INSTRUCTION MANUAL

CDM-VW300 Series Dynamic Vibrating-Wire Analyzers

Revision: 11/13

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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.

Appendices

Figures

Tables

CDM-VW300 Series Dynamic Vibrating-Wire Analyzers

Configuring a dynamic vibrating-wire measurement system requires an integrated system-wide approach. Please review this manual before connecting hardware together or to the PC. The ResourceDVD*, which ships free of charge with most Campbell Scientific instrumentation orders, contains the following tools that will help you configure a dynamic vibrating-wire analyzer system:*

- *A copy of this manual*
- DVWTool Dynamic Vibrating-Wire Toolbox *software for CDM-VW300 support*
- DevConfig Device Configuration Utility *software*
- *Required datalogger operating systems*

Other support information and downloads are available at www.campbellsci.com/cdm-vw300-support.

1. Introduction

Vibrating-wire sensors are commonly used in geotechnical or structural monitoring applications to measure strain, load, tilt, inclination, temperature, pressure, extension, and crack movement. CDM-VW300 Series Dynamic Vibrating-Wire Analyzers facilitate sub-second measurement of vibrating-wire sensors. These analyzers perform advanced excitation, spectral analysis, and digital signal processing to obtain high-accuracy measurements. Data are stored on a Campbell Scientific datalogger, which is normally used to control the system in field installations.

The CDM-VW300 has two modes of operation:

- Laboratory mode
  - Manual operation
  - Does not require a datalogger
  - Requires a PC
  - Used in short-term evaluation
  - Real-time data and metadata are monitored with PC
- Field mode
  - Automated operation
  - Requires a datalogger
  - PC used only for setup and collection of data from datalogger
  - Used in long-term monitoring applications
  - Time-series data and metadata stored in datalogger memory

Two analyzer models are available in the CDM-VW300 series:

- CDM-VW300 (two channels)
- CDM-VW305 (eight channels)

See TABLE 5-1, *CDM / Datalogger Compatibility*, in Section 5, *Specifications*, for datalogger compatibility information.

Other than a few clearly noted exceptions, any discussion in this manual of the CDM-VW300 also applies to the CDM-VW305.

Before using the CDM-VW300, please study

- Section 2, *Cautionary Statements*
- Section 3, *Initial Inspection*

Detailed installation, operation, and troubleshooting information can be found in the remaining sections.

2. Cautionary Statements

- CAUTION — Do not connect power to the system until it is completely assembled.

- IMPORTANT — Do not connect the CDM-VW300 analyzer or SC-CPI interface to a PC until AFTER installing *DVWTool* or *DevConfig* on the PC. Consult Section 7.1.1, *Software and Driver Installation,* for more information.

- All references to *DVWTool* mean *Dynamic Vibrating-Wire Tool Box* software version 1.0 or later. *DVWTool* is available on current versions of the *ResourceDVD* that ships with CDM-VW300 series analyzers. All references to *DevConfig* mean *Device Configuration Utility* software version 2.04 or later. *DevConfig* is available from the these three sources:
    - *ResourceDVD* shipped with CDM-VW300 series analyzers
    - *www.campbellsci.com/downloads* (no charge)
    - Installations of *LoggerNet*, *PC400*, *PC200W*, or *RTDAQ* software. Check the **Help** | **About** screen in *DevConfig* for the version number.

3. Initial Inspection

- CDM-VW300 series analyzers ship with,
    - 1 each pn 29389 CDM Parts Kit
    - 1 each *ResourceDVD*, which contains *DVWTool* and current *DevConfig* software.

- Upon receipt of the CDM-VW300, inspect the packaging and contents for damage. File damage claims with the shipping company.

- Thoroughly check all packaging material for product that may be concealed inside it. Check model and part numbers, and product descriptions against the shipping documents. Model or part numbers are found on each product. Cable numbers are normally found at the end of the cable that connects to the measurement device. Check that expected cable lengths were received. Contact Campbell Scientific immediately concerning any discrepancies.

4. Overview

Single-coil vibrating-wire sensors are preferred in many applications because they are stabile, accurate, and durable. CDM-VW300 Series Dynamic Vibrating-Wire Analyzers make accurate high-speed measurements of the resonant frequencies of these sensors at sub-second intervals using advanced excitation and signal processing techniques, including spectral analysis. Resonant frequency data are passed with diagnostics to a Campbell Scientific datalogger. Applications include characterization of events that require rapid measurements and data storage, and measurement of sensor signals too weak to be measured with other instrumentation. See Appendix A, *Measurement Theory*, for more information.

Dynamic vibrating-wire measurements require a complete system of instrumentation. This manual focuses on the use of CDM-VW300 series analyzers, but it also gives basic guidance on system configuration.

4.1 Channel Allocations

As illustrated in FIGURE 4-1, the CDM-VW300 simultaneously measures two vibrating-wire sensors. FIGURE 4-2 shows that the CDM-VW305 has the capacity to measure eight sensors. When more than eight channels are needed, multiple devices are attached to the same datalogger through the CPI bus. See Section 7.7.7, *Maximum Number of Analyzers on a Datalogger*, and Appendix C, *CDM Devices and CPI Bus*, for details on connecting multiple analyzers to a CPI bus.

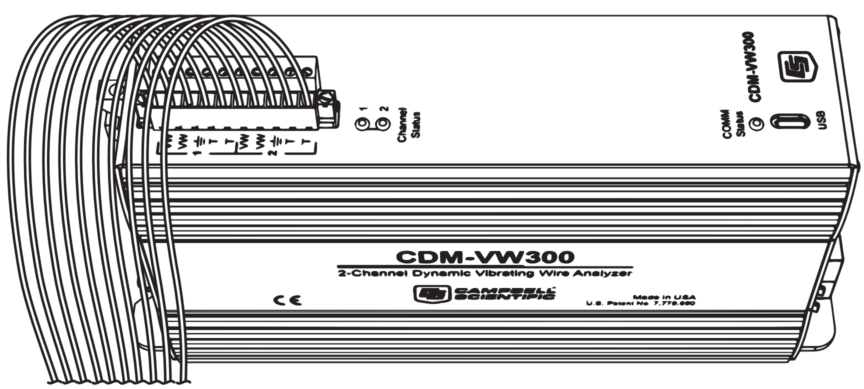


FIGURE 4-1. Two-channel CDM-VW300 wiring panel

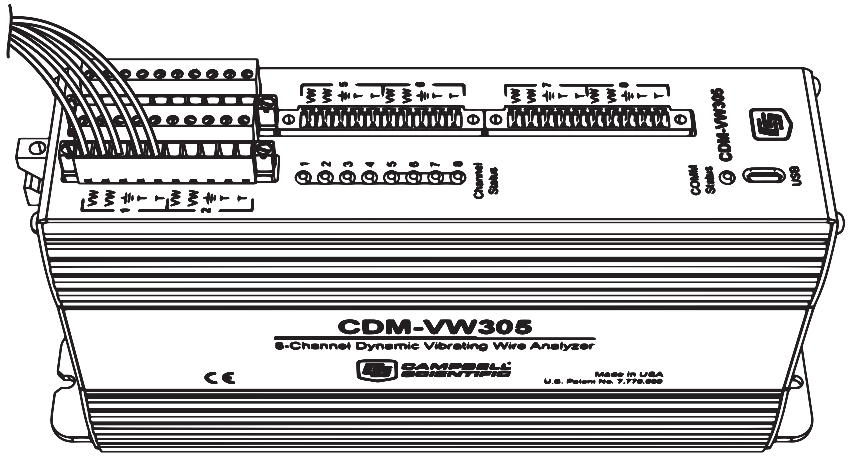


FIGURE 4-2. Eight-channel CDM-VW305 wiring panel

4.2 Measurement Rates

CDM-VW300 analyzers use patented techniques to measure sensors at rates from 1 to 333.3 Hz. Systems that exclusively require rates slower than 1 Hz should use a Campbell Scientific AVW200-Series Vibrating-Wire Spectrum Analyzer.

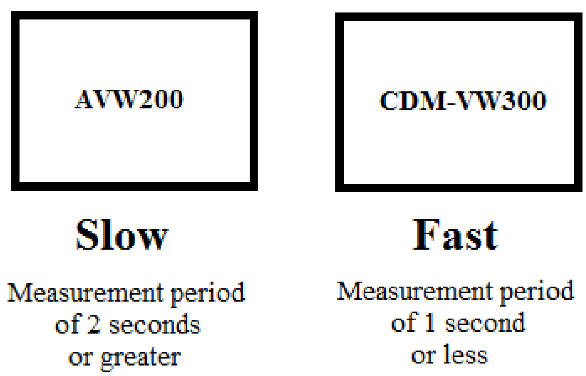


FIGURE 4-3. Measurement speeds of the AVW200 and CDM-VW300 analyzers

4.3 Integrated Thermistor Measurement

Many vibrating-wire sensors include an integrated thermistor to allow for temperature compensation of the vibrating-wire measurement. The CDM-VW300 supports thermistor measurements and the associated temperature compensation required in some applications.

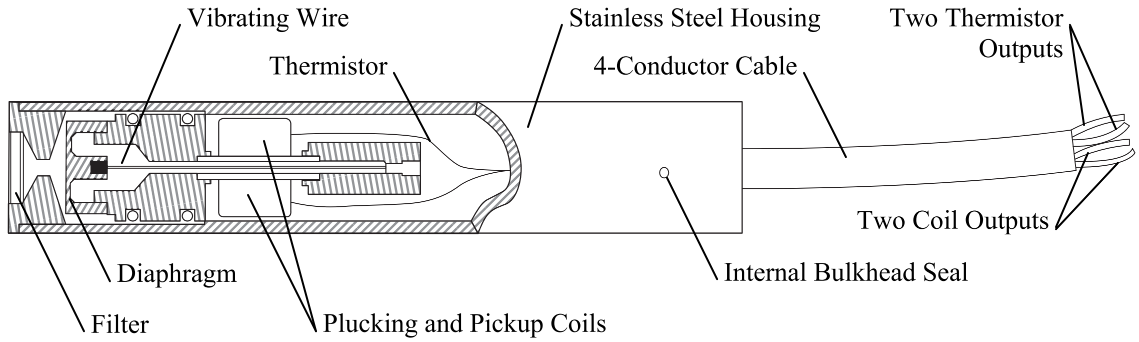


FIGURE 4-4. Single-coil vibrating-wire sensor including coil and thermistor outputs

4.4 Laboratory Mode

Laboratory mode allows for examination and validation of specific measurements types without a datalogger, such as might occur before field deployment. As shown in FIGURE 4-5, a connection is made from the CDM-VW300 to a personal computer using a USB cable. Campbell Scientific *DVWTool* software on the PC enables observation of sensor outputs and configuration of the CDM-VW300 to measure sensors. Specific procedures can be found in Section 6.1.2, *Laboratory-Mode Installation Procedure*.

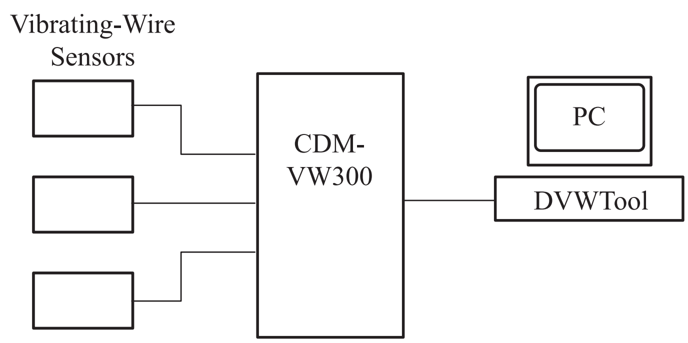


FIGURE 4-5. Laboratory-mode measurement system diagram

4.5 Field Mode

Field mode is used for long-term measurement and data acquisition. As shown in FIGURE 4-6, a connection is made from the CDM-VW300 to a Campbell Scientific datalogger through the SC-CPI interface. A Campbell Scientific datalogger with a customized CRBasic program configures, controls, and collects data from the CDM-VW300. Specific installation procedures are found in Section 6.2.2, *Field-Mode Installation Procedure*.

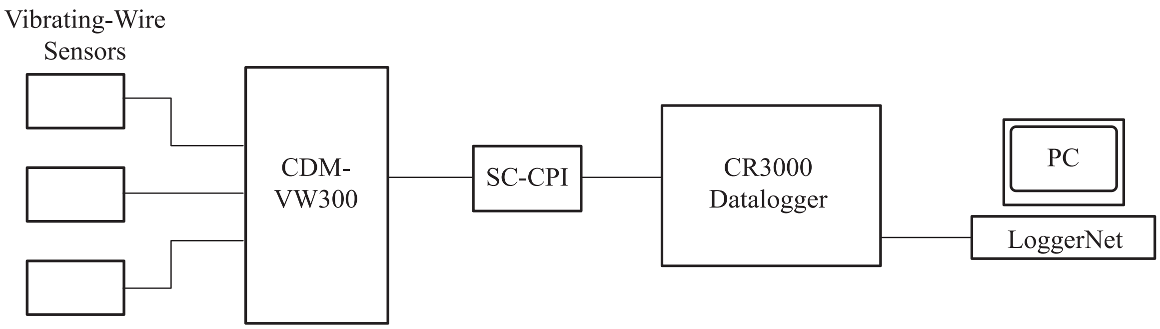


FIGURE 4-6. Field-mode data-acquisition system diagram

4.6 Data Uses

Users should consult authoritative sources concerning the use of vibrating-wire data in structural analysis applications. Following is a short introduction to the use of data made available by CDM-VW300 series analyzers.

4.6.1 Static Measurements

Each sensor is measured for a static frequency once per second. The static frequency is used to obtain a result with finer spectral bin resolution than that which can be achieved at the dynamic measurement rates. This measurement can be helpful in detecting the rare case, for example, in which a noise frequency very near the resonant frequency affects dynamic sampling measurements.

4.6.2 Dynamic Measurements

Each analyzer can be configured in a 20, 50, 100, 200, or 333.3 Hz sampling mode. By capturing multiple readings each second from a vibrating-wire sensor, rapid changes or events can be captured and evaluated. Due to the Nyquist sampling theorem, only responses equal to or less than half of the sampling frequency can be detected and characterized. Event-based data capture techniques programmed into the controlling datalogger can be helpful to ensure useful data are captured under the right event conditions. In this way, storage and retrieval of less-useful data are avoided.

4.6.3 Thermistor Measurements

Each vibrating-wire sensor input channel has inputs for the thermistor that is usually built into a vibrating-wire sensor. The temperature measurement is normally used to correct the frequency measurement for temperature changes. A 24-bit measurement circuit ensures high-accuracy resistance measurements, which are converted to temperature. Guidance about the impact of temperature on the vibrating wire is usually provided by the manufacturer in documentation provided with each individual sensor. Contact the sensor manufacturer if more information is required.

4.6.4 Rainflow Histograms

Rainflow histograms are 3-D representations of the rainflow counting algorithm of Matsuiski and Endo (1968). Rainflow histograms can be used to monitor fatigue levels of structures under stress, such as components of a large-scale transportation bridge. The histograms are calculated by the CDM-VW300 analyzer to ease the processing burden required of the controlling datalogger.

CRBasic Help topic for the **Rainflow()** instruction has more information about rainflow histograms.

4.6.5 System Diagnostics

Several diagnostic values will help you scrutinize basic CDM-VW300 measurements. Excitation level and low / high frequency or amplitude warnings are provided for each dynamic measurement. A standard deviation is provided once each second.

Excitation level is bounded by setting the amplitude at which the wire in the sensor is to be maintained. That figure is reported so that excitation levels can be monitored. If the analyzer-sensor system experiences a low amplitude, high amplitude, low-frequency, or high frequency condition, that information is also provided.

Once each second, a standard deviation of a dynamic measurement is provided. Unexplained changes in the standard deviation from baseline levels may indicate noise or other interference.

5. Specifications

5.1 Features

- Measurement of standard, single-coil circuit, vibrating-wire sensors
- Dynamic-sampling rates of 20 to 333.3 Hz
- On-board frequency-output conversion
- Two (CDM-VW300) or eight (CDM-VW305), simultaneously-sampled channels per module
- Time synchronization of multiple modules using one datalogger
- Thermistor input for each vibrating-wire channel measured at 1 Hz
- On-board temperature conversion
- Rainflow-histogram compilation
- Superior noise immunity and effective measurement resolution (precision)
- Continuous resonant vibration in the sensor
- Spectral analysis method protected under U.S. patent no. 7,779,690. An additional U.S. patent that relates to the dynamic vibrating-wire measurement technique is pending.

5.2 Specifications

Electrical specifications are valid from –25 to 50 °C unless otherwise specified. Non-condensing environment required. Specifications are subject to change.

Compatibility:

TABLE 5-1. CDM-VW300 / Datalogger Compatibility

Datalogger	Connect with SC-CPI[1] Module	Maximum Measurement Rate (Hz)	Maximum CDM-VW305 Analyzers at Max Rate / Maximum Channels
CR3000	*	100[2]	1/8
–	–	50	3/24
–	–	20	6/48
CR800 / CR1000	*	50	1/8
–	–	20	4/32

Frequency measurement: A vibrating-wire circuit is excited and measured through the same coil connection. Sinusoidal excitation persists for a few cycles of the wire oscillation. The wire is maintained in a continuously vibrating state. Excitation voltage varies automatically to maintain the desired return signal strength.

Dynamic measurement rates: 20, 50, 100, 200[3], and 333.3[3] Hz

Accuracy: ±(0.005% of reading + effective measurement resolution)

Input resistance: 5 kΩ

Excitation voltage

Range: 0 to ±3 V (6 V peak-to-peak)

Resolution: 26 mV

Sensor resonant frequency range:

TABLE 5-2. CDM-VW300/305 Sensor Resonant Frequency Range (Hz)		
Sample Rate	**Minimum Sensor Frequency**	**Maximum Sensor Frequency**
20	290	6000
50	290	6000
100	580	6000
200[3]	1150	6000
333.3[3]	2300	6000

Effective resolution (precision):

TABLE 5-3. CDM-VW300/305 Effective Frequency Measurement Resolution[4]	
Sample Rate (Hz)	**Noise Level (Hz RMS)[5]**
1	0.005
20	0.008
50	0.015
100	0.035
200[3]	0.11
333.3[3]	0.45

Sustained input voltage without damage: –0.5 to 7.1 V

Temperature measurement: Temperature measurement is available for sensors so equipped. Excitation and half-bridge measurement circuits are integrated into the CDM-VW300 and CDM-VW305 analyzers.

Accuracy: 0.15% of reading[6]

Resolution: 0.002 Ω RMS @ 5 kΩ thermistor resistance

Bridge resistor: 4.99 kΩ 0.1%

Excitation voltage: 1.5 V

Measurement rate: 1 Hz

Operating temperature	
Standard:	–25° to 50°C
Extended:	–55° to 85°C
Power requirement	
Voltage:	9.6 to 32 Vdc
Typical current drain	
CDM-VW300:	115 mA @ 12 Vdc
CDM-VW305:	190 mA @ 12 Vdc
Output	
CPI:	Connects to datalogger. Baud rate selectable from 50 kbps to 1 Mbps. Cable length varies depending on baud rate, number of nodes, cable quality, and noise environment. 2500 ft maximum.
USB:	Connects to PC. USB 2.0 full speed. Provided for configuration, updates, and communication with *DVWTool* software. The USB port does not support collection of time-series data.
Weight:	< 1 kg, < 2 lb
Dimensions:	20.3 x 12.7 x 5.1 cm (8 x 5 x 2 in)
Mounting:	One-inch grid. Optional DIN rail mounting is available using Campbell Scientific pn 29388.

[1]SC-CPI module connects to terminals C1, C2, C3 (not SDM-C1, SDM-C2, SDM-C3).

[2]CR3000 is the recommended datalogger.

[3]These rates available only on PC with fast processor using USB cable in lab mode.

[4]The effective resolution (precision) of the output is limited by noise and varies with the sample rate.

[5]Typical values for a 2.5 kHz resonant sensor.

[6]Thermistor accuracy and resistance of the wire should be considered as additional errors.

6. Installation

The CDM-VW300 system is designed for use with a PC or as part of a field data-acquisition system using a Campbell Scientific CR3000 datalogger. When sensors are sampled at slower rates equal to or less than 50 Hz, a CR1000 or CR800 datalogger can be used.

Pre-configure and test the system before taking it to the field. Issues that are unresolved before placing instrumentation in the field will usually be more difficult to resolve. Data-acquisition systems, from the sensors to the telecommunications equipment, are complex. Campbell Scientific equipment and software are among the best available, but the integration process can be demanding and involves trial and error; contingencies should be developed to address possible problems. Do the bulk of the integration work in a comfortable and dry location that has a communications link with Campbell Scientific during regular business hours. If you are experienced with field deployments, set aside at least a full day for pre-configuration work. Otherwise, set aside three to seven days for system development before travelling to the field.

6.1 Laboratory-Mode Installation

IMPORTANT — Do not connect the CDM-VW300 analyzer or SC-CPI interface to a PC until AFTER installing *DVWTool* 1.0 or later or *DevConfig* 2.04 or later. Consult Section 7.1.1, *Software and Driver Installation,* for more information.

Laboratory mode allows for easy examination and validation of measurements. To ensure a successful field deployment, perform this procedure before stepping through the field-mode installation procedure of Section 6.2, *Field-Mode Installation*.

As illustrated in the following figure, a connection is made directly between the CDM-VW300 and a PC via USB cable. No datalogger is required. *DVWTool* support software is used to configure, communicate with, and obtain sensor readings from the CDM-VW300.

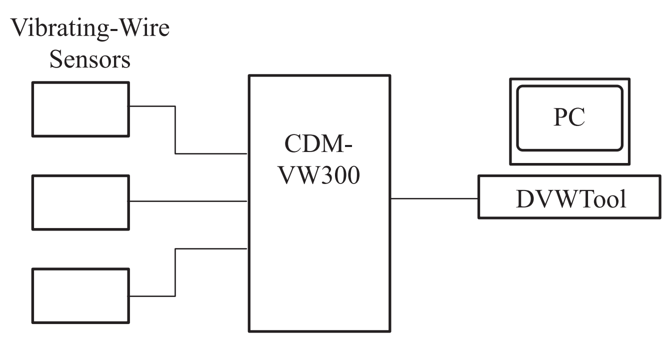


FIGURE 6-1. Laboratory-mode measurement system

6.1.1 Laboratory-Mode Installation Equipment

The following equipment is used in a laboratory-mode installation:

- Vibrating-wire sensors
- CDM-VW300 measurement module
- PC
- *DVWTool* software

6.1.2 Laboratory-Mode Installation Procedure

The following procedure sets up the measurement system in laboratory mode:

1. Install *DVWTool* software on the PC. Do this before connecting the CDM-VW300 to the PC. *DVWTool* installation automatically installs drivers for the CDM-VW300 USB connection.

   Reference Section 7.1.1, *Software and Driver Installation*.

2. Connect 12 Vdc power to the CDM-VW300 as shown in FIGURE 6-2.

   Reference Section 7.4, *Using Power Supplies*.

   Campbell Scientific pn 29796, a 24 Vdc, 1670 mA wall charger, is recommended.

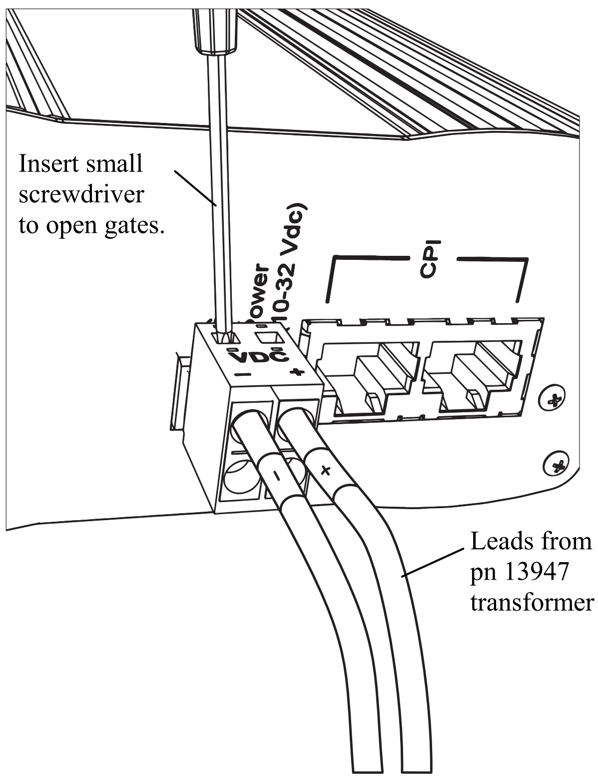


FIGURE 6-2. 12 Vdc power connection on the CDM-VW300

3. Connect a type-A male to type-micro-B male USB cable (Campbell Scientific pn 27555, supplied with the analyzer) between the CDM-VW300 and the PC as shown in FIGURE 6-3.

   Reference Section 7.7.1, *CDM-VW300 to PC Connection*.

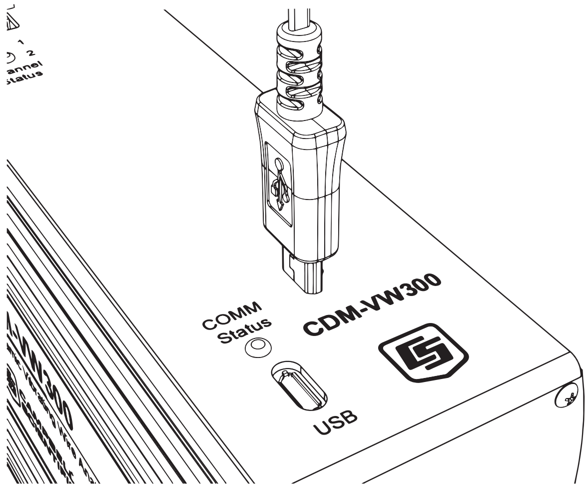


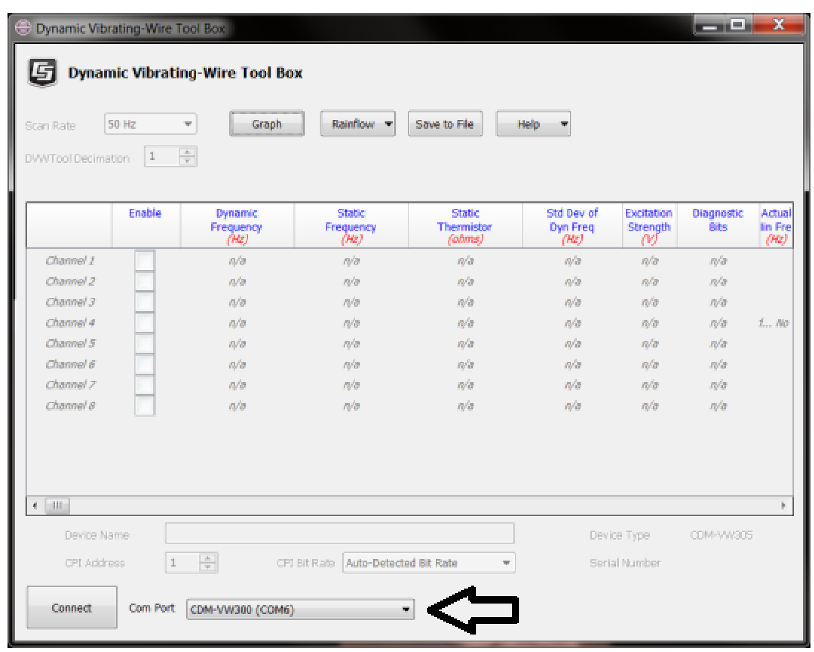
FIGURE 6-3. USB receptacle on CDM-VW300 and Type-Micro-B connector of USB cable

With the driver installed (step 1) and the power connected and live (step 2), connecting the USB cable will start an automatic process that creates a new communication (COM) port for the CDM-VW300 on the PC. Watch the *Windows*® system tray to see that the PC completes the process. Once complete, a new port will appear as an available communication port in *DVWTool*.

