Using BQ76952 AFE Polynomial for external NTCs

Versions	Date	Author	Reviewer	Approver	Modifications / comments
A0	19/01/2023	NT	RS	TN	Creation of the document

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Objective

This document describes how to generate the coefficients for the two NTC polynomial equations for any thermistor using TI's GPC tool.

Introduction

The NTC temperature measurement can be carried out either by using the Arrhenius equation (similar to FS-LT and ACPA) or by using the dedicated polynomial in the AFE. The problem with the first approach is that we are using an internal pull up resistor inside the AFE for biasing the NTCs. The value of the resistor in the datasheet is -

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
$R_{(TS\_PU)}$	Internal pullup resistance[(2)]	Setting for nominal 18-kΩ	14.4	18.3	21.6	kΩ
		Setting for nominal 180-kΩ	140	178	216	kΩ

Even though the typical value of the resistor is 18.3kΩ, the minimum and maximum values are 14.4kΩ and 21.6kΩ respectively. This value of this resistor is measured and stored in the AFE by TI, but is inaccessible to the user. Using 18.3kΩ value resistor value in the Arrhenius equation to measure NTC resistance will lead to a large error in measurement. Hence this method is unsuitable. The polynomial method also uses the internal pullup resistor, the difference being it has access to the measured resistance value and hence more accurate measurement can be made. We will be using the polynomial method for temperature measurement.

The BQ76952 makes use of two polynomial equations to calculate temperature from the NTC resistance. Below are the two polynomials which can be configured in the AFE to obtain accurate Temperature readings.

AFE Polynomial 1

$$y1 = A1 * x^4 + A2 * x^3 + A3 * x^2 + A4 * x^1 + A5$$

AFE Polynomial 2

$$y2 = B1 * x^3 + B2 * x^2 + B3 * x^1 + B4$$

The coefficients A1, A2, A3, A4, A5, B1, B2, B3, B4 are to be calculated using a TI utility. The coefficient values are unique for each NTC, hence for every NTC, these have to be newly generated.

The coefficients are generated from a lookup table present in the NTC datasheet hence there is no need for NTC beta (β) value or the NTC resistance. Below is an example of the NTC lookup table. If the NTC lookup table is not present in the datasheet, the coefficients cannot be calculated.

JR Sensing & Elecctronisc Technologies							
8. R-T Table							
R_{25}=10KΩ±1%		$B_{25/85}$=3435K ±1%					
T(°C)	Rmin (KΩ)	Rnor (KΩ)	Rmax (KΩ)	T(°C)	Rmin (KΩ)	Rnor (KΩ)	Rmax (KΩ)
-40	196.8935	204.981	213.3791	1	25.8277	26.343	26.8649
-39	185.9977	193.526	201.3393	2	24.7453	25.228	25.7167
-38	175.7809	182.792	190.0627	3	23.7146	24.166	24.6244
-37	166.1964	172.727	179.4960	4	22.7329	23.156	23.5849
-36	157.2007	163.286	169.5898	5	21.7975	22.194	22.5953
-35	148.7540	154.426	160.2984	6	20.9061	21.277	21.6529
-34	140.8190	146.108	151.5797	7	20.0562	20.404	20.7553
-33	133.3615	138.294	143.3946	8	19.2458	19.571	19.9001
-32	126.3497	130.951	135.7071	9	18.4728	18.777	19.0850
-31	119.7539	124.048	128.4836	10	17.7353	18.020	18.3079
-30	113.5469	117.555	121.6932	11	17.0313	17.298	17.5669
-29	107.7033	111.446	115.3072	12	16.3594	16.609	16.8601
-28	102.1994	105.695	109.2989	13	15.7177	15.951	16.1856
-27	97.0134	100.279	103.6435	14	15.1048	15.323	15.5420
-26	92.1248	95.176	98.3181	15	14.5192	14.723	14.9275
-25	87.5149	90.366	93.3014	16	13.9596	14.150	14.3408
-24	83.1658	85.831	88.5735	17	13.4246	13.602	13.7803
-23	79.0613	81.554	84.1160	18	12.9131	13.079	13.2449
-22	75.1860	77.517	79.9118	19	12.4239	12.578	12.7332
-21	71.5258	73.706	75.9449	20	11.9559	12.100	12.2441
-20	68.0673	70.107	72.2005	21	11.5081	11.642	11.7764

Fig. 1 - Lookup table of NTED103C2R1L401 sensor used by Hero Electric.

