User Manual for the

Temperature Sensors

TEMP-UM-2.0

Delta-T Devices Ltd

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Introduction

This User Manual contains data sheets about a range of temperature sensors, including yours.

This User Manual should be used in conjunction with the appropriate logger's user manual or online help when using these sensors with a Delta-T Logger

Figure 1 Delta-T temperature sensors

Thermistor Probes

Thermistors have a non- linear resistance response to temperature, so the measured resistance is converted to temperature in a data logger by the use of a look-up table. Loggers made by Delta-T can do this.

Historically thermistors were not as accurate as a Platinum resistance thermometers, but for many years now the precision obtainable with thermistors (±0.1 or ±0.2°C) has been acceptable for many purposes.

Thermistors supplied by Delta-T are usually 2K or 10K – which describes their resistance at 25°C. We supply a range of 2K thermistors, differentiated by their accuracy and construction - the way they are sealed and the cabling - these being optimised for different environments and uses.

The 2K thermistor probes supplied by Delta-T conform to the Fenwall UUA32J2 specification.

The 10K thermistor, used in the ST4 sensor has a resistance of 10K at 25°C and conforms to Fenwall code UUA41J1 and the BetTherm code 10K3A1B.

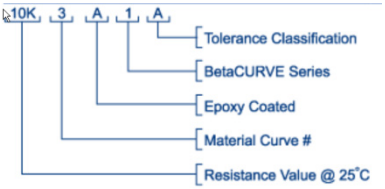


Figure 2: Part numbering system used by BetaTHERM

Notes

DL2e and DL6 loggers are optimised for use with 2K thermistors

GP2 logger-controllers can be used with both 2K and 10K thermistors without significantly affecting their accuracy.

GP1 logger accuracy with 10K and 2K thermistors depends on the logger temperature. See ***GP1 contribution to thermistor reading accuracy*** on page 15. Note also we only quote typical values for the GP1 contribution to thermistor accuracy, whereas for our other loggers we quote worst case figures.

DL2e logger supports 2K and also 2.252K, 10K and 100K thermistors

General Purpose Thermistor probes.

ST1 and GT1

The ST1 and GT1 (which is identical) are general purpose probes utilising a 2K thermistor sensor. This is contained in a stainless steel sheath of 4.8mm nominal outside diameter, 125mm long, which is, in turn, connected to a two core cable, 5m long. Accuracy over a temperature range of 0 to 70 °C is ±0.2°C.

ST2

The ST2 is similar to ST1, but with higher accuracy. It is fitted with a 2K thermistor sensor whose accuracy over a temperature range of 0 to 70 °C is ±0.1°C.

ST4

The ST4 has a 10K thermistor in a 120 mm long stainless steel shaft of diameter 6mm attached to 5 or 10m of co-axial cable with PVC outer sheath, the screen acting as part of the signal loop.
Accuracy: ± 0.2°C.
Minimum operating temperature: -10°C
Maximum operating temperature: +40°C
Environmental rating: IP67

This sensor is supported by a selectable sensor type in the DL2e logger program (Ls2Win) and the DeltaLINK software (used with GP1, GP2 and DL6 loggers).

The linearization table is of type 10K3A1B.

MT2

The MT2 has a 2K microchip thermistor accurate to ±0.1°C over 0-70°C.
It has a thin protective coating of vinyl. The thermistor is connected to a four-core extension cable, 5 metres long.

The vinyl dip provides an electrically insulating coating but is quite thin and not rugged, so the probe should not be used in water or other electrically conductive liquids.

This sensor is suitable as a high accuracy small temperature sensor with a fast response time for use in situations not requiring hermetic sealing against moisture.

Thermistor resistance: 2000 Ohm at 25°C.
Resistance vs temperature table: Fenwal UUA32J2, also Betatherm 2K3A9

Accuracy:	±0.1°C over 0-70°C
	±0.2°C at -40°C
	±0.15°C at 100°C
	± 1.0°C at 150°C
Range:	-50 to + 150°C
Stability :	±0.2°C in 8 years at 25°C
Size:	2.4 mm square (max)
Probe operating temp :	-30°C to 80°C - limited by cable

Cable : 5 metre long, 3.2mm diameter,
4-core, so suitable for 4,3 or 2-wire connection.

Thermistor Probes for Immersion in Water

ST3

The ST3 is similar to the general purpose ST2, except that it has a sheath-to-cable seal and corrosion-resistant PVDF cable that will improve operational life if immersed for long periods in FRESH water.

BT1

The BT1 thermistor probe is designed for immersion in SALT or FRESH water. The sensor is 150mm long by 6 mm diameter, with a 5 metre two core cable. The cable is covered in corrosion - resistant PVDF and may also be immersed.

These probes can be supplied to special order with a longer cable for use at greater immersion depths, or with an extension lead of PVC covered cable where immersion is to be less than 5 metres.

MT3

This is a sealed miniature catheter-style probe in a flexible nylon tube (100mm x 2mm), with a fast response suitable for immersion in sea water.

