

INSTRUCTION MANUAL



05103, 05106, and 05305 R.M. Young Wind Monitors

Revision: 9/07



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05103, 05106, and 05305 R.M. Young Wind Monitors

1. General Description

The 05103, 05106, and 05305 Wind Monitor sensors are used to measure horizontal wind speed and direction. The 05305 is a high performance version of the 05103 designed to meet PSD specifications for air quality applications. The 05106 is recommended for marine applications.

Wind speed is measured with a helicoid-shaped, four-blade propeller. Rotation of the propeller produces an AC sine wave signal with frequency proportional to wind speed.

Vane position is transmitted by a 10K ohm potentiometer. With a precision excitation voltage applied, the output voltage is proportional to wind direction.

The R.M. Young Instruction Manual includes additional information on the operating principles, installation and maintenance of the sensor.

Lead length for the Wind Monitor is specified when the sensor is ordered. Table 1-1 gives the recommended lead length for mounting the sensor at the top of the tripod/tower with a 019ALU or CM200 series crossarm.

TABLE 1-1. Recommended Lead Lengths							
CM6	CM10	CM110	CM115	CM120	UT10	UT20	UT30
10'	13'	13'	19'	24'	13'	24'	34'

The 05103 / 05106 / 05305 ships with:

- (1) Allen wrench from mfg
- (1) Bearing spacer from mfg
- (1) Calibration Sheet
- (1) Instruction Manual
- (1) 3659 Mounting pipe

2. Specifications

	<u>05103 and 05106</u>	<u>05305</u>
Wind Speed		
Range:	0-224 mph (0-100 m s ⁻¹)	0-112 mph (0-50 m s ⁻¹)
Accuracy:	±0.6 mph (±0.3 m s ⁻¹) or 1% of reading	±0.4 mph (±0.2 m s ⁻¹) or 1% of reading
Starting threshold:	2.2 mph (1.0 m s ⁻¹) 05103; 2.4 mph (1.1 m s ⁻¹) 05106	0.9 mph (0.4 m s ⁻¹)
Distance constant (63% recovery):	8.9 ft (2.7 m)	6.9 ft (2.1 m)

	05103 and 05106	05305
Output:	ac voltage (3 pulses per revolution). 1800 rpm (90 Hz) = 19.7 mph (8.8 m s ⁻¹)	ac voltage (3 pulses per revolution) 1800 rpm (90 Hz) = 20.6 mph (9.2 m s ⁻¹)
Wind Direction		
Range:	0-360° mechanical, 355° electrical (5° open)	Same
Accuracy:	±3°	±3°
Starting threshold at 10° displacement:	2.4 mph (1.1 m s ⁻¹)	1.0 mph (0.5 m s ⁻¹)
Delay distance (50% recovery):	4.3 ft (1.3 m)	3.9 ft (1.2 m)
Damping ratio:	0.3	0.45
Damped natural wavelength:	24.3 ft (7.4 m)	16.1 ft (4.9 m)
Undamped natural wavelength:	23.6 ft (7.2 m)	14.4 ft (4.4 m)
Output:	Analog dc voltage from potentiometer – resistance 10 kΩ, linearity 0.25%, life expectancy 50 million revolutions.	Same
Power	Switched excitation voltage supplied by the datalogger.	Same
Physical		
Operating Temperature	-50° to +50°C, assuming non-riming conditions	-50° to +50°C, assuming non-riming conditions
Dimensions		
Overall:	14.6” H x 21.7” L (37 cm x 55 cm)	15.0” H x 25.6” L (38 cm x 65 cm)
Main housing Diameter:	2.0” (5 cm)	Same
Propeller Diameter:	7.1” (18 cm)	7.9” (20 cm)
Mounting Pipe:	1.34” (34 mm) OD; standard 1.0” IPS schedule 40	Same
Weight (shipping approx.)	3.2 lbs (5.5 lbs); 1.5 kg (2.3 kg)	2.5 lbs (5.5 lbs); 1.1 kg (2.3 kg)

Manufactured by RM Young (Traverse City, MI) and cabled by Campbell Scientific for use with our dataloggers.

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. Installation

3.1 Siting

Locate wind sensors away from obstructions (e.g. trees and building). As a general rule of thumb there should be a horizontal distance of at least ten times the height of the obstruction between the windset and the obstruction. If it is necessary to mount the sensors on the roof of a building, the height of the sensors above the roof, should be at least 1.5 times the height of the building. See Section 9 for a list of references that discuss siting wind speed and direction sensors.

