CS2100 Tutorial 8

MSI Components

Slides by Theodore, adapted from Prof. Aaron's slides

Recap

- Decoders and Encoders
- Multiplexers and Demultiplexers
- Half adders, Full-adders, Multi-bit adders

Overview

Q1) Using multiplexers

Q2) Implementing boolean functions with decorders

Q3) [Past paper] Block-level design

Q4) [Past paper] Equivalent gate

Q5) [Past paper] Finding boolean function from diagram

Q1) Using multiplexers

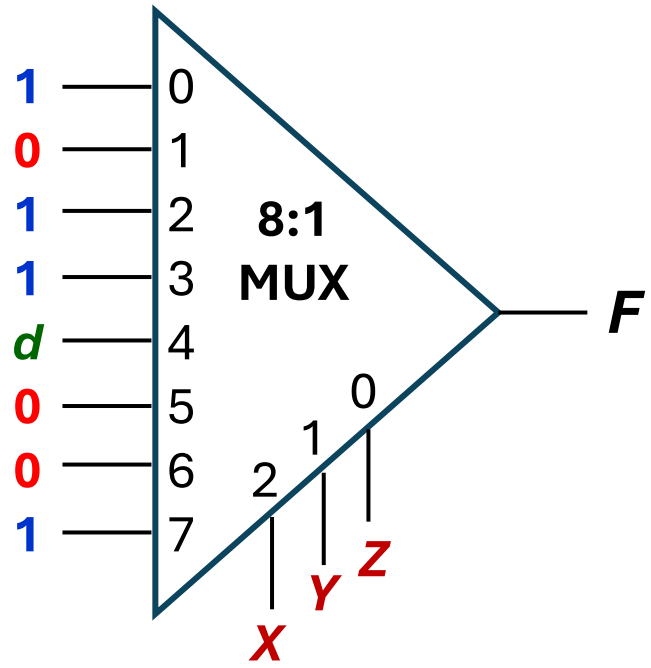
X	Y	Z	F
0	0	0	1
0	0	1	0
0	1	0	1
0	1	1	1
1	0	0	*d*
1	0	1	0
1	1	0	0
1	1	1	1

$$F(X,Y,Z) = \Pi\, M(1,5,6) \cdot D(4)$$

Note:
Using *d* instead of *X* for don't care to avoid confusion with input *X*.

Q1) Using multiplexers

X	Y	Z	F
0	0	0	1
0	0	1	0
0	1	0	1
0	1	1	1
1	0	0	*d*
1	0	1	0
1	1	0	0
1	1	1	1

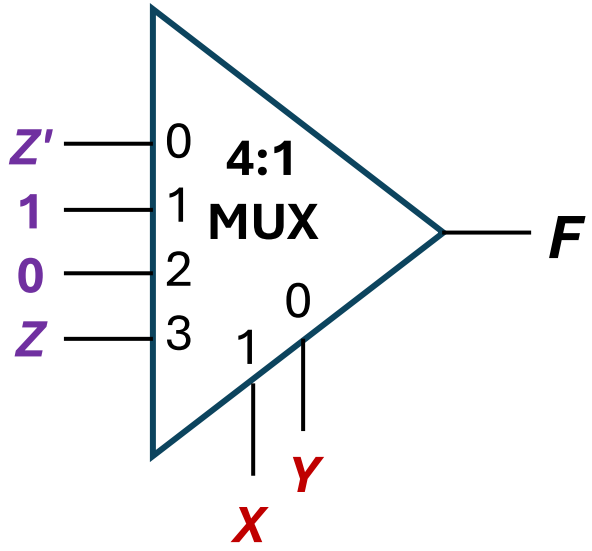


$$F(X,Y,Z) = \Pi\, M(1,5,6) \cdot D(4)$$

Q1) Using multiplexers

X	Y	Z	F	F
0	0	0	1	Z’
0	0	1	0	
0	1	0	1	1
0	1	1	1	
1	0	0	*d*	0 or ~~Z’~~
1	0	1	0	
1	1	0	0	Z
1	1	1	1	

