System Design of W-band Fully Polarimetric Radiometer for Target Identification.

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Abstract:

For the last few decades, microwave radiometers have played an important role in various remote sensing applications of the earth environment such as atmosphere, ocean, and soil. Especially, various polarimetric emission of the target provides additional information compared with single polarization emission for more accurate estimation. In general, the electromagnetic wave is represented as full Stokes parameters[1]. The Stokes parameters can be defined as the horizontal and vertical polarization for the first and second parameters, and the 45 degree linear and circular polarization for the third and fourth parameters, respectively. The third and fourth Stokes parameters give more understanding about the physical parameter of materials such as the orientation distribution of hydrometers, surface soil moisture, and sea wind vector.

In this study, we developed the fully polarimetric radiometer to measure full Stokes parameter at 94 GHz. In practical, the brightness temperature of the third and fourth Stokes parameter is a few Kelvin. For this reason, it was required to design the radiometer with a low noise and stable receiver. For stable and high sensible Stokes parameters measurements, we implemented a wideband analog correlator and a total power type receiver with periodic calibration. The internal correlated noise source generates the third and fourth Stokes parameter and the radiometer performs periodic full Stokes calibration. The measured system temperatures in

vertical and horizontal channels by the Y-factor method are about 3990 K at vertical and 3450 K, respectively. To quantify the stability of the radiometer, we use the Allan variance [2] with a function of an integration time. The measured optimal integration time was 20 s. From the performance test, the measured sensitivities with the integration time of 10 ms are approximately 1.26 K and 1.27 K in the horizontal and vertical polarization, respectively.

In order to measure full Stokes parameters [3], it needs the calibration by using the additional polarized references. The fully polarimetric calibration standard is composed of a polarizing grid, 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. In general, the metal wire grid has been used for the polarizing grid for polarimetric calibration. In this work, a grid on microwave substrate was applied for polarizing grid. The characteristic of calibration standards was measured and evaluated. By these standards, the linearly independent brightness temperatures were obtained for fully polarimetric calibration. Using these temperatures, the calibration gain-offset matrix was estimated. To evaluate it, the brightness temperatures of full Stokes parameters were measured at specific angle of grid and retardation. The uncertainties of parameters of calibration standards were also estimated to evaluate the error of measured Stokes parameters of the developed radiometer.

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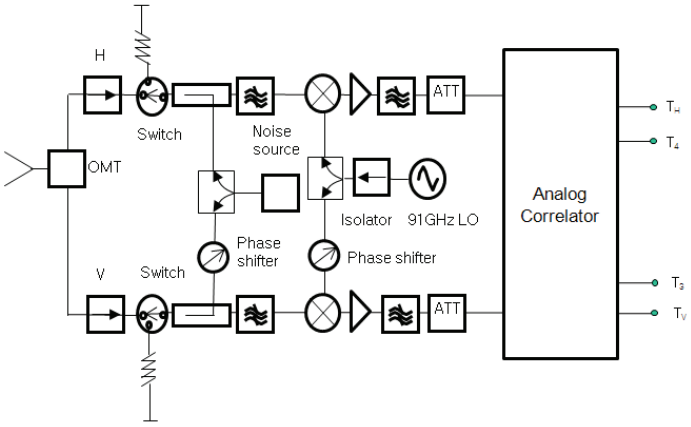
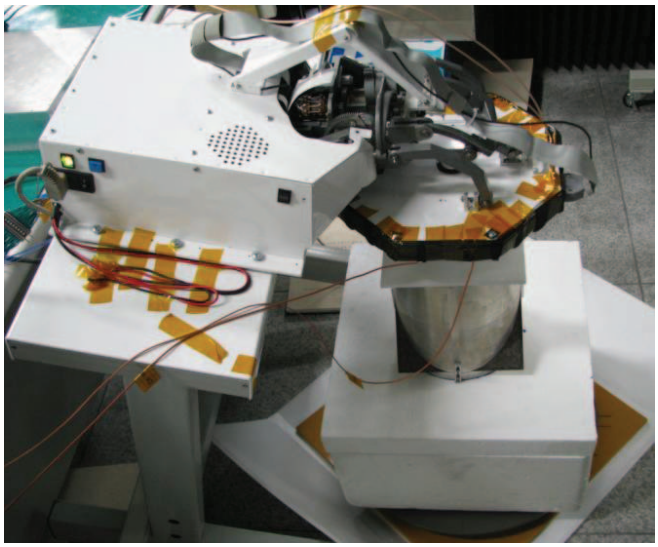


Receiver block diagram of the polarimetric radiometer.



Developed fully polarimetric radiometer with suggested calibration standard

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