Final Project Report

Multisensor PLENT (PET PLANT) with FPGA BASYS3

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Abstract

To make our earth greener, we aim to utilize technology to cultivate agriculture in a fun and innovative way, by creating a prototype of a pet plant (PLENT) with multi sensors. Light, temperature and humidity, and soil moisture sensor was assembled on a single breadboard, processed with arduino UNO, and their corresponding values are displayed on the OLED. The digital output from the sensor reading through arduino UNO was transferred to the FPGA through the PMOD. The states from the input were used to program the car to behave according to the states i.e. soil moisture low: the car circles, all plant conditions are ok: the car roams around.

Keywords: *fpga, plant, pet*

1 Introduction & Motivation

Plants play a crucial role in our ecosystem as the lungs of the world. Human ignorance and their inconsistency in taking care of plants resulted in the deterioration of the environment through depletion of natural resources. Most developed industrial countries with optimal weather and environment for plant growth have low plant mortality. In this digital era, an alternative way to take care of plants includes utilizing programmable and consistent machines.

A lot of People nowadays have indoor plants. However, taking care of them might be troublesome because humans are inconsistent and forgetful. Forgetting to water the plant and taking care of it would highly result in plant death.

This project aims to utilize technology to cultivate agriculture. Multiple sensors; humidity, temperature, light, and soil moisture sensor, acts as an indicator, providing the current condition of the plant and its surrounding. These sensors are connected to a BASYS3 Programmed car that will mimic a pet. These plant conditions, states, will determine the behaviour of the car. to indicate certain behaviour.

The motivation behind this project is to make our earth greener through technology in a fun and innovative way. By utilizing a BASYS3 programmed car to move and behave like a pet depending on the state and current condition of the plant. Creating a prototype of a PLENT (Pet Plant).

2 Method & System Specification

Prepare the sensors needed to monitor the plant's condition. The sensors used in this project are: Soil Moisture Sensor from Sparkfun, TSL2561 Luminosity Sensor, and DHT11 Temperature and Humidity Sensor. And an I2C 168 x 64 OLED. The sensors and OLEd are connected through a Half Breadboard. Then combine all the sensor modules in a single *.ino* file, and utilize the OLED to portray the values of the sensors. The output from the Arduino UNO is 6 bits through the digital pins. The soil moisture , light intensity, and temperature values are 2 bits each, with 4 states for each variable. Connect the Arduino UNO digital pins with the BASYS3 board through PMOD.

The FPGA on the car will receive the digital signal of the car and trigger the car to behave like a pet, moving in a certain way for different states of the current plant state.

Most of the sensors are analog devices, Arduino UNO is used to convert these analog values from the sensors into digital values in order to connect with BASYS3 through PMOD.

The sensors are all connected in a single breadboard, powered by a single Arduino UNO for simplicity and convenience. The OLED display will show the current state for soil moisture, light intensity, humidity, and temperature according to the plant condition.

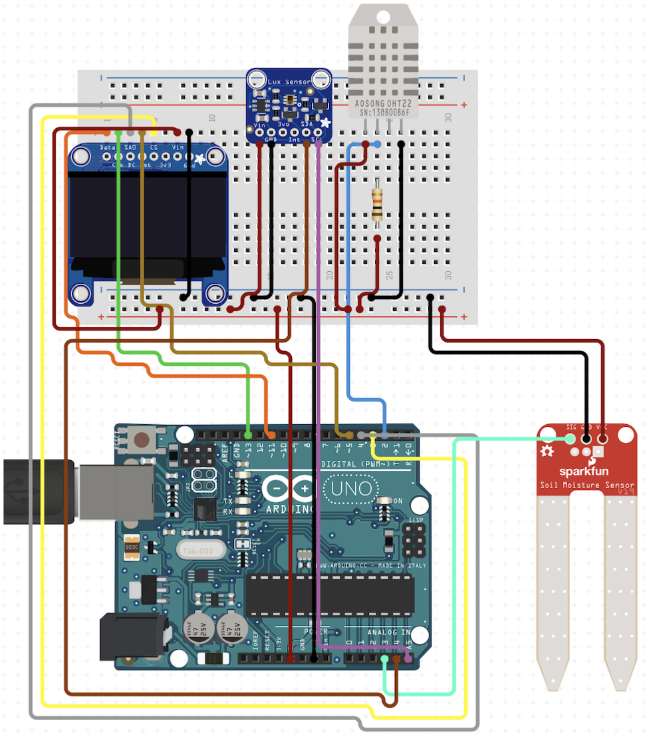


FIg 1. The schematic diagram of the sensors.

