



Dam Monitoring Systems

Data acquisition for reliable, stand-alone dam-structure monitoring

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Representative Of Campbell Scientific Inc. USA in IRAQ
IRAQ



Data Acquisition Systems for Dams



Weather



Water



Energy



Gas Flux &
Turbulence



Infrastructure



Soil



Partner of Campbell Scientific Inc. USA in IRAQ

Al-Worod Al-Dania ES Co. Ltd.-IRAQ

شركة الورود الدانية للأنظمة الهندسية المحدودة – العراق

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www.worodania.net



Dam Monitoring

Data acquisition for reliable, stand-alone dam-structure monitoring

Dam monitoring data-acquisition systems are unique because of the many types of measurements they are required to collect. Our systems can measure everything from water level and flow to strain and vibration, as well as a variety of other parameters. In addition to real-time data measurement, our systems will alert you of changes in factors such as water level, load, pressure, and tilt if they move beyond acceptable ranges. Our systems are rugged, low power, and adaptable to the harshest, most remote environments. Our team is ready to help you build a dam monitoring system customized to the measurements you need.

Monitoring systems customized to the measurements you need:
water level, flow, strain, vibration, load, pressure, tilt, etc.



Sensors used for Geotechnical Measurement

- **The versatility of our systems begins with sensor compatibility—they can measure virtually every commercially available sensor—allowing them to be used in a variety of ways for a variety of measurements. Typical sensors that can be used include:**
- Carlson strain meters
- Geokon vibrating-wire strain gauges
- Slope Indicator vibrating-strip sensors
- Foil strain gauges (in quarter-, half-, or full-bridge strain configurations)
- Inclinometers
- Crack and joint sensors
- Tilt sensors
- Piezoresistive accelerometers
- Piezoelectric accelerometers
- Capacitive accelerometers
- Borehole accelerometers
- Servo-force balance accelerometers



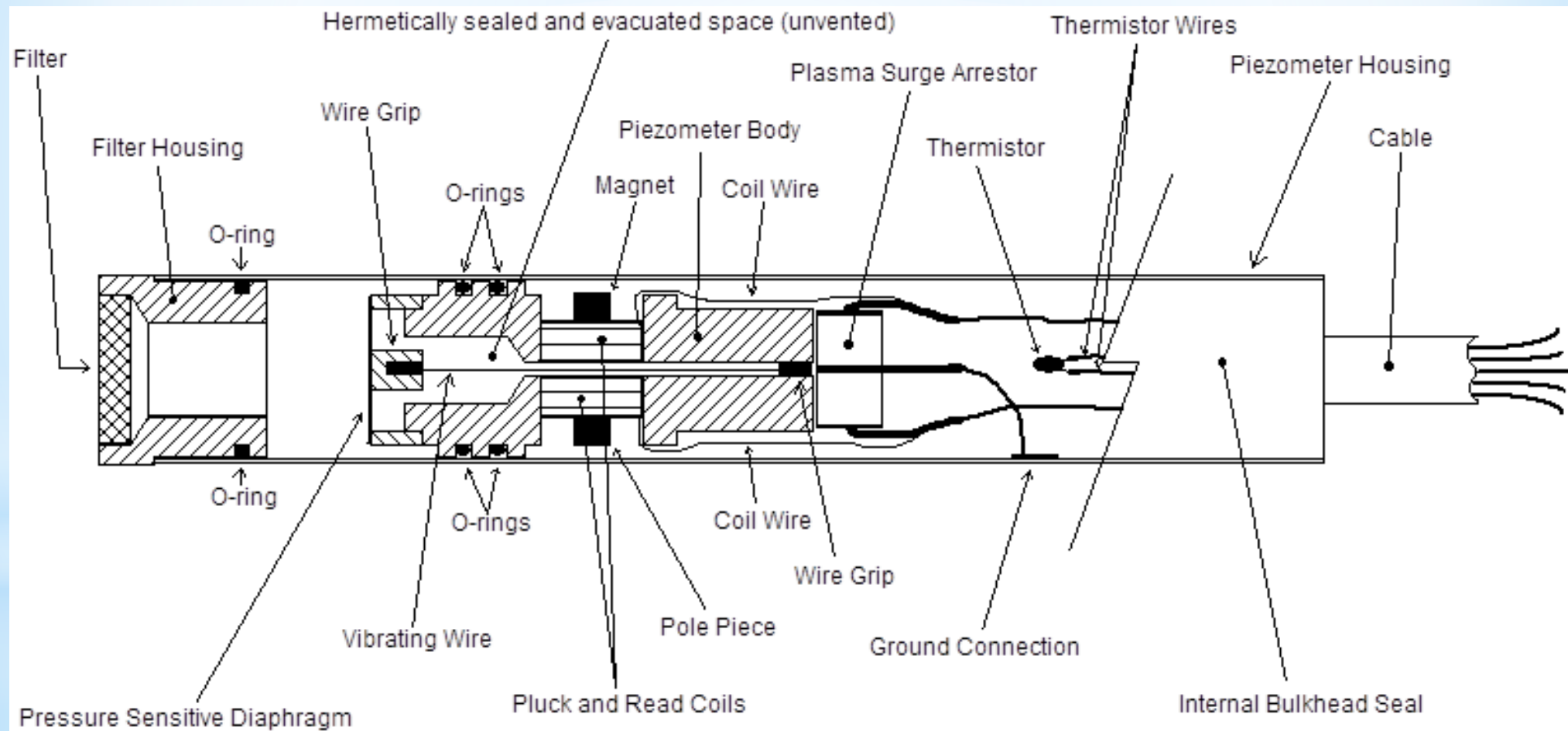
Vibrating Wire (VW) Sensors

- Strain
- Force and Load
- Pressure: barometric and liquid
- Displacement
- Tilt
- Water level
- Temperature





