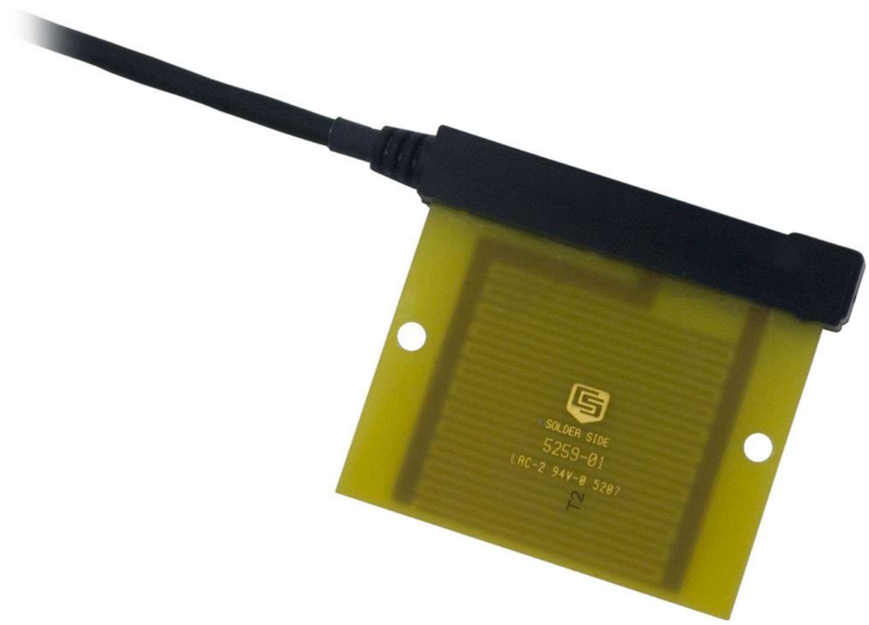
CAMPBELL SCIENTIFIC
WHEN MEASUREMENTS MATTER

USER GUIDE

237 and 237F Leaf Wetness Sensing Grids



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CSL 21

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WHEN MEASUREMENTS MATTER

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PLEASE READ FIRST

About this manual

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/in^2) = 68.95 mb

Volume: 1 UK pint = 568.3 ml
1 UK gallon = 4.546 litres
1 US gallon = 3.785 litres

Recycling information

At the end of this product's life it should not be put in commercial or domestic refuse but sent for recycling. Any batteries contained within the product or used during the products life should be removed from the product and also be sent to an appropriate recycling facility.

Campbell Scientific Ltd can advise on the recycling of the equipment and in some cases arrange collection and the correct disposal of it, although charges may apply for some items or territories.

For further advice or support, please contact Campbell Scientific Ltd, or your local agent.

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Precautions

DANGER — MANY HAZARDS ARE ASSOCIATED WITH INSTALLING, USING, MAINTAINING, AND WORKING ON OR AROUND **TRIPODS, TOWERS, AND ANY ATTACHMENTS TO TRIPODS AND TOWERS SUCH AS SENSORS, CROSSARMS, ENCLOSURES, ANTENNAS, ETC**. FAILURE TO PROPERLY AND COMPLETELY ASSEMBLE, INSTALL, OPERATE, USE, AND MAINTAIN TRIPODS, TOWERS, AND ATTACHMENTS, AND FAILURE TO HEED WARNINGS, INCREASES THE RISK OF DEATH, ACCIDENT, SERIOUS INJURY, PROPERTY DAMAGE, AND PRODUCT FAILURE. TAKE ALL REASONABLE PRECAUTIONS TO AVOID THESE HAZARDS. CHECK WITH YOUR ORGANIZATION'S SAFETY COORDINATOR (OR POLICY) FOR PROCEDURES AND REQUIRED PROTECTIVE EQUIPMENT PRIOR TO PERFORMING ANY WORK.

