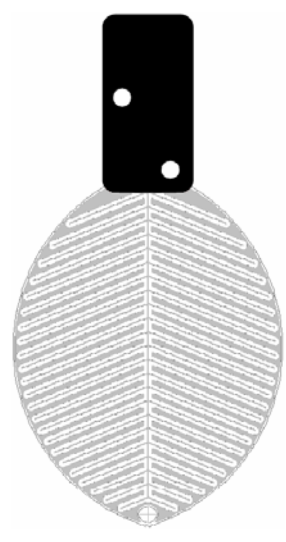
INSTRUCTION MANUAL

LWS-L Dielectric Leaf Wetness Sensor

Revision: 3/09



PLEASE READ FIRST

About this manual

Please note that this manual was originally produced by Campbell Scientific Inc. (CSI) primarily for the US market. Some spellings, weights and measures may reflect this origin.

Some useful conversion factors:

Area:	1 in^2 (square inch) = 645 mm^2
Length:	1 in. (inch) = 25.4 mm 1 ft (foot) = 304.8 mm 1 yard = 0.914 m 1 mile = 1.609 km
Mass:	1 oz. (ounce) = 28.35 g 1 lb (pound weight) = 0.454 kg
Pressure:	1 psi (lb/in2) = 68.95 mb
Volume:	1 US gallon = 3.785 litres

In addition, part ordering numbers may vary. For example, the CABLE5CBL is a CSI part number and known as a FIN5COND at Campbell Scientific Canada (CSC). CSC Technical Support will be pleased to assist with any questions.

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LWS-L Dielectric Leaf Wetness Sensor

1. General Description

Direct measurement of leaf wetness is problematic. Secure long-term attachment of a sensor to a representative living leaf is difficult. Leaf position, sun exposure, and health are in constant flux. To avoid these problems, leaf wetness “sensors” have been developed to estimate by inference the wetness of nearby leaves. The LWS-L estimates leaf surface wetness by measuring the dielectric constant of the sensor’s upper surface. The sensor is able to detect the presence of miniscule amounts of water or ice. Individual sensor calibration is not normally necessary.

2. Specifications

Measurement Time:	10 ms
Excitation:	2.5 VDC (2 mA) to 5.0 VDC (7 mA)
Minimum Excitation Time:	10 mS
Output:	10% to 50% of excitation
Operating Temperature:	-20 to 60 °C
Probe Dimensions:	11.2 cm x 5.8 cm x .075 cm
Datalogger Compatibility:	CR10X, CR200, CR800, CR1000, CR3000, CR5000
Maximum Lead Length:	250 ft
Interchangeability:	Interchangeable without painting or individual calibration

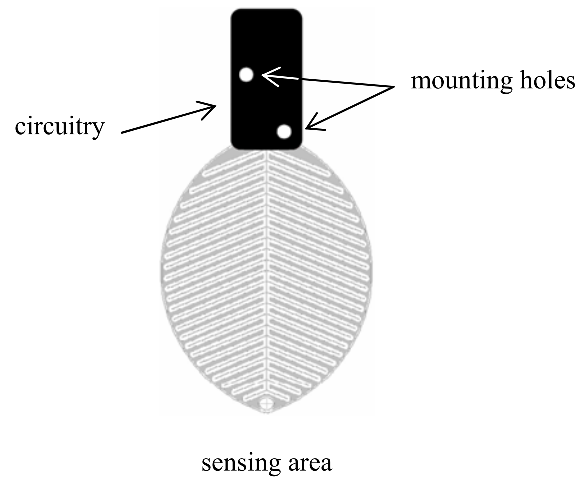

FIGURE 1. LWS-L Dielectric Leaf Wetness Sensor

3. Installation

The LWS-L is designed to be mounted on a small diameter rod. Deployment in a plant canopy or on a weather station mast is typical. Two holes in the sensor body are available for mounting with zip ties or 4-40 bolts.

