Encoder

Sparsh Mittal

- 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.

Octal-to-binary encoder

- It has eight inputs (one for each of the octal digits) and three outputs that generate the corresponding binary number.
- Only one input should have a value of 1 at any given time.

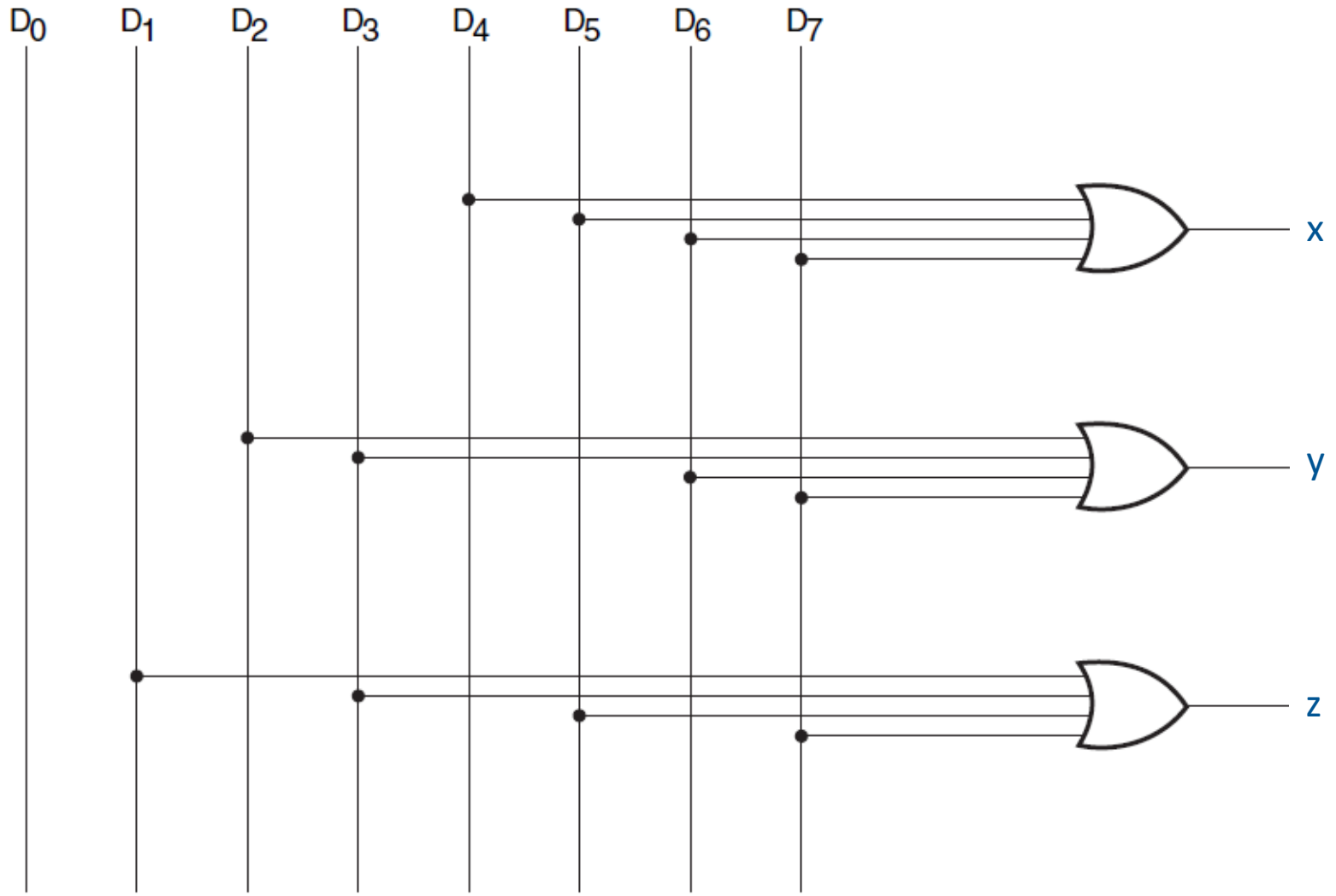
Truth Table of an Octal-to-Binary Encoder

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

Logic design of encoder

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

$$z = D_1 + D_3 + D_5 + D_7$$
$$y = D_2 + D_3 + D_6 + D_7$$
$$x = D_4 + D_5 + D_6 + D_7$$



Challenge #1 with encoder

- 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.
- **Solution:** 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.

Challenge #2 with encoder

- When all the inputs are 0, an output with all 0's is generated.
- This output is the same as when D0 is equal to 1.
- Solution: Provide one more output to indicate whether at least one input is equal to 1.

Solution: Priority Encoder

- It includes the priority function.
- If two or more inputs are equal to 1 at the same time, the input having the highest priority will take precedence.

Truth Table of 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

- The third output V, 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.

Compact representation

- 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.

