11.13 Top-down design + examples

This section has been set as optional by your instructor.

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, possibly involving simplification.

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 equation can be converted to a circuit by multiplying out to product terms (if not already), with each term becoming an AND gate, followed by one OR gate.

PARTICIPATION ACTIVITY 11.13.1: Top-down design: Capture, convert.

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

Convert: Truth table to equation | Capture as truth table | Convert: Equation to circuit | Use the circuit

(A)

(B)

(C)

(D)

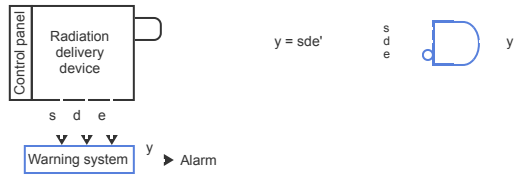
Reset

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

PARTICIPATION ACTIVITY 11.13.2: Medical radiation therapy device: Warning system.

Start 2x speed



PARTICIPATION ACTIVITY 11.13.3: 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:

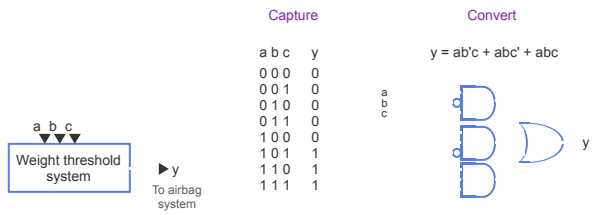
- Therac-25 : A well-known radiation therapy device with a bug that caused patient injury/death. (Source: Wikipedia)

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 from 000 to 111 (heaviest). A designer wishes to design a "weight threshold" system that activates an airbag system (y = 1) if the weight is 101 (5) or more. For this system, the designer chooses to capture desired behavior with a truth table, then converts to a circuit.

PARTICIPATION ACTIVITY 11.13.4: Weight threshold system.

Start 2x speed



PARTICIPATION ACTIVITY 11.13.5: 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

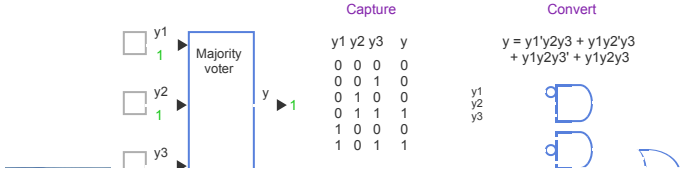
3) To continue converting, the designer converted an equation to ____ .
   - gates
   - a truth table

Example: Majority voter circuit

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

PARTICIPATION ACTIVITY 11.13.6: Majority voter circuit.

Start 2x speed



PARTICIPATION ACTIVITY 11.13.7: Majority voter circuit.

Consider the example above.

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

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

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

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

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

Exploring further:

- Triple modular redundancy (Source: Wikipedia)

Provide feedback on this section