Resistance:	2K at 25˚C
Table type:	UUA32J2
Accuracy:	±0.1°C over 0-70°C
Range:	-50 to +150°C
Probe length/dia:	2.5mm
Cable :	5 metre long, 2-core

Tables of resistance versus temperature

Delta-T loggers have look-up tables in memory for thermistor sensors.

The appropriate table is identified by the sensor type code. For example for a 2K thermistor the sensor type code is TM1 or Fenwall UUA32J2, depending on which logger you are using. This code corresponds to the UUA32J2 specification and converts the signal from the sensor into degrees centigrade before logging the data.

Note that the look up tables behind these codes only cover a limited range , typically -20 to + 60˚C , or -40 to + 70˚C, depending on the logger. You may extend the range by defining your own non-linear look-up table, using the data below. Your logger User Manual explains how to do this.

2K Thermistor Table – in 1°C steps

°C	Ohms	°C	Ohms	°C	Ohms	°C	Ohms	°C	Ohms	°C	Ohms	°C	Ohms
-50	134020	-20	19414	10	3980	40	1065.4	70	350.4	100	135.7	130	60.2
-49	124820	-19	18322	11	3794	41	1023.4	71	338.6	101	131.8	131	58.7
-48	116300	-18	17298	12	3618	42	983.4	72	327.2	102	128.1	132	57.3
-47	108440	-17	16338	13	3450	43	945.4	73	316.4	103	124.4	133	55.8
-46	101141	-16	15436	14	3292	44	908.6	74	306	104	120.9	134	54.4
-45	94380	-15	14590	15	3142	45	874	75	295.8	105	117.5	135	53.1
-44	88120	-14	13796	16	3000	46	840	76	286.2	106	114.2	136	51.9
-43	82320	-13	13048	17	2864	47	808	77	276.8	107	111	137	50.6
-42	76940	-12	12346	18	2736	48	778	78	268	108	107.9	138	49.4
-41	71940	-11	11686	19	2614	49	748.6	79	259.4	109	105	139	48.2
-40	67300	-10	11066	20	2498	50	720.6	80	251	110	102.1	140	47.1
-39	62980	-9	10480	21	2388	51	693.4	81	243	111	99.3	141	45.9
-38	58960	-8	9930	22	2284	52	668	82	235.4	112	96.6	142	44.9
-37	55240	-7	9412	23	2184	53	643.4	83	228	113	94	143	43.8
-36	51760	-6	8924	24	2090	54	619.8	84	220.8	114	91.5	144	42.8
-35	48540	-5	8466	25	2000	55	597.2	85	214	115	89	145	41.8
-34	45520	-4	8032	26	1914.6	56	575.6	86	207.2	116	86.7	146	41.8
-33	42720	-3	7622	27	1833.4	57	554.8	87	200.8	117	84.3	147	39.9
-32	40100	-2	7238	28	1755.4	58	535	88	194.7	118	82.1	148	39
-31	37660	-1	6874	29	1681.4	59	515.8	89	188.8	119	80	149	38.1
-30	35400	0	6530	30	1611.4	60	497.6	90	183.1	120	77.9	150	37.2
-29	33260	1	6206	31	1544.6	61	480	91	177.5	121	75.9		
-28	31280	2	5900	32	1480.6	62	463.2	92	172.2	122	73.9		
-27	29440	3	5610	33	1419.4	63	447	93	167.1	123	72		
-26	27700	4	5338	34	1361.4	64	431.4	94	162.1	124	70.12		
-25	26080	5	5078	35	1306	65	416.6	95	157.3	125	68.34		
-24	24560	6	4834	36	1253.4	66	402.2	96	152.7	126	66.6		
-23	23140	7	4602	37	1203.4	67	388.4	97	148.2	127	64.9		
-22	21820	8	4384	38	1155.4	68	375.2	98	143.9	128	63.3		
-21	20580	9	4176	39	1109.4	69	362.6	99	139.7	129	61.7		

Effect of cable resistance

For probes using a thermistor sensor, the resistance of any extension lead fitted would be additional to the probe values shown in the Table of Resistance vs Temperature.

The standard cable sheath material used for ST1 & 2 is PVC, and for ST3 & BT1 is PVDF. These both have an operating temperature range of -20 to +80*C.

Typically, the resistance of each cable core is 5.85 and 7.92 per 100m for PVC and PVDF sheathed cables respectively.

With 2000 ohm and other low value thermistors on long cables, the cable resistance may cause small errors. The increased resistance reading causes a reduction in the temperature reading. The following table shows the temperature error in degrees error per ohm of cable resistance:

For thermistor types 2K and 2K252:

Sensor Temperature, °C	Cable Error, °C/Ω
-20	-0.001
+20	-0.009
+40	-0.023
+60	-0.055

Note that:

The effect is temperature dependant and most pronounced at higher temperatures when the thermistor resistance is low.

For 2-wire connection, the resistance of both connecting leads must be included.

For 3-wire connection, only the return lead contributes to the error.

Data Logger accuracy

The accuracy of temperature measurement depends both on the accuracy of the sensor, given above, and on the accuracy of the logger.