4. Test to see that *DVWTool* can access the USB connection.

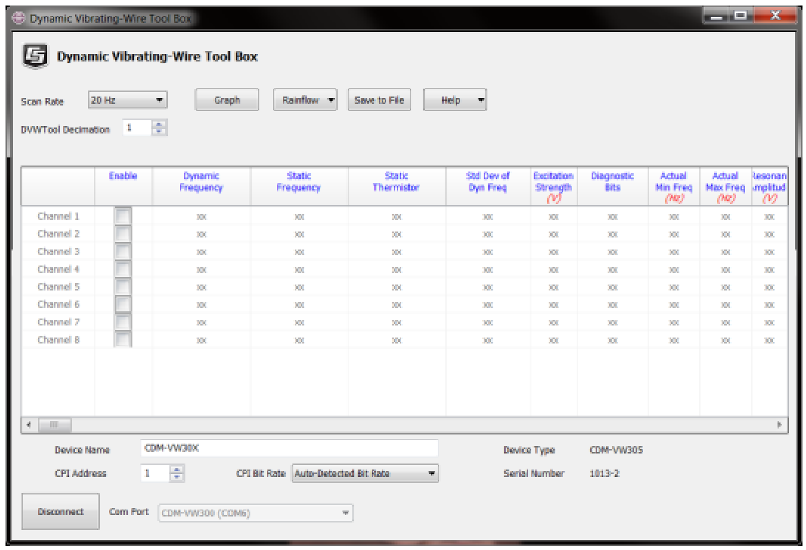
   Reference Section 7.1.2, *Using DVWTool*.

   Run *DVWTool*. Select **CDM-VW300** from the **Com Port** drop-down list as indicated in the following figure.

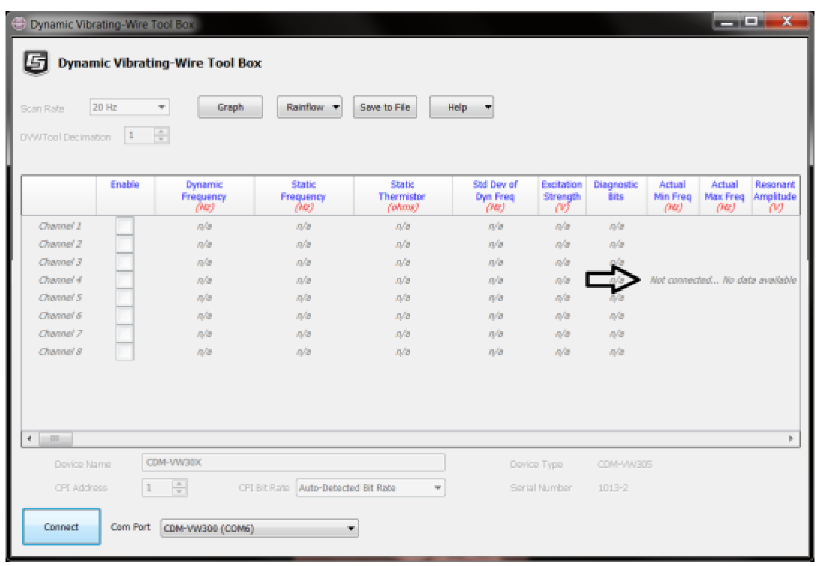


NOTE If COM port **CDM-VW300** does not appear, there is a problem with the installation of the device driver or the creation of the COM port. See Section 7.1.1, *Software and Driver Installation*, for remedial steps.

Press **Connect** in the lower left of the *DVWTool* window. If *DVWTool* connects with the CDM-VW300, the channel list on the *DVWTool* interface becomes available and the button at lower left reads **Disconnect** as shown in the following figure.



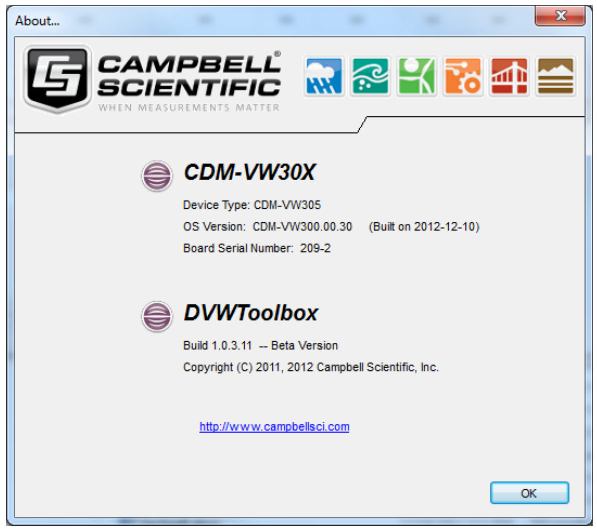
Notice that the fields **Device Type**, **Serial Number**, **Device Name**, and **CPI address** are active and populated in the lower portion of the *DVWTool* window. Otherwise, the channel list remains dimmed and the notice **Not connected... No data available** is displayed at the right of the channel list, as shown in the following figure.



5. Check the operating system version of the CDM-VW300.

   Reference Section 7.8, *Operating System*.

   Operating systems are occasionally updated. To ensure the CDM-VW300 has the latest, search through *www.campbellsci.com/downloads* for the most recent release. Compare the version information on the website with the version shown in the *DVWTool* **Help | About** screen, which is sampled in the following figure.



6. If *DVWTool* is running, click **Disconnect.** Remove the 12 Vdc power from the CDM-VW300.

7. Connect the vibrating-wire sensors to the CDM-VW300 as shown in the following figures.

   Reference Section 7.7.2, *CDM-VW300 to Sensor Connection.*

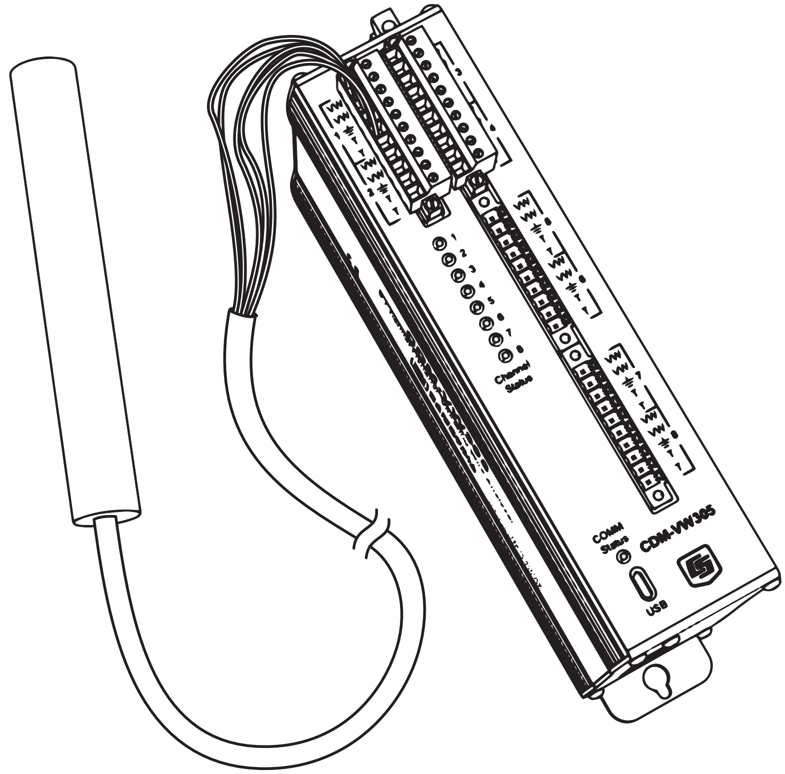


FIGURE 6-4. Sensor connection on a CDM-VW305

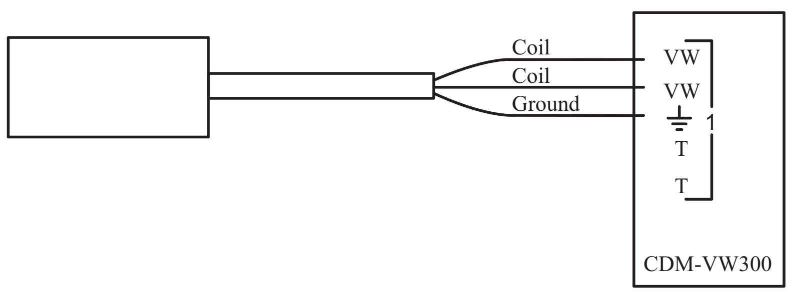


FIGURE 6-5. Three-wire vibrating-wire sensor connections

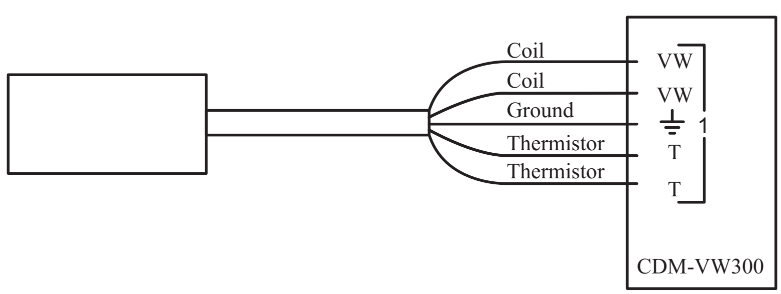


FIGURE 6-6. Five-wire vibrating-wire sensor connections

8. Reconnect 12 Vdc power to the CDM-VW300.

9. Confirm sensor operation.

   Reference Section 7.12.1, *Sensor Validation*.

   Two status LED lights are provided on the CDM-VW300 for each sensor connection. Eight are provided on the CDM-VW305. The following table lists LED functions and interpretations:

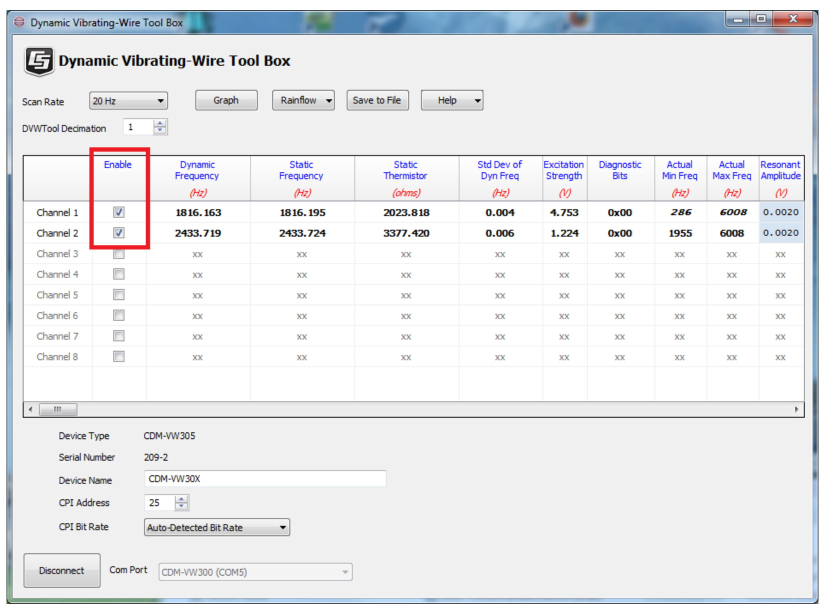
TABLE 6-1. CDM-VW300 Status LED States

Green or red flash at three-second interval	Channel is activated.
Green flash	Response received from sensor.
Red flash	Diagnostic flags indicate there may be a problem.
No flash, unlit	Channel is not activated.

10. Ensure that frequency readings can be obtained from the sensors.

    Reference Section 7.12.2.1, *Monitoring with DVWTool Software.*

    Click **Connect** on the *DVWTool* window. Check the box associated with each channel to which a sensor is connected. If all sensor systems are operational, the *DVWTool* main window will appear much as it does in the following figure:



   a. Frequency reading of each sensor will correspond to the frequency range specified by the sensor manufacturer.

   b. No faults are indicated. If faults are indicated (**Diagnostic Bits** does not equal **0x00**, measurement results are in red type, or cells are shaded red), consult Section 7.12.2.1, *Monitoring with DVWTool Software*, for troubleshooting help.

6.2 Field-Mode Installation

IMPORTANT — Do not connect the CDM-VW300 analyzer or SC-CPI interface to a PC until AFTER installing *DVWTool* 1.0 or later or *DevConfig* 2.04 or later. Consult Section 7.1.1, *Software and Driver Installation,* for more information.

A simple field-mode configuration, using one CDM-VW300, is covered in this section. Additional details concerning field-mode configuration and daisy-chaining power and RJ45 connections are discussed in Section 7, *System Operation*. Capacity of the power supply is a critical element of field installations. Most field-mode installations will require continuous ac power or large solar panels and batteries.

6.2.1 Field-Mode Installation Equipment

The following components are used in a field-mode installation:

- Vibrating-wire sensors
- CDM-VW300 measurement modules
- SC-CPI interface
- Datalogger
- Datalogger power supply
- Personal computer (PC)
- *DVWTool* analyzer software
- Datalogger support software (*LoggerNet*, *PC400*, or *RTDAQ*)

6.2.2 Field-Mode Installation Procedure

FIGURE 6-7 illustrates the final form of a simplified field-mode installation. With reference to this figure, work through the following procedure. Reference Section 7.7, *System Connections*, for more information.

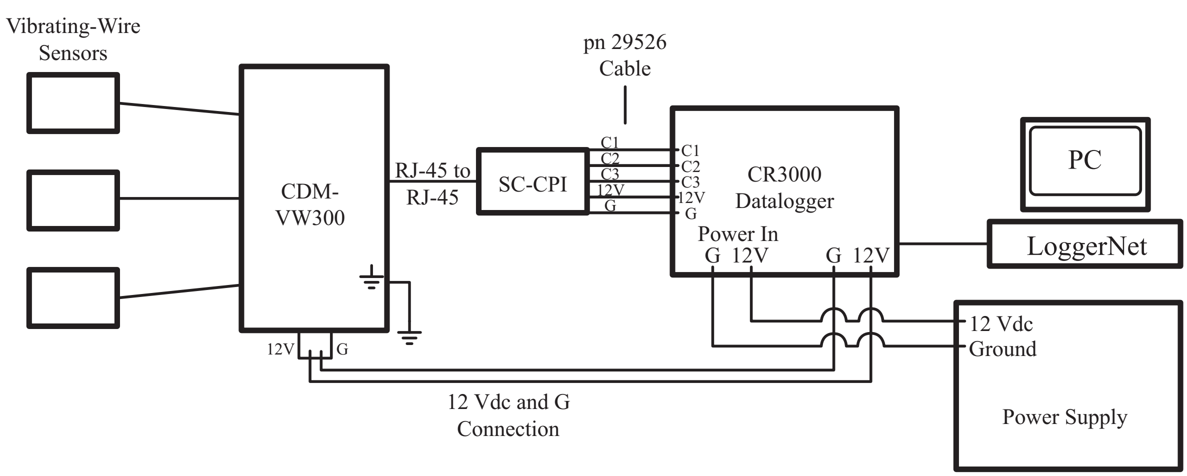


FIGURE 6-7. Field data-acquisition system

Procedure:

1. Install *DVWTool* before connecting the SC-CPI or CDM-VW300 to the PC. Reference Section 7.1.1, *Software and Driver Installation*.

2. Before proceeding, follow the procedure outlined in Section 6.1, *Laboratory-Mode Installation* for all sensors connected to the CDM-VW300. Record settings determined in *DVWTool* for later use in the CRBasic program. The following work sheet (TABLE 6-2) lists *DVWTool* settings and corresponding CRBasic instruction settings, and provides a place to record settings for one sensor. Copy and fill in this worksheet for each sensor to be connected.

TABLE 6-2. DVWTool and CRBasic Settings

***DVWTool* Setting**	**Corresponding CRBasic Instructions and *Parameters***	**Setting**
Device Name	No corresponding setting	
	Scan()	
Scan Rate[1]	***Interval***[1]	
No corresponding setting	***Units = msec***	
No corresponding setting	***Buffer = 500***	
No corresponding setting	***Count = 0***	
	CDM_VW300Config()	
Device Type (auto-detected)	*DeviceType*	
CPI Address	***CPIAddress***	
No corresponding setting	***SysOptions***	
Channel X Enable check box	***ChanEnable***	
Resonant Amplitude (V)	***ResonAmp***	
Minimum Frequency (Hz)	***LowFreq***	
Maximum Frequency (Hz)	***HighFreq***	
Output Format (**Hz** or **Hz^2**)	***ChanOptions***	
Multiplier	***Mult***	
Offset	***Offset***	
Steinhart-Hart Thermistor Coeff A	***SteinA***	
Steinhart-Hart Thermistor Coeff B	***SteinB***	
Steinhart-Hart Thermistor Coeff C	***SteinC***	
Rainflow | Number of Mean Bins	***RF_MeanBins***	

Rainflow | Number of Amp Bins	***RF_AmpBins***	
Rainflow | Low Limit	***RF_LowLim***	
Rainflow | High Limit	***RF_HighLim***	
Rainflow | Minimum Change	***RF_Hyst***	
	RF_Form	
Rainflow | Rainflow Form | reset list	***A***	
Rainflow | Rainflow Form | total list	***B***	
Rainflow | Rainflow Form | form list	***C***	
[1]Scan rate is automatically set based on the datalogger CRBasic **Scan()** instruction ***Interval*** parameter. Set the ***Interval*** parameter such that the desired CDM-VW300 scan rate is achieved. Relationship between **Scan Rate** and ***Interval*** is: CRBasic **Scan()** instruction ***Interval*** = (1 / *DVWTool* **Scan Rate**) * 1000		

3. When the laboratory-mode installation has been performed on all sensors, click **Disconnect** in the *DVWTool* window. Disconnect or turn off power to the CDM-VW300.

4. Assemble the datalogger and power supply using FIGURE 6-7, *Field data-acquisition system*, as a guide. Do not turn power on until the system is completely assembled.

5. A reliable data-acquisition system requires a reliable power supply. CDM-VW300 analyzers consume more power than do many Campbell Scientific products, so the power supplies often used with other data-acquisition systems may not be adequate. Consult Section 7.4, *Using Power Supplies*, for sizing guidance. For large systems, consult with a Campbell Scientific application engineer.

6. The following figure illustrates the connections between the datalogger, SC-CPI interface, and CDM-VW300. With this figure as a reference, work through the following procedure.

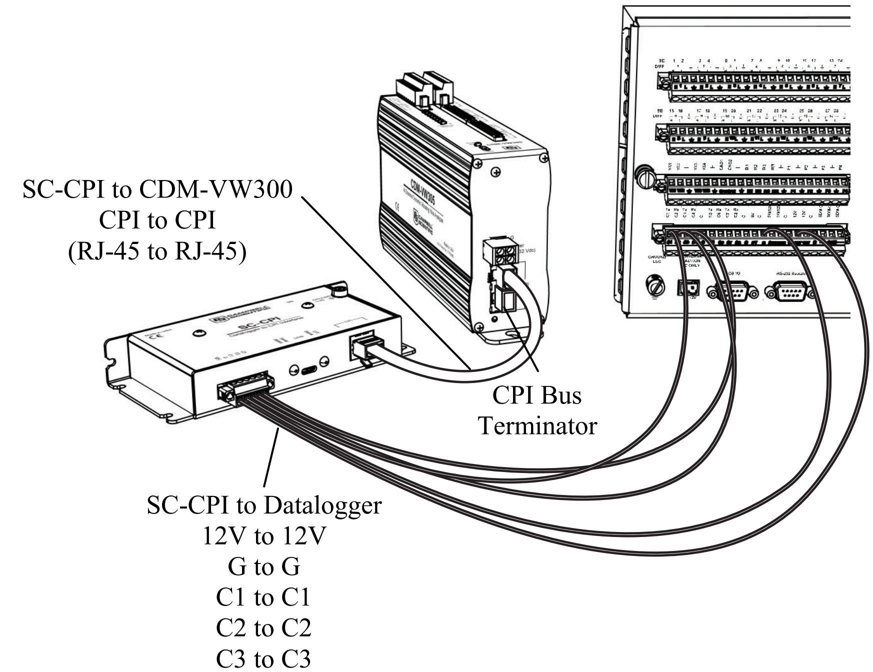


FIGURE 6-8. CPI communications links

a. Connect the SC-CPI to the datalogger. Reference FIGURE 6-9, *Datalogger to SC-CPI Connection*.

   CR3000, CR1000, and CR800 dataloggers require that a SC-CPI interface the datalogger to the CDM-VW300. Connect **12V**, **G**, **C1**, **C2**, and **C3** from the SC-CPI to the corresponding **12V**, **G**, **C1**, **C2**, and **C3** ports of the datalogger.

NOTE SC-CPI module connects to terminals **C1**, **C2**, **C3** (not SDM-C1, SDM-C2, SDM-C3).

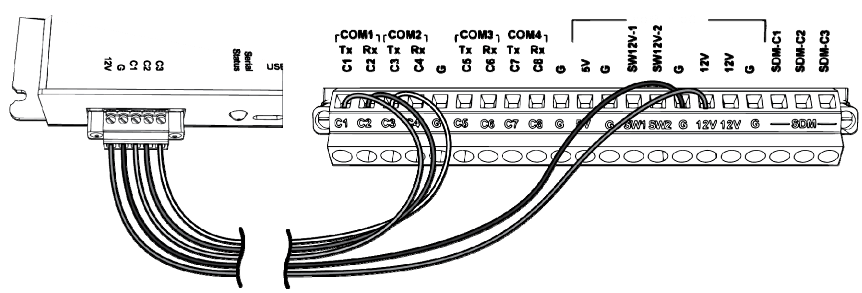


FIGURE 6-9. Datalogger to SC-CPI connection

b. As shown in FIGURE 6-10, connect the CDM-VW300 to the SC-CPI. Reference Section 7.7.3, *CDM-VW300 to SC-CPI Connection*, and Appendix B, *SC-CPI Datalogger to CPI Interface*.

Use the RJ45 CPI cable between the CPI ports of the CDM-VW300 and the SC-CPI interface. Use the yellow tape included in the CPI Network Kit (pn 29370) to differentiate a cable used for CPI bus communications from cables used for Ethernet communications.

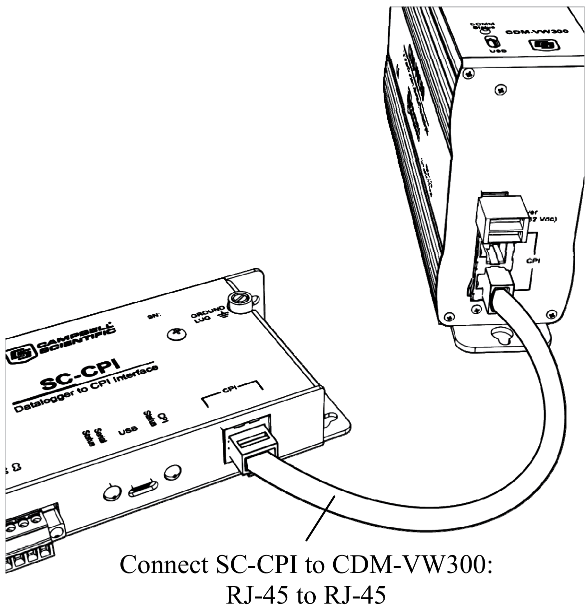


FIGURE 6-10. Connecting the CPI ports of the SC-CPI and CDM-VW300

c. As shown in FIGURE 6-11, place a CPI terminator in the remaining open CPI port of the CDM-VW300 unless more CDM-VW300 devices will be daisy-chained.

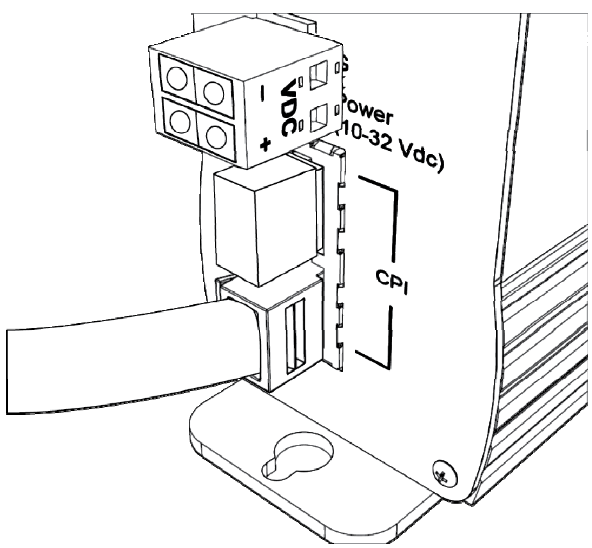


FIGURE 6-11. Install CPI bus terminator

7. As shown in FIGURE 6-12, connect power leads to the CDM-VW300. Do not turn power on until the system is fully assembled.

   Connect dc power to the **Power** connector on the side of the CDM-VW300. Voltages from 10 to 32 Vdc may be used. Do not connect ac power directly to the CDM-VW300. A convenient power source is the combination of **12V** and **G** terminals on the face of the datalogger.

