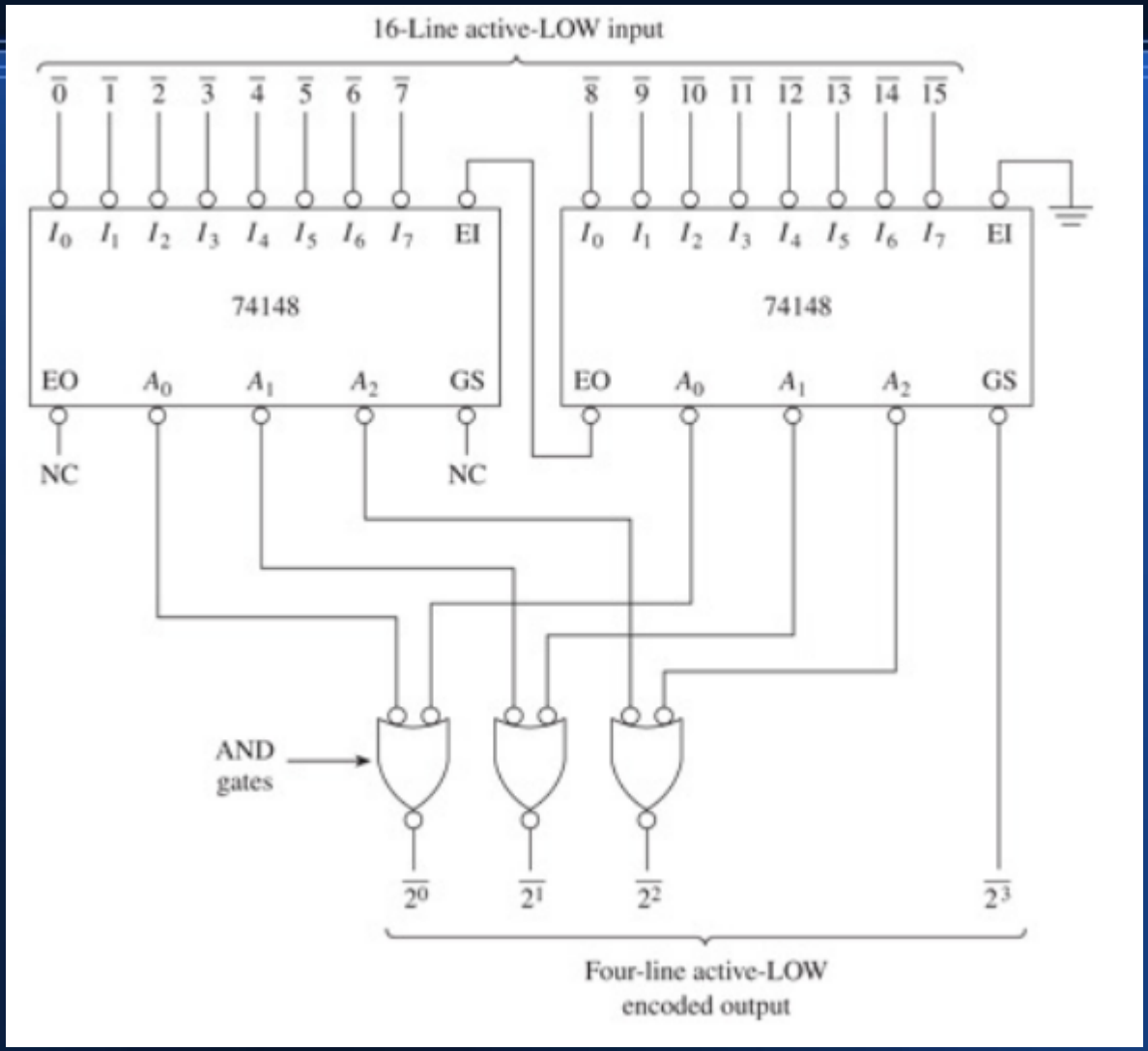


Since inverting the input of the BUF gate has the same effect as inverting the output, an inverting buffer symbol could also be drawn as