GP2: The contribution of the GP2 logger to the accuracy of our standard 2K and 10K thermistor readings is considered to be negligible.

GP1: The GP1 logger electronics is optimised for 10K thermistors.

DL2e & **DL6**: These loggers give optimum accuracy for 2K thermistors.

For more detail see the respective user manuals.

Thermocouple Probes

General Purpose probes.

STK1

The STK1 is a general purpose probe utilising a nickel-chromium (Chromal)/nickel-aluminium (Alumel), K type, thermocouple sensor. This is contained in a stainless steel sheath of 4.8mm nominal outside diameter, 125mm long, which is, in turn, connected to a two core cable, 5m long.

Cable information

Lead colour	Core material	Connect to
Brown	nickel-chromium	Instrumentation terminal +ve
Blue	nickel-aluminium	Instrumentation terminal -ve

The materials used in the construction of the probe allow its use over a temperature range of -50 to 250 *C.

The STK1 provides a direct millivolt output complying with ANSI C96:Special specification. This results in an output of approximately 42 microvolts per °C above reference junction temperature. This voltage can be converted to °C by DL2e and GP2 loggers, using the logger as the reference junction. The resultant sensor accuracy over a temperature range of 0 to 70 °C is ±1.5°C.

The logger software allows direct conversion to temperature over the range from -120 to +200 °C, using sensor type TCK or 'Thermocouple, type K', depending on the logger used. This can be modified by defining your own non-linear look-up table. For details of how to do this, please refer to your logger User Manual or on-line help in the logger software.

Logger accuracy

The uncertainty in a temperature measurement depends on the accuracy of the sensor, given above, and on the accuracy of the logger. The Delta-T Loggers accuracy contribution at different equipment temperatures is given in the appropriate logger user manual.
This is added to the accuracy of the sensor to obtain system accuracy.
See also page 27

Appendix 1: GP1 and DL6 Logger Thermistor Tables

GP1 and DL6 loggers use the following lookup tables.

Note that these tables differ slightly from the standard thermistor resistance vs temperature tables. This is done to optimise the logger's contribution to the overall accuracy when interpolating between the points on the lookup table.

DeltaLINK's 2K thermistor table for GP1 and DL6 Loggers

UUA32J2

Ohm	Degrees C
26034.0	-25
19388.0	-20
14576.0	-15
11058.0	-10
8462.6	-5
6530.3	0
5079.2	5
3980.9	10
3142.9	15
2498.8	20
2000.0	25
1611.2	30
1306.0	35
1064.9	40
873.31	45
720.13	50
596.96	55
497.38	60
416.44	65

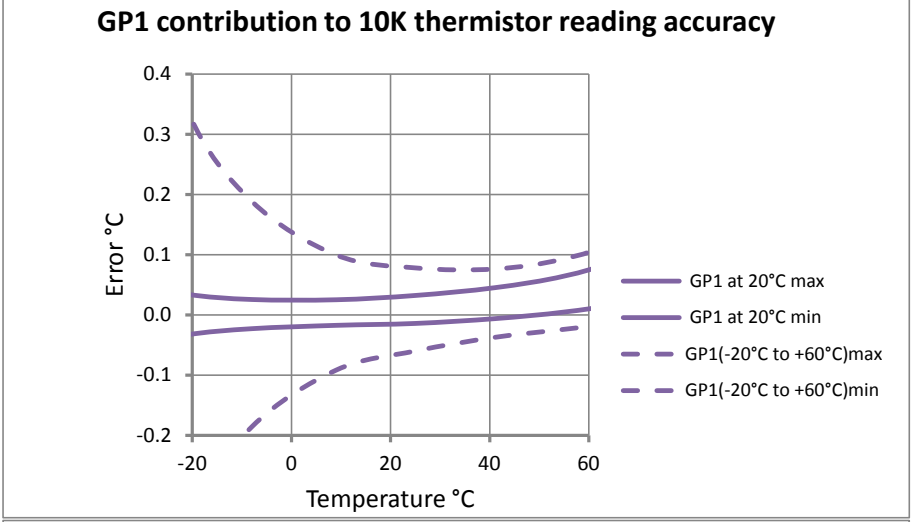
Note: See also the contribution of the GP1 to reading accuracy on page 15

