CPE201
Digital Design

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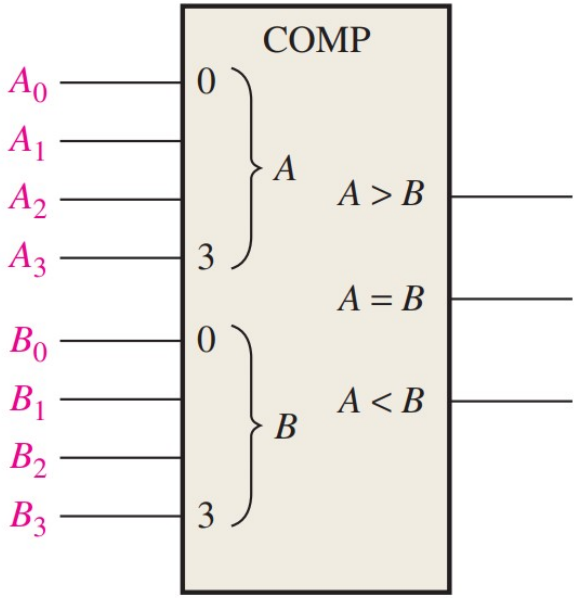
Class 15: Comparators and Decoders/Encoders

University of Nevada, Reno

Comparator

- End Goal:
  - 4-bit input numbers
  - <, >, = outputs

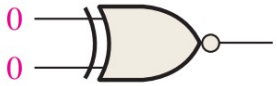


Starting Small

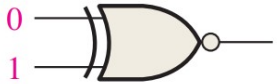
- 1-bit
  - A<B
  - A=B
  - A>B

Equality

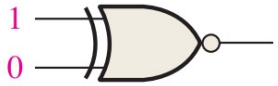
- XNOR (A B)



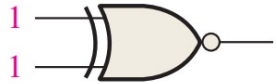
The input bits are equal.



The input bits are not equal.



The input bits are not equal.



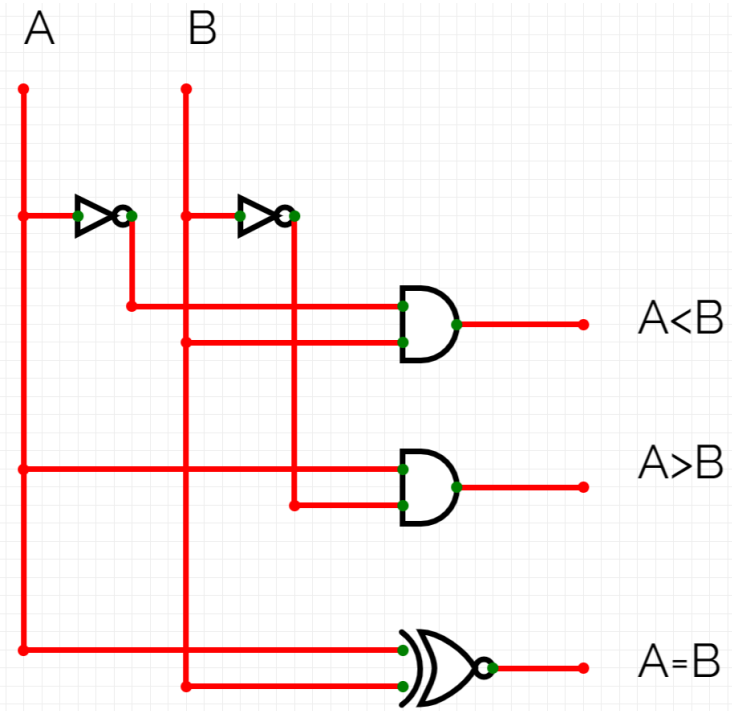
The input bits are equal.

