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NOTES ON THE ISEE A+B DATA POOL TAPE

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NOTES ON THE ISEE A + B DATA POOL TAPE

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INTRODUCTION

The purpose of the data pool tape is to act as a low-cost but reasonably effective alternative to a full interactive data de-commutation system. In the latter, data users are linked by means of terminals to a central computer, and call out data from a large store for their immediate use. The data pool tape acts as a co-located store of a fraction of the data from the spacecraft. The time resolution and selection of the data is limited, but the tape lends itself to a number of uses, for example

(1) An experimenter can use it as an index, and to identify interesting time periods. He can then obtain data from other experimenters for a collaborative study.

(2) A non-experimenter can use it, or the plots to be derived from it, to correlate with ground observations, or observations from other spacecraft.

For these, or any of the other uses which will easily come to mind, the user needs a good description of the tape and of the algorithms used to generate the quantities on the tape. He also needs a description of the experiments to enable him to make an informed judgment of the uses to which data derived from them can legitimately be put. It is intended that these will be supplied in part by this document.

Following this introduction, we have included a description of the tape itself. This precedes sections which have short descriptions of each instrument and the method by which the corresponding data are reduced to yield the quantities on the tape. Finally there is a list of Principal Investigators, with addresses, and telephone numbers.

Data Pool Quantities From Preliminary Algorithms

Original Proposal	Preliminary Algorithm
(1) Magnetic Field, 3 Components/Min. (3 Words)	<u>Russell</u> 3 Spin Corrected Magnetic Field Components, Payload Coord's. (1 Minute Intervals) 25 Parameters (Hourly)
(2) Plasma-Velocity, Density, Temperature. (3 Words)	<u>Bame</u> 4 Electron Energy Levels 1 Ion Pseudo Density 1 Ion Average Energy 1 Solar Wind Peak Speed 1 Solar Wind Pseudo Density (5 Minute Intervals)
(3) 20-50 keV and 50-100 keV Electrons and Protons (4 Words)	<u>Williams</u> 1 32-50 keV e's 1 32-50 keV p's 1 80-126 keV e's 1 80-126 keV p's (5 Minute Intervals)
(4) Number Density and Energy Density of Low Energy Electrons and Ions (4 Words)	<u>Frank</u> 1 Spin Averaged Proton Number Density. 1 10 keV Electron Flux 1 Energy Range Indicator (5 Minute Intervals) <u>Anderson</u> 1 8-200 keV Electron Flux. 1 8-200 keV Proton Flux. (5 Minute Intervals)
(5) E-Field Bandpass Channel, 400 Hz.	<u>Gurnett</u> 1 562 Hz Wave Electric Field Magnitude. (5 Minute Intervals)

Data Pool Quantities From Preliminary Algorithms (Continued)

Original Proposal	Preliminary Algorithm
(6) B-Field Bandpass Channel, 400 Hz.	<u>Gurnett</u> 1 562 Hz Wave Magnetic Field Magnitude (5 Minute Intervals)
(7) Harvey On-Off	<u>Harvey</u> 1 6-Level Status Word. (1 Minute Intervals)
(8) Electron Gun On-Off	<u>Mozer</u> 1 Gun On or Off Indicator. (1 Minute Intervals)
(9) Electron Density from Sharp	<u>Sharp</u> 1 Cold Plasma Density 1 Flow Angle Indicator 1 Temperature Indicator (5 Minute Intervals)
(10) 15 Minute Averages of Higher Energy Counting Rates. 300 keV-1 meV 10-30 meV* 30-60 meV*	Hovestadt 1 0.17-0.4 MeV Protons 1 0.12-0.25 MeV Alphas 1 Heavies (Z > 2) Greater than 100 keV/Nucleon 1 5-10 MeV Protons 1 10-20 MeV Protons (15 Minute Intervals)

*Simpson was to have provided these.

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NOTES ON THE ISEE A + B DATA POOL TAPE

GENERAL DESCRIPTION AND USAGE

I. Structure of the Data Pool Tape

(A) Tapes

Each data pool user receives one reel of tape per week. This tape may be 7-track 556 cpi or 9-track 1600 cpi, depending upon the user's preference. All tapes are odd parity. Inter-record gaps are 1/2 inch for 9-track tapes and 3/4 inch for 7-track tapes.

(B) Files

Data pool information for a 7-day period is presented as a single tape file, beginning with a label record and ending with a standard tape mark (EOF mark). All tape records, including the label, are of the same length. The data pool file contains approximately 160 data records spanning 7 days of telemetry data. Redundant telemetry data (due to overlap in ground station coverage) has been removed. The data pool file coincides in time with a "shipping group" of the usual telemetry data (decom tapes) which is sent to each experimenter.

The data pool file appears 3 times on the tape for redundancy backup. See Figure 1.

(C) Data Words

(1) Word Size

Each data pool tape is written in computer words of a length compatible with the intended user's computer. Tapes thus constructed can be read directly into the user's computer with no reformatting. This holds true for both 7-track and 9-track tapes. For example, records intended for use with a CDC 6000 series computer would appear as packed strings of 60-bit fields. On a 9-track tape, each such 60-bit field occupies 7-1/2 tape characters. But the total number of words per record is an even number, so that the 60-bit fields can all be written in pairs, 15 tape characters per pair, and thus can be read normally by the CDC. (Other combinations of word size and tape type work out in a similar fashion.)

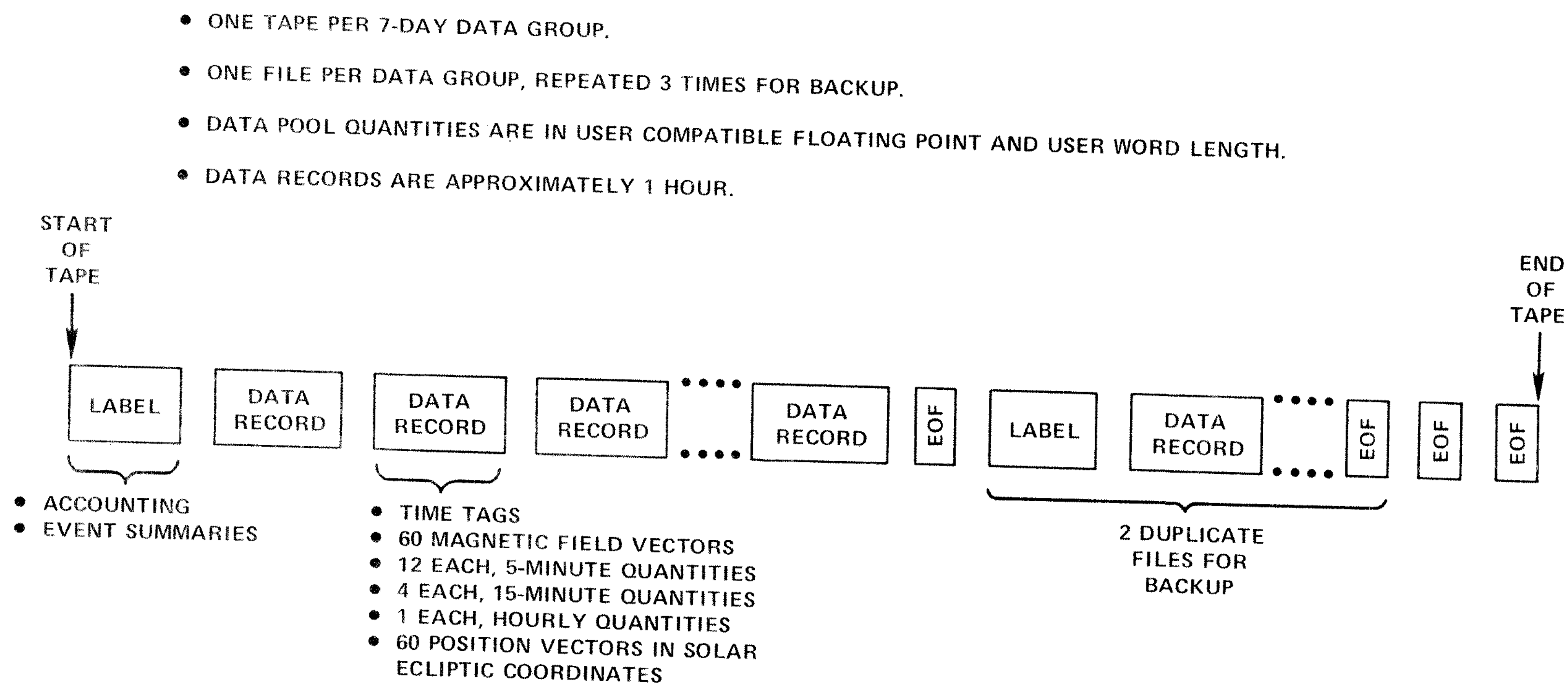


Figure 1. Data Pool Tape

(2) Floating Point Format

The entire data pool tape, the file label record and all data records, are in floating point format. (This provides a uniform, standard appearance of all information, facilitates conversion to the various computer word sizes, and simplifies tape printing and verification.) The floating point representation used on each tape is specified by the user, and, like the word size, is compatible with the computer which will process the tape.

Most data pool tape quantities are originally computed in floating point and should be interpreted as such. Certain items, however, are obvious as integer values converted to floating point representation (day-of-year, seconds-of-day, clock, various indicator flags, etc.). The user may interpret such items either as floating point (in which case tests for equality may be invalid) or as integer (in which case appropriate precautions should be taken to prevent possible truncation during conversion to integer).

(3) Missing Data

Missing data items are indicated by a negative value fill code in place of the missing item. The exact value of the fill code is dependent on the type of floating point used, but will in all cases be outside the legitimate range of any data item.

Missing data pool items may be the result of gaps in data recovery at the ground station, or the result of data being rejected by one of the experiment processing algorithms.

It is possible that uncertain conditions may lead to a data pool result of questionable validity. Rather than be rejected, such results may, in certain cases, be presented as the negative of the actual result. Thus, a negative number other than the fill code, if in a field which should normally be positive, represents a doubtful result and may be used, but with caution. (Note that this does not apply to those values which may normally be negative, such as magnetic field components.)

II. Contents of the Data Pool Tape

(A) Time

The time values given on the data pool tape are UTC (Universal Time Code) at the time the data was transmitted from the spacecraft (i.e. transmission lag time has been removed). Times have been smoothed to remove random errors and then verified by intercomparison among all the ground stations. Time is given as Julian day (1-366) and seconds-of-day.

(B) Clock

The clock used on the data pool tape is a minor frame counter, at both the high and the low bit rates, having a cycle time of approximately 97 days. It is constructed by combining the 24-bit raw spacecraft clock with part of the frame counter. (This is the same clock as used on the telemetry data tapes.) Maximum clock size is 25 bits at low bit rate and 27 bits at high bit rate.

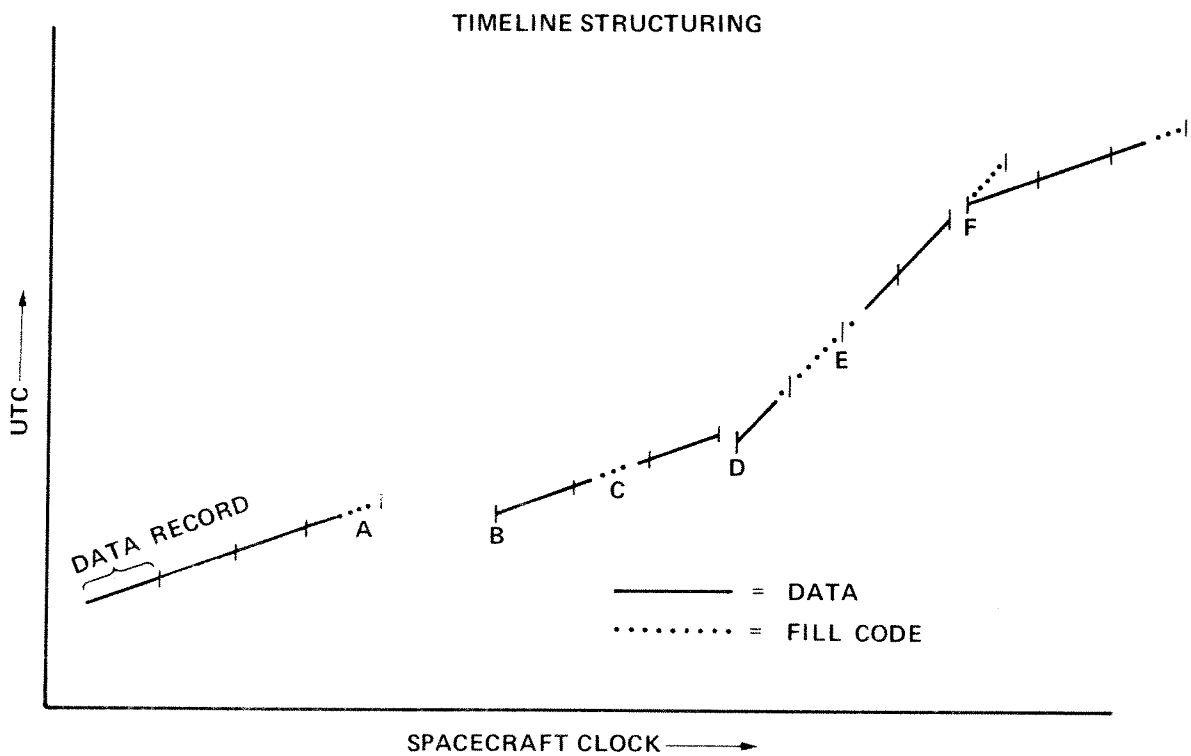
Since the full clock will not fit in all types of floating point words without truncation, it is broken into 2 pieces, the low order 21 bits in one word, the remaining high order portion in another. The full clock can be re-constructed by converting both clock pieces to integer, then adding them together.

