UESTC1008: Microelectronic Systems

Multiplexer and De-multiplexer

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Overview

- The following topics are covered in this lecture:
  - Binary Code Decimal
  - Encoder
  - Decoder
  - Multiplexer
  - Demultiplexer
  - Applications

Binary Code Decimal (BCD)

- Any one decimal numeral can be represented by a four bit pattern
- The most obvious way of representing/encoding digits is "natural BCD" (NBCD), where each decimal digit is represented by its corresponding four-bit binary value
- This is also called "8421" encoding

Decimal	Binary Code Decimal
0	0000
1	0001
2	0010
3	0011
4	0100
5	0101
6	0110
7	0111
8	1000
9	1001

Encoder and Decoder

- Before discussing a multiplexer and demultiplexer, we will first learn about encoders and decoders
  - Encoder is a circuit that changes a set of binary signals into a code
  - Decoder is the opposite of an encoder as it is a circuit that changes a code into a set of binary signals

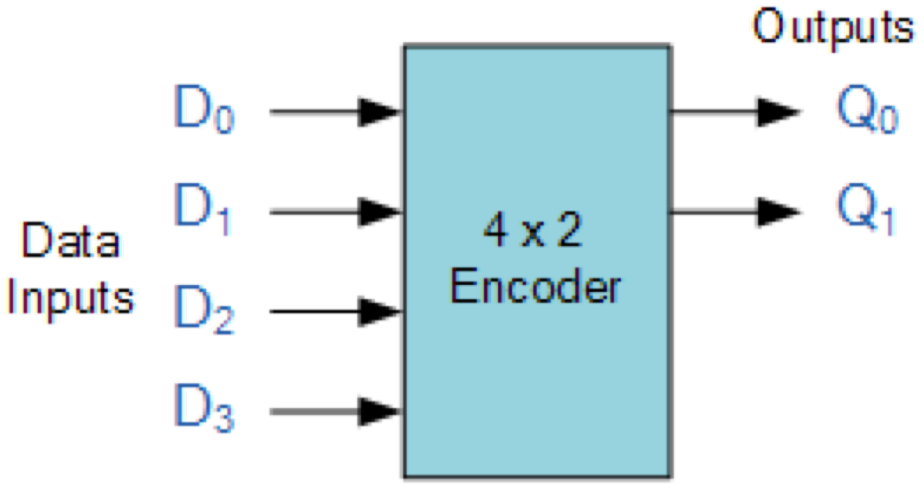
Binary Encoder

- A Binary Encoder takes ALL its data inputs one at a time and then converts them into a single encoded output
- A binary encoder, is a multi-input combinational logic circuit that converts the logic level “1” data at its inputs into an equivalent binary code at its output
- Generally, binary encoders produce outputs of 2-bit, 3-bit or 4-bit codes depending upon the number of data input lines
- An “n-bit” binary encoder has 2^n input lines and n-bit output lines with common types that include 4-to-2, 8-to-3 and 16-to-4 line configurations

2x1 Bit Binary Encoder

D_1	D_0	Q_0
0	0	Not allowed combination of inputs
0	1	0
1	0	1
1	1	Not allowed combination of inputs

4x2 Bit Binary Encoder



Inputs				Outputs	
D_3	D_2	D_1	D_0	Q_1	Q_0
0	0	0	1	0	0
0	0	1	0	0	1
0	1	0	0	1	0
1	0	0	0	1	1
0	0	0	0	x	x

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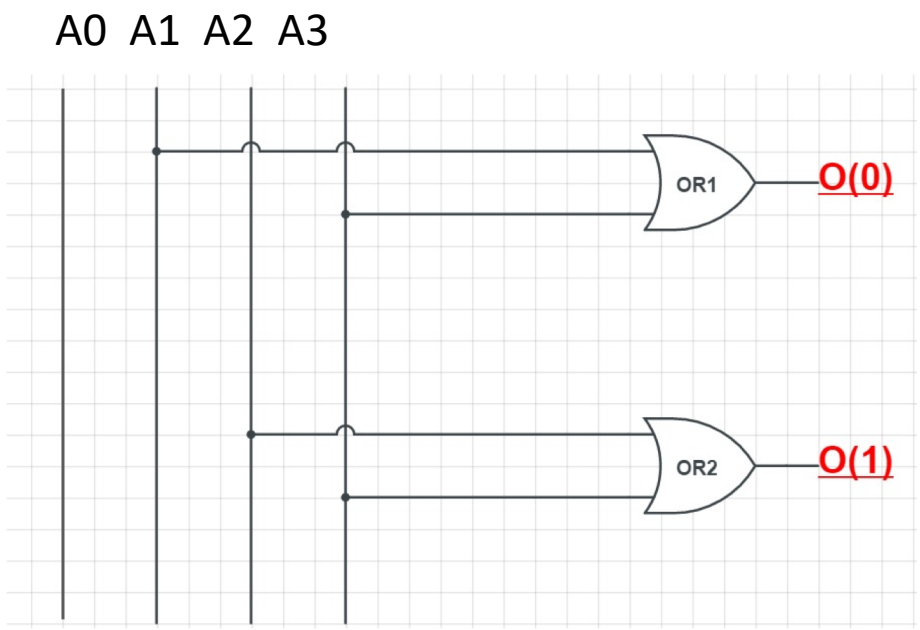
4x2 Bit Binary Encoder



