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February 17, 2004

Lucky One
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RE: ENSC 440 Project Lord of the Seeds Functional Specification

Dear Mr. One,

The attached document, Functional Specification of Lord of the Seeds (LOTS), is a detailed functional specification of our proposed ENSC 440 project previously submitted. Our product aims to provide proper care to hydroponics crops by accurately measuring and controlling the pH and electro-conductivity (EC) level in the hydroponics solution.

The product functional specification provides a comprehensive list of technical goals our project will meet. Operational functions of individual components of our product, as well as the complete system itself will be discussed. The document also includes a detailed test plan. In addition, the functional specification will list industrial and regulatory standards our product adheres to.

Please feel free to contact us if you have any questions, comments or concerns. We can be reached by email at poseidon-microsys@sfu.ca or by cell phone at 604-726-5989.

Sincerely,

Abdul Haseeb Ma

Abdul Haseeb Ma
CEO and President
Poseidon Microsystems

Enclosure: Functional Specification for the Lord of the Seeds

Poseidon Microsystems

Functional Specification for Lord of the Seeds

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Date Issued:

February 18, 2004
Revision 1.0

Executive Summary

Hydroponics, or soil less gardening, has been taken up by more than 1 million gardeners world wide over the traditional in-soil gardening since it was first popularized by the astronauts. The digging and weeding of traditional gardening is gone for good. The general ease and high-quality yield of planting by hydroponics has created an entirely new market, and also fashioning a much anticipated need for automation of these hydroponics systems.

The existing systems are expensive, use outdated technologies and provide user interface that is nearly impossible to use for the average grower. Hence, there is an obvious need for an inexpensive system directed towards the everyday home gardener. Poseidon Microsystems is devoted to the development of such systems.

Poseidon Microsystems brings together the joy of planting and maximum yield available in a single user-friendly package for growers of all levels everywhere. Control of electrolytic conductivity (EC) and pH (acidic levels in the water) level is the cornerstone in hydroponics, hence maintaining a constant desired level of EC and pH is essential. EC and pH sensors in the automated system will feedback readings of EC and pH levels of the nutrient solution in the system. Other than conductivity and pH levels, our system is to monitor air and water temperatures, humidity and water levels.

These sensors can be categorized to air sensors and water reservoir sensors. The air sensors unit would include air temperature and humidity sensors, while the water reservoir unit will contain control valves, pumps, pH, EC, water temperature and water level sensors.

Essentially, the output of these sensors is analog and will be driven by an amplifier circuit before it reaches the A/D of a microcontroller. The microcontroller will then relay the information to a transceiver module. Via long range RF, the information is sent to a base station where the user will be able to view sensor readings and change control constants at the PC via a GUI. The automated control algorithm will also reside at the PC and thus communication between the base station and the sensor units is essential.

Testing will be done vicariously on device interfaces and communication signals to ensure that accurate information is transmitted to the PC. The GUI will allow the users to accurately read sensor readings, while RF communication to the PC will allow users to view these readings without setting foot into the growing environment. Poseidon Microsystems will conduct further testing to make certain that applicable international standards are met while producing a reliable and high quality product.

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Glossary

AC	Alternating Current
CSA	Canadian Standards Association
EC	Electro-Conductivity: ion concentration in liquid; measured in µSiemens/cm^3
GUI	Graphical User Interface
IEEE	Institute of Electrical and Electronics Engineers
ISM	Industrial, Scientific and Medical equipment
LED	Light Emitting Diode
LOTS	Lord of the Seeds: our product, plant monitoring system for hydroponics
pH	potential of Hydrogen
RF	Radio Frequency
RS232	Serial communication connection
TDMA	Time Division Multiple Access

1 Introduction

Lord of the Seeds is an automated hydroponics control system for home growers and hobbyists. The system will enhance plant growth by monitoring and controlling the temperature, pH and nutrient level of the solution. The information of air temperature and humidity data are collected through sensing devices and logged into our innovative software for a convenient history resource. Liquid sensing and control allows total freedom for planters, since the automated system will be controlling the nutrient solution constantly. The *Functional Specification of Lord of the Seeds* will include a thorough discussion of the functional requirements of assembling this system.

1.1 Scope

The Functional Specification describes the basic specifications of *LOTS* as well as enhanced features of the system if time permits.

1.2 Objectives

The following notations are used throughout this document:

[F#-i]: Functional Specification requirement

#: Requirement number.
I: Priority of the requirement.
When *i* is one of the following, it means:
A: Required specification.
B: Desired/Enhanced feature.

