Digital Systems Design Project Report

- 52-3899 Karim Mohamed Gamaleldin Yehia Gamaleldin T-19
- 52-1008 Aly Raafat AbdelFattah T-19
- 52-2292 Marwan Amgad Mohamed T-19
- 52-1805 Bassel Mohamed Farouk T-15
- 52-13386 Omar Ashraf Atteya T-19

December 2022

Smart Car برق بنزين

Parts Used:

- DE10-Lite FPGA
- Two DC motors
- Breadboard
- Lane Sensor
- IR Sensor
- DC Motor Controller
- Two Wheels

Project Idea:

In this project, we were tasked to create a Smart Car using a DE10-Lite FPGA. This project simulates multiple requirements which may be required of a real life self driving smart vehicle. Firstly, the model uses an IR sensor to detect obstacles in front of it. If an obstacle is detected, the car is stopped. Moreover, the model also has a lane sensor which keeps track of the surface the car is moving on and if a lane change is detected, ALERT is written on the FPGA's seven segment display.

GUC
German University in Cairo
الجامعة الألمانية بالقاهرة

__Software Implementation:__

```vhdl
library ieee;
use ieee.std_logic_1164.all;
ENTITY Project1 IS
    PORT( I , B : IN STD_LOGIC;
          A,L,E,R,T: OUT STD_LOGIC_VECTOR(6 DOWNTO 0);
          M0,M1,M2,M3 : OUT STD_LOGIC);
END Project1;
ARCHITECTURE Lans_Sensor_Arch OF Project1 IS
BEGIN
PROCESS (I , B)
BEGIN
IF I = '1' THEN
    M0 <= '0';
    M1 <= '1';
    M2 <= '0';
    M3 <= '1';
ELSE
--STOP
    M0 <= '1';
    M1 <= '1';
    M2 <= '1';
    M3 <= '1';
    --REVERSE
    --M0 <= '0';
    --M1 <= '1';
    --M2 <= '0';
    --M3 <= '1';
END IF;
If B = '1' THEN
    A <= "0001000";
    L <= "1000111";
    E <= "0000110";
    R <= "0101111";
    T <= "0001111";
ELSE
    A <= "1111111";
    L <= "1111111";
    E <= "1111111";
    R <= "1111111";
    T <= "1111111";
END IF ;
END PROCESS ;
END Lans_Sensor_Arch;
```

Above is the software implementation of the smart car, using VHDL. Required Libraries are first imported. An entity is then created and within it is described two inputs I and B where I is the IR sensor and B is the lane sensor. If B ='1' , 5 seven bit outputs which were defined in the entity are displayed for each of the letters on the FPGA seven segment display. Else, the seven segment display will remain empty. In the seven segment display, a character's segment is activated if it is set to '0' and deactivated if it is set to '1'.For the IR sensor I, if I is '1', M0M1M2M3 is set to '0101'. Else it is set to '1111'. M0-M3 each represent the rotation direction of the wheels for each motor. M0-M3 were also defined as std_logic outputs of the entity.

GUC
German University in Cairo
الجامعة الألمانية بالقاهرة

<u>Hardware Implementation:</u>

We used a breadboard to create nodes extending the FPGA 5v VCC as well as the Ground so they can be used by multiple components on the car as the FPGA only has one pin for 5v VCC and two pins for the ground. Using jumper wires, we connected each sensor's pins to their respective node on the breadboard, either its VCC or ground. We then connected every sensor's output pin to a pin on the FPGA so it can pass its signal to the FPGA. DC motor controller has 11 pins. 4 output pins. Each 2 pins are connected to each motor to determine its movement(clockwise, anticlockwise or stopped when both). 3 pins , 2 for VCC and 1 for ground and 4 pins for M0M1M2M3, 2 for each motor to connect the DC motor controller to the FPGA.

