Model 4700

Vibrating Wire

Temperature Sensor

Instruction Manual

GEOKON®

Document Revision: K | Release Date: 4/8/24

Note: The Model 4700HT High Temperature Sensor is not CE approved.

WARRANTY STATEMENT

GEOKON warrants its products to be free of defects in materials and workmanship, under normal use and service for a period of 13 months from date of purchase. If the unit should malfunction, it must be returned to the factory for evaluation, freight prepaid. Upon examination by GEOKON, 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, misapplication, misuse or other operating conditions outside of GEOKON's control. Components that wear or are damaged by misuse are not warranted. This includes fuses and batteries.

GEOKON manufactures scientific instruments whose misuse is potentially dangerous. The instruments are intended to be installed and used only by qualified personnel. There are no warranties except as stated herein. There are no other warranties, expressed or implied, including but not limited to the implied warranties of merchantability and of fitness for a particular purpose. GEOKON is not responsible for any damages or losses caused to other equipment, whether direct, indirect, incidental, special or consequential which the purchaser may experience as a result of the installation or use of the product. The buyer's sole remedy for any breach of this agreement by GEOKON or any breach of any warranty by GEOKON shall not exceed the purchase price paid by the purchaser to GEOKON for the unit or units, or equipment directly affected by such breach. Under no circumstances will GEOKON reimburse the claimant for loss incurred in removing and/or reinstalling equipment.

Every precaution for accuracy has been taken in the preparation of manuals and/or software, however, GEOKON neither assumes responsibility for any omissions or errors that may appear nor assumes liability for any damages or losses that result from the use of the products in accordance with the information contained in the manual or software.

TABLE OF CONTENTS

1. INTRODUCTION 1

2. INSTALLATION 2

2.1 SPLICING AND JUNCTION BOXES 2

2.2 LIGHTNING PROTECTION 2

3. TAKING READINGS 4

3.1 COMPATIBLE READOUTS AND DATALOGGERS 4

3.2 MEASURING TEMPERATURES 5

4. DATA REDUCTION 6

5. TROUBLESHOOTING 7

APPENDIX A. SPECIFICATIONS 9

A.1 MODEL 4700 VW TEMPERATURE SENSOR 9

APPENDIX B. TYPICAL CALIBRATION REPORTS 10

APPENDIX C. THERMISTOR TEMPERATURE DERIVATION 12

C.1 3KΩ THERMISTOR RESISTANCE (STANDARD) 12

C.2 10KΩ THERMISTOR RESISTANCE (HIGH TEMP) 13

1. INTRODUCTION

The Model 4700 Vibrating Wire (VW) Temperature Sensor is designed to provide accurate, real-time, continuous monitoring of temperatures over extended periods of time. Standard sensors have an operating range of -20 °C to +80 °C.

Model 4500HT High Temperature Sensors are an option capable of operation under extreme conditions and at temperatures up to 250 °C.

Model 4500LT Low Temperature Sensors are an option capable of operation under extreme conditions and at temperatures as low as -40 °C.

The sensor consists of a tensioned steel wire clamped axially inside a cylindrically shaped body. This wire is made to vibrate at its fundamental frequency by means of electrical pulses fed from a readout to an electronic coil and permanent magnet assembly mounted close to the wire.

Temperature changes cause the stainless steel body to expand and contract at a different rate than the vibration wire. This causes a corresponding change in the wire tension and in its vibrational frequency. Vibration of the wire in the permanent magnetic field induces an alternating current in the electronic coil with the same frequency. This frequency can then be related to the temperature by means of a calibration factor supplied with each sensor.

All exposed components are made from stainless steel for corrosion protection. The sensors are waterproof and contain internal protection against lightning damage. Each sensor also incorporates a thermistor for use as a backup or as an independent check on the temperature reading.

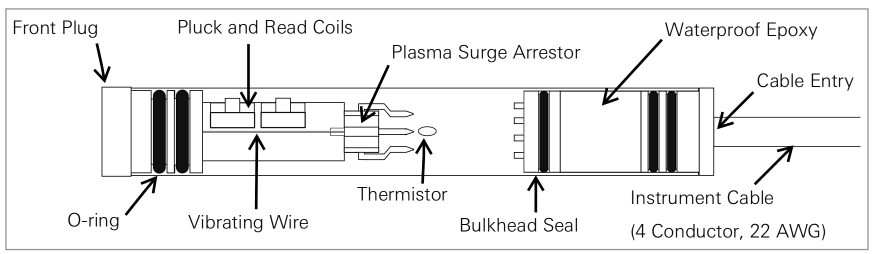

FIGURE 1: *Model 4700 Vibrating Wire Temperature Sensor*

The thermal response of the Model 4700 is quite slow; it is not suitable for the measurement of rapidly changing temperatures. (See Appendix A for details.)

