Development of Precision Resistors and available Models

Metrology Meeting 2021
Sa. 11. Sept. 2021

Agenda

- What are Precision Resistors
- Reasons for Deviation and external influences
- How we started (and have moved on)
- How to mitigate external influences
- What are High-Power Precision resistors
- Latest Resistors and measurement results
- Wekomm as manufacturer of metrology products and electronics
- Q&A

What are precision resistors

?

What are precision resistors

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They don‘t change their value!

What are precision resistors

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They don‘t change their value!

At least not much

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Reasons for Deviation and external influences

- Time (ageing)
- Mechanical influences, like movement, material drift, bending, etc.
- Influences caused by temperature (material expansion -> mechanical influences)
- Humidity
- Air Pressure
- Electrical fields
- Magnetical fields

Reasons for Deviation and external influences

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How critical is this?

Reasons for Deviation and external influences

Material move of 1Angström = 0.00000001mm

Reasons for Deviation and external influences

0.0000001mm
Translates into
0.01 ppm deviation

Reasons for Deviation and external influences

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Every influence factor has to be addressed separately

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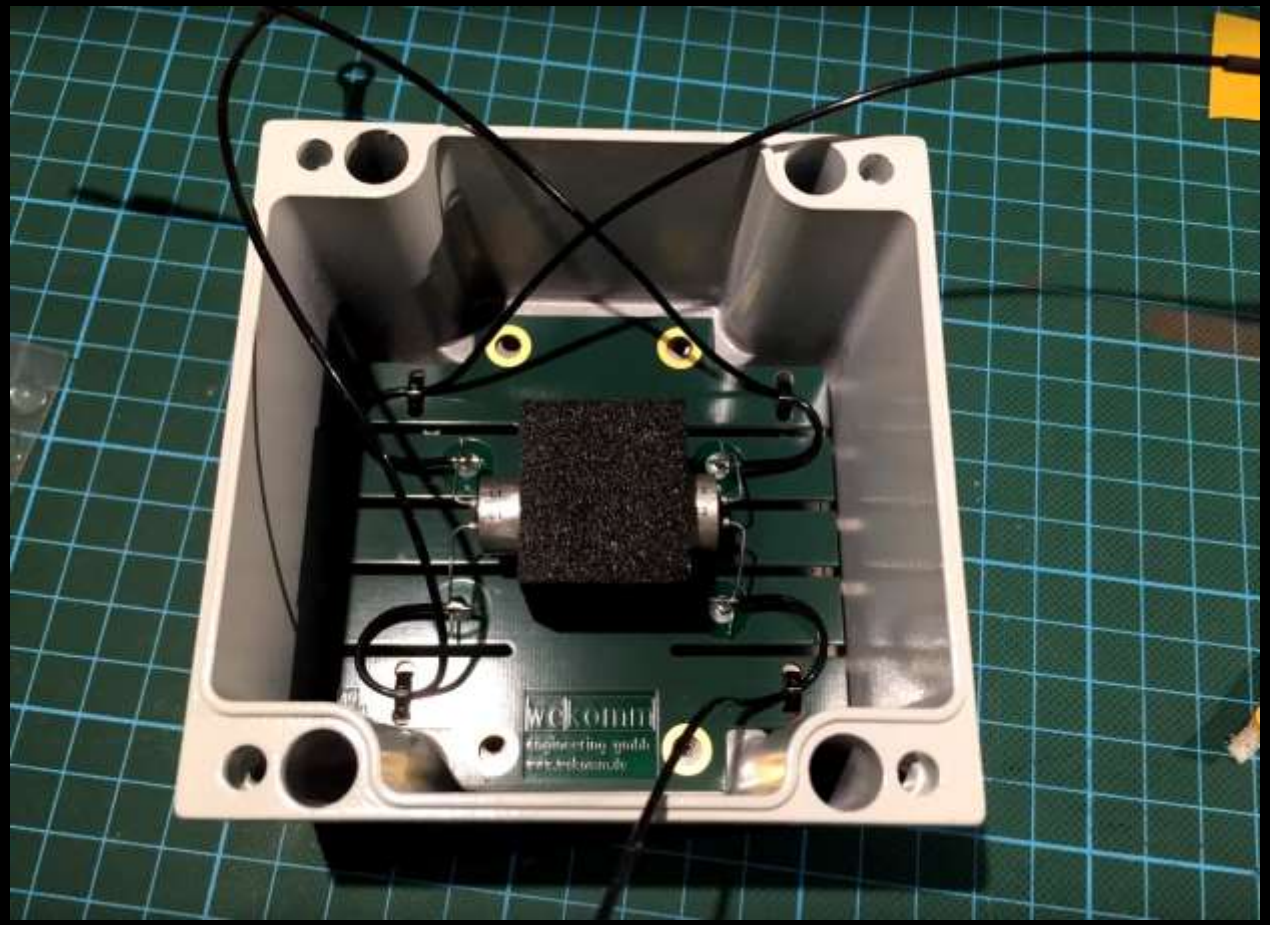
How we started



How we started

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This construction is history

How we started

- The first of our products relied heavily on readily avaliable components from established manufacturers
- Those components were extremely expensive and difficult to bring into specifications
- A lot of negotiation with manufacturers was necessary to obtain components which could be used.
- Yield was still very bad – unsuitable for higher production capacity
- An early model of one of those resistors was presented from Dave Jones at EEVBlog

We were mainly depending on the delivered components

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We changed everything

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We changed everything

(except the outer case)

