

# VibWire-108

8 Channel Vibrating Wire Sensor Interface

User Guide & Installation Manual

Version 1.11

Last updated 24/09/2015

## WARRANTY

Keynes Controls Ltd warrants its products to be free of defects in materials and workmanship, under normal use and service for a period of 12 months from the date of purchase. If the unit should malfunction, it must be returned to Keynes Controls for evaluation, freight prepaid. Upon examination by Keynes Controls Ltd, if the unit is found to be defective, it will be repaired or replaced at no charge.

However the WARRANTY is VOID if the unit shows evidence of having been tampered with or shows evidence of being damaged as a result of excessive corrosion or current, heat, moisture or vibration., improper specification misuse outside of the companies control.

Components which wear or become damaged by misuse are not warranted. This includes batteries, fuses and connectors.

Models VibWire-108-SDI12 and VibWire-108-485 are fully integrated into the Keynes Controls Free Q-LOG Data Acquisition & Display Software. Copies of this software can be downloaded from the company web site.

### Release Information

This manual refers to products sold and supplied after August 2015.

Introduction

The following document is the User Manual and installation guide for the VibWire-108 range of instruments.

The User is expected to have some prior knowledge of the SDI-12, RS-485 or Modbus network and protocols since this manual is not meant as a teaching aid for network applications.

The VibWire-108 family of vibrating wire sensor interfaces have been designed to interface vibrating wire sensors from any manufacture to a data logger, PC data acquisition system, or SCADA applications.

The principle operating feature of the VibWire-108 is its ability to accurately measure and report the vibrating wire sensor frequency. The instrument uses an auto-resonance technique to energise the sensor coil and adjusts the ping rate automatically to follow the sensor operation. The auto-resonance feature enables the sensors to be automatically configured as the instrument adjusts the coil excitation to maximise the signal to noise ratio without excessive strain put to the sensor coil.



Model VibWire-108 SDI-12



Model VibWire-108-485

Hardware Options

- VibWire-108-RS485 with RS-485 network option
- VibWire-108-SDI12 with SDI-12 network option
- VibWire-108-Modbus with RS-485 Modbus option
- VibWire-108-Analog with analogue output option

Dynamic & Static Measurement Applications

The VibWire-108 is ideally suited to static measurement applications. In applications requiring samples rates of 1 - 10 Samples/ Sec then a new keynes Controls product the VibWire-101-RS232 will be required. See

<http://www.aquabat.net/HighSpeedVW/high-speed-vw101v1.html>

Configuration

For SDI-12, RS485 and Modbus network devices the frequency input configuration settings for each of the VW sensor connected to the devices are automatically assigned.

Only the model VibWire-108-Analog instrument of the VW-108 range requires any VW sensor frequency configuration and this is only when the analogue output representation of the input signal is being assigned.

SI Units

The VibWire-108 can be set-up to supply results directly in units of Hz, Digits (Hz<sup>2</sup>) , and Engineering units. The vibrating wire sensor engineering unit conversion is carried out using the industry standard quadratic equation expansion. The vibrating wire

# FEATURES

- 8 x 4 Wire Vibrating Wire Sensor Inputs
- Resolves the VW signal to less than 0.001 Hz (industry standard 0.1 Hz)
- Gas Discharge Tube Sensor Protection
- Real-time Frequency Display - 5 digit
- Audible Output
- Auto Resonance VW Excitation
- SDI-12 Network Support
- Firmware Upgrade facility
- Automatic VW sensor configuration
- Digital communications to remove noise sources and errors.
- Simplified configuration and data logger support.
- Output - Frequency, Digits, SI Units, Temp Deg C
- Steinhart-Hart Thermistor Linearisation Support
- Integrated Polynomial Linearisation - Quadratic Support direct from VW sensor calibration data sheet.

Photo VibWire-108

## Field Operations

All of the VibWire-108 family of interfaces contain a real-time 5 digit, 7 segment LED display that can be used to show real-time sensor frequencies for the vibrating wire sensors, and to configure the most commonly used features of the instrument. This feature is useful when configuring and testing sensors in the field.

The VibWire-108 automatically resets to the network operation after a time-out period of 10 minutes and so prevents a User leaving in the wrong mode of operation. This feature ensures the instrument is always ready for operation and is useful for widely distributed applications and systems deployed in hard to reach locations.

## Terminal Port

The VibWire-108 supports a terminal port configuration and upgrade facility. The terminal port can be used by any industry standard terminal emulator software such as the Microsoft Hyper-terminal or Token-2. The terminal port enables the vibrating wire sensor calibration factors to be stored easily into the instrument.

## Fully Integrated Data Recording Solutions

The VibWire-108 can be connected to any suitable third party data logger or communication system supporting SDI-12, RS-485 or Modbus operations. Simple industry standard commands are used to make a reading and acquire data.

The Modbus network protocol is supported for easy integration into SCADA applications.

## Q-LOG

The VibWire-108 is fully integrated into the free Keynes Controls Q-LOG data recording and display software. The Q-LOG application software enables the VibWire-108 to be used to create PC based data recording and display solutions with little or no programming experience.

The Q-Log software can be downloaded for free

<http://www.aquabat.net/QLOGFree/qlogv2.html>



## 1.0 Care & Maintenance

The VibWire-108 family of products have been designed for long term operation and so will operate reliably for many years as long as the instrument is not mis-used and operated as shown in the manual..

### Step 1

Remove any signal cables and terminal blocks from the instrument.

### Step 2

Clean the 4 and 5 way plug and sockets using ionised water to remove the buildup of any dirt or foreign bodies that build up on the termination pins. It is essential to remove any grease that can cause corrosion to the pins.

### Step 3

Allow the sockets to dry out before connecting any signal cables.

Description	
Operating temperature	–10 to 60 °C
Storage temperature	–10 to 85 °C
Operating humidity	10 to 90% RH, non-condensing
Storage humidity	5 to 95% RH, non-condensing

## 2.0 Default Factory Settings

All instruments are set for No of Channels = 8 Temp = 8

Default ID = 0 Models VibWire-108-SDI12, VibWire-108-RS485, VibWire-108-Modbus

## 3.0 Required Software

The VibWire-108 requires a terminal software package supporting VT100 emulation only.

Recommended software

Microsoft Hyper-terminal  
Token2

### 3.1 Q-Log Software

The Q-Log data acquisition and display software operates with all of the USB-SDI12 and USB-RS485 media converters

Q-Log enables the VibWire-108 to operate with a PC or laptop and give the User access to the data in a familiar Windows environment

When used with a USB-SDI12-Pro or USB-RS485-Pro media converters, the VibWire-108 can directly powered from the PC/Laptop USB port.

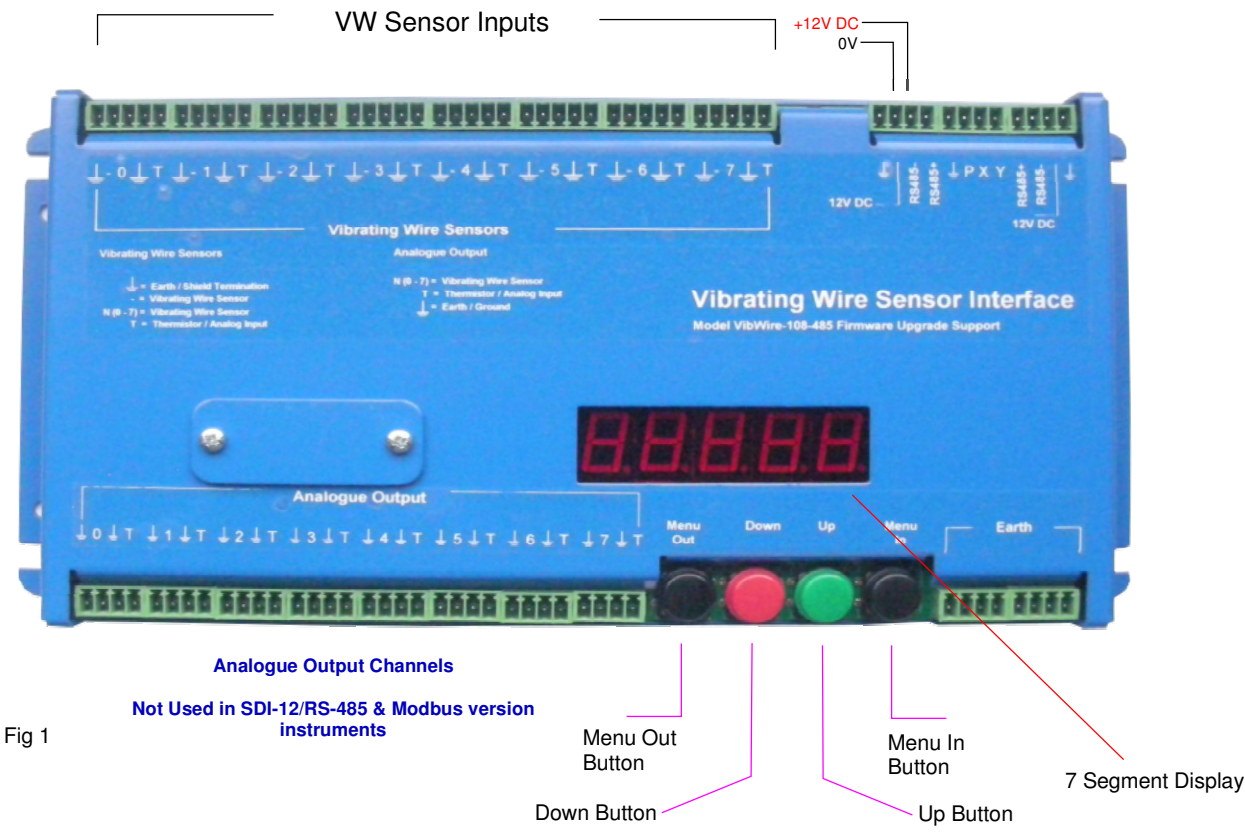
Download at <http://www.aquabat.net/QLOGFree/qlogv2.html>

#### Warranty Information

The information in this document is subject to change without notice. Keynes Controls Ltd . has made a reasonable effort to be sure that the information contained herein is current and accurate as of the date of publication.

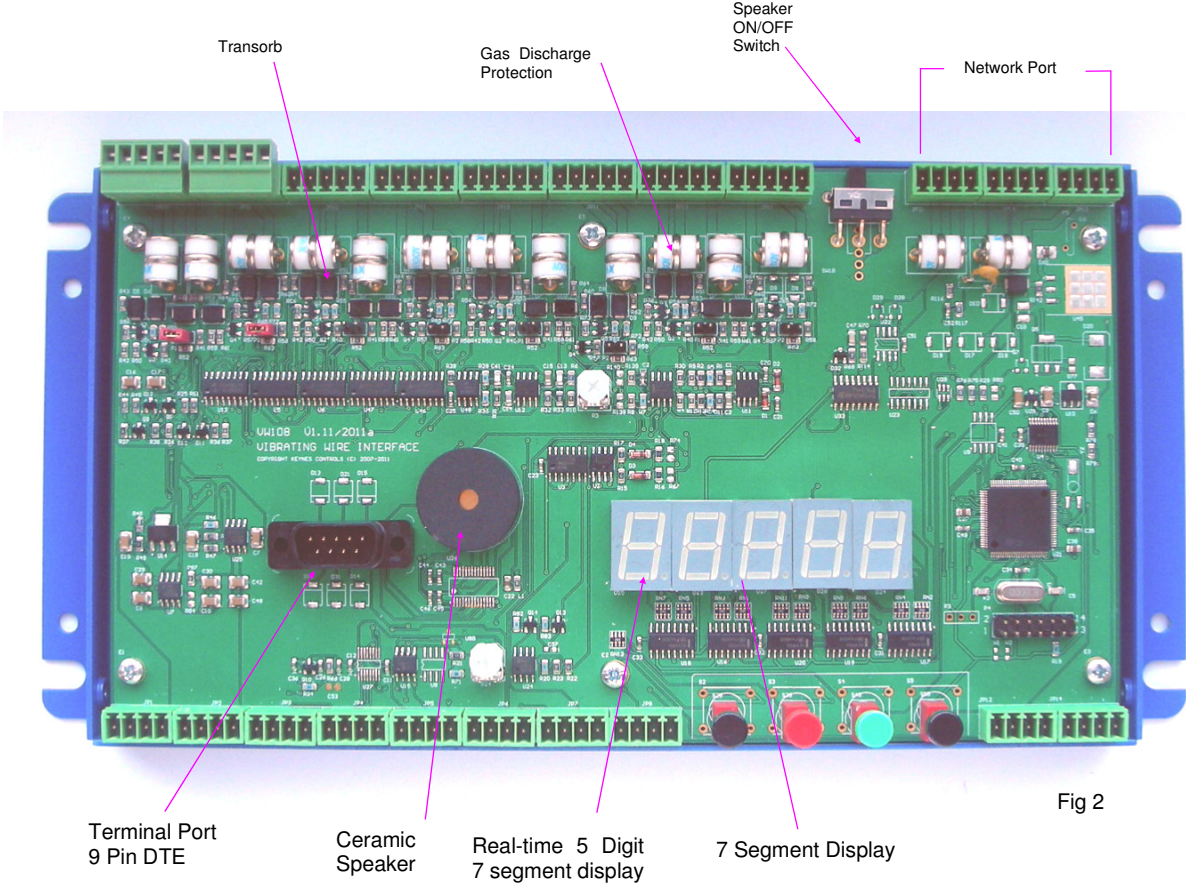
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In no event shall Keynes Controls Ltd . be liable for any claim for direct, incidental, or consequential damages arising out of, or in connection with, the sale, manufacture, delivery, or use of any product.



The keyboard controls and menu system remains the same between models

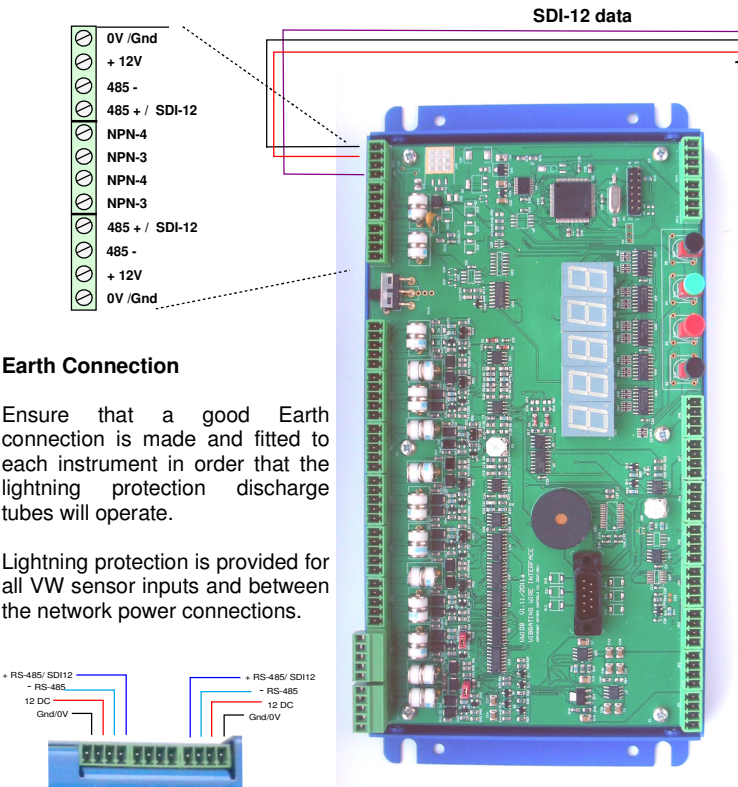
4.1 Circuit Board Features





5.0 SDI-12 Serial Network Connection

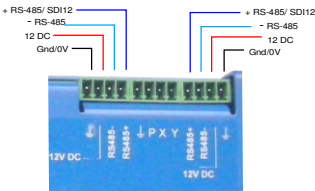
The following page describes connecting the VibWire-108 to an SDI-12 network.



Earth Connection

Ensure that a good Earth connection is made and fitted to each instrument in order that the lightning protection discharge tubes will operate.

Lightning protection is provided for all VW sensor inputs and between the network power connections.



RS-485 Network Connection

Use the same network connection for any 3rd party logger



Fig 3

Main Menu

- 1 Device Setup
- 2 Zigbee Mode Settings
- 3 GPRS Mode Settings
- 4 USB Memory Stick Settings
- 5 SDI12 Setup
- 6 Formulas
- 7 Alarms
- 8 Logging Operations
- 9 Diagnostics
- A System Maintenance
- U Up. T Top.

The menu system shown below is used by the AquaLOG data logger.

Acquire data across the SDI-12 network for 2 x VW108 instruments and store data into the logger starting at the free cell [D] in the data table.

[D] 3M! 3D0! 7M! 7D0!

5.2 Multi-Instrument Solutions

For multiple instruments to operate together on an SDI-12 network then they must each have a unique ID number assigned.

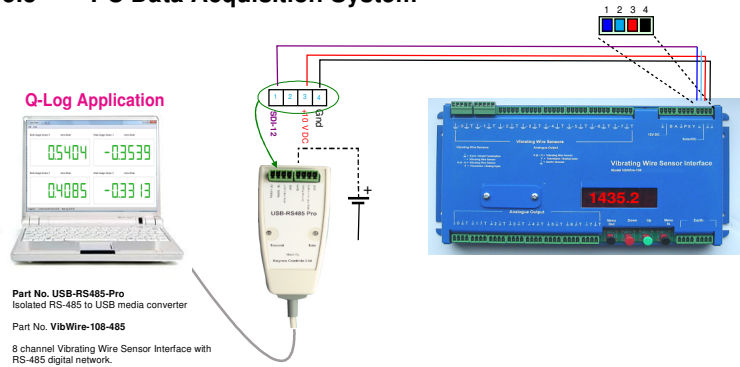
As soon as a measurement instruction is sent by the data logger the the SDI-12 bus is activated and all the instruments are powered on. Upon receipt of the correct start measurement command then then a scan of the sensors is made and data is sent in turn to the data recorder. After all data is received the the instruments are all powered off.

The image below shows how a simple multi-instrument system is connected together to a data logger.