Single Coil Piezometer Internals





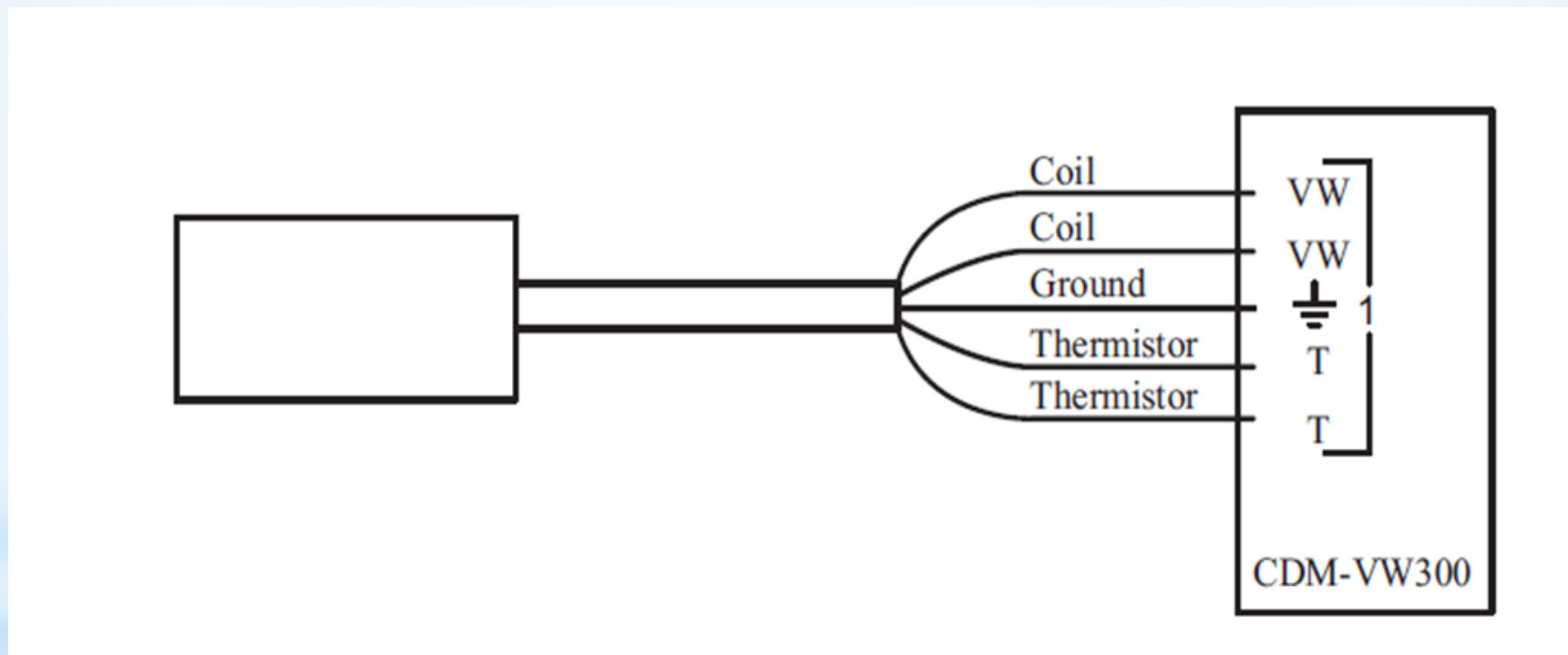
Single Coil VW Sensors



- ▶ All Campbell Scientific VSPECT vibrating wire products are designed around single coil (pluck type) vibrating wire sensors
- ▶ Auto resonant sensors, also referred to as dual coil VW sensors may not be measured properly. Sensor designs may incorporate active circuitry that we cannot activate



Wiring a Single Coil VW Sensor





The Campbell Scientific Method





VSPECT What it means to you

- › Patented Spectral Analysis on vibrating wire sensors
- › Patents held for both Static and Dynamic VW Measurements
- › Static: US: 779690 China: 200780050979 EU: EP2111535
- › Dynamic: US: 8671758 China: 201280056542 EU: EP2780676
- › Superior noise rejection through FFT analysis
- › Exceeds Sensor Resolution (0.001 Hz) and Accuracy (for all sensors available worldwide)
- › Maintains resolution and accuracy, even if sensor amplitude degrades over time
- › Campbell Scientific is the only company that offers this technology for sale*



So.....
What is

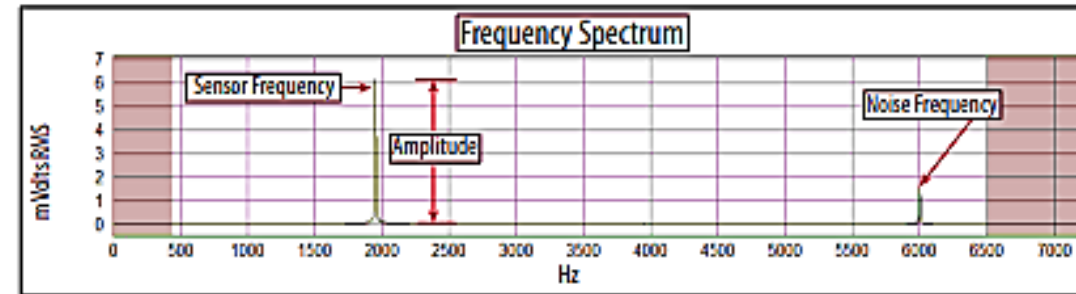


VSPECT

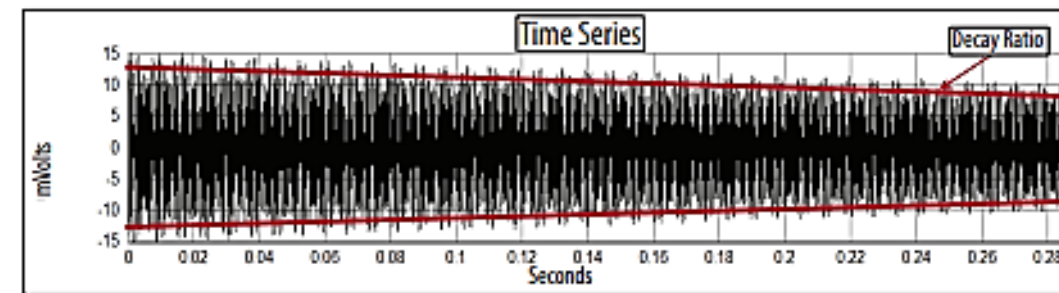
Is an innovative, patented technology that delivers the best measurement for vibrating wire sensors.

VSPECT

Observes the incoming sensor signal, performs a Fourier transform and spectral analysis (transforming the Time Series into individual sinusoidal components in the Frequency Spectrum). The frequency is determined by identifying the largest signal in the acceptable range and disregarding unwanted noise



VSPECT technology determines the sensor frequency from the Frequency Spectrum while ignoring noise signals.



Traditional vibrating-wire readers determine the sensor frequency from the Time Series where signal and noise can't be distinguished.



CAMPBELL SCIENTIFIC
WHEN MEASUREMENTS MATTER



Vibrating Wire Spectral Analysis Technology

VSPECT
The only solution for vibrating-wire measurements



- Eliminate noise spikes, false alarms
- Patented spectral analysis
- Have confidence in your measurements

Kindly watch the below video:
<https://www.campbellsci.com/videos/vspect1>



Static VW Measurements

- › AVW200 has become the state-of-the-art VW Interface
- › AVW200 uses Patented spectral analysis to determine the resonant frequency of the sensor
- › AVW200 offers exceptional measurement resolution and noise immunity (FFT based algorithms)
- › AVW200 is limited to static measurements (taking 1 second or longer)
- › Low power consumption!! (25 mA averaged over a 2 second measurement period)





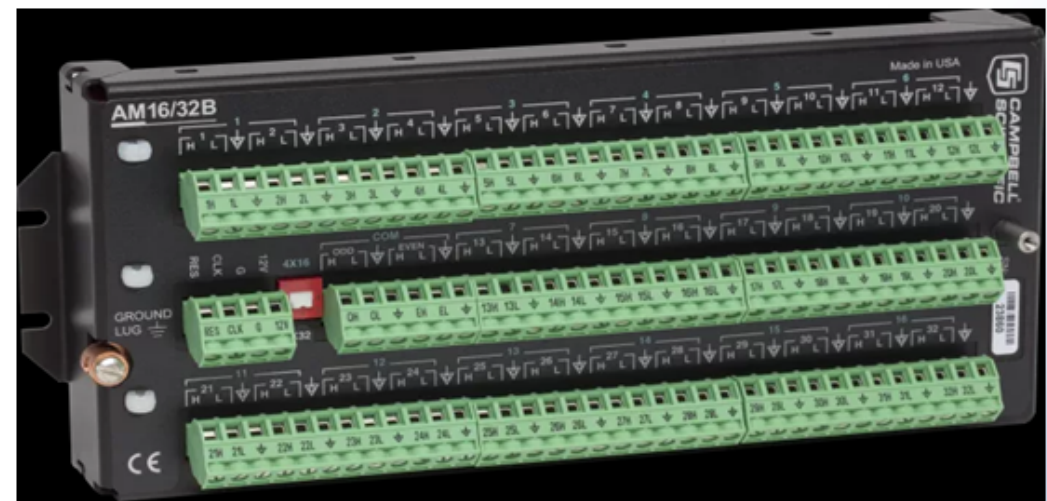
CR6 Contains Built-In VSPECT Measure Technology