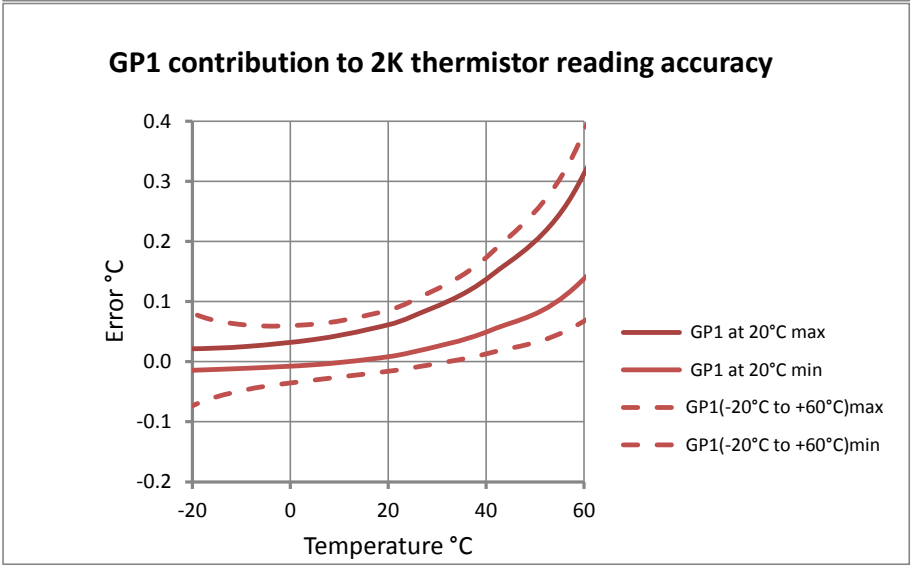
DeltaLINK's 10K thermistor table for GP1 and DL6 Loggers

10K3A1B

Ohm	Degrees C
129940	-25
108747	-22
91327	-19
76961	-16
65067	-13
55192	-10
46960	-7
40078	-4
34307	-1
29451	2
25355	5
21888	8
18945	11
16441	14
14305	17
12477	20
10908	23
9560	26
8397	29
7393	32
6523	35
5767	38
5110	41
4537	44
4036	47
3598	50
3213	53
2874	56
2576	59
2313	62
2081	65

GP1 contribution to thermistor reading accuracy

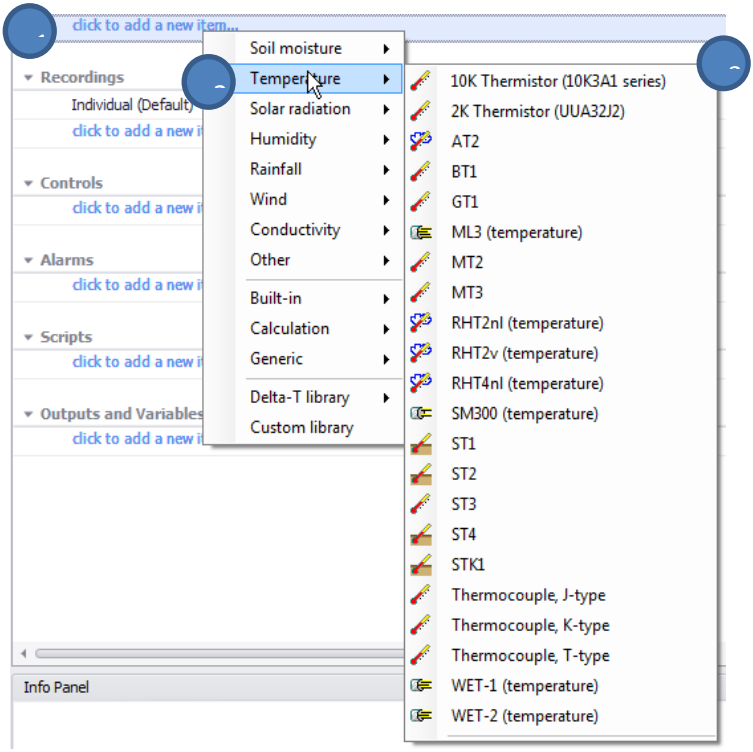




A 10K thermistor is usually considered to be more accurate than a 2K thermistor when used with a GP1 logger, but as these graphs show, at lower temperatures the GP1 may perform better with a 2K thermistor. Note: these values are typical, not worst case.

Appendix 2: GP2 Logger-Controller Temperature Sensors

DeltaLINK version 3 and later provides easy-to-configure pre-defined sensor type support in the GP2 Logger Controller for the following Delta-T temperature sensors:



This screenshot shows the simple three clicks needed to select a temperature sensor when creating a simple logger-control program for the GP2 using the DeltaLINK3 PC software.

Comprehensive user instructions are provided within the DeltaLink3 software for wiring-up and using each sensor.

A typical “Info Panel ” information page from the DeltaLINK3 sensor library for the GP2 logger-controller is shown here for a 10K thermistor probe …

Info Panel

10K Thermistor probe

Delta-T Devices
SENSOR

DESCRIPTION

Sensor type: 10K Thermistor (10K3A1 series)
Measures temperature, in the range -25 to +150 deg C, using 10K3A1 series thermistor

WIRING

Click image to toggle it's size.

Colour	Thermistor wiring	GP2 terminal	Notes
-	Resistance HI	CH (+) and CH (-)	Fit wire link
-	Resistance LO	SGND	

Note: The channel numbers are for illustration only. Other channel numbers are also possible.