5.1 SDI-12 Network Operation

The SDI-12 multi-drop network requires only 3 wires to be connected between instruments for the communication of data. This ensures that the installation and use of the SDI-12 network is a very simple operation. The VibWire-108 is powered by the SDI-12 network +12V and 0V supply operations. The SDI-12 network only goes active during a measurement operation and is switched off at any other time. The SDI-12 network is controlled by the data recorder.

5.3 PC Data Acquisition System



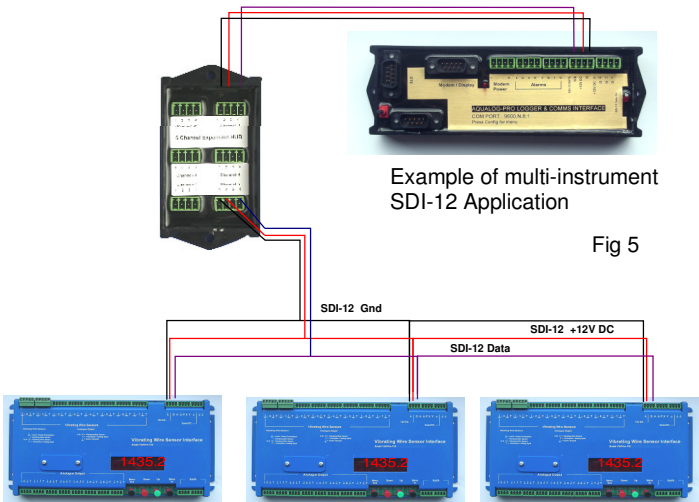
Part No. USB-RS485-Pro  
Isolated RS-485 to USB media converter  
Part No. VibWire-108-485  
8 channel Vibrating Wire Sensor Interface with  
RS-485 digital network.

Additional Information

The USB-SDI12 media converter only controls the network lines. Individual instruments use their own local power supply and are active continuously.

5.4 Multi-instrument Data Logger Solution

Figure 5 below shows how a typical multi-instrument data logger system is wired together.



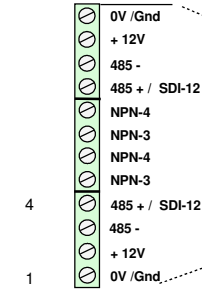
Example of multi-instrument SDI-12 Application

Fig 5

Earth, -RS485, +RS485 lines are connected in common to all units

RS485 + Common to all instruments

The same port configuration on all models of this instrument



Control Signal Lines

- 1 Gnd
- 2 Power
- 3 - RS485
- 4 + RS485 / SDI12

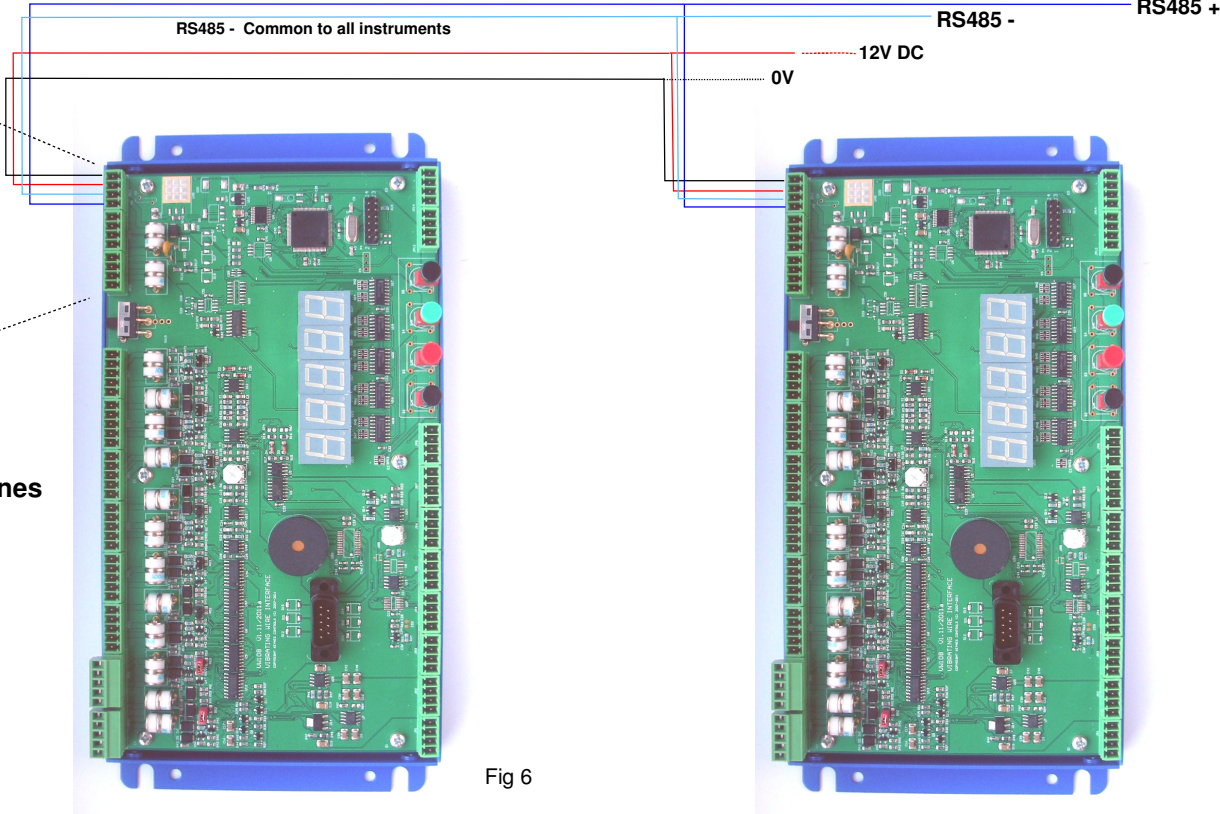
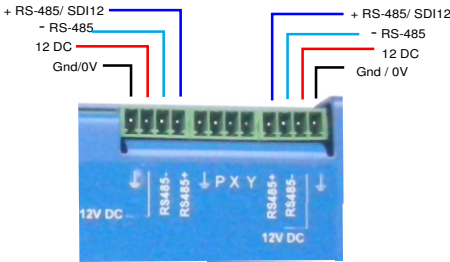


Fig 6



RS-485 Network Connection

6.1 Earth Connection

Ensure that a good Earth connection is made and fitted to each instrument in order that the lightning protection discharge tubes will operate.

Lightning protection is provided for all VW sensor inputs and between the RS-485 - 0V pins.

Important Note

Failure to fit the Earth connection will prevent the lightning protection from operating.

6.2 PC Data Acquisition System - RS-485 Solution

Additional Information

A PC based RS-485 system can operate with up to 32 instruments and to a direct network span of up to 1000 m. This is an ideal solution for large distributed applications. Use an external power supply for more 3 units on a network string.

The USB-RS-485 converter only controls the network lines. Individual instruments use their own local power supply and are active continually.

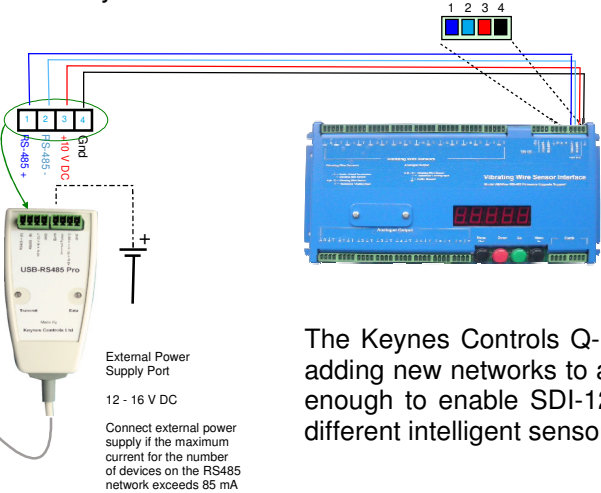
Q-Log Application



Part No. USB-RS485-Pro  
Isolated RS-485 to USB media converter

Part No. VibWire-108-485

8 channel Vibrating Wire Sensor Interface with RS-485 digital network.



View looking into port

6.3 Large Scale Systems Deployment

For applications requiring a large number of distributed instruments then simply adding a new USB-RS485 media converter to a PC will enable multiple network systems to operate together.

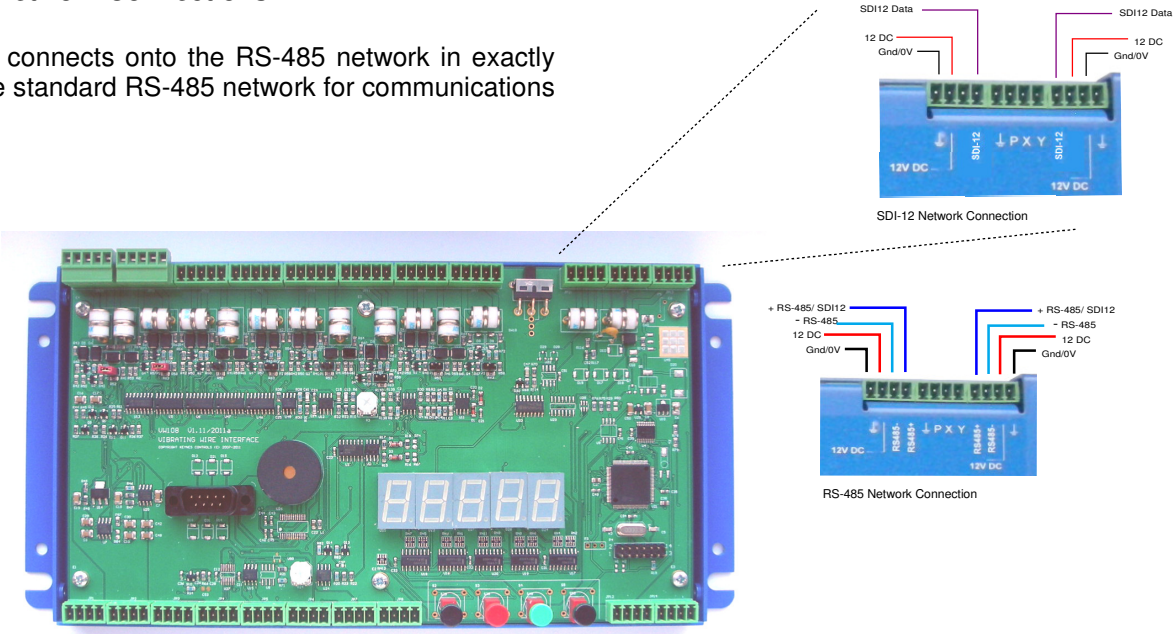
The Keynes Controls Q-LOG software enables unlimited expansion by adding new networks to a PC at any time. In fact the software is flexible enough to enable SDI-12 and 485 networks to coexist enabling many different intelligent sensors to be used.



7.0 Modbus RS-485 Network Connections

The VibWire-108-Modbus connects onto the RS-485 network in exactly the same way as using the standard RS-485 network for communications

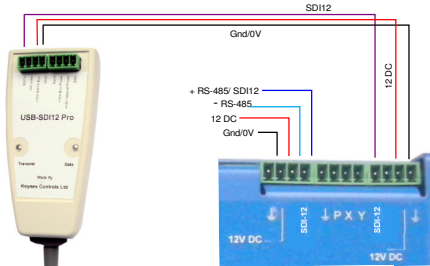
Fig 8



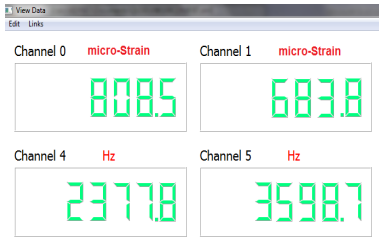
Laptop / PC Computer

The diagram above shows the VibWire-108 connected to a USB-SDI-12-Pro media converter.

SDI-12 / RS-485 digital communications

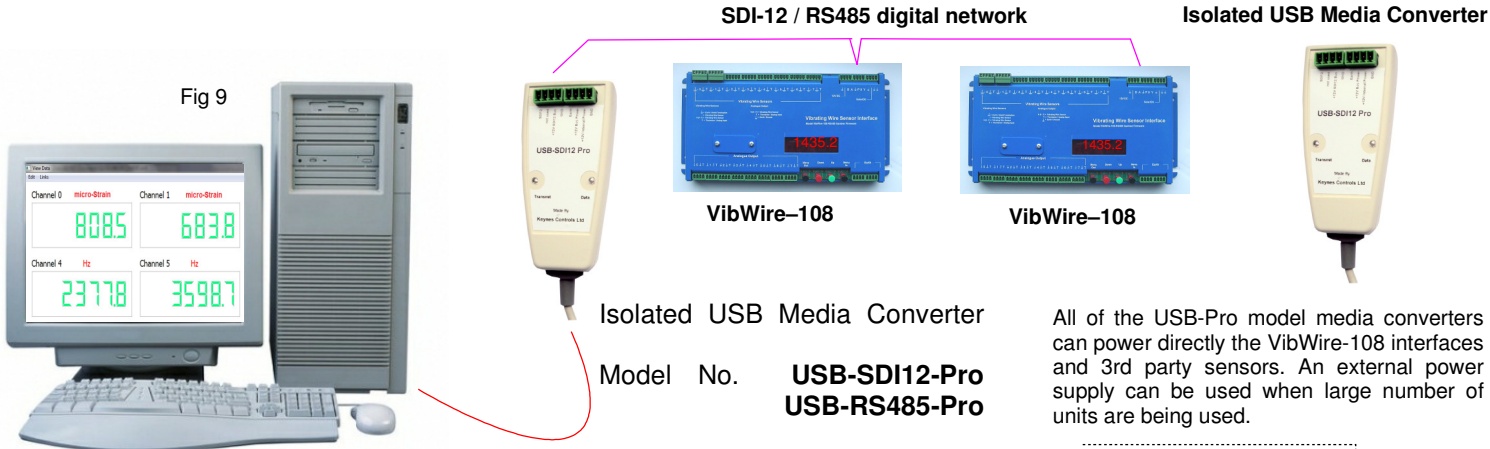


Network Connection on a VibWire-108



Typical Q-Log Panel Meter Display

8.0 PC/Laptop Data Recording & Display System

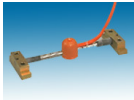


The image above shows how the VibWire-108 can be integrated into a PC based data recording and display solution using the Q-LOG application software. The VibWire-108 will operate with 3rd party software and hardware supporting the correct network protocols.

The USB-SDI12-Pro and USB-RS485-Pro media converters are fully integrated into the Q-LOG application software, and can also be used to power the vibrating wire sensor interfaces directly from the PC USB port.

The Q-LOG software will also operate with many third party intelligent sensors .

All of the USB-Pro model media converters can power directly the VibWire-108 interfaces and 3rd party sensors. An external power supply can be used when large number of units are being used.



0 - 5 Km depending upon signal cable quality

## 9.0 Technical Specifications

The technical specification for the different models is shown below.

All of the VibWire-108 family of products use the same terminal port setting for configuration operations.

Measurement Data:	
Number of channels	8 x 4 Wire VW Inputs - User Selectable
VW sensor coil resistance	to 2 K Ohm (standard):- other ranges on request
Distance of VW sensor to interface	0 .. 10 Km depending on cabling.
Frequency range	400 - 6 KHz (standard) Other ranges on request
Frequency Resolution Accuracy	32 bit resolution 0.001 Hz
Long term stability	± 0.05 % FS max / year
Temperature range	- 50 to 70 Deg C
Temperature resolution	0.1 °C +/- 0.2 Deg Thermistor 10 K Ohm standard 3.3 K Ohm on request
Temperature accuracy	± 0.2 °C / 0.2 °F SDI-12
Thermistor measurement	A half bridge ratio-metric measurement. Value returned in mV. Is used for temperature compensation on VW measurements using Steinhart-Hart thermistor equation or beta value.
Thermistor excitation	2.5 V DC 50 ppm /Deg C
Input resistance	10 K Ohm 0.1 % Completion resistor (Standard) 3.3 K Ohm on request
Units	Freq (Hz), Digits (Hz <sup>2</sup> ), SI Units, Temperature Deg C, mV
Display only - Resolution	5 digit - 0.1 Hz
Electrical Data	
Voltage supply	<b>SDI-12</b> 10.5 to 16V DC
Current compensation SDI-12 Option only	Typical values are @ 12 V DC Excitation
Idle mode	1.2 mA
Active / measurement	8 mA data transmission 58 mA including frequency display These values may change slightly between sensors. Use figures as a guide only.
Measuring time warm up response	500 ms 3 seconds per channel depending on the VW sensor being used (Typical)
Length of data lines SDI-12	0 .. 100 m
SDI-12 Address mode	Supports enhanced addressing 0 .. 9 A .. Z
General Data:	
Dimensions (mm)	L =260 W = 127 D = 38
Material	Powder coated aluminium
SDI-12 Digital Port	SDI-12, 1200 Baud, 7 bit, N stop bit, Even Parity - other speeds on request
CE Conformity	CE conformity according to EN 61000-6
Weight	400 g
Communications	
Terminal Port	9 Way Male - 9600 Baud 8 data, No Parity, 1 stop bit, No Flow control - DTE
SDI-12 Digital Port	1200 Baud, 7 bit, N stop bit, Even Parity - other speeds on request
RS-485 Network Settings	1200 Baud, 7 data bit, N stop bit, even parity
RS-485 Network Settings - modbus	9600 Baud, 8 data bit, 1 stop bit, even parity

## 10.0 System Test - Power on sequence

The instructions are the same for all models.

**Step 1** - Power on the VibWire-108.      Apply 12V DC to the power connector shown on Fig 1, Page 6  
Response      The VibWire-108 will briefly show the message '**HELLO**' on the 5 Digit LED Display.

**Step 2** - The display will default to '**0**' on the LED display.

The instrument will wait until a start measurement command is received before a measurement is made.

11.0 VibWire-108 Digital Communications

The instructions below detail the operations to follow to operate the VibWire-108 across both the SDI-12 and RS-485 serial networks.

No sensor configuration details need be applied to the VibWire-108 when operating with the cable free transmitter, RS-485 or SDI-12 network. Simply connect the sensors to the interface as shown in Fig 2 and initiate the commands listed below.

Recommended Test

Use a single instrument only when undertaking initial measurements with a VibWire-108 on the RS-485 or SDI-12 network. This simplifies the software and will speed up the understanding of the command used to obtain data. It is very easy to test the results measured across the RS-485 and SDI-12 network with the ones shown on-board frequency display of the unit.