Use tripods, towers, and attachments to tripods and towers only for purposes for which they are designed. Do not exceed design limits. Be familiar and comply with all instructions provided in product manuals. Manuals are available at www.campbellsci.eu or by telephoning +44(0) 1509 828 888 (UK). You are responsible for conformance with governing codes and regulations, including safety regulations, and the integrity and location of structures or land to which towers, tripods, and any attachments are attached. Installation sites should be evaluated and approved by a qualified engineer. If questions or concerns arise regarding installation, use, or maintenance of tripods, towers, attachments, or electrical connections, consult with a licensed and qualified engineer or electrician.

General

- Prior to performing site or installation work, obtain required approvals and permits. Comply with all governing structure-height regulations, such as those of the FAA in the USA.
- Use only qualified personnel for installation, use, and maintenance of tripods and towers, and any attachments to tripods and towers. The use of licensed and qualified contractors is highly recommended.
- Read all applicable instructions carefully and understand procedures thoroughly before beginning work.
- Wear a **hardhat** and **eye protection**, and take **other appropriate safety precautions** while working on or around tripods and towers.
- **Do not climb** tripods or towers at any time, and prohibit climbing by other persons. Take reasonable precautions to secure tripod and tower sites from trespassers.
- Use only manufacturer recommended parts, materials, and tools.

Utility and Electrical

- **You can be killed** or sustain serious bodily injury if the tripod, tower, or attachments you are installing, constructing, using, or maintaining, or a tool, stake, or anchor, come in **contact with overhead or underground utility lines**.
- Maintain a distance of at least one-and-one-half times structure height, or 20 feet, or the distance required by applicable law, **whichever is greater**, between overhead utility lines and the structure (tripod, tower, attachments, or tools).
- Prior to performing site or installation work, inform all utility companies and have all underground utilities marked.
- Comply with all electrical codes. Electrical equipment and related grounding devices should be installed by a licensed and qualified electrician.

Elevated Work and Weather

- Exercise extreme caution when performing elevated work.
- Use appropriate equipment and safety practices.
- During installation and maintenance, keep tower and tripod sites clear of un-trained or non-essential personnel. Take precautions to prevent elevated tools and objects from dropping.
- Do not perform any work in inclement weather, including wind, rain, snow, lightning, etc.

Maintenance

- Periodically (at least yearly) check for wear and damage, including corrosion, stress cracks, frayed cables, loose cable clamps, cable tightness, etc. and take necessary corrective actions.
- Periodically (at least yearly) check electrical ground connections.

WHILE EVERY ATTEMPT IS MADE TO EMBODY THE HIGHEST DEGREE OF SAFETY IN ALL CAMPBELL SCIENTIFIC PRODUCTS, THE CUSTOMER ASSUMES ALL RISK FROM ANY INJURY RESULTING FROM IMPROPER INSTALLATION, USE, OR MAINTENANCE OF TRIPODS, TOWERS, OR ATTACHMENTS TO TRIPODS AND TOWERS SUCH AS SENSORS, CROSSARMS, ENCLOSURES, ANTENNAS, ETC.

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237/237F Leaf Wetness Sensing Grids

The 237 and 237F Leaf Wetness Sensing Grids are suitable for a range of Scientific and Industrial wetness sensing applications. They provide a simple measure of the 'degree of wetness' of the surface to which they are attached. After calibration they can also be used to measure the percentage of time for which the surface is wet or dry.

1. Description

The 237 sensor consists of a rigid epoxy circuit board (75 x 60 mm) with interlacing gold-plated copper fingers. The 237F sensor consists of a flexible polyamide film circuit (14 x 90 mm) with interlacing gold-plated copper fingers. The design of the 237F allows it to be easily attached to uneven surfaces.

Condensation or rain on the sensor lowers the resistance between the fingers which is measured by the datalogger. Droplets small enough not to touch two fingers simultaneously do not change the sensor resistance. The 237F sensor has a very small spacing between the fingers (0.25 mm), which makes it very sensitive to fine droplets.

