DC characterization of AC current shunts for wideband power applications

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Abstract **The dc properties of a set of recently developed ac-dc transfer current shunts in the range of 30 mA to 10 A are presented. The characterization includes the long-term drift, temperature coefficient (TCR) and power coefficient (PCR), which all appear to have effects on the level of 1 – 10 μΩ/Ω. After corrections for the TCR and PCR, the uncertainty in the shunt resistance is between 1 and 3 μΩ.**
These results prove the suitability of the shunts for wideband power applic¬ations where both small ac-dc transfer differences as well as stable dc characteristics are required.

Aim

Evaluate whether recently developed current shunts for ac-dc measurements are suitable for wideband power measurements, where additional DC requirements are present.

Shunt design optimized for wideband properties

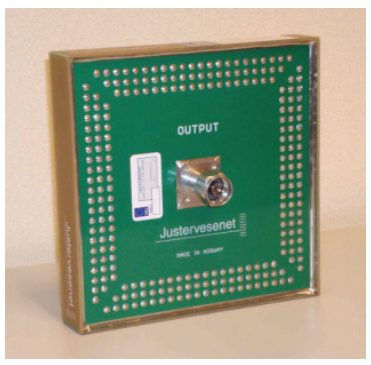
Seven shunts in the range 30 mA – 10 A, with 0.9 V output.

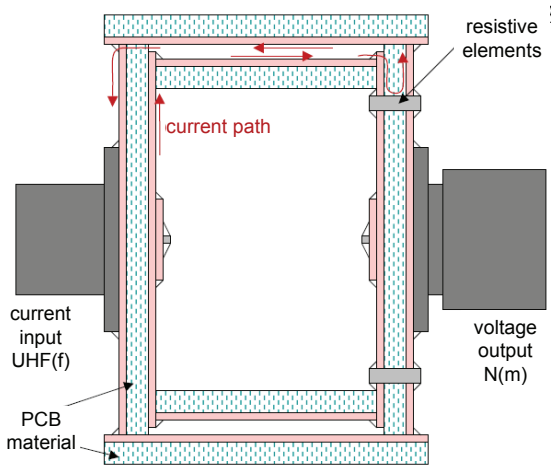
AC requirements:

- small capacitance and inductance → MELF surface mount R's
- small stray magnetic fields → coaxial design
- good heat dissipation → good thermal contact
- and a small skin effect → thin copper layers on PCB

DC requirements:

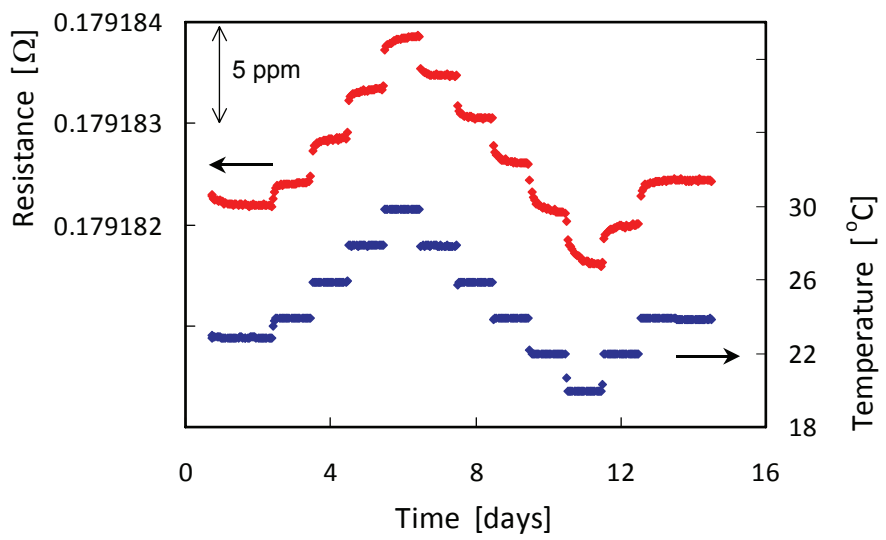
- small temperature coefficient (TCR) → 10 ppm/K per single R
- small power coefficient (PCR) → small TCR, good cooling
- long term stability → multiple R elements