The results obtained across the RS-485 and SDI-12 network will be same as those shown on the display for a specified channel.

The default instrument address for a unit straight out of the box is 0 - results will be random numbers with no sensors installed.

Test Measurement

Issue command **0M!** to start measurement operations. The VibWire-108 will scan all channels  
**0D0!** returns items of data *0 + Freq Chan 0 + Freq Chan 1 + Freq Chan 2 + Freq Chan 3*

Ensure that each instrument used on a network has a unique ID number assigned within its configuration in order to correctly identify the data that is being recorded.

11.1 Command Structure & Operations across an RS-485 network

The VibWire-108 uses a command structure across the RS-485 network very similar to that used by the SDI-12 network in order to simplify the overall system operations. Understanding the control of the instrument on one network be that RS-485 or SDI-12 will make using the the unit on the other a very simple operation.

The RS-485 and SDI-12 network both operate at the same speed of 1200 baud. The RS-485 network speed can be increased at the time of manufacture. Currently it is factory set.

Even though this is a relatively slow rate, as networks go, it is more than adequate for the small amounts of data transmitted by the instrument. No break characters are transmitted in an RS-485 command and any sent will be ignored by the instrument.

A short delay of approximately **10 ms** is added between a command received by VibWire-108 and its transmission of data since this delay is used to allow time for the host PC to turn off its transmitter when using soft-negotiation for data flow control operations. Under normal RS-485 data transmission operations the RTS line on the serial port is used for flow control operations.

Keynes Controls recommends an RS-485 interface with hardware negotiation is used to control the VibWire-108 across a network.

11.2 Timing Constraints RS-485 / SDI-12 Network

There are no timing constraints for the transmission of instructions and receipt of data across an RS-485 network compared to the operations on and SDI-12 network.

Data Access Time

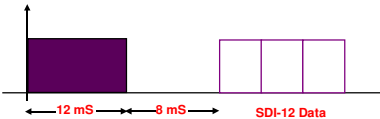


Figure 10 shows timing delay used on SDI-12 serial bus prior to sending data

Typically the VibWire-108 takes 5 seconds to complete the scan of the first sensor and a further 3 seconds for any other sensor connected to the instrument. The actual response time for the instrument is dependent upon number of sensor fitted and can interrogated using the aM! command.

11.3 RS-485/ SDI-12 Commands

The commands used by instruments on the SDI-12 and RS485 network are the same

In the following commands 'a' and 'b' are the address of the instrument and can only be integers 0 to 9 or the characters a - z.

where

- 'ttt' represents a time in seconds (0 to 999 seconds)
- 'n' or 'nn' represents a number of channels (00 to 99 channels)
- \r and \n are the Carriage Return and Line Feed characters - ASCII 13 and 10.

## 11.4 Assigning Data Transmission over the SDI-12 or RS-485 Network

All of the VibWire-108 models use the **SERIAL** option to assign the data transmission operations across the digital network. A 10 minute time-out feature ensures that the instruments cannot be left displaying real-time frequency results.

For Modbus operations the instrument scans automatically at the pre-set sample time as soon as power is applied, see page 24 for setting the sample time.

The Modbus ID is set exactly the same as for the SDI-12 and normal RS-485 operations.

## 11.5 Starting Data Acquisition Operation on a SDI-12 Network

To activate the analogue output channels on the VibWire-108.

1. Starting at



2. Select **"Menu In"** button

3. Use the Up & Down Keys to select the option **"SERIAL"**

**"Analg C0d C1d C2d C3d C4d C5d C6d C7d"** are the other options available

Once the **"Serial"** output is selected the **"Menu Out"** key has to be pressed to confirm this option.

4. The VW-108 will return to the display



and now the SDI-12/RS-485 port for the instrument is now activated.

### Instrument Identifier

Each instrument deployed on the SDI-12 multi-drop network must have a unique instrument identifier set in order to identify specific instrument on the network. For the SDI-12 network this identifier is 0-9. The SDI-12 ID can be expanded upon request.

See Page 8 for details on setting the ID number.

SDI-12 and RS485 operations are only possible when the VibWire-108 is in serial port mode. This is indicated by activating the **'SErAL'** option.

## 11.6 Starting Data Acquisition Operation on a 485 Network Instrument Identifier

To activate the SDI-12/ 485 output channels on the VibWire-108

1. Starting at




2. Select **"Menu In"** button

3. Use the Up & Down Keys to select the option **"SErAL"**

**"Analg C0d C1d C2d C3d C4d C5d C6d C7d"** are the other options available

Once the **"SErAL"** output is selected the **"Menu Out"** key has to be pressed to confirm this option.

4. The VW-108 will return to the display



and now the SDI-12/RS-485 port of the instrument are now activated.

Each instrument deployed on the RS-485 multi-drop network must have a unique instrument identifier (ID) set in order to identify specific instrument on the network. For the RS-485 network this identifier is 0-31. The SDI-12 ID can be expanded upon request.

See Page 26 for details on setting the ID number using the keyboard menu system. System Maintenance option of the terminal menu system page 23.

## 11.7 Modbus version instrument

The Modbus version instrument will start the scan sequence automatically as soon as power is applied. The scan period is set using the built in menu system using the keyboard. See page 24, section 23.3 for details.



## 12.0 Instrument Identifier

Each instrument deployed on the multi-drop network must have a unique instrument identifier set in order to identify specific instrument on the network:

For the RS-485 network this identifier is in the range 0-9 / a-z.

For the SDI-12 network then the ID number is in the range 0..9 - Additional ID numbers are supported a .. z.

For Modbus operations the ID number is currently limited to 1 .. 32.

## 13.0 Start Measurement Commands

There are 2 separate commands supported by the VibWire-108 for initiating measurements across an RS-485 network and are named '**aM!**' and '**aC!**'. Table 1 includes a complete description of the commands used by the VibWire-108

The '**aM!**' starts a measurement and responds as soon as the data is ready to be transmitted from the instrument. This command returns all instrument sensor inputs as a string

The '**aC!**' command starts concurrent operations that are used to initiate measurements upon multiple instruments deployed across the network. The '**aC!**' command frees the network bus so that other devices can operate freely.

## 14.0 Advice on the choice of measurement commands

The VibWire-108 supports both the individual and concurrent start measurement commands.

Keynes recommends using individual start measurement commands where there are large distances between devices and the network cable installation quality is poor. Should there be substantial voltage losses on the supply cable then the additional load of a lot of sensors scanning simultaneously may cause errors with some instruments being unable to operate correctly.

For fast results and small scale systems then the concurrent start measurement command can be used.

### 14.1 Possible Network Problems

Should a larger than expect load be put onto the SDI-12 network then the voltage drop between 0 V and SDI-12 12 V supply can be as high as 2 V. If this is the case then the instrument may not respond as expected.

## 15.0 SDI-12 Supported Commands

The following commands are supported by the VibWire-108 SDI-12 model

Description	Master	VibWire-108 Response
Acknowledge active	a!	a\r\n
<b>Send ID:</b>	al!	a13KEYNESCOVibWire-1080001\r\n
provided to complement SDI-12 protocol		Part Description assigned by Keynes
<b>Address Query</b>	?!	a\r\n
identifies instrument address and commonly used on single instrument operations only.	Used to make command set SDI-12 compatible	Where a = ID number 0 - 9 (standard) / (a..z) Enhanced SDI-12 0 - 9 / a - z for RS485
<b>Change Address:</b>	aAb!	b\r\n
used to change instrument address from <b>a</b> (initial) to <b>b</b> new ID for network operations	<b>a</b> = initial address <b>b</b> = new address	<b>a : b</b> = number 0 - 9 or a - z
<b>Start Measurement</b>	aM!	a0268\r\n
instruct an instrument to make measurement	<b>a</b> = address of instrument example 0M! starts scan for ID 0	instrument with address a returns 8 x vibwire & 8 x temp after 60 seconds
<b>Concurrent measurement:</b>	aC!	a0268\r\n
Used for starting a measurement for all instruments on a network at the same time.	start measurement instrument address <b>a</b>	initial response only after receipt of instruct and no response when data ready to be sent.
This command frees RS-485 bus for other devices		
<b>Send data</b>	aD0! aD1! aD2! or aD3!	+xxxx.x+xxxx.x+xxxx.x+xxxx.x\r\n
data returned aND! = Vib + Vib + Therm + Therm and has same format for each command	aD0! = channel 0 and 3 VibWire Sens aD1! = channel 4 and 7 VibWire Sens aD2! = channel 0 and 3 Therm/analog aD3! = channel 4 and 7 Therm/analog	
<b>Thermistor 1 &amp; 2</b>	VibWire-108 supports 2 thermistor types	
<b>Thermistor Type 1</b> Temperature sensor settings  Parameters from the sensor calibration sheet	aXT1RE! aXT1T0! = 25 aXT1BET!	Resistance at 25 Deg C T0 - generally 25 Deg C Beta Value
Steinhart-Hart Parameters Thermistor resistance/temp calculation	aXT1ST0! aXT1ST1! aXT1ST2! aXT1ST3!	A in Steinhart-Hart B in Steinhart-Hart C in Steinhart-Hart D in Steinhart-Hart
<b>Thermistor Type 2</b> Temperature sensor settings  Parameters from the sensor calibration sheet	aXT2RE! aXT2T0! = 25 aXT2BET!	Resistance at 25 Deg C T0 - generally 25 Deg C Beta Value
Steinhart-Hart Parameters Thermistor resistance/temp calculation	aXT2ST0! aXT2ST1! aXT2ST2! aXT2ST3!	A in Steinhart-Hart B in Steinhart-Hart C in Steinhart-Hart D in Steinhart-Hart
Page 36 shows sample calibration data sheet		
<b>VW Sensor Input Channel Settings</b>	aXCH0FN!  F = Frequency type N = VW Channel 0 .. 7	0 = output in Hz 1 = output in digits = F^2/1000 2 = use formula A + B*digits + C*digits^2 + D*temperature  digits = Frequency <sup>2</sup> in units of Hz <sup>2</sup>
<b>Therrmistor Type</b>  The VW108 supports 2 different thermistor types for temperature measurement.	aXCH0TN! = Thermistor type  where a = ID T = Thermistor Type N = Thermistor Channel Input = 0..7	0 = Voltage ratio 1 = Type 1 thermistor (use XT1RE etc. as above) 2 = Type 2 thermistor 11 = Type 1 resistance ratio, output Rt/R25 12 = Type 2 resistance ratio, output Rt/R25 99 = Output mV at terminal
<b>Thermistor Temperature Calculation</b>	aXT1TYn!  a = ID n = integer 0 .. 2	0 = resistance ratio - thermistor data sheet (Rt/R25)  1 = Beta value calculation 1/T = 1/T <sub>0</sub> + log(r)/Beta where r = Rt/R <sub>25</sub>  2 = Steinhart-hart equation  1/T = A + B(Ln Rt/R <sub>25</sub> ) + C(Ln Rt/R <sub>25</sub> ) <sup>2</sup> + D(Ln Rt/R <sub>25</sub> ) <sup>3</sup>

16.0 RS-485 Supported Commands

The instrument commands for the RS-485 and SDI-12 versions of the instrument are identical except for the “%” prefix at the start of the command. See table below

Description	Master	VibWire-108 Response
Acknowledge active	%a!	a\r\n
Send ID:  provided to complement SDI-12 protocol	%a!  	a13KEYNESCOVibWire-1080001\r\n  Part Description assigned by Keynes
Address query  identifies instrument address and commonly used on single instrument operations only.	%?!  Used to make command set SDI-12 compatible	a\r\n  Where a = number 0 - 9 for SDI-12 0 -9 letters a - z for RS485 A - Z
Change Address:  used to change instrument address from a (initial) to b new ID for network operations	%aAb!  a = initial address b = new address	b\r\n  a : b = number 0 - 9 or a - z
Start Measurement  instruct an instrument to make measurement	%aM!  a = address of instrument example 0M! starts scan for ID 0	a0268\r\n  instrument with address a returns 8 x vibwire & 8 x temp after 60 seconds
Concurrent measurement:  Used for starting a measurement for all instruments on a network at the same time.  This command frees RS-485 bus for other devices	%aC!  start measurement instrument address a	a0268\r\n  initial response only after receipt of instruct and no response when data ready to be sent.
Send data  data returned aND! = Vib + Vib + Therm + Therm and has same format for each command	%aD0! aD1! aD2! or aD3!  aD0! = channel 0 and 3 VibWire Sens aD1! = channel 4 and 7 VibWire Sens aD2! = channel 0 and 3 Therm/analog aD3! = channel 4 and 7 Therm/analog	+xxxx.x+xxxx.x+xxxx.x+xxxx.x\r\n
Thermistor 1 & 2	VibWire-108 supports 2 thermistor types	
Thermistor Type 1 Temperature sensor settings  Parameters from the sensor calibration sheet  Steinhart-Hart Parameters Thermistor resistance/temp calculation  See page 36	%aXT1RE! %aXT1T0! = 25 %aXT1BET!  %aXT1ST0! %aXT1ST1! %aXT1ST2! %aXT1ST3!	Resistance at 25 Deg C T0 - generally 25 Deg C Beta Value  A in Steinhart-Hart B in Steinhart-Hart C in Steinhart-Hart D in Steinhart-Hart
Thermistor Type 2 Temperature sensor settings  Parameters from the sensor calibration sheet  Steinhart-Hart Parameters Thermistor resistance/temp calculation  See page 36	%aXT2RE! %aXT2T0! = 25 %aXT2BET!  %aXT2ST0! %aXT2ST1! %aXT2ST2! %aXT2ST3!	Resistance at 25 Deg C T0 - generally 25 Deg C Beta Value  A in Steinhart-Hart B in Steinhart-Hart C in Steinhart-Hart D in Steinhart-Hart
VW Sensor Input Channel Settings	%aXCH0FN!  F = Frequency type N = VW Channel 0 .. 7	0 = output in Hz 1 = output in digits = F^2/1000 2 = use formula A + B*digits + C*digits^2 + D*temperature  digits = Frequency <sup>2</sup> in units of Hz <sup>2</sup>
Therrmistor Type  The VW108 supports 2 different thermistor types for temperature measurement.	%aXCH0TN! = Thermistor type  where a = ID T = Thermistor Type N = Thermistor Channel Input = 0..7	0 = Voltage ratio 1 = Type 1 thermistor (use XT1RE etc. as above) 2 = Type 2 thermistor 11 = Type 1 resistance ratio, output Rt/R25 12 = Type 2 resistance ratio, output Rt/R25 99 = Output mV at terminal
Thermistor Temperature Calculation	%aXT1TYn!  a = ID n = integer 0 .. 2	0 = resistance ratio - thermistor data sheet (Rt/R25)  1 = Beta value calculation 1/T = 1/T0 + log(r)/Beta where r = Rt/R25  2 = Steinhart-hart equation  1/T = A + B(Ln Rt/R25) + C(Ln Rt/R25) <sup>2</sup> + D(Ln Rt/R25) <sup>3</sup>

17.0 Examples Of Using RS-485/SDI-12 Commands

The following examples show how to undertake the various tasks needed to setup and make readings across the RS-485 and SDI-12 networks. The command structure between the SDI-12 and RS485 models is essentially the same except all RS-485 commands use the '%' sign at the start of all instructions.

The SDI-12 networks only supports up to 10 instruments with address range: 0 to 9 unless otherwise stated.

17.1 Changing the ID Number (address)

The following example demonstrates how to change the instrument ID number from the default factory setting 0 to 5.

Use the command 'aAb!' where a = Start ID b = Final ID

SDI-12	master sends:	'0A5!'	Instrument responds	5\r\n	Return New Line	(5 representing new ID number)
RS-485	master sends	'%0A5!'	Instrument responds	5\r\n	Return New Line	(5 representing new ID number)

17.2 ID Number Query

This command has been included to remain compatible with the SDI-12 and should be used for used with single instrument operations only. Useful command when identifying ID numbers for instruments to be deployed on a multi-instrument network.

The example below is to show the ID number of a single instrument

Use the command '?!' .

*The '?' command only works when a single instrument is in operation.*

master sends:	'?!'	Instrument responds	3\r\n	Return New Line	(3 is the ID number)
---------------	------	---------------------	-------	-----------------	----------------------

17.3 Start measurements for Instruments on a network

The following example shows how to start measurements on instruments with ID numbers 2, 7, and 9 respectively.

For this example the instruments are instructed to start readings one at a time and the network is not freed up until each instrument responds that the readings are being undertaken.

The instruments will start their measurement operations but will not send data across the network until instructed to do so.

Use the command 'aM!' where a = Instrument ID Number  
Use the command '%aM!' for RS-485 network operation

Examples of use.

The following example is based upon a simple application of 3 x VibWire-108 units connected together on a local SDI-12 network. Unit 1 with address 2 has 4 vibrating wire sensors, Unit 2 with address 7 has 6 sensors connected and finally Unit 3 has only 2 sensors connected.

master sends:	'2M!'	Instrument responds	'20144\r\n'	indicated readings available after 60 secs when the measurement is completed
		followed by	'2\r\n'	
	7M!		'70206\r\n'	
			'7\r\n'	
	9M!		'90082\r\n'	
			'9\r\n'	

Note. For this command the RS-485 network will not become available until each instrument completes its measurement cycle.

The VibWire-108 is fully integrated into the Keynes Controls AquaLOG SDI-12 data recorder and communications interface.

The menu opposite shows a typical SDI-12 network command as used by the AquaLOG to start a measurement on an instrument with ID=4 and used to download 8 x frequency inputs and 8 x temperature levels.

A power-up delay of 500 ms is needed before a measurement can be made.

SDI12 Setup

1 Powerup delay (ms)

2 Powerdown delay (ms)

3 Device 1 Command

4 Device 2 Command

5 Device 3 Command

6 Device 4 Command

7 Device 5 Command

8 Device 6 Command

9 Device 7 Command

A Device 8 Command

B Device 9 Command

C Device 10 Command

U Up. T Top

500

0

[D] 4M! 4D0! 4D1! 4D2! 4D3!





18.0 Connection to an Analogue Data Acquisition System

The following details show how to configure and optimise the VibWire-108 analogue outputs to operate with a analogue input data acquisition system or logger unit.

