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Decoder, Encoder

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Decoder :- In digital systems, instructions as well as numbers are conveyed by means of binary levels or pulse trains. In BCD we use a 4-bit character. The 4-bits in binary can be arranged in 16 distinct ways and therefore 16 different instructions can be coded (16 codes) in a binary form. We may design the circuit is such a way that for each of the 16 codes, one and only one line is to be excited. This process of identifying a particular code is called decoding.

Suppose a decoder fig ① produces 1 output only for a BCD input of 1001

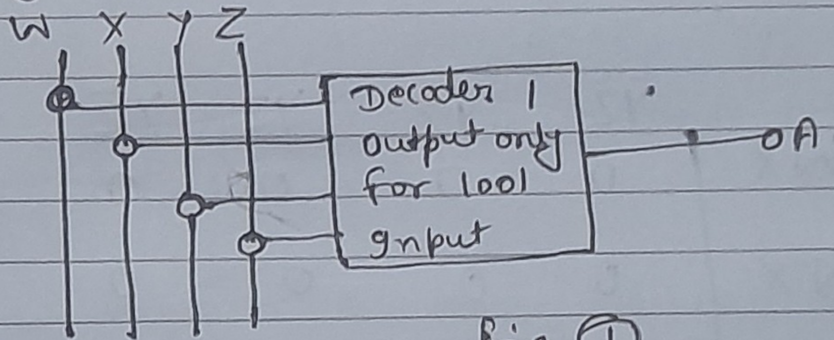

fig ①

(equivalent to decimal 9) [note that in BCD, binary numbers are from 0000 to 1001 and number 1010 through 1111 cannot occur for normal operation] so that truth table is as shown in fig 2. We use Karnaugh map to find the logic circuit inside the decoder (of fig 1). We have 1 output only for one

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input condition

$WXYZ = 1001$

Referring to fig 2(a), the fundamental product for this is $W\bar{X}\bar{Y}Z$, fig 3(a) also show '0's corresponding to other input conditions of the truth table.

The empty spaces refer to the forbidden BCD inputs, not listed in the truth table.

W	X	Y	Z	A
0	0	0	0	0
0	0	0	1	0
0	0	1	0	0
0	0	1	1	0
0	1	0	0	0
0	1	0	1	0
0	1	1	0	0
0	1	1	1	0
1	0	0	0	0
1	0	0	1	1

fig 2

	$\bar{Y}\bar{Z}$	$\bar{Y}Z$	YZ	$Y\bar{Z}$
$\bar{W}\bar{X}$	0	0	0	0
$\bar{W}X$	0	0	0	0
WX				
$W\bar{X}$	0	1		

fig 3(a)

	$\bar{Y}\bar{Z}$	$\bar{Y}Z$	YZ	$Y\bar{Z}$
$\bar{W}\bar{X}$	0	0	0	0
$\bar{W}X$	0	0	0	0
WX	X	X	X	X
$W\bar{X}$	0	1	X	X

fig 3(b)

	$\bar{Y}\bar{Z}$	$\bar{Y}Z$	YZ	$Y\bar{Z}$
$\bar{W}\bar{X}$	0	0	0	0
$\bar{W}X$	0	0	0	0
WX	X	X	X	X
$W\bar{X}$	0	1	X	X

fig 3(c)

Since forbidden BCD inputs do not occur under normal operating conditions, these empty space of K-map can be treated as '0's or '1's whichever is more convenient and mark them by X the don't care conditions fig 3(b). We can use these 'X' to the best possible advantage by following these ideas:

(i) Enter '1's on K-map for fundamental products that produce output '1's in the truth table. Enter '0's for the other inputs listed in the truth table, and enter 'X's for the forbidden inputs.

(ii) Encircle the actual '1's on the K-map in the largest groups we can find by treating the don't care conditions as '1's.

(iii) After actual '1's have been included in groups, disregard the remaining don't cares by visualising them 0's.

Thus, as pointed out in point (ii) above we include in a quad (fig 3c) and form the largest group by visualising all 'X's (that are included in the quad) as '1's. Therefore Boolean eqn will be

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$$A = WX\bar{Y}Z + W\bar{X}\bar{Y}Z + W\bar{X}YZ$$

Because X and Y have been complemented they drop out and therefore reduced expression is

$$A = WZ$$

which is the output of an AND gate fig(4)

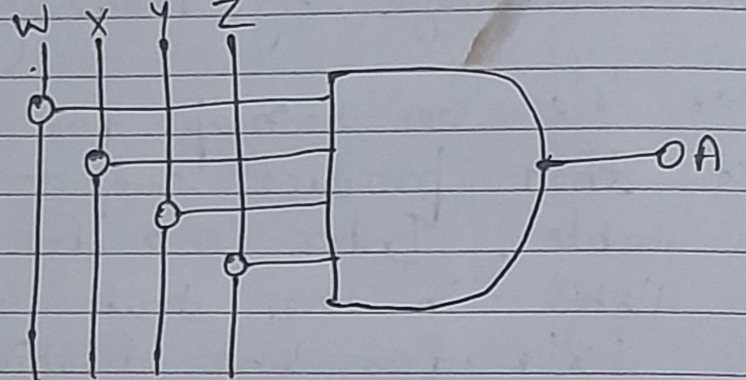

fig (4) An AND gate for decoding 1001

which gives that when W and Z both are '1's (which happens only for a BCD input of 1001) the output A equal a 1.

Decoding 0111:

The simplest logic circuit for decoding a BCD input of 0111 as a output is shown in fig (5), with K-map. The most efficient way to encircle is to group 1 into a pair with the don't care as shown. Since this is the largest group possible, all other don't care are treated as '0's. The equation for the pair is

	$\bar{Y}\bar{Z}$	$\bar{Y}Z$	YZ	$Y\bar{Z}$
$\bar{W}\bar{X}$	0	0	0	0
$\bar{W}X$	0	0	1	0
WX	X	X	X	X
$W\bar{X}$	0	0	X	X

→ <u>fig(5) Decoding 0111.</u>

$A = XYZ$

The three input gate produces a 1 o/p only for a BCD input of 0111.