CHAMP Accelerometer and Star Sensor Data Combination

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Summary. The STAR accelerometer on board CHAMP measures the non-gravitational accelerations, which are needed to separate them from the gravitational ones when determining the Earth gravity field from orbit perturbations. Besides translational accelerations the test mass of the accelerometer is also sensitive to angular accelerations of the spacecraft. Therefore it is possible to combine the accelerometer data with the star sensor data, which provide the orientation of the spacecraft. The combination of both measurement data was performed in the frequency domain and by applying Kalman filter techniques. As a result, the reduction of the star sensor measurement noise was achieved and the estimation of accelerometer parameters like scale factor and bias became possible.

Key words: accelerometer, star sensor, Kalman filter

1 Introduction and Analysis Strategy

The STAR accelerometer on board CHAMP measures the non-gravitational accelerations. They have to be known in order to separate them from the gravitational ones when determining the Earth gravity field from orbit perturbations. Apart from the measurement of the translational accelerations, the STAR accelerometer is capable to measure the angular motion of the spacecraft. Therefore it is possible to combine the accelerometer data with the star sensor data, which provide the orientation of the spacecraft. In addition the housekeeping data contain a record of thruster firing events which can be used for the calculation of the angular accelerations, too. Here, we discuss measurements of the accelerometer and of the star sensor from day 324 in 2001. The sensor data and satellite housekeeping data were compared in the time and frequency domain. The data were processed in different steps. First we remove peaks in the accelerometer data which are not caused by thruster events. After that we show the strong coupling of the radial accelerometer circuits with accelerometer temperature control and remove this effect from the data. In the next step, we estimate the angular acceleration scale factors of the accelerometer by comparing them with the thruster housekeeping data. Finally, prefiltered and scaled accelerometer and star sensor measurements...
ments were combined by applying KALMAN filter techniques in order to get optimal attitude information.

2 The Accelerometer

The accelerometer [1] consists of six electrode pairs (denoted X1 to X6) which control the motion of the test mass in six degrees of freedom. The measurement signal is a linear combination of the voltage applied to the electrodes. For example, the sum of the voltages of X4 and X5 multiplied by a scale factor which depends on the accelerometer parameters represents the along track acceleration of center of mass of the satellite. The difference of X4 and X5 represents the rotational acceleration about the yaw axis of the spacecraft.

Electrode voltages of the accelerometer with an arbitrary bias are shown in Fig. 2. As expected, the highest amplitudes are observed in the along track direction (X4, X5). Spikes in the signal are caused by thruster activities.

3 Accelerometer Coupling with Heater Activities

All three accelerometer control circuits in radial direction are affected by the accelerometer temperature control. As example the pitch angular acceleration signal is discussed. The heater activities around the accelerometer are shown in the upper part of Fig. 3. A strong correlation between the accelerometer temperature control and the accelerometer angular acceleration output was detected. The coupling of heater activities and angular acceleration signal was estimated in the frequency domain using a first order filter. The modeled disturbance is shown in the lower curve. It has to be subtracted from the measurements which results in corrected angular accelerations. In the control circuits for along and normal direction, a similar effect has not been detected.