Technical Specifications - Analogue Output Ports

- 8 x 0 - 2.5V DC single analogue output ports - 16 bit DAC
- 8 x thermistor outputs - 3.3 KOhm completion resistors

User Control Keys

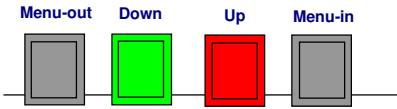


Fig 11

18.1 Theory of Operation

The VW-108 can be connected to an external data acquisition system or data logger using the analogue output ports fitted onto the instrument. In order that the correct values can be interpreted by the logger/acquisition system they are first scaled into a suitable analogue signal by the VW-108 before being passed on for measurement. Each output channel can be uniquely configured to support any manufactures sensor.

When defining the operation of the analogue output each channel has to have the sensor operating characteristics defined. For the VW-108 this means that the minimum operating frequency and span are set into the instrument.

Once the operating frequencies for the sensor are assigned the instrument scales the measured sensor frequency over the range 0V = minimum frequency and 2.5V = maximum frequency.

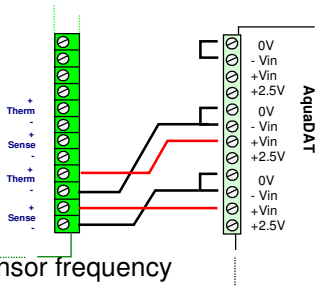


Figure 9

18.2 Connection to an Analogue Input or Data Acquisition System

The analogue output ports are singles ended and as such, care should be taken when connecting to a differential input channel.

- Sense = 0V (single ended ) or -Vin (Differential Input)
- + Sense = +Vin

The example shown in Fig 9 shows the analogue output from the VibWire-108 connected to the AquaDAT analogue data acquisition unit. The AquaDAT supports a full differential or single ended input measurements. The device also features an auto-ranging inputs to optimise measurements.

18.3 VibWire-108 Analogue Port Configuration

- Low Frequency := 500 - 3000Hz defined in 100 Hz intervals
- Range := 100 Hz steps.

Analogue Data Acquisition System Example

18.4 Starting Analogue Output Ports

To activate the analogue output channels on the VibWire-108

- 1. Starting at



- 2. Select "Menu In" button
- 3. Use the Up & Down Keys to select the option "Analg"

"Serial C0d C1d C2d C3d C4d C5d C6d C7d" are the other options available

Once the "Analg" output is selected the "Menu Out" key has to be pressed to confirm this option.

- 4. The VW-108 will return to the display



and now the analogue output channels for the instrument is now activated.

Each of the vibrating wire sensor inputs can be individually configured. Setting the analogue output channel is only needed when using the instrument with an external data logger or analogue acquisition system and is not required when measurements are to be made across the SDI-12 and RS485 networks.

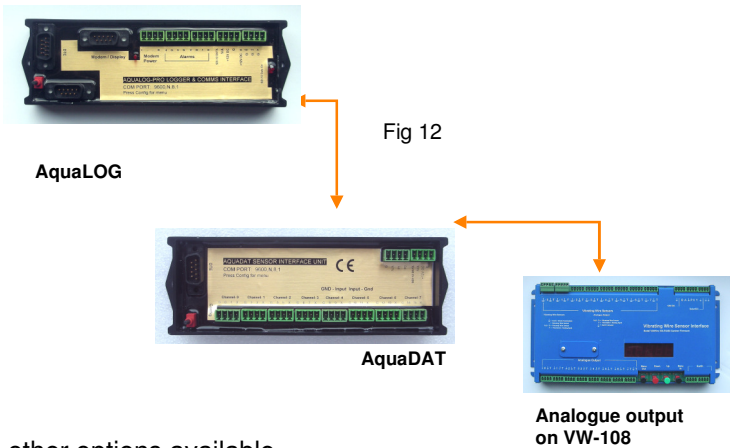


Fig 12

## 18.5 Optimising the Analogue Output Settings

### Example 1

The VibWire-108 contains 8 independently configurable analogue output ports and they are used to represent the output signal from the sensor.

Each analogue output is of the range **0 - 2.5V DC** and any analogue output must scale a result to within this range. Care should be taken to ensure that the output signal is scaled as close as possible to sensor range.

For example, Channel 0 is used to output a signal from a sensor with operating range of 1452 - 3176 Hz.

It is not possible to set the output range of the DAC directly to represent the absolute range of the sensor and so it must be set to cover the sensor range with the minimum overlap in order to obtain the highest resolution.

a range of

**0V = 1400 Hz** & **2.5V = 3200 Hz** so **CH0 LF = 1400** and **CH0 RA = 3200 - 1400 = 1800 Hz**

will give the highest resolution for this example

**DAC Resolution output port = 16 Bit** so **Frequency Resolution = 1800 / 65536 = 0.03 Hz**

In practice accuracy of around 0.5 Hz can be achieved when connecting the VW-108 to an analogue data acquisition system after allowing for the losses due to the Digital-analogue and Analogue-digital conversion process. The 0.5 Hz measurement accuracy is achieved using the AquaDAT as the input signal measuring device..

Only when operating the VibWire-108 with an active analogue output port need the operating characteristics for the vibrating wire sensor be defined.

For general purpose operations the analogue output should be set to represent the full operating range of the sensor.

## 18.6 Integration to the AquaDAT Analogue Sensor Interface

### Example 2

A vibrating wire pressure sensor with operating frequency 400 Hz to 1000 Hz connected to channel 5 on the VW-108 and the analogue output is to be connected to an AquaDAT Sensor interface.

CH5 LF = 400 CH5 RA = 600 (where range = 1000 - 400) and CH(0-7).RA is the range parameter.

the AquaDAT input channel range is to be set to 2.5 V

therefore 0V = 400 Hz and 2.5V = 1000 Hz

The AquaLOG will auto-range to optimise the signal measurement

The data logger will scale the results over the full range Resolution = 600/65536 = 0.01 Hz

In practice an measurement accuracy of 0.05 Hz will be achieved after allowing for losses in the analogue conversion process.

## Unit Conversions

**Celsius to Fahrenheit**  $(^{\circ}\text{C} \times 9/5) + 32 = ^{\circ}\text{F}$

**Fahrenheit to Celsius**  $(^{\circ}\text{F} - 32) \times 5/9 = ^{\circ}\text{C}$

Example: Convert 26° Celsius (a nice warm day) to Fahrenheit

First:  $26 \times 9/5 = 234/5 = 46.8$

Then:  $46.8 + 32 = 78.8^{\circ}\text{F}$

19.0 Real-time Frequency Display

All of the VibWire-108 models contain a 5 digit 7 segment display and this can be used to display the instantaneous frequency from any of the individual vibrating wire sensor inputs.

Vibrating wire sensors can be deployed a considerable distance from the VibWire-108 interface and may well be embedded into a structure. To ensure that the sensors are operating correctly, simply observe the sensor operating frequency on the 7 segment display and then confirm the result is within the operating range as specified by the manufacturer.

When operating in a real-time mode the instrument frequency display responds instantly to effects upon the sensor.

To use the VibWire-108 as a real-time frequency display follow the instructions below:

19.1 Assigning the real-time display to a VW sensor input

To activate the real-time frequency display

- 1. Starting at



The “Basic” menu item is the first menu item available after the instrument is powered on.

- 2. Select “Menu In” button
- 3. Use the Up & Down Keys to select the option



The Display above shows the option required to place Channel 0 for real-time frequency output  
the other options available are:

“Analg Seral C0d C1d C2d C3d C4d C5d C6d C7d” C0d = Channel 0 ..... C7d = Channel 7

Once the “C0d” option is selected then the “Menu Out” key has to be pressed to confirm this option.

- 4. The VW-108 will now display the real-time sensor frequency for channel 0.



The above example shows a typical real-time frequency result .

20.0 Loud Speaker

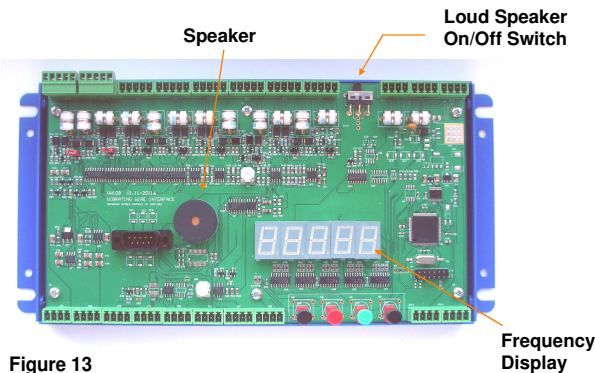


Figure 13

All of the VW-108 range of instruments are supplied with an internal ceramic speaker. The speaker can be activated and the sensor ping and resultant echo can be heard.

The speaker used in collaboration of the frequency display should enable nearly all sensors to be tested no matter their location using only the VW-108 interface unit.

Sensor problems

Should a clean ping not be heard when the vibrating wire sensor is being sampled by the instrument the following guide should help.

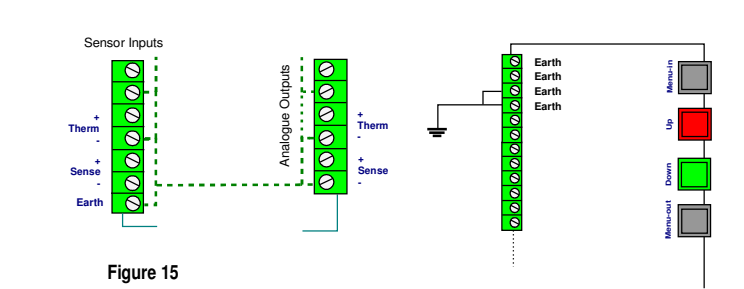
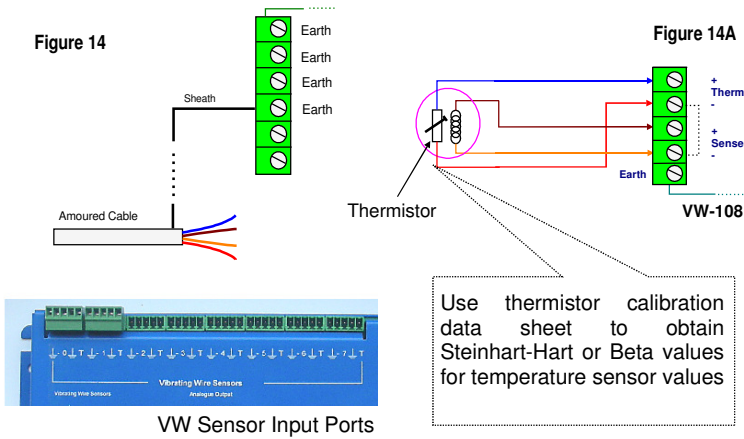
- 1) If there is only random noise on the speaker for the defined channel then check the wiring and circuit resistance. The most common error is an open circuit. Locate and fix the broken cable.
- 2) If a ping can be heard but it is faint then the sensor cable may be too long, or a too high cable resistance is being used causing degradation of the signal amplitude. Finally the gauge sensitivity may be too low.
- 3) If the ping is not a pure tone then the gauge is possibly faulty. The gauge may have become damaged during installation.
- 4) If a low frequency hum is heard then noise pickup can be a problem. If the gauge cabling is routed near a transformer, electric motor, high current power cables, etc, then relocate or reorient the gauge for minimum pickup. Ensure that only shielded cable is used and that the shielding is terminated at a single point to prevent capacitive pickup.



21.0 Vibrating Wire Sensor Installation

The vibrating wire sensors are connected directly into the VW Sensor Input channels as shown below. The instrument contains a completion resistor for the thermistor sensor enabling the temperature reading to be made along with the vibrating wire sensor readings. The VibWire-108 can be used with most different thermistors used within the vibrating wire sensors.

Connection to the instrument is as follows:



21.1 Common Earth Points

In order to ensure that there are sufficient points to terminate sensor sheathing when armoured cable is used to connect a sensor to the VibWire-108 the following terminal points are internally wired in common:

- Earth
- Earth
- Earth
- Earth
- Gnd

On the power supply connection terminals

- Therm -
- Sense -

on both the sensor input and analogue output terminals.

Fig 14A shows how the channels are wired together to form common earth connection. Effectively all of the Earth, Gnd, Sense - and T<sub>therm</sub> - terminals are wired together.

Any earth Sheathing from armoured cable etc.. can be connected to any of terminals mentioned above for ease of installation.

21.4 Lightning Protection

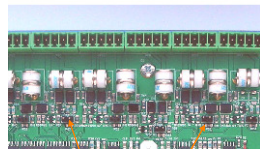
The lightning protection within the VibWire-108 cannot protect the instrument from a direct lightning strike. It is used to protect the instrument from local ground strikes close to the sensors and cabling.

All of the sensor inputs are protected by transorb and gas discharge tubes. The transorb are high capacitance devices and are not used on all systems as they can distort low level signals to a point where the instrument can not be accurately measured. The transorb does protect the instrument at lower levels than the gas discharge tube, and starts to become active around 12V.

The gas discharge tube protection activates at around 92V DC and resets instantaneously after the lightning strike effect has died away.

Fig 14 shows the VibWire-108 connected to a system earth using the Earth terminators mounted adjacent to the power connectors.

21.2 PCB Jumper Settings



All of the VibWire-108 models support both thermistor and analogue inputs for the range 0 - 2.5 V DC and current loop inputs.

For current loop operations such as those 0- 20 mA, 4- 20 mA then external excitation is required.

- Jumper Open = 0-2.5V DC
- 4-20 mA loop
- Jumper Closed = Thermistor

21.3 Multiple Instrument Installation

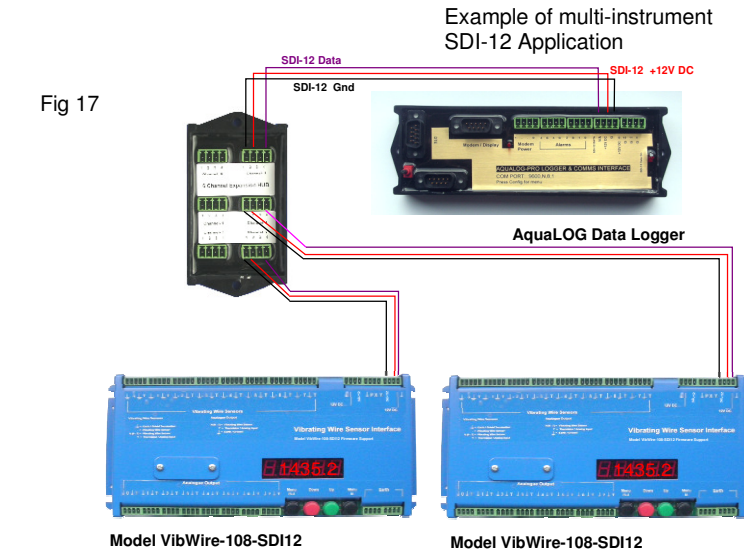
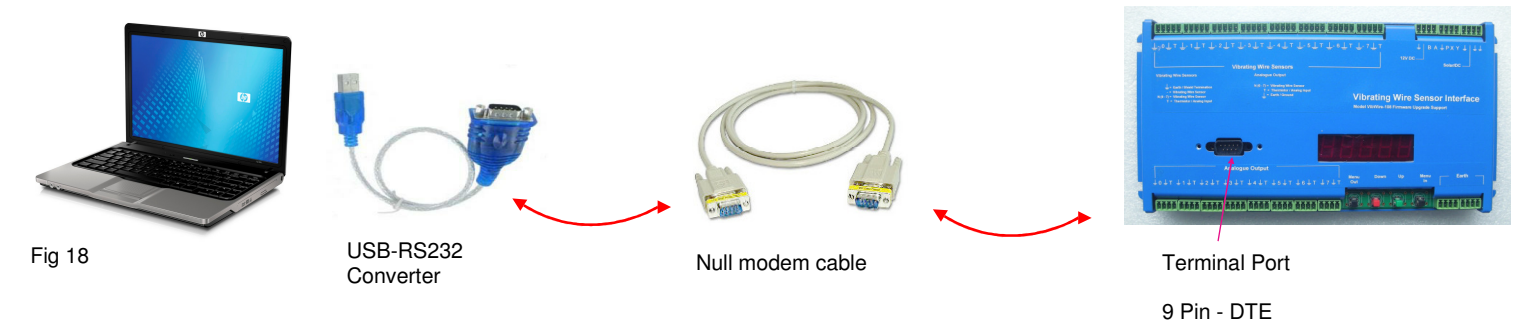


Figure 17 shows how to Earth multiple instruments within a single enclosure. Ensure that good quality cable of around 2.5 mm diameter core is used to connect the instruments earths together and that a good connection to a main system earth is obtained. The Earth connection is essential for the lightning protection to work.

22.0 Terminal Port



Models **VibWire-108-SDI12**, **VibWire-108-RS485**, and **VibWire-108-Modbus** can be configured using the instrument terminal port.

The following instructions are for the Microsoft Windows Operating system.

Step 1:

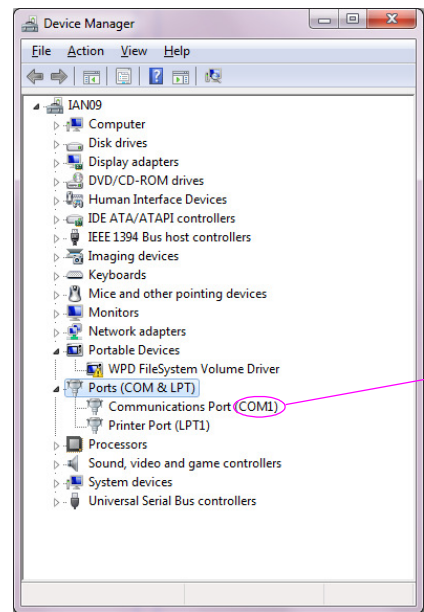
Connect the PC/Laptop to the VibWire-108 using the USB-RS232 interface and null modem cable as shown above. The terminal port is configured as a 9-way DTE device.

Step 2:

Plug the USB-RS232 adapter into the PC/Laptop.

From the operating system control panel select the “**device manager**” option. A Window similar to that shown opposite will appear.

Select the ‘Ports (COM & LPT)’ option from the menu list to identify the **Comm port number** used by the USB-RS232 interface.