It should be noted that time, rather than clock, is the primary reference for data pool items. Clock is subject to rollover within the data pool file, as well as to unpredicted jumps forward or backward.

(C) Timelines

The time versus clock relationship may not be linear throughout the entire data pool file. Breaks occur when the bit rate changes, at end-of-year, and if the clock jumps or rolls over. A segment of data in which time versus clock is linear is defined as a time/clock baseline or "timeline."

Data accumulation intervals for experiment algorithms do not continue across timelines; that is, each data pool quantity is computed using data which begins and ends in the same timeline. See Figure 2.



Spacecraft Clock

A. Last record of timeline contains fill beyond the end of the timeline.

B. A new timeline begins due to a clock reset. No gap in data coverage.

C. Data gap within a record results in fill code.

D. New timeline begins due to a bit rate change.

E. Large data gap results in an entire record of fill code. Note that the record following the all-fill record begins with fill, but has a start time assigned as if data were present.

F. New timeline begins due to a bit rate change.

Figure 2. Timeline Structuring

(D) Data Records

Data records are fixed length, 810 words long. A full record holds 64 minutes of information, taken from 60 major frames of data at low bit rate or from 240 major frames at high bit rate.

Within a timeline, each data record represents a 64-minute partition in time. Data items are positioned within the records by time, relative to the start of the record (see "Time Tagging," below). Fill code is substituted where data is unavailable. If a gap in data coverage greater than 64 minutes occurs, it is possible that an entire record will be fill code. In this case the dummy record indicator is turned on.

When a new timeline starts, the uniform 64-minute spacing of records is interrupted and a new sequence of 64-minute records is established. The first record of the new timeline will not, in general, increment by 64 minutes from the previous record. Subsequent records will increment by 64 minutes until another timeline begins. Data records which begin a new timeline are flagged both in the records themselves and in the file label.

The format of the data record is given in Table 3.

(E) Time Tagging

There are four types of data pool information, according to frequency of readout: (1) 60 per record, 1-minute intervals; (2) 12 per record, 5-minute intervals; (3) 4 per record, 15-minute intervals; (4) once per record, hourly interval. ("Minute," as used here, is more correctly an "ISEE minute," or 64 seconds, which is the time period of one major frame at low bit rate.)

The start time of the data record (words 1 and 2) is the start time of sampling interval number 1 at all four frequencies of readout. The start times of subsequent intervals are computed relative to interval number 1.

Examples (Refer to Table 3):

Example 1 — Words 227 through 406 of the data record contain 60 magnetic field vectors labeled {Bp(1), Bx(1), By(1)} through {Bp(60), Bx(60), By(60)}. The vector {Bp(1), Bx(1), By(1)}, in words 227-229, was computed over the 64-second interval beginning at the record start time.

The vector $\{Bp(60), Bx(60), By(60)\}$, in words 404-406, was computed over the 64-second interval beginning at t = (record start time) + (59 x 64 seconds). Similarly, vector $\{Bp(3), Bx(3), By(3)\}$, words 233-235, was computed over the 64-second interval beginning at t = (record start time) + (128 seconds).

Example 2 — Find the 8-200 keV proton flux at a point in time 20 minutes from the start of the record.

The required information set is from the Anderson algorithm, words 635-646, labeled PFLUX (1) - PFLUX (12). This data is given at intervals of 5 ISEE-minutes or every 320 seconds. Let RST equal the record start time. Then,

$$RST + 20\,min = RST + 1200\,sec = RST + 3.75\ intervals$$

The desired value would thus be best approximated by interval No. 4, word 638.

(F) File Label

The file label record, Table 1, contains identification and accounting information for the data pool file. It also contains the minimum and maximum spin periods encountered over the 7-day file period, a summary of the shadow periods, and an index to all timelines in the file. The record is padded to the length of the data records.

As indicated in Table 1, the first 1440 bits should be ignored by the user. These bits are used for internal accounting purposes by Goddard Space Flight Center.

EXPERIMENT DESCRIPTION - ANDERSON EXPERIMENT

The Anderson experiment on ISEE/A and B consists of identical pairs of of solid state telescopes and two fixed voltage analyzers. The solid state telescopes are mounted on cold plates and operate around -50°C. The experiments are mounted to view along the spin axis of the spacecrafts.

The solid state experiment is designed to detect electrons and protons from about 8 to 200 keV. The separation of electron and proton fluxes above $\gtrsim$8 keV is accomplished by the use of two identical semiconductor detectors, one of which is covered by a thin low-Z absorber foil which stops low-energy protons. Electrons

Table 1

Data Pool File Label

Word Number*	Description (All Values are Floating Point)
1 . . . n	1440 bits for Goddard Space Flight Center internal use. (1440 bits = n words, where n depends on the word size used.)
n+1	Satellite ID number.
n+2	Intended recipient of this tape. (See Table 2.)
n+3	YY, start of file, 2 digits of year.
n+4	DDD, start of file, Julian day 1-366.
n+5	SSSSS, start of file, seconds of day.
n+6	YY, end of file, 2 digits of year.
n+7	DDD, end of file, Julian day 1-366.
n+8	SSSSS, end of file, seconds of day.
n+9	High order bits — Clock at start of the data pool file.
n+10	Low order 21 bits — Clock at start of the data pool file.
n+11	Group number (corresponds to telemetry data tape group numbers).
n+12	Minimum value of spin period found within this file, seconds.
n+13	Maximum value of spin period found within this file, seconds.
n+14 . . . . n+29	Spares.

*Word size is dependent on the intended recipient.

Table 1 (Continued)

Word Number	Description (All Values are Floating Point)		
n+30	Number of shadow periods (maximum 10)		Up to 10 shadow periods
n+31	Day of year	Start time of shadow period (1)	
n+32	Seconds of day		
n+33	Day of year	Stop time of shadow period (1)	
n+34	Seconds of day		
n+35	Start record number of shadow period (1)		
.	.		
.	.		
.	.		
n+76	Day of year	Start time of shadow period (10)	
n+77	Seconds of day		
n+78	Day of year	Stop time of shadow period (10)	
n+79	Seconds of day		
n+80	Start record number of shadow period (10)		
n+81	Number of time lines (maximum 80)		Up to 80 time lines
n+82	Start day of year (1)		
n+83	Start seconds of day (1)		
n+84	High order bits of start spacecraft clock (1)		
n+85	Low order 21 bits of start spacecraft clock (1)		
n+86	Bit rate (1–low bit rate; 4–high bit rate) (1)		
n+87	Start record number (1)		
.	.		
.	.		
.	.		
n+656	Start day of year (80)		
n+657	Start seconds of day (80)		
n+658	High order bits of start spacecraft clock (80)		
n+659	Low order 21 bits of start spacecraft clock (80)		
n+660	Bit rate (1–low bit rate; 4–high bit rate) (80)		
n+661	Start record number (80)		
n+662 . . 810	Fill to equal data record length		

Table 2

Experimenter Identification Codes

Experimenter ID Code	Experimenter Name
201	Anderson (ISEE-A/B)
202	Bame (ISEE-A)
203	Frank (ISEE-A/B)
204	Gurnett (ISEE-A/B)
205	Harvey (ISEE-A/B)
206	Helliwell (ISEE-A)
207	Hovestadt (ISEE-A)
208	Heppner (ISEE-A)
209	Mozer (ISEE-A)
210	Ogilvie (ISEE-A)
211	Russell (ISEE-A/B)
212	Sharp (ISEE-A)
213	Williams (ISEE-A)
215	Egidi (ISEE-B)
219	Keppler (ISEE-B)
220	Paschmann (ISEE-B)

Table 3

Data Pool Record

Word Number*	Description (All Values are Floating Point)	
1	Day-of-year, record start	
2	Seconds-of-day, record start	
3	Clock, record start. High order portion.	
4	Clock, record start. Low order 21 bits.	
5	Recovery factor: For LBR = (minor frames processed)/(60. x 256.) For HBR = (minor frames processed)/(240. x 256.)	
6	Bit rate: 1.0 = LBR (Low Bit Rate) 4.0 = HBR (High Bit Rate)	
7	Dummy record indicator: 0. = at least one minor frame of data within this record's span. 7.0 = no data within the span of this record. The record is a dummy.	
8	Timeline indicator 0. = this record lies on an existing timeline 7.0 = this record begins a new timeline	
9	Data record number	
10-21	Spares	
22	GSEX(1)	Satellite position in GSE coordinates, interval No. 1 (of 60)
23	GSEY(1)	
24	GSEZ(1)	
.	.	.
.	.	.
.	.	.
199	GSEX(60)	Satellite position in GSE coordinates, interval No. 60 (of 60)
200	GSEY(60)	
201	GSEZ(60)	

*Word size is dependent on the intended recipient.

Table 3 (Continued)

Word Number	Description (All Values are Floating Point)	
Russell Algorithm:		
202	A_1	Hourly parameters from magnetometer algorithm.
203	$R_{21} = AM_2/AM_1$	
204	$R_{31} = AM_3/AM_1$	
205	S_{21}	
206	C_{21}	
207	S_{31}	
208	C_{31}	
209	A_{IA}	
210	T_1	
211	T_2	
212	FS	
213	AS, Analog status	
214	AP, Flipper state	
215	MD-SD, Mag delay-Sun delay	
216	SP, Sun period	
217	MP, Mag period	
218	SE, Sun elevation	
219	DS (of first sample in hour)	
220	T	
221	O_1	
222	O_2	
223	O_3	
224	RS_1	
225	RS_2	
226	RS_3	

Table 3 (Continued)

Word Number	Description (All Values are Floating Point)	
227	Bp(1) - spin axis coordinate	Magnetic field vector, interval No. 1 (of 60)
228	Bx(1) - satellite-sun line coordinate	
229	By(1) - 3rd coordinate of triad	
.	.	
.	.	
.	.	
404	Bp(60)	Magnetic field vector, interval No. 60 (of 60)
405	Bx(60)	
406	By(60)	
Harvey Status:		
407	HASTAT(1)	Status during interval No. 1 (of 60)
.	.	.
.	.	.
.	.	.
466	HASTAT(60)	Status during interval No. 60 (of 60)
Mozer Status:		
467	MOSTAT(1)	Electron gun status during interval No. 1 (of 60)
.	.	.
.	.	.
.	.	.
526	MOSTAT(60)	Electron gun status during interval No. 60 (of 60)
Bame Algorithm:		
527	ESPEC1(1)	4-level electron spectrum for interval No. 1 (of 12)
528	ESPEC2(1)	
529	ESPEC3(1)	

Table 3 (Continued)

Word Number		Description (All Values are Floating Point)
530	ESPEC4(1)	4-level electron spectrum for interval No. 1 (of 12)
.	.	.
.	.	.
.	.	.
571	ESPEC1(12)	4-level electron spectrum for interval No. 12 (of 12)
572	ESPEC2(12)	
573	ESPEC3(12)	
574	ESPEC4(12)	
575	IONPD(1)	Ion pseudo-density, interval No. 1 (of 12)
.	.	.
.	.	.
.	.	.
586	IONPD(12)	Ion pseudo-density, interval No. 12 (of 12)
587	IONAE(1)	Ion average energy, interval No. 1 (of 12)
.	.	.
.	.	.
.	.	.
598	IONAE(12)	Ion average energy, interval No. 12 (of 12)
599	WINDPS(1)	Solar wind peak speed, interval No. 1 (of 12)
.	.	.
.	.	.
.	.	.
610	WINDPS(12)	Solar wind peak speed, interval No. 12 (of 12)

Table 3 (Continued)

Word Number		Description (All Values are Floating Point)
611	WINDEN(1)	Solar wind pseudo-density, interval No. 1 (of 12)
.	.	.
.	.	.
.	.	.
622	WINDEN(12)	Solar wind pseudo-density, interval No. 12 (of 12)
Anderson Algorithm:		
623	EFLUX(1)	8-200 keV electron flux, interval No. 1 (of 12)
.	.	.
.	.	.
.	.	.
634	EFLUX(12)	8-200 keV electron flux, interval No. 12 (of 12)
635	PFLUX(1)	8-200 keV proton flux, interval No. 1 (of 12)
.	.	.
.	.	.
.	.	.
646	PFLUX(12)	8-200 keV proton flux, interval No. 12 (of 12)
Gurnett Algorithm:		
647	EF562(1)	Wave electric field, 562 Hz, interval No. 1 (of 12)
.	.	.
.	.	.
.	.	.
658	EF562(12)	Wave electric field, 562 Hz, interval No. 12 (of 12)

Table 3 (Continued)

Word Number		Description (All Values are Floating Point)
659	MF562(1)	Wave magnetic field, 562 Hz, interval No. 1 (of 12)
.	.	.
.	.	.
.	.	.
670	MF562(12)	Wave magnetic field, 562 Hz, interval No. 12 (of 12)
Williams Algorithm:		
671	ELOW(1)	32-50 keV electrons, interval No. 1 (of 12)
.	.	.
.	.	.
.	.	.
682	ELOW(12)	32-50 keV electrons, interval No. 12 (of 12)
683	EHIGH(1)	80-126 keV electrons, interval No. 1 (of 12)
.	.	.
.	.	.
.	.	.
694	EHIGH(12)	80-126 keV electrons, interval No. 12 (of 12)
695	PLOW(1)	21-50 keV protons, interval No. 1 (of 12)
.	.	.
.	.	.
.	.	.
706	PLOW(12)	32-50 keV protons, interval No. 12 (of 12)
707	PHIGH(1)	80-126 keV protons, interval No. 1 (of 12)
.	.	.
.	.	.
.	.	.
718	PHIGH(12)	80-126 keV protons, interval No. 12 (of 12)

Table 3 (Continued)