… and how we moved on

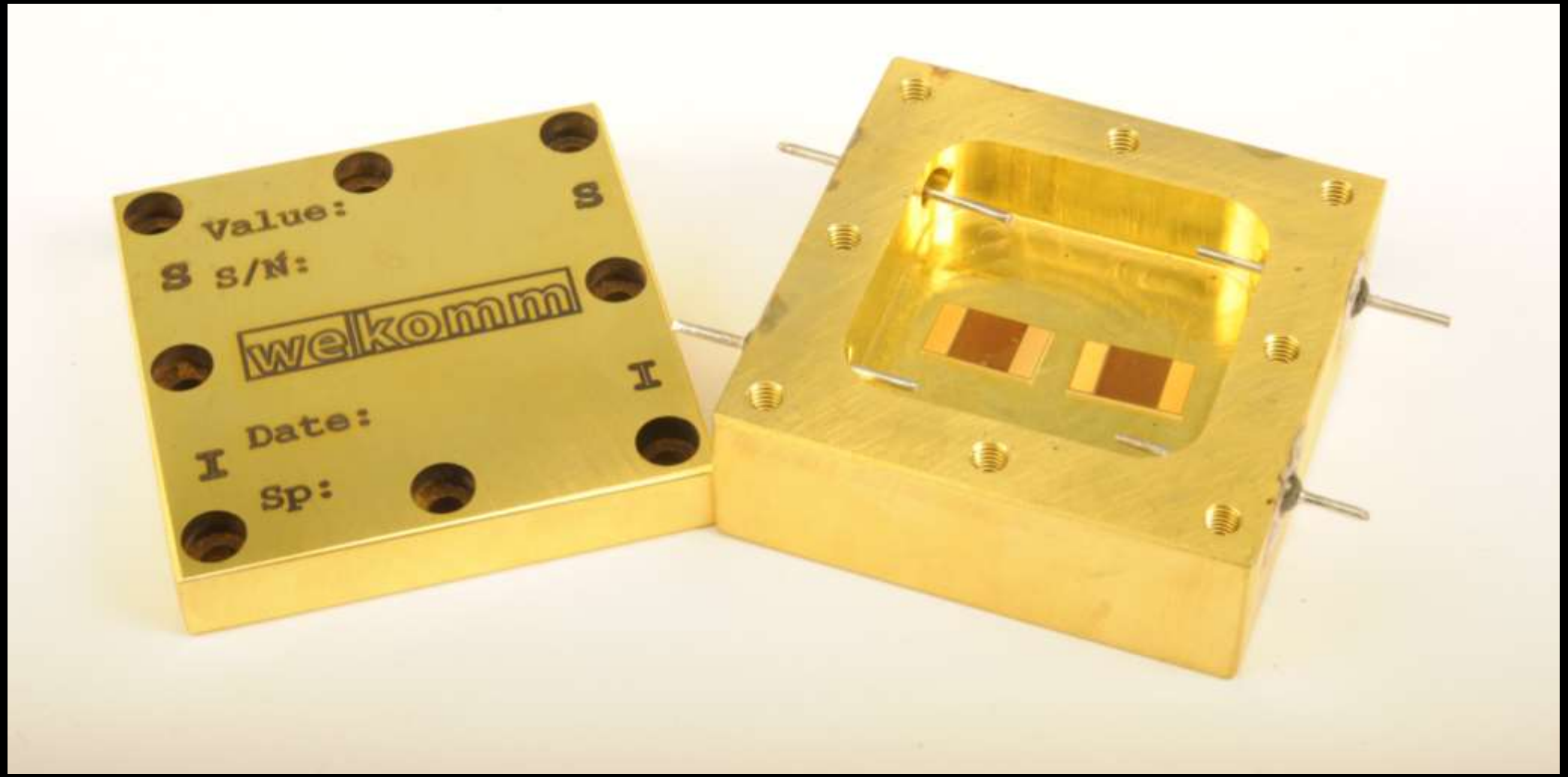
… and how we moved on

… and how we moved on

… and how we moved on

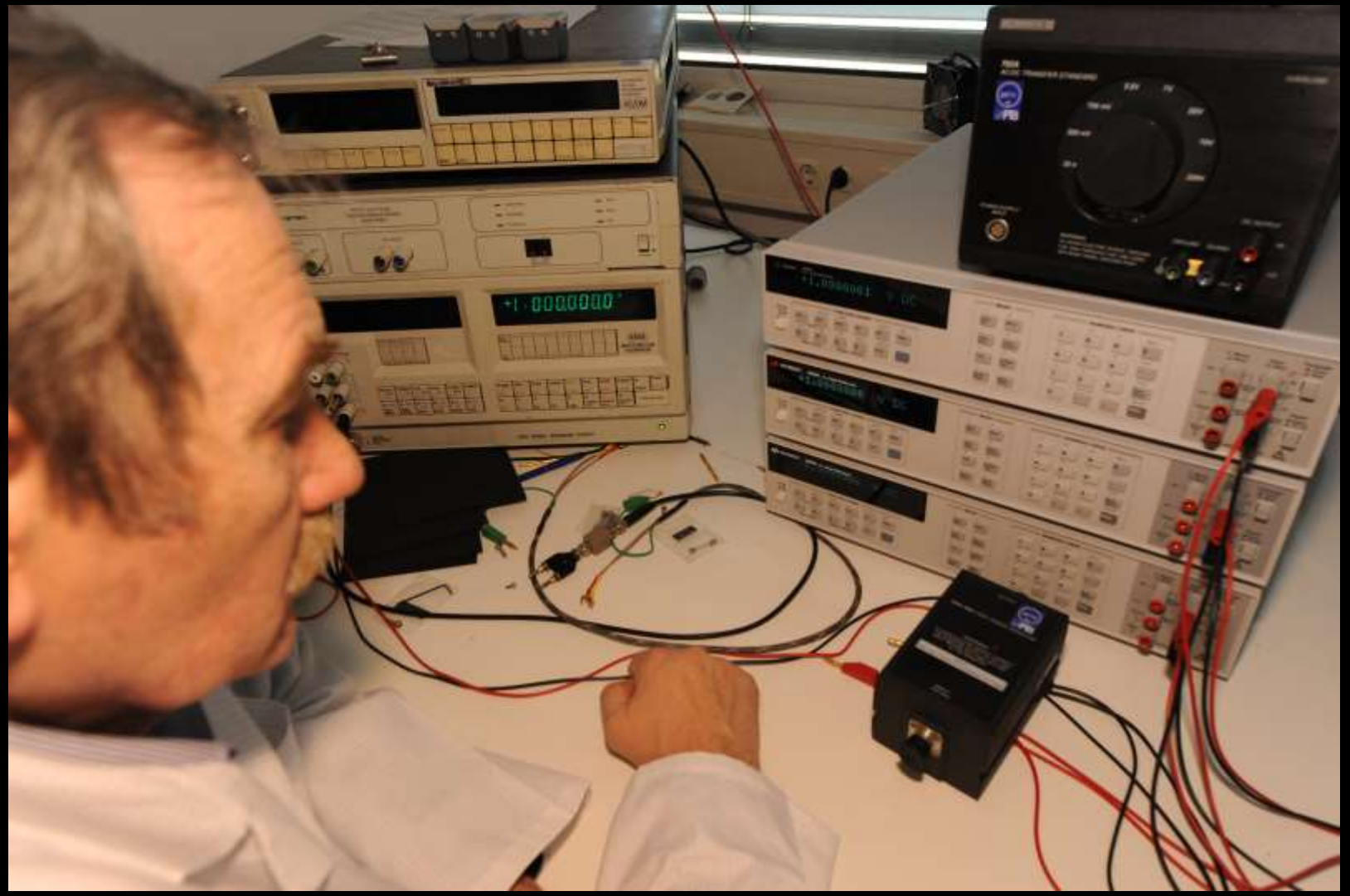
… and how we moved on

… and how we moved on



… and how we moved on

… and how we moved on



… Finally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RS9010A-100
Resistance Standard
Temp.: 18°C to 28°C
Max. Voltage = 5.0V
Max. Amperes = 0.05A
Nominal Value = 100Ω
100Ω

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How to mitigate external influences

- Use extremely stable cases
- Use carefully selected resistor components
- Use matched and selected glue and fixtures
- Precision machining and manufacture
- Thermal treatment of components and the finished products
- Electrical treatment
- Using oil or inert gases to fill the resistor cases

How to mitigate external influences

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Every change was applied and tested seperately

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What are high power precision resistors ?

What are High-Power Precision resistors

A load of 1A at 1V causes a deviation of less than

0.4 ppm

External influences