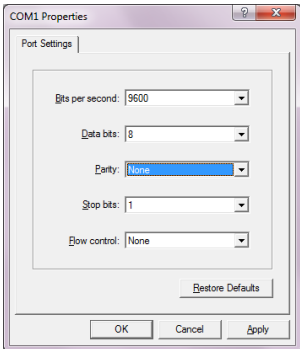


Comm Port in use by the USB-RS232 media converter

Microsoft Windows 7 Device Manager Window



Microsoft Hyper-terminal - Connect To Window



Microsoft Hyper-terminal - Comm Port Properties Window

22.1 Terminal Port Operation

The terminal port built-in to the VibWire-108 enables the instrument to be easily configured using the built in menu system to set all the calibration parameters.

There is no software required with this device part from a terminal emulator package, which is frequently a feature included most operating systems.

Each VW sensor input channel can be individually configured using details taken directly from a sensor calibration data sheet.

Currently the VibWire-108 supports 2 pre-defined temperature sensors configuration options that can be assigned to each VW sensor input.

22.2 The Terminal Port Menu System

The menu system can be accessed and used by any modern terminal emulator software such as Microsoft Hyper-terminal or Token-2 etc. The terminal software has to be **VT100** compatible to operate correctly.

The example Windows above, are taken from the Hyper-terminal software, however the communication port settings are the same no matter which package is used.

Step 3

Start the Terminal emulator software and configure the communications port to 9600 Baud, 8 data bits, 1 stop bit, No parity.

The Comm port number used by the USB-RS232 media converter is shown in the Windows ‘Device Manager’ Window.

Step 4

Power on the VibWire-108, see instructions on page 6 with the terminal port connected to a laptop as shown on page 22.

After the 'HELLO' message flashes on the 7 segment display and the instrument is connect to the PC/Laptop as shown on page 22, then the main menu will appear. The Comm port setting are shown in the specification table.

Main Menu

- 1 System Maintenance
- 2 Thermistor type 1
- 3 Thermistor type 2
- 4 Diagnostics
- 5 Channel 0
- 6 Channel 1
- 7 Channel 2
- 8 Channel 3
- 9 Channel 4
- A Channel 5
- B Channel 6
- C Channel 7
- U Up. T Top.

Fig 20

Important Note

The 'Thermistor Type' calculation option determines which calculation is used regardless to the calibration parameters that are configured.

22.4 Temperature Sensor Configuration

The VibWire-108 uses the in-built thermistor inside a VW sensor to measure temperature. The menu system enables two different thermistor sensor details to be predefined and stored into the instrument.

.The menu system enables both the VW sensor linearisation and thermistor temperature equations to be configured. The thermistor resistance and therefore temperature is calculated using the Steinhart-Hart equation. The output SI unit is in Deg C.

The VW sensor linearisation uses the industry standard quadratic equation to convert the VW signal into engineering units.

The parameters for this part of the instrument configuration can be found on the VW sensor calibration data sheet.

For lower accuracy temperature readings or when the calibration factors are not known then the thermistor Beta value, T<sub>0</sub> and R<sub>0</sub> parameters can be assigned.

Warranty Information

The information in this document is subject to change without notice. Keynes Controls Ltd . has made a reasonable effort to be sure that the information contained herein is current and accurate as of the date of publication. Keynes Controls Ltd. makes no warranty of any kind with regard to this material, including, but not limited to, its fitness for a particular application. Keynes Controls Ltd. will not be liable for errors contained herein or for incidental or consequential damages in connection with the furnishing, performance, or use of this material.

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22.3 Selecting the VW sensor output units.

The following procedure is for the **VibWire-108-SDI12**, **VibWire-108-RS485**, and **VibWire-108-Modbus** models only.

The VibWire-108 supports output units of Hz, Digits (Hz<sup>2</sup>), and SI units.

Main Menu

- 1 System Maintenance
- 2 Thermistor type 1
- 3 Thermistor type 2
- 4 Diagnostics
- 5 Channel 0
- 6 Channel 1
- 7 Channel 2
- 8 Channel 3
- 9 Channel 4
- A Channel 5
- B Channel 6
- C Channel 7
- U Up. T Top.

Frequency proc

0 = Hz 1 = Digits ( Hz<sup>2</sup>) 2 = SI Units

where SI Units is by Quadratic Expansion

Channel 0

- 1 Frequency proc 1
- 2 Thermistor type 1
- 3 Cal A 0
- 4 Cal B 0
- 5 Cal C 0
- 6 Cal D 0
- U Up. T Top.

Common VW Sensor Thermistor Part Numbers

**YSI 44005**  
**Vishay 1C 3001 B3**  
**RS Part no: 151-215**

The part numbers are for 3 K Ohm thermistor commonly used by most different VW sensor manufacturers to measure temperature

The sensors give 3 K Ohm resistance at 25 Deg C

The most common material used in these sensors uses material type F from GE sensing.

Recommended Steinhart-Hart Cal Parameters

Thermistor type 1

- 1 Type 1
- 2 Resistance at T<sub>0</sub> (ohms) 3000
- 3 T<sub>0</sub> (Celcuis) 25
- 4 Beta 5234
- 5 Steinhart-Hart 0th order (A) 3.35E-3
- 6 Steinhart-Hart 1st order (B) 2.56E-4
- 7 Steinhart-Hart 2nd order (C) 2.08E-6
- 8 Steinhart-Hart 3rd order (D) 7.30E-8

U Up. T Top.

Fig 21

Use the following parameters for defining the operation of the 3 K Ohm thermistor temperature sensor often used by Vibrating Wire sensors.

(Steinhart-Hart Factors)			
A	=	3.35E-3	
B	=	2.56E-4	
C	=	2.08E-6	
D	=	7.30E-8	

The VibWire-108 range of instruments uses the Steinhart-Hart parameters in priority to Beta value temperature calculations once the calibration parameters have been defined.

Thermistor type 1

- 1 Type 1
- 2 Resistance at T<sub>0</sub> (ohms) 3000
- 3 T<sub>0</sub> (Celcuis) 25
- 4 Beta 5234
- 5 Steinhart-Hart 0th order (A) 0.0
- 6 Steinhart-Hart 1st order (B) 0.0
- 7 Steinhart-Hart 2nd order (C) 0.0
- 8 Steinhart-Hart 3rd order (D) 0.0

U Up. T Top.

Beta Value temperature calibration factors.

Often available sensor data sheets but calculations based on using them are less accurate than the Steinhart-Hart Calculations

23.0 Modbus Supported Instrument

The VibWire-108 supports Modbus protocol across the RS-485 digital network and acts as a slave unit only.

The layout of the registers used to hold the sensor data values is shown in the tables below.

Modbus version instruments do not operate within Q-LOG and require Modbus client software to operate.

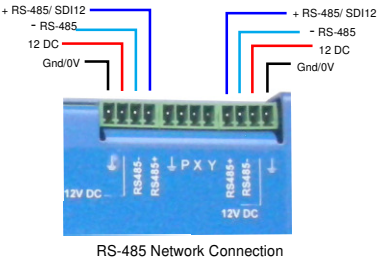


Fig 22

RS-485 Network Connection



Model: VibWire-108-485

23.1 Set-up

The VibWire-108-Modbus has the calibration factors for the sensors installed via the terminal port. See page 22 for details. The same procedure for assigning calibration factors is used throughout the VibWire-108 range.

The number and type of sensor inputs to scan is assigned from the keyboard using the menu system. See page 26 for more details.

The instrument scans automatically at the preset sample period and updates the register values upon completion of the operation. New data values are only transmitted to the Modbus master upon receipt of the Read Register Input Command.

23.2 Data Format

The Modbus version of the instrument stores data into a series of 4 byte registers as shown below. Information is stored as a floating point 4 byte number. The data is Hex format with the high word being the first 2 bytes and the last being in the next 2 bytes as shown.

System Information

The last 2 registers in the VibWire-108 are used to check the data integrity. Register with address 32 increments upon the completion of an instrument scan and is used to show that the instrument is still operating.

Register with address 34 increments when the VibWire-108 receives a new Modbus 'Read Input Registers' FC=04 command.

23.3 Scanning The Instrument

The VibWire-108 scans the Modbus network the automatically at a preset time period.

The User can select from scan period of:

1S, 5S, 15S, 1 MIN, 1 HR, 6 HR, 24 HR

The following Modbus command is used to get data from the VibWire-108

Read Input Registers (FC=04) command

The tables below show how the registers holding the VibWire-108 data is stored.

Address Offset	Parameter	Description
0	Chan-0 Freq	High order word
1		Low order word
2	Chan-1 Freq	High order word
3		Low order word
4	Chan-2 Freq	High order word
5		Low order word
6	Chan-3 Freq	High order word
7		Low order word
8	Chan-4 Freq	High order word
9		Low order word
10	Chan-5 Freq	High order word
11		Low order word
12	Chan-6 Freq	High order word
13		Low order word
14	Chan-7 Freq	High order word
15		Low order word

2 Bytes2 Bytes

Floating Point Data Value

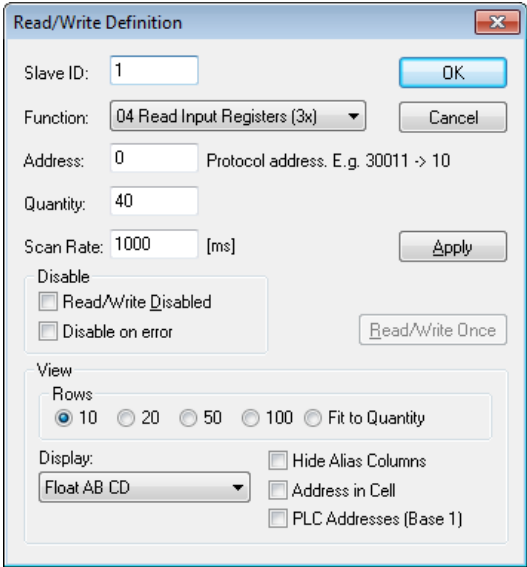
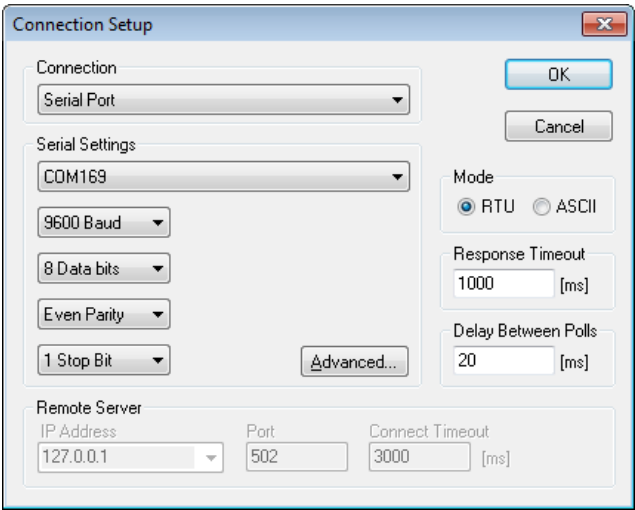
High WordLow Word

Address Offset	Parameter	Description
16	Chan-0 Temp	High order word
17		Low order word
18	Chan-1 Temp	High order word
19		Low order word
20	Chan-2 Temp	High order word
21		Low order word
22	Chan-3 Temp	High order word
23		Low order word
24	Chan-4 Temp	High order word
25		Low order word
26	Chan-5 Temp	High order word
27		Low order word
28	Chan-6 Temp	High order word
29		Low order word
30	Chan-7 Temp	High order word
31		Low order word
32	Number of Scans	High order word
33		Low order word
34	Number of Modbus read attempts	High order word
35		Low order word



Modbus over 485 Network Configuration

The images below shows the 485 network for Modbus operations.



23.4 RS-485 Network Connection & Installation

The VibWire-108-Modbus instrument will connect to any suitable Modbus system supporting RS-485 digital communications. This could be a plant wide SCADA solution or simply a stand-alone system running on a PC or laptop. So long as a suitable communications port is available then the instrument will communicate.

The image below shows how the VibWire-108-Modbus units are connected to the media converter or similar 485 digital communications port. The Modbus operations are transparent over the network. The Keynes Controls USB-485 media converter is shown but any other similar device can be used. The VibWire-108-Modbus instrument operates as a master /slave system where the SCADA system or data recorder is the master and the instrument acts as the slave.

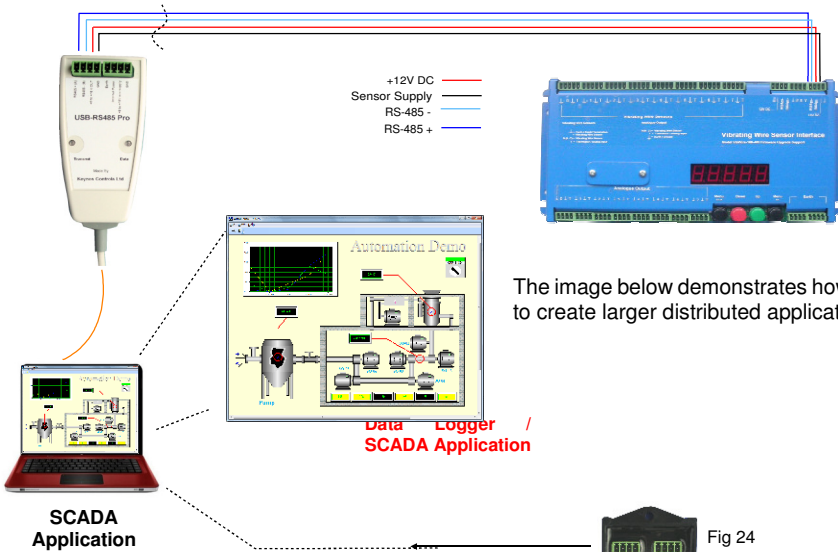
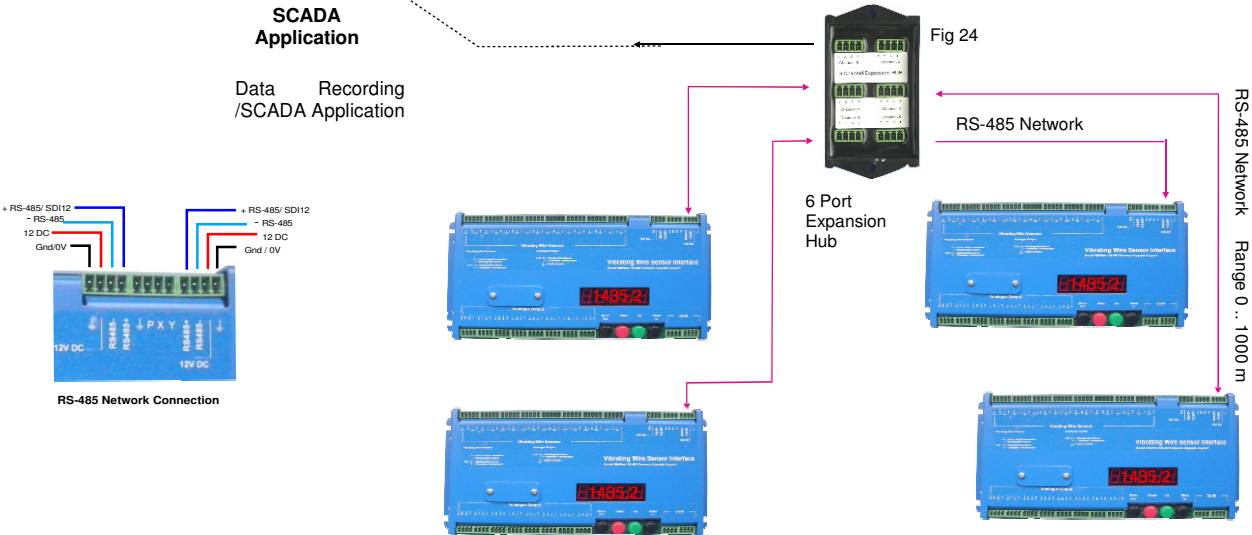


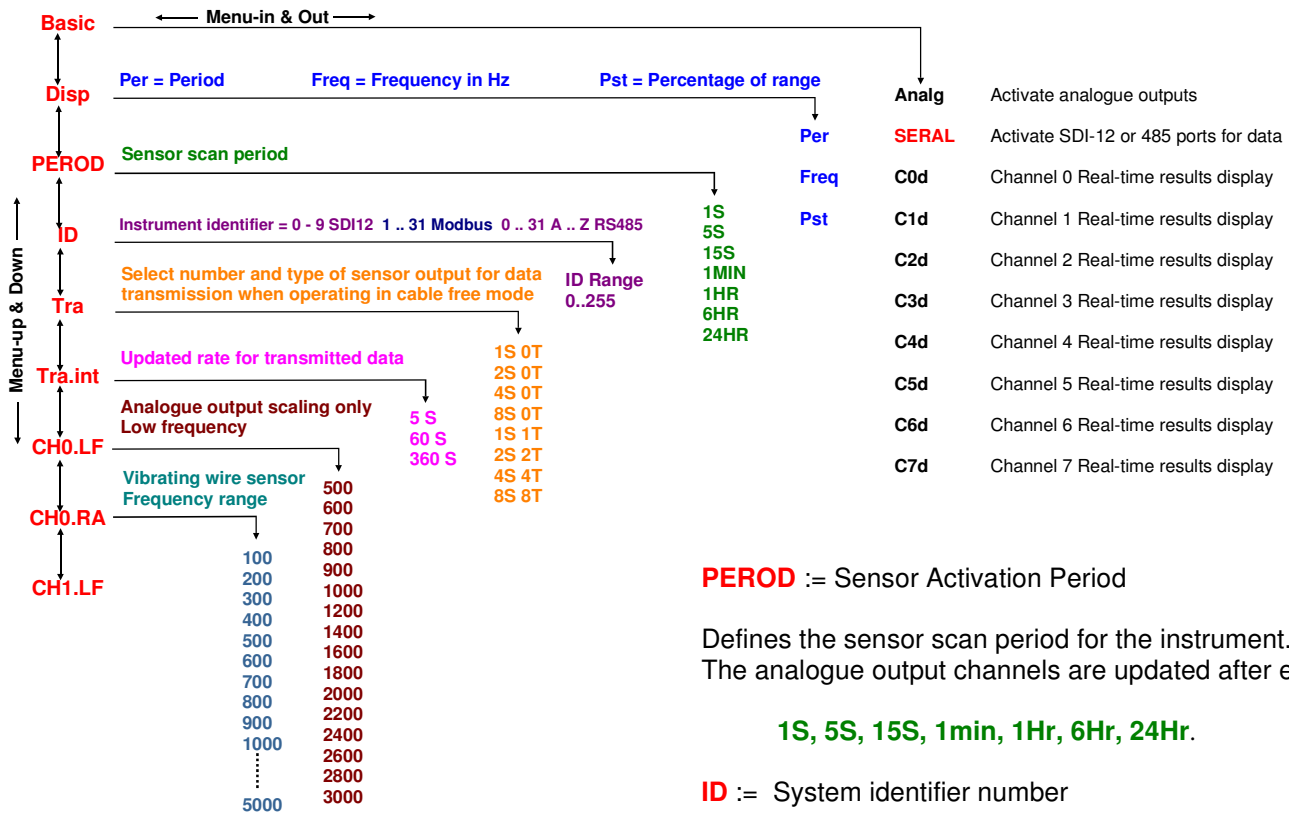
Fig 23

The image below demonstrates how additional units can be connected together to create larger distributed applications.