Using TI's GPC tool

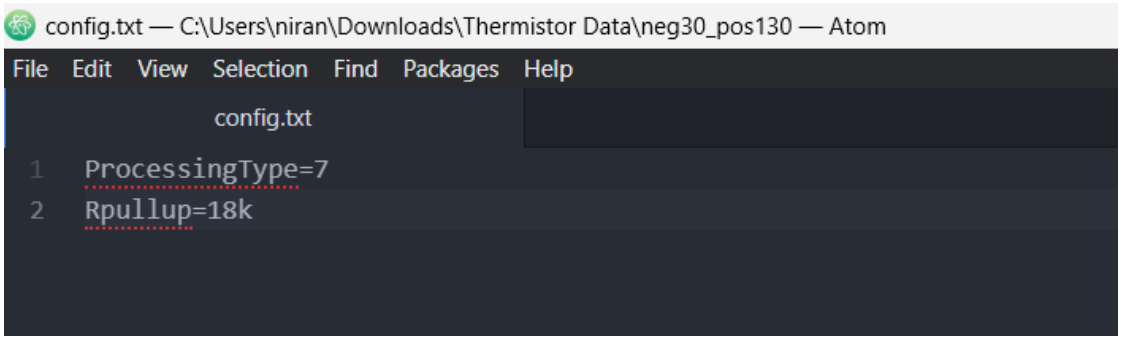
The GPC tool requires a single .zip file containing one configuration file, and one data file, as input. The name of the .zip file is not important. The .zip file must contain these files:

- config.txt
- thermistor.txt

Configuration File

The configuration filz
ProcessingType = 7 Determines the type of tool used. Value must be 7 for the Thermistor Coefficient Calculator
Rpullup = 18k or 180k depending on the pullup resistance needed for the thermistor

Example config.txt File:

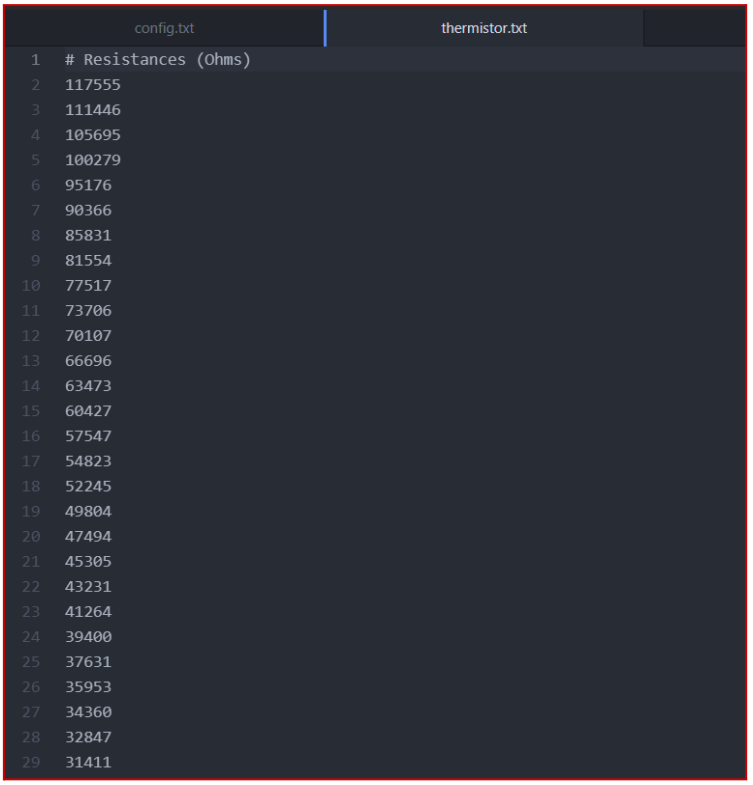


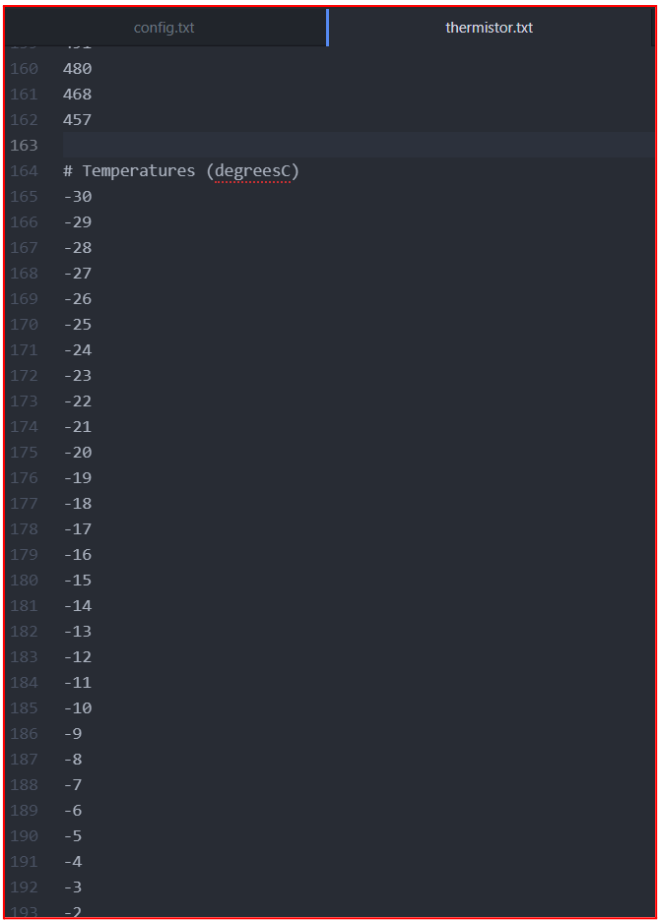
The above config.txt file can be found here. Use this file as a template for all the other NTCs.