2. INSTALLATION

Preliminary readings should be taken to ensure that the sensor is functioning properly, see Section 3 for compatible readouts and other information.

The Model 4700 Vibrating Wire Temperature Sensor is fully waterproof and can be installed inside boreholes, buried in fill, or cast inside concrete with no particular requirements needed.

For borehole installation, push the sensor into the borehole by whatever means are chosen. This may include attachment to grout pipes, special installation rods or other apparatuses being inserted into the borehole at the same time.

2.1 SPLICING AND JUNCTION BOXES

Because the vibrating wire output signal is a frequency rather than a current or voltage, variations in cable resistance have little effect on sensor readings. Therefore, splicing of cables has no effect, and in some cases may in fact be beneficial. For example, if multiple sensors are installed in a borehole, and the distance from the borehole to the terminal box or datalogger is great, a splice (or junction box) could be made to connect the individual cables to a single multi-conductor cable. This multi-conductor cable would then be run to the readout station. For these types of installations, it is recommended that the sensor be supplied with enough cable to reach the installation depth, plus extra cable to pass through drilling equipment (rods, casing, etc.).

Cable used for making splices should be a high-quality twisted pair type, with 100% shielding and an integral shield drain wire. **When splicing, it is very important that the shield drain wires be spliced together.** Splice kits recommended by GEOKON incorporate casts that are placed around the splice and then filled with epoxy to waterproof the connections. When properly made, this type of splice is equal or superior to the cable in strength and electrical properties. Contact GEOKON for splicing materials and additional cable splicing instructions.

Junction boxes and terminal boxes are available from GEOKON for all types of applications. In addition, portable readouts and dataloggers are also available. Contact GEOKON for specific application information.

2.2 LIGHTNING PROTECTION

In exposed locations, it is vital that the sensor be protected against lightning strikes. A tripolar plasma surge arrestor, which protects against voltage spikes across the input leads, is built into the body of the sensor (see Figure 1).

Additional lightning protection measures available include:

- Placing a Lightning Arrestor Board (Model 4999-12L), in line with the cable, as close as possible to the installed sensor (see Figure 2). These units utilize surge arrestors and transzorbs to further protect the sensor. This is the recommended method of lightning protection.
- Terminal boxes available from GEOKON can be ordered with lightning protection built in. The terminal board used to make the sensor connections has provision for the installation of plasma surge arrestors. Lightning Arrestor Boards (Model 4999-12L) can also be incorporated into the terminal box. The terminal box must be connected to an earth ground for these levels of protection to be effective.

- If the instruments will be read manually with a portable readout (no terminal box), a simple way to help protect against lightning damage is to connect the cable leads to a good earth ground when not in use. This will help shunt transients induced in the cable to ground, away from the instrument.

