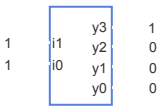
12.9 Decoders

Basics

A ***decoder*** is a combinational circuit that converts N inputs to a 1 on one of 2^N outputs. A ***2x4 decoder***, spoken as "2 to 4 decoder", converts two inputs to a 1 on exactly one of four outputs.

PARTICIPATION ACTIVITY 12.9.1: A 2x4 decoder.

Start ☐ 2x speed



i1	i0	y3	y2	y1	y0
0	0	0	0	0	1
0	1	0	0	1	0
1	0	0	1	0	0
1	1	1	0	0	0

PARTICIPATION ACTIVITY 12.9.2: 2x4 decoder.

Consider a 2x4 decoder.

1) If i1i0 = 00, then y1 = _____ .

Check **Show answer**

2) If i1i0 = 01, then y1 = _____ .

Check **Show answer**

3) i1i0 = _____ configures the decoder to output y0 = 0, y1 = 0, y2 = 0, and y3 = 1.

Check **Show answer**

4) How many outputs are set to 1 at any given time?
Type: 0, 1, 2, 3, or 4

Check **Show answer**

5) i1i0 = _____ configures the decoder to output y0 = 0, y1 = 0, y2 = 1, and y3 = 1.
Type: 00, 01, 10, 11, or ** if not possible.

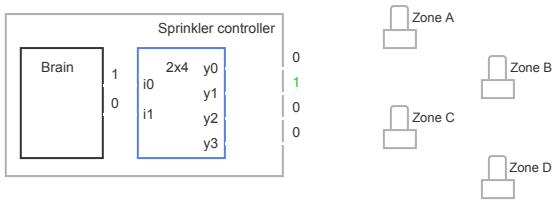
Check **Show answer**

Example: Lawn sprinkler controller

A lawn sprinkler system may have multiple zones. A sprinkler controller activates only one zone at a time, due to limited incoming water. The brain of the controller, typically a small computer, may encode the active zone in binary on output pins, to save pins: If a system has 8 zones, only 3 pins are needed, while 4 zones need only 2 pins. A decoder can convert the binary encoded zone into the activation of the appropriate zone.

PARTICIPATION ACTIVITY 12.9.3: Lawn sprinkler example using a decoder.

Start ☐ 2x speed



PARTICIPATION ACTIVITY 12.9.4: Lawn sprinkler system with a decoder.

Consider the example above.

1) If the brain outputs 11, what zone is activated?
   - A
   - D

2) What brain output values will activate all zones at once?
   - 11
   - No such values

3) If a system has 32 zones instead of 4, how many outputs would the brain need?
   - 4
   - 5
   - 32

Decoder equation and circuit

A 2x4 decoder has four outputs. Each output's behavior is easily converted to an equation and then to a circuit.

PARTICIPATION ACTIVITY 12.9.5: Each decoder output is easily converted to an equation and circuit.

Start 2x speed

i1	i0	y3	y2	y1	y0	
0	0	0	0	0	1	y0 = i1'i0'
0	1	0	0	1	0	y1 = i1'i0
1	0	0	1	0	0	y2 = i1i0'
1	1	1	0	0	0	y3 = i1i0

PARTICIPATION ACTIVITY 12.9.6: Decoder design.

1) How many inputs does a 2x4 decoder have?

   Check Show answer

2) How many outputs does a 2-input decoder have?

   Check Show answer

3) How many AND gates does a 2x4 decoder require?

   Check Show answer

4) How many OR gates does a 2x4 decoder require?

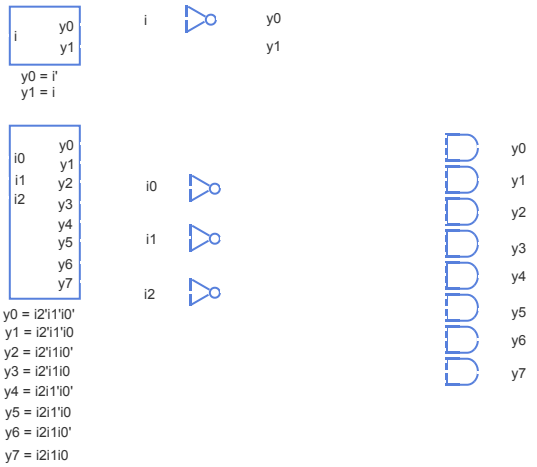
   Check Show answer

Decoder sizes

Other size decoders can be designed similarly.

PARTICIPATION ACTIVITY 12.9.7: Designing other sized decoders.

Start 2x speed



PARTICIPATION ACTIVITY 12.9.8: Various sized decoders.

1) How many inputs are required for a decoder with 8 outputs?

Check Show answer

2) How many inputs are required for a decoder with 2 outputs?

Check Show answer

3) How many outputs does a 2-input decoder have?

Check Show answer

4) How many outputs does a 4-input decoder have?

Check Show answer

5) How many AND gates does a 3x8 decoder require?

Check Show answer

6) How many OR gates does a 5x32 decoder require?

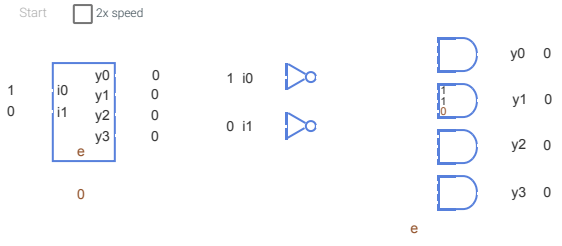
Check Show answer

Decoder with enable

Some decoders have an additional input called an ***enable input*** that when 0 sets all outputs to 0s, and when 1 enables the decoder for normal behavior.

A decoder's equations and circuit are easily extended for an enable input by including the enable in each AND.

PARTICIPATION ACTIVITY 12.9.9: A decoder with an enable input.



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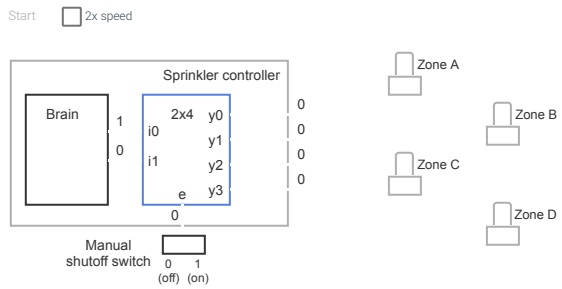
PARTICIPATION ACTIVITY 12.9.10: Lawn sprinkler example using a decoder.



PARTICIPATION ACTIVITY 12.9.11: Decoders with enable.

1) If i1i0 = 01 and enable = 1, then y1 = ____.

Check Show answer

2) If i1i0 = 00 and enable = 1, then y1 = ____.

Check Show answer

3) If i1i0 = 11 and enable = 0, then y3 = ____.

Check Show answer

Provide feedback on this section