The output from the Arduino UNO is 6 bits through the digital pins. The soil moisture , light intensity, and temperature values are 2 bits each, with 4 states for each variable. The states of the sensors are determined as the following:

```
//STATES LIGHT (VIS)
if(Vis <300){
  u8g.print("Dark");
  out_Light = 0;
}
else if(Vis <1100){
  u8g.print("OK");
  out_Light = 1;
}
else if (Vis<1700){
  u8g.print("-_-");
  out_Light = 2;
}
else if(Vis>2000){
  u8g.print("*_*");
  out_Light = 3;
}
```

```
//STATE SOIL MOISTURE
if (moist <=50){
  u8g.print(":(");
  out_Soil = 0;
}
else if(moist <=100){
  u8g.print(":|");
  out_Soil = 1;
}
else if (moist<=900){
  u8g.print(":)");
  out_Soil = 2;
}
else if(moist >900){
  u8g.print(":D");
  out_Soil = 3;
}
```

```
//STATE TEMP
if(*temp < 20.0){
  out_Temp = 0;
  u8g.print("COLD ");
}
else if(*temp < 25.0){
  out_Temp = 1;
  u8g.print("OK   ");
}
else if(*temp < 28.0){
  out_Temp = 2;
  u8g.print("HOT  ");
}
else if(*temp >=28.0){
  out_Temp = 3;
  u8g.print("BURN ");
}
```

FIg 2. The state conditions of the sensors.

The result from the sensor reading will be transferred to the BASYS3 through PMOD and act as an input for the BASYS3. The figure below shows the system architecture of our prototype.

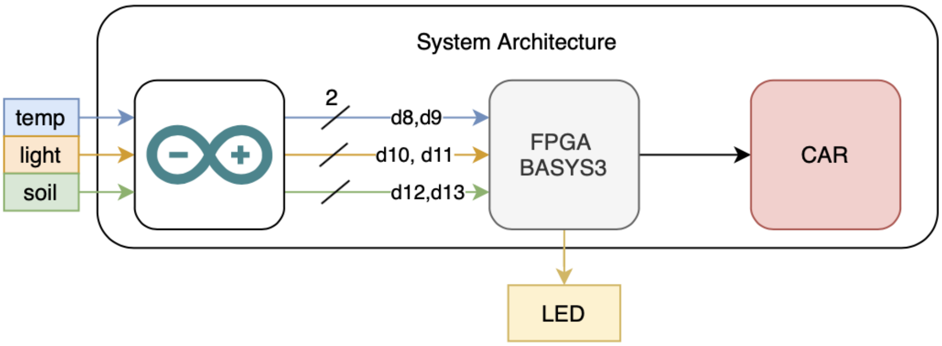
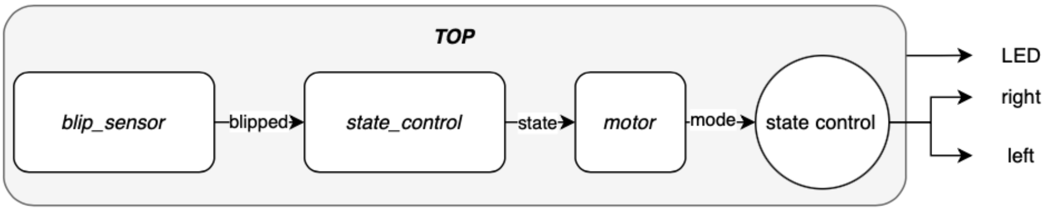