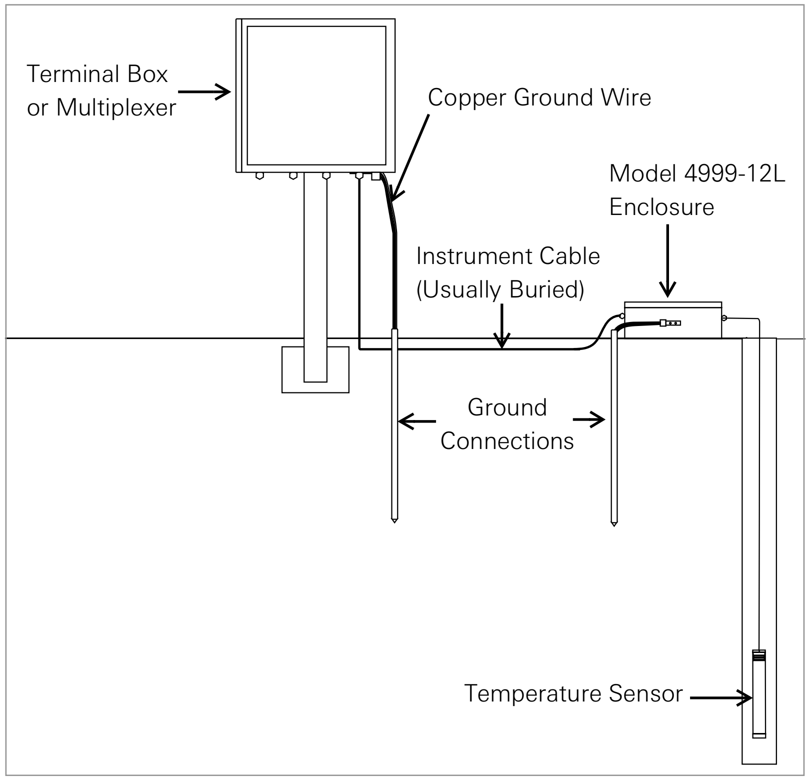

FIGURE 2: *Recommended Lightning Protection Scheme*

3. TAKING READINGS

3.1 COMPATIBLE READOUTS AND DATALOGGERS

GEOKON can provide several readout and datalogger options. Devices compatible with this product are listed below. For further details and instruction consult the corresponding Manual(s) at geokon.com/Readouts and geokon.com/Dataloggers.

Readouts

DIGITAL READOUTS:

- **GK-404**

  The Model GK-404 VW Readout is a portable, low-power, hand-held unit capable of running for more than 20 hours continuously on two AA batteries. It is designed for the readout of all GEOKON Vibrating Wire (VW) instruments, and is capable of displaying the reading in digits, frequency (Hz), period (µs), or microstrain (µε). The GK-404 displays the temperature of the transducer (embedded thermistor) with a resolution of 0.1 °C.

- **GK-406**

  The Model GK-406 is a field-ready device able to quickly measure a sensor, save data, and communicate results with custom PDF reports and spreadsheet output. Measurements are geo-located with the integrated GPS allowing the GK-406 to verify locations and lead the user to the sensor locations. The large color display and VSPECT™ technology create confidence of getting the best measurement possible both in the field and in the office.

Dataloggers

DATALOGGERS:

- **8600 Series**

  The MICRO-6000 Datalogger is designed to support the reading of a large number of GEOKON Vibrating Wire instruments for various unattended data collection applications through the use of GEOKON Model 8032 Multiplexers. Weatherproof packaging allows the unit to be installed in field environments where inhospitable conditions prevail. The Nema 4X enclosure also has a provision for locking to limit access to responsible field personnel.

- **8800 and 8900 Series**

  The GeoNet Wireless Mesh Data Acquisition system consists of a Gateway and subordinate Wireless Mesh Data Loggers that transmit data collected from the connected sensors. The Gateway controls the network and is the aggregator of all the data from the Loggers in the system. The Cellular and Wi-Fi Gateways transfer the collected data to the GEOKON Cloud data storage platform, where it is securely stored and can be viewed in GEOKON Agent Software or exported to a third-party software platform through the Open API. A Local Gateway (no cellular or Wi-Fi capabilities) is available for applications where the data is to remain local or a third-party modem or ethernet connection is desired.

- **8920, 8930, and 8950 Series**

  GEOKON Model 8920, 8930, and 8950 Series Loggers offer a high-value, networked data collection option for all GEOKON Vibrating Wire instruments and digital sensor (MEMS IPI and VW) strings. Each logger comes from the factory ready for deployment and may commence with data acquisition in minutes.

Sensor data is collected and transferred via a cellular, Wi-Fi, or satellite network to a secure cloud-based storage platform where it can be accessed through the GEOKON OpenAPI. Industry leading data visualization software, such as Vista Data Vision, or the free GEOKON Agent program can be used with the OpenAPI for data viewing and reporting. Commissioning, billing and configuration are accomplished via the easy-to-use GEOKON API Portal.

- **8940 Series**

  GEOKON Model 8940 Series Dataloggers offer a high-value data collection option for all GEOKON Vibrating Wire instruments and digital sensor strings. Waterproof single and four-channel GeoNet dataloggers housed inside rugged PVC enclosures are also available. Each logger is ready to be installed from the factory and acquires data in minutes.

  Sensor data is collected on site by connecting the 8940 to a P.C. and using the free GEOKON Agent software program for data viewing and reporting.

3.2 MEASURING TEMPERATURES

All GEOKON vibrating wire instruments are equipped with a thermistor for reading temperature. The thermistor gives a varying resistance output as the temperature changes. The white and green leads of the instrument cable are normally connected to the internal thermistor.