3.2 Assembly and Mounting

Tools Required:

- 5/64" Allen wrench
- 1/2" open end wrench
- compass and declination angle for the site (see Appendix A)
- small screw driver provided with datalogger
- UV resistant cable ties
- small pair of diagonal-cutting pliers
- 6 - 10" torpedo level

Install the propeller to the propeller shaft using the nut provided with the sensor.

The 05103 mounts to a standard 1" IPS schedule 40 pipe (1.31" O.D.). A 12" long mounting pipe ships with the 03001 for attaching the sensor to a 019ALU (Figure 3-1), or CM200 series crossarm with the CM220 or PN 1049 (Figures 3-2 and 3-3). The 05103 can also be mounted to a CM110 series tripod mast with the CM216 Mast Mounting Kit.

Mount the 019ALU or CM200 series crossarm to the tripod or tower. Orient the crossarm North-South, with the 1" Nu-Rail or CM220 on the North end. Appendix A contains detailed information on determining true north using a compass and the magnetic declination for the site.

Secure the mounting pipe to the 019ALU or CM220. Place the orientation ring, followed by the 05103 on the mounting pipe. Orient the junction box to the south, and tighten the band clamps on the orientation ring and mounting post. Final sensor orientation is done after the datalogger has been programmed to measure wind direction as described in Appendix A.

Route the sensor cable along the underside of the crossarm to the tower/tripod mast, and to the instrument enclosure. Secure the sensor cable to the crossarm and mast using cable ties.