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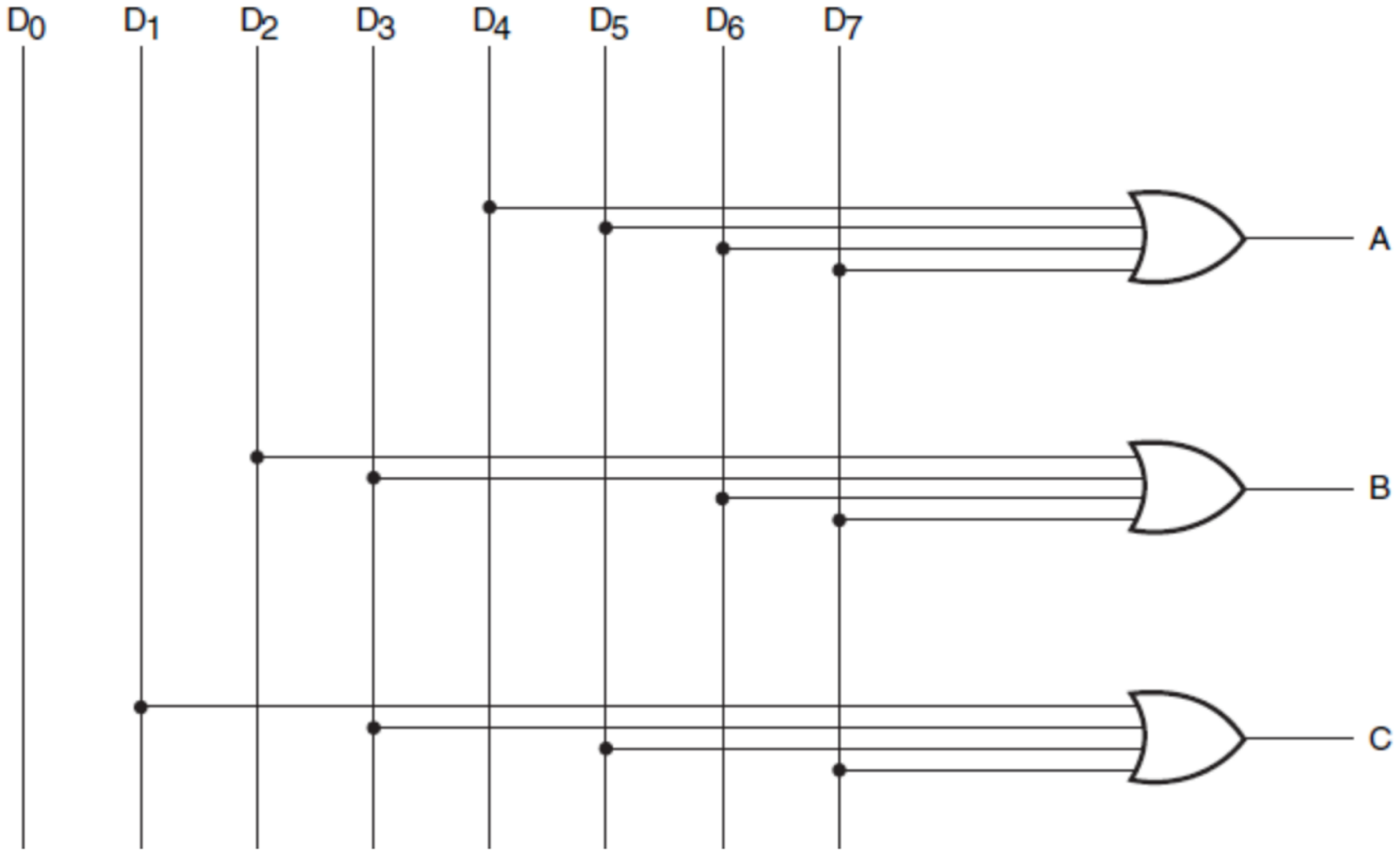
8x3 Bit Binary Encoder