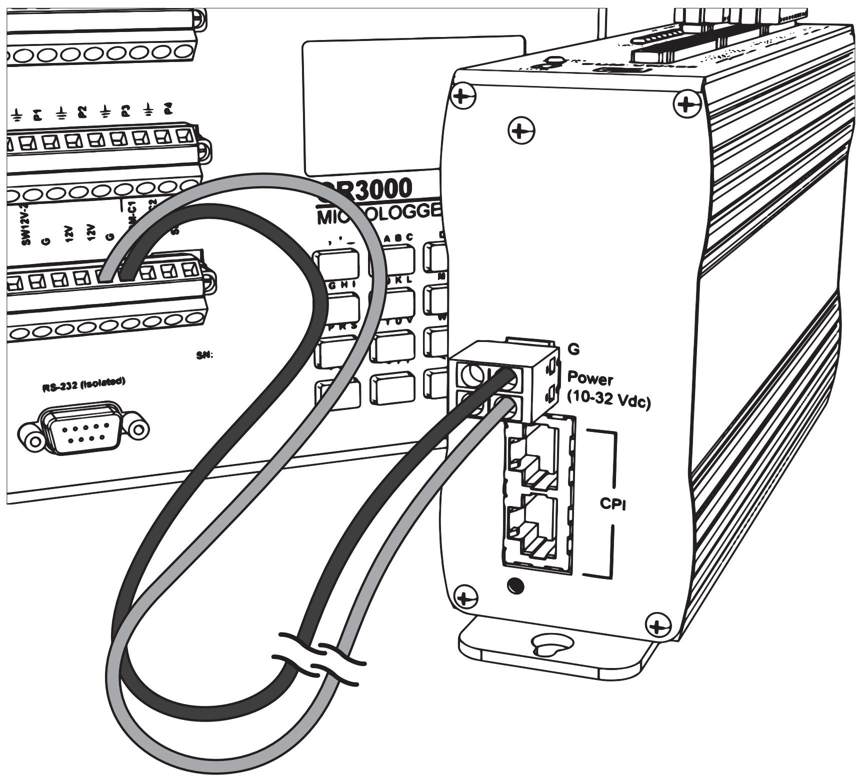


FIGURE 6-12. Power connection

8. As shown in FIGURE 6-13, connect earth grounds.

   Ground lugs are provided for tying the CDM-VW300 and datalogger to earth ground with large gage wire. 14 AWG wire or larger is recommended. Reference Section 7.7.5, *Earth Ground Connections*.

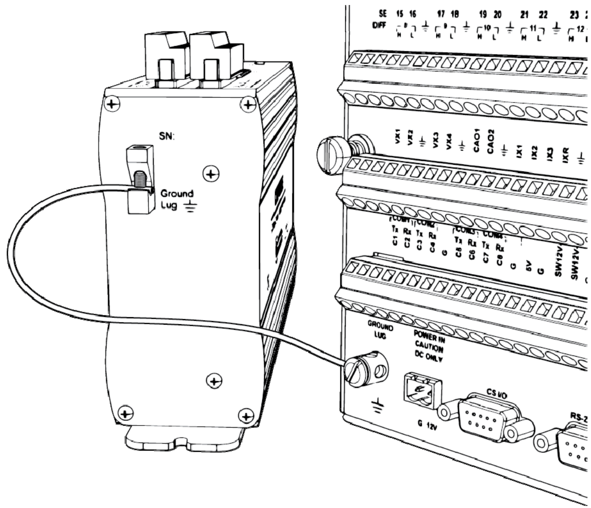


FIGURE 6-13. Earth ground connections

9. Write or obtain a CRBasic program for the datalogger. Reference Section 7.10, *CRBasic Programming*, and Appendix G, *CRBasic Program Library*.

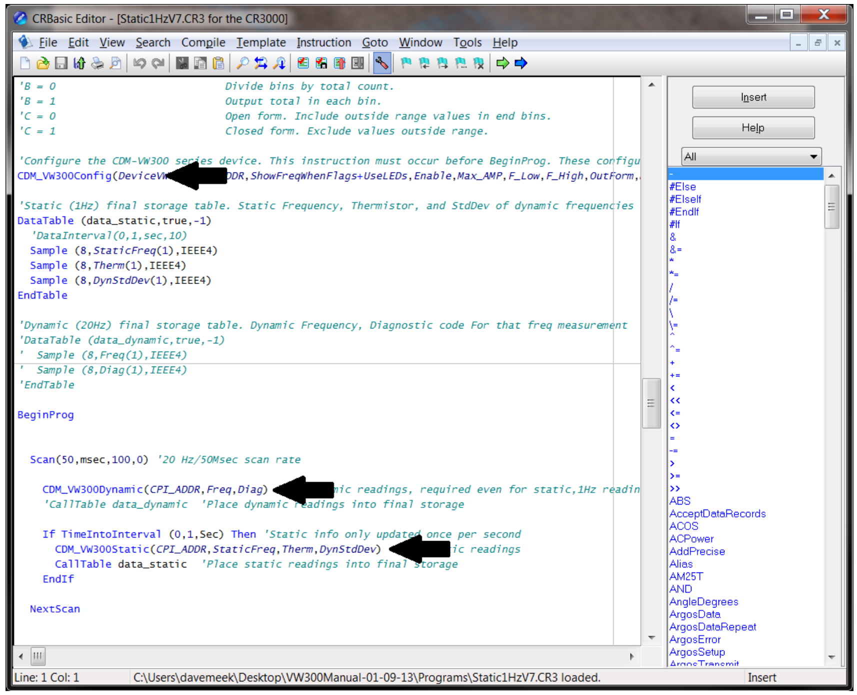
   CDM-VW300 and CDM-VW305 programs use the following CRBasic instructions:

   ```
   CDM_VW300Config()
   CDM_VW300Dynamic()
   CDM_VW300Static()
   ```

   The CRBasic program must be enabled specifically for the CDM-VW300 or the CDM-VW305. Programs enabled for a CDM-VW300 use a ***DeviceType*** argument of ***0*** in the **CDM_VW300Config()** instruction. Programs enabled for a CDM-VW305 use a ***DeviceType*** of ***1***. Check that other settings recorded in step 2 are integrated into the CRBasic program.

NOTE Do not attempt to use a program written for the CDM-VW300 when using a CDM-VW305. Configurations for a particular analyzer are deeply rooted in the CRBasic program. Simply changing the ***DeviceType*** argument will not make all the necessary changes.

The following figure points out essential elements of the CRBasic program for a datalogger controlling a CDM-VW300.



To simply confirm that readings can be obtained, one of the following example programs can be used. These programs measure only basic frequency:

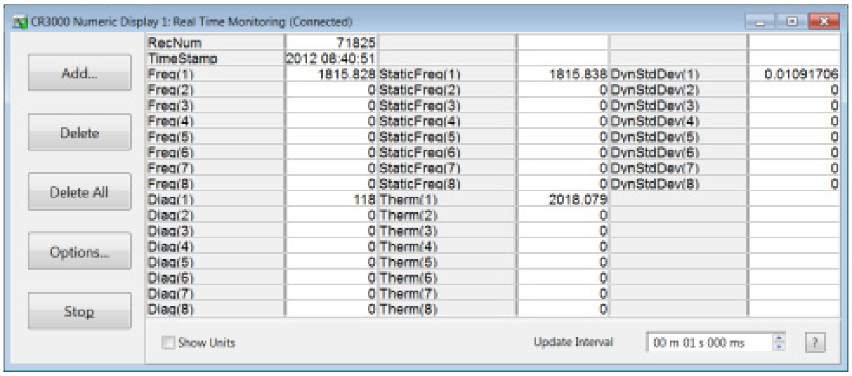
- Appendix G.1.1, *20 Hz Measurement Example – One CDM-VW300, Two Channels*
- Appendix G.1.2, *20 Hz Measurement Example – One CDM-VW305, Eight Channels*

10. Send the CRBasic program to the datalogger using the program **Send** command in the datalogger support software (*RTDAQ*, *LoggerNet*, or *PC400*).

11. Monitor the operation of the system.

    Reference Section 7.12.2, *Monitoring System Performance*.

    Using the datalogger support software, monitor the datalogger **Public** table as indicated in the following figure. In the **Public** table, frequency data can be displayed that correspond to the channels selected for measurement. The following figure shows **Public** table variables **Freq(1)**, **Diag(1)**, **StaticFreq(1)**, **Therm(1)**, **DynStdDev(1)** as active with frequency data from one sensor. The sensor is connected to channel **1** of the CDM-VW305.



A clean display of data, as shown in the previous figure, is obtained by deactivating all but channel **1** in the CRBasic program. If channels **2** through **8** had not been deactivated, erroneous, but perhaps seemingly-real, data would be displayed. Channels **2** through **8** are deactivated by setting line 24 in the CRBasic example in Appendix G.1.2, *20 Hz Measurement Example – One CDM-VW305, Eight Channels*, to the following:

```
Dim Enable(8) As Long =       {     1,      0,      0,      0,      0,      0,      0,      0}
```

If proper frequencies are shown, the datalogger has successfully communicated with the CDM-VW300 via the SC-CPI device and obtained data. A permanent data collection program for field operation can now be loaded.

7. System Operation

IMPORTANT — Do not connect the CDM-VW300 analyzer or SC-CPI interface to a PC until AFTER installing *DVWTool* 1.0 or later or *DevConfig* 2.04 or later. Consult Section 7.1.1, *Software and Driver Installation,* for more information.

7.1 PC Based Tools

All PC software is for use on *Windows® XP*, *Windows® Vista*, *Windows® 7*, or *Windows® 8* operating systems.

7.1.1 Software and Driver Installation

USB communication between the PC and the CDM-VW300 analyzer, and between the PC and the SC-CPI interface, require that USB drivers be installed on the PC. For driver installation to work seamlessly, the drivers must be installed before making the physical USB connections. These drivers are installed automatically when *DVWTool* 1.0 software or *DevConfig* 2.04 software or later are installed.

- If the physical USB connection is attempted before the installation of the drivers, a non-functional placeholder definition is created in the Windows® USB device list. This placeholder prevents that device from becoming active during subsequent driver installs and device connections via USB. The following procedure should correct this condition:

1. Install either *DVWTool* 1.0 or later or *DevConfig* 2.04 or later.

2. Connect the device to the computer with the USB cable.

3. Open the *Windows® Device Manager*. In *Windows® 7*, this is done by choosing **Control Panel | Hardware and Sound**, and then clicking on the **Device Manager** icon found in the *Devices and Printers* section.

4. Find the placeholder device (CDM-VW300 or SC-CPI) identified with a super-imposed exclamation point in a yellow bubble box. Right-click on the device. Select **Scan for hardware changes** or **Update Driver Software...**.

5. The driver will be found and the disabled placeholder will be overridden.

- If USB drivers are installed on *Windows® 8*:

  The installation of the USB drivers can fail silently on the *Windows® 8* platform under certain circumstances. This problem is indicated by the absence of the CDM-VW300 COM port from the list of available COM ports associated with the **Connect** button in the main screen of *DVWTool*.

  To correct this problem, connect the device to the computer with the USB cable. Open the *Windows® Device Manager*. Find the placeholder device (**CDM-VW300** or **SC-CPI**) identified with a super-imposed exclamation point in a yellow bubble box. Right-click on the device. Select **Update Driver Software...**.

7.1.2 Using DVWTool

The *Dynamic Vibrating-Wire Tool Box* (*DVWTool*) is a software package that enables a PC to communicate with the CDM-VW300 via USB, configure CDM-VW300 settings, and display the output of attached sensors. No datalogger is required. Data are output in the main window table, on a line graph, and in a rainflow histogram.

Users of the CDM-VW300 should become familiar with the function and operation of *DVWTool*. Detailed information about this software can be found in the *DVWTool Help* system.

7.1.2.1 Ensure Connection is Active

The installation of *DevConfig* 2.04 or later or *DVWTool* 1.0 or later automatically installs the drivers required to make a connection between the CDM-VW300 and the PC. Do not connect a USB cable between your CDM-VW300 and the PC until after *DevConfig* or *DVWTool* has been installed. Before starting *DVWTool* , ensure that the CDM-VW300 analyzer is connected to the PC via USB cable. After opening *DVWTool*, choose the **CDM-VW300** port from the **Com Port** dropdown list, as indicated in FIGURE 7-1. Click the **Connect** button.

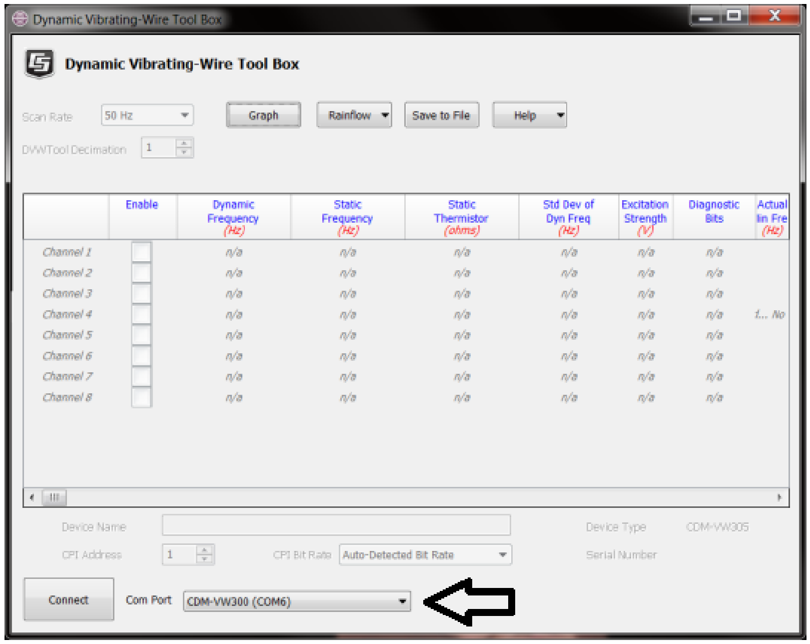


FIGURE 7-1. DVWTool Settings Editor and Data Display

NOTE If **CDM-VW300** does not appear in the available selections for **Com Port**, there is a problem with the installation of the device driver or the creation of the COM port. See Section 7.1.1, *Software and Driver Installation*, for remedial steps.

7.1.2.2 DVWTool Settings Editor

See TABLE 7-1, *Summary of CDM-VW300 Configuration Settings*, for a listing of settings that can be viewed and edited with *DVWTool*.

7.1.2.3 Button and Field Descriptions

Enable — select each checkbox to turn on the respective channel.

Dynamic Frequency is the resonant frequency of the vibrating-wire sensor sampled at the specified scan rate. This is the primary output of the attached analyzer. If the **Output Format** field is set to **Freq** then this field represents the resonant frequency of the vibrating-wire sensor. If the **Output Format** field is set to **Freq**^{2}, this is the square of the resonant frequency. In either format, the resulting number is modified by the **Multiplier** and **Offset** fields before being output to this field.

Static Frequency (Hz or Hz^2**)** represents the same information as the **Dynamic Frequency** field in all respects except for the slower rate at which it is computed.

Static Thermistor (ohms) is a measure of the resistance across the thermistor inputs. It is measured once per second. If the **Steinhart-Hart Thermistor Coefficients** (**A**, **B**, and **C**) are entered for the channel, then they are used to convert the measured resistance to degrees Celsius.

Standard Deviation of Dynamic Frequency (Hz or Hz^2) is the standard deviation of the **Dynamic Frequency** field computed on one-second data. It is output once per second. It is computed after the **Output Format**, **Multiplier**, and **Offset** have been applied.

Resonant Amplitude (V) sets the desired amplitude of the steady-state signal response from the sensor.

Excitation Strength (V) is the peak-to-peak amplitude of the excitation waveform that is required to produce the desired response amplitude. An increase in the **Scan Rate** corresponds to a decrease in the excitation strength needed.

Diagnostic Bits provides information on the operation of the module and can indicate conditions during which the data may be suspect.

The **Minimum Frequency (Hz)** and **Maximum Frequency (Hz)** are the bounds in which the resonant frequency of the sensor is expected to fall during its operation. Signal frequencies measured outside of this range are not included in the spectral analysis, except as noted in Section 8.5.1.1, *Description of Diagnostic Parameters*.

Graph button brings up a graphical display of the frequency output of the sensors.

Pressing the **Rainflow** button and selecting a channel brings up a rainflow histogram of the frequency output of the sensor on that channel.

7.1.3 Using DevConfig

The *Device Configuration Utility* (*DevConfig*) is a software package that enables a PC to communicate with many Campbell Scientific products. It communicates with the CDM-VW300 via USB to configure settings and display the output of attached sensors. No datalogger is required. Data are output to the main window in tabular form.

Users of the CDM-VW300 should become familiar with the function and operation of *DevConfig*. Detailed information about this software can be found in the *DevConfig Help* system and the *LoggerNet* software manual, which is available at *www.campbellsci.com*.

7.1.3.1 Ensure Connection is Active

The installation of *DevConfig* 2.04 or later or *DVWTool* 1.0 or later automatically installs the drivers required to make a connection between the CDM-VW300 and the PC. Do not connect a USB cable between your CDM-VW300 and the PC until after *DevConfig* or *DVWTool* has been installed. Before starting *DevConfig*, ensure that the CDM-VW300 analyzer is connected to the PC via USB cable. After opening *DevConfig*, choose the **CDM-VW300** port from the **Communication Port** dropdown list as indicated in FIGURE 7-2. Click the **Connect** button.

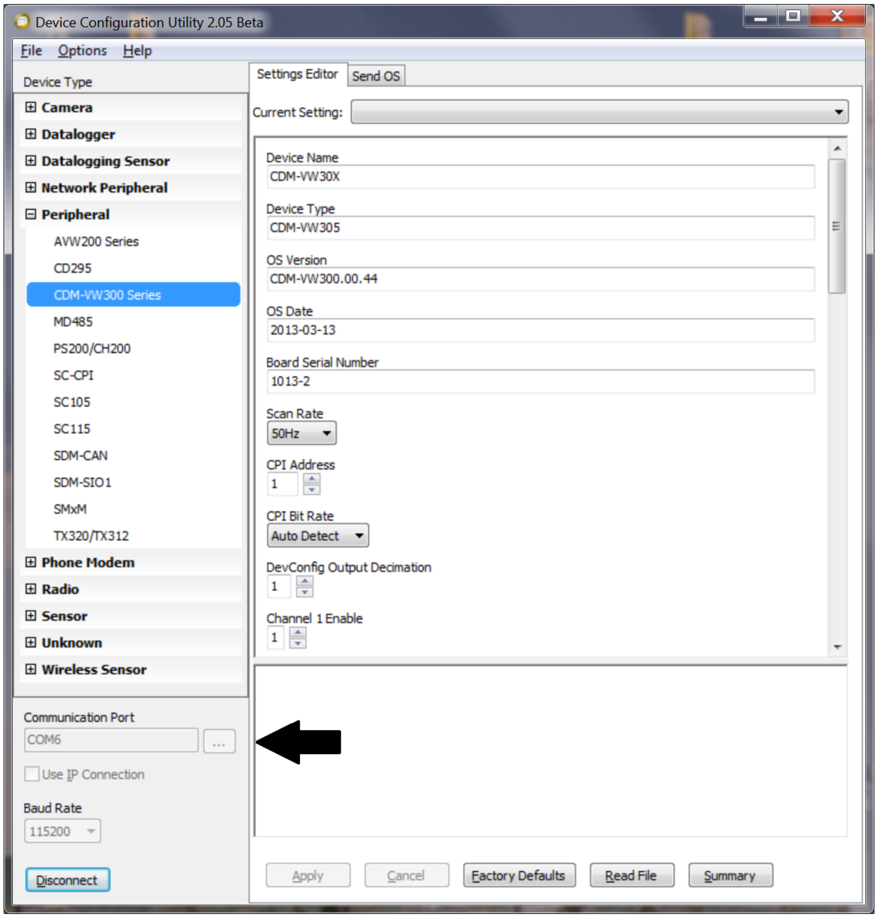


FIGURE 7-2. DevConfig Settings Editor

Details about using *DevConfig* can be found in *DevConfig Help* or in the *LoggerNet* datalogger support software manual, which is available at *www.campbellsci.com*.

NOTE If a COM port CDM-VW300 does not appear in the available selections for **Communications Port**, then there is a problem with the installation of the device driver or the creation of the COM port. See Section 7.1.1, *Software and Driver Installation*, for remedial steps.

7.1.3.2 DevConfig Settings Editor

See TABLE 7-1, *Summary of CDM-VW300 Configuration Settings*, for a listing of settings that can be viewed and edited with *DevConfig*.

7.2 Using the Datalogger

Outputs from the CDM-VW300 are captured by a CR3000, CR1000, or CR800 datalogger via the SC-CPI communications interface. A custom CRBasic program written to capture and store device outputs is loaded into the datalogger.

Write or obtain a CRBasic program for the datalogger. Reference Section 7.10, *CRBasic Programming*. Example programs are available in Appendix G, *CRBasic Program Library*, and at *www.campbellsci.com/cdm-vw300-support*.

7.3 Using the SC-CPI Interface

See Appendix B, *SC-CPI Datalogger to CPI Interface*.

7.4 Using Power Supplies

See Section 7.7.4, *CDM-VW300 to Power Connection*, for instructions and precautions when connecting power.

7.4.1 CDM-VW300 Series Analyzer Power

The purchase of a CDM-VW300 series analyzer does not include a power supply. A 12 Vdc power source must be specifically ordered or provided by other means. Power supplies providing 9.6 to 32 Vdc, with a 200 mA or greater current rating, can be used. Transformer pn 29796, which is illustrated in FIGURE 7-3, is a 24 Vdc, 1.67 A wall charger. It can be purchased from Campbell Scientific. Alternatively, if an adequate power supply used with a Campbell Scientific datalogger is available, power for the CDM-VW300 series analyzer can be drawn from the datalogger wiring panel.

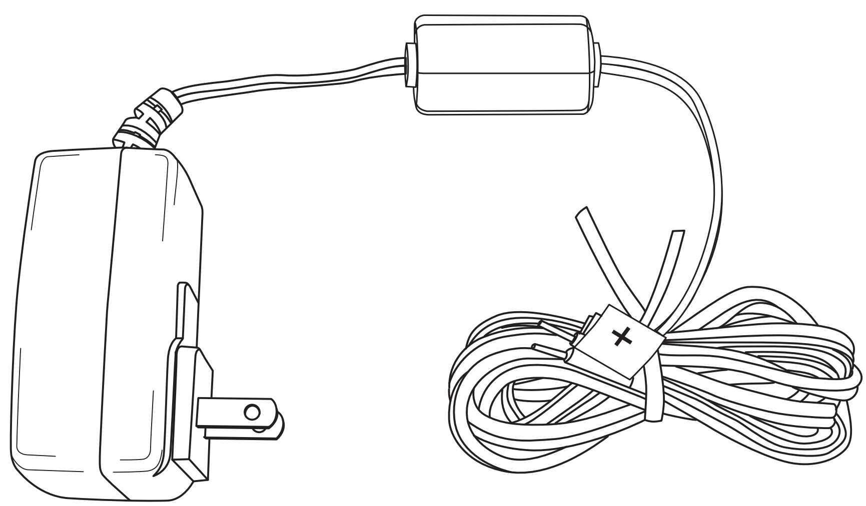


FIGURE 7-3. 12 Vdc power transformer for laboratory-mode installation

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NOTE The transformer sometimes used to provide charging power to a Campbell Scientific PS100 power supply, or to a CR3000 datalogger with a battery base (Campbell Scientific pn 9591), does <u>not</u> have the correct power output for the CDM-VW300.

7.4.2 Data-Acquisition System Power

Power supply requirements will vary depending on system configuration and location. The following power supplies are typically adequate to power a data-acquisition system consisting of one datalogger, one CDM-VW300, and the SC-CPI interface:

- PS100 connected to ac
- PS200 connected to ac
- CR3000 rechargeable base connected to ac

NOTE CR3000 with alkaline base is NOT an adequate power supply and will fail shortly after deployment.

A solar powered system requires careful planning including a power budget. For example, to power a data-acquisition system consisting of a CR3000 datalogger, an SC-CPI interface, and a CDM-VW300 series analyzer, the following battery and solar panel specifications are required to operate the system year-round in a remote installation in northern Utah using standard silicon cell solar panels, lead-acid rechargeable batteries, and industry accepted reserve margins:

- CDM-VW300, two channels enabled
  - 60 watts of solar panel capacity
  - 91 ampere-hours of battery reserve
- CDM-VW305, eight channels enabled
  - 84 watts of solar panel capacity
  - 130 ampere-hours of battery reserve.

Many applications will require the use of several analyzers. A carefully considered power budget in these applications is essential to ensuring system reliability and data continuity. Contact a Campbell Scientific application engineer for assistance in configuring an adequate power supply.

7.5 Configuring the CDM-VW300 Analyzer

CDM-VW300 series analyzers must be configured by the user before sensor measurement will be successful. Configuration can be done using *DVWTool* or *DevConfig* software or a datalogger CRBasic program. See Section 7.1, *PC Based Tools*, for more information about the software. See Section 7.10, *CRBasic Programming*, for more information about using the datalogger.

IMPORTANT — Do not connect the CDM-VW300 analyzer or SC-CPI interface to a PC until AFTER installing *DVWTool* 1.0 or later or *DevConfig* 2.04 or later. Consult Section 7.1.1, *Software and Driver Installation,* for more information.

If using software to configure the analyzer, which is recommended, physically connect the CDM-VW300 to the PC with a USB cable. See Section 7.7.1, *CDM-VW300 to PC Connection*, for assistance in making this connection. Check that the software is pointing to the correct communications port.

TABLE 7-1, summarizes the configuration settings. Each configuration setting is discussed in the following sections.

TABLE 7-1. Summary of CDM-VW300 Configuration Settings

Setting Description	DVWTool PC Software Setting Name	DevConfig PC Software Setting Name	CRBasic Datalogger Instructions / Parameters
Device name	**Device Name**	**Device Name**	ncs
CPI bus speed (kbps)	**CPI Bit Rate**	**CPI Bit Rate**	**CPISpeed()**
Operating system version	ncs[1]	**OS Version**	ncs
Operating system date	ncs	**OS Date**	ncs
Analyzer serial number	**Serial Number**	**Board Serial Number**	ncs
Display rate	**DVWTool Decimation**	**DevConfig Output Decimation**	ncs
Dynamic sample rate	**Scan Rate**	**Scan Rate Hz**	**Scan()** ***Interval*** **=** (1/DVWTool Scan Rate * 1000)
Device type	**Device Type**	**Device Type**	**CDM_VW300Config()** ***DeviceType***
CPI bus address	**CPI Address**	**CPI Address**	**CDM_VW300Config()** ***CPIAddress***
System options	ncs	ncs	**CDM_VW300Config()** ***SysOptions***
Channels enabled	**Enable**	**Channel X Enable**	**CDM_VW300Config()** ***ChanEnable***
Desired resonant amplitude	**Resonant Amplitude (V)**	**RMS Amplitude Set Point**	**CDM_VW300Config()** ***ResonAmp***
Minimum cut-off frequency	**Minimum Frequency (Hz)**	**Low Freq. bound**	**CDM_VW300Config()** ***LowFreq***
Maximum cut-off frequency	**Maximum Frequency (Hz)**	**High Freq. bound**	**CDM_VW300Config()** ***HighFreq***
Frequency-output format	**Output Format** (**Hz** or **Hz^2**)	**Output Format**	**CDM_VW300Config()** ***ChanOptions***

Setting Description	DVWTool PC Software Setting Name	DevConfig PC Software Setting Name	CRBasic Datalogger Instructions / Parameters
Multiplier	**Multiplier**	**Multiplier**	**CDM_VW300Config()** ***Mult***
Offset	**Offset**	**Offset**	**CDM_VW300Config()** ***Offset***
Steinhart-Hart coefficients	**Steinhart-Hart Thermistor Coeff A**	**Thermistor A**	**CDM_VW300Config()** ***SteinA***
	Steinhart-Hart Thermistor Coeff B	**Thermistor B**	**CDM_VW300Config()** ***SteinB***
	Steinhart-Hart Thermistor Coeff C	**Thermistor C**	**CDM_VW300Config()** ***SteinC***
Rainflow-histogram output configuration	**Rainflow | Number of Mean Bins**	**Rainflow Mean Bins**	**CDM_VW300Config()** ***RF_MeanBins***
	Rainflow | Number of Amp Bins	**Rainflow Amp Bins**	**CDM_VW300Config()** ***RF_AmpBins***
	Rainflow | Low Limit	**Rainflow Low Limit**	**CDM_VW300Config()** ***RF_LowLim***
	Rainflow | High Limit	**Rainflow High limit**	**CDM_VW300Config()** ***RF_HighLim***
	Rainflow | Minimum Change	**Rainflow Min Change**	**CDM_VW300Config()** ***RF_Hyst***
	Rainflow | Rainflow Form	**Rainflow Form**	**CDM_VW300Config()** ***RF_Form***

7.5.1 Device Name

This setting specifies an alphanumeric name for the analyzer. This is an optional setting and is not available in the CRBasic datalogger instruction setup.

