Project: Walking Stick

CSEN 605: Digital System Design

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1) Project Description

The goal of the project was to design and code a functional circuit for a Walking Stick that would work to help assist blind people in avoiding everyday obstacles. The stick gets activated or deactivated by the user using a simple switch to turn it on or off.

As the user is using the stick to guide their walking, the stick vibrates if there is a nearby object in the user's path, alerting them that they're about to run into something. It does so by using an Infrared Sensor as an obstacle avoidance sensor whose waves bounce back off of nearby objects, sending a signal to the circuit.

Additionally, if the user drops the stick for any reason, a warning sound is produced by the stick to help the user locate the stick by moving towards the source of the noise produced by the buzzer.
Both these features ensure that blind people will be able to walk with ease, avoiding any difficulties that may arise.

We coded the circuit functionality using VHDL on Quartus Prime Lite and the code was uploaded onto an FPGA (Field Programmable Gate Array) which controls the circuit inputs/outputs.

The components we used to implement the project were:
  a) FPGA (includes Switch)
  b) Infrared Sensor
  c) 5V Buzzer
  d) Touch Sensor
  e) Vibrational Motor
  f) Breadboard
  g) Jumper Wires (Male-Male / Male-Female)

2) Truth Table

Switch	Infrared sensor	Touch sensor	Buzzer	Motor
0	0	0	0	0
0	0	1	0	0
0	1	0	0	0
0	1	1	0	0
1	0	0	1	1
1	0	1	0	1
1	1	0	1	0
1	1	1	0	0

→ If the infrared sensor does not detect any near object (Infrared = 1) the motor should not vibrate (Motor = 0).

→ If the touch sensor does not detect any touching hand (Touch sensor = 0) the buzzer should produce a sound (Buzzer = 1).

3) K-Maps

a) Motor

	B'C'	B'C	BC	BC'
A'	0	0	0	0
A	1	1	0	0

Motor = AB' = (Switch) AND (NOT Infrared sensor)

b) Buzzer

	B'C'	B'C	BC	BC'
A'	0	0	0	0
A	1	0	0	1

Buzzer = AC' = (Switch) AND (NOT Touch Sensor)

4) VHDL Code

```vhdl
library ieee;                  -- import libraries
use ieee.std_logic_1164.all;            -- use std_logic library

Entity WalkingStick IS          -- create entity
   Port (Touch, IR, SW: IN std_logic;      -- define inputs (Touch sensor, Infrared sensor, Switch)
         Buzz, Motor : OUT std_logic          -- define outputs (Buzzer, Motor)
   );
End WalkingStick;

Architecture arch of WalkingStick IS     -- create architecture for entity
BEGIN           -- begin architecture body

Process (Touch, IR, SW)           -- create a process with a sensitivity list to detect changes in values of
                                  touch sensor, infrared sensor, and switch signals
BEGIN           -- begin process

      IF SW = '1' THEN          -- if switch is turned on (SW = 1), Motor takes value of Infrared
   Motor <= IR;                 Sensor (since both are active low)

      -- if infrared sensor detects nearby object (IR = 0), motor turns on (Motor = 0)
      -- if there is no object detected (IR = 1), motor is off (Motor = 1)

      ELSE
         Motor <= '1';          -- if switch is off (SW= 0), Motor is always off (Motor = 1)

      END IF;

      BUZZ <= (NOT Touch) AND SW;              -- buzzer produces sound if No touch is
                                             detected (Touch = 0) AND switch is on (SW = 1)
END Process;

END arch;               -- end architecture body
```

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5) Explanation of Code

1. Entity Creation

→ Created an Entity called Walking Stick that takes the Switch, Infrared Sensor and Touch sensor signals as inputs *(Touch, IR, SW)* and controls the Motor and Buzzer outputs signals *(Motor, Buzz)* based on the input values.

2. Motor Controls

→ If the switch is on *(Walking stick is working),* the motor works based on the input from the IR sensor. Since both the motor and the IR sensor are active low, the motor simply takes the value of the IR sensor.

    a) If the IR sensor signal is 0 *(there's an object near the stick)*, the motor turns on *(the stick vibrates to alert the user)*

    b) If the IR sensor signal is 1 *(there are no objects detected)*, the motor remains off

→ If the switch is off, the motor is given the value '1' → motor is off *(stick isn't working)*

3. Buzzer Controls

→ Buzzer produces sound when the switch is on (Walking Stick is working) and no touch is detected by the touch sensor (user dropped the stick).

→ Otherwise, if the touch signal is high (Touch = 1) (user is holding the stick), the buzzer remains silent

6) Pin Assignments

- Buzzer → V8
- IR Sensor → W10
- Motor → W6
- SW → C10
- Touch → V10