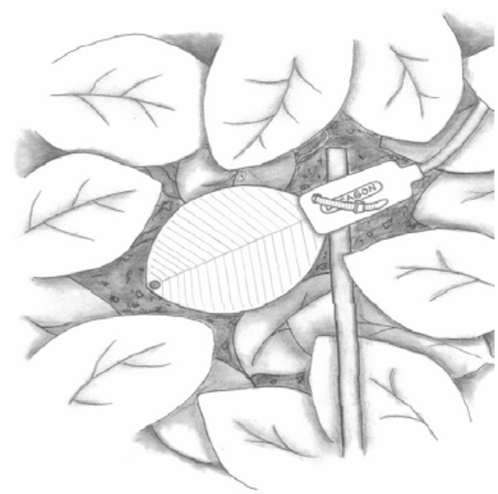

FIGURE 2. Top View of a Typical LWS-L Installation

4. Wiring

Color	Description	CR800/850 CR5000 CR3000 CR1000	CR500/510 CR10/10X	21X CR7 CR23X	CR200
White	Excitation	Switched Excitation	Switched Excitation	Switched Excitation	Switched Excitation
Red	Analog Out	Single-Ended Channel	Single-Ended Channel	Single-Ended Channel	Single-Ended Channel
Bare	Analog Ground	⏚	AG	⏚	⏚

5. Measurement

The LWS-L requires excitation voltage between 2.5 and 5 VDC. It produces an output voltage dependent on the dielectric constant of the medium surrounding the probe. Output voltage ranges from 10 to 50% of the excitation voltage.

NOTE The LWS-L is intended only for applications wherein the datalogger provides short excitation, leaving the probe quiescent most of the time. Continuous excitation may cause the probe to exceed government specified limits on electromagnetic emissions.

6. Interpreting Data

Many leaf wetness applications, such as phytopathology, require a Boolean interpretation of leaf wetness data, i.e. whether or not water is present. A Boolean threshold is determined by analyzing a few days of time series data. Consider time series data in Fig. 3, which were obtained at 5 VDC excitation. The sensor yields ≈445 mV when dry, ≈475 mV when frosted, and >>475 mV when wet. Therefore, a Boolean wetness threshold of 500 mV should serve well for interpreting these data.

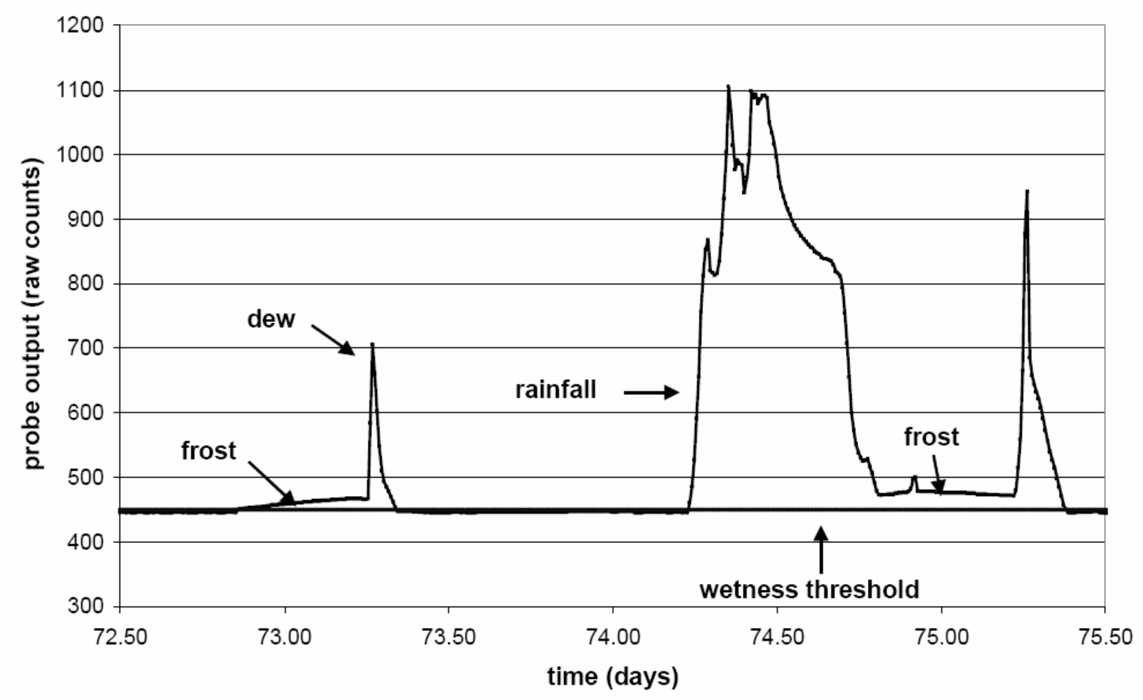

FIGURE 3. Typical LWS-L Response

Duration of leaf wetness can be determined either by post processing of data, or by programming the datalogger to accumulate time of wetness based on the Boolean threshold. Accumulation of dust and debris, such as avian fecal matter, will change the Boolean threshold. So, while having the datalogger accumulate time of leaf wetness, or time of frost, may be convenient, assurance of data quality requires retention of the base mV measurements.

