# 6.111 Final Project Proposal

# Soil-Water Characterization Unit

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# Soil-Water Characterization Unit

When a water sprinkler system is installed in a lawn, the lawn must be surveyed in order to ensure that the sprinklers are distributing water evenly. If water is not distributed in a uniform manner, parts of the lawn may dry up while others become swampy. The current method of characterizing the water distribution by sprinklers involves placing cups across the lawn and allowing the sprinkler system to run for some time. After the system finishes its watering cycle, the level of the water collected in each cup is recorded and used in industry standard formulae that give relevant measures of water distribution. While this method of charactering water distribution has been used for some time, error is introduced because of human error in the measurement of water levels in the cups and in the measurement of cup locations. Moreover, because this method measures the water distributed above ground level, it can only be used as an indirect indication of water penetration into the soil. Water penetration into the soil is a better measurement of water distribution in lawns because the goal of watering is to ensure that the roots of the lawn are obtaining proper amounts of water.

My final project for 6.111 will be to develop a device for use by sprinkler system installers that will characterize the penetration of water into soil. The device will be composed of a sensor for detecting water penetration, an LCD and button inputs for display and user interaction, a GPS for recording position information, as well as a digital controller FSM that will interface with each of the components and perform calculations. Figure 1 shows a rough sketch of the overall configuration of the device.

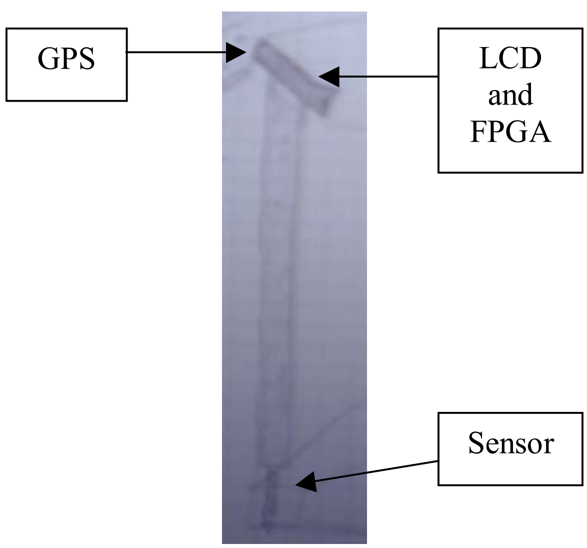


Figure 1: Rough sketch of Water-Characterization Unit

The sensor will measure the resistance across twenty pairs of pads along its shaft and convert those signals to digital voltages. The sensor will be driven into the ground at a desired location and the presence of water will detectibly lower the resistance across the pads on the sensor's shaft. The sensor will be four inches long and will take measurements every quarter inch along the shaft. Figure 2 shows the sensor prototype to be used in the project along with the controlling electronics. A GPS will be used to record the date, time, latitude, and longitude of each measurement. In addition, the GPS may be useful as a non-volatile memory, however, this has not been verified as of yet. An LCD screen will be used to interact with the user, providing a calibration interface, a display of individual measurement information, as well as the results of formulae computed by the controller that characterize the water penetration and distribution for a set of samples.

Figure 2: Sensor prototype and controlling electronics

The block diagram in Figure 3 provides an overview the inputs and outputs of the system as well as the main modules. The system uses several buttons, a clock, digital voltage readings from the sensor, and NMEA802 sentences from the GPS as inputs. The system outputs control signals to the sensor as well as signals to an LCD for display. A module is used for the control of each of the main system components.