- Heat induced by the measurement current
- Mechanical stress caused by heat
- Connection components (Binding Posts, cables and contacts) need to be carefully examined and taken into account
- High currents generate material diffusion -> construction needs to take care of this effect

… and how to mitigate them

- Carefully applied thermal management with huge themal masses
- User several resistive elements with different temperature coefficients
- Connection elements need to be sized right so their effect is neglegible
- Use much material and much mass in construction
- Internal temperature sensors help reduce heat influences by numeric correction

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Bigger is better


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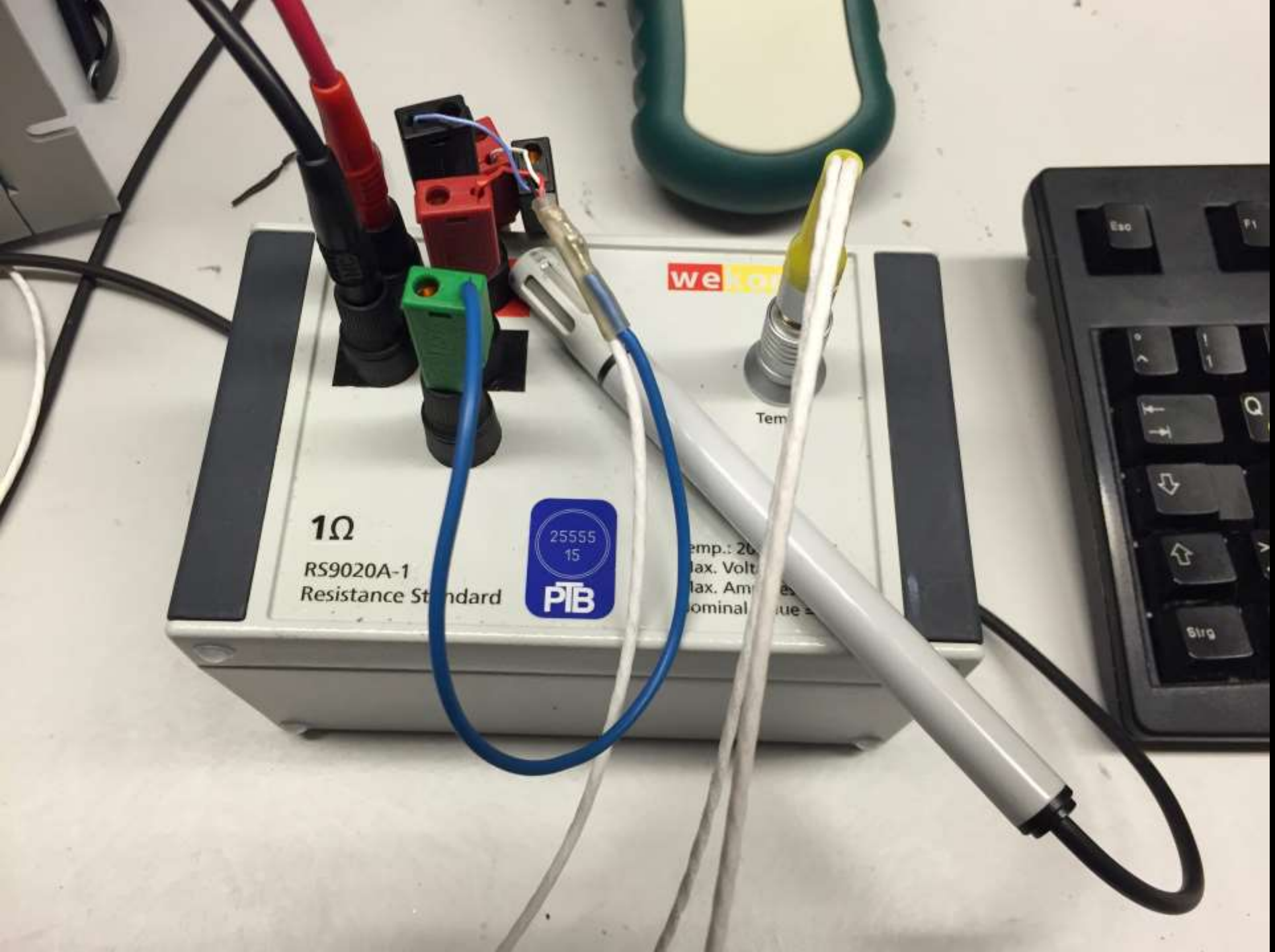
Temp
100Ω
RS9020A-100
Resistance Standard
Temp.: 20°C to 30°C
Max. Voltage = 10.0V
Max. Amperes = 0.1A
Nominal Value = 100Ω


1Ω
RS9020A-1
Resistance St ndard
25555
15
PTB
Esc
F1
Sirg


RS9010A-001
Resistance Standard
wekomm
Temp.: 20°C to 30°C
Max. Voltage = 0.3V
Max. Amperes = 30A
Nominal Value = 0.001Ω
0.001Ω
S

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Why high power resistors?