The 237 is designed for short duration ac excitation; dc excitation or continuous ac excitation may damage the sending grid.

1.1 Specifications

Temperature Range:	Operational 0° to 100 °C
Short-Term Survivability Temperature Range:	-40 to +150 °C; sensor may crack when temperature drops below -40 °C
Dimensions:	7.1 x 7.6 x 0.64 cm (2.75" W x 3.0" L x 0.25" D)
Weight:	91 g per 3.1 m cable (3 oz per 10' cable)

2. Wiring

2.1 237 Sensor

Figure 1 is a schematic of the 237 Leaf Wetness Sensing Grid. The 237 uses a single-ended analogue 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 power ground (G) on the CR10/10X or to any other non-signal ground.

The purple lead connects to Analogue Ground. Note that Analogue Ground, labelled 'AG' on the CR10/10X, CR510 or ⏚ (Ground) for other dataloggers.

If using Shortcut to program your datalogger follow the wiring diagram produced by the program.

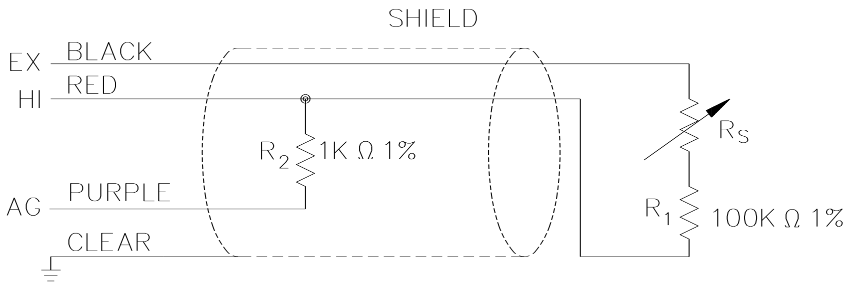

Figure 1. 237 Sensor Schematic

Table 1. Connections to Campbell Scientific Dataloggers

Colour	Description	CR200(X) CR6, CR300 CR800 CR5000 CR3000 CR1000	CR510 CR500 CR10X	21X CR7 CR23X
Black	Excitation	Switched Excitation	Switched Excitation	Switched Excitation
Red	Resistance Signal	Single-Ended Input	Single-Ended Input	Single-Ended Input
Purple	Signal Ground	⏚	AG	⏚
Clear	Shield	⏚	G	⏚

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.

2.2 237F Sensor

The 237F is supplied as a 'bare' circuit plus separate bridge resistors. This will allow you to select the most appropriate type of cable and resistor position for your own particular application. The sensor should be used in the same circuit configuration as shown in Figure 1, using the 1 kΩ and 100 kΩ 1% resistors as indicated.

Ensure that you fit the correct resistor to the appropriate part of the circuit. The resistors are colour coded (six colour bands) for identification as shown in Table 1.

For short cable runs (10 m and under) between the 237F and the datalogger, virtually any type of 2-conductor cable can be used. The 100 kΩ resistor, shown in Figure 1, can be mounted at the datalogger in the wire that is connected to its excitation output.

For long cable runs (over 10 m), select a low capacitance screened cable with polyethylene or polypropylene (*not* PVC) conductor insulators. For long cables, the 100 kΩ resistor *must* be mounted adjacent to the sensor, as shown in Figure 1, to prevent settling errors.

CAUTION In all cases it is critical that the resistor is kept dry (e.g. by using an adhesive-lined heatshrink) as even a thin film of water bridging the resistor will cause significant errors in the measured resistance, and negative readings can result.

Solder the free end of the cable to the 237F circuit at the pads shown in Figure 2. When soldering to the film use a clean soldering iron and a high-grade solder.

