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# A modified dielectric probe for increased measurement volume of soil water content

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The information of water amount in soil is essential in many fields (e.g. agriculture, forestry, hydrology). Methods to determine water content (WC) can be classified as direct and indirect. Direct methods are connected with the destruction of a sample, are time-consuming and impractical for the measurements in the crop fields. Indirect methods ensure non-destructive and in situ measurements and depend on monitoring a dielectric soil property which is a function of WC. The soil dielectric permittivity is one of the used properties which may be determined by time domain reflectometry (TDR) or frequency domain reflectometry (FDR) techniques. TDR probes are expensive and can be easily damaged at multiple insertions to soil. The open-ended (OE) probes, well-known for their application in the measurements of the complex dielectric permittivity of materials in broadband frequency range, are more resistant to mechanical damage but they are characterized by low penetration depth of electromagnetic waves. Therefore, there is a need to develop sensors able to measure bigger volumes and at the same time sufficiently durable for multiple insertions in soil.

The objective of this work was to test the performance of an open-ended dielectric probe with an antenna (OE-A) in the frequency range 1 MHz – 6 GHz for two mineral soils using vector network analyzer (VNA) one port (reflective) measurements. Firstly, numerical simulations of the probe using Ansys HFSS software were performed. Secondly, the probe calibration was done on the reference materials (air, distilled water and ethanol). Thirdly, the soils measurements were done to check the possibility to determine soil moisture.

The obtained results show that the tested probe can be applied for fast moisture measurement with minimal soil disturbance. The real part of dielectric permittivity (ε') obtained for the tested soils was connected with their moisture and the relation between ε' and volumetric water content was determined. Additionally, the effect of the sample volume was considered and the relation between the high-frequency limit and diameter of the sample was determined.

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