PRAG 304L: Electrical Diagnostics for Farm Machinery Lab
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Lab 7 Sensors and Signal Processing: Soil Moisture Sensor

1. Overview

Soil moisture sensors are critical tools in precision agriculture, allowing for real-time monitoring of soil water content to optimize irrigation and improve crop yield. In farm machinery systems, accurate soil moisture measurement ensures efficient water usage, reduces waste, and supports sustainable farming practices. The proper functioning of soil moisture sensors is essential to prevent erroneous readings, which can lead to over-irrigation, under-irrigation, or improper fertilization strategies. Diagnosing and ensuring the accurate operation of these sensors help farmers and agricultural engineers maintain optimal field conditions, reduce operational costs, and enhance crop productivity. This lab focuses on the use of the Meter Group's EC-5 soil moisture sensor to measure soil moisture levels using an Arduino Uno and Simulink. You will learn to process sensor signals and develop a calibration equation within Simulink for accurate soil moisture estimation.

The EC-5 soil moisture sensor provides an analog voltage output that corresponds to the volumetric water content (VWC) of the soil. This sensor operates on the principle of measuring the dielectric permittivity of the soil, which varies with moisture levels. The voltage output can be converted into soil moisture content using a linear calibration equation:

$$VWC = Gain \times mVolt \pm offset$$

where the **gain** and **offset** values are determined experimentally. Simulink is used to read, process, and deploy this equation to the Arduino for real-time measurements.