## 24.0 Keyboard - User Command Summary

The details below show the keyboard menu system built into the VibWire-108



**DISP** := This option is used to select the type of engineering results that are shown on the 7 segment display.

Per = 1/ Freq = period of oscillation in mSec  
 Freq = XXXX.X in Hz - units changed by terminal  
 Pst = Percentage of range

the percentage of range is used to optimise the settings for the analogue output port in order to achieve the best result

Example. A vibrating wire sensor showing a **PSt = 0.1** on the display and settings of LF (Low frequency) of 500 Hz and range of 2000 Hz. This indicates that the results from the sensor is only operating over the lower 10% of the defined range i.e 500 - 700 Hz

For the assigned range above the analogue output port has a scaling of 0 - 2.5V DC using a 16 bit DAC (65536 levels) and will therefore have 0V = 500 Hz & 2.5V = 2500 Hz, so

$$\text{resolution} = (2500-500)/65536 = 0.03 \text{ Hz.}$$

However with the instrument adjusted to operate over the range of 500 to 700 Hz as observed above then

$$0V = 500 \text{ Hz} \quad \& \quad 2.5V = 700 \text{ Hz} \text{ so resolution} = \frac{200}{65536} \\ = 0.003 \text{ Hz}$$

**PEROD** := Sensor Excitation Period

This option defines the update period for the sensor excitation and measurement operation. There is always a trade off between the sensor update rate and the power supply requirements of the instruments.

For fast dynamic changes a fast sensor update rate is required but for slow static measurements only a low update rate is required.

**PEROD** := Sensor Activation Period

Defines the sensor scan period for the instrument.  
The analogue output channels are updated after each scan.

1S, 5S, 15S, 1min, 1Hr, 6Hr, 24Hr.

**ID** := System identifier number

Each instrument requires a unique identification number that is required to locate a specific instrument upon a network. Currently the identifier is an integer of range 0 .. 32.

**TRa** := Transmission Data Options. (Not used RS485/SDI-12)

To optimise the network bandwidth in order to ensure the maximum number of sensors can be deployed the User is allowed to select the number and type of sensor inputs used on the VibWire-108 for data transmission across a network.

1S 0T represents 1 vibrating wire sensors - no temperature  
2S 0T represents 2 vibrating wire sensors - no temperature

**1S 1T** represents 1 vibrating wire sensor - 1 temp sensor  
**2S 2T** represents 2 vibrating wire sensors - 2 temp sensors

**Tra.int** := Defines the rate of data transmission across a cable free network.

The transceiver fitted inside the VibWire-108 is powered on during the data transmission operation and powered off into a sleep mode between updates.

The faster the data transmission rate the greater the power required to drive the instrument. A compromise is needed to adjust power requirements to the amount of data to be transmitted to guarantee that not readings are lost. **(Not used on RS485/SDI-12 networks)**

## 24.1 Keyboard Operations

The keyboard menu system has been designed to be easy to use. Use the menu keys

Move up and down the menu system until the desired parameter is shown in the display. Use the 'Up' and 'Down' keys to change the values. Once the new value is selected press the 'Menu Out' button to store the new value.

25.0 Vibrating Wire Sensors

The VibWire-108 supports most manufacturers sensors and a small summary of these is shown below.



Figure 35



Figure 36

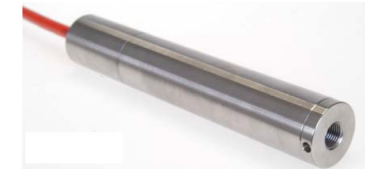


Figure 37

**Encardio-rite** Vibrating Wire are well tested with the VibWire-108 and are the recommended sensor range for this product range.

Frequency signals i.e. those generated using vibrating wire sensors are particularly suitable for demanding environments such as that often occur within Civil Engineering applications

Vibrating wire sensors ideally suit the harsh civil engineering environment since the signals are capable of long transmission distances without degradation, tolerant of wet wiring conditions and resistant to external electrical noise.

Specifications

<b>Excitation:</b>	Auto-resonance
<b>Voltage Protection:</b>	Semitron Bi-Polar 230 V
<b>Thermistor:</b>	3k Ohms at 25 °C
<b>Over-range:</b>	minimum twice pressure
<b>Resolution:</b>	0.025% FSO (minimum)
<b>Accuracy:</b>	< 0.25 % FSO (see Notes)
<b>Thermal Effect:</b>	< 0.02% FSO /°C
<b>Operating range:</b>	-20 °C +100 °C
<b>Cable:</b>	2 pair PVC outer sheath.
<b>Typical range:</b>	3500-2200 Hz
<b>Nominal zero value:</b>	3130 Hz

For additional details contact : Encardio-Rite Ltd India

Encardio-rite



Crack meter

Crack meters are available with ranges up to 100 mm

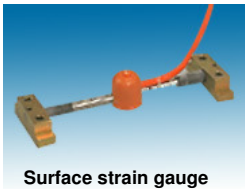
<b>Resolution</b>	0.025% of range
<b>Accuracy</b>	± 0.2% of range
<b>Temperature effect</b>	-0.02mm/°C (typical)
<b>Operating temperature</b>	-30 to +70°C
<b>Cable: 2 and 4 Core screened</b>	



Joint meters

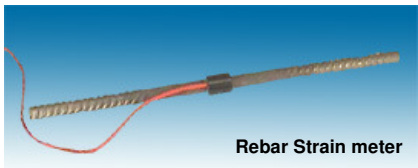
Joint meters are available with ranges up to 100 mm

<b>Resolution:</b>	0.025% of range
<b>Accuracy:</b>	± 0.2% of range
<b>Temperature effect:</b>	-0.02mm/°C (typical)
<b>Operating temperature:</b>	-30 to +70°C
<b>Cable:</b>	2 Core screened



Surface strain gauge

<b>Gauge Type:</b>	TSR/5.5/T surface mounting strain gauge.
<b>Gauge factor:</b>	3.025 x 10-3 micro-strain per Hz squared.
<b>Measurement range:</b>	> 3000 micro-strain.
<b>Resolution:</b>	Generally better than 1 micro-strain.
<b>Coil Resistance:</b>	Approximately 100 ohms.
<b>Operating temp range:</b>	-200C to 800C.
<b>Thermal coefficient:</b>	11 ppm per 0C.

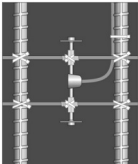
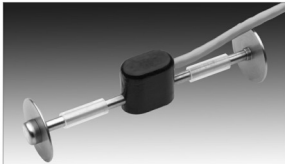


Rebar Strain meter

<b>Effective Gauge length:</b>	50 mm ( nominal )
<b>De-bonded length:</b>	175 mm
<b>Overall length:</b>	1.39 m
<b>Standard diameter :</b>	15 mm
<b>Resolution :</b>	0.5 micro-strain
<b>Strain range:</b>	2500 micro-strain
<b>Thermal expansion:</b>	12 ppm /deg C

<b>Range:</b>	3,000 micro-strain, set mid-range.
<b>Resolution:</b>	1 micro-strain
<b>Accuracy:</b>	± 0.1% FS.
<b>Thermal Coefficient:</b>	11 ppm / °C.
<b>Operating Temp:</b>	-20 °C to 80 °C.

The details on this page have been obtained from the sensor manufacturers web sites and are liable for change at any time.



Embedment Strain Gauge

26.0 Main Menu - Terminal Port

Models VibWire-108-SDI12 and VibWire-108-RS485 support a terminal menu system to enable the instrument to be configured. Refer to page 22 for details of connecting the instrument to a 'Terminal Emulator' program running on a PC.

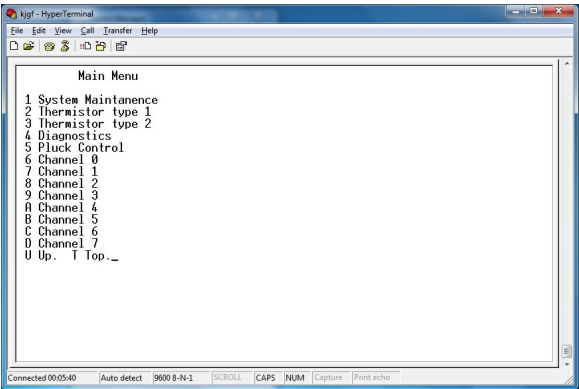


Fig 38 - Main Menu

This is the **Main Menu** that appears on starting the menu system

Quick Menu Guide

- 1. Option 4 'Diagnostics' - use menu system available here to start a instrument scan on demand and observe data.
- 5. Option 5 'Pluck Control' - restricts sensor ping frequency Used when poor quality sensors with 3rd harmonic oscillations are encountered.

27.0 Sensor Excitation Control

The pluck control system built into the VibWire-108 is a useful feature to activate upon observing unusual spikes in what should be steady state data values for sensors that change little over time.

Spikes in the VW Sensor Data

Depending on how well a vibrating wire sensor is made the sensor coil could become damaged, or if the sensor extreme physical shock once it is deployed. Damage to the sensor often means the coil seating has been damaged an the sensor can oscillate at a different harmonic than the designed fundamental frequency.

In order to obtain the correct sensor frequency in the face of oscillations from higher harmonics then the pluck control feature is used.

Setting the Pluck Control

Go to the 'Pluck Control' menu as shown in Fig 39 below.

Select the channel to be configured.

Enter the 'Centre Frequency' for the normal operation of the sensor,

The operating frequency for the VW sensor input is now limited to a minimum frequency of 1/2 of the 'Centre Frequency', and to a maximum of 2 x 'Centre Frequency'. This range removes the third harmonic oscillation which is a common cause of spikes in VW data .

Worked Example

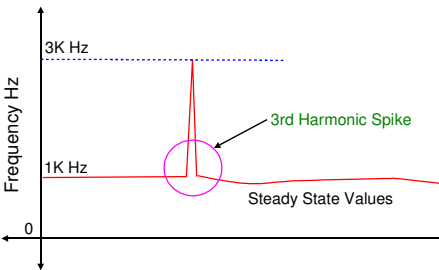


Fig 39 - Spike in data

Example - setup channel 0  
Press item '2'  
Set Frequency to '1000'

Fig 39 opposite demonstrates how a typical spike in a stream of steady state data values will appear to the User.

The spikes in the data are often caused by faulty seating of the sensor coil.

The Pluck Control option will remove the false peaks caused by sensor oscillation away from the fundamental operating frequency.

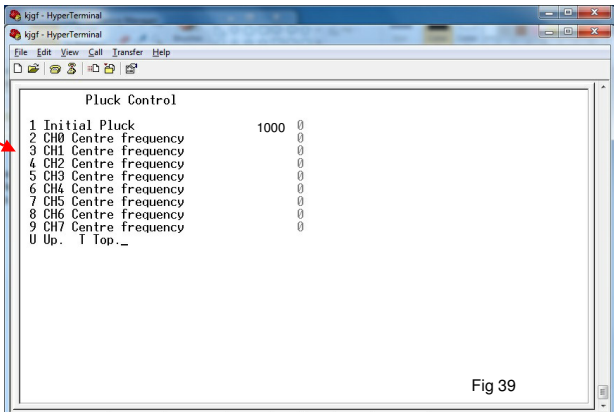


Fig 39

The pluck control range

Therefore with

Range = (1/2 x Centre Freq) - Centre Freq - (2 x Centre Freq )

Centre Freq = 1000 Hz

Centre Frequency	Low Frequency	Mid Frequency	Max Frequency
800	400	800	1600
900	450	900	1800
1000	500	1000	2000
1200	600	1200	2400

Pluck Range = (1/2 x 1000) - 1000 - (2 x 1000)  
= 500 Hz to 2 K Hz with 1 K Hz centre frequency

28.0     **Firmware Upgrade Facility**

Using the Terminal Port menu system

- 1. From the ‘Main Menu’ select option 1 ‘Systems Maintenance’
- 2. The following menu will appear -

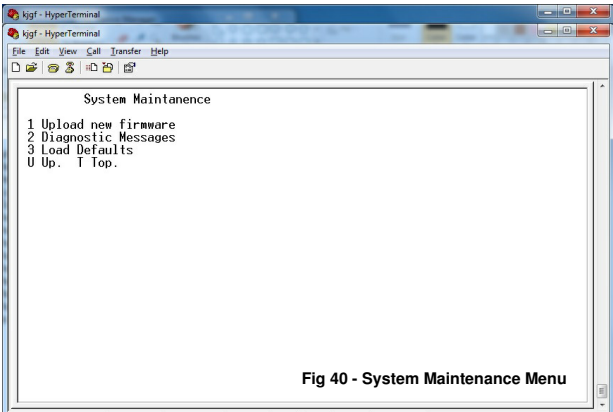
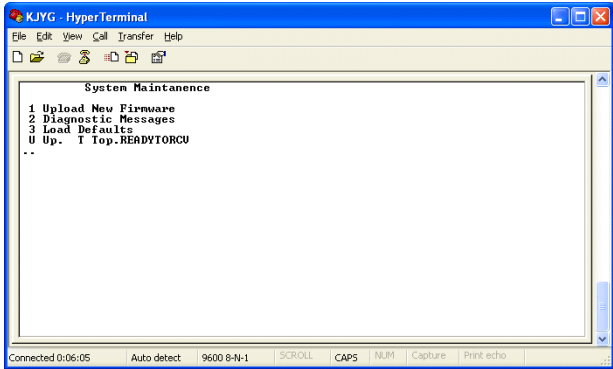


Fig 40 - System Maintenance Menu

- 3. Select option 1 ‘Upload new firmware’



- 4. Using the HYPER-TERMINAL menu system

Select ‘Transfer/Send Text File’ option.

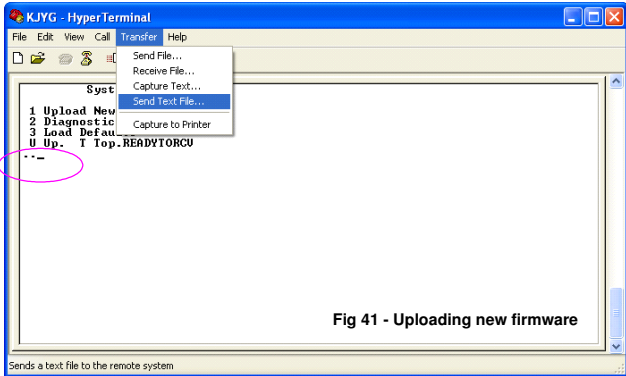


Fig 41 - Uploading new firmware

..... appears on the screen as the firmware loads into the sensor interface.

‘Burning’ message shows that the firmware has been loaded correctly.

**Firmware Update**

Any new firmware is sent out from Keynes Controls technical support only. Only a competent software engineer should undertake this task.

Keynes Controls offer a back to base firmware upgrade service. A small cost is incurred if using this service.

Make sure the latest firmware which is in the form of a text data file, is stored into a suitable location.

Example firmware for this documentation is titled ‘vw101.txt’

Once option ‘1’ is selected then the ‘Upload new firmware’ Window, as shown opposite will appear.

Locate and select the new firmware data file.

Fig 41 opposite shows how the ‘Hyper-terminal’ software appears once the firmware file is selected and data is being sent to the sensor interface.

Fig 42 shows how the ‘Hyper-terminal’ emulator ‘System Maintenance’ Window will appear once the firmware has loaded into the sensor interface correctly.

The ‘Burning’ message has to be displayed to show the new firmware has been loaded correctly.

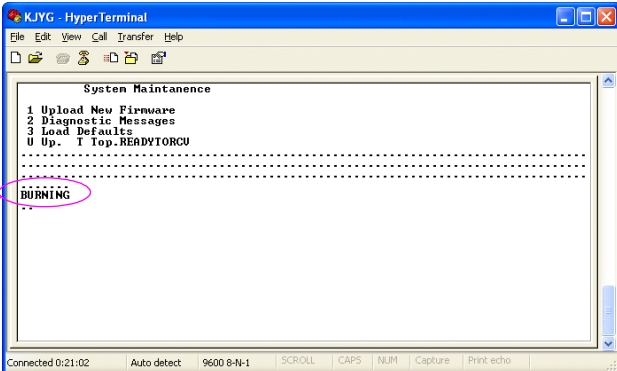
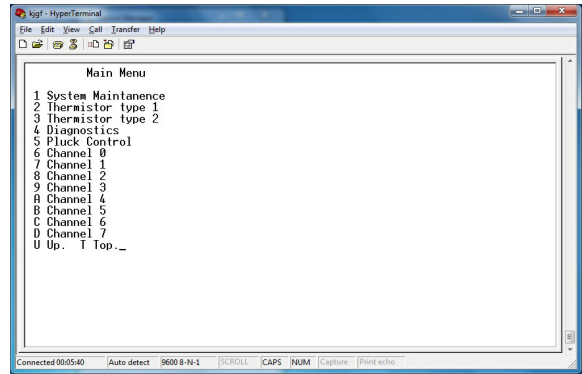


Fig 42 - Firmware upload successful

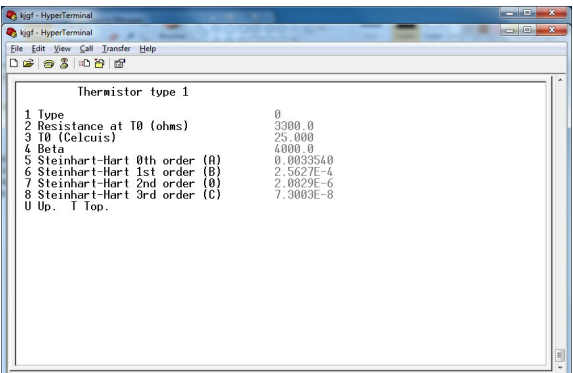


Main Menu



This is the default menu that appears upon activating the terminal menu system.