Truth Table

A	B	A< B	A= B	A> B
0	0	0	1	0
0	1	1	0	0
1	0	0	0	1
1	1	0	1	0

- $A<B = A'B$
- $A=B = A'B' + AB = A \odot B$
- $A>B = AB'$

Circuit



- A<B = A’B
- A=B = A B
- A>B = AB’

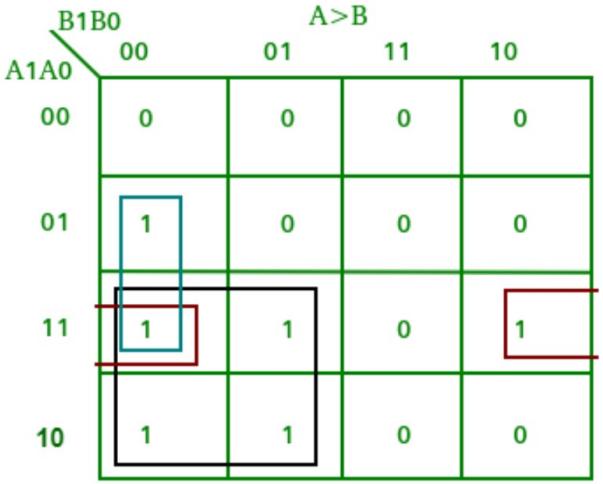
2-bit Comparator

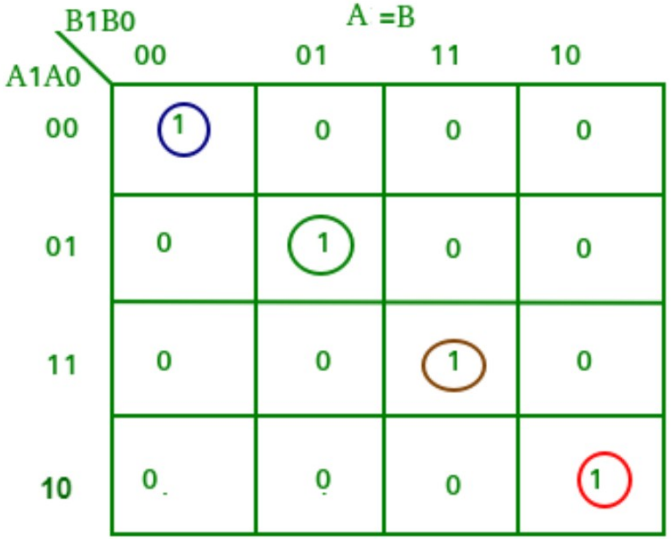
- Same process

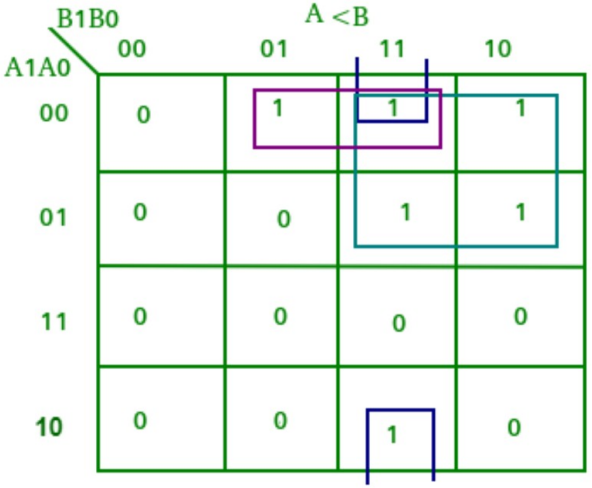
A1	A0	B1	B0	A< B	A= B	A> B
0	0	0	0	0	1	0
0	0	0	1	1	0	0
0	0	1	0	1	0	0
0	0	1	1	1	0	0
0	1	0	0	0	0	1
0	1	0	1	0	1	0
0	1	1	0	1	0	0