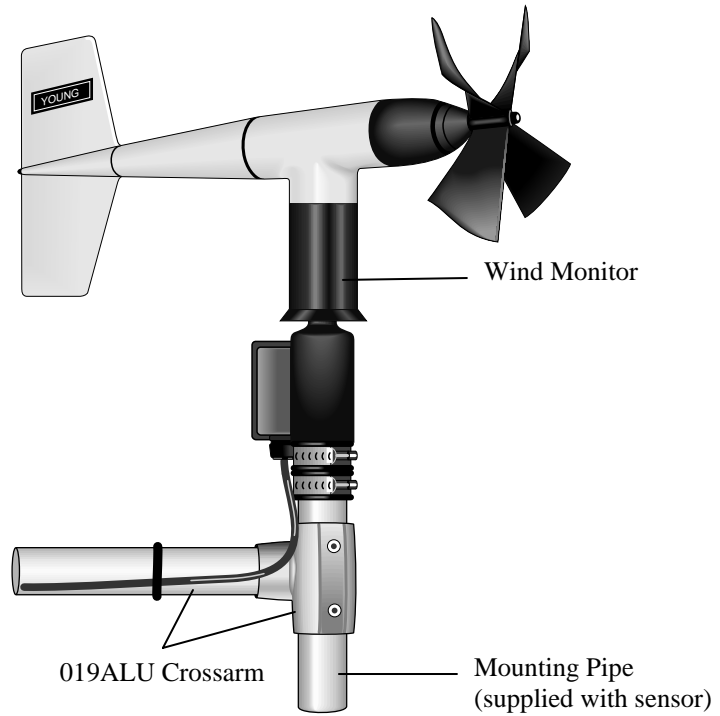


FIGURE 3-1. Wind Monitor Mounted to the 019ALU Crossarm

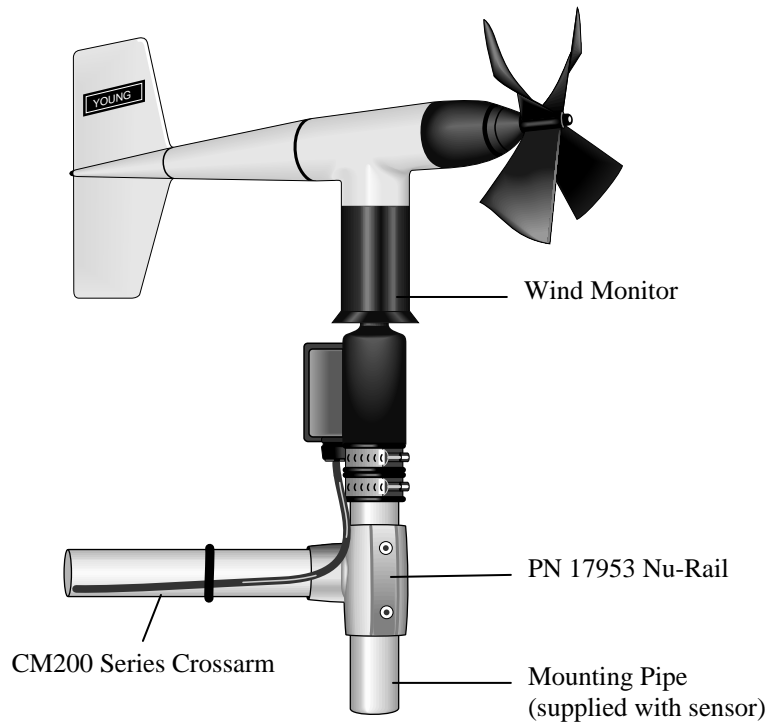


FIGURE 3-2. Wind Monitor Mounted to a CM200 Series Crossarm with PN 17953 Nu-Rail

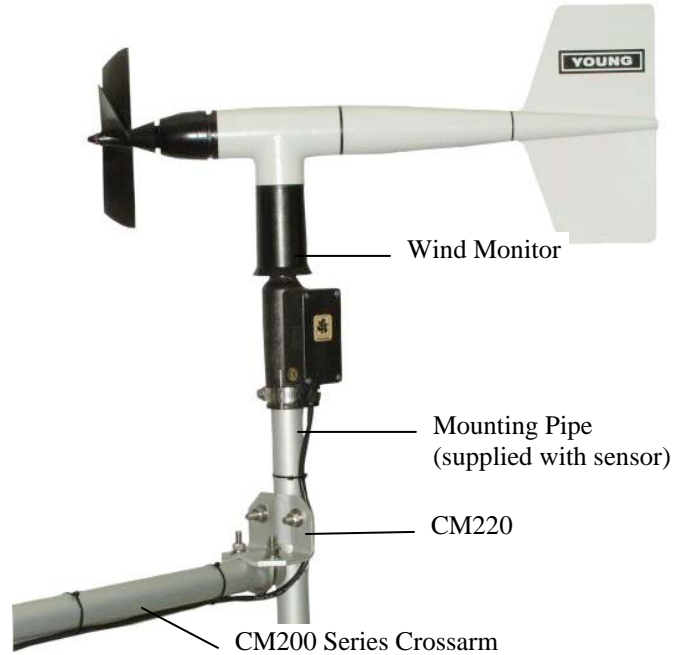


FIGURE 3-3. Wind Monitor Mounted to a CM200 Series Crossarm with CM220 Right Angle Mounting Kit

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 in the wiring diagram created by Short Cut.

TABLE 4-1. Connections to Campbell Scientific Dataloggers					
Color	Description	CR800 CR5000 CR3000 CR1000	CR510 CR500 CR10(X)	21X, CR7 CR23X	CR200
Red	Wind Spd. Signal	Pulse	Pulse	Pulse	P_LL
Black	Wind Spd. Reference	⊕	G	⊕	⊕
Green	Wind Dir. Signal	SE Analog	SE Analog	SE Analog	SE Analog
Blue	Wind Dir. Excitation	Excitation	Excitation	Excitation	Excitation
White	Wind Dir. Reference	⊕	AG	⊕	⊕
Clear	Shield wire	⊕	G	⊕	⊕

5. Example Programs

This section is for users who write their own 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.

5.1 Wind Speed

Wind speed is measured with the Pulse Count instruction, and with the low level AC configuration. For dataloggers programmed with Edlog, specify configuration code 21 to output frequency in Hertz.

The expression for wind speed (U) is:

$$U = MX + B$$

where

M = multiplier

X = number of pulses per second (Hertz)

B = offset

Table 5-1 lists the multipliers to obtain miles/hour or meters/second when the Pulse Count instruction is configured to output Hz (configuration code 21). The helicoid propeller has a calibration that passes through zero, so the offset is zero (Gill, 1973; Baynton, 1976).

TABLE 5-1. Wind Speed Multiplier (With Configuration Code 21*)		
Model	Miles/Hour Output	Meters/Second Output
05103 or 05106	0.2192	0.0980
05305	0.2290	0.1024
*When configuration code 11 is used, the multiplier above is divided by the execution interval in seconds.		

