DEVELOPMENT OF A THREE-ELEMENT INTERFEROMETER AT 50~56 GHZ FOR GEOSTATIONARY INTERFEROMETRIC MICROWAVE SOUNDER (GIMS)

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1. INTRODUCTION

Realizing millimeter or sub-millimeter wave observations for atmospheric sounding from Geostationary Earth Orbit (GEO) has been an emerging research field in recent years [1][2]. GEO can guarantee the fixed continuous observation to a particular region, while the relative low frequency band (compared with infrared waves) can guarantee all-weather observation with a 3D image capability for the atmospheric temperature and moisture. Those features make the GEO microwave sounding very appealing for short term meteorological forecasting.

The Geostationary Interferometric Microwave Sounder (GIMS) is millimeter wave imaging sounder concept proposed for China's next generation geostationary meteorological satellite (FY-4M). A minimum version of GIMS instrument has already been defined with focusing on the purpose of atmospheric temperature sounding, which operates at 50~56GHz band and utilizes aperture synthesis based on a circular thinned array [3].

The conceptual design and the breadboarding activities of the GIMS prototype have already been carried out in CSSAR. So far, a three-element interferometer has been developed and tested to investigate the feasibility of the GIMS system design. In this paper, the preliminary results of these activities will be introduced.

2. SYSTEM ARCHETECTURE OF THE THREE-ELMENT INTERFEROMETER

The interferometer can be divided into four parts: element antennas, mm-wave front-ends, IF IQ modules and digital modules. All of these four parts have already been developed and tested. The element antennas are designed as corrugated horn with circular polarizer, which ensures the good pattern rotational symmetry property with compromise on antenna directivity. The receiving chain employs two-stage down conversion: the first stage is in the front-end to realize SSB down conversion (from 50~56GHz to 2.4~8.4GHz) with high image rejection ratio (better than 70dB); the second stage is in the IF module to realize DSB IQ down conversion (B=400MHz) with selectable LO signals. The output IQ signals (10~200MHz) are then locally sampled by ADC boards (at 1Gsps), and transferred through optical fibres to the central correlation unit to perform 2bit*2bit digital correlation. All the ADC boards are trigged and synchronized by a separated board. Fig. 2 shows a photo of the three-element interferometer, which is configured in the mode for correlated noise injection tests.

