



TSSP-1
(Stainless Steel Thermistor Probe)
MANUAL

57-6028 Rev A

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NOTICES

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All other trademarks are property of their respective owners.

Manufacturer

Dyacon, Inc.
220 West 300 South
Newton, UT 84327
USA

Declarations

Dyacon TSSP-1™ is a passive resistor device and contains no digital or radio frequency components.

RoHS

All electronic and mechanical components conform to RoHS, Directive 2002/95/EC.

FCC CFR Part 15

This equipment complies with the limits for a Class A digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a commercial installation.

Warranty Information

Limited Hardware Warranty

Dyacon, Inc. warrants that all Dyacon products and components shall be free from defects in materials and workmanship for a period of one (1) year from the date of shipment when installed according to instruction manuals accompanying said hardware and used for the purpose for which said hardware was designed. In the event a defect in materials or workmanship is discovered and reported to Dyacon within the warranty period, Dyacon will at its option repair the defect or replace the defective product. This warranty does not apply where the product has been operated outside the specifications of the product. Dyacon's obligation hereunder will be limited to such repair or replacement. Customers shall have the responsibility to ship the defective equipment to Dyacon at its (customer's) expense, with all cost of shipment prepaid. Dyacon will ship the repaired or replaced item at its (Dyacon's) expense using the preferred shipment method of Dyacon.

Disclaimer of Warranties

The warranties set forth above are in lieu of all other warranties of Dyacon, whether written, oral, or implied. Dyacon makes no warranties regarding its products (hardware or software), including without limitation warranties as to merchantability, fitness for a particular purpose, any warranty arising from course of performance, course of dealing or usage of trade whether any of the foregoing warranties are either expressed or implied. Dyacon specifically makes no warranties as to the suitability of its products for any particular application. Dyacon shall in no event be liable for performance, or use of any product covered by this agreement whether such claim is based upon warranty contract (express or implied), strict liability, negligence, or otherwise. Any responsibility and/or liability of Dyacon shall, in connection with a warranted product, be limited in maximum amount to the original purchase price of that product.

Removal of Serial Number

Removal of the original serial number label voids any warranty on the device. Dyacon will not repair or update products if the serial number label is missing or legitimate ownership cannot be verified. Dyacon may not return equipment that is missing serial numbers or where legitimate ownership is in question.

Updates or Modifications

Dyacon shall be under no obligation to update or modify its products except as herein noted to correct defects or errors. Customer agrees that all representation and warranties contained herein shall be immediately null and void in the event of incorrect installation, modification, alteration, or change in or to any product affected by or on behalf of customer except for a change made by Dyacon or other direct supervision thereof.

TSSP-I INTRODUCTION

Scope

The content of this document is intended for integrators, installers, and users of TSSP-1™, which may hereinafter be referred to as “TSSP” or “thermistor”.

This document includes installation instructions, technical specifications, electrical requirements, and data protocol information. Some aspects of the equipment operation may be covered in other documents. Please contact Dyacon or visit the Dyacon.com website.

Technical Support

Contact Information

Dyacon, Inc.

220 West 300 South
Newton, UT 84327

Phone: (435) 753-1002

Email: support@dyacon.com

Internet: www.dyacon.com

Normal business hours are from 8:00 am to 5:00 pm. (Mountain Time Zone, GMT -0700)

Phone / Email Support

If you need technical support via the phone or email, please have the following information ready:

Product name, model number, and serial number.

Your name and name of the purchaser of the equipment.

Name of company, institution, or agency.

Phone number, email address.

Billing and Shipping address.

A clear description of the question or problem.

QUICK START

The following is for those who are already familiar with thermistors and their application.

Description

TSSP-1 is a precision NTC (Negative Thermal Coefficient) thermistor. The thermistor die is fully manufactured and assembled in the U.S.

Thermistor Connection

TSSP-1 is a simple thermistor probe. The cable leads connect directly to the thermistor.

White	Thermistor lead 1
Black	Thermistor lead 2

Thermistor Characteristics

R25C: 10 kohm at 25°C

Interchangeability Tolerance: +/-0.1°C at 0°C to 70°C

Response Curve: -4.4%/°C at 25°C

Steinhart-Hart Coefficients

$$^{\circ}\text{C} = -273.15 + \left[\frac{1}{A + B \cdot \ln(r) + C \cdot \ln(r)^2 + D \cdot \ln(r)^3} \right]$$

Where:

r = Thermistor resistance (Ω)

A = 0.001116401465500

B = 0.000237982973213

C = -0.000000372283234

D = 0.000000099063233

PRODUCT DETAILS

Product Description

TSSP-1 is a rugged sensor suitable for use in soil temperature, surface temperature, and liquid submersion temperature measurements.