Fig 3. System Architecture of PLENT

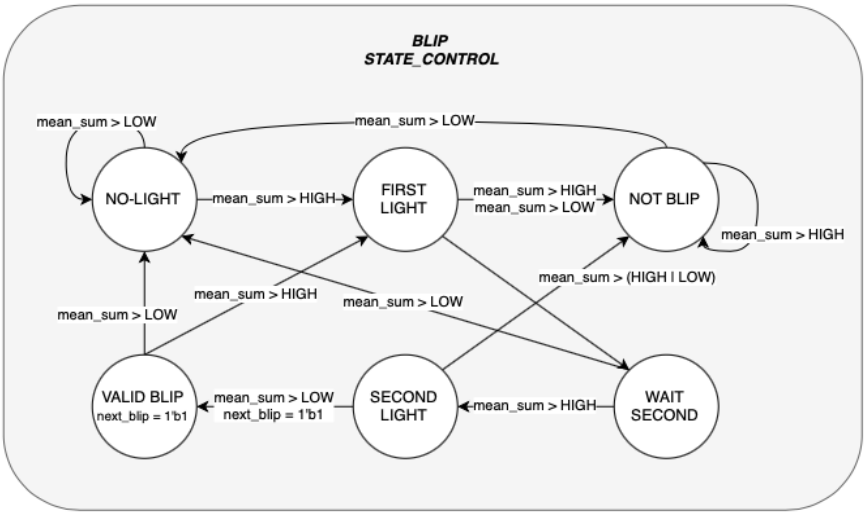
For the inputs, temp, light, and soil will determine the levels of temperature, light intensity and moisture levels respectively. The output from the arduino is each 2 bits to determine the levels of the indicators. Each output bit is set to HIGH or LOW. The input of the FPGA is the temperature. light and temperature digital input bus. A 2 bit signal that sends the state of each indicator. THe FPGA will then process the data inputs and the car will move according to the FPGA output, according to the indicator states.

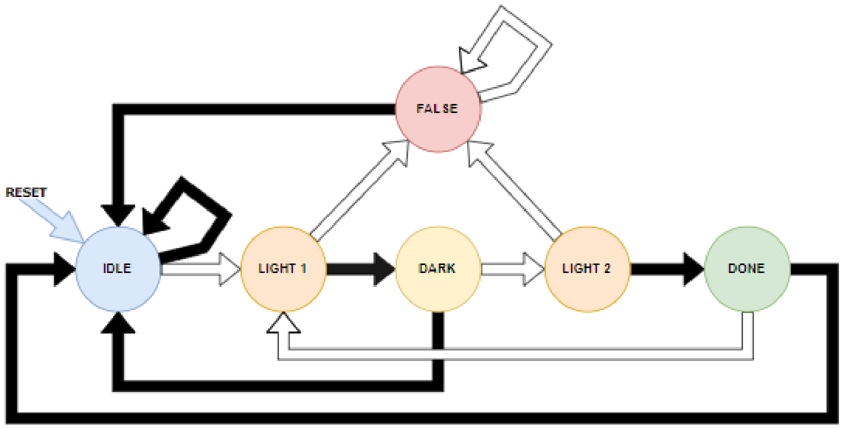
Block Diagram & State transition diagram

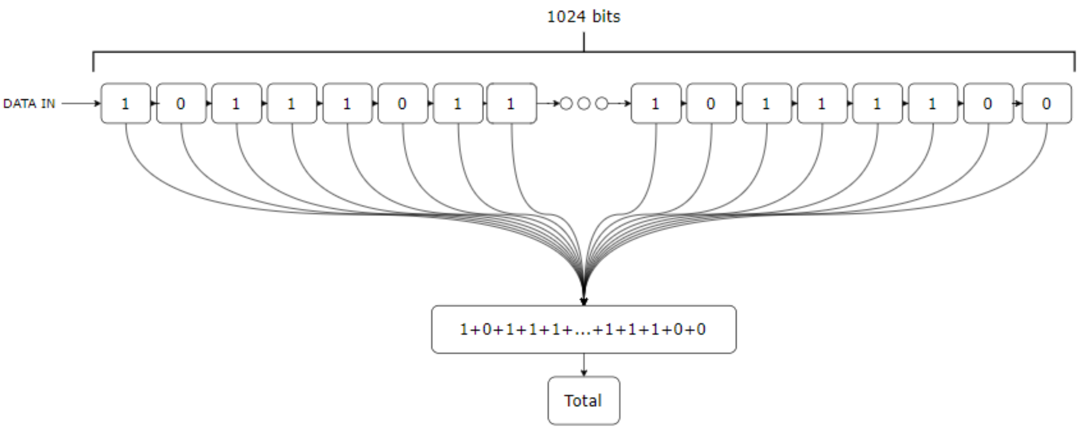


Top module is responsible to do the data wiring on each module that is being used for this design and to assign the value for the left and right variable, which is going to control the direction the motor would spin. Inside this module exist several key modules such as blip_sensor, state_control, motor and several clock_div, where each has its own task.

