

INSTRUCTION MANUAL



CDM-VW300 Series **Dynamic Vibrating Wire** **VSPECT Analyzers**

Revision: 5/16



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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.ca or by telephoning (780) 454-2505 (Canada). 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 personnel (e.g. 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.
- 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, 6 meters (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 CLIENT 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.

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/in ²) = 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.

About sensor wiring

Please note that certain sensor configurations may require a user supplied jumper wire. It is recommended to review the sensor configuration requirements for your application and supply the jumper wire is necessary.

Table of Contents

PDF viewers: These page numbers refer to the printed version of this document. Use the PDF reader bookmarks tab for links to specific sections.

1. Introduction	1
1.1 Typography	1
1.2 Product Series	1
2. Precautions	1
3. Initial Inspection.....	2
4. Overview	2
4.1 Input Channels	2
4.2 Dynamic Sample Rates	3
4.3 Static Measurement.....	3
4.4 Embedded Thermistor or RTD.....	3
4.5 Rainflow Histograms	4
4.6 Diagnostics.....	4
4.7 Data Use.....	4
5. Specifications.....	4
6. Installation.....	6
6.1 Power Supply Tips	6
6.2 Installation Tips	6
6.3 Bench Test	7
6.3.1 Bench Test Equipment.....	7
6.3.2 Bench Test Procedure	8
6.4 Field Installation	12
6.4.1 Field Installation Equipment.....	12
6.4.2 Field Installation Procedure	13
7. Operation.....	14
7.1 CDM-VW300 Sample Rate	15
7.2 CDM-VW300 Settings.....	15
7.3 CDM-VW300 Outputs.....	18
7.4 Connections.....	19
7.4.1 Sensor Connections.....	19
7.4.2 CPI Connections	20
7.4.2.1 CPI Speed and Cable Length.....	21
7.4.2.2 CPI Network Status	21
7.4.2.3 CPI Network Reset.....	22
7.4.3 Power Connections	22
7.4.4 Ground Connections	23
7.4.5 PC Connection	23
7.5 Analyzer and Channel Numbers	24
7.6 Datalogger Program	24

7.6.1	Program Code	24
7.6.1.1	Pipeline Mode.....	25
7.6.1.2	CDM_VW300Config().....	25
7.6.1.3	Scan().....	25
7.6.1.4	CDM_VW300Dynamic()	26
7.6.1.5	CDM_VW300Static().....	26
7.6.1.6	CDM_VW300RainFlow()	26
7.6.1.7	RainFlowSample().....	26
7.6.1.8	CPISpeed()	26
7.6.1.9	Processing Diagnostic Codes.....	26
7.6.2	Sending Programs to the Datalogger.....	26
7.7	Data Quality	26
7.7.1	Amplitude Warning Flags	27
7.7.2	Diagnostic Codes	27
7.7.2.1	Inside Diagnostic Codes	27
7.7.2.2	Creating the Diagnostic Code Variable Array	28
7.7.2.3	Decoding Excitation Strength.....	29
7.7.2.4	Decoding Warning Flags	30
7.7.3	DVWTool Errors.....	31
7.7.4	Excitation Strength.....	31
7.7.5	Frequency Filters.....	32
7.7.5.1	Harmonics.....	32
7.7.5.2	Estimated-Frequency Range.....	32
7.7.5.3	Actual-Frequency Range	32
7.7.5.4	Matching Estimated and Actual-frequency ranges	33
7.7.6	Frequency Warning Flags	33
7.7.7	Sample Rate and Noise Performance	34
7.7.8	Standard Deviation.....	34
7.8	Operating Systems.....	34
7.9	Power Supplies.....	35
7.9.1	CDM-VW300 Power Supply	35
7.9.2	Field Station Power Supplies	35
7.10	Power-Up Sequence	35
7.11	Sensors	36
7.11.1	Sensor Basic Design Features	36
7.11.2	Basic Measurement of the Sensor	36
7.11.3	Vibrating Wire Length and Tension.....	36
7.11.4	Sensor Output Frequency Range and Maximum Sample Rate ..	37
7.11.5	Sensor Versatility	37
7.11.6	Temperature Sensor	37
7.12	Station Validation.....	38
7.12.1	Monitoring System Performance	38
7.12.2	Status of Input Channels and Sensors	39

8. Troubleshooting.....39

8.1	Connections.....	39
8.2	CPI Network.....	40
8.3	Factory Default Reset.....	40
8.4	Fault Detection	40
8.5	Isolating Components.....	40
8.6	Power.....	40
8.7	Repair	41

9. Glossary.....41

10. References and Attributions41**Appendices****A. Typography A-1****B. VSPECT Measurement Theory B-1**

B.1 Dynamic Vibrating Wire Measurement B-1

C. Vibrating Wire Digits Conversion C-1**D. Calculating Vibrating Wire Measurement Error ... D-1**

D.2 Error Example: Geokon Strain Gage D-1

D.3 Error Example: DGSI Embedment Strain Gage..... D-2

D.4 Error Example: DGSI Spot-Welded Strain Gage..... D-2

D.5 Error Example: Geokon 4420 Crack Meter D-2

D.6 Error Example: DGSI Piezometer 52611099 D-3

E. Measuring Thermistors and RTDs E-1

E.1 Converting RTD Resistance to Temperature E-1

E.2 Converting Thermistor Resistance to Temperature..... E-1

E.2.1 Thermistor Measurement Accuracy and Resolution..... E-2

F. CRBasic Program Examples F-1F.1 20 Hz Measurement Example — One CDM-VW305, Eight
Channels F-2F.2 50 Hz Measurement Example — Three CDM-VW305s, 24
Channels F-3F.3 50 Hz Diagnostic Example — One CDM-VW300, Two Geokon
4000 Sensors with FieldCal() F-5**G. Supplemental Hardware and Software G-1**

G.1 Dataloggers G-1

G.2 Datalogger Support Software..... G-1

G.3 Items Often Sold With the CDM-VW300..... G-1

Figures

4-1. CDM-VW300 Analyzer (Two Channels)3

4-2. CDM-VW305 Analyzer (Eight Channels).....3

6-1. General Schematic of Bench Test Connections7

6-2. Power Connection.....8

6-3. Three-Wire Sensor Connection Schematic (No Embedded
Thermistor).....10

6-4. Five-Wire Sensor Connection Schematic11

6-5. General Schematic of Simple Field Station13

6-6. CPI Terminator Placement.....13

7-1. Three-Wire Sensor Connection Schematic (No Embedded
Temperature Sensor).....19

7-2.	Five-Wire Sensor Connection Schematic.....	20
7-3.	CDM-VW305s in a Daisy-Chain CPI Network	21
7-4.	Open Quad-Connector Gates.....	23
7-5.	Earth Ground Connections	23
7-6.	CRBasic Program Basics.....	25
7-7.	DVWTool Error Indicators	31
7-8.	Relationship of Estimated- and Actual-frequency ranges and Frequency Warning Flags	32
7-9.	Basic Design Features of a Vibrating Wire Sensor	36
C-1.	Geokon Calibration Report	C-2
E-1.	Temperature-induced measurement error on a 1000 foot lead. Wire is 22 AWG, 16 Ω per 1000 feet.	E-3
E-2.	Temperature error offsets at three temperatures as a function of lead length. Wire is 22 AWG, 16 Ω per 1000 feet	E-3

Tables

7-1.	CDM-VW300 Sample Rates and Derivatives	15
7-2.	CDM-VW300 Settings	16
7-3.	CDM-VW300 Outputs	18
7-4.	COMM Status Light.....	22
7-5.	Diagnostic Code Ranges	28
7-6.	Warning Flags, FlagBit, Triggers.....	30
7-7.	Channel Status Lights.....	39
9-1.	Recommended Wire Gage (AWG) Values	41

CDM-VW300 Series Dynamic Vibrating Wire VSPECT Analyzers

1. Introduction

Designed around Campbell Scientific's VSPECT™ measurement technology, the CDM-VW300 and CDM-VW305 Dynamic Vibrating Wire VSPECT Analyzers measure vibrating wire sensors at rates up to 333.3 Hz with high accuracy. You can use an analyzer without a datalogger in a bench test, or one or more analyzers with a CR6 datalogger in a field installation. A single CR6 datalogger supports up to eight analyzers measuring up to 64 vibrating wire sensors.

This manual discusses the use of the CDM-VW300 with the following products, which are sold separately:

- pn 13947, *Wall Charger 12Vdc 800mA Output, 100-240Vac*
- pn 29370, *CPI Network Kit*
- CR6 datalogger
- *LoggerNet* datalogger support software

If you wish to use a different datalogger or other software, see Appendix G, *Supplemental Hardware and Software (p. G-1)*.

1.1 Typography

Appendix A, *Typography (p. A-1)*, defines the typography used in this manual. For example, italics and bold type have special meanings.

1.2 Product Series

When this manual mentions the CDM-VW300, the feature descriptions also apply to the CDM-VW305, unless otherwise noted. Likewise, when CR6 datalogger features are described, descriptions apply to all members of the CR6 datalogger series.

2. Precautions

- CAUTION: The CDM-VW300 uses significantly more power than other Campbell Scientific instruments. Pay attention to the recommendations made in Section 7.9, *Power Supplies (p. 35)*.
- IMPORTANT: Use only firmware and software versions listed in Section 5, *Specifications (p. 4)*.
- IMPORTANT: If your CPI network involves long cable lengths, or if your network requires a star topology, see the technical paper *Designing Physical Network Layouts for the CPI Bus*, which is available at <https://www.campbellsci.com/cdm-vw300>.

- **IMPORTANT:** The following are items you may need that must be purchased separately: pn 13947, *Wall Charger 12Vdc 800mA Output, 100-240Vac* and pn 29370, *CPI Network Kit*. See Appendix G, *Supplemental Hardware and Software (p. G-1)*, for a description of these items.

3. Initial Inspection

- The CDM-VW300 ships with the following:
 - Pn 29389, CDM Parts Kit (1)
 - RESOURCEDVD (1), which includes manuals, *DVWTool* software, and *DevConfig* software.
- Inspect packages and contents for damage immediately. File damage claims with the shipping company.
- Check packaging for product hidden in folds of the cushioning material. Check model numbers, part numbers, product descriptions, and cable lengths against shipping documents. Find model and part numbers on each product. Find cable numbers at cable ends, usually printed on a white label. Contact Campbell Scientific immediately if you received a product that was not ordered, or if a product is missing.

4. Overview

Vibrating wire sensors measure load, tilt, inclination, temperature, pressure, extension, and crack movement. Measurements are stable and accurate, and sensors often survive a long time in harsh conditions. However, the conventional technology has two problems: sensors cannot be measured rapidly and, over a long time, sensor signals, while still present, often become undetectable.

The dynamic VSPECT measurement technology used in the CDM-VW300 overcomes these problems and yields measurements with superior precision and noise immunity.

Section 6, *Installation (p. 6)*, includes simplified procedures that give a good orientation of the equipment and software. There are nuances to the CDM-VW300 that can nullify the validity of measurements, so you should review this entire manual before collecting actionable data.

4.1 Input Channels

The following figures show the two-channel CDM-VW300 and the eight-channel CDM-VW305. Each removable connector has two channels, and each channel measures one vibrating wire sensor and one embedded thermistor or RTD. All channels are measured simultaneously. The CR6 datalogger supports up to eight analyzers of either type to measure up to 64 channels at 20 Hz.

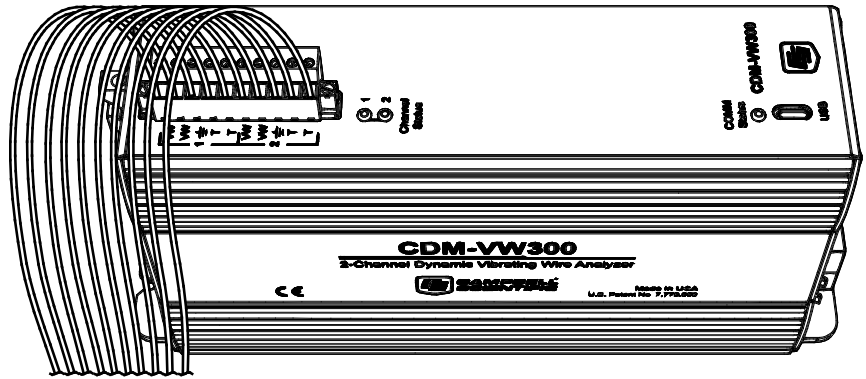


FIGURE 4-1. CDM-VW300 Analyzer (Two Channels)

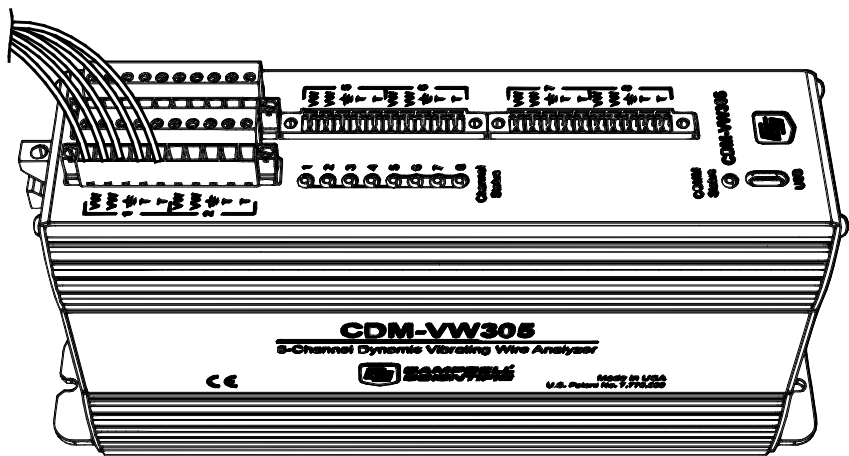


FIGURE 4-2. CDM-VW305 Analyzer (Eight Channels)

4.2 Dynamic Sample Rates

The CDM-VW300 makes dynamic measurements at 20, 50, 100, 200, or 333.3 Hz depending on the resonant frequency. See TABLE 7-1, *CDM-VW300 Sample Rates and Derivatives* (p. 15).

4.3 Static Measurement

As part of the dynamic measurement, the CDM-VW300 makes a static measurement at 1 Hz. The CDM-VW300 uses this measurement to get fine spectral-bin resolution in the dynamic-frequency measurements. The static measurement also helps detect when a noise frequency that is near the resonant frequency is affecting the dynamic measurement.

4.4 Embedded Thermistor or RTD

Vibrating wire sensors often have an embedded thermistor or RTD that measures the temperature of the sensor for compensation of thermal effects on the vibrating wire measurement. The CDM-VW300 measures this sensor at 1 Hz.

4.5 Rainflow Histograms

Fatigue monitoring of large structures often requires rainflow histograms. The CDM-VW300 calculates histograms using the rainflow algorithm developed by Matsuishi and Endo (1968).

4.6 Diagnostics

The following diagnostic data are output with each dynamic measurement. You can use these data to improve measurement quality:

- Excitation level
- Low-frequency and high-frequency warnings
- Low-amplitude and high-amplitude warnings
- Standard deviation

4.7 Data Use

Campbell Scientific does not make recommendations about how to interpret or use vibrating wire data, nor does it endorse the use of any manufacturer's sensors. Examples given in this manual are for educational purposes only. Consult competent and authoritative sources for guidance in selecting sensors and interpreting vibrating wire data.

5. Specifications

Electrical specifications are valid from –25 to 50 °C unless otherwise noted. A non-condensing environment is required. Maintenance of desiccant is recommended. Specifications are subject to change.

VSPECT Technology Patents:

U.S. Patent No. 7,779,690
U.S. Patent No. 8,671,758

Compatibility:

- Full compatibility with CR6 datalogger
- Partial compatibility with CR800, CR1000, and CR3000 dataloggers when using an SC-CPI interface

Software and Firmware Compatibility:

- CDM-VW300 OS 2
- CR6 datalogger OS 2, 3, 4
- *DVWTool* 1.1, 1.2
- *DevConfig* 2.08, 2.09, 2.10, 2.11, 2.12
- *LoggerNet* 4.3, 4.4
- *Windows Vista*, *Windows 7*, *Windows 8.1*.

Dynamic vibrating wire measurement rate:	20, 50, 100, 200, or 333.3 Hz. Depends on resonant frequency, numbers of channels, analyzer models, and datalogger model. See TABLE 7-1, <i>CDM-VW300 Sample Rates and Derivatives</i> (p. 15).
Accuracy:	$\pm(0.005\%$ of reading + effective measurement resolution)
Input resistance:	5 k Ω
Excitation voltage	
Range:	0 to ± 3 V (6 V peak-to-peak)
Resolution:	26 mV
Sensor resonant frequency output range:	See column three of TABLE 7-1, <i>CDM-VW300 Sample Rates and Derivatives</i> (p. 15).
Effective resolution (precision):	0.005 to 0.45 Hz RMS, depending on CDM-VW300 scan rate. See column five of TABLE 7-1, <i>CDM-VW300 Sample Rates and Derivatives</i> (p. 15).
Sustained input voltage without damage:	-0.5 to 7.1 V
Temperature measurement:	Effective 24 bit resistance measurement of thermistor or RTD embedded in the vibrating wire sensor.
Rate:	1 Hz
Accuracy:	0.15 % of reading. Does not include cable resistance error, or thermistor or RTD error.
Resolution:	0.002 Ω RMS @ 5 k Ω
Bridge resistor:	4.99 k Ω 0.1 %
Excitation voltage:	1.5 V
Operating temperature	
Standard:	-25 to 50 $^{\circ}\text{C}$
Extended:	-55 to 85 $^{\circ}\text{C}$
Power requirement	
Voltage:	10 to 32 Vdc
Typical current drain	
CDM-VW300:	115 mA @ 12 Vdc
CDM-VW305:	190 mA @ 12 Vdc

Communications

PC:	USB 2.0 full speed. Does not support data collection.
CR6 Datalogger:	CPI
CPI speed:	Selectable; 50 kbps to 1 Mbps
CPI cable lengths:	Depends on baud rate, number of analyzers, cable quality, noise environment; all other variables being optimum, the total of all cable lengths cannot exceed 2500 ft.
Weight:	< 1 kg (2 lb)
Dimensions:	203 x 127 x 51 mm (8 x 5 x 2 in)
Mounting:	Flanges with one-inch center holes. Compatible with Campbell Scientific enclosure back plates. DIN rail mounting optional (pn 29388, purchased separately).