Word Number		Description (All Values are Floating Point)
Sharp Algorithm:		
719	PLADEN(1)	Cold plasma density, interval No. 1 (of 12)
720	PLANGL(1)	Plasma flow angle indicator, interval No. 1 (of 12)
721	PLATEM(1)	Plasma temperature indicator, interval No. 1 (of 12)
.	.	.
.	.	.
.	.	.
752	PLADEN(12)	Cold plasma density, interval No. 12 (of 12)
753	PLANGL(12)	Plasma flow angle indicator, interval No. 12 (of 12)
754	PLATEM(12)	Plasma temperature indicator, interval No. 12 (of 12)
Frank Algorithm:		
755	PRODEN(1)	Proton density, interval No. 1 (of 12)
756	EFLX10(1)	10 keV electron flux, interval No. 1 (of 12)
757	FRANGE(1)	Energy range indicator, interval No. 1 (of 12)
.	.	.
.	.	.
.	.	.
788	PRODEN(12)	Proton density, interval No. 12 (of 12)
789	EFLX10(12)	10 keV electron flux, interval No. 12 (of 12)
790	FRANGE(12)	Energy range indicator, interval No. 12 (of 12)

Table 3 (Continued)

Word Number		Description (All Values are Floating Point)
Hovestadt Algorithm:		
791	PROLP(1)	0.17-0.4 MeV protons, interval No. 1 (of 4)
.	.	.
.	.	.
.	.	.
794	PROLP(4)	0.17-0.4 MeV protons, interval No. 4 (of 4)
795	ALFLA(1)	0.12-0.25 MeV alphas, interval No. 1 (of 4)
.	.	.
.	.	.
.	.	.
798	ALFLA(4)	0.12-0.25 MeV alphas, interval No. 4 (of 4)
799	HEAVYS(1)	Heavies (Z > 2) greater than 0.1 MeV, interval No. 1 (of 4)
.	.	.
.	.	.
.	.	.
802	HEAVYS(4)	Heavies (Z > 2) greater than 0.1 MeV, interval No. 4 (of 4)
803	PROHP1(1)	5-10 MeV protons, interval No. 1 (of 4)
.	.	.
.	.	.
.	.	.
806	PROHP1(4)	5-10 MeV protons, interval No. 4 (of 4)
807	PROHP2(1)	10-20 MeV protons, interval No. 1 (of 4)
.	.	.
.	.	.
.	.	.
810	PROHP2(4)	10-20 MeV protons, interval No. 4 (of 4)

lose very little energy in the foil. The foil is chosen so that it stops protons up to the energy of electrons which just penetrate the detector. In the absence of protons energetic enough to penetrate the foil, the foil-covered detector counts only electrons while the open detector counts both electrons and protons. When the energetic protons are present, their fluxes are obtained by subtracting the foil detector counting rate from the open detector counting rates.

Two fixed electric field analyzers complement the solid state telescopes to detect electrons and protons below ~8 keV. The analyzers consist of cylindrical plates, and the particles are detected by means of channel multipliers. One array is made up of funnel-mouthed multipliers (for large geometry factors) while another is made up with multipliers without funnels (small geometry factor).

Relevant information concerning the geometry factors, apertures, dynamic range, temporal resolution, and energies of the particles detected is summarized in Table 1. Some of the numbers shown are preliminary and may be modified at a later date. It is highly recommended that all users of the Anderson experimental data verify and/or clarify with the Principal Investigator any uncertainties or peculiarities concerning the data.

Algorithm for Processing the Pool Data from the Anderson Experiment

From the Anderson Energetic Particle Fluxes Experiment, the data pool contains the following quantities:

a. energy-integrated electron fluxes in the energy range of 8-200 keV, designated EFLUX in the data pool format.

b. energy-integrated proton fluxes in the same energy range, designated PFLUX in the data pool format.

The fluxes are averaged every 5 minutes and 20 seconds, which precisely covers 5 major frames at low bit rate. Only the measurements from the mother spacecraft are included in the data pool. The electron fluxes are directly measured by the foil telescope, labeled in the experiment as FT8. Besides the foil telescope, the experiment has an open telescope, OT8, which measures both electron and proton fluxes. The proton fluxes are then deduced by taking the difference of OT8 and FT8, OT8 - FT8.

OT8 and FT8 can be located in the telemetry stream as follows:

(1) Note that the experiment can be operated either in slow or fast telemetry format. For each format, the telemetry structure is different. The

Table 1

Measurements, Geometric Factors, Dynamic Ranges, Temporal Resolution (Mother and Daughter)

Detector	Geometric Factor (cm^2 ster)	Aperture	Dynamic Range	Particle Species	Energy Range (keV)	Temporal Resolution (sec)
Open Telescope (OT)	0.1	40° FWHM Cone	0 to 10^9	e, p e, p p	8-200 30-200 200-380	1/4 2 2
Foil Telescope (FT)	0.1	40° FWHM Cone	0 to 10^9	e e	8-200 30-200	1/4 2
Fixed Voltage Analyzers (FVA)						
FMSEM	10^{-2} E	5 x 8° FWHM	Up to 2.10^9	p	$\Delta E/E$ 50%	1/2
SEM	5.10^{-5} E		(cm^2 sr ske V)	p		1/2
FMSEM	10^{-2} E	5 x 8° FWHM	Up to 2.10^9	e	$\Delta E/E$ 50%	1/2
SEM	5.10^{-5} E			e		1/2

operation mode can be checked every 16 seconds or 64 minor frames. To know the telemetry mode, first obtain the housekeeping bits at the word 39 of minor frame 14. Counting from left to right, the last bit specifies the mode. Note that each word has 8 bits.

(2) Acquire the 24 bits of the data select word, DSEL. DSEL consists of three words, word 39 of minor frames 30, 46, 62. These three words are assembled from left to right as received to form a 24 bit word.

(3) Divide DSEL into 8 3-bit groups. The content of the 3-bit group specifies the detector and its experimental condition. Eight possible types of measurements can be assigned for each group. It is therefore necessary to check through DSEL to find out which group has the measurements FT8 and OT8. FT8 is specified as 010 and OT8 specified as 000.

(4) Corresponding to each 3-bit group, the telemetry stream has a pre-assigned word, called data accumulator, containing the measured data from the specified detector. Dividing DSEL from left to right in sequence, the corresponding eight accumulators are called F1, F2, F3, F4, F5, S1, S2 for the slow mode. For the fast mode, the eight accumulators in sequence are called F1, F2, F3, S3, S4, S5, S1, S2. Table 1 and Table 2 give locations of the accumulators per 64 minor frames.

(5) The eight bit output of each accumulator comes from a type 623 converter, operating in the "19 to 8 bit," "clock normally low" mode. To recover the original 19 bit count rate, a decoding algorithm is needed. For completeness, the decoding algorithm is included.

(6) Multiply the count rate by a detector efficiency factor to obtain the particle flux. The efficiency factor is determined empirically.

(7) Note that the content of accumulators depends on the telemetry mode (slow or fast). The average algorithm should also consider the fact that FT8 and OT8 can be contained in either F-accumulators or S-accumulators. NOTE: Zero is represented by "0", the letter "oh" is represented by "O". All counts start with 0.

CONVERSION ALGORITHM FOR 623

The following algorithm is used to recover the original binary count (C) from the telemetered values of X and Y. In the serial data the value of Y is shifted out first followed by X. The most significant bit of each is transmitted first.

Table 1

Slow Mode

Accumulator	Location	
	Word Number	Minor Frame
F1	36	All
F2	37	All
F3	38	All
F4	100	All
F6	101	All
F6	102	All
S1	39	0, 8, 16, 24, 32, 40, 48, 56
S2	39	2, 10, 18, 26, 34, 42, 50, 58

Table 2

Fast Mode

Accumulator	Location	
	Word Number	Minor Frame
F1	36	All
F2	37	All
F3	38	All
F1	100	All
F2	101	All
F3	102	All
S3	39	0, 16, 32, 48
S4	39	2, 18, 34, 50
S5	39	4, 20, 36, 52
S1	39	6, 22, 38, 54
S2	39	8, 24, 40, 56

For the 19 to 8 bit mode:

(a) if n, X are 14, 15 C = 0

(b) if n = -0 C = X + 1

(c) Otherwise, $C = 1 + (X + 16)\ 2^n$ where n is given in Table 1.

For count values less than 129 only the last value of X given in the Table should ever occur.

Table 1

Y to n/P Conversion for 19 to 8 Mode

Y	n
0	0
1	11
2	10
3	1
4	12
5	-0
6	14
7	13
8	8
9	3
10	2
11	9
12	4
13	7
14	6
15	5

FAST PLASMA EXPERIMENT

MOTHER AND DAUGHTER

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EXPERIMENT DESCRIPTION

The primary focus of the joint Max Planck Institute - Los Alamos Scientific Laboratory experiment is an investigation of the thicknesses, motions, and structures of the permanent and transient plasma discontinuities found in space about the earth. Nearly identical plasma instruments on the Mother and Daughter spacecraft comprise the whole experiment designed to discriminate between permanent and transient structures. Primary interest is devoted both to permanent structures such as the bow shock, magnetosheath, magnetopause, plasma sheet, neutral sheet, and plasmapause and to transient structures such as shock waves, tangential discontinuities, and the various types of waves which are found in the solar wind, magnetosheath, and plasma sheet. Only an incomplete list can be given here of the specific phenomena which can be studied with the combined observations from the plasma analyzers on the Mother and Daughter spacecraft: (1) Evolution of structures in the solar wind propagating over 0.01 AU from the Heliocentric spacecraft to M/D. (2) Alfven waves in the interplanetary medium. (3) Phenomena in the solar wind caused by the downstream bow shock, such as bow shock protons, solar wind electron heat flux from the bow shock and upstream waves. (4) Discontinuities and waves in the solar wind propagating into the magnetosheath and magnetosphere regions probed by M/D. (5) Bow shock thickness, structure, and velocity. (6) Magnetosheath structure and propagation of waves and discontinuities within it. (7) Magnetopause thickness, X-692-77-129

NOTES ON THE ISEE A + B DATA POOL TAPE

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structure, and velocity. (8) Reflection of ions and electrons at the magnetopause. (9) Boundary layer of the near magnetotail. (10) Thickness, structure, and motions of the plasma sheet and its boundaries. (11) Plasma flow within the plasma sheet. (12) Thickness, structure, and motions of the plasma-pause, etc.

Measurements of the electron and ion velocity distributions in one-, two-, and three-dimensional form are made as fast as possible and repeated as often as possible. The determinations are made on both spacecraft using identical experiments. The fast plasma experiment package consists of three 90° spherical section electrostatic analyzers. Two of the analyzers have oppositely directed look angles and are devoted to making two-dimensional measurements as fast as possible. These analyzers have an electron multiplier counter with an added special large first dynode which accepts analyzed particles over a ±55° polar angle range. Complete energy distributions with 16 levels are made at 16 evenly spaced angles for both electrons and protons in one spacecraft revolution, 3 sec. The measurements are repeated every 3 seconds at the high bit rate. A single energy spectrum is obtained in 0.16 sec. At the low bit rate there are two commandable modes. With one, the same 16 x 16, E and P measurements are made in a single revolution but measurements from only every 4th revolution can be telemetered. With the second mode, interleaved sets of counts at 8 levels and 8 equally spaced angles are telemetered, so that partial data are obtained every revolution and a full set every 4 revolutions.

A third 90° spherical section analyzer has its first dynode divided into four parts in front of the multiplier which detects the analyzed particles. Secondary electrons are separately counted from the four parts, on which the polar angle distribution is imaged, giving three-dimensional measurements. These measurements take longer than 2-D, of course, being completed in 24 sec. At the low bit rate data are acquired four times slower.

All three 90° analyzers operate over two commandable energy ranges, $50\,\text{eV} \leqslant E_p \leqslant 10\,\text{keV}$ and $5\,\text{eV} \leqslant E_e \leqslant 3\,\text{keV}$ for solar wind and magnetosheath measurements, and $70\,\text{eV} \leqslant E_p \leqslant 40\,\text{keV}$ and $11\,\text{eV} \leqslant E_e \leqslant 20\,\text{keV}$ for magnetosheath and magnetosphere measurements.

To support the fast plasma experiment studies as well as the other experiments on M/D, the Mother package includes a solar wind experiment. This instrument consists of a single 150° electrostatic analyzer with two entrance apertures and two multiplier-counting systems. Ions entering the entrance apertures from fan-shaped acceptance solid angles are analyzed and counted in four sets of energy sweeps of 14 levels each. The sweeps are made at 8 angles centered on the solar direction. Two sets of interleaved angles are used so that by combining sets of measurements, a total of 16 angles are covered. The acceptance fans are tilted in opposite directions from the vertical (spin axis) by 45°. Combining data from the two counters permits determination of the 3-D flow vector of the solar wind and information on the 3-D moments of the velocity distributions. The experiment operates over a proton energy range of 180 eV to 7 keV and has a sweep energy resolution of 6%. At the high bit rate the complete range of 56 energy levels at 16 angles is acquired in 24 sec. Eight-angle subsets of data usually sufficient for determining the parameters are obtained in 12 sec. At the low bit rate subsets of the data are selected to be transmitted so that a complete set is acquired in 24 x 4 = 96 sec and a subset usually sufficient for parameter calculation is obtained in 48 sec.

FAST PLASMA EXPERIMENT PARAMETERS SUPPLIED FOR THE DATA POOL

It must be emphasized that rather sophisticated data manipulations and editing are generally required to construct accurate plasma parameters from the data acquired with plasma instrumentation. Data processing at these levels is too complicated and lengthy to be appropriate for the pool data so somewhat simplified "pseudo" parameters are supplied. Caution should be exercised in the use of these parameters because at best they are only rough preliminary approximations to the parameters which are obtained with more sophisticated treatments and at worst the pseudo-parameters could be seriously misleading. It should be kept in mind that main objectives of the data supplied are to permit identification of the regions of space through which the spacecraft is passing and to identify times of particular interest for which more accurate values of the plasma parameters may be of particular importance.