5.2 Wind Direction

The wind vane is coupled to a 10K potentiometer, which has a 5 degree electrical dead band between 355 and 360 degrees.

The EX-DEL_SE measurement instruction is used for dataloggers that are programmed with Edlog (e.g. CR10X, CR23X) and the CR200. The measurement result is mV; the multiplier to convert mV to degrees is 355deg/excitation mV.

The BRHalf measurement instruction is used for dataloggers that are programmed with CRBasic (e.g. CR1000, CR3000). The multiplier to convert the measurement result (mV/excitation mV) to degrees is 355.

The excitation voltage, range codes, and multipliers for the different datalogger types are listed in Table 5-2. Appendix B has additional information on the P4 and BRHalf measurement instructions.

	CR10(X), CR510, CR200	CR7, 21X, CR23X	CR800 CR1000	CR5000, CR3000
Measurement Range	2500 mV, slow	5000 mV, slow/60 Hz	2500 mV, 60 Hz, reverse excitation	5000 mV, 60 Hz, reverse excitation
Excitation Voltage	2500 mV	5000 mV	2500 mV	5000 mV
Multiplier	0.142	0.071	355	355
Offset	0	0	0	0

5.3 Wind Vector Processing Instruction

The Wind Vector output instruction is used to process and store mean wind speed, unit vector mean wind direction, and Standard Deviation of the wind direction (optional) using the measured wind speed and direction samples.

5.4 Example Programs

The following programs measure the Wind Monitor 05103 every 5 seconds, and store mean wind speed, unit vector mean direction, and standard deviation of the direction every 60 minutes. Wiring for the examples is given in Table 5-3.

Color	Description	CR1000	CR10X
Red	Wind Spd. Signal	P1	P1
Black	Wind Spd. Reference	$\underline{\underline{\text{G}}}$	G
Green	Wind Dir. Signal	SE 1	SE 1
Blue	Wind Dir. Excitation	EX 1	E1
White	Wind Dir. Reference	$\underline{\underline{\text{G}}}$	AG
Clear	Shield wire	$\underline{\underline{\text{G}}}$	G

5.4.1 CR1000 Example Program

```
'CR1000
'Declare Variables and Units
Public Batt_Volt
Public WS_ms
Public WindDir

Units Batt_Volt=Volts
Units WS_ms=meters/second
Units WindDir=Degrees

'Define Data Tables
DataTable(Table1,True,-1)
    DataInterval(0,60,Min,10)
    WindVector (1,WS_ms,WindDir,FP2,False,0,0,0)
    FieldNames("WS_ms_S_WVT,WindDir_D1_WVT,WindDir_SD1_WVT")
EndTable

'Main Program
BeginProg
    Scan(5,Sec,1,0)
        'Default Datalogger Battery Voltage measurement Batt_Volt:
        Battery(Batt_Volt)
        '05103 Wind Speed & Direction Sensor measurements WS_ms and WindDir:
        PulseCount(WS_ms,1,1,1,1,0.098,0)
        BrHalf(WindDir,1,mV2500,1,1,1,2500,True,0,_60Hz,355,0) ' mV5000
        'range, 5000 mV excitation for CR3000 and CR5000 dataloggers

        If WindDir>=360 Then WindDir=0
        'Call Data Tables and Store Data
        CallTable(Table1)
    NextScan
EndProg
```

5.4.2 CR10X Example Program

```
:{CR10X}
*Table 1 Program
    01: 5.0000      Execution Interval (seconds)

1: Pulse (P3)
    1: 1           Reps
    2: 1           Pulse Channel 1
    3: 21          Low Level AC, Output Hz
    4: 3           Loc [ WS_ms   ]
    5: 0.098       Multiplier
    6: 0           Offset
```

```

2: Excite-Delay (SE) (P4)
  1: 1      Reps
  2: 5      2500 mV Slow Range ; 5000 mV(slow/60 hz) Range for CR23X, 21X, CR7
  3: 1      SE Channel
  4: 1      Excite all reps w/Exchan 1
  5: 2      Delay (0.01 sec units)
  6: 2500   mV Excitation ; 5000 mV for CR23X, 21X, CR7
  7: 4      Loc [ WindDir ]
  8: 0.142  Multiplier ; 0.071 for CR23X, 21X, CR7
  9: 0      Offset

3: If (X<=>F) (P89)
  1: 4      X Loc [ WindDir ]
  2: 3      >=
  3: 360    F
  4: 30     Then Do

4: Z=F x 10^n (P30)
  1: 0      F
  2: 0      n, Exponent of 10
  3: 4      Z Loc [ WindDir ]

5: End (P95)

6: 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)

7: Set Active Storage Area (P80)
  1: 1      Final Storage Area 1
  2: 101    Array ID

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

9: Wind Vector (P69)
  1: 1      Reps
  2: 0      Samples per Sub-Interval
  3: 0      S, theta(1), sigma(theta(1)) with polar sensor
  4: 3      Wind Speed/East Loc [ WS_ms ]
  5: 4      Wind Direction/North Loc [ WindDir ]

