

CPE/EE 422/522

Logic Design Building Blocks

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Alternate Source

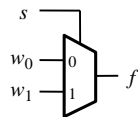
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Combinational Circuit Building Blocks

- Multiplexers
- Decoders
- Encoders
- Code Converters
- Comparators
- Adders/Subtractors
- Multipliers
- Shifters

Multiplexers: - 2-to-1 Multiplexer

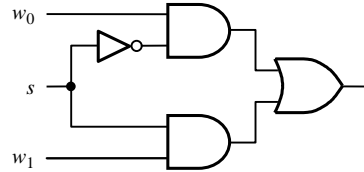
- Think of a multiplexer as selecting between multiple sources which may be multiple bits wide.



(a) Graphical symbol

<i>s</i>	<i>f</i>
0	<i>w</i> ₀
1	<i>w</i> ₁

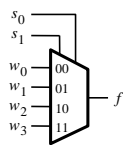
(b) Truth table



(c) Sum-of-products circuit

$$f = s'w_0 + sw_1$$

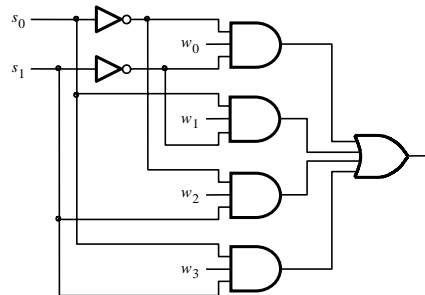
Multiplexers: - 4-to-1 Multiplexer



(a) Graphic symbol

<i>s</i> ₁	<i>s</i> ₀	<i>f</i>
0	0	<i>w</i> ₀
0	1	<i>w</i> ₁
1	0	<i>w</i> ₂
1	1	<i>w</i> ₃