Thermistor Type 1 - Menu



Models VibWire-108-SDI12 and VibWire-108-RS485 support 2 individually configured thermistor temperature sensors.

The sensors configuration details are stored as ‘**Thermistor type 1**’ and ‘**Thermistor type 2**’.

The menu opposite shows the thermistor type menu.

Use this menu to set the thermistor calculation to Steinhart-Hart or Beta.

Pluck Control - Menu

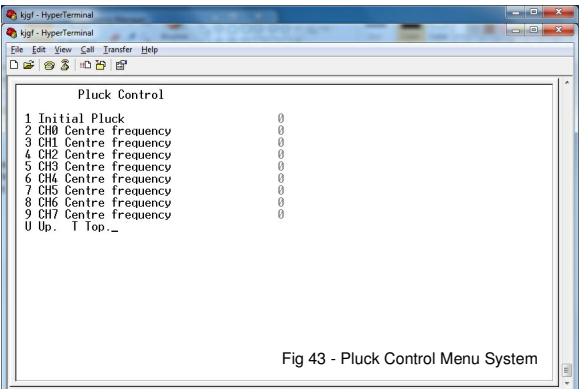


Fig 43 - Pluck Control Menu System

The pluck control menu system defines the operating range of a vibrating wire sensor input channels. The sensor excitation frequency will never exceed the limits set here.

The pluck control system prevents 3rd harmonic sensor frequencies from contaminating the measurements due to sensor coil problems.

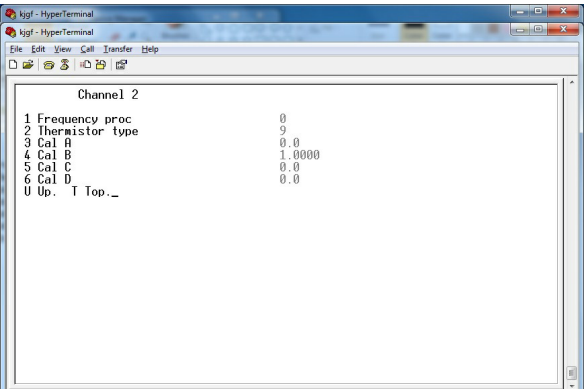
Each vibrating wire sensor input can be individually configured.

Range =  $\left(\frac{1}{2} \times \text{Centre Freq}\right) - \text{Centre Freq} - (2 \times \text{Centre Freq})$   
Low Frequency                      Centre Frequency                      High Frequency

The image opposite shows the default Vibrating wire sensor input channel configuration menu system.

Option 1 ‘Frequency’ - Hz , Hz<sup>2</sup> or SI units

Repeat for each sensor input channel.



Case Study - Bore Hole Pump Control

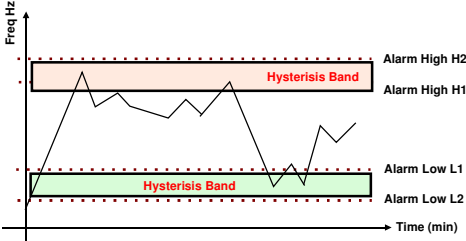
The following examples detail the use the VibWire-108 range of instruments within water flow and control systems. Two examples are shown. The first example demonstrates the VibWire-108 as a stand-alone control system used to monitor bore hole water and the second example, shows how the VibWire-108 is used with a data logger to report on and control the water flow in a v-notch weir.

Borehole Water Level Control

The VibWire-108 can be configured to operate as a stand-alone control system when used with Vibrating wire piezometers and the transistor output ports.

Fig 43 shows a sealed bore hole with 2 piezometers deployed. The lower level sensor reports the water level height. The top sensor acts as a reference and reports the internal bore hole pressure only.

The water level height measurement can be in error if there is a build up of gas pressure in the hole and it is to correct for gas pressure changes that the reference is fitted.



The VibWire-108 is configured to activate the digital output when the water height exceeds the higher alarm levels. Upon detection of a water level exceeding the pre-determined upper alarm level then the transistor output is activated to switch a relay.

The relay switching can be used to activate the ignition circuit on the pump if it is powered by a petrol engine or switch the power supply if an electric pump is being used.

Summary

As long as the Peizometer frequency settings are defined correctly and a suitable hysteresis level is set, then the VibWire-108 can run indefinitely to control a pump to maintain the water level within a bore hole below a pre-set level.

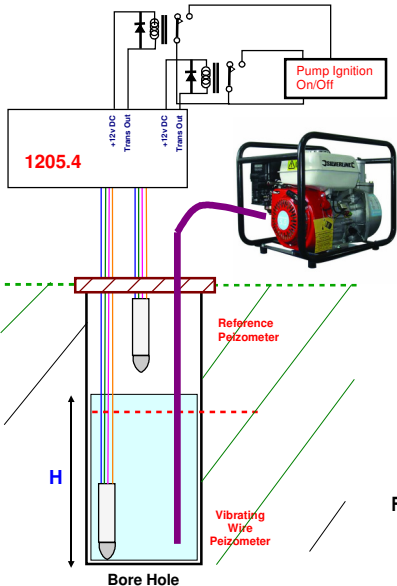


Figure 43

Stand-alone Weir Control System with Data Logger

For applications where a control system is required to let a set amount of water to flow and to maintain a record of events then a control system similar to that shown below will be required. Apart from maintaining details of flow the control unit can also act as an alarm system and shut of water flow should the defined limited be exceeded.

Consider the example of the V-notch weir below. A dedicated complex formula is required to calculate the discharge over the bottom of the notch. There are a number of different formula available for this calculation but they depend upon the water height at different positions within the weir.

A series of vibrating wire piezometers are used to monitor the water height and are connected to the VibWire-108. The VibWire-108 communicates the water height details to a programmable logger, such as the Keynes Controls AquaLOG systems. The logger is used to calculate the discharge and to record the results.

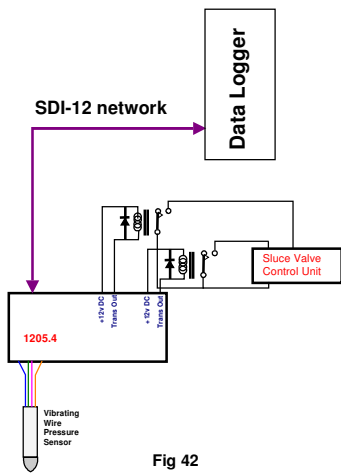


Fig 42

Fig 42 shows the basic control system showing the VW-108 connected to a logger across a digital network.

The instantaneous pressure levels are monitored by the logger and used within the V-notch discharge formula.

The logger can be used to produce a permanent result record that can be downloaded by an operator and also to trigger the transistor outputs within the VibWire-108 when used for alarm level control.

Fig 45 shows the v-notch weir profile. The water height is measured accurately using a precision vibrating wire sensor and these types of sensors are very accurate and stable over long periods of time.

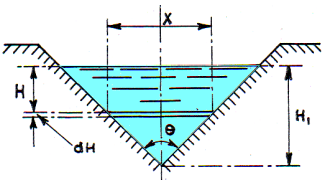


Fig 45

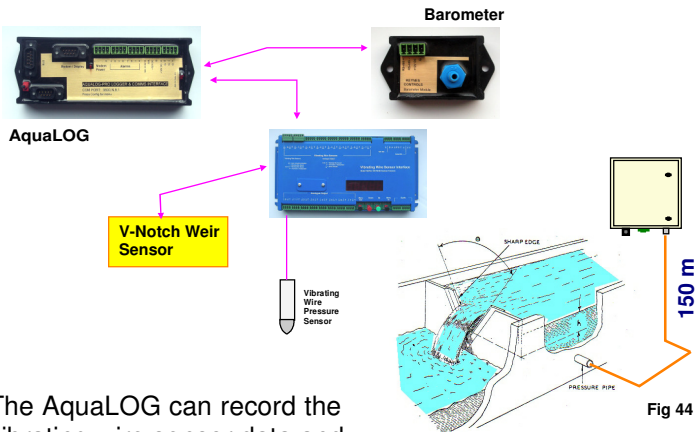


Fig 44

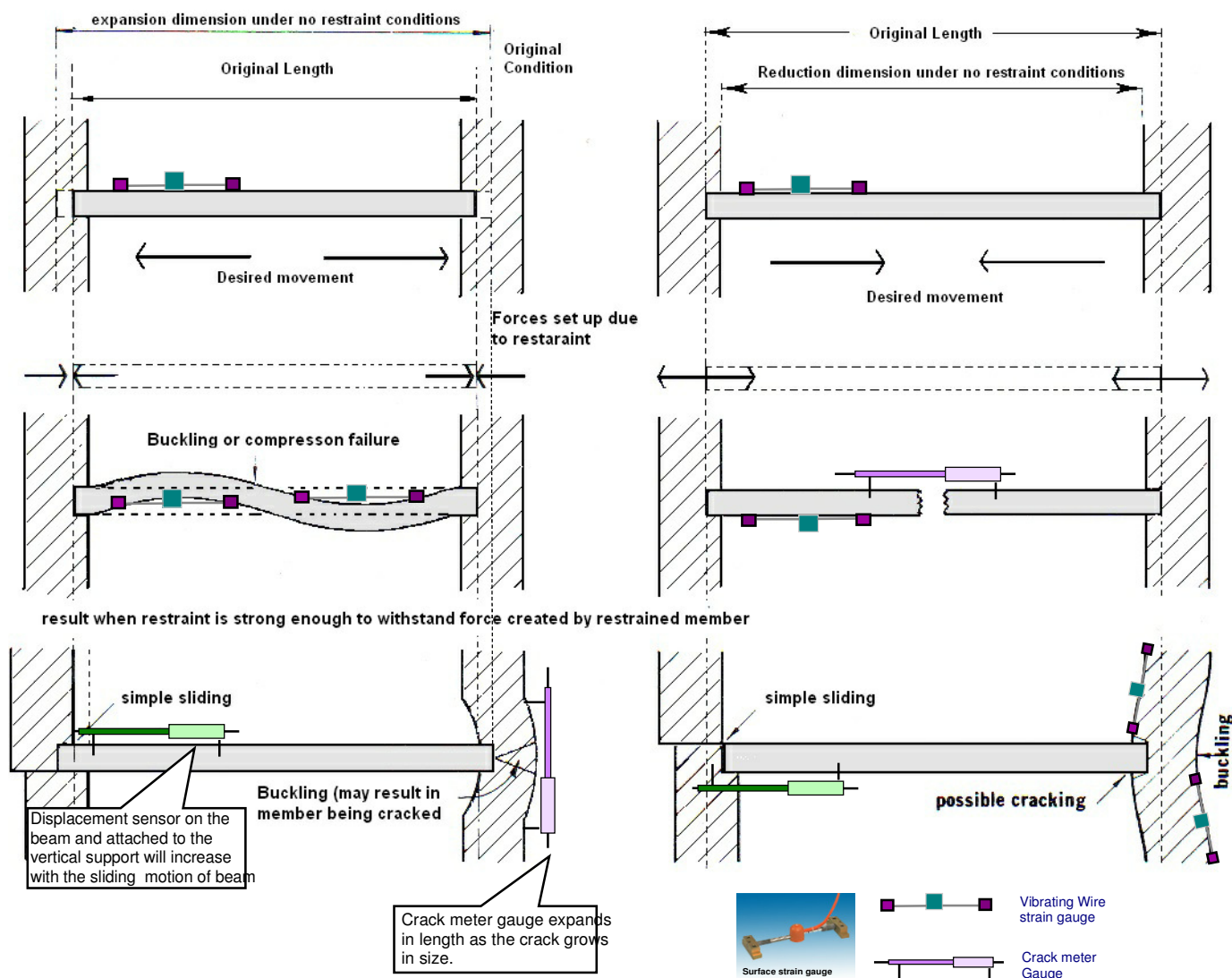
The AquaLOG can record the vibrating wire sensor data and convert it into engineering units.

The various sensors forming the weir monitoring system are combined within the AquaLOG to determine the correct flow rate. The Alarm operations of the AquaLOG can then be used to inform an operator should pre-set conditions be exceeded.

## Vibrating Wire Sensor Applications

The details below show just a few of the applications for which vibrating wire sensors are used. The best results from the instrumentation are only achieved when a good understanding for the overall structural behaviour is available. The examples demonstrate the common uses of structural monitoring within civil engineering applications.

A lot of vibrating wire sensor applications are undertaken with the sensors buried into the structure such as within concrete or within a bore hole. The vibrating wire sensors maintain very accurate results without need for re-calibration over many years and generally more reliable than other forms of sensor, less prone to failure in damp conditions and relatively easy to install.



The images opposite show sister bar strain gauges and examples of their installation and use. The sister bar strain gauge comprises of two lengths of ribbed rebar welded to a central gauge section. The central gauge section has a miniature stainless steel, vibrating wire strain gauge element, fitted along the longitudinal axis of the gauge. Incorporated within the gauge section are two coils for excitation and output of the vibrating wire strain gauge element. This type of gauge is particularly rugged and reliable. They are particularly applicable for strain measurements in mass concrete pours where placing of concrete is remote and uncontrolled such as typically occurs in diaphragm walls or deep piles.

The sister bars can be connected to the VibWire-108 instruments.



The embedment or dumbbell gauge (See below) is designed to measure strain in concrete. This vibrating wire strain gauge is typically tied to a reinforcing cage. It is usual to install them in arrays of three or four gauges at several depths horizons within the structure.





## Temperature Measurement - Using the Steinhart-Hart Equation for temperature calculation

### Introduction

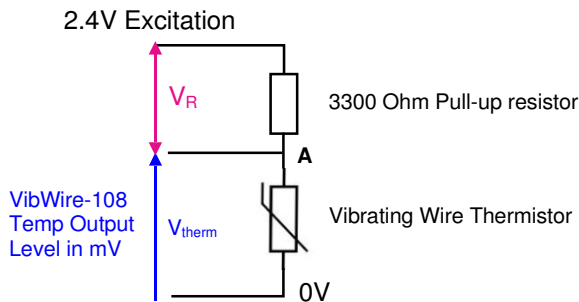
The following technical note shows how to obtain the thermistor resistance values for a vibrating wire temperature sensor connected to the temperature input of the VibWire-101 or VibWire-108 interfaces.

The VibWire-108/101 vibrating wire sensor interface supports the 4 wire sensor interface. This page demonstrates how the temperature calculation is carried out by the VibWire instruments. Page 23 shows the menu configuration options for the temperature sensors.

The results that can be achieved will depend on how well the thermistor calibration factors have been assigned.

The circuit below shows the VibWire-108 temperature input with pull-up resistor completion

The VibWire-101 and 108 models use 2.4 V excitation for the sensor thermistor.



$V_{therm}$  = Voltage across thermistor

$V_R$  = Voltage across pull up resistor

Example. A VibWire-108/101 provides an output temperature value of 1086 mV then

$$I_{therm} = (2.4 - V_{therm}) / 3300 \quad \text{where } 3300 = \text{pull-up resistor value} \quad \text{where } V_{therm} = 1.086 \text{ V}$$

therefore

$$I_{therm} = (\text{Excitation volt} - V_{therm}) / 3300(\text{Pull-up Resistor}) = (2.4 - 1.086) / 3300 = 1.414 / 3300 = 0.398 \text{ mA}$$

using Ohms Law

Note 1086 mV = 1.086 Volts

The Resistance of the Thermistor is calculated

$$R_{therm} = V_{therm} / I_{therm} = 1.086 / 0.000398 = 2727.4 \text{ Ohm}$$

Now 2727.4 ohms is the resistance of the thermistor at the at temp (T)

### Temperature Conversion

The thermistor resistance value is converted to temperature using the Steinhart-Hart Equation.

$$T = \frac{1}{C_1 + C_2 \cdot \ln(R_{therm}) + C_3(\ln(R_{therm}))^3} \quad \text{where } T = \text{absolute temperature in Kelvin} \quad R_{therm} \text{ in Ohms.}$$

Conversion to Deg C is

$$T(C) = \frac{1}{C_1 + C_2 \cdot \ln(R_{therm}) + C_3(\ln(R_{therm}))^3} - 273.15$$

The sensor data sheet will show for the thermistor a calibration equation similar to that below. The values for the parameter  $C_1$ ,  $C_2$ , &  $C_3$  will be listed.

$$(1/T) = C_1 + C_2 \cdot \ln(R_{therm}) + C_3 \cdot (\ln(R_{therm}))^3 - 273.15$$



Example

In Vibrating Wire sensors is the 44005RC Precision Epoxy NTC Thermistor is commonly used for temperature monitoring applications.

The data sheet for this product can be downloaded at

<http://www.aquabat.net/downloads/1350009-2.pdf> – The thermistor data sheet is valid to 11/12/2013  
refer to the manufactures data sheet for the latest information.

An example Excel spreadsheet that demonstrates the temperature calculations can be downloaded at

<http://www.aquabat.net/downloads/ThermistorWorksheet.xls>

Example

The VibWire-101 is can be set to give ratiometric or mV temperature values from the built in thermistor of a vibrating wire sensor. depending upon the sensor configuration. Ratiometric values are calculated between the 3300 Ohm pull up resistor and thermistor resistance and is value between 0 – 1. The Vibwire-101 has returned a value of 0.663 from the thermistor.

In the spreadsheet below the VW-101 gives a temperature value (Ratiometric) of 0.663. The constants A, B and C are from the calibration data sheet. The spreadsheet below shows the temperature to be 7 Deg C,

ThermistorWorksheet.xls Screen image

Calculation of temperature based on voltage ratio

Voltage ratio	0.663	Input
Excitation (Ohm)	3300	Fixed
Thermistor resistance	6905	Calculated
Thermistor R0	3000	Thermistor property
A	1.41E-03	Thermistor property
B	2.37E-04	Thermistor property
C	1.02E-07	Thermistor property
Inv Temperature	3.57E-03	
Temperature (Celsius)	7.0	Calculated value

Steinhart-Hart Calibration  
Parameters obtained from  
calibration data sheet.