For FPE the parameters are derived from basic sets of data consisting of electron counts C_E (i, j) and ion counts C_P (i, j) at 16 energy levels, E_i, and 16 measurement angles, ϕ_j. The energy levels extend from 5 eV to 3 keV for electrons and from 50 eV to 10 keV for protons when the lower ranges, appropriate for the solar wind and magnetosheath are used. When the higher ranges, appropriate for the magnetosphere, are used, the levels extend from 10 eV to 20 keV for electrons and from 67 eV to 39 keV for protons. Angular separations between measurements are ~22.5°.

FPE ELECTRON SPECTRA

For enabling identification of the spatial region a 4-level spectrum is supplied. Data from 16 consecutive electron sweeps are generated as follows:

$$\sum_{i=m}^{n} \sum_{j=1}^{16} C_E(i, j);\ m = 1, 5, 9, 13;\ n = m + 3$$

In the data pool format, these numbers are designated ESPEC1, ESPEC2, ESPEC3, and ESPEC4 for m = 1, 5, 9, and 13 respectively. After some experience, experimenters should be able to look at these four numbers and tell whether the S/C is in the solar wind, magnetosheath, plasma sheet, or high latitude tail.

For the low energy sweep the energy bands are approximately 5 eV to 21 eV, 21 eV to 86 eV, 86 eV to 355 eV, and 355 eV to 3.0 keV. When the experiment is operating from the high sweep level, the bands are 10 eV to 52 eV, 52 eV to 287 eV, 287 eV to 1.57 keV, and 1.57 keV to 20 keV.

FPE PSEUDO-DENSITY

$$N_P = K_N \sum_{i=1}^{16} \frac{1}{\sqrt{E_i}} \sum_{j=1}^{16} C_P(i, j)$$

In the data pool format this is designated IONPD.

FPE COUNTS-AVERAGED AVERAGE ION ENERGY

$$\overline{E}_P = \frac{K_E \sum_{i=1}^{16} E_i \sum_{j=1}^{16} C_P(i, j)}{\sum_{i=1}^{16} \sum_{j=1}^{16} C_P(i, j)}$$

In the data pool format this is designated as IONAE.

SOLAR WIND EXPERIMENT PARAMETERS

For the SWE a basic set of data consists of a matrix of counts $C_{wa}(i, j)$ from two counters (a = counter 1 or 2) at 56 energy levels E_i and 16 angles ϕ_j centered on the sun. This experiment is expected to generate useful data only when the spacecraft is in the solar wind because of the limited angular range of measurements.

SWE PEAK COUNT SPEED V_p

In order to ascertain that the experiment is probably in the solar wind, the maximum count $C_{wa\ max}(i, j)$ is determined for a complete cycle. This count is then compared to the sum of all the counts obtained during the cycle. If $C_{wa\ max}$ exceeds a certain fraction K_W of the summed counts, the proton spectrum is relatively cool and the experiment is probably in the solar wind instead of the magnetosheath or magnetosphere where the energy distributions are much broader. The energy level E_i associated with $C_{wa\ max}$ is then used to calculate the peak count speed V_p.

SOLAR WIND PSEUDO-DENSITY

When in the solar wind, a pseudo-density is calculated.

$$N_{WP} = K_{WN} \sum_{i=1}^{16} \frac{1}{\sqrt{E_i}} \sum_{j=1}^{16} C_{W1}(i, j)$$

K_{WN} is a constant related to the analyzer geometry. Solar wind pseudo-density is designated WINDEN in the data pool format.

QUADRISPHERICAL LEPEDEA

FRANK EXPERIMENT

(ISEE Mother and Daughter Spacecraft)

The observational objectives of the Quadrispherical LEPEDEAs on the ISEE Mother and Daughter spacecraft are (1) to obtain directional, differential intensities of electrons and positive ions, separately and simultaneously, over the energy (E/Q) range of 1 eV to 50,000 eV, (2) to measure the angular distributions of electron and positive-ion intensities over all but 2% of the 4π-steradian solid angle at the satellite position with good angular resolution, (3) to provide adequate sensitivities, dynamic ranges and energy resolution for comprehensive measurements of these plasmas in the magnetosheath and all regions of the magnetosphere accessible to the spacecraft, and (4) to obtain these plasma observations with meaningful temporal resolution.

The mechanical configuration of the Quadrispherical LEPEDEA comprises three concentric, quadrispherical plates with radii of curvature 10.8 cm, 11.2 cm, and 11.7 cm, respectively. The outer two plates are grounded and the center plate is biased with a stepped, programmed voltage. This electrostatic analyzer geometry allows simultaneous determinations of the directional, differential intensities of electrons and positive ions as well as determination of their angular distributions within a fan-shaped field of view, 162° x 6°, via suitable positioning of individual detectors at the exit apertures of the electrostatic analyzer. For the ISEE Quadrispherical LEPEDEAs, seven continuous-channel electron multipliers are employed at each of the exit apertures (electron and positive ion) to divide the fan-shaped solid angle into seven contiguous segments. A thin-windowed Geiger-Mueller tube has been included in each of the Quadrispherical LEPEDEAs for determinations of the directional intensities of electrons $E \gtrsim 45$ keV and protons $E \gtrsim 600$ keV in directions perpendicular to the spacecraft spin axis. The field-of-view of each Geiger-Mueller tube is conical with full-angle 25°. The capabilities for plasma measurements of the two ISEE Quadrispherical LEPEDEAs are identical in all important aspects such as energy range, angular coverage and temporal resolution.

The energy range and resolution of the Quadrispherical LEPEDEAs are $1\,eV \lesssim E \lesssim 50{,}000\,eV$ and $\Delta E/E = 0.17$, respectively. E is the energy per unit charge. The entire energy range is spanned by 63 contiguous energy passbands. Four sequences of energy passbands are available: all 63 energy passbands, every other passband, the lower 32 energy passbands and the higher 32 passbands. The desired sequence of energy passbands is selected by ground command.

Intensity ranges and thresholds have been chosen to yield definitive measurements of all the known divers plasmas in the earth's magnetosphere and its environs, excluding only the solar wind ions and electrons. These plasmas within the capabilities of the Quadrispherical LEPEDEAs include those in the ring current, plasma sheet, high-latitude magnetotail, and magnetosheath. The practical threshold intensities for positive ions are 7×10^3 and 1.5×10^{-1} $(cm^2\text{-sec-sr-eV})^{-1}$ at 1 eV and 50 keV, respectively. The corresponding threshold electron intensities are 2×10^4 and 4×10^{-1} $(cm^2\text{-sec-sr-eV})^{-1}$ at 1 eV and 50 keV, respectively. These threshold intensities vary approximately as E^{-1} over the instruments' energy range. The maximum positive-ion and electron intensities within the ranges of the Quadrispherical LEPEDEA are a factor of 3×10^5 greater than the above corresponding thresholds.

Comprehensive coverage of the angular distributions is provided by the combination of the wide field-of-view, 162° x 6°, of the Quadrispherical LEPEDEAs and the spin motion of the spacecraft. The axes of the fields-of-view are directed perpendicular to the spin axis with the 162° dimension lying in a plane parallel to the spin axis. The seven fields-of-view comprising each of the two wide fans of acceptance, one each for positive ions and electrons, sweep out seven latitudinal bands on a unit sphere as the satellite rotates. If latitude is measured from the spin axis direction at 0°, these seven latitude ranges are 9°-18°, 18°-39°, 39°-71°, 71°-109°, 109°-141°, 141°-162°, and 162°-171°. The only portions of the 4π-steradian solid angle for charged-particle velocity directions at the satellite position that are not sampled by the Quadrispherical LEPEDEA are thus two small cones with half-angle 9° and directed parallel and antiparallel to the spin axis, respectively. All but 2% of this 4π-steradian solid angle is sampled by these plasma analyzers. Each of the above latitudinal bands is further divided into sectors as the spacecraft rotates. This sectoring can be slaved to a sun-referenced pulse or to the spacecraft clock pulses via ground command. Typical inflight operation of the instrument will yield 16 sun-referenced sectors. Hence the angular distributions of electron and positive-ion intensities would be usually telemetered for 7 x 16 = 112 directions.

The temporal resolution of the Quadrispherical LEPEDEAs for measurements of various plasma parameters is dependent upon the spacecraft telemetry rates, the energy passband sequence, the sectoring mode and the specific parameter of interest. Specific examples of plasma measurements and the corresponding temporal resolutions are (electron and positive-ion intensities, separately and simultaneously): pitch-angle distribution at fixed energy, 250 ms; full coverage of angular distributions at fixed energy, 4 seconds; three-dimensional bulk velocities of ions, 128 seconds; comprehensive (7056-sample) three-dimensional distribution functions, 256 seconds. The combination of operational modes, and hence the temporal resolution, is tailored by ground commands for specific plasma regimes and phenomena.

ALGORITHM FOR PROCESSING THE POOL DATA FROM THE FRANK EXPERIMENT

GENERAL DESCRIPTION

The Quadrispherical LEPEDEA provided by the University of Iowa supplies two measurements to the Data Pool tape: (1) spin averaged proton number density, designated PRODEN in the data pool format, and (2) spin averaged flux of electrons $E_e \approx 10\,\text{keV}$, designated EFLX10. The data are obtained from detectors measuring charged particle intensities perpendicular to the spin axis of the spacecraft ($71° \leqslant \theta \leqslant 109°$) and are read out once per minor frame. All data during a given energy step are averaged to obtain a spin averaged flux at that energy.

The number density is obtained by numerically integrating the spin averaged proton differential flux over the energies sampled by the instrument. Depending on the instrumental operating mode this energy range is $1\,\text{eV} \leqslant E_p \leqslant 50,000\,\text{eV}$, $1\,\text{eV} \leqslant E_p \leqslant 200\,\text{eV}$, or $200\,\text{eV} \leqslant E_p \leqslant 50,000\,\text{eV}$, and is identified by the "energy range flag" (designated FRANGE in the data pool format) values of 1, 2, or 3 respectively. The time required to obtain observations at all energies can be as long as 1024 seconds and limits the temporal resolution of the proton number density to that time period. The units of the number density are ions $(\text{cm})^{-3}$; isotropy is assumed.

The spin averaged flux of electrons, $E_e \approx 10\,\text{keV}$, is available whenever the instrumental operating mode includes that energy, i.e. whenever the "energy range flag" is equal to 1 or 3. Depending on the instrumental mode the average is obtained from 16 or 64 samples during a 4 or 16 second time period. The units of the electron flux are electrons $(\text{cm}^2\text{-sec-eV})^{-1}$; isotropy is assumed.

At the high bit rate, data pool measurements for the Frank experiment are computed over intervals of approximately 5 minutes. At low bit rate, the same measurements are computed over intervals of approximately 20 minutes. The data pool tape format specifies 12 time intervals for the Frank measurements. At high bit rate, all 12 will be used. At low bit rate, only one of every 4 intervals will be used, with the other 3 set to the negative fill code. The intervals used at low bit rate are No.'s 1, 5, and 9. These represent 3 intervals of approximately 20 minutes each.

METHOD OF COMPUTATION OF DATA POOL QUANTITIES

The University of Iowa Quadrispherical LEPEDEA (FRM) is to provide two quantities for the data pool type, the spin averaged proton number density and the flux of 10 keV electrons, and a flag (= 1, 2, or 3) indicating the energy range covered. The following items in the telemetry stream are used in the algorithm: (a) words 15 and 63 of Analog Subcom 1 (word 58) provide experiment ON/OFF status, (b) word 28 of the Digital Subcom (word 59) provides the instrument mode/stepping sequence, (c) telemetry word 103 from frames 6 and 7 (modulo 8) provides the energy step number, (d) telemetry word 2 provides the electron data, and (e) word 3 provides the proton data.

The spin averaged proton number density basically consists of a weighted sum of the decompressed data from word 3 of every minor frame. To perform the sum three vectors of 64 floating point numbers each are required. The first vector consists of 64 constants to be supplied following final calibration of the flight instrument. The second vector contains the sums of all data for each of the 64 possible energy steps, and the third contains the number of samples comprising each of the above sums for each of the energy steps. The energy step number (0-63) associated with each datum (in word 3) is obtained from word 103 (see Appendix A). The conversion to decompressed counts is given in the attached table. When decompressed data from a minimum of 4096 minor frames have been accumulated the number density is computed as follows:

$$\text{DENSITY} = M\ B \sum_{i=0}^{63} \frac{C_i\, A_i}{N_i}$$

where

B = 1 for low bit rate

= 4 for high bit rate

M = 1 for stepping sequences 1, 2, and 3

= 2 for stepping sequence 4 (see Appendix B)

C_i = constant to be supplied for step i

A_i = accumulated decompressed counts for step i

N_i = number of samples for step i

Note that the arrays A_i and N_i must be cleared to zero before starting each accumulation interval of 4096 minor frames.

The spin averaged electron flux at $E_e \approx 10\,keV$ is obtained from telemetry word 2 as follows:

$$FLUX = \frac{B\,C_e\,R}{N}$$

where

$B = 1$ for low bit rate

$= 4$ for high bit rate

C_e = constant to be supplied

R = accumulated decompressed counts for step 53 (provisional)

N = number of samples in R

Depending on telemetry mode, stepping sequence, and bit rate this energy step will occur once every 512, 1024, 2048, 4096 minor frames, or, in stepping sequence 2, it will not appear at all.

The energy range flag is determined by the stepping sequence obtained from word 28 of the Digital Subcom (word 59).