6. Installation

This section includes procedures for a bench test and for a simplified field installation.

6.1 Power Supply Tips

- While the input power requirements of Campbell Scientific instruments vary, there is one constant – they all run on 12 Vdc. To keep things simple, we only discuss the use of 12 Vdc power supplies in this manual.
- Do not connect live leads to an instrument. All connections discussed assume dead leads, so switch off power supplies before making connections.
- Double check the polarity of connections before switching on power supplies.

6.2 Installation Tips

The bench test procedure should take only a few hours. Field stations are more complex, and the time required to install a field station reflects that complexity. Observe the following:

- Preconfigure and test stations in an indoor location before doing the field installation.
- After installing a field station, wait around long enough to confirm that good measurements are being made, that data are collected to the CR6, and that data from the CR6 can be collected to a PC.

6.3 Bench Test

The primary purpose of this procedure is to get the CDM-VW300 set up to make measurements before connecting it to the CR6 datalogger. This procedure, makes real-time measurements of vibrating wire sensors. It does not store data (storing data requires an attached datalogger). The bench test can be performed in the lab or in the field.

6.3.1 Bench Test Equipment

- Vibrating wire sensor
- CDM-VW300 or CDM-VW305 analyzer
- Power supply (pn 13947, *Wall Charger 12Vdc 800mA Output, 100-240Vac 50-60Hz, 6ft Cable* is used in this procedure)
- USB cable (pn 27555, *Cable Data USB 2.0 Type A Male to Micro B Male, 6/6.5ft* is used in this procedure; part of pn 29370, *CPI Network Kit*)
- PC
- *DVWTool* software

The following figure is a general schematic of bench test connections:

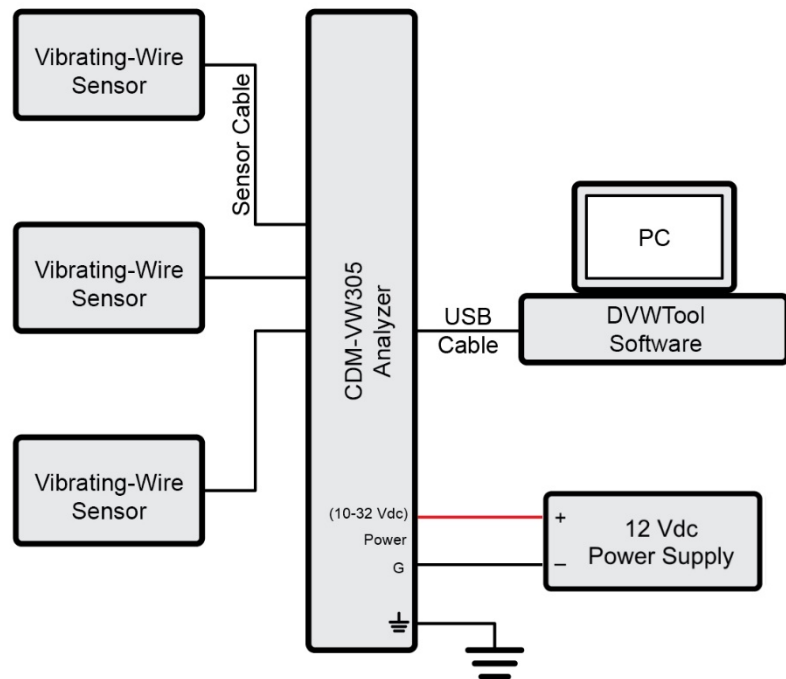


FIGURE 6-1. General Schematic of Bench Test Connections

6.3.2 Bench Test Procedure

1. Install *DVWTool* software on the PC. The *DVWTool* installation also installs USB drivers for the CDM-VW300.
2. Connect the power supply from the preceding equipment list to the CDM-VW300 as shown in FIGURE 6-2, *Power Connection*.

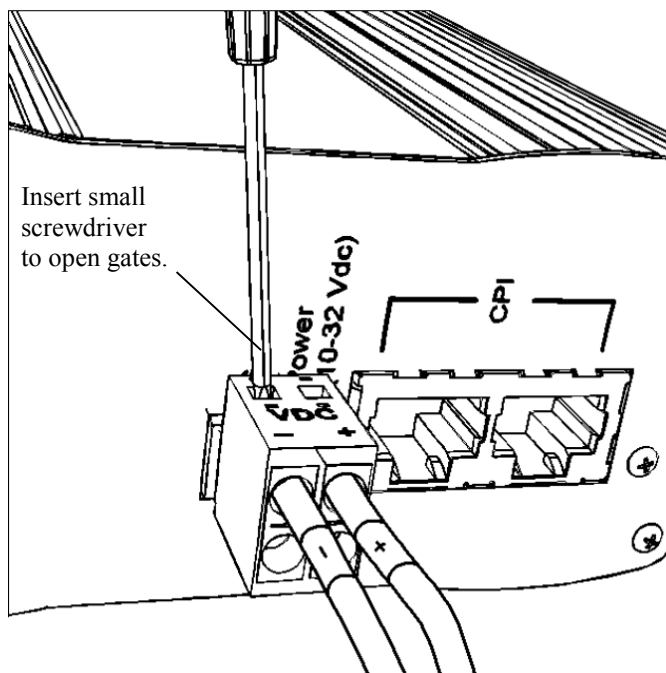
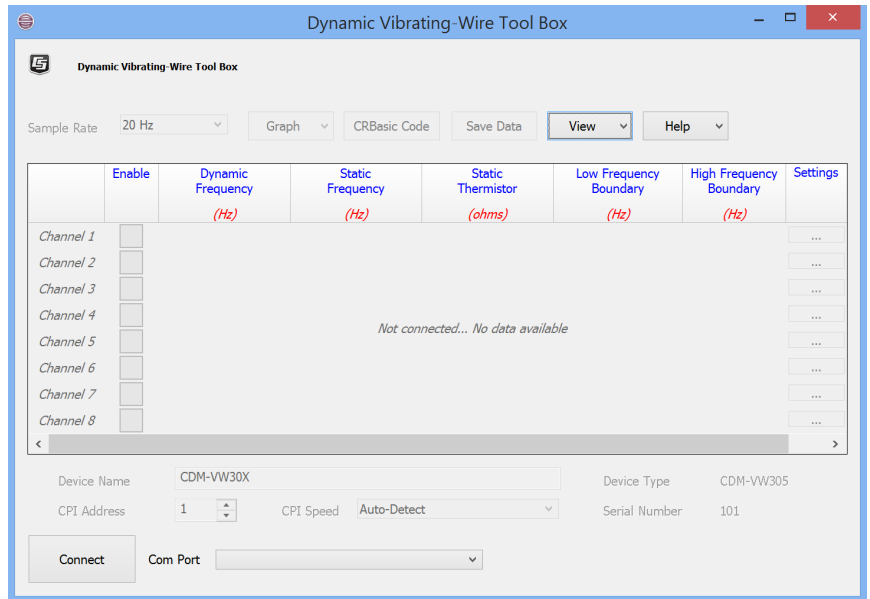


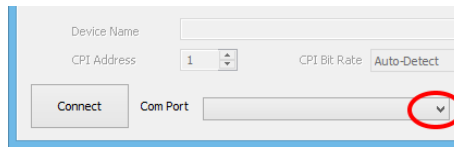
FIGURE 6-2. *Power Connection*

3. Plug in the power supply. The CDM-VW300 **COMM Status** light flashes yellow.
4. Connect the USB cable between a standard PC USB port and the CDM-VW300 **USB** port.

5. Open *DVWTool*. A window similar to the following figure appears:

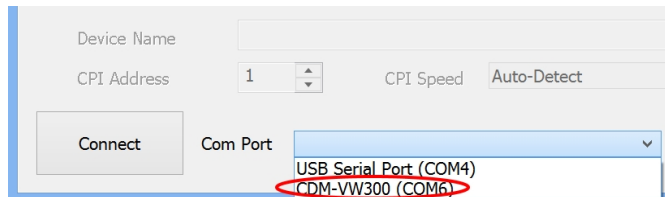


6. Click the **Com Port** list button in the lower-left of the main window.



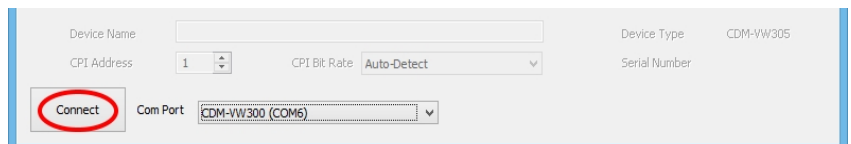
A list of available COM ports appears.

7. In the list of available COM ports, select **CDM-VW300 (COMn)**.



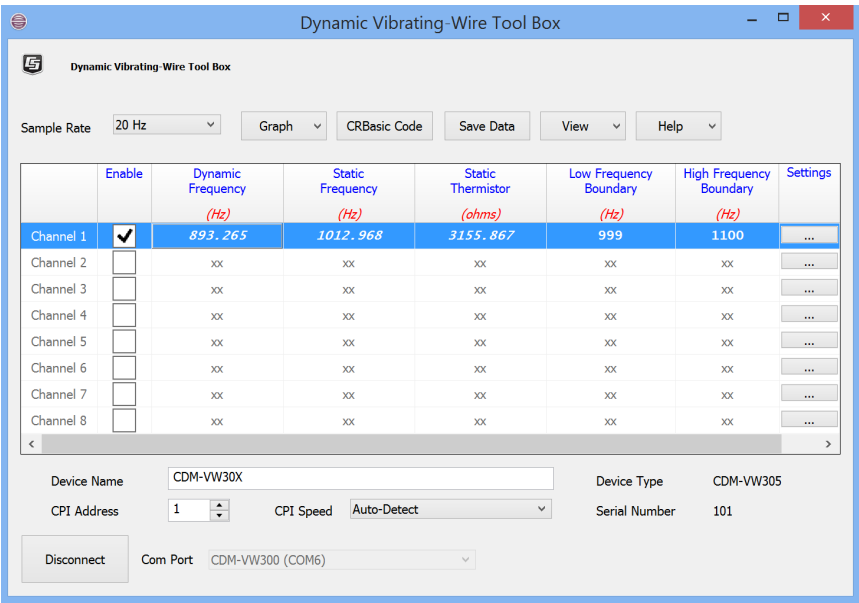
The **Com Port** box displays **CDM-VW300 (COMn)**. Your **COMn** number may differ from that shown.

8. Click **Connect** in lower-left main window.



DVWTool and the CDM-VW300 connect and the button at lower left shows **Disconnect**, as shown in the following figure. **Device Type**, **Serial Number**, **Device Name**, and **CPI address** at lower center are active. Depending on the state in which the CDM-VW300 was last used, channels

may or may not be enabled.



- 9. Uncheck all **Enable** boxes. Fields for all channels display **xx**.
- 10. Before connecting sensors, click **Disconnect** to disconnect *DVWTool* from the CDM-VW300. The **Disconnect** button will change to **Connect**.
- 11. Unplug the power supply. All lights go dark.
- 12. Using the following figures as guides, connect sensors to the CDM-VW300. For further guidance on connecting sensors, see Section 7.4.1, *Sensor Connections* (p. 19).

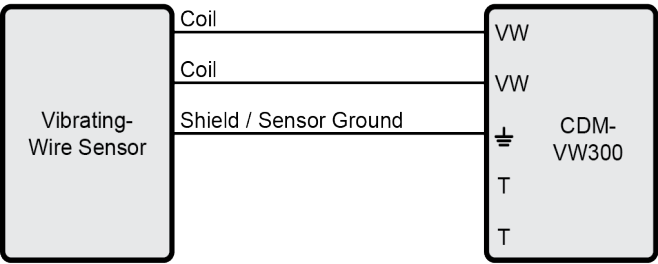


FIGURE 6-3. Three-Wire Sensor Connection Schematic (No Embedded Thermistor)

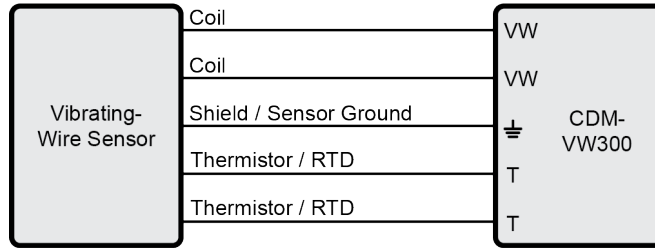
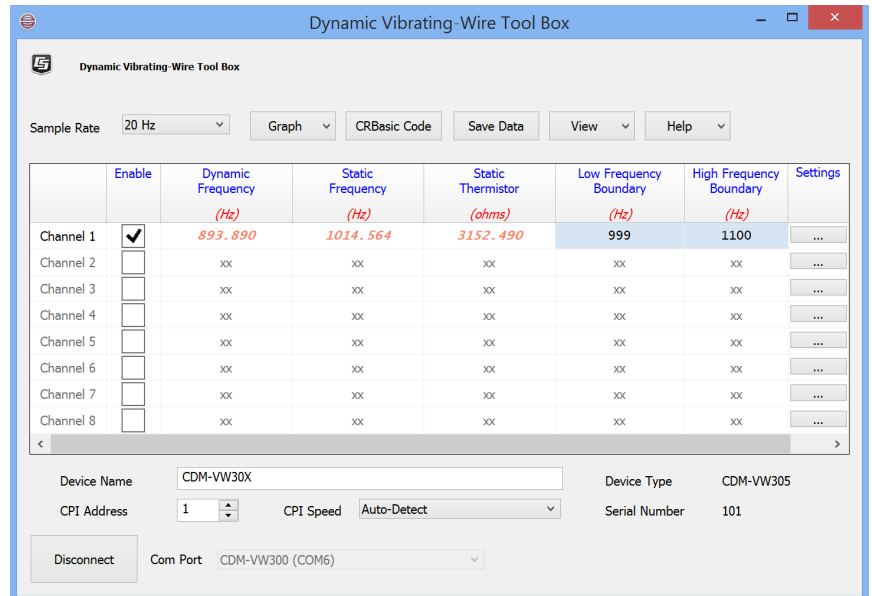


FIGURE 6-4. Five-Wire Sensor Connection Schematic

13. Switch on the power supply. Several lights flash, but after a few seconds things settle down and **Channel Status** lights flash distinct red or green, or yellow, or remain dark. The **COMM Status** light flashes yellow.
14. In the *DVWTool* window, check the **Enable** box for channels to which sensors are connected. If the correct channels are selected, a green **Channel Status** flash indicates the sensor attached to that channel is working. Lights of disabled channels are dark. For other flash combinations, see TABLE 7-7, *Channel Status* (p. 39).

The main *DVWTool* window should now appear similar to the following figure:



- If a sensor does not have a temperature sensing element, the value in the **Static Thermistor** column is negative (**Channel 1**).
- Reasonable values in the **Dynamic Frequency** and **Static Frequency** columns indicate the sensor outputs a vibrating wire signal. Check the values against the manufacturer provided documentation to see if sensor output is within the correct frequency output range.

- The absence of warning and information icons indicates the CDM-VW300 detects no measurement faults. If you see a warning or information icon, see Section 7.7.3, *DVWTool Errors* (p. 31).
15. Work through Section 7.2, *CDM-VW300 Settings* (p. 15), and Section 7.3, *CDM-VW300 Outputs* (p. 18), and make adjustments in *DVWTool* as needed. Settings that commonly need adjustments include sample rate, enabled channels, and frequency boundaries.

6.4 Field Installation

This section discusses installation of a simple CDM-VW300 field station. Unlike the bench test, a field station includes a datalogger to control and collect data from the CDM-VW300. Capacity of the power supply is CRITICAL. CDM-VW300 field stations require continuous ac power or large solar panels and batteries. See Section 7.9, *Power Supplies* (p. 35). When doing a field installation, be prepared to perform the bench test for troubleshooting purposes. If switching back and forth between *DVWTool* and datalogger control, cycle the power after each switch to let the CDM-VW300 adapt to the new connection.

6.4.1 Field Installation Equipment

- Vibrating wire sensor
- CDM-VW300 or CDM-VW305 analyzer
- CR6 datalogger
- Power supply
- PC
- *DVWTool* software
- *LoggerNet* software
- RJ45 cabling
- USB comms link with CR6 for initial setup. Other comms link may be needed for long term monitoring.

The following figure is a general schematic of a simple field station.

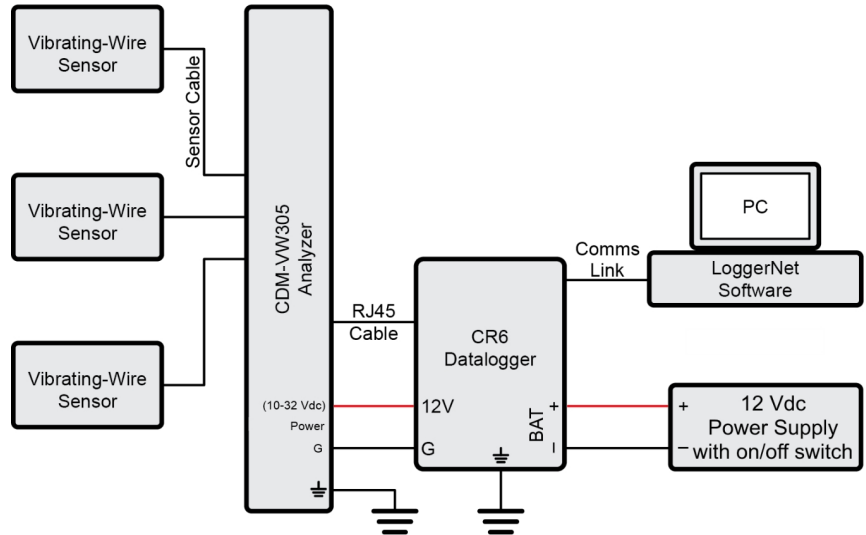


FIGURE 6-5. General Schematic of Simple Field Station

6.4.2 Field Installation Procedure

1. Do Section 6.3.2, *Bench Test Procedure* (p. 8).
2. After the bench test, select **CRBasic Code** in the *DVWTool* main window. A **CRBasic Code** window appears that contains a CRBasic program to be used later in this procedure. Click **Save...** and follow the prompts to save the code as a .CR6 file. Make note of the file name and location.
3. Click **Disconnect** in *DVWTool*. Switch off the power supply.
4. Connect the CR6 **CPI** port to the CDM-VW300 **CPI** port using an RJ45 terminated cat5a cable.
5. As shown in the following figure, place the CPI terminator (supplied in pn 29370, *CPI Network Kit*) in the remaining open **CPI** port.