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

8x3 Bit Binary Encoder



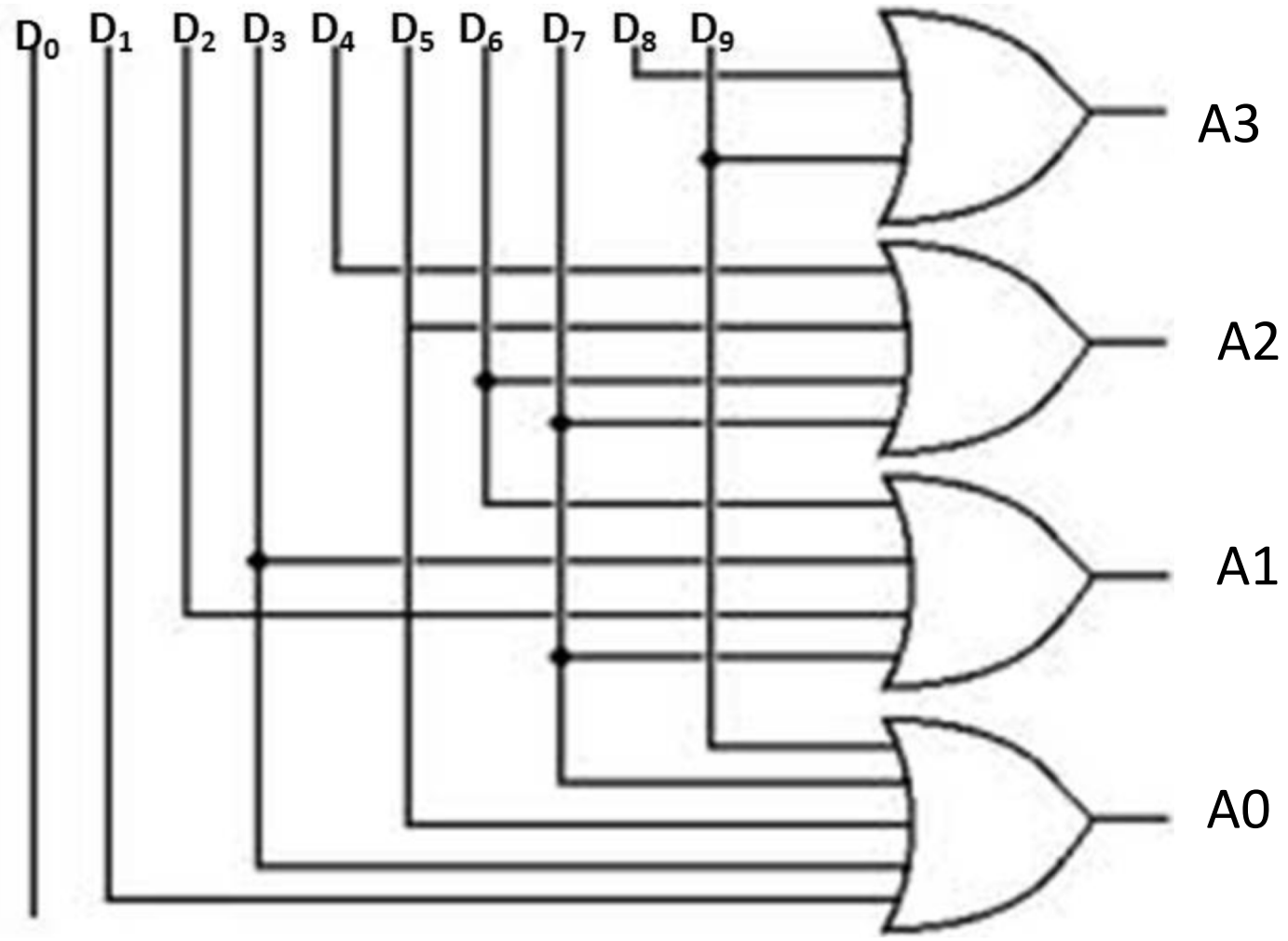
8x3 Bit Binary Encoder

A = D4 + D5 + D6 + D7

B = D2 + D3 + D6 + D7

C = D1 + D3 + D5 + D7

10 to 4 Encoder (Decimal to Binary)



10 to 4 Encoder (Decimal to Binary)

Truth table of the decimal-to-BCD encoder

D9	D8	D7	D6	D5	D4	D3	D2	D1	D0	A3	A2	A1	A0
0	0	0	0	0	0	0	0	0	1	0	0	0	0
0	0	0	0	0	0	0	0	1	0	0	0	0	1
0	0	0	0	0	0	0	1	0	0	0	0	1	0
0	0	0	0	0	0	1	0	0	0	0	0	1	1
0	0	0	0	0	1	0	0	0	0	0	1	0	0
0	0	0	0	1	0	0	0	0	0	0	1	0	1
0	0	0	1	0	0	0	0	0	0	0	1	1	0
0	0	1	0	0	0	0	0	0	0	0	1	1	1
0	1	0	0	0	0	0	0	0	0	1	0	0	0
1	0	0	0	0	0	0	0	0	0	1	0	0	1

From table:

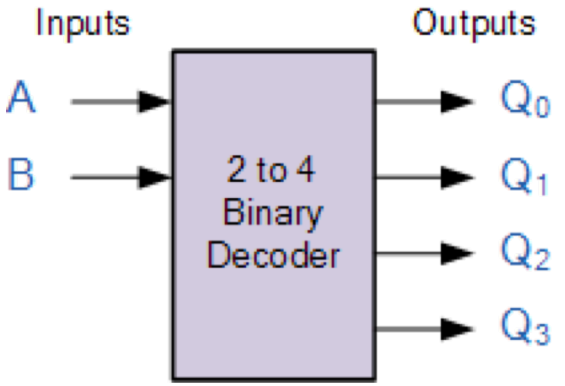
A3 = D8 + D9
A2 = D4 + D5 + D6 + D7
A1 = D2 + D3 + D6 + D7
A0 = D1 + D3 + D5 + D7 + D9

We made use of the fact that only one input can be "1" at one time

Binary Decoder

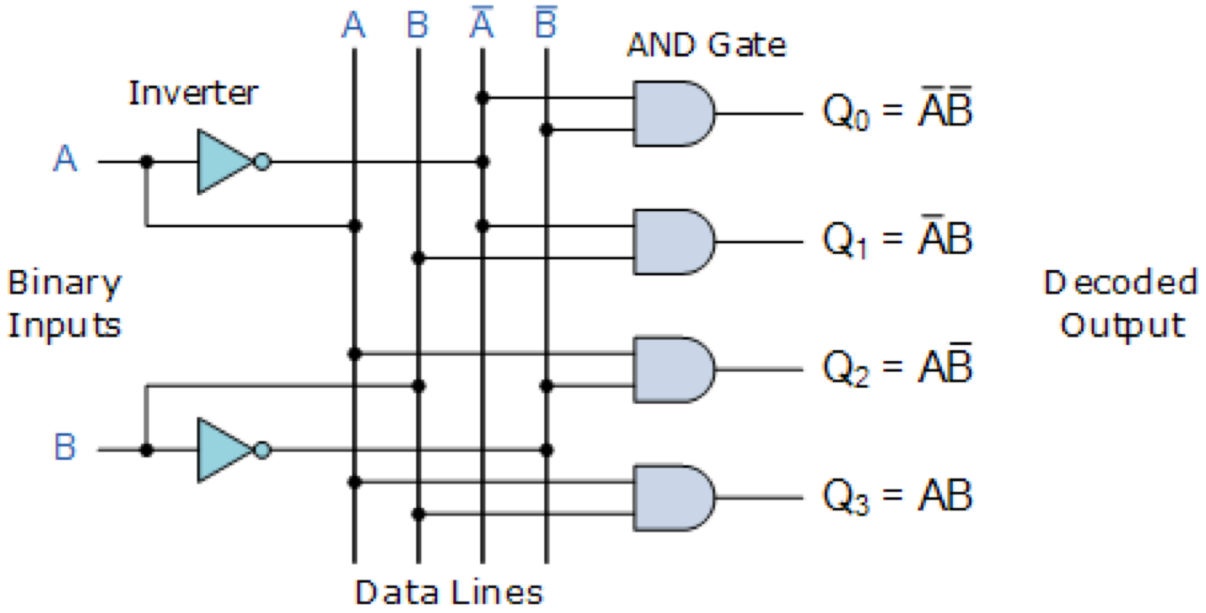
- The Binary Decoder is the exact opposite to that of an “Encoder”
- The name “Decoder” means to translate or decode coded information from one format into another
- A digital decoder transforms a set of digital input signals into an equivalent decimal code at its output