MEASUREMENT PROPERTIES

Property	*Value*
Settling time (ms) (Advanced property)	The default settling time of 12 ms is suitable for measuring temperatures down to -25 deg C using up to 25 m of cable with 5 nF total cable capacitance. For longer cables or larger cable capacitance see Settling time (ms)
Cable resistance (ohm) (Advanced property)	To correct for resistance of long cable lengths measure the cable resistance with a multimeter and enter the value here. Include the combined series resistance of both (i.e. Signal HI and Signal LO) wires. At 60 deg C the sensitivity of a 10K Thermistor is 90 ohm per deg C, so the cable resistance correction will not significantly affect accuracy. At 150 deg C the sensitivity is 4 ohm per deg C, so 1 ohm of cable resistance will cause a 0.25 deg C error.
Power channel	The default value 'None' is suitable because 10K Thermistor doesn't require a power supply.

See also:
General (Measurement) properties
Input (Measurement) properties
Resistance (Input) properties
Linearization table (Calculation) properties
Result properties

CHECK SENSOR IS WORKING

1. Connect the sensor to the logger as shown above.
2. Connect the logger to the PC and run DeltaLINK.
3. Make sure the logger is programmed to read a 10k thermistor from the channel it is connected to, and is selected into a suitable Recording.
4. Select the Sensors window and click **Read now**. You should have a reading from the sensor.
5. Put the sensor between your hands and try to warm it up - you should see the temperature reading increase.
6. Hold the sensor in the air and wave it around - you should see the temperature reading decrease.

GP2 Thermistor Tables

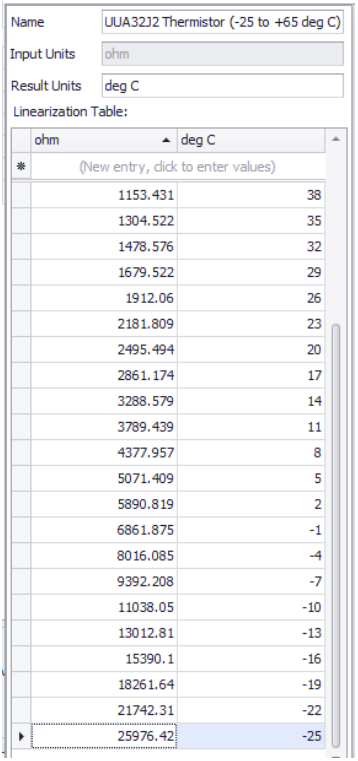
Five look-up tables are provided in the GP2 sensor library for three different types of thermistor.

Ω at 25°C	Type	Table Range
2K	UUA32J2	-25 to + 65°C
2K	UUA32J2	-40 to + 125°C
10K	10K3A1	-25 to + 65°C
10K	10K3A1	-25 to + 150°C
10K	ERTJ1VG103FA*	-25 to + 65°C

* Used in Delta-T soil moisture sensors type ML3 and SM300

Note: The temperature range over which a particular thermistor can be used may be restricted by other parts, (for instance the ST4's PVC sheath's limit is from -10 to +40°C)

The screenshot at right shows part of the GP2's 2K thermistor table, displayed in DeltaLINK, and which covers, and is optimised for, -25 to + 65°C.



Name: UUA32J2 Thermistor (-25 to +65 deg C)
Input Units: ohm
Result Units: deg C
Linearization Table:

ohm	deg C
(New entry, click to enter values)	
1153.431	38
1304.522	35
1478.576	32
1679.522	29
1912.06	26
2181.809	23
2495.494	20
2861.174	17
3288.579	14
3789.439	11
4377.957	8
5071.409	5
5890.819	2
6861.875	-1
8016.085	-4
9392.208	-7
11038.05	-10
13012.81	-13
15390.1	-16
18261.64	-19
21742.31	-22
25976.42	-25

Appendix 3: DL2e Logger

DL2e Logger:- 2K Thermistor Wiring

This measures temperatures in the range -20 to +60 deg C, using Fenwall UUA32J2 or BetaCURVE 2K3A1 thermistor types. This the type of thermistor that is fitted to the DL2e's terminal panel as the built-in cold-junction thermistor, and several Delta-T temperature probes (types **AT2, BT1, MT2,MT3, RHT2nl-02, ST1, ST2, ST3,ST4, GT1**) thermistor use this type of thermistor as their sensing element.

Sensors may have two or four wires. Generic sensor connections are shown below for each of the analogue input card types, followed by specific details for the Delta-T probes and sensors.

Note that the sensors are electrically symmetrical, so **Resistance HI** is interchangeable with **Resistance LO**, and in the four wire version, Resistance and Sense HI and LO are interchangeable in pairs.

Generic 2-wire connection:

FUNCTION	**LAC1 30-ch**	**LAC1 15-ch and ACD1**	**LFW1**
Resistance HI	IN (+)	IN (+), IN (--)	IN (+), IN (I}
Resistance LO	IN (--)	AGND	IN (--), AGND
Screen	DGND*	DGND*	DGND*

Generic 4-wire connection:

FUNCTION	**LAC1 30-ch**	**LAC1 15-ch and ACD1**	**LFW1**
Resistance HI	IN (+)	IN (+)	IN (I}
Sense HI	n/c	IN (--)	IN (+)
Resistance LO	IN (--)	AGND	AGND
Sense LO	n/c	AGND	IN (--)
Screen	DGND*	DGND*	DGND*

* If present, connect the screen to DGND unless the screen is connected to DGND elsewhere (eg connected to the body of the sensor, and the sensor body is connected to DGND).

