Verilog HDL: Designing Smarter Systems with Logic Gates

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Outline

- Discussion about digital Logic
- Example projects
- Real-life Digital logic Exercises

Difficulty and Complexity

DIFFICULTY ≠ COMPLEXITY

DIFFICULTY

How much effort is needed to answer a question, address a problem, or accomplish a task?

How many people can answer a question, address a problem, or accomplish a task correctly or successfully?

Easy or Hard

COMPLEXITY

What kind of thinking, action, or knowledge must be demonstrated and communicated to answer a question, address a problem, or accomplish a task?

How many different ways can a question be answered, a problem be addressed, or a task be accomplished?

Simple or Complex

Low Fuel Warning System

Low Fuel Warning System

In a vehicle, the fuel level sensor provides a signal indicating whether the fuel level is above a certain threshold. A NOT gate can be used to trigger a warning light when the fuel level is below this threshold.

Inputs:

- **A**: Binary input signal from the fuel level sensor (1 if fuel level is above threshold, 0 if below).

Output:

- **Y**: Binary output signal to the warning light (1 to turn on the warning light, 0 to turn it off).

Industry Emergency Indicator

Emergency Stop System

Emergency Stop System: In an industrial environment, multiple emergency stop buttons are placed at different locations. Pressing any one of these buttons should stop the machinery to ensure safety.

Inputs:

- A: Signal from emergency stop button 1.
- B: Signal from emergency stop button 2.

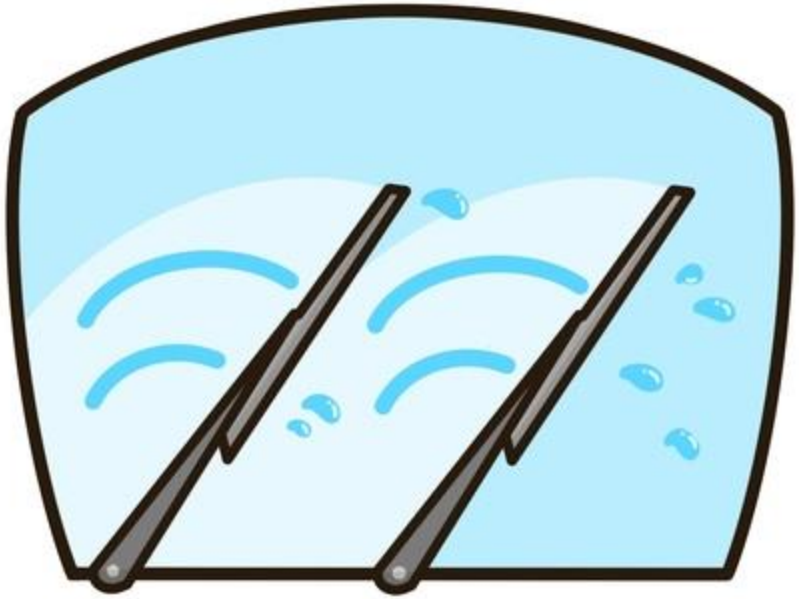
Output:

- Y: Signal to stop the machinery (1 if any emergency stop button is pressed).

OR Gate:

- Output Y will be high (1) if either A or B is high (1), stopping the machinery.

Car Wiper Control System



Car Wiper Control System

Car wiper control system to ensure the wipers operate only when both the ignition is on and the wiper switch is activated.

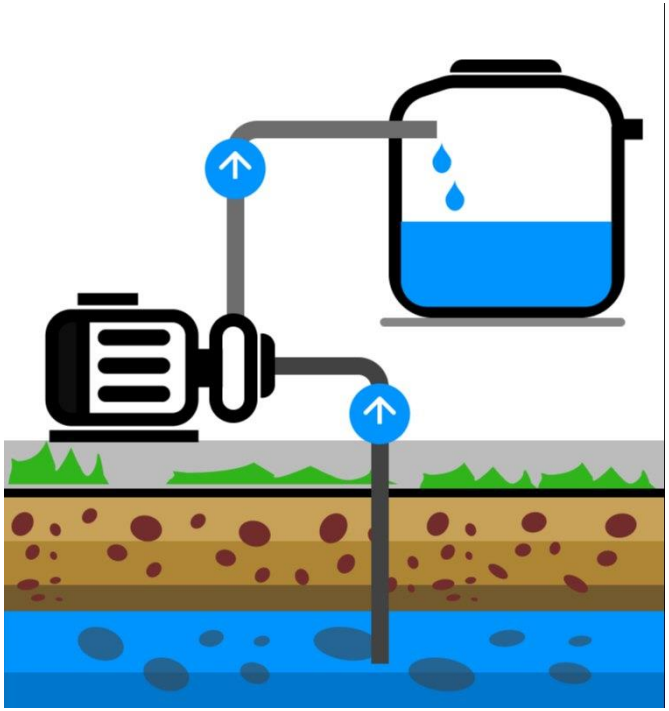
Inputs:

- **A**: Binary input signal from the ignition switch (1 if ignition is on, 0 if off).
- **B**: Binary input signal from the wiper switch (1 if wiper switch is on, 0 if off).

Output:

- **Y**: Binary output signal to the wiper motor (1 to activate the wipers, 0 to deactivate them).

Water Level Control System



Water Level Control System

The water level control system should ensure that the water pump operates only when the water level is below a certain threshold and the system is enabled. Once the water reaches the desired level, the pump should automatically turn off.

Inputs:

L: Binary input signal from the low water level sensor (1 if water is below threshold, 0 otherwise).

H: Binary input signal from the high water level sensor (1 if water is at or above desired level, 0 otherwise).

E: Binary input signal for enabling the system (1 if system is enabled, 0 otherwise).

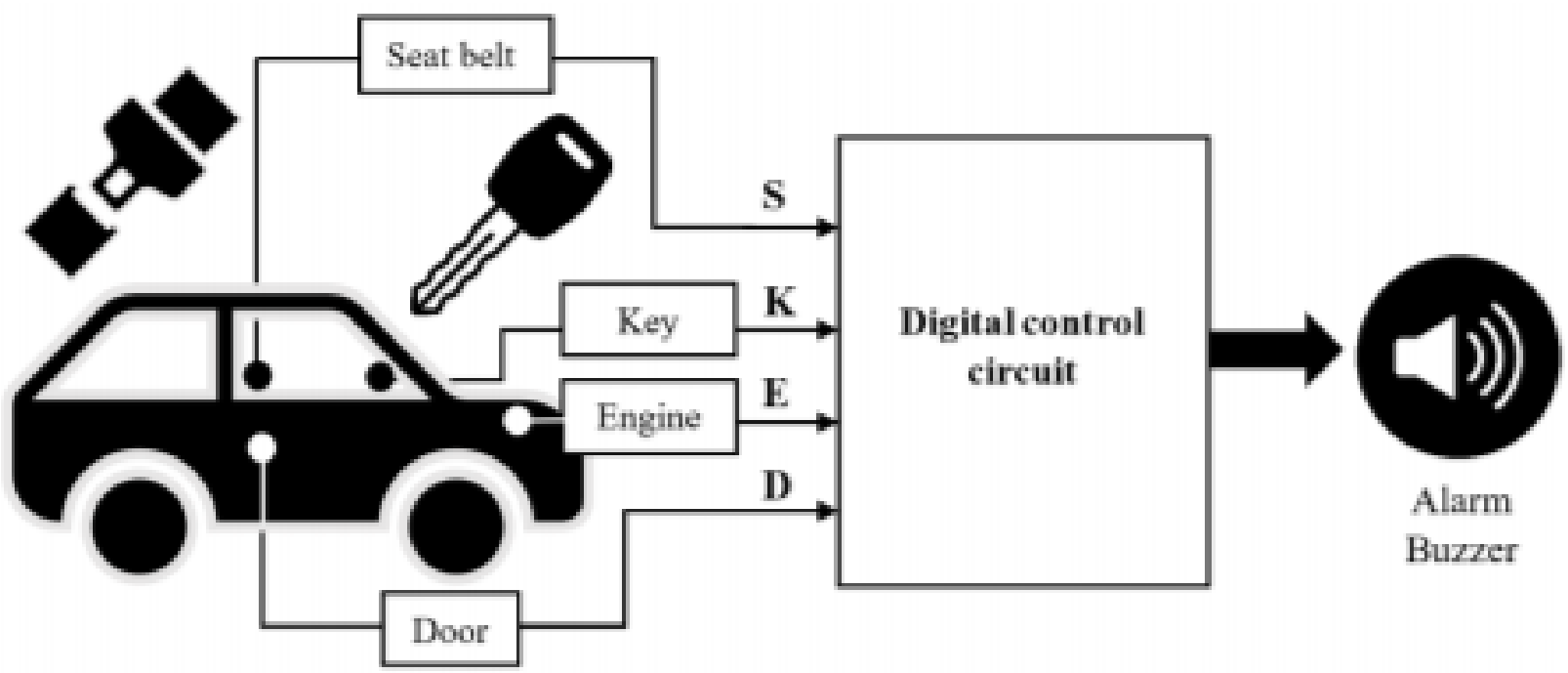
Outputs:

P: Binary output signal controlling the water pump (1 to turn on the pump, 0 to turn it off).

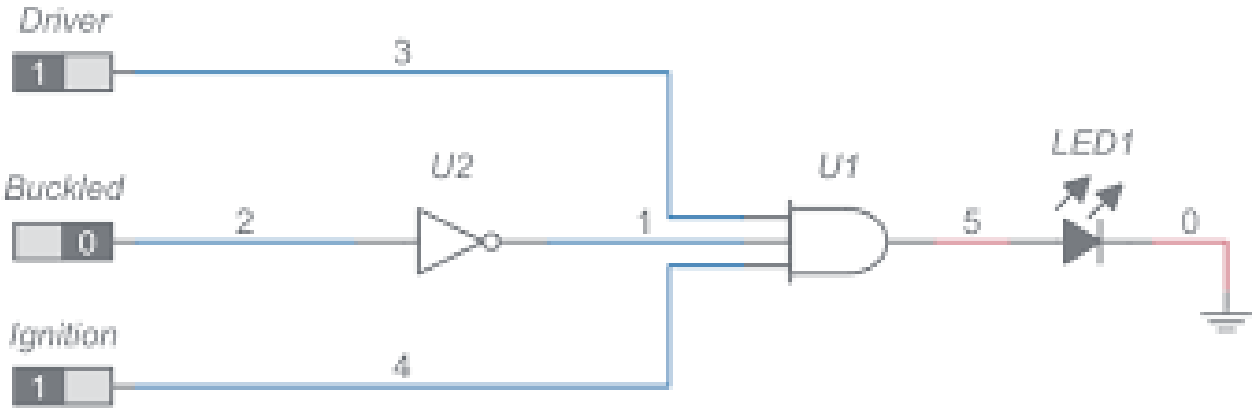
Water Level Control System

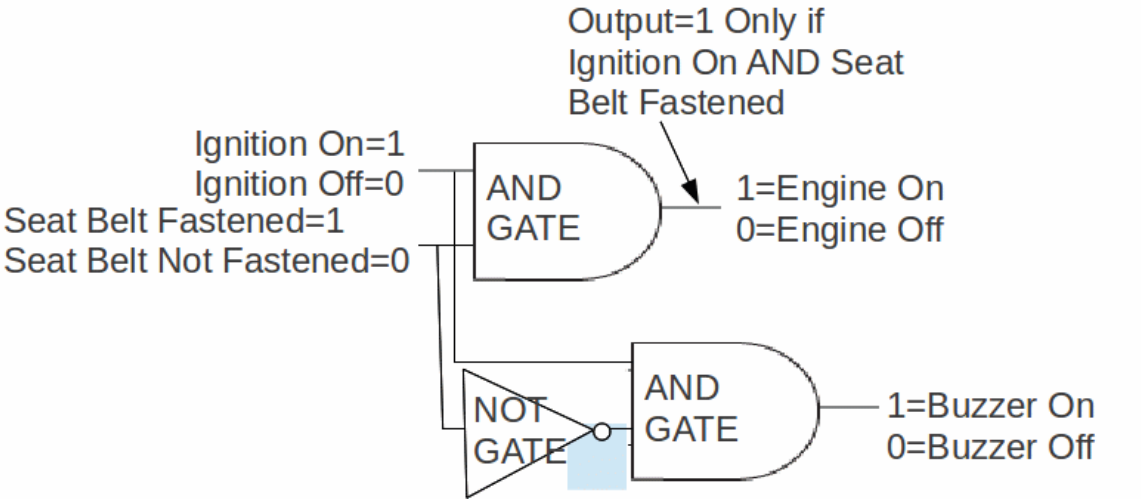
Low Level (L)	High Level (H)	System Enabled (E)	NOT H	Pump (P = NOT H AND L AND E)
0	0	0	1	0
0	0	1	1	0
0	1	0	0	0
0	1	1	0	0
1	0	0	1	0
1	0	1	1	1
1	1	0	0	0
1	1	1	0	0

