Portable Soil EC - Development of an electronic device for determining soil electrical conductivity

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A paper from the Proceedings of the
16th International Conference on Precision Agriculture
21-24 July 2024
Manhattan, Kansas, United States

Abstract.

Decision-making in agriculture demands continuous monitoring, a factor that propels the advancement of tools within Agriculture 4.0. In this context, understanding soil characteristics is essential. Electrical conductivity (EC) sensors play a pivotal role in this comprehension. Given this backdrop, the core motivation of this research was developing an accessible and effective electronic device to measure the apparent EC of the soil. It provides features like geolocation, recording of the date and time of collection, expandable digital storage capacity, and USB connectivity, making it a valuable tool for field surveys in the application of PA. The project focused on developing an electronic circuit, starting with a schematic detailing the component connections. Reading the manufacturer's data sheets is essential to avoid mistakes. Subsequently, the printed circuit board layout was designed, considering the optimization of space and centralized positioning of the main components. The present research yielded that the portable EC meter, which demonstrates versatility in its application, is easy to handle and offers promising results for field application. The name proposed by the developers is Portable Soil EC. Field testing revealed significant variability in the soil EC in apple plantations.

Keywords.
Conductivity; soil; GPS; precision agriculture

Rauber, L. A., Bazzi, C. B., Oliveira, W. K. O., Schenatto, K., Sobjak. R. & Gebler, L. (2024). Portable Soil EC - Development of an electronic device for determining soil electrical conductivity. In Proceedings of the 16th International Conference on Precision Agriculture (unpaginated, online). Monticello, IL: International Society of Precision Agriculture.

Introduction

Decision-making in agriculture demands continuous monitoring, a factor that propels the advancement of tools within Agriculture 4.0 (Liu et al. 2021). In this context, understanding soil characteristics is essential. Electrical conductivity (EC) sensors are pivotal in this comprehension (Hamidi and Roshani 2023). They are especially relevant in precision agriculture (PA), which delves into the analysis of spatial variability in cultivated areas and prioritizes specific soil aspects such as salinity and moisture (Moral et al. 2010).

Conductivity can be measured through methods like electromagnetic induction or direct contact. Well-known equipment, such as Veris® and EM 38®, as well as Terram, are employed for this purpose. Additionally, there's an innovation from EMBRAPA in this field, showcasing the potential for enhancement.

Given this backdrop, the core motivation of this research was developing an accessible and effective electronic device to measure the apparent EC of the soil. It provides features like geolocation, recording of the date and time of collection, expandable digital storage capacity, and USB connectivity, making it a valuable tool for field surveys in the application of PA.

Materials and methods

The applied diagram was based on the study by Rabello et al. (2011), which describes the implementation of location and data storage systems. The GPS and Memory systems connect to the Microprocessor, requiring serial communication. Therefore, our proposal consists of a central controller that manages information, synchronizes with the GPS, stores data, and communicates via USB. The conductivity measurement circuits remain, with adjustments to the new circuit board (Fig. 1).

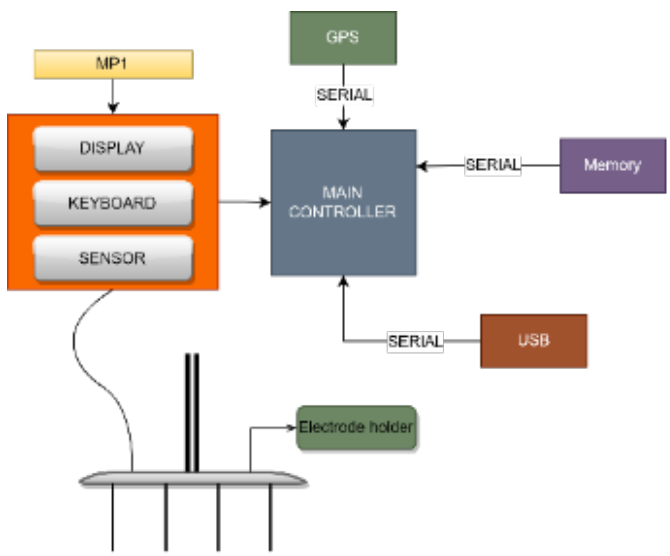

Fig. 1. Proposed block diagram for the Portable Soil EC.

For testing, prototyping materials were used. Field tests demand a robust prototype, requiring circuit board manufacturing and casing. The board manufacturing uses CNC milling, which is suitable for prototypes.

The ESP32-WROOM microcontroller has integrated WI-FI, a power supply of 3.0-3.6V, and supports various communication protocols. The memory uses an SD card, SPI communication, and a socket for support. The 1.8” TFT LCD Display has a resolution of 128 x 160 pixels. The positioning component is the NEO-6M, famous for its ease and cost. The GY-GPS6MMV2 GPS module sends information in the NMEA 0183 format.

Results and Discussion

The project focused on developing an electronic circuit, starting with a schematic detailing the component connections (Fig. 2). Reading the manufacturer's data sheets is essential to avoid mistakes. Subsequently, the printed circuit board layout was designed, considering the optimization of space and centralized positioning of the main components. A Gerber file was generated for the board fabrication, which, after production, had its members soldered and tested. The microcontroller programming was done in the C language. The final equipment, housed in a protective case, features a display with various functions and a Wi-Fi communication system for data transfer (Fig. 3). Figure 4 shows the results obtained from the field surveys using the Portable Soil EC.

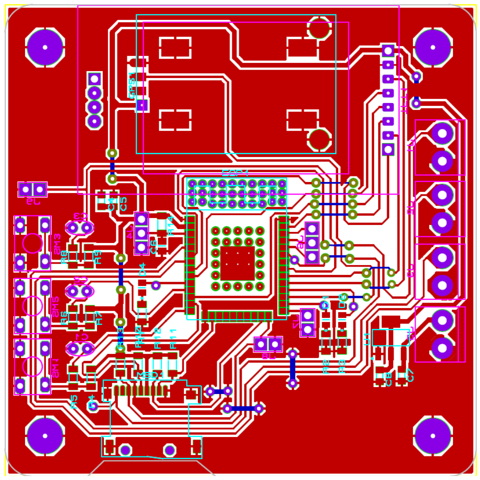

Fig. 2. Component layout design.

Fig. 3. Completed equipment.

Fig. 4. Sample set

Conclusion or Summary

The present research yielded that the portable EC meter, which demonstrates versatility in its application, is easy to handle and offers promising results for field application. The name proposed by the developers is Portable Soil EC. Field testing revealed significant variability in the soil EC in apple plantations. It was observed that the quality of the georeferencing system influenced the precision of the collection, with some points recording distinct locations for the same place. The lack of conductivity homogeneity indicates differences in soil compaction. An advantage of the Portable Soil EC was the efficiency in data collection, especially when compared to devices without automatic geolocation, and it has good application in perennial crops due to its versatility in groups between the plants in the rows.

Acknowledgments

The authors are grateful to the Federal University of Technology - Paraná (UTFPR), the Araucária Foundation (Fundação Araucária), the Coordination for the Improvement of Higher Education Personnel (CAPES), the National Council for Scientific and Technological Development (CNPq), the Itaipu Technological Park Foundation (FPTI), AgriLab, and The Brazilian Agricultural Research Corporation (Embrapa), for the support received.

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