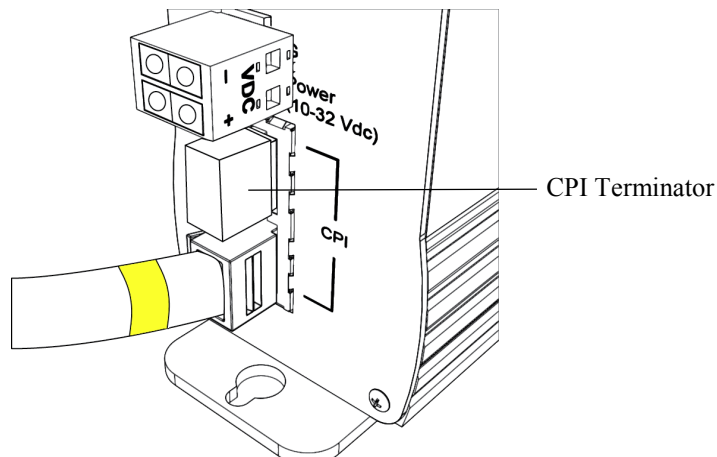


FIGURE 6-6. CPI Terminator Placement

6. Interconnect ground lugs to an Earth ground. Use 14 *AWG* (p. 41) wire or larger. See Section 7.4.4, *Ground Connections* (p. 23).
7. Connect the CR6 to the power supply.
8. Switch on the power supply. During power up, lots of lights flash. After things settle down (5 to 10 seconds), **Channel Status** lights should flash green (because you already performed the bench test procedure). The **COMM Status** light should flash red.
9. Send the CRBasic program created in step 2 using the program **Send** command in *LoggerNet* | **Connect**. With the program loaded, the CPI network becomes active as indicated by a flashing distinct green **COMMS Status** light and flashing green and yellow lights on the CR6 CPI port.
10. Monitor the operation of the system with the a numeric monitor in *LoggerNet* | **Connect** to monitor the following datalogger variables: **Freq**, **Diag**, **StaticFreq**, **Therm**, and **DynStdDev**.

For example, consider a field station that includes a CDM-VW305 analyzer with a sensor connected to input channel **1**. The datalogger **Public** table appears in the numeric monitor similar to the following figure:

RecNum	TimeStamp	StaticFreq(1)	DynStdDev(3)
1136	2016 15:08:18	831.6588	0
		StaticFreq(2)	DynStdDev(4)
		StaticFreq(3)	DynStdDev(5)
		StaticFreq(4)	DynStdDev(6)
		StaticFreq(5)	DynStdDev(7)
		StaticFreq(6)	DynStdDev(8)
		StaticFreq(7)	
		StaticFreq(8)	
		Therm(1)	
		Therm(2)	
		Therm(3)	
		Therm(4)	
		Therm(5)	
		Therm(6)	
		Therm(7)	
		Therm(8)	
		DynStdDev(1)	
		DynStdDev(2)	

Only variables **Freq(1)**, **Diag(1)**, **StaticFreq(1)**, **Therm(1)**, **DynStdDev(1)** have data, indicating channel **1** is active.

See Section 7.12.1, *Monitoring System Performance* (p. 38).

11. Monitoring and verify data in the other data tables in the CR6 datalogger before leaving the field.

7. Operation

This section documents details of CDM-VW300 operation. Major topics are arranged in alphabetical order.

7.1 CDM-VW300 Sample Rate

The sample rate, the rate at which the CDM-VW300 samples the vibrating wire signal, is a key setting from which other CDM-VW300 settings and outputs are derived. Allowed sample rate is a function of the natural-resonant frequency of the sensor. For example, if a strain gage is designed to operate with a frequency between 500 – 1200 Hz, do not sample it faster than 50 Hz.

The following table lists the five available sample rates and their derivatives. This table is referenced throughout this manual.

TABLE 7-1. CDM-VW300 Sample Rates and Derivatives

Allowed Sample Rate (Hz) ¹	CR6 Scan() Interval (mSec)	Allowed Sensor Output Range (Hz) ²	Allowed Sensor Output Range Boundary Resolution	Noise Level (Hz RMS) ³	Maximum Supported Channels ⁴	Maximum CDM-VW305s ⁵
1				0.005		
20	50	290 – 6000	47.68	0.008	64	8
50	20	290 – 6000	95.37	0.015	32	4
100	10	580 – 6000	190.73	0.035	24	3
200	5	1150 – 6000	381.47	0.11	24	3
333.3	3	2300 – 6000	762.94	0.45	16	2

¹ Rates include the time needed to write data to a memory card. They do not include time needed to measure sensors outside the CDM-VW300 network. The fastest that a vibrating wire gage can be measured is approximately 20 percent of the resonant frequency.

² Find the output range of a sensor in the documentation sent by the manufacturer.

³ Usual values for a 2500 Hz resonant sensor

⁴ Specifications are subject to installation factors such as CPI bus speed, CPI cable length, and unrelated demands on the datalogger. As testing continues on system setups using the CR6 datalogger, the specified module and channel limits may increase.

⁵ CDM-VW305 has eight channels.

7.2 CDM-VW300 Settings

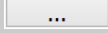
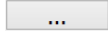
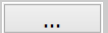
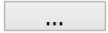
Settings configure the CDM-VW300. Use *DVWTool* software to edit and apply settings.

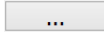
NOTE

The CR6 datalogger re-configures the CDM-VW300 when it is connected regardless of what was done in *DVWTool*. The way to get *DVWTool* settings to “stick” is to do the configuration in *DVWTool*, then have *DVWTool* write the datalogger program (**CRBasic Code** button), then load that program into the CR6.

The following table summarizes CDM-VW300 settings and how to access them in *DVWTool* and *CRBasic Editor*.

TABLE 7-2. CDM-VW300 Settings

Setting (alphabetically)	Definition	DVWTool Location, Options/Range	CRBasic Editor Instruction, Parameter (Arguments)
Channel Enable	Activates a CDM-VW300 input channel	<ul style="list-style-type: none"> Main window, left Enable column check box 	<ul style="list-style-type: none"> CDM_VW300Config() ChanEnable (0 or 1)
CPI Address	Address of CDM-VW300 on the CPI network	<ul style="list-style-type: none"> Main window, lower left 1 to 120 	<ul style="list-style-type: none"> CDM_VW300Config() CPIAddress (1 to 120)
CPI Speed	Rate of CDM-VW300 CPI network communications. Default is usually OK.	<ul style="list-style-type: none"> Main window, lower center Auto-Detect, 50, 125, 250, 500, 1000 (kbps) 	<ul style="list-style-type: none"> CPISpeed() BitRate (50, 125, 250, 500, and 1000 kbps) Usually optional. Default is 250 if CPISpeed() not in program.
Device Name	Optional CDM-VW300 alphanumeric name. Used only by <i>DVWTool</i> .	<ul style="list-style-type: none"> Main window, lower left Optional – used only by <i>DVWTool</i> 	n/a
Device Type	Identifies to CRBasic if the analyzer is a CDM-VW300 (type 0) or a CDM-VW305 (type 1). Type is automatically detected by <i>DVWTool</i>	<ul style="list-style-type: none"> Main window Auto detected 	<ul style="list-style-type: none"> CDM_VW300Config() DeviceType (0 or 1)
DVWTool Update Rate	<i>DVWTool</i> data display rate. Default is usually OK.	<ul style="list-style-type: none"> Click View Advanced Main window, lower right 	n/a
High-Frequency Boundary	Upper boundary of the operator-determined range of valid frequencies. See Section 7.7.2, <i>Diagnostic Codes</i> (p. 27).	<ul style="list-style-type: none"> Click Settings  Range: 290 to 6000 Hz View/set in main window 	<ul style="list-style-type: none"> CDM_VW300Config() HighFreq (290 to 6000 Hz)
Low-Frequency Boundary	Lower boundary of the operator-determined range of valid frequencies. See Section 7.7.2, <i>Diagnostic Codes</i> (p. 27).	<ul style="list-style-type: none"> Click Settings  Range: 290 to 6000 Hz View/set in main window 	<ul style="list-style-type: none"> CDM_VW300Config() LowFreq (290 to 6000 Hz)
Multiplier	Slope or gain applied to the raw measurement. See Appendix C, <i>Vibrating Wire Digits Conversion</i> (p. C-1), and Appendix D, <i>Calculating Vibrating Wire Measurement Error</i> (p. D-1).	<ul style="list-style-type: none"> Click Settings  Click View Frequency Conversion to view/set in main window 	<ul style="list-style-type: none"> CDM_VW300Config() Mult
Offset	Offset or y-intercept applied to the raw measurement. See Appendix C, <i>Vibrating Wire Digits Conversion</i> (p. C-1), and Appendix D, <i>Calculating Vibrating Wire Measurement Error</i> (p. D-1).	<ul style="list-style-type: none"> Click Settings  Click View Frequency Conversion to view/set in main window 	<ul style="list-style-type: none"> CDM_VW300Config() Offset



Setting (alphabetically)	Definition	DVWTool Location, Options/Range	CRBasic Editor Instruction, Parameter (Arguments)
Output Format	Sets the units for the output data.	<ul style="list-style-type: none"> Click Settings  Options: Hz, Hz², Digits, Scaled Hz, or Scaled Hz² Click View Frequency Conversion to view/set in main window 	<ul style="list-style-type: none"> CDM_VW300Config() ChanOptions (Hz, Hz²)
Rainflow Form	Sets form of output for a rainflow histogram. Click field then F1 for guidance.	<ul style="list-style-type: none"> Click Graph Rainflow Histogram Channel n Click lists then F1 for guidance. 	<ul style="list-style-type: none"> CDM_VW300Config() RF_Form
Rainflow High Limit	High limit in a rainflow histogram. Click field then F1 for guidance.	<ul style="list-style-type: none"> Click Graph Rainflow Histogram Channel n Click field then F1 for guidance. 	<ul style="list-style-type: none"> CDM_VW300Config() RF_HighLim
Rainflow Low Limit	Low limit in a rainflow histogram. Click field then F1 for guidance.	<ul style="list-style-type: none"> Click Graph Rainflow Histogram Channel n Click field then F1 for guidance. 	<ul style="list-style-type: none"> CDM_VW300Config() RF_LowLim
Rainflow Minimum Change	Minimum change in a rainflow histogram. Click field then F1 for guidance.	<ul style="list-style-type: none"> Click Graph Rainflow Histogram Channel n Click field then F1 for guidance. 	<ul style="list-style-type: none"> CDM_VW300Config() RF_Hyst
Rainflow Number of Amp Bins	Number of amplitude bins in a rainflow histogram. Click field then F1 for guidance.	<ul style="list-style-type: none"> Click Graph Rainflow Histogram Channel n Click field then F1 for guidance. 	<ul style="list-style-type: none"> CDM_VW300Config() RF_AmpBins
Rainflow Number of Mean Bins	Number of mean bins in a rainflow histogram.	<ul style="list-style-type: none"> Click Graph Rainflow Histogram Channel n Click field then F1 for guidance. 	<ul style="list-style-type: none"> CDM_VW300Config() RF_MeanBins
Resonant Amplitude	Amplitude target. CDM-VW300 automatically adjusts the vibrating wire excitation to maintain the target. Default (2 mV or 0.002 V) is usually OK	<ul style="list-style-type: none"> Click Settings  Range: 1 to 10 mV View Advanced to view/set 	<ul style="list-style-type: none"> CDM_VW300Config() ResonAmp (0.001 to 0.010 V)
Sample Rate	Rate at which the CDM-VW300 samples vibrating wire resonant frequencies. Sample rate determines the range of frequencies that can be measured as listed in the third column of TABLE 7-1, <i>CDM-VW300 Sample Rates and Derivatives</i> (p. 15).	<ul style="list-style-type: none"> Main window upper left Options: 20, 50, 100, 200, 333.3 (Hz) 	<ul style="list-style-type: none"> Scan() Interval (50, 20, 10, 5, 3) Units (mSec)
Steinhart-Hart Thermistor Coefficient A, B, C	Thermistor coefficients. See Appendix E, <i>Measuring Thermistors and RTDs</i> (p. E-1).	<ul style="list-style-type: none"> Click Settings  View Temperature Conversion to view/set 	<ul style="list-style-type: none"> CDM_VW300Config() SteinA, SteinB, SteinC

Setting (alphabetically)	Definition	DVWTool Location, Options/Range	CRBasic Editor Instruction, Parameter (Arguments)
System options	Determines if a numeric value or NAN is stored in datalogger memory when a warning flag is raised, and whether or not diagnostic lights are active. See <i>CRBasic Editor Help</i> topic CDM_VW300Config() SysOptions and TABLE 7-7, <i>Channel Status</i> (p. 39).	n/a	<ul style="list-style-type: none"> • CDM_VW300Config() • SysOptions (0, 1, 10, 11)

7.3 CDM-VW300 Outputs

The following table summarizes CDM-VW300 outputs in *DVWTool* and *CRBasic Editor*.

TABLE 7-3. CDM-VW300 Outputs

Output	Definition	DVWTool Location, Options	CRBasic Editor Instruction, Output Variable Parameter
Actual Low Frequency	Low-frequency boundary set by the CDM-VW300 based on the operator-entered <i>low-frequency boundary</i> (p. 16) and the results of measurements.	View Advanced then main screen	n/a
Actual High Frequency	High-frequency boundary set by the CDM-VW300 based on the operator-entered <i>high-frequency boundary</i> (p. 16) and the results of measurements.	View Advanced then main screen	n/a
Diagnostic Code	Diagnostic code includes: <ul style="list-style-type: none"> • Excitation strength • Low-amplitude flag • High-amplitude flag • Low-frequency flag • High-frequency flag 	Click ephemeral information icon  in Channel column and ephemeral warning icon  in column of affected setting or output.	<ul style="list-style-type: none"> • CDM_VW300Dynamic() • DestDiag
Dynamic Output	Dynamic resonant output of the vibrating wire sensor.	Main screen	<ul style="list-style-type: none"> • CDM_VW300Dynamic() • DestFreq
Excitation Strength	Voltage of the vibrating wire excitation expressed in bits $2^0 - 2^7$ of the diagnostic code	View Advanced then main screen	n/a
OS Date	Date the operating system was released	Help About	n/a
OS Version	Version of the CDM-VW300 operating system	Help About	n/a
Serial Number	Serial number of the CDM-VW300	Main screen lower center	n/a

Std Dev of Dyn Freq	Standard deviation of the dynamic output computed on one-second data and output at 1 Hz.	View Advanced then main screen	<ul style="list-style-type: none"> • CDM_VW300Static() • DestStdDev
Static Output	Static resonant output of the vibrating wire sensor.	Main screen	<ul style="list-style-type: none"> • CDM_VW300Static() • DestFreq
Static Thermistor	Temperature of the thermistor or resistance of the thermistor or RTD that is embedded in the vibrating wire sensor. See <i>Steinhart-Hart Thermistor Coefficient A, B, and C</i> .	Main screen	<ul style="list-style-type: none"> • CDM_VW300Static() • DestTherm

7.4 Connections

7.4.1 Sensor Connections

Vibrating wire sensors have either a three- or five-wire configuration. The five-wire configuration includes a thermistor or RTD embedded in the body of the sensor. Refer to the sensor documentation provided by the manufacture to confirm the function of each lead.

As shown in FIGURE 7-1, *Three-Wire Sensor Connection Schematic*, three-wire sensors have two leads that bridge the sensor coil to the two **VW** terminals on the input channel. The **VW** terminals have no polarity. The third lead is a cable shield that bridges the sensor ground to the \perp terminal.

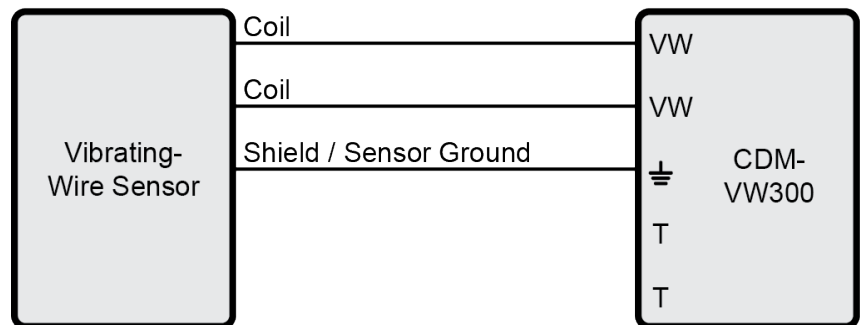


FIGURE 7-1. *Three-Wire Sensor Connection Schematic (No Embedded Temperature Sensor)*

Temperature changes in the body of a vibrating wire sensor can cause measurement errors. The embedded thermistor or RTD in a five-wire sensor measures temperature change so that a compensation algorithm can be applied to the output data.

As shown in FIGURE 7-2, *Five-Wire Sensor Connection Schematic*, five-wire sensors have two additional leads that bridge the embedded thermistor or RTD to the two **T** terminals on the input channel. **T** terminals have no polarity.

