Analysis and Verification of Calibration Methods for Fully Polarimatric W-band Radiometer

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Abstract:

In single and dual polarized radiometers, only two unpolarized reference sources are required for the precise calibration. However, the calibration of the fully polarimetric radiometer needs an additional calibration standard to calibrate the third and fourth Stokes parameters with the information of 45 ° linear and circular polarization. The calibration unit for all Stokes parameters has been called "fully polarimetric calibration standard" [1].

In general the calibration unit is composed of two blackbodies with different known brightness temperature and a polarized wire grid which splits the polarization from the unpolarized blackbodies[2]. This calibration unit generates first three Stokes parameters. Generally, it has been called "linearly polarization standard". However, this linearly polarization standard generates only first three Stokes parameters and do not perform the calibration of the fourth Stokes parameter. To calibrate the fourth Stokes parameter, it is required to generate the circular polarization in the calibration unit. The calibration method of circular polarization was suggested by using a phase retardation plate between the antenna and the linearly polarized standard[1][3]. In general, the metal wire grid is used for the polarizing grid to polarimetric calibration. However, its fabrication is very complicate and quite expensive at millimeter-wave band.

In this work, a practical method is proposed for accurate calibration of tripolarimetric radiometer, which measures first three Stokes parameters. In this work, a printed grid on microwave substrate is applied for polarizing grid. The fist approach of this method was introduced at 10.7 GHz and the grid on a substrate was suggested to have an equal characteristic with a metal grid at the measurement frequency[1]. However, it supposes that the polarizing grid on the dielectric material has a different property with a metal grid in W-band. In order to perform the suggested calibration method for fully polarimetric calibration at W-band, a few types of the calibration standards were developed in our laboratory. The calibration standard is composed of a printed polarizing grid on the microwave substrate, a retardation plate, and reference sources. The reference sources are a hot target at ambient temperature and a cold source made by the liquid nitrogen. Firstly, the characteristic of calibration standards was measured and evaluated. By rotating the linearly polarized standard and the retardation plate, the linearly independent brightness temperatures were obtained for fully polarimetric calibration. Using these measured brightness temperatures, the calibration gain-offset matrix was estimated. At specific angle of grid and retardation, the brightness temperatures of full Stokes parameter were measured and evaluated. Finally, the uncertainties of parameters of calibration standards were estimated to evaluate the error of measured Stokes parameters of the developed radiometer.

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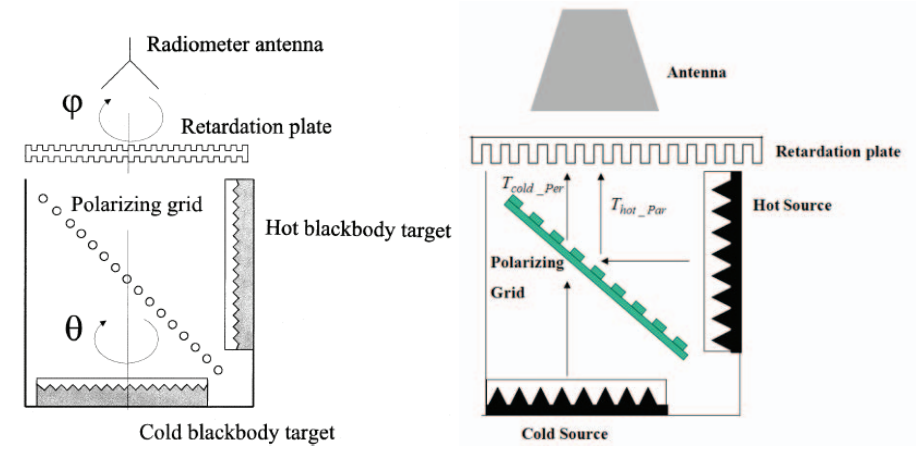
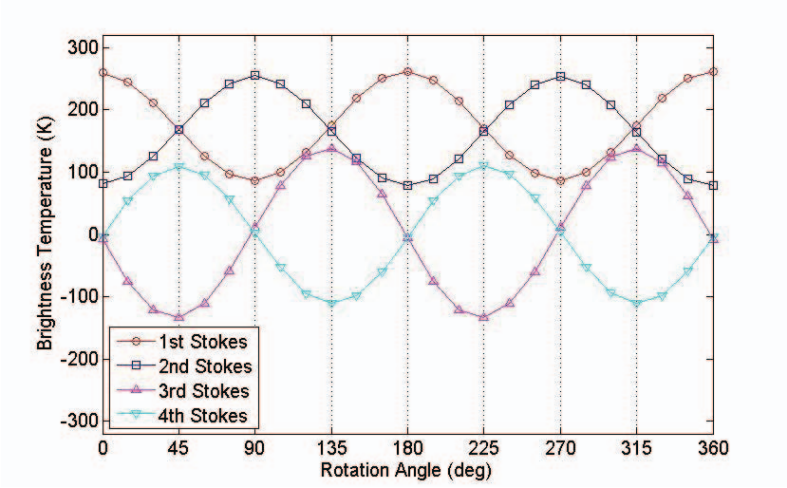
(a) (b)



Configuration of (a) fully polarimatric calibration standard and (b) suggested standard



Calibrated Stokes parameter response of the developed radiometer as a function of angle of linearly polarized standard at $\varphi = 90^{\circ}$

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