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Using Geokon Vibrating Wire Instruments

Sensor Application Note #13

Overview

Vibrating wire instruments are used extensively in Geotechnical and Civil Engineering applications due to their long-term stability, reliability and suitability to operating in harsh environments.

This Sensor Application Note will provide details specific to configuring MultiLogger for using Geokon vibrating wire instruments.

More information on the company and it's products may be found by visiting their website at www.geokon.com

Wiring

Generally all Geokon vibrating wire instruments have a 5-conductor cable attached, configured as 2 twisted-pairs with foil shield and a drain wire, with either a blue (polyvinylcloride) jacket, green (polyethylene), or red (narrow diameter, polyvinylchoride) jacket. The internal conductor color code is the same for all these cables (it includes the vibrating wire gage as well as a thermistor for measuring temperature), as follows:

Color	Description	AVW1 Connection	VWDSP Connection	Multiplexer Connection
Red	VW gage +[1]	C+	VW+	1H
Black	VW gage -[1]	C-	VW-	1L
White	Thermistor +[2]	T+	TH+	2H[3]
Green	Thermistor -[2]	T-	TH-	2L[3]
Bare	Shield	G	SHLD	S

Notes:
[1] Strictly speaking the VW gage leads are NOT polarity sensitive.
[2] Strictly speaking the Thermistor leads are NOT polarity sensitive.
[3] In some cases it may not be desirable nor necessary to connect the thermistor leads, in this case the multiplexer will be configured as a 32-channel multiplexer and will only have the vibrating wire connections.

Contact Geokon for wiring of direct burial and/or multi-pair cables.

MultiLogger Configuration

There are a number of specific software configuration issues to be aware of when configuring MultiLogger to read Geokon vibrating wire sensors, as detailed in the following sections.

<u>Multiplexer Configuration</u>

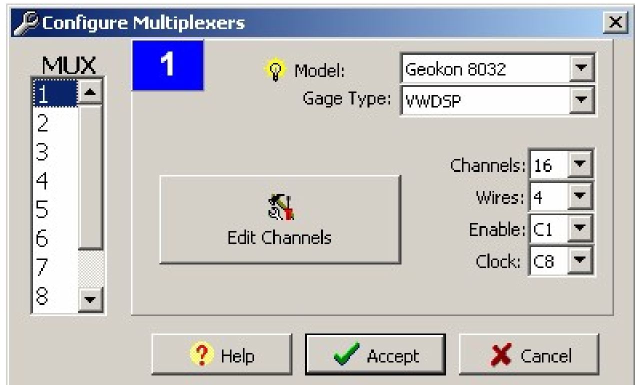
Configure multiplexers using the **Configure | Multiplexers** menu item in the Logger configuration form. Up to 10 multiplexers, or a maximum of 256 channels (including thermistors), may be configured.

- **Model** – Notice in the **Model** list there are 2 Geokon models, the **Geokon 8032**, the standard multiplexer, and the **Geokon 8033**, the distributed multiplexer. Select **Geokon 8032**.

- **Gage Type** – This selection will depend on whether certain peripheral products are installed in the MICRO-10 system, specifically the MultiSensor Interface or the VWDSP Interface.

  In most cases the correct selection will be **VWDSP**, as shown at right.

  If the system includes the MultiSensor Interface then select **MultiSensor** as the Gage Type.



  If the system has neither device then select **Vibrating Wire** as the Gage Type.

Note: The MultiSensor Gage Type will not appear in the list when configuring a CR2xx, CR800 or CR1000 based datalogger.

  In all of these cases Vibrating Wire gages will be configured on the respective mux channels, the configuration in the Configure Multiplexers form has more to do with how the multiplexers are controlled by the MCU, not what gages will be connected.

  If you aren't sure what **Gage Type** should be selected then contact Geokon for clarification.

- **Channels** – Most multiplexers are configured for 16-Channel operation, usually it is visible on the cover of the multiplexers. This setting must match the multiplexer hardware setting, otherwise the channel clocking will be in error.

- **Enable** – Generally the default selections should be used. An exception would be in the case of DaisyMux's, or multiplexers connected in series on the same cable, in this case the **Enable** setting would need to match for all multiplexers on the same cable.

- **Clock** – Generally the default selection should be used, which is C8 for all multiplexers.