Truth Table of 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

Truth table of a priority encoder (expanded)

Inputs				Outputs		
D0	D1	D2	D3	x	y	z
0	0	0	0	X	X	0
1	0	0	0	0	0	1
0	1	0	0	0	1	1
1	1	0	0	0	1	1
0	0	1	0	1	0	1
0	1	1	0	1	0	1
1	0	1	0	1	0	1
1	1	1	0	1	0	1
0	0	0	1	1	1	1
0	0	1	1	1	1	1
0	1	0	1	1	1	1
0	1	1	1	1	1	1
1	0	0	1	1	1	1
1	0	1	1	1	1	1
1	1	0	1	1	1	1
1	1	1	1	1	1	1

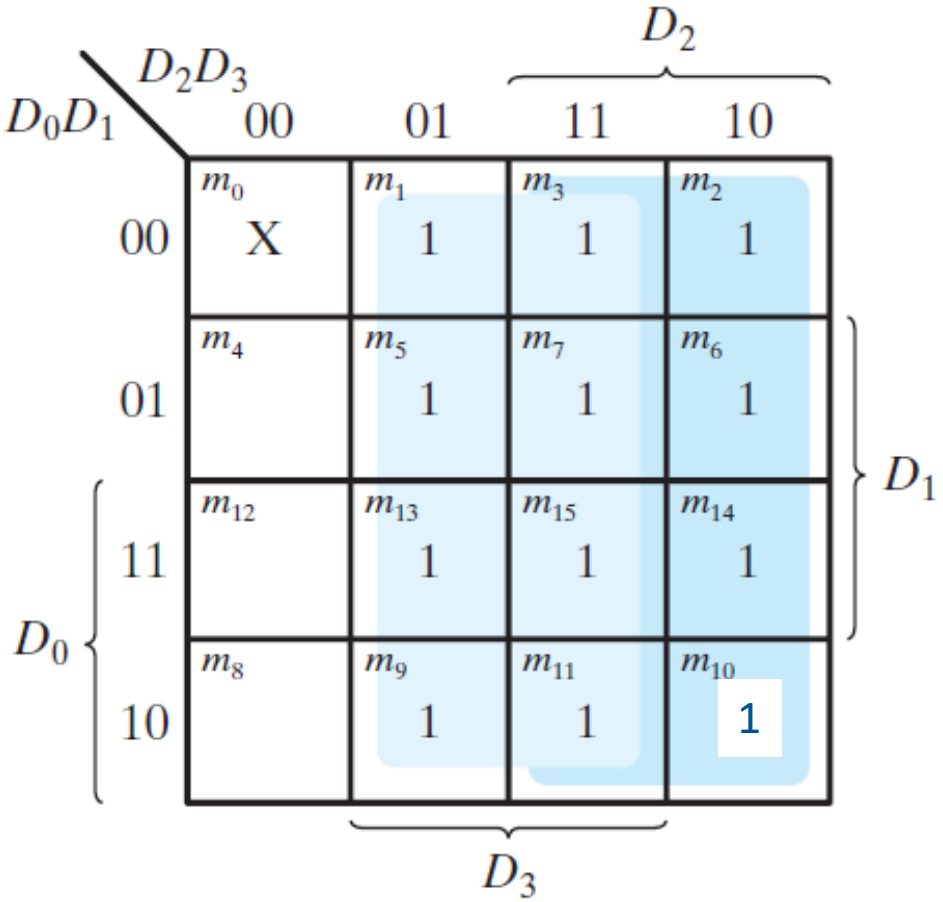
Truth Table of a Priority Encoder (compact)

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

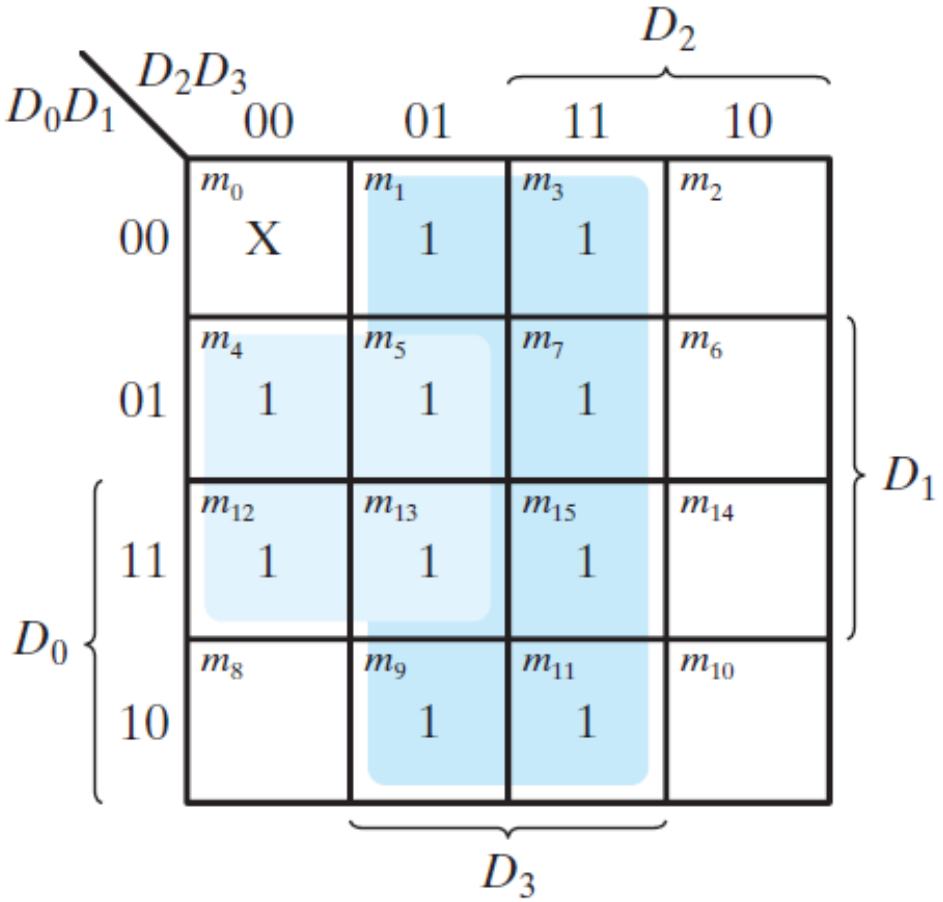
- The higher the subscript number, the higher the priority of the input.
- Input $D3$ has the highest priority, so, regardless of the values of the other inputs, when this input is 1, the output for xy is 11 (binary 3).