7.5.2 CPI Bus Speed

This setting specifies the speed at which the CDM-VW300 communicates with the CPI bus. Speed options are 50, 125, 250, 500, and 1000 kbps. In a CRBasic program, use the **CPISpeed()** instruction to set this setting. Shorter CPI cable lengths allow for a faster CPI bus speed.

7.5.3 Operating System Version

This field reports the version of the CDM-VW300 operating system. This setting is viewable only in *DevConfig*.

7.5.4 Operating System Date

This field reports the release date of the CDM-VW300 operating system. This setting is viewable only in *DevConfig*.

7.5.5 Analyzer Serial Number

This field reports the serial number of the CDM-VW300. The same serial number is on a tag on CDM-VW300 case. This setting is viewable *DVWTool* and *DevConfig.*

7.5.6 Display Rate

This setting specifies the rate at which PC displays are updated. This is not an option in the CRBasic datalogger instruction setup.

7.5.7 Dynamic Sample Rate

This setting is entered in units of Hz (hertz) in *DVWTool* and *DevConfig*. Options are 20, 50, 100, 200, or 333.3 kHz. This is set for lab mode using *DVWTool*. In field mode, it is determined automatically from the ***Interval*** argument CRBasic program **Scan()** instruction. It is calculated for the ***Interval*** parameter as:

Interval = (1 / DVWTool **Scan Rate** • 1000).

7.5.8 Device Type

This setting specifies whether the analyzer is a CDM-VW300 (Option **0**) or CDM-VW305 (Option **1**).

7.5.9 CPI Bus Address

Each CDM-VW300 series analyzer must be given a unique address on the CPI bus using *DVWTool* or *DevConfig* software. This address is used as the argument in the ***CPIAddress*** parameter in the CRBasic program instruction **CDM_VW300Config()**. For more information about the operation of the CPI bus, see Appendix B, *SC-CPI Datalogger to CPI Interface*. Addresses range from 1 to 120.

7.5.10 System Options

This setting determines if a numeric value or **NAN** will be stored in the datalogger when a flag condition occurs, and whether or not the diagnostic LEDs are on or off. This option is available for only the CRBasic datalogger program. Options are 0, 1, 10, and 11.

7.5.11 Channels Enabled

Each channel on a CDM-VW300 series analyzer can be individually enabled for measurement. If a channel is not enabled, the LED corresponding to it will not flash. If the channel is enabled, but there is a diagnostic warning, the LED will flash red. If the device is enabled and obtaining a reading properly from the attached sensor, the LED will flash green. Channels are enabled either with check boxes or Boolean values.

7.5.12 Desired Resonant Amplitude

This is the target amplitude, measured in volts, for keeping the wire of the sensor in constant excitation. The excitation voltage is adjusted automatically by the analyzer to accommodate the target resonant amplitude. This is set to a minimum of 100 µV and a maximum of 10 mV. Default is 2 mV.

7.5.13 Minimum- and Maximum Cut-Off Frequencies

Band-pass filters can be set to isolate a certain frequency range within which a reading is expected to fall. See Section 7.11.1, *Frequency Range*, for more information. Settings are frequency values.

7.5.14 Frequency-Output Format

Use this setting to select whether the output from the sensor will be given as frequency (Hz) or frequency squared (Hz^2). Settings are selected from lists in the PC software. Entry in CRBasic is Boolean (0 = Hz, 1 = Hz^2).

7.5.15 Multipliers and Offsets

Multipliers (gain, slope, or scaling) and offsets (y-intercept or shifting) allow for linear scaling of the frequency output of each sensor. Some vibrating-wire sensors, however, require polynomial calculations to obtain the desired engineering units. If transformation other than linear scaling is required, the multiplier should be set to **1** and the offset to **0**, and the transformation made through other datalogger calculations or by post-processing of the data. Please refer to the calibration sheet that came with each sensor to understand how the frequency output should be transformed to obtain the desired engineering units. Appendix D, *Digits Conversion*, and Appendix E, *Calculating Measurement Error*, contain additional information about conversion from frequency to engineering units.

7.5.16 Steinhart-Hart Coefficients

These coefficients are used to convert thermistor resistance from ohms to temperature in degrees Celsius. See Appendix F, *Thermistor Information*, for more information.

7.5.17 Rainflow-Histogram Output Configurations

Output configuration settings in *DevConfig* and CRBasic are three digit values. For example, an entry of 100 means reset histogram, divide bins by total count, and use open form.

Options:

- 0 = reset histogram each output / 1 = Do not reset histogram.
- 0 = Divide bins by total count / 1 = use the total of each bin.
- 0 = Open form (includes half cycles) / 1 = Closed form (use full cycles)

Settings in *DVWTool* are selected from lists.

7.6 Sensor Selection

CDM-VW300 series analyzers work well with standard vibrating-wire sensors that use a single-coil circuit design. In this design, two sensor leads are used to both excite the sensor and read back the resonant frequency. When selecting a vibrating-wire sensor, consider its frequency range and the sample rate at which that frequency will be sampled by the datalogger or PC.

7.6.1 Frequency Considerations

In general, sensors with higher resonant-frequency ranges are more versatile when used with a CDM-VW300 series analyzer. Higher sample rates require a higher-frequency range on the sensor.

Based on the dynamic rate used to sample the sensor, be aware of the low-end (minimum) frequency limitations of the CDM-VW300 as given in the following table:

TABLE 7-2. Relationship of Sample Rate and Sensor Frequency

Sample Rate (Hz)	Min Sensor Freq (Hz)	Max Sensor Freq (Hz)
20	290	6000
50	290	6000
100	580	6000
200	1150	6000
333.3	2300	6000

Be sure that the expected frequency response of the sensor does not fall outside the specified limits even when responding to maximum or minimum measurement conditions.

7.6.2 Noise Performance

See Section 5.2, *Specifications*, for more information about the noise and accuracy of frequency readings at various sampling rates.

7.7 System Connections

IMPORTANT — Do not connect the CDM-VW300 analyzer or SC-CPI interface to a PC until AFTER installing *DVWTool* 1.0 or later or *DevConfig* 2.04 or later. Consult Section 7.1.1, *Software and Driver Installation,* for more information.

7.7.1 CDM-VW300 to PC Connection

A PC to CDM-VW300 USB connection is used in a laboratory-mode installation and in the initial setup and troubleshooting of field-mode installations.

Connect a male-USB to type-micro-B male-USB cable between the PC and the CDM-VW300 analyzer; pn 27555, provided in the CDM network kit (pn 29370), which is shipped with each analyzer, can be used. The type-micro-B male-USB connector connects to the CDM-VW300. The USB port is located on the analyzer as shown in FIGURE 7-4, *USB port on the CDM-VW300*.

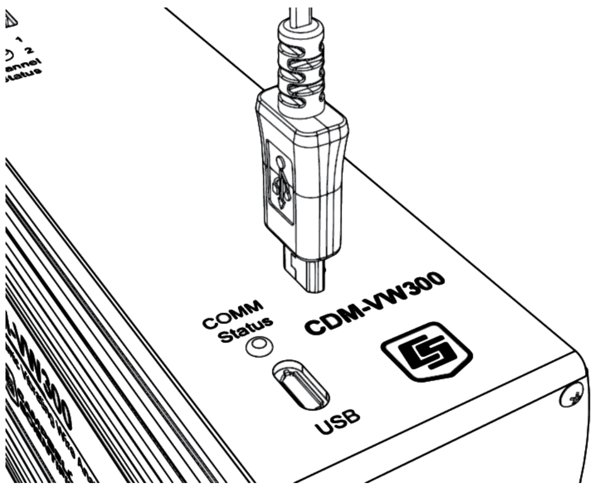


FIGURE 7-4. USB port on the CDM-VW300

When the connection is made, *DVWTool or DevConfig* can be used to communicate with and configure the analyzer. *DVWTool* is the preferred software tool.

7.7.2 CDM-VW300 to Sensor Connection

Typical single-coil vibrating-wire sensors come with either three- or five-wire connection leads. Refer to the specifications of a particular sensor to understand the function of each lead.

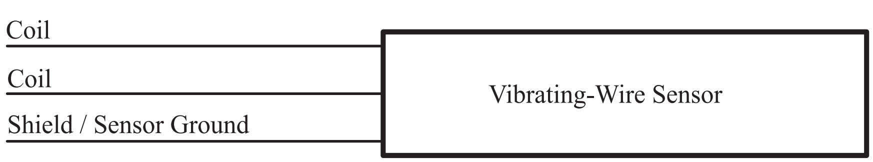


FIGURE 7-5. Three-wire vibrating-wire sensor leads

As illustrated in FIGURE 7-5 and FIGURE 7-6, in the three-wire configuration, two wires are provided as connections to the coil circuit of the sensor. The third wire is a shield wire to be connected to ground. Most vibrating-wire sensors operate equally well with either polarity position of the two signal wires. Two coil connections (**C**) are provided on each channel on the CDM-VW300 to which these leads are connected.

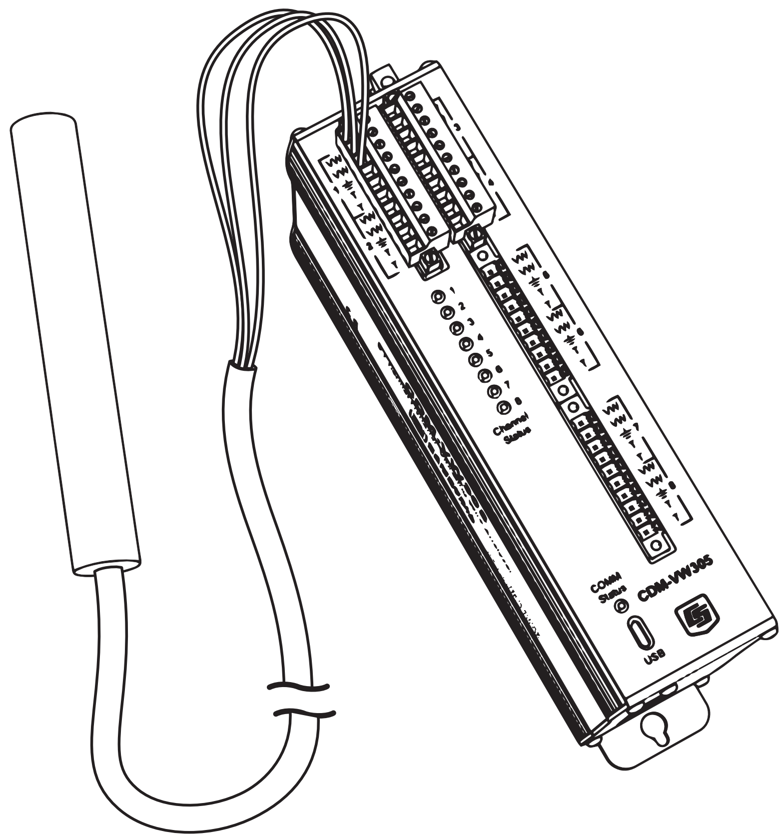


FIGURE 7-6. Three-wire vibrating-wire sensor connection

The third lead is the shield wire, or sensor ground, and should be connected to the ground connection corresponding to the measurement channel.

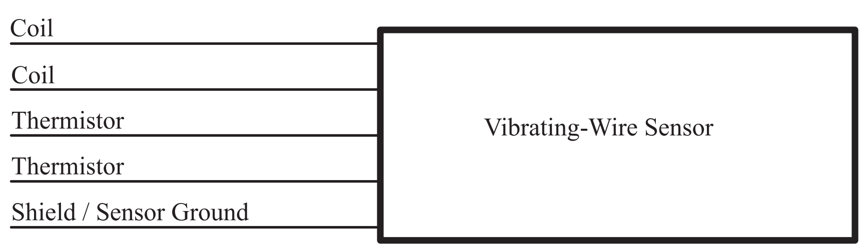


FIGURE 7-7. Five-wire, vibrating-wire sensors leads

For sensors with five lead wires, three wires operate as described previously for a three-wire configuration. The additional two leads are thermistor leads, and, as illustrated in FIGURE 7-7 and FIGURE 7-8, can be wired to the thermistor (**T**) channels on the analyzer.

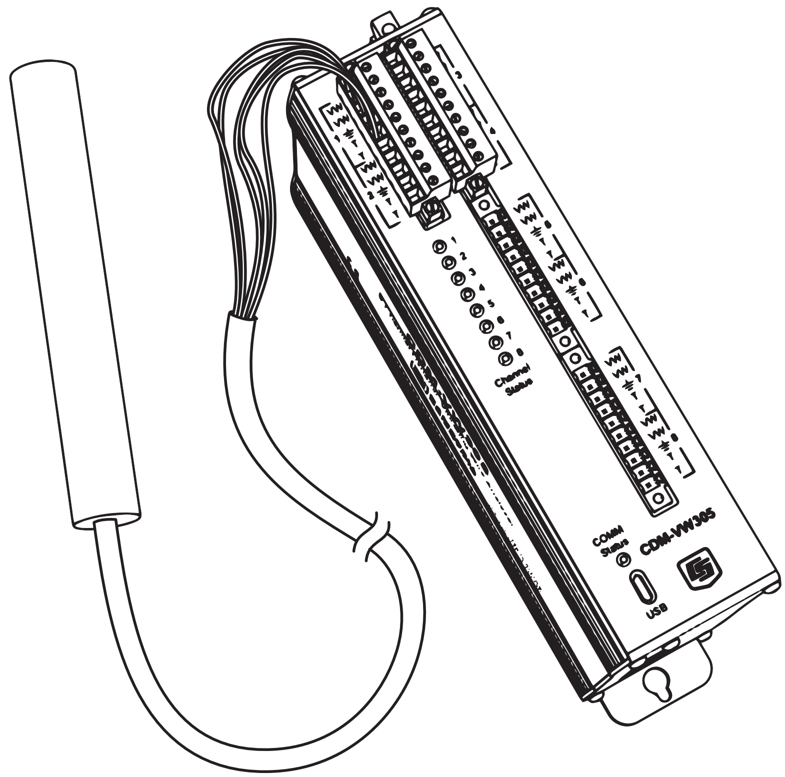


FIGURE 7-8. Five-wire vibrating-wire sensor connection

Since temperature is a factor that can influence the frequency output of a vibrating-wire sensor, a temperature measurement is often part of the calculation used to convert the frequency output of the sensor to the desired engineering units. A thermistor is a specialized resistor used for measuring temperature and as such has no polarity.

7.7.3 CDM-VW300 to SC-CPI Connection

Connect a CPI cable between the CPI port of the CDM-VW300 and the SC-CPI interface as shown in FIGURE 7-9. A standard RJ45 cable, such as those used in Ethernet networks, may be used. Yellow tape included in the CPI Network Kit (pn 29370) can be used to identify an RJ45 cable that is being used for CPI bus communications.

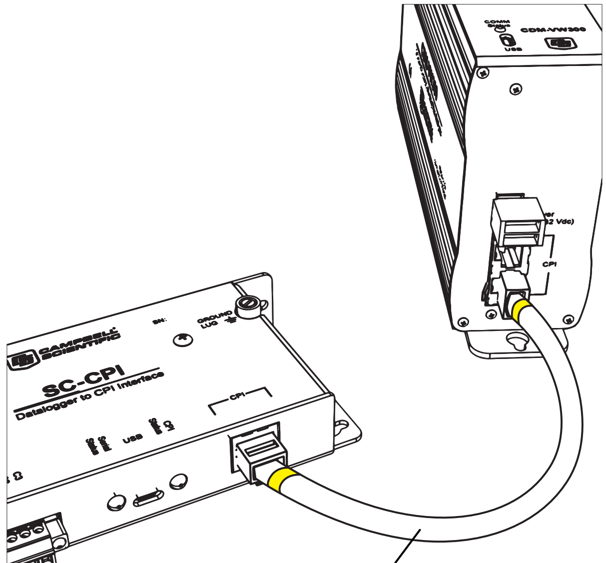


FIGURE 7-9. SC-CPI and CDM-VW300 CPI ports with RJ45 cable marked with yellow tape

Place a terminator in the remaining open CPI port of the CDM-VW300 as shown in FIGURE 7-10.

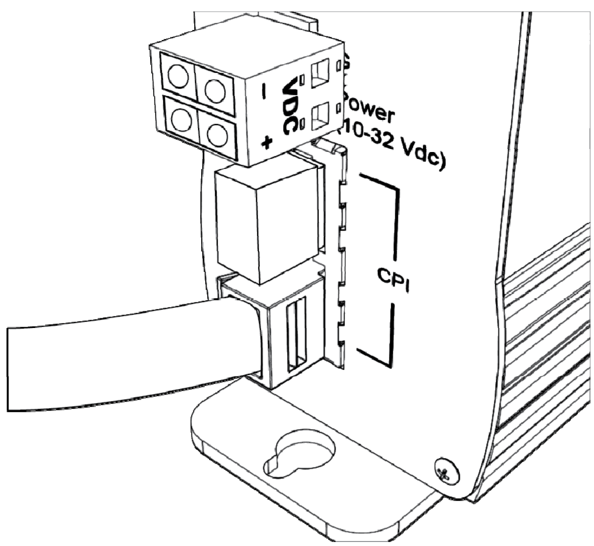


FIGURE 7-10. CPI terminator installed

Apply power to the CDM-VW300, the datalogger, and the SC-CPI interface to confirm connectivity.

Multiple CDM-VW300 analyzers can be connected to the CPI bus. The following figure shows these connections. The last open CPI port should have a CPI terminator installed.

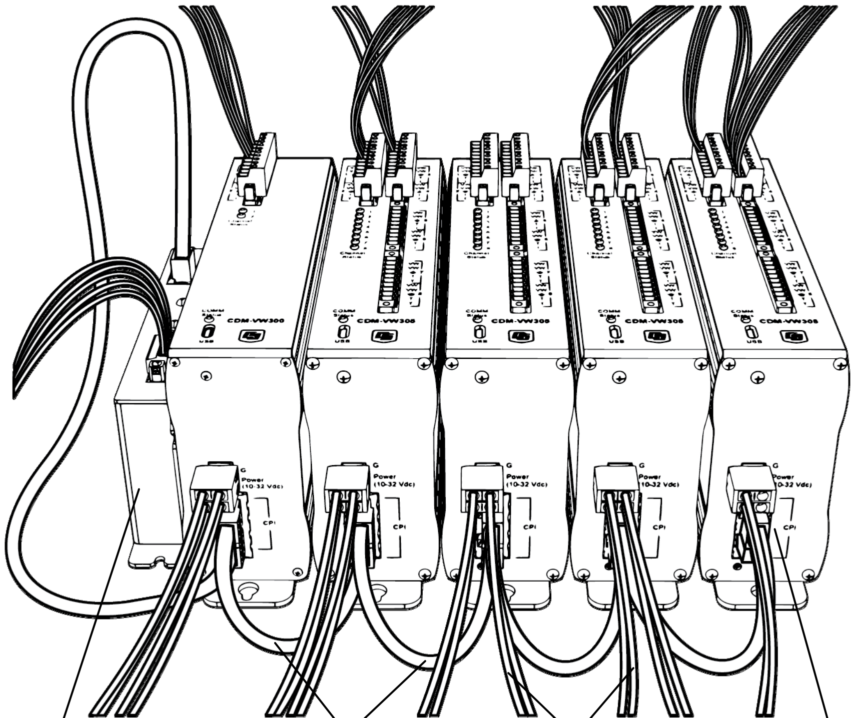


FIGURE 7-11. Multiple analyzers on a CPI bus

7.7.4 CDM-VW300 to Power Connection

Connect 12 Vdc power to the **Power In** connector on the side of the CDM-VW300. Power supplies providing voltages from 9.6 to 32 Vdc, with a minimum 200 mA current rating, may be used. Connect dc power to the CDM-VW300 as illustrated in the following figure.

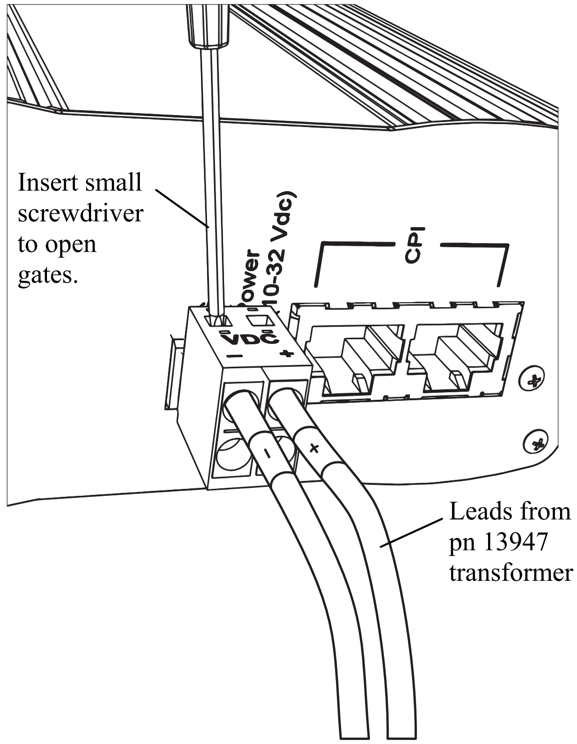


FIGURE 7-12. Installing 12 Vdc transformer on the CDM-VW300

In field-mode installations, power is connected and daisy-chained as shown in the following figures.

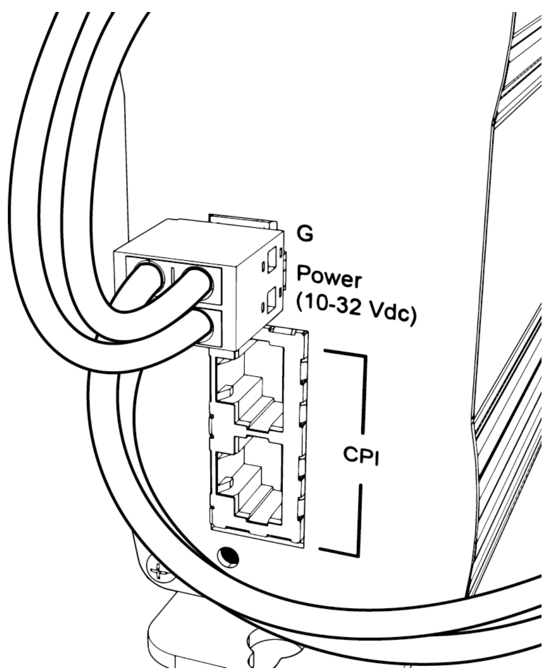


FIGURE 7-13. Daisy-chaining 12 Vdc power input on the CDM-VW300

7.7.5 Earth Ground Connections

Earth grounding provides protection from static discharge, transients, and power surges. Ground lugs are provided on the CDM-VW300 and the datalogger for connection to earth ground with high-gage wire. Minimum 14 AWG ground wire is recommended. The earth side of the connection should be to a grounding rod or other grounded device. Consult the datalogger manual for more information on earth grounding.

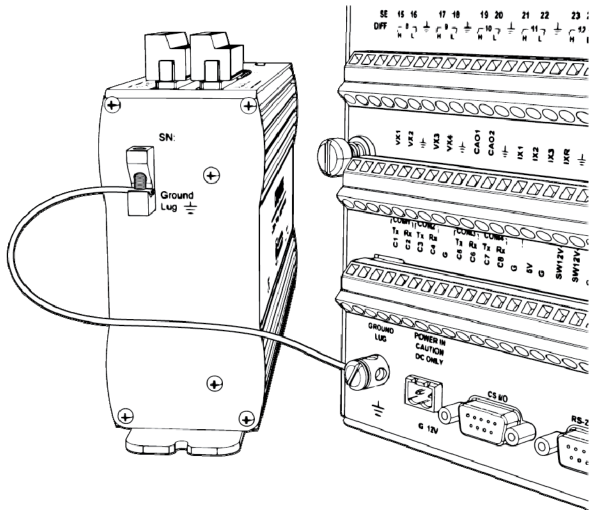


FIGURE 7-14. Earth ground connections

7.7.6 Communication Connections

A CDM-VW300 analyzer can connect to both PC software via USB (*DVWTool* or *DevConfig*) and the datalogger (through the SC-CPI, via RJ-45) simultaneously. When connecting to a CDM-VW300 analyzer that is active via CPI in this way, the device settings are locked. The settings shown in *DVWTool* will reflect the settings that were configured on the device by the datalogger CRBasic program using the **CDM_VW300Config()** instruction. Even if the interface of the *DVWTool* software appears to make a change to one of these locked settings, it will not be executed at the hardware level, so it will have no impact on the operation of the device.

7.7.6.1 SC-CPI to CPI Bus Connection

See Appendix B, *SC-CPI Datalogger to CPI Interface*.

7.7.6.2 Datalogger to SC-CPI Connection

CR3000, CR1000, and CR800 dataloggers require a SC-CPI interface to connect with the CDM-VW300. Connect **12V**, **G**, **C1**,**C2** and **C3** from the SC-CPI to the corresponding **12V**, **G**, **C1**, **C2**, **C3** ports of the datalogger, as shown in FIGURE 7-15.

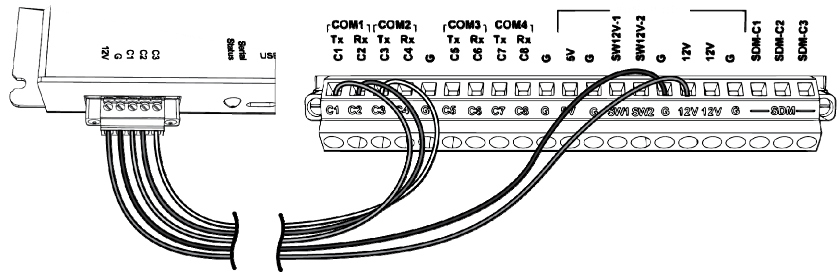


FIGURE 7-15. CR3000 and SC-CPI connections

NOTE SC-CPI module connects to terminals C1, C2, C3 (not SDM-C1, SDM-C2, SDM-C3).

7.7.7 Maximum Number of Analyzers on a Datalogger

The maximum number of active CDM-VW300 or CDM-VW305 analyzers and channels that can be managed by a single datalogger is a function of the dynamic sample or scan rate. The following table lists example configurations that have a full complement of analyzers.