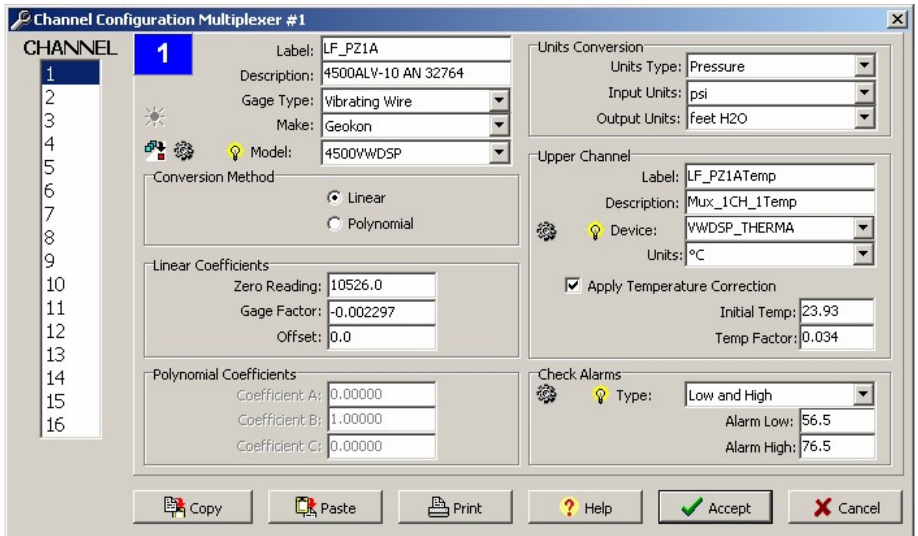
Configure each multiplexer to be connected to the MICRO-10 by selecting from the MUX list shown on the left side of the form. The MICRO-10 usually has a maximum of 6 multiplexers.

Once the multiplexers are configured then click **Edit Channels** to configure the channels of the selected multiplexer. See the following sections.

Channel Configuration – Gage Type | Make | Model Selections

Each channel must be configured using the **Channel Configuration** form. Notice on the left the list of channels, it will be numbered to 1-16 for 16-channel multiplexers, to 1-32 for 32-channel multiplexers. When using 32-channel multiplexers the Upper Channel (temperature devices) group will be disabled.

Notice the **Gage Type | Make | Model** selection lists. In all cases select **Vibrating Wire** as the Gage Type, **Geokon** as the Make, and then the appropriate Model to match the instrument connected and the type of interface being used to read it. The table shown in the following section provides more detail regarding the Model(s) shown and what type of instruments this applies to.



In general, if the MICRO-10 includes the **VWDSP Interface**, which is reading the vibrating wire gages attached to the system, then look for the Model selections that include **VWDSP** as the suffix to the model number, an example shown above for the Geokon Model 4500 Piezometer.

However, systems with a VWDSP may also use the **Campbell AVW200** to read the vibrating wire gages. In this case VWDSP is specified as the multiplexer Gage Type but the Models with the AVW200 suffix are used to read the gages.

Channel Configuration – Conversion Method

Usually **Linear** is used, since the improved accuracy of the math when using **Polynomial** provides only marginal improvements in measurement accuracy. Most Geokon instruments include coefficients using either type of Conversion Method.

Channel Configuration – Zero Reading or Coefficient C

Most Geokon instruments include a Factory Zero on the calibration, or in the case of the Polynomial Coefficients a Coefficient C. This value is only provided for REFERENCE PURPOSES. **To obtain accurate measurements in the field a field Zero MUST BE OBTAINED**! This is often done using the Zero function of MultiLogger, alternately a portable readout may be used to obtain the Field Zero. The units of the Zero Reading must match the “raw” measurement units of the instruments, or the units used to derive the calibration factors for the instrument, usually this is in “Digits”, or frequency2 x 10-3. When using a portable readout to obtain a field zero for the Polynomial Coefficient C the “digits” value must be run through the equation using the Coefficient A and Coefficient B values (see the supplied Calibration Sheet for the sensor to obtain these values).