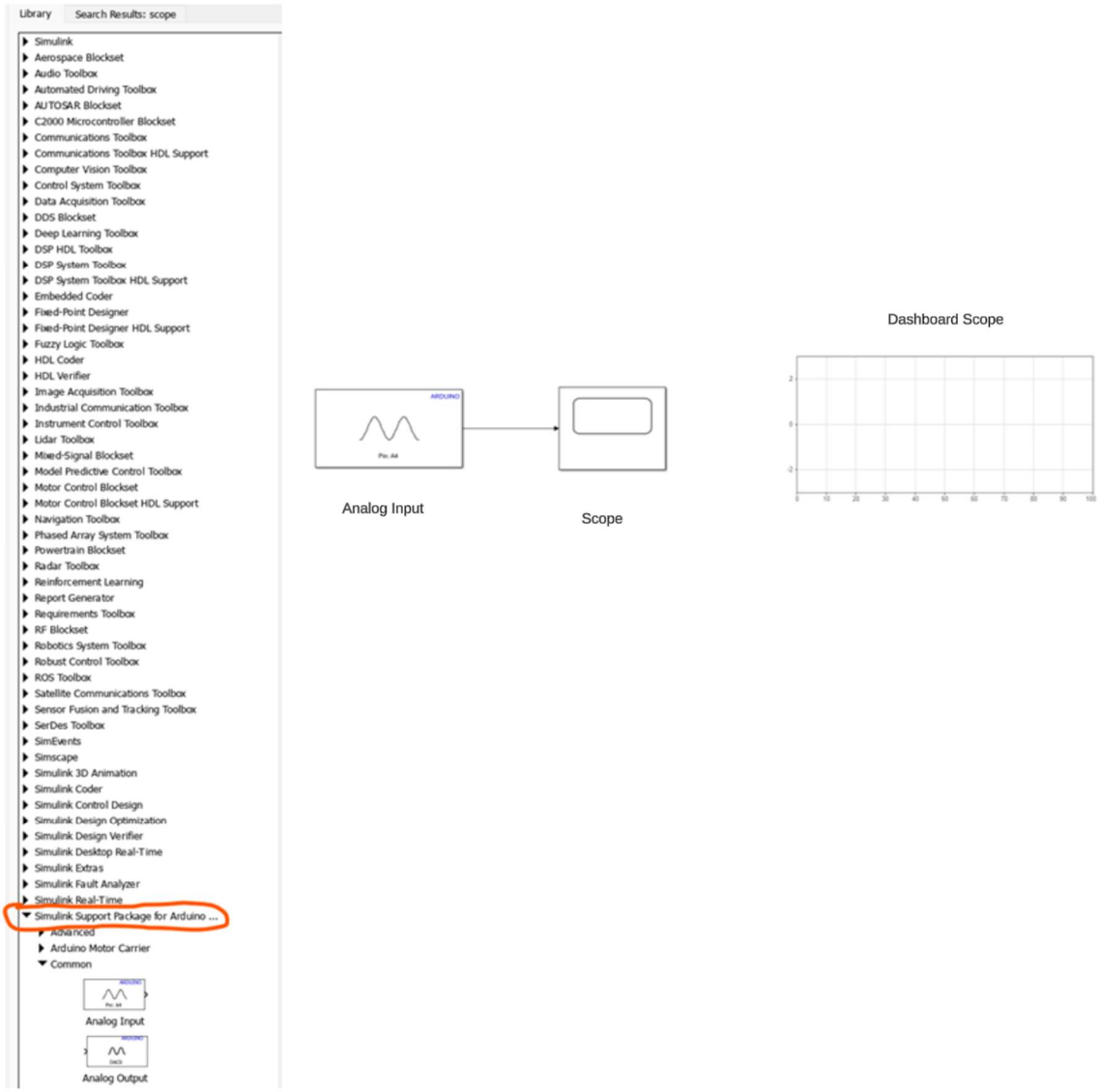
2. Objectives

i. Understand the working principles of the EC-5 soil moisture sensor.
ii. Learn to acquire and process analog sensor data using Simulink and Arduino Uno.
iii. Develop a soil moisture calibration equation by adjusting gain and offset values.
iv. Deploy the Simulink model to Arduino Uno for real-time soil moisture monitoring.

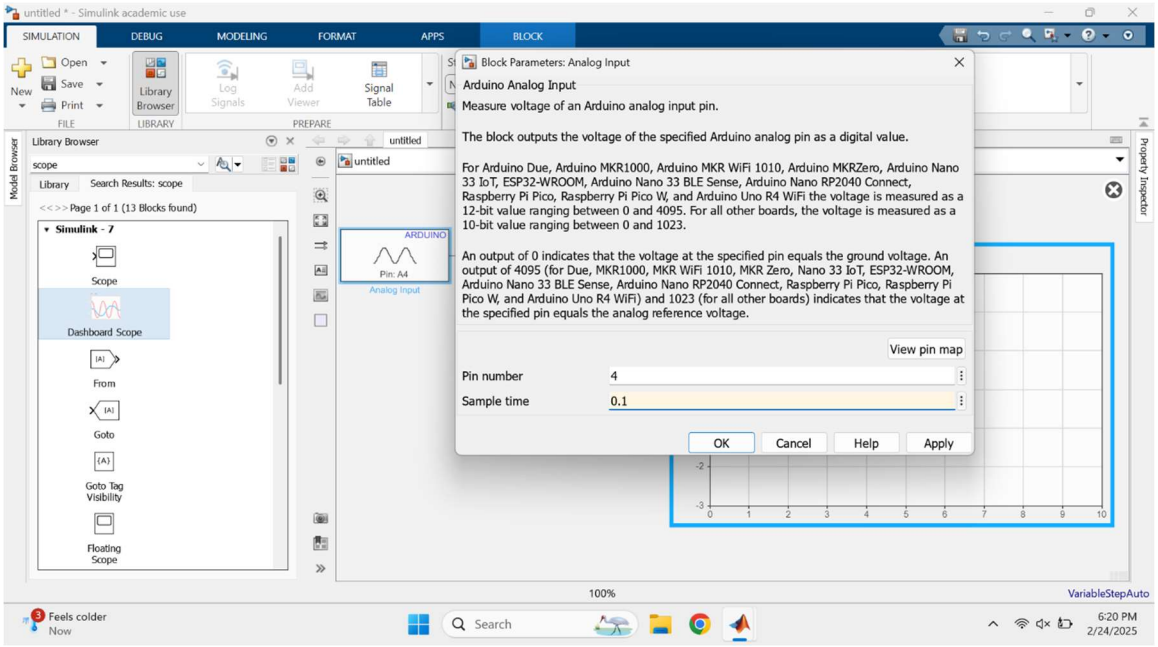
3. **Experiment 1:** Read Analog Voltage Output from EC-5 Soil Moisture Sensor Using Arduino Uno and Simulink