TABLE 7-3. Number of Analyzers and Channels Supported by a Datalogger Writing to CF Card

Measurement Rate	CR3000 Datalogger	CR1000 Datalogger	CR800 Datalogger
20 Hz	48 Channels on 6 CDM-VW305s	32 Channels on 4 CDM-VW305s	32 Channels on 4 CDM-VW305s
50 Hz	24 channels on 3 CDM-VW305s	8 channels on 1 CDM-VW305	8 channels on 1 CDM-VW305
100 Hz	8 channels on 1 CDM-VW305	Not supported	Not supported

These channel counts predict best case scenarios wherein no other measurements are made on the dataloggers. Additional measurements will likely reduce the channel counts.

Note that each analyzer uses the bandwidth of the full channel compliment whether or not all channels are active. For example, consider a CR3000 datalogger controlling eight CDM-VW305 analyzers with two active channels on each analyzer making measurements at 20 Hz. The number of active channels is 16, but the system fails because the maximum number of analyzers (6) has been exceeded, even though the maximum number of channels has not.

Two notes about CR1000 and CR800 dataloggers with a full analyzer compliment:

- Final storage will significantly lag behind real time — several minutes in some cases.

- These dataloggers get into a state wherein they measure and store so intensely that little time remains to communicate with *LoggerNet* or *RTDAQ* software.

The CR3000 datalogger is the only datalogger currently available (as of August 2013) that will allow near real-time monitoring of events.

7.8 Operating System

The following components of a dynamic vibrating-wire data-acquisition system require an operating system (OS):

- CDM-VW300 series analyzer
- Datalogger
- SC-CPI interface

Operating systems may be updated on occasion to address new or enhanced features, or bugs fixes. The frequency of updates decreases as a product matures. If a product is received within six to twelve months of its first shipment, check the operating system identifiers against those listed at *www.campbellsci.com/downloads* upon receipt. The CDM-VW300 series analyzers and SC-CPI interface were first shipped in April of 2013.

NOTE Updating an operating system usually clears all settings. Always save the current settings of the device before loading an operating system.

Use *DevConfig* to update the CDM-VW300 operating system. In the *DevConfig* **CDM-VW300** option, check the operating system version in the **Settings Editor** tab. Download operating system updates in the **Send OS** tab by following the instruction outlined therein.

7.9 Power-Up Sequence

Switch power to the CDM-VW300 analyzers, the datalogger, and the SC-CPI interface simultaneously.

If powering devices sequentially is necessary, first switch power to each analyzer. The **COMM Status** LED on each analyzer will flash orange, meaning that the device has not yet established a connection with the SC-CPI. Next, switch power to the datalogger and the SC-CPI. The SC-CPI will begin initializing the CPI network. The **COMM Status** light on the analyzers may flash both green and red intermittently. When the SC-CPI is finished initializing the network, the **CPI Status** and **Serial Status** LEDs will flash green, as will the **COMM Status** light for each analyzer. If initialization fails, LEDs on all devices will flash red.

If the datalogger or SC-CPI interface loses power, and the CDM-VW300 analyzers do not, the **COMM Status** light on each device will change to red indicating that the connection to the CPI network is lost. Usually, restoring power to the datalogger (assuming it is still running a CDM-VW300 enabled program) and SC-CPI will automatically reinitialize the network.

7.10 CRBasic Programming

7.10.1 Writing Programs

In field-mode installations, the system datalogger requires a user-entered CRBasic program. Programs can be written either from scratch using CRBasic instructions or copied from the example programs provided in Appendix G, *CRBasic Program Library*. The following CRBasic instructions are used. For details concerning each instruction, consult *CRBasic Editor Help*. *CRBasic Editor* is included with *PC400*, *LoggerNet*, and *RTDAQ* datalogger support software.

CDM_VW300Config() sends configuration settings to the CDM-VW300. It is placed before the **BeginProg** statement in the CRBasic program. Before starting the datalogger program, the datalogger configures the specified analyzer according to the arguments in this instruction.

CDM_VW300Config() cannot be used to set the CPI address of the CDM-VW300. See Section 7.5.9, *CPI Bus Address*, for information on how to set the CPI address.

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

Scan() sets the scan interval to match the desired scan rate used for CDM-VW300 dynamic readings. For example:

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

is the **Scan()** instruction with arguments set for a 20 Hz CDM-VW300 scan rate. TABLE 7-4 lists other scan matches.

TABLE 7-4. CDM-VW300 Scan Rate / Datalogger Scan() Interval Pairings

CDM-VW300 Scan Rate	Datalogger Scan() Interval
20 Hz	50 ms
50 Hz	20 ms
100 Hz	10 ms

NOTE The CR3000, CR1000, and CR800 dataloggers do not support operation of the CDM-VW300 in 200 and 333.3 Hz modes.

CDM_VW300Dynamic() captures dynamic readings from sensors. It is used in the main scan of the CRBasic program.

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

CDM_VW300Static() captures static readings such as thermistor, static frequency, and standard deviation of dynamic frequencies at 1 Hz. It is used in the main scan inside of a **TimeIntoInterval()** conditional statement. Set **TimeIntoInterval()** to capture static data at 1 Hz. Capturing static data less frequently is possible, but when doing so, only the latest static frequency sample will be available.

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

CDM_VW300RainFlow() obtains rainflow-histogram data. It is used in a slow sequence.

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

RainFlowSample() writes the rainflow-histogram data to a data table. A typical rate for obtaining rainflow data is once per minute (60 s interval).

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

For more information, see the *CRBasic Editor Help* topics for each instruction.

Sample CRBasic programs for the CR3000 datalogger and CDM-VW300 and CDM-VW305 combinations are listed in Appendix G, *CRBasic Program Library*. These programs are examples and will likely need to be adapted for a specific application.

CPISpeed() controls the speed of the CPI bus. Use of this instruction is optional.

```
CPISpeed(BitRate)
```

7.10.2 Sending Programs to the Datalogger

Several options are available for sending programs to dataloggers. Detailed information can be found in the manuals for those options. Manuals are available at *www.campbellsci.com*. Software options are preferred and assume that the datalogger has an active communications link with a PC. The following datalogger support software have **Send Program** utilities to send programs over the active communications link:

- *DevConfig*
- *PC400*
- *LoggerNet*
- *RTDAQ*

In addition, the following portable memory devices have provisions for transferring programs from a PC to the datalogger:

- CompactFlash® (CF) card with CFM100 or NL115 CompactFlash® Modules
- SC115 CS I/O 2G Flash Memory Drive with USB Interface

7.11 System Adjustments

7.11.1 Frequency Range

Assuming a reasonable level of certainty about the maximum and minimum frequency response of a sensor (that is, what frequency values are returned when the sensor experiences maximum and minimum phenomena or stimulus conditions), the minimum and maximum frequency settings (***LowFreq*** and ***HighFreq*** in CRBasic **CDM_VW300Config()** instruction) can be used to implement further noise reduction of the sensor response. For example, at 100 Hz, the CDM-VW300 is capable of measuring frequencies between 580 and 6000 Hz. However, if a sensor frequency will always fall between 2000 and 3000 Hz, even for the lowest or highest reasonable readings, the minimum frequency (***LowFreq***) can be set to 2000 Hz, and the maximum frequency (***HighFreq***) set to 3000 Hz. The result will be that unwanted signals, such as noise, between 580 and 2000 Hz, and between 3000 and 6000 Hz will be filtered out.

7.12 System Validation

7.12.1 Sensor Validation

Confirm sensors are working with the CDM-VW300 by using a USB connection with *DevConfig* or *DVWTool* software. Status-indicating LED lights are provided for each sensor channel — two on the CDM-VW300 and eight on the CDM-VW305. TABLE 7-5 lists meanings of these indicators.

TABLE 7-5. CDM-VW300 Channel-Status LED States

Flash green or red at 3 s interval	Channel set to actively measure.
Flash green	Response received from sensor.
Flash red	Diagnostic flags indicate there may be a problem.
No flash, unlit	Channel not designated as active for measurement.

For more detail on how to activate individual channels for measurement, see Section 7.1.2, *Using DVWTool* or Section 7.1.3, *Using DevConfig*.

7.12.2 Monitoring System Performance

RTDAQ or *LoggerNet* software is typically used to monitor system performance. For complete information about using these software, consult the associated *Help* or respective manuals, which are available at *www.campbellsci.com*.

To use the tools for datalogger monitoring provided in *RTDAQ* or *LoggerNet*, start the software and open a numeric display of the **Public** table (*LoggerNet*: **Num Display**, *RTDAQ*: **Monitor Data** tab). In the **Public** table, observe the frequencies or readings that correspond to the analyzer channels selected for measurement. FIGURE 7-16 and FIGURE 7-17 shows a data displays in *LoggerNet* and *RTDAQ*.

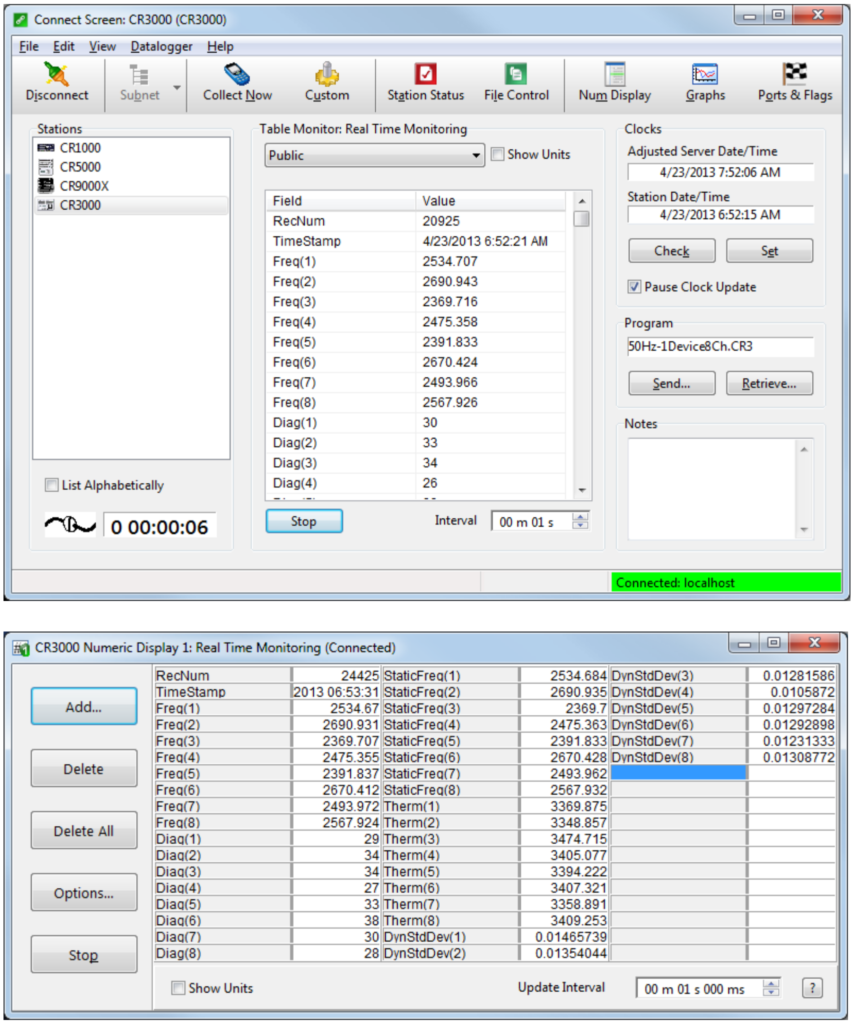


FIGURE 7-16. LoggerNet connect screens showing frequencies from CDM-VW300

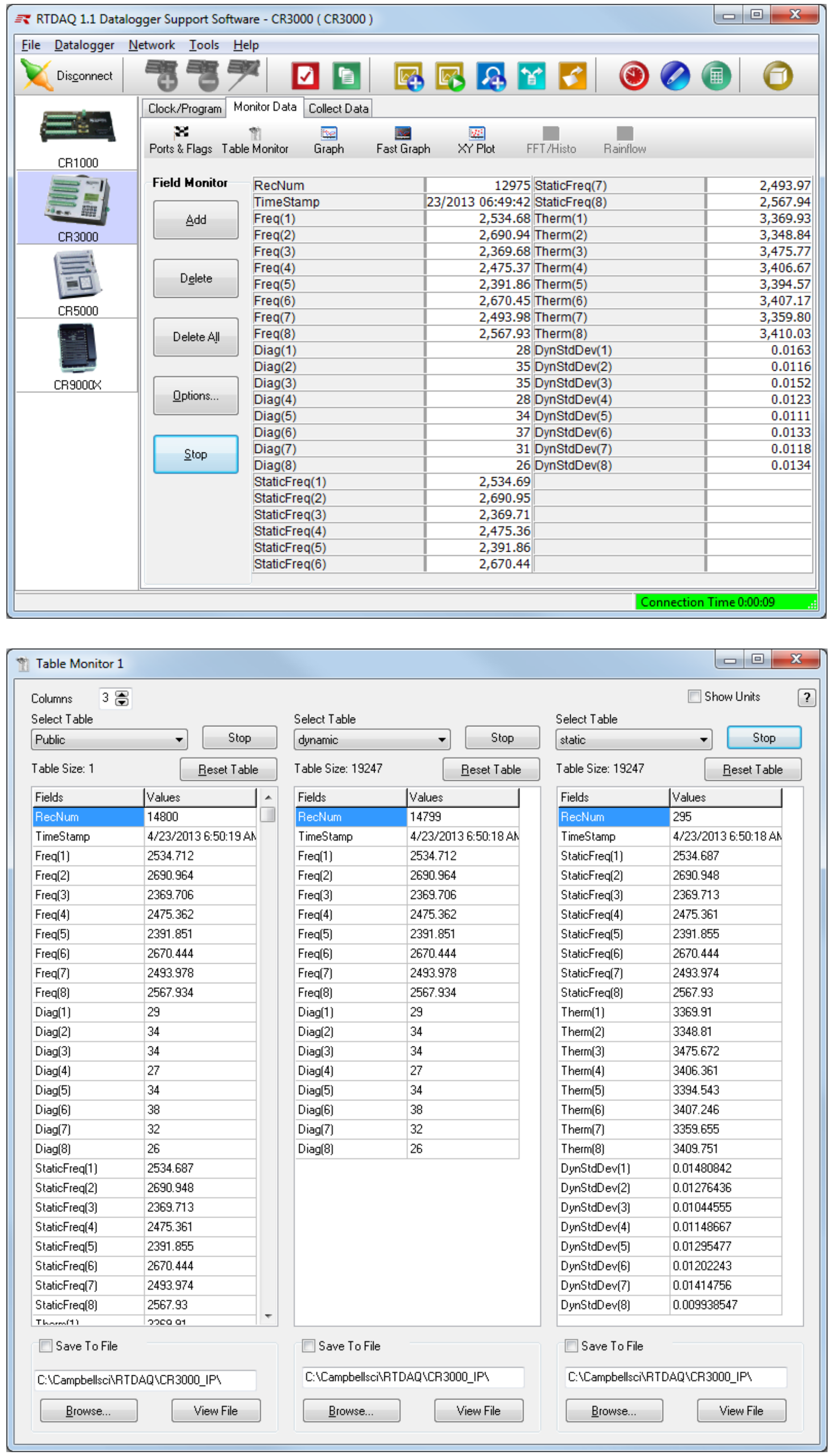


*FIGURE 7-17. RTDAQ screens showing frequencies in **Public** table*

If proper frequencies are showing, the datalogger has successfully communicated with the CDM-VW300 and obtained data.

7.12.2.1 Monitoring with DVWTool Software

The *Dynamic Vibrating-Wire Tool Box* (*DVWTool*) is a software package that enables a PC to communicate with the CDM-VW300 via USB (no datalogger required), configure CDM-VW300 settings, and display the output of attached sensors. The output data can be graphed on a line graph or in a rainflow histogram. For more information, refer to Section 7.1.2, *Using DVWTool*.

7.12.2.1.1 Fault Detection

Fault indication are shown in FIGURE 7-18, *Dynamic Vibrating-Wire Tool Box Fault Indicators*. A value other than **0x00** in the *DVWTool* **Diagnostic Bits** field indicates a fault. The fault is emphasized by measurement results appearing in red type, as illustrated in the following figure. Occasionally, the display of the measurement values will also be flashing. A fault is accompanied by an information icon (**i** inside a blue circle) in the **Diagnotic Bits** field. Click on the **i** to view a short decription of the fault. An argument input error is indicted by a red field and a **!** inside a yellow triangle. Click on the **!** to view a short description of the error.

When the frequency of a sensor changes quickly (corresponding to rapid changes of the phenomenon under test), the energy in the vibrating wire may drop briefly until the excitation mechanism can insert energy at the new frequency. The result is that a low-amplitude diagnostic condition may appear for a short time. This is expected behavior. Low- and high-amplitude diagnostic codes that appear briefly are usually no cause for concern. For these instances, there is no loss of fidelity in the values measured by the analyzer. However, low- and high-amplitude diagnostic codes that occur for long continuous periods require investigation.

See Section 8.5, *Diagnostic Outputs*, for more detail about the faults that are displayed in the **Diagnostic Bits** field.

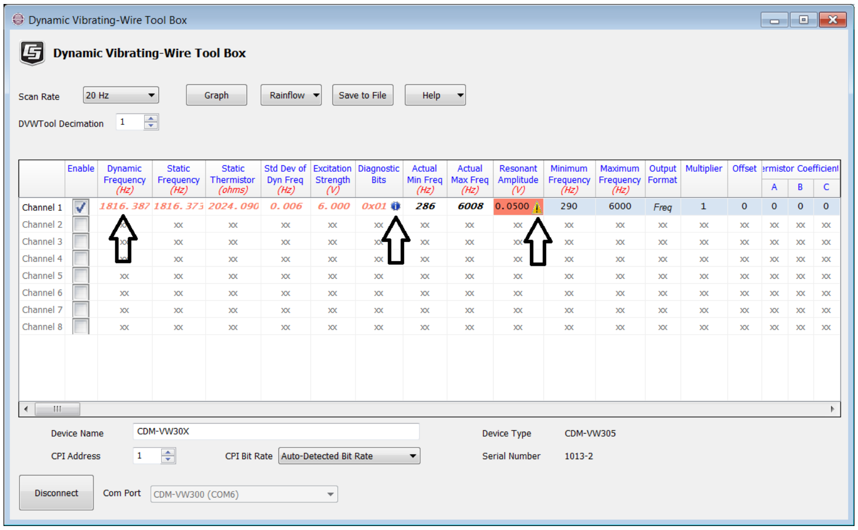


FIGURE 7-18. Dynamic Vibrating-Wire Tool Box Fault Indicators

8. Troubleshooting

CDM-VW300 series analyzers are designed to give years of trouble-free service with reasonable care. However, if factory repair is needed, you must first contact a Campbell Scientific application engineer to obtain an RMA (Return Materials Authorization) number. See the *Assistance* statement at the beginning of this manual for more information.

If the procedures in Section 6, *Installation*, do not lead to successful measurements, review the following suggestions. If these suggestions do not resolve the problem, please contact a Campbell Scientific application engineer. Essential troubleshooting tools include a PC and a volt-ohm meter (multimeter).

8.1 Connections

Re-check all connections:

- Sensor wiring
- Analyzer wiring and connections
- Datalogger wiring and connections
- Communications interface and PC connections

8.2 Power

Use a volt meter to check that adequate power is provided to:

- CDM-VW300 analyzer
- SC-CPI communications interface
- Datalogger

8.3 Isolating Components

Isolating components is an effective troubleshooting strategy. The following procedure isolates various components for independent verification.

1. Isolate the CDM-VW300 and sensors from the datalogger. Disconnect the analyzer from the datalogger and connect it to a PC with *DevConfig* or *DVWTool* software installed (ensure that the CDM-VW300 driver is installed properly on the PC Windows® operating system before going to the field).

2. Attempt to measure sensors in the lab-mode configuration (refer to Section 6.1, *Laboratory-Mode Installation*).

If the above procedure results in successful measurements, the problem likely resides with the datalogger. Otherwise, the problem likely resides with the CDM-VW300 analyzer or the sensors.

3. With the datalogger and CDM-VW300 still disconnected, send a CRBasic program to the datalogger that measures only panel temperature and battery voltage. *CRBasic Editor* defaults to this type of program. Ensure

that those readings are correct and can be viewed with *RTDAQ* or *LoggerNet*.

4. If temperature and battery measurements in step 1 are successful, reconnect the CDM-VW300 to the datalogger and send the 1 Hz program listed in Appendix G.2, *Static Measurements*, to the datalogger. If the temperature and battery measurement are unsuccessful, contact a Campbell Scientific application engineer.

8.4 Filtering Harmonics

Occasionally, a sensor output can consistently report a harmonic instead of the fundamental frequency. Most vibrating-wire sensors are designed such that harmonic frequencies are much less prominent in the signal than the fundamental. However, especially in worn or damaged sensors, harmonics can become a significant part of wire motion. A knowledge of the spectral response of a sensor will help set the maximum and minimum response frequencies properly. See Section 7.11.1, *Frequency Range*, and Section 8.5.1.2, *Calculating Low- and High-Frequency Boundaries*, for more details. If adjustment of max and min response settings does not remedy the problem, force the CDM-VW300 device to re-assess the primary frequency by a) disabling and re-enabling a channel, or b) re-sending the CRBasic program to the datalogger.

8.5 Diagnostic Outputs

Diagnostic outputs given by CDM-VW300 series analyzers include:

- Long integer diagnostic codes output at 20, 50, 100, 200 or 333.3 Hz for each enabled channel.
- Standard deviation calculated from the dynamic readings output at 1 Hz for each enabled channel.

8.5.1 Diagnostic Codes (Dynamic)

Diagnostic codes are returned with each dynamic frequency measurement made by the CDM-VW300 analyzer. Each diagnostic code is a 32-bit unsigned integer encoded with five diagnostic parameters. This method of reporting diagnostics minimizes data sent over the CPI bus, which helps to maximize measurement throughput rates. The five diagnostic parameters are:

1. Excitation strength
2. Low-amplitude warning flag
3. High-amplitude warning flag
4. Low-frequency warning flag
5. High-frequency warning flag

Each parameter is explained fully in Section 8.5.1.1, *Description of Diagnostic Parameters*. The third argument of the **CDM_VW300Dynamic()** instruction specifies the variable array to which the 32-bit diagnostic codes are written. This array is dimensioned up to a number equal to the maximum number of channels of the analyzer. For example, when the CDM-VW305 is measuring eight channels at 100 Hz, the diagnostic code array should be dimensioned to **(8)**. Each variable in the array receives 100 diagnostic codes per second, or one diagnostic code for each measurement. In total, 800 diagnostic codes are received each second.

8.5.1.1 Description of Diagnostic Parameters

Excitation strength — reports the voltage applied by the CDM-VW300 analyzer to keep the vibrating-wire of a sensor in motion. Excitation strength is reported as bit values between 0 and 255, which represent excitation voltages between 0 and 6 V.

NOTE Excitation voltage is set indirectly by the user when the user enters the **Resonant Amplitude** of the vibrating wire in *DVWTool* or the ***ResonAmp*** parameter of the **CDM_VW300Config()** CRBasic instruction. The excitation level is calculated by the analyzer and applied each time a measurement is made.

To translate the bit value to volts, divide the bit value by 42.5. For example, an excitation bit value of 180 is equivalent to an excitation voltage of 4.235 V. To reduce the computational load on the datalogger processor, multiply the bit value by the reciprocal of 42.5, which is 0.02353. A multiplication operation consumes less datalogger processor time than a division operation, which is a consideration in fast throughput applications. Results will be substantially the same as those obtained by a division operation.

Low-amplitude warning flag — flag is set true when the resonant amplitude of the vibrating wire falls to or below 50% of the value entered in *DVWTool* or **CDM_VW300Config()**. Resonant amplitude must be maintained higher than 50% to ensure an accurate measurement.

High-amplitude warning flag — flag is set true when the resonant amplitude of the vibrating wire reaches or exceeds 200% of the value entered in *DVWTool* or **CDM_VW300Config().** Resonant amplitude must be maintained less than 200% to ensure an accurate measurement.

Low-frequency warning flag — flag is set true when the frequency of the vibrating wire falls between the **Actual Min Freq (Hz)** shown in *DVWTool* and the **Minimum Frequency (Hz)** entered in *DVWTool*. The **CDM_VW300Config()** instruction equivalent to **Minimum Frequency (Hz)** is the ***LowFreq*** parameter. When a low-frequency limit is entered into *DVWTool* or the CRBasic program, an error window is created that spans the bandwidth between the frequency cut-off requested (**Minimum Frequency** or ***LowFreq***) and the frequency cut-off the analyzer can actually establish (**Actual Min Freq**). If a measured frequency falls within the error band, the low-frequency warning flag is set true. For example, if a low-frequency limit of 500 Hz is entered, and the closest the analyzer can come to complying is to set the limit at 476.85 Hz, any frequency below 476.85 Hz is discarded, and any frequency above 476.85 Hz is used. However, any frequency between 476.85 Hz and 500 Hz will activate the low-frequency warning flag, indicating that the data includes at least one measurement below the user set limit. See Section 8.5.1.2, *Calculating Low- and High-Frequency Boundaries*, for more information.

High-frequency warning flag — flag is set true when the frequency of the vibrating wire falls between the **Actual Max Freq (Hz)** shown in *DVWTool* and the **Maximum Frequency (Hz)** entered in *DVWTool*. The **CDM_VW300Config()** instruction equivalent to **Maximum Frequency (Hz)** is the ***HighFreq*** parameter. When a high-frequency limit is entered into *DVWTool* or the CRBasic program, an error window is created that spans the bandwidth between the frequency cut-off requested (**Maximum Frequency** or ***HighFreq***) and the frequency cut-off the analyzer can actually establish (**Actual Max Freq**). If a measured frequency falls within the error band, the high-frequency warning flag is set true. For example, if a high-frequency limit of 1000 Hz is entered, and the closest the analyzer can come to complying is to set the limit at 1049.07 Hz, any frequency above 1049.07 Hz is discarded, and any frequency below 1049.07 Hz is used. However, any frequency between 1000 Hz and 1049.07 Hz will activate the high-frequency warning flag, indicating that the data include at least one measurement above the user set limit. See Section 8.5.1.2, *Calculating Low- and High-Frequency Boundaries*, for more information.

8.5.1.2 Calculating Low- and High-Frequency Boundaries

The easiest way to minimize the size of the low- and high-frequency error windows is to enter estimated limits into the **Minimum Frequency** and **Maximum Frequency** columns in the *DVWTool* main screen, record the resulting values displayed in the **Actual Min Freq** and **Actual Max Freq** columns, then turn around and enter those values back into the **Minimum Frequency** and **Maximum Frequency** columns or the ***LowFreq*** and ***HighFreq*** parameters in the **CDM_VW300Config()** CRBasic instruction.

