ACTIVE BLACKBODY CALIBRATION TARGET FOR MICROWAVE RADIOMETER CALIBRATION

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1.Introduction

Microwave radiometers should be calibrated by introducing two specified temperature levels to radiometer system input. Ambient temperature is mostly one of the levels, and liquid nitrogen temperature, 77 K, is often preferred as the other for being within the range of detected temperatures.

As the radiometric system includes an antenna, the both calibration noise temperatures should be introduced externally.

In the systems using scanning antennas as e.g.(1), this can be done by pointing the scanning antenna downwards to a "blackbody target", usually a metal plate covered with a suitable absorber.

This "blackbody target" produces the radiation level corresponding to the ambient temperature, around 290 K. Fig.1.

The other temperature level, e.g. the 77K, should be, however, introduced from outside as shown in Fig.2 (1).

Often it is difficult to carry liquid nitrogen to a radiometer located in the field.

Many radiometers contain a noise injection circuit which injects noise from a noise generator through a directional coupler towards the radiometer input, Fig.3. In this way, again two noise levels can be introduced to the radiometer for calibration, when its antenna is pointed to the blackbody target.

The directional coupler, however, introduces certain loss to the signal path, and its location excludes antenna from calibration. Also, it can cause some malfunctions (2).

2. New concept

Microwave absorbers are attenuators for signals passing through the layer: losses of 20-40 dB per layer can be observed.

By locating a noise generator behind the absorber being used as "blackbody target", the generator noise is attenuated to a desired level, e.g. 10-100 K over the ambient temperature. This is equivalent to a noise level generated by the use of the directional coupler. In the new concept, however, antenna is included in the calibration process, and no loss is introduced to signal path.

The noise generator requires a well matched load: in the new concept, its load consists of a matched attenuator and the absorber layer. A small horn can be used to direct the noise towards the antenna, as shown in Fig.4.

The noise generator produces typically the ENR= 30 dB. To calibrate a radiometer, ENR of less than 1 dB is required to avoid saturation (temperature range typically is 0 to 500 K).

Thus, the sum of absorber loss and attenuator loss should be adjusted to near 30 dB.

While the use of liquid-nitrogen calibration is not affected by the described design, the radiometric system can be easily calibrated any time and automatically. The noise generator can be built in any system using an absorber as a blackbody target.

Similar device can be built in a portfolio and located close to radiometer for calibration, being easier to carry than a liquid-nitrogen cooled target.

3. Noise injection system improvement

As described above, noise injection in radiometers is used for calibration or for gain stabilization. Also here the system can be improved by translating the noise injector to the (scanning) antenna as shown in Fig.5. Again, no directional coupler is installed to the signal path to degrade system performance. At millimeter waves, a typical noise-path loss is 15-20 dB, while the noise-horn blockage can be neglected.

The arrangement shown in Fig.5 offers also a simpler mechanical solution than that used in (3). The scanning antenna can be divided into the horn-parabolic section with(out) an aperture window, and this part would rotate using bearings supporting the horn neck and noise-injection waveguide. The feedhorn could be stationary, or, it can rotate with the antenna together with the radiometer, as the microwave system is smaller than the antenna.

4. References

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(2) Solheim,F.S.: Use of Pointed Water Vapor Radiometer Observations to Improve Vertical GPS Surveying Accuracy, Ph.D. Thesis, Univ.of Colorado, 1993

(3) Jacobson,M.D.,et al.: A Dual-Frequency mm-Wave Radiometer Antenna, Microwave Journal, Sep.1994,p.24-37

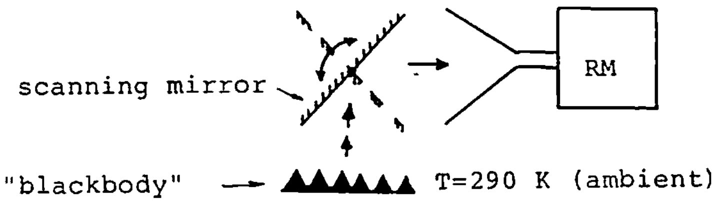

Fig.1 Ambient temperature calibration, using a "blackbody target" absorber, the noise temperature of which is radiated to the system antenna by the scanning mirror

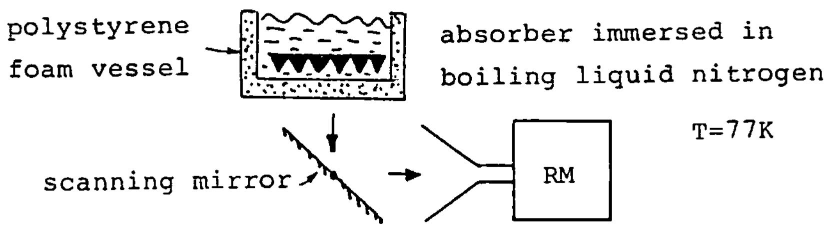

Fig.2 Calibration by the external absorber cooled e.g. by boiling liquid nitrogen at 77 K

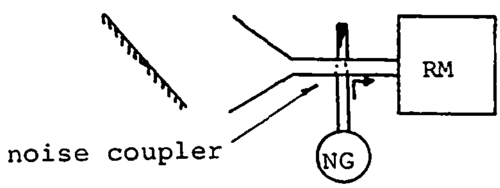

Fig.3 Noise injection using a directional coupler located between the antenna and radiometer input. In this way, antenna itself is excluded from the calibration process.

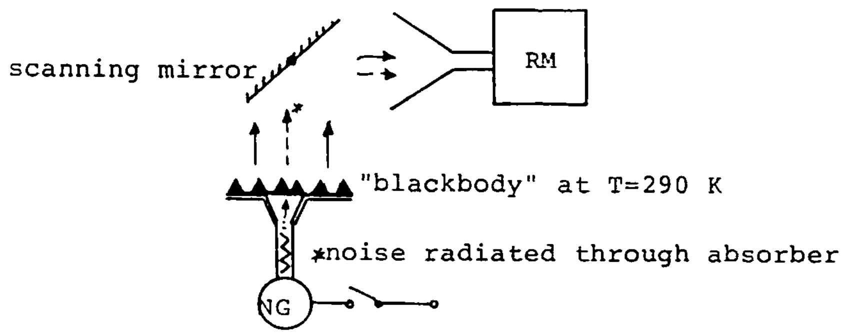

Fig.4 New concept employs a noise generator, radiating through the absorber used as "blackbody target" the emission of which produces a noise temperature of 290 K. When the noise generator is on, the noise temperature emitted towards the antenna-radiometer system is higher by the contribution of the noise generator attenuated by the absorber.

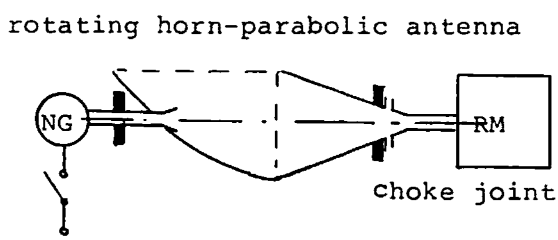

Fig.5 Noise injection system is emitting the noise temperature from a noise generator through its radiator towards the radiometer input. The scanning antenna is rotated as usual, the bearings are located at noise injection waveguide and at horn parabola neck.