11.6 Equations to/from circuits

Equations to circuits

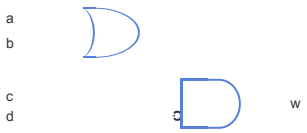
An equation is one way to represent a Boolean function. Another way is using a circuit.

An equation can be converted to a circuit by converting each operation to a gate. Conversion is done first for items within parentheses. In a term like cd', NOT is converted before AND or OR. Converting behavior (like an equation) to a circuit is called ***design***.

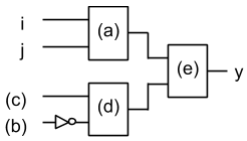
PARTICIPATION ACTIVITY 11.6.1: Convert equation to circuit.

Start 2x speed

w = (a + b)cd'



PARTICIPATION ACTIVITY 11.6.2: Converting an equation to a circuit.



Use the figure above to determine the missing value.
Original equation: y = ij + mn'

1) (a)
- AND
- OR
- NOT

2) (b)
- m
- n
- mn'
- i

3) (c)
- m
- n
- mn'
- i

4) (d)
- AND
- OR
- NOT

5) (e)
- AND
- OR
- NOT

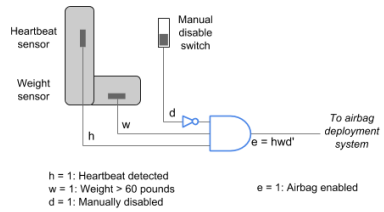
Example: Airbag enabler

Figure 11.6.1: Airbags deployed.

Cars have airbags that deploy during an accident to reduce injuries to occupants. Airbags can harm kids, and aren't needed for non-human objects. Thus, cars have sensors to help detect whether an airbag should be enabled by a large enough human being seated. In one car, a seat back sensor detects a heartbeat (h = 1). A seat bottom sensor indicates if over 60 pounds is detected (w = 1). A switch can be used to manually disable the airbags (d = 1). An output e indicates that the airbag is enabled (e = 1).

A designer specifies the system as: e = hwd' (heartbeat detected, and enabled if weight over 60, and not manually disabled).

Figure 11.6.2: Airbag enabler system.



PARTICIPATION ACTIVITY 11.6.3: Airbag example.

1) What is h if a heartbeat is detected?

Check Show answer

2) What is w if the sensed weight is 30 pounds?

Check Show answer

3) What is e if h = 1, w = 1, and d = 1?

Check Show answer

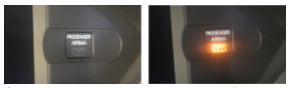
4) e becomes an input to another system, the airbag deployment system. That system has another input to detect a hard front-end collision (c = 1). That system's output a should be 1 if a hard collision is detected and the airbag is enabled. Write the equation for a.

Check Show answer

5) Write an equation to deploy the airbag (a = 1) only if a collision is detected (c = 1) and the airbag is enabled. Use input variables h, w, d, c only (do not use e). Order input variables alphabetically. Do not use parentheses.

Check Show answer

6) A light illuminates if the airbag is disabled. Which is the appropriate equation to turn on the light (o = 1)?
o = h'w'd
o = (hwd')'



(Note: Answer by re-typing one of the equations provided)

Check Show answer

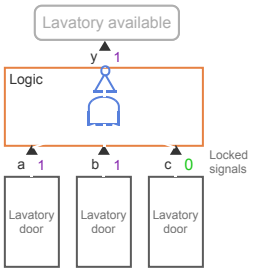
Example: Aircraft lavatory sign

Airplanes typically have a lighted sign to let passengers know if at least one of several lavatories (bathrooms) is available, so that passengers can choose to stay seated until a bathroom becomes available. A designer may think about the logic as follows: If all doors are locked, the sign should be off, otherwise the sign should be on. From that thought, the designer may create an equation.

PARTICIPATION ACTIVITY 11.6.4: Aircraft lavatory sign.

Start 2x speed

y = (abc)'



PARTICIPATION ACTIVITY 11.6.5: Lavatory sign example.

1) If a, b, c are all 1's, should the sign illuminate?
   - Yes
   - No

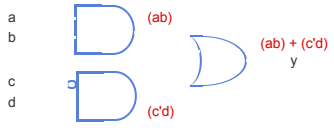
2) The designer created the equation y = (abc)', and then a circuit consisting of AND followed by ___.
   - NOT
   - OR

Circuits to equations

A circuit can be converted to an equation. Starting from the inputs, the process replaces gates by terms while moving towards the output, labeling gate outputs along the way. Converting a circuit to behavior (like an equation) is called ***analysis***.

PARTICIPATION ACTIVITY 11.6.6: Circuit to equation.

Start 2x speed



y = (ab) + (c'd)

A circuit whose output value is determined solely by the present *combination* of input values is called a ***combinational circuit***. A combinational circuit is also called ***combinational logic***.

A circuit whose output values may depend on the past *sequence* of input values, and not just the present input values, is called a ***sequential circuit***. This material discusses sequential circuits later.

PARTICIPATION ACTIVITY 11.6.7: Combinational vs. sequential circuits.

Indicate whether each description would involve a combinational or sequential circuit.

1) If one or more people are in a room, turn on the lights.

- Combinational
- Sequential

2) If the weight in an elevator exceeds 1500 pounds, sound an alarm.
   - Combinational
   - Sequential

3) If the sleep mode button is pressed and released, turn phone ringer off until the sleep mode button is pressed again.
   - Combinational
   - Sequential

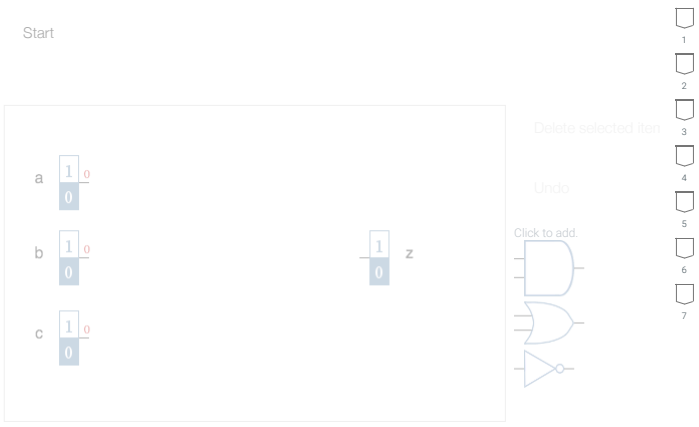
4) Turn faucet on while motion is detected.
   - Combinational
   - Sequential

5) If the garage door button is pressed, turn motor on until garage door is fully opened.
   - Combinational
   - Sequential

CHALLENGE ACTIVITY 11.6.1: Convert the equation to a circuit.

Convert the equation provided to a circuit.

- Add gate to workspace: Click the gate image in the bottom-right.
- Create wire: Drag from a pin.
- Toggle input between 0 and 1: Click on input.
- Delete gate or wire: Select item then click "Delete selected item(s)".



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