A1	A0	B1	B0	A< B	A= B	A> B
1	0	0	0	0	0	1
1	0	0	1	0	0	1
1	0	1	0	0	1	0
1	0	1	1	1	0	0
1	1	0	0	0	0	1
1	1	0	1	0	0	1
1	1	1	0	0	0	1

arnaugh Maps



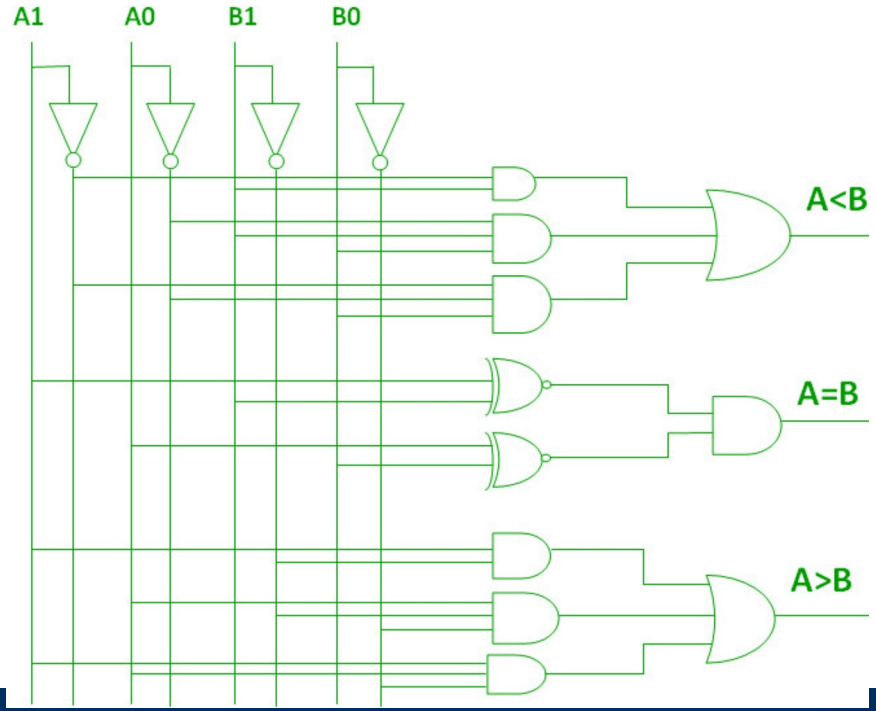




Boolean Expressions

- A>B: A1B1′ + A0B1′B0″ + A1A0B0′
- A=B: A1′A0′B1′B0′ + A1′A0B1′B0 +
  A1A0B1B0 + A1A0′B1B0′
- : A1′B1′ (A0′B0′ + A0B0) + A1B1 (A0B0 + A0′B0′)
- : (A0B0 + A0′B0′) (A1B1 + A1′B1′)
- : (A0 B0) (A1 B1)
- A<B: A1′B1 + A0′B1B0 + A1′A0′B0

