Moisture•Point™

MP-917 Technical Brief 18

Use of the Probe Emulator

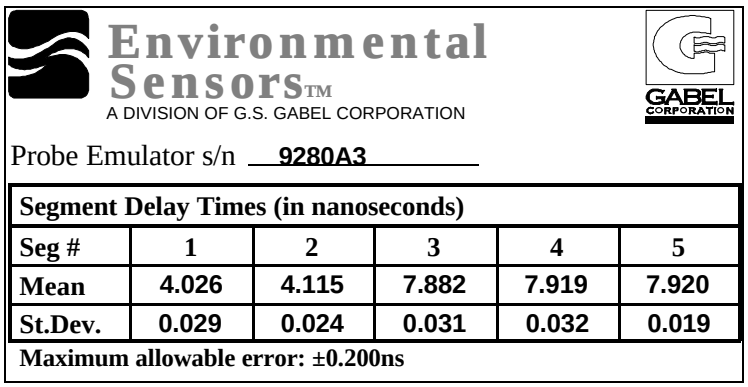
G. D. (Joe) Young

Introduction

The Moisture•Point Probe Emulator is an encapsulated length of transmission line with control circuitry which operates like a Moisture•Point type A profiling probe. The length of the sections of transmission line have been chosen to produce a time-interval measurement which is within the range of times found for a probe in moist soil. When the Probe Emulator is connected to the MP-917, the measured time intervals will be constant: nominally 4.1, 4.1, 8.0, 8.0, 8.0 nsec. The known-constant time measurements can be used as a system integrity check, as a problem-isolation diagnostic aid, and as a time base calibration check.

Table of Contents

Example Probe Emulator Factory Calibration



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Probe Emulator s/n **9280A3**

Segment Delay Times (in nanoseconds)					
Seg #	**1**	**2**	**3**	**4**	**5**
Mean	**4.026**	**4.115**	**7.882**	**7.919**	**7.920**
St.Dev.	**0.029**	**0.024**	**0.031**	**0.032**	**0.019**

Maximum allowable error: ±0.200ns

Figure 1. Probe Emulator Label showing factory calibration data.

Because the MP-917 time-interval measurement has accompanying noise, a factory probe emulator calibration is performed by repeatedly measuring the five segment times (using a MP-917). Then, the segment delay times are presented as the average of several readings together with the standard deviation of the calibration set. The behaviour the user may expect with a different MP-917 must consider the statistical nature of this data. In addition to the variation expected due to noise of the measurement, there are small differences from one Probe Emulator to the next resulting from uncontrolled circuit component variation. There will also be differences caused by choosing different parameters for the MP-917 signal acquisition and processing--gain, number of data points, averaging time, etc. The total of these variations should fall within the range stated on the last line of the label.

Generally, Probe Emulator times should measure 4.1 nsec +/- .2 nsec for the short segments (1 and 2), and 8.0 nsec +/- .2 nsec for the long segments (3, 4, and 5).

Figure 2 shows a View•Point screen of one probe scan from the set of several scans which produced the calibration shown in Figure 1. The MP-917 is using a probe-type selection of 2.

The Probe Emulator characteristics are expected to remain constant. To use this fact as a diagnostic aid, the performance of a particular Probe Emulator with a particular MP-917 (setup for its normal use) should be measured and recorded. A good starting point would be to use the MP-917 with its factory-default parameters, obtain 15 to 20 probe scans with it connected to the Probe Emulator, and record the mean and standard deviation for the time intervals for each segment. Then, the moisture readings which correspond to each segment's time intervals with the probe calibration factors being used, should be noted because the moisture values shown on the second line in figure 2 (using factory default calibration parameters) may not match the values calculated with different probe calibration parameters--segment length, T_s/T_{air}, A and B.

