DECODERS

- Digital systems use binary codes to represent information.
- Therefore the codes used become very important - especially the length of the codes. The longer the code, greater the amount of distinct information it can represent.

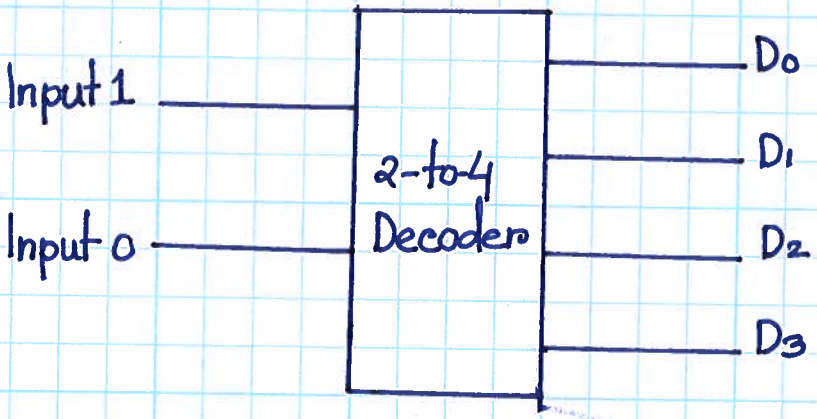
Code Length v/s Number of Distinct Representation

Code Length	Possible Representation	Number of Representations
1	0, 1	$2^1 = 2$
2	00, 01, 10, 11	$2^2 = 4$
3	000, 001, 010, 011, 100, 101, 110, 111	$2^3 = 8$

If code length = n, number of distinct representation = 2^n

- A decoder is a circuit that converts the n-bit binary code (on n input lines) to 2^n distinct elements (on 2^n unique output lines).
- Sometimes the n-bit coded information has a few unused combinations. In such cases fewer than 2^n outputs are required
- In general they can be referred to as n-to-m line decoders where $m \leq 2^n$.

To get a better idea of the circuit, use the following examples: Block diagram of 2-to-4 line decoder



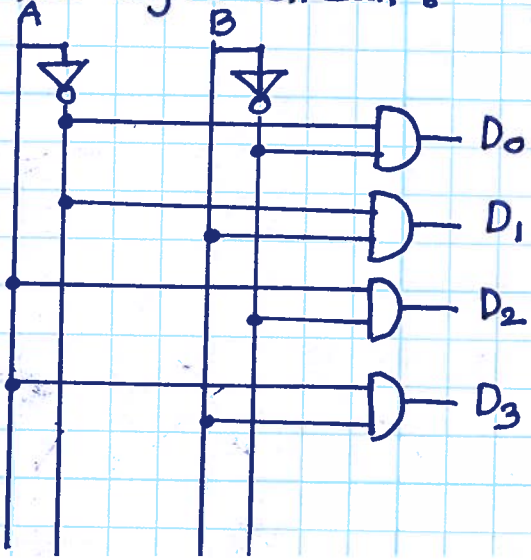
– The truth table for 2-to-4 line decoder can be shown as follows:

Input		Output			
A	B	D_0	D_1	D_2	D_3
0	0	1	0	0	0
0	1	0	1	0	0
1	0	0	0	1	0
1	1	0	0	0	1

– Get the simplified logic function of the outputs

$D0 = A'B'$, $D1 = A'B$, $D2 = AB'$, $D3 = AB$

– Draw the logic circuit:



– No. of AND gates = No. of outputs

– No. of NOT gates = No. of inputs.

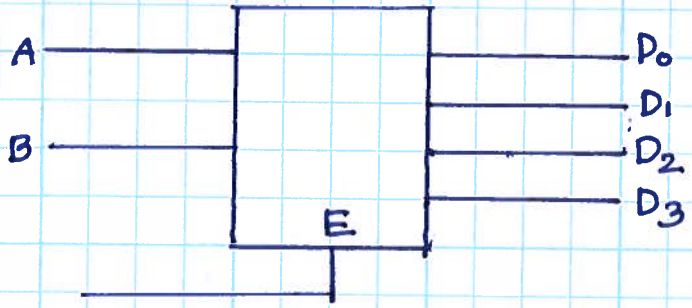
Decoder Applications:

- Microprocessor Memory Systems
  - Select different banks of memory.
- Microprocessor input/output systems
  - Select different devices
- Microprocessor Instruction Decoding
  - Enabling different functional units
- Memory chips
  - Enabling different rows of memory depending on address.

Self Study: Design a 3-to-8 line decoder (block diagram, truth table, simplified logic function, logic diagram).

Enable input:

- Apart from the inputs we have already seen, decoders commonly use an additional "enable" input.
- This input (generally labeled E) provides additional control over the decoder circuit.