Circuit



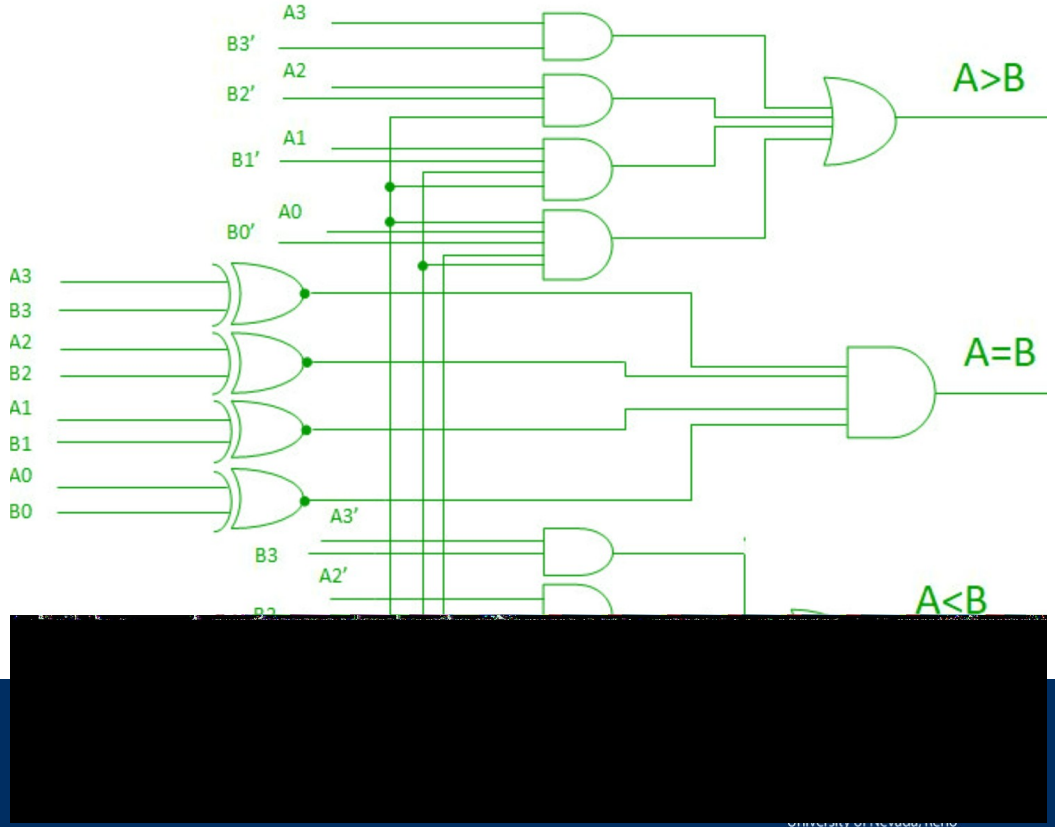
Generalize

- A>B
  - If A1 = 1 and B1 = 0
  - If A1 = B1 and A0 = 1 and B0 = 0
    - A1=B1 means when they are both 0 and both 1
- A<B
  - If A1 = 0 and B1 = 1
  - If A1 = B1 and A0 = 0 and B0 = 1
- A=B
  - (A1 B1) (A0 B0)

4-bit Comparator

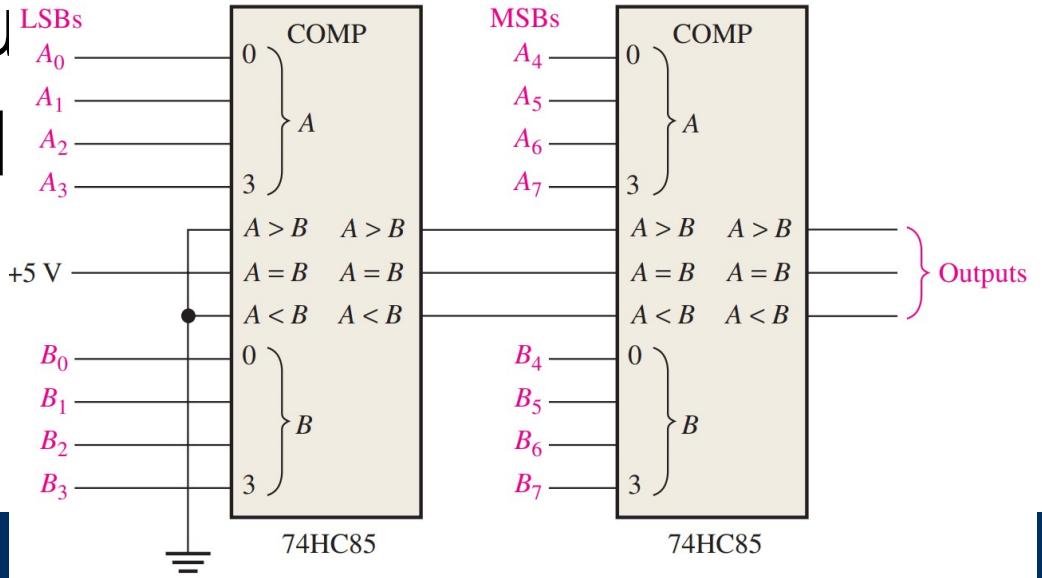
- Use generalized rules
  - 8-bits is too many inputs for a Karnaugh map
  - Create a circuit from the rules
- A>B
  - If A3 = 1 and B3 = 0
  - If A3 = B3 and A2 = 1 and B2 = 0
  - If A3 = B3, A2 = B2 and A1 = 1 and B1 = 0
  - If A3 = B3, A2 = B2, A1 = B1 and A0 = 1 and B0 = 0

4-bit Comparator



Larger Comparators

- Input AND output comparator signals to ripple the resu
- Inputs treated as 5th bit