Air Temperature Probe, type AT2:

WIRE	FUNCTION	LAC1 30-ch	LAC1 15-ch and ACD1	LFW1
Red	Resistance HI	IN (+)	IN (+), IN (--)	IN (+), IN (I}
Braid	Resistance LO	IN (--)	AGND	IN (--), AGND

Sealed Thermistor Probe, type BT1:

WIRE	FUNCTION	LAC1 30-ch	LAC1 15-ch and ACD1	LFW1
Brown	Resistance HI	IN (+)	IN (+), IN (--)	IN (+), IN (I}
Black	Resistance LO	IN (--)	AGND	IN (--), AGND

Miniature Thermistor Probe, types MT2, MT3:

WIRE	FUNCTION	LAC1 30-ch	LAC1 15-ch and ACD1	LFW1
Red	Resistance HI	IN (+)	IN (+)	IN (I}
Yellow	Sense HI	n/c	IN (--)	IN (+)
Blue	Resistance LO	IN (--)	AGND	AGND
Green	Sense LO	n/c	AGND	IN (--)
Braid	Screen	DGND	DGND	DGND

Air Temperature Sensor, type RHT2nl-02:

WIRE	FUNCTION	LAC1 30-ch	LAC1 15-ch and ACD1	LFW1
Blue	Thermistor HI,	IN (+)	IN (+), IN (--)	IN (+),IN (I}
Yellow	Thermistor LO	IN (--)	AGND	IN (--), AGND
Braid	Screen	61 or 62 (--)	for EMC compliance	

Soil Temperature Probes, types ST1, ST2, GT1:

WIRE	FUNCTION	LAC1 30-ch	LAC1 15-ch and ACD1	LFW1
Red	Resistance HI	IN (+)	IN (+), IN (--)	IN (+), IN (I}
Braid	Resistance LO	IN (--)	AGND	IN (--), AGND

Immersible Temperature Probes, type ST3:

WIRE	FUNCTION	LAC1 30-ch	LAC1 15-ch and ACD1	LFW1
Brown	Resistance HI	IN (+)	IN (+), IN (--)	IN (+), IN (I}
Black	Resistance LO	IN (--)	AGND	IN (--), AGND

DL2e Logger:- 2.252K Thermistor wiring

This measures temperatures in the range -20 to +60°C, using the Fenwall UUA32J3 thermistor.

Sensors may be supplied with two or four wires. Generic sensor connections are shown below for each of the analogue input card types.

Note that the sensors are electrically symmetrical, so Resistance HI is interchangeable with Resistance LO, and in the four wire version, Resistance and Sense HI and LO are interchangeable in pairs.

2-wire connection:

FUNCTION	LAC1 30-ch	LAC1 15-ch and ACD1	LFW1
Resistance HI	IN (+)	IN (+), IN (--)	IN (+), IN (I}
Resistance LO	IN (--)	AGND	IN (--), AGND
Screen	DGND*	DGND*	DGND*

4-wire connection:

FUNCTION	LAC1 30-ch	LAC1 15-ch and ACD1	LFW1
Resistance HI	IN (+)	IN (+)	I
Sense HI	n/c	IN (--)	IN (+)
Resistance LO	IN (--)	AGND	AGND
Sense LO	n/c	AGND	IN (--)
Screen	DGND*	DGND*	DGND*

* If present, connect the screen to DGND unless the screen is connected to DGND elsewhere (eg connected to the body of the sensor, and the sensor body is connected to DGND).

DL2e Logger:- 10K Thermistor Wiring

This measures temperatures in the range -20 to +60°C, using the Fenwall UUA41J1 thermistor.

Sensors may be supplied with two or four wires. Generic sensor connections are shown below for each of the analogue input card types.

Note that the sensors are electrically symmetrical, so Resistance HI is interchangeable with Resistance LO, and in the four wire version, Resistance and Sense HI and LO are interchangeable in pairs.

2-wire connection:

FUNCTION	LAC1 30-ch	LAC1 15-ch and ACD1	LFW1
Resistance HI	IN (+)	IN (+), IN (--)	IN (+), IN (I}
Resistance LO	IN (--)	AGND	IN (--), AGND
Screen	DGND*	DGND*	DGND*

4-wire connection:

FUNCTION	LAC1 30-ch	LAC1 15-ch and ACD1	LFW1
Resistance HI	IN (+)	IN (+)	I
Sense HI	n/c	IN (--)	IN (+)
Resistance LO	IN (--)	AGND	AGND
Sense LO	n/c	AGND	IN (--)
Screen	DGND*	DGND*	DGND*

* If present, connect the screen to DGND unless the screen is connected to DGND elsewhere (eg connected to the body of the sensor, and the sensor body is connected to DGND).

DL2e Logger:- 100K Thermistor Wiring

This measures temperatures in the range -20 to +60°C, using the Fenwall UUAT51J1 thermistor.