2x4 Decoder



Truth Table

A	B	Q_0	Q_1	Q_2	Q_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



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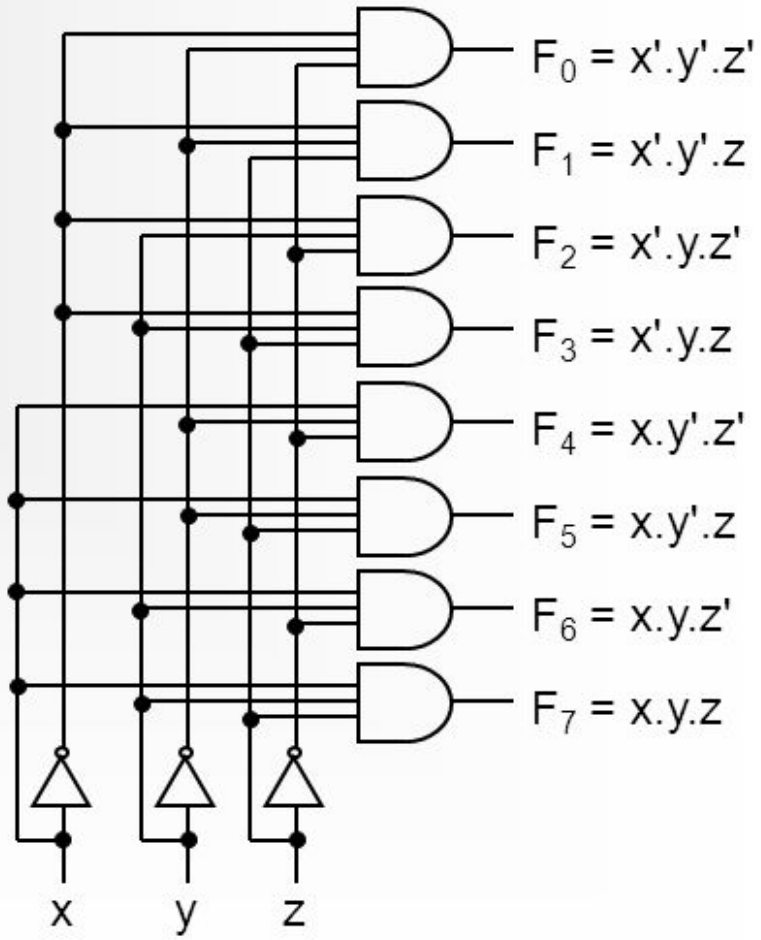
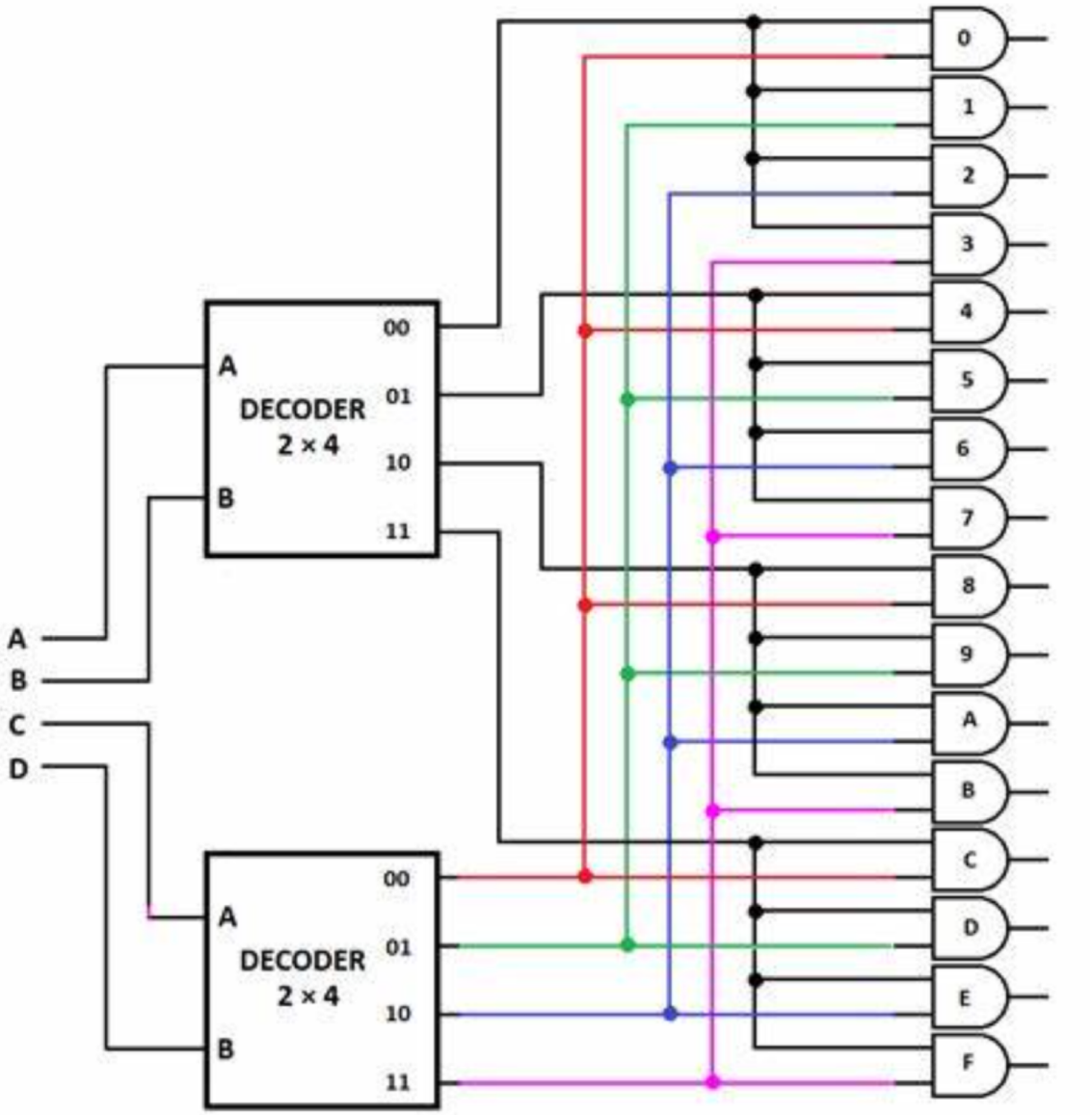
3x8 Decoder