<u>Pin Assignments:</u>

Node Name	Direction	Location	I/O Bank	VREF Group	itter Locatior	I/O Standard	Reserved	urrent Streng	Slew Rate	ifferential Pai	ict Preservati
A[6]	Output	PIN_N20	6	B6_N0	PIN_N20	2.5 V		12mA ...ault)	2 (default)		
A[5]	Output	PIN_N19	6	B6_N0	PIN_N19	2.5 V		12mA ...ault)	2 (default)		
A[4]	Output	PIN_M20	6	B6_N0	PIN_M20	2.5 V		12mA ...ault)	2 (default)		
A[3]	Output	PIN_N18	6	B6_N0	PIN_N18	2.5 V		12mA ...ault)	2 (default)		
A[2]	Output	PIN_L18	6	B6_N0	PIN_L18	2.5 V		12mA ...ault)	2 (default)		
A[1]	Output	PIN_K20	6	B6_N0	PIN_K20	2.5 V		12mA ...ault)	2 (default)		
A[0]	Output	PIN_J20	6	B6_N0	PIN_J20	2.5 V		12mA ...ault)	2 (default)		
B	Input	PIN_AB2	3	B3_N0	PIN_AB2	2.5 V		12mA ...ault)			
E[6]	Output	PIN_E17	6	B6_N0	PIN_E17	2.5 V		12mA ...ault)	2 (default)		
E[5]	Output	PIN_D19	6	B6_N0	PIN_D19	2.5 V		12mA ...ault)	2 (default)		
E[4]	Output	PIN_C20	6	B6_N0	PIN_C20	2.5 V		12mA ...ault)	2 (default)		
E[3]	Output	PIN_C19	7	B7_N0	PIN_C19	2.5 V		12mA ...ault)	2 (default)		
E[2]	Output	PIN_E21	6	B6_N0	PIN_E21	2.5 V		12mA ...ault)	2 (default)		
E[1]	Output	PIN_E22	6	B6_N0	PIN_E22	2.5 V		12mA ...ault)	2 (default)		
E[0]	Output	PIN_F21	6	B6_N0	PIN_F21	2.5 V		12mA ...ault)	2 (default)		
I	Input	PIN_AA2	3	B3_N0	PIN_AA2	2.5 V		12mA ...ault)			
L[6]	Output	PIN_F20	6	B6_N0	PIN_F20	2.5 V		12mA ...ault)	2 (default)		
L[5]	Output	PIN_F19	6	B6_N0	PIN_F19	2.5 V		12mA ...ault)	2 (default)		
L[4]	Output	PIN_H19	6	B6_N0	PIN_H19	2.5 V		12mA ...ault)	2 (default)		
L[3]	Output	PIN_J18	6	B6_N0	PIN_J18	2.5 V		12mA ...ault)	2 (default)		
L[2]	Output	PIN_E19	6	B6_N0	PIN_E19	2.5 V		12mA ...ault)	2 (default)		
L[1]	Output	PIN_E20	6	B6_N0	PIN_E20	2.5 V		12mA ...ault)	2 (default)		
L[0]	Output	PIN_F18	6	B6_N0	PIN_F18	2.5 V		12mA ...ault)	2 (default)		
M0	Output	PIN_V10	3	B3_N0	PIN_V10	2.5 V		12mA ...ault)	2 (default)		
M1	Output	PIN_W10	3	B3_N0	PIN_W10	2.5 V		12mA ...ault)	2 (default)		
M2	Output	PIN_V9	3	B3_N0	PIN_V9	2.5 V		12mA ...ault)	2 (default)		
M3	Output	PIN_W9	3	B3_N0	PIN_W9	2.5 V		12mA ...ault)	2 (default)		
R[6]	Output	PIN_B22	6	B6_N0	PIN_B22	2.5 V		12mA ...ault)	2 (default)		
R[5]	Output	PIN_C22	6	B6_N0	PIN_C22	2.5 V		12mA ...ault)	2 (default)		
R[4]	Output	PIN_B21	6	B6_N0	PIN_B21	2.5 V		12mA ...ault)	2 (default)		
R[3]	Output	PIN_A21	6	B6_N0	PIN_A21	2.5 V		12mA ...ault)	2 (default)		
R[2]	Output	PIN_B19	7	B7_N0	PIN_B19	2.5 V		12mA ...ault)	2 (default)		
R[1]	Output	PIN_A20	7	B7_N0	PIN_A20	2.5 V		12mA ...ault)	2 (default)		
R[0]	Output	PIN_B20	6	B6_N0	PIN_B20	2.5 V		12mA ...ault)	2 (default)		
T[6]	Output	PIN_B17	7	B7_N0	PIN_B17	2.5 V		12mA ...ault)	2 (default)		
T[5]	Output	PIN_A18	7	B7_N0	PIN_A18	2.5 V		12mA ...ault)	2 (default)		
T[4]	Output	PIN_A17	7	B7_N0	PIN_A17	2.5 V		12mA ...ault)	2 (default)		
T[3]	Output	PIN_B16	7	B7_N0	PIN_B16	2.5 V		12mA ...ault)	2 (default)		
T[2]	Output	PIN_E18	6	B6_N0	PIN_E18	2.5 V		12mA ...ault)	2 (default)		
T[1]	Output	PIN_D18	6	B6_N0	PIN_D18	2.5 V		12mA ...ault)	2 (default)		
T[0]	Output	PIN_C18	7	B7_N0	PIN_C18	2.5 V		12mA ...ault)	2 (default)		

- From A[6] to A[0], using pins PIN_N20, PIN_N19, PIN_M20, PIN N_18, PIN L_18, PIN_K20 and PIN_J20, with each pin representing one bit, which represent a single segment of the letter A on the 7 segment display.

- From L[6] to L[0], using pins PIN_F20, PIN_F19, PIN_H19, PIN_J18, PIN E_19, PIN_E20 and PIN_F18, each pin representing one bit which represent a single segment of the letter L on the 7 segment display.
- From E[6] to E[0], using pins PIN_E17, PIN_D19, PIN_C20, PIN_C19, PIN_E21, PIN_E22 and PIN_F21, with each pin representing one bit, which represents a single segment of the letter E on the 7 segment display.
- From R[6] to R[0], using pins PIN_B22, PIN_C22, PIN_B21, PIN_A21, PIN_B19,PIN_A20 and PIN_B20, with each pin representing one bit, which represents a single segment of the letter R on the 7 segment display.
- From T[6] to T[0], using pins PIN_B17, PIN_A18, PIN_A17, PIN_B16, PIN_E18, PIN_D18 and PIN_C18, with each pin representing one bit, which represents a single segment of the letter T on the 7 segment display.
- From M0 to M3, using pins PIN_V10, PIN_W10, PIN_V9 and PIN_W9 each pin representing the bit which controls the motor rotation direction of each motor respectively.
- B uses PIN_AB2 and I uses PIN_AA2 to represent the signal coming from each sensor.