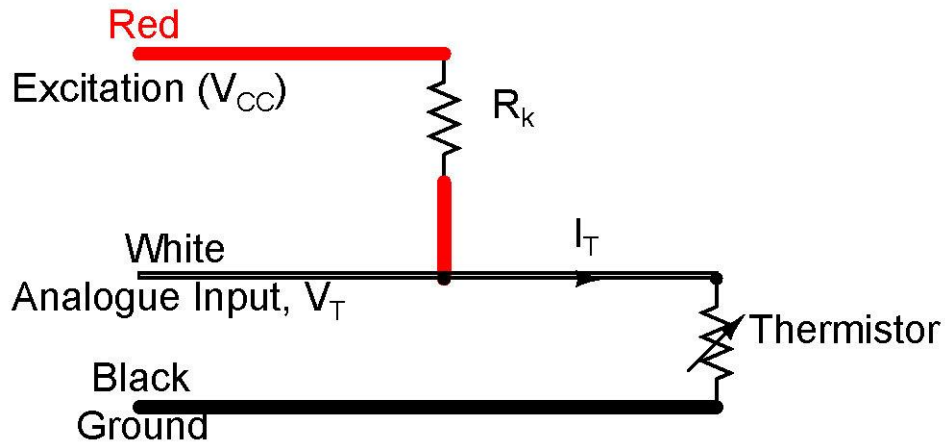


The thermistor is a resistive element, where resistance changes with temperature. The resistance of the thermistor is determined from a half bridge measurement, where an excitation voltage is applied across both the thermistor and a resistor component,  $R_K$ .



The resistor component,  $R_K$  and excitation,  $V_{CC}$  are chosen carefully so that for any thermistor temperature in the range of  $-40^{\circ}\text{C}$  to  $150^{\circ}\text{C}$  there will be a maximum of  $70\mu\text{A}$  through the thermistor (which minimises self-heating effects in the thermistor) and secondly the voltage measured across the thermistor is less than the maximum input to the ADC. Possible values for  $R_K$  given a discrete set of excitation voltages are given in the following table where the maximum ADC input is  $2.5\text{V}$ . The table shows the analogue input voltage,  $V_T$  and current,  $I_T$  through the thermistor for a discrete set of temperatures including the minimum and maximum temperatures. The resistor/supply combinations in the following table will work except for where a  $5\text{V}$  excitation is used with a  $200\text{k}\Omega$  resistor, however if measuring temperatures to  $-20^{\circ}\text{C}$ , a  $5\text{V}$  excitation and  $200\text{k}\Omega$  resistor could be used. It is recommend to apply the excitation voltages to the thermistors only when taking a measurement, not continuously.

$V_{CC}$ (V)	$R_K$ ( $\text{k}\Omega$ )	Thermistor Temperature									
		$-40^{\circ}\text{C}$		$-10^{\circ}\text{C}$		$25^{\circ}\text{C}$		$50^{\circ}\text{C}$		$125^{\circ}\text{C}$	
		Input, $V_T$ (V)	$I_T$ ( $\mu\text{A}$ )	Input, $V_T$ (mV)	$I_T$ ( $\mu\text{A}$ )	Input, $V_T$ (mV)	$I_T$ ( $\mu\text{A}$ )	Input, $V_T$ (mV)	$I_T$ ( $\mu\text{A}$ )	Input, $V_T$ (mV)	$I_T$ ( $\mu\text{A}$ )
2.5	200	1.75	3.7	582	9.6	119	11.9	44.1	12.2	4.5	12.5
2.5	100	2.06	4.4	944	15.6	227	22.7	86.6	24.1	8.9	24.9
3.6	200	2.52	5.4	838	13.8	171	17.1	63.4	17.7	6.4	17.9
5	500	2.41	6.0	541	8.9	98	9.8	35.6	9.9	3.6	10.0
5	200	3.5	7.5	1164	19.1	238	23.8	88.1	24.6	8.9	24.9
10	1200	2.8	6.0	481	7.9	82	8.3	29.8	8.3	3.0	8.3
12	1300	3.16	6.7	535	8.8	91	9.2	33.0	9.2	3.3	9.2