CAUTION Please use the following guidelines when soldering to the film:

a) *Do not* use excessive heat when soldering, and use the *minimum* amount of solder and flux to give a good joint.

b) Clean off all residual flux to prevent it corroding the circuit – use a solvent (such as isopropanol) to remove the flux.

c) *Do not* abrade the circuit as this may damage the gold plating.

d) For long-term installations, paint the solder joints with a circuit-board lacquer rated for external use. *Do not paint the grid!*

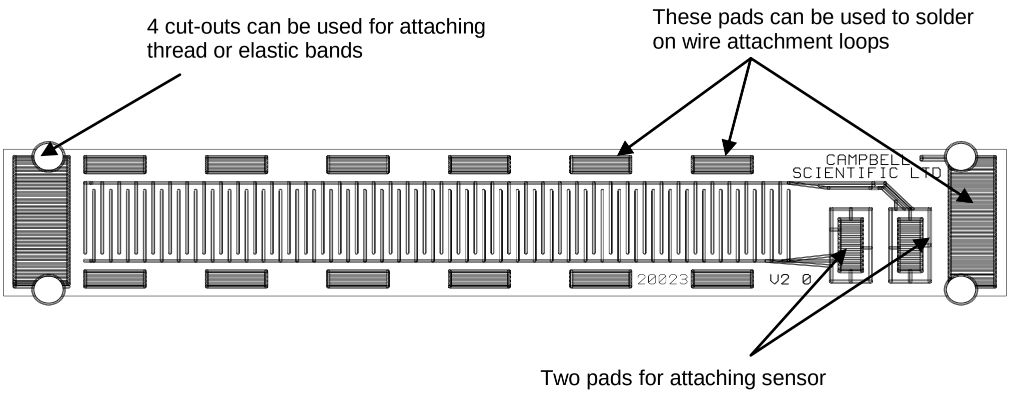

Figure 2 Enlarged Diagram of 237F Leaf Wetness Sensing Grid

3. Installation

3.1 Avoiding Secondary Paths to Ground (Both Models)

The datalogger calculates the sensor wetness by measuring the voltage drop across a reference resistor connected to ground. During installation you should take great care to ensure that there are no secondary paths to ground from the exposed elements of the grid. Any secondary paths will lower the measured voltage and so cause an apparent increase in the sensor resistance.

In practice, it is very difficult to avoid all such secondary paths, as moisture will inevitably provide some pathway to ground – via the support arm or plant material for example. To minimise reading errors, try to ensure that any potential pathways to ground are as long as possible.

Where multiple sensors are installed in very close proximity it may be necessary to use an isolating multiplexer, such as the AM16/32, so that adjacent sensors do not act as parallel pathways to ground. Contact Campbell Scientific for further details.

3.2 237 Sensor

When the 237 sensor is used to estimate leaf wetness, mount it within the plant canopy at an angle which represents the average leaf angle relative to the horizontal. The sensor can be mounted, using insulated nylon screws through the mounting holes in the circuit board, on a suitable mounting arm.

CAUTION Do *not* mount the sensor on a large thermal mass, such as a metal plate, as this will make its thermal response much different from that of a leaf and can affect the rate of dew formation or drying after rainfall.

If you will be using the sensor simply to detect rain, it can be mounted on a pole or the crossarm of a weather station. In this case, mount the sensor at an angle of 45 degrees, which will allow excessive moisture to run off quickly and so give a better estimate of when rainfall stops.

In some cases birds can cause problems if they stand or urinate on the sensor. This can be prevented by placing some spikes adjacent to the sensor. When the sensor is mounted on a tripod crossarm you can use cable ties around the arm, pointing upwards.

3.3 237F Sensor

The 237F can be installed in several ways, depending on the application.

For flat surface mounting the sensor can be stuck to the surface using a suitable adhesive compatible with polyamide film. For permanent installation, epoxy-type or solvent-based adhesives can be used. For a temporary installation, waterproof, double-sided adhesive tape may be more convenient.