Energy range flag = 1 for stepping sequences 1 and 4

= 2 for stepping sequence 2

= 3 for stepping sequence 3 (see Appendix B)

EXPERIMENT OFF/ON STATUS

Word 15 of Analog Subcom 1 (word 58) contains the "A system" power monitor and word 63 of Analog Subcom 1 (word 58) contains the "B system" power monitor. For each monitor an analog voltage of 0.00 volts is OFF and a voltage of either 1.00, 2.00, 3.00, or 4.30 volts (±5%) is ON. For the purposes of this algorithm a voltage greater than ~0.50 volts may be considered "ON".

System A must be ON for the algorithm to be valid. In addition, if <u>either</u> bit 6 or bit 14 of the housekeeping word described in Appendix A is "1" then "System B" must also be ON.

APPENDIX A

DETERMINATION OF ENERGY STEP NUMBER

Construct one 16-bit binary number from word 103 of minor frame number 6 (modulo 8) and from word 103 of minor frame number 7 (modulo 8) as follows:

	Word 103 Minor Frame 6 (modulo 8)								Word 103 Minor Frame 7 (modulo 8)							
Bit No.	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
				B									A			
									EGP							

If bit 6 is zero (0) save counter A (bits 5-0) for subsequent operations. If bit 6 is one (1) save counter B (bits 13-8) for subsequent operations. Let us call this resulting 6-bit binary number "S".

Next perform an "inclusive OR' operation of bit 7 (EGP) with the most significant bit of S. Thus bit 7 will be "ORed" with bit 5 (if counter A was selected) or with bit 13 (if counter B was selected). The resulting 6-bit binary number is the step number, i, associated with the eight values of word 2 and of word 3 occurring in minor frame numbers 0-7 modulo 8.

APPENDIX B

DETERMINATION OF STEPPING SEQUENCE

The stepping sequence is obtained from word 28 of the digital Subcom (word 59) as follows:

Bit No.	7	6	5	4	3	2	1	0
	Step Seq.		TM Mode		Step Seq.		TM Mode	
	"B System Status"				"A System Status"			

If bit 14 in Appendix A is "0" use the A stepping sequence. If bit 14 in Appendix A is "1" use the B stepping sequence, where

00 = stepping sequence 4

01 = stepping sequence 1

10 = stepping sequence 2

11 = stepping sequence 3

Table 1

ISEE LEPEDEA FRM/FRD

Conversion of Log Compressed 8 Bit Word
into Counts (19 Bit Equiv.)

Format

1st Bit							8th Bit
0	0	0	0	0	0	0	0
M S B	Y		L S B	M S B	X		L S B

Counts = $(X + 16)\ 2^{N} + 1$

except if $Y = 5$; $C = X + 1$

if $Y = 6$ and $X = 15$; $C = 0$

where N is listed below

Y	N
0	0
1	11
2	10
3	1
4	12
5	-0
6	14
7	13
8	8
9	3
10	2
11	9
12	4
13	7
14	6
15	5

ground via the special purpose analog transmitter so that detailed high resolution frequency-time analyses of these signals can be performed. The signals will be transmitted to the ground in one of 4 ground selectable spectrums selected via CMD's 9 and 10 [P 94, P95]. See Figure 2.

(1) 650 Hz-40 kHz baseband only.

(2) 650 Hz-10 kHz baseband only.

(3) 13.5 kHz FM subcarrier only (1 kHz BW).

(4) 650 Hz-10 kHz baseband and 13.5 kHz FM subcarrier (1 kHz BW).

In addition a low level pilot carrier (F_{ref}) of 62.5 kHz is added to the output signal for constant monitoring of the 4 MHz Master Oscillator frequency. An automatic gain control is used to maintain a nearly constant signal strength into the wide-band transmission link. Since this removes signal strength information, the AGC gain voltages are included as part of the science data. The broadband AGC receiver can be commanded by CMD's 6, 7, and 8 [P91, 92, and 93] to one of 8 frequency ranges as shown below:

	Lower Freq.		Lower Freq.
1	baseband	5	250 kHz
2	31.2 kHz	6	500 kHz
3	62.5 kHz	7	1 MHz
4	125 kHz	8	2 MHz

The bandwidths are determined by the four selectable modes listed at the top of this page.

(The frequencies include those used on the IMP-J Plasma Wave Experiment.) The wide-band receiver can be switched to any one of the 3 orthogonal electric antennas or the Z axis magnetometer.

III. Experiment/Instrument Description - Gurnett Experiment

A. Brief Description

1. Antenna System

a. The plasma wave antenna system consists of three orthogonal search coil type magnetic antennas and three electric field antenna inputs. The electric antennas consist of the following:

E_x — (Heppner Antenna) Long Wire Dipole ≈215 meters tip-to-tip. Preamp frequency range (5 Hz-2 MHz).

E_y — (Mozer Antenna) Cable mounted spheres ≈80 m tip-to-tip. Mozer will buffer the signal, inside his main electronics. Preamp frequency range (0-100 kHz).

E_s — (Short Electric Antenna) A short dipole consisting of two spheres 61 cm between centers mounted on rigid booms. The entire assembly including preamp is mounted on the search coil boom ≈61 cm inches inboard from the tip mounted triaxial search coils. The unit will be oriented parallel to the spin plane when deployed. Preamp frequency range (5.6 Hz-100 kHz).

The triaxial magnetic field sensors are mounted on the -x axis boom tip ≈3 m from the spacecraft as shown in Figure 1. Each search coil consists of a high permeability core 40.64 cm long wound with approximately 5,000 turns of #40 copper wire. The experiment can be connected by ground command to one electric field antenna and one of the search coils.

2. Electronics Instrumentation

A block diagram of the plasma wave instrumentation for ISEE A is shown in Section III (B). A brief description of each block follows.

a. Wide-band Receiver

The wide-band receiver is an important and essential element of this experiment. The purpose of the wide-band receiver is to transmit wide-band radio noise signals to the

b. Wave-Normal and Poynting Flux Analyzer

The wave-normal and Poynting flux analyzer consists of five narrow-band receivers all tuned to the same frequency. The relative phase of the signals in all five receivers is preserved by using the same frequency conversion signal to each receiver. Each receiver channel produces two outputs which correspond to the Cosine and Sine (or real and imaginary parts) of the signal being detected by that channel. The Sine output is obtained by shifting the Phase of the frequency conversion signal by 90° relative to the frequency conversion signal for the Cosine output. The ten Sine and Cosine outputs from the five receivers are all sampled simultaneously and held for transmission by sample and hold circuits.

The bandwidth of the individual receiver channels of the wave-normal analyzer is 20 Hz and the center frequency can be tuned to any one of the 32 frequencies from 100 Hz to 5 kHz or can be commanded to automatically sweep from 100 Hz to 5 kHz in 32 logarithmic related steps at a 32 second/step rate. The electric and magnetic field channels of the wave-normal analyzer each have an automatic gain control which maintains the output amplitudes within the proper dynamic range. The automatic gain control has 16 discrete gain settings and is updated once every second. In addition there is a final gain switch (gain of 8) that is activated just prior to the hold function of the sample hold.

c. Multi-Channel Spectrum Analyzers

Two multi-channel spectrum analyzers covering the frequency range from 5 Hz to 311 kHz and 5 Hz to 10 kHz are used to determine electric and magnetic field amplitudes. These spectrum analyzers have relatively coarse frequency resolution, with four frequency channels per decade and bandwidths of ±15% up to the 10 kHz channel and ±7.5% 10 kHz and above, and very good time resolution (~0.1 sec) to resolve spatial and temporal variations of phenomena observed by the two satellites. The inputs to the two spectrum analyzers can be connected to various antennas via the antenna selection switches shown in the block diagram. Normally one spectrum analyzer is used for electric field measurements and the other is used for magnetic field measurements. Each spectrum analyzer channel provides a 0 to 5 volt analog voltage proportional to the logarithm of the signal strength in that channel with a 100 dB dynamic range.

d. Narrow-Band Sweep Frequency Receiver

The narrow-band sweep frequency receiver is intended to provide high resolution frequency spectrum measurements of electric fields above the frequency range of the wide-band receiver. The sweep frequency receiver has 32 frequency steps in each of 4 bands covering the frequency range from approximately 100 Hz to 400 kHz as shown below:

(1) 50 kHz-400 kHz

(2) 6.7 kHz-50 MHz

(3) 830 Hz-6.7 kHz

(4) 100 Hz-830 Hz

The primary scientific purpose of this receiver is to make high frequency resolution measurements. Such measurements can be used, for example, to obtain very accurate (±1%) electron density measurements within the magnetosphere from the frequency of upper hybrid resonance noise. Power to the SFR can be removed by a single ground command if required to reduce experiment power consumption.

e. (Impedance Measurement)

The Z measurement function occurs 8m 32s when not inhibited by serial command 6 [Z Measurement inhibit]. This function lasts ≈ 2 seconds [8 minor frames at low bit rate]. During this time the Heppner Angennas (E_X) and the Triaxial search coil inputs are stimulated at 30 Hz and ≈ 970 Hz respectively. The Heppner antenna is differentially driven at ≈ 100 mV RMS through a small, <10 pf, capacitance and the magnetic preamps via a calibration winding on each search coil.

f. Interface with other experiments

The GUM unit interfaces with two other experiments, MOM and HEM.

(1) MOM

The E_y electric field preamp output is buffered by Mozer in his main electronics unit and supplied to the [GU-01] main electronics unit. The signal is differential.

(2) HEM

Helliwell also uses the output of the Long E Antenna preamps [GU-01].

g. Rapid Sample

The Analog Output (prior to sample and hold) of one of 16 electric field spectrum analyzer channels is sampled at equally spaced intervals at a rate of 2 times/minor frame. The channels to be sampled can either be selected manually via 4 serial command bits or stepped sequentially at 16 sec intervals. The sequential advance resets to zero when commanded from lock mode (manual) to sweep (sequential).

h. DPU (Digital Processing Unit)

The majority of the GUM interface with the spacecraft is via the DPU. This unit is furnished by GSFC but powered by the GUM power converter. The DPU performs two main functions:

(1) Multiplexes the Science Analog Data and Digital Parameter converting them from parallel to serial outputs. This function is described in the enclosed GUM Requirements for Digital Processing Unit.

(2) Protects the experiment from RFI. Virtually every line leaving or entering the main box must pass through a filter feedthrough of ≈1000 pf. Many of the spacecraft signals (clock line, pulses, serial commands, etc.) cannot drive this capacitance. The DPU receives these lines and processes them before they reach the experiment.

DESCRIPTION OF THE GUM DATA POOL TAPE ALGORITHM

INTRODUCTION

The GUM plasma wave experiment on ISEE A uses two identical frequency spectrum analyzers to perform on-board frequency spectrum analysis of both electric and magnetic field waves in the earth's magnetosphere and the solar wind. These spectrum analyzers provide coverage in the frequency range 5.6 Hz to 311 kHz in 20 filter channels (electric spectrum analyzer) and 5.6 Hz to 10 kHz in 14 filter channels (magnetic spectrum analyzer). The electric spectrum analyzer will usually be connected to one of the three electric dipole antennas on ISEE A, and the magnetic spectrum analyzer will usually be connected to one of the three orthogonal search coil magnetometers. The antennas used are selected by ground command. The spectrum analyzers are logarithmic detectors that convert an input signal with a dynamic range of about 100 db into a dc output voltage between 0 and 5 volts, which is subsequently sampled by the spacecraft encoder.

Two science data words will be included on the data pool tape from the GUM experiment. These words consist of instantaneous samples from the 562 Hz filter channels of the two frequency spectrum analyzers in the GUM experiment. These words are identified in the algorithm by the notation E8 and M8. In the data pool format they are designated EF562 and MF562, respectively. In addition to the science data it is necessary to determine which of the six antennas is connected to each of the spectrum analyzers. This information is given by the state of the GUM digital parameters DP1-DP4.

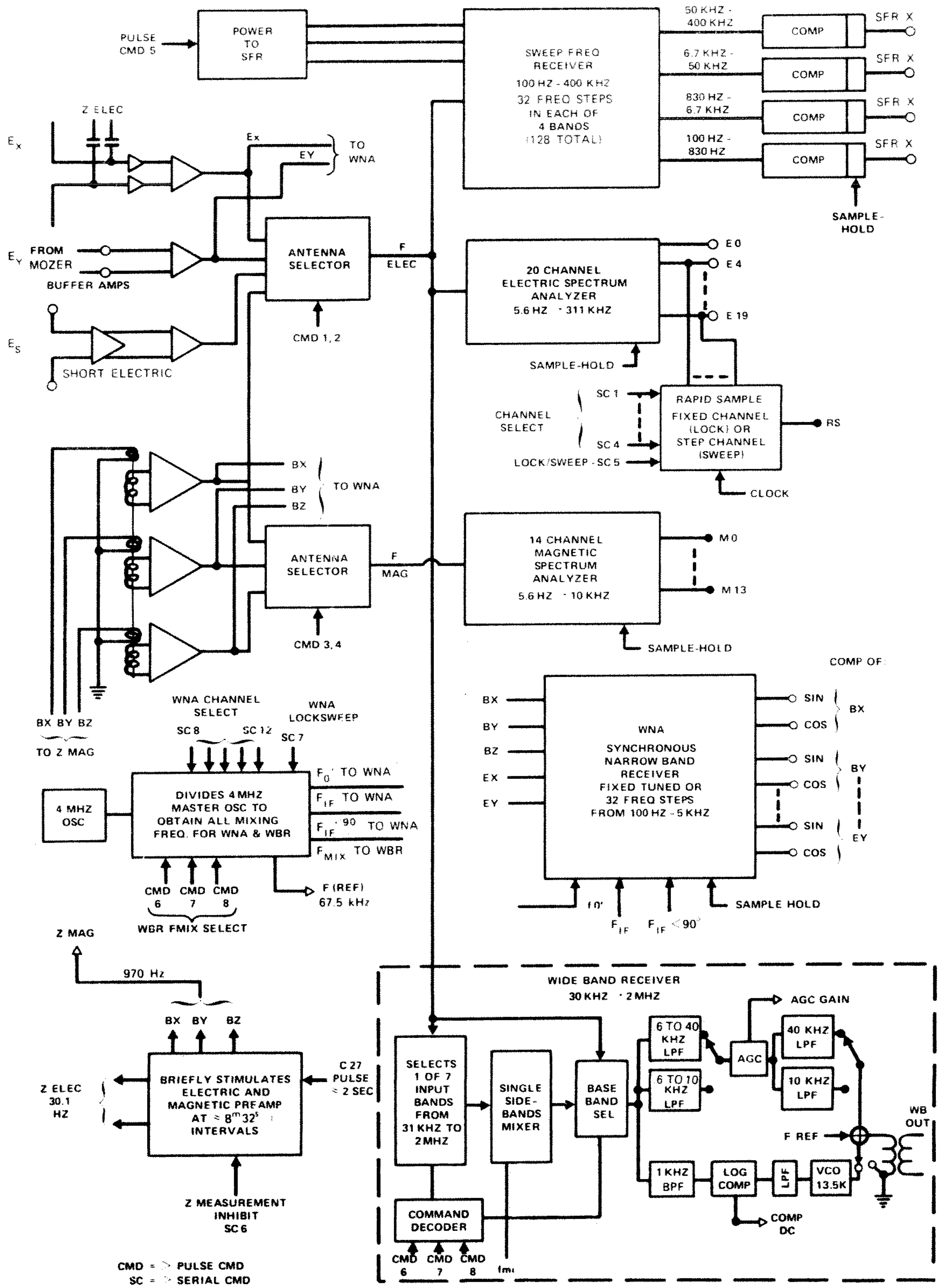
LOCATION IN THE SPACECRAFT TELEMETRY

Designation	Word No.	Minor Frame No.
E8	76	1, 5, 9 . . . 253 (every 4 minor frames)
M8	12	2, 6, 10 . . . 254 (every 4 minor frames)
DP1-DP4	79	11, 27, 43 . . . 251 (every 16 minor frames)

