Temperature probe assessment

Measurement report

Project	E3METER
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Revision History

Revision	Date	Autor	Modification
0.1	05.05.15	Antoine Zen-Ruffinen	Draft
1.0	07.05.15	Antoine Zen-Ruffinen	Styling. Released

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1. Sumary

This document reports the measurement of the E3METER IPS's optional temperature probes. The goal of this measurement is to verify the overall accuracy of the temperature measurement of the E3METER system.

1.1 Result overview

The following table gives an overview the system accuracy (including uncertainty of measurement setup, test chamber):

Sensor (condition)	25°C	35°C	45°C	55°C
RN1091 (air) ΔT [°C]	± 0.3	± 0.3	± 0.3	± 0.2
RN1091 (metal) ΔT [°C]	± 0.3	± 0.4	± 0.3	± 0.3
RN1097 (air) ΔT [°C]	± 0.2	± 0.3	± 0.3	± 0.3
RN1097 (metal) ΔT [°C]	± 0.4	± 0.3	± 0.2	± 0.3

Table 1: Typical Error

2. Introduction

The manufacturer of the sensing element used inside the RN1091 and RN1097 gives accuracy for their parts. The accuracy of the sensing element used inside the RN1097 is given by figure 1 while the accuracy of the sensing element inside the RN1091 is given by the figure 2.

The temperature test chamber used has an accuracy of 0.1 °C (T-40/100 operating manual, chapter 4.2).

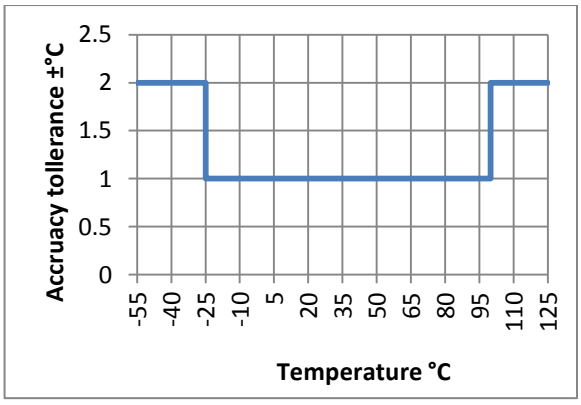

Figure 1: Accuracy sensing element of RN1097

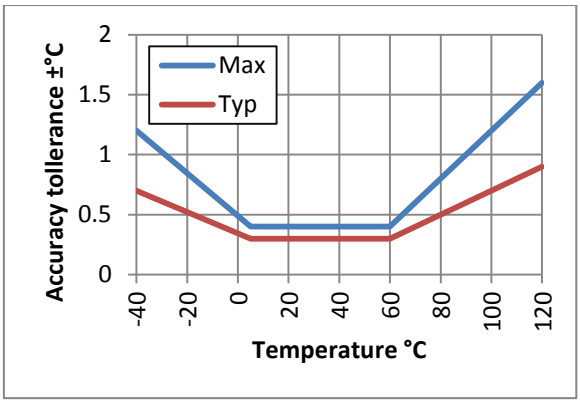

Figure 2: Accuracy sensing element of RN1091

This report makes a measurement of the accuracy of the whole system, taking into account all sub-systems that can be involved into the measurement result (Case, Sensing element, Power supplies, processing).

3. Test Setup

This test uses four different temperature probes (sensor) that have been placed inside a temperature test chamber (CTS T-40/100). Two RN1091 and two RN1097 have been uses. For each type, one is fixed to a metal (galvanized steel) bar, one remains in free air. The following illustration shows the placement of the probes inside the chamber and the connection mapping of the probes to the IPSs.