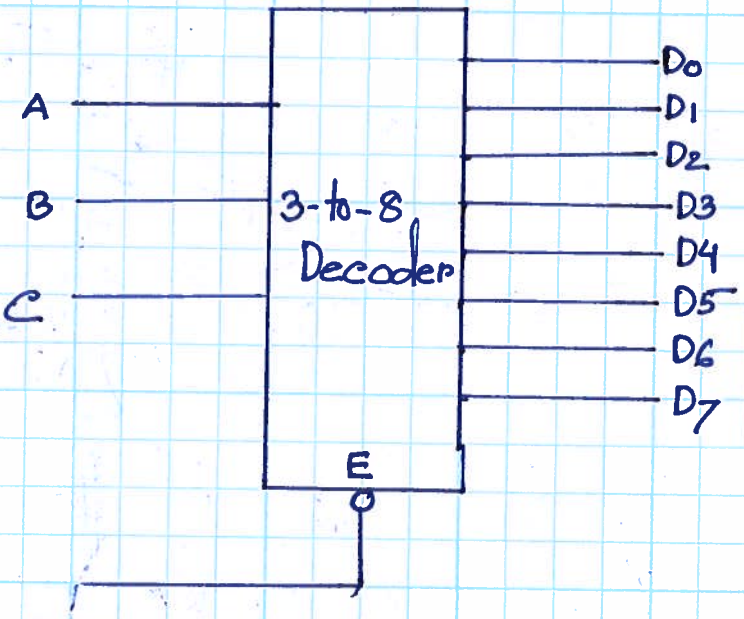


E = 1 (logic high): Decoder operation is normal.

E = 0 (logic low): All outputs are inactive

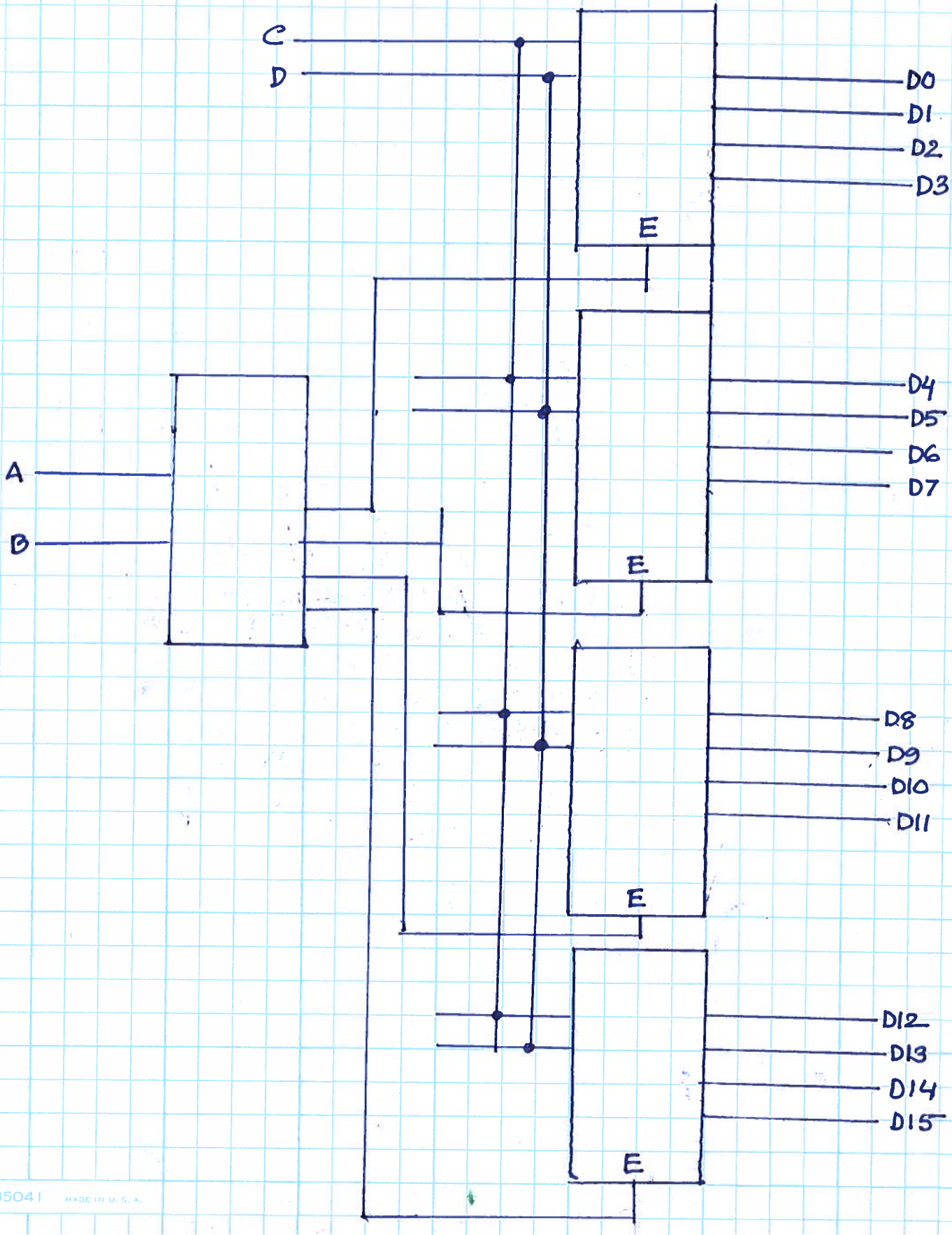
– The previous decoder had an active high enable input.