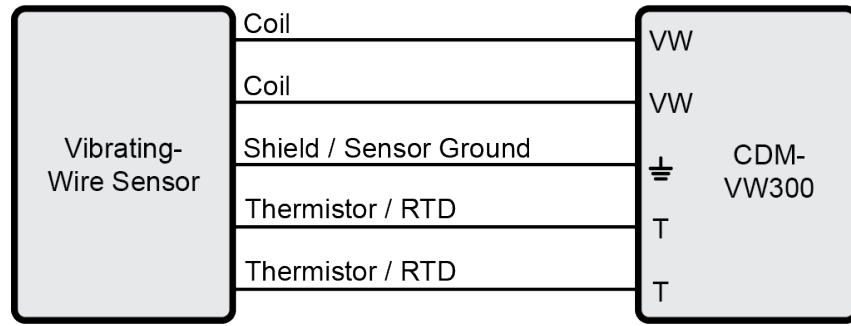


FIGURE 7-2. Five-Wire Sensor Connection Schematic

7.4.2 CPI Connections

NOTE

The CPI technology that networks multiple CDM-VW300s to the CR6 datalogger allows for two topologies: daisy-chain and star. This manual only discusses the use of the daisy-chain topology with short cable runs. If your network requires a star topology or requires long cable runs, see the technical paper *Designing Physical Network Layouts for the CPI Bus*, which is available at <https://www.campbellsci.com/cdm-vw300>. Cable runs of more than a few feet may require a CPI terminator, which is an additional item that must be purchased as a component in pn 29370, *CPI Network Kit*.

A CDM-VW300 CPI daisy-chain network consists of one datalogger plus up to eight CDM-VW300s or 305s. Connect the CDM-VW300 **CPI** port to the datalogger **CPI** port using a RJ45 terminated Cat5e cable, such as those commonly used in Ethernet applications. As shown in the following figure, connect subsequent analyzers to each other using the same type of cable.

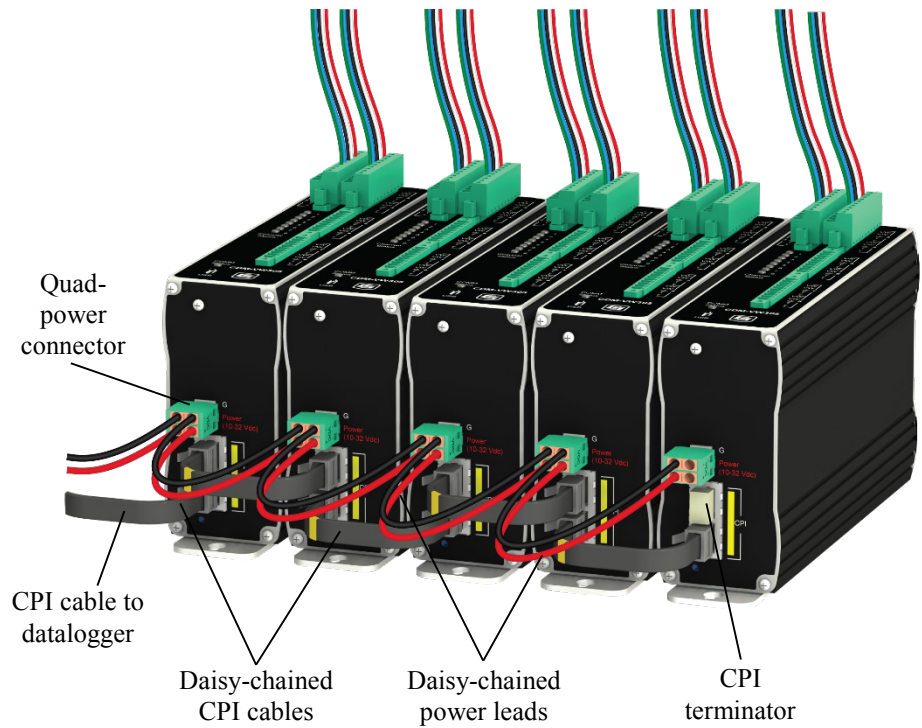


FIGURE 7-3. CDM-VW305s in a Daisy-Chain CPI Network

7.4.2.1 CPI Speed

For most applications, use the default CDM-VW300 CPI speed setting of **Auto Detect**¹. You must use **AutoDetect** if you include the **CPISpeed()** instruction in the datalogger CRBasic program.

7.4.2.2 CPI Network Status

The **COMM Status** light indicates CPI network status. The following table summarizes the information communicated by the **COMM Status** light:

TABLE 7-4. COMM Status Light

Light Color / State	CPI Communications Status
Regular cycle of green and red flashes	Too many channels or analyzers for the configuration. As confirmation, check: <ul style="list-style-type: none"> • CR6 Status.SkippedScan field. Numerous skipped scans indicate an overloaded system. • CR6 CPIStatus table. Sometimes you can see the CPI network load slowly increasing.
Green and red flashes	CPI network initializing
Red flash	<ul style="list-style-type: none"> • Power lost to CPI network, but CDM-VW300 is still powered • CPI speed mismatch
Yellow ¹ flash	Power connected but CDM-VW300 not connected to CPI network.
Green flash	Network is set up and running and the CDM-VW300 is communicating with it

¹ Depending on the view angle, the yellow light may have hints of green or red.

The **CPITable** in the CR6 (active only when connected to a CPI network) has the following details about the CPI network:

- CPI communication
- CPI load
- CPI frame errors
- CPI network information

7.4.2.3 CPI Network Reset

Cycling power on the CR6 datalogger resets the CPI network.

7.4.3 Power Connections

Connect power with the **Power In** quad connectors as shown in FIGURE 7-3, *CDM-VW305s in a Daisy-Chain CPI Network (p. 21)*. The power supply needs to supply voltage anywhere from 10 to 32 Vdc and current ≥ 200 mA. As shown in the following figure, use a small screw driver to open the gates of the quad connectors.

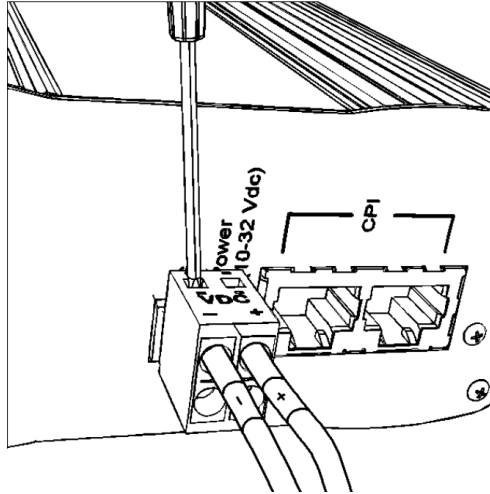


FIGURE 7-4. Open Quad-Connector Gates

During a bench test, you can use pn 13947 transformer as a convenient power supply. In a field installation, the system battery is the power source. See Section 7.9, *Power Supplies* (p. 35), for more information.

7.4.4 Ground Connections

As shown in FIGURE 7-5, *Earth Ground Connections*, ground all station components to Earth using the large lug connectors and 14 AWG wire. This helps protect the station from discharge of static, transients, and power surges, which are common in field installations. Use a ground rod or equivalent for the connection to Earth. More information on Earth grounding is in the datalogger manual.

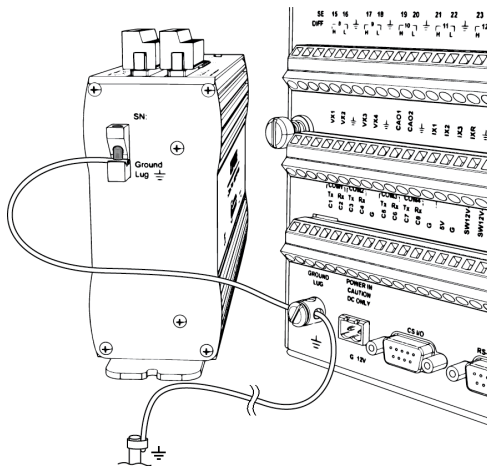


FIGURE 7-5. Earth Ground Connections

7.4.5 PC Connection

Connect the supplied USB cable from a PC type-A-female port (type-A-male end) to the CDM-VW300 micro-type-B-female port (micro-type-B-male end). CDM-VW300 USB port is labelled **USB**. The supplied cable is (pn 27555).

A CDM-VW300 can communicate simultaneously to a datalogger and to a PC. When this is done, the datalogger has read/write access and the PC has read-only access. *DVWTool* indicates at the top of the main window when the datalogger has the analyzer locked.

The **COMM Status** light next to the USB port is NOT an indicator of USB function.

7.5 Analyzer and Channel Numbers

The maximum number of analyzers that can be connected to a CR6 datalogger through the CPI network is eight.

NOTE Each analyzer requires the same system bandwidth whether or not all channels are active.

The sample rate determines the maximum number of vibrating wire sensors that can be measured in a CDM-VW300 CPI network. See the seventh and eighth column in TABLE 7-1, *CDM-VW300 Sample Rates and Derivatives (p. 15)*.

NOTE These channel counts are valid only when sensors in the CDM-VW300 network are measured exclusive of all other sensors.

7.6 Datalogger Program

The datalogger controls and collects data from the CDM-VW300, and the CRBasic program controls the datalogger. In most applications that use one analyzer, let *DVWTool* generate the program. After setting up the CDM-VW300 and sensors, you generate the program by clicking the **CRBasic Code** button in the main *DVWTool* window. Save the program to a file, or copy and paste the displayed code into another program using *CRBasic Editor*.

7.6.1 Program Code

If you use more than one analyzer with a single datalogger, or if you need a non-standard program, you can write a new program or edit an existing program using *CRBasic Editor*. Appendix F, *CRBasic Program Examples (p. F-1)*, has example programs and directs you to other programming resources. Find the program that most closely fits your application and work from there.

NOTE Programs are coded throughout for a specific device type. CDM-VW300 is *DeviceType 0*. CDM-VW305 is *DeviceType 1*. Simply changing the *DeviceType* argument does not make all necessary changes.

The following figure points to essential instructions of the CRBasic program:

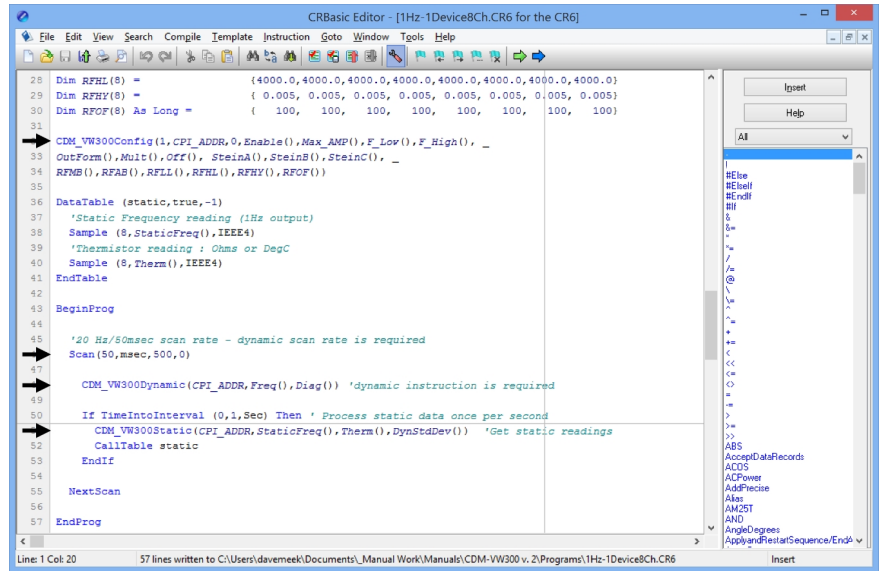


FIGURE 7-6. CRBasic Program Basics

The following sections give short descriptions of CDM-VW300 related CRBasic instructions. *CRBasic Editor* software *Help* has full descriptions of these instructions.

7.6.1.1 Pipeline Mode

When controlling the CDM-VW300, the datalogger automatically runs the CRBasic program in pipeline mode to synchronize all measurement and control functions on the CPI network. You can read more about pipeline mode in the datalogger manual. If you modify a program to include control instructions such as **PortSet()** or **SW12()**, do not nest the instructions inside any type of **If** statement. Otherwise, the program will not compile.

7.6.1.2 CDM_VW300Config()

CDM_VW300Config() sends configuration settings to the CDM-VW300. Place it before the **BeginProg** statement. It does not set the CPI address of the CDM-VW300. The CPI address must be set with *DVWTool*.

```
CDM_VW300Config(DeviceType, CPIAddress, SysOption, ChanEnable,
    ResonAmp, LowFreq, HighFreq, ChanOptions, Mult, Offset,
    SteinA, SteinB, SteinC, RF_MeanBins, RF_AmpBins,
    RF_LowLim, RF_HighLim, RF_Hyst, RF_Form)
```

7.6.1.3 Scan()

Scan() (p. 17) sets the scan interval of the datalogger and the sample rate of the CDM-VW300.

See the first and second columns of TABLE 7-1, *CDM-VW300 Sample Rates and Derivatives* (p. 15), for a list of available sample rate/scan interval pairs. For example:

```
Scan(50,msec,100,0)
```

sets the datalogger scan interval to 50 ms and the CDM-VW300 scan rate to 20 Hz.

7.6.1.4 CDM_VW300Dynamic()

This instruction captures the dynamic output. Place it inside the main scan of the program.

```
CDM_VW300Dynamic(CPIAddress, DestFreq, DestDiag)
```

7.6.1.5 CDM_VW300Static()

This instruction captures static frequency, standard deviation of dynamic frequency at 1 Hz, and temperature of the embedded thermistor or RTD. It is used in the main scan inside a **TimeIntoInterval()** conditional statement. Set **TimeIntoInterval()** to capture static data at 1 Hz. You can capture static data less frequently, but only the latest sample will be available.

```
CDM_VW300Static(CPIAddress, DestFreq, DestTherm, DestStdDev)
```

7.6.1.6 CDM_VW300RainFlow()

Place this instruction in a slow sequence to capture data for a rainflow histogram. See **SlowSequence** instruction in *CRBasic Editor* software *Help*.

```
CDM_VW300RainFlow(CPIAddress, RF1, RF2, RF3, RF4, RF5, RF6,  
RF7, RF8)
```

7.6.1.7 RainFlowSample()

This instruction writes rainflow histogram data to a data table. The data table is usually set up to store data once per minute. See **DataTable** instruction in *CRBasic Editor* software *Help*.

```
RainFlowSample(Source, DataType)
```

7.6.1.8 CPISpeed()

This instruction controls the speed of the CPI bus. This instruction is not normally needed. Use it only when CPI bus communications need fine tuning.

```
CPISpeed(BitRate)
```

7.6.1.9 Processing Diagnostic Codes

See Section 7.7.2, *Diagnostic Codes* (p. 27).

7.6.2 Sending Programs to the Datalogger

Send the CRBasic program to the datalogger with the *Connect* utility in *LoggerNet*. You can also transfer programs from a PC to the CR6 using the SC115 memory drive or a micro SD card. These procedures are discussed in the *LoggerNet* and CR6 manuals.

7.7 Data Quality

The CDM-VW300 and *DVWTool* have the following features (presented in alphabetical order) to help you improve the quality of vibrating wire data. For more discussion about some of these features, read Appendix B, *VSPECT Measurement Theory* (p. B-1).

7.7.1 Amplitude Warning Flags

An accurate measurement requires the resonant amplitude of the sensor to be greater than 50 % and less than 200 % of the **Resonant Amplitude** setting. If the resonant amplitude is less than 50 % of the resonant amplitude setting, a low-amplitude warning flag is triggered. Greater than 200 % triggers a high-amplitude warning flag. When a low-amplitude warning flag is triggered, decrease the resonant amplitude setting until warning flags are no longer triggered. Likewise, increase the resonant amplitude setting until high-amplitude warning flags are no longer triggered.

When the frequency of a sensor changes fast, the measured phenomenon is probably changing fast. When this happens, energy in the vibrating wire may drop briefly until the excitation mechanism can insert energy at the new frequency. A low-amplitude warning flag may occur briefly; this is usually OK.

If a warning flag is present for a long time, check the source of the error as follows:

- Check the sensor connection.
- Check that the sensor is outputting correct data.
- Fine tune the CDM-VW300 scan rate. See **Sample Rate** in TABLE 7-2, *CDM-VW300 Settings* (p. 16).
- Check that the frequency being output by the sensor is within one of the frequency output ranges supported by the CDM-VW300. See the first and third columns in TABLE 7-1, *CDM-VW300 Sample Rates and Derivatives* (p. 15).

7.7.2 Diagnostic Codes

The CDM-VW300 outputs binary diagnostic codes with each measurement at the CDM-VW300 sample rate. These codes include information about excitation strength, frequency warning flags, and amplitude warning flags.

When using a datalogger with the CDM-VW300, write program code to interpret the diagnostic codes. An alternative is to save diagnostic codes with the measurement data and interpret the codes with post processing.

Following are details about diagnostic codes and guidelines for calculating their interpretations.

7.7.2.1 Inside Diagnostic Codes

Each diagnostic code is a 32 bit unsigned integer encoded with the following diagnostic parameters.

- Excitation strength
- Low-amplitude warning flag
- High-amplitude warning flag
- Low-frequency warning flag
- High-frequency warning flag

When there are no warning flags, the diagnostic code is between 0 and 255 and indicates only excitation strength. When there are warning flags the diagnostic code is greater than 255 and is the sum of the excitation strength and the flag value. The following table summarizes diagnostic codes that indicate warning flags:

TABLE 7-5. Diagnostic Code Ranges

Diagnostic code range ¹	Excitation Only	Low-amplitude warning flag present ²	High-amplitude warning flag present ²	Low-frequency warning flag present ²	High-frequency warning flag present ²
0 – 255	✓				
256 – 511		✓			
512 – 767			✓		
768 – 1023					
1024 – 1279				✓	
1280 – 1535		✓		✓	
1536 – 1791			✓	✓	
1792 – 2047					
2048 – 2303					✓
2304 – 2559		✓			✓
2560 – 2815			✓		✓

¹ Diagnostic codes outside these ranges may occur when hardware, firmware, or CRBasic programming errors occur.

