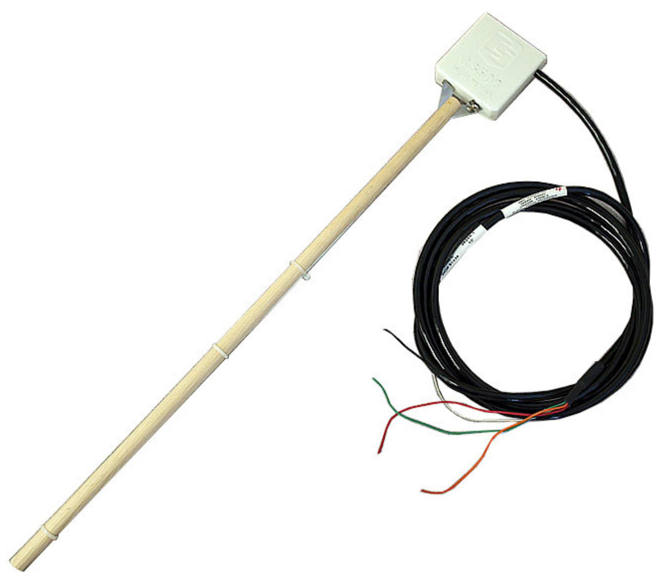
INSTRUCTION MANUAL

CS506 Fuel Moisture Sensor

Revision: 3/12



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CS506 Fuel Moisture Sensor

1. General Description

The CS506 Fuel Moisture Sensor provides an automated measurement of the moisture content of a standard 10-hour fuel moisture dowel. The moisture content of the 10-hour fuel sensor represents the moisture content of small-diameter (10-hour time lag) forest fuels.

Traditionally, the standard fuel moisture stick consists of a rack of four 1/2 inch diameter ponderosa pine dowels. The resulting rack is about 20 inches long with an oven-dry weight of 100 grams. The characteristic time constant of the rack is 10 hours. The rack is mounted 12 inches or about 30 centimeters above the forest floor. The rack is left outside continually exposed to the same conditions as forest fuels. The rack absorbs and desorbs moisture from its surroundings. As the rack transfers moisture, its weight changes. Periodic weighing of the rack determines changes in moisture content and provides an indication of moisture changes in forest fuels.

The CS506 sensor incorporates the same carefully selected USFS standard ponderosa dowels as the traditional weighing fuel moisture racks. No artificial materials (e.g., epoxy sealant) are added to the dowel that would adversely influence the natural behavior characteristics of the dowel. Because the complete dowel surface is accessible for moisture exchange, the response of the CS506 is similar to that of the traditional weighing racks. To optimize probe-to-probe repeatability and to allow probe interchangeability without individual calibration, two additional sorts are performed on the dowels before they are selected to be used as a sensor. First, the dowels are sorted dry by density to improve accuracy in the dry range of 0 to 15%. Second, the dowels are sorted after a 50-minute soak by weight to reduce probe-to-probe time response variation and minimize variability in the wet range of 20 to 50%.

Even after careful selection and sorting is performed to choose the most representative dowels, the majority of measurement error is due to the variability of wood. Wood's ability to transfer moisture is dependent on many variables, primarily cell structure and wood resin content. These variables change over time and after repeated wetting and drying cycles. Only a small amount of overall measurement error is due to the electronic circuitry.

2. Specifications

The fuel moisture sensor consists of two stainless steel strips pressed into groves in a standard 1/2 inch ponderosa pine dowel and secured with nylon tie wraps. The probe connects to the electronics with two Phillips head screws. A shielded four-conductor cable is connected to the circuit board to supply power, enable the electronics, and monitor the signal output. The printed circuit board is encapsulated in a waterproof epoxy housing.

High speed electronic components on the circuit board are configured to oscillate when power is applied. The output of the circuit is connected to the fuel moisture probe which acts as a wave guide. The oscillation frequency and therefore output signal of the circuit is dependent on the dielectric constant of the media surrounding the stainless steel strips. The dielectric constant is predominantly dependent on the water content of the wood. Digital circuitry scales the oscillation frequency to an appropriate range for measurement with a datalogger. The CS506 output is essentially a square wave with an amplitude of ±0.7 VDC. The frequency of the square wave output ranges from approximately 31 to 58 kHz. Its output period ranges from 17 to 32 µs.