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

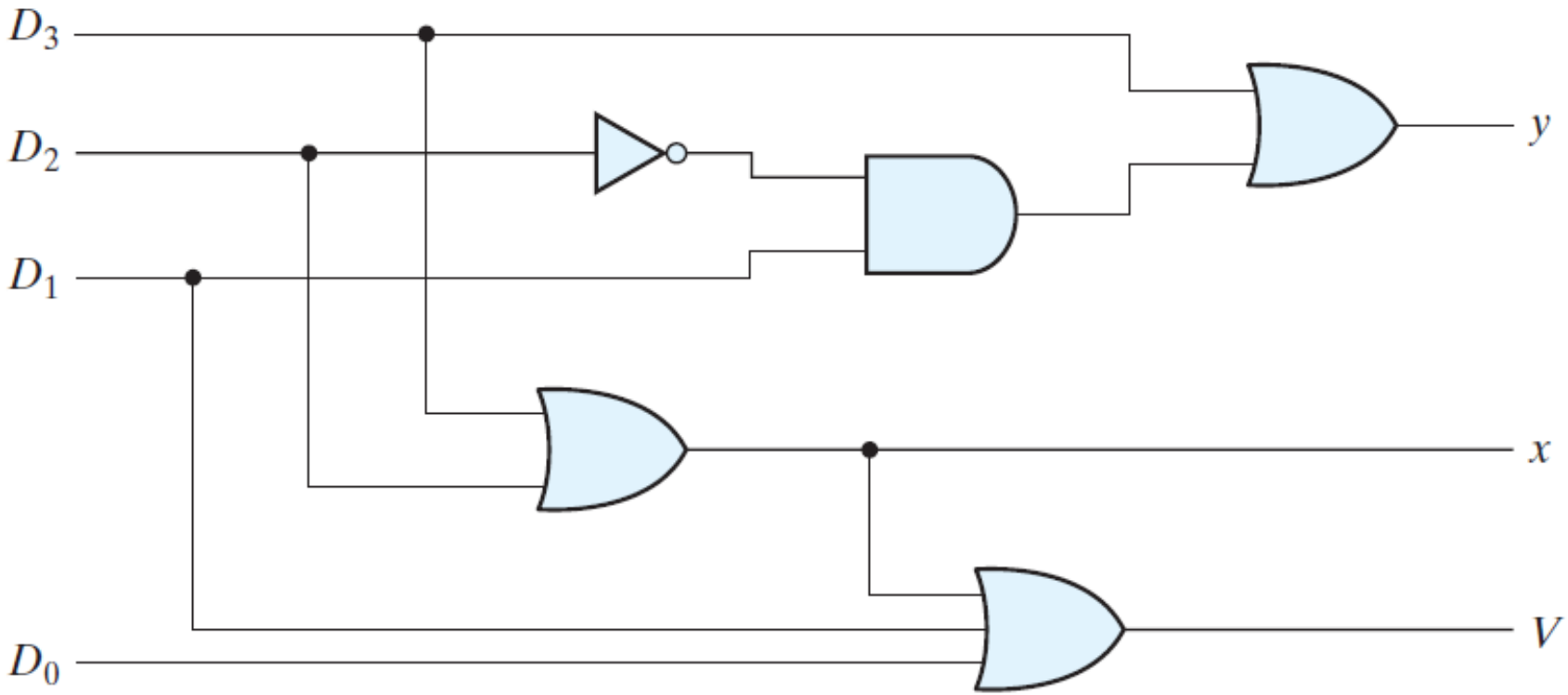
Maps for priority encoder



$x = D_2 + D_3$



$y = D_3 + D_1D'_2$

Output functions of 4-input priority encoder

$$x = D_2 + D_3$$
$$y = D_3 + D_1 D_2'$$
$$V = D_0 + D_1 + D_2 + D_3$$