– This means that the decoder operates as normal only when E=1 or logic high. However, if the decoder only operates when E=0 or logic low, it is said to have an active low enable input.



Decoder Cascading:

4-to-16 decoder with 2-to-4 decoders

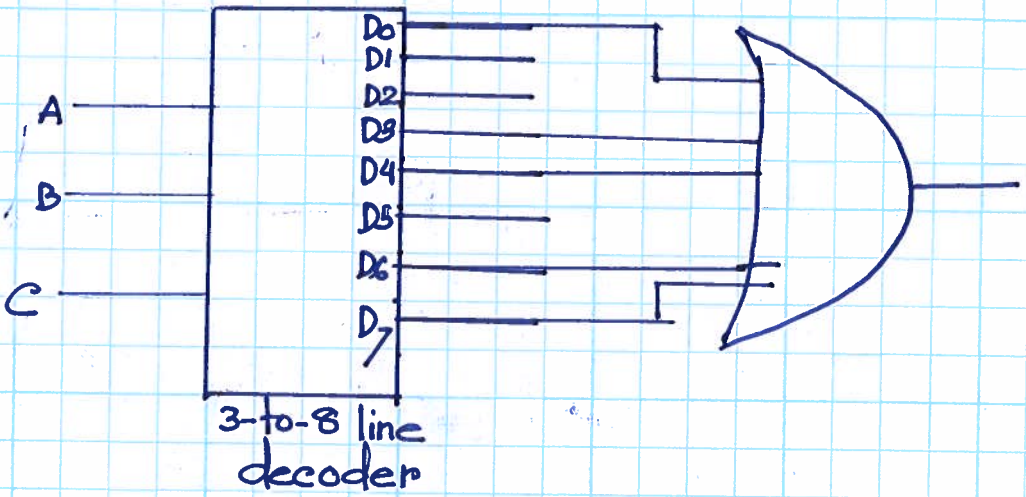


Use of decoders in combinational circuits

- The decoder provides 2^n minterms of n input
- Any boolean function can be expressed in sum of minterms.

This means that any combinational circuit can be implemented using an appropriate decoder and an OR gate to form the logical sum.

$$F(A, B, C) = \sum(1, 3, 4, 6)$$



Number of inputs: 3 (A, B & C)

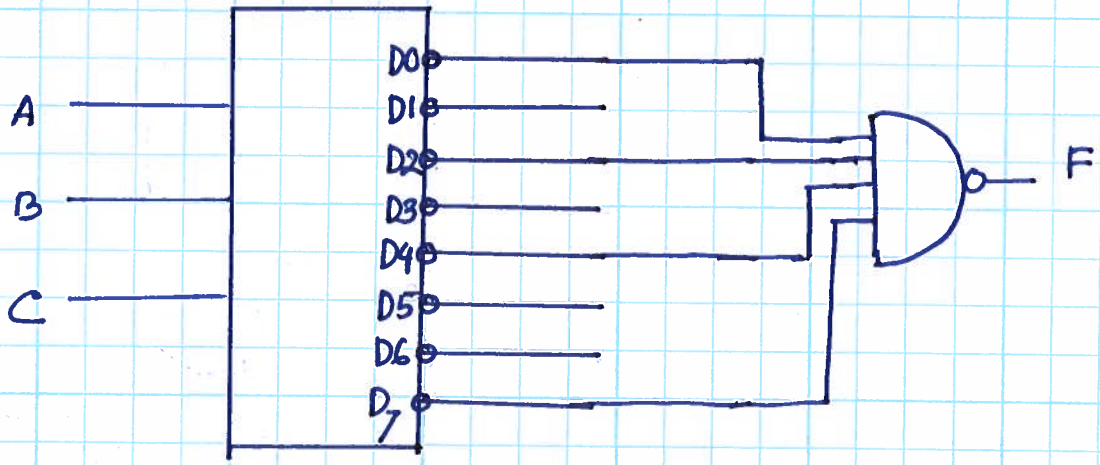
Possible no. of outputs: $2^3 = 8$

No. of outputs selected: 4 (D1, D3, D4, D6)

Use of active low decoders in combinational circuits:

- An active high decoder was used in the previous exercise to implement the combinational logic function.
- In the same manner an active low implementation is possible

$$F(A,B,C) = \Sigma(0,2,4,7)$$



OR