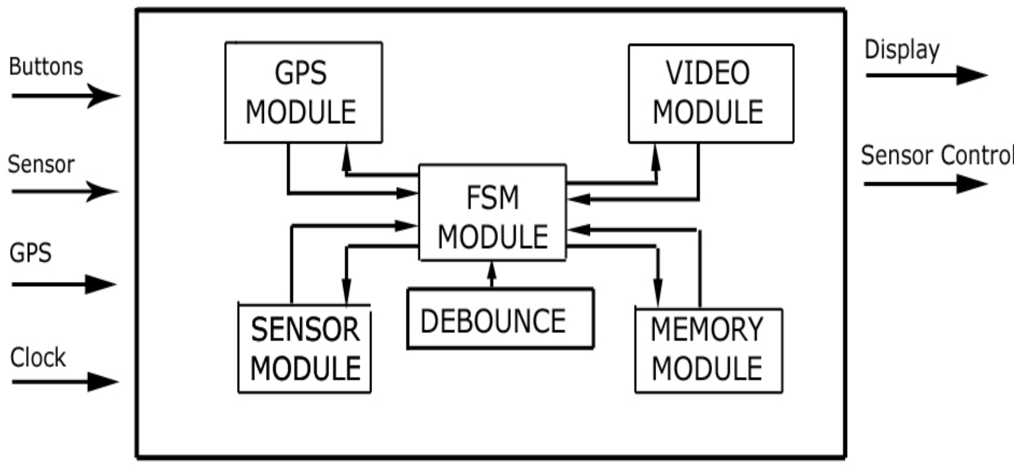


Figure 2: System overview block diagram

The GPS module is responsible for communication with the GPS. The module accepts a position request from the FSM module. The GPS module uses the GPS input and decodes the signal into useful position and time information. The module outputs the latest time and position for further processing. A handheld GPS will be used to output position and time information using the NMEA802 protocol. The protocol communicates in 8-bit ASII at 4800 baud and uses commas to separate a set number of outputs. Upon request, the GPS module will sample the GPS input, count commas to locate the latest position and time fields, and output these data. This module will be tested to be functional if a position request successfully results in the outputs of the latest position and time.

The Sensor module is responsible for sampling the sensor as well as outputting sensor control signals. The Sensor module accepts a sample request from the FSM module. The Sensor module then creates the appropriate signals on Sensor Control to sample the sensor at 16 different locations. The Sensor Control signal will be used to control a 16 input op-amp that selects which resistance to measure on the Sensor's shaft. The Sensor module samples the sensor by reading an 8-bit number from a 3-bit addressable A-D converter. Upon request, the Sensor module will generate the appropriate control signals for the sensor, address and sample the A-D converter, and output a 16x8-bit number that accounts for each of the 16 samplings. This module will be tested to be functional if a sample request successfully results in the 16x8-bit sample output.

The Video module is responsible for generating controlling signals for an LCD. The Video module accepts state information from the FSM module as well as other data. The module outputs appropriate signals to drive an LCD that will be selected by November 15. The Video module will display a GUI containing an idle state, a sensing state, a calibration state, and a calculation state. The Video module will generate a display at all times, generating a different display for each state as directed by the FSM. This module will be tested to be functional if changes in functional states result in the appropriate display on the LCD.

The Memory module is responsible for intermediate storage and buffering of Sensor inputs and GPS NMEA802 strings. The memory will be addressable and be capable of storing one GPS string, 25 position and time records from the GPS module, as well as 25 16x8-bit samplings from the Sensor module. This module will be tested to be functional if the Memory module can be addressed to successfully store and retrieve the stated information on request.

The FSM module is responsible for integrating the control of each of the modules. The FSM module uses button inputs to control the state (idle, sensing, calibration, or calculation). The FSM sequences requests to and from the other modules differently in each state to achieve the behavior desired in each state. The FSM module will be tested to be functional if it successfully uses the button inputs to control the state and generate the appropriate control signals described earlier for each module.

If this base project can be accomplished and time permits further development, the controller will use the sensor inputs to create graphical representations of the measurements and the results of computed water penetration formulae. For example, I will continue to create a graphical representation for the water distribution over the lawn using a blue color for complete soil saturation, a brown color for completely dry soil, and a combination of the two colors for soils between the extreme conditions. Another goal is to develop a 3D-linear interpreter to estimate the water penetration between measurements. Work for the linear interpreter would commence if the base project were completed with time to spare.