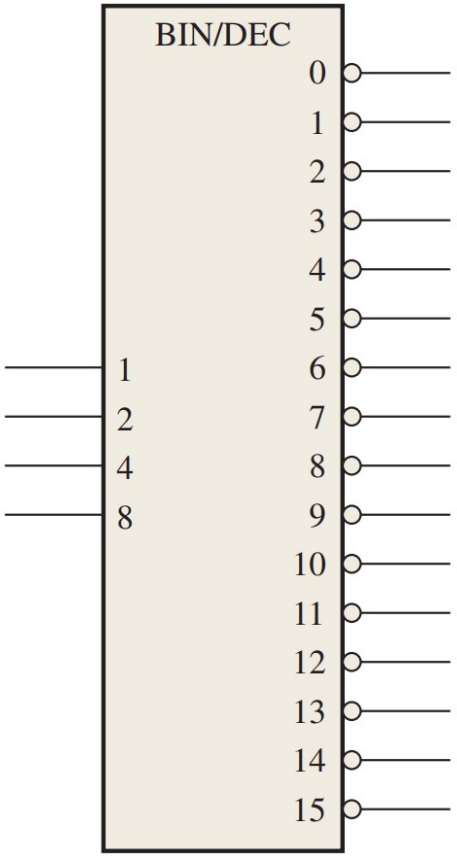
An 8-bit magnitude comparator using two 74HC85s.

Comparator Applications

- Sensors
  - Temperature, position compared to a setting
- Motor control
  - Like in 3-D printers
- Password verification

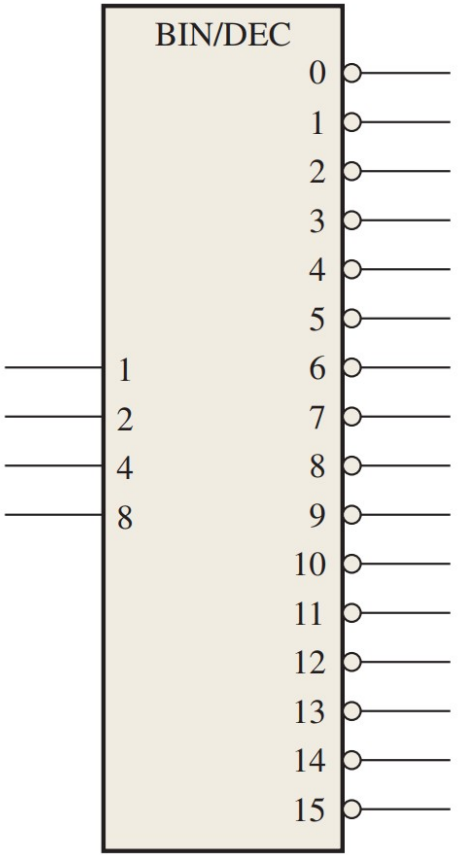
Decoders

- An input combination activates one output
- n inputs, 2^n outputs
  - 1 to 2, 2 to 4, 3 to 8, 4 to 16