Where the sensor is to be attached to a cylindrical object, such as a fruit or plant stem, an elastic band or nylon thread can be used. The sensor has four semi-circular cut-outs in the corners which can be used with a loop of thread or elastic band to pull the sensor tightly around the stem. Alternatively you can solder small loops or hooks of wire onto the copper pads which are incorporated around the edge of the sensor, to provide other attachment points (see Figure 2).

For small objects, the sensor film can be cut off across the grid to form a shorter sensor. The resistance characteristics of the sensor will change in direct proportion to the remaining length of the grid compared to its original length.

CAUTION Take great care when mounting the 237F sensors. Although flexible, they can be damaged, and should never be bent at very sharp angles. Also the sensors will be subject to fatigue damage if they are allowed to flex continually. They should, therefore, *always* be stuck or held securely in a fixed position in normal operational conditions.

4. Maintenance

The only maintenance required for either type of sensor is to clean off any dirt at regular intervals (a few weeks to a few months depending on site conditions). Clean using a soft cloth with water, a detergent or isopropanol.

CAUTION Do not scrub or abrade the sensor as this may damage the gold plating.

In highly corrosive atmospheres, the sensor may eventually corrode as a result of a breakdown in the gold plating. This will eventually require a replacement of the sensor, but the sensor can be used with partial corrosion with only a small loss of accuracy. The operation of the sensor can be easily checked by monitoring the output through a wet/dry cycle.

5. Programming

Refer to programming examples in Section 6 for suggested implementation of measurement and processing concepts.

5.1 Measurement of Vs / Vx

The base measurement of the 237 sensor is Vs/Vx where Vs is the voltage measured and Vx is the excitation voltage supplied by the datalogger. Vs/Vx is measured by the datalogger with the instructions and parameters listed in Table 2.

Table 2. Measurement Instructions, Parameters, Results

Datalogger	Measurement Instruction	Excitation (mV)	Input Range	Integration/ Delay	Multiplier	Offset	Result
CR6	BrHalf ()	2500	±200 mV	15000	1	0	Vs/Vx
CR300	BrHalf ()	2500	±2500 mV	4000 Hz	1	0	Vs/Vx
CR200(X)	ExDelSE ()	2500	n/a	500 µs	0.0004	0	Vs/Vx
CR800, CR1000	BrHalf ()	2500	±25 mV	250 µs	1	0	Vs/Vx
CR3000, CR9000X	BrHalf ()	5000	±50 mV	250 µs	1	0	Vs/Vx

5.2 Calculating Sensor Resistance

The CRBasic program should include an expression that calculates sensor resistance. With reference to Figure 1, sensor resistance (Rs), expressed in kΩ, is calculated as follows:

$$Rs = R_2 / (Vs/Vx) - R_2 - R_1.$$

Therefore,

$$Rs\ (k\Omega) = 1/(Vs/Vx) - 101$$

Except for the CR200(X), Campbell Scientific also suggests including the following after the resistance calculation:

```
If Rs > 10000 Then
   Rs = 10000
EndIf
```

The high resolution of Campbell Scientific dataloggers can pick up very small signals, which can result in an erratic signal when the sensor is dry. The wet/dry transition is less than 1000 kΩ, and therefore, 10,000 kΩ gives plenty of range outside of what one would consider to be dry.

5.3 Interpreting Resistance Values

Table 3 lists 237 sensor resistance ranges and their interpretation.

