**THEMIS Calibration Algorithm Document**

**Spacecraft**

**Fields**

**EFI:**

PROCEDURE NAME:

THM\_CAL\_EFI

CALIBRATION FILES:

The calibration file for each probe is located in the $ROOT\_DATA\_DIRECTORY/th(probe)/l1/eff/0000, where ROOT\_DATA\_DIR is the default data directory for THEMIS data. (See THM\_ROOT\_DATA\_DIR.pro.)

PROCESS DESCRIPTION:

Inputs: From Level 1 files,

1) Voltages: vaf, vbf, vap, vbp, vaw, vbw and fields: eff, efp and efw. Level 1 voltages have 6 components, one per boom, v1 to v6. Level 1 fields have 6 components, eac12, eac34, eac56, edc12, edc34, edc56, for the three different boom pairs, for AC and DC coupling.

Datatypes are calibrated separately. For fields, additional variables are created; ef?\_0 is the field with the Z component (in DSL coordinates) set to zero; ef?\_dot0 contains the field with the Z component calculated under the assumption E dot B = 0. The X and Y components are unchanged.

For each datatype:

2) Gains and offsets are input from calibration files. Currently these are not time-dependent, but may vary from probe to probe, thus there is a different file for each probe. The calibration structure for voltage variables contains a calibration time, gain, offset and units.

For Electric field variables, the calibration structure contains a calibration time, gain values for EAC and EDC data, offsets for each axis (in ADC units, 70, 113, 0 for E12, E34 ,E56), boom length (meters, 49.6 for boom 12, 40.4 for boom 34, 5.63 for boom 56), boom shorting (0.714 for booms12 and 34, 0.50 for boom 56) and a despun field offset (2.5, 0, 0 for E12, E34 ,E56, respectively, subtracted from calibrated data after despin).

3) For voltage variables, for each value v1 through v6, the offset is subtracted from raw data, then the result is multiplied by the gain factor.

4) For field data, a number of extra steps are needed. First the header information is accessed to determine AC or DC coupling. If both AC and DC coupled modes are present (only possible with efw (wave burst) data), then the appropriate gain is used to convert the raw ADC value.

The offsets input from the calibration files are not used for the spin-plane field components in the default case. Instead, offset values are calculated from the raw data smoothed over a number of spacecraft spin periods (20 by default, but due to the presence of data gaps, may be as short as one spin period). This option may be turned off using keywords, which are summarized below.

Once the offsets are found, the variables are adjusted for gain and offset. For each field component:

cal\_data = -1000\*gain\*(raw\_data - offset)/(boom\_length\*boom\_shorting\_factor).

5) The data variables are now in physically meaningful units of mV/m, but in a coordinate system spinning with the spacecraft (SPG, space probe geometric coordinates). The default is to return the calibrated data in DSL (despun spacecraft) coordinates. This is done in the program THM\_EFI\_DESPIN.

The despin procedure is slightly different from a typical THEMIS coordinate change in that the dsc\_offset parameter is subtracted from the field after despinning. Thus, if a user simply loads calibrated data in SPG coordinates and then despins using THM\_COTRANS, the result will be different from data which are despun in the calibration procedure.

6) Once despun, the \_0 and \_dot0 fields are calculated. The \_0 variables are simply the DSL fields with the spin-axis component (the Z component) set to zero. The \_dot0 variables are more complicated. FGM data (by default FGL-low time resolution for EFF and FGH- high time resolution for EFP and EFW), interpolated to the appropriate EFI time array are used for the local magnetic field. For the \_dot0 variables, the Z component is a linear combination of the X and Y components calculated so that E dot B is zero (E is perpendicular to the local magnetic field).

7) If the user has requested output in coordinate systems other than SPG or DSL, then coordinate transforms are performed as the final step.

**FBK:**

PROCEDURE NAME:

THM\_CAL\_FBK

CALIBRATION FILES:

There is no calibration file input. Calibration parameters are defined in the procedure, THM\_GET\_FBK\_CAL\_PARS.pro.

PROCESS DESCRIPTION:

Inputs: From Level 1 files

1) There are a number of possible different datatypes, but not all are included in the Level 1 files. Typically one SCM datatype and one EFI datatype are stored in variables th?\_fb1 and th?\_fb2. (For example, a common configuration would have EDC34 data contained in the fb1 variabel, and SCM1 data contained in the fb2 variable). The th?\_fbh variable contains high frequency field data. The first step for each variable is to determine the data source (SCM or EFI).

2) Once the data source is determined, the calibration gain and frequency response are input via a call to THM\_GET\_FBK\_CAL\_PARS. Data values are decompressed, and then multiplied by the gain and frequency response factor for the appropriate source.

3) Data times are adjusted for each sample. The header time for a given sample corresponds to the sample from roughly half a sample period earlier. This is accounted for in the same code block as the calibration.

4) Data points are collated and sorted. Only data points with finite values are retained.

**FFT**

**FGM**

**FIT**

**HSK**

**MOM**

**SCM**

**Particles**

**ESA**

**SST**

**Ground**

**All-Sky Image**

**ASI**

**ASK**