The GK-404 and GK-406 readouts will read the thermistor and display the temperature in degrees Celsius.

USING AN OHMMETER TO READ TEMPERATURES:

Connect an ohmmeter to the green and white thermistor leads coming from the instrument. Since the resistance changes with temperature are large, the effect of cable resistance is usually insignificant. For long cables a correction can be applied equal to approximately 48.5Ω per km (14.7Ω per 1000') at 20 °C. Multiply these factors by two to account for both directions

Look up the temperature for the measured resistance in Appendix C.

4. DATA REDUCTION

Temperature is calculated using the collected digit readings. Use the equation below to find the sensor temperature.

The temperature (T) is given by the formula:

$$T = G(R_1 - R_0)$$

EQUATION 1: *Convert Digits to Temperature*

Where:

G = is the gauge factor found on the calibration sheet.

R_0 = is the initial reading on channel B at 0 °C (from the calibration sheet).

R_1 = is the subsequent reading on channel B

For greater accuracy, use the polynomial equation found on the calibration sheet provided with the instrument.

5. TROUBLESHOOTING

Technical Support

Maintenance and troubleshooting of Model 4700 VW Temperature Sensor is confined to periodic checks of the cable connections. The sensors are sealed and are not user serviceable. **Sensors should not be opened in the field.**

Should difficulties arise, consult the following list of problems and possible solutions. For additional troubleshooting and support visit geokon.com/ Technical-Support.

SYMPTOM: THERMISTOR RESISTANCE IS TOO HIGH

☐ Check for an open circuit. Check all connections, terminals, and plugs. If a cut is in the cable, splice according to instructions in Section 2.1.

SYMPTOM: THERMISTOR RESISTANCE IS TOO LOW

☐ Check for a short circuit. Check all connections, terminals, and plugs. If a short is in the cable, splice according to instructions in Section 2.1.

☐ Water may have penetrated the interior of the sensor. There is no remedial action.

SYMPTOM: TEMPERATURE SENSOR READING UNSTABLE

☐ Make sure the shield drain wire is connected to the blue clip on the flying leads.

☐ Isolate the readout from the ground by placing it on a piece of wood or another insulator.

☐ Check for sources of nearby electrical noise such as motors, generators, antennas, or electrical cables. Move the sensor cable away from these sources if possible. Contact the factory for available filtering and shielding equipment.

☐ The sensor may have been damaged by over-ranging or shock. Inspect the housing for damage.

☐ The body of the sensor may be shorted to the shield. Check the resistance between the shield drain wire and the housing. If the resistance is very low, the sensor conductors may be shorted.

SYMPTOM: TEMPERATURE SENSOR FAILS TO GIVE A READING

☐ Check the readout with another sensor to ensure it is functioning properly.

☐ The sensor may have been shocked. Inspect the housing for damage.

☐ Check the resistance of the cable by connecting an ohmmeter to the sensor leads. Cable resistance is about 48.5Ω per km (14.7Ω per 1000'). If the resistance is very high or infinite, the cable is probably broken. If the resistance is very low, the sensor conductors may be shorted. If a break or a short is present, splice according to the instructions in Section 2.1.

☐ Refer to the expected resistance for the various wire combinations below.

Vibrating Wire Sensor Lead Resistance Levels

Red/Black coil resistance values may vary for different model sensors:

- Standard and Low Temperature: ≅180Ω
- High Temp (HT): ≅50Ω

Green/White 3000Ω at 25 °C

Any other wire combination will result in a measurement of infinite resistance.

Note: Tests should be performed with a quality multimeter to accurately show possibilities of shorts. Sensors should be disconnected from other equipment while performing resistance tests, this includes surge modules, terminals, multiplexers and dataloggers. Fingers cannot be touching the multimeter leads or sensor wires while testing.

Table 1 shows the expected resistance for the various wire combinations.

Table 2 is provided for the customer to fill in the actual resistance found.