$$F(X,Y,Z) = \Pi\, M(1,5,6) \cdot D(4)$$

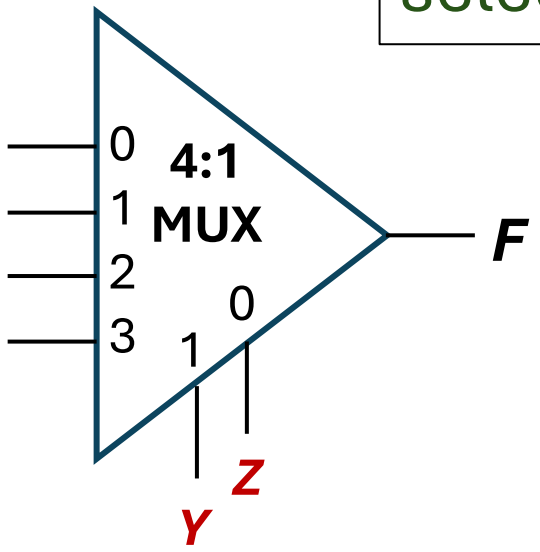


Q1) Using multiplexers

$F(X,Y,Z) = \Pi\, M(1,5,6) \cdot D(4)$

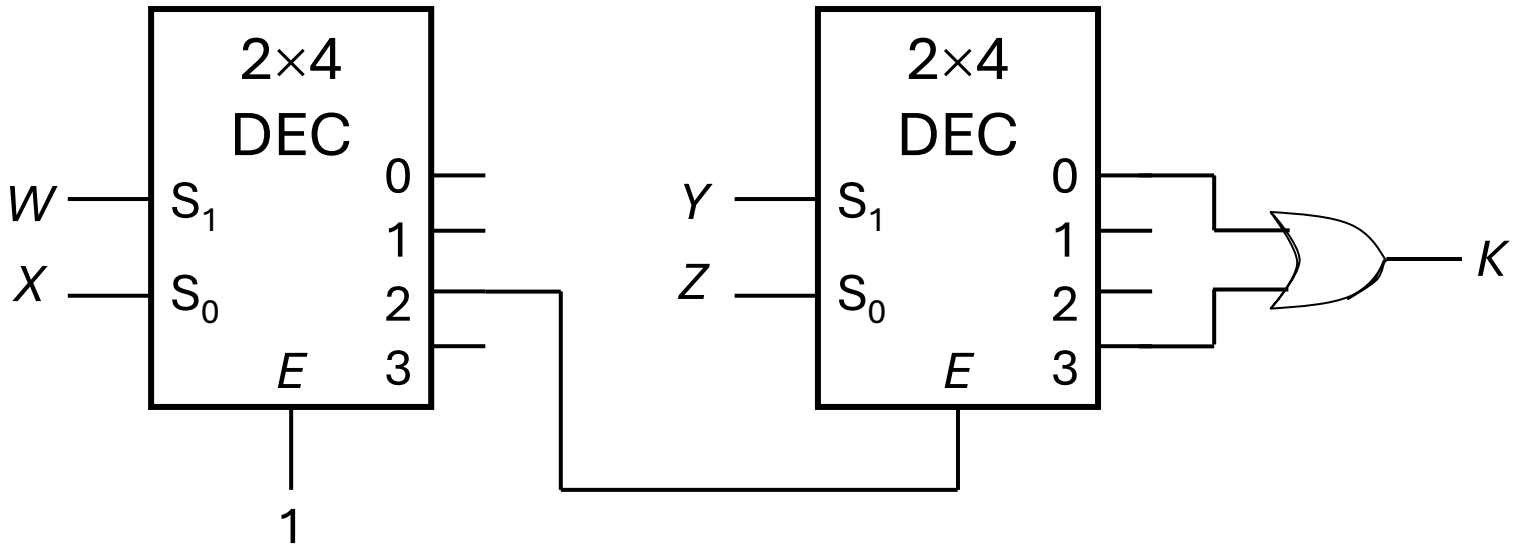
X	Y	Z	F	F
0	0	0	1	Z’
0	0	1	0	
0	1	0	1	1
0	1	1	1	
1	0	0	*d*	0 or ~~Z’~~
1	0	1	0	
1	1	0	0	Z
1	1	1	1	

Extra question:
What if we change the selector lines to *YZ*?