NOTE: All numbering conventions for frames, bits, etc. are per ISEE Project Document ISEE-730-75-603, Telemetry Formats and Telemetry List.

CODING OF WORD IN SPACECRAFT TELEMETRY

Designation	Coding
E8 and M8	8 bit binary word (256 level digital representation of 0-5 volt dc analog output signal)



Simplified Block Diagram, GUM - ISEE

Designation	Coding
DP1	Binary Bit 7 of word 79
DP2	Binary Bit 6 of word 79
DP3	Binary Bit 5 of word 79
DP4	Binary Bit 4 of word 79

CONVERSION SCIENTIFIC UNITS

The calibration of the spectrum analyzer filter channels is performed in two steps. The first step requires conversion of E8 and M8 into the equivalent rms differential voltage at the input of the experiment (the point at which the antenna is connected to the GUM experiment). This conversion is performed with a look-up table for each channel based on the instrument calibration. The actual numbers in these tables are subject to change following spacecraft level systems testing.

The second step of the conversion to scientific units requires the multiplication of the input voltage by a constant factor. This constant factor is different for each antenna. For the electric dipole antennas it is equal to the inverse of the product of the effective antenna length and the square root of the noise bandwidth of the filter channel. The antenna length may change as a function of time after launch. For the search coil antenna it is determined from the measured sensitivity of the search coil antenna divided by the square root of the noise bandwidth. Because there are six different antennas on ISEE A, the proper constant must be selected by monitoring DP1-DP4. These digital parameters identify the antenna that is connected to each spectrum analyzer. The following table shows the antenna configuration for each state of DP1-DP4.

DP1	DP2	E8 Antenna Configuration (Electric Spectrum Analyzer)
0	0	EX
1	0	EY
0	1	ES
1	1	BZ

DP3	DP4	M8 Antenna Configuration (Magnetic Spectrum Analyzer)
0	0	EX
1	0	BX
0	1	BY
1	1	BZ

In addition to the parameters given above, the encoder calibration voltages must be checked in order to verify that the 256 digitizing levels correspond to the proper 0-5 volt dc analog input to the encoder. If the encoder calibration changes with time, it may be necessary to change the look-up tables to compensate for changes in the encoder.

PRELIMINARY REMARKS

The conversion described here will give measurements of electric field spectral density in units of volts meters $Hz^{-1/2}$ and magnetic field spectral density in units of $gamma^2\ Hz^{-1}$. These calculations are made with the assumption that the effective electric antenna length is equal to one-half the tip-to-tip length for the long wire antenna and equal to the sphere separation for the spherical antennas. Corrections due to antenna impedance are not performed. For some types of wave phenomena these criteria may be violated, and, because the task of making such corrections is interpretive in nature, it is left to the user to supply these corrections if needed.

In addition, the spectral density calculations are performed with the assumption that the wave phenomena are of greater bandwidth than the bandwidth of the filter channels (±15%). For some types of wave phenomena this assumption will be invalid; however, it is not possible to make this determination in a routine fashion from the spectrum analyzer data.

ALGORITHM FOR THE DATA FLAG FROM THE HARVEY EXPERIMENT

The floating point word will be written on to the ISEE A data pool tape every 64 s, to indicate the activity of the HAM experiments during the corresponding 64 s block of data. The word is designated HASTAT in the data pool format.

DESCRIPTION OF WORD

This word will be the floating point conversion of an integer in the range

$$0 \leqslant N \leqslant 2^{10} - 1$$

The ten bits in this word will be split up into three groups, as follows:

$$b_9\ b_8 \qquad b_7\ b_6\ b_5\ b_4 \qquad b_3\ b_2\ b_1\ b_0$$

The two most significant bits are derived from the other eight bits, and have the following significance:

$b_9 = 0$ if the sounder transmitter has not been active at any time during the 64 s of data being processed

$b_9 = 1$ otherwise

$b_8 \rightarrow$ same thing for propagation experiment transmitter

The remaining eight bits are used to localize the transmission activity if either b_9 or b_8 are not zero.

$b_{4+i} = 0$ if the sounder has not been active at any time during the period $16\,i \leqslant t \leqslant 16\,(i+1)$ seconds, measured from the start of the 64 s interval

$= 1$ otherwise

$b_i \rightarrow$ same thing for propagation experiment transmitter

Thus b_9 and b_8 are given by

$b_9 = 1$ if $b_4 + b_5 + b_6 + b_7 > 0$

$= 0$ otherwise

$b_8 = 1$ if $b_0 + b_1 + b_2 + b_3 > 0$

$= 0$ otherwise

If ever this word cannot be evaluated owing (for example), to a telemetry drop-out, N will be assigned a negative value.

For many purposes the following simple tests will be adequate

if $N \leqslant 511$ the sounder transmitter has not been active

if $N \leqslant 255$ neither the sounder nor the propagation transmitters have been active

ALGORITHM TO EVALUATE WORD

The word is derived from the six-level HAM signal in step 39 of analog Subcom 1 (word 58). This word indicates, once per sequence of 64 minor frames, whether the sounder nor the propagation experiment has been active during the current sequence, as follows:

$V < 0.44$ HAM experiments OFF

$0.44 \leqslant V < 1.28$ Propagation OFF, sounder passive (receiver only)

$1.28 \leqslant V < 2.04$ Propagation ON, sounder OFF

$2.04 \leqslant V < 2.82$ Propagation ON, sounder passive

$2.82 \leqslant V < 4.01$ Propagation OFF, sounder active (receiver + transmitter)

$4.01 \leqslant V$ Propagation ON, sounder active

In low bit-rate each 64 minor frame sequence takes 16 s, and therefore can be used for determining b_i and b_{i+4} directly. In high bit-rate data compression by a factor of 4 is to be effected by "OR"ing the bits four at a time.

DESCRIPTION OF THE QUASI-STATIC ELECTRIC FIELD EXPERIMENT

SUMMARY

The description of the Quasi-DC Electric Field Experiment (MOM) on the ISEE A spacecraft is divided into two sections. The first, included here, describes the analog circuitry and gives an indication of the operation of the experiment. The second, given in the appendix to the MOM ERD, lists the capabilities of the digital control processor which performs all experiment control functions and interfaces with the ISEE A spacecraft. The references to Section 2 in the following description refer to the appendix of the MOM ERD. For a description of the ISEE A telemetry format and interface, refer to GSFC document number ISEE-733-74-001, "International Sun-Earth Explorer-A/C Electrical Interface Specification, Revision B," 20 March 1976.

I. Description of the Analog Circuitry

The MOM experiment is designed to measure dc and low frequency electric fields in the magnetosphere. This is accomplished by measuring the potential difference between two conducting spherical probes, each of which is connected to the S/C by about 40 meters of cable, and which are stabilized by centrifugal force. The surface of each sphere is connected to a high input impedance unity gain preamplifier which is inside the sphere, and this signal is transmitted to the MOM electronics package in the S/C. The preamplifier band width is about 200 kHz, and the differential signal dynamic range is ±16 volts. The two preamplifiers are operated from a common ±12 volt power supply, the common terminal of which is floating with respect to the experiment signal ground. The voltages on the spheres, which are called V_1 and V_2, are averaged and this signal is used to drive a unity gain amplifier which operates from a ±50 volt supply fixed with respect to the experiment ground, which drives the common terminal of the floating preamplifier supply. This circuit allows the common mode voltage of V_1 and V_2 to be plus or minus 50 volts with respect to the spacecraft. To reduce power consumption, the band width of the signal which drives the power supply is limited to 100 Hz. The effect of this is that the differential mode dynamic range of the preamplifiers is reduced as the slewing rate and amplitude of any common mode signal present is increased.

These voltages V_1 and V_2, referenced to the experiment signal ground (which is essentially the S/C skin potential), are each multiplied by 0.07115 and called V_{1S} and V_{2S} respectively. V_{1S} and V_{2S} are two of sixteen voltages in the MOM experiment which can be addressed by an analog multiplexer, digitized to 12 bit accuracy and transferred to the S/C telemetry system as digital data. This operation is under the control of the digital processor, and is described in Section 2.3. The overall block diagram of the MOM experiment is shown in Figure 1.1.

The sphere voltages V_1 and V_2 are connected to a high accuracy dc coupled differential amplifier with a gain of 0.3122, which is called V_{12L} and is another of the voltages which can be digitized and telemetered. V_{12L} is amplified by a factor of -50.11 to become V_{21H}. The output of the differential amplifier is also connected to the input of a 6 pole high pass filter which has its -3 dB point at 1.5 Hz. This filter greatly reduces the signal at the spin rate and so allows further

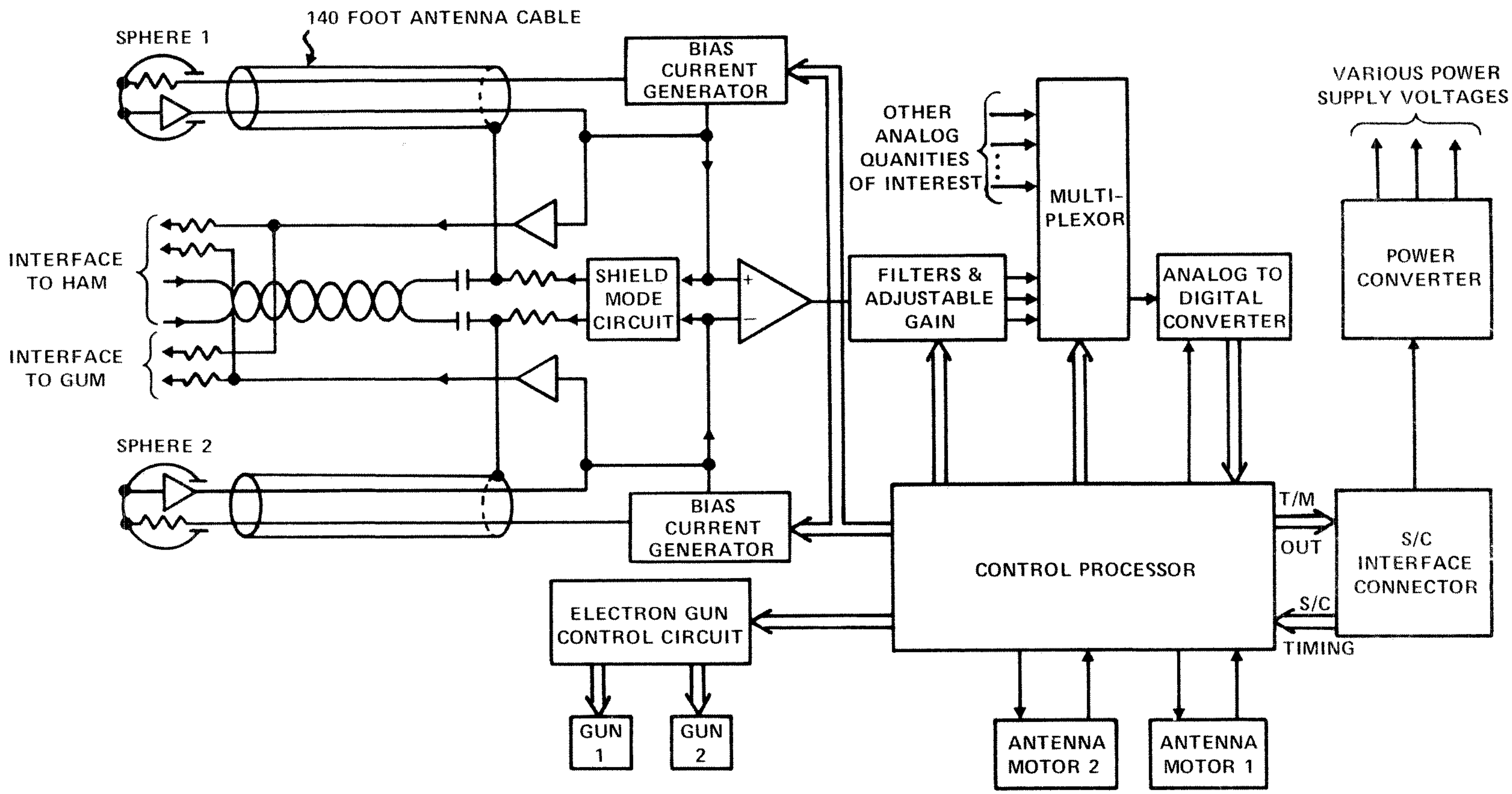


Figure 1.1. Block Diagram of the MOM Experiment

amplification of V_{21}. The filter has a fixed gain of 50 and its output is connected to the input of a bank of 3 bandpass filters with center frequencies at 6 Hz, 32 Hz, and 256 Hz. Each of these filters consists of a 2 pole bandpass function followed by a logarithmic amplifier, a full wave rectifier, and an integrator. The Q of the bandpass filters is 0.4. This value is chosen to make the overall response of the filter bank constant in the frequency range from 4 Hz to 256 Hz; i.e., the filter band widths are made sufficiently large that there is no loss of signals with frequencies between the center frequencies of the filters. The result of this is to provide for each of the 3 frequency ranges a voltage which is proportional to the logarithm of the power in that frequency range. These voltages are called V_{f1}, V_{f2}, and V_{f3}, which correspond to the 4, 32, and 256 Hz filters respectively. The output of the filter which suppresses the spin rate signal is also connected to an amplifier in which setting 2 latching relays selects one of 4 possible gains. These gains, referred to $V_{21} = V_2 - V_1$, are: 10, 80, 640, and 5120 to within a measuring accuracy of 3%. The output of this circuit is connected to an anti-aliasing filter, which is a 2 pole low pass 1 dB Chebychev, the upper 3 dB frequency of which is either 50 Hz or 800 Hz, depending on the setting of a latching delay. The output of this circuit is called V_{burst}. The V_{burst} circuit is used to collect short bursts of AC data in a manner which is described in Section 2.8.

