A Study of the Compact Water Vapor Radiometer for the Karl G. Jansky Very Large Array

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We report on laboratory test results of the Compact Water Vapor Radiometer (CWVR) prototype for the Karl G. Jansky Very Large Array (VLA), a five channel design centered around the 22 GHz water vapor line. Fluctuations in precipitable water vapor cause fluctuations in atmospheric brightness emission, T_B, which are assumed to be proportional to phase fluctuations of the astronomical signal, $\Delta\phi_V$, seen by an antenna. Water vapor radiometry consists of using a radiometer to measure variations in T_B to correct for $\Delta\phi_V$. The design is intended to support empirical radiometric phase correction for each baseline in the array.

The dynamic range, channel isolation and gain stability of the device were characterized. The device has a useful dynamic range of order 18 dB after calibration and the CWVR channel isolation requirement of $<$ -20 dB is met, indicating $< 1\%$ power leakage between any two channels.

For the gain stability test, the diode detectors were operated in the square-law region, where the input power is proportional to output voltage, and a K-band noise diode was used as the input power source to the CWVR for a period of 64 hours. Results indicate that Channel 1 needs repair, and that the fluctuations in output counts for Channel 2 to 5 are negatively correlated to the CWVR enclosure ambient temperature, with a change of ~ 405 counts per 1°C change in temperature.

A correction for the CWVR ambient temperature makes a considerable improvement in stability for $\tau \geq 10^{2.6}$ sec. With temperature correction, the single channel and channel difference gain stability for Channels 2 to 5 is $< 2 \times 10^{-4}$ over $\tau = 2.5$ - 10^3 sec, which meets the < 2 - 4×10^{-4} requirement. The observable gain stability is $< 2.5 \times 10^{-4}$ over $\tau = 2.5$ - 10^3 sec, which meets the < 2.5 - 5×10^{-4} requirement.

Overall, the test results indicate that the CWVR meets required specifications for dynamic range, channel isolation, and gain stability to be tested on a pair of VLA antennas.