Table 3. 237 Resistance Interpretations
(Wet / Dry Threshold Set at 150 kΩ)

	CR1000		CR200(X)	CR10X	
Interpretation	**IEEE4[a]**	**FP2[b]**	**IEEE4[a,b]**	**Input Loc[a]**	**Low Res FS[b]**
Wet	0 to 150				
Slightly Wet	150 to ≥ 99999	150 to 7999	150 to ≥ 9999	150 to ≥ 99999	150 to 6999
Dry[c]	INF, ≥ 99999, ≤ -99999	INF, ±7999	-INF, ≥ 9999, ≤ -9999	INF, ≥ 99999, ≤ -99999	±6999
Voltage Input Over-range[d]	NAN	NAN	-100, -INF	-101	-101
Bridge Over-range[e]	< 0				
Missing Sensor[f]	Any Value				

[a] Input Memory

[b] Final Storage Memory

[c] The 1 kΩ bridge resistor holds the input channel at 0 mV when the sensor is completely dry. However, the measurement may intermittently deviate from zero slightly, but still be within the resolution specifications of the datalogger. When this occurs, Rs = either a very large or a very small number.

[d] Voltage input over-range is a state wherein voltage from the sensor exceeds the recommended 25 mV input voltage range. This highly conductive state may occur if the sensor is very very wet with very ionic water.

[e] If the measured voltage exceeds 24.75 mV, but does not exceed the input voltage range, the result of the bridge equation becomes negative.

[f] When no sensor is connected, or a cable has been cleanly cut, a “floating” voltage can occur and falsely indicate the presence of a missing sensor. In the CR1000, this can be avoided by using the mv25c range code.

5.4 Calculating Wet Time Fraction

Fraction of time wet are common data derived from 237 measurements. Calculating time fraction requires a wetness threshold. Refer to Section 5.4 Calibration for more information on determining the threshold.

Fraction of time wet is calculated in all current Campbell Scientific dataloggers, except the CR200, by using the Histogram instruction (P75 in Histogram () in CRBasic) with a single bin and closed form. The bin select value for the histogram is the Input Location / Variable containing sensor resistance (Rs). The lower limit of the histogram is zero, and the upper limit is the wet / dry threshold. This will give the fraction of the output interval that the sensor is wet. A fraction of time wet of .33 when the output interval is one hour means that the sensor was wet for 20 minutes during that hour.

Refer to programming example 6.2 for information on calculating fraction of time wet with the CR200.

6. Programming Examples

Each example program measures leaf wetness and outputs a sample resistance and a time fraction the sensor is wet. In these examples, the output interval is set to 60 minutes, so a time fraction wet of .33 is equivalent to 20 minutes during that hour. Wetness threshold is set at 150 kΩ.

6.1 CR1000 Program Example

```
Public Vs_Vx
Public Rs_kOhms

DataTable(Wetness,true,-1)
      OpenInterval
      DataInterval(0,60,Min,10)
      Sample(1, Rs_kOhms, FP2)
      Histogram(Rs_kOhms, FP2, 0, 1, 001, 1 , 0, 150)       'Enter threshold in 8th parameter
EndTable

BeginProg
      Scan(60,Sec, 3, 0)
            BRHalf(Vs_Vx, 1, mV25, 1, VX1, 1, 2500, True, 0, 250, 1, 0)
            Rs_kOhms = (1 / Vs_Vx) – 101
            If Rs_kOhms > 10000 Then
               Rs_kOhms – 10000
            EndIf
            CallTable Wetness
      NextScan
EndProg
```

6.2 CR200(X) Programming

```
'CR200(X) Series Datalogger
Public Vs_Vx
Public Rs_kOhm
Public ScanIntervalWet
Public ScanIntervalSum
Public TimeFractionWet

DataTable (Wetness,1,-1)
    DataInterval (0,60,min)                    'Interval must match IfTime interval (below)
    Sample (1,Rs_kohm)
    Sample (1,TimeFractionWet)
EndTable

BeginProg
    Scan (1,Min)

        'Measure Wetness
        ExDelSE(Vs_Vx,1,1,1,mV2500,500,.0004,0)

        'Zero measurement when measurement < 0
        If Vs_Vx < 0 Then Vs_Vx = 0
        Rs_kOhm = (1 / Vs_Vx) - 101

        'Sum Scan Intervals
        ScanIntervalSum = ScanIntervalSum + 1

        'Check if Leaf wetness is below 150 kOhms transition and count as time dry
        If Rs_kohm < 150 AND Rs_kohm > 0 Then
            ScanIntervalWet = ScanIntervalWet + 1
        EndIf

        'Calculate Time Fraction Wet at top of each hour
        If IfTime (0,60,Min) Then              'Interval must match data table interval
            TimeFractionWet = ScanIntervalWet / ScanIntervalSum
            ScanIntervalWet = 0
            ScanIntervalSum = 0
        EndIf

        CallTable (Wetness)
    NextScan
EndProg
```