Vibrating Wire Sensor Lead Grid - SAMPLE VALUES					
	Red	**Black**	**White**	**Green**	**Shield**
Red					
Black	**≅180Ω**				
White	Infinite	Infinite			
Green	Infinite	Infinite	**3000Ω at 25°C**		
Shield	Infinite	Infinite	Infinite	Infinite	

TABLE 1: *Sample Resistance*

Vibrating Wire Sensor Lead Grid - SENSOR NAME/##					
	Red	**Black**	**White**	**Green**	**Shield**
Red					
Black					
White					
Green					
Shield					

TABLE 2: *Resistance Worksheet*

APPENDIX A. SPECIFICATIONS

A.1 MODEL 4700 VW TEMPERATURE SENSOR

Model	4700	4700HT	4700LT
Range	-20 °C to +80 °C	-40 °C to +250 °C[1]	-40 °C to +60 °C
Resolution	0.034 °C (Approximate)		
Accuracy[2]	±0.5°C		
Response Time[3]	2.5 minutes		
Thermal Equilibrium[4]	15 minutes		
Frequency Range	1400 – 3500 Hz		
Diameter	19.05 mm (0.75")		
Length	130.175 mm (5.125")	131.750 mm (5.187") (Not including Swagelok Cable Connector)	130.175 mm (5.125")
Weight	115 gm		
Cable	Four conductor, shielded, 22 AWG	Teflon Jacketed (200°C max rating) OR 316SS encapsulated (250°C max rating)	Four conductor, shielded, 22 AWG

TABLE 3: *Model 6140 Inclinometer Specifications*

Note:

1 Maximum temperature is cable dependent.
2 Established under laboratory conditions.
3 Time required to reach 63.2% of an instantaneous temperature change.
4 Maximum time required to reach thermal equilibrium.

GEOKON®

Vibrating Wire Temperature Gauge Calibration Report

This Calibration has been Verified/ Validated as of: February 27, 2024

Model Number: 4700

Date of Calibration: February 14, 2024

Serial Number: 2258660

Calibration Instruction: CI-4700

Technician: [signature]

Temperature (°C)	Gauge Reading	Calculated Temperature (°C)	Linearity (%FS)	Polynomial Fit (%FS)
-21.53	3480.4	-21.84	-0.30	0.04
-0.82	4151.2	-0.81	0.01	-0.07
19.95	4821.9	20.22	0.26	-0.01
40.62	5482.2	40.92	0.29	0.04
58.72	6053.5	58.82	0.10	0.04
79.87	6712.5	79.48	-0.38	-0.03

Linear Gauge Factor (G): 0.03135 (°C/ digit)

Reference Reading at 0 °C (R_0): 4177.0 (Regression Zero)

Polynomial Gauge Factors: A: 2.472E-07 B: 0.02883 C: -124.83

Calculated Temperature: Linear, $T = G(R_1 - R_0)$ Polynomial, $T = AR_1^2 + BR_1 + C$

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

Calibration results: above instrument is found to be within tolerance in all operating ranges.

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

FIGURE 3: *Model 4700 Calibration Report*

GEOKON

Vibrating Wire High Temperature Gauge Calibration Report

This Calibration has been Verified/ Validated as of: October 06, 2023

Model Number: 4700HT

Date of Calibration: October 02, 2023

Serial Number: 2310968

Calibration Instruction: CI-4700

Technician: K.J.Bellerose

Temperature (°C)	Gauge Reading	Calculated Temperature (°C)	Linearity Error (%FS)	Calculated Temperature (°C) using Polynomial	Polynomial Error Fit (%FS)
-1.4	3622.3	-3.2	-0.72	-1.4	0.00
49.0	4844.5	49.0	0.01	49.0	0.00
99.4	6057.6	100.9	0.59	99.4	-0.01
148.6	7218.7	150.5	0.74	148.6	0.00
197.7	8339.2	198.4	0.25	197.7	0.00
245.5	9386.1	243.1	-0.98	245.5	0.00

Linear Gauge Factor (G): 0.04274 (°C/ digit)

Reference Reading at 0 °C (R_0): 3697 (Regression Zero)

Polynomial Gauge Factors: A: 6.9782E-11 B: -8.97E-07 C: 4.51E-02 D: -1.56E+02

Calculated Temperature: Linear, $T = G(R_1 - R_0)$ Polynomial, $T = AR_1^3 + BR_1^2 + CR_1 + D$

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

Calibration results: above instrument is found to be within tolerance in all operating ranges.

