User Guide for Analysis of

FAST Fields Data

Introduction

Before proceeding, please read the following document for an overview of FAST Data Analysis:

http://sprg.ssl.berkeley.edu/fast/scienceops/docs/fast_da_overview.doc

IDL Routine Overview

Categorization of IDL routines for fields data analysis

FAST fields routines can be grouped into five categories:

- Routines that get fields data
- Routines that determine the DC perturbation magnetic field
- Routines that despin electric field data
- Routines that compute auto- or cross-spectra
- Other utility routines

Routines That Return Fields Data Structures

One needs to know what data is available, and then transfer it from shared memory to data structures accessible from within IDL. Currently the FAST fields routines return two sorts of data. The first sort is an anonymous IDL structure known as a 'FAST fields data' structure. Such a structure contains sample times, data values, units, calibration information, and data gap information. The second sort is known as a 'TPLOT quantity', which is a set of anonymous data structures stored on the IDL memory heap and accessible to the TPLOT plotting package in IDL.

Most of the data reduction routines (FA_FIELDS_COMBINE, FF_FILTER, FA-FIELDS_SPEC, etc) operate on FAST fields data structures to produce either other FAST fields data structures or TPLOT quantities.

- Data Acquisition Routines

GET_FA_FIELDS: basic routine for acquiring data from shared memory. Data can be loaded in calibrated or uncalibrated form (enforced calibration depending upon setting of the FAST_CALIBRATE environment variable), and is returned as either a FAST fields structure or as a TPLOT quantity.

FF_POTENTIAL:

GET_DENSITY:

FA_FIELDS_CYCLOTRON: computes electron, H+, He+, and O+ cyclotron frequencies from measured magnetic field data (the DQI MagDC is required), as well as |B| and angle between spin plane and B.

FA_FIELDS_DSP: acquire DSP spectral data and compute OMNI spectral density, then store results as TPLOT quantities.

FA_FIELDS_SFA: acquire SFA spectral data and compute OMNI spectral density, then store results as TPLOT quantities.

FA_FIELDS_PWT: acquire PWT data, compute spectral density, offset frequencies, and store as a TPLOT quantity.

FF_DSP_POWER: compute integrated spectral density of OMNI electric field and Mag3ac magnetic field DSP data. Frequency interval for integration can be specified.

DC Perturbation Magnetic Field Estimation

UCLA_MAG_DESPIN: The extraction of an estimate of the vector DC perturbation magnetic field from low- or mid-altitude satellite magnetometer data is a daunting task. It requires on-orbit estimation of fluxgate magnetometer calibration parameters, precision attitude estimation, despin and projection of estimated field into various coordinate systems, and finally subtraction of model (IGRF) magnetic field, all to a precision of at least 1 part in 1000. This task is accomplished on FAST using the UCLA_MAG_DEPSPIN routine. This routine is conservative, and will warn the user about both the assumptions that it is using in order to accomplish its task, and when those assumptions appear to have broken down. When operating correctly, it estimates of the vector perturbation magnetic field suitable for studies of current systems, low-frequency electromagnetic perturbations, and stress transmission. Details of the algorithm can be found in the IDL code itself (ucla_mag_despin.pro). Be certain to read the caveats on DC Magnetic Field Data in the Pitfalls section above prior to interpreting any reduced magnetometer data.

Ignore all the other DC B-field reduction routines (FA_FIELDS_MAGDC and supporting code).

Despin

The electric field estimates from a spinning spacecraft such as FAST are useful in and of themselves, but are much easier to interpret if transformed (or despun) into a geophysically-relevant coordinate system, such as one organized around the local magnetic field. This process of despinning the data is described in greater detail in the Despinning section below, and involves estimating and correcting for any gain or offset differences between the two (or three in the case of 3d despin of HSBM data) antennas used as input to the despinning procedure. An accurate estimate of the relative orientation of the antennas and the ambient magnetic field is also required (although not with the precision needed in the DC magnetic field estimation procedure).

FA_FIELDS_PHASE: estimates the angle of the vector pointing towards the Sun and along the ambient magnetic field in the spacecraft spin plane using on-board sun sensor and magnetometer data.

FA_FIELDS_DESPIN: estimates despun spin plane electric field (original version, optimized for DC E-field estimation (few Hz and below)).

FA_FIELDS_DESPIN_SVY_LONG: newer version of FA_FIELDS_DESPIN, again optimized for DC E-field estimation.

FA_FIELDS_DESPIN_{4K,16K,HSBM}: newer versions of despin codes optimized for Burst and HSBM data; HSBM supports three-axis despin. Results are stored as TPLOT quantities.

FA_FIELDS_DESPIN_HG: refilters HG-type data from the original high-pass frequency of 3.5 kHz to 300 Hz, then despins and stores as a TPLOT quantity.

SIMPLE_DESPIN: a bare-bones despin routine that handles the transformation of contiguously sampled data from pairs of antennas. No gain or offset adjustment is performed. Suitable for careful use on AC electric fields. Produces FAST fields data structures.

All the newer versions of DESPIN support spectral density estimation of the despun electric field data within the routines themselves, rather than through a separate call to the spectral density estimation routines (see Spectral Estimates below).

Spectral Estimates

Auto and cross spectra.

FA_FIELDS_SPEC: computes the auto-spectrum (aka. power spectrum) of a given time series stored in a FAST fields data structure, and return as either a FAST fields data structure or a TPLOT quantity. The spectrum is estimated using an averaged FFT algorithm, and the parameters of that algorithm (overlap, points/FFT, FFTs/spectrum, etc.) can be specified via keywords. Specification of a valid sampling rate (allowing the selection FastSurvey over SLowSurvey data) is also allowed.

FA_FIELDS_CROSS: similar to FA_FIELDS_SPEC, but computes the cross-spectrum (coherence and phase shift) of two signals using an averaged FFT algorithm.

Utility Routines

Informational Routines

SHOW_DQIS: lists the DQDs (or DQIs) currently loaded into shared memory by SDT, along with the timespans and number of points available for each.

Interpolation, Merging of Channels, Sensor Information

FF_INTERP, FA_FIELDS_COMBINE, FA_MODE_INFO, FF_INFO