TSSP is interchangeable to within 0.1°C. This means that the thermistor may be replaced with another TSSP and the temperature will not vary by more than 0.1°C throughout the range of 0°C to 70°C.

Other thermistors may be point-matched, or tested on only a single temperature point. TSSP thermistors are curve matched to all points within the 0°C to 70°C range.

The sensing element is a negative temperature coefficient (NTC) resistor that changes resistance with respect to temperature, otherwise known as a thermistor. Calculations performed on the resistance measurement will result temperature value.

Mechanical

TSSP-1 probe encloses a precision thermistor, made in the USA from raw materials, not a low cost off-shore source. Each thermistor chip is sorted and classified in a temperature controlled bath, rather than graded from a sample or batch process.

The thermistor component is dual potted using thermally conductive epoxy and then swaged (crimped) into a stainless steel tube. The swaging provides a robust cable strain relief and water-tight seal. This mechanical package ensures long product life and durability.



Unlike thermistors that are simply potted in simple straight tubes, the swaged stainless steel tube used for TSSP-1 will not come off in cyclic temperature environments.

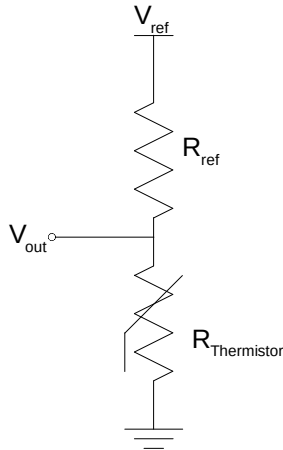
Dyacon TSSP-1 is sold with a 20 ft (6 m) cable. The cable may be trimmed to suit the needs of the application.

Thermistor Connection

TSSP-1 can be connected to a resistance meter or to an analog input port of a measurement instrument, such as a data logger.

The analog to digital converter (ADC) port on a data logger only measures resistance. Connecting the thermistor leads directly to the ADC will not provide a resistance value. A voltage divider must be constructed in order to measure the resistance.

This can be done by using a series resistor of a known value (R_{ref}) in series with the thermistor.



Additional length may be spliced to the cable without adverse consequence. The series resistance of the cable extension adds minimal resistance when compared to the thermistor resistance value. 1000 ft of 20 AWG wire only adds about 10 ohms, less than 0.2% of the thermistor resistance at 105°C. At lower temperatures and in most applications, the added resistance of an extension cable can be ignored.

Calculations

Thermistor Resistance

Based on the input voltage (V_{ref}), the reference resistor (R_{ref}), and the measured output voltage (V_{out}), the resistance value of the thermistor can be calculated.

$$R_{Thermistor} = \frac{R_{ref} \cdot V_{out}}{V_{ref} - V_{out}}$$

Steinhart-Hart Equation

The Steinhart-Hart equation models the resistance of the thermistor at different temperatures.

$$^{\circ}C = -273.15 + \left[\frac{1}{A + B \cdot \ln(r) + C \cdot \ln(r)^2 + D \cdot \ln(r)^3} \right]$$

Where:

$$r = R_{Thermistor} (\Omega)$$

$$A = 0.001116401465500$$

$$B = 0.000237982973213$$

$$C = -0.000000372283234$$

$$D = 0.000000099063233$$

The $C \cdot \ln(r)^2$ term is a small value and is typically neglected in most references since it usually has no significant effect on the results.

What Do You Get?

TSSP-1 Ships with the following

3 Outdoor-rated cable ties



What You Need

In order to utilize the TSSP-1 you will need the following.

Dyacon Control Module, data logger, or other analog to digital instrument.

10 kohm resistor (depending on instrument)

Wiring

TSSP-1 is not polarity dependent, it may be connected in either polarity. The cable leads connect directly to the thermistor. No stimulus voltage is required beyond that required to measure the resistance.