to denote an active low input

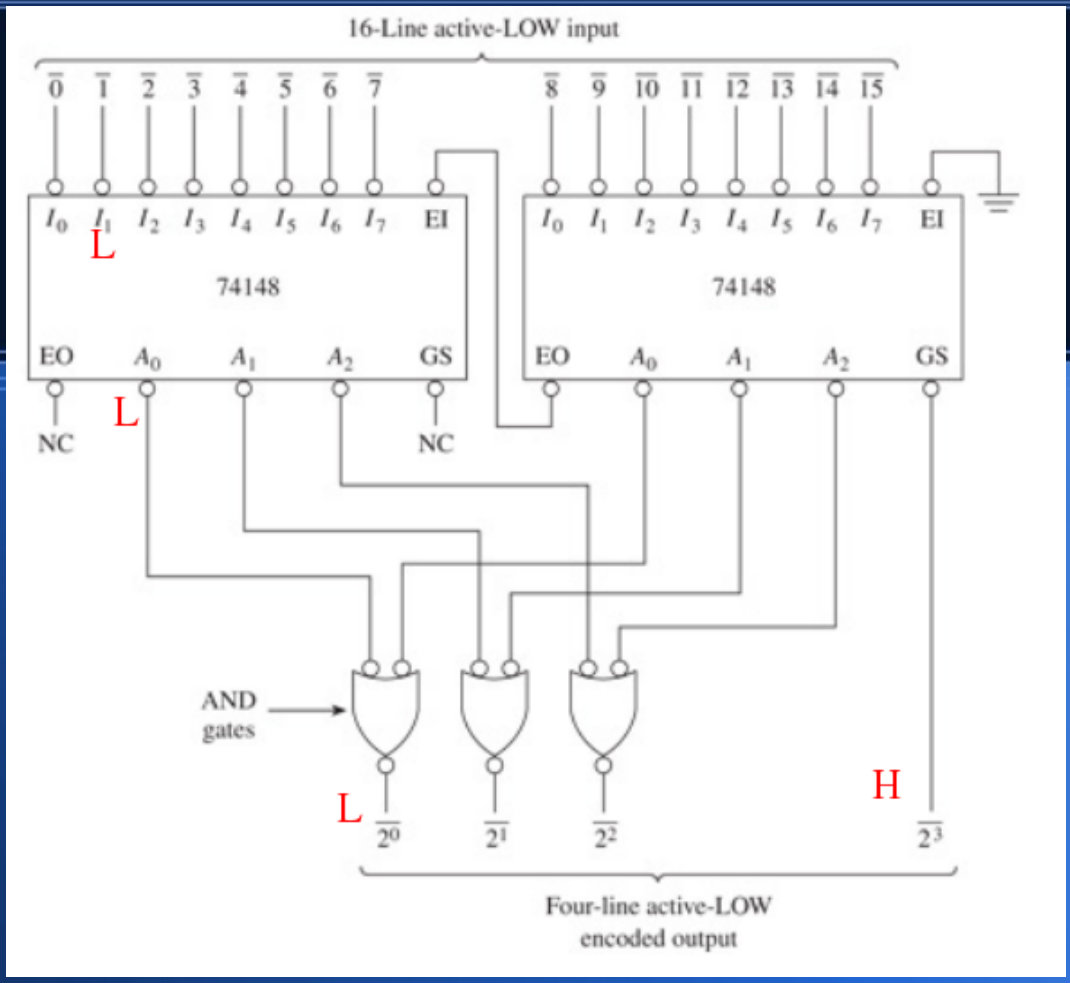
Active-LOW input, active-LOW output hexadecimal (16-line-to-4-line) priority encoder using GS (group select).



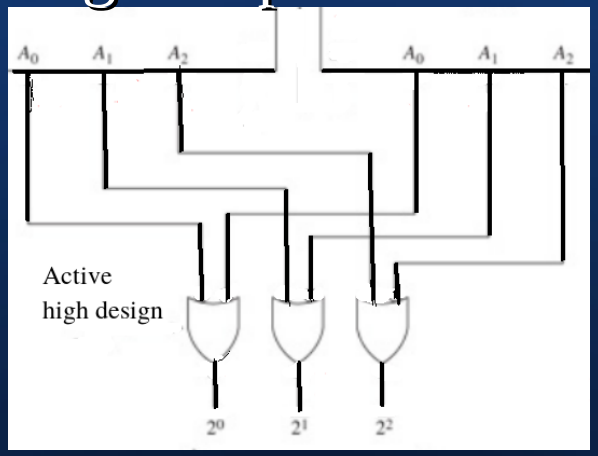
Bobbles signify whether a signal is active low or active high. The operation of a gate depends on how you interpret the signal levels.

For example, an AND gate with all active-high signals can be redrawn as an OR gate with all active-low signals, and vice versa.