- Design a 3×8 decoder.

x	y	z	F_0	F_1	F_2	F_3	F_4	F_5	F_6	F_7
0	0	0	1	0	0	0	0	0	0	0
0	0	1	0	1	0	0	0	0	0	0
0	1	0	0	0	1	0	0	0	0	0
0	1	1	0	0	0	1	0	0	0	0
1	0	0	0	0	0	0	1	0	0	0
1	0	1	0	0	0	0	0	1	0	0
1	1	0	0	0	0	0	0	0	1	0
1	1	1	0	0	0	0	0	0	0	1

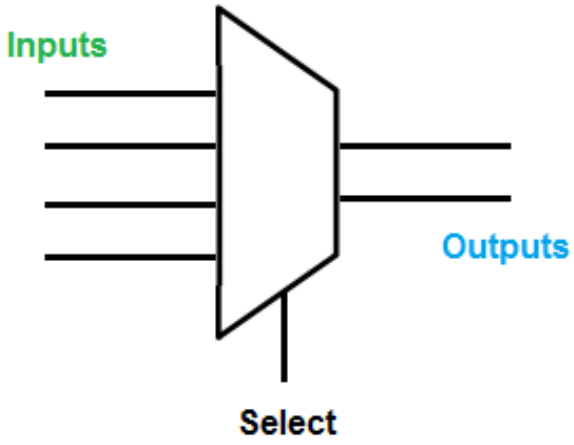


4x16 Decoder (Binary to Hexadecimal)

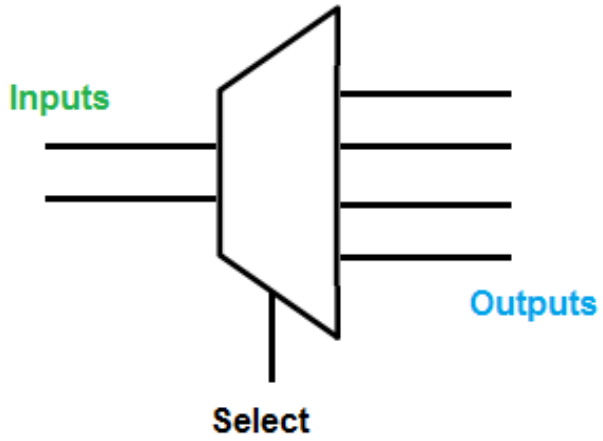


MUX and DeMUX

- The multiplexer and de-multiplexer are used in many applications as a way to reduce the number of wires needed to communicate between subsystems
- The multiplexer and de-multiplexer are represented as trapezoids
- The short end of the trapezoid faces the outputs for a multiplexer and faces the inputs for a de-multiplexer.



