Environmental Controls for a Chip-Scale Seed Culture Laboratory

Senior Design Dec1212

Abstract

Seedling growth chambers are able to house hundreds of seedlings, but are limited by the fact that each seedling is exposed to the same environmental conditions. The purpose of the chip-scale laboratory is to offer numerous individual seedling chambers that each house a single seed. The advantage is that each chamber can have a uniquely specified set of environmental conditions such as temperature, humidity and CO2 levels. In this way, optimal grown conditions can be found for multiple types of seedlings at a fraction of the time, space cost.

Objectives

- Implement a sensor array that can be expanded to facilitate up to 128 sensors.
- Using Verilog, develop a solenoid control program capable of 7-bit addressing and peristaltic pump action
- Fabricate a 2-layer channel system capable of delivering small amounts of water to seedling chambers
- Integrate sensor, solenoid and chamber systems into system capable of controlling humidity of one seedling chamber

System Characterization

The operation of the system, shown in Figure 1, is dependent on feedback from the sensor placed in each of the 128 seedling chambers. When a sensor is addressed by the system, its output is read and is compared to the preset conditions for that chamber. If a mismatch is found, the system works to correct the environmental conditions of that chamber. When the sensor output matches the preferred conditions, the next chamber is addressed.

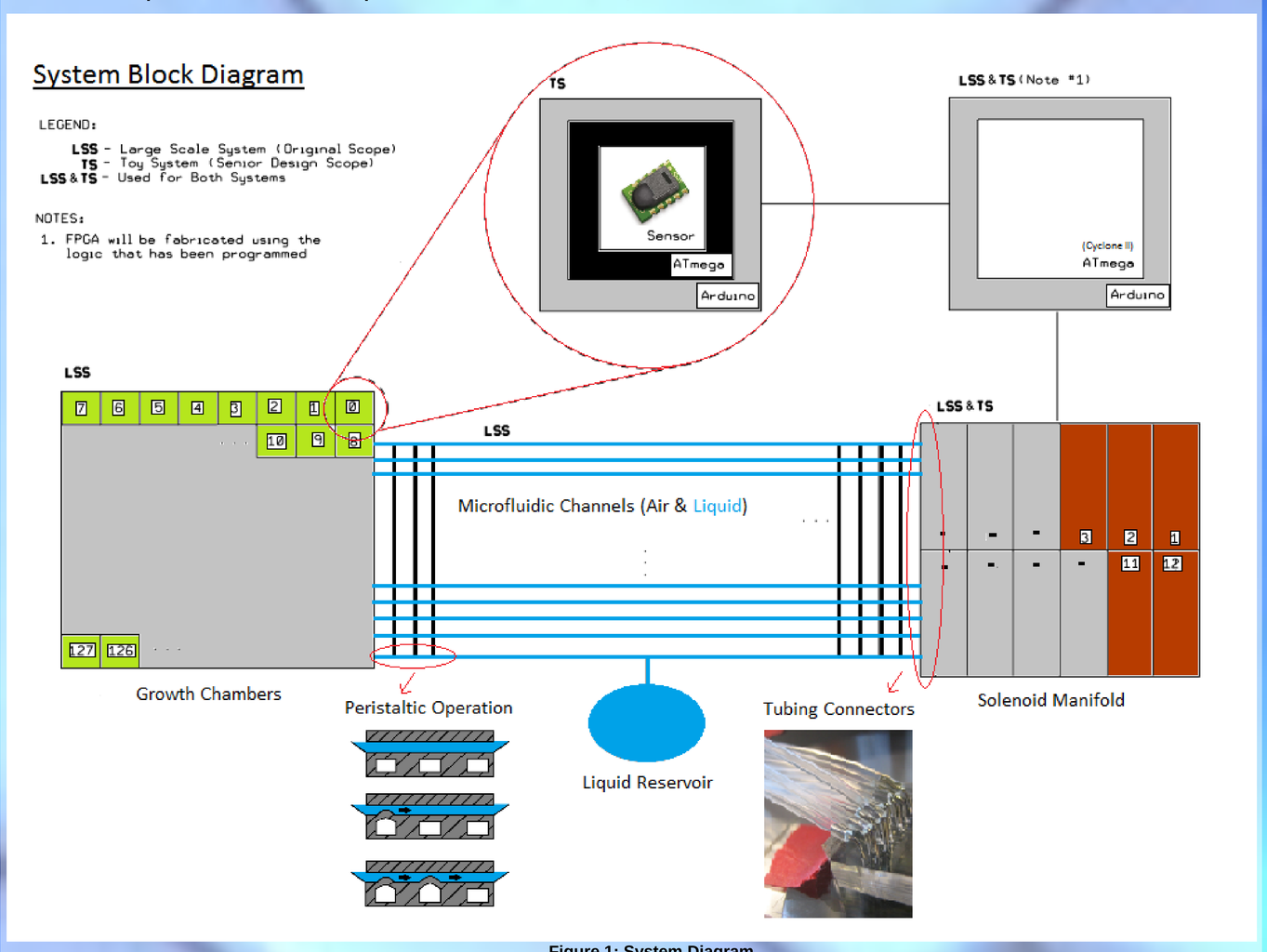

Figure 1: System Diagram

To access an individual chamber, the path to all other chambers must be restricted. The air control channels are ticker in some areas and thinner in others. Shown below in Figure 2; when are pressure is passed into the channels, the weaker areas inflate (shown as x below) and restrict flow to that chamber. The nature of this system only allows for one chamber to be addressed at any time.

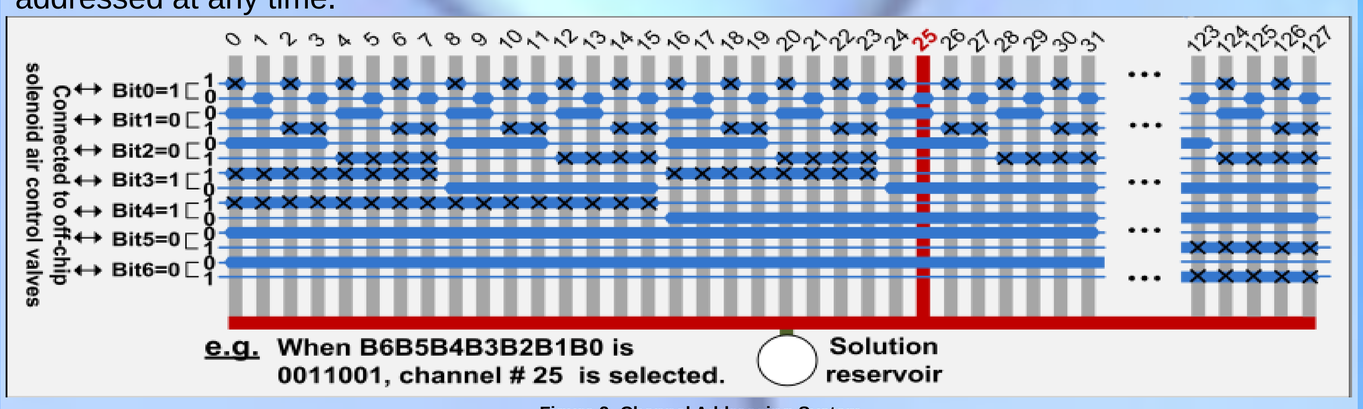

Figure 2: Channel Addressing System

Relation to Large Scale System

The purpose of the Large Scale System is to monitor the growth of 128 seedlings, each under a set of different environmental conditions. Accurately monitoring and controlling the humidity of each chamber is important to maintain the scientific integrity of any experiment conducted using this system. Due to system only being able to address one chamber at a time, the addressing system developed during this project is also viable for checking and adjusting temperature and CO2 levels, even though they use different methods to adjust their levels, such as heating coils.

Team Members

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Client/Advisor

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Component Descriptions

The three components of humidity control are the sensory array, solenoid manifold(Controlled by Cyclone II FPGA), and the 2-layer water and air channel system.