² Amplitude warning flags and frequency warning flags have the following restrictions:

- A measurement can have a low-amplitude warning flag or high-amplitude warning flag, but not both.
- A measurement can have a low-frequency warning flag or a high-frequency warning flag, but not both.
- A measurement can have both an amplitude warning flag and a frequency warning flag.

7.7.2.2 Creating the Diagnostic Code Variable Array

As shown in the following code snippets from Appendix F.3, *50 Hz Diagnostic Example — One CDM-VW300, Two Geokon 4000 Sensors with FieldCal()* (p. F-5), write CRBasic programming to decode diagnostic codes with the following elements:

- Declare the variable array that holds the diagnostic codes as **Public**.
- Set the **DestDiag** parameter in the **CDM_VW300Dynamic()** instruction to the name you gave to the array.

- Dimension the array such that the number of elements equals the number of active CDM-VW300 channels.

```

Public DCode(2) As Long 'Declare dynamic diagnostic code

'...other code...

DataTable (slow,true,-1)
DataInterval (0,1,Min,10)
Sample (2,LowAmpCount(),UINT2)
Sample (2,HighAmpCount(),UINT2)
Sample (2,LowFreqCount(),UINT2)
Sample (2,HighFreqCount(),UINT2)
EndTable

'...other code...

Scan(20,msec,500,0)

CDM_VW300Dynamic(CPI_ADDR,Strain(),DCode())

'...other code...

'Process the Diagnostic codes to keep an eye on the health of the monitored date
ExciteStr(1) = ( DCode(1) AND 255) * VoltFactor : ExciteStr(2) = ( DCode(2) AND 255) * _
VoltFactor
If (DCode(1) AND 256) Then LowAmpCount(1) += 1
If (DCode(2) AND 256) Then LowAmpCount(2) += 1
If (DCode(1) AND 512) Then HighAmpCount(1) += 1
If (DCode(2) AND 512) Then HighAmpCount(2) += 1
If (DCode(1) AND 1024) Then LowFreqCount(1) += 1
If (DCode(2) AND 1024) Then LowFreqCount(2) += 1
If (DCode(1) AND 2048) Then LowFreqCount(1) += 1
If (DCode(2) AND 2048) Then LowFreqCount(2) += 1

If ResetCounts Then
    LowAmpCount(1) = 0 : LowAmpCount(2) = 0
    HighAmpCount(1) = 0 : HighAmpCount(2) = 0
    LowFreqCount(1) = 0 : LowFreqCount(2) = 0
    HighFreqCount(1) = 0 : HighFreqCount(2) = 0
    ResetCounts = False
EndIf

CallTable slow

'...other code...

NextScan

EndProg

```

Each element in the array receives one diagnostic code per measurement, so, in this example, the array receives 100 diagnostic codes per second.

7.7.2.3 Decoding Excitation Strength

The eight least-significant bits (0 – 128) of the diagnostic code represent the excitation strength. The following methods decode excitation strength from the diagnostic code:

- Use the following CRBasic statement:

$$\text{ExciteStrengthV} = (\text{DiagCode AND } 255) \cdot 0.02353$$

where,

DiagCode = the diagnostic code

ExciteStrengthV = a variable declared as data type **Float**

- Calculate

Subtract the low diagnostic code boundary value (shown in the first column of TABLE 7-5, *Diagnostic Code Ranges* (p. 28)), from the diagnostic code and then divide the difference by 42.5. For example, to calculate excitation from the diagnostic code 1650, subtract 1536 from 1650 and divide the difference (114) by 42.5. The result is 2.68 V.

7.7.2.4 Decoding Warning Flags

To decoding a warning flag from the diagnostic code, isolate each warning flag from the diagnostic code and count their occurrence. Use one CRBasic statement for each flag. The CRBasic statement has the following general form:

If (DiagCode AND FlagBit) Then Count = Count + 1

where,

DiagCode = the diagnostic code

FlagBit = bit listed in the following table:

TABLE 7-6. Warning Flags, FlagBit, Triggers		
Warning Flag	FlagBit	Triggers
Low amplitude	256	Actual resonant amplitude is ≤ 50 % of the Resonant Amplitude (<i>ResonAmp</i>) set point
High amplitude	512	Actual resonant amplitude is ≥ 200 % of the Resonant Amplitude (<i>ResonAmp</i>) set point
Low frequency	1024	Resonant frequency falls between the Actual Low Frequency and the Low-Frequency Boundary (<i>LowFreq</i>)
High frequency	2048	Resonant frequency falls between the Actual High Frequency and the High-Frequency Boundary (<i>HighFreq</i>)

The following CRBasic statements isolate and count the four warning flags:

```

'Isolate excitation voltage
ExciteStrengthV = (DiagCode AND 255) • 0.02353

'Isolate and count low-amplitude flag
If (DiagCode AND 256) Then LowAmpCount = LowAmpCount + 1

'Isolate and count high-amplitude flag
If (DiagCode AND 512) Then HiAmpCount = HiAmpCount + 1

'Isolate and count low-frequency flag
If (DiagCode AND 1024) Then LowFreqCount = LowFreqCount + 1

'Isolate and count high-frequency flag
If (DiagCode AND 2048) Then HiFreqCount = HiFreqCount + 1

```

Appendix F.3, *50 Hz Diagnostic Example — One CDM-VW300, Two Geokon 4000 Sensors with FieldCal()* (p. F-5), shows how these statements are included in the CRBasic program.

7.7.3 DVWTool Errors

As shown in FIGURE 7-7, *DVWTool Error Indicators*, DVWTool indicates measurement errors in the following ways:

- Information icon (i) in the **Channels** and a warning icon (⚠) in the affected field. Click on an icons for more information.
- Red or flashing-red measurement values
- A warning icon (⚠) if the **Resonant Amplitude** (0.1 to 10 mV) or the frequency boundary settings are out of range. Click on the icon for more information.

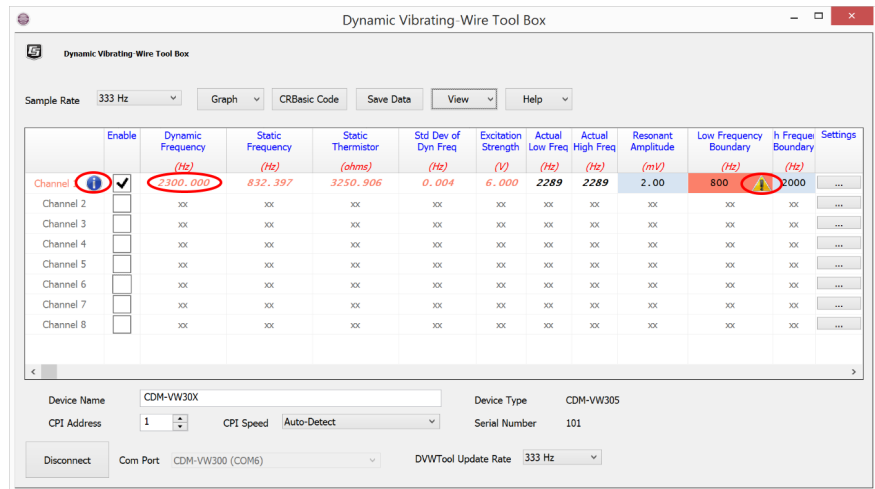


FIGURE 7-7. DVWTool Error Indicators

7.7.4 Excitation Strength

Excitation strength is output with each dynamic measurement as part of the diagnostic code. See Section 7.7.2, *Diagnostic Codes* (p. 27). If it changes significantly, spend time to figure out what is causing the change. Significance of change depends on the application, but a sudden or large permanent change from a baseline (be sure to determine and record a baseline when first installing a station) indicates there is likely a problem with the sensor.

An increase in excitation strength usually means the sensor is less responsive, so it must be driven harder to get the same response. Some sensors become less responsive with age.

A change in the phenomenon being measured usually has a negligible effect on the excitation strength. One exception is if the phenomenon being measured changes its frequency band of variation. For example, consider a sensor measuring strain on a structure. It measures an oscillation in the range of 1 to 2 Hz, which is the natural harmonic frequency of the structure. Then a change is made to the structure to stiffen it so that the natural frequency is now 10 to 20 Hz. When this happens, more energy is dissipated in the sensor as variations occur faster. So, even though the mean value of the strain in the sensor did not

change, more energy (higher excitation strength) is required to produce the signal.

7.7.5 Frequency Filters

7.7.5.1 Harmonics

Some sensors consistently report a harmonic instead of a fundamental frequency. You can minimize or eliminate harmonics by adjusting the frequency boundaries. By putting the harmonic outside the range of allowed frequencies, it is eliminated as a source of error. If adjusting frequency boundaries does not reduce error, force the CDM-VW300 to re-assess the primary frequency by either disabling then re-enabling the input channel or by resending the CRBasic program to the datalogger.

7.7.5.2 Estimated-Frequency Range

The CDM-VW300 filters unwanted frequencies, such as harmonics, from vibrating wire output using the operator-entered low-frequency boundary and high-frequency boundary. The range bounded by these estimates is the *estimated-frequency range*. Enter boundary estimates into *DVWTool* **low-frequency boundary** and **high-frequency boundary** columns or CRBasic **CDM_VW300()** instruction *LowFreq* and *HighFreq* parameters. The best source for boundary estimates is the sensor manufacturer — perhaps in a calibration report.

7.7.5.3 Actual-Frequency Range

Because the CDM-VW300 cannot usually comply with the exact boundary estimates, it establishes the *actual-frequency range*, which is bounded by the actual-low frequency and actual-high frequency. Boundary values are excluded from the frequency ranges.

The following figure shows how boundaries and ranges relate to each other:

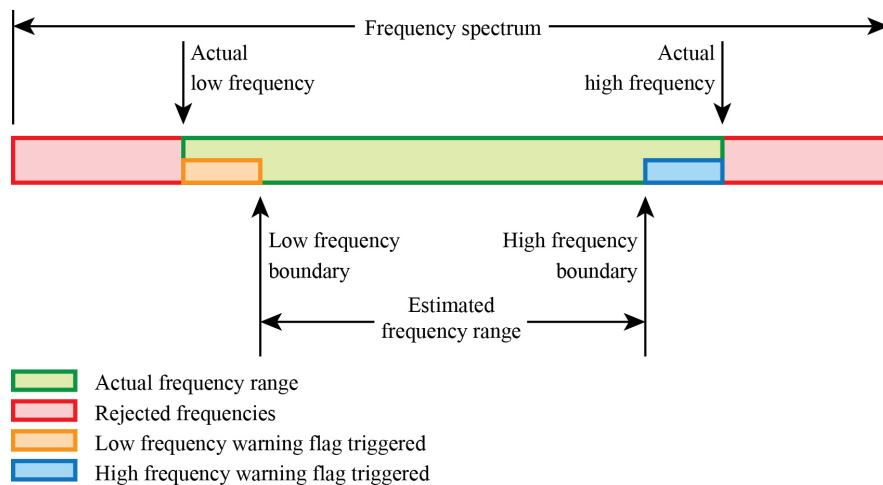


FIGURE 7-8. Relationship of Estimated- and Actual-frequency ranges and Frequency Warning Flags

The actual range is equal in size or larger than the estimated range. If you wish to know the actual boundaries, in *DVWTool*, click on **View | Advanced**. Two

new columns, **Actual Low Frequency** and **Actual High Frequency**, appear on the main window.

If using *DVWTool* is not practical, you can calculate the actual boundaries. Calculate the actual-frequency range using boundary resolution value in the fourth column of TABLE 7-1, *CDM-VW300 Sample Rates and Derivatives* (p. 15), as a reference. For example, if the datalogger scan interval is set to 500 ms, the CDM-VW300 sample rate is 20 Hz and its boundary resolution is 47.68 Hz. If you estimate the low-frequency boundary at 150 Hz, the nearest multiple of 47.68 Hz that is less than the estimate is 143.04 Hz ($3 \cdot 47.68$ Hz). Enter **143.04** into **low-frequency boundary** in *DVWTool* or **LowFreq** in CRBasic. Likewise, if you estimate the high-frequency boundary at 500 Hz, the nearest multiple of 47.68 Hz that is more than the estimate is 476.80 ($10 \cdot 47.68$ Hz). Enter **476.80** into **high-frequency boundary** in *DVWTool* or **LowFreq** in the CRBasic program.

7.7.5.4 Matching Estimated and Actual-frequency ranges

Minimize the difference between the estimated-frequency range and the actual-frequency range by entering the actual frequency values as the low-frequency boundary and high-frequency boundary. However, there are benefits to not having the estimated-frequency range match the actual-frequency range. The CDM-VW300 issues warning flags if the measured frequency falls in the gaps between the two ranges.

7.7.6 Frequency Warning Flags

Frequency warning flags are triggered at the following times:

- When a resonant frequency falls between the estimated- and actual-frequency ranges. This may indicate a change in the output of a sensor before the output moves outside the actual-frequency range. See FIGURE 7-8, *Relationship of Estimated- and Actual-frequency ranges and Frequency Warning Flags* (p. 32).
- When the low-frequency boundary or high-frequency boundary is set outside the range allowed by the selected sample rate.
- When the *Sample Rate* setting is invalid for the resonant frequency. See TABLE 7-2, *CDM-VW300 Settings* (p. 16).

For example, at the CDM-VW300 sample rate of 100 Hz, the CDM-VW300 can measure frequencies anywhere from 580 to 6000 Hz. A resonant frequency outside this range will trigger a flag. Furthering this example, if signal frequencies output by the sensor always fall between 2000 and 3000 Hz, you can set the low-frequency boundary to 2000 Hz and the high-frequency boundary to 3000 Hz. The CDM-VW300 will adjust the boundaries to 1907.3 Hz and 3051.68. If a measurement falls between 1907.3 and 2000, a low-frequency warning flag is raised. If a measurement falls between 3000 and 3051.68, a high frequency warning flag is raised.

See Section 7.7.2, *Diagnostic Codes* (p. 27), for further discussion of warning flags and how they are tagged to a measurement.

7.7.7 Sample Rate and Noise Performance

Electrical noise limits the effective resolution, or precision, of a vibrating wire measurement. To increase precision, decrease the measurement sample rate. The fifth column of TABLE 7-1, *CDM-VW300 Sample Rates and Derivatives* (p. 15), lists the noise level associated with each sample rate.

Other topics that discuss noise performance are found in the following sections:

- Section 4.3, *Static Measurement* (p. 3)
- Section 7.7.5, *Frequency Filters* (p. 32)
- Appendix B.1, *Dynamic Vibrating Wire Measurement* (p. B-1)
- Appendix D, *Calculating Vibrating Wire Measurement Error* (p. D-1)

7.7.8 Standard Deviation

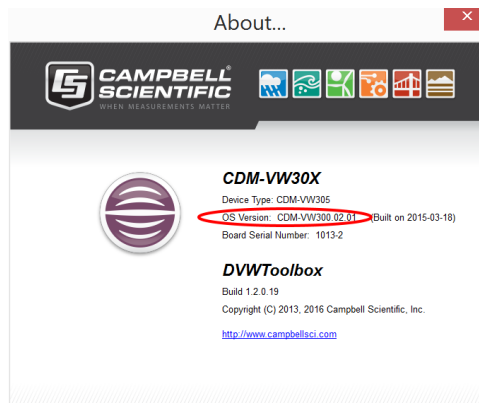
The **CDM_VW300Static()** instruction has an option to output a 1 Hz calculation of the standard deviation of the dynamic readings. If the standard deviation changes significantly, spend time to figure out what is causing the change. Significance of change depends on the application. For example, a significant increase from a baseline (be sure to determine and record a baseline when first installing a station) may indicate a problem with the sensor or a significant shift in the structure or phenomenon being measured.

7.8 Operating Systems

Use the software and operating system versions listed in Section 5, *Specifications* (p. 4).

Use *DevConfig* software to check and update operating systems. *DevConfig* is automatically installed with *LoggerNet*. It is also available at no charge at www.campbellsci.com. Updating operating systems with *DevConfig* is fairly intuitive, and *DevConfig* has extensive context sensitive Help. Written instructions are also found in the *LoggerNet* software manual.

You can also check the operating system version of the CDM-VW300 in *DVWTool Help* | **About**, as shown in the following figure:



Be aware that updating an operating system usually clears all data and settings, so save all data to a PC before doing the update.

7.9 Power Supplies

7.9.1 CDM-VW300 Power Supply

The CDM-VW300 requires 10 to 32 Vdc (nominal 12 Vdc). Current requirement is ≥ 200 mA per analyzer. The datalogger is a convenient power source when using one analyzer, and power supplies for higher current demand are available from Campbell Scientific. Assuming sourcing current is available from the datalogger power supply, use the **12V** and **G** terminals on the datalogger to supply power to one analyzer. For convenience in the absence of a datalogger, you can use pn 29796, an ac receptacle transformer during a bench test.

7.9.2 Field Station Power Supplies

Current sourcing requirements vary depending on the size and configuration of a field station. The following power supply is adequate for a field station that includes a CR6 datalogger and one CDM-VW300 or CDM-VW305:

- CR6 connected to ac mains power through ac to dc transformer at **CHG** terminal.
- BP7 12V 7 ah rechargeable battery connected to CR6 at **BAT** terminal.

Following are power supplies suitable for year around use in Northern Utah in locations not serviced by ac mains power:

- Station: C6 and CDM-VW300 with two active input channels:
 - Solar panel: at least 60 watts
 - Lead acid battery: at least 91 amp-hours
- Station: CR6 and CDM-VW305 with eight active input channels
 - Solar panel: at least 84 watts
 - Lead-acid battery: at least 130 amp-hours

A reliable station requires a reliable power supply, so calculate an accurate power budget for large systems. For help in doing this, see *Power Supplies Application Note* at www.campbellsci.com.