3.1 Procedure

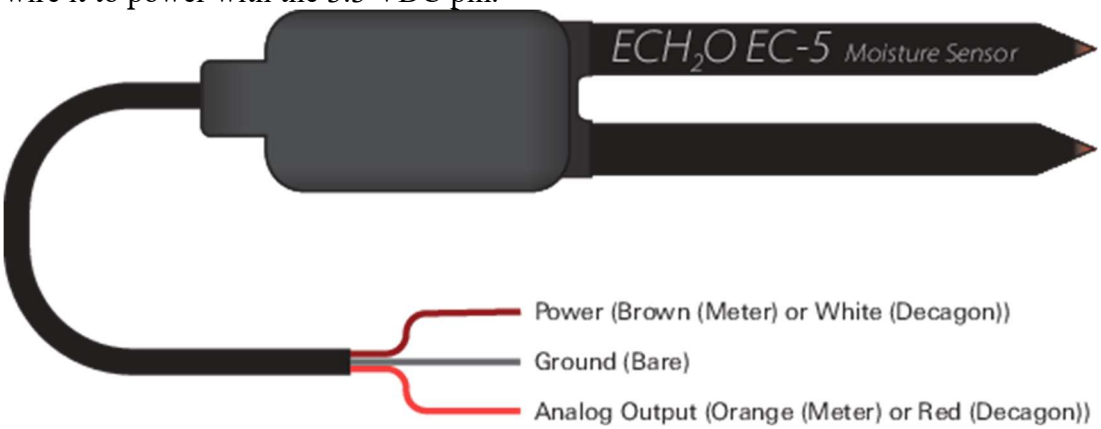
i. Following lab 4's experiment 3 steps build the following Simulink model and deploy it on your Arduino Uno board. *Please note that this time you will be using "**Simulink Support Package for Arduino**" unlike last time in which you used the support package for Raspberry Pi.*



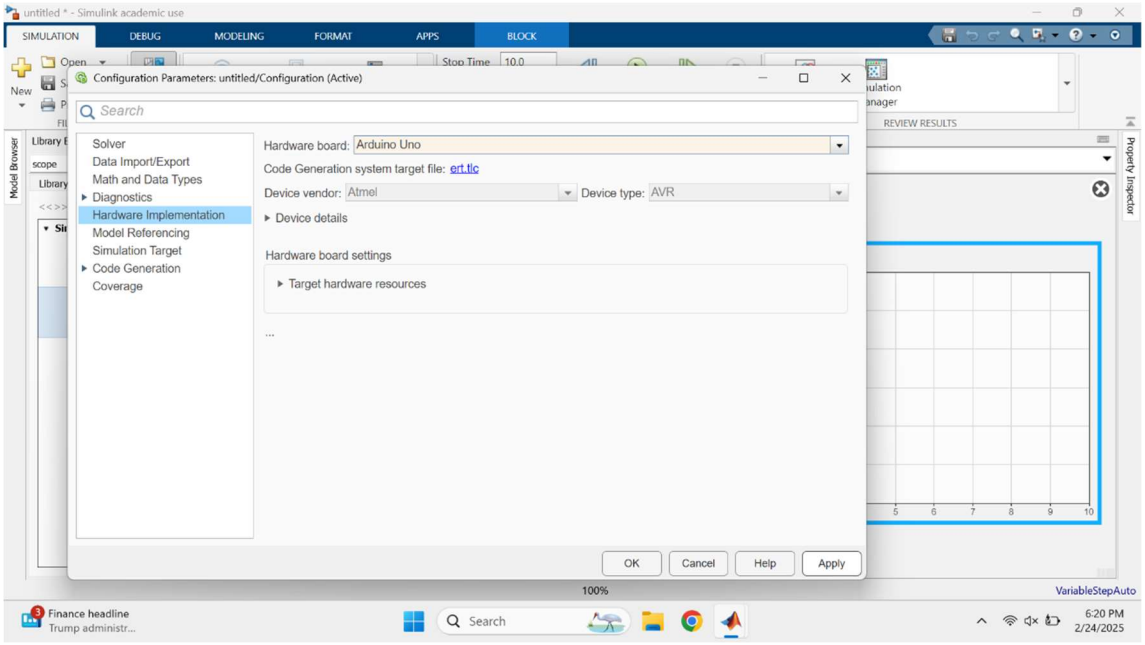
ii. Double-click the Analog Input block and do the following settings.



iii. Wire the EC-5 sensor to Arduino using the following wiring diagram. Please note EC-5 usually needs 2.5VDC but Arduino Uno has either 5VDC or 3.3 VDC. So, you will wire it to power with the 3.3 VDC pin.



iv. Use the CTRL+E on your keyboard to configure hardware setup for the Arduino Uno board before building and deploying the model.



v. After the model is built and deployed, make sure to set "Stop Time" as "inf" to continuously monitor real-time analog raw voltage outputs from the soil moisture sensor.

vi. Now put the soil moisture sensor in a cup of water and observe the change in the graphical display. You can see the graphical display directly on Dashboard Scope.

vii. Stop it when done and move to the next experiment.

