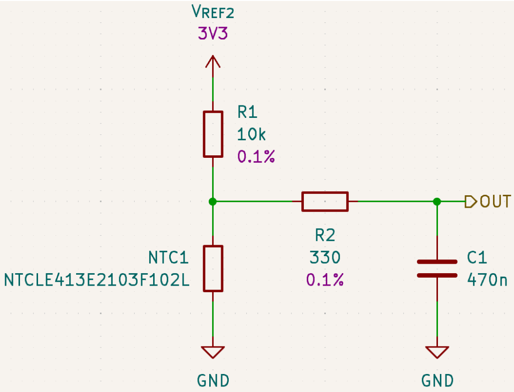

Figure 1: NTC Voltage Divider and Filter

The following calculation is based on the Look-Up Table (LUT) provided by Vishay[3], which is used in the AMS software.

Since the characteristic curve of the NTC thermistor is nonlinear, determining the absolute maximum measurement error is not straightforward. Therefore, we will calculate the maximum error specifically at 60 °C.

As seen in Fig.1 our voltage measurement system consists of an NTC thermistor (NTCLE413E2103F102L) and a 10 kΩ 0.1% resistor forming a voltage divider. The output voltage is then passed through an RC filter before being fed to an ADC.

To estimate the error, we calculate the highest possible measured voltage at 60 °C. According to the design of the voltage divider, the lower the temperature, the higher the output voltage.

As shown in Fig. 2, the supply voltage V_{REF2} for the voltage divider can reach a maximum value of 3.006 V. Additionally, the total measurement error of the GPIO is ±0.0028 V (as shown in Fig. 3). Lastly, the maximum resistance of the NTC at 60 °C, according to the LUT (Tab. 1), is 3086.8 Ω. The maximum possible voltage measurement can then be calculated as such:

$$V_{worstcase} = V_{REF2} \cdot \frac{R_{NTC}}{R_{NTC} + R_1} + V_{err} \tag{1}$$

$$= 3.006\,\text{V} \cdot \frac{3086.8\,\Omega}{3086.8\,\Omega + 9990\,\Omega} + 0.0028\,\text{V} \tag{2}$$

$$\approx 0.7124\,\text{V} \tag{3}$$

To find the largest possible error, the lowest possible matching temperature should be calculated, which theoretically can produce the same voltage output. The calculation is as follows:

$$V_{worstcase} = V_{REF2} \cdot \frac{R_{NTC}}{R_{NTC} + R_1} + V_{err} \tag{4}$$

$$0.7124\,\text{V} = 2.994\,\text{V} \cdot \frac{R_{NTC}}{R_{NTC} + 10010\,\Omega} - 0.0028\,\text{V} \tag{5}$$

$$R_{NTC} \approx 3141.6\,\Omega \tag{6}$$

Since the LUT is used to match the voltage to the temperature, and the nominal resistance from the LUT is used for the calculation, the closest matching temperature is 58.7 °C.

Table 5. Voltage Reference Specifications

Parameter	Test Conditions/Comments	Min	Typ	Max	Unit
FIRST REFERENCE VOLTAGE	V_{REF1} pin, no load	3	3.2	3.3	V
FIRST REFERENCE VOLTAGE TEMPERATURE COEFFICIENT (TC)	V_{REF1} pin, no load		3		ppm/°C
FIRST REFERENCE VOLTAGE HYSTERESIS	V_{REF1} pin, no load		20		ppm
FIRST REFERENCE VOLTAGE LONG-TERM DRIFT	V_{REF1} pin, no load		20		ppm/√kHr
SECOND REFERENCE VOLTAGE	V_{REF2} pin, no load	2.994	3	3.006	V
	V_{REF2} pin, 1 kΩ load to V−	2.994	3	3.006	V
OUTPUT CURRENT	ΔV_{REF2} < ± 2 mV	−0.2		+5	mA
SECOND REFERENCE VOLTAGE TC	V_{REF2} pin, no load		10		ppm/°C
SECOND REFERENCE VOLTAGE HYSTERESIS	V_{REF2} pin, no load		100		ppm
SECOND REFERENCE VOLTAGE LONG-TERM DRIFT	V_{REF2} pin, no load		60		ppm/√kHr