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

FIGURE 4: *Model 4700HT Calibration Report*

APPENDIX C. THERMISTOR TEMPERATURE DERIVATION

C.1 3KΩ THERMISTOR RESISTANCE (STANDARD)

Thermistor Types include YSI 44005, Dale #1C3001–B3, Alpha #13A3001–B3, and Honeywell 192–302LET–A01

Resistance to Temperature Equation:

$$T = \frac{1}{A + B(LnR) + C(LnR)^3} - 273.15$$

EQUATION 2: *3KΩ Thermistor Resistance*

Where:
T = Temperature in °C
LnR = Natural Log of Thermistor Resistance
$A = 1.4051 \times 10^{-3}$
$B = 2.369 \times 10^{-4}$
$C = 1.019 \times 10^{-7}$
Note: Coefficients calculated over the –50 to +150 °C span.

Ohms	Temp	Ohms	Temp	Ohms	Temp	Ohms	Temp	Ohms	Temp
201.1K	-50	15.72K	-9	2221	32	474.7	73	137.2	114
187.3K	-49	14.90K	-8	2130	33	459.0	74	133.6	115
174.5K	-48	14.12K	-7	2042	34	444.0	75	130.0	116
162.7K	-47	13.39K	-6	1959	35	429.5	76	126.5	117
151.7K	-46	12.70K	-5	1880	36	415.6	77	123.2	118
141.6K	-45	12.05K	-4	1805	37	402.2	78	119.9	119
132.2K	-44	11.44K	-3	1733	38	389.3	79	116.8	120
123.5K	-43	10.86K	-2	1664	39	376.9	80	113.8	121
115.4K	-42	10.31K	-1	1598	40	364.9	81	110.8	122
107.9K	-41	9796	0	1535	41	353.4	82	107.9	123
101.0K	-40	9310	1	1475	42	342.2	83	105.2	124
94.48K	-39	8851	2	1418	43	331.5	84	102.5	125
88.46K	-38	8417	3	1363	44	321.2	85	99.9	126
82.87K	-37	8006	4	1310	45	311.3	86	97.3	127
77.66K	-36	7618	5	1260	46	301.7	87	94.9	128
72.81K	-35	7252	6	1212	47	292.4	88	92.5	129
68.30K	-34	6905	7	1167	48	283.5	89	90.2	130
64.09K	-33	6576	8	1123	49	274.9	90	87.9	131
60.17K	-32	6265	9	1081	50	266.6	91	85.7	132
56.51K	-31	5971	10	1040	51	258.6	92	83.6	133
53.10K	-30	5692	11	1002	52	250.9	93	81.6	134
49.91K	-29	5427	12	965.0	53	243.4	94	79.6	135
46.94K	-28	5177	13	929.6	54	236.2	95	77.6	136
44.16K	-27	4939	14	895.8	55	229.3	96	75.8	137
41.56K	-26	4714	15	863.3	56	222.6	97	73.9	138
39.13K	-25	4500	16	832.2	57	216.1	98	72.2	139
36.86K	-24	4297	17	802.3	58	209.8	99	70.4	140
34.73K	-23	4105	18	773.7	59	203.8	100	68.8	141
32.74K	-22	3922	19	746.3	60	197.9	101	67.1	142
30.87K	-21	3748	20	719.9	61	192.2	102	65.5	143
29.13K	-20	3583	21	694.7	62	186.8	103	64.0	144
27.49K	-19	3426	22	670.4	63	181.5	104	62.5	145
25.95K	-18	3277	23	647.1	64	176.4	105	61.1	146
24.51K	-17	3135	24	624.7	65	171.4	106	59.6	147
23.16K	-16	3000	25	603.3	66	166.7	107	58.3	148
21.89K	-15	2872	26	582.6	67	162.0	108	56.8	149
20.70K	-14	2750	27	562.8	68	157.6	109	55.6	150
19.58K	-13	2633	28	543.7	69	153.2	110		
18.52K	-12	2523	29	525.4	70	149.0	111		
17.53K	-11	2417	30	507.8	71	145.0	112		
16.60K	-10	2317	31	490.9	72	141.1	113		

TABLE 4: *3KΩ Thermistor Resistance*

C.2 10KΩ THERMISTOR RESISTANCE (HIGH TEMP)

Thermistor Type: US Sensor 103JL1A

Resistance to Temperature Equation:

$$T = \frac{1}{A + B(LnR) + C(LnR)^3 + D(LnR)^5} - 273.15$$

EQUATION 3: *10KΩ Thermistor Resistance*

Where:
T = Temperature in °C
LnR = Natural Log of Thermistor Resistance
A = 1.127670×10^{-3}
B = 2.344442×10^{-4}
C = 8.476921×10^{-8}
D = 1.175122×10^{-11}
Note: Coefficients optimized for a curve **J** Thermistor over the temperature range of 0 °C to +250 °C.