However, to calculate the actual-minimum and actual-maximum frequencies, use the information in TABLE 8-1 to size the value. For example, to calculate the actual-minimum frequency, assuming a measurement is to be taken at a scan rate of 20 Hz, use an integer multiple of 47.68 to calculate the actual-minimum frequency. If the low-frequency limit is estimated to be 150 Hz, enter 3 x 47.68, or 143.04 Hz, as the **Minimum Frequency** in *DVWTool* or as the ***LowFreq*** argument in the **CDM_VW300Config()** CRBasic instruction.

To calculate the actual-maximum frequency, assuming a measurement is to be taken at a scan rate of 20 Hz, use an integer multiple of 47.68 to calculate the actual-maximum frequency. If the high-frequency limit is estimated to be 500 Hz, enter 10 x 47.68, or 476.80 Hz, as the **Maximum Frequency** in *DVWTool* or as the ***HighFreq*** argument in the **CDM_VW300Config()** CRBasic instruction.

TABLE 8-1. Scan Rate and Boundary Resolution

Scan Rate (Hz)	Boundary Resolution (Hz)[1]
20	47.68
50	95.37
100	190.73

[1]The low-frequency limit or the high-frequency limit must be an integer multiple of this frequency.

8.5.1.3 Using Diagnostic Parameters

Although a frequency reading may be provided when an amplitude or frequency warning flag is true, the measurement should be accepted only with caution. Rather than risk accepting bad data, consider setting the ***SysOptions*** argument of the **CDM_VW300Config()** instruction to force the analyzer to report the frequency measured under these conditions as **NAN**. A low- or high-amplitude warning flag can be set for any one measurement, but not both. A low- or high-frequency warning flag can be set for any one measurement, but not both. Any one amplitude flag and any one frequency flag can be set simultaneously.

8.5.1.4 Decoding the Diagnostic Code

To recover the five diagnostic parameters from a diagnostic code, the bit pattern represented by the twelve least-significant bits of the 32-bit diagnostic code is decoded.

8.5.1.4.1 Excitation Strength

The eight least-significant bits (2^0 through 2^7) of the diagnostic code represent the excitation strength (0 to 255). When no low- or high-amplitude or frequency warning flags are true, the diagnostic code has a value between 0 and 255. If amplitude- or frequency-warning flags are set, the integer will be larger than 255. To strip the warning flags out of the diagnostic code, a bit-masking operation is performed.

The bit-masking operation uses the AND operator in CRBasic. The following CRBasic statement decodes excitation strength in volts from the integer:

```
ExciteStrengthV = (DiagCode AND 255) / 42.5
```

where **DiagCode** is the diagnostic code and **ExciteStrengthV** is assigned a **Float** data type. This ensures that only the eight least-significant bits are considered, resulting in an intermediate value between 0 to 255 and a result between 0 and 6 V.

8.5.1.4.2 Low-Amplitude Warning Flag

The ninth bit (2^8 or 256) corresponds to the low-amplitude warning flag. Use the following expression to isolate the state of this bit:

```
(DiagCode AND 256)
```

This expression results in zero if the bit is not set (in other words, low-amplitude warning flag is false) and 256 if the bit is set (in other words, low-amplitude warning flag is set true). Since many diagnostic codes are given each second, a counter is normally used to track occasional instances of this flag being set. The following CRBasic statement counts the number of times a low-amplitude warning flag is set true.

```
If (DiagCode AND 256) Then LowAmpCount=LowAmpCount + 1
```

where **LowAmpCount** is assigned a **Long** data type. An alternative is to assign the expression to a Boolean value. However, seeing the warning will be difficult if it is set and reset too rapidly:

```
LowAmpWarning = (DiagCode AND 256)
```

where **LowAmpWarning** is assigned a Boolean data type.

8.5.1.4.3 High-Amplitude Warning Flag

The tenth bit (2^9 or 512) corresponds to the high-amplitude warning flag. Use the following expression to isolate the state of this bit:

```
(DiagCode AND 512)
```

Similar techniques to those described in the preceding section for the low-amplitude warning flag can be used with this expression.

8.5.1.4.4 Low-Frequency Warning Flag

The eleventh bit (2^{10} or 1024) corresponds to the low-frequency warning flag and can be isolated with the expression,

```
(DiagCode AND 1024)
```

Similar techniques to those described in the preceding section for the low-amplitude warning flag can be used with this expression.

8.5.1.4.5 High-Frequency Warning Flag

The twelfth bit (2^{11} or 2048) corresponds to the high-frequency warning flag and can be isolated with this expression:

```
(DiagCode AND 2048)
```

Similar techniques to those described in the preceding section for the low-amplitude warning flag can be used with this expression.

8.5.1.4.6 Interpreting the Diagnostic Code

Although the above techniques constitute the preferred way for processing and communicating the state of diagnostic parameters, examining the ranges of values within which the returned code falls may be useful.

The following table summarizes these ranges and their meaning:

TABLE 8-2. Diagnostic Code Ranges

If diagnostic code falls within this range:	Low-amplitude warning flag is:	High-amplitude warning flag is:	Low-frequency warning flag is:	High-frequency warning flag is:
0 – 255 (0 – FF Hex)				
256 – 511 (100 – 1FF Hex)	True			

512 – 767 (200 – 2FF Hex)		True		
1024 – 1279 (400 – 4FF Hex)			True	
1280 – 1535 (500 – 5FF Hex)	True		True	
1536 – 1791 (600 – 6FF Hex)		True	True	
2048 – 2303 (800 – 8FF Hex)				True
2304 – 2559 (900 – 9FF Hex)	True			True
2560 – 2815 (A00 – AFF Hex)		True		True

The excitation level associated with a diagnostic code can be calculated. This is done by subtracting the low diagnostic code boundary value (shown in the first column) from the raw diagnostic value and dividing the difference by 42.5. For example, a raw diagnostic value of 1650 falls within the range 1536 to 1791. Subtract 1536 from 1650 and divide the result, 114 (the result will always fall between 0 and 255), by 42.5. The result is 2.68 V.

Ranges outside those listed in TABLE 8-2, *Diagnostic Code Ranges*, should only occur in conjunction with hardware or operational errors reported by the datalogger.

8.5.2 Standard Deviation of Dynamic Output

A 1 Hz calculation of standard deviation from an array of dynamic readings can be obtained from the output of the **CDM_VW300Static()** instruction. A significant increase in standard deviation from a baseline may indicate a problem with either the sensor or the structure or phenomena being measured. Take appropriate steps to identify the source of any unexpected change in standard deviation.

8.6 Factory Default Reset

Products that use an operating system and memory may occasionally require a reset to factory defaults. A default reset is probably near the end of the list of troubleshooting techniques used when some aspect of a data-acquisition system is not functioning or returning the expected results.

Use DevConfig to reset Campbell Scientific products to factory defaults. The following procedure is a guide to resetting factory defaults. When resetting to factory defaults, first preserve the current state of the device.

1. Connect the product to the PC. For the CDM-VW300 and SC-CPI interface, connection is made via a male-USB to type-micro-B male USB cable.

2. To reset the product to factory defaults,

   i. From the list at the left of the main *DevConfig* window, select the product that was just physically connected. A series of tabs related to the selected product is displayed.

   ii. Select the **Communication Port** associated with the physical connection.

   iii. Click **Connect**. A series of tabs is presented. Select **Settings Editor**.

   iv. Save the old settings by clicking **Summary,** then **Save** in the lower portion of the **Settings Editor** tab.

   v. To reset factor defaults, click **Factory Defaults**, then click **Apply**.

9. Glossary

DevConfig — Device Configuration Utility. Use version 2.04 or later with dynamic vibrating-wire data-acquisition systems. When *DevConfig* is installed, USB drivers for CDM-VW300 series analyzers and the SC-CPI interface are automatically sent to the PC running *Windows® XP, Windows® Vista, Windows® 7, or Windows® 8* operating system.

DVWTool — Dynamic Vibrating-Wire Tool software. It was specifically written to support CDM-VW300 series analyzers. *DVWTool* enables a PC to initiate and request measurements from the CDM-VW300 without use of a datalogger. When *DVWTool* is installed, USB drivers for CDM-VW300 series analyzers and the SC-CPI interface are automatically sent to the PC. running *Windows® XP, Windows® Vista, Windows® 7, or Windows® 8 operating system*

Datalogger support software — for the purposes of Campbell Scientific dynamic vibrating-wire data-acquisition systems, this includes *RTDAQ*, *LoggerNet*, and *PC400*. *RTDAQ* is preferred.

AWG — gage. Units used when expressing the thickness of wire. The higher the AWG value, the thinner the wire. 20 AWG to 24 AWG wire is often used in all connections except power and earth ground. Power connections often use 16 AWG to 18 AWG wire. Earth ground connections usually use 14 AWG or larger diameter.

NAN — not a number. An indication that an invalid measurement has been made.

10. References and Attributions

Matsuishi, M. and T. Endo, "Fatigue of Metals Subjected to Varying Loading," *Japan Society of Mechanical Engineers*, Fukuoka, Japan, 1968.

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

Appendix A. Measurement Theory

A.1 Dynamic Vibrating-Wire Measurements

The key components of standard, single-coil vibrating-wire sensors are 1) a taut wire suspended between two anchor points, and 2) an electromagnetic coil positioned at the center of the wire. The coil serves two functions: first as an actuator to put energy into the wire and, second, as a pickup to detect the motion of the wire. Static vibrating-wire measurements are typically performed in a two-step process of exciting the wire and then measuring the wire response for a period of time to determine its resonant frequency. The excitation waveform must be spectrally broad, such as a swept-frequency sine wave, so as to provide sufficient energy at the unknown resonant frequency of the wire. After the excitation, the resonant motion of the wire is sampled, the frequency is determined, and then the resonant energy dissipates prior to making the next measurement. The time required for these steps typically limits this measurement method to rates slower than 1 Hz.

Dynamic measurements compress the measurement cycle and achieve much higher sample rates by eliminating the broadband excitation and not allowing the wire oscillation to decay. FIGURE A-1, *Timing of dynamic vibrating-wire measurements* illustrates the timing of this process. If energy can be injected into the oscillation at precisely the right frequency and with the correct phase, then a very short excitation waveform with a small amplitude can maintain the resonance of the wire. If the excitation is not phase-aligned to the wire motion, then the resonance will be dampened rather than reinforced. In between these excitation windows, the wire motion can be sampled and the resonant frequency determined. Using the newly calculated frequency, the excitation is adjusted slightly as needed to track the changes in the resonant frequency of the wire. The excitation mechanism has very fine frequency resolution to precisely track even very subtle changes in the resonant frequency. As can be seen in FIGURE A-1, there are usually only a few oscillation cycles of the wire available for determining the wire resonant frequency. This difficulty is overcome by the spectral analysis algorithm, which can determine the frequency of the wire precisely, even with this short data sample.

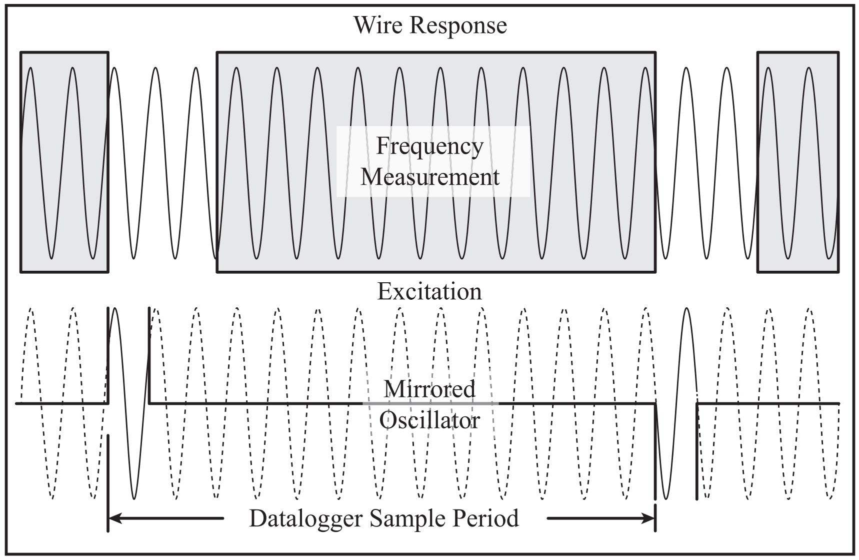


FIGURE A-1. Timing of dynamic vibrating-wire measurements

An important aspect of dynamic measurement timing is synchronizing the process to an external timing source that is independent of the wire oscillation. Synchronization has intrinsic benefits to the measurement quality and also allows simultaneous sampling of multiple channels. FIGURE A-1 shows that the datalogger sample period dictates when the excitations are introduced and when the frequency measurement is made. Since this sample period is independent of the wire motion, the excitation may begin at any point in the phase of the oscillation. When measuring single-coil sensors, inclusion of the excitation in the measurement can skew the measured frequency and result in increased noise and a diminished dynamic response. The remedy to excitation noise is synchronization, which guarantees that the frequency measurement never overlaps the excitation window. The multi-channel simultaneity enabled by time-synchronization is another important benefit when correlating measurements from multiple sensors. Time-synchronized excitation control is a key differentiator between this approach and other auto-resonant, coil-excitation methods.

A.1.1   Dynamic and Static Frequencies

CDM-VW300 series analyzers output a dynamic-frequency value for each sensor at the rates of 20, 50, 100, 200, or 333.3 Hz. A static frequency is given once each second. The same multiplier and offset apply to both the static and dynamic frequency outputs.

Since only a few cycles of the wire are sampled each time a dynamic reading is made (less than 50 ms, 20 ms, or 10 ms is available for sampling, depending on the dynamic sample frequency used), the resolution in the spectrum is larger (coarser) than the spectral resolution obtained when using all of the data captured during a one-second period. As a result, there can occasionally be noise frequencies that end up in the same FFT (Fast Fourier Transform) bin as the signal of interest, causing measurement error. To detect such conditions, a static, one-second frequency is provided by the analyzer. This finer resolution reading can be examined to detect and respond to cases such as those described above.

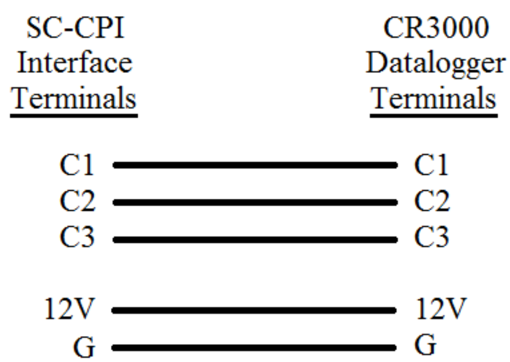
Appendix B. SC-CPI Datalogger to CPI Interface

B.1 Introduction

The SC-CPI is designed to interface the CR3000, CR1000, and CR800 dataloggers to a network of CDMs (Campbell Distributed Modules) using the CPI bus communications protocol. Only one SC-CPI interface is required per datalogger. The datalogger and the SC-CPI should be installed in the same enclosure.

B.2 Quickstart

The following figure shows SC-CPI to CR3000, CR1000, or CR800 series datalogger connection wiring. Cable length should not exceed five feet.



NOTE SC-CPI module connects to terminals C1, C2, C3 (not the CR3000 SDM-C1, SDM-C2, SDM-C3).

B.3 Overview

The SC-CPI allows Campbell Scientific CR3000, CR1000, and CR800 dataloggers to interface to CDM modules. The datalogger communicates with the SC-CPI module using control ports C1, C2 and C3.

There are two LED indicator lights on the SC-CPI module. The indicator lights show status of the link and give a visual indication that it is operating correctly. The LED closest to the CPI port shows status of the CPI bus. The LED closest to the terminal block shows status of the serial connection to the datalogger.

Connection to the datalogger consists of connecting **12V** and **G** terminals of one device to the other. Power can come from the datalogger, but may also be provided by another source. A ground connection to the datalogger is required for a reference for the data signals. A ground-wire connection from the ground lug to a suitable ground should be made. Cabling between the datalogger and the SC-CPI should be as short as possible.

To configure the SC-CPI with a PC requires a software driver be installed on the PC. This driver is automatically installed when *DVWTool* or *DevConfig* software is installed. Once the driver is installed, a USB cable can be connected between the PC and the SC-CPI. As indicated in FIGURE B-1, *DevConfig* can then be used to check the SC-CPI OS version and examine other settings and operational statistics such as:

- CPI communication diagnostics
- Serial or CPI load
- CPI frame errors
- CPI network information

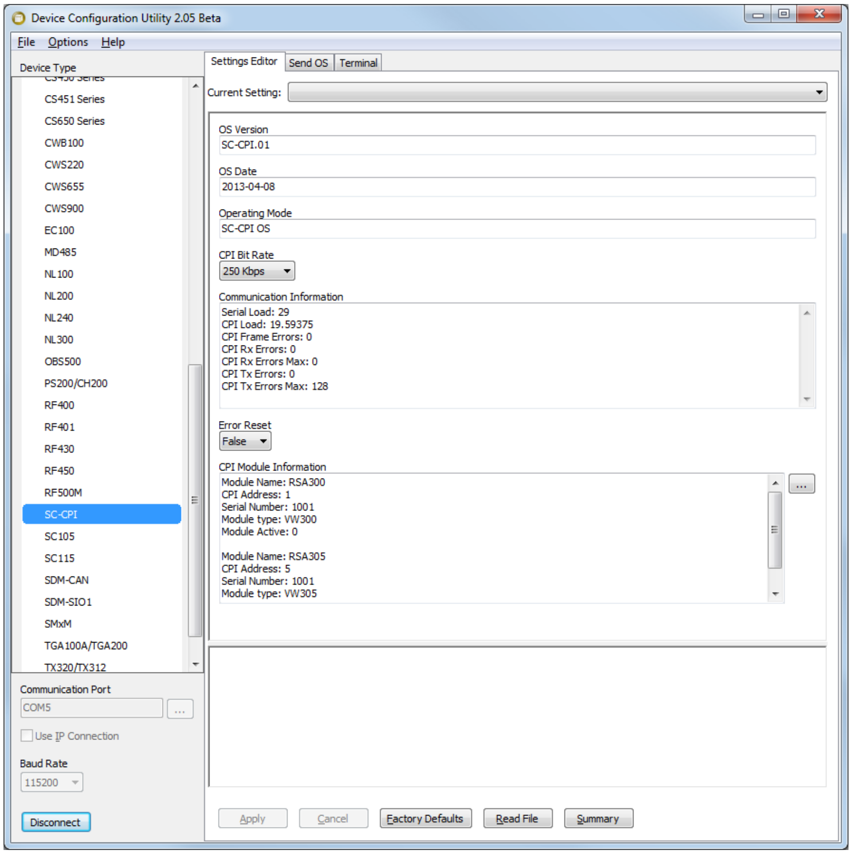


FIGURE B-1. Connection to the SC-CPI in DevConfig

Refer to the help window in the *DevConfig* **Settings Editor** tab for further details about operations that can be performed and information that is available.

B.4 Specifications

Compatibility	
Dataloggers:	CR800 Series CR1000 CR3000
Operating temperature:	–25° to 50°C –55° to 85°C optional
Power requirement	
Source:	9.6 to 16 Vdc
Load:	50 mA continuous
Connectors	
CPI to CDM:	RJ45
Serial to datalogger:	Screw terminal
Serial to PC:	Type-micro-B male USB
Certification:	Tested in accordance to EM directive 2004/108/EC and BS EN61326:2006
Weight:	0.188 kg (0.415 lb)
Dimensions:	15.94 x 7.49 x 3.18 cm (6.28 x 2.95 x 1.25 in)

Appendix C. CDM Devices and CPI Bus

Campbell Scientific is introducing the CDM (Campbell Distributed Module) line of peripherals, starting with the CDM-VW300 series of vibrating-wire analyzers. As multiple CDM devices become available, they will be able to be networked to communicate measurement information to a central datalogger. The communications protocol used is the CAN (Controller Area Network) Peripheral Interface (CPI) protocol.

CPI is a proprietary interface for communications between Campbell Scientific dataloggers and Campbell Scientific CDM peripheral devices. It consists of a physical layer definition and a data protocol. CDM devices are similar to Campbell Scientific SDM devices in concept, but the use of the CPI bus enables higher data-throughput rates and use of longer cables. CDM devices require more power to operate in general than do SDM devices.

C.1 CDM Interconnection and Datalogger Connection

C.1.1 Power

The transmission of dc power to CDM modules is not governed by the CPI specification but is left to the system integrator to implement. Most CDMs require modest power from a regulated dc voltage between 11 and 32 Vdc. This power may come from the datalogger power source or through the datalogger wiring panel.

C.1.2 Interconnect Cable

Current Campbell Scientific dataloggers require the SC-CPI Interface to connect with one or more CDM devices. Cat5e cable with RJ45 terminations connects a CDM devices with the SC-CPI and other CDM devices. Cabling and connections must be managed carefully to achieve the highest data rates and longest transmission distances. Ideally, four twisted-pair (data, synchronization, clock, and ground) are contained in a single shielded cable.

The data pair carries data between the SC-CPI and CDM using the CAN protocol with ISO 11898 as the electrical standard. The CAN protocol covers device addressing, bus arbitration, prioritization, bit-error checking, and failed-message retransmission. The synchronization pair uses the RS-485 (TIA/EIA-485A) electrical standard. This signal is a pulse that marks the beginning of each scan. CDMs use this precision timing to remain synchronized, to latch, and to buffer and transmit data to the datalogger unprompted over the data pair.

Use a pn 28558 termination resistor plug (included with the pn 29370 CPI network kit) on the final device of a CPI chain to ensure cable communications are working at high speeds and over very long distances. CPI pin assignments are provided in the following figure as implemented with Cat5e cabling.

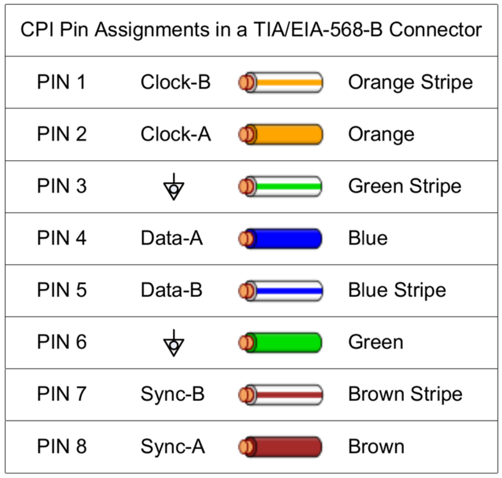


FIGURE C-1. CPI pin assignments

C.1.3 Speed as a Function of Distance

TABLE C-1. Maximum Potential Speed as a Function of Distance[1]

Bit Rate (kbps)	Cable Length, m (ft)
1000	45 (150)
500	91 (300)
250	182 (600)
125	365 (1200)
50	914 (3000)
25	1219 (4000)

[1]for a two-node CDM network under optimal conditions

Cable lengths shown in the preceding table can usually be adapted to CPI networks containing multiple CDM devices if the total distance for all cable in a network does not exceed the given length.

For most CPI bus deployments, all CDM devices should be set with a **CPI Bit Rate** setting of **Auto Detect[1]**. Doing so allows the bit rate to be controlled by either the **CPISpeed()** CRBasic instruction, or the **CPI Bit Rate** setting of the SC-CPI interface[1]. The **CPISpeed()** setting takes priority. When a CDM device is set to **Auto Detect**, it initializes into the mode given to it by the SC-CPI interface, which comes from either the SC-CPI setting or the **CPISpeed()** instruction. Any CDM device that is set to a bit rate that differs from the current SC-CPI setting will not operate on the CPI network, and the **COMM Status** indicator light on the CDM device will flash red.

[1]The SC-CPI interface and all CDM devices can be configured using Campbell Scientific *Device Configuration Utility* (*DevConfig*). CDM-VW300 series analyzers can also be configured using *DVWTool* software.

C.1.4 CPI Grounding

To keep the common mode of the signals in range, a common reference (ground) connection is advised for any non-isolated communication link. If a ground potential difference exists, then current will flow on the common wire from one end of the cable to the other. This current is restricted only by the dc resistance of the common wire which is often quite low. To increase this resistance, a 100-Ω resistor is placed inside each CDM device, SC-CPI interface, or CDM equipped datalogger between the CPI ground and the local ground. This is a compromise between directly connecting the two points and leaving the common connection entirely disconnected. It limits current while still helping to prevent the two node voltage potentials from drifting too far apart.

C.1.6 Addressing

The CPI bus uses an addressing scheme that supports up to 120 CDM devices on the bus connected to a single SC-CPI interface. In the case of the CDM-VW300, fewer devices must be used because of limitations of bandwidth caused by high-speed measurement rates. Future CDM devices may be used on a CPI bus managed by a SC-CPI interface device connected to a datalogger.

C.2 Distributed Architecture

CDM devices can operate with longer cable distances between modules and the datalogger than might be expected for sub-second data acquisition. A common long cable network is illustrated in the following FIGURE C-2.

The CDM-VW300 uses the CPI communications protocol to communicate with Campbell Scientific dataloggers or other CDM devices. Two CPI connectors are provided on each device. The network kit supplied with each CDM device provides yellow tape with which to optionally mark RJ45cables dedicated to CPI communications.

A single CDM device can be connected to a CR800 series, CR1000, or CR3000 datalogger using an SC-CPI interface. One CPI port on the CDM device connects to a CPI port on the SC-CPI. The other CPI port is terminated with a CPI terminator (supplied with pn 29370 network kit). When multiple CDM devices are used in a daisy-chain topology, one CPI port of the CDM device nearest the datalogger connects to the SC-CPI interface and the other CPI port connects to a neighboring CDM device. Any CDM devices in the middle of the chain will have both CPI ports connected to neighboring CDM devices. Once CPI port of the CDM device at the end of the CPI bus/chain connects to a neighboring CPI device, and the other port is fitted with a termination plug (pn 28558). Contact a Campbell Scientific application engineer for information about using a optional star topology.

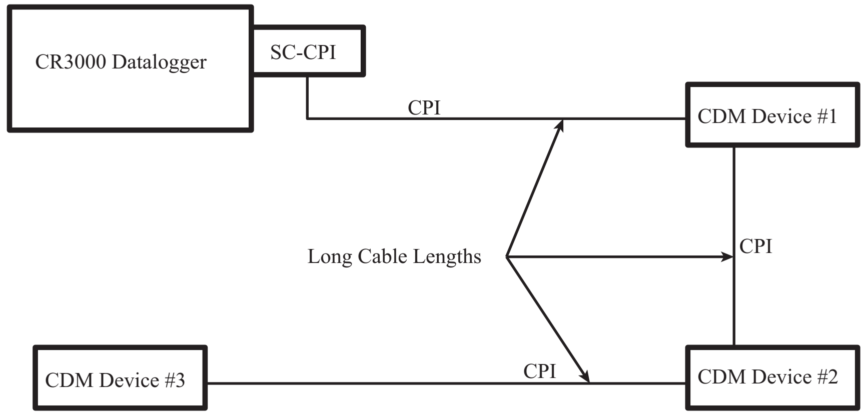


FIGURE C-2. Long cable lengths of a distributed CPI bus

Appendix D. Digits Conversion

Vibrating-wire sensors are typically supplied with a calibration report from the manufacturer. Use the calibration data to convert the frequency output of the CDM-VW300 to engineering units. While basic measurement of CDM-VW300 analyzers is frequency, which is expressed in hertz (Hz), some calibration reports express the base measurement in terms of 'digits'. If this is the case, first convert the frequency output of the CDM-VW300 to a digits equivalent using the following formula,

$$\text{digits} = \text{Hz}^2 / 1000.$$

Use gage factor and polynomial fit data from the calibration report to then convert digits to engineering units. Following is an example that converts the frequency output of the CDM-VW300 first to digits, then to engineering units of millimeters of displacement.

