3.14 Top-down design + examples

Top-down design: Capture, convert

Designers commonly follow a two-step design process:

1. ***Capture***: The task of precisely describing a circuit's desired behavior.
2. ***Convert*** (aka ***implement***): The task of translating captured behavior into a circuit.

Capture: For combinational circuits, designers commonly capture behavior as truth tables or equations.

Convert: A truth table can be converted to an equation first by ORing the minterms of each table row having an output 1. An be converted to a circuit by multiplying out to product terms (if not already), with each term becoming an AND gate, followe gate.

PARTICIPATION ACTIVITY 3.14.1: Top-down design: Capture, convert.

Consider a designer who wishes to design a circuit. Order the steps.

Convert: Truth table to equation. **Convert: Equation to circuit.** **Capture as truth table**

Use the circuit

(A)

(B)

(C)

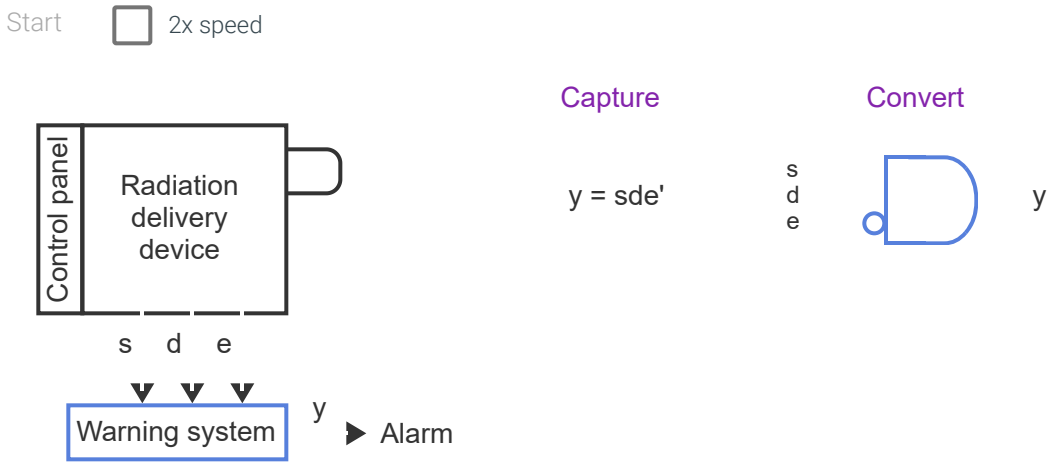
(D)

Reset

Example: Medical radiation therapy device

A particular medical device delivers radiation to a patient to treat cancer. The device has two radiation strength levels, low ((s = 1). The device has two radiation durations: short (d = 0) and long (d = 1). The device normally is used to deliver high str duration, or low strength for long duration. A hardware safety component can be enabled (e = 1) that detects high strength and automatically turns off the device after a minute, but on rare occasion a radiation therapist may disable that componer accidents, a designer wishes to sound an alarm if the device is ever configured to high strength for long duration with the s

PARTICIPATION ACTIVITY 3.14.2: Medical radiation therapy device: Warning system.



PARTICIPATION ACTIVITY 3.14.3: Radiation delivery device.

Consider the radiation delivery device above.

1) For the warning system, how many inputs exist?

Check Show answer

2) A truth table would have had how many rows?

Check Show answer

3) The designer captured the desired behavior using what equation?

Check Show answer

4) The equation converted to how many AND and OR gates total?

Check Show answer

Exploring further:

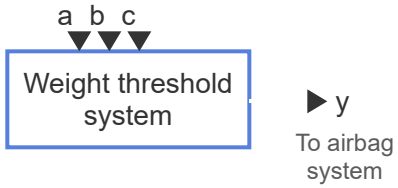
- Therac-25 : A well-known radiation therapy device with a bug that caused patient injury/death. (Source: Wikipedia)

Example: Weight threshold

A car's seat weight sensor provides three values a, b, c, to a system, indicating an object's relative weight in binary, ranging (heaviest). A designer wishes to design a "weight threshold" system that activates an airbag system (y = 1) if the weight is For this system, the designer chooses to capture desired behavior with a truth table, then converts to a circuit.

PARTICIPATION ACTIVITY 3.14.4: Weight threshold system.

Start 2x speed

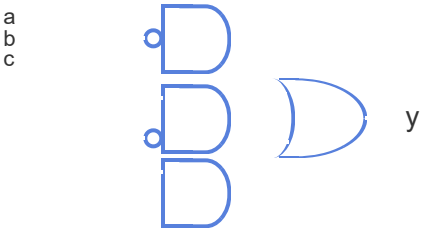


Capture

a	b	c	y
0	0	0	0
0	0	1	0
0	1	0	0
0	1	1	0
1	0	0	0
1	0	1	1
1	1	0	1
1	1	1	1

Convert

y = ab'c + abc' + abc



PARTICIPATION ACTIVITY 3.14.5: Weight threshold system.

Consider the weight threshold system above.

1) To capture the system's behavior, the designer used _____ .
   - ○ a truth table
   - ○ an equation

2) To convert the captured behavior to a circuit, the designer first _____ .
   - ○ simplified
   - ○ converted to an equation

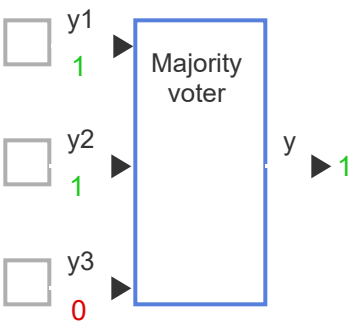
3) To continue converting, the designer converted an equation to _____ .
   - ○ gates
   - ○ a truth table

Example: Majority voter circuit

Some systems are more prone to errors due to complexity or noise. And, some systems cannot tolerate errors. Ex: Spacecı complex control systems, are prone to errors due to noise/vibrations/heat, and may crash or explode if digital circuit outpu Such systems often have three independent calculations of output, and then use a circuit to take a majority vote, an arrang *triple modular redundancy*.

PARTICIPATION ACTIVITY 3.14.6: Majority voter circuit.

Start ☐ 2x speed

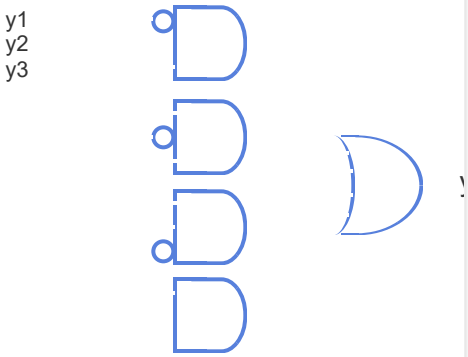


Capture

y1	y2	y3	y
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

Convert

$y = y1'y2y3 + y1y2'y3 + y1y2y3' + y1y2y3$



PARTICIPATION ACTIVITY 3.14.7: Majority voter circuit.

Consider the example above.

1) The gray boxes on the left each _____ .
   - are majority voter circuits
   - carry out different functions
   - carry out the same function

2) The majority voter circuit has three inputs. What other number of inputs would be most reasonable?
   - One
   -

- Five
- Twenty nine

3) If the inputs to the majority voter circuit are 1 0 1, the output should be _____ .
   - 0
   - 1
   - Error

4) The inputs to the voter circuit are _____ .
   - always the same
   - always different
   - usually the same

5) The voter circuit _____ correct output.
   - helps yield
   - guarantees

Exploring further:

- Triple modular redundancy (Source: Wikipedia)

Provide feedback on this section