### Calculating the Thermistor Resistance

Thermistor resistance,  $R_T$  in ohms is measured with a half bridge measurement, requiring a known excitation voltage,  $V_{CC}$  and a measurement of the output voltage.

$$R_T = \frac{R_K}{\frac{V_{CC}}{V_t} - 1}$$

Where,  $R_K$  is the resistance of the resistor in ohms,  $V_{CC}$  is the excitation voltage in mV,  $V_T$  is the measured voltage from the half bridge in mV.

### Calculating the Temperature from Resistance

From resistance, the temperature is determined by either a lookup table or Steinhart-Hart equation. The lookup table for the Therm-SS is given on the following page. The Steinhart-Hart equation is:

$$T_K = \frac{1}{A + B \ln(R_T) + C (\ln(R_T))^3}$$

Where

$T_K$  is the temperature of the thermistor (in Kelvin)

$A$ ,  $B$  and  $C$  are the Steinhart-Hart coefficients

$$A = 2.774438e-03$$

$$B = 2.514554e-04$$

$$C = -1.275852e-07$$

If desired, the measured temperature in Kelvin can be converted to Degrees Celsius ( $T_C$ )

$$T_C = T_K - 273.15$$

The maximum error between the Steinhart-Hart equation and the reference table is less than 0.5°C for temperatures from -40°C to 120°C and less than 3°C from 120°C to 150°C.

# Therm SS R-T Table

R(25°C)=10kohm±0.5%				B(25/85)= 3976K±1%			
Temp.	Resistance(kΩ)			resistance tol. (%)		Temp.tol. (°C)	
°C	Rmin	R(t)Normal	Rmax	MIN	MAX	MIN	MAX
-40	446.29	466.10	486.78	-4.3%	4.4%	-0.56	0.59
-39	413.34	431.35	450.14	-4.2%	4.4%	-0.56	0.58
-38	383.10	399.49	416.57	-4.1%	4.3%	-0.55	0.58
-37	355.34	370.26	385.79	-4.0%	4.2%	-0.55	0.57
-36	329.82	343.41	357.55	-4.0%	4.1%	-0.54	0.56
-35	306.36	318.74	331.62	-3.9%	4.0%	-0.54	0.56
-34	284.76	296.05	307.78	-3.8%	4.0%	-0.53	0.55
-33	264.86	275.17	285.86	-3.7%	3.9%	-0.53	0.55