2 System Overview

The LOTS system will automate two major tasks of growers: adjusting the nutrients in the solution and adjusting for the correct pH. Aside from controlling, the unit will monitor air temperature, air humidity, water EC, water pH and water temperature. When the water level is below a certain threshold, the system will be able to alert user to add water. Valves will be used to control acid, base and nutrient solutions entering into the reservoir. Below is a basic functional diagram of our integrated system and the intended interfacing methods.

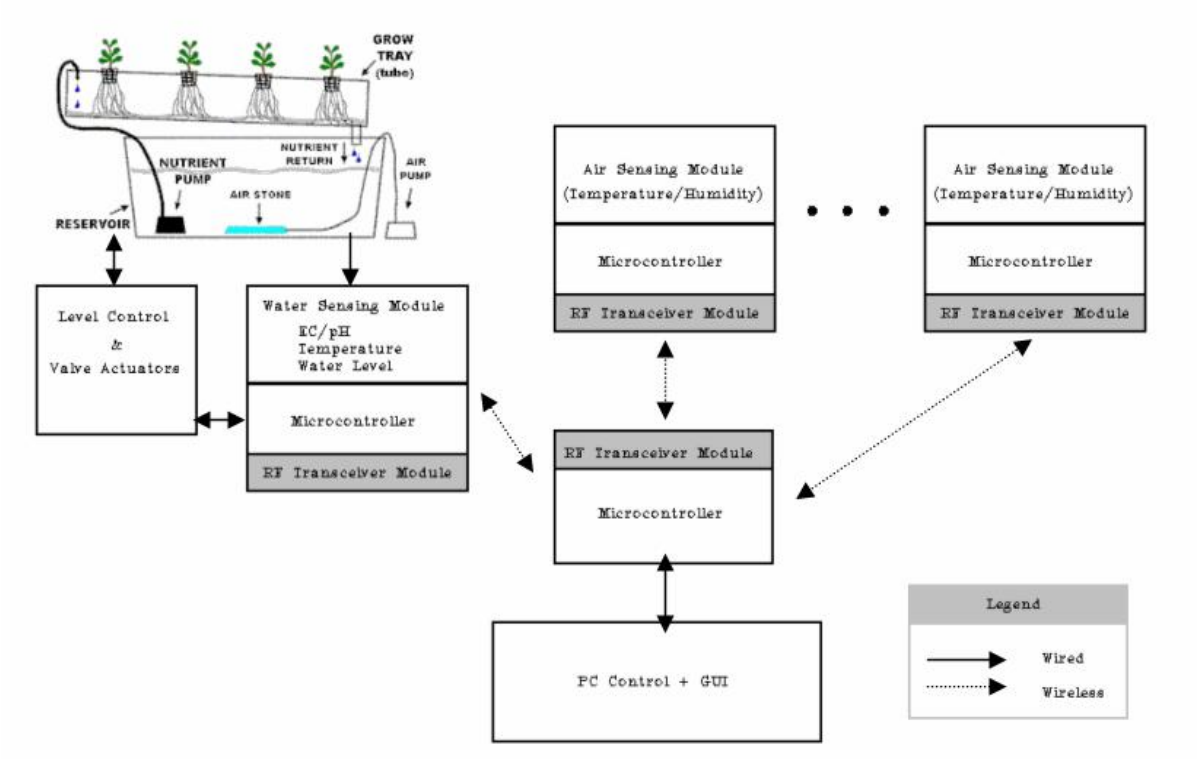

Figure 1: Block Diagram for LOTS

Additional air sensor modules can be produced to provide extra monitoring when required. For the purpose of our project, however, we will be developing only two. The GUI interface should provide an easy to use and user-friendly interaction with the control and monitoring system.

3 System Requirements

The specification listed in this section pertains to the overall system. The specifications of the individual components of the LOTS system will be discussed in the subsequent sections.

Mandatory and desired requirements of Environmental and Standards Compliance specifications of the system are listed in this section. Environmental specification defines the operating conditions of the system; Standards Compliance specification lists all the operation and safety standards for the product.

3.1 Environmental Specifications

The system need to be able to operate under variety of conditions to accommodate the necessity of the plants.

[F1-A] The system should function properly in indoor environments under 1 atmosphere and 26°C.
[F2-A] The system should function properly in the 10 to 30 °C environment.
[F3-A] The power consumption should not exceed a common household appliance.

[F4-B] The system should function in an outdoor environment.
[F5-B] The system should function properly in the 0 to 50 °C.
[F6-B] The system should function properly in the non-condensing humidity of 0 to 98%.
[F7-B] The system should function normally in high frequency environments.