- For current measurements the voltage range can be lifted into the most precise range of the used multimeter (typ. 1V or 10V)
- This allows current mesurements within the sub-ppm range!
- Medium currents up to 30A can be measured directly with errors less than 5ppm
- High currents can be measured with differential current sensors

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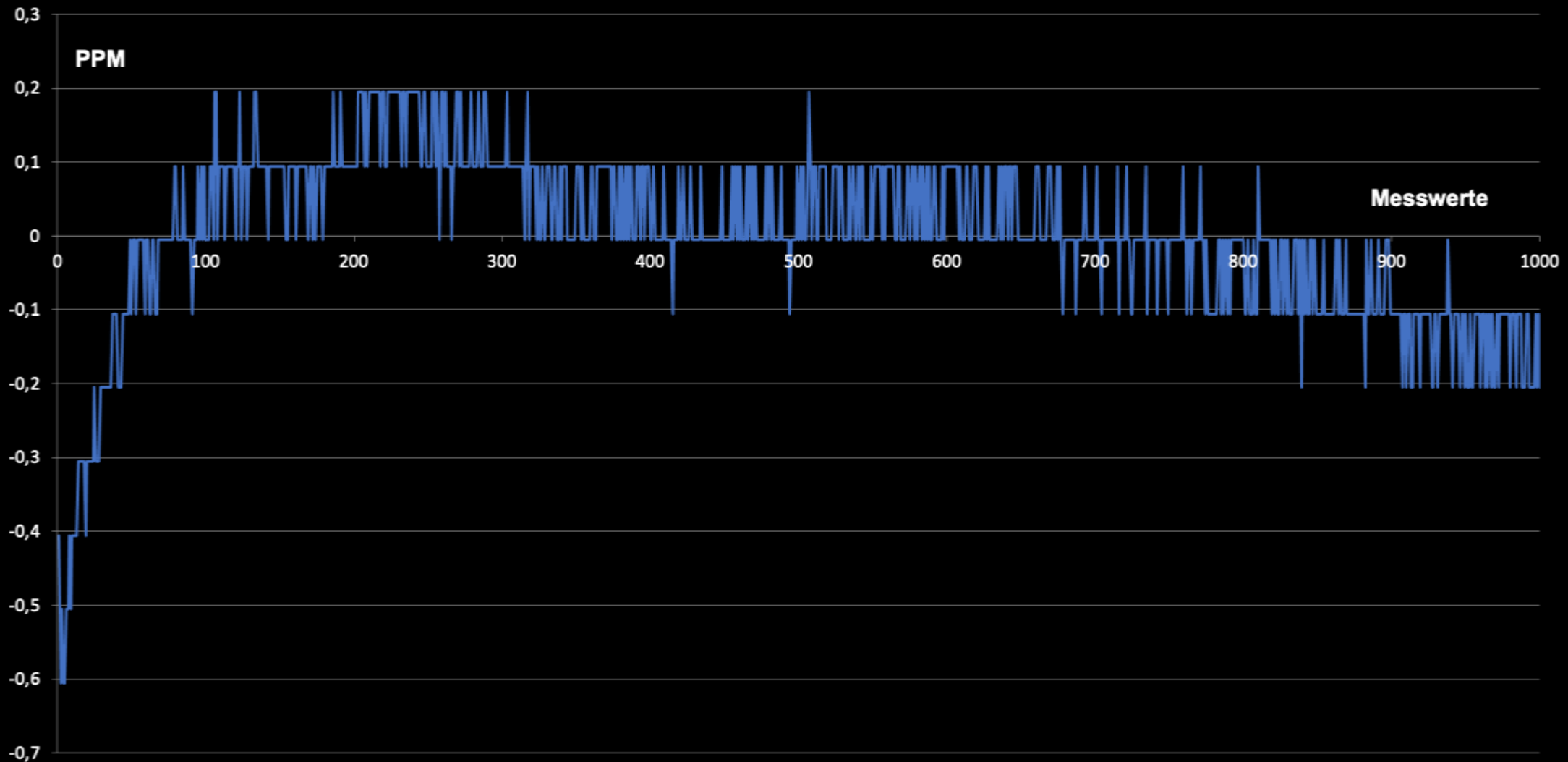
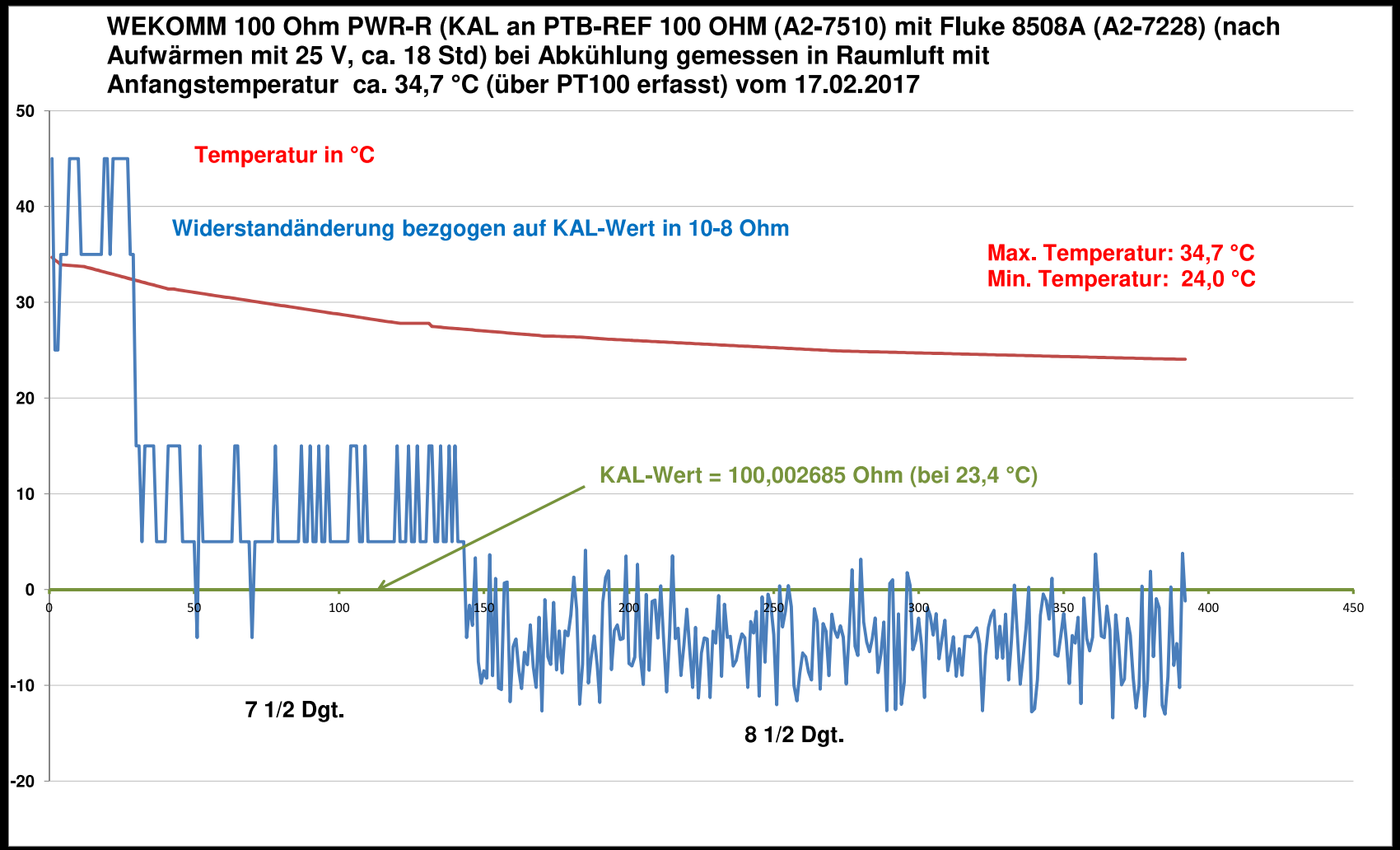
