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Application Report

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Thermistor Coefficient Calculator for TI Advanced Fuel Gauges

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Battery Management

ABSTRACT

TI advanced fuel-gauge battery-management ICs use a polynomial model to translate the voltage measured across the thermistor terminals into a temperature value. While the recommended Semitec AT103 is readily available, some customers prefer to use an alternate device. This report describes the use of a companion Excel® spreadsheet that automates coefficient calculation for a given thermistor. Project collateral discussed in this application report can be downloaded from the following URL: www.ti.com/lit/zip/SLUA398.

1 Introduction

The firmware algorithm in TI advanced fuel gauge battery management ICs uses a polynomial model to translate voltage measured across the thermistor terminals into temperature. While the recommended Semitec AT103 is readily available in various shapes, some customers prefer to use an alternate device. This report describes the use of a companion Excel spreadsheet that automates the calculation of coefficients for a given thermistor.

The Thermistor Coefficient Calculator is a Microsoft® Excel spreadsheet, which is available as a zip file in the same location as this report. It can be used for various advanced fuel gauge ICs such as the bq2084, bq20z70, bq20z80, bq20z90, etc.

2 Theory of Operation

Solver, an add-in tool for Excel, which is part of the standard installation, is used in this case to find a solution to a set of 3rd order polynomials. Given a few points on an unknown curve, it finds the coefficients of a cubic polynomial equation that best fits the available data. The fuel-gauge device firmware uses the cubic polynomial along with the dataflash-based coefficients at 1-s intervals when converting the A/D reading from the thermistor into a temperature value.

Solver's job is to minimize the value in cell B33 (see Figure 1), which is the sum of the norms for each known data point. The norms are simply the square of the difference between what you want and what you get. Solver updates the polynomial coefficients in E25 ~ E28 for the best overall fit. You can, of course, change the coefficients manually to see what happens. The values in E31 ~ E36 should be programmed into the respective fuel gauge dataflash locations.

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	A	B	Calculation of A/D Count	Data Flash Thermistor Constants	E	G	J	K
1	**Temperature**	**Resistance**	**Calculation of A/D Count**	**Calculation of best-fit (using 3rd order polynomial)**	**Norm**	**Instructions**	**Partial Result Bounds Check**	
2	-20	67770	25982	-19.55338015	0.199469	1. Insert Temperature and Resistance values in colums A&B	10248.5197	-3774.69
3	-15	53410	25309	-15.13893104	0.019302	2. Verify A/D count value in cell C2 does not exceed 27000	10557.1208	-3760.757
4	-10	42470	24537	-10.40258881	0.162078	If necessary, raise value of R1 in cell B24 to a higher standard	10911.1179	-3752.579
5	-5	33900	23646	-5.334192226	0.111684	resistor value so that C2 is under 27000.	11319.6818	-3753.509
6	0	27280	22657	-0.155141665	0.024069	3. Select Solver from Tools menu. Use Add-Ins menu if not available.	11773.1833	-3767.55
7	5	22050	21562	5.103094832	0.010629	4. Set Target Cell to $B$33	12275.2905	-3799.063
8	10	17960	20391	10.26512627	0.070292	5. Choose Equal to: Value Of 0 (choose "Value Of", enter 0	12812.2472	-3851.329
9	15	14690	19143	15.35518484	0.126156	6. Set "By Changing Cells" to $E$25:$E$28	13384.5119	-3928.155
10	20	12090	17853	20.30002249	0.090013	7. Press Solve button - Accept the solution, even though not "feasible"	13976.0355	-4030.476
11	25	10000	16537	25.1540882	0.023743	8. Compare columns A and D to evaluate the accuracy	14579.4813	-4158.854
12	30	8313	15220	29.96452929	0.001258	A lower number in B33 indicates a better fit	15183.3856	-4311.593
13	35	6940	13920	34.80931675	0.03636	9. Linearity may be improved by changing R2 in some cases	15779.4947	-4486.165
14	40	5827	12668	39.69777558	0.09134	10. Insure none of the values in columns J or K exceed +/- 32767	16353.5936	-4676.647
15	45	4911	11469	44.70168577	0.088991		16903.3895	-4879.628
16	50	4160	10344	49.78340483	0.046913		17419.2531	-5088.375
17	55	3536	9293	54.9514734	0.002355		17901.1844	-5299.392
18	60	3020	8328	60.11969589	0.014327		18343.6807	-5506.755
19	65	2588	7445	65.25409511	0.064564		18748.5763	-5707.915
20	70	2228	6648	70.25884332	0.067		19114.0371	-5898.852
21	75	1924	5927	75.11718798	0.013733		19444.6483	-6079.239
22	80	1668	5283	79.74269257	0.066207		19739.9516	-6246.513
23								
24	R1	8450						
25	R2	61900						
26	Vref	3.3						
27	Vadref	3.3						
28	ADres	0.000100708						
29	Vadmax	2.64						
30	Rs	7435.03909						
31	Vs	2.903624733						
32								
33	Sum of Norms:	1.330484661						

Polynomial coefficients	**Value**
A0	4032.48
A1	-7837.818
A2	22162.45
A3	-30050.77

Data Flash Thermistor Constants	
A0 (** Coefficient 4)	4032
A1 (** Coefficient 3)	-7838
A2 (** Coefficient 2)	22162
A3 (** Coefficient 1)	-30051
Min A/D	0
Max Temp (K)	4032

** The polynomial coefficients have alternate names in some fuel gauges

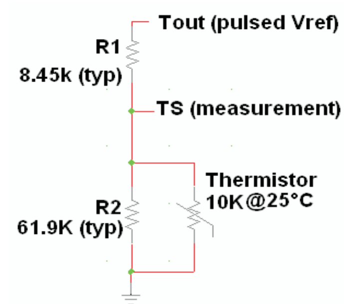

Figure 1. Thermistor Coefficient Calculator Spreadsheet

3 Thermistor Tables

Enter the data for the desired thermistor into cells B2 ~ B22 which correspond to the temperatures in column A. Some vendors include resistance tables in their catalog; others provide a calculator for you to generate them. If a given vendor only supplies a small table with multiples of 10°C, then use it as-is in the spreadsheet, but include some of the degree-resistance pairs twice to fill up the table of 21 pairs.

4 Circuit Modifications

For maximum accuracy, the voltage input voltage to the A/D converter in the fuel gauge should be limited to around 82% of the reference voltage, which is the same as V_{CC} in this case. Looking at it another way, the A/D count should not exceed 27000 (82% of full scale 32767) counts for low temperature readings that must be accurate. Column C displays the expected A/D count for a given temperature. Measurements between 27000 and 32767 will be degraded somewhat, but still useful.

The recommended thermistor circuit, where R1 = 8.45 kΩ, R2 = 61.9 kΩ and Thermistor = 10 kΩ at 25°C, should satisfy the above requirement in most cases. However, if a 10-kΩ thermistor cannot be used, the fixed resistors should be modified in cells B24 and B25 to optimize the measurement. B25 is used to linearize the thermistor curve somewhat, enhancing the polynomial curve-fitting accuracy.

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