The MOM antennas are also used by the AC experimenters, HAM and GUM, to detect AC electric fields. This is the reason that the preamplifier response extends to 200 kHz. The interface between MOM and HAM and GUM consists of a pair of LM110 voltage followers which are AC coupled to V_1 and V_2 with a 50 Hz roll-off. The output of each voltage follower is connected to a pair of 100 ohm resistors in a series with 0.068 microfarad capacitors, one of which drives a coaxial cable connected to the HAM experiment, and the other a coaxial cable connected to the GUM experiment.

The cable which supports the MOM spheres consists of a number of wires which supply various voltages to the preamplifier surrounded by a stainless steel braid which acts both as an electrically conducting outer shield, and as the mechanical member which supports the centrifugal force load of the probes. The outer shield is broken electrically at a connector which is one meter from the sensor sphere. The section closest to the sphere, which is called the guard section, is normally electrically connected to the preamplifier output so as to force its potential to be equal to that of the sphere and thus minimize the perturbing effect of the cable on the plasma. To guard against the possibility of oscillations being set up by this arrangement due to resonances in the plasma, it is possible to insert a low pass RC filter with 100 Hz roll-off between the preamplifier and the guard section, by actuating a ground command latching relay in the sphere. The remainder of the outer shield is shared by the MOM and HAM experiments. About 90% of the time it is controlled by the MOM experiment in a similar manner to that described above, but with some additional options which are described in Section 2.1. The remaining 10% of the time it is used as a transmitting antenna by the HAM active plasma experiment. The interface which accomplishes this sharing consists of the HAM sounder being connected to the shield through a 0.1 microfarad capacitor and the shield being connected to the MOM experiment through a resistance of 2 k ohms.

An important capability of the MOM experiment is that of putting a bias current on the sensor spheres. The impedance between the sphere and the plasma is a non-linear function of the current flowing between them and in fact exhibits a rather strong minimum for some optimum value of bias current which depends on the plasma conditions. Thus, the accuracy of the electric field measurement can be maximized by applying the optimum value of bias current to the sensor spheres. The analog circuitry which accomplishes this consists of an 8 bit DAC which floats with the preamplifier supply, connected to the appropriate amplifiers so as to produce a voltage which can vary from +36.00 volts to -35.78 volts, fixed with respect to the preamplifier output. This voltage is connected to the sensor sphere through a 2×10^8 ohm resistor which is inside the sphere. A ground commanded latching relay inside the sphere, in series with the resistor, gives the option of disabling this circuit. The DAC is driven by the digital control circuitry through a set of logic translators. Thus, the digital control circuitry can program a bias current to the spheres which ranges from $+1.8 \times 10^{-7}$ amperes to -1.79×10^{-7} amperes, in 256 linear steps. The value of the bias current can be either set by ground command, or set to an optimum value determined by the digital control circuitry using the algorithm described in Section 2.9.

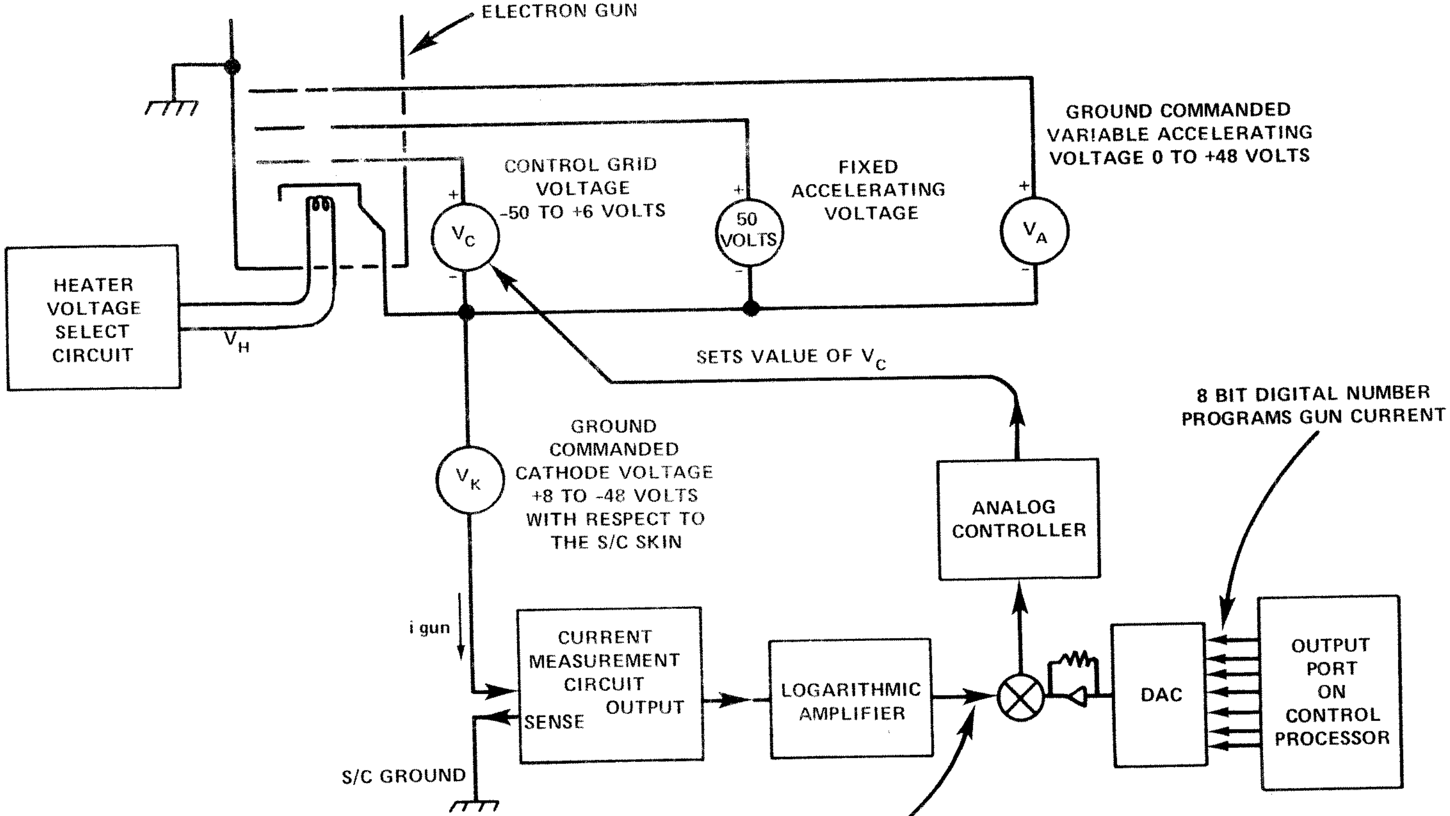
Two electron guns under the control of the MOM experiment are used to control the ISEE A S/C potential. This is desirable for two reasons. During plasma conditions in which the hot electron current exceeds the emission due to the photoelectric effect, the S/C will charge to large negative potentials, much exceeding the 50 volt common mode range of the preamplifiers, and thus preventing any electric field measurement entirely. The emission of a beam from the electron guns will raise the S/C potential, so that the guns may be used to maintain the S/C potential near the plasma potential. Even when the S/C floats positive or only slightly negative, the guns are useful because by raising the S/C potential, the asymmetric cloud of photoelectrons which exists in the vicinity of the S/C can be collapsed, and thus its effect in perturbing the electric field measurement minimized.

Figure 1.2 is a schematic representation of the electron gun and its associated control circuitry. There are four voltages which control the operation of the gun: V_H, V_K, V_A, and V_C. V_H, the heater voltage, can be set independently for each gun, to one of eight values (one of which is zero) which are selected by ground command and stored in the RAM. This allows compensation for reduced emission efficiency as the filaments age. The desired voltage is generated by setting 3 latching relays which select the appropriate tap on a special winding of the power converter transformer. When a gun is turned on (see Section 2.1 command 7) V_H is first set to the lowest value, then increased one step every 8 seconds until the value stored in the RAM is reached. This algorithm, which is performed by the digital control processor, is intended to minimize thermal stresses on the filament. The highest filament voltage is used to reactivate the emitting surface, should that be necessary after the satellite is in orbit.

V_K is the potential between the gun cathodes and the S/C skin. It is generated by amplifying the output voltage of a DAC which is driven by the control processor so as to obtain a voltage which can vary between +8 and -45 volts. V_A, a focusing voltage which defines the electron beam energy at the point where it emerges from the gun is similarly obtained, and can vary from 0 to +48 volts. The voltages V_K and V_A are the same for both guns, and are set to fixed values by ground command.

V_C is the control grid voltage which regulates the gun beam current. Values from -50 to +6 volts for V_C cause the gun current to vary between 0 and its maximum value. The gun current is regulated by a feedback control system with a logarithmic response such that an 8 bit digital input from the control processor programs a gun current which varies between 0.05 and 500 microamperes. The beam current may be set either to a fixed value determined by ground command, or to a value calculated by the control processor using the algorithm described in Section 2.9 which is intended to optimize the S/C potential.

A final analog circuit is used to give an indication of the S/C altitude. This is desirable because the algorithms described in Section 2 which automatically set the sphere bias currents, electron gun currents, shield voltages, and the AGC operation, must be modified at low altitudes where the particle densities, magnetic field, and S/C velocity become higher. The circuit consists of a bandpass filter with band width of 10% tuned to the spin frequency, the input of which is V_{12L}, followed by a full wave rectifier, and an integrator with a time constant of 30 seconds. The output of the integrator is called $V_{V \times B}$. The gain of the circuit is such that the dc voltage $V_{V \times B}$ is 0.505 times the amplitude of V_{21}. It is proportional to the average value of the magnitude of the electric field present. Since at low altitudes the largest contribution to this field is that due to the $\overline{V} \times \overline{B}$ term (the cross product of the S/C velocity with the local magnetic



i gun (μA)	LOG AMP OUTPUT (VOLTS)
500.0	0.0
50.0	1.0
5.0	2.0
0.5	3.0
0.05	4.0

Figure 1.2. Schematic Representation of Electron Gun and Associated Control Circuitry

field), and since both the S/C velocity and the magnetic field increase with decreasing altitude, the voltage $V_{V \times B}$ can be used to indicate when the S/C is at low altitudes. In addition to being used to turn off the electron guns, sphere bias currents, shield voltages, and modify the AGC algorithm at low altitudes, $V_{V \times B}$ is used at high altitude to offset the shield voltages with respect to their preamplifier outputs (see Section 2.1 command 11).

ALGORITHM FOR THE POOL DATA FROM THE MOZER EXPERIMENT

The status of the Mozer electron guns is given on the data pool tape every 64 seconds. This status word is designated MOSTAT in the data pool format, and is interpreted as follows:

MOSTAT = 0., if Mozer electron guns were OFF throughout the entire 64 seconds.

MOSTAT = 7., if Mozer electron guns were ON at any time during the 64 seconds.

MOSTAT < 0., if insufficient data.

At low bit rate, the Mozer indicator can only be computed once every 128 seconds. Since the data pool format provides for 64 second intervals regardless of bit rate, the Mozer indicators will each be written 2 times when in low bit rate.

The electron gun status is derived from the telemetry data as follows:

One or both electron guns are turned ON if the Goddard Project Relay is closed (it will normally be closed), and the following logical expression is true:

$$\overline{(B_{101} \wedge B_{94})} \wedge (B_{123} \vee B_{122} \vee B_{121} \vee B_{115} \vee B_{114} \vee B_{113})$$

Where $\wedge$ signifies a logical AND, and $\vee$ is a logical OR.

The description of the MOM digital subcommutator is contained in the document, "A Description of the Quasi-static Electric Field Experiment (MOM) for the ISEE A Satellite," which is included as Appendix I of the MOM ERD.

Principal Investigator: D. Hovestadt
Max Planck Institute

OBJECTIVES

To measure low energy charged particles in the earth's vicinity.

