MODEL 237
LEAF WETNESS SENSOR

REVISION: 6/96

WARRANTY AND ASSISTANCE

The **237 LEAF WETNESS SENSOR** is warranted by CAMPBELL SCIENTIFIC, INC. to be free from defects in materials and workmanship under normal use and service for twelve (12) months from date of shipment unless specified otherwise. Batteries have no warranty. CAMPBELL SCIENTIFIC, INC.'s obligation under this warranty is limited to repairing or replacing (at CAMPBELL SCIENTIFIC, INC.'s option) defective products. The customer shall assume all costs of removing, reinstalling, and shipping defective products to CAMPBELL SCIENTIFIC, INC. CAMPBELL SCIENTIFIC, INC. will return such products by surface carrier prepaid. This warranty shall not apply to any CAMPBELL SCIENTIFIC, INC. products which have been subjected to modification, misuse, neglect, accidents of nature, or shipping damage. This warranty is in lieu of all other warranties, expressed or implied, including warranties of merchantability or fitness for a particular purpose. CAMPBELL SCIENTIFIC, INC. is not liable for special, indirect, incidental, or consequential damages.

Products may not be returned without prior authorization. To obtain a Returned Materials Authorization (RMA), contact CAMPBELL SCIENTIFIC, INC., phone (435) 753-2342. After an applications engineer determines the nature of the problem, an RMA number will be issued. Please write this number clearly on the outside of the shipping container. CAMPBELL SCIENTIFIC's shipping address is:

CAMPBELL SCIENTIFIC, INC.
RMA#_____
815 West 1800 North
Logan, Utah 84321-1784

CAMPBELL SCIENTIFIC, INC. does not accept collect calls.

Non-warranty products returned for repair should be accompanied by a purchase order to cover the repair.

CAMPBELL SCIENTIFIC, INC.

815 W. 1800 N.
Logan, UT 84321-1784
USA
Phone (435) 753-2342
FAX (435) 750-9540
www.campbellsci.com

Campbell Scientific Canada Corp.
11564 -149th Street
Edmonton, Alberta T5M 1W7
CANADA
Phone (780) 454-2505
FAX (780) 454-2655

Campbell Scientific Ltd.
Campbell Park
80 Hathern Road
Shepshed, Loughborough
LE12 9GX, U.K.
Phone +44 (0) 1509 601141
FAX +44 (0) 1509 601091

MODEL 237
LEAF WETNESS SENSOR

1. GENERAL

Leaf wetness sensors are classified into three types: surface contact types that measure the electrical resistance of a water film on the leaf surface, artificial leaf electrical resistance types, and mechanical types that detect a change in sensor length or weight. The 237 is an artificial leaf type for use with the CR7, CR10, and 21X dataloggers.

The sensor consists of a circuit board with interlacing gold-plated copper fingers. Condensation on the sensor lowers the resistance between the fingers which is measured by the datalogger. Droplets small enough to not touch two fingers simultaneously do not change the sensor resistance. For this reason, this type of sensor is often coated with flat latex paint to spread the water droplets. The color and type of paint affect sensor performance. Campbell Scientific supplies only the raw sensor since individual modifications vary depending on the application. The following paper details the effect of paint color and sensor angle on the response of the leaf wetness sensor:

Gillespie, T.J. and Kidd, G.E. 1978. Sensing duration of leaf moisture retention using electrical impedance grids. Can. J. Plant Sci. 58:179-187.

2. WIRING

Figure 1 is a schematic of the 237 Leaf Wetness Sensor. The 237 Sensor uses a single-ended analog channel, the red lead "HI" can be inserted into either a HI or LO input.

The black lead "EX" connects to any excitation channel, and the clear lead is the shield which connects to ground.

The purple lead connects to Analog Ground. Analog Ground, labeled "AG" on the CR10, is the same as Ground for the 21X and CR7.

> **NOTE:** The black outer jacket of the cable is Santoprene® rubber. This compound was chosen for its resistance to temperature extremes, moisture, and UV degradation. However, this jacket will support combustion in air. It is rated as slow burning when tested according to U.L. 94 H.B. and will pass FMVSS302. Local fire codes may preclude its use inside buildings.

3. PROGRAMMING

There are three steps involved in programming the datalogger to output results of leaf wetness with the 237 Sensor. There is the excitation and measurement of the sensor, the calculation of sensor resistance, and programming for the desired output.

3.1 MEASUREMENT

The AC Half Bridge Instruction 5 is used to read the 237 sensor. Instruction 5 returns the ratio of the measured voltage to the excitation voltage (V_s/V_x), which is equal to a ratio of sensor resistances as shown below (refer also to Figure 1).