Q2) Is there a simpler circuit?

$K(W,X,Y,Z) = \Sigma\, m(8,11)$



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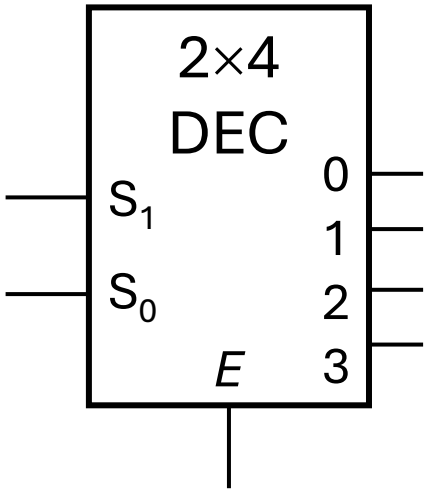


Q3. Designing converter

A	*B*	*C*	*D*	*F*	*G*	*H*
0	0	0	0	0	0	0
1	0	0	0	0	0	1
1	1	0	0	0	1	0
1	1	1	0	0	1	1
1	1	1	1	1	0	0
0	1	1	1	1	0	1
0	0	1	1	1	1	0
0	0	0	1	1	1	1

What is your observation?

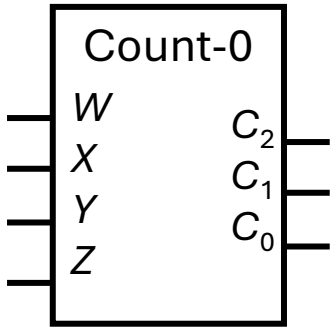
Ideas:

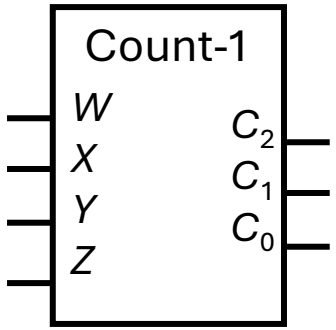
1. If *A*=1 (or *D*=0), count #1s in *ABCD*.
2. If *A*=0…?

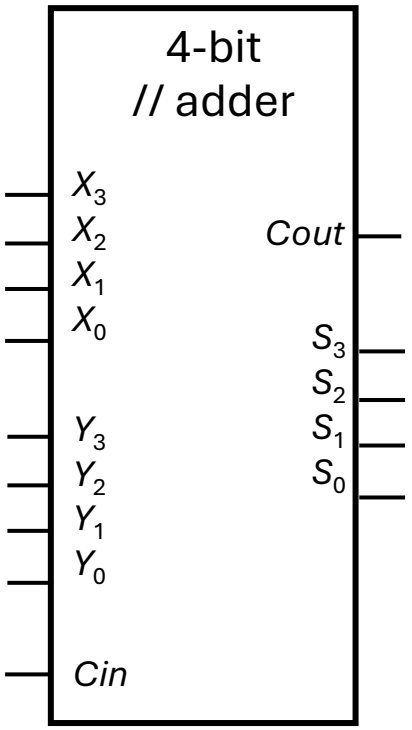
A	B	C	D	F	G	H
0	0	0	0	0	0	0
1	0	0	0	0	0	1
1	1	0	0	0	1	0
1	1	1	0	0	1	1
1	1	1	1	1	0	0
0	1	1	1	1	0	1
0	0	1	1	1	1	0
0	0	0	1	1	1	1

