12.8 Muxes

Basics

A ***multiplexor*** is a combinational circuit that passes one of multiple data inputs through to a single output, selecting which one based on additional control inputs. ***Mux*** is short for multiplexor. A mux's control inputs are called ***select lines***.

Analogy: Due to road construction, four lanes (the data inputs) may be reduced to a single lane (the single output). A policeman (the select inputs) selects which one lane currently passes through by blocking the other lanes.

A ***4x1 mux***, spoken as "4 to 1 mux", has 4 data inputs, 1 data output, and requires 2 select inputs.

PARTICIPATION ACTIVITY   12.8.1: A 4x1 mux.

Start   ☐ 2x speed

i3	Mux
i2	
i1	y
i0	
s1 s0	

s1	s0	y
0	0	i0
0	1	i1
1	0	i2
1	1	i3

1   1

PARTICIPATION ACTIVITY   12.8.2: Muxes.

Given a 4x1 mux. Assume i3 i2 i1 i0 are 0 1 1 0.

1) If s1s0 = 00, then y = _____ .
   - ○ 1
   - ○ 0

2) If s1s0 = 10, then y = _____ .
   - ○ 1
   - ○ 0

3) s1s0 = _____ allows i3 to pass through to y.
   - ○ 10
   - ○ 11

4) Suppose s1s0 = 11, and i3 is 0, so y = 0. Then, suppose i3 changes from 0 to 1. What will y become?
   - ○ 1
   - ○ 0

Mux equation and circuit

A mux's truth table can be converted to an equation, and then to a circuit.

PARTICIPATION ACTIVITY   12.8.3: A 4x1 mux's behavior can be captured as an equation.

Start   ☐ 2x speed

i3	Mux
i2	
i1	y
i0	
s1 s0	

s1	s0	y
0	0	i0
0	1	i1
1	0	i2
1	1	i3

$y = s1's0' \, i0 + s1's0 \, i1 + s1s0' \, i2 + s1s0 \, i3$

Let s1s0 = 11

$y = (1)'(1)' \, i0 + (1)'(1) \, i1 + (1)(1)' \, i2 + (1)(1)i3$

$y = (0)(0) \, i0 + (0)(1) \, i1 + (1)(0) \, i2 + (1)(1)i3$

$y = \quad 0 \quad + \quad 0 \quad + \quad 0 \quad + \quad i3$

$y = i3$

PARTICIPATION ACTIVITY   12.8.4: The equation for a 4x1 mux is easily converted to a circuit.

Start   ☐ 2x speed
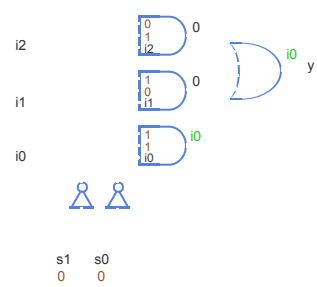
i3

$y = s1's0'i0 + s1's0i1 + s1s0'i2 + s1s0i3$

$i2$

0 0
0 1
$i2$
0

$i1$

1 0
0 0
$i1$
0

Let s1s0 = 00

$y = (0)'(0)'\ i0\ \ + (0)'(0)i1\ \ + (0)(0)'i2\ \ + (0)(0)\ i3$

$i0$

1 1
0 0
$i0$

$y = (1)(1)i0 + (1)(0)i1 + (0)(1)i2 + (0)(0)i3$

$y = \ \ i0\ \ \ \ + \ \ \ 0\ \ \ \ + \ \ \ 0\ \ \ \ + \ \ \ 0$

$i0$
y

$y = \ \ i0$

s1   s0
0   0

PARTICIPATION ACTIVITY   12.8.5: Mux design.

1) How many select lines does a 4x1 mux require?

   [   ]

   Check   Show answer

2) If s1s0 = 01, then y = _____ .
   Type: i0, i1, i2, or i3

   [   ]

   Check   Show answer

3) y = _____ + s1's0i1 + s1s0'i2 + s1s0i3

   [   ]
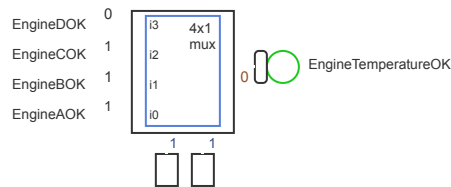
   Check   Show answer

Example: Jet cockpit engine status display

A jet cockpit has limited space for switches and lights. A particular jet has four "Engine OK" inputs coming from sensors at each of four engines. The cockpit has a single "Engine temperature OK" light, and two switches for pilots to select among the four Engine OK inputs. A circuit should pass the selected sensor input to the light.

A 4x1 mux readily achieves the desired behavior.

PARTICIPATION ACTIVITY   12.8.6: Mux example: Jet cockpit status light display.

Start   [ ] 2x speed

EngineDOK   0   i3   4x1
EngineCOK   1   i2   mux
EngineBOK   1   i1   0   EngineTemperatureOK
EngineAOK   1   i0

            1   1

PARTICIPATION ACTIVITY   12.8.7: Engine status display.

Consider the example above.

1) If the pilots set the switches to 00, will the light illuminate?

   O Yes
   O No

2) If the pilots set the switches to 11, will the light illuminate?

   O Yes
   O No

3) Suppose the switches are set to 11, and Engine D's status input is 0, so the light is not illuminated. Now suppose the pilots fix the problem with Engine D, such that D's status changes from 0 to 1. Will the light illuminate?
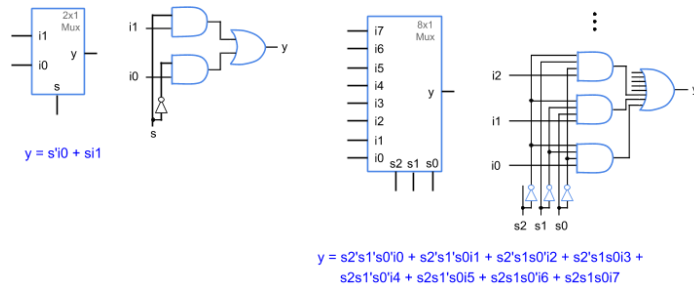
   O Yes

○ No

Mux sizes

Mux sizes may be 2x1, 4x1, 8x1, 16x1, etc. For N data inputs, a mux requires $\log_2 N$ select inputs.

Figure 12.8.1: 2x1 and 8x1 muxes.

$y = s'i0 + si1$

$y = s2's1's0'i0 + s2's1's0i1 + s2's1s0'i2 + s2's1s0i3 +$
$s2s1's0'i4 + s2s1's0i5 + s2s1s0'i6 + s2s1s0i7$

PARTICIPATION ACTIVITY	12.8.8: Muxes.

1) How many select lines does a 2x1 mux require?

Check   Show answer

2) How many select lines does an 8x1 mux require?

Check   Show answer

3) How many select lines does a 16x1 mux require?

Check   Show answer

4) How many AND gates does a 2x1 mux require?

Check   Show answer

5) How many AND gates does an 8x1 mux require?

Check   Show answer

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