7.10 Power-Up Sequence

The best practice is to power up all instruments in a station simultaneously from a single power supply. If this is not possible, first power up CDM-VW300 analyzers, then power up the CR6 datalogger. This procedure will minimize the chance of CPI network problems.

When the CDM-VW300 is powered up, the **COMM Status** light will flash yellow. Depending on the state the CDM-VW300 was left in when last powered up, one or more of the **Channel Status** lights may also flash.

When the CR6 datalogger is power up, the **COMM Status** light will flash red then flash a steady green.

If **COMM Status** lights behave differently from these descriptions, see Section [7.4.2, CPI Connections](#) (p. 20).

7.11 Sensors

Vibrating wire sensors come in many varieties for many applications, but they all have the same basic design features and fundamentals of operation. When choosing a sensor, beside the form and fit, the basic fundamentals of operation affect how well your sensor performs with the CDM-VW300.

7.11.1 Sensor Basic Design Features

Vibrating wire sensors have the following components, which are illustrated in FIGURE 7-9, *Basic Design Features of a Vibrating Wire Sensor*:

- Sensing element
- Taut wire attached to sensing element
- Plucking and pickup coils
- Optional thermistor or RTD
- Two coil input/outputs
- Two thermistor input/outputs

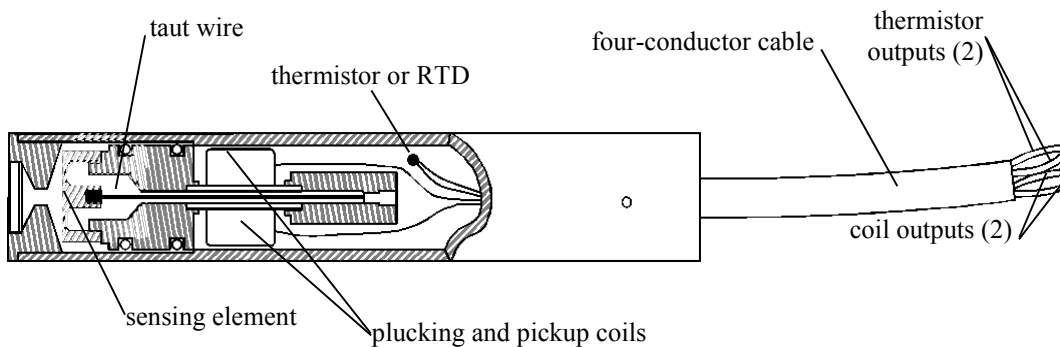


FIGURE 7-9. *Basic Design Features of a Vibrating Wire Sensor*

7.11.2 Basic Measurement of the Sensor

The CDM-VW300 applies excitation and measures the return vibrating wire signal on the plucking and pickup coil leads. It applies excitation and measures the return temperature signal on the thermistor leads.

7.11.3 Vibrating Wire Length and Tension

Vibrating wire sensors vibrate within a discrete frequency-output range that is determined by the manufacturer. The frequency of the vibration is a function of two factors: the length of the wire and the tension of the wire.

Length is fixed because that is how the sensor is built. Tension, however, changes as the environment around the sensor changes. For example, the wire in a pressure sensor is attached at one end to a diaphragm. As the diaphragm flexes with changes in external pressure, the wire is stretched or relaxed. The stretch or relaxation is proportional to external pressure.

Depending on the purpose of the sensor, the manufactured lengths of vibrating wires vary widely. Shorter wires vibrate at higher frequencies, longer wires at lower frequencies. For example, one to two inch wires vibrate near 3000 Hz, while six inch wires vibrate near 900 Hz.

7.11.4 Sensor Output Frequency Range and Maximum Sample Rate

To capture rapid changes, sensor response must be equal to or less than one-half of the sampling frequency (Nyquist sampling theorem).

Higher CDM-VW300 sampling rates require higher and tighter sensor frequency-output ranges. The vibrating wire in a sensor must vibrate five to 10 times per measurement for the CDM-VW300 to pick it up. Longer wires, such as those that vibrate near 900 Hz, cannot be measured at higher CDM-VW300 scan rates because the wire does not vibrate fast enough to get the required number of vibrations for a measurement.

As a general rule, the fastest that a vibrating wire gage can be measured is approximately 20 percent of the resonant frequency. For example, a gage that resonates at about 1100 Hz can be measured at a maximum of 20 % of 1100 Hz, or at 220 Hz, so the **200 Hz** measurement range is used.

The third column of TABLE 7-1, *CDM-VW300 Sample Rates and Derivatives (p. 15)*, lists the sensor frequency-output ranges that can be measured at the CDM-VW300 sample rates.

7.11.5 Sensor Versatility

Some applications may require that a sensor be used that can be sampled over a wide range of sample rates. Sensors with higher resonant frequencies are more versatile. For example, as shown in the previous table, a sensor with a resonant frequency of 2000 Hz can be measured at scan rates 20, 50, 100, 200, and 333.3 Hz. On the other hand, a sensor with a resonant frequency of 290 Hz can be measured only at 20 or 50 Hz.

7.11.6 Temperature Sensor

FIGURE 7-9, *Basic Design Features of a Vibrating Wire Sensor (p. 36)*, shows the location of the temperature sensor. Sensor manufacturers have many thermistors and RTDs to choose from, so this manual has only general guidelines about measuring an embedded temperature sensor. Additional information is in Appendix E, *Measuring Thermistors and RTDs (p. E-1)*.

Be aware that some manufacturers, Slope Indicator, for example, use thermistors or RTDs in the same model of sensor according to what the client orders. So be alert when specifying and ordering sensors.

You will avoid significant trouble by figuring out the nuances of how to measure the temperature sensing element in your vibrating wire sensor before going to the field.

Procedure:

1. Do the procedure in Section 6.3.2, *Bench Test Procedure (p. 8)*.

2. If there are values other than zero in the *DVWTool* **Steinhart-Hart Coefficients A, B, and C** columns for the sensor, write these down because you may need them later.
3. Set **Steinhart-Hart Coefficients A, B, and C** to 0.
4. Connect one lead from the temperature sensing element (it does not matter which one) to either of the **T** terminals of the same input channel to which you connected the vibrating wire sensor. Connect the other lead to the other **T** terminal. You should immediately see a resistance value in the **Static Thermistor** column of *DVWTool*. This is the resistance value of the temperature sensing element. It is expressed in ohms (Ω). Check this resistance against the documentation that came with your sensor to confirm that the correct resistance is displayed for the current temperature.
5. Convert the measured resistance to temperature:
 - If the temperature sensing element is a thermistor, do the following:
 - a. Enter the Steinhart-Hart coefficients provided by the manufacturer into the **Steinhart-Hart Coefficients A, B, and C** columns. The value in the **Static Thermistor** column should now be the current temperature expressed in degrees Celsius. For DGSi sensors, our **C** coefficient equals their **D** coefficient.
 - b. Set up the CDM-VW300 to convert the resistance to temperature by entering the Steinhart-Hart coefficients into CDM-VW300 settings using *DVWTool*, *DevConfig*, or a program created with *CRBasic Editor*.
 - If the element is an RTD, do the following:
 - Most RTDs are PRTs. If your RTD is a PRT, find the Calendar-Van Dusen coefficients on the manufacturers calibration sheet.
 - Add code to the program created with *CRBasic Editor* to convert resistance to temperature. The PT100 PRT discussion in Campbell Scientific datalogger manuals may help you do this.
 - The other option for both thermistors and RTDs is to simply store the resistance data then convert resistance to temperature on a PC after collecting data from the field.

Preserve the original vibrating wire measurements. Convert the original vibrating wire measurements to temperature compensated measurements by adding code to the datalogger program, or by calculating the compensation on a PC after data are collected from the field. For either option, you need to get the compensation equation and factors from the sensor manufacturer. These may be on the calibration sheet.

7.12 Station Validation

7.12.1 Monitoring System Performance

You can monitor the performance of a CDM-VW300 station with *LoggerNet* with the following procedure:

Procedure:

1. Run *LoggerNet*.
2. Open a numeric display by clicking on **Connect** | **Num Display**.
3. Select **Public** table.
4. Check that the displayed measurements correspond to the selected CDM-VW300 input channels and that measurements are correct.

7.12.2 Status of Input Channels and Sensors

The status of CDM-VW300 input channels and the sensors connected to them can be determined by interpreting the state of the **Channel Status** lights. The following table summarizes the interpretation of these states.

TABLE 7-7. Channel Status Lights	
Light State	Channel Status
Flashing red or green at 3 s interval	Channel enabled
Flashing green	Channel enabled; sensor active; measurements within set ranges
Flashing red	Channel is enabled; sensor is active; some measurements are outside set range(s), so diagnostic warning flag(s) is True .
Dark; not flashing	Channel disabled

8. Troubleshooting

When problems arise, use the following troubleshooting tools:

- PC running *DVWTool*
- This manual
- Multimeter (volt-ohm meter)

8.1 Connections

Check the integrity of all connections:

- Sensors
- CDM-VW300
- Datalogger
- PC

8.2 CPI Network

If you are trying to capture data from too many channels or analyzers, the **COMM Status** light will flash a green/red cycle in sequence. As confirmation, check the **SkippedScan** field in the datalogger **Status** table. Numerous skipped scans indicate an overloaded system.

Another place to look for clues about CPI network problems are the CPI fields in the **CPIStatus** data table of the datalogger, as sometimes you can see the CPI network load slowly increasing.

8.3 Factory Default Reset

Components may require a reset to factory defaults. Use *Device Configuration Utility (DevConfig)* to perform the reset. Save the original settings with *DevConfig* before doing the reset.

8.4 Fault Detection

See Section 7.7.2, *Diagnostic Codes* (p. 27), and Section 7.7.3, *DVWTool Errors* (p. 31).

8.5 Isolating Components

Divide and conquer when troubleshooting. Independently verify the function of each component. The following procedure isolates and tests components in a typical CDM-VW300 field station.

1. Disconnect the CDM-VW300 from the datalogger and connect it to a PC running *DVWTool*.
2. Do the procedure in Section 6.3.2, *Bench Test Procedure* (p. 8).

If the bench test procedure does not result in good measurements, the fault is probably with the CDM-VW300 or with the sensors. Otherwise, continue with the following steps to further troubleshoot the datalogger:

3. In *CRBasic Editor*, click **File | New** and select the CR6 datalogger. A new file opens that is pre-loaded with a program that measures only datalogger wiring panel temperature and supply voltage. This is a good program to test basic datalogger functions. With the datalogger and CDM-VW300 disconnected, send this program to the datalogger. Monitor the temperature and voltage measurements.
4. If measurements from step 3 are not correct or are not displayed in *LoggerNet*, contact a Campbell Scientific application engineer.

If temperature and voltage measurements in step 3 are correct, and if you can monitor them on a PC, then the datalogger, PC, and software are probably working.

8.6 Power

Use a multimeter to check power connections to the CDM-VW300 analyzer and the datalogger. A supply voltage between 10 and 14 Vdc is adequate.

8.7 Repair

If the CDM-VW300 needs repair, first contact a Campbell Scientific application engineer and get an RMA number (Return Materials Authorization). Be prepared to provide your troubleshooting findings, answer questions, and do further trouble shooting. The [Assistance](#) statement at the beginning of this manual has complete instructions for returning an item to Campbell Scientific.

9. Glossary

AWG

Unit of wire gage or thickness. The higher the AWG value, the thinner the wire. Following is a table of recommended AWG values:

TABLE 9-1. Recommended Wire Gage (AWG) Values

Use	AWG
Sensor to instrument connections	20 – 24
12 Vdc power connections	16 – 18
Earth grounding	≤ 14

10. References and Attributions

Matsuishi, M. and T. Endo.: 1968, "Fatigue of Metals Subjected to Varying Stress." *J. of the Japan Society of Mechanical Engineers*, Fukuoka, Japan, 37–40.

Jacobsen, L.E., D.L. Israelsen, J.A. Swenson, "Vibrating Wire Sensor Using Spectral Analysis", *U.S. Patent 7779690*, August 24, 2010.

Jacobsen, L.E. and S.S. Cornelsen, "System And Method For Measuring The Frequency Of A Vibrating Object." *U.S. Patent 8671758*, March 18, 2014.

Microsoft and Windows are either registered trademarks or trademarks of Microsoft Corporation in the United States and/or other countries.

Geokon 4000 and Geokon 4420 are products of Geokon, Inc.

CompactFlash is a registered trademark of the SanDisk Corporation.

Madsen, C., S. Cornelsen, "Designing Physical Network Layouts for the CPI Bus", Campbell Scientific, Inc, March 20, 2014.

Appendix A. Typography

This manual has the following typefaces. Type colors other than black on white do not appear in printed versions:

- CAPS — Beginning of sentences, phrases, titles, and names
- ALL CAPS — Campbell Scientific model numbers
- **Bold** — CRBasic instructions within the body text, input commands, output responses, GUI commands, text on product labels, and names of data tables
- *Italic* — Glossary entries, software, and titles of publications, sections, tables, figures, and CRBasic examples.
- ***Bold italic*** — CRBasic instruction parameters and arguments within the body text
- *Italic blue* — External hyperlinks and internal cross references
- Lucida Sans Typewriter — CRBasic programs, CRBasic code snips, input commands, and output responses, when set outside the body text or in program examples as in the following list:
 - *Instructions*
 - *'Comments*
 - All other code

Appendix B. VSPECT Measurement Theory

B.1 Dynamic Vibrating Wire Measurement

In a vibrating wire sensor, the coil serves the following functions:

- Actuator to put energy into the wire
- Pickup to detect the motion of the wire

The resonant frequency of a vibrating wire cannot be measured at static rates faster than about 1 Hz. A static measurement excites the wire and measures the response. Excitation is a swept frequency sine wave that supplies a broad spectrum of frequencies to the wire. If you listen closely to most vibrating wire sensors, during a static measurement you can hear tones ascending through the swept frequency excitation. Time is then required for the non-resonant frequencies to die out, and then more time is needed to sample the resonant frequency. Additional time is required for the resonant frequency to die out before the next excitation/measurement cycle begins.

In contrast, the CDM-VW300 makes dynamic measurements at rates as high as 333.3 Hz. The dynamic process eliminates the swept frequency sine wave. Instead, the CDM-VW300 injects energy into the oscillation at just the right frequency and phase, so a very short excitation with small amplitude maintains wire resonance. Phase alignment of excitation strengthens wire resonance and decreases measurement noise.

Phase alignment requires precise timing of excitation and measurement. To get the precision needed, the system synchronizes the process to the datalogger clock through the CRBasic program and CPI bus. Synchronization has the added benefit of allowing for simultaneous sampling of channels, so there is good measurement correlation across multiple sensors. Synchronized excitation is a key difference between dynamic VSPECT™ measurements and other auto-resonant excitation schemes.

To improve dynamic measurements, the CDM-VW300 measures a static frequency at 1 Hz and uses it as a reference in noise rejection. Since the CDM-VW300 samples only a few cycles of the wire each time it makes a dynamic measurement, the spectral resolution is coarser than when using all captured data. As a result, occasional noise frequencies are gathered into the same FFT (Fast Fourier Transform) bin as those of the signal, which causes measurement error. The CDM-VW300 measures the static frequency at a finer resolution to detect the noise and prompt you to take corrective action.

Appendix C. Vibrating Wire Digits Conversion

Manufacturers usually include calibration data with vibrating wire sensors. Use the data to convert frequency to a unit of measure.

The CDM-VW300 is usually set up to measure frequency in units of hertz (Hz), but some calibration sheets report data in units of *digits* or *B units*. If this is the case with your sensor, convert hertz to digits with the following formula:

$$\text{digits or } B \text{ units} = \text{Hz}^2 / 1000$$

Use the gage factor and polynomial from the manufacturer's calibration sheet to convert to units of measure.

Using the calibration report shown in FIGURE C-1, *Geokon Calibration Report*, the following example converts frequency to displacement:

For example, the CDM-VW300 measures a displacement sensor and reports a frequency of 2400 Hz. The relationship of sensor output to displacement, s , is expressed in the calibration report as follows:

$$s = (9.139\text{E-}08) \cdot \text{digits}^2 + (0.03054) \cdot \text{digits} + (-80.471)$$

The conversion procedure follows:

1. Convert hertz to digits:

$$\text{digits} = (2400 \text{ Hz})^2 / 1000 = 5760$$

2. Convert digits to displacement:

$$s = (9.139\text{E-}08) \cdot (5760)^2 + (0.03054) \cdot 5760 + (-80.471)$$

$$s = 98.47 \text{ mm}$$


 48 Spencer St. Lebanon, N.H. 03766 USA							
Vibrating Wire Displacement Transducer Calibration Report							
Range: <u>150 mm</u>				Calibration Date: <u>January 7, 2010</u>			
Serial Number: <u>0939696</u>				Temperature: <u>23.4 °C</u>			
				Calibration Instruction: <u>CI-4400</u>			
				Technician:			
GK-401 Reading Position B							
Actual Displacement (mm)	Gage Reading 1st Cycle	Gage Reading 2nd Cycle	Average Gage Reading	Calculated Displacement (Linear)	Error Linear (%FS)	Calculated Displacement (Polynomial)	Error Polynomial (%FS)
0.0	2614	2613	2614	-0.30	-0.20	-0.03	-0.02
30.0	3580	3579	3580	30.08	0.05	30.03	0.02
60.0	4539	4539	4539	60.26	0.18	60.04	0.03
90.0	5492	5489	5491	90.19	0.13	89.98	-0.02
120.0	6437	6439	6438	120.00	0.00	119.95	-0.04
150.0	7385	7383	7384	149.76	-0.16	150.03	0.02
(mm) Linear Gage Factor (G): <u>0.03146</u> (mm/ digit) Regression Zero: <u>2623</u>							
Polynomial Gage Factors: A: <u>9.139E-08</u> B: <u>0.03054</u> C: <u>-80.471</u>							
(inches) Linear Gage Factor (G): <u>0.001238</u> (inches/ digit)							
Polynomial Gage Factors: A: <u>3.598E-09</u> B: <u>0.001202</u> C: <u>-3.1682</u>							
Calculated Displacement: Linear, $D = G(R_1 - R_0)$ Polynomial, $D = AR_1^2 + BR_1 + C$ Refer to manual for temperature correction information.							
Function Test at Shipment:							
GK-401 Pos. B : <u>4239</u> Temp(T_0): <u>24.1</u> °C Date: <u>January 28, 2010</u> The above instrument was found to be in tolerance in all operating ranges.							
The above instrument was found to be in tolerance in all operating ranges. The above named instrument has been calibrated by comparison with standards traceable to the NIST, in compliance with ANSI Z540-1. This report shall not be reproduced except in full without written permission of Geokon Inc.							