Channel Configuration – Linear Coefficients Gage Factor

An important key to keep in mind when using Geokon vibrating wire gages is the **polarity** of the Gage Factor that is entered when using **Linear Coefficients** to convert from the raw reading (digits, which is frequency2 x 10-3) to engineering units (usually psi, or kPa). MultiLogger uses the following formula when generating the program for the datalogger:

$$Output = (R - Zero\,\mathrm{Re}\,ading) \times GageFactor \times CF + Offset$$

Where;
R = Current reading
ZeroReading = Zero Reading
GageFactor = Linear Gage Factor
CF = Conversion Factor (function of the Units Conversion selections)
Offset = Offset

However, the formula generally used by Geokon when reducing raw readings is as follows:

$$Output = (Zero\,\mathrm{Re}\,ading - R) \times GageFactor \times CF + Offset$$

This has been done to provide for a positive **Gage Factor** even though in many cases the vibrating wire gage will show a *decreasing* value for *increasing* pressure/displacement. This necessitates CHANGING THE SIGN OF THE GAGE FACTOR for certain instruments, as summarized in the table on the following page.

There are also other considerations with the **Gage Factor**, for example some instruments, such as strain gages, have a "standard" factor that is usually used for the Gage Factor. The table on the following page summarizes the Gage Factor issues for the commonly used Geokon vibrating wire instruments.

Channel Configuration – Polynomial Coefficients – Coefficient A

Enter the Coefficients as they appear on the calibration sheet. See our FAQ #14 in our support directory at www.canarysystems.com for additional information related to entering the Polynomial Coefficients.

Channel Configuration – Units Conversion

The key to correct configuration of the Units conversion is to match the **Input Units** with the units of the calibration coefficients, i.e. if the **Gage Factor** is psi per digit then the **Input Units** must be set to **psi**.

Additional conversions may be added to the MultiLogger selections by using the MLSetup program, included with MultiLogger, to edit the multilogger.ini configuration file. See the MultiLogger User's Guide for details on using MLSetup.

Channel Configuration – Upper Channel Device

Most Geokon Vibrating Wire sensors include a thermistor for measuring the temperature. The Device selection will depend on the hardware configuration of the system. See the following table for an explanation regarding which types are commonly used.

Device Type	VWDSP Equipped	Description
BR55KA822J-°C	NO	High temperature thermistor with output in °C
BR55KA822J-°F	NO	High temperature thermistor with output in °F
Thermistor-°C	NO	Standard thermistor (YSI44005) with output in °C
Thermistor-°F	NO	Standard thermistor (YSI44005) with output in °F
VBR55KA822J-°C	YES	High temperature thermistor with output in °C
VBR55KA822J-°F	YES	High temperature thermistor with output in °F
VWDSP_THERMA	YES	Standard thermistor (YSI44005) with output in °C
VWDSP_THERMA°F	YES	Standard thermistor (YSI44005) with output in °F
VWDSP_THERMB	YES	Standard thermistor (YSI44005) with output in °C Connected to the B input of the VWDSP (non-standard)
VWDSP_THERMB°F	YES	Standard thermistor (YSI44005) with output in °F Connected to the B input of the VWDSP (non-standard)
AVW200_YSI44005-°C	YES	Standard thermistor (YSI44005) with output in °C Connected to the CH1 input of the AVW200
AVW200_YSI44005-°F	YES	Standard thermistor (YSI44005) with output in °F Connected to the CH1 input of the AVW200

Channel Configuration – Temperature Factor

Multilogger uses the following formula to apply linear temperature correction to gage readings:

$$Corrected\ Reading = Output - \left(\left(CurrentTemp - InitialTemp\right) \times TempFactor \times CF\right)$$

However, Geokon usually represents the correction formula as follows:

$$Corrected\ Reading = Output + \left(\left(CurrentTemp - InitialTemp\right) \times TempFactor \times CF\right)$$

Note the difference in sign for the temperature correction, hence the supplied **TempFactor** will usually require the sign reversed for entry into the MultiLogger Channel Configuration. See an example following the Model table.