Sensors may be supplied with two or four wires. Generic sensor connections are shown below for each of the analogue input card types.

Note that the sensors are electrically symmetrical, so Resistance HI is interchangeable with Resistance LO, and in the four wire version, Resistance and Sense HI and LO are interchangeable in pairs.

2-wire connection:

FUNCTION	LAC1 30-ch	LAC1 15-ch and ACD1	LFW1
Resistance HI	IN (+)	IN (+), IN (--)	IN (+), IN (I}
Resistance LO	IN (--)	AGND	IN (--), AGND
Screen	DGND*	DGND*	DGND*

4-wire connection:

FUNCTION	LAC1 30-ch	LAC1 15-ch and ACD1	LFW1
Resistance HI	IN (+)	IN (+)	I
Sense HI	n/c	IN (--)	IN (+)
Resistance LO	IN (--)	AGND	AGND
Sense LO	n/c	AGND	IN (--)
Screen	DGND*	DGND*	DGND*

* If present, connect the screen to DGND unless the screen is connected to DGND elsewhere (eg connected to the body of the sensor, and the sensor body is connected to DGND).

DL2e Thermistor Tables – in 2.5 °C steps

Temp (°C)	Resistance (kΩ) for sensor code and thermistor type:			
	TM1 (2K) Fenwal UUA 32J2	TM2 (2K252) Fenwal UUA 32J3	TM3 (10K) Fenwal UUA 41J1	TM4 (100K) Fenwal UUT 51J1
60.0	0.49760	0.56025	2.48780	22.5900
57.5	0.54490	0.61355	2.72450	24.9025
55.0	0.59720	0.67245	2.98610	27.4750
52.5	0.65570	0.73830	3.27840	30.3660
50.0	0.72060	0.81125	3.60230	33.5910
47.5	0.79300	0.89295	3.96510	37.2265
45.0	0.87400	0.98375	4.36840	41.2920
42.5	0.96440	1.08580	4.82140	45.8900
40.0	1.06540	1.19950	5.32640	51.0480
37.5	1.17940	1.32765	5.89530	56.8980
35.0	1.30600	1.47090	6.53140	63.4800
32.5	1.45000	1.63280	7.25045	70.9700
30.0	1.61140	1.81140	8.05680	79.4220
27.5	1.79440	2.02035	8.97120	89.0740
25.0	2.00000	2.25200	10.00000	100.0000
22.5	2.23400	2.51560	11.17050	112.5200
20.0	2.49800	2.81320	12.49200	126.7400
17.5	2.80000	3.15300	14.00100	143.0950
15.0	3.14200	3.53810	15.71100	161.7300
12.5	3.53400	3.97960	17.67150	183.2450
10.0	3.98000	4.48130	19.89900	207.8500
7.5	4.49300	5.05900	22.46450	236.3600
5.0	5.07800	5.71810	25.39100	269.0800
2.5	5.75500	6.48000	28.77450	307.1550
0.0	6.53000	7.35280	32.65000	351.0200
-2.5	7.43000	8.36640	37.15100	402.2750
-5.0	8.46600	9.53180	42.32600	461.5500
-7.5	9.67100	10.89050	48.35900	531.1000
-10.0	11.06600	12.45900	55.32600	611.8700
-12.5	12.69700	14.29700	63.48700	707.0600
-15.0	14.59000	16.42900	72.95100	818.0700
-17.5	16.81800	18.93700	84.09150	949.5050
-20.0	19.41400	21.86100	97.07200	n/a

DL2e Thermocouple Tables

Temp (°C)is the temperature difference between hot and cold junctions.

Temp (°C)	Output (mV) for sensor code and thermocouple type:		
	TCJ, type J, (Iron/Constantan)	TCK, type K, (Chromel/Alumel)	TCT, type T, (Copper/Constantan)
-120	-5.426	-4.138	-3.923
-110	-5.036	-3.852	-3.656
-100	-4.632	-3.553	-3.378
-90	-4.215	-3.242	-3.089
-80	-3.785	-2.920	-2.788
-70	-3.344	-2.586	-2.475
-60	-2.892	-2.243	-2.152
-50	-2.431	-1.889	-1.819
-40	-1.960	-1.527	-1.475
-30	-1.481	-1.156	-1.121
-20	-0.995	-0.777	-0.757
-10	-0.501	-0.392	-0.383
0	0.000	0.000	0.000
10	0.507	0.397	0.391
20	1.019	0.798	0.789
30	1.536	1.203	1.196
40	2.058	1.611	1.611
50	2.585	2.022	2.035
60	3.115	2.436	2.465
70	3.649	2.850	2.908
80	4.186	3.266	3.357
90	4.725	3.681	3.813
100	5.268	4.095	4.277
110	5.812	4.508	4.749
120	6.359	4.919	5.227
130	6.907	5.327	5.712
140	7.457	5.733	6.204
150	8.008	6.137	6.702
160	8.560	6.539	7.207
170	9.113	6.939	7.718
180	9.667	7.338	8.235
190	10.222	7.737	8.757
200	10.777	8.137	9.286