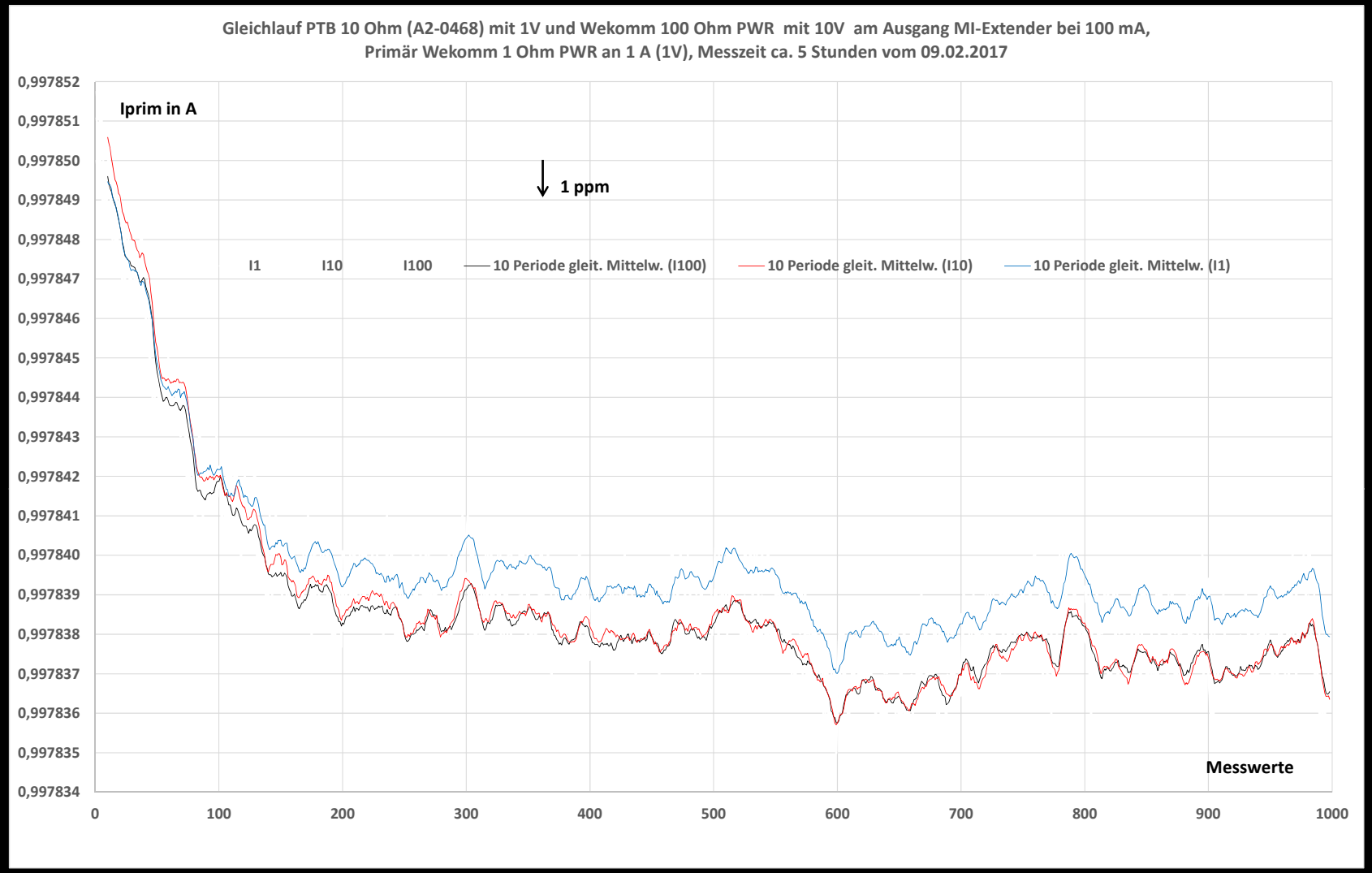
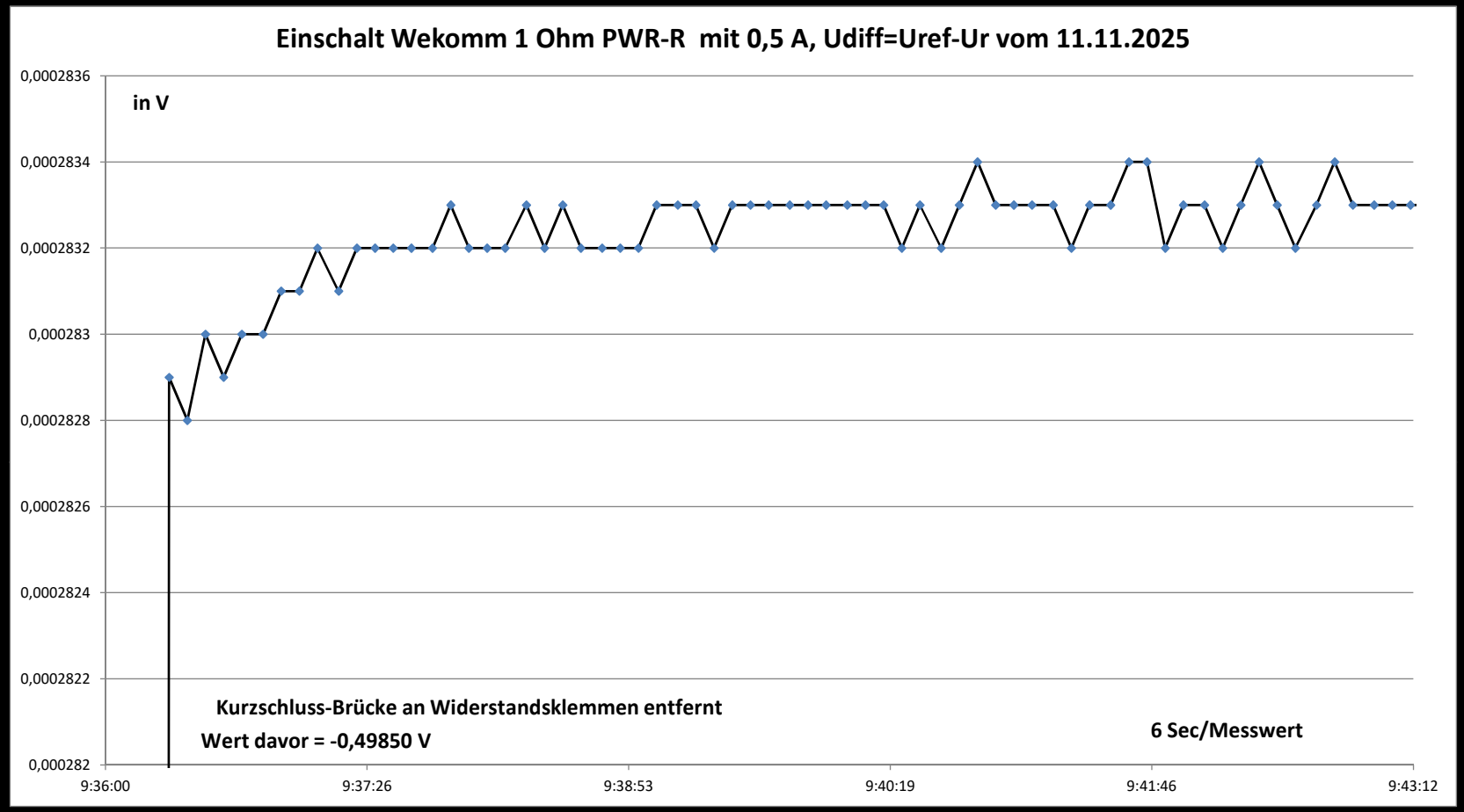
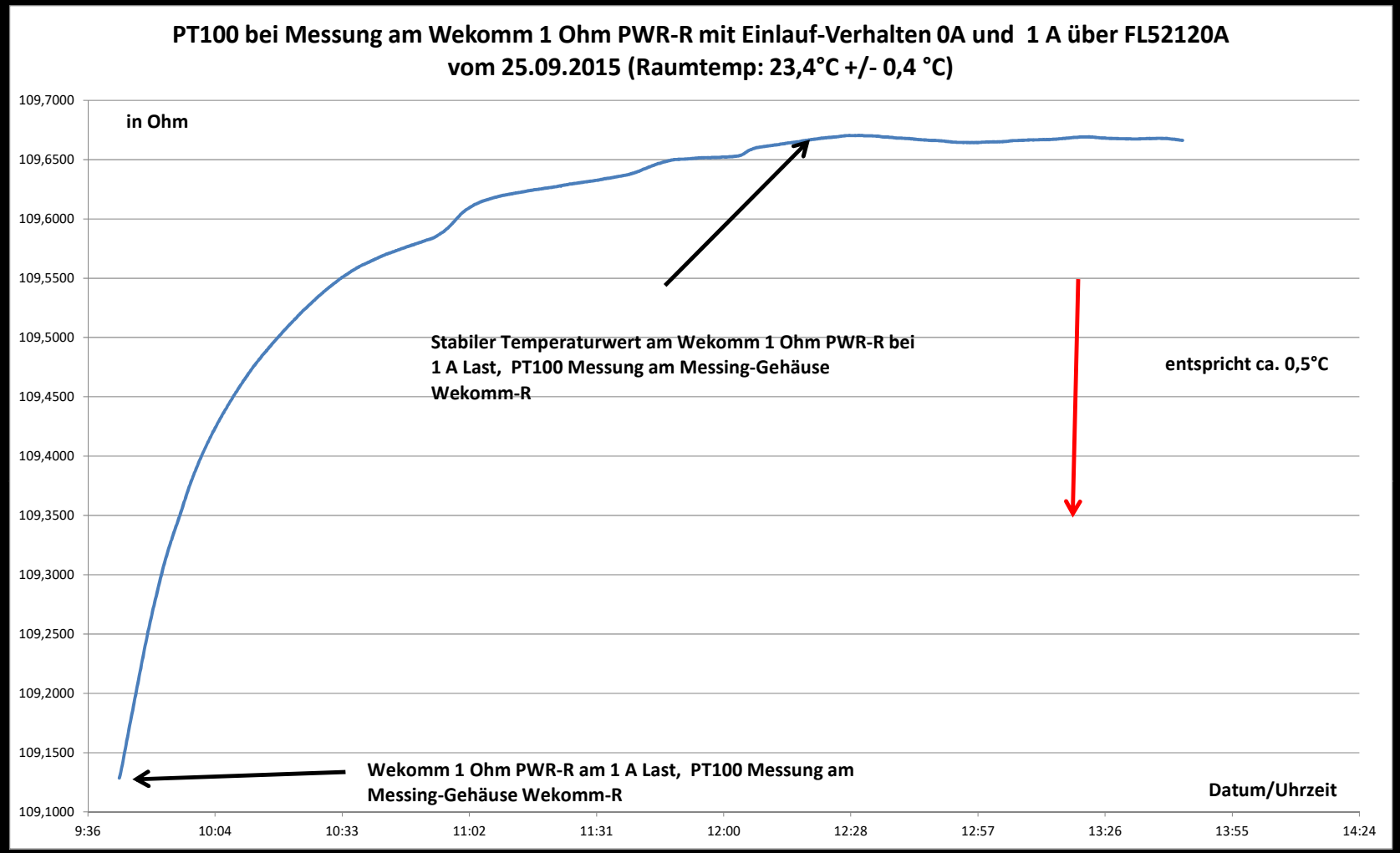
WEKOMM Pwr-R 100 Ohm nach ca. 60 min Aufheizen bei 15 V, dann Abklemmen und nach ca. 15 sec. Beginnder Widerstandsmessung