Vibrating Wire | Geokon | Model Table

Model	Description	Polarity	Factor	Notes
4000	VSM-4000 Strain Gage	+[3]	4.062	
4000 AVW200 [8]	VSM-4000 Strain Gage read with AVW200	+[3]	4.062	
4000Alarm[1,7]	VSM-4000 Strain Gage + filtering	+[3]	4.062	
4000sca[2,7]	VSM-4000 Strain Gage for SCA	+[3]	4.062	
4000scaAlarm[1,2,7]	VSM-4000 Strain Gage for SCA & Alarm	+[3]	4.062	
4000VWDSP	VSM-4000 Strain Gage for VWDSP Interface	+[3]	4.062	
4100	VK-4100 Strain Gage	+[3]	0.391	Use for VSM-4050, VK-4150, VCE-4202/4204
4100 AVW200 [8]	VK-4100 Strain Gage read with AVW200	+[3]	0.391	Use for VSM-4050, VK-4150, VCE-4202/4204
4100sca[2,7]	VK-4100 Strain Gage for SCA	+[3]	0.391	
4100VWDSP	VK-4100 Strain Gage for VWDSP	+[3]	0.391	Use for 4900, 4911
4200	VCE-4200 Strain Gage	+[3]	3.304	
4200 AVW200 [8]	VCE-4200 Strain Gage read with AVW200	+[3]	3.304	
4200sca[2,7]	VCE-4200 Strain Gage for SCA	+[3]	3.304	
4200VWDSP	VCE-4200 Strain Gage for VWDSP	+[3]	3.304	
4210	VCE-4210 Strain Gage	+[3]	Cal Sheet	Use for VCE-4212/4214
4210sca[2,7]	VCE-4210 Strain Gage for SCA	+[3]	Cal Sheet	Use for VCE-4212/4214
4300BX	4300BX Stressmeter	+	Note 5	
4300EX	4300EX Stressmeter	+	Note 5	
4300NX	4300NX Stressmeter	+	Note 5	
4360	4360 SISC gage	+	Note 5	
4360 AVW200 [8]	4360 SISC gage for AVW200	+	Note 5	
4360P	4360 SISC gage	+	Note 5	
4360P AVW200 [8]	4360 SISC Gage Period for AVW200	+	Note 5	Period is uSec
4360PVWDSP	4360 SISC Gage for VWDSP Period	+	Note 5	Period is uSec
4360sca[2,7]	4360 SISC Gage for SCA	+	Note 5	
4360VWDSP	4360 SISC Gage for VWDSP	+	Note 5	
4400	4400 Crackmeter	+	Cal Sheet	Use for 4410, 4425, 4450
4400sca[2,7]	4400 Crackmeter for SCA	+	Cal Sheet	Use for 4410, 4425, 4450
4400VWDSP	4400 Crackmeter for VWDSP	+	Cal Sheet	Use for 4410, 4450, 4900
4425 AVW200 [8]	4425 Convergence Meter for AVW200	+	Cal Sheet	
4425VWDSP	4425 Convergence Meter for VWDSP	+	Cal Sheet	
4500	4500 Piezometer	-	Cal Sheet	
4500 AVW200 [8]	4500 Piezometer for AVW200	-	Cal Sheet	
4500sca[2,7]	4500 Piezometer for SCA	-	Cal Sheet	
4500VWDSP	4500 Piezometer for VWDSP	-	Cal Sheet	Use for 4580, 4600, 4650, 4675, 4700, 4800, 4850
4580	4580 Piezometer	+	Cal Sheet	
4580sca[2,7]	4580 Piezometer for SCA	+	Cal Sheet	
4600	4600 Settlement	-	Cal Sheet	Use for 4675
4650	4650 Settlement	-	Cal Sheet	
4700	4700 Temperature	+	Cal Sheet	
4700 AVW200 [8]	4700 Temperature for AVW200	+	Cal Sheet	
4700sca[2,7]	4700 temperature for SCA	+	Cal Sheet	
4800	4800 Pressure Cell	-	Cal Sheet	Use for 4850
4800 AVW200 [8]	4800 Pressure Cell for AVW200	-	Cal Sheet	Use for 4850
4800sca[2,7]	4800 Pressure Cell for SCA	-	Cal Sheet	Use for 4850
4900	4900 Load Cell	-	Cal Sheet	Use for 4911
4900 AVW200 [8]	4900 Load Cell for AVW200	-	Cal Sheet	Use for 4911
4900sca[2,7]	4900 Load Cell for SCA	-	Cal Sheet	Use for 4911
6300	6300 In-Place Inclinometer	+	Cal Sheet	
6300 AVW200 [8]	6300 In-Place Inclinometer for AVW200	+	Cal Sheet	
6300VWDSP	6300 In-Place Inclinometer for VWDSP	+	Cal Sheet	
6350	6350 Tiltmeter	+	Cal Sheet	
6350 AVW200 [8]	6350 Tiltmeter for AVW200	+	Cal Sheet	
6350Alarm[1,7]	6350 Tiltmeter with Alarm	+	Cal Sheet	
6350scaAlarm[1,2,7]	6350 Tiltmeter for SCA with Alarm	+	Cal Sheet	
6350VWDSP	6350 Tiltmeter for VWDSP	+	Cal Sheet	
VWDSP_REVB	Generic VWDSP type	NA	Note 6	
VWDSP_REVB_B	Generic VWDSP type – Ch B	NA	Note 6	
VWDSP_REVBP	Generic VWDSP type output Period	NA	Note 6	Period is uSec

