Moisture•Point™

MP-917 Technical Brief 11

Region of Influence Around the MP-917 Soil Moisture Probe

David Gregson

ABSTRACT

This document presents a discussion of the measurement volume, or region of influence, around the MoisturePoint MP-917 soil moisture probes.

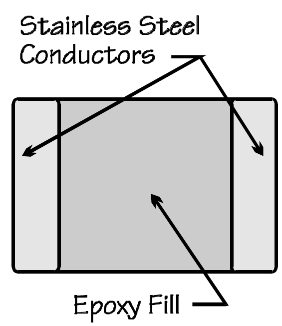
Water in a free, or bulk, state has a high dielectric constant, ~80, relative to most other materials. Thus changes in the moisture content of a porous media, such as soil, may be detected by measuring the *apparent dielectric constant* of the media. Apparent dielectric constant is the term used to refer to the dielectric constant measured by electromagnetic field techniques such as Time Domain Reflectometry (TDR) or change in Capacitance. Having measured the apparent dielectric constant of a media, the instrument computes a value for volumetric moisture content. This computation is based on the assumption the apparent dielectric constant is a ratiometric combination of the dielectric constants of the three materials present in the porous media; the material itself, the interstitial (bulk) water, and the interstitial air. In many applications the water will be present in other states, for example as bound water, and these assumptions will result in erroneous data. In many applications, media specific calibration will compensate for these errors.

All instruments utilizing electromagnetic field techniques to measure the apparent dielectric constant of a porous media require a device that can establish an electromagnetic field within that media. For systems utilizing TDR techniques that device is constructed to emulate a transmission line. For systems utilizing capacitance techniques that device is constructed to emulate the parallel plates of a capacitor. Although the procedures used by the two approaches to sense changes in the apparent dielectric constant are different, the distribution of the electromagnetic fields established about the devices and the influence the moisture content of the porous media has on them, are governed by the same fundamental laws of physics.

A description of the structure and distribution of the electromagnetic fields established in soil by the Moisture Point MP-917 probes and the effect this has on the moisture readings obtained from the instrument follows.

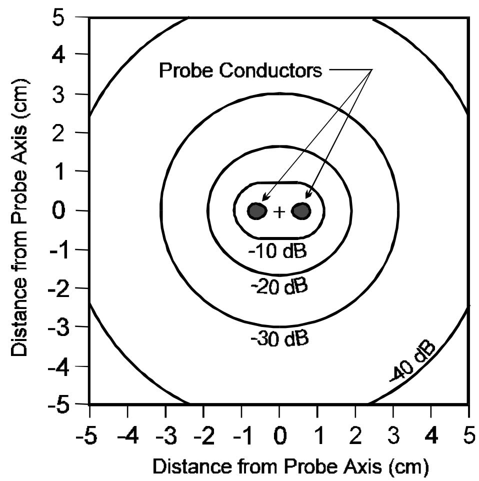
MP-917 SOIL MOISTURE PROBE

The MP-917 Soil Moisture Probe is designed to emulate a two wire, parallel conductor transmission line. It has a rectangular cross section (16 mm x 12.5 mm) and is constructed of two stainless steel conductors laminated to an epoxy core. It is available in various configurations with different lengths and numbers of segments. The large rectangular conductors were selected to increase the sensitivity of the probe to conditions in the surrounding soil by extending its region of influence further into the soil than would occur with conventional circular conductors. They also provide the necessary structural integrity and facilitate the connection of the shorting diodes used to delineate the segment boundaries.