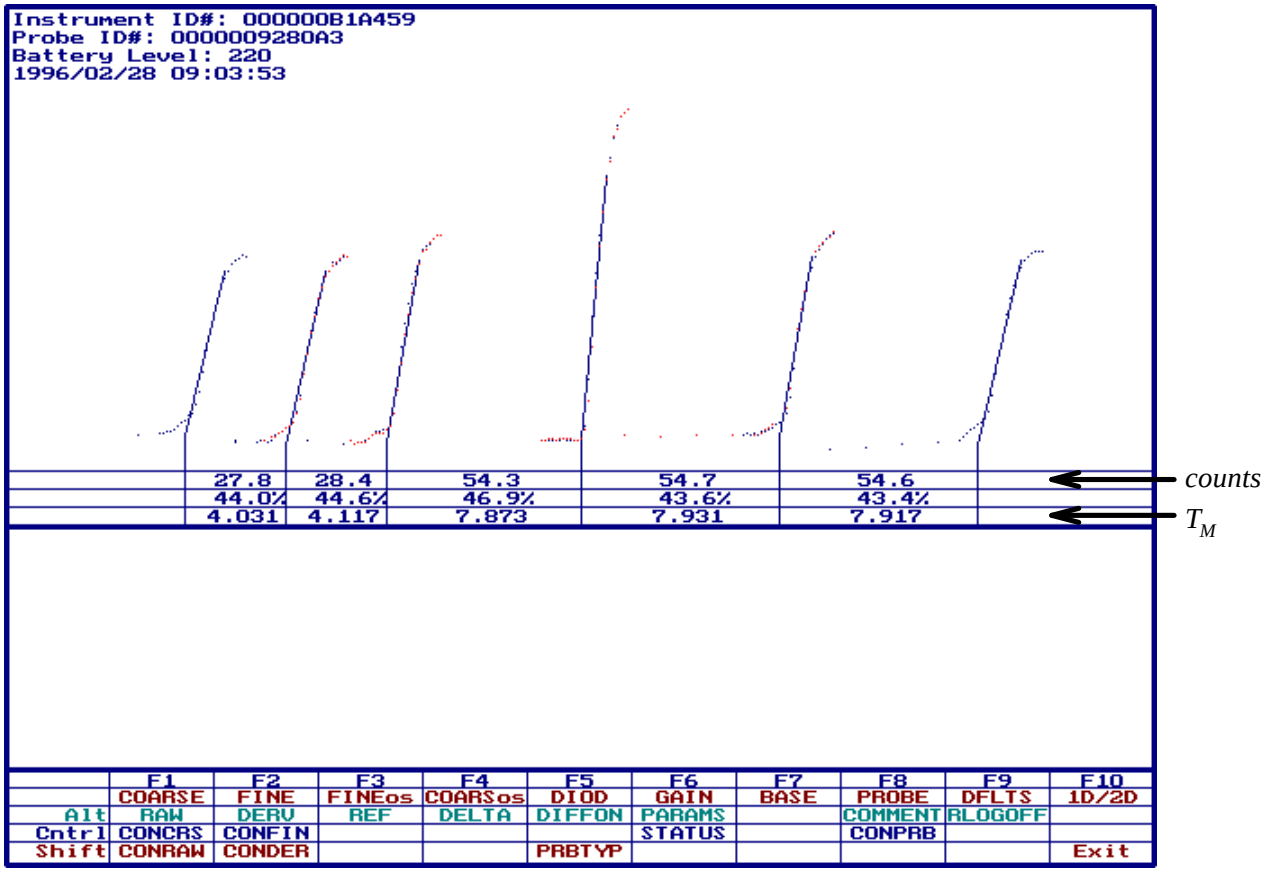

Figure 2. Type 2 probe scan with MP-917 connected to the Probe Emulator.

Identifying a malfunctioning probe

To use the Probe Emulator to diagnose the source of a suspect measurement (from among a damaged probe, damaged MP-917, or damaged cable), the user should have **recorded** the moisture readings the test probe produces with the probe calibration coefficients being used for the probe type deployed. Then later, when a suspect measurement is to be checked, the MP-917 and cable can be connected to the test probe, and a probe scan set of measurements taken. The MP-917/cable assembly is verified to be functioning correctly by observing readings similar to those previously recorded. Then, observing wrong readings when connected to the probe indicates probe damage.

For this comparison, it is not strictly necessary to use moisture values, since the MP-917 should also reproduce the recorded time interval values. However, observing the correct moisture readings also checks that the probe calibration factors stored in the MP-917 have not been altered. It may also be more convenient to recall that the moisture reading should be about 40% - 45% for all segments (when probe type 2 is selected).