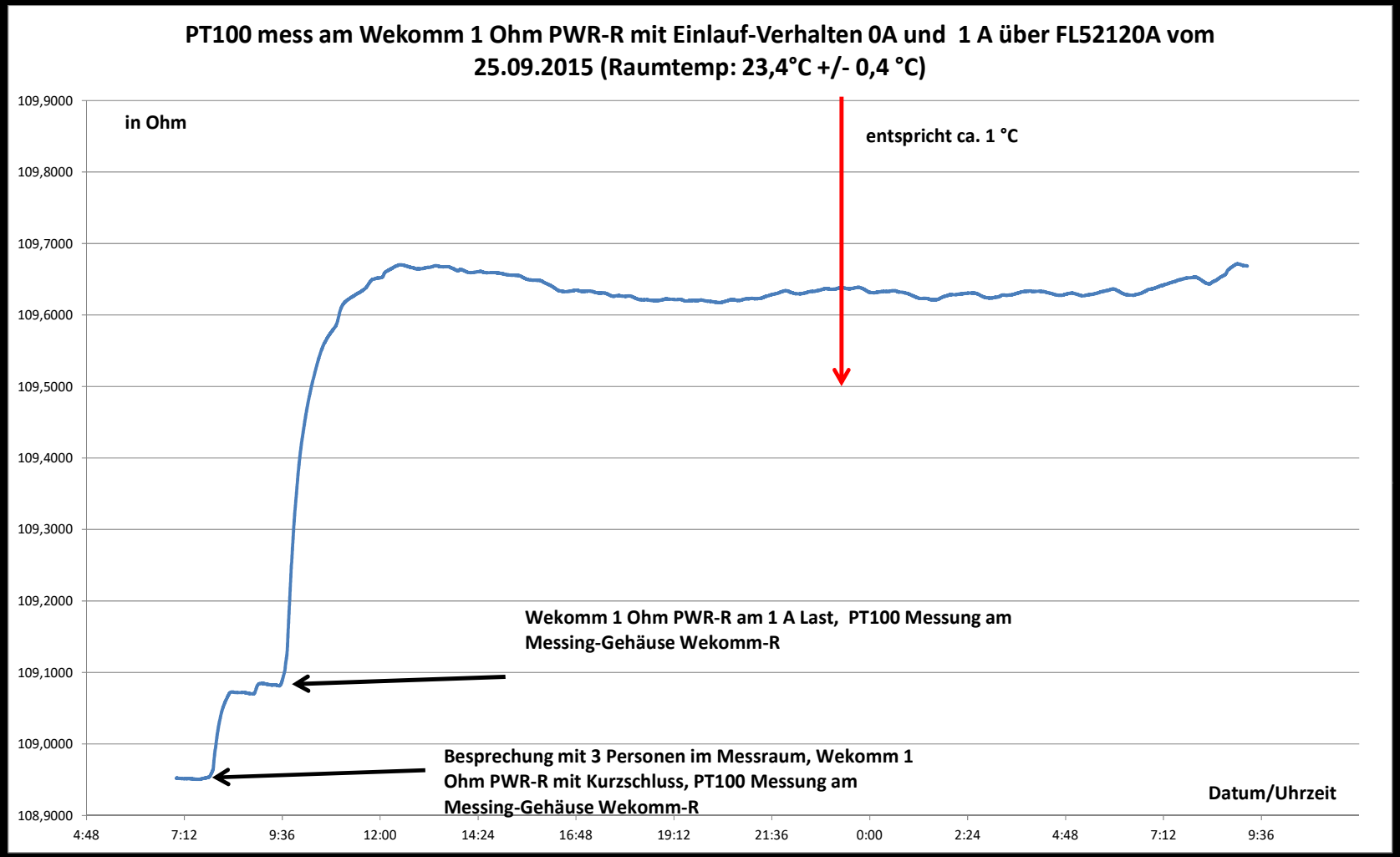



WEKOMM 100 Ohm PWR-R (KAL an PTB-REF 100 OHM (A2-7510) mit Fluke 8508A (A2-7228) (nach Aufwärmen mit 25 V, ca. 18 Std) bei Abkühlung gemessen in Raumluft mit Anfangstemperatur ca. 34,7 °C (über PT100 erfasst) vom 17.02.2017
Temperatur in °C
Widerstandänderung bezogen auf KAL-Wert in 10-8 Ohm
Max. Temperatur: 34,7 °C
Min. Temperatur: 24,0 °C
KAL-Wert = 100,002685 Ohm (bei 23,4 °C)
7 1/2 Dgt.
8 1/2 Dgt.
50
40
30
20
10
0
-10
-20
0
50
100
150
200
250
300
350
400
450


