35) Temperature Measurement of an Object Using Blackbody Radiation with Compensation of Impedance Mismatch

Dawei Xu(1)(2), Klaus Thelen(1), Jörg Himmel(1), Daniel Erni(2)

(1) Institute of Measurement Engineering and Sensor Technology,
University of Applied Sciences Ruhr West,
D- 45479 Mülheim an der Ruhr, Germany

E-Mail: dawei.xu@hs-ruhrwest.de, klaus.thelen@hs-ruhrwest.de,
joerg.himmel@hs-ruhrwest.de

(2) General and Theoretical Electrical Engineering (ATE),
Faculty of Engineering, University of Duisburg-Essen,
D-47048 Duisburg, Germany

E-Mail: daniel.erni@uni-duisburg-essen.de

Abstract – In this talk a measurement method for non-contact temperature monitoring of an object in an electromagnetic shielded cavity is introduced. The thermal noise of the measured object can be determined by using a coupling loop at 600 – 2000 MHz (microwave bandwidth) inside the cavity. The scale of the measurement for very low radiant energy from the object is defined by the physical concepts by radiometer, and the coupling rate between object and coupling loop [1]. In order to measure the correct absolute temperature, the low noise amplifier (LNA) and radiometric detector needs to be calibrated first. Since the object may change its physical properties, like electrical properties or position, the coupling rate needs to be monitored frequently during the measurement. The mode of the electromagnetic wave in the cavity can also be influenced, when the wavelength and the dimension of the cavity are almost the same size. Measuring the impedance of the coupling loop within the cavity can help to obtain the coupling rate, which is used for calculating the scale from the object to the radiometer. With the corrected scale the absolute temperature can be exactly calculated.

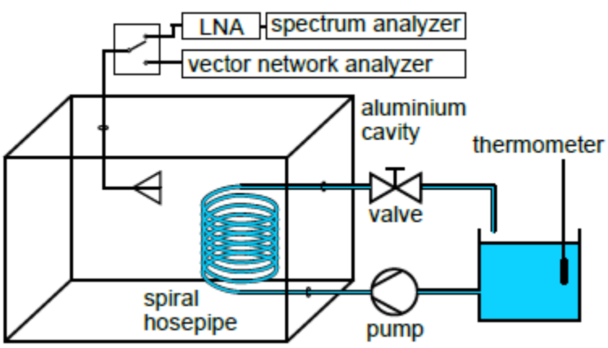

Fig.1: Experimental setup

Fig.1 shows the experimental setup. The weak thermal noise coming from the object is amplified by a cascade LNA. A spectrum analyzer is used for measuring the thermal noise after it was amplified by the LNA, the impedance is measured with a network analyzer. They are measured separately after the calibration of the instruments. During the experiment the power supply and room temperature is kept at a constant level to keep the intrinsic noise of the measure system strictly stable. The intrinsic noise therefore can be considered as a constant parameter in the calculation.

This measurement method is especially suitable for real-time temperature monitoring of objects which are placed randomly in the cavity, and are changing their conditions continuously. Because of the large measurement bandwidth, the electromagnet wave has a variable penetration depth, which means the sensor can 'see' the temperature inside the object. This measurement method could be used for example to monitor industrial production lines for quality control purposes or to monitor warmed plasma to avoid overheating [2] in medical applications.

References

[1] Richard C Willson, "Active cavity radiometer". *Applied Optics*, 12(4):810–817, 1973.
[2] Dawei Xu, Dirk Rüter, and Daniel Erni. „Non-contact radiative temperature monitoring of blood plasma and packed red blood cells in a powerful microwave environment", 1 st. in YRA MedTech Symposium (YRA-MedTech 2016), YRA–Young Researchers Academy MedTech in NRW, April, volume 8, pages 66–67, 2016.