***Fuel moisture accuracy:**
(with a new stick)

range	90% of all measurements	rms error
0 to 10%	±1.25%	±0.74%
10 to 20%	±2.00%	±0.90%
20 to 30%	±3.40%	±1.94%
30 to 50%	±4.11%	±2.27%

Range: 0-50%

Power Supply: 5 VDC minimum to
18 VDC maximum

Enable voltage: off at 0 V (<1 VDC)
on at 5 V (>4 VDC maximum 18 VDC)

Current usage: 65 mA active/ 45 uA quiescent

Output signal: ±0.7 V square wave with an output frequency of approximately 31 to 58 kHz.

Weight: <0.5 kg (<1 lb)

Dimensions
Dowel: 1.3 cm (1/2 in) diameter, 50.8 cm (20 in) long
Electronics: 10.2 x 6.4 x 1.9 cm (4 x 2.5 x 0.75 in)

*The above accuracy is a static accuracy derived at slow changing conditions with experimental data for the CS505. See Appendix A for explanation of accuracy.

3. Installation

As shown in Figure 3-1 and Figure 3-2, both the CS506 and CS205 install on the 26817 mounting stake. The probes install horizontally and should point south in the northern hemisphere and north in the southern. The rack is mounted above a representative forest-floor duff layer. The stake is carefully hammered into the ground so that it is vertical. The mounting bracket is positioned so that the sensor will be approximately 12 in. (30 cm) above the ground, and then secured by tightening the nuts on the U-bolts. Once the bracket is installed, insert the CS506 electronics into the two spring clips. The fuel moisture sensor (part number 26601) installs on the CS506 electronics with the supplied Phillips-head screws. The CS205 fuel temperature stick is inserted into the mounting stake's compression fitting. The 107 temperature probe is then inserted into the CS205 stick. Tighten the compression fitting so that it compresses the split wood and snugly holds the 107 probe.

The mounting stake ships with a package of three ultraviolet light resistant cable ties. One cable tie passes through the two slots where the fuel moisture stick attaches to the CS506 sensor in order to loosely secure the cable of the CS205/107. The other two cable ties are used to secure both cables to the mounting stake.

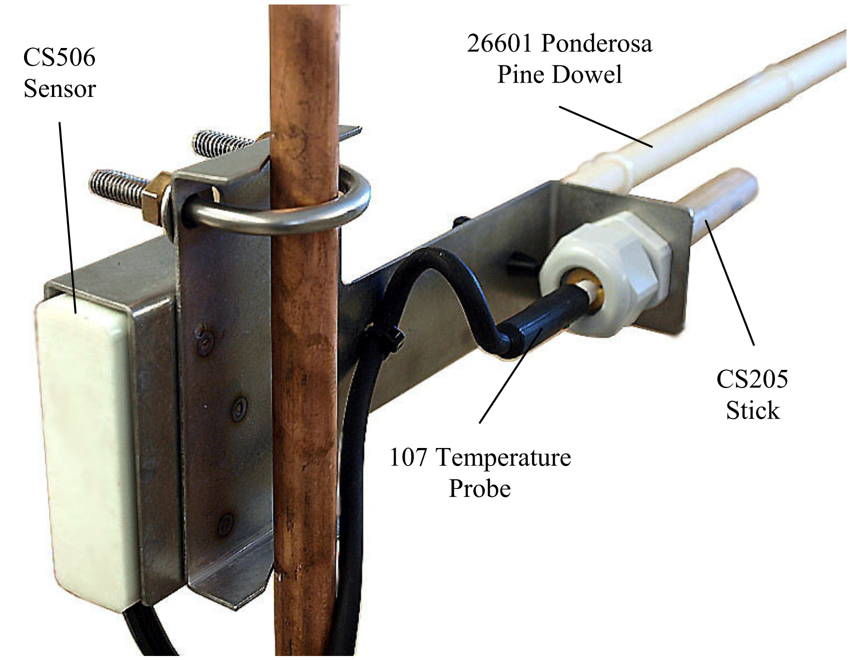

FIGURE 3-1. Back view of the 26817 fuel moisture/temperature mounting stake; mount ~12-in. over duff layer