FIGURE C-1. Geokon Calibration Report

Appendix D. Calculating Vibrating Wire Measurement Error

The base measurement of the CDM-VW300 is frequency, f . For most vibrating wire sensors, the sensor signal represents a linear relationship between wire tension and measured phenomena.

Wire tension is the square of the resonant frequency (f^2). The calibration report from the sensor manufacturer provides a formula for converting frequency, f , to the target unit of measure, U_E , as follows:

$$U_E = Kf^2 \quad \text{Eq. 1}$$

K is the calibration constant.

For a very small change in frequency, Δf , change in U_E , ΔU_E , is expressed as follows:

$$\Delta U_E = 2Kf\Delta f \quad \text{Eq. 2}$$

Eq. 2 is the first derivative of Eq.1 with respect to f .

Effective resolution of a measurement, R_e , is calculated using Eq. 2 and a noise level, N . Values for N are found in the fifth column of TABLE 7-1, *CDM-VW300 Sample Rates and Derivatives* (p. 15). For a specific CDM-VW300 scan rate, use the corresponding N value in place of Δf . Eq. 2 is then expressed as follows:

$$R_e = 2KfN \quad \text{Eq. 3}$$

D.2 Error Example: Geokon Strain Gage

K is calculated as follows:

$$K = GB / 1000$$

G is gage factor 4.062 or 0.391, depending on gage type. B is the batch factor, which is usually a number within a few hundredths of 1. These values are found on documentation provided by the sensor manufacturer.

Microstrain:

$$\mu\epsilon = GBf^2 / 1000$$

Effective resolution, (R_e):

$$R_e = \Delta\mu\epsilon$$

$$\Delta\mu\epsilon = 2GBfN / 1000$$

$$\Delta\mu\epsilon = GBfN / 500$$

N is the noise level given in TABLE 7-1, *CDM-VW300 Sample Rates and Derivatives (p. 15)*, corresponding to the CDM-VW300 scan rate being used.

D.3 Error Example: DGSI Embedment Strain Gage

$$K = G$$

$$G = 4.0624\text{E-}03$$

Microstrain:

$$\mu\epsilon = Gf^2$$

Effective resolution, (R_e):

$$R_e = \Delta\mu\epsilon$$

$$\Delta\mu\epsilon = 2GfN$$

D.4 Error Example: DGSI Spot-Welded Strain Gage

Microstrain:

$$\mu\epsilon = Af^2 + C$$

$$A = 7.576\text{E-}04 \text{ and } C = -2030.1$$

So, $K = A$.

For effective resolution, C does not vary with frequency, so it can be ignored for very small changes in frequency.

Effective resolution, (R_e):

$$R_e = \Delta\mu\epsilon$$

$$\Delta\mu\epsilon = 2AfN$$

D.5 Error Example: Geokon 4420 Crack Meter

Displacement (s):

$$s = (Gf^2 / 1000) + Kt$$

G = linear gage factor

K = thermal factor

t = temperature of the sensor

During a short measurement interval, assume no change in sensor temperature. So, for small changes in sensor displacement, K is assumed to be constant, and the Kt term is ignored when calculating the output error:

$$\Delta s = 2GfN / 1000$$

$$\Delta s = GfN / 500$$

D.6 Error Example: DGSI Piezometer 52611099

Pressure:

$$P = Af^2 + Bf + C$$

A , B , and C are gage factors.

Effective resolution:

$$R_e = \Delta P$$

$$\Delta P = (2Af + B)N$$

$$\Delta P = 2AfN + BN$$

Appendix E. Measuring Thermistors and RTDs

Vibrating wire sensors may include an embedded thermistor or RTD (resistance temperature device). The RTD in vibrating wire sensors is usually a PRT (platinum resistance thermometer).

E.1 Converting RTD Resistance to Temperature

The CDM-VW300 analyzer does not support direct RTD measurement conversion to temperature, but it does measure RTD resistance. You can add lines of code to the CRBasic datalogger program to convert RTD resistance to temperature, or you can convert the resistance as part of a post-processing operation in a spread sheet or other software. You will need to get RTD conversion factors from the sensor manufacturer.

E.2 Converting Thermistor Resistance to Temperature

Convert resistance of most thermistors using the Steinhart-Hart equation as follows:

$$^{\circ}\text{C} = 1 / ((A+B(\ln(R)) + C(\ln(R))^3) - 273.15)$$

Where $\ln(R)$ is the natural log of the resistance measurement and A , B , and C are Steinhart-Hart equation coefficients. Each thermistor type has unique coefficients. Sensor manufacturers provide the coefficients. Our C coefficient is DGSi's D coefficient.

Example:

The Steinhart-Hart coefficients for the thermistor embedded in a standard Geokon vibrating wire sensor are as follows:

$$A = 1.4051\text{E-}03$$

$$B = 2.369\text{E-}04$$

$$C = 1.019\text{E-}07$$

The Steinhart-Hart equation to convert thermistor resistance to degrees Celsius is as follows:

$$^{\circ}\text{C} = 1 / ((1.4051\text{E-}03 + 2.369\text{E-}04(\ln(R)) + 1.019\text{E-}07(\ln(R))^3) - 273.15)$$

If R is 2221 Ω , temperature is calculated as follows:

$$^{\circ}\text{C} = 1 / ((1.4051\text{E-}03 + 2.369\text{E-}04(\ln(2221)) + 1.019\text{E-}07(\ln(2221))^3) - 273.15)$$

$$^{\circ}\text{C} = 31.98$$

E.2.1 Thermistor Measurement Accuracy and Resolution

Accuracy of a thermistor temperature measurement is a function of the following factors listed in order of importance:

1. Thermistor interchangeability
2. Change in cable resistance
3. Cable resistance
4. Steinhart-Hart equation error
5. Precision of the bridge resistors
6. Accuracy of the datalogger voltage measurement
7. Temperature coefficient of the bridge resistors

Factor 1, interchangeability, expresses how tightly sensing elements of the same type conform to the ideal. Deviations from the ideal are caused by slight manufacturing differences. Thermistor manufacturers do not calibrate each thermistor produced. Instead, each thermistor is manufactured to meet the ideal within certain tolerances. For example, the Measurement Specialties 100K6A1iA thermistor is manufactured to be within ± 0.10 °C of the ideal at 0 to 50 °C. So, one 100K6A1iA thermistor can be interchanged with another. Each thermistor will measure within ± 0.10 °C of the ideal.

Factor 2 is primarily caused by changes in cable temperature. Increase in temperature causes an increase in cable resistance. Increase in cable resistance passes into the measurement as an increase in thermistor or RTD resistance. The following figure show how wire resistance affects the temperature measurement for a Geokon 4500 vibrating wire piezometer. The vibrating wire measurement is not affected significantly by cable temperature, but the temperature measurement is affected.

If the vibrating wire measurement is temperature corrected, then Factor 2 does affect the vibrating wire measurement. For this reason, in applications where temperature measurement errors must be minimized, the sensor cable should be shielded from the sun and other sources of significant thermal potential, hot or cold.

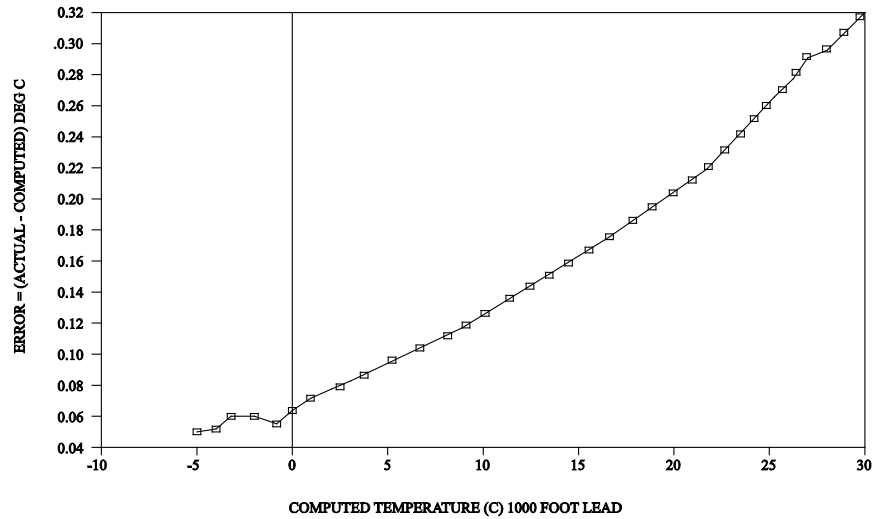


FIGURE E-1. Temperature-induced measurement error on a 1000 foot lead. Wire is 22 AWG, 16 Ω per 1000 feet.

Factor 3, cable resistance, is primarily an offset error and is usually removed by the manufacturer's initial calibration. The following figure emphasizes the importance of removing offset by showing how offsets due to cable length influence measurement error. Offset correction is valid so long as cable length and type are not altered from that received from the manufacturer.

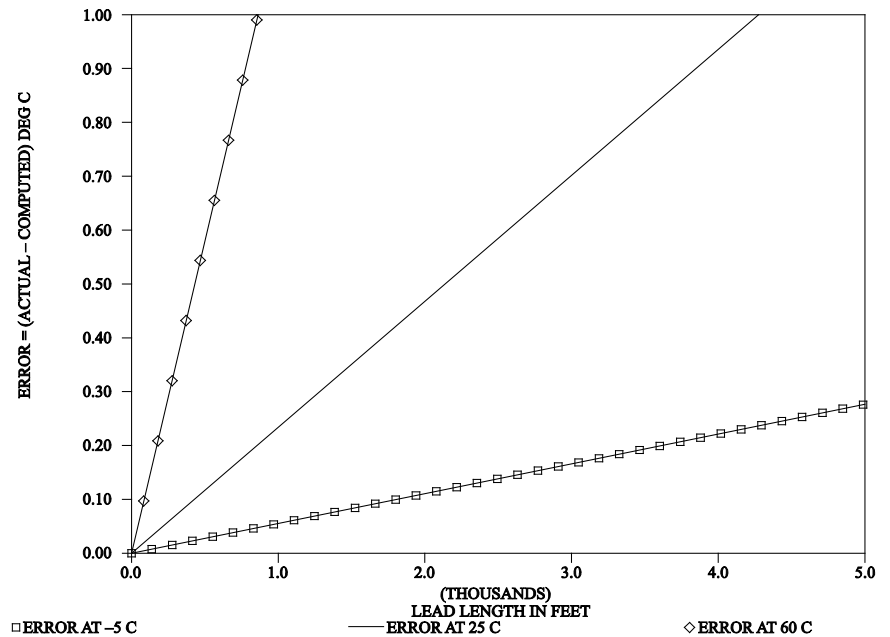


FIGURE E-2. Temperature error offsets at three temperatures as a function of lead length. Wire is 22 AWG, 16 Ω per 1000 feet.

Factors 4 through 7 are usually very small and ignored.

Appendix F. *CRBasic* Program Examples

The Campbell Scientific webpage, www.campbellsci.com/cdm-vw300, has the following *CRBasic* programs available for download under the **Downloads** option:

- 20 Hz Measurement Example — One CDM-VW300, Two Channels
- 20 Hz Measurement Example — One CDM-VW305, Eight Channels
- 20 Hz Measurement Example — Three CDM-VW305s, 24 Channels
- 20 Hz Measurement Example — Three CDM-VW305s, 24 Channels
- 20 Hz Measurement Example — Six CDM-VW305s, 48 Channels
- 50 Hz Measurement Example — One CDM-VW300, Two Channels
- 50 Hz Measurement Example — One CDM-VW305, Eight Channels
- 50 Hz Measurement Example — Three CDM-VW305s, 24 Channels
- 50 Hz Measurement Example — One CDM-VW300, Two Channels, Rainflow Histogram
- 50 Hz Measurement Example — One CDM-VW305, Eight Channels, Rainflow Histogram
- 50 Hz Diagnostic Example — One CDM-VW300, Two Geokon 4000 Sensors with FieldCal()
- 50 Hz Measurement Example — One CDM-VW300, Two Geokon 4000 Sensors with FieldCal()
- 50 Hz Measurement Example — One CDM-VW300, Two Geokon 4000 Sensors with FieldCal() and CardOut() to CF
- 50 Hz Measurement Example — One CDM-VW300, Two Geokon 4000 Sensors with FieldCal() and TableFile() to CF
- 50 Hz Measurement Example — One CDM-VW300, Two Geokon 4000 Sensors with FieldCal() and TableFile() to CF
- 100 Hz Measurement Example — One CDM-VW300, Two Channels
- 100 Hz Measurement Example — One CDM-VW305, Eight Channels
- 1 Hz Static Measurement Example — One CDM-VW300, Two Channels
- 1 Hz Static Measurement Example — One CDM-VW305, Eight Channels

Programs on the webpage are ready to be loaded into a CR6 datalogger. If you copy code from this manual into *CRBasic Editor*, keep the following in mind. If an example crosses pages, select and copy only the code content of one page at a time. Otherwise, you will probably get unwanted characters that originate from PDF page headings, page numbers, and hidden formatting characters.

F.1 20 Hz Measurement Example — One CDM-VW305, Eight Channels

```

'==20Hz-1Device8Ch_4-25===
'CR3000 datalogger
'CDM-VW305 vibrating wire analyzer
'Program to read 20-Hz dynamic data from one CDM-VW305 analyzer measuring eight channels

'IMPORTANT -- Check that the CPI address coded on the following line matches the address
'reported for the attached analyzer in the DevConfig or DVWTool software.
Const CPI_ADDR = 1 '<<<<<<<<<<SET CPI ADDRESS HERE

Public Freq(8) 'dynamic frequencies
Public Diag(8) As Long 'diagnostic code

Public StaticFreq(8) 'Static (1Hz output) frequencies
Public Therm(8) 'Thermistor readings
'Standard Deviation of the dynamic readings that occurred during the latest one-second interval
Public DynStdDev(8)

'The following arrays are used to configure the CDM-VW300 series device. Refer to the
'CDM_VW300Config instruction used below.
,
,
CH1    CH2    CH3    CH4    CH5    CH6    CH7    CH8
---    ---    ---    ---    ---    ---    ---    ---
'Set to true (Enabled=1, Disabled=0) only those channels which have sensors connected
Dim Enable(8) As Long = { 1, 1, 1, 1, 1, 1, 1, 1}
'Specify the target resonant amplitude at which the sensor will be maintained
'via excitation, given in volts. This should be in the range 0.010 to 0.001
Dim Max_AMP(8) = { 0.002, 0.002, 0.002, 0.002, 0.002, 0.002, 0.002, 0.002}
'Low Frequency Boundary (sensor frequency should never fall below
'this value regardless of environmental changes)
Dim F_Low(8) = { 300, 300, 300, 300, 300, 300, 300, 300}
'High Frequency Boundary (sensor frequency should never exceed
'this value regardless of environmental changes)
Dim F_High(8) = { 6000, 6000, 6000, 6000, 6000, 6000, 6000, 6000}
'Output Format - Hz vs. Hz^2 :: Value of 0 - measured frequency is given in units of Hz,
'Value of 1 - measured frequency is squared and given in units of Hz^2
Dim OutForm(8) As Long = { 0, 0, 0, 0, 0, 0, 0, 0}
'Multiplier (factor) to be applied to sensor output frequency
Dim Mult(8) = { 1.0, 1.0, 1.0, 1.0, 1.0, 1.0, 1.0, 1.0}
'Offset (shift) to be applied to sensor output frequency
Dim Off(8) = { 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0}
'Steinhart-Hart coefficients [A,B,C] for converting thermistor ohms to
'temperature in Celsius. Specifying zeroes for A,B,C results in a reading in Ohms.
Dim SteinA(8) = { 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0}
Dim SteinB(8) = { 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0}
Dim SteinC(8) = { 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0}

'Rainflow configuration (not used in this program, but required as configuration arguments)
Dim RFMB(8) As Long = { 20, 20, 20, 20, 20, 20, 20, 20}
Dim RFAB(8) As Long = { 20, 20, 20, 20, 20, 20, 20, 20}
Dim RFLl(8) = { 400.0, 400.0, 400.0, 400.0, 400.0, 400.0, 400.0, 400.0}
Dim RFHL(8) = { 4000.0, 4000.0, 4000.0, 4000.0, 4000.0, 4000.0, 4000.0, 4000.0}
Dim RFHY(8) = { 0.005, 0.005, 0.005, 0.005, 0.005, 0.005, 0.005, 0.005}
Dim RFOF(8) As Long = { 100, 100, 100, 100, 100, 100, 100, 100}

'Configure the CDM-VW300 series device. Use the variable declared above.
CDM_VW300Config(1,CPI_ADDR,0,Enable(),Max_AMP(),F_Low(),F_High(), _
OutForm(),Mult(),Off(), SteinA(),SteinB(),SteinC(), _
RFMB(),RFAB(),RFLl(),RFHL(),RFHY(),RFOF())

DataTable (static,true,-1)
'Static Frequency reading (1Hz output)
Sample (8,StaticFreq(),IEEE4)
'Thermistor reading : Ohms or DegC
Sample (8,Therm(),IEEE4)
'Standard Deviation of dynamic readings taken during the most recent second
Sample (8,DynStdDev(),IEEE4)
EndTable

DataTable (dynamic,true,-1)
'Dynamic Frequency (20Hz output)
Sample (8,Freq(),IEEE4)
'Diagnostic code for the current dynamic reading