CR6 - AM16/32B Static VW System

- ▶ Easy to program in ShortCut
- ▶ “Cost per Channel” is very cost effective
- ▶ Flexibility to grow the channel count





CRVW3 Self-Contained, Ready to Deploy, Network Friendly 3-Channel Vibrating Wire





CRVW3-NE w/o Enclosure & Battery





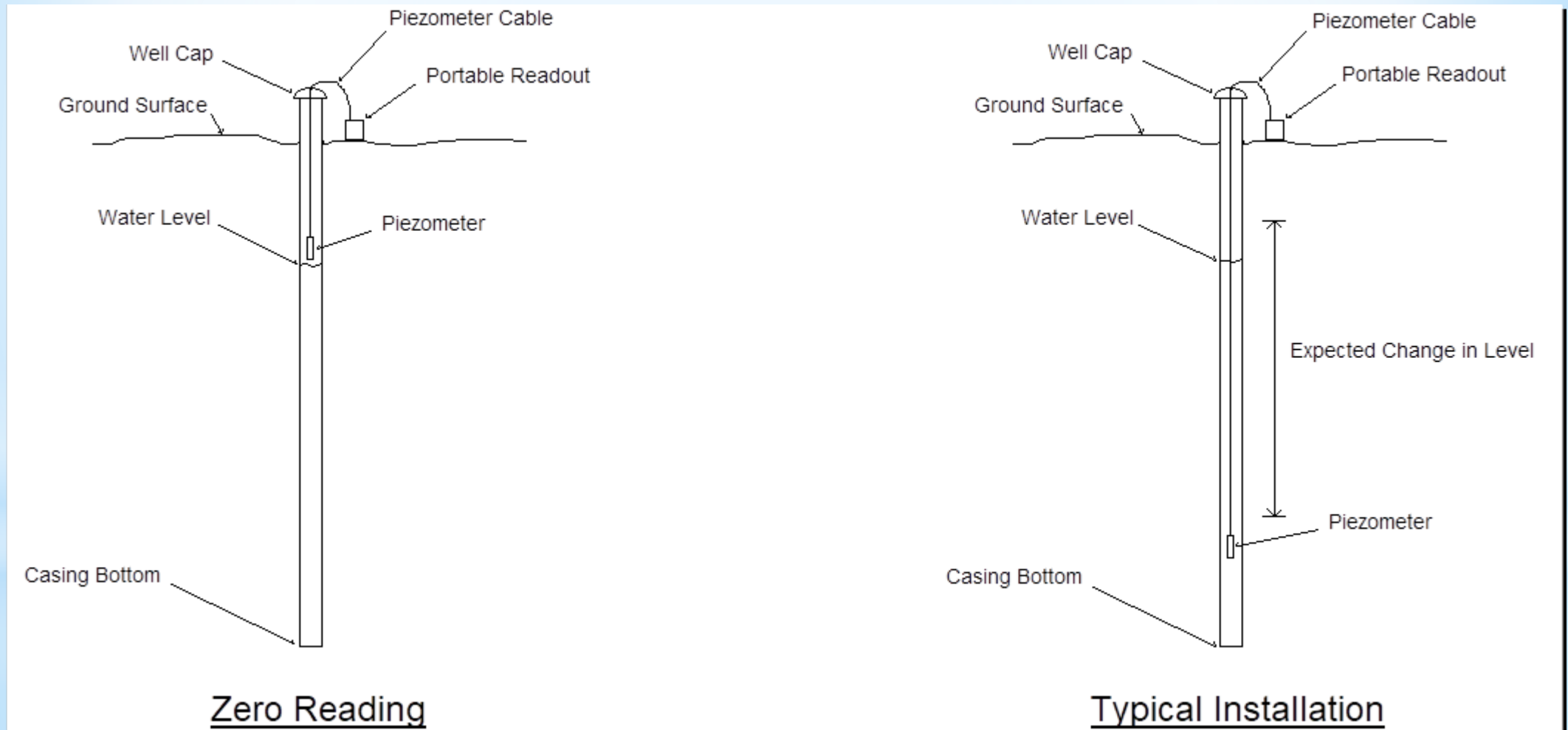
VWAnalyzer (aka VW Handheld)

- Field Installation
- Sensor Validation
- User Field Notes
- GPS Coordinates
- Print Reports
- Sensor Maintenance





VWAnalyzer: Use during Installation





Dynamic Vibrating Wire Measurements

Campbell Scientific Inc is the only manufacturer (globally) to offer a dynamic vibrating wire measurement interface





Static versus Dynamic

1. Excite wire with a long, frequency-rich waveform
2. Sample response for several hundred milliseconds
3. Determine resonant response from a long time sample
4. Allow response to decay, then repeat

1. Excite wire with a **very short monotonic** waveform that is delivered at the **exact frequency and phase** of the wire oscillation
2. Sample for only a **few milliseconds**
3. Determine resonant response from a **very short time sample**
4. Repeat before response decays -- **continuous wire vibration**



Dynamic Vibrating Wire





SC-CPI Interface required for CDM to CR800, CR1000, CR3000. CDM Performance is limited!





Benefits of making dynamic VW measurements using the VWIRE 305 series devices

- Obtain dynamic readings from existing VW sensors, already prevalent and popular in the markets
- Improved long-term stability and reliability of the measurement (VW sensors vs. foil bonded strain gages)
- Eliminate the need for dual instrumentation of measurement systems
 - Replace the use of bonded-foil strain gages for dynamic measurement
 - Cost savings for instrumentation & installation
- Leverage existing deployments of VW sensors (convert static sensor deployments into dynamic reading stations, event capture, trigger cameras).
- Simultaneous, Anti-Aliased, frequency measurements (2 MHz sample rate per channel, down sampled to 50 kHz for spectral processing)
- Improved noise immunity
 - Obtain results from analysis of lower noise data not possible with other noisier measurements (e.g., low frequency modal analysis)



VWIRE 305 Key Specifications

- › Scan Rates: 20, 50, 100, 200, 333.33 Hz
- › Excitation Voltage Range: 0 to ± 3 V (6 V peak-to-peak)
- › Excitation amplitude auto-scales to maintain desired signal level (wire element stays in constant resonance)
- › Measurement Accuracy: $\pm(0.005\%$ of reading + Resolution)
- › Simultaneous measurements to within <10 useconds (scan rate dependent)

