ASSESSMENT ON LINEARITY ERRORS IN DETECTORS FOR INTERFEROMETRIC RADIOMETERS

F. Torres(1), N. Duñó(1), C. González-Haro(1), R. Vilaseca(2), Ll. Sagués(2), M. Martín-Neira(3)
(1) Remote Sensing Laboratory, Universitat Politècnica de Catalunya, Barcelona
SMOS Barcelona Expert Centre, e-mail: xtorres@tsc.upc.es
(2) MIER SA. Space Department. La Garriga, Spain
(3) European Space Agency, European Space Research and Technology Centre (ESTEC)

1. INTRODUCTION

The performance of the power detectors used to denormalize the digital correlations in interferometric radiometers is degraded due to the non-linear behavior of the diode response. This work presents a comprehensive analysis of the impact of detector non-linearity and related correction techniques in the performance of the MIRAS (Microwave Imaging Radiometer with Aperture Synthesis) instrument [1], which is the single payload of the ESA-SMOS mission [2].

The MIRAS instrument is compounded of 63 receiver equally distributed in the arms of a “Y” shape array. Other 9 receivers are also used as reference real aperture radiometers and/or redundancy. This set of 72 receivers has been thoroughly characterized on-ground and the following results are presented:

a) Impact of linearity error in the estimation of main interferometer magnitudes
b) Results of linearity characterization of the 72 MIRAS detectors
c) Performance of the iterative method to remove linearity errors
d) Effect of temperature in the detector linearity behavior

2. IMPACT OF LINEARITY ERRORS

In order to denormalize the digital correlations the system temperature is measured by a PMS (Power Measurement System) placed in each MIRAS receiver. The PMS are also used to measure the fringe-wash term (correlator efficiency). In a first approach the PMS are characterized by determining their offset and gain, which assumes a linear behavior.

In order to calibrate the PMS for short and long term drift, their main parameters are measured on-board by the so-called four-point method [5][6]. This work presents the impact on the estimation of system temperature caused by the second order behavior of the diode response. It is shown that, in addition to the non-linear error, the four point method introduces a bias (non-zero mean error) in the estimation of system temperature. Non-linear errors related to the four-point method are also compared to the error given by a Least Squares estimation.

3. LINEARITY ERRORS

This section presents the results of characterizing the second order behavior of the 72 PMS in the MIRAS instrument by the constant deflection method [3][4]. The test set-up and measurements have been performed by Mier SA. Space Department, Spain. The impact on system performance of non-linearity error has been found moderate (around 1% error). However, some kind of correction is required in order to comply with system requirements.

4. THE ITERATIVE METHOD

This section presents the performance of a simple method to correct the second order PMS response, even in the case when the diode non-linear behavior is not perfectly known. PMS response is linearized by subtracting from PMS voltage readings an estimate of the second order contribution. This estimate is computed by assuming a linear behavior of the PMS. It is
shown that this method is very robust, even in the case where the error in the second order estimation is quite large. The performance of the method is illustrated taking into account the 72 PMS flight units in MIRAS.

5. LINEARITY DEPENDENCY WITH TEMPERATURE

Finally, this section shows that the second order behavior of PMS response presents very low sensitivity with relation to physical temperature. As a conclusion the PMS non-linear term can be measured at a single temperature and assumed constant throughout the measurement temperature range. The second order term has been characterized for each unit at three temperatures during the flight tests at Mier S.A. An additional assessment has been performed at system level during the Large Space Simulator tests performed by EADS-CASA Espacio at ESA facilities in Noordwijk, Holland.

11. REFERENCES


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