Ohms	Temp	Ohms	Temp	Ohms	Temp	Ohms	Temp	Ohms	Temp	Ohms	Temp	Ohms	Temp	Ohms	Temp
32,650	0	7,402	32	2,157	64	763.5	96	316.6	128	148.4	160	76.5	192	42.8	224
31,029	1	7,098	33	2,083	65	741.2	97	308.7	129	145.1	161	75.0	193	42.1	225
29,498	2	6,808	34	2,011	66	719.6	98	301.0	130	142.0	162	73.6	194	41.4	226
28,052	3	6,531	35	1,942	67	698.7	99	293.5	131	138.9	163	72.2	195	40.7	227
26,685	4	6,267	36	1,876	68	678.6	100	286.3	132	135.9	164	70.8	196	40.0	228
25,392	5	6,015	37	1,813	69	659.1	101	279.2	133	133.0	165	69.5	197	39.3	229
24,170	6	5,775	38	1,752	70	640.3	102	272.4	134	130.1	166	68.2	198	38.7	230
23,013	7	5,545	39	1,693	71	622.2	103	265.8	135	127.3	167	66.9	199	38.0	231
21,918	8	5,326	40	1,637	72	604.6	104	259.3	136	124.6	168	65.7	200	37.4	232
20,882	9	5,117	41	1,582	73	587.6	105	253.1	137	122.0	169	64.4	201	36.8	233
19,901	10	4,917	42	1,530	74	571.2	106	247.0	138	119.4	170	63.3	202	36.2	234
18,971	11	4,725	43	1,480	75	555.3	107	241.1	139	116.9	171	62.1	203	35.6	235
18,090	12	4,543	44	1,432	76	539.9	108	235.3	140	114.5	172	61.0	204	35.1	236
17,255	13	4,368	45	1,385	77	525.0	109	229.7	141	112.1	173	59.9	205	34.5	237
16,463	14	4,201	46	1,340	78	510.6	110	224.3	142	109.8	174	58.8	206	33.9	238
15,712	15	4,041	47	1,297	79	496.7	111	219.0	143	107.5	175	57.7	207	33.4	239
14,999	16	3,888	48	1,255	80	483.2	112	213.9	144	105.3	176	56.7	208	32.9	240
14,323	17	3,742	49	1,215	81	470.1	113	208.9	145	103.2	177	55.7	209	32.3	241
13,681	18	3,602	50	1,177	82	457.5	114	204.1	146	101.1	178	54.7	210	31.8	242
13,072	19	3,468	51	1,140	83	445.3	115	199.4	147	99.0	179	53.7	211	31.3	243
12,493	20	3,340	52	1,104	84	433.4	116	194.8	148	97.0	180	52.7	212	30.8	244
11,942	21	3,217	53	1,070	85	421.9	117	190.3	149	95.1	181	51.8	213	30.4	245
11,419	22	3,099	54	1,037	86	410.8	118	186.1	150	93.2	182	50.9	214	29.9	246
10,922	23	2,986	55	1,005	87	400.0	119	181.9	151	91.3	183	50.0	215	29.4	247
10,450	24	2,878	56	973.8	88	389.6	120	177.7	152	89.5	184	49.1	216	29.0	248
10,000	25	2,774	57	944.1	89	379.4	121	173.7	153	87.7	185	48.3	217	28.5	249
9,572	26	2,675	58	915.5	90	369.6	122	169.8	154	86.0	186	47.4	218	28.1	250
9,165	27	2,579	59	887.8	91	360.1	123	166.0	155	84.3	187	46.6	219		
8,777	28	2,488	60	861.2	92	350.9	124	162.3	156	82.7	188	45.8	220		
8,408	29	2,400	61	835.4	93	341.9	125	158.6	157	81.1	189	45.0	221		
8,057	30	2,316	62	810.6	94	333.2	126	155.1	158	79.5	190	44.3	222		
7,722	31	2,235	63	786.6	95	324.8	127	151.7	159	78.0	191	43.5	223		

TABLE 5: *10KΩ Thermistor Resistance*

GEOKON
48 Spencer Street
Lebanon, New Hampshire
03766, USA

Phone: +1 (603) 448-1562
Email: info@geokon.com
Website: www.geokon.com

GEOKON
is an **ISO 9001:2015**
registered company