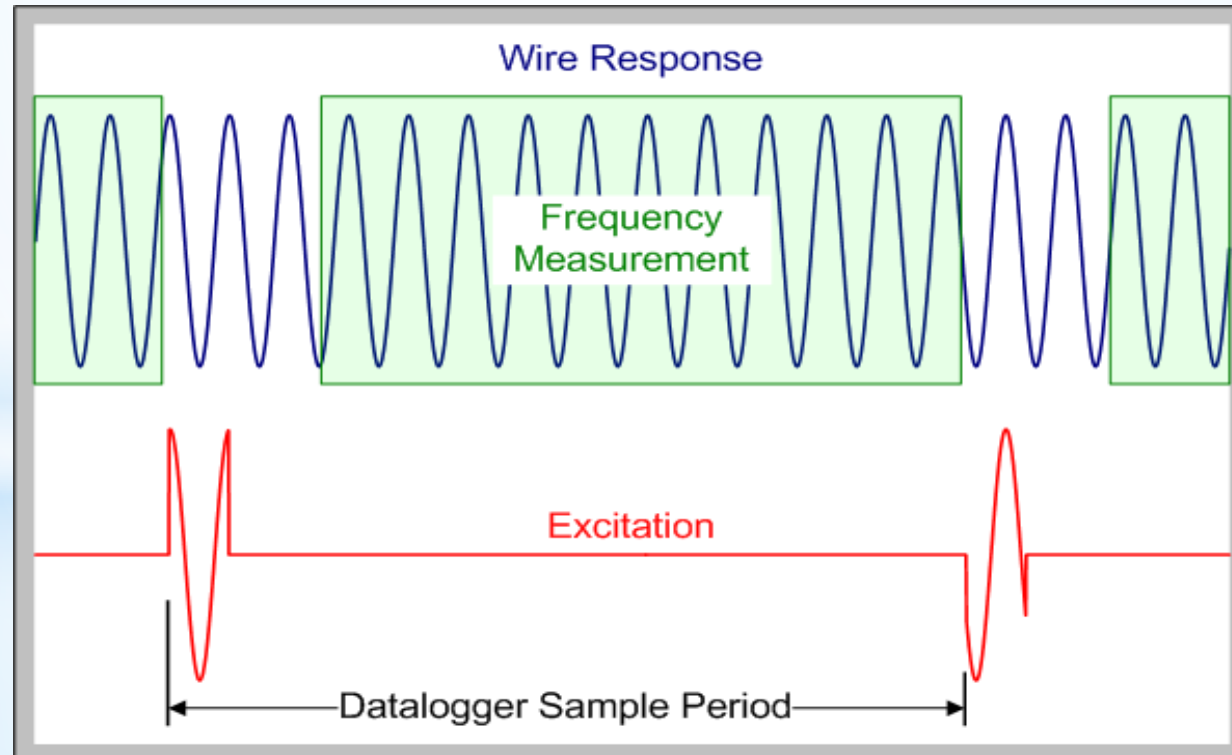
Sample Rate (Hz)	Resolution/ Noise (Hz RMS)	
1	0.005	
20	0.008	
50	0.015	
100	0.035	
200	0.110	
333.3	0.450	
Sample Rate (Hz)	Min Gage Freq (Hz)	Max Gage Freq (Hz)
20	290	6000
50	290	6000
100	580	6000
200	1150	6000
333.3	2300	6000



Dynamic Excite-Measure Cycle

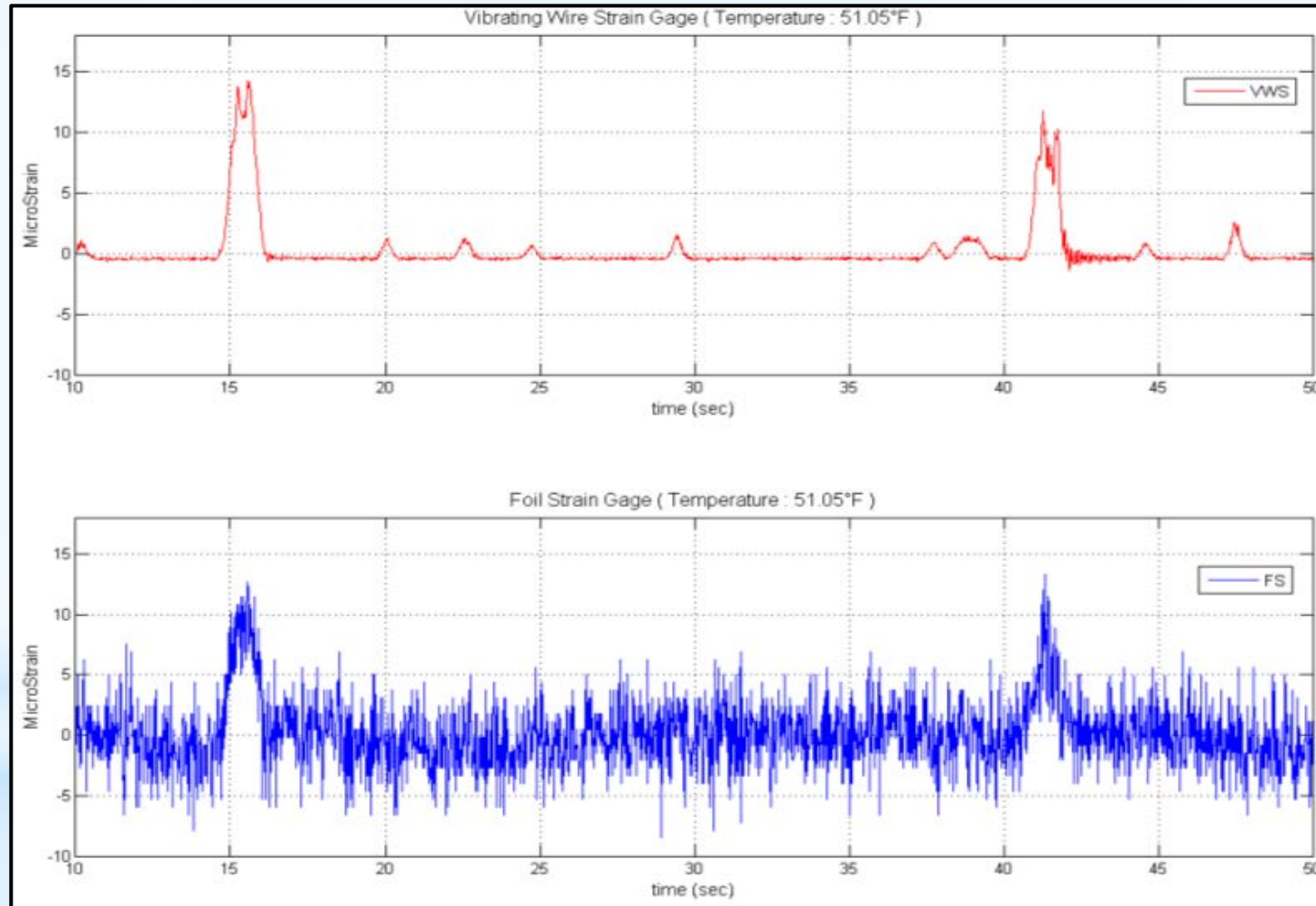
The two key requirements are:

- Generating an agile & synchronized excitation waveform
- Determining the wire resonant frequency from only a few cycles





Instrument Comparison on Perry Bridge





VWIRE 305 to PC Software

No DataLogger Required





DVW ToolBox v. 1.2

https://www.campbellsci.com/cdm-vw305

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Downloads

DVW Tool Box v.1.2 (13.0 MB) 10-10-2016

DVW Tool Box is an application-specific software tool for demonstration and evaluation of the CDM-VW300 and CDM-VW305 dynamic vibrating-wire interfaces.