Active High vs Active Low

- Active High = ON means 1
- Active Low = ON means 0
- This chip is active low

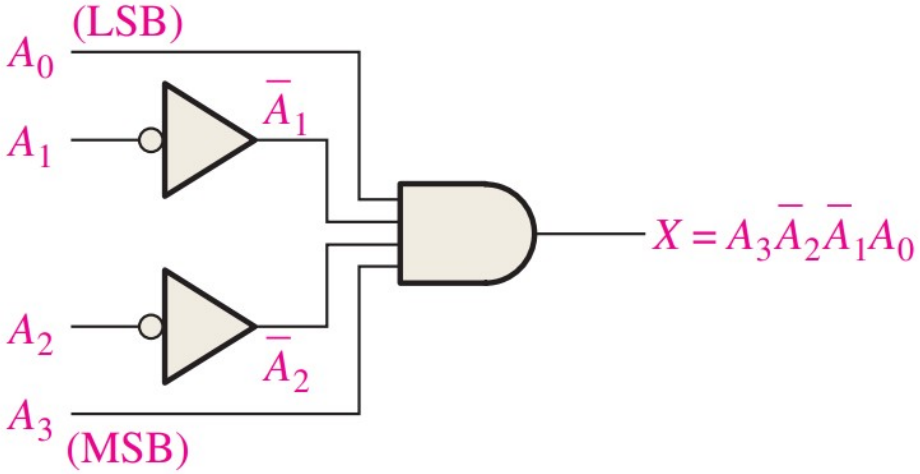


Active Low Decoder

Decimal Digit	Binary Inputs A_3	A_2	A_1	A_0	Decoding Function	Outputs 0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
0	0	0	0	0	$\overline{A}_3\overline{A}_2\overline{A}_1\overline{A}_0$	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
1	0	0	0	1	$\overline{A}_3\overline{A}_2\overline{A}_1A_0$	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1
2	0	0	1	0	$\overline{A}_3\overline{A}_2A_1\overline{A}_0$	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1
3	0	0	1	1	$\overline{A}_3\overline{A}_2A_1A_0$	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1

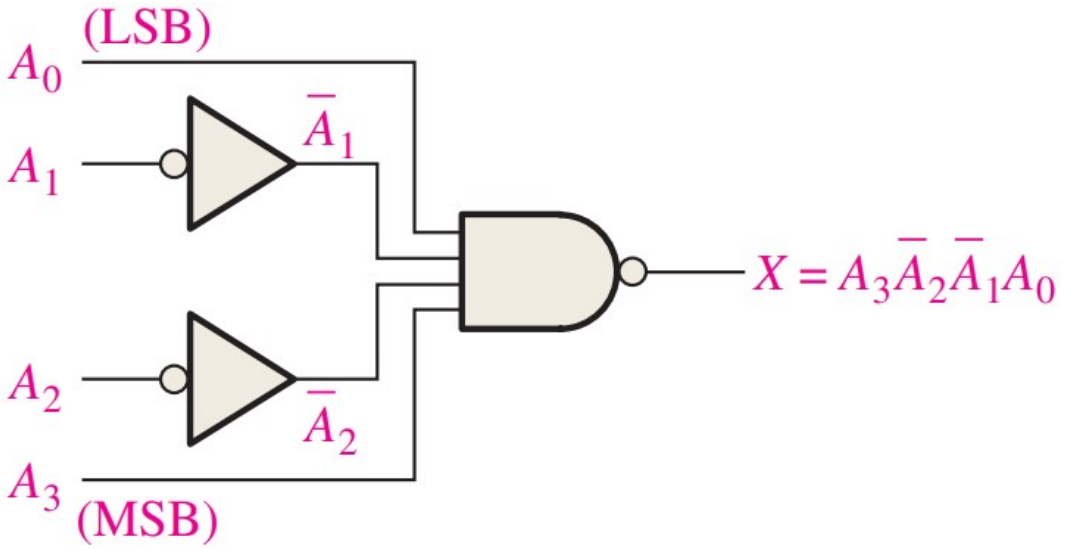
Basics

- Input = 1001
- Active high output
- AND



Basics

- Input = 1001
- Active low outpu
- NAND
- Chip would have
  16 of these

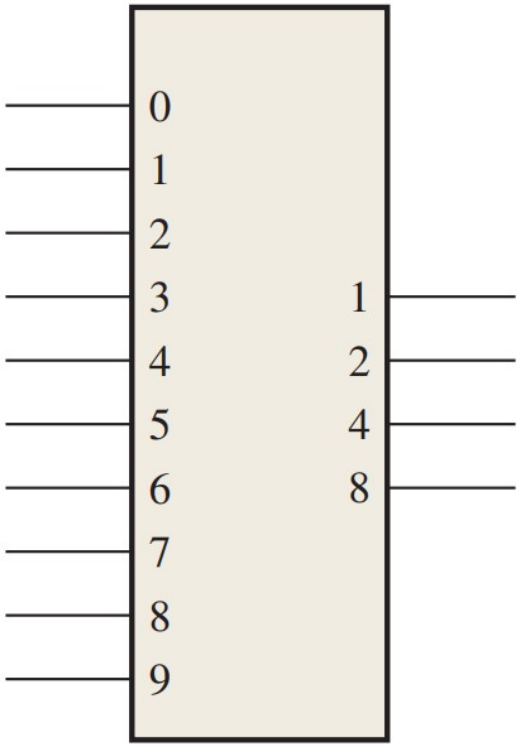


Applications

- Memory Addressing
  - Turn on a specific bank of memory
- Turn specific things on and off
  - Ex TV vs projector screen