White Thermistor connection

Black Thermistor connection

Table of Thermistor Values

Temp (°C)	Min Resistance	Nominal (Ohms)	Max Resistance	NTC	Max Dev	+/- (°)
-40	323136.00	336600.00	350064.00	6.70	2.51	0.37
-39	302768.51	315200.00	327631.49	6.65	2.45	0.37
-38	283635.37	295100.00	306564.64	6.60	2.40	0.36
-37	265923.88	276500.00	287076.13	6.54	2.34	0.36
-36	249350.07	259100.00	268849.93	6.49	2.27	0.35
-35	233912.70	242900.00	251887.30	6.44	2.21	0.34
-34	219514.91	227800.00	236085.09	6.39	2.15	0.34
-33	206060.23	213700.00	221339.78	6.34	2.09	0.33
-32	193550.92	200600.00	207649.08	6.29	2.02	0.32
-31	181890.78	188400.00	194909.22	6.25	1.97	0.32
-30	170982.00	177000.00	183018.00	6.20	1.91	0.31
-29	160732.28	166300.00	171867.72	6.15	1.86	0.30
-28	151240.36	156400.00	161559.64	6.11	1.81	0.30
-27	142316.31	147100.00	151883.69	6.07	1.76	0.29
-26	133962.90	138400.00	142837.10	6.03	1.72	0.29
-25	126182.52	130300.00	134417.48	5.98	1.67	0.28
-24	118977.24	122800.00	126622.76	5.94	1.62	0.27
-23	112156.11	115700.00	119243.89	5.91	1.57	0.27
-22	105813.91	109100.00	112386.09	5.87	1.52	0.26
-21	99856.22	102900.00	105943.78	5.83	1.47	0.25
-20	94303.52	97120.00	99936.48	5.80	1.41	0.24
-19	89067.49	91670.00	94272.51	5.77	1.35	0.23
-18	84147.37	86550.00	88952.63	5.74	1.29	0.22
-17	79522.39	81740.00	83957.61	5.71	1.22	0.21
-16	75170.58	77220.00	79269.42	5.68	1.16	0.20
-15	71082.52	72980.00	74877.48	5.65	1.11	0.20
-14	67238.43	69000.00	70761.57	5.62	1.06	0.19
-13	63621.32	65260.00	66898.68	5.59	1.02	0.18
-12	60213.17	61740.00	63266.83	5.56	0.98	0.18
-11	57015.82	58440.00	59864.18	5.53	0.95	0.17
-10	54011.84	55340.00	56668.16	5.50	0.91	0.17
-9	51181.84	52420.00	53658.16	5.46	0.87	0.16
-8	48516.66	49670.00	50823.34	5.43	0.83	0.15
-7	46006.11	47080.00	48153.89	5.38	0.79	0.15
-6	43640.06	44640.00	45639.94	5.34	0.75	0.14
-5	41408.52	42340.00	43271.48	5.30	0.71	0.13
-4	39301.93	40170.00	41038.07	5.26	0.67	0.13
-3	37320.88	38130.00	38939.12	5.22	0.63	0.12
-2	35445.95	36200.00	36954.05	5.18	0.59	0.11
-1	33677.62	34380.00	35082.38	5.14	0.55	0.11
0	32493.43	32660.00	32826.57	5.10	0.51	0.10
1	30882.72	31040.00	31197.28	5.07	0.51	0.10

Temp (°C)	Min Resistance	Nominal (Ohms)	Max Resistance	NTC	Max Dev	+/- (°)
2	29361.39	29510.00	29658.61	5.04	0.50	0.10
3	27919.50	28060.00	28200.50	5.01	0.50	0.10
4	26557.11	26690.00	26822.89	4.98	0.50	0.10
5	25274.27	25400.00	25525.73	4.95	0.50	0.10
6	24061.01	24180.00	24298.99	4.92	0.49	0.10
7	22907.41	23020.00	23132.59	4.89	0.49	0.10
8	21813.45	21920.00	22026.55	4.86	0.49	0.10
9	20779.15	20880.00	20980.85	4.83	0.48	0.10
10	19804.48	19900.00	19995.52	4.80	0.48	0.10
11	18879.51	18970.00	19060.49	4.77	0.48	0.10
12	18004.24	18090.00	18175.76	4.74	0.47	0.10
13	17168.74	17250.00	17331.26	4.71	0.47	0.10
14	16382.95	16460.00	16537.05	4.68	0.47	0.10
15	15636.95	15710.00	15783.05	4.65	0.47	0.10
16	14930.72	15000.00	15069.29	4.62	0.46	0.10
17	14254.31	14320.00	14385.69	4.59	0.46	0.10
18	13617.67	13680.00	13742.33	4.56	0.46	0.10
19	13010.83	13070.00	13129.17	4.53	0.45	0.10
20	12433.80	12490.00	12546.21	4.50	0.45	0.10
21	11886.56	11940.00	11993.44	4.48	0.45	0.10
22	11369.12	11420.00	11470.88	4.46	0.45	0.10
23	10871.56	10920.00	10968.44	4.44	0.44	0.10
24	10403.84	10450.00	10496.16	4.42	0.44	0.10
25	9956.00	10000.00	10044.00	4.40	0.44	0.10
26	9531.05	9573.00	9614.95	4.38	0.44	0.10
27	9126.00	9166.00	9206.00	4.36	0.44	0.10
28	8739.86	8778.00	8816.14	4.35	0.43	0.10
29	8372.64	8409.00	8445.36	4.32	0.43	0.10
30	8023.35	8058.00	8092.65	4.30	0.43	0.10
31	7689.99	7723.00	7756.01	4.27	0.43	0.10
32	7372.57	7404.00	7435.43	4.25	0.42	0.10
33	7069.08	7099.00	7128.92	4.21	0.42	0.10
34	6780.52	6809.00	6837.48	4.18	0.42	0.10
35	6504.89	6532.00	6559.11	4.15	0.42	0.10
36	6242.19	6268.00	6293.81	4.12	0.41	0.10
37	5991.42	6016.00	6040.58	4.09	0.41	0.10
38	5751.58	5775.00	5798.42	4.06	0.41	0.10
39	5522.68	5545.00	5567.32	4.03	0.40	0.10
40	5304.70	5326.00	5347.30	4.00	0.40	0.10
41	5096.65	5117.00	5137.35	3.98	0.40	0.10
42	4896.55	4916.00	4935.45	3.96	0.40	0.10
43	4706.40	4725.00	4743.60	3.94	0.39	0.10
44	4525.20	4543.00	4560.80	3.92	0.39	0.10
45	4350.96	4368.00	4385.04	3.90	0.39	0.10
46	4184.70	4201.00	4217.30	3.88	0.39	0.10
47	4025.40	4041.00	4056.60	3.86	0.39	0.10
48	3873.07	3888.00	3902.93	3.84	0.38	0.10