[Download Now](#)

[View Update History](#)

CDM-VW300/305 OS v.04 (563 KB) 10-25-2017

Execution of this download installs the CDM-VW300/305 Operating System on your computer for upload to the CDM-VW300/305 device with Device Configuration Utility.

Note: The **CDM-VW300/305 OS V.02** or greater is required to use the CDM-VW300/305 with the CR6 datalogger or with a CR3000/1000/800 datalogger that is using **OS 28** or higher. The SC-CPI Operating System will also need to be upgraded to **SC-CPI OS V.02**. If using a CR3000/1000/800 datalogger with an older OS, an operating system upgrade to the datalogger will be required.

[Download Now](#)

[View Update History](#)

CDM-VW300 Example Programs (45.4 KB) 05-23-2013

CRBasic program examples for use with the CDM-VW300 and CDM-VW305.

[Download Now](#)

Device Configuration Utility v.2.18 (46.5 MB) 08-24-2018

A software utility used to download operating systems and set up Campbell Scientific hardware. Also will update PakBus Graph and the Network Planner if they have been installed previously by another Campbell Scientific software package.

Supported Operating Systems:

Windows 10, 8.1, 8, and 7 (Both 32 and 64 bit)

[Download Now](#)

[View Update History](#)

CPI Calculator v.1.0 (2.49 MB) 07-06-2016

The CPI Calculator is a downloadable Microsoft Excel spreadsheet used to estimate the usage and capacity of a CPI network. The calculator provides an overview on CPI devices including the CDM-A108, CDM-A116, CDM-VW300, CDM-VW305, and the CSAT3B. The calculator can also estimate the measurement speed of the CDM-A108 and CDM-A116 based on the number of channels and measurement parameters.

The CPI Calculator is an estimation tool and will help you better understand and design CPI networks by considering the following:

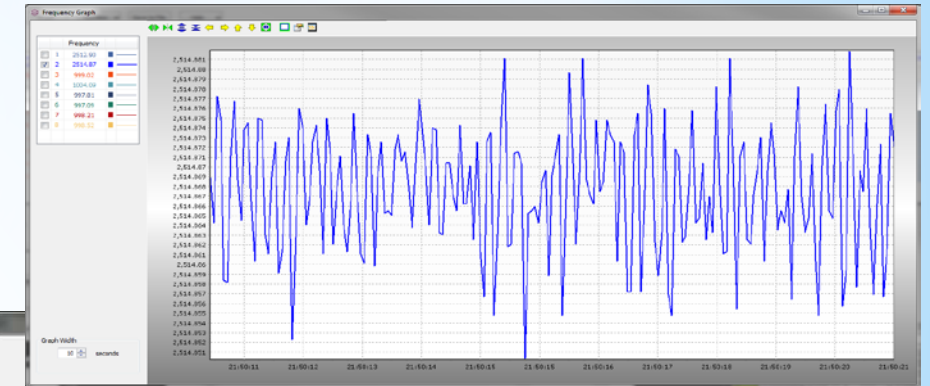
1. What is the capability of each CDM or CPI device
2. What is the CPI network capacity
3. How much of the CPI capacity are the CDMs or CPI devices using

[Download Now](#)



DVW Toolbox VWIRE 305 to PC Software

- Primary purpose lab evaluation, product demonstration, or functional verification
- Application specific representation of DevConfig parameters
- Time-series graphing
- Rainflow (Stress Cycle Count) graphing
- Save ASCII data to file



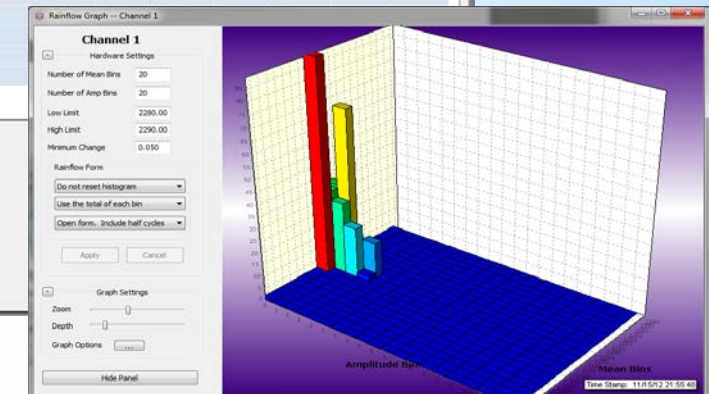
Dynamic Vibrating-Wire Tool Box

Scan Rate: 20 Hz | Graph | Rainflow | Save to File | Help

DVWTool Decimation: 1

	Enable	Dynamic Frequency (Hz)	Static Frequency (Hz)	Static Thermistor (mVms)	Std Dev of Dyn Freq (Hz)	Excitation Strength (V)	Diagnostic Bits	Actual Min Freq (Hz)	Actual Max Freq (Hz)	Resonant Amplitude (V)	Minimum Frequency (Hz)	Maximum Frequency (Hz)	Output Format	Multiplier	Offset	Steinhart-Hart Thermistor Coefficients (or 0 to disable)		
																A	B	C
Channel 1	<input checked="" type="checkbox"/>	2512.892	2512.909	3359.940	0.010	1.294	0x00	286	6008	0.0020	300	6000	Freq	1	0	0	0	0
Channel 2	<input checked="" type="checkbox"/>	2514.856	2514.875	3327.146	0.006	1.012	0x00	286	6008	0.0020	300	6000	Freq	1	0	0	0	0
Channel 3	<input checked="" type="checkbox"/>	998.347	998.381	50549544.000	0.192	6.000	0x01	286	6008	0.0020	300	6000	Freq	1	0	0	0	0
Channel 4	<input checked="" type="checkbox"/>	999.371	998.242	50336748.000	0.069	6.000	0x01	286	6008	0.0020	300	6000	Freq	1	0	0	0	0
Channel 5	<input checked="" type="checkbox"/>	1004.011	1004.263	25402690.000	0.130	6.000	0x01	286	6008	0.0020	300	6000	Freq	1	0	0	0	0
Channel 6	<input checked="" type="checkbox"/>	1000.449	1000.762	25272276.000	0.145	6.000	0x01	286	6008	0.0020	300	6000	Freq	1	0	0	0	0
Channel 7	<input checked="" type="checkbox"/>	999.131	999.170	25158312.000	0.097	6.000	0x01	286	6008	0.0020	300	6000	Freq	1	0	0	0	0
Channel 8	<input checked="" type="checkbox"/>	999.589	999.110	25030390.000	0.240	6.000	0x01	286	6008	0.0020	300	6000	Freq	1	0	0	0	0

Device Type: CDM-VW305
Serial Number: 201-2
Device Name: New CDM-VW305
CPI Address: 21
CPI Bit Rate: Auto-Detected Bit Rate
Com Port: CDM-VW300 (COM14)





Water Level Sensors

Radar Level Sensors

Why do customers care about water level?




In most systems, water level directly relates to water volume; therefore level can be used to calculate volume or flow.