-32	246.53	255.93	265.69	-3.7%	3.8%	-0.52	0.54
-31	229.61	238.20	247.10	-3.6%	3.7%	-0.52	0.54
-30	214.00	221.85	229.97	-3.5%	3.7%	-0.51	0.53
-29	199.58	206.75	214.18	-3.5%	3.6%	-0.51	0.52
-28	186.25	192.81	199.59	-3.4%	3.5%	-0.50	0.52
-27	173.92	179.92	186.12	-3.3%	3.4%	-0.50	0.51
-26	162.51	168.00	173.67	-3.3%	3.4%	-0.49	0.51
-25	151.94	156.97	162.16	-3.2%	3.3%	-0.48	0.50
-24	142.15	146.75	151.50	-3.1%	3.2%	-0.48	0.49
-23	133.06	137.28	141.63	-3.1%	3.2%	-0.47	0.49
-22	124.64	128.50	132.48	-3.0%	3.1%	-0.47	0.48
-21	116.81	120.35	124.00	-2.9%	3.0%	-0.46	0.47
-20	109.54	112.79	116.13	-2.9%	3.0%	-0.45	0.47
-19	102.77	105.76	108.82	-2.8%	2.9%	-0.45	0.46
-18	96.485	99.221	102.03	-2.8%	2.8%	-0.44	0.45
-17	90.631	93.141	95.719	-2.7%	2.8%	-0.44	0.45
-16	85.178	87.483	89.848	-2.6%	2.7%	-0.43	0.44
-15	80.097	82.213	84.383	-2.6%	2.6%	-0.42	0.43
-14	75.359	77.302	79.294	-2.5%	2.6%	-0.42	0.43
-13	70.938	72.723	74.552	-2.5%	2.5%	-0.41	0.42
-12	66.812	68.452	70.130	-2.4%	2.5%	-0.40	0.41
-11	62.958	64.464	66.005	-2.3%	2.4%	-0.40	0.41
-10	59.356	60.740	62.155	-2.3%	2.3%	-0.39	0.40
-9	55.989	57.261	58.560	-2.2%	2.3%	-0.38	0.39
-8	52.838	54.007	55.200	-2.2%	2.2%	-0.38	0.38
-7	49.889	50.963	52.059	-2.1%	2.2%	-0.37	0.38
-6	47.128	48.115	49.121	-2.1%	2.1%	-0.36	0.37
-5	44.540	45.447	46.371	-2.0%	2.0%	-0.36	0.36
-4	42.115	42.948	43.796	-1.9%	2.0%	-0.35	0.35
-3	39.840	40.605	41.384	-1.9%	1.9%	-0.34	0.35
-2	37.705	38.408	39.123	-1.8%	1.9%	-0.33	0.34
-1	35.700	36.346	37.002	-1.8%	1.8%	-0.33	0.33
0	33.818	34.410	35.012	-1.7%	1.7%	-0.32	0.32
1	32.049	32.593	33.145	-1.7%	1.7%	-0.31	0.32
2	30.385	30.884	31.391	-1.6%	1.6%	-0.30	0.31
3	28.821	29.278	29.742	-1.6%	1.6%	-0.30	0.30
4	27.348	27.768	28.193	-1.5%	1.5%	-0.29	0.29
5	25.962	26.347	26.736	-1.5%	1.5%	-0.28	0.28