3.2 Standards Compliance

The final version of the LOTS system will comply with the following standards

[F8-B] The system should comply with the FCC Title 47, chapter 1, section 18 of the Code of Federal Regulations regarding ISM device requirements.
[F9-B] The system should comply with the FCC Title 47, chapter 1, section 15 of the Code of Federal Regulations regarding Radio Frequency devices.
[F10-B] The system should pass the necessary IEEE standards.
[F11-B] The system should pass the necessary CSA standards.

4 Wireless Module

This section describes the requirements for the wireless module.

4.1 General Requirements

[F12-A] Central unit must be able to communicate with all other RF modules units.
[F13-A] RF transceiver must operate in the 900MHz ISM carrier frequency.

[F14-B] All RF units must be shock resistant – able to withstand drop from 1.5m.
[F15-B] Packaged RF units should be resilient to minor water damage (i.e. coffee spill).
[F16-B] Each RF module should cost less than CDN $100.

4.2 Performance Requirements

[F17-A] RF units must be able to communicate bi-directionally within 10 meters in an indoor environment.
[F18-A] RF transmission must achieve data rate of 15kbps.
[F19-A] RF units must be able to communicate stably when operating in the temperature range of 0 to 45°C.
[F20-A] Central unit must be able to distinguish messages communicating to and from other RF modules.

[F21-B] RF units communicate bi-directionally within 100 meters indoor.
[F22-B] Communication between RF modules achieved using a TDMA protocol.

4.3 Physical Requirements

[F23-A] RF modules (excluding antennas) must be within a 15cm x 6cm x 3cm dimension.
[F24-A] Each module must be less than 300g.
[F25-A] Air modules must be wall mountable.

[F26-B] Antenna should be less than 10cm in length.

4.4 Testing Requirements

The RF modules are to be placed indoors, 10m away from central unit.

[F27-A] The central unit will transmit a specified message to an individual RF module and that module shall respond in turn.
[F28-A] Each RF module shall transmit a message to central unit and the central unit shall respond in turn.
[F29-A] Verify signal integrity of every signal sent and received by all RF modules.

5 PC Communication Interface

This section outlines the requirements for the communication between the PC and the wireless module.

5.1 General Requirements

[F30-A] User's PC will be operating under Windows 2000/XP environment.

[F31-A] Bidirectional communication between the central RF module and PC will be through a RS232 serial connection.

[F32-B] Bidirectional communication between the central transceiver RF module and PC will be through a USB2.0 connection.

[F33-B] User's PC can operate in either Linux or Windows environment.

5.2 Performance Requirements

[F34-A] RS232 communication must achieve minimum 38400 bits per second.

[F35-A] Raw serial transmission must be achieved without error control or compression.

5.3 Physical Requirements

[F36-A] PC and the central transceiver module should be connected within 0.5m.

[F37-B] PC and the central transceiver unit should maintain connection within 1.5m.

5.4 Testing Requirements

[F38-A] After the proper physical connection is ensured, central transceiver shall send a digital message to PC via the RS232 link, the PC shall display the correct message.

[F39-A] PC shall send a digital signal to the central transceiver and the microcontroller shall route the signal to another output pin to a waveform analyzer to verify the message.

6 Air Sensor

This section describes the specifications for the air sensors unit.

6.1 General Requirements

[F40-A] The system should have two air modules to allow multiple air detectors to be placed in a room.

[F41-A] Each air sensor shall consist of humidity and temperature sensors.

[F42-A] The air sensor shall be compatible with the microcontroller in the wireless module through bidirectional serial communication.

[F43-A] The sensor outputs must be in digital format.

6.2 Performance Requirements

[F44-A] The temperature sensor must be able to measure -20°C to +40°C to with in ±0.5°C.

[F45-A] The humidity sensor must be able to measure 0 to 100% RH to with in ±3.5%.

[F46-A] The response time for both the temperature and humidity sensor should be at most 20 seconds.

6.3 Physical Requirements

[F47-A] The air sensor must be small in size for portability.

[F48-A] The air sensor module must have good ventilation and heat dissipation capabilities to prevent inaccurate temperature readings.

[F49-A] The air sensor module shall be powered with 5 V DC with supply current of 28 µA.

[F50-B] The air sensor shall be enclosed in a casing.

[F51-B] The air sensor must be mounted tightly and sturdily.

6.4 Testing Requirements

To ensure the functionality of the air sensor, the following test shall be carried out.

[F52-A] Obtain reading from the air sensor and convert the digital output to corresponding temperature through a set of mathematical calculation by the microcontroller on the wireless module. Then compare the stored value with a hand held thermometer and humidity meter.