Level sensor – contact/no-contact

Product Line

	<i>Measurement Time</i>	<i>Output Options</i>	<i>Operating Temperature Range</i>	<i>Temperature Accuracy</i>
CS451 Stainless-Steel Pressure Transducer 	< 1.5 s	SDI-12 (version 1.3) 1200 bps; RS-232 9600 bps	0° to 60°C WARNING: Sensor could be damaged if encased in frozen ice.	±0.2°C
CS475A-L Radar Water-Level Sensor 	> < 1.0 s (normal power mode) > 60.0 s + (5 • Integration Time) + (Measurement Time) (low power mode)	SDI-12	-40° to +80°C	—
LevelVUEB10 Water-Level Continuous Flow Bubbler with Integrated Screen 	—	Communications: SDI-12, RS-485	-40° to +60°C	—



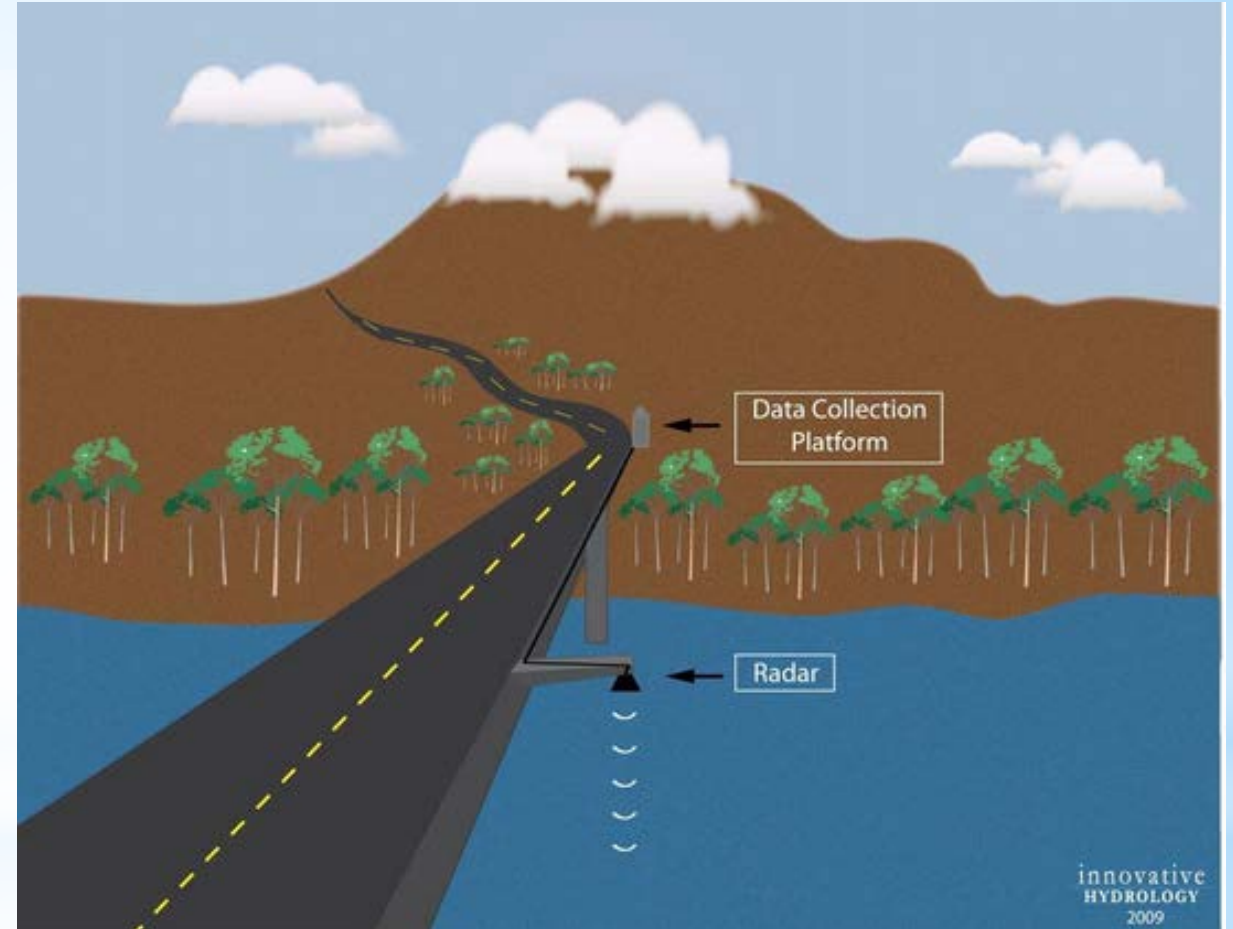
Other Products

	<i>Measurement Time</i>	<i>Output Options</i>	<i>Operating Temperature Range</i>	<i>Temperature Accuracy</i>
CS456 Titanium Pressure Transducer 	< 1.5 s	SDI-12 (version 1.3) 1200 bps; RS-232 9600 bps	0° to 60°C WARNING: Sensor could be damaged if encased in frozen ice.	±0.2°C
CRS451V Stainless-Steel Vented Stand-Alone Pressure Transducer 	< 1.0 s	micro USB	0° to 60°C WARNING: Sensor could be damaged if encased in frozen ice.	±0.2°C
CRS456V Titanium Vented Stand-Alone Pressure Transducer 	< 1.0 s	micro USB	0° to 60°C WARNING: Sensor could be damaged if encased in frozen ice.	±0.2°C
CRS451 Stainless-Steel Stand-Alone Pressure Transducer 	< 1.0 s	micro USB	0° to 60°C WARNING: Sensor could be damaged if encased in frozen ice.	±0.2°C
CRS456 Titanium Stand-Alone Pressure Transducer 	< 1.0 s	micro USB	0° to 60°C WARNING: Sensor could be damaged if encased in frozen ice.	±0.2°C



Water-level technology: radar

- ▶ Radio-frequency transmission
 - 26 GHz
 - Signal is generally immune to weather conditions
 - Sensors are internally programmed to convert radar-frequency reflections from units of distance to the water surface to stage.





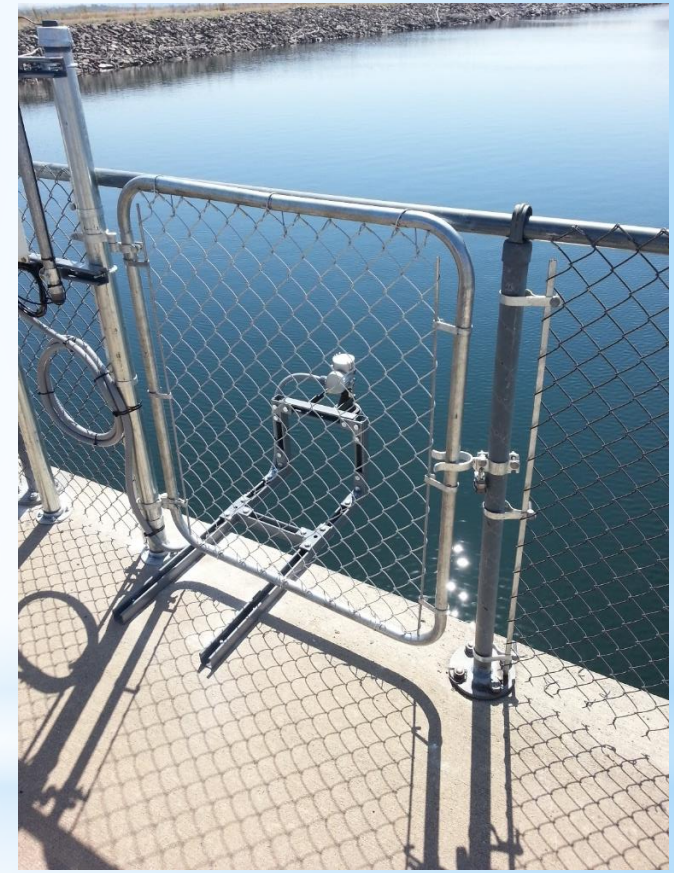
Why use radar?