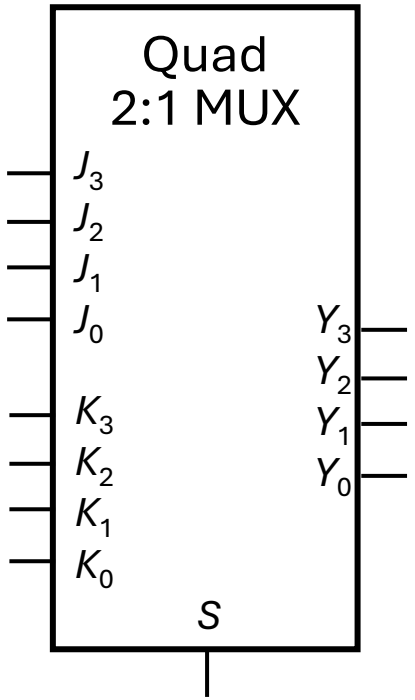
Solution #1

Ideas:
1. If A=1 (or D=0), count #1s in $ABCD$.
2. If A=0 (or D=1), 4 + #0s.





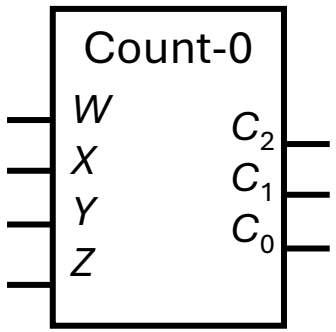


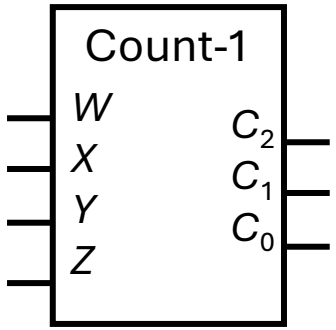


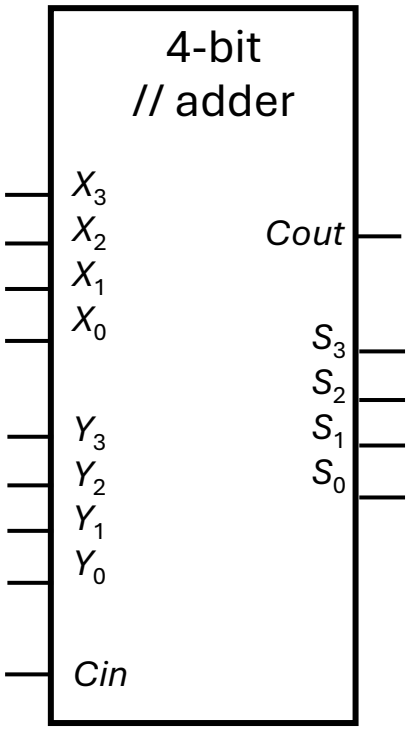
A	B	C	D	F	G	H
0	0	0	0	0	0	0
1	0	0	0	0	0	1
1	1	0	0	0	1	0
1	1	1	0	0	1	1
1	1	1	1	1	0	0
0	1	1	1	1	0	1
0	0	1	1	1	1	0
0	0	0	1	1	1	1

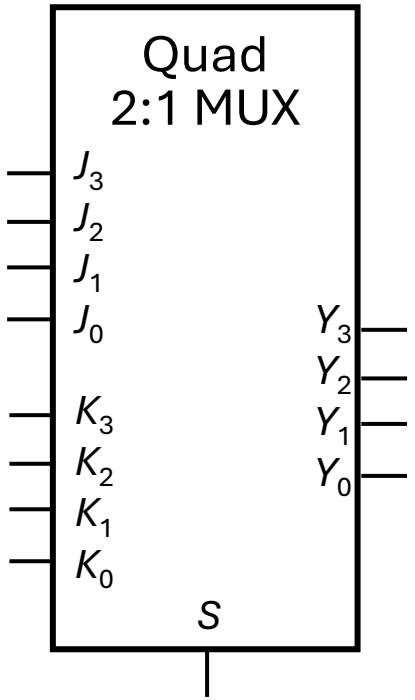
Solution #2

Ideas:
1. If A=1 (or D=0), count #1s in $ABCD$.
2. If A=0 (or D=1), #1s + 2 × #0s.