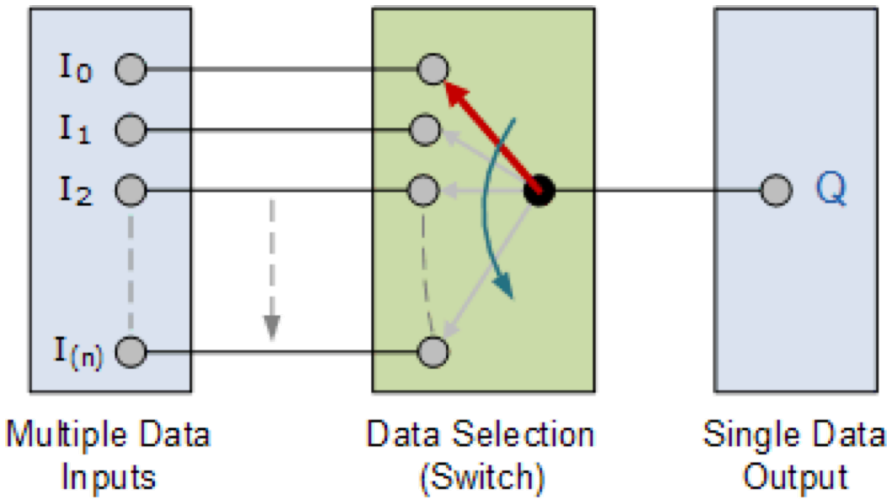
4 x 2 multiplexer



2 x 4 demultiplexer

Multiplexer

- A multiplexer (MUX) is used to select which of the many input signals should be transferred to its output based upon the value of an equivalent binary number or sometimes the binary code decimal (BCD) on the select pins



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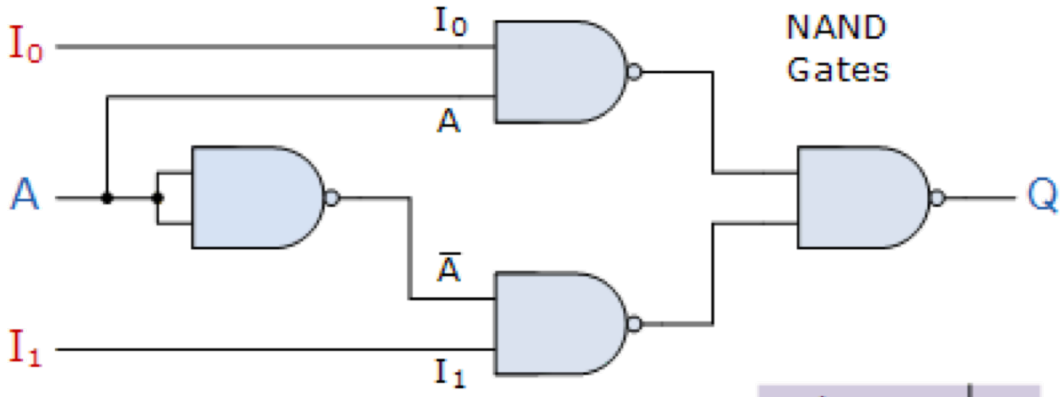
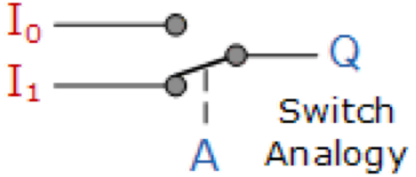
2-input Multiplexer



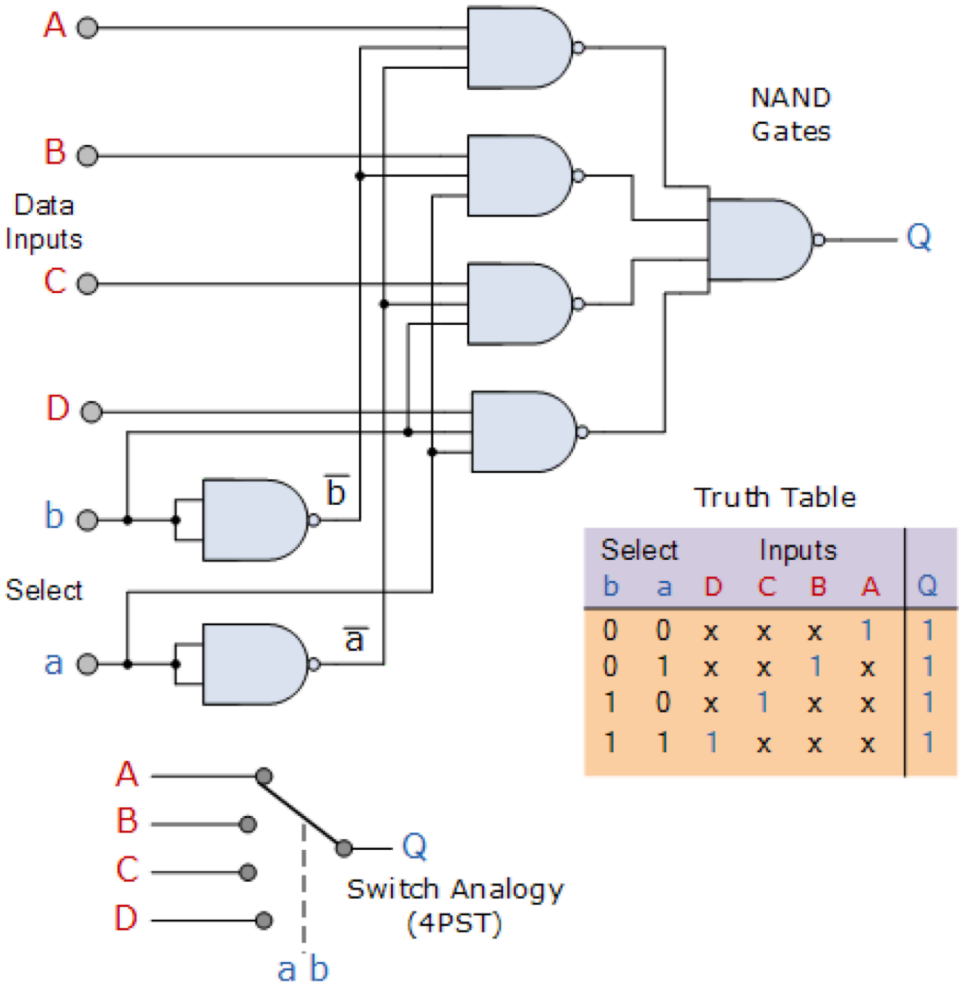


Truth Table

Inputs			
A	I_1	I_0	Q
0	0	0	0
0	0	1	0
0	1	0	1
0	1	1	1
1	0	0	0
1	0	1	1
1	1	0	0
1	1	1	1