6.3 CR10(X) Programming Example

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

1:  AC Half Bridge (P5)
  1:   1               Reps
  2:   13              25 mV Fast Range
  3:   1               SE Channel
  4:   1               Excite all reps w/Exchan 1
  5:   2500            mV Excitation
  6:   1               Loc [ Vs_Vx     ]
  7:   1               Multiplier
  8:   0               Offset

2:  Z=1/X (P42)
  1:   1               X Loc [ Vs_Vx     ]
  2:   2               Z Loc [ Rs_kOhms  ]

3:  Z=X+F (P34)
  1:   2               X Loc [ Rs_kOhms  ]
  2:   -101            F
  3:   2               Z Loc [ Rs_kOhms  ]

4:  If time is (P92)
  1:   0               Minutes (Seconds --) into a
  2:   60              Interval (same units as above)
  3:   10              Set Output Flag High (Flag 0)

5:  Real Time (P77)
  1:   1220            Year,Day,Hour/Minute (midnight = 2400)

6:  Sample (P70)
  1:   1               Reps
  2:   2               Loc [ Rs_kOhms  ]

7:  Histogram (P75)
  1:   1               Reps
  2:   1               No. of Bins
  3:   1               Closed Form
  4:   2               Bin Select Value Loc [ Rs_kOhms  ]
  5:   0000            WV Loc Option [ _________ ]
  6:   0               Low Limit
  7:   150             High Limit                 ;<<<<<<<<<<<<<<<<<<<Enter threshold
here
```

NOTE When compiling this program, the message “Warning: zero is an invalid input address, Line: xx” will be returned from the compiler. Ignore the message, so long as “Line: xx” corresponds to the line number in the program where “WV Loc Option [__________]” appears.

7. Plant Pathology Application

Plant diseases are often associated with wet leaves. Duration of wetness and air temperature during wetness are inputs to many disease models. When estimating leaf wetness, the sensor emulates a leaf, thereby approximating the wetness state of surrounding foliage. The sensor does not (and should not!) come in contact with leaves. Water droplets that form at the onset of condensation are often too small to bridge the electrodes and so remain undetected. Droplets can be detected earlier in formation by application of a non-conductive spreader to the surface of the sensing grid. The spreader most commonly employed is flat latex paint.

7.1 Sensor Preparation

Campbell Scientific supplies only uncoated sensors since coating preferences vary between applications.

NOTE Campbell Scientific has not researched, nor does it recommend, paint formulations. The following information regarding paint formulation is intended only to introduce the concept.

Preparing the sensor surface with a thin coat of flat latex paint is a generally accepted practice in plant disease applications. In addition to providing some protection for the gold plated electrodes, flat latex allows tiny water droplets to spread and bridge the electrodes. Gillespie and Kidd[1] found that paint colour had significant effects on performance and found off-white worked well. Their paint was formulated with 1 part black pigment to 1000 parts white paint. East[2] found that greater precision is obtained using a high quality flat latex paint. Some researchers and agricultural weather networks do not paint the sensor.

However the surface is prepared, the response of the sensor is, in reality, only an index against which actual leaf wetness can be estimated. While the absence of a spreader will decrease sensitivity and increase the chance of scratching the gold plated electrodes, bare sensors may grant greater consistency and less maintenance across a network.