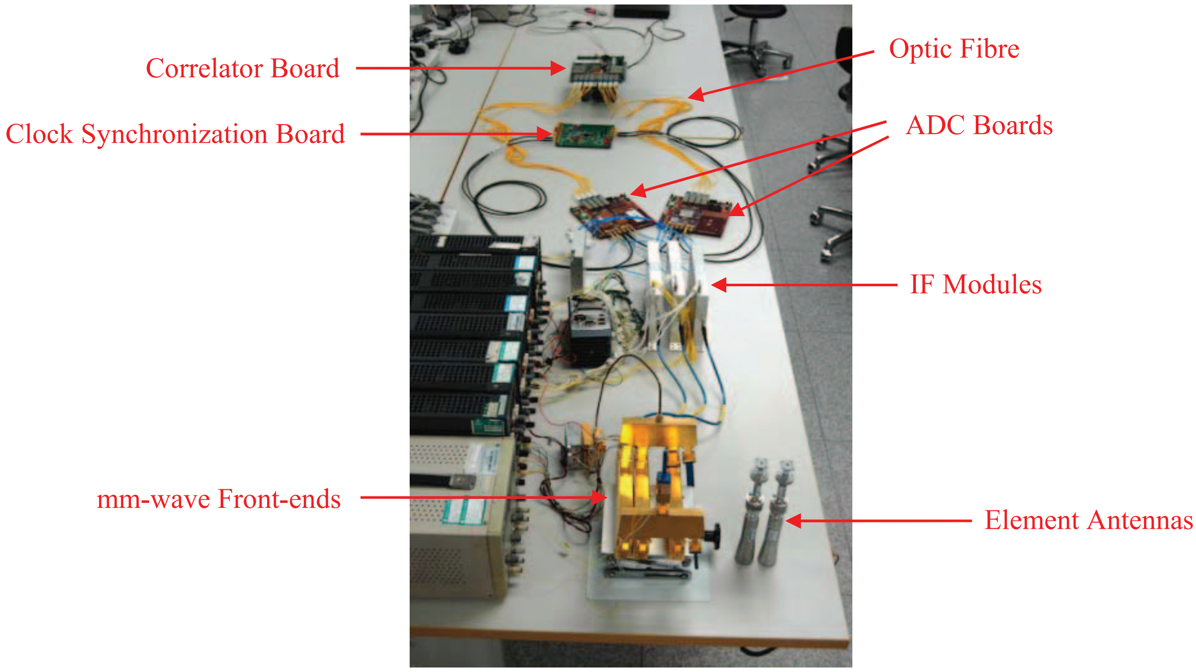


Fig. 2 Photo of the Three-Element Interferometer at 50~56GHz

3. SYSTEM TEST RESLUTS AND ANALYSIS

3.1. Uncorrelated/Correlated Noise Injection Tests

The main purpose of noise injection tests is to verify the performance of the receivers and correlators. Two types of noise have been injected to the inputs of the front-ends. Firstly, uncorrelated noise has been injected, which can simply be implemented by connecting separated waveguide match loads to the front-end inputs; Secondly, the correlated noise has also been injected via a power divider, as shown in Fig.2. Both tests have been performed from several tens minutes to several hours to watch the system stability.

Fig. 3 illustrates 20mins results of uncorrelated noise injection (the unit of horizontal axis is minute): the first row figures represent the auto-correlation amplitude of the three receivers (not corrected for 2bit truncation); the second row figures are corresponding to the normalized amplitude of the cross-correlation outputs of the three correlators (correlation coefficient); the third row figures are then corresponding to the cross-correlations phases. In general, the test results show very low system correlation biases. The correlation bias <1,2> is higher than <1,3> and <2,3>. It is easily understood since receiver 1 and 2 share one single ADC board, and receiver 3 use another separated one.

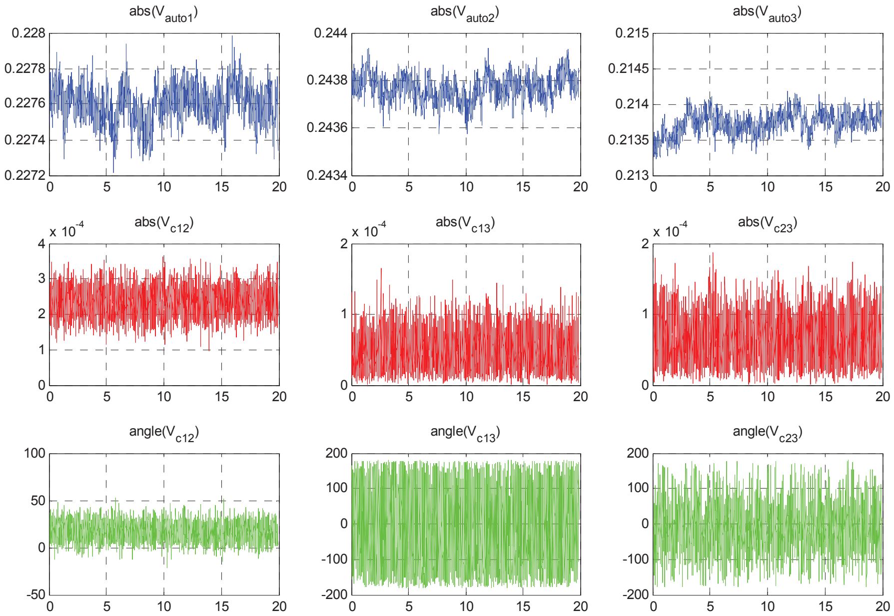


Fig. 3 Visibility Outputs of Uncorrelated Noise

Fig. 4 illustrates the results of a long duration (>5 hours) correlated noise injection test. It can be found that the whole system get into stable after around 100mins under ambient temperature environment. The phase difference between channel 1 and channel 2 is around 113.2^{o}, and the phases of channel 2 and channel 3 are approximately same.

