CALIBRATION CONSISTENCY TOOL FOR INTERFEROMETRIC RADIOMETERS

V. González-Gambau(1), F. Torres(1), M. Martín-Neira(2)
(1) Remote Sensing Laboratory, Universitat Politècnica de Catalunya, Barcelona
SMOS Barcelona Expert Centre, e-mail: xtorres@tsc.upc.es
(2) European Space Agency, European Space Research and Technology Centre (ESTEC)

1. INTRODUCTION

Amplitude calibration is a major issue in interferometric radiometers devoted to Earth observation since it has a major impact in the final performance of the sensor. This work presents a tool developed to easily assess the self-consistency of the amplitude calibration coefficients used in the MIRAS (Microwave Imaging Radiometer with Aperture Synthesis) instrument, the single payload of the ESA-SMOS mission [1] [2].

The MIRAS consists of a Y-shape interferometric radiometer basically formed by 63 receivers called LICEF (Lightweight Cost Effective Front End) placed along the three arms. Cross-correlation of the signals collected by each receiver pairs “k,j” give the samples of the so-called visibility function, \( V_{kj} \), which develops into a brightness temperature map by means of a Fourier synthesis technique. Therefore, random amplitude errors in the visibility samples are directly translated into image distortion (the so-called pixel bias) through this Fourier synthesis process.

The self-consistency tool takes profit of the intrinsic properties of the signals measured by the 63 receivers, both internal and external, to give a good estimation of the amplitude errors after calibration. This tool can be used to monitor the quality of the amplitude calibration coefficients during the SMOS mission. It also opens the door to additional error reduction techniques.

2. CALIBRATION BASICS

MIRAS uses 1-bit digital correlators, which measure normalized correlations. A Noise Injection Radiometer (NIR) placed in the hub, measures the scene mean temperature. It also acts as reference radiometer to calibrate the PMS (Power Measuring System) in each LICEF, when switched to the internal Noise Distribution Network (NDN) at LICEF port C. The visibility samples are corrected from instrumental errors and denormalized according to:

\[
V_{kj} = \frac{\sqrt{T_{\text{sys},k}\cdot T_{\text{sys},j}}}{G_{kj}} M_{kj}, \quad T_{\text{sys},k} = \frac{V_{Ak} - v_{\text{off},k}}{G_{k}^A}
\]

Computation of normalized correlations \( M_{kj} \) and the Fringe Wash term \( G_{kj} \) is thoroughly detailed in [3]. LICEF_A system temperature referred to the antenna plane, \( T_{\text{sys},k} \) (A=V,H), is obtained from PMS_A voltage reading. The PMS amplitude at the antenna plane \( G_{k}^A \) and offset \( v_{\text{off},k} \) are calibrated by means of the so-called two-level four-point method [5,6]. The calibration procedure makes use of two-level (HOT and WARM) noise sources that injected the signals to the LICEF C port by means of a noise distribution network (NDN). A switch placed at the LICEF front end is used to select the measurement mode.

2. AMPLITUDE SELF-CONSISTENCY TOOL

The rationale of the amplitude self-consistency tool is based in a quite simple principle: When a set of PMS are fed by the same noise source the difference in system temperatures at port C measured by each PMS can be computed as:
Since the differential measurement removes the individual noise contribution from each LICEF (equivalent noise temperature) and the contribution from the NDN itself, all PMS should measure the same magnitude $\Delta T_{\text{HW}}^{\text{sys}}$, except for the NDN unbalance. However, since the NDN unbalance has been thoroughly characterized on-ground [4], a common virtual reference port can be defined to equalize the measured signals.

Now, for a set of LICEF, the self-consistency tool gives the fractional error in the magnitude $\Delta T_{\text{HW}}^{\text{sys}}$ measured by each PMS with respect to their mean. This error, computed at the virtual reference port to compensate for the NDN unbalance, is a direct estimation of the error in PMS gain, and, consequently, a direct estimator of visibility amplitude errors.

The self-consistency tool can be used to monitor the quality of the amplitude calibration coefficient during the mission. As additional features it allows a comparison of different calibration techniques and opens the possibility to include additional error correction techniques during the external calibration of the instrument (deep sky views).

2. EXPERIMENTAL RESULTS

The MIRAS instrument has been successfully tested by EADS CASA Espacio during the integration and system performance tests conducted at EADS-CASA Espacio premises, Spain, first and at ESA facilities in Noordwijk, Netherlands secondly. The self-consistency tool has proved a high degree of consistency of system and subsystem ground characterization coefficients.

11. REFERENCES


ACKNOWLEDGMENT

This work was supported by the European Space Agency and EADS-CASA Space Division in the frame of the SMOS project. This work has been partially funded by the Spanish Ministry of Science and Technology (MCYT) under project MIDAS 4: ESP2005-06823-C05-01.