- ▶ What makes radar a good choice for water level measurement?
 - Accuracy better than 0.01 ft up to 114.8 ft
 - Ease of mounting
 - Low maintenance cost
 - Cost of hardware





Installation: mounted on the edge of a dam





Installation: mounted to measure head and tail water at a lock and dam





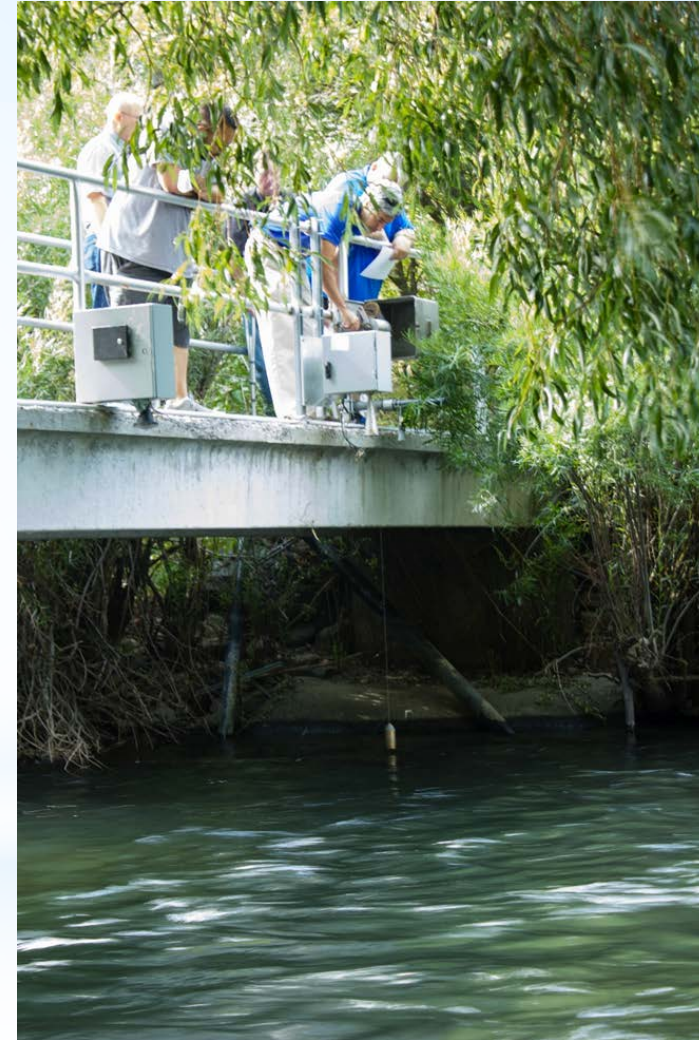
Summary: surface water installations

- Radars are typically installed over open water
 - Mounted on a Bridge
 - Edge of a stream
 - Mounted on the edge of a Dam
 - Mounted inside a stilling well
 - Mounted inside reservoir intake towers
 - Mounted to measure head and tail water at a lock and dam



Radar water level installation

- › Mount radar
- › Make sure radar is mounted **level**
- › Connect SDI-12 radar cable to datalogger
- › Allow radar to be powered for two minutes
- › Use datalogger to send SDI-12 aXWSR=sss.ss! (Write Stage)
- › Verify water level reading by issuing an SDI-12 Measure command aM!
- › Repeat the last two steps if needed.





GRANITE DAO



13th -14th November 2021



About GRANITE Data Acquisition (DAQ)

The GRANITE™ Series comprises Campbell Scientific's most powerful data-acquisition products, which are the core to a successful data-acquisition network. Each GRANITE DAQ connects with the GRANITE measurement modules to create a custom network specific for each unique application.

Kindly watch the video

<https://www.campbellsci.com/videos/granite-daq>





What is GRANITE

- › Distributed Data Acquisition
- › Expandable
- › Form Factor
- › Compatible with other Campbell Scientific
 - CS I/O
 - CPI
 - RS232
 - PakBus



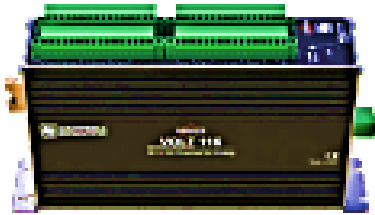
Distributed DAQ Benefits

- › Easy to add channels
- › Higher measurement speeds
- › Locate the measurement near the sensor
- › Simpler programming
- › Reduced cabling costs
- › Reduced installation costs



Granite Measurements

GRANITE Measurements



The GRANITE measurement modules allow flexibility both in measurement type and channel count.

GRANITE Module	Measurement	Channels	Notes
TEMP 120	Thermocouple	20	Measures all thermocouple types. Each channel has a dedicated reference temperature.
VOLT 108	Analog	8 or 16	The most cost effective analog measurement with 24 bit ADC resolution for voltage and bridge measurements. The VOLT 116 is capable of 16 2-wire measurements or 32 1-wire measurements. CAN 2.0B/2.0A capable.
VOLT 116	Analog	16 or 32	
SPECTRUM 103	High Speed Analog	3	10,000 Hz anti-aliased synchronous measurements with 32 bit ADC resolution for voltage and bridge measurements.
SPECTRUM 109	High Speed Analog	9	
VWIRE 305	Dynamic Vibrating Wire	8	Dynamic and simultaneous vibrating-wire measurements at 20, 50, 100, 200 and 333 Hz.






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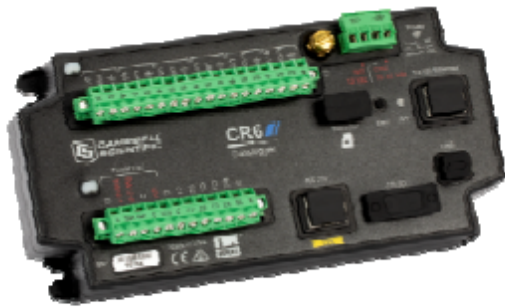