Identifying a malfunctioning MP-917/cable assembly

The MP-917 measures the round-trip propagation time along each segment in a probe. To use the Probe Emulator to verify that the MP-917 operation is correct and that its calibration is correct, the Probe Emulator is used as a time interval reference--the MP-917 should reproduce the test probe time-interval measurements supplied with the Probe Emulator. The MP-917 is set to display time intervals for each of the segment

measurements being checked by moving the TIME DELAY/MOISTURE switch to the TIME DELAY position (up). The readings displayed on the MP-917 front panel will then be time intervals in nanoseconds. Alternatively, the MP-917's time-interval measurements are always available when using the View•Point program. On the View•Point program's graphic display during the execution of the PROBE command, the 3rd line of data under each segment shows the measured round-trip times, T_M, for that segment--see Figure 2.

Using the Probe Emulator with other probe-type selections

The Probe Emulator acts like a standard 5-segment probe. However, it may be used to check the MP-917/cable assembly for some other probe type selections, without changing the probe selection, if the other probe types have compatible segment arrangements as outlined below. But generally, checking the instrument calibration and operation when it is being used with a probe type other than those listed, the MP-917 will have to be switched to select a 5-segment probe.

Probe types which are directly compatible with the Probe Emulator:

- single-segment--type 0 or type 1 selected in MP-917

  MP-917 reads one value -- the test probe seg 5

- two-segment--type 5 selected in MP-917

  MP-917 reads value from Probe Emulator seg 4 as seg 1 and the value from emulator seg 5 as seg 2

If other probe-type selections remain in effect when the Probe Emulator is connected, one or more of the segment values will be incorrectly measured--usually displayed as an error, 1.111 moisture or 000 time.

Checking the MP-917 time base calibration

The MP-917 measures time in terms of a number of steps of its internal time base, then converts that time into a reading in nsec by multiplying by a conversion factor which is normally determined at the factory. The factor is called the "U0 calibration factor". It is available for inspection and modification in the "Instrument Defaults" sub-menu of View•Point's "DFLTS" (F9) menu. The factory calibration of this instrument characteristic is performed using a Tektronix 1502 cable tester which is itself calibrated by measuring known lengths of an air-dielectric transmission line.

The constant-time nature of the Probe Emulator offers a method of determining the "U0 calibration factor" in the field. Some care is required to reduce the probability of error in calculating the calibration factor from inherently noisy readings, and to avoid systematic error which may arise because of different parameter settings in the MP-917.

To illustrate the measurement of the "U0 calibration factor" with the Probe Emulator, consider the following data from a pair of probe scans:

seg #	1	2	3	4	5
counts	27.8	28.4	54.3	54.7	54.6
nsec	4.031	4.117	7.873	7.931	7.917

seg #	1	2	3	4	5
counts	27.9	28.4	53.9	54.8	54.3
nsec	4.045	4.117	7.815	7.946	7.873

The first set of data is from the probe scan illustrated above in Figure 2, *counts* line, the second set is from another like scan. The four measurements of the short segments are averaged (considered as four samples of the same time interval) to give:

avg. counts	28.125	
avg. nsec	4.071	U0 cal = 4.071/28.125 = 0.1447 nsec/count

Similarly, the 6 measurements of the long segments are averaged to give:

avg. counts	54.43	
avg. nsec	7.907	U0 cal = 7.907/54.43 = 0.1453 nsec/count

And the U0 calibration factor for this MP-917 used for the probe scans is 0.145 nsec/count = 145 psec/count.

Obviously, there is a circularity to the foregoing: the T_M values displayed were calculated from the count values displayed--dividing each T_M by its corresponding count gives the same U0 calibration value (within the available arithmetic precision). But if the times measured for the Probe Emulator when the MP-917 is new are recorded and taken as correct, then a subsequent check of the calibration can be done by using the original times and the check counts in the calculation. If the calibration has changed in the meantime, the factor calculated would differ from that stored in the instrument. Also, the calculation shows that averaging just a few readings is enough to control for the measurement noise.