```

5.5 Long Lead Lengths

When sensor lead length exceeds 100 feet, the settling time allowed for the measurement of the vane should be increased to 20 milliseconds.

For dataloggers programmed with Edlog (and the CR200), the EX-DEL-SE (P4) measurement instruction should be used. Enter a 2 in the P4 “Delay” parameter for a 20 millisecond delay.

For dataloggers programmed with CRBasic, increase the “Settling Time” parameter of the BRHalf instruction to 20 milliseconds (20,000 microseconds).

CAUTION

The 60 Hz rejection option can not be used with the DC Half Bridge instruction, when the delay is not zero. Do not use long lead lengths in electrically noisy environments.

6. Sensor Maintenance

Every month do a visual/audio inspection of the anemometer at low wind speeds. Verify that the propeller and wind vane bearing rotate freely. Inspect the sensor for physical damage.

Replace the anemometer bearings when they become noisy, or the wind speed threshold increases above an acceptable level. The condition of the bearings can be checked with a paper clip as described in the R.M. Young manual.

The potentiometer has a life expectancy of fifty million revolutions. As it becomes worn, the element can produce noisy signals or become non-linear. Replace the potentiometer when the noise or non-linearity becomes unacceptable.

Contact Campbell Scientific for a Return Materials Authorization (RMA) number at (435) 753-2342.

7. Troubleshooting

7.1 Wind Direction

Symptom: -9999 or no change in direction

1. Check that the sensor is wired to the Excitation and Single-Ended channel specified by the measurement instruction.
2. Verify that the excitation voltage and Range code are correct for the datalogger type.
3. Disconnect the sensor from the datalogger and use an ohm meter to check the potentiometer. Resistance should be about 10K ohms between the Blue and White wires. The resistance between either the Blue/Green or White/Green wires should vary between about 1K to 11K depending on vane position. Resistance when the vane is in the 5 degree dead band should be about 1M ohm.

Symptom: Incorrect wind direction

1. Verify that the Excitation voltage, Range code, multiplier and offset parameters are correct for the datalogger type.
2. Check orientation of sensor as described in Section 3.

7.2 Wind Speed

Symptom: No wind speed

1. Check that the sensor is wired to the Pulse channel specified by the Pulse count instruction.
2. Disconnect the sensor from the datalogger and use an ohm meter to check the coil. The resistance between the red and black wires should be about 2075 ohms. Infinite resistance indicates an open coil; low resistance indicates a shorted coil.
3. Verify that the Configuration Code, and Multiplier and Offset parameters for the Pulse Count instruction are correct for the datalogger type.

Symptom: Wind speed does not change

1. For the dataloggers that are programmed with Edlog, the input location for wind speed is not updated if the datalogger is getting "Program Table Overruns". Increase the execution interval (scan rate) to prevent overruns.

8. References

Gill, G.C., 1973: The Helicoid Anemometer Atmosphere, II, 145-155.

Baynton, H.W., 1976: Errors in Wind Run Estimates from Rotational Anemometers Bul. Am. Met. Soc., vol. 57, No. 9, 1127-1130.

The following references give detailed information on siting wind speed and wind direction sensors.

EPA, 1989: *Quality Assurance Handbook for Air Pollution Measurements System*, Office of Research and Development, Research Triangle Park, NC, 27711.

EPA, 1987: *On-Site Meteorological Program Guidance for Regulatory Modeling Applications*, EPA-450/4-87-013, Office of Air Quality Planning and Standards, Research Triangle Park, NC 27711.

The State Climatologist, 1985: *Publication of the American Association of State Climatologists: Height and Exposure Standards*, for Sensors on Automated Weather Stations, vol. 9, No. 4.

