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Low-Cost, High-Precision Temperature Monitoring Electronics for Harsh Environments

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For numerous scientific applications, highly precise temperature measurement in the millikelvin (mK) range is essential, particularly under challenging environmental conditions. Measurement systems must provide stable and reproducible results over a wide temperature range while operating reliably under low atmospheric pressure, down to vacuum conditions.

A relevant application example is the GLORIA Lite instrument, a compact remote sensing system designed to measure infrared radiation in the Earth's atmosphere and analyze trace gas concentrations. This instrument is deployed on a stratospheric balloon at altitudes of up to 40 km. For accurate calibration of the onboard spectrometer during measurements, a blackbody radiator is integrated, requiring highly precise temperature sensing.

This work presents a low-noise and temperature-drift compensated measurement electronics system based on PT100 platinum temperature sensors in a four-wire measurement configuration. The goal is to achieve an absolute measurement accuracy of ±50 mK and a relative accuracy of ±10 mK over a temperature range from -40 ℃ to +60 ℃. The PT100 sensors are calibrated according to the ITS-90 temperature scale.

We present initial results of the circuit design and the necessary calibration procedures to determine and compensate for internal and external influencing factors. In particular, aspects such as offset compensation, temperature drift of the electronics, and the characterization of sensor coefficients are investigated.

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