Figure 3: SHT11X Sensor

SHT11X Humidity/Temperature Sensor:

- Range from -40 to 115 C and 0-100% RH
- Analog and Digital out configurable
- Very compact design

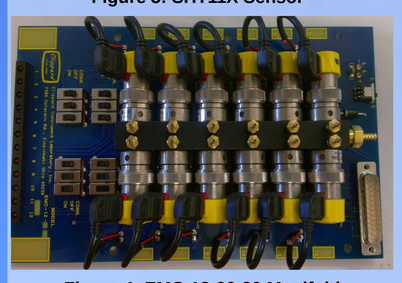


Figure 4: EMC-12-06-20 Manifold

EMC-12-06-20 Solenoid Manifold:

- 12 Mounted Solenoids
- Can deliver up to 100PSI
- 5-10ms response time
- Low power consumption(6V 0.4mA Normally off)

Figure 5: 2-Layer Channel System

Channel Overlay System:

- Allows for individual chambers to be selected for humidity control
- Facilitates peristaltic pumping through compression/decompression of three air chambers

Testing Methods

Sensor Array:

- Program Arduino using an individual sensor and check the accuracy of the output
- Add 3 sensors to the array and expand program to incorporate as many sensors as needed

Solenoid Manifold:

- Using MultiSim, verify code by using testbench code and observing for expected output in simulation
- Load code to Cyclone II and verify function by observing on/off condition of solenoids

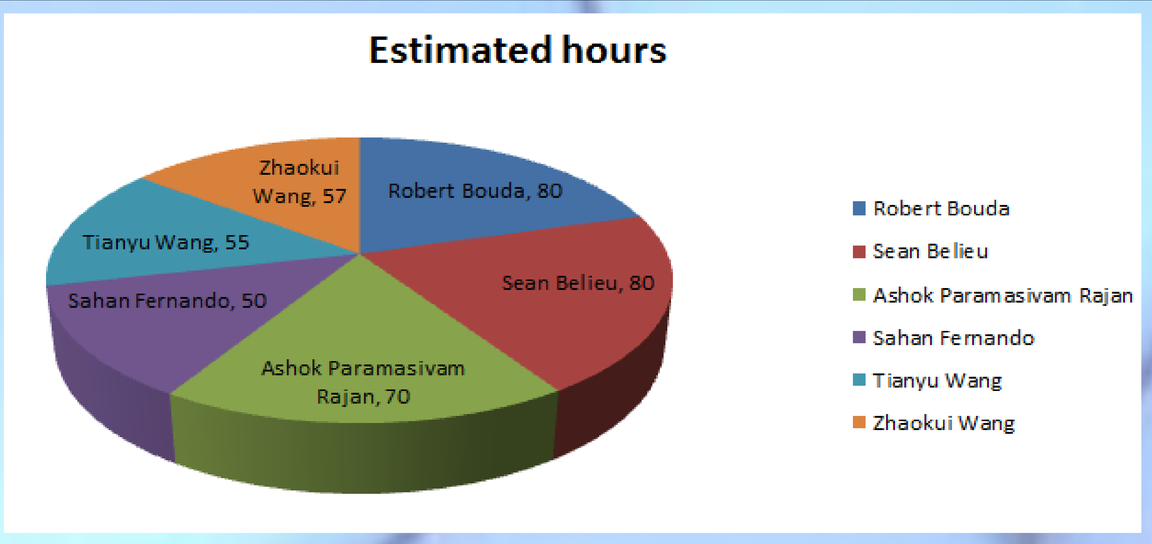
Channel Overlay System:

- Perform stress tests on material to verify proper layer bonding
- Apply air pressure and verify proper inflation of thin layer areas

Small Scale System:

- After verifying function of individual units, incorporate and check for expected operation

Budget and Labor



Parts:	Cost
SHT11X Sensor (x4)	$200
EMC-12-06-20	$500
MISC Cables/Connectors	$20
Total	$720