Thermistor.txt File

The thermistors.txt file lists the resistances (in Ohms) and temperatures (in degrees C) from the thermistor datasheet. Do not alter from the example provided.

Example thermistors.txt file:



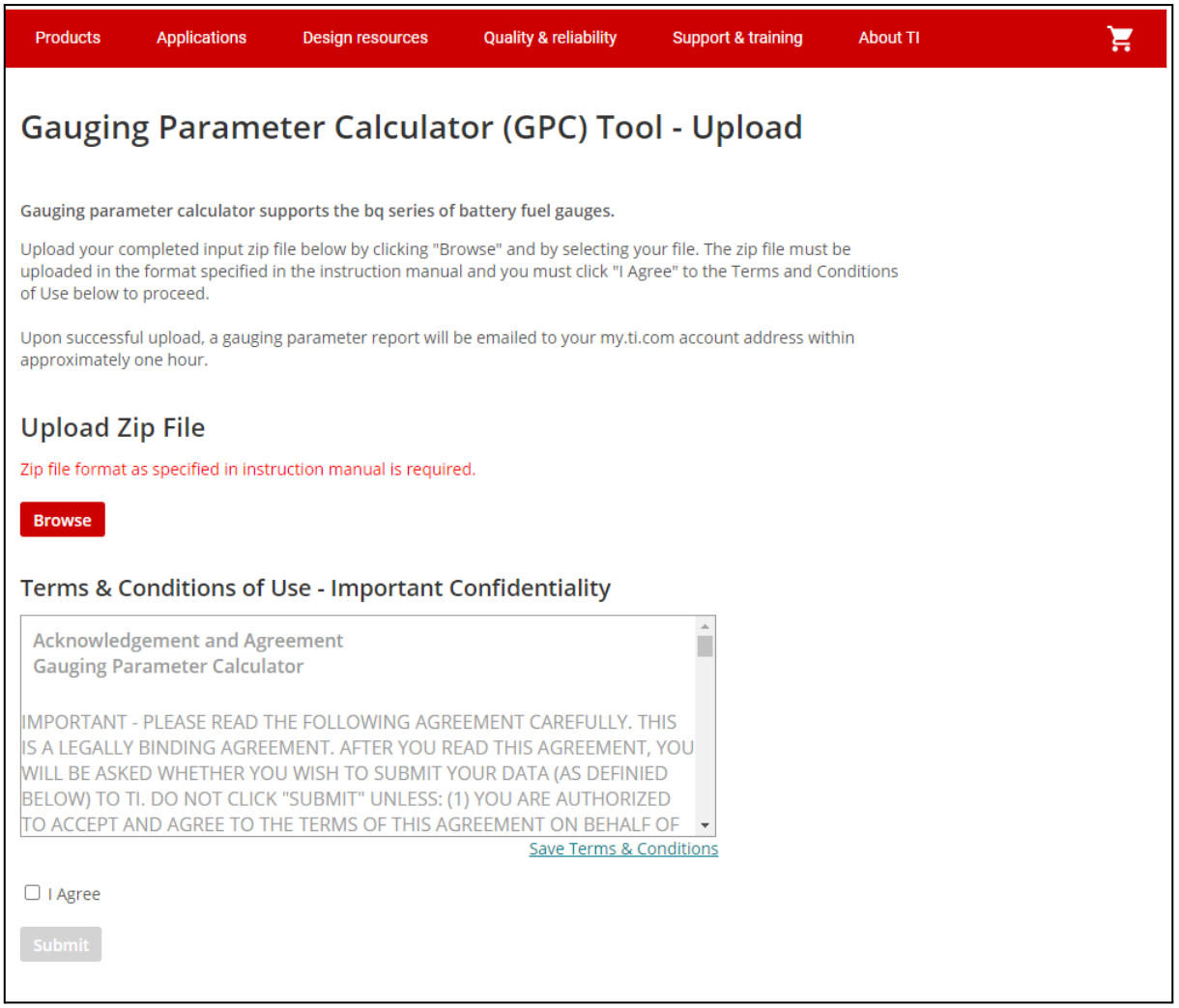


The above thermistor.txt file can be found here. Use this file as a template for all the other NTCs.