Notes:

[1] The **Alarm** types describe an instrument measurement whereby a group of readings are obtained and the deviations within the group are analyzed to determine if the group represents a good set of readings, otherwise another group is obtained, up to a maximum number of iterations, usually 10.
[2] The Single Coil Adaptor is an auto-resonant vibrating wire adaptor developed by Geokon.
[3] Polarity of Gage Factors for strain gages will depend on whether compressive or tensile strains should be shown as positive. Compressive strains shown as positive will require a negative gage factor, tensile strains shown as positive will require a positive gage factor.
[4] There may be a batch calibration factor that needs to be applied to the theoretical gage factor.
[5] Gage factor, or sensitivity factor, for Stressmeters will depend on rock modulus, see Instruction Manual.
[6] This is a generic gage type, gage factor and polarity would depend on type of gage being read.
[7] This Model is not applicable to the CR800/1000 based dataloggers.
[8] This Model is not applicable to the CR500/510/7/10/10X/23X based dataloggers.

For example, consider the following calibrating sheet from a Geokon Model 4500 Piezometer wired to a Geokon 8032 multiplexer connected to a MICRO-10 system.

GEOKON

Vibrating Wire Pressure Transducer Calibration

Model Number: 4500S-100 Pressure Range: 100 psi

Serial Number: 48056 Mfg. Number: 8-3275

Customer: Temperature: 21.1 °C

Cust. I.D. #: n/a Barometric Pressure: 998.1 mbar

Job Number: 13053 Date: Nov. 7, 1998

Cal. Std. Control #(s): 183, 468 Technician:

Pressure (psi)	Reading 1st Cycle	Pressure (psi)	Reading 2nd Cycle	Average Pressure	Average Reading	Change	Linearity (%FS)	Polynomial Fit (%FS)
0	9136	0	9141	0	9139		0.18	-0.04
20	8453	20	8456	20	8455	684	0.03	0.08
40	7772	40	7774	40	7773	682	-0.19	-0.01
60	7085	60	7083	60	7084	689	-0.19	-0.01
80	6392	80	6390	80	6391	693	-0.08	-0.03
100	5694	100	5687	100	5691	701	0.25	0.03

Linear Gage Factor (G): 0.029021 (psi/digit) Regression Zero: 9145

Polynomial Gage Factors: A: -1.40E-07 B: -0.026943 C:* 257.8826

Thermal Factor (K): -0.004326 (psi/°C)

Calculated Pressures: **Linear,** $P = G(R_0 - R_1) + K(T_1 - T_0) - (S_1 - S_0)$**

Polynomial, $P = AR_1^2 + BR_1 + C + K(T_1 - T_0) - (S_1 - S_0)$**

***Barometric compensation is not required with vented transducers.*

Factory Zero Reading:

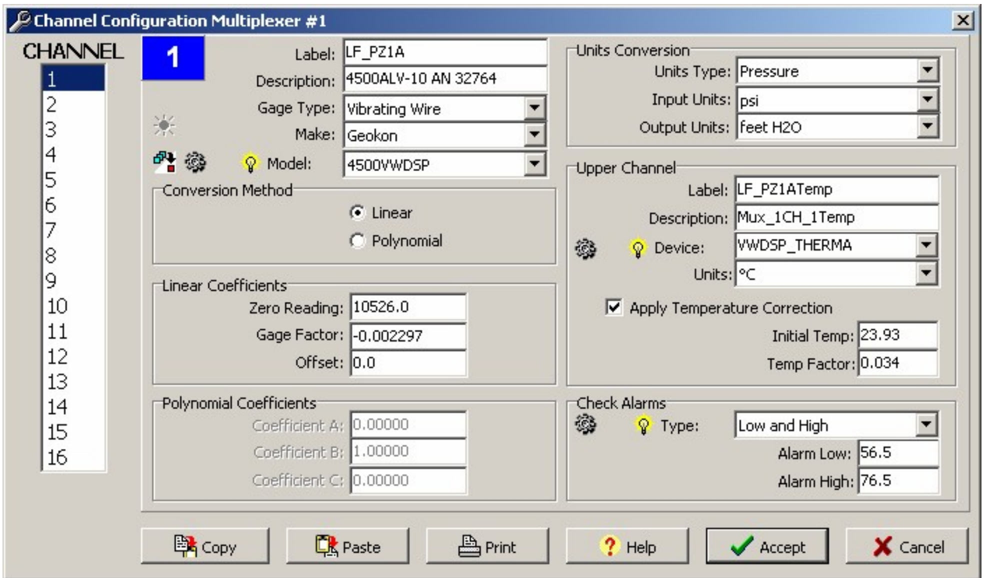
GK-401 Pos. B or F(R_0): 9128 Temp(T_0): 21.8 °C Baro(S_0): 1001.4mbar Date: Jan. 27, 1997

**The user is advised to establish zero conditions in the field by recording the reading at a known temperature and barometric pressure.*

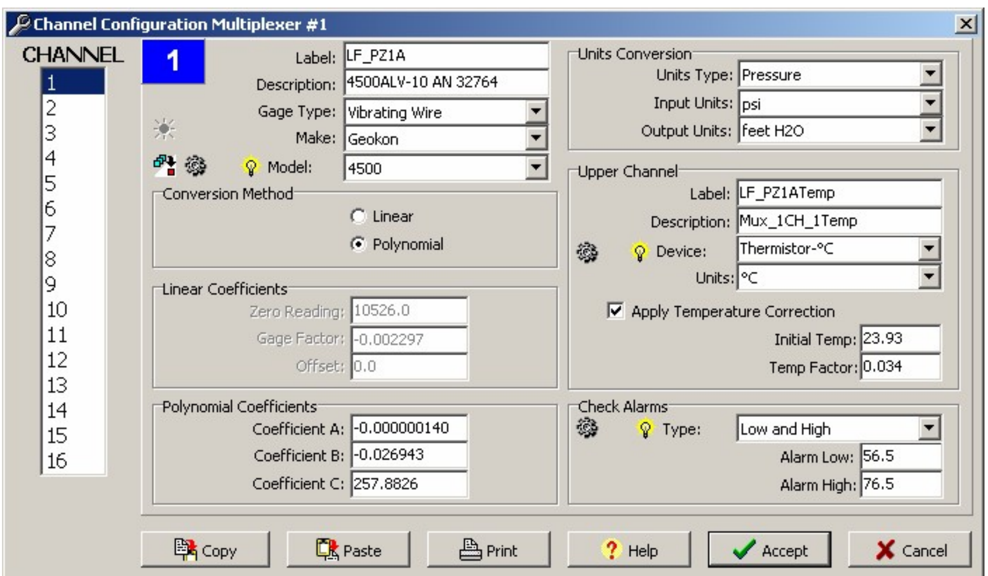
Wiring Code: Red and Black: Gage White and Green: Thermistor Bare: Shield

The above named instrument has been calibrated by comparison with standards traceable to the NIST, in compliance with ANSI Z540-1.

The channel configuration for a VWDSP equipped system using **Linear Coefficients** would be as follows:



The channel configuration for a non-VWDSP equipped system using **Polynomial Coefficients** would be as follows:



Note in the examples that the factory zero readings are used, whether **Zero Reading** for the Linear Conversion or **Polynomial C** for the Polynomial Conversion, but these values should be obtained in-situ.

Conclusion

This Sensor Application Note provides the key details for accurately configuring your MICRO-10 system with MultiLogger, however there may be exceptions and/or other issues with a specific set of hardware and/or instruments. If you require further clarification regarding these issues then contact Geokon. They may be reached in the US by phone, fax, email as follows:

Phone: 603-448-1562
Fax: 603-448-3216
Email: support@geokon.com