Multi-Frequency Measurement Of Dielectric Properties Of Dry Soils Over Bare And Vegetated Fields


Abstract: The dielectric constant ε', dielectric loss ε", and emissivity of 4 dry soil samples have been measured in the frequency range 100 Hz-2 MHz using a precision LCR meter (IM 3570 HIOKI). The variation of these properties with frequency is consequences of formation and alignment of induced dipoles at the molecular scale within the material. It has been observed that dielectric constant ε' and dielectric loss ε" decrease with increase in the frequency range from 100 Hz to 2 MHz. The dielectric properties of four different soil samples collected from various remote areas of Marathawada region are determined using LCR meter. The soil samples are converted into pellets of known dimensions so as to affix them in the sample holder.

Keywords: LCR meter, series capacitance, parallel capacitance dielectric constant, dielectric loss, quality factor, emissivity.

1. INTRODUCTION:
The vast majority of the exposed portion of the earth covers layer of soil. Soil nature is an important factor influencing the productivity of our planet’s ecosystem. It is vital for the existence of many forms of life that have evolved on our planet. Soil itself is very complex and it would be very wrong to think of soil just as a collection of fine mineral particle. Soil contains water, air, dead organic matter and different types of living organism. The soil is influenced by organism, climate, topography, parent material and time. These parameters filter and clean water that passes through them. They can change the chemistry of water and the amount that recharges the groundwater or returns to the atmosphere to form rain. Frequency plays an important role when studying the dielectric properties. Many researchers have estimated the dielectric properties of many materials using different ranges of LCR meter. LCR meter read the value of parallel capacitance, series capacitance, quality factor, dissipation factor etc of the material under study from which it is easy to calculate dielectric properties. Dissipation factor is the ratio of resistance of the insulating material to the capacitive resistance at a given fixed frequency. The value of dissipation factor is smaller than the dielectric constant. Impurity or contamination of material can be determined by the Dissipation factor. When moisture in the material change continuously it effects the value of the dissipation factor. The study of dielectric properties of soil includes dielectric constant, dielectric loss, emissivity etc. The dielectric permittivity is the most important parameter in microwave remote sensing studies of dry and wet soils. Hence through knowledge of dielectric properties of different types of soils is necessary for efficient use of microwave remote sensing technique [1-3]. A study of soil profile supplemented by physical and chemical properties of the soil will give full picture of soil fertility and productivity. Every soil has its natural fertility, which differs from soil-to-soil. In the world, cropping pattern is not same; it changes from one place to another place with response to types of soil and its characteristics [4-6].

2. METHODOLOGY
LCR meter measures the electrical parameters at a wide range of frequencies ranging from 100Hz to 5MHz [Agilent Technologies]. Presently IM 3570 HIOKI LCR meter and impedance analyser is used for the measurements of the dielectric parameters. Every material has a unique set of electrical characteristics that are dependent on its dielectric properties. Accurate measurements of these properties can provide scientists and engineers with valuable information. At low frequencies (Hz-MHz) the perturbation of charges at the solution solid interface is responsible for the permittivity or impedance variation. The large enhancement in the perturbation results from two mechanism. They are polarization of the counter ion in the diffuse double layer known as DDL polarization and polarization of charge imbalance created at the contact of the two phases with different permittivity known as Maxwell-Wagner polarization [9]. To measure the dielectric properties of soil samples at radio frequency soil pallets were made of known diameter and thickness by a compressor machine. During preparation of pallets acetone and polyvinyl alcohol were used as a binder. Further, to remove trace of binder from the samples they were sintered at 400°C for half hour and then cooled to room temperature. These pallets are then placed in the sample holder of LCR meter in which electrical properties of these samples were determined for frequencies ranging from 100 Hz to 2 MHz.

1) Experimental set up
FORMULAE

Dielectric Constant = \( \varepsilon = \frac{C_p \times d}{\varepsilon_0 \times A} \)

Dielectric Loss = \( \varepsilon'' = \tan \delta' \varepsilon' \)

Where,

\( C_p = \) parallel capacitance value
\( A = \) surface area of the pellet
\( \varepsilon_0 = 8.85 \times 10^{-14} \, \text{F/cm}, \)
\( \tan \delta = 1/Q, \) quality factor
\( w = \) angular frequency = 2\( \pi f \)
\( d = \) thickness of the pellet

2. RESULTS AND DISCUSSION

Dielectric behaviour of sample:
The variation of dielectric constant and dielectric loss of Marathwada soil over the frequency range from 100 Hz to 2 MHz is shown in Fig (4 and 5).

Graphs

CONCLUSION

The paper explores the relevance of usage of microwave frequencies for the dielectric-property extraction of soil. Study of the properties of dry soil at microwave frequencies is useful in agriculture. It has been observed that the Dielectric Constant and Dielectric Loss decreases
with increase in frequency but emissivity increases as frequency increases. It is also observed that the Dielectric Constant and Dielectric Loss of vegetated field (sample 2, 3 and 4) is more as compare to bare field it may be because of presence of fertilizers but the emissivity of these samples is comparatively less than sample 1. This data is helpful in designing sensors for microwave remote sensing and for the retrieval of soil-moisture content from the remotely-sensed satellite data. Hence, research in this area will enrich our knowledge of soil science and will prove beneficial to the agriculturists.

REFERENCES