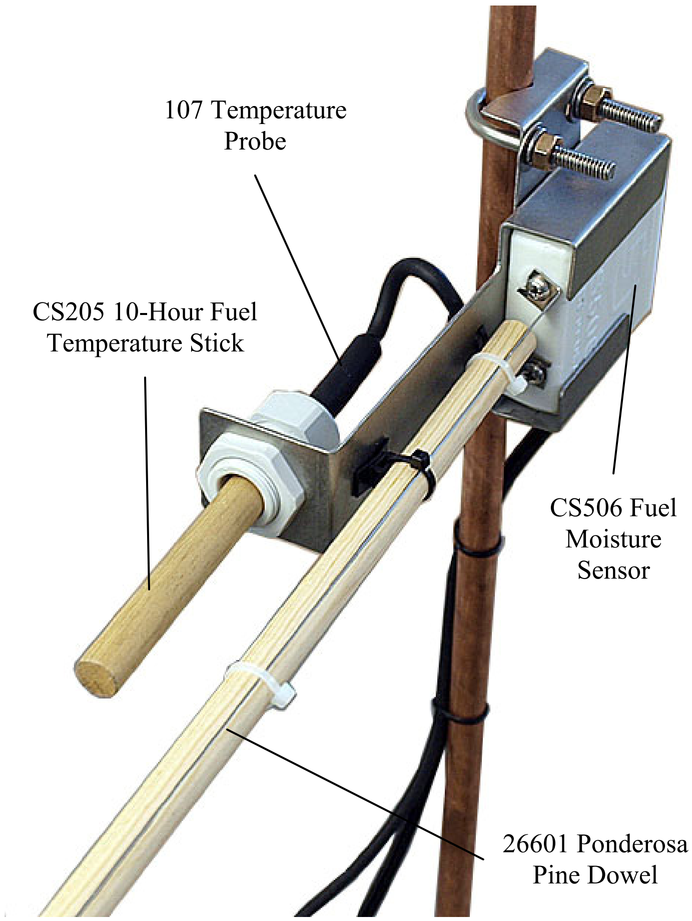

FIGURE 3-2. Front view of the 26817 fuel moisture/temperature mounting stake

4. Wiring

Connections to Campbell Scientific dataloggers are given in Table 4-1. When Short Cut for Windows software is used to create the datalogger program, the sensor should be wired to the channels shown on the wiring diagram created by Short Cut.

TABLE 4-1. CS506 Wiring

Color	Description	CR800/CR1000/ CR3000	CR10(X)/CR500/ CR510	CR23X
Red	Power	12 V	12 V	12 V
Black	Ground	G	G	G
Green	Signal	Analog Channel	Analog Channel	Analog Channel
Orange	Enable	Control Port	Control Port	Control Port
Clear	Ground	⏚	G	⏚

5. Datalogger Programming

This section is for users who write their own datalogger programs. A datalogger program to measure this sensor can be created using Campbell Scientific's Short Cut Program Builder software. You do not need to read this section to use Short Cut.

The CS506 has a built in enable circuit. When voltage on the enable lead is less than 1 VDC, the sensor is off. When a voltage greater than 4 VDC, commonly 5 VDC, is applied to the enable lead, the sensor is on. The output signal is a ±0.7 volt square wave. The CRBasic instruction PeriodAvg is used with the CR800-series, CR1000, and CR3000 dataloggers to measure the period of the output signal in microseconds on a single-ended analog input channel. For Edlog dataloggers, instruction P27 Period Average may be used with the CR500, CR510, CR10, CR10X, and CR23X dataloggers. The CS506 is not compatible with 21X, CR7, or CR200-series dataloggers.

Since fuel moisture does not change very rapidly, the sensor is typically measured only once per hour.

After the period of the output signal in microseconds is measured it is converted to percent water content using one of two equations:

$$\theta(\tau \le 17.7) = 7.6298\tau - 130.0904$$

$$\theta(\tau > 17.7) = 0.0406\tau^2 + 3.7685\tau - 73.7974$$

where θ is the percent of water by weight in the fuel moisture stick and τ is period average in microseconds.