DESCRIPTION

The instrument, carried on the Mother spacecraft only, consists of two sensors and associated electronics:

- An Ultra Low Energy nuclear charge (Z), total energy (E), and ionic charge (Q) assembly (ULEZEQ); this sensor consists of two physically separated units.

- An Ultra Low Energy Wide Angle Telescope designated ULEWAT.

THE ULEZEQ SENSOR

Charged particles entering the large area (200 cm^2) collimators, are electrostatically deflected in four different deflection systems, with deflection voltages and spacings of the deflection plates to cover the energy range 3 keV/charge to 2 MeV/charge. The total energy of the particles is measured by 7 silicon detectors. The positions of the L and M detectors determine the particle deflection, while the deflection in the MP and H channels are measured by position sensitive solid state detectors. The deflection voltages are: -600 to 1800 V in 32 steps for the L, +3 kV for the M, +20 kV for the H, -12 kV and +3 kV for the MP section.

The L, MP and M detectors are backed by solid state detector anticoincidence detectors.

In a range from 200 keV/charge to 2 MeV/charge, a thin window proportional counter in front of a position-sensitive silicon detector serve as a dE/dx-E device for the additional determination of the nuclear charge of the deflected particles. This detector system is able, therefore, to determine simultaneously the nuclear charge (Z), the total energy (E), and the ionic charge (Q). The view direction of ULEZEQ is perpendicular to the spin axis with the long edge of the collimator along the spin axis.

THE ULEWAT SENSOR

Two position sensitive multiwire proportional counters pos 1 and pos 2 determine the geometrical factor of $\sim 1\ cm^2$ ster. Two proportional counters P_1 and P_2 for double dE/dx measurement are placed in between the multiwire counters. The residual energy of the incoming particles is determined with two solid state detectors D1 (200μ thick) and D2 (2000μ thick).

The detector assembly is surrounded by an anti-coincidence detector (A) and an array of proportional counters (AP). The entrance window of 120μ g polypropylene confines the isobutane gas in the proportional counters.

The ULEWAT will be mounted with its axis perpendicular to the satellite spin. The angular range out of the ecliptic plane is ±55 degrees and the resolution in elevation is ~ 5 degrees. The opening angle is azimuth of 20 degrees (half angle) is matched to the 22.5 degree angular resolution obtained from the 16 sector analysis.

THE GAS SYSTEM

All three proportional counters (P1 and P2 of ULEWAT and PC of ULEZEQ) use a gas supply system similar to the one now being used for the ULET telescope of the University of Maryland IMP-H/-J experiment.

The function of the gas system is to actively stabilize the gas density (isobutane) to within ±0.5 percent. (The operating gas pressure is 35 torr at 23°C.)

A small ionization chamber with a built-in Am^{241} -60μc source produces a current related to the gas density. This current is sensed by appropriate electronics and converted to signals controlling a low power thermal valve which transmits the gas from a tank containing about 100 g of liquefied isobutane to the proportional counters.

For redundancy, the ULEWAT counters and the PC counter of ULEZEQ will have separate gas control and valve systems.

DATA POOL QUANTITIES FROM THE HOVESTADT EXPERIMENT

The HOM experimenters will provide 5 rate channels for the data pool tape. All 5 rates are from the ULEWAT sensor of the HOM experiment. They are accumulated continuously over the S/C spin and will be included on the tape approximately every 15 minutes. The rates are coincidence rates and require up to 7 logic conditions. The detectors included in the event selection logic of each rate are listed in Column 3 of Table I. The response of all 5 rates in nuclear charge, energy and direction is summarized in Table I, and a schematic cross-section of the ULEWAT sensor is given in Figure 1.

The ~15 minutes averaging time corresponds to the 4096 bps bit rate of the S/C.

During high speed mode (16384 bps) the averaging time is ~15 min/4. For the proper use of the data some notes should be recognized.

(1) The ULEWAT sensor will be switched OFF inside the earth's magnetosphere. Therefore, there will be no data from the HOM experiment during these time periods on the data pool tape.

(2) It is possible to change the response of the sensor by ground command (in case of detector noise, etc.). If this will be the case an updated version of Table I will be provided for all who get the data pool tapes or plots from the project.

(3) The rates do not include dead time corrections. The proper corrections for rates $\gtrsim 5.10^4$ cts/sec will be provided later.

The rate ID's shown in Column 1 of Table I correspond to the data pool tape format as follows:

Rate ID	Pool Tape Designator
LP	PROLP
LA	ALFLA
MH	HEAVYS
HP1	PROHP1
HP2	PROHP2

Table I

Rate ID	Particle	Detectors**	Energy (MeV/Nucleon)	ϑ*	Geom. Factor (cm^2 ster)
LP	Proton	P1, P2, D1, D2, A, AP	0.17-0.4	~20°	~0.6
LA	Alpha	P1, P2, D1, D2, A, AP	0.12-0.25	~20°	~0.6
MH	$Z > 2$	P2, D1, D2, A, AP	>0.1	~20°	~0.6
HP1	Proton	D1, D2, A, AP	5-10	~60°	~2.0
HP2	Proton	D1, D2, A, AP	10-20	~60°	~2.0

*Full acceptance angle perpendicular to the ecliptic plane

**P1, P2 Proportional counters

AP Anticoincidence Proportional counter

D1, D2 Silicon surface barrier detectors

A Anticoincidence surface barrier detector

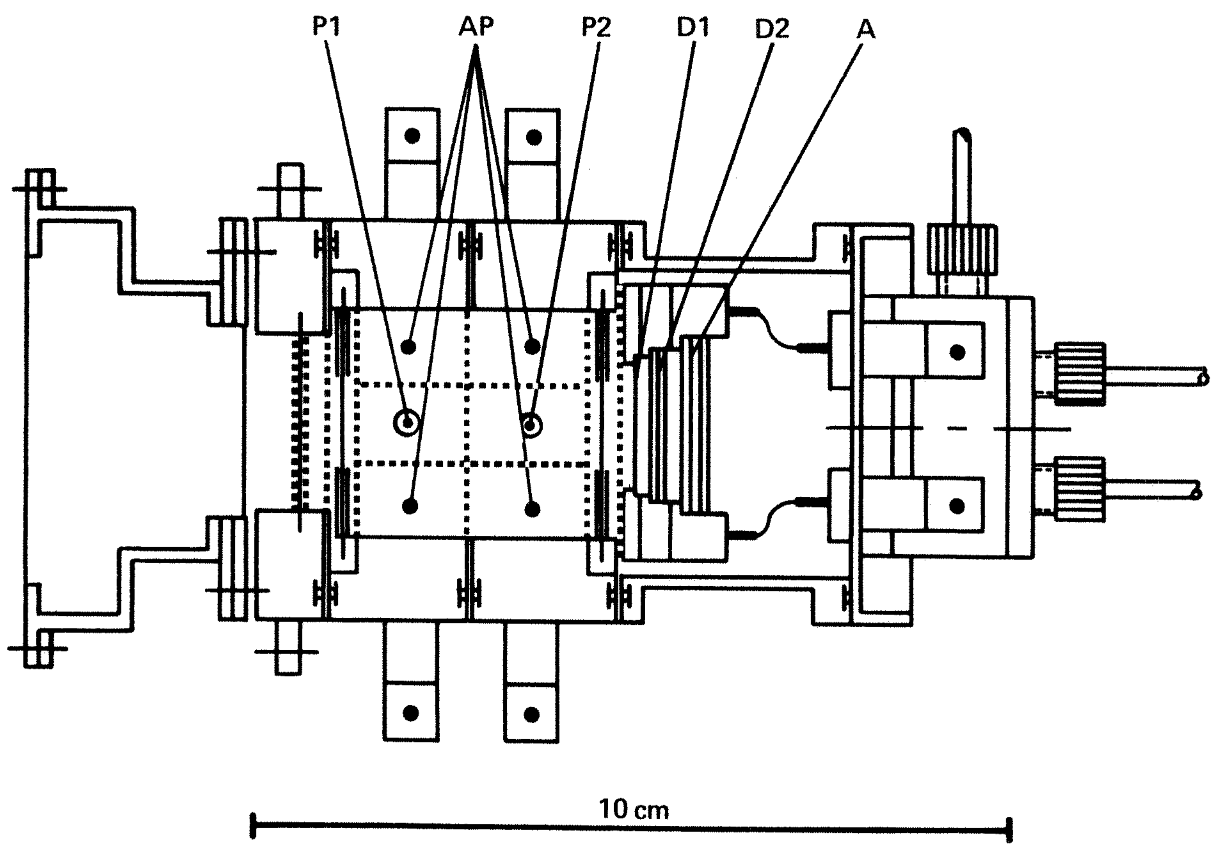


Figure 1. ULEWAT Sensor

ISEE FLUXGATE MAGNETOMETER INSTRUMENT

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The ISEE fluxgate magnetometers are designed to measure both the static and time-varying magnetic fields with identical instrumentation on both the Mother and Daughter spacecraft. Among the phenomena to be studied are: solar wind discontinuities, waves upstream from the bow shock, the structure of the bow shock, magnetosheath structure, the magnetopause, magnetospheric wave particle interactions, plasma sheet dynamics, and magnetospheric substorms. The measurements will be correlated both with spacecraft within the magnetosphere (e.g., GEOS) and without. The magnetometer is also a service instrument providing on-board magnetic sectoring to energetic particle experiments, pitch angle measurements and $\bar{V} \times \bar{B}$ measurements for the electric field experiment.

Three Naval Ordnance Laboratory ring core sensors in an orthogonal triad are enclosed in a flipper mechanism at the end of the magnetometer boom, with the main electronics unit on the main body of the spacecraft at the foot of the boom. The basic magnetometers are capable of measuring fields in two commandable ranges of $\pm 8192\ \gamma$ and $\pm 256\ \gamma$ to an accuracy of 0.025% (equivalent to one part in 2^{13}). The data are digitized within the instrument by a 12-bit analog to digital converter which is accurate to one-quarter of the least significant bit. The analog data from each magnetometer axis is continuously sampled at the rate of 512 times per second and averaged in a digital averaging circuit by adding and right shifting to obtain samples which are accurately averaged to 16-bits for read-out. The 16-bit read-out reduces quantization noise to insignificant values even in the quietest fields.

Averaging is also a filtering function. Thus, the rate at which data is shifted out of the averaging register automatically controls the effective filtering to restrict the bandwidth of the data and reduce aliasing. Six averaging registers, two for each axis, are used to provide overlapped averages which results in the averaging filter having an exact zero at the Nyquist frequency for all modes and data rates. In fact the transfer function of all three sensors is identical for all modes, ranges and data rates when referenced to the Nyquist filter.

The data system has two modes, termed double precision and single precision. In the double precision mode the entire 16-bits are transferred from the output buffer to the spacecraft in two successive 8-bit words resulting in sample rates of 4 and 16 samples per second at the low and high telemetry rates respectively. In the single precision mode any 8 adjacent bits of the averaging register may be selected for transmission. This gives a sample rate twice as fast as the double precision rate.

ALGORITHM FOR PROCESSING THE POOL DATA FROM THE RUSSELL EXPERIMENT

INTRODUCTION

This algorithm produces a vector measure of the magnetic field at a rate of 1 sample every 64 seconds, in spacecraft coordinates, from the output of the Mother (ISEE A) fluxgate magnetometer. Vector components are designated Bp, Bx, and By in the data pool format. In addition a number of quantities useful in the interpretation of the data are produced with one hour sample periods.

TECHNIQUE

The raw telemetry is decoded to form four times every second one 3 component vector with either 16 or 8 bits per component if the instrument is in double precision or single precision modes, respectively. The output from each of the three sensors are averaged and multiplied by sine and cosine ωt where $\omega = 2\pi /$ spin period and averaged over 64 seconds. The sine and cosine weighted output from the fixed sensor in the spin plane (sensor 1) is used to measure the two components of the magnetic field in the spin plane. Comparison of the sine and cosine weighted outputs of the other two sensors with the former output tells which of the other two sensors is along the spin axis. The average field along the spin axis gives the third component of the field.

Hourly Quantities

1. A_1 — Average field of sensor 1
2. R_{21} — Ratio of amplitude of signal at spin frequency on sensor 2 to the amplitude on sensor 1.
3. R_{31} — Ratio of amplitude of signal at spin frequency on sensor 3 to the amplitude on sensor 1.
4. S_{21} — Sine of phase angle between sensor 2 and sensor 1.
5. C_{21} — Cosine of phase angle between sensor 2 and sensor 1.
6. S_{31} — Sine of phase angle between sensor 3 and sensor 1.
7. C_{31} — Cosine of phase angle between sensor 3 and sensor 1.

8. A_{IA} Average field along spin axis.

9. T_1 Electronics Temperature

10. T_2 Sensor Temperature

11. FS Flipper state. 0 = flip right entire hour, 56 = flip left entire hour. Intermediate values between 1 and 55 indicate flip has occurred part way through hour.

12. AS Experiment analog status word.

13. AP Flipper power on.

14. MD-SD Mag delay minus sun delay.

15. SP Sun period

16. MP Mag period

17. SE Sun elevation

18. DS Digital status word, first sample of hour.

19. T Spin period assumed in analysis.

20. O_1 Sensor 1 offsets assumed.

21. O_2 Sensor 2 offsets assumed.

22. O_3 Sensor 3 offsets assumed.

23. RS_1 Sensor 1 scale factors assumed.

24. RS_2 Sensor 2 scale factors assumed.

25. RS_3 Sensor 3 scale factors assumed.

III. Experiment/Instrument Description - Sharp

A. Brief Description

A major outstanding problem in magnetospheric physics is the determination of the source, transport and energization of the magnetospheric plasma. For example, the recent discovery of 0^+ ions with energies in the keV range has shown that