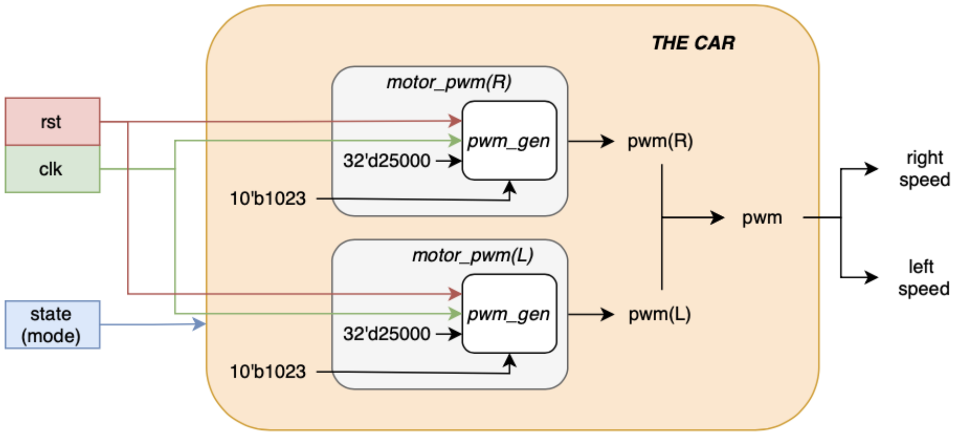
Clock divider module is responsible for dividing a clock, which is 10 Mega Hz. By assigning the param REFRESH on 10,000,000 would set 1 the output for every 1 second. In this design, we used the divider to divide into 1/s, 10/s, and 100/s to update things fast enough but not too fast. The outputs are named as follows: clk_1, clk_10, and clk_100.