http://www.electronics-tutorials.ws/combination/comb_2.html

4-to-1 Channel Multiplexer



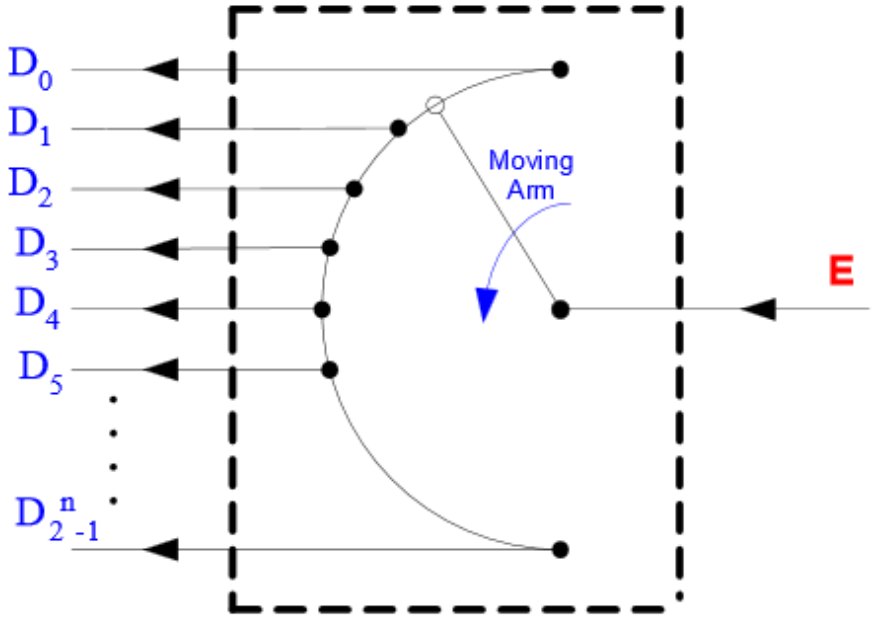
Truth Table

Select		Inputs				
b	a	D	C	B	A	Q
0	0	x	x	x	1	1
0	1	x	x	1	x	1
1	0	x	1	x	x	1
1	1	1	x	x	x	1

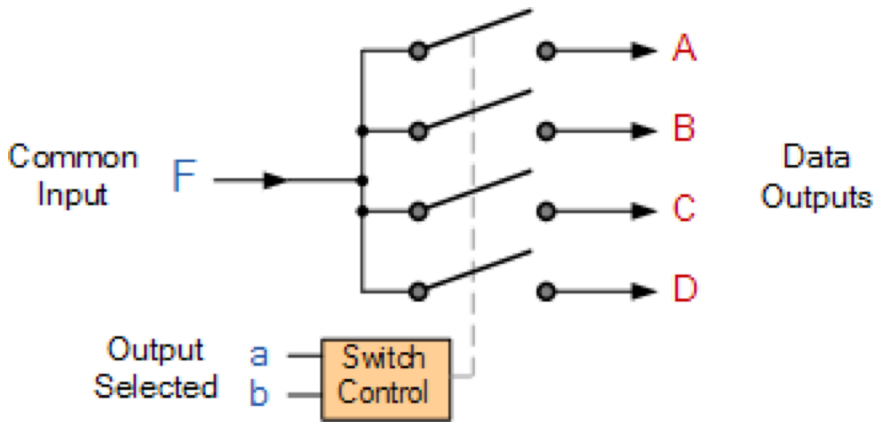
http://www.electronics-tutorials.ws/combination/comb_2.html

Demultiplexer

- A demultiplexer (DeMUX) uses a binary number or binary code decimal select pins to determine which output pin should receive the data at its input