Encoders

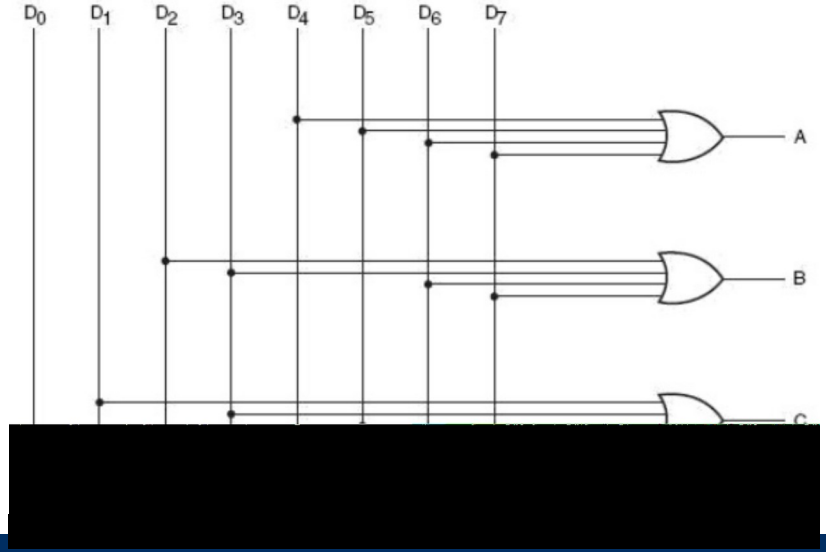
- Reverse of decoder
- 2^n inputs, n outputs



Basics

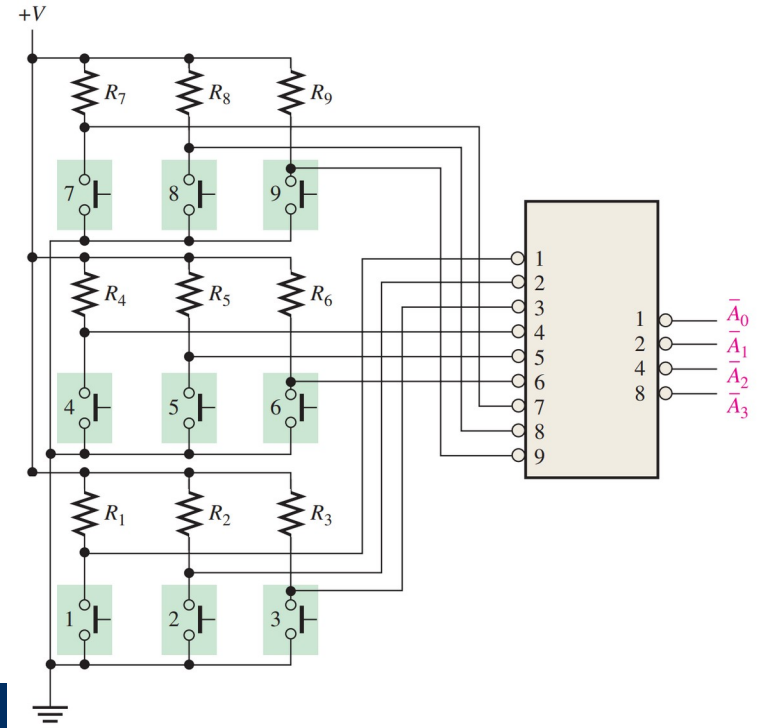
- 8 to 3 encoder (binary to octal)

D_0	D_1	D_2	D_3	D_4	D_5	D_6	D_7	A	B	C
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



Application

- Keypad
- Encoded output
  is easier to transmit
  and use



Reading

- This lecture
  - Sections 6.4-6.6
- Next lecture
  - Sections 6.8-6.10