Products

Product Line		Digital I/O	Communications Ports	Data Storage	Static Vibrating-Wire Measurements
GRANITE 6 Measurement and Control Data-Acquisition System 	16 terminals (C1 to C4, U1 to U12) configurable for digital input and output. Terminals are configurable in pairs for 5 V or 3.3 V logic for some functions.	<ul style="list-style-type: none"> > Ethernet > USB Micro B > USB host > CS I/O > 0 to 5 V serial > SDI-12 > RS-485 > RS-422 > CPI/RS-232 	4 MB SRAM + 72 MB flash (Storage expansion of up to 16 GB with removable microSD flash memory card.)	Supported	
GRANITE 9 Measurement and Control Data-Acquisition System 	8 terminals (C1 to C8) configurable for digital input and output. Terminals are configurable in pairs for 5 V or 3.3 V logic for some functions.	<ul style="list-style-type: none"> > Ethernet > USB Micro B > USB host > CS I/O > 0 to 5 V serial > SDI-12 > RS-485 > RS-422 > CPI/RS-232 > EPI 	4 MB SRAM + 128 MB NOR flash (Storage expansion of up to 16 GB with removable microSD flash memory card.)	Not supported	
GRANITE 10 Measurement and Control Data-Acquisition System 	8 terminals (C1 to C8) configurable for digital input and output. Terminals are configurable in pairs for 5 V or 3.3 V logic for some functions.	<ul style="list-style-type: none"> > CAN FD > CAN > Ethernet > USB Micro B > USB host > CS I/O > 0 to 5 V serial > SDI-12 > RS-485 > RS-422 > CPI/RS-232 > EPI 	4 MB SRAM + 128 MB NOR flash (Storage expansion of up to 16 GB with removable microSD flash memory card.)	Not supported	



Standard DAQ vs GRANITE DAQ



CR6

- 1 ADC
- 1 processor
- Full feature data logger
- Wireless options



GRANITE6

- 1 ADC
- 1 processor
- Full feature data logger
- Native Wi-Fi
- USB host



GRANITE9

- No ADC
- Quad core processor
- Digital aggregator data logger
- USB host
- Native GPS
- Large memory



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Standard DAQ vs GRANITE DAQ

CR6



The CR6 and the GRANITE6 are almost the same data logger

GRANITE 6



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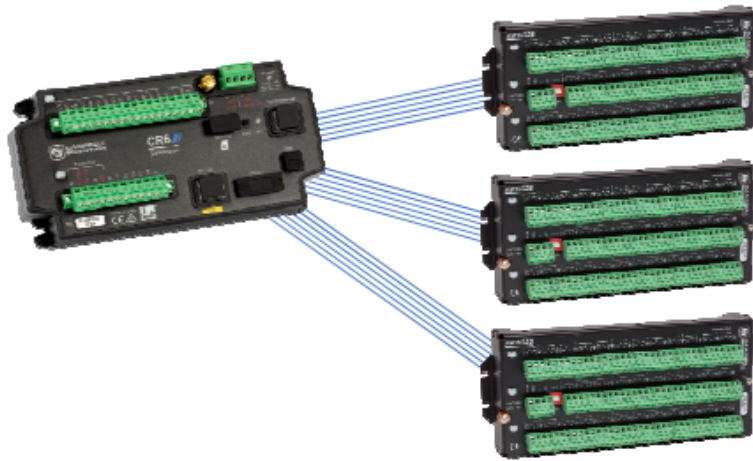


GRANITE



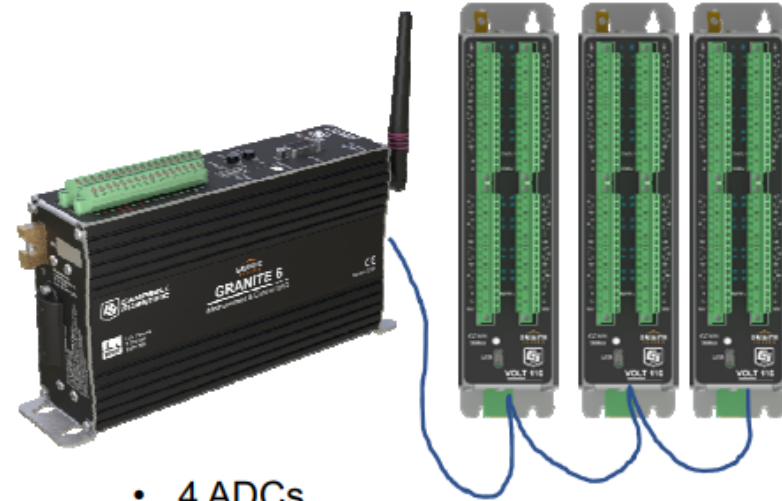
Standard DAQ vs GRANITE DAQ

Expanded CR6 w/ AM1632B



- 1 ADC
- 1 processor
- Multiple wires to connect and manage

Expanded GRANITE 6



- 4 ADCs
- 4 processors
- Single Ethernet cable
- Quicker install
- Higher speed
- Expansion still possible



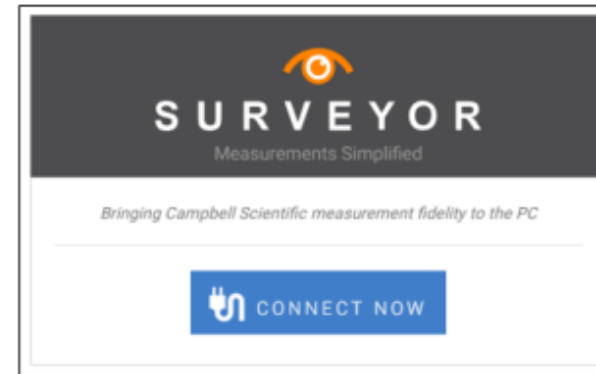
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Software – CS SURVEYOR

- › Direct PC link to a single module
- › Oscilloscope-like experience
 - Near-Zero learning curve
 - Quickly setup measurements
- › Instant visual feedback
 - Changes take effect immediately
 - Streaming data
 - Effortless graphing
- › Simple save-data-to-PC functionality
- › Fully meets the needs of some users
- › Serves as a training gateway to advanced users



ROCK
SOLID



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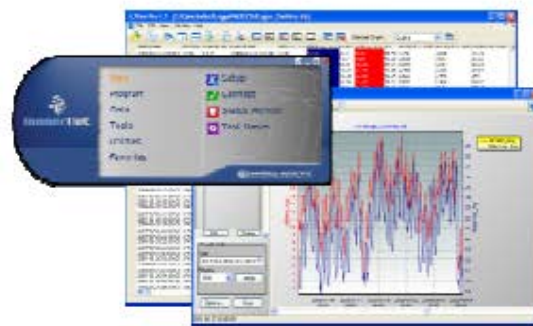
GRANITE

13th -14th November 2021



Software – LoggerNet

- › Optimized for data viewing and collection at moderate rates
- › Scheduled data collection
- › Programming
- › Supports many devices on a network



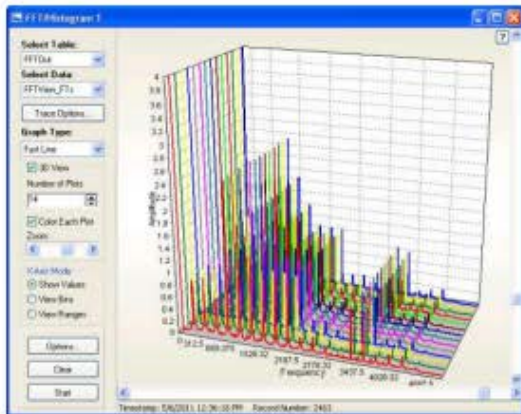
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Software – RTDAQ

- › Optimized for high-speed data viewing and collection
- › Programming
- › Supports many devices on a network



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Software – ShortCut

- › Generate datalogger programming files from a menu-style user interface
- › Starting point for building specialized CRBasic programs



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Photo from the GRANITE Workshop 2019 participants came from more than 20 countries.



Hand-on training

Attendees



Saadi Al-Musawi
Granite workshop Campbell
Scientific Inc. 2019



Thank you

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