Seat Belt Indicator



Seat Belt Indicator





Electronic Lock

The electronic lock should only unlock when a specific combination of inputs is provided.

The lock should unlock only when A=1, B=0, and C=1.

Washing Machine Control

Washing Machine Control System

Problem Definition

The washing machine should only start its operation when the following conditions are simultaneously satisfied:

- Water is present
- Laundry is loaded
- The lid is closed

Solution : Washing Machine Control System

Inputs:

- **X**: Binary input signal indicating the presence of water (1 if water is present, 0 otherwise).
- **Y**: Binary input signal indicating the presence of laundry (1 if laundry is loaded, 0 otherwise).
- **Z**: Binary input signal indicating whether the lid is closed (1 if the lid is closed, 0 otherwise).

Output:

- C: Binary output signal controlling the washing machine (0 to start the machine, 1 to stop the machine).

Logic Design : Washing Machine Control System

AND Gate 1:

- Inputs: X, Y
- Output: A (X AND Y)
- Description: This gate ensures that both water and laundry are present.

AND Gate 2:

- Inputs: A, Z
- Output: B (A AND Z)
- Description: This gate ensures that the machine will only consider starting if both the previous condition (water and laundry present) is met and the lid is closed.

NOT Gate:

- Input: B
- Output: C (NOT B)
- Description: This gate inverts the signal, so the washing machine starts (C=0) only if all conditions are satisfied (B=1).

Logic Design : Washing Machine Control System

X Water	Y Laundry	Z Lid	A (X AND Y)	B (A AND Z)	C (NOT B)
0	0	0	0	0	1
0	0	1	0	0	1
0	1	0	0	0	1
0	1	1	0	0	1
1	0	0	0	0	1
1	0	1	0	0	1
1	1	0	1	0	1
1	1	1	1	1	0

- The designed control circuit ensures that the washing machine operates only when all required conditions (**water present, laundry loaded, lid closed**) are met.
- This prevents the machine from starting under unsafe or incorrect conditions, thereby **ensuring efficient and safe operation**.

Majority Circuit
(Electronic Voting Machine)

Majority Circuit

A majority circuit outputs true (1) if the majority of the inputs are true (1). For three inputs, the output should be true if at least two of the three inputs are true. (Voting Machine/Committee Decisions/Fault Tolerant Systems/ etc…..)

A	B	C	A AND B	A AND C	B AND C	Y (Majority)
0	0	0	0	0	0	0
0	0	1	0	0	0	0
0	1	0	0	0	0	0
0	1	1	0	0	1	1
1	0	0	0	0	0	0
1	0	1	0	1	0	1
1	1	0	1	0	0	1
1	1	1	1	1	1	1

Exercise Projects

- Traffic Light Controller using Logic Gates
- Smart Elevator Control System using Combinational Logic
- Fire Alarm System using OR and NAND Logic
- Home Security System using Basic Logic Gates
- Railway Crossing Gate Control using Sensor Logic
- Automatic Street Lighting System using AND/NOT Logic
- Burglar Alarm with Code Lock using Logic Gates
- Digital Voting Machine using Majority and XOR Logic
- Smart Parking System using Combinational Logic
- Industrial Conveyor Belt Control using Logic Gates
- Fire Sprinkler Control using AND Gate Logic
- Patient Monitoring Alarm using OR Logic
- Garage Door Controller using Safety Interlocks
- Multi-Floor Water Tank Control using Logic Gates
- Industrial Machine Interlock System using AND/NOT Logic

Thank you !

Happy Designing