4. **Experiment 2:** EC-5 Soil Moisture Sensor Factory Calibration

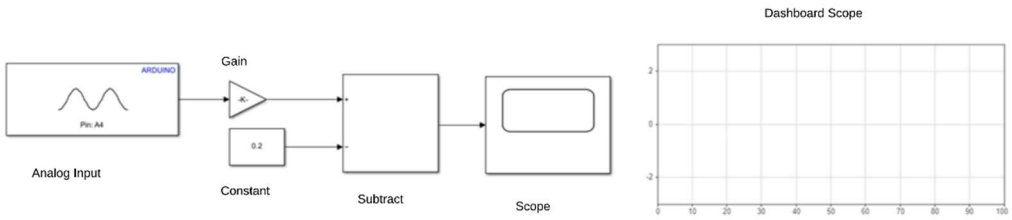
Soil moisture sensors are usually provided with factory calibration equations. Similarly, Meter Group has provided the following factory calibration equation for the EC-5 in potting soil type:

$$VWC = 0.00211 \times mV - 0.675$$

Here, gain = 0.00211 and offset = -0.675. By using this equation you can convert the raw voltage output from the EC-5 into volumetric water content value. Values closer to 0 mean dryer end and values closer to 1 mean wetter end. To implement this, following the following process.

4.1 Procedures

i. Build the following Simulink model and then build and deploy on Arduino as before.



ii. Make sure to double-click gain and constant blocks and set the appropriate values based on the above equation.
iii. Then follow steps iv, v and vi as in Experiment 1.

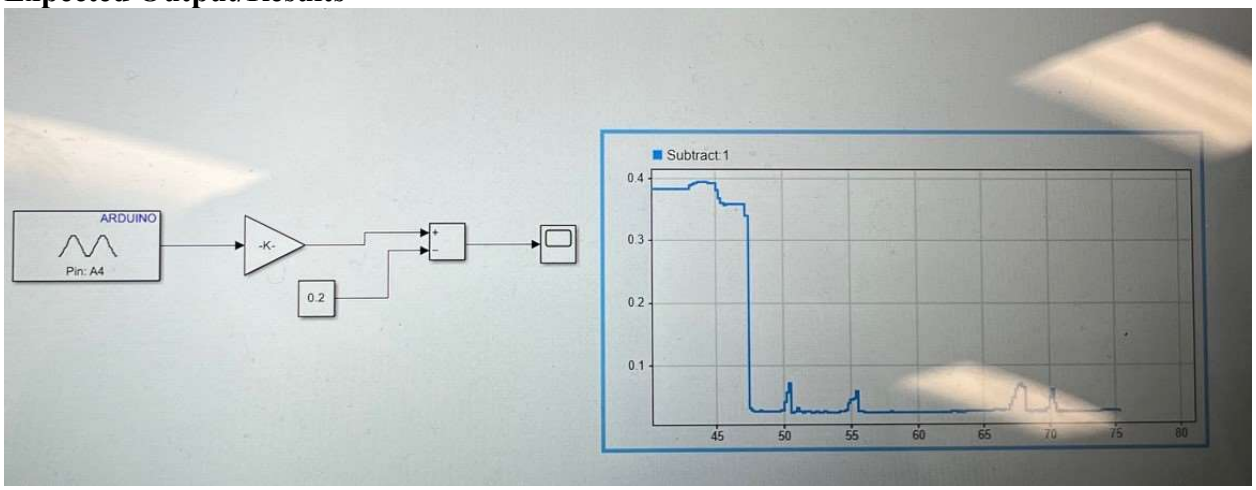
Please note if you get values closer to 0 when the EC-5 sensor in dry in air. If not then you need to custom calibrate your sensor following the steps in Experiment 3.

5. Experiment 3: EC-5 Soil Moisture Sensor Custom Calibration

5.1 Procedures

i. Simply adjust the offset value by adjusting the constant block value and keep building and deploying the model until you start seeing values closer to 0 when the soil moisture sensor is in air dry conditions.
ii. Based on the above finalized values, write down your custom calibration equation in your lab report.
iii. When done so, you can put the EC-5 in a cup of soil provided and then add water to it in slow increment and observe real-time graph on Dashboard Scope.

6. Expected Output/Results



Submit lab report with only methods, results and discussion of your results.