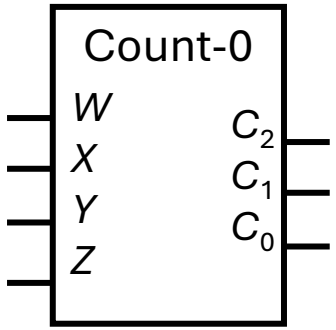


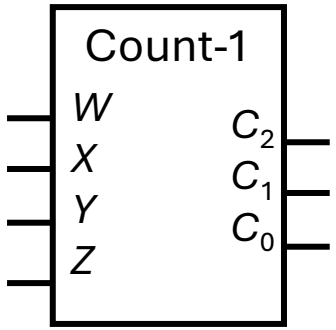
A	B	C	D	F	G	H
0	0	0	0	0	0	0
1	0	0	0	0	0	1
1	1	0	0	0	1	0
1	1	1	0	0	1	1
1	1	1	1	1	0	0
0	1	1	1	1	0	1
0	0	1	1	1	1	0
0	0	0	1	1	1	1

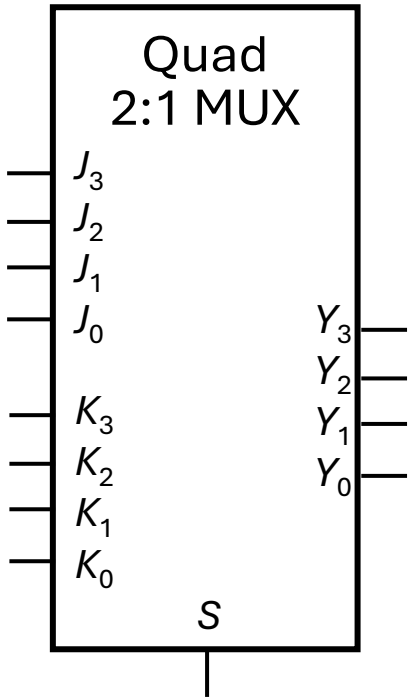
Solution #3

Ideas:

1. D = F
2. If D = 0, GH = #1s in ABCD
3. If D = 1, GH = #0s in ABCD





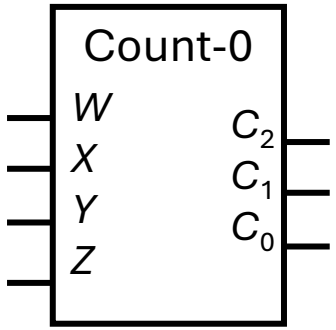


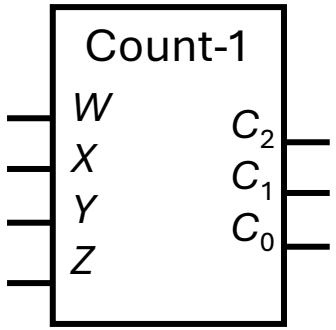
A	B	C	D	F	G	H
0	0	0	0	0	0	0
1	0	0	0	0	0	1
1	1	0	0	0	1	0
1	1	1	0	0	1	1
1	1	1	1	1	0	0
0	1	1	1	1	0	1
0	0	1	1	1	1	0
0	0	0	1	1	1	1

Solution #4

Ideas:

1. F = D
2. G = LSB of #1s in BD
3. H = LSB of #0s in ABCD



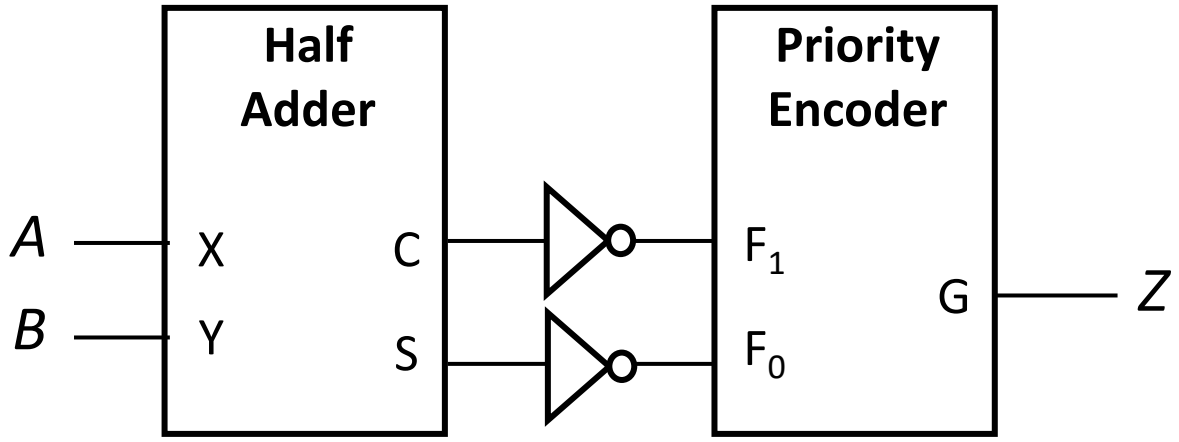


Q4. Equivalent logic gate

NAND gate

A Boolean function $Z(A,B)$ is implemented as shown below.

The circuit may be replaced by a single 2-input logic gate. What is the logic gate?



Half-adder

X	Y	C	S
0	0	0	0
0	1	0	1
1	0	0	1
1	1	1	0

Priority encoder

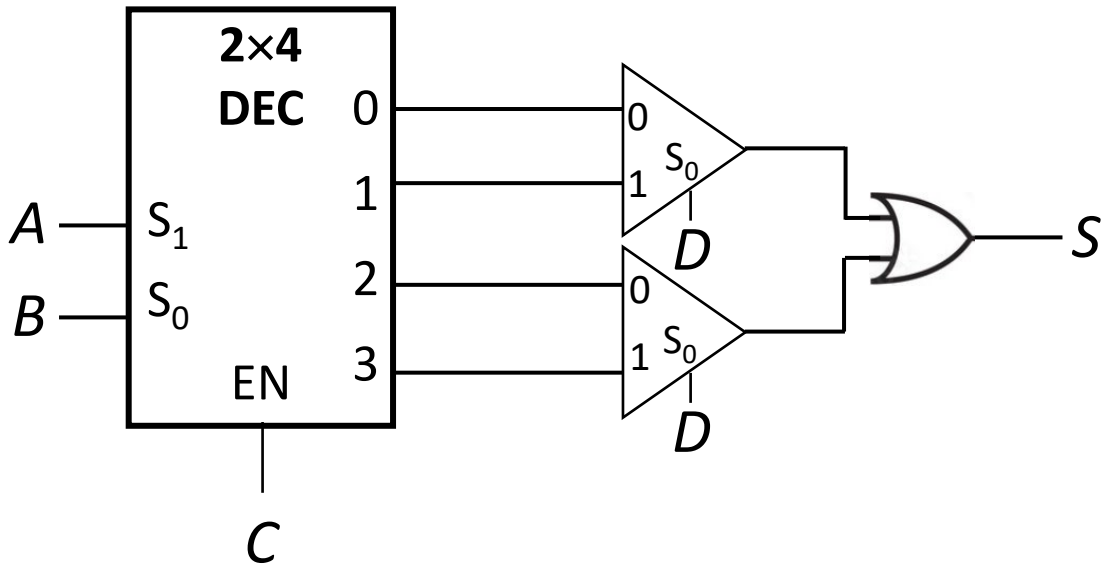
F_1	F_0	G
0	0	X
0	1	0
1	X	1

X	Y	C	S	F_1	F_0	G
0	0	0	0	1	1	1
0	1	0	1	1	0	1
1	0	0	1	1	0	1
1	1	1	0	0	1	0

Q5. Finding boolean fn from diagram

A Boolean function $S(A,B,C,D)$ is implemented with a 2×4 decoder with one-enable, two 2:1 multiplexers and an OR gate as shown below.

What is $S(A,B,C,D)$ in Σm notation?



$S(A,B,C,D) = \Sigma m(\mathbf{2,7,10,15})$.

End of Tutorial 8

- Slides uploaded on github.com/theodoreleebrant/TA-2425S1
- Email: theo@comp.nus.edu.sg
- Anonymous feedback:
  bit.ly/feedback-theodore
  (or scan on the right)

(Also reminder for me to take attendance)