OPERATING INSTRUCTIONS FOR AN ELECTRONIC TENSIOMETER IRROMETER MODELS R-RSU & MLT-RSU (~$180)

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INTRODUCTION

Tensiometers measure soil moisture based on soil water tension. They consist of a sealed, water-filled tube with a porous ceramic cup at the bottom and a pressure gauge at the top. The ceramic cup is installed in the root zone of the soil profile. Changes in soil moisture cause water to move in and out of the ceramic cup, creating a tension in the water-filled tube. The tension is measured by the pressure gauge.

Model "-RSU" (Remote Sensing Unit) tensiometers use an electronic pressure transducer instead of the usual analog pressure gauge to measure the water potential of the media. Connecting the transducer to a datalogger makes it possible to irrigate at a selected tension rather than a fixed time period, resulting in higher irrigation efficiency.

Irrometer R-RSU tensiometers have fine porous cups with bubbling pressures of 100 kPa. These are adequate for fine-textured mineral soils but have inadequate response time to control irrigation in soil-less media and coarse sands. Coarse textured growing media are depleted of plant available water at relatively low tensions (8 to 20 kPa). The Irrometer MLT-RSU (Miniature Low Tension-RSU) uses a porous cup with a bubbling pressure of 50 kPa. The lower bubbling pressure makes it better suited for typical greenhouse growing media because it has a faster response.

The Crop Physiology Laboratory owns three three 12-inch R-RSU and three 6-inch MLT-RSU tensiometers. The range of each is inscribed on the back or top of the transducer.

PREPARATION

When not in use, the porous cup should be covered in its plastic bag and the PVC protective cover in which it was shipped. This helps to keep the cup from drying out and protects it from damage. If the tensiometer cup has dried out, soak it in deionized water overnight prior to use.

Tensiometer preparation should be performed *after* the tensiometer is successfully wired to a datalogger (see below) to insure that the suction used to remove air bubbles from the water-filled tube does not exceed the range of the pressure transducer.

To maintain the tensiometer, fill the body with Irrometer fluid, which is green in color making it easier to determine the amount of water in the tensiometer. The Irrometer fluid is made by adding one or two drops of Irrometer fluid concentrate to 0.25 liters of deionized water. The solution will be light green in color. To remove the air from the tensiometer insert the syringe, half full of Irrometer fluid, into the top of the tensiometer so it seats on the o-ring. With the tensiometer at a 45^{o} angle, pull gently on the syringe until full scale for the

specific transducer is reached (-16 or -32 kPa). Release the suction slowly. The transducer is a delicate instrument. We have irreparably damaged several tranducers during the de-airing process. ***Do not release tension abruptly***. Repeat several times. Fill the tensiometer to the top with fluid and replace the cap. Do not over-tighten.

INSTALLATION

To install a prepared tensiometer, bore a hole in the soil (or other porous media) using a piece of PVC pipe or other cylinder that is roughly the same diameter as the tensiometer's water-filled tube. Fill the hole with water, then push the tensiometer down so that the the porous cup is firmly seated in the bottom of the hole. Leave at least 2 cm of space between the bottom of the pressure transducer and the soil surface. "Grout in" any air gaps between the tensiometer body and the soil using a slurry made from the soil and water. Tamp down the the back-filled hole and around the sides of the instrument.

CONVERTING THE MILLIAMP OUTPUT TO MILLIVOLTS

The RSU pressure transducers have a milliamp (mA) output. To translate the loop current to voltage a resistor with a precisely known value must be used. The resistor size depends on the desired output (2500 mV for CR10 loggers, 5000 mV for CR21X loggers). The following calculation illustrates the conversion from mA to mV and the necessary resistor size for a 0 to –16 kPa MLT-RSU tensiometer with a 4 to 20 mA output wired to a CR10T datalogger.

Determine the size of resistor to get a 2500 mV output:

mVolts/mAmps = **resistance**
2500 mV/20 mA = **125 ohms**

The resistor translates the 4 to 20 mA output to a 500 (4*125) to 2500 (20*125) mV output for the range 0 to –16 kPa. To convert mV to kPa, the **multiplier** is:

–16 kPa/2000mV = **–0.008 kPa/mV**
mV*–0.008 = kPa

An offset is needed to correct for the 500 mV at minimum output. The **offset** is:

at full scale: 2500 mV * -0.008 = –20
–20 **+ 4** = –16 kPa
at zero: 500 mV * –0.008 = –4
–4 **+ 4** = 0 kPa

This shows, for a tensiometer with a 0 to –16 kPa pressure range and 500 to 2500 mV output range, a multiplier of –0.008 (the value of the multiplier must be changed to a negative value to correspond with a negative water potential) and an offset of 4 is needed. Tables 1 and 2 give the results of these calculations for each of the R-RSU and MLT-RSU tensiometers owned by the Crop Physiology Laboratory.

Table 1. Irrometer R-RSU and MLT-RSU pressure transducer operation parameters with a CR10 logger (2500 mV range).

