Using a thermistor temperature sensor

Revision 1

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1 Overview

Thermistors are common types of temperature sensors for engine oil or water temperature.

Most thermistors are Negative Temperature Coefficient (NTC).
Therefore, the term “NTC” is commonly used instead of “NTC thermistor”.
“**Negative**” means that the electrical resistance of the sensor **decreases** when the temperature increases.
For a PTC (**Positive** Temperature Coefficient) thermistor, the electrical resistance of the sensor **increases** when the temperature increases.

Enginemeter EFMS100 AUX1 input (sender/TX100 unit) can be used with most thermistors to measure and display a temperature.

AUX2 input is not recommended for this application
(because “AUX2 has a 1kOhm/1% resistor internally connected to a 2.5V voltage reference and a 150Ohm/1% resistor is series with the terminal”)

A thermistor has 2 electrical terminals.
In most cases one of the 2 terminals is threaded and connected/screwed on the engine chassis.
It is therefore important that the ground of EFMS100 (TX100 unit) is properly connected to the engine chassis.

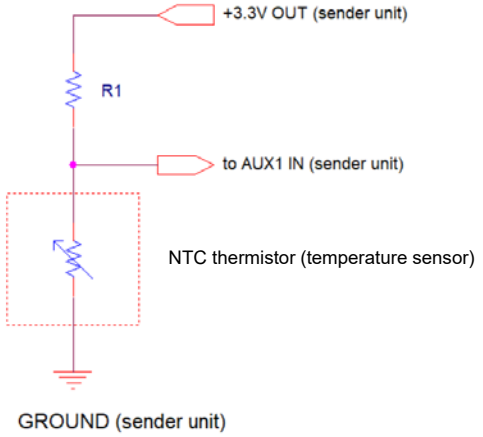
If your thermistor has 2 wires you should connected one (it doesn’t matter which one) to the GROUND of TX100 unit.

Information from EFMS100 user manual:

- AUX1 voltage range = **0 to 2.5V**
- AUX1 input leakage current = 50nA max. (not significant here)
- “+3.3V OUT”: “Maximum output (sourcing current only / no sinking current) current = **10mA** !!!”

2 Electrical schematic

One additional resistor (R1) is used to create a resistor divider between “+3.3V OUT” (3.3V output) and “AUX1 IN” analog input.



The voltage on AUX1 input is given by the following formula:
V(AUX1) = R_NTC / (R_NTC + R1) x 3.3 in volts

Note that AUX1 voltage must always stay in the range 0 to 2.5V since this range is the useful range for measurements.

3 Step 1 = Selection of the thermistor and the resistor R1

The accuracy of the temperature reading is mostly important around the “normal/optimal” engine temperature (oil or water temperature).

For maximum accuracy, select a thermistor which resistance is above 330ohm at the “normal/optimal” engine temperature.

Also, for maximum accuracy, select a thermistor which resistance tolerance is good/best near the “normal/optimal” engine temperature.

Then select R1 = resistance of the thermistor at the “normal/optimal” engine temperature.
R1 tolerance should be +/-1% or better.

!!!!!!!!!!!! However, R1 should never be less than 330 Ohm in order to limit the current below 10mA !!!!!!!!!!

3.1 Application example

This example will assume that the “normal/optimal” engine temperature is around +100degC

Here is an example of a suitable NTC thermistor for this application:

Kennlinie-Tabelle / Characteristic Curve Table 10

Heißleiter / Thermistor 92-027-079

Temp. °C	Geber / Sensor R (Ohm)	± Tol (%)	± Tol (Ohm)
-25.0	296776.75	45.07	133772.00
-20.0	244764.88	40.86	99999.21
-15.0	199555.48	36.74	73325.48
-10.0	161040.78	32.87	52928.31
-5.0	128865.90	29.32	37778.61
.0	102463.83	26.17	26812.55
5.0	81141.90	23.41	18997.22
10.0	64133.61	21.04	13496.08
15.0	50695.18	19.00	9634.20
20.0	40140.31	17.24	6921.48
25.0	31913.54	15.79	5040.00
30.0	25470.75	14.51	3696.58
35.0	20420.35	13.37	2729.88
40.0	16452.20	12.32	2027.02
45.0	13324.39	11.35	1511.76
50.0	10848.26	10.43	1131.70
55.0	8879.55	9.56	849.01
60.0	7306.76	8.72	637.35
65.0	6044.02	7.92	478.57
70.0	5025.16	7.13	358.44
75.0	4194.78	6.36	266.61
80.0	3518.73	5.59	196.75
85.0	2963.76	4.90	145.37
90.0	2507.67	4.23	105.98
95.0	2131.15	3.55	75.68
100.0	1819.13	2.89	52.63
105.0	1555.71	3.53	54.95
110.0	1335.78	4.17	55.75
115.0	1151.39	4.82	55.45
120.0	996.30	5.47	54.50
125.0	863.76	6.09	52.58
130.0	751.51	6.71	50.44
135.0	655.66	7.33	48.07
140.0	573.94	7.96	45.66
145.0	503.72	8.58	43.20
150.0	443.47	9.20	40.80
155.0	391.39	9.82	38.43
160.0	346.44	10.44	36.17
165.0	307.33	11.06	33.99
170.0	273.37	11.68	31.92
175.0	243.79	12.29	29.97
180.0	217.95	12.91	28.14