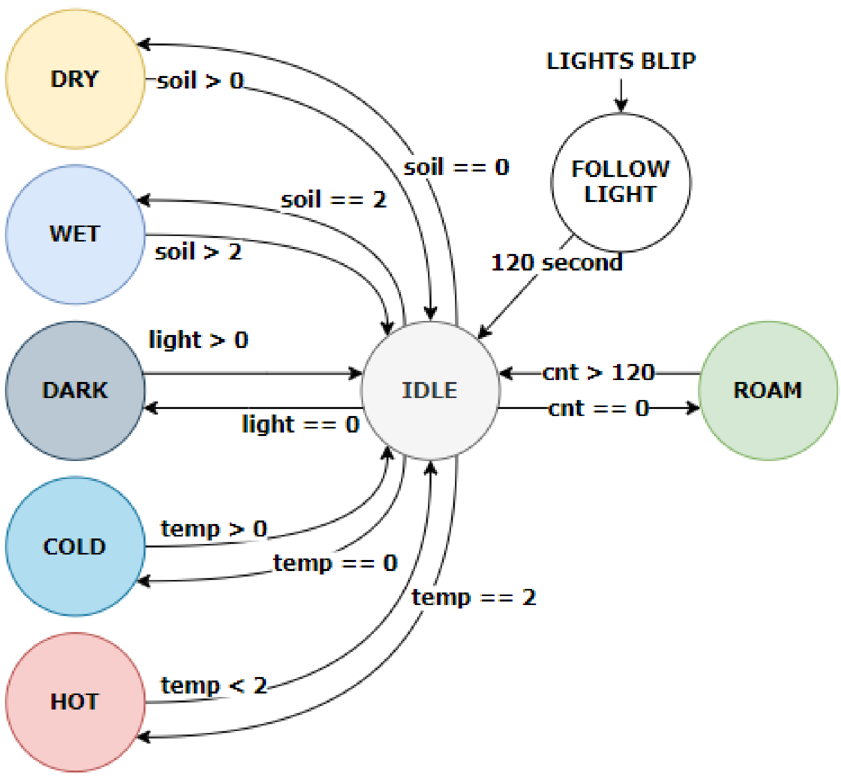




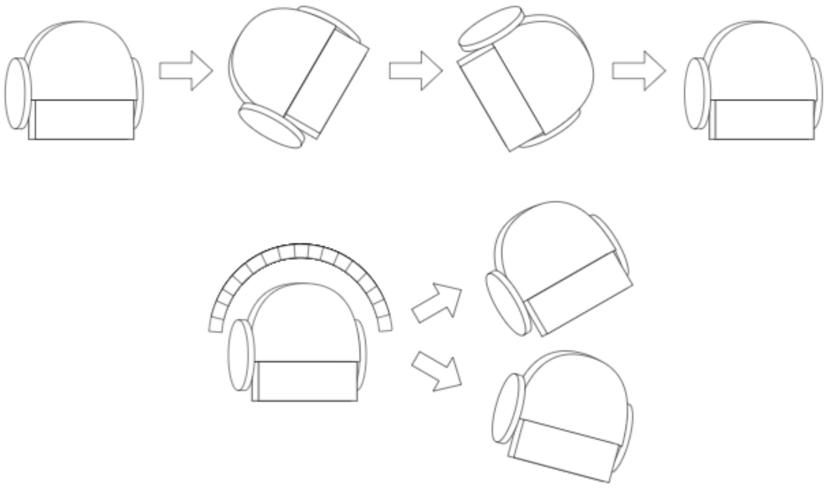
Blip sensor is responsible for sensing a blip of a light when a light turns on, off, on, and off for some period of time. Basically it is a sequence detector for a light sensor. The threshold is set so this module will only sense a high intensity of light source. The module is being used to detect a "clap" of a light in front of the light sensor. This module is set to detect the light/dark for a second for a time. The output of this module would be 1 bit and it's named "blipped". To trigger this variable you would need to point a light in front of the light sensor for a second and then remove it and do it one more time, thus the output will get triggered.



Motor is designed to control the input state and to determine the velocity of the motor. The L298 module is detecting the voltage inserted. The average of the voltage will determine how the wheels are going to spin. We set some action on every state. The set of action got its period and the period of the sequence will be set on a variable named cnt. It basically works as a time teller to this module. This module has the clock divided to 100 times a second. thus for every 100 cnt cycle is 1 second. Therefore, the cnt is written to be "16'd <some number>_00" for the sake of reading their value and avoiding mistakes.



State Control is responsible for every action this design would do. This module got input from all the physical sensors, such as: 2-bits temperature sensor, 2-bits light sensor, and 2-bit soil moisture sensor. This module is designed to do some "update" on every sensor and the update will happen for every constant of a time and the constant is different for every sensor and for every case the input. The soil sensor will take longer to update, especially if the condition is after someone water their plants. That's why it's set to update slower if the input of the sensor is when the soil is wet compared to when the soil is dry. This happened for every sensor. The light sensor will update the fastest compared to the other since a light can change rapidly unlike a moisture on a dirt and the surrounding temperature. This input will determine the state of this design.



There is some kind of special performance and it will follow the light. It happens when it's in IDLE condition and the blip_sensor output 1. The car will follow the optimal brightness from the light sensor.

3 Experimental Results

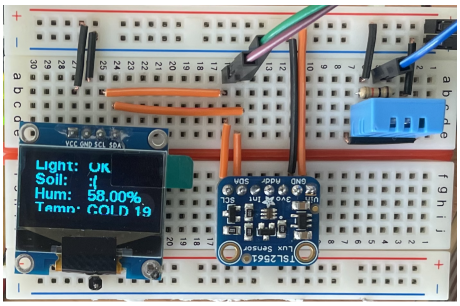


Fig 4. Multisensor reading

This is the output for the OLED, showing the condition of the plant and its surrounding. Our PLENT is shown on the youtube link attached.

4 Discussion

Conclusions

The PLENT prototype can be utilized for implementing technology to cultivate agriculture through BASYS3.

Further Applications:

- Use a motor servo to rotate the light sensor, so it can detect the optimal source of light.
- Car will act as a light following car.
- Attach a mini water tank so the plant can automatically water itself when dehydrated.

Acknowledgements

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