$$V_s/V_x = R_2/(R_2+R_1+R_s)$$

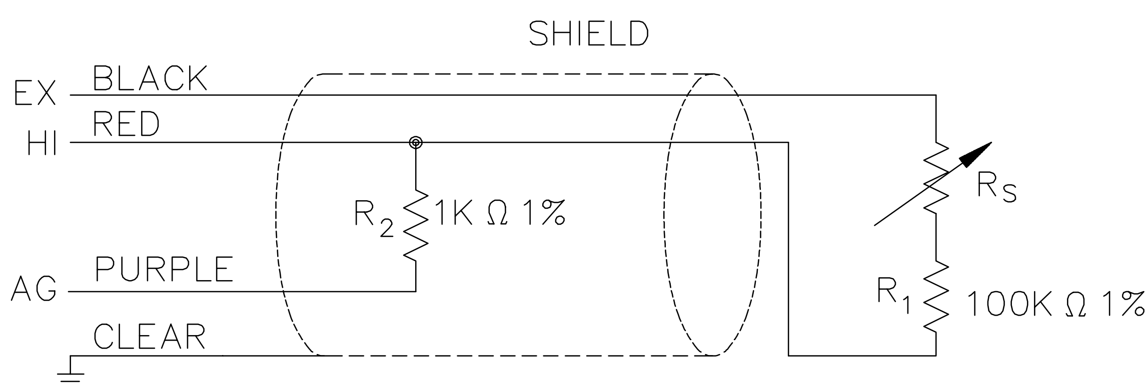

FIGURE 1. 237 Leaf Wetness Sensor Schematic

TABLE 1. Excitation and Range Codes

DATALOGGER	EXCITATION	INPUT RANGE CODE
CR7	5000 mV	14 (50 mV fast)
CR10	2500 mV	13 (25 mV fast)
21X	5000 mV	13 (50 mV fast)

Program the datalogger using the appropriate excitation voltage and range code as given in Table 1. Use a multiplier of 1.0 and an offset of 0 to output V_s/V_x directly.

3.2 CALCULATING SENSOR RESISTANCE

An alternate expression of leaf wetness is sensor resistance (R_s) in thousands of ohms (kohms). R_s is calculated as follows:

$$R_s = R_2/(V_s/V_x) - R_2 - R_1$$

where R_2 is 1 kohm and R_1 is 100 kohms, substituting these values yields:

$$R_s = 1/(V_s/V_x) - 101.$$

After Instruction 5, use Instruction 42 to invert V_s/V_x. Instruction 34 is then used to add -101 kohms. The result is the resistance of the sensor in kohms. See Section 5 "Program Example For The CR10."

The sensor resistance varies from above 3,000,000 ohms when dry to around 1,000 ohms when wet. If outputting resistance measurements, the reading will be 99999 if the sensor is completely dry. A completely dry sensor is an open circuit, and therefore has infinite resistance.

3.3 OUTPUT - RECORDING FRACTION OF TIME WET AND DRY

Outputting the fraction of time wet or dry cannot be done until the resistance at the wet/dry transition point is determined. See Section 4 "Calibration."

The fraction of time the sensor is wet or dry can be obtained using the Histogram Instruction 75 with a single bin and closed form. The bin select value for the histogram is the Input Location containing sensor resistance. The lower limit of the histogram is zero and the upper limit is the calibrated wet/dry transition point. This will give the fraction of the output interval the sensor is wet. Subtract this fraction from 1 to get the fraction of the output interval the sensor is dry. Multiply both fractions by 100 to obtain the percent of time wet and the percent of time dry.

4. CALIBRATION

The resistance of the sensor at the wet/dry transition point should be determined. A sharp change in resistance occurs in the wet-dry transition on the uncoated sensor. Coated sensors have a poorly defined transition. The resistance of the uncoated sensor at the wet/dry transition is normally between 50 and 200 kohms. The coated sensor transition normally occurs from 20 kohms to above 1,000 kohms.

For best results, the leaf wetness sensor should be field calibrated. The transition point will vary for different areas and vegetation. Place the sensor among the vegetation whose wetness is to be monitored. Observe the vegetation until it reaches the desired wetness by natural means. When the vegetation is at the desired "wetness", note the measured resistance on the datalogger. This resistance is the transition point.

The sensor's resistance is artificially reduced by contaminants such as fingerprints and smudges. Before painting and calibrating the sensor, wash it with alcohol to remove possible contaminants.

5. PROGRAM EXAMPLE FOR THE CR10

The following CR10 datalogger program is an example only, parts of this program will vary for each application. This program measures one 237 Leaf Wetness Sensor every 15 minutes, calculates resistance, and outputs the fraction of time wet on a daily basis.

```
*1                   Table 1 Programs               15 minute
    01:    900       Sec. Execution Interval        table ex.

01:         P5       AC Half Bridge                 Excite and
    *01:     1       Rep                            Measure the
    02:     13       25 mV fast Range               237 Sensor
    *03:     1       IN Chan
    *04:     1       Excite all reps w/EXchan 1
    05:   2500       mV Excitation
    *06:     1       Loc : VS/VX Loc                resulting in
    07:      1.0     Mult                           VS/VX
    08:      0.0000  Offset

02:        P42       Z=1/X                          Invert VS/VX
    *01:     1       X Loc
    *02:     2       Z Loc : Res Loc

03:        P34       Z=X+F                          and
    *01:     2       X Loc                          Add -101.0
    02:  -101.0      F                              to get
    *03:     2       Z Loc : Res Loc                Res.(kohm)

04:        P92       If time is                     Every 24
    *01:     0       minutes into a                 hours
    *02:  1440       minute interval
    *03:    10       Set high Flag 0 (output)       Output

05:        P77       Real Time                      Julian Day
    *01:   220       Day,Hour-Minute                and Time

06:        P75       Histogram                      and
    *01:     1       Rep                            the fraction
    *02:     1       No. of Bins                    of time
    *03:     1       Closed form                    wet for
    04:      2       Bin Select Value Loc           that day
    05:   0000       WV Loc Option
    06:      0.0000  Low Limit
    *07:   150       High Limit

07:          P       End Table 1
```

*** Parameter entries will vary depending on the program and datalogger channel usage**