```

```

Sample      (8,Diag(),IEEE4)
EndTable

BeginProg

'20 Hz/50msec scan rate
Scan(50,msec,500,0)

    CDM_VW300Dynamic(CPI_ADDR,Freq(),Diag()) 'Get dynamic readings
    CallTable dynamic

    If TimeIntoInterval (0,1,Sec) Then 'Process static data only once per second
        CDM_VW300Static(CPI_ADDR,StaticFreq(),Therm(),DynStdDev()) 'Get static readings
        CallTable static
    EndIf

NextScan

EndProg

```

F.2 50 Hz Measurement Example — Three CDM-VW305s, 24 Channels

```
'===50Hz-3Devices8Ch_4-25-13.CR3===  
'CR3000 datalogger  
'CDM-VW305 vibrating wire analyzer  
'Program to read 50-Hz dynamic data from three CDM-VW305 analyzers (8x3=24 channels)  
  
'IMPORTANT -- Check that the CPI addresses coded on the following lines matches the addresses  
'reported for each attached analyzer in the DevConfig or DVWTool software.  
Const CPI_ADDR1 = 5 '<<<<<<<<<<<Const CPI_ADDR2 = 15  
Const CPI_ADDR3 = 25  
  
Public Freq1(8), Freq2(8), Freq3(8) 'dynamic frequencies  
Public Diag1(8) As Long, Diag2(8) As Long, Diag3(8) As Long 'diagnostic codes  
  
Public StaticFreq1(8), StaticFreq2(8), StaticFreq3(8) 'Static (1Hz output) frequencies  
Public Therm1(8), Therm2(8), Therm3(8) 'Thermistor readings  
Public DynStdDev1(8), DynStdDev2(8), DynStdDev3(8) 'Dynamic Standard Deviations  
  
'Setup for First Device  
'  
CH1 CH2 CH3 CH4 CH5 CH6 CH7 CH8  
--- --- --- --- --- --- --- ---  
Dim Enable1(8) As Long = { 1, 1, 1, 1, 1, 1, 1, 1}  
Dim Max_AMP1(8) = { 0.002, 0.002, 0.002, 0.002, 0.002, 0.002, 0.002, 0.002}  
Dim F_Low1(8) = { 300, 300, 300, 300, 300, 300, 300, 300}  
Dim F_High1(8) = { 6000, 6000, 6000, 6000, 6000, 6000, 6000, 6000}  
Dim OutForm1(8) As Long = { 0, 0, 0, 0, 0, 0, 0, 0}  
Dim Mult1(8) = { 1.0, 1.0, 1.0, 1.0, 1.0, 1.0, 1.0, 1.0}  
Dim Off1(8) = { 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0}  
Dim SteinA1(8) = { 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0}  
Dim SteinB1(8) = { 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0}  
Dim SteinC1(8) = { 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0}  
  
'Setup for Second Device  
Dim Enable2(8) As Long = { 1, 1, 1, 1, 1, 1, 1, 1}  
Dim Max_AMP2(8) = { 0.002, 0.002, 0.002, 0.002, 0.002, 0.002, 0.002, 0.002}  
Dim F_Low2(8) = { 300, 300, 300, 300, 300, 300, 300, 300}  
Dim F_High2(8) = { 6000, 6000, 6000, 6000, 6000, 6000, 6000, 6000}  
Dim OutForm2(8) As Long = { 0, 0, 0, 0, 0, 0, 0, 0}  
Dim Mult2(8) = { 1.0, 1.0, 1.0, 1.0, 1.0, 1.0, 1.0, 1.0}  
Dim Off2(8) = { 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0}  
Dim SteinA2(8) = { 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0}  
Dim SteinB2(8) = { 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0}  
Dim SteinC2(8) = { 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0}  
  
'Setup for Third Device  
Dim Enable3(8) As Long = { 1, 1, 1, 1, 1, 1, 1, 1}  
Dim Max_AMP3(8) = { 0.002, 0.002, 0.002, 0.002, 0.002, 0.002, 0.002, 0.002}  
Dim F_Low3(8) = { 300, 300, 300, 300, 300, 300, 300, 300}  
Dim F_High3(8) = { 6000, 6000, 6000, 6000, 6000, 6000, 6000, 6000}  
Dim OutForm3(8) As Long = { 0, 0, 0, 0, 0, 0, 0, 0}
```

```

Dim Mult3(8) = { 1.0, 1.0, 1.0, 1.0, 1.0, 1.0, 1.0, 1.0}
Dim Off3(8) = { 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0}
Dim SteinA3(8) = { 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0}
Dim SteinB3(8) = { 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0}
Dim SteinC3(8) = { 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0}

'Shared rainflow configuration (not used, but required as configuration arguments)
Dim RFMB(8) As Long = { 20, 20, 20, 20, 20, 20, 20, 20}
Dim RFAB(8) As Long = { 20, 20, 20, 20, 20, 20, 20, 20}
Dim RFL(8) = { 400.0, 400.0, 400.0, 400.0, 400.0, 400.0, 400.0, 400.0}
Dim RFHL(8) = {4000.0,4000.0,4000.0,4000.0,4000.0,4000.0,4000.0,4000.0}
Dim RFHY(8) = { 0.005, 0.005, 0.005, 0.005, 0.005, 0.005, 0.005, 0.005}
Dim RFOF(8) As Long = { 100, 100, 100, 100, 100, 100, 100, 100}

'Configure First Device
CDM_VW300Config(1,CPI_ADDR1,0,Enable1(),Max_AMP1(),F_Low1(),F_High1(), _
OutForm1(),Mult1(),Off1(), SteinA1(),SteinB1(),SteinC1(), _
RFMB(),RFAB(),RFL(),RFHL(),RFHY(),RFOF())
'Configure Second Device
CDM_VW300Config(1,CPI_ADDR2,0,Enable2(),Max_AMP2(),F_Low2(),F_High2(), _
OutForm2(),Mult2(),Off2(), SteinA2(),SteinB2(),SteinC2(), _
RFMB(),RFAB(),RFL(),RFHL(),RFHY(),RFOF())
'Configure Third Device
CDM_VW300Config(1,CPI_ADDR3,0,Enable3(),Max_AMP3(),F_Low3(),F_High3(), _
OutForm3(),Mult3(),Off3(), SteinA3(),SteinB3(),SteinC3(), _
RFMB(),RFAB(),RFL(),RFHL(),RFHY(),RFOF())

DataTable (static,true,-1)
Sample (8,StaticFreq1(),IEEE4)
Sample (8,Therm1(),IEEE4)
Sample (8,DynStdDev1(),IEEE4)
Sample (8,StaticFreq2(),IEEE4)
Sample (8,Therm2(),IEEE4)
Sample (8,DynStdDev2(),IEEE4)
Sample (8,StaticFreq3(),IEEE4)
Sample (8,Therm3(),IEEE4)
Sample (8,DynStdDev3(),IEEE4)
EndTable

DataTable (dynamic,true,-1)
Sample (8,Freq1(),IEEE4)
Sample (8,Diag1(),IEEE4)
Sample (8,Freq2(),IEEE4)
Sample (8,Diag2(),IEEE4)
Sample (8,Freq3(),IEEE4)
Sample (8,Diag3(),IEEE4)
EndTable

BeginProg

'50 Hz/20msec scan rate
Scan(20,msec,500,0)

CDM_VW300Dynamic(CPI_ADDR1,Freq1(),Diag1()) 'Get dynamic readings
CDM_VW300Dynamic(CPI_ADDR2,Freq2(),Diag2())
CDM_VW300Dynamic(CPI_ADDR3,Freq3(),Diag3())
CallTable dynamic

If TimeIntoInterval (0,1,Sec) Then
CDM_VW300Static(CPI_ADDR1,StaticFreq1(),Therm1(),DynStdDev1()) 'Get static readings
CDM_VW300Static(CPI_ADDR2,StaticFreq2(),Therm2(),DynStdDev2())
CDM_VW300Static(CPI_ADDR3,StaticFreq3(),Therm3(),DynStdDev3())
CallTable static
EndIf

NextScan

EndProg

```

F.3 50 Hz Diagnostic Example — One CDM-VW300, Two Geokon 4000 Sensors with FieldCal()

```

'==Geokon4000-50Hz2ChDiags_4-25-13.CR3===
'CR3000 datalogger
'CDM-VW300 vibrating wire analyzer
'Program to read 50-Hz diagnostic data from one CDM-VW300 analyzer measuring two Geokon 4000
'strain gages.
'Diagnostic code evaluation example -- use counters to track diagnostic flag counts.

'IMPORTANT -- Check that the CPI address coded on the following line matches the address
'reported for the attached analyzer in the DevConfig or DVWTool software.
Const CPI_ADDR = 1 '<<<<<<<<<<SET CPI ADDRESS HERE

'Constants specific to the Geokon 4000 strain gages
Const GageFactor = 4.062 'G = 4.062 - Gage factor taken from sensor manual
Const NomBatchFactor = 0.97 'B=0.97 - Batch Factor taken from cal sheet provided with sensors

'Output will be in Strain, not Digits nor Frequency
Public Strain(2) : Units Strain() = Microstrain 'Measured strain output in units of Microstrain
Public StrainBL(2) : Units Strain() = Microstrain 'Baseline/offset strain reading in units of
'Microstrain (for calibration)

Public DCode(2) As Long 'Dynamic diagnostic code

Public StaticStrain(2) : Units StaticStrain() = Microstrain 'Static (1Hz) strain reading in
'microstrain
Public StaticDigits(2) 'Calculated Static (1Hz) Digits output (for troubleshooting)
Public StaticFreq(2) : Units StaticFreq() = Hz 'Calculated Frequency (1Hz) from static
'digits (for troubleshooting).

Public Temp(2) : Units Temp() = DegC ' Temperature in DegC
Public TempBL(2) : Units TempBL() = DegC ' Temperature Baseline in DegC

Public StrainStdDev(2) : Units StrainStdDev() = Microstrain 'StdDev of dynamic strain readings

Public ZeroMode 'Mode variable for baseline/offset zeroing calibration

'Diagnostic Code flags
Public ExciteStr(2) : Units ExciteStr() = Volts 'Excitation strength on the VW channel in volts
Const VoltFactor = 1/42.5 'For converting 0-255 range of excitation into 0 to 6V
Public LowAmpCount(2) As Long
Public HighAmpCount(2) As Long
Public LowFreqCount(2) As Long
Public HighFreqCount(2) As Long

Public ResetCounts As Boolean

'Configure the CDM-VW300 device
Dim Enable(2) As Long = { 1, 1}
Dim Max_AMP(2) = { 0.002, 0.002}
Dim F_Low(2) = { 300, 300}
Dim F_High(2) = { 6000, 6000}
'Use Hz^2 (1) instead of Hz (0) so we can get to digits
Dim OutForm(2) As Long = { 1, 1}
'Use a multiplier of 0.001 to divide by 1000 and get digits, then scale further to get Strain.
Dim Mult(2) = { 0.001*GageFactor*NomBatchFactor,
0.001*GageFactor*NomBatchFactor } 'Digits (Hz^2/1000) times G times B results in strain
Dim Off(2) = { 0.0, 0.0}
'Use Steinhart-Hart coefficients To get Thermistor output in DegC
Dim SteinA(2) = {1.4051E-3, 1.4051E-3}
Dim SteinB(2) = { 2.369E-4, 2.369E-4}
Dim SteinC(2) = { 1.019E-7, 1.019E-7}
Dim RFMB(2) As Long = { 20, 20}
Dim RFAB(2) As Long = { 20, 20}
Dim RFL(2) = { 400.0, 400.0}
Dim RFHL(2) = {4000.0,4000.0}
Dim RFHY(2) = { 0.005, 0.005}
Dim RFOF(2) As Long = { 100, 100}

CDM_VW300Config(0,CPI_ADDR,0,Enable(),Max_AMP(),F_Low(),F_High(), _
OutForm(),Mult(),Off(),SteinA(),SteinB(),SteinC(), _
RFMB().RFAB().RFL().RFHL().RFHY().RFOF())

```



```

DataTable (static,true,-1)
  Sample (2,StaticStrain(),IEEE4)
  Sample (2,Temp(),IEEE4)
  Sample (2,StrainStdDev(),IEEE4)
EndTable

DataTable (slow,true,-1)
  DataInterval (0,1,Min,10)
  Average (2,StaticStrain(),IEEE4,False)
  Average (2,Temp(),IEEE4,False)
  Average (2,StrainStdDev(),IEEE4,False)
  Average (2,ExciteStr(),IEEE4,False)
  Sample (2,LowAmpCount(),UINT2)
  Sample (2,HighAmpCount(),UINT2)
  Sample (2,LowFreqCount(),UINT2)
  Sample (2,HighFreqCount(),UINT2)
EndTable

DataTable (dynamic,true,-1)
  Sample (2,Strain(),IEEE4)
  Sample (2,DCode(),IEEE4)
  Sample (2,ExciteStr(),IEEE4)
EndTable

DataTable(CalHist,NewFieldCal,-1)
  SampleFieldCal
EndTable

BeginProg

'50 Hz/20msec scan rate
Scan(20,msec,500,0)

  CDM_VW300Dynamic(CPI_ADDR,Strain(),DCode()) 'Get unshifted strain

  'Now shift the given Strain using the Baseline/Offset value
  Strain(1) = Strain(1) + StrainBL(1) : Strain(2) = Strain(2) + StrainBL(2)

  'Zeroing calibration for Geokon 4000 Vibrating Wire Strain Gage
  'Strain offset and Temperature baseline readings
  FieldCal(0,Strain(),2,0,StrainBL(),ZeroMode,0,1,100) 'Calibrate for 2 seconds
  FieldCal(4,Temp(),2,0,TempBL(),ZeroMode,0,1,100)

  'Process the Diagnostic codes to keep an eye on the health of the monitored date
  ExciteStr(1) = ( DCode(1) AND 255) * VoltFactor : ExciteStr(2) = ( DCode(2) AND 255) * _
  VoltFactor
  If (DCode(1) AND 256) Then LowAmpCount(1) += 1
  If (DCode(2) AND 256) Then LowAmpCount(2) += 1
  If (DCode(1) AND 512) Then HighAmpCount(1) += 1
  If (DCode(2) AND 512) Then HighAmpCount(2) += 1
  If (DCode(1) AND 1024) Then LowFreqCount(1) += 1
  If (DCode(2) AND 1024) Then LowFreqCount(2) += 1
  If (DCode(1) AND 2048) Then LowFreqCount(1) += 1
  If (DCode(2) AND 2048) Then LowFreqCount(2) += 1

  If ResetCounts Then
    LowAmpCount(1) = 0 : LowAmpCount(2) = 0
    HighAmpCount(1) = 0 : HighAmpCount(2) = 0
    LowFreqCount(1) = 0 : LowFreqCount(2) = 0
    HighFreqCount(1) = 0 : HighFreqCount(2) = 0
    ResetCounts = False
  EndIf

  CallTable dynamic
  CallTable CalHist
  CallTable slow

  If TimeIntoInterval (0,1,Sec) Then
    CDM_VW300Static(CPI_ADDR,StaticStrain(),Temp(),StrainStdDev()) 'Obtain un-shifted
    'static strain.

    'Calculate static digits reading (for troubleshooting)
    StaticDigits(1) = StaticStrain(1)/GageFactor/NomBatchFactor
    StaticDigits(2) = StaticStrain(2)/GageFactor/NomBatchFactor
    'Now shift the given StaticStrain using the Offset/Baseline reading to obtain
    'Final/adjusted StaticStrain.
    StaticStrain(1) = StaticStrain(1) + StrainBL(1) : StaticStrain(2) = StaticStrain(2) + _
    StrainBL(2)
    'Calculate static frequency from static digits (for troubleshooting)

```

```
StaticFreq(1) = SQR(StaticDigits(1)*1000) : StaticFreq(2) = SQR(StaticDigits(2)*1000)

  CallTable static
EndIf

NextScan
EndProg
```


Appendix G. Supplemental Hardware and Software

G.1 Dataloggers

If you wish to use an older CR800, CR1000, or CR3000 datalogger (not recommended), you need the old version of this manual, *Instruction Manual CDM-VW300 Series Dynamic Vibrating Wire Analyzers Revision: 11/13*, which is available at <https://www.campbellsci.com/old-manuals>. Be aware of the following:

- CR800, CR1000, and CR3000 dataloggers require use of the SC-CPI interface, which is an additional piece of hardware *not* included in most CDM-VW300 purchases.
- The CR800, CR1000, and CR3000 have restricted analyzer, vibrating wire sensor, and measurement rate capacities.
- Use the latest CR800, CR1000, CR3000, SC-CPI, and CDM-VW300 operating systems.

G.2 Datalogger Support Software

RTDAQ and PC400 software can be used as the datalogger support software in a limited capacity compared with *LoggerNet*.

G.3 Items Often Sold With the CDM-VW300

The following are items you may need that must be purchased separately:

- pn 13947, *Wall Charger 12Vdc 800mA Output, 100-240Vac*

Power supply for use only during the bench test procedure. You can provide a power supply that has equal or greater capacity.

- pn 29370, *CPI Network Kit*.

27555 Cable Data USB 2.0 Type A — USB cable that connects the CDM-VW300 to a PC.

28558 CON MODULAR RJ45 RESISTOR — CPI terminator; a resistive device that may need to be plugged into the last port in a CPI daisy-chain topology. Most daisy-chain networks do not require the terminator.

28899 CABLE DATA CAT6 ETHERNET — A short cable with RJ45 terminations meant to connect the CR6 to the first CDM-VW300 in the daisy-chain topology.

29492 ADH TAPE ELECTRICAL .500 — You can use this tape to mark the ends of the CPI cables if you wish to differentiate them from Ethernet cables.

31440 SUB POWER CABLE SET — Wire for connecting power to the CDM-VW300. Cut to length.

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