6	24.656	25.008	25.365	-1.4%	1.4%	-0.27	0.28
7	23.426	23.748	24.074	-1.4%	1.4%	-0.27	0.27
8	22.266	22.561	22.859	-1.3%	1.3%	-0.26	0.26
9	21.172	21.441	21.713	-1.3%	1.3%	-0.25	0.25
10	20.140	20.386	20.634	-1.2%	1.2%	-0.24	0.24
11	19.165	19.390	19.616	-1.2%	1.2%	-0.23	0.24
12	18.245	18.449	18.656	-1.1%	1.1%	-0.22	0.23
13	17.376	17.562	17.749	-1.1%	1.1%	-0.22	0.22
14	16.554	16.723	16.893	-1.0%	1.0%	-0.21	0.21
15	15.777	15.930	16.085	-1.0%	1.0%	-0.20	0.20
16	15.042	15.181	15.321	-0.9%	0.9%	-0.19	0.19
17	14.347	14.472	14.599	-0.9%	0.9%	-0.18	0.18
18	13.689	13.802	13.916	-0.8%	0.8%	-0.17	0.17
19	13.065	13.167	13.269	-0.8%	0.8%	-0.17	0.17
20	12.475	12.566	12.658	-0.7%	0.7%	-0.16	0.16
21	11.915	11.997	12.078	-0.7%	0.7%	-0.15	0.15
22	11.384	11.457	11.530	-0.6%	0.6%	-0.14	0.14
23	10.881	10.945	11.010	-0.6%	0.6%	-0.13	0.13
24	10.403	10.460	10.517	-0.5%	0.5%	-0.12	0.12
25	9.9500	10.000	10.050	-0.5%	0.5%	-0.12	0.12
26	9.5111	9.5632	9.6153	-0.5%	0.5%	-0.12	0.12
27	9.0946	9.1485	9.2024	-0.6%	0.6%	-0.13	0.13
28	8.6993	8.7546	8.8101	-0.6%	0.6%	-0.14	0.14
29	8.3238	8.3804	8.4372	-0.7%	0.7%	-0.16	0.16
30	7.9671	8.0248	8.0827	-0.7%	0.7%	-0.17	0.17
31	7.6282	7.6867	7.7455	-0.8%	0.8%	-0.18	0.18
32	7.3059	7.3651	7.4246	-0.8%	0.8%	-0.19	0.19
33	6.9995	7.0592	7.1192	-0.8%	0.9%	-0.20	0.20
34	6.7080	6.7681	6.8285	-0.9%	0.9%	-0.21	0.21
35	6.4306	6.4909	6.5516	-0.9%	0.9%	-0.22	0.22
36	6.1665	6.2269	6.2878	-1.0%	1.0%	-0.23	0.24
37	5.9151	5.9755	6.0363	-1.0%	1.0%	-0.25	0.25
38	5.6755	5.7359	5.7967	-1.1%	1.1%	-0.26	0.26
39	5.4473	5.5075	5.5681	-1.1%	1.1%	-0.27	0.27
40	5.2298	5.2897	5.3501	-1.1%	1.1%	-0.28	0.28
41	5.0224	5.0819	5.1420	-1.2%	1.2%	-0.29	0.29
42	4.8246	4.8837	4.9435	-1.2%	1.2%	-0.30	0.31
43	4.6359	4.6946	4.7538	-1.2%	1.3%	-0.32	0.32
44	4.4558	4.5140	4.5728	-1.3%	1.3%	-0.33	0.33
45	4.2839	4.3415	4.3998	-1.3%	1.3%	-0.34	0.34
46	4.1197	4.1768	4.2344	-1.4%	1.4%	-0.35	0.36
47	3.9629	4.0193	4.0764	-1.4%	1.4%	-0.36	0.37
48	3.8131	3.8689	3.9253	-1.4%	1.5%	-0.38	0.38
49	3.6700	3.7250	3.7808	-1.5%	1.5%	-0.39	0.39
50	3.5331	3.5874	3.6425	-1.5%	1.5%	-0.40	0.41
51	3.4026	3.4562	3.5106	-1.6%	1.6%	-0.41	0.42
52	3.2776	3.3305	3.3841	-1.6%	1.6%	-0.43	0.43
53	3.1578	3.2099	3.2628	-1.6%	1.6%	-0.44	0.44
54	3.0429	3.0943	3.1465	-1.7%	1.7%	-0.45	0.46
55	2.9328	2.9834	3.0348	-1.7%	1.7%	-0.46	0.47
56	2.8267	2.8766	2.9272	-1.7%	1.8%	-0.48	0.48
57	2.7248	2.7739	2.8237	-1.8%	1.8%	-0.49	0.50
58	2.6269	2.6751	2.7242	-1.8%	1.8%	-0.50	0.51