Model	Output range (mA)	Output range (kPa)	Resistor size (ohms)	Multiplier	Offset
R-RSU	4.00 to 20	0 to 93	125	-0.04650	23.25
MLT-RSU	3.85 to 20	0 to 16	125	-0.00793	3.814
MLT-RSU	4.00 to 20	0 to 32	125	-0.01600	8.000

Table 2. Irrometer R-RSU and MLT-RSU pressure transducer operation parameters with a CR21X logger (5000 mV range).

Model	Output range (mA)	Output range (kPa)	Resistor size (ohms)	Multiplier	Offset
R-RSU	4.00 to 20	0 to 93	250	-0.02325	23.25
MLT-RSU	3.85 to 20	0 to 16	250	-0.00400	3.850
MLT-RSU	4.00 to 20	0 to 32	250	-0.00800	8.000

The tensiometer should read close to zero when the screw cap is removed and there is no water in the small portion of the tensiometer body above the pressure transducer. When the tensiometer is de-aired and the screw cap is replaced, the tensiometer reading will reflect the height of the water column between the pressure transducer and the ceramic cup. To determine the additional offset necessary to yield a reading of zero, submerge only the porous cup in water while holding the tensiometer vertical. The additional offset should be around -3 kPa for the R-RSU models and -1 kPa for the MLT-RSU models. To correct for the additional offset, subtract it from the reading. For example, and R-RSU reading of -5 kPa would be corrected to -2 kPa.

WIRING

The tensiometers may be wired to the datalogger in single-ended (SE) or differential (DIFF) configuration (Figure 1). Differential measurements require more input channels than single-ended measurements, but give measurements with better resolution.

For either SE or DIFF measurement, the red transducer wire is connected to the 12V power supply. The input does not have to be exactly 12V, but it must be constant voltage. The black transducer wire is connected to either the SE input channel or the high (H) side of the differential input channel. For SE measurement, the resistor should be wired from the SE input channel to ground. For DIFF measurement, the resistor should be wired from the high side to the low side of the differential channel.

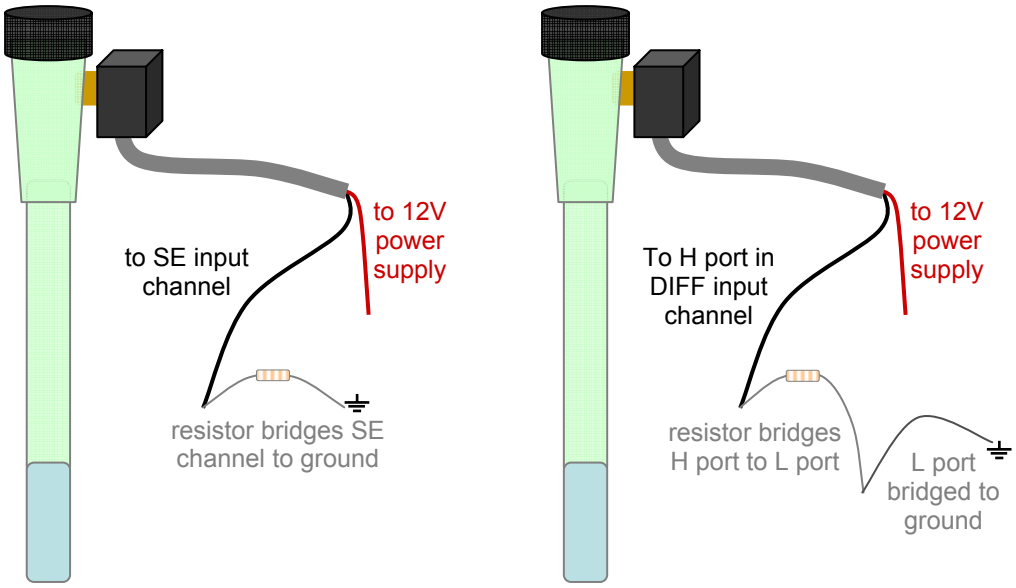

Figure 1. How to wire the electronic pressure transducers to a datalogger in single-ended (left) and differential (right) configuration.

For SE measurement of the mV output, a P1 instruction is used. The following example illustrates the proper instruction for SE measurement of a MLT-RSU with 0 to -16 kPa operating range connected to a CR10T datalogger.

```
; Read mV tensiometer output and convert to kPa

1:      Volts (SE) (P1)
   1:   1          Reps
   2:   25         2500 mV 60 Hz Rejection Range
   3:   1          SE Channel
   4:   1          Loc [ kPa ]
   5:   -0.008     Mult
   6:   4          Offset
```

For DIFF measurement of the mV output, a P2 instruction is used. The following example illustrates the proper instruction for DIFF measurement of a MLT-RSU with 0 to -16 kPa operating range connected to a CR10T datalogger.

```
; Read mV tensiometer output and convert to kPa

1:      Volts (Diff) (P2)
   1:   1          Reps
   2:   25         2500 mV 60 Hz Rejection Range
   3:   1          DIFF Channel
   4:   1          Loc [ kPa ]
   5:   -0.008     Mult
   6:   4          Offset
```