Temperature coefficient

Temperature cycle of shunts between 20 °C and 30 °C via temperature-controlled enclosure. Result for 5 A shunt:



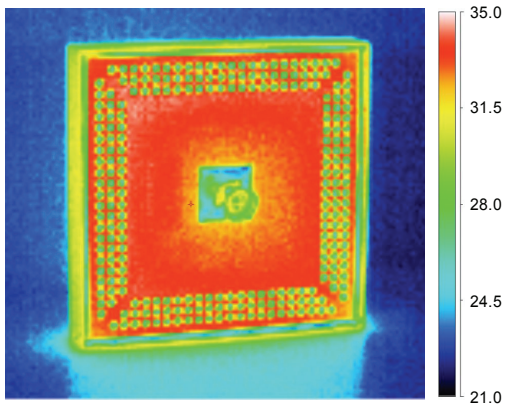
Typical values (1 – 3) μΩ/Ω per °C, maximum –9 μΩ/Ω per °C.
Stabilisation time several hours, up to 2 days.

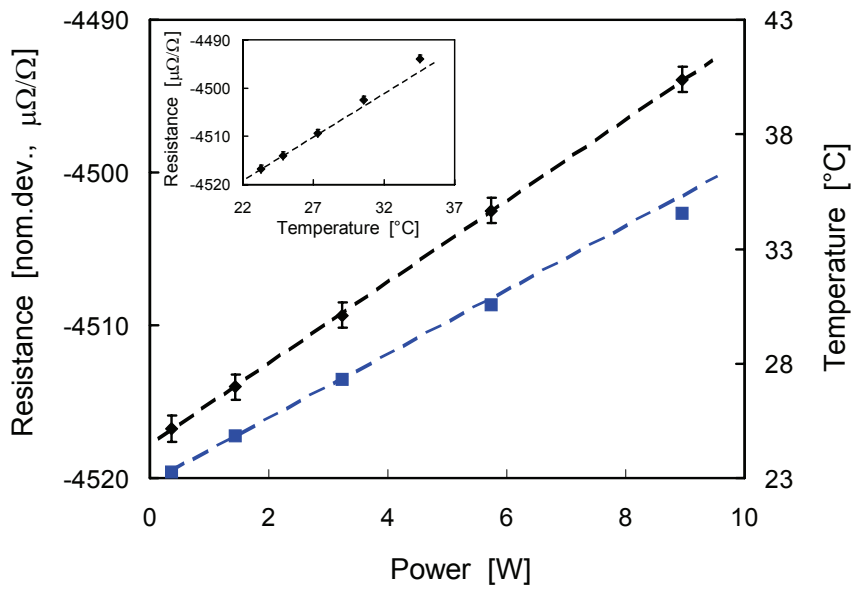
Power coefficient

Heating is homogeneous, resistors are within 2 °C.

Result: linear relation between R / T and power
⇒ **T measurement can correct for both TCR and PCR**

Thermometer on PCB near resistive elements is crucial: PCR depends on cooling!
(also small additional uncertainty due to cooling for 10 A shunt at 9 W)





Overview of DC shunt properties

Nom.current [A]	Nom.power [W]	Actual value [Ω]	TCR [μΩ/Ω/°C]	Drift [μΩ/Ω/yr]	PCR [μΩ/Ω/W]
10	9	0.0896	1.8	5.8	2.7
5	4.5	0.1792	1.3	7.7	2.6
3	2.7	0.3072	1.3	8.3	3.6
1	0.9	0.9036	-7.9	-42	
0.3	0.27	3.031	3.3	7.7	
0.1	0.09	10.002	0.6	11	
0.03	0.027	41.672	-8.8	5.8	

Conclusions

AC-DC shunts show good DC properties, which make them suitable for wideband power measurements. After correction of environmental effects, an uncertainty in shunt resistance of 1 – 3 μΩ/Ω is achieved.

Reference

[1] K. Lind, T. Sørsdal, and H. Slinde, "*Design, modeling, and verification of high-performance AC-DC current shunts from inexpensive components*," IEEE Trans. Instr. Meas., vol. 57, pp. 176 – 181, 2008.

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