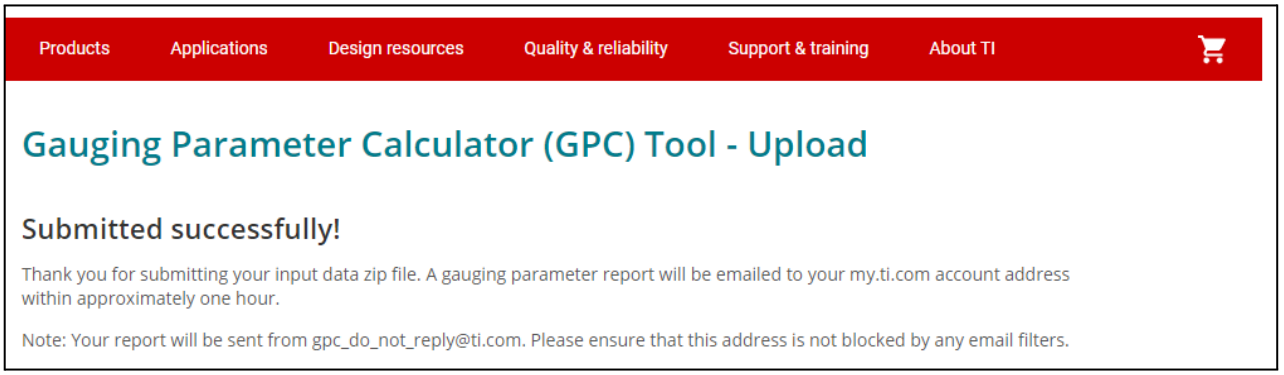
After you have created the thermistor.txt and config.txt, put both of them in the same directory and create a zip folder. The zip folder from the above example can be downloaded from here.

Here is the link to the GPC tool. To use this tool you have to create your account on ti.com using your maxwell email ID.

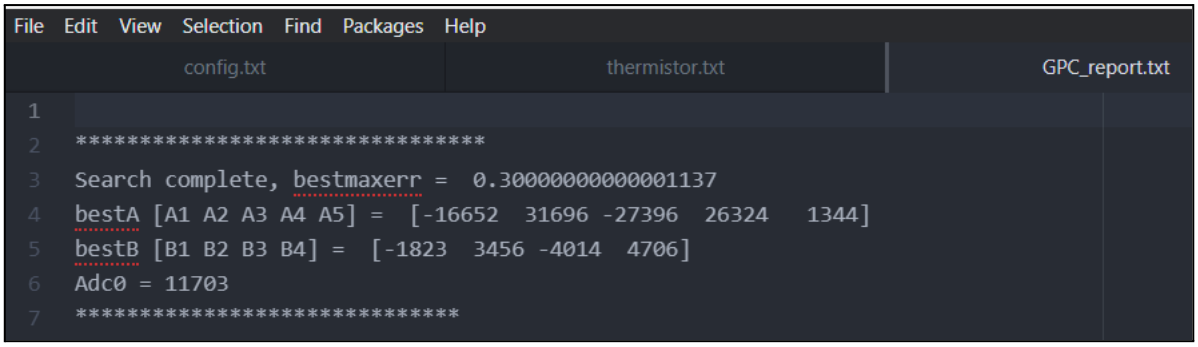
Upload the zip folder to the GPC tool.



After the file has been submitted successfully you should see the below message.



The usual wait time is ~15 mins after which you should receive an email on registered email with attachment. Download and unzip the attachment. The folder will contain a file named GPC_report.txt. This file contains the coefficients for both the equations.



The generated coefficients are configurable and can be updated in the BMS configuration as below -

Config ID	Coefficient	Value
320	A1	-16652
321	A2	31696
322	A3	-27396
323	A4	26324
324	A5	1344
325	B1	-1823
326	B2	3456
327	B3	-4014
328	B4	4706

Error Compensation

The polynomial method has been tested here by emulating the NTC behavior with use of potentiometer. It has been observed that, at lower temperatures (typically below -5°C) there is a linear increase in the NTC error. It has been found that with further decrease in temperature the measurement error lies outside the specified range of ±2°C. This error has to be compensated.

The compensation shall be done with the help of BMS configuration. In the configuration, we will be specifying the temperature value after which we apply the error correction factor. The second configuration parameter will be the slope of the observed error equation.

Observation Table -

Temp measured with AFE polynomial	Measured Resistance(kOhm)	Measured Resistance(Ohm)	Actual Temperature	Error in measurement in DegC	Thermistor
-17.4	88.11	88110	-20.61	-3.21	BGUASS
-19.4	113.12	113120.0	-22.54	-3.14	Euler
-20.2	83.66	83660	-22.56	-2.36	Tork
-20.5	82.300	82300.00	-23.61	-3.11	HE