



METER
ENVIRONMENT

MEASURING METER TENSIO METERS WITH NON-METER CONTROL AND DATA ACQUISITION SYSTEMS

Contributors

METER designs and manufactures a range of [high-quality tensiometers](#) for the measurement of soil water tension ([water potential](#)). The tensiometer cables are designed for interface with the METER “Infield 7” readout device. However, there are applications where long-term logging is desired and therefore a need to connect these tensiometers to data loggers other than the Infield 7. This paper addresses the capabilities of the METER tensiometers with respect to their ability to interface with non-METER data loggers.

METER [tensiometers](#) use a thin wafer piezoresistive pressure transducer to measure [water tension](#). The resistance of the pressure transducer changes as it is deformed by the pressure difference across it, defined by atmospheric pressure on one side and the tension held on the water in the shaft on the opposite side. An asymmetric Wheatstone full bridge is used to analyze the resistance of the thin wafer, which is proportional to the tension in the soil water relative to atmospheric pressure. With the Wheatstone bridge used here

$$\frac{V_{out}}{V_{in}} \propto \Psi_T$$

Equation 1

where V_{out} is the signal millivolt output from the pressure sensor, V_{in} is the excitation voltage provided to the pressure sensor, and Ψ_T is the tension on the water in the tensiometer shaft immediately adjacent to the pressure transducer. METER tensiometers are calibrated with $V_{in} = 10.6\text{V DC}$. When using the 10.6V excitation, there is a linear calibration

$$\Psi_T \text{ (kPa)} = V_{\text{out}} \text{ (mV)}$$

with the convention that $\Psi_T > 0$ is tension and $\Psi_T < 0$ is pressure. Since many popular control and data acquisition devices (e.g., Campbell Scientific data loggers) have 5V DC or user-defined excitation ports readily available, it is often convenient to use these power supplies for excitation rather than 10.6 V. This is accomplished by using the following equation

$$\Psi_T = V_{\text{out}} * 10.6 / V_{\text{in}}$$

where Ψ_T is in kPa, V_{out} is in mV, and V_{in} is in volts.

POTENTIAL DATA ACQUISITION PITFALLS

Because the pressure transducer is configured in a Wheatstone full bridge, the input voltage and signal mV output cannot be connected to the same reference (ground). Hence, the signal mV output can only be measured using a differential voltage measurement. Therefore, do not attempt to make a single-ended measurement of the pressure transducer mV output.

Additionally, both the signal “+” and signal “-” are very close to ½ of the excitation voltage (i.e., if a 5V excitation is used, the signal “+” and “-” will be ~2.5 V above the excitation ground, although only a few mV from each other). If the signal voltage referenced against the excitation ground exceeds the common mode range* of the logger, the measurement will fail. Therefore, an appropriate excitation voltage must be chosen to avoid exceeding the common mode range.

This can be accomplished in two ways. First, the excitation voltage can be limited with a simple voltage divider or by setting the analog output at a small enough value. Alternatively, METER manufactures a tensiometer power supply (model TV-Batt) that provides a voltage of +5.6 V, referenced against -5 V, to provide a 10.6 V excitation with the signal output very near 0 V compared to the logger ground. The TV-Batt can be powered from 7 to 16 V DC and can supply power to up to 60 tensiometers.

* The common mode range is ± 2.5 V for CR10X loggers and ± 5 V for CR21X and CR23X loggers. Check the specifications in your logger manual to identify the common mode range for other data acquisition systems.

It should also be noted here that any instability in the excitation voltage (e.g., weakening battery power at a remote site) will be reflected in the output as indicated by Equation 3 above. It is therefore advisable to either excite the tensiometer pressure transducer with a regulated voltage source, or to record the excitation voltage and correct for drift. Also note that Equation 3 is not valid for the METER model T8 tensiometer, which will output a stable 0 to 2 V with any excitation voltage in the 6 to 20 V DC range.

CAUTIONS

Keep in mind that the METER tensiometer pressure transducers are rated for excitation voltages from 5 to 15 V DC. We have successfully used the tensiometers with excitation voltages as low as 2.5 V but would not recommend exciting at voltages above the specified range. Also note that allowing the tension on the water in the tensiometer to reach suction below ~85 kPa will cause cavitation in the tensiometer requiring refilling before meaningful readings can be made. If the tension reaches ~200 kPa, the pressure transducer may be destroyed. With the [T5](#) tensiometer, this can occur within a matter of seconds after removing the porous cup from a moist environment and exposing it to dry air. With the T8, over-tightening of the water column corpus will break the pressure transducer, so care must be taken to hand-tighten it. Additionally, the ceramic cups of the tensiometers can be harmed by exposure to skin oils from direct handling of the cups with bare hands.

EXAMPLE PROGRAMS

EDLOG

The following program is an example that can be used with a Campbell Scientific CR21X data logger or adapted to other Edlog type loggers.

```
:{21X}  
  
;  
  
;Program to read METER tensiometer pressure transducers  
  
;  
  
;Wiring (with black adapter cable)  
  
;
```

;Brown – supply (+) – Ex. Ch. 1

;Blue – supply (-) – Ground

;White – signal (+) – differential channel 1 H

;Thin Black – signal (-) – differential channel 1 L

;Thick Black – shield – ground

;

;The output of this program is in kPa with negative values indicating suction

;

*Table 1 Program 01: 1 Execution Interval (seconds)

;The value 2.12 = 10.6V/5V

;

1: Ex-Del-Diff (P8)

1: 1 Reps

2: 4 500 mV Slow Range

3: 1 DIFF Channel

4: 1 Excite all reps w/Exchan 1

5: 1 Delay (0.01 sec units)

6: 5000 mV Excitation

7: 1 Loc [Psi_kPa]

8: -2.12 Mult

9: 0.0 Offset

*Table 2 Program

02: 0.0000 Execution Interval (seconds)

*Table 3 Subroutines

End Program

CR BASIC

The following program is an example that can be used with a Campbell Scientific CR1000 data logger or adapted to other CR Basic type loggers.

'CR1000

'program to measure METER analog tensiometer (T4, T5) with CR1000 data logger

'Wiring

'Brown – supply (+) – Ex. Ch. 1

'Blue – supply (-) – Ground

'White – signal (+) – differential channel 1 H

'Thin Black – signal (-) – differential channel 1 L

'Thick Black – shield – ground

Public WP

Units WP=kPa

DataTable(Table1,1,-1)

DataInterval(0,30,Min,10)

Sample (1,WP,FP2)

EndTable

BeginProg

Scan(1,Sec,0,0)

BrFull(WP,1,mV250,1,Vx1,1,2500,False,False, 0,_60Hz,-10.6,0.0)

'note that RevEx and RevDiff must both be false

'to read UMS tensiometers note that multiplier of

'-10.6 adjusts the sign of output to standard

'convention (pressure = positive number and

'tension = negative number)

CallTable(Table1)

NextScan

EndProg