WMO, 1983: *Guide to Meteorological Instruments and Methods of Observation*, World Meteorological Organization, No. 8, 5th edition, Geneva, Switzerland.

Appendix A. Wind Direction Sensor Orientation

A.1 Determining True North and Sensor Orientation

Orientation of the wind direction sensor is done after the datalogger has been programmed, and the location of True North has been determined. True North is usually found by reading a magnetic compass and applying the correction for magnetic declination; where magnetic declination is the number of degrees between True North and Magnetic North. Magnetic declination for a specific site can be obtained from a USGS map, local airport, or through a computer service offered by the USGS at www.ngdc.noaa.gov/seg/geomag/. A general map showing magnetic declination for the contiguous United States is shown in Figure A-1.

Declination angles east of True North are considered negative, and are subtracted from 0 degrees to get True North as shown Figure A-2. Declination angles west of True North are considered positive, and are added to 0 degrees to get True North as shown in Figure A-3. For example, the declination for Logan, Utah is 14° East. True North is $360^\circ - 14^\circ$, or 346° as read on a compass.

Orientation is most easily done with two people, one to aim and adjust the sensor, while the other observes the wind direction displayed by the datalogger.

1. Establish a reference point on the horizon for True North.
2. Sighting down the instrument center line, aim the nose cone, or counterweight at True North. Display the input location or variable for wind direction using a hand-held keyboard display, PC, or palm.
3. Loosen the u-bolt on the CM220 or the set screws on the Nu-Rail that secure the base of the sensor to the crossarm. While holding the vane position, slowly rotate the sensor base until the datalogger indicates 0 degrees. Tighten the set screws.

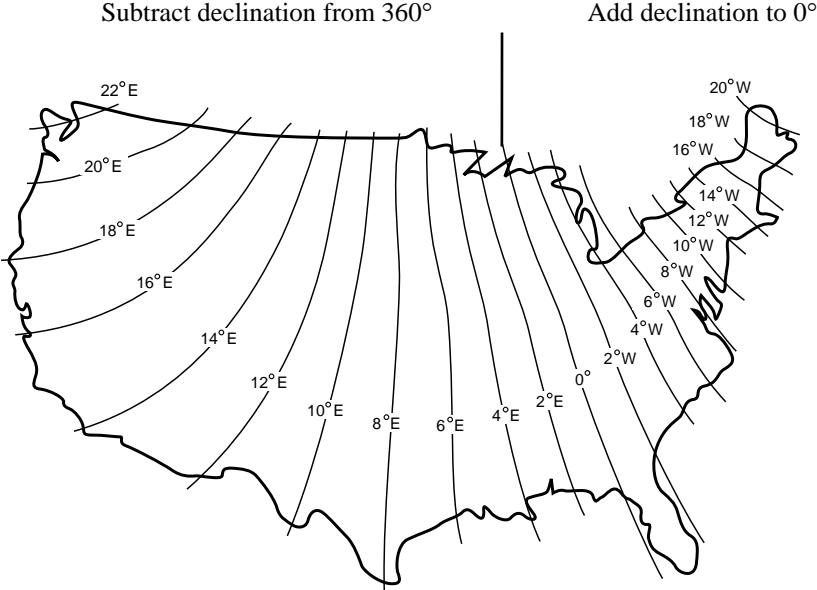


FIGURE A-1. Magnetic Declination for the Contiguous United States

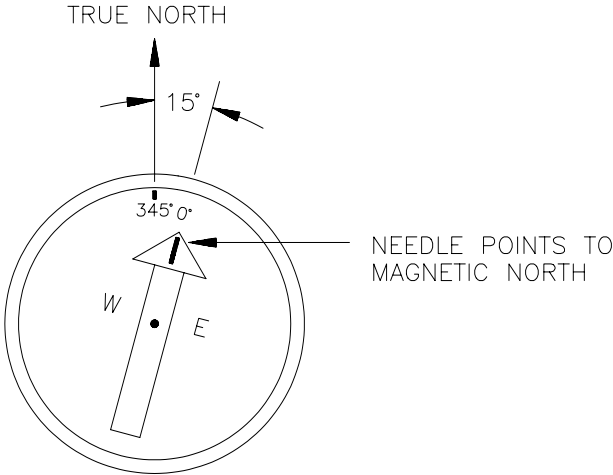


FIGURE A-2. Declination Angles East of True North Are Subtracted From 0 to Get True North