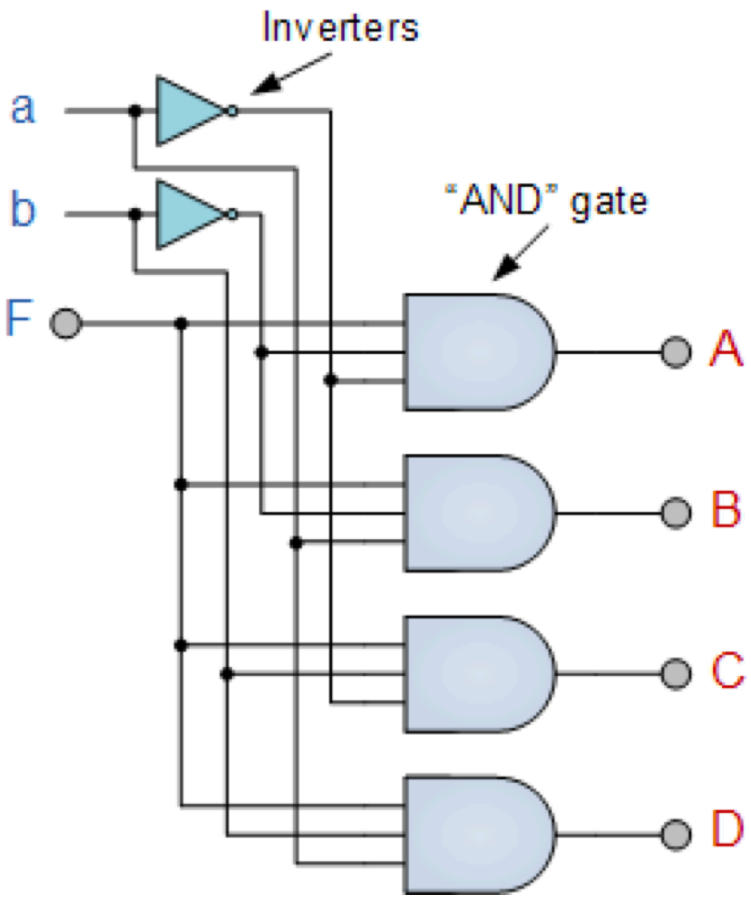
1-to-4 Channel Demultiplexer



Output Select		Data Output Selected
a	b	
0	0	A
0	1	B
1	0	C
1	1	D

http://www.electronics-tutorials.ws/combination/comb_3.html

1-to-4 Channel Demultiplexer



Applications of MUX/DeMUX

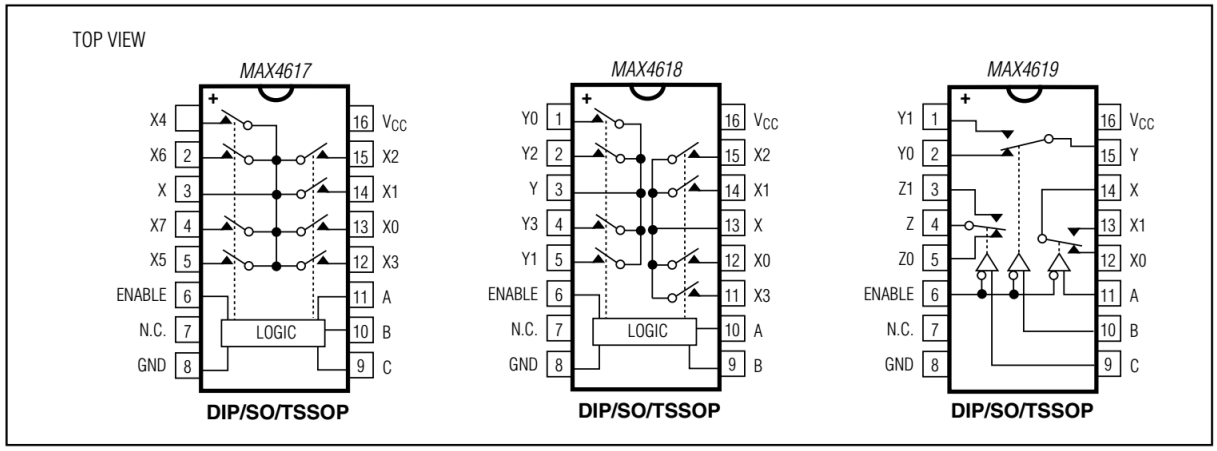
- **Telephone network:** In telephone network, multiple audio signals are integrated on a single line for transmission with the help of multiplexers. At the other end of the network, a de-multiplexer is used to convert a particular signal back to its original form and transfer it to the phone that is supposed to receive the data.
- **Computer memory:** Multiplexers are used to implement huge amount of memory into the computer, at the same time reduces the number of copper lines required to connect the memory to other parts of the computer circuit. In an Arithmetic Logic Unit (ALU) circuit, the output is stored in multiple registers with the help of de-multiplexer.
- **Serial to parallel converter:** Used to reconstruct parallel data from incoming serial data stream. In this technique, data from the incoming serial data stream is the data input to the demultiplexer at the regular intervals. A counter is attach to the control input of the demultiplexer. This counter directs the data signal to the output of the demultiplexer where the data signals are stored. When all data signals have been stored, the output of the demultiplexer can be retrieved and read out in parallel.

MAX4617/MAX4618/ MAX4619

The MAX4617/MAX4618/MAX4619 are high-speed, low voltage, CMOS analog ICs configured as an 8-channel
multiplexer (MAX4617), two 4-channel multiplexers
(MAX4618), and three single-pole/double-throw (SPDT)

switches (MAX4619)

Pin Configurations/Functional Diagrams



MAX4617/MAX4618/MAX4619

High-Speed, Low-Voltage, CMOS Analog Multiplexers/Switches

Table 1. Truth Table/Switch Programming

ENABLE INPUT	SELECT INPUTS			ON SWITCHES		
	C*	B	A	MAX4617	MAX4618	MAX4619
H	X	X	X	All switches open	All switches open	All switches open
L	L	L	L	X–X0	X–X0, Y–Y0	X–X0, Y–Y0, Z–Z0
L	L	L	H	X–X1	X–X1, Y–Y1	X–X1, Y–Y0, Z–Z0
L	L	H	L	X–X2	X–X2, Y–Y2	X–X0, Y–Y1, Z–Z0
L	L	H	H	X–X3	X–X3, Y–Y3	X–X1, Y–Y1, Z–Z0
L	H	L	L	X–X4	X–X0, Y–Y0	X–X0, Y–Y0, Z–Z1
L	H	L	H	X–X5	X–X1, Y–Y1	X–X1, Y–Y0, Z–Z1
L	H	H	L	X–X6	X–X2, Y–Y2	X–X0, Y–Y1, Z–Z1
L	H	H	H	X–X7	X–X3, Y–Y3	X–X1, Y–Y1, Z–Z1

X = Don't care

**C not present on MAX4618.*

Note: *Input and output pins are identical and interchangeable. Either may be considered an input or output; signals pass equally well in either direction.*