59	2.5327	2.5801	2.6284	-1.8%	1.9%	-0.51	0.52
60	2.4422	2.4888	2.5363	-1.9%	1.9%	-0.53	0.54
61	2.3548	2.4006	2.4473	-1.9%	1.9%	-0.54	0.55
62	2.2708	2.3159	2.3617	-1.9%	2.0%	-0.55	0.56
63	2.1901	2.2344	2.2795	-2.0%	2.0%	-0.57	0.58
64	2.1126	2.1561	2.2004	-2.0%	2.1%	-0.58	0.59
65	2.0381	2.0808	2.1243	-2.0%	2.1%	-0.59	0.60
66	1.9668	2.0086	2.0513	-2.1%	2.1%	-0.61	0.62
67	1.8983	1.9393	1.9813	-2.1%	2.2%	-0.62	0.63
68	1.8325	1.8728	1.9139	-2.2%	2.2%	-0.63	0.65
69	1.7693	1.8089	1.8493	-2.2%	2.2%	-0.65	0.66
70	1.7086	1.7474	1.7871	-2.2%	2.3%	-0.66	0.67
71	1.6500	1.6880	1.7269	-2.3%	2.3%	-0.67	0.69
72	1.5938	1.6312	1.6693	-2.3%	2.3%	-0.69	0.70
73	1.5402	1.5768	1.6142	-2.3%	2.4%	-0.70	0.72
74	1.4888	1.5247	1.5614	-2.4%	2.4%	-0.71	0.73
75	1.4396	1.4748	1.5108	-2.4%	2.4%	-0.73	0.74
76	1.3943	1.4288	1.4642	-2.4%	2.5%	-0.74	0.76
77	1.3504	1.3843	1.4190	-2.4%	2.5%	-0.76	0.77
78	1.3079	1.3412	1.3752	-2.5%	2.5%	-0.77	0.79
79	1.2667	1.2994	1.3328	-2.5%	2.6%	-0.78	0.80
80	1.2268	1.2588	1.2916	-2.5%	2.6%	-0.80	0.82
81	1.1852	1.2165	1.2486	-2.6%	2.6%	-0.81	0.83
82	1.1451	1.1758	1.2072	-2.6%	2.7%	-0.83	0.85
83	1.1066	1.1367	1.1674	-2.6%	2.7%	-0.84	0.86
84	1.0696	1.0990	1.1292	-2.7%	2.7%	-0.86	0.88
85	1.0340	1.0628	1.0923	-2.7%	2.8%	-0.87	0.89
86	1.0024	1.0306	1.0596	-2.7%	2.8%	-0.88	0.91
87	0.9721	0.9997	1.0281	-2.8%	2.8%	-0.90	0.92
88	0.9429	0.9700	0.9979	-2.8%	2.9%	-0.91	0.94
89	0.9149	0.9415	0.9689	-2.8%	2.9%	-0.93	0.96
90	0.8880	0.9141	0.9409	-2.9%	2.9%	-0.94	0.97
91	0.8608	0.8864	0.9126	-2.9%	3.0%	-0.96	0.99
92	0.8345	0.8595	0.8853	-2.9%	3.0%	-0.97	1.00
93	0.8091	0.8336	0.8588	-2.9%	3.0%	-0.99	1.02
94	0.7845	0.8085	0.8332	-3.0%	3.1%	-1.00	1.03
95	0.7607	0.7843	0.8085	-3.0%	3.1%	-1.02	1.05
96	0.7382	0.7613	0.7850	-3.0%	3.1%	-1.03	1.07
97	0.7165	0.7391	0.7624	-3.1%	3.2%	-1.05	1.08
98	0.6957	0.7179	0.7407	-3.1%	3.2%	-1.06	1.10
99	0.6757	0.6974	0.7198	-3.1%	3.2%	-1.08	1.11
100	0.6564	0.6777	0.6996	-3.1%	3.2%	-1.10	1.13
101	0.6378	0.6587	0.6803	-3.2%	3.3%	-1.11	1.15
102	0.6200	0.6404	0.6616	-3.2%	3.3%	-1.13	1.16
103	0.6028	0.6229	0.6436	-3.2%	3.3%	-1.14	1.18
104	0.5862	0.6059	0.6262	-3.3%	3.4%	-1.16	1.20
105	0.5702	0.5896	0.6095	-3.3%	3.4%	-1.17	1.21
106	0.5548	0.5738	0.5934	-3.3%	3.4%	-1.19	1.23
107	0.5400	0.5586	0.5778	-3.3%	3.4%	-1.21	1.25
108	0.5257	0.5440	0.5628	-3.4%	3.5%	-1.22	1.26
109	0.5119	0.5298	0.5483	-3.4%	3.5%	-1.24	1.28
110	0.4986	0.5162	0.5344	-3.4%	3.5%	-1.26	1.30
111	0.4857	0.5030	0.5209	-3.4%	3.6%	-1.27	1.32