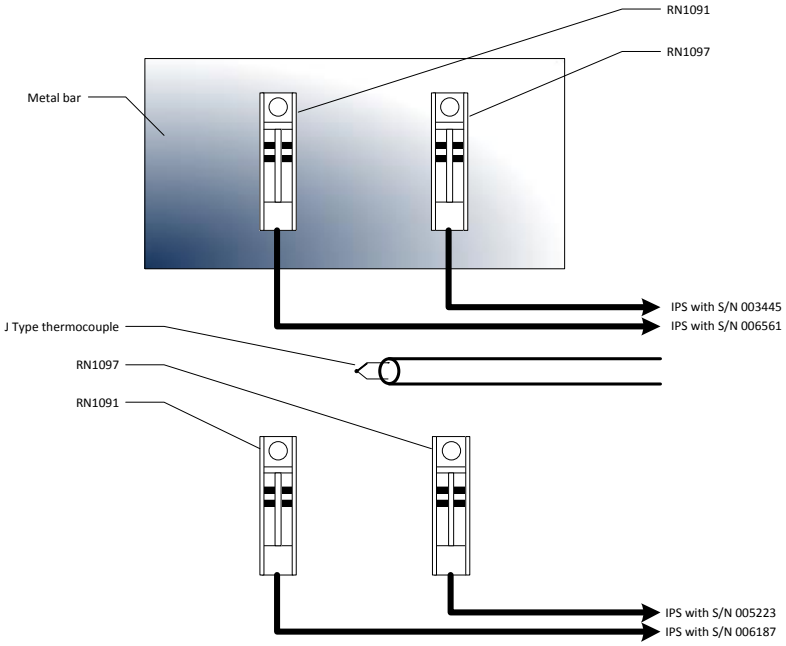

Figure 3: Temperature probes arrangement inside the controlled climatic chamber

The probes in free air have been fixed using cable ties. The probes on the metal (galvanized steel) have been fixed using the build-in magnets.

The thermocouple in the middle is connected to a multi-meter (Agilent U1253B). This measure is for informal used only, as its precision is limited (+/-1°C + 1%). The measurement made out of it will not be part of the report.

The following picture shows the test fixture inside the controlled climatic test chamber.

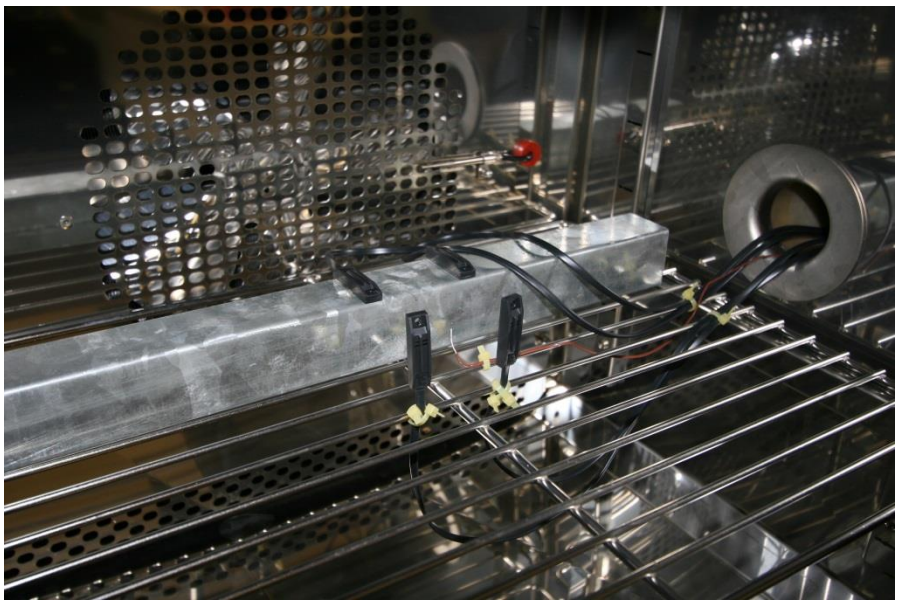

Figure 4: Close view of the sensors inside the chamber

Each probe is connected to a different Intelligent Power Strip (IPS). A Data concentrator (CTR) is used to collect all the data. The data are then processed to get the accuracy of the system. The following picture gives overall view or the chamber and the IPS and data concentrator next to it.

Figure 5: Overall view of the temperature test chamber

2.1 Devices under test

Type	Position
RN1091	Left on metal bar
RN1091	Left front (air)
RN1097	Right on metal bar
RN1097	Right front

Table 2: DUT list

3.1 Test equipment's

Use	Type	S/N
Temperature Test Chamber	T-40/100	077135
E3METER data concentrator	RN1400	005757
E3METER Inteligent Power Strip (IPS)	RN1229	003445
E3METER Inteligent Power Strip (IPS)	RN1208	005223
E3METER Inteligent Power Strip (IPS)	RN1208	006187
E3METER Inteligent Power Strip (IPS)	RN1223	006561

Table 3: Equipment list

4. Test procedure

The controlled climatic chamber is programmed to step through temperatures from -20°C to 60°C by steps of 5°C from 0°C to 60°C and by step of 10°C otherwise. Each step was hold for 30 minutes. 15 minutes are used for the temperature stabilization and remaining 15 minutes are used for the actual measurement.

The data concentrator is configured to record the min and the max for each sensor over a period of one minute. This data is then decimated again over the 15 minutes period using the same functions as outputted by the concentrated (e.g. the max of all max, the min of all min) to get the maximum and the minimum measured over the whole measurement period (15 minutes).

5. Results

The following table gives the maximum, the minimum and the mean (average) temperature measured by each sensor for each temperature step performed.