7 Liquid Sensor

This section outlines the requirements for the liquid sensor.

7.1 General Requirements:

[F53-A] Liquid sensor includes pH, EC, temperature and water level sensors.
[F54-A] The liquid sensors at the hydroponics system's reservoir must have a means of connecting to a nearby microcontroller by wire.
[F55-A] The output of these sensors must be a voltage or digital output, readable by the microcontroller A/D, RS232 or SPI.
[F56-A] The complete package of all reservoir liquid sensors must be less then $300.

[F57-B] The liquid sensors should be linked to the microcontroller via RF.
[F58-B] The complete package of all reservoir liquid sensors at production cost should be $150.

7.2 Performance Requirements:

[F59-A] pH sensor must have a resolution of 0.5 pH.
[F60-A] pH sensor should measure in a range 0 to 14 pH.
[F61-A] EC probe must have a resolution of 0.5 µSiemens.
[F62-A] Water temperature sensor must have a resolution of 0.1 °C.
[F63-A] Water level detector must be able to detect the absence of water when the reservoir level falls below 25%.
[F64-A] All sensors must have a temperature range of 0 to 40 °C.
[F65-A] All sensors must have a water pressure range of 0 to 100 psig.
[F66-A] All sensors must have minimal output noise.

[F67-B] pH sensor should have a resolution of 0.05 pH.
[F68-B] Water level sensor should be able to give out numerical values of water levels.
[F69-B] All sensors should have no output noise.

7.3 Physical Requirements:

[F70-A] All liquid sensors must be water submersible. (i.e. material must not corrode in water).
[F71-A] All sensors should not exceed 0.5 meters in length and 0.5 meter wide.
[F72-A] Output wires of all sensors must also be water submersible with PVC.

[F73-B] All sensors should be less then 300 g in weight.
[F74-B] pH and EC probes should be less then 20 cm in length.

7.4 Test Requirements:

The following outlines the tests that will be conducted to ensure the reliability and functionality of the reservoir liquid sensors:

[F75-A] All analog outputs can be examined on oscilloscopes.
[F76-A] Since most analog outputs are in the millivolt range, signal-conditioning circuits must be used. Then output can be compared with other means of measurement (i.e. litmus paper or digital pH meter for pH).
[F77-A] Precision must be tested by repetition.

8 Reservoir Liquid Control

This section outlines the requirements for the liquid control used to pour the acid, base, and nutrient solutions.

8.1 General Requirements

[F78-A] There shall be one actuator valve for each of acid, base, and nutrient solutions.
[F79-A] The actual opening and closing of the valve shall be powered by 120 V AC source.

[F80-B] The liquid controllers could be linked to the microcontroller via RF.

8.2 Physical Requirements

[F81-A] All liquid actuators must be water resistant.
[F82-A] Control Valves must fit PVC piping for in-line mounting.
[F83-A] All liquid actuators must be durable and should not clog up over time.
[F84-A] I/O wires of all sensors must also be water resistant with PVC.
[F85-A] The valves should connect to the tanks holding the acid, base and nutrient solutions.

8.3 Performance Requirements

[F86-A] Valves must be turned on and off by analog or digital signal originating from the microcontroller for the liquid sensor.

[F87-B] The valves should be able to control the flow rate of the solution being poured.

8.4 Testing Requirements

[F88-A] Electrical pulse from a function generator should turn the valve on and off.
[F89-A] Digital signal from the microcontroller should turn the valve on and off at specified moments.

9 Graphical User Interface

This section describes the specifications for the GUI. Requirements for the graphical user interface are defined in terms of the program displayed on the PC monitor. The GUI is divided into four parts: main, option, water and air interface.

9.1 Main Interface Requirements

This section defines the visuals on the main user interface.

[F90-A] There shall be large digital numeric displays of the current sensor readings (pH, EC, water temperature, air temperature, humidity).
[F91-A] There shall be a digital LED indicator for the water level.
[F92-A] There shall be a digital LED indicators for the pH, EC, water temperature, air temperature and humidity warnings.
[F93-A] There shall be digital numeric control of the set pH level and set EC level.

[F94-B] There shall be an option to select the number of air sensor modules displayed.

9.2 Option Interface Requirements

This section defines the options available on the user interface.

[F95-A] There shall be the option to choose which user interface to display (main, water or air).
[F96-A] There shall be an option to set the desired pH and EC level.
[F97-A] There shall be an option to monitor and control the pH level.
[F98-A] There shall be an option to monitor and control the EC level.
[F99-A] There shall be an option to set the range for pH warning.
[F100-A] There shall be an option to set the range for EC warning.
[F101-A] There shall be an option to set the range for water temperature warning.
[F102-A] There shall be an option to set the range for air temperature warning.
[F103-A] There shall be an option to set the range for humidity warning.
[F104-A] There shall be an option to choose the file to save the data.

