Electrical noise could cause a problem

$$NM_H = V_{OH} - V_{IH}$$
$$NM_L = V_{IL} - V_{OL}$$

NOISE MARGIN

These parameters describe how much noise can be tolerated before causing trouble.

Example: Low-voltage CMOS logic family

Parameters: $V_{DD} = 3.3\ v$
$V_{IL} = 0.9\ v$
$V_{IH} = 1.8\ v$
$V_{OL} = 0.36\ v$
$V_{OH} = 2.7\ v$

Find noise margin: $NM_L = V_{IL} - V_{OL}$
$= 0.9 - 0.36 = 0.54\ v$

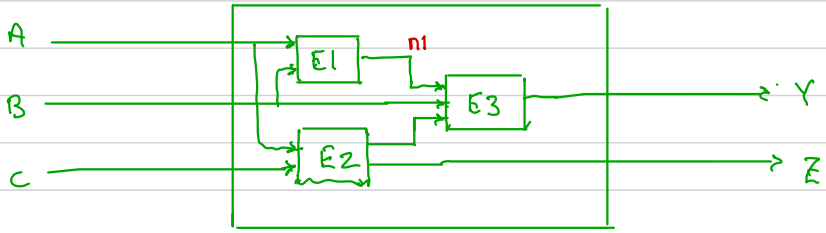
$NM_H = V_{OH} - V_{IH}$
$= 2.7 - 1.8 = 0.9\ v$

Suppose voltage is 3.1 v

voltage without noise = V_{OL} = 0.36 v
→ if noise increases this to 0.9 v, trouble!

Combinational Circuit Design (Chapter 2)

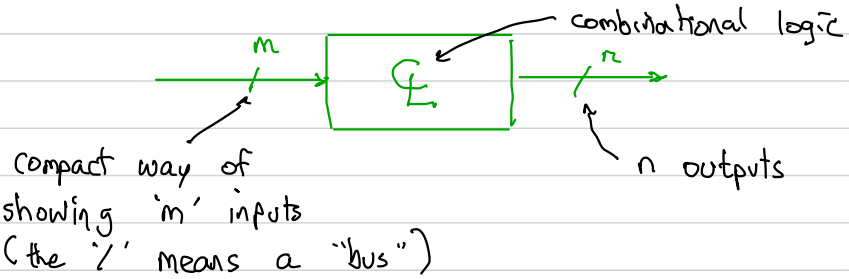
Composition of a simple logic circuit



The circuit is generally described in terms of elements and nodes

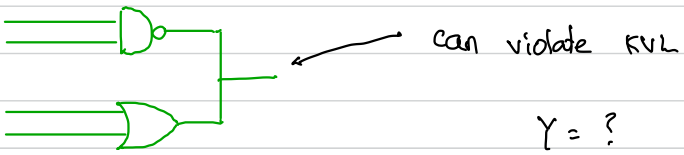
- E1, E2, E3 are <u>elements</u> (which can themselves be a logic circuit)
- a <u>node</u> is connection between elements (i.e., a wire!)
- Node types
  - <u>input nodes</u> A, B, C; output nodes (Y, Z).
  - <u>internal nodes</u>, like n1.

The generic symbol for a combination circuit

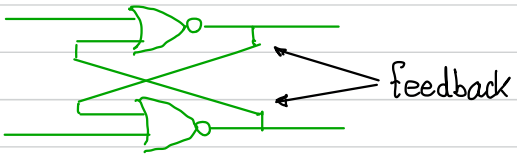


Definition of a combinational circuit.

- all of E_1, E_2, etc. must be combinational)
- Nodes are all either inputs or outputs; if an output, it connects to the output of just <u>one</u> other circuit element.



- No cyclic path (i.e., no feedback path)



<u>Boolean algebra</u>

Boolean equations operate on binary variables, so are ideal for describing digital logic circuits.

Terminology

There is much in common with conventional algebra, but with some important new terms:

- complement
- literal
- minterm
- maxterm ... and more

A literal

- is defined as a single Boolean variable or its complement

E.g., A, $\bar{A}$, B, $\bar{B}$ (each are one literal)

$A + \bar{B}C$ → is an expression containing 3 literals

$A + \bar{B}C\bar{A}$ → has 4 literals ('A' used twice)

True form of a literal: A (not complemented)

Complementary form: $\bar{A}$

Product term

- can be a single literal
- or the ANDing of 2 or more literals

E.g.,
- A
- $AB\bar{C}\bar{D}$
- $AB\bar{C} + \bar{D}$ (not a product term overall, but ORing of two product terms)

- also called an implicant.

A minterm

A product term that contains all system variables in either true or complementary form

2-variable system

minterms: $\bar{A}\bar{B}$, $\bar{A}B$, $A\bar{B}$, AB } all 4 combinations

3-variable system

minterms: $\bar{A}\bar{B}\bar{C}$, $\bar{A}\bar{B}C$, $\bar{A}B\bar{C}$, $\bar{A}BC$, $A\bar{B}\bar{C}$, $A\bar{B}C$, $AB\bar{C}$, ABC } all 8 combinations