Temp (°C)	Min Resistance	Nominal (Ohms)	Max Resistance	NTC	Max Dev	+/- (°)
49	3727.71	3742.00	3756.29	3.82	0.38	0.10
50	3588.31	3602.00	3615.69	3.80	0.38	0.10
51	3454.89	3468.00	3481.11	3.78	0.38	0.10
52	3327.44	3340.00	3352.56	3.76	0.38	0.10
53	3204.97	3217.00	3229.03	3.74	0.37	0.10
54	3087.47	3099.00	3110.53	3.72	0.37	0.10
55	2974.95	2986.00	2997.05	3.70	0.37	0.10
56	2867.41	2878.00	2888.59	3.68	0.37	0.10
57	2763.85	2774.00	2784.15	3.66	0.37	0.10
58	2665.26	2675.00	2684.74	3.64	0.36	0.10
59	2570.66	2580.00	2589.34	3.62	0.36	0.10
60	2479.04	2488.00	2496.96	3.60	0.36	0.10
61	2391.41	2400.00	2408.59	3.58	0.36	0.10
62	2307.75	2316.00	2324.25	3.56	0.36	0.10
63	2227.09	2235.00	2242.91	3.54	0.35	0.10
64	2149.41	2157.00	2164.59	3.52	0.35	0.10
65	2074.71	2082.00	2089.29	3.50	0.35	0.10
66	2003.01	2010.00	2016.99	3.48	0.35	0.10
67	1934.29	1941.00	1947.71	3.46	0.35	0.10
68	1868.56	1875.00	1881.44	3.44	0.34	0.10
69	1805.81	1812.00	1818.19	3.42	0.34	0.10
70	1745.05	1751.00	1756.95	3.40	0.34	0.10
71	1647.45	1692.00	1736.55	3.39	0.37	0.11
72	1592.43	1636.00	1679.57	3.38	0.40	0.12
73	1539.41	1582.00	1624.59	3.37	0.43	0.13
74	1488.37	1530.00	1571.63	3.36	0.46	0.14
75	1439.30	1480.00	1520.70	3.35	0.49	0.15
76	1392.18	1432.00	1471.82	3.34	0.52	0.16
77	1346.05	1385.00	1423.95	3.33	0.55	0.17
78	1301.90	1340.00	1378.10	3.33	0.58	0.17
79	1259.74	1297.00	1334.26	3.31	0.61	0.18
80	1219.58	1256.00	1292.42	3.30	0.64	0.19
81	1180.44	1216.00	1251.56	3.28	0.66	0.20
82	1143.31	1178.00	1212.69	3.26	0.69	0.21
83	1107.17	1141.00	1174.83	3.24	0.71	0.22
84	1072.04	1105.00	1137.96	3.22	0.72	0.22
85	1038.87	1071.00	1103.13	3.20	0.74	0.23
86	1006.68	1038.00	1069.32	3.18	0.76	0.24
87	975.46	1006.00	1036.54	3.16	0.78	0.25
88	945.12	974.90	1004.68	3.14	0.80	0.25
89	916.03	945.10	974.17	3.12	0.82	0.26
90	887.99	916.40	944.81	3.10	0.84	0.27
91	860.92	888.70	916.48	3.08	0.87	0.28
92	834.80	862.00	889.20	3.06	0.90	0.29
93	809.56	836.20	862.84	3.04	0.93	0.31
94	785.29	811.40	837.51	3.02	0.96	0.32
95	761.81	787.40	812.99	3.00	0.99	0.33