Accuracy Table for all Sensors

	Probe Type	Probe accuracy (°C)	Probe range (°C)	Cable type	Number of cores	Cable range (°C)	DL2e accuracy[b] (°C)	DL6 accuracy[c] (°C)	GP1 accuracy[d] (°C)
ST1-05	2k	±0.2	-50 to 150	PVC	2	-10 to +105	±0.14	±0.4	±0.4
ST2-05	2k	±0.1	-50 to 150	PVC	2	-10 to +105	±0.14	±0.4	±0.4
ST3-05	2k	±0.2	-20 to +80	poly-ethelene	2	-20 to +80	±0.14	±0.4	±0.4
ST4-05	10k	±0.2	-10 to +40	PVC	2[a]	-10 to +40			±0.14
STK1-05	K	±1.5	-50 to 250	PTFE	2	-50 to+250	±1.0		
BT1-05	2k	±0.1	-50 to 150	poly-ethelene	2	-20 to +80	±0.14	±0.4	±0.4
GT1-05	2k	±0.2	-50 to 150	PVC	2	-10 to +105	±0.14	±0.4	±0.4
MT2-05	2k	±0.1[f]	-50 to 150	Vy/TEFL[g]	4		±0.14	±0.4	±0.4
MT3-05	2k	±0.1	-50 to 150	nylon - PVC	2	-10 to +105	±0.14	±0.4	±0.4
AT2-05	2k	±0.1	-50 to 150	PVC	2	-10 to +105	±0.14	±0.4	±0.4

Notes
a: co-axial single-core with screen acting as signal loop
b: Additional (worst case) error due to DL2e at +15 to +25 °C
c: Additional (worst case) error due to DL6 at -10 to +50 °C
d: Additional (typical) error due to GP1 at 0 to +60 °C
e: Additional (worst case) error due to GP2 at -20 to +60 °C
see also page 14 of the Temperature Sensors User Manual v2
f: Over 0-70°C
g: Teflon lead, Vynyl tip

Warranty and Service

Terms and Conditions of Sale

Our Conditions of Sale (ref: COND: 1/07) set out Delta-T's legal obligations on these matters. The following paragraphs summarise Delta-T's position but reference should always be made to the exact terms of our Conditions of Sale, which will prevail over the following explanation.

Delta-T warrants that the goods will be free from defects arising out of the materials used or poor workmanship for a period of **two years** from the date of delivery.

Delta-T shall be under no liability in respect of any defect arising from fair wear and tear, and the warranty does not cover damage through misuse or inexpert servicing, or other circumstances beyond their control.

If the buyer experiences problems with the goods they shall notify Delta-T (or Delta-T's local distributor) as soon as they become aware of such problem.

Delta-T may rectify the problem by replacing faulty parts free of charge, or by repairing the goods free of charge at Delta-T's premises in the UK during the warranty period.

If Delta-T requires that goods under warranty be returned to them from overseas for repair, Delta-T shall not be liable for the cost of carriage or for customs clearance in respect of such goods. However, Delta-T requires that such returns are discussed with them in advance and may at their discretion waive these charges.

Delta-T shall not be liable to supply products free of charge or repair any goods where the products or goods in question have been discontinued or have become obsolete, although Delta-T will endeavour to remedy the buyer's problem.

Delta-T shall not be liable to the buyer for any consequential loss, damage or compensation whatsoever (whether caused by the negligence of the Delta-T, their employees or distributors or otherwise) which arise from the supply of the goods and/or services, or their use or resale by the buyer.

Delta-T shall not be liable to the buyer by reason of any delay or failure to perform their obligations in relation to the goods and/or services if the delay or failure was due to any cause beyond the Delta-T's reasonable control.

Service, Repairs and Spares

Users in countries that have a Delta-T distributor or technical representative should contact them in the first instance.

Spare parts for our own instruments can be supplied and can normally be despatched within a few working days of receiving an order.

Spare parts and accessories for products not manufactured by Delta-T may have to be obtained from our supplier, and a certain amount of additional delay is inevitable.

No goods or equipment should be returned to Delta-T without first obtaining the return authorisation from Delta-T or our distributor.

On receipt of the goods at Delta-T you will be given a reference number. Always refer to this reference number in any subsequent correspondence. The goods will be inspected and you will be informed of the likely cost and delay.

We normally expect to complete repairs within one or two weeks of receiving the equipment. However, if the equipment has to be forwarded to our original supplier for specialist repairs or recalibration, additional delays of a few weeks may be expected. For contact details see below.

Technical Support

Users in countries that have a Delta-T distributor or technical representative should contact them in the first instance.

Technical Support is available on Delta-T products and systems. Your initial enquiry will be acknowledged immediately with a reference number. Make sure to quote the reference number subsequently so that we can easily trace any earlier correspondence.

In your enquiry, always quote instrument serial numbers, software version numbers, and the approximate date and source of purchase where these are relevant.

Contact Details:

Tech Support Team
Delta-T Devices Ltd
130 Low Road, Burwell, Cambridge CB25 0EJ, UK
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