Active-LOW input, active-LOW output hexadecimal (16-line-to-4-line) priority encoder



If the encoder had active high outputs:

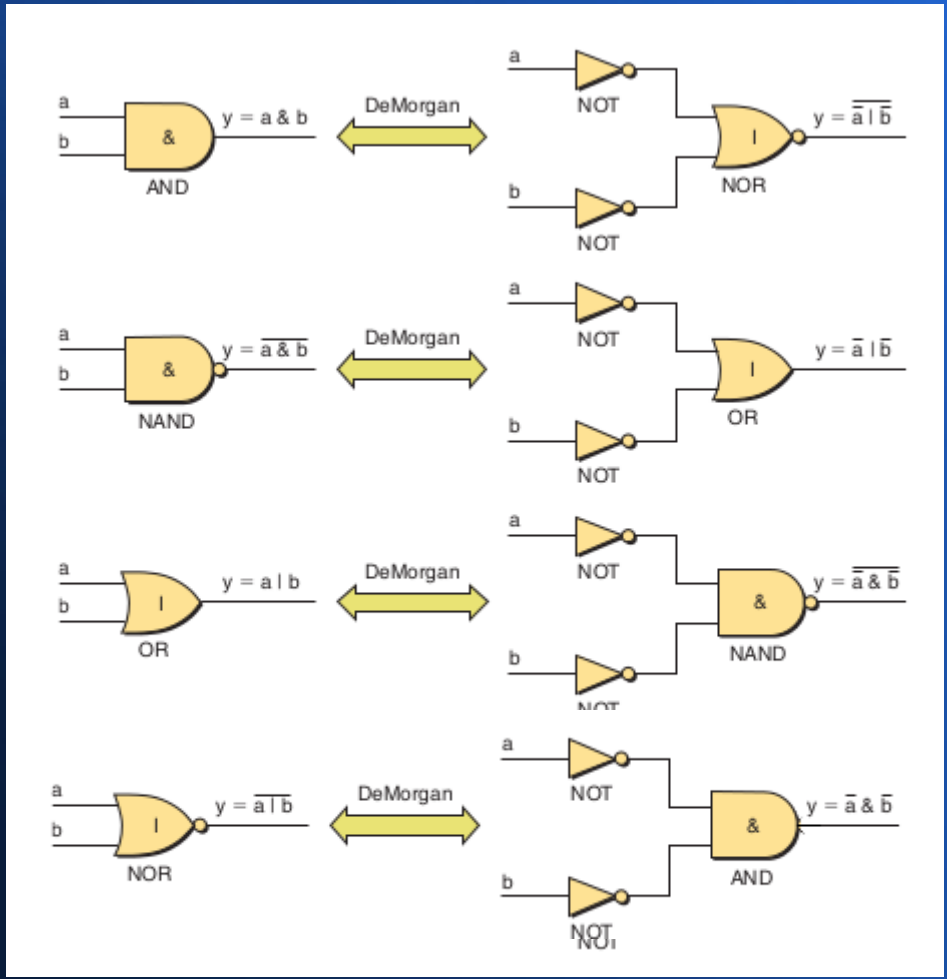


FUNCTION TABLE – '148, 'LS148

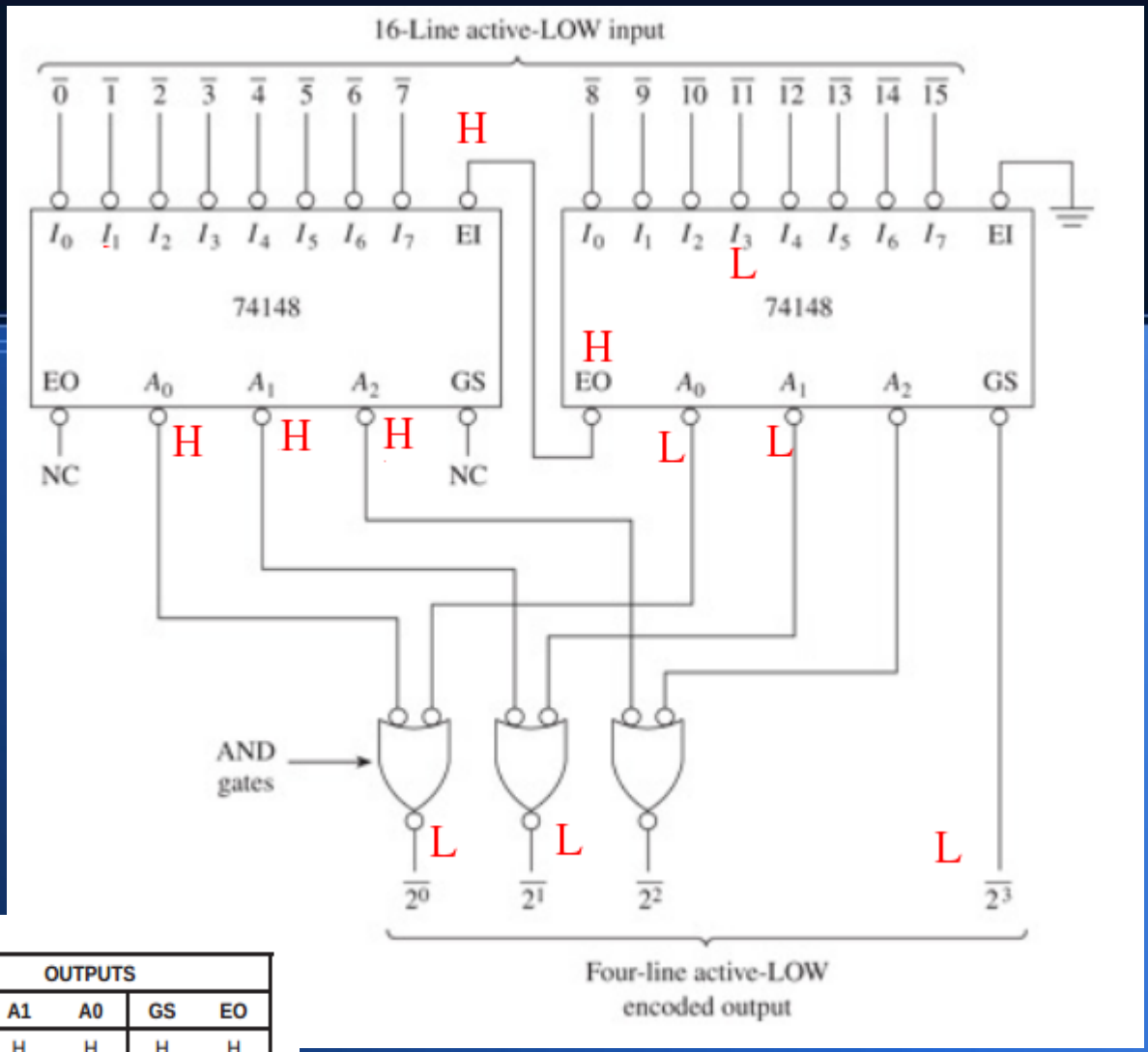
INPUTS									OUTPUTS				
EI	0	1	2	3	4	5	6	7	A2	A1	A0	GS	EO
H	X	X	X	X	X	X	X	X	H	H	H	H	H
L	H	H	H	H	H	H	H	H	H	H	H	H	L
L	X	X	X	X	X	X	X	L	L	L	L	L	H
L	X	X	X	X	X	X	L	H	L	L	H	L	H
L	X	X	X	X	X	L	H	H	L	H	L	L	H
L	X	X	X	X	L	H	H	H	L	H	H	L	H
L	X	X	X	L	H	H	H	H	H	L	L	L	H
L	X	X	L	H	H	H	H	H	H	L	H	L	H
L	X	L	H	H	H	H	H	H	H	H	L	L	H
L	L	H	H	H	H	H	H	H	H	H	H	L	H

H = high logic level, L = low logic level, X = irrelevant

DeMorgan Transformations of AND, OR, NAND, and NOR functions.



Active-LOW input, active-LOW output hexadecimal (16-line-to-4-line) priority encoder



FUNCTION TABLE – '148, 'LS148

INPUTS									OUTPUTS				
EI	0	1	2	3	4	5	6	7	A2	A1	A0	GS	EO
H	X	X	X	X	X	X	X	X	H	H	H	H	H
L	H	H	H	H	H	H	H	H	H	H	H	H	L
L	X	X	X	X	X	X	X	L	L	L	L	L	H
L	X	X	X	X	X	X	L	H	L	L	H	L	H
L	X	X	X	X	X	L	H	H	L	H	L	L	H
L	X	X	X	X	L	H	H	H	L	H	H	L	H
L	X	X	X	L	H	H	H	H	H	L	L	L	H
L	X	X	L	H	H	H	H	H	H	L	H	L	H
L	X	L	H	H	H	H	H	H	H	H	L	L	H
L	L	H	H	H	H	H	H	H	H	H	H	L	H

H = high logic level, L = low logic level, X = irrelevant