Prüfmedium
Test fluid:
Marlotherm S

This thermistor is suitable for this application because:

- #1: The accuracy (tolerance %) of this thermistor is best around +100degC (tolerance = +/-2.89%)
- #2: The resistance of the thermistor at +100degC (1819ohm) is above 330ohm

With this thermistor, R1 should be chosen around 1819 ohm (e.g. 1800 ohm)

4 Step 2 = Enter the characteristic in the display unit

This step uses the “CALIBRATION block” which is built in EFMS100 display unit software.

Here is a summary this calibration block:

- The characteristic of the calibration block is defined by 11 data points and 2 values (MIN CALIBRATED VALUE and MAX CALIBRATED VALUE).
- By definition, 100% = “MAX CALIBRATED VALUE” – “MIN CALIBRATED VALUE”
- The 11 data points are
  - Point 1 = 0% = MIN CALIBRATED VALUE
  - Point 2 = 10%
  - Point 3 = 20%
  - Point 4 = 30%
  - Point 5 = 40%
  - Point 6 = 50%
  - Point 7 = 60%
  - Point 8 = 70%
  - Point 9 = 80%
  - Point 10 = 90%
  - Point 11 = 100% = MAX CALIBRATED VALUE

As an example, we will assume that we want a temperature measurement range of 0 to +150degC.

Therefore you need to set these 2 parameters in the display unit

- MIN CALIBRATED VALUE = 0
- MAX CALIBRATED VALUE = 150

and indicate to the display unit that you want to display calibrated values (i.e. temperatures) on the main screen.

The 11 data points are

Point number	%	Temperature (degC)	Parameter in the display unit
Point 1	0	0	RAW AT CAL=MIN
Point 2	10	15	RAW AT CAL=MIN+10%
Point 3	20	30	RAW AT CAL=MIN+20%
Point 4	30	45	RAW AT CAL=MIN+30%
Point 5	40	60	RAW AT CAL=MIN+40%
Point 6	50	75	RAW AT CAL=MIN+50%
Point 7	60	90	RAW AT CAL=MIN+60%
Point 8	70	105	RAW AT CAL=MIN+70%
Point 9	80	120	RAW AT CAL=MIN+80%
Point 10	90	135	RAW AT CAL=MIN+90%
Point 11	100	150	RAW AT CAL=MAX

The raw values to enter in EFMS100 display unit can be calculated using the electrical characteristic of the thermistor and the following formulas:

- RAW_VALUE = AUX1_voltage / 2.5V x 4096
- with AUX1_voltage = R_thermistor / (R1 + R_thermistor) x 3.3V

Example for

- The thermistor is the thermistor used in the above example
- “Point 8” = 105degC => R_thermistor = 1555.71ohm
- R1 = 1800ohm

AUX1_voltage = 1555.71 / (1800 + 1555.71) x 3.3 = 1.52988V

RAW_VALUE = 1.52988 / 2.5 x 4096 = 2506.555392

=> enter “RAW AT CAL=MIN+70%” = 2506 in the display unit

5 Alternative method for Step 2

The previous section describes a method based on calculations.
This section describes an alternative method based on experimentation / measurements.

This method requires an accurate thermometer as well as the ability to heat a sample of water/oil (or any other liquid) from the minimum temperature to the maximum temperature (MIN CALIBRATED VALUE to MAX CALIBRATED VALUE) chosen.

5.1 Initial steps

- Setup the display unit to display RAW VALUES (for AUX1 input) on the main screen.
- Install an accurate thermometer to measure the temperature of the liquid sample.
- Install the thermistor in contact with the sample of liquid
- Connect the thermistor to AUX1 input (and R1 resistor)

5.2 Measure the 11 data points

Step A = set the temperature of the liquid sample to the temperature of point 1

Step B = write down the RAW VALUE indicated on the display unit for point 1

Repeat step A and step B for the 11 data points.

5.3 Final steps

- Store the 11 data points in the display unit
- Store MIN CALIBRATED VALUE and MAX CALIBRATED VALUE in the display unit
- Setup the display unit to display CALIBRATED VALUES (for AUX1 input) on the main screen.
- Your display unit should no indicate the actual temperature of the thermistor