Figure 2: Voltage Reference Specifications

Table 3. Auxiliary (AUX) ADC DC Specifications

Parameter	Test Conditions/Comments	Min	Typ	Max	Unit
MEASUREMENT RESOLUTION			0.15		mV/bit
INPUT RANGE	GPIOx to V−	−0.3		V_{REG}	V
ADC OFFSET VOLTAGE[1]			−0.2		mV
ADC GAIN ERROR[1]			±0.01		%
ADC UPDATE RATE		0.9	1	1.1	kHz
ADC TRANSITION NOISE			50		μV rms
GPIOx TOTAL MEASUREMENT ERROR					
	0 V < GPIOx to V− ≤ 3.3 V			±2.8	mV
	3.3 V < GPIOx to V− ≤ 5 V			±4.2	mV
DIAGNOSTIC MEASUREMENTS	Internal temperature, T = maximum specified temperature		±5		°C
	V_{REG} pin		±0.1	±0.25	%
	V_{REF2}, VRES		±0.02	±0.2	%
	Digital supply voltage, V_{REGD}		±0.1	±1.6	%
	V+ to V−, V+ > 20 V	−1	±0.05	+0.5	%
	−0.1 V ≤ S1N to V− ≤ 0.1 V		±0.02	0.2	%
INPUT LEAKAGE CURRENT	AUX ADC off, GPIOx = 5 V		10	±250	nA
INPUT RESISTANCE	AUX ADC on	1.5	2.7	3.5	MΩ
INPUT CURRENT DURING OPEN WIRE DETECTION	Pull-down current: GPIOx > 1.5 V	−140	−200	−260	μA
	Pull-up current: GPIOx < V_{REG} − 1.5 V	140	200	260	μA
ADC SAMPLING FREQUENCY		3.7	4.1	4.5	MHz

Figure 3: Auxiliary (AUX) ADC DC Specifications

Table 1: NTC Look Up Table

Temp. [°C]	$R_{nom}[\Omega]$	$R_{min}[\Omega]$	$R_{max}[\Omega]$	$\Delta R/R[\%]$	$\Delta T[°C]$
58	3214.99	3145.6	3284.4	2.16	0.69
58.1	3204.88	3135.6	3274.2	2.16	0.69
58.2	3194.81	3125.6	3264.0	2.17	0.69
58.3	3184.78	3115.7	3253.9	2.17	0.69
58.4	3174.78	3105.8	3243.7	2.17	0.69
58.5	3164.81	3096.0	3233.7	2.18	0.69
58.6	3154.89	3086.2	3223.6	2.18	0.69
58.7	3145.00	3076.4	3213.6	2.18	0.69
58.8	3135.15	3066.7	3203.6	2.18	0.70
58.9	3125.33	3056.9	3193.7	2.19	0.70
59	3115.55	3047.3	3183.8	2.19	0.70
59.1	3105.80	3037.7	3173.9	2.19	0.70
59.2	3096.09	3028.1	3164.1	2.20	0.70
59.3	3086.41	3018.5	3154.3	2.20	0.70
59.4	3076.77	3009.0	3144.6	2.20	0.70
59.5	3067.17	2999.5	3134.9	2.21	0.71
59.6	3057.60	2990.0	3125.2	2.21	0.71
59.7	3048.06	2980.6	3115.5	2.21	0.71
59.8	3038.56	2971.2	3105.9	2.22	0.71
59.9	3029.09	2961.9	3096.3	2.22	0.71
60	3019.66	2952.5	3086.8	2.22	0.71
60.1	3010.26	2943.3	3077.3	2.23	0.71

Reference

[1] *Table 3 Data Sheet ADBMS6830B Rev.0 page 6*. www.analog.com, 01.2024

[2] *Table 5 Data Sheet ADBMS6830B Rev.0 page 7*. www.analog.com, 01.2024

[3] *NTC RT Calculation Tool*. www.vishay.com, 03.2025