D.1 Example: Frequency to Digits to Displacement

Measuring a Geokon vibrating-wire displacement sensor, the CDM-VW300 analyzer outputs a value of 2400 Hz. FIGURE D-1 shows the calibration report for the sensor. The relationship of sensor output to displacement, *s*, is expressed as,

$$s = (3.598e{-}9) \cdot \text{digits}^2 + (1.202e{-}3) \cdot \text{digits} + ({-}3.1682)$$

First, 2400 Hz is converted to digits using the following formula:

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

Next, the digits value is placed in the polynomial equation:

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

$$s = 98.53\ \text{mm}$$

GEOKON 48 Spencer St. Lebanon, N.H. 03766 USA

Vibrating Wire Displacement Transducer Calibration Report

Range: 150 mm

Calibration Date: January 7, 2010

Serial Number: 0939696

Temperature: 23.4 °C

Calibration Instruction: CI-4400

Technician:

GK-401 Reading Position B

Actual Displacement (mm)	Gage Reading 1st Cycle	Gage Reading 2nd Cycle	Average Gage Reading	Calculated Displacemen (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): 0.03146 (mm/ digit) **Regression Zero: 2623**

Polynomial Gage Factors: A: 9.139E-08 B: 0.03054 C: -80.471

(inches) Linear Gage Factor (G): 0.001238 (inches/ digit)

Polynomial Gage Factors: A: 3.598E-09 B: 0.001202 C: -3.1682

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 : 4239 Temp(T_0): 24.1 °C Date: January 28, 2010

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.

FIGURE D-1. Geokon Calibration Report of a Sensor without a Thermistor

Appendix E. Calculating Measurement Error

When using a CDM-VW300 analyzer, the basic output of a measurement is frequency (Hz) or frequency squared (Hz^2). Vibrating-wire sensors are usually designed with a linear relationship between wire tension and the phenomenon being measured. Further, wire tension usually has a linear relationship to the square of the resonant frequency (f^2). Manufacturers typically provide a formula for converting frequency to an engineering unit (U_E) in the form,

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

where K is a constant determined from sensor specifications.

So, for a very small change in frequency, Δf, change in output, ΔU_E, is given by,

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

where Eq. 2 is obtained by taking the first derivative of Eq.1 with respect to f, and f is the present frequency on the wire.

Use Eq. 2 together with noise levels, N (Hz RMS), found in TABLE 5-3, *CDM-VW300/305 Effective Frequency Measurement Resolution,* to calculate the effective resolution (R_e) of a measurement. For a specific sample rate in TABLE 5-3, use the corresponding value of N in place of Δf. Eq. 2 can then be expressed as,

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

E.1 Example Error Calculation: Geokon Strain Gage

When using a Geokon strain gage, constant K is given by,

$$K = GB / 1000$$

Where G is the gage factor 4.062 or 0.391, dependent on gage type, and B is a batch factor (a number usually near 1, such as 0.97), given on the sensor calibration sheet.

Substituting into Eq. 1 using engineering units of microstrain ($\mu\varepsilon$):

$$\mu\varepsilon = GBf^2 / 1000,$$

The effective resolution, R_e, of the output, or $\Delta\mu\varepsilon$, is:

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

or

$$\Delta\mu\varepsilon = GBfN / 500,$$

where N is the noise value given in TABLE 5-3, *CDM-VW300/305 Effective Frequency Measurement Resolution,* corresponding to the sample rate being used.

E.2 Example Error Calculation: DGSI Embedment Strain Gage

For Durham Geo Slope Indicator embedment strain gages, $K = G$, where G = 4.0624E–03.

So, for microstrain,

$$\mu\varepsilon = Gf^2$$

And for effective resolution,

$$\Delta\ \mu\varepsilon = 2GfN$$

E.3 Example Error Calculation: DGSI Spot-Welded Strain Gage

For Durham Geo Slope Indicator spot-welded strain gages,

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

Where A = 7.576E–04 and C = –2030.1

So, $K = A$, and the above formula stands as it is for specifying the output.

When calculating the effective resolution, the constant C does not vary with frequency, so it can be ignored for the very small changes in frequency that are of concern. The formula becomes,

$$\Delta\ \mu\varepsilon = 2AfN$$

E.4 Example Error Calculation: Geokon 4420 Crack Meter

The displacement, s, measured by the crack meter is given by the formula:

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

where G is the linear gage factor, K is a thermal factor, and t is the temperature of the sensor. During a short measurement interval, the assumption is made that there is no change in the temperature of the sensor. So, for small changes in sensor displacement, K is assumed to be constant, and the Kt term is ignored when calculating the output error. The resulting equation is,

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

or

$$\Delta s = GfN / 500$$

E.5 Example Error Calculation: DGSI Piezometer 52611099

For Durham Geo Slope Indicator piezometer 52611099, when using gage factors *A*, *B*, and *C*, the formula for pressure, *P*, derived from frequency is given as:

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

The resulting noise (effective resolution) formula is then:

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

or

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

Appendix F. Thermistor Information

F.1 Converting Resistance to Temperature

The CDM-VW300 outputs a resistance value for sensors that contain a thermistor. Temperature is normally calculated by applying the resistance to the Steinhart-Hart equation, which converts resistance to temperature.

The Steinhart-Hart equation for converting resistance to degree Celsius is as follows:

Temperature = 1/(A + B • LN(resistance) + C • (LN(resistance))^3) - 273.15

Where *A*, *B*, and *C* are coefficients for the Steinhart-Hart equation.

The coefficients for the Steinhart-Hart equation are specific to the thermistor contained in your sensor and are obtained from the sensor manufacturer.

NOTE Please contact the sensor manufacturer to get coefficients for a specific thermistor.

F.1.1 Resistance Conversion Example – Geokon Sensor

If the coefficients for the Steinhart-Hart equation are as follows

A = 1.4051E–03
B = 2.369E–04
C = 1.019E–07

The equation for converting the resistance measurement to degrees Celsius is:

Temperature = 1/(1.4051E–03 + 2.369E–04 • LN(resistance) +
1.019E–07 • (LN(resistance))^3) – 273.15

If the measured resistance is 2221 Ω, the calculated temperature in degree Celsius is:

Temperature = 1/(1.4051E–03 + 2.369E–04 • LN(2221) +
1.019E–07 • (LN(2221))^3) – 273.15

Temperature = 31.98°C

F.2 Accuracy and Resolution

The accuracy of the temperature measurement is a function of the following factors:

1. Thermistor interchangeability

2. Resistance of the wire

3. Steinhart-Hart equation error

4. Precision of the bridge resistors

5. Accuracy of the datalogger voltage measurement

6. Temperature coefficient of the bridge resistors

Errors three through six are usually sufficiently small that they can be ignored. The wire resistance is primarily an offset error and its effect can be removed by the initial calibration. Errors caused by the change in wire resistance due to temperature and thermistor interchangeability are not removed by the initial calibration. FIGURE F-1 through FIGURE F-4 show how wire resistance affects the temperature measurement for a Geokon 4500 vibrating-wire piezometer.

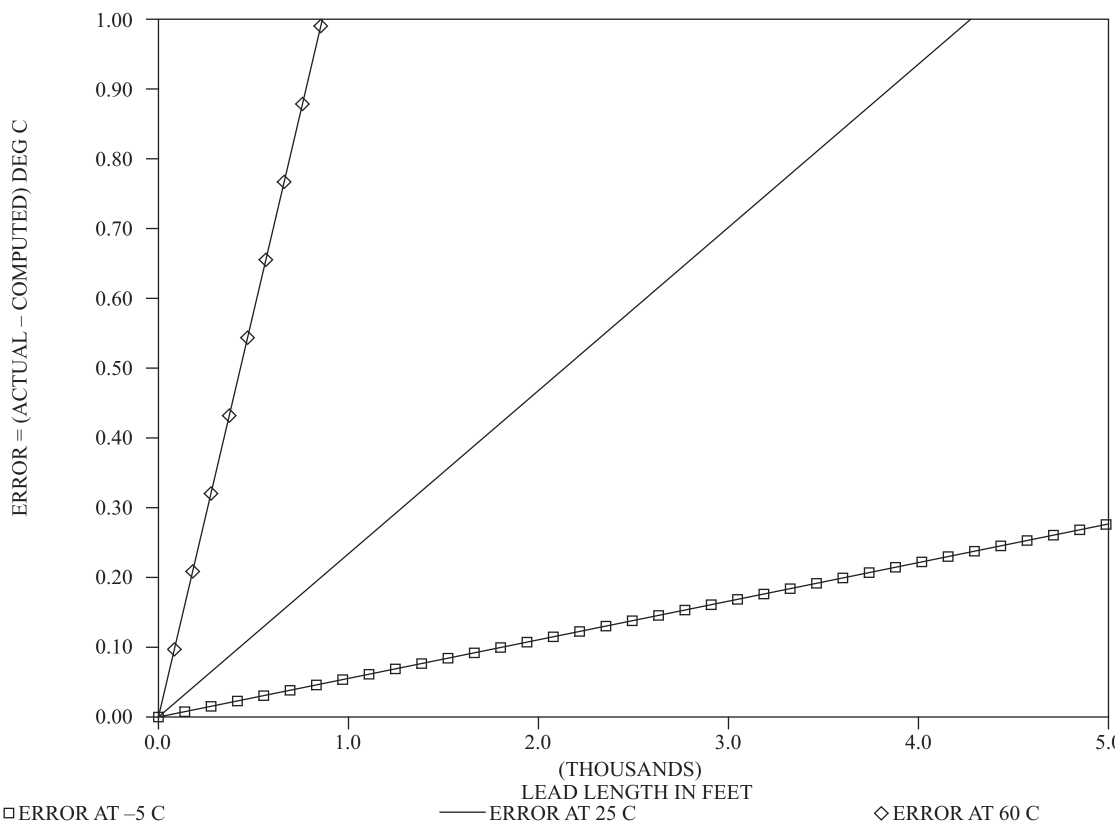


FIGURE F-1. Temperature measurement error at three temperatures as a function of lead length. Wire is 22 AWG with 16 ohms per 1000 feet.

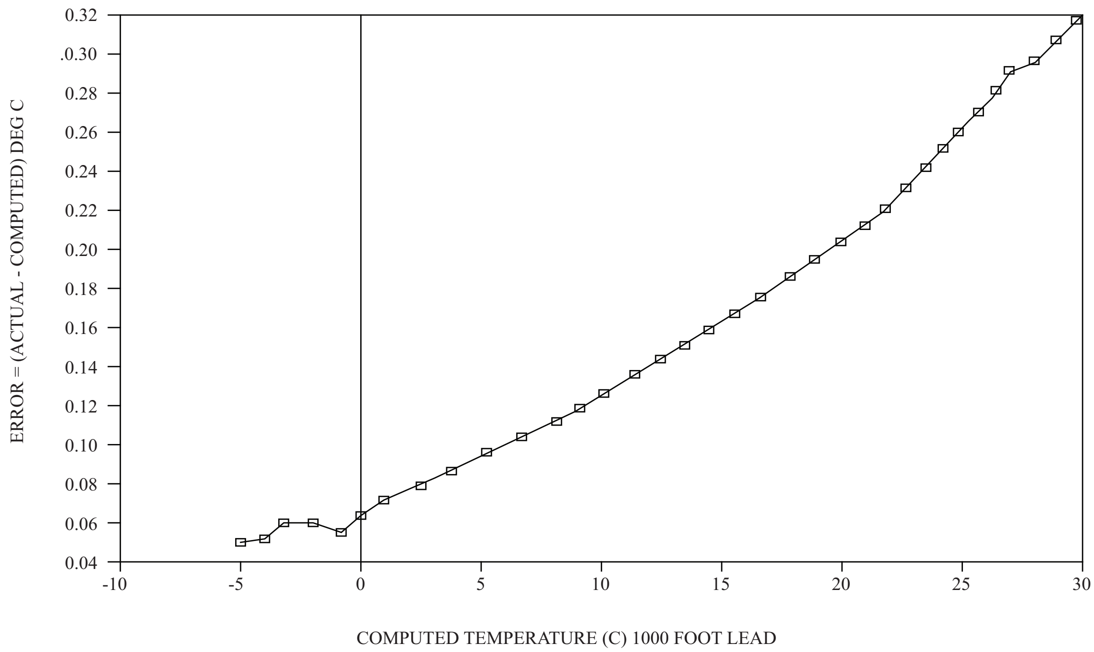


FIGURE F-2. Temperature measurement error on a 1000 foot lead. Wire is 22 AWG with 16 ohms per 1000 feet.

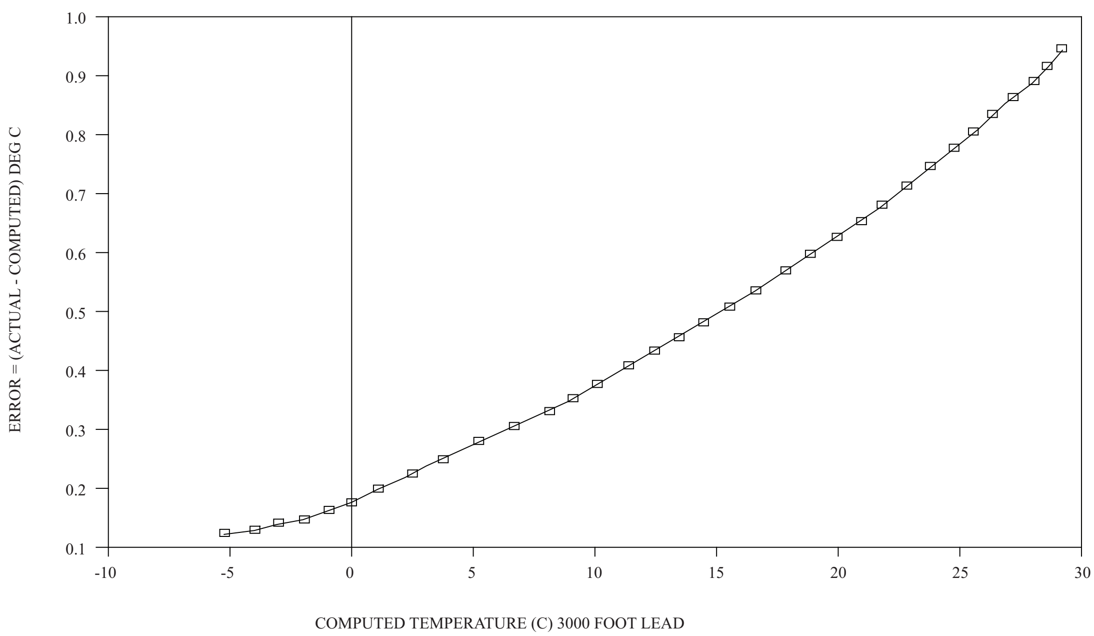


FIGURE F-3. Temperature measurement error on a 3000 foot lead. Wire is 22 AWG with 16 ohms per 1000 feet.

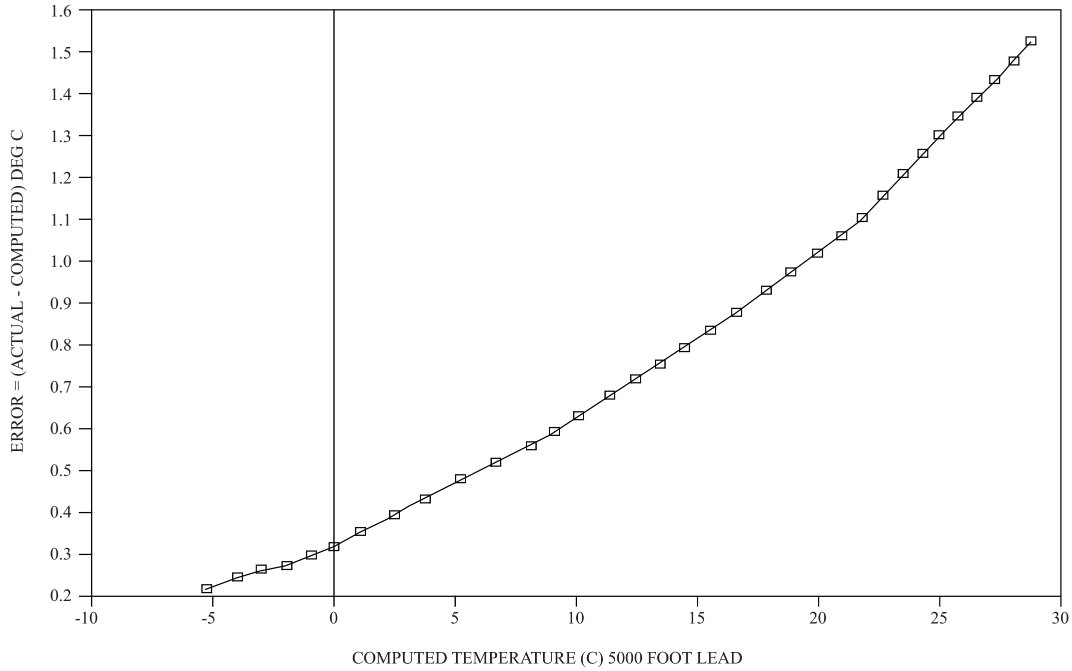


FIGURE F-4. Temperature measurement error on a 5000 foot Lead. Wire is 22 AWG with 16 ohms per 1000 feet.

Appendix G. CRBasic Program Library

The following example programs are compatible with CR3000, CR1000, and CR800 dataloggers without modification. The programs are available for download at *www.campbellsci.com/downloads*. Look for "CDM-VW300 Example Programs." The programs are named with a .CR3 extension and can be renamed as .CR1 or .CR8 without modification to run on the CR1000 or CR800 dataloggers. To use programs from this library,

1. Select the desired program and save it to your PC.
2. Open *CRBasic Editor*.
3. Open the program file just downloaded to edit, if necessary.
4. Send the program to the datalogger using the program **Send** command in *RTDAQ* or *LoggerNet*.
5. Monitor the operation of the system with the numeric and graphical monitors available with *RTDAQ* or *LoggerNet*.

G.1 Dynamic Measurements

G.1.1 20 Hz Measurement Example — One CDM-VW300, Two Channels

```
'===20Hz-1Device2Ch_4-25-13.CR3===
'CR3000 datalogger
'CDM-VW300 vibrating-wire analyzer
'Program to read 20 Hz dynamic data from one CDM-VW300 analyzer measuring two channels

'IMPORTANT -- Ensure 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(2) 'dynamic frequencies
Public Diag(2) As Long 'diagnostic code

Public StaticFreq(2) 'Static (1 Hz output) frequencies
Public Therm(2)  'Thermistor readings
'Standard Deviation of the dynamic readings that occurred during the latest one-second interval
Public DynStdDev(2)

'The following arrays are used to configure the CDM-VW300. Refer to the CDM_VW300Config
'instruction used below
'                                 CH1    CH2
'                                 ---    ---
'Set to true (Enabled=1, Disabled=0) only those channels which have sensors connected
Dim Enable(2) As Long =       {     1,     1}
'Specify the target/desired 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(2) =              { 0.002, 0.002}
'Low Frequency Boundary (sensor frequency should never fall below
'this value regardless of environmental changes)
Dim F_Low(2) =                {   300,   300}
'High Frequency Boundary (sensor frequency should never exceed
'this value regardless of environmental changes)
Dim F_High(2) =               {  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(2) As Long =      {     0,     0}
'Multiplier (factor) to be applied to sensor output frequency
Dim Mult(2) =                 {   1.0,   1.0}
```

```
'Offset (shift) to be applied to sensor output frequency
Dim Off(2) =                 {    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(2) =              {    0.0,    0.0}
Dim SteinB(2) =              {    0.0,    0.0}
Dim SteinC(2) =              {    0.0,    0.0}

'Rainflow configuration (not used in this program,
'but required as configuration arguments)
Dim RFMB(2) As Long =        {     20,     20}
Dim RFAB(2) As Long =        {     20,     20}
Dim RFLL(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}

'Configure the CDM-VW300 series device
'Use the variable arrays declared above
CDM_VW300Config(0,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 (1 Hz output)
  Sample (2,StaticFreq(),IEEE4)
  'Thermistor reading : Ohms or DegC
  Sample (2,Therm(),IEEE4)
  'Standard Deviation of dynamic readings
  'taken during the most recent second
  Sample (2,DynStdDev(),IEEE4)
EndTable

DataTable (dynamic,true,-1)
  'Dynamic Frequency (20 Hz output)
  Sample (2,Freq(),IEEE4)
  'Diagnostic code for the current dynamic reading
  Sample (2,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
```

G.1.2 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 -- Ensure 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/desired 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 arrays 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
```

G.1.3 20 Hz Measurement Example — Three CDM-VW305s, 24 Channels

```
'===20Hz-3Devices8Ch_3-25-13.CR3===
'CR3000 datalogger
'CDM-VW305 vibrating-wire analyzer
'Program to read 20-Hz dynamic data from three CDM-VW305 analyzers (8x3=24 channels)

'IMPORTANT -- Ensure 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 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 First Device
CDM_VW300Config(1,CPI_ADDR1,0,Enable1(),Max_AMP1(),F_Low1(),F_High1(), _
OutForm1(),Mult1(),Off1(), SteinA1(),SteinB1(),SteinC1(), _
RFMB(),RFAB(),RFLL(),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(),RFLL(),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(),RFLL(),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

  '20 Hz/50msec scan rate
  Scan(50,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
```

G.1.4 20 Hz Measurement Example — Six CDM-VW305s, 48 Channels

```
'===20Hz-6Devices8Ch_4-25-13.CR3===
'CR3000 datalogger
'CDM-VW305 vibrating-wire analyzer
'Program to read 20-Hz dynamic data from six CDM-VW305 analyzers (8x6=48 channels)

'IMPORTANT -- Ensure 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 '<<<<<<<<<<<<<<SET CPI ADDRESSES HERE
Const CPI_ADDR2 = 15
Const CPI_ADDR3 = 25
Const CPI_ADDR4 = 35
Const CPI_ADDR5 = 45
Const CPI_ADDR6 = 55

Public Freq1(8), Freq2(8), Freq3(8) 'dynamic frequencies
Public Freq4(8), Freq5(8), Freq6(8)
Public Diag1(8) As Long, Diag2(8) As Long, Diag3(8) As Long 'diagnostic codes
Public Diag4(8) As Long, Diag5(8) As Long, Diag6(8) As Long

Public StaticFreq1(8), StaticFreq2(8), StaticFreq3(8) 'Static (1-Hz output) frequencies
Public StaticFreq4(8), StaticFreq5(8), StaticFreq6(8)
Public Therm1(8), Therm2(8), Therm3(8)  'Thermistor readings
Public Therm4(8), Therm5(8), Therm6(8)
```

```
Public DynStdDev1(8), DynStdDev2(8), DynStdDev3(8) 'Dynamic standard deviations
Public DynStdDev4(8), DynStdDev5(8), DynStdDev6(8)

'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}

'Setup for Fourth Device
Dim Enable4(8) As Long =       {     1,     1,     1,     1,     1,     1,     1,     1}
Dim Max_AMP4(8) =              { 0.002, 0.002, 0.002, 0.002, 0.002, 0.002, 0.002, 0.002}
Dim F_Low4(8) =                {   300,   300,   300,   300,   300,   300,   300,   300}
Dim F_High4(8) =               {  6000,  6000,  6000,  6000,  6000,  6000,  6000,  6000}
Dim OutForm4(8) As Long =      {     0,     0,     0,     0,     0,     0,     0,     0}
Dim Mult4(8) =                 {   1.0,   1.0,   1.0,   1.0,   1.0,   1.0,   1.0,   1.0}
Dim Off4(8) =                  {   0.0,   0.0,   0.0,   0.0,   0.0,   0.0,   0.0,   0.0}
Dim SteinA4(8) =               {   0.0,   0.0,   0.0,   0.0,   0.0,   0.0,   0.0,   0.0}
Dim SteinB4(8) =               {   0.0,   0.0,   0.0,   0.0,   0.0,   0.0,   0.0,   0.0}
Dim SteinC4(8) =               {   0.0,   0.0,   0.0,   0.0,   0.0,   0.0,   0.0,   0.0}

'Setup for Fifth Device
Dim Enable5(8) As Long =       {     1,     1,     1,     1,     1,     1,     1,     1}
Dim Max_AMP5(8) =              { 0.002, 0.002, 0.002, 0.002, 0.002, 0.002, 0.002, 0.002}
Dim F_Low5(8) =                {   300,   300,   300,   300,   300,   300,   300,   300}
Dim F_High5(8) =               {  6000,  6000,  6000,  6000,  6000,  6000,  6000,  6000}
Dim OutForm5(8) As Long =      {     0,     0,     0,     0,     0,     0,     0,     0}
Dim Mult5(8) =                 {   1.0,   1.0,   1.0,   1.0,   1.0,   1.0,   1.0,   1.0}
Dim Off5(8) =                  {   0.0,   0.0,   0.0,   0.0,   0.0,   0.0,   0.0,   0.0}
Dim SteinA5(8) =               {   0.0,   0.0,   0.0,   0.0,   0.0,   0.0,   0.0,   0.0}
Dim SteinB5(8) =               {   0.0,   0.0,   0.0,   0.0,   0.0,   0.0,   0.0,   0.0}
Dim SteinC5(8) =               {   0.0,   0.0,   0.0,   0.0,   0.0,   0.0,   0.0,   0.0}