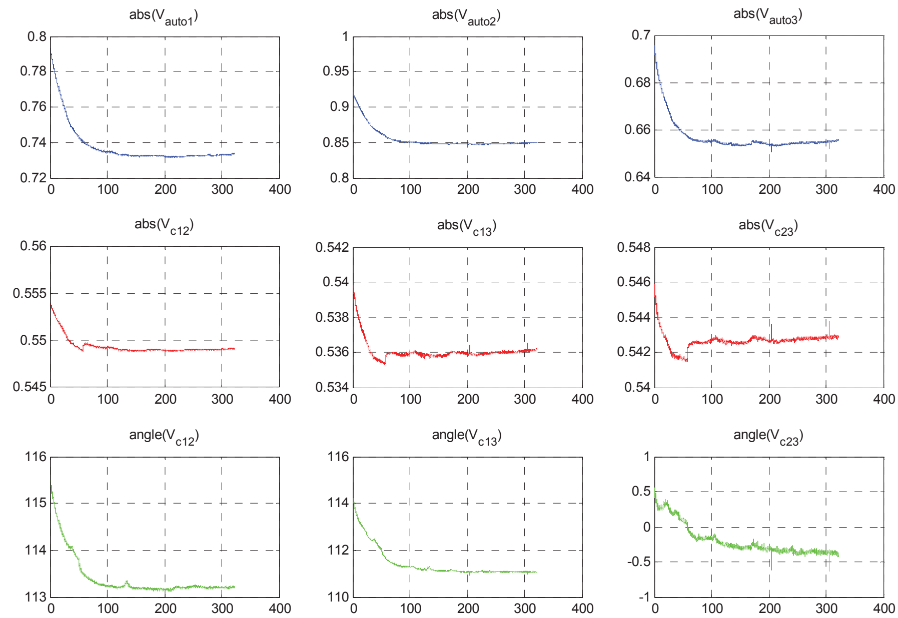
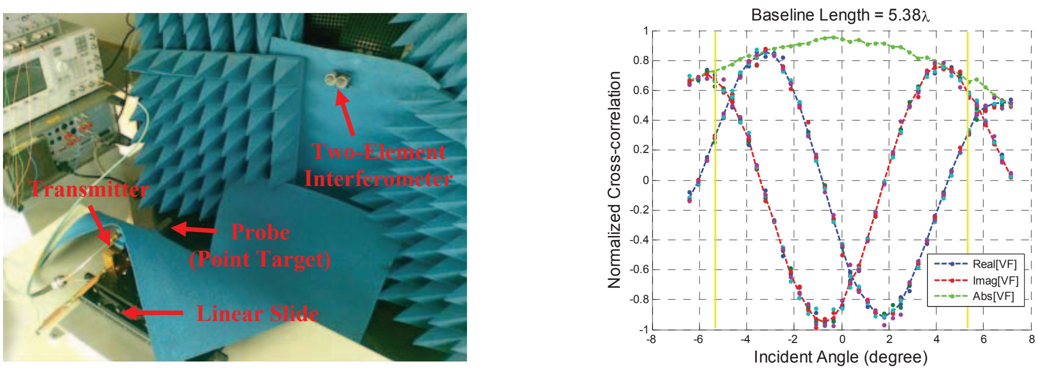


Fig. 4 Visibility Outputs of Correlated Noise Injection

3.2. Interferometric Tests with a Moving Noise Source

After noise injection tests of the receivers, interferometric tests with a moving noise source have been conducted to verify the performance of the overall system, including the unit antennas. These tests are crucial to demonstrate the functionality of the system. Fig. 5(a) illustrates the test set-up: a noise source transmitter is installed on a linear slide, and positioned at 2 m distance away from the two-element interferometer. The transmitter has been moved along the linear slide. The corresponding complex visibility has been measured during the source moving. Fig. 5(b) shows the measured visibility curves. The real and image parts of the complex visibilities are very close to the expected ideal orthogonal sinusoids, which truly reflect the nature of the two-element interferometry.



(a). Test-setup (b). Complex Visibility Outputs

Fig. 5 Interferometric Tests with a Point Noise Source

4. FURTHER WORKS

The development of the three-element interferometer has been finished and summarized. The full-scale GIMS demonstrator is now under going and planned to be finished before the end of 2010. Some further works are still need to be done, including: 1). Radiometric analysis and calibration scheme design; 2). improvement on receiver design (especially on package); 3). imaging retrieving algorithm research. Preliminary results on these aspects are expected to be achieved before June, 2010.

5. REFERENCES

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