There is a slight disconnect in the two equations at 17.7 µs where the linear equation gives a water content of 4.98% while the quadratic equation gives 5.68%. A sudden small increase or decrease in the measured water content near 5% is to be expected as the datalogger changes from one equation to the other.

TABLE 5-1. Wiring for Example Programs

Color	**CR1000**	**CR10X**
Red	12 V	12 V
Black	G	G
Green	SE1	SE1
Orange	C1	C1
Clear	⏚	G

5.1 CR1000 Programming

The following program measures a CS506 fuel moisture sensor using the CRBasic **PeriodAvg()** instruction. See Table 5-1 for wiring details that match this program.

```
'CR1000

'CR1000 Program for CS506

'Declare Variables and Units
Public FuelM
Public PA_uS

Units FuelM=%
Units PA_uS=uSec

'Define Data Tables
DataTable(Table1,True,-1)
    DataInterval(0,60,Min,10)
    Sample(1,FuelM,FP2)
    Sample(1,PA_uS,FP2)
EndTable

'Main Program
BeginProg
    Scan(10,Sec,1,0)
        'CS506 Fuel Moisture Sensor measurement FuelM and PA_uS:
        If IfTime(0,1,Hr) Then
            PortSet (1,1)
            PeriodAvg(PA_uS,1,mV250,1,0,0,100,10,1,0)
            PortSet (1,0)
            If PA_uS <= 17.7 Then
                FuelM = 7.6298* PA_uS - 130.0904
            Else
                FuelM= 0.0406* PA_uS ^2 + 3.7685 * PA_uS -73.7974
            EndIf
        EndIf
        'Call Data Tables and Store Data
        CallTable(Table1)
    NextScan
EndProg
```

5.2 CR10X Programming

The following program measures a CS506 fuel moisture sensor using Edlog's Instruction 27 (Period Averaging). See Table 5-1 for wiring details that match this program.

```
;{CR10X}

;CR10X Program for CS506

*Table 1 Program
  01: 10.0000       Execution Interval (seconds)

1: If time is (P92)
  1:   0            Minutes (Seconds --) into a
  2:   60           Interval (same units as above)
  3:   30           Then Do

    2: Do (P86)
      1:   41           Set Port 1 High

    3: Period Average (SE) (P27)
      1:   1            Reps
      2:   4            200 kHz Max Freq @ 2 V Peak to Peak, Period Output
      3:   1            SE Channel
      4:   100          No. of Cycles
      5:   1            Timeout (0.01 sec units)
      6:   1            Loc [ PA_uS     ]
      7:   1            Multiplier
      8:   0            Offset

    4: Do (P86)
      1:   51            Set Port 1 Low

    5: If (X<=>F) (P89)
      1:   1            X Loc [ PA_uS     ]
      2:   4            <
      3:   17.701       F
      4:   30           Then Do

        6: Polynomial (P55)
          1:   1            Reps
          2:   1            X Loc [ PA_uS     ]
          3:   2            F(X) Loc [ FuelM     ]
          4:   -130.09      C0
          5:   7.6298       C1
          6:   0.0          C2
          7:   0.0          C3
          8:   0.0          C4
          9:   0.0          C5

    7: Else (P94)
```

```
        8:  Polynomial (P55)
           1:   1               Reps
           2:   1               X Loc [ PA_uS     ]
           3:   2               F(X) Loc [ FuelM     ]
           4:   -73.797         C0
           5:   3.7685          C1
           6:   0.0406          C2
           7:   0.0             C3
           8:   0.0             C4
           9:   0.0             C5

    9:  End (P95)

10:  End (P95)

11:  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)

12:  Set Active Storage Area (P80)^18555
  1:   1               Final Storage Area 1
  2:   60              Array ID

13:  Real Time (P77)^12334
  1:   1220            Year,Day,Hour/Minute (midnight = 2400)

14:  Sample (P70)^15015
  1:   2               Reps
  2:   1               Loc [ PA_uS     ]
```

6. Maintenance

The sensor dowel rod should be changed at least once a year with a new dowel rod in the spring. Since the characteristics of wood change so rapidly, more frequent replacements may be desirable.

To change the sensor dowel rod, loosen the Phillips head screws and replace with the new dowel rod. Tighten the screws after replacing the element.

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