Gleichlauf PTB 10 Ohm (A2-0468) mit 1V und Wekomm 100 Ohm PWR mit 10V am Ausgang MI-Extender bei 100 mA,
Primär Wekomm 1 Ohm PWR an 1 A (1V), Messzeit ca. 5 Stunden vom 09.02.2017
Iprim in A
1 ppm
I1
I10
I100
10 Periode gleit. Mittelw. (I100)
10 Periode gleit. Mittelw. (I10)
10 Periode gleit. Mittelw. (I1)
Messwerte
0,997852
0,997851
0,997850
0,997849
0,997848
0,997847
0,997846
0,997845
0,997844
0,997843
0,997842
0,997841
0,997840
0,997839
0,997838
0,997837
0,997836
0,997835
0,997834
0
100
200
300
400
500
600
700
800
900
1000


Einschalt Wekomm 1 Ohm PWR-R mit 0,5 A, Udiff=Uref-Ur vom 11.11.2025
in V
0,0002836
0,0002834
0,0002832
0,000283
0,0002828
0,0002826
0,0002824
0,0002822
0,000282
9:36:00
9:37:26
9:38:53
9:40:19
9:41:46
9:43:12
Kurzschluss-Brücke an Widerstandsklemmen entfernt
Wert davor = -0,49850 V
6 Sec/Messwert


PT100 bei Messung am Wekomm 1 Ohm PWR-R mit Einlauf-Verhalten 0A und 1 A über FL52120A
vom 25.09.2015 (Raumtemp: 23,4°C +/- 0,4 °C)
in Ohm
109,7000
109,6500
109,6000
109,5500
109,5000
109,4500
109,4000
109,3500
109,3000
109,2500
109,2000
109,1500
109,1000
Stabiler Temperaturwert am Wekomm 1 Ohm PWR-R bei 1 A Last, PT100 Messung am Messing-Gehäuse Wekomm-R
entspricht ca. 0,5°C
Wekomm 1 Ohm PWR-R am 1 A Last, PT100 Messung am Messing-Gehäuse Wekomm-R
Datum/Uhrzeit
9:36
10:04
10:33
11:02
11:31
12:00
12:28
12:57
13:26
13:55
14:24


PT100 mess am Wekomm 1 Ohm PWR-R mit Einlauf-Verhalten 0A und 1 A über FL52120A vom 25.09.2015 (Raumtemp: 23,4°C +/- 0,4 °C)
in Ohm
entspricht ca. 1 °C
Wekomm 1 Ohm PWR-R am 1 A Last, PT100 Messung am Messing-Gehäuse Wekomm-R
Besprechung mit 3 Personen im Messraum, Wekomm 1 Ohm PWR-R mit Kurzschluss, PT100 Messung am Messing-Gehäuse Wekomm-R
Datum/Uhrzeit
109,9000
109,8000
109,7000
109,6000
109,5000
109,4000
109,3000
109,2000
109,1000
109,0000
108,9000
4:48
7:12
9:36
12:00
14:24
16:48
19:12
21:36
0:00
2:24
4:48
7:12
9:36

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Wekomm as manufacturer

- Wekomm is developing electronics and precision metrology since 15 years
- Cooperation with PTB (Physikalisch Technische Bundesanstalt) since many years
- Wekomm standard resistors are among the best resistors worldwide available
- Wekomm has know-how in electronics since decades

Wekomm as manufacturer

- We do research in resistor manufacturing
- We produce three families of standard resistors
- We have developed own measurements devices
- We develop and manufacture electronics for global companies
- We do consulting for calibration and manufacturers
- We operate one of the most precise Cal Labs for DC-Measurements in Germany (for own use only)

Re-development of the new 3458A multimeter

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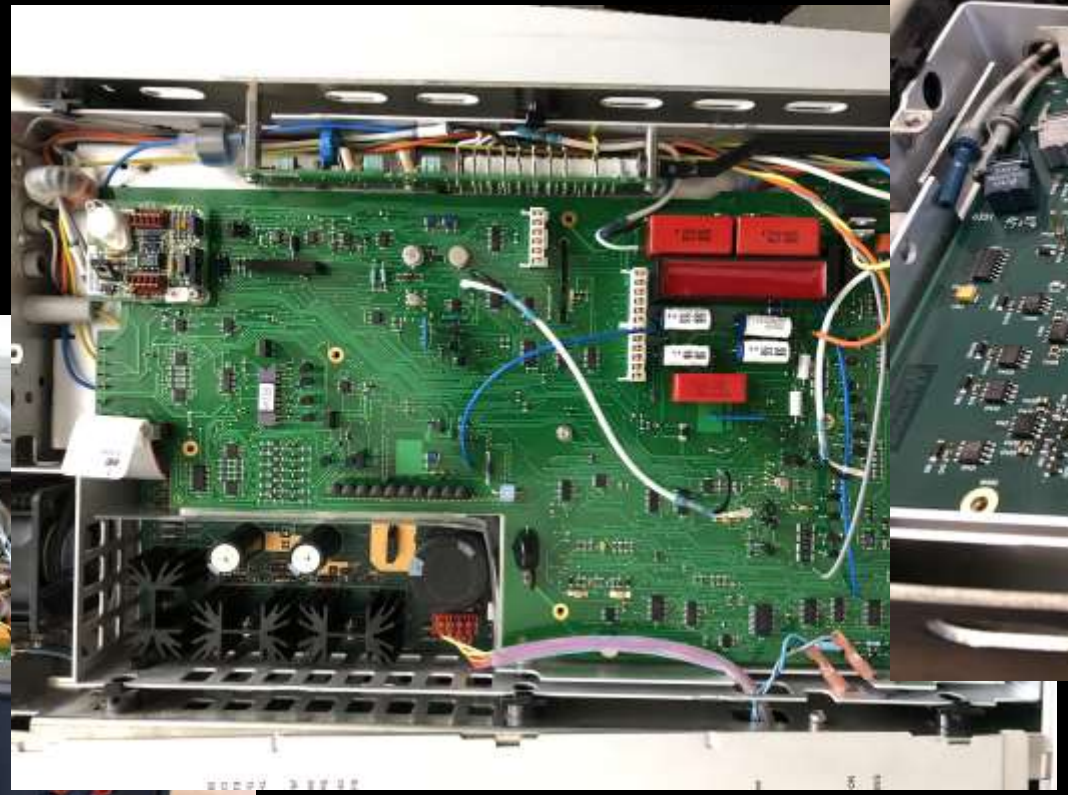

Precision resistor matrix for production calibration of medical instruments

Environment Monitor with „SensorFusion“

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Q&A