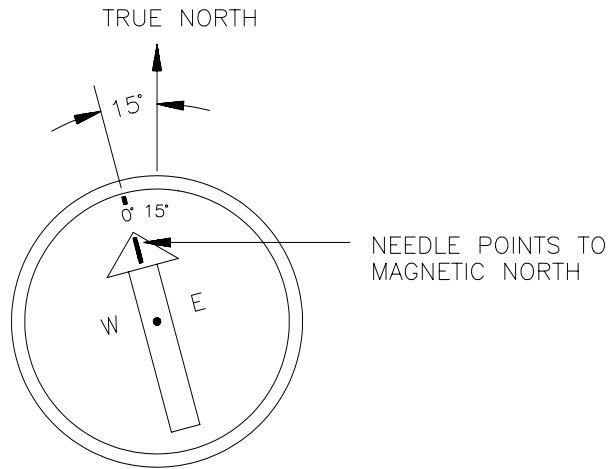


FIGURE A-3. Declination Angles West of True North Are Added to 0 to Get True North

Appendix B. Wind Direction Measurement Theory

It is not necessary to understand the concepts in this section for the general operation of the 05103 with Campbell Scientific's datalogger.

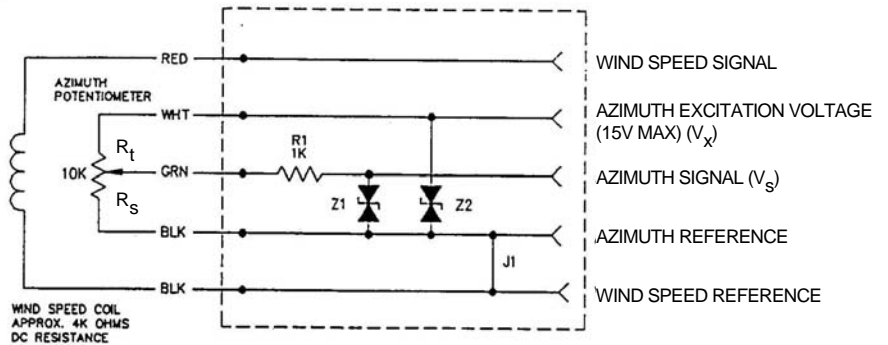


FIGURE B-1. 05103 Potentiometer in a Half Bridge Circuit

B.1 BRHalf Instruction

The BRHalf instruction outputs a precise excitation voltage (V_x), and measures the voltage between the wiper and ground (V_s). The resistance between the wiper and ground, R_s , and V_s varies with wind direction. The measurement result is the ratio of the measured voltage to the excitation voltage (V_s/V_x). This ratio is related to the resistance as shown below:

$$V_s/V_x = R_s / (R_t + R_s)$$

The maximum value that R_s will reach is R_f , just before it crosses over from the west side of north to the east side of north (at this point $R_t = 0$). V_s/V_x reaches its maximum value of 1.0 mV/mV at 355 degrees. The multiplier to convert V_s/V_x to degrees is 355 degrees / 1.0 $V_s/V_x = 355$. Since the datalogger outputs the ratio V_s/V_x , the multiplier is the same for both the CR10(X) and CR3000, even though they use a different excitation voltage. See Section 13.5 in the datalogger manual for more information on the bridge measurements.

B.2 EX-DEL-SE (P4) Instruction

Instruction 4 outputs a precise excitation voltage (V_x) and measures the voltage between the wiper and analog ground, V_s . The resistance between the wiper and analog ground, R_s , and V_s varies with wind direction. Instruction 4 outputs the measured voltage, V_s . This measured voltage is related to resistance as shown below:

$$V_s = V_x \cdot R_s / (R_t + R_s)$$

The maximum value that R_s will reach is R_t just before it crosses over from the west side of north to the east side of north (at this point $R_t = 0$). V_s reaches its maximum value of V_x . This maximum voltage equals 2500 mV for an excitation voltage of 2500 mV recommended for the CR10(X) and 5000 mV for an excitation voltage of 5000 mV recommended for the CR23X at 355 degrees. The multiplier to convert V_s to degrees is $355 \text{ degrees} / 2500 \text{ mV} = 0.142$ for the CR10X, or, $355 \text{ degrees} / 5000 \text{ mV} = 0.071$ for the CR23X. See Section 13.5 in the datalogger manual from more information on the bridge measurements

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