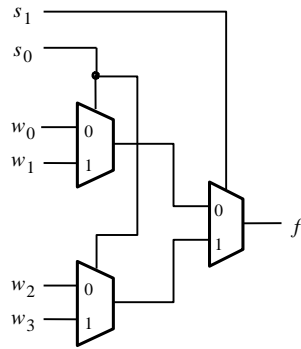
(b) Truth table



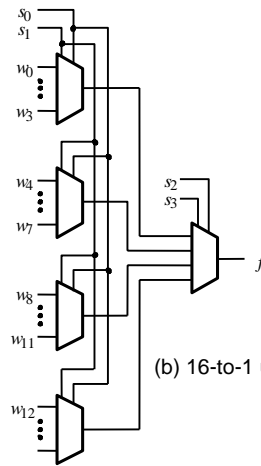
(c) Circuit

f =

Multiplexers - Building Larger Multiplexers



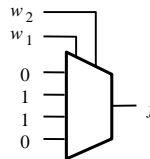
(a) 4-to-1 using 2-to-1



(b) 16-to-1 using 4-to-1

Synthesis of Logic Functions Using Multiplexers

w_1	w_2	f
0	0	0
0	1	1
1	0	1
1	1	0

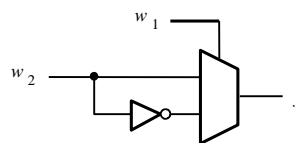


(a) Implementation using a 4-to-1 multiplexer

w_1	w_2	f
0	0	0
0	1	1
1	0	1
1	1	0

w_1	f
0	w_2
1	\bar{w}_2

(b) Modified truth table

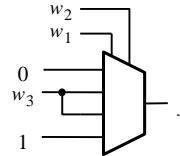


(c) Circuit

Synthesis of Logic Functions Using Multiplexers - Another Example

w_1	w_2	w_3	f
0	0	0	0
0	0	1	0
0	1	0	0
0	1	1	1
1	0	0	0
1	0	1	1
1	1	0	1
1	1	1	1

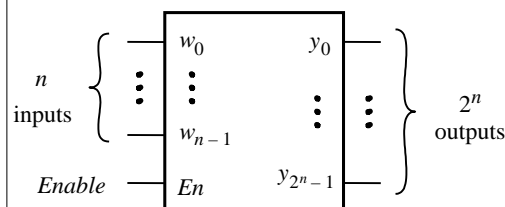
(a) Modified truth table



(b) Circuit

Decoders - n-to- 2^n Decoder

- If $En = 1$, _____
- If $En = 0$, _____
- One-hot encoded output

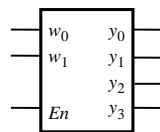


$$\begin{aligned}
 y_0 &= w_{n-1}' \dots w_1' w_0' En \\
 y_1 &= w_{n-1}' \dots w_1' w_0 En \\
 y_2 &= w_{n-1}' \dots w_1 w_0' En \\
 &\dots \\
 y_{2^n-1} &= w_{n-1} \dots w_1 w_0 En
 \end{aligned}$$

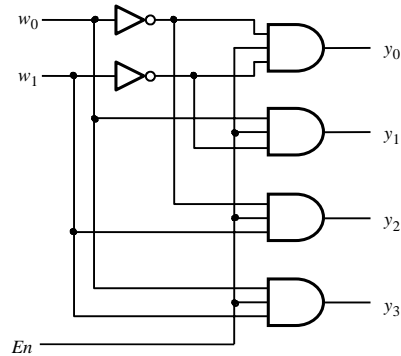
Decoders - 2-to-4 Decoder

En	w_1	w_0	y_0	y_1	y_2	y_3
1	0	0	1	0	0	0
1	0	1	0	1	0	0
1	1	0	0	0	1	0
1	1	1	0	0	0	1
0	x	x	0	0	0	0

(a) Truth table



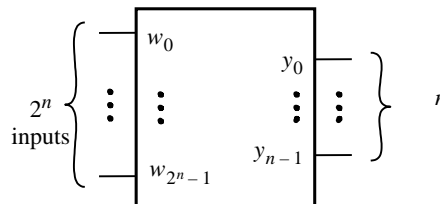
(b) Graphic symbol



(c) Logic circuit

Encoders

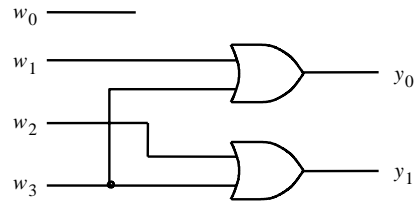
- Opposite of decoders
 - _____
- Binary encoders
 - _____
 - Exactly _____ of the input signals should have a value of 1, and outputs present the _____ that identifies which input is equal to 1
- Use: reduce the number of bits (transmitting and storing information)



Encoders 4-to-2 Encoder

w_3	w_2	w_1	w_0	y_1	y_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

(a) Truth table



(b) Circuit

Encoders: Priority Encoders

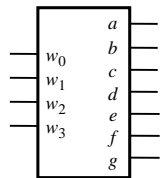
- Each input has a priority level associated with it
- The encoder outputs indicate the active input that has the highest priority

(a) Truth table for a 4-to-2 priority encoder

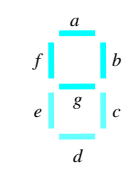
w_3	w_2	w_1	w_0	y_1	y_0	z
0	0	0	0	d	d	0
0	0	0	1	0	0	1
0	0	1	x	0	1	1
0	1	x	x	1	0	1
1	x	x	x	1	1	1

Code Converters

- Convert from one type of input encoding to a different output encoding
 - E. g., BCD-to-7-segment decoder



(a) Code converter



(b) 7-segment display

w_3	w_2	w_1	w_0	a	b	c	d	e	f	g
0	0	0	0	1	1	1	1	1	1	0
0	0	0	1	0	1	1	0	0	0	0
0	0	1	0	1	1	0	1	1	0	1
0	0	1	1	1	1	1	1	0	0	1
0	1	0	0	0	1	1	0	0	1	1
0	1	0	1	1	0	1	1	0	1	1
0	1	1	0	1	0	1	1	1	1	1
0	1	1	1	1	1	1	0	0	0	0
1	0	0	0	1	1	1	1	1	1	1
1	0	0	1	1	1	1	1	0	1	1

(c) Truth table