Temperature  
value



## Thermistor Temperature Calculation using the thermistor Beta Value

An NTC (Negative Temperature Coefficient) Thermistor is a passive electrical component whose resistance varies inversely with temperature. It is often used as a temperature sensor inside **vibrating wire sensors**.

The relationship between resistance and temperature can be described with the 'beta' formula.

The VibWire-108 range of sensor interfaces offers the beta value temperature calculation as an option within the thermistor setup. The Beta value thermistor calculation is a simplified version of the Steinhart-Hart equation that is most often used in temperature measurement solutions.

For applications when the Steinhart-Hart calibration factors are not known then the sensor 'Beta' value can often be found on the thermistor manufactures data sheet.

The example below demonstrates how the VibWire-108 calculates temperature

The temperature calculations are undertaken internally within the VibWire-108 and are not yet currently part of the Q-Log software.

Refer to Page 23 for assigning the Beta value into the

$$T = \frac{B}{\ln\left(\frac{R_e T_0}{R_0}\right)}$$

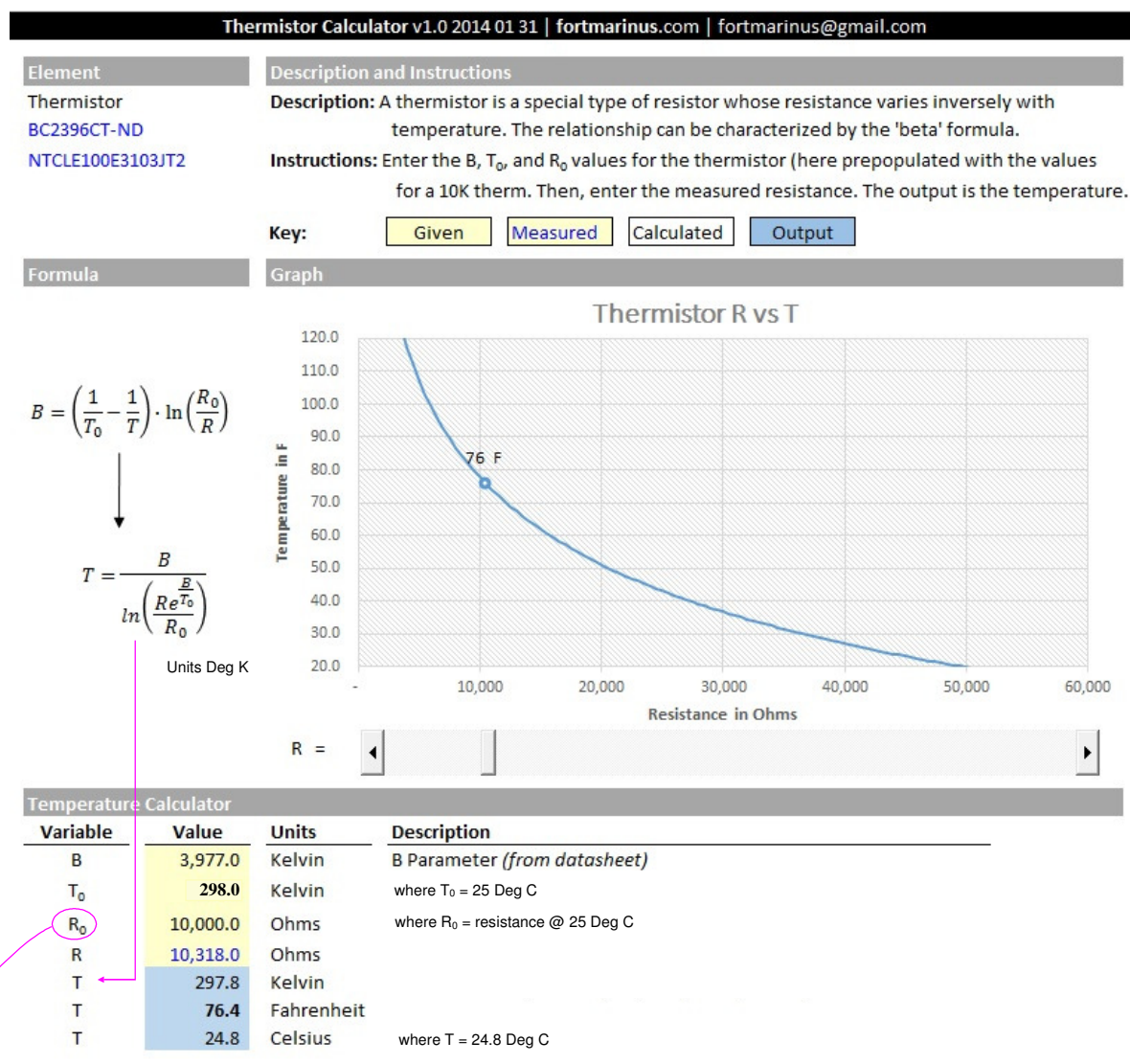
where T = temp in units K (Kelvin)

B = Thermistor Beta value

T<sub>0</sub> = Temperature at 25 ° C

R<sub>0</sub> = Resistance at 25 ° C

and to convert Deg K to Deg C then T<sub>o</sub> = T<sub>k</sub> - 273





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## TEST CERTIFICATE

DWT Traceable to standard no. : J082301 T8F 281 TC

Customer :  
 P.O. No. :  
 Instrument : V W Piezometer  
 Serial number : xxxxx  
 Capacity : 350 kPa

Date : 02.02.2012  
 Temperature : 19°C  
 Atm. Pressure : 100 kPa

Input pressure (kPa)	Up1 (Digit)	Observed value Down (Digit)	Up2 (Digit)	Average (Digit)	End Point Fit (kPa)	Poly Fit (kPa)
0.0	6555.9	6556.9	6556.9	6556.4	0.0	0.3
70.0	6312.4	6312.6	6312.4	6312.4	69.3	69.5
140.0	6064.0	6064.3	6063.1	6063.5	139.9	140.1
210.0	5817.1	5818.4	5816.2	5816.7	210.0	210.1
280.0	5569.8	5570.7	5568.0	5568.9	280.3	280.3
350.0	5323.3	5323.3	5323.7	5323.5	350.0	349.8

Digit :  $f^2/1000$   
 Linear gage factor (G) : 2.8388E-01 kPa/digit  
 (Use gage factor with minus sign with our read out unit Model : EDI-51V)  
 Thermal factor(K) : -0.087 kPa/°C  
 Polynomial constants :

A= -2.2253E-07

B= -2.8085E-01

C= 1.8512E+03

Pressure "P" is calculated with the following equation:

Linear :  $P(\text{kPa}) = G(R0 - R1) + K(T1 - T0) - (S1 - S0)$ Polynomial :  $P(\text{kPa}) = A(R1)^2 + B(R1) + C + K(T1 - T0) - (S1 - S0)$ 

R1 = current reading &amp; R0 is initial reading in digit.

S1 and T1 = current atmospheric pressure(kPa) and temperature (°C)

Readings at the time of shipment

f : Hz  
 $f^2$  : Digit  
 Temperature : °C  
 Thermistor : Ohm  
 Atm. pressure : kPa  
 Coil resistance : Ohm

The terms  $K(T1 - T0)$  are the temperature compensation terms for this sensor.

Temperature compensated readings only work if the thermistor operation is defined.

(Zero conditions in the field must be established by recording the reading R0 (digit) along with temperature T0 (°C) and atmospheric pressure S0 (kPa) at the time of installation. If polynomial constants are used, determine value of 'C' as per § 6.2 of user's manual.)

### Main Menu

1 System Maintenance  
 2 Thermistor type 1  
 3 Thermistor type 2  
 4 Diagnostics  
 5 Channel 0  
 6 Channel 1  
 7 Channel 2  
 8 Channel 3  
 9 Channel 4  
 A Channel 5  
 B Channel 6  
 C Channel 7  
 U Up. T Top.

### Frequency proc

0 = Hz 1 = Digits (Hz<sup>2</sup>) 2 = SI Units

where SI Units is by Quadratic Expansion

### Channel 0

1 Frequency proc 1  
 2 Thermistor type 1  
 3 Cal A -2.2253E-07  
 4 Cal B -2.8085E-01  
 5 Cal C 1.8512E+03  
 6 Cal D -0.087

U Up. T Top.

The example above is for a VW Piezometer and so the engineering units calculations vary between the different sensor types.

For a Piezometer the local barometric levels are taken into consideration.

The engineering units for this example is K Pa

The term  $(S1 - S0)$  is a constant offset that allows for local atmospheric conditions and be taken from a barometer module such as models **Barom-SDI12** or **Barom-485**.

The VW sensor units have to be set to 'Digits' that is Hz<sup>2</sup>/1000.

**VIBRATING WIRE INSTRUMENTS CALIBRATION CERTIFICATE**

Instrument Type : Displacement Transducer	Serial No. : 012453
Instrument Range : 0.00 to 50.0 mm	Calibration Date. : 14th March 2014
Gauge Factors in mm	Ambient Temp. : 23 Deg C
Period Gauge Factor (K : 92.1053900	Barometric Pressure : 1015 mb
Linear Gauge Factor (G) : (mm/digit) -0.0092090	Calibrator Personnel : Ian Thomas
Polynomial Gauge Factor A: 0.000000024979750	Calibration Equipment : Digital micrometer with scale VibWire-108 sensor interface
Polynomial Gauge Factor B: 0.0089750451	Regression Zero: 3185.7
Polynomial Gauge Factor C: 28.976750	

Reading (Period)	Digits F <sup>2</sup> /1000	Calculated (Linear)	Error %FS (Linear)	Linear Increment	Applied (mm)	Calculated (Polynomial)	Error %FS (Polynomial)
5610.9	3176.4	-0.088	-0.18	0.0	0.00	0.023	0.05
5182.9	3722.6	4.943	-0.11	546.2	5.00	4.987	-0.03
4840.0	4268.8	9.974	-0.05	546.2	10.00	9.966	-0.07
4555.8	4818.0	15.032	0.06	549.2	15.00	14.988	-0.02
4316.6	5366.8	20.087	0.17	548.8	20.00	20.021	0.04
4112.2	5913.5	25.123	0.25	546.7	25.00	25.049	0.10
3937.9	6448.8	30.053	0.11	535.3	30.00	29.987	-0.03
3782.8	6988.5	35.024	0.05	539.7	35.00	34.981	-0.04
3643.9	7531.2	40.023	0.05	542.7	40.00	40.017	0.03
3521.8	8062.5	44.917	-0.17	531.3	45.00	44.961	-0.08
3409.0	8604.8	49.912	-0.18	542.3	50.00	50.022	0.04

Formulae:      Linear                       $E = G(R_0 - R_1)$   
                     Polynomial                 $E = AR_1^2 + BR_1 + C$   
                     Offset                         $C = -(AR_0^2 + BR_0)$

Where  $R_0$  = is the initial zero reading at the time of installation.

$R_1$  = current reading    Units Hz<sup>2</sup>/1000    (Digits)

These equations give displacement only without any temperature compensation.

**Displacement calculations within Q-Log**

Q-Log is the free data display and recording software from Keynes Controls Ltd.

**Main Menu**

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 7 Channel 2  
 8 Channel 3  
 9 Channel 4  
 A Channel 5  
 B Channel 6  
 C Channel 7  
 U Up. T Top.

**Frequency proc**

0 = Hz    1 = Digits ( Hz<sup>2</sup>)    2 = SI Units  
 where SI Units is by Quadratic Expansion

**Channel 0**

1 Frequency proc                      1  
 2 Thermistor type                    1  
 3 Cal A                                  0.000000024979750  
 4 Cal B                                  0.0089750451  
 5 Cal C                                  28.976750  
 6 Cal D                                  -2.3069E-3  
 U Up. T Top.

**Linear**                       $E = G(R_0 - R_1)$   
                                      $E = G.R_0 - G.R_1$

where  $G.R_0$  is a constant term.

Enter this formula into Q-log and the results will be in mm.

See

<http://www.aquabat.net/QLOGFree/qlogv2.html>



## CALIBRATION DATA VIBRATING WIRE PIEZOMETER

Serial No 0 9 -1 3 4 8 9

MAXIMUM PRESSURE 10 MPa

MAXIMUM OVERLOAD PRESSURE 20 MPa

BAROMETRIC PRESSURE AT CALIBRATION 1012 mBar

FACTORY ZERO READING 9061.304 Hz<sup>2</sup>/1000

CABLE RESISTANCE (TWO WAY) 51.25 Ohms

### PRESSURE CHANNEL COEFFICIENTS

P4= -1.08331E-15  
P3= 0.00000E+00  
P2= -2.21240E-05  
P1= 0.00000E+00  
P0= FROM TEMP CH

### TEMPERATURE CHANNEL COEFFICIENTS

C4= 8.50983E-14  
C3= -2.05402E-09  
C2= 1.84317E-05  
C1= -8.09166E-02  
C0= 2.10758E+04

SWEEP FREQUENCY MIN 1978 Hz

SWEEP FREQUENCY MAX 3311 Hz

### TEMPERATURE STEINHART-HART

X<sup>3</sup> (B) 1.01900E-07

X<sup>2</sup> (D) 2.36900E-04

X<sup>0</sup> (E) 1.40510E-03

CYCLES 250

SETTLING TIME (mSec) 150

### Frequency Input Configuration

#### Channel 0

1 Frequency proc  
2 Thermistor type  
3 Cal A  
4 Cal B  
5 Cal C  
6 Cal D  
U Up. T Top.

Output in Digits  
Freq<sup>2</sup>/1000  
1  
0.0  
-2.21240E-05  
0.0  
-1.08331E-15

### Thermistor Configuration

#### Thermistor type 1

1 Type 1  
2 Resistance at T0 (ohms) 3000  
3 T0 (Celcius) 25  
4 Beta 5234  
5 Steinhart-Hart 0th order (A) 3.35E-3  
6 Steinhart-Hart 1st order (B) 2.56E-4  
7 Steinhart-Hart 2nd order (C) 2.08E-6  
8 Steinhart-Hart 3rd order (D) 7.30E-8

U Up. T Top.

### Common VW Sensor Thermistor Part Numbers

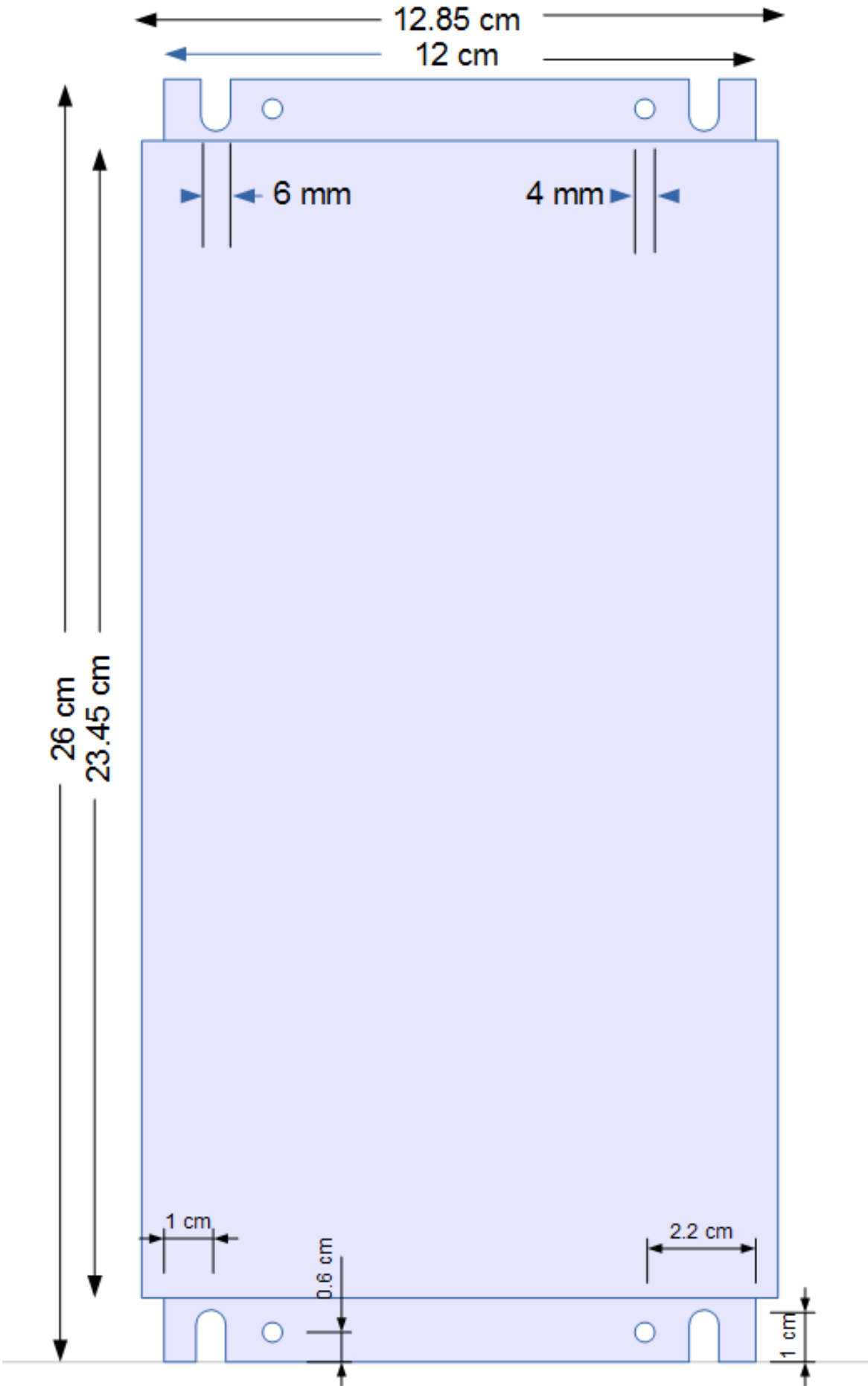
YSI 44005  
Vishay 1C 3001 B3  
RS Part no: 151-215

The part numbers are for 3 K Ohm thermistor commonly used by most different manufacturers.

The sensors give 3 K Ohm resistance at 25 Deg C.

**Dimensions of the VibWire-108 Back Mounting Panel**

The image below shows the dimensions of the back mounting panel for the VibWire-108 range of vibrating wire sensor interfaces.





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