[F105-B] There shall be an option to bring up old data logs.

9.3 Water Interface Requirements

This section defines the visuals on the water user interface.

[F106-A] There shall be large digital numeric displays of the current water sensor readings (pH, EC, water temperature).
[F107-A] There shall be a digital LED indicator for the water level.
[F108-A] There shall be a digital LED indicators for the pH, EC, and water temperature.
[F109-A] There shall be digital numeric control of the set pH level and set EC level.

[F110-A] There shall be graphs tracking the sensor readings.

[F111-B] There shall be an option to change the scale on the graph to display readings from the last 24 hours, last week, last month, or entire growth cycle.

9.4 Air Interface Requirements

This section defines the visuals on the air user interface.

[F112-A] There shall be large digital numeric displays of the current air sensor readings (air temperature, humidity).

[F113-A] There shall be a digital LED indicators for the air temperature and humidity warnings.

[F114-A] There shall be graphs tracking the sensor readings.

[F115-B] There shall be an option to change the scale on the graph to display readings from the last 24 hours, last week, last month, or entire growth cycle.

[F116-B] There shall be an option to select the number of air sensor modules displayed.

10 System Test Plan

The LOTS system is to undergo vigorous testing to ensure all functions work properly.

[F117-A] The system shall undergo RF range testing in an indoor environment. RF units will be moved away from system until they can no longer operate.

[F118-A] The system shall undergo RF interference testing. A 900 MHz cordless phone and cellular phones shall be used while the system is operating.

[F119-A] The system shall undergo two pH control tests, disturbance and user control. The reservoir pH will be monitored with an external digital pH meter.

- For the disturbance testing, the pH of the system will be changed drastically in the reservoir.
- For user control testing, the pH will be changed in the GUI.

[F120-A] The system shall undergo pH monitoring testing. The GUI measurement will be compared to the external digital pH meter in the reservoir.

[F121-A] The system shall undergo two EC control tests, disturbance and user control. The reservoir EC will be monitored with an external digital EC meter.

- For disturbance testing, the EC of the system will be changed drastically in the reservoir.
- For user control testing, the EC will be changed in the GUI.

[F122-A] The system shall undergo EC monitoring testing. The GUI measurement will be compared to the external digital EC meter in the reservoir.

[F123-A] The system shall undergo water level testing. Water will be removed from the reservoir until the sensor is triggered and displayed on the GUI.

[F124-A] The system shall undergo water temperature testing. The water temperature displayed on the GUI will be compared to the external digital thermometer in the reservoir.

[F125-A] The system shall undergo air temperature testing. The air temperature displayed on the GUI will be compared to the external digital thermometer beside the sensor.

[F126-A] The system shall undergo humidity testing. The humidity displayed on the GUI will be compared to the external humidity meter beside the sensor.

11 User Documentation

User manuals will be included to provide assistance for the use of LOTS.

[F127-A] The manual will have instructions in English.

[F128-A] The manual will be written for an audience with no or minimal experience with electronic devices, but will assume basic knowledge of growing hydroponics plants.

[F129-B] There will be example cases throughout the manual.

[F130-B] The manual will be written in multiple languages: French, Japanese, Spanish, and Chinese.

[F131-B] Users can contact us for further assistance.

12 Conclusion

The Functional Specification document contains in depth outline of technical requirements, functions, and industry standards that the Lord of the Seeds prototype system must achieve in order for it to be a viable product. Specification of the overall system shows how the product as a whole should perform, while component specification shows how the system works internally. Having a detail list of functionalities allows Poseidon Microsystems a guideline to design and produce our product. Also, by having an exhaustive test plan, we can check the reliability of our product in the real world. Potential functionality has also been mentioned in the Functional Specification, making available future expansion of the product.

13 References

Canadian Standards Association
(http://www.csa.ca/standards/Default.asp?language=English)

Federal Communications Commission (FCC), Wireless Telecommunications Bureau
(http://wireless.fcc.gov/rules.html)

IEEE Standards Association (http://standards.ieee.org/)

Proposal for Lord of the Seeds. Poseidon Microsystems.

Sensirion. Retrieved January 28, 2004.
(http://www.sensirion.com/en/sensors/humidity/sensors_devices/sensorSHT11.htm)

Sensorex, Educational Support
(http://www.sensorex.com/support/support_education.html)