112	0.4733	0.4903	0.5078	-3.5%	3.6%	-1.29	1.33
113	0.4614	0.4780	0.4952	-3.5%	3.6%	-1.30	1.35
114	0.4498	0.4661	0.4830	-3.5%	3.6%	-1.32	1.37
115	0.4386	0.4547	0.4713	-3.5%	3.7%	-1.34	1.39
116	0.4278	0.4436	0.4599	-3.6%	3.7%	-1.35	1.40
117	0.4174	0.4329	0.4489	-3.6%	3.7%	-1.37	1.42
118	0.4073	0.4225	0.4383	-3.6%	3.7%	-1.39	1.44
119	0.3975	0.4125	0.4280	-3.6%	3.8%	-1.40	1.46
120	0.3881	0.4028	0.4180	-3.6%	3.8%	-1.42	1.47
121	0.3790	0.3934	0.4084	-3.7%	3.8%	-1.44	1.49
122	0.3701	0.3843	0.3990	-3.7%	3.8%	-1.46	1.51
123	0.3616	0.3755	0.3900	-3.7%	3.9%	-1.47	1.53
124	0.3533	0.3670	0.3812	-3.7%	3.9%	-1.49	1.55
125	0.3453	0.3587	0.3727	-3.8%	3.9%	-1.51	1.57
126	0.3375	0.3507	0.3645	-3.8%	3.9%	-1.52	1.58
127	0.3300	0.3430	0.3565	-3.8%	3.9%	-1.54	1.60
128	0.3227	0.3355	0.3488	-3.8%	4.0%	-1.56	1.62
129	0.3156	0.3282	0.3413	-3.8%	4.0%	-1.58	1.64
130	0.3087	0.3211	0.3340	-3.9%	4.0%	-1.60	1.66
131	0.3021	0.3143	0.3270	-3.9%	4.0%	-1.61	1.68
132	0.2956	0.3077	0.3202	-3.9%	4.1%	-1.63	1.70
133	0.2894	0.3012	0.3135	-3.9%	4.1%	-1.65	1.71
134	0.2833	0.2950	0.3071	-3.9%	4.1%	-1.67	1.73
135	0.2774	0.2889	0.3008	-4.0%	4.1%	-1.68	1.75
136	0.2717	0.2830	0.2947	-4.0%	4.1%	-1.70	1.77
137	0.2662	0.2773	0.2888	-4.0%	4.2%	-1.72	1.79
138	0.2608	0.2717	0.2831	-4.0%	4.2%	-1.74	1.81
139	0.2556	0.2663	0.2775	-4.0%	4.2%	-1.76	1.83
140	0.2505	0.2611	0.2721	-4.1%	4.2%	-1.78	1.85
141	0.2455	0.2560	0.2669	-4.1%	4.3%	-1.79	1.87
142	0.2407	0.2510	0.2617	-4.1%	4.3%	-1.81	1.89
143	0.2361	0.2462	0.2568	-4.1%	4.3%	-1.83	1.91
144	0.2315	0.2415	0.2519	-4.1%	4.3%	-1.85	1.93
145	0.2271	0.2370	0.2472	-4.2%	4.3%	-1.87	1.95
146	0.2228	0.2325	0.2427	-4.2%	4.4%	-1.89	1.97
147	0.2187	0.2282	0.2382	-4.2%	4.4%	-1.91	1.99
148	0.2146	0.2240	0.2339	-4.2%	4.4%	-1.93	2.01
149	0.2106	0.2199	0.2296	-4.2%	4.4%	-1.94	2.03
150	0.2068	0.2160	0.2255	-4.2%	4.4%	-1.96	2.05