ELECTROMAGNETIC FIELD AROUND THE PROBE

The figure on the next page illustrates the radial distribution of the energy contained in the electromagnetic field around a parallel, two conductor transmission line with dimensions similar to the MP-917 probe. The two circles in the center represent the probe conductors. The circles around the conductors are contours of equivalent energy density, or energy per unit volume. The values on the x and y axis' represent distance, in centimetres, from the center of the probe. The relative energy density at each contour is labeled in decibels with the energy density immediately adjacent to the probe conductors used as the 0 dB reference. As the decibel scale is logarithmic, the -10dB change between contours represents a 90% reduction in energy density from one contour to the next. Thus for this transmission line the energy density 3 probe is approximately 0.1% of its value at the field is distributed symmetrically around along its entire length.



centimetres from the center of the the probe conductors. The energy in the probe as shown and extends

REGION OF INFLUENCE

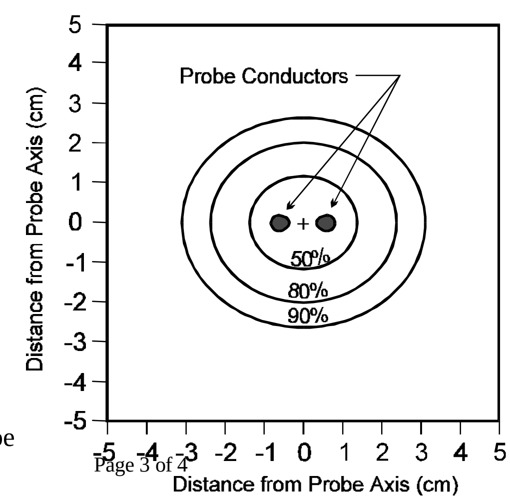
The region of influence about a soil is defined as that area in which a change in result in a detectable change in the apparent by the instrument. The apparent dielectric the volume integral of the product of the electromagnetic field established by the probe moist soil at each point within that field. The

moisture measurement probe the moisture content of the soil will dielectric constant of the soil as read constant read by the instrument is energy density of the and the dielectric constant of the region of influence thus surrounds the probe and extends along its full length. The value of apparent dielectric constant read by the instrument is a function of both the quantity of moisture present within the region of influence and its distribution throughout the region.

Theoretically, the claim can be made that the field of influence is very large as the electromagnetic field extends to infinity. In practice, the extent of the field of influence is limited by the relationship between the energy densities close to the probe and the measurement resolution of the instrument. For example consider an instrument connected to a probe inserted into a homogeneous material with an evenly distributed moisture content. Assume a mechanism exists for adjusting the moisture content of a fixed, unit volume of the material, e.g. 1 cubic cm, and that water is added to this volume of material immediately adjacent to the probe. The quantity of water necessary to increase the measured volumetric water content by 10% is determined. This same quantity of water is subsequently added to the same volume of the material but at a location where the energy density of the field is half its value adjacent to the probe. As the energy density at this location is half its value at the first location the instrument will detect a change in the apparent dielectric constant equivalent to a 5% increase in the volumetric water content.

This relationship between the energy density about the probe and the apparent dielectric constant as measured by the instrument is illustrated in the figure to the right. The scale identical to that of the previous figure however contours of equal influence around the probe. cumulative influence and have been adjusted to occupied by the probe.

The innermost contour delineates the of influence, i.e. 50% of the field is located physical perimeter of the probe. The outermost boundary, i.e. 90% of the field of influence is the physical perimeter of the probe. Under



on the axis' in this figure are the contours now delineate The values on the contours are compensate for the volume

50% boundary of the field between this contour and the contour represents the 90% located between this contour and normal operational conditions, i.e.

volumetric soil moisture content between 0 and 30%, changes outside the 90% boundary will not result in numerically valid changes in the measured water content. For example; a 100% change in the volumetric water content of the region outside this contour, i.e. from air to water, will result in a change in measured water content of ~10%. Thus a 10% change in volumetric soil moisture at this boundary will just fall within the 1% measurement resolution of the instrument. It should be noted the contours associated with the MP-917 probe are more rectangular in shape than those presented in the figure.

Changes in the water content of the soil immediately adjacent to the probe have a far greater effect on the readings presented by an instrument than equivalent changes occurring further away. Similarly, discontinuities in the distribution of the soil such as rocks and voids can have a significant effect if located immediately adjacent to the probe. An advantage TDR based transmission line probes have relative to capacitive parallel plate probes is the integration of the signal along the full length of the probe. This integration averages out the effects of localized discontinuities such as large rocks or layers of differing soil types.