	RN1091 (air)			RN1091 (metal)			RN1097 (in air)			RN1097 (metal)		
	Max [°C]	Mean [°C]	Min [°C]	Max [°C]	Mean [°C]	Min [°C]	Max [°C]	Mean [°C]	Min [°C]	Max [°C]	Mean [°C]	Min [°C]
-20°C	-20.1	-20.7	-20.9	-19.1	-20.3	-20.5	-19.7	-20.4	-20.7	-18.5	-19.8	-20.1
-10°C	-10.4	-10.6	-10.8	-10.3	-10.4	-10.6	-10.2	-10.4	-10.5	-9.6	-9.9	-10.1
0°C	0.7	-0.1	-0.4	0.7	0.0	-0.3	0.8	0.0	-0.4	0.9	0.2	-0.1
5°C	4.9	4.9	4.8	5.0	5.0	5.0	5.1	5.0	4.9	5.4	5.4	5.3
10°C	10.0	10.0	9.9	10.1	10.1	10.1	10.1	10.0	9.9	10.4	10.3	10.2
15°C	15.1	15.0	15.0	15.3	15.1	15.1	15.1	15.0	14.9	15.4	15.2	15.1
20°C	20.1	20.0	20.0	20.2	20.2	20.1	20.1	20.0	19.9	20.4	20.2	20.1
25°C	25.2	25.1	25.0	25.2	25.2	25.1	25.1	25.0	24.9	25.3	25.1	25.0
30°C	30.2	30.1	30.0	30.3	30.2	30.1	30.1	29.9	29.8	30.3	30.1	30.0
35°C	35.2	35.1	35.0	35.3	35.2	35.1	35.1	35.0	34.8	35.2	35.1	35.0
40°C	40.2	40.1	40.0	40.3	40.2	40.1	40.0	39.9	39.8	40.2	40.0	39.9
45°C	45.2	45.1	45.0	45.2	45.1	45.1	45.1	44.9	44.8	45.1	45.0	44.9
50°C	50.1	50.1	50.0	50.1	50.1	50.1	50.0	49.9	49.8	50.0	49.9	49.8
55°C	55.1	55.1	55.0	55.2	55.1	55.1	55.0	54.9	54.8	55.0	54.9	54.8
60°C	60.2	60.1	60.0	60.3	60.1	60.1	60.0	59.9	59.8	60.0	59.9	59.8
70°C	70.1	70.0	70.0	70.1	70.1	70.1	70.0	69.9	69.8	69.9	69.8	69.7
80°C	80.0	80.0	80.0	80.0	80.0	80.0	79.9	79.8	79.7	79.7	79.6	79.5

Table 4: Results table

The negative temperatures are less accurate because the temperature test chamber needs more time to reach the settled temperature. So the measurements include some data were the temperature inside the chamber was still changing.

From those data, the following error table can be computed:

	RN1091 (air) ΔT [°C]	RN1091 (metal) ΔT [°C]	RN1097 (in air) ΔT [°C]	RN1097 (metal) ΔT [°C]
-20°C	± 1.0	± 1.0	± 0.8	± 1.6
-10°C	± 0.9	± 0.7	± 0.6	± 0.5
0°C	± 0.8	± 0.8	± 0.9	± 1.0
5°C	± 0.3	± 0.1	± 0.2	± 0.5
10°C	± 0.2	± 0.2	± 0.2	± 0.5
15°C	± 0.2	± 0.4	± 0.2	± 0.5
20°C	± 0.2	± 0.3	± 0.2	± 0.5
25°C	± 0.3	± 0.3	± 0.2	± 0.4
30°C	± 0.3	± 0.4	± 0.3	± 0.4
35°C	± 0.3	± 0.4	± 0.3	± 0.3
40°C	± 0.3	± 0.4	± 0.3	± 0.3
45°C	± 0.3	± 0.3	± 0.3	± 0.2
50°C	± 0.2	± 0.2	± 0.3	± 0.3
55°C	± 0.2	± 0.3	± 0.3	± 0.3
60°C	± 0.3	± 0.4	± 0.3	± 0.3
70°C	± 0.2	± 0.2	± 0.3	± 0.4
80°C	± 0.1	± 0.1	± 0.4	± 0.6

Table 5: Full error table

The errors shown here is the worst measure against the expected temperature (maximum deviation, including max. error of test chamber).

6. Conclusion

This measurement shows that for all positive temperatures the error of the temperature sensor (both types) never exceed ±1.0°C (taking also the test chamber accuracy). Negative measures are tainted by the chamber slower change rate.

For the typical usage range of 25°C to 60°C the error remains lower than ±0.4°C (chamber accuracy into account). This observation is coherent with the sensing element's supplier specifications.

The mounting method has no impact inside a homogenous environment. It has shown that it has a little impart on transient temperature (slower change on metal).