NOTE Collect data frequently enough to capture changes in surface wetness. A sample frequency of 15 minutes or less is usually necessary to accurately capture leaf wetness duration.

7. Operational Principles

7.1 Measurement

The LWS-L measures the dielectric constant of a zone approximately 1 cm from the upper surface of the sensor. The dielectric constant of water (≈80) and ice (≈5) are much higher than that of air (≈1), so the measured dielectric constant is strongly dependent on the presence of moisture or frost on the sensor surfaces. The sensor outputs a mV signal proportional to the dielectric of the measurement zone, and therefore proportional to the amount of water or ice on the sensor surface.

7.2 Leaf Mimicry

The LWS-L is designed to approximate the thermodynamic properties of most leaves. If the specific heat of a typical leaf is estimated at 3750 J kg^{-1} K^{-1}, density estimated at 0.95 g/cm^3, and thickness estimated at 0.4 mm, then the heat capacity of the leaf is ≈1425 J m^{-2} K^{-1}. This heat capacity is closely approximated by the thin (0.65mm) fiberglass construction of the LWS-L, which has a heat capacity of 1480 J m^{-2} K^{-1}. By mimicking the thermodynamic properties of a real leaf, the LWS-L closely matches the wetness state of the canopy.

The sensor closely matches the radiative properties of real leaves. Healthy leaves generally absorb solar radiation in much of the visible portion of the spectrum, but selectively reject much of the energy in the near-infrared. The surface coating of the LWS-L absorbs well in the near-infra red region, but the white color reflects most of the visible radiation. Spectroradiometer measurements indicate that the overall radiation balance of the sensor closely matches that of a healthy leaf. During normal use, prolonged exposure to sunlight can cause some yellowing of the coating, which does not affect the probe's function. The surface coating is hydrophobic — similar to a leaf with a hydrophobic cuticle. The sensor should match the wetness state of these types of leaves well, but may not match the wetness duration of pubescent leaves or leaves with less waxy cuticles.

8. Example Programs

8.1 CR10X Datalogger Program

Color	**Description**	**CR10X**
White	Excitation	EX1
Red	Analog Out	SE1
Bare	Analog Ground	AG

```
;{CR10X}
;

*Table 1 Program
   01:  60              Execution Interval (seconds)

1:  Excite-Delay (SE) (P4)
   1:    1              Reps
   2:    5              2500 mV Slow Range
   3:    1              SE Channel
   4:    1              Excite all reps w/Exchan 1
   5:    1              Delay (0.01 sec units)
   6:    2500           mV Excitation
   7:    1              Loc [ LWS_mV    ]
   8:    1              Multiplier
   9:    0              Offset
```

8.2 CR1000 Datalogger Program

Color	Description	CR1000
White	Excitation	EX1 or VX1
Red	Analog Out	SE1
Bare	Analog Ground	⏚

```
Public LWS_mV

BeginProg

    Scan(60,Sec, 3, 0)
        'BRHalf(Dest,Reps,Range,SeChan,ExChan,MeasPEx,ExmV,RevEx,Settling,Integ,Mult,Offset)
        BRHalf(LWS_mV, 1, mV2500, 1, VX1, 1, 2500, False, 10000, _60Hz, 2500, 0)
    NextScan

EndProg
```

9. Maintenance

Over time, the accumulation of dust and debris will cause the dry output to increase and changing the Boolean threshold. Clean the sensing surface with a moist cloth periodically or when elevated dry output is detected.

LWS-L sensors exposed to high levels of UV radiation develop a chalky residue on the sensor surface. This causes the surface to lose its “sheen” over time and a small amount of chalky residue can be rubbed off the board during aggressive cleaning. Accelerated UV testing, equivalent to five years high UV exposure, as well as field testing, show there is no apparent change in sensor function as a result of the chalky residue.

Acknowledgement

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