'Setup for Sixth Device
Dim Enable6(8) As Long =       {     1,     1,     1,     1,     1,     1,     1,     1}
Dim Max_AMP6(8) =              { 0.002, 0.002, 0.002, 0.002, 0.002, 0.002, 0.002, 0.002}
Dim F_Low6(8) =                {   300,   300,   300,   300,   300,   300,   300,   300}
Dim F_High6(8) =               {  6000,  6000,  6000,  6000,  6000,  6000,  6000,  6000}
Dim OutForm6(8) As Long =      {     0,     0,     0,     0,     0,     0,     0,     0}
Dim Mult6(8) =                 {   1.0,   1.0,   1.0,   1.0,   1.0,   1.0,   1.0,   1.0}
Dim Off6(8) =                  {   0.0,   0.0,   0.0,   0.0,   0.0,   0.0,   0.0,   0.0}
Dim SteinA6(8) =               {   0.0,   0.0,   0.0,   0.0,   0.0,   0.0,   0.0,   0.0}
Dim SteinB6(8) =               {   0.0,   0.0,   0.0,   0.0,   0.0,   0.0,   0.0,   0.0}
Dim SteinC6(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 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 First Device
CDM_VW300Config(1,CPI_ADDR1,0,Enable1(),Max_AMP1(),F_Low1(),F_High1(), _
OutForm1(),Mult1(),Off1(), SteinA1(),SteinB1(),SteinC1(), _
RFMB(),RFAB(),RFLL(),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(),RFLL(),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(),RFLL(),RFHL(),RFHY(),RFOF())
'Configure Fourth Device
CDM_VW300Config(1,CPI_ADDR4,0,Enable4(),Max_AMP4(),F_Low4(),F_High4(), _
OutForm4(),Mult4(),Off4(), SteinA4(),SteinB4(),SteinC4(), _
RFMB(),RFAB(),RFLL(),RFHL(),RFHY(),RFOF())
'Configure Fifth Device
CDM_VW300Config(1,CPI_ADDR5,0,Enable5(),Max_AMP5(),F_Low5(),F_High5(), _
OutForm5(),Mult5(),Off5(), SteinA5(),SteinB5(),SteinC5(), _
RFMB(),RFAB(),RFLL(),RFHL(),RFHY(),RFOF())
'Configure Sixth Device
CDM_VW300Config(1,CPI_ADDR6,0,Enable6(),Max_AMP6(),F_Low6(),F_High6(), _
OutForm6(),Mult6(),Off6(), SteinA6(),SteinB6(),SteinC6(), _
RFMB(),RFAB(),RFLL(),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)
  Sample (8,StaticFreq4(),IEEE4)
  Sample (8,Therm4(),IEEE4)
  Sample (8,DynStdDev4(),IEEE4)
  Sample (8,StaticFreq5(),IEEE4)
  Sample (8,Therm5(),IEEE4)
  Sample (8,DynStdDev5(),IEEE4)
  Sample (8,StaticFreq6(),IEEE4)
  Sample (8,Therm6(),IEEE4)
  Sample (8,DynStdDev6(),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)
  Sample (8,Freq4(),IEEE4)
  Sample (8,Diag4(),IEEE4)
  Sample (8,Freq5(),IEEE4)
  Sample (8,Diag5(),IEEE4)
  Sample (8,Freq6(),IEEE4)
  Sample (8,Diag6(),IEEE4)
EndTable

BeginProg

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

    CDM_VW300Dynamic(CPI_ADDR1,Freq1(),Diag1()) 'Get dynamic readings
    CDM_VW300Dynamic(CPI_ADDR2,Freq2(),Diag2())
    CDM_VW300Dynamic(CPI_ADDR3,Freq3(),Diag3())
    CDM_VW300Dynamic(CPI_ADDR4,Freq4(),Diag4())
```

```
    CDM_VW300Dynamic(CPI_ADDR5,Freq5(),Diag5())
    CDM_VW300Dynamic(CPI_ADDR6,Freq6(),Diag6())
    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())
      CDM_VW300Static(CPI_ADDR4,StaticFreq4(),Therm4(),DynStdDev4())
      CDM_VW300Static(CPI_ADDR5,StaticFreq5(),Therm5(),DynStdDev5())
      CDM_VW300Static(CPI_ADDR6,StaticFreq6(),Therm6(),DynStdDev6())
      CallTable static
    EndIf

  NextScan

EndProg
```

G.1.5 50 Hz Measurement Example — One CDM-VW300, Two Channels

```
'===50Hz-1Device2Ch_4-25-13.CR3===
'CR3000 datalogger
'CDM-VW300 vibrating-wire analyzer
'Program to read 50-Hz dynamic data from one CDM-VW300 analyzer measuring two channels

'IMPORTANT -- Ensure 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(2) 'dynamic frequencies
Public Diag(2) As Long 'diagnostic code

Public StaticFreq(2) 'Static (1Hz output) frequencies
Public Therm(2)  'Thermistor readings
'Standard Deviation of the dynamic readings that occurred during the latest one-second interval
Public DynStdDev(2)

'The following arrays are used to configure the CDM-VW300 series device. Refer to the
'CDM_VW300Config instruction used below.
'
'                                 CH1    CH2
'                                 ---    ---
'Set to true (Enabled=1, Disabled=0) only those channels which have sensors connected
Dim Enable(2) As Long =        {     1,     1}
'Specify the target/desired 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(2) =               { 0.002, 0.002}
'Low Frequency Boundary (sensor frequency should never fall below
'this value regardless of environmental changes)
Dim F_Low(2) =                 {   300,   300}
'High Frequency Boundary (sensor frequency should never exceed
'this value regardless of environmental changes)
Dim F_High(2) =                {  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(2) As Long =       {     0,     0}
'Multiplier (factor) to be applied to sensor output frequency
Dim Mult(2) =                  {   1.0,   1.0}
'Offset (shift) to be applied to sensor output frequency
Dim Off(2) =                   {   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(2) =                {   0.0,   0.0}
Dim SteinB(2) =                {   0.0,   0.0}
Dim SteinC(2) =                {   0.0,   0.0}

'Rainflow configuration (not used in this program,
'but required as configuration arguments)
Dim RFMB(2) As Long =          {    20,    20}
Dim RFAB(2) As Long =          {    20,    20}
Dim RFLL(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}

'Configure the CDM-VW300 series device
'Use the variable arrays declared above
CDM_VW300Config(0,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 (2,StaticFreq(),IEEE4)
  'Thermistor reading : Ohms or DegC
  Sample (2,Therm(),IEEE4)
  'Standard Deviation of dynamic readings
  'taken during the most recent second
  Sample (2,DynStdDev(),IEEE4)
EndTable

DataTable (dynamic,true,-1)
  'Dynamic Frequency (50Hz output)
  Sample (2,Freq(),IEEE4)
  'Diagnostic code for the current dynamic reading
  Sample (2,Diag(),IEEE4)
EndTable

BeginProg

  '50 Hz/20msec scan rate
  Scan(20,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
```

G.1.6 50 Hz Measurement Example — One CDM-VW305, Eight Channels

```
'===50Hz-1Device8Ch_3-25-13.CR3===
'CR3000 datalogger
'CDM-VW305 vibrating-wire analyzer
'Program to read 50-Hz dynamic data from one CDM-VW305 analyzer measuring eight channels

'IMPORTANT -- Ensure 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
'1 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/desired 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 arrays 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 (50Hz output)
  Sample (8,Freq(),IEEE4)
  'Diagnostic code for the current dynamic reading.
  Sample (8,Diag(),IEEE4)
EndTable

BeginProg

  '50 Hz/20msec scan rate
  Scan(20,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
```

G.1.7 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 -- Ensure 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  '<<<<<<<<<<<<<<SET CPI ADDRESSES HERE
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 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 First Device
CDM_VW300Config(1,CPI_ADDR1,0,Enable1(),Max_AMP1(),F_Low1(),F_High1(), _
OutForm1(),Mult1(),Off1(), SteinA1(),SteinB1(),SteinC1(), _
RFMB(),RFAB(),RFLL(),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(),RFLL(),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(),RFLL(),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
```

G.1.8 50 Hz Measurement Example — One CDM-VW300, Two Channels, Rainflow Histogram

```
'===RFH-50HzExample2Ch_3-25-13.CR3===
'CR3000 datalogger
'CDM-VW300 vibrating-wire analyzer
'Program to read 50-Hz dynamic data from one CDM-VW300 analyzer measuring two channels.
'Demonstrate use of rainflow histogram.

'IMPORTANT -- Ensure 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(2)
Public Diag(2) As Long
Public StaticFreq(2)
Public Therm(2)
Public DynStdDev(2)

'Rainflow : Mean Bins and Amplitude Bins dimensions
Const MBINS = 10
Const ABINS = 10
'Rainflow-Histogram Outputs - 2 dimensional arrays
Public RF1(MBINS,ABINS)
Public RF2(MBINS,ABINS)
```

```
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}
Dim OutForm(2) As Long =      {     0,     0}
Dim Mult(2) =                 {   1.0,   1.0}
Dim Off(2) =                  {   0.0,   0.0}
Dim SteinA(2) =               {   0.0,   0.0}
Dim SteinB(2) =               {   0.0,   0.0}
Dim SteinC(2) =               {   0.0,   0.0}
'Rainflow-Histogram configuration
Dim RF_mean_bins(2) As Long = { MBINS, MBINS} 'Mean Bins
Dim RF_amp_bins(2) As Long =  { ABINS, ABINS} 'Amplitude Bins
Dim RF_Lo_lim(2) =            { 400.0, 400.0} 'Low Limit
Dim RF_Hi_lim(2) =            {4000.0,4000.0} 'High Limit
Dim RF_Hyst(2) =              { 0.005, 0.005} 'Hysteresis
'Output format consists of three digits ABC, that can be either 1 or 0
Dim RF_OutForm(2) As Long =   {   110,   110}
'RF Histogram Digit Code         Histogram output result
'-----------------------         -----------------------
'A = 0                           Reset histogram after each output.
'A = 1                           Do not reset histogram.
'B = 0                           Divide bins by total count.
'B = 1                           Output total in each bin.
'C = 0                           Open form. Include outside range values in end bins.
'C = 1                           Closed form. Exclude values outside range.

CDM_VW300Config(0,CPI_ADDR,0,Enable(),Max_AMP(),F_Low(),F_High(), _
OutForm(),Mult(),Off(), SteinA(),SteinB(),SteinC(), _
RF_mean_bins(),RF_amp_bins(),RF_Lo_lim(), _
RF_Hi_lim(),RF_Hyst(),RF_OutForm())

DataTable (static,true,-1)
  Sample (2,StaticFreq(),IEEE4)
  Sample (2,Therm(),IEEE4)
  Sample (2,DynStdDev(),IEEE4)
EndTable

DataTable (dynamic,true,-1)
  Sample (2,Freq(),IEEE4)
  Sample (2,Diag(),IEEE4)
EndTable

'Store rainflow-histogram output
DataTable (rainflhist,true,-1)
  RainflowSample(RF1(),IEEE4)
  RainflowSample(RF2(),IEEE4)
EndTable

BeginProg

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

    CDM_VW300Dynamic(CPI_ADDR,Freq(),Diag())
    CallTable dynamic

    If TimeIntoInterval (0,1,Sec) Then
      CDM_VW300Static(CPI_ADDR,StaticFreq(),Therm(),DynStdDev())
      CallTable static
    EndIf

  NextScan

SlowSequence
  Scan(5,sec,10,0)
      'Rainflow-histogram call must be in a slow sequence scan
      CDM_VW300Rainflow(CPI_ADDR,RF1(),RF2())
      CallTable rainflhist
  NextScan

EndProg
```

G.1.9 50 Hz Measurement Example — One CDM-VW305, Eight Channels, Rainflow Histogram

```
'===RFH-50HzExample8Ch_4-25-13.CR3===
'CR3000 datalogger
'CDM-VW305 vibrating-wire analyzer
'Program to read 50-Hz dynamic data from one CDM-VW305 analyzer measuring eight channels.
'Demonstrate use of rainflow histogram.

'IMPORTANT -- Ensure 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)
Public Diag(8) As Long
Public StaticFreq(8)
Public Therm(8)
Public DynStdDev(8)

'Rainflow : Mean Bins and Amplitude Bins dimensions
Const MBINS = 10
Const ABINS = 10
'Rainflow-Histogram Outputs - 2 dimensional arrays
Public RF1(MBINS,ABINS)
Public RF2(MBINS,ABINS)
Public RF3(MBINS,ABINS)
Public RF4(MBINS,ABINS)
Public RF5(MBINS,ABINS)
Public RF6(MBINS,ABINS)
Public RF7(MBINS,ABINS)
Public RF8(MBINS,ABINS)


Dim Enable(8) As Long =       {     1,     1,     1,     1,     1,     1,     1,     1}
Dim Max_AMP(8) =              { 0.002, 0.002, 0.002, 0.002, 0.002, 0.002, 0.002, 0.002}
Dim F_Low(8) =                {   300,   300,   300,   300,   300,   300,   300,   300}
Dim F_High(8) =               {  6000,  6000,  6000,  6000,  6000,  6000,  6000,  6000}
Dim OutForm(8) As Long =      {     0,     0,     0,     0,     0,     0,     0,     0}
Dim Mult(8) =                 {   1.0,   1.0,   1.0,   1.0,   1.0,   1.0,   1.0,   1.0}
Dim Off(8) =                  {   0.0,   0.0,   0.0,   0.0,   0.0,   0.0,   0.0,   0.0}
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-Histogram configuration
Dim RF_mean_bins(8) As Long = { MBINS, MBINS, MBINS, MBINS, MBINS, MBINS, MBINS, MBINS} 'Mean
Bins
Dim RF_amp_bins(8) As Long =  { ABINS, ABINS, ABINS, ABINS, ABINS, ABINS, ABINS, ABINS}
'Amplitude
                                                                                        'Bins
Dim RF_Lo_lim(8) =            { 400.0, 400.0, 400.0, 400.0, 400.0, 400.0, 400.0, 400.0} 'Low
Limit
Dim RF_Hi_lim(8) =            {4000.0,4000.0,4000.0,4000.0,4000.0,4000.0,4000.0,4000.0} 'High
                                                                                        'Limit
Dim RF_Hyst(8) =              { 0.005, 0.005, 0.005, 0.005, 0.005, 0.005, 0.005, 0.005}
'Hysteresis
'Output format consists of three digits ABC, that can be either 1 or 0
Dim RF_OutForm(8) As Long =   {   110,   110,   110,   110,   110,   110,   110,   110}
'RF Histogram Digit Code          Histogram output result
'-----------------------          ------------------------
'A = 0                            Reset histogram after each output.
'A = 1                            Do not reset histogram.
'B = 0                            Divide bins by total count.
'B = 1                            Output total in each bin.
'C = 0                            Open form. Include outside range values in end bins.
'C = 1                            Closed form. Exclude values outside range.

CDM_VW300Config(1,CPI_ADDR,0,Enable(),Max_AMP(),F_Low(),F_High(), _
OutForm(),Mult(),Off(), SteinA(),SteinB(),SteinC(), _
RF_mean_bins(),RF_amp_bins(),RF_Lo_lim(), _
RF_Hi_lim(),RF_Hyst(),RF_OutForm())

DataTable (static,true,-1)
  Sample (8,StaticFreq(),IEEE4)
  Sample (8,Therm(),IEEE4)
  Sample (8,DynStdDev(),IEEE4)
EndTable
```

```
DataTable (dynamic,true,-1)
  Sample (8,Freq(),IEEE4)
  Sample (8,Diag(),IEEE4)
EndTable

'Store Rainflow-Histogram Output
DataTable (rainflhist,true,-1)
  RainflowSample(RF1(),IEEE4)
  RainflowSample(RF2(),IEEE4)
  RainflowSample(RF3(),IEEE4)
  RainflowSample(RF4(),IEEE4)
  RainflowSample(RF5(),IEEE4)
  RainflowSample(RF6(),IEEE4)
  RainflowSample(RF7(),IEEE4)
  RainflowSample(RF8(),IEEE4)
EndTable

BeginProg

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

    CDM_VW300Dynamic(CPI_ADDR,Freq(),Diag())
    CallTable dynamic

    If TimeIntoInterval (0,1,Sec) Then
      CDM_VW300Static(CPI_ADDR,StaticFreq(),Therm(),DynStdDev())
      CallTable static
    EndIf

  NextScan

SlowSequence
  Scan(5,sec,10,0)
      'Rainflow-Histogram call must be in a slow sequence scan
      CDM_VW300Rainflow(CPI_ADDR,RF1(),RF2(),RF3(),RF4(),RF5(),RF6(),RF7(),RF8())
      CallTable rainflhist
  NextScan

EndProg
```

G.1.10 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 -- Ensure 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 RFLL(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(),RFLL(),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
```

G.1.11 50 Hz Measurement Example — One CDM-VW300, Two Geokon 4000 Sensors with FieldCal()

```
'===Geokon4000-50Hz2Ch_4-25-13.CR3===
'CR3000 datalogger
'CDM-VW300 vibrating-wire analyzer
'Program to read 50-Hz dynamic data from one CDM-VW300 measuring two Geokon 4000 strain gages

'IMPORTANT -- Ensure 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 sensor calibration sheet

'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

'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 to 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 RFLL(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(),RFLL(),RFHL(),RFHY(),RFOF())

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

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

    CallTable dynamic
    CallTable CalHist

    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

SlowSequence
  Scan(5,sec,10,0)
      'Rainflow-Histogram call must be in a slow sequence scan
      CDM_VW300Rainflow(CPI_ADDR,RF1(),RF2(),RF3(),RF4(),RF5(),RF6(),RF7(),RF8())
      CallTable rainflhist
  NextScan

EndProg
```

G.1.12 50 Hz Measurement Example — One CDM-VW300, Two Geokon 4000 Sensors with FieldCal() and CardOut() to CF

```
'===Geokon4000-50Hz2ChEventCard_4-22-13.CR3===
'CR3000 datalogger
'CDM-VW300 vibrating-wire analyzer
'Program to read 50-Hz dynamic data from one CDM-VW300 measuring two Geokon 4000 strain gages.
'  Write data to CF card at each event.
'  Demonstrate use of CardOut(), DataEvent(), and DataInterval() to conserve data storage.

'IMPORTANT -- Ensure 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 calibration 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

'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 to 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 RFLL(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(),RFLL(),RFHL(),RFHY(),RFOF())

DataTable (static,true,-1)
  DataInterval (0,1,Min,10)
  CardOut (0 ,-1)
  Average (2,StaticStrain(),IEEE4,False)
  Average (2,Temp(),IEEE4,False)
  Average (2,StrainStdDev(),IEEE4,False)
EndTable

DataTable (dynamic,true,-1)
  CardOut (0 ,-1)
  DataEvent (100,(Strain(1) > 200) OR (Strain(2) > 200),1,100)
  Sample (2,Strain(),IEEE4)
  Sample (2,DCode(),IEEE4)
EndTable

DataTable(CalHist,NewFieldCal,-1)
  CardOut (0 ,-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)

    CallTable dynamic
    CallTable CalHist

    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
```

G.1.13 50 Hz Measurement Example — One CDM-VW300, Two Geokon 4000 Sensors with FieldCal() and TableFile() to CF

```
'===Geokon4000-50Hz2ChEventTableFile_4-25-13.CR3===
'CR3000 datalogger
'CDM-VW300 vibrating-wire analyzer
'Program to read 50-Hz dynamic data from one CDM-VW300 measuring two Geokon 4000 strain gages.
'Write data to CF card at each event.
'Demonstrate use of TableFile() with Option 64, DataEvent(), and DataInterval() to conserve
' data storage.

'IMPORTANT -- Ensure 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 calibration 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

Public NewDynFileStored As Boolean 'Needed for TableFile
Public NewStaticFileStored As Boolean 'True when a new file was just created on the card
Public LastDynFileName As String * 35 'The name of the new file just created on the card
Public LastStaticFileName As String * 35

'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 to 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 RFLL(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(),RFLL(),RFHL(),RFHY(),RFOF())

DataTable (static,true,-1)
  'Even though data is observed once per second,
  'write out 1 minute averages
```

```
  DataInterval (0,1,Min,10)
  'Using TableFile, write the 1 minute averages out each
  '15 minutes to a file on the CRD (Compact Flash) device
  TableFile ("CRD:"&Status.StationName(1,1)&".TFStatic", _
  64,-1,0,15,Min,NewStaticFileStored,LastStaticFileName)
  Average (2,StaticStrain(),IEEE4,False)
  Average (2,Temp(),IEEE4,False)
  Average (2,StrainStdDev(),IEEE4,False)
EndTable

DataTable (dynamic,true,-1)
  'Using DataEvent, only store data in this table when
  'the Microstrain reading is greater than 200 on either channel
  DataEvent (100,(Strain(1) > 200) OR (Strain(2) > 200),1,100)
  'Using TableFile, write out the 50Hz data to the CRD (Compact
  'flash) into a new file whenever 600 data records have been captured
  TableFile ("CRD:"&Status.StationName(1,1)&".TFDynamic", _
  64,-1,600,0,Sec,NewDynFileStored,LastDynFileName)
  Sample (2,Strain(),IEEE4)
  Sample (2,DCode(),IEEE4)
EndTable

DataTable(CalHist,NewFieldCal,-1)
  CardOut (0 ,2000)
  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)

    CallTable dynamic
    CallTable CalHist

    If TimeIntoInterval (0,1,Sec) Then
      CDM_VW300Static(CPI_ADDR,StaticStrain(),Temp(),StrainStdDev()) 'Obtain unshifted 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
```

G.1.14 100 Hz Measurement Example — One CDM-VW300, Two Channels

```
'===100Hz-1Device2Ch_3-25-13.CR3===
'CR3000 datalogger
'CDM-VW300 vibrating-wire analyzer
'Program to read 100-Hz dynamic data from one CDM-VW300 analyzer measuring two channels

'IMPORTANT -- Ensure 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(2) 'dynamic frequencies
Public Diag(2) As Long 'diagnostic code

Public StaticFreq(2) 'Static (1Hz output) frequencies
Public Therm(2)  'Thermistor readings
'Standard Deviation of the dynamic readings that occurred during the latest one-second interval.
Public DynStdDev(2)

'The following arrays are used to configure the CDM-VW300 series device. Refer to the
'CDM_VW300Config instruction used below
'
'                                  CH1    CH2
'                                  ---    ---
'Set to true (Enabled=1, Disabled=0) only those channels which have sensors connected
Dim Enable(2) As Long =       {     1,      1}
'Specify the target/desired 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(2) =              { 0.002, 0.002}
'Low Frequency Boundary (sensor frequency should never fall below
'this value regardless of environmental changes)
Dim F_Low(2) =                {   300,    300}
'High Frequency Boundary (sensor frequency should never exceed
'this value regardless of environmental changes)
Dim F_High(2) =               {  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(2) As Long =      {     0,      0}
'Multiplier (factor) to be applied to sensor output frequency
Dim Mult(2) =                 {   1.0,    1.0}
'Offset (shift) to be applied to sensor output frequency
Dim Off(2) =                  {   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(2) =               {   0.0,    0.0}
Dim SteinB(2) =               {   0.0,    0.0}
Dim SteinC(2) =               {   0.0,    0.0}

'Rainflow configuration (not used in this program, but required as configuration arguments)
Dim RFMB(2) As Long =         {    20,     20}
Dim RFAB(2) As Long =         {    20,     20}
Dim RFLL(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}

'Configure the CDM-VW300 series device. Use the variable arrays declared above.
CDM_VW300Config(0,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 (2,StaticFreq(),IEEE4)
  'Thermistor reading : Ohms or DegC
  Sample (2,Therm(),IEEE4)
  'Standard Deviation of dynamic readings
  'taken during the most recent second
  Sample (2,DynStdDev(),IEEE4)
EndTable

DataTable (dynamic,true,-1)
  'Dynamic Frequency (100Hz output)
  Sample (2,Freq(),IEEE4)
  'Diagnostic code for the current dynamic reading
```

```
  Sample (2,Diag(),IEEE4)
EndTable

BeginProg

  '100 Hz/10msec scan rate
  Scan(10,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
```

G.1.15 100 Hz Measurement Example — One CDM-VW305, Eight Channels

```
'===100Hz-1Device8Ch_4-25-13.CR3===
'CR3000 datalogger
'CDM-VW305 vibrating-wire analyzer
'Program to read 100-Hz dynamic data from one CDM-VW305 analyzer measuring eight channels

'IMPORTANT -- Ensure 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/desired 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 arrays 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 (100Hz output)
  Sample (8,Freq(),IEEE4)
  'Diagnostic code for the current dynamic reading
  Sample (8,Diag(),IEEE4)
EndTable

BeginProg

  '100 Hz/10msec scan rate
  Scan(10,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
```

G.2 Static Measurements

G.2.1 1 Hz Measurement Example — One CDM-VW300, Two Channels

```
'===1Hz-1Device2Ch_3-25-13.CR3===
'CR3000 datalogger
'CDM-VW300 vibrating-wire analyzer
'Program to read 1-Hz static data from one CDM-VW300 analyzer measuring two channels

'IMPORTANT -- Ensure 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 StaticFreq(2) 'Static (1Hz output) frequencies
Public Therm(2)  'Thermistor readings

Dim Freq(2) 'dynamic instruction is required
Dim Diag(2) As Long
Dim DynStdDev(2)

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}
Dim OutForm(2) As Long =      {     0,     0}
Dim Mult(2) =                 {   1.0,   1.0}
Dim Off(2) =                  {   0.0,   0.0}
```

```
Dim SteinA(2) =             {   0.0,   0.0}
Dim SteinB(2) =             {   0.0,   0.0}
Dim SteinC(2) =             {   0.0,   0.0}
Dim RFMB(2) As Long =       {    20,    20}
Dim RFAB(2) As Long =       {    20,    20}
Dim RFLL(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(),RFLL(),RFHL(),RFHY(),RFOF())

DataTable (static,true,-1)
  'Static Frequency reading (1Hz output)
  Sample (2,StaticFreq(),IEEE4)
  'Thermistor reading : Ohms or DegC
  Sample (2,Therm(),IEEE4)
EndTable

BeginProg

  '20 Hz/50msec scan rate - dynamic scan rate is required
  Scan(50,msec,500,0)

    CDM_VW300Dynamic(CPI_ADDR,Freq(),Diag()) 'dynamic instruction is required

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

  NextScan

EndProg
```

G.2.2 1 Hz Measurement Example — One CDM-VW305, Eight Channels

```
'===1Hz-1Device8Ch_3-25-13.CR3===
'CR3000 datalogger
'CDM-VW305 vibrating-wire analyzer
'Program to read 1-Hz static data from one CDM-VW305 analyzer measuring eight channels

'IMPORTANT -- Ensure 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 StaticFreq(8) 'Static (1 Hz output) frequencies
Public Therm(8)  'Thermistor readings

Dim Freq(8) 'dynamic instruction is required
Dim Diag(8) As Long
Dim DynStdDev(8)

Dim Enable(8) As Long =     {     1,     1,     1,     1,     1,     1,     1,     1}
Dim Max_AMP(8) =            { 0.002, 0.002, 0.002, 0.002, 0.002, 0.002, 0.002, 0.002}
Dim F_Low(8) =              {   300,   300,   300,   300,   300,   300,   300,   300}
Dim F_High(8) =             {  6000,  6000,  6000,  6000,  6000,  6000,  6000,  6000}
Dim OutForm(8) As Long =    {     0,     0,     0,     0,     0,     0,     0,     0}
Dim Mult(8) =               {   1.0,   1.0,   1.0,   1.0,   1.0,   1.0,   1.0,   1.0}
Dim Off(8) =                {   0.0,   0.0,   0.0,   0.0,   0.0,   0.0,   0.0,   0.0}
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}
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}
```

```
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 (1 Hz output)
  Sample (8,StaticFreq(),IEEE4)
  'Thermistor reading : Ohms or DegC
  Sample (8,Therm(),IEEE4)
EndTable

BeginProg

  '20 Hz/50msec scan rate - dynamic scan rate is required
  Scan(50,msec,500,0)

    CDM_VW300Dynamic(CPI_ADDR,Freq(),Diag()) 'dynamic instruction is required

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

  NextScan

EndProg
```

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