Temp (°C)	Min Resistance	Nominal (Ohms)	Max Resistance	NTC	Max Dev	+/- (°)
96	739.12	764.20	789.28	2.98	1.02	0.34
97	717.31	741.90	766.49	2.96	1.05	0.35
98	696.21	720.30	744.39	2.94	1.09	0.37
99	675.80	699.40	723.00	2.92	1.11	0.38
100	656.11	679.20	702.29	2.90	1.14	0.39
101	637.11	659.70	682.29	2.89	1.16	0.40
102	618.82	640.90	662.98	2.88	1.19	0.41
103	601.03	622.60	644.17	2.87	1.20	0.42
104	583.93	605.00	626.07	2.86	1.22	0.43
105	567.42	588.00	608.58	2.85	1.24	0.44

Max Dev

Max Deviation is the manufacturing tolerance represented as a percent of the resistance value. This deviation is added to the tolerance of the part.

NTC

The NTC column is a representation of the slope of the response curve, the percentage of resistance value change per degree Celsius ($\Delta R\% / ^\circ C$)

TSSP is curve matched and does not have a fixed tolerance. The following is given for reference information only.

For point-matched thermistors, the NTC value can also be used to determine the temperature tolerance at any given temperature.

$$\text{Tolerance} / \text{NTC}_{25} = \text{Tolerance}$$

For a 1% thermistor, the NTC value at 25°C is 4.4%:

$$1\% / 4.4 = +/-0.23^\circ C \quad (\text{TSSP is } +/-0.1^\circ C)$$

At 40°C:

$$1\% / 4.0 = +/-0.25^\circ C \quad (\text{TSSP is } +/-0.1^\circ C)$$

Even for a 1% thermistor, you can see that TSSP has much better performance through the 0°C to 70°C range.

Note: Other resistance characteristics may be appropriate from some applications. Contact Dyacon if you would like to explore options for point-matched or different curve-matched thermistors.

+/- (Temp Tolerance)

The temperature tolerance value is calculated from the NTC value.

CONVERSIONS

Temperature Conversion

$$\text{Temperature (°F)} = \text{°C} * 1.8 + 32$$

REPAIR AND SERVICE

Return Authorization

All equipment sent to Dyacon for calibration, warranty, or service should have a return material authorization (RMA) number indicated on the outside of the package. Include a detailed description of the problem and any to be performed on the returned unit.

An RMA number may be requested by phone or email.

Phone: 1-435-753-1002

Email: support@dyacon.com

Normal business hours are 8 am to 5 pm. (Mountain Time Zone, GMT -0700)

Street Address

Dyacon, Inc.
220 West 300 South
Newton, UT 84327

US Mail Addresses

Dyacon, Inc.
PO Box 33
Newton, UT 84327

SPECIFICATIONS

THERMISTOR SPECIFICATIONS

Resistance	10 k ohms @ 25°C
Interchangeability Tolerance	+/- 0.1°C (within 0°C to 70°C/ 32°F to 158°F)
Measurement Range	-40°C to 105°C (-40°F to 220°F)
Storage Temperature	-40°C to 105°C (-40°F to 220°F)
Dissipation Constant	2 mW/°C
Time Constant	8 s, still air

MECHANICAL FEATURES

Sealed	IP68
Cable to Thermistor Connection	Thermistor leads welded to cable
Submersion Depth	Greater than 2 m (6 ft)
Cable Length	6.1 m (20 ft)
Wire	22 AWG, 7 x 30, Tin plated, PVC
Cable Jacket	PVC, Gray
Cable Diameter	3.8 mm (0.15 in)
Probe Dimensions	4.8 mm x 38.1 mm (0.188 in x 1.5 in)
Weight	
Probe Materials	Double potted with thermally conductive epoxy. Swaged in 305 stainless steel probe.

REVISION HISTORY

Rev	Description	Author	Date
A	Initial Release	E. Bodrero	05May2014