7.2 Plant Pathology Application Programming

An exact range of measurements is impossible to give since the 237 is field calibrated. The manufacture of the sensor is not precise and the quality of water bridging the electrodes varies. As demonstrated in program examples in Section 4, a common practice is to measures grid resistance in terms of kOhms using a 1 bin histogram to calculate at what fraction of the output interval the sensor is wet. If resistance is $\leq$ 150 kΩ, the grid is considered wet. Since the output interval is 60 minutes, if the histogram fraction equals 0.33, the leaf was wet for 20 minutes during that hour.

7.3 Sensor Deployment

The sensor is not supplied with a mounting bracket. Gillespie and Kidd[1] found that sensor orientation affects performance. As with surface preparation, orientation varies across applications and users. A common practice is to mount the sensor such that it receives minimal direct sunlight at mid-day during the growing season. Gillespie and Kidd favour a 60 degree tilt on a north facing sensor such that water runs away from the cable connection to minimize puddling on the electrodes. Figure 3 shows a simple-to-construct mounting bracket.

Reference 3 describes use and deployment of a sensor similar to the 237F in tomato crops.[3]

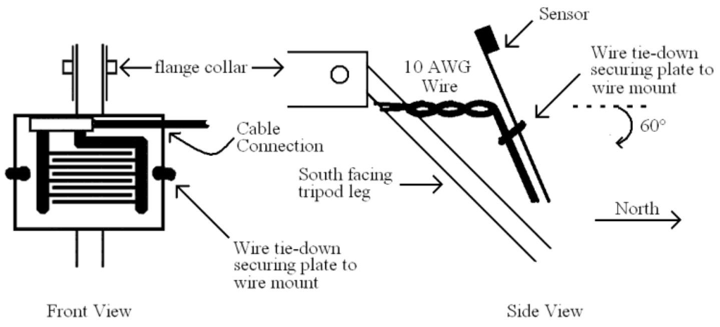

Figure 3. Mounting the 237 Sensor

7.4 Calibration

A wet / dry threshold of 150 kΩ is used in the programming examples in Section 6. While this threshold may work well, refining the threshold for a specific sensor and installation is recommended. A sharp change in resistance occurs at the threshold on uncoated sensors. A less defined threshold occurs with coated sensors. The threshold of uncoated sensors is normally between 50 and 200 kΩ. The threshold of the coated sensor is normally between 20 and 1,000 kΩ.

For best results, the sensor should be field calibrated. The transition point will vary for different areas, vegetation, and water quality. Place the sensor in vegetation, the wetness of which is to be monitored. Observe the vegetation until it reaches the desired wetness. When the vegetation is at the desired "wetness", the measured resistance can be used as a threshold. Sensitivity of the sensor is changed by contaminants such as fingerprints and smudges. Before painting and calibrating the sensor, clean it gently with alcohol.

8. Troubleshooting

Table 4 lists the causes of unusual resistance readings.

TABLE 4. Symptoms/Causes

Resistive Value		
IEEE4	**FP2**	**Causes**
INF, ≥ 99999, ≤ -99999	INF, ±7999	The 1 kΩ bridge resistor holds the input channel at 0 mV when the sensor is completely dry. However, the measurement may intermittently deviate from zero slightly, but still be within the resolution specifications of the datalogger. When this occurs, Rs = either a very large or a very small number.
NAN, -100, -INF	NAN	NAN can indicate that no sensor is connected or a cable has been cleanly cut if the ***mV200C***, ***mV25C***, or ***mV50C*** range code was used for the **BrHalf** instruction. Another cause of these outputs is a highly conductive state (> 25 mV) that occurs if the sensor is very wet with very ionic water.
< 0		If the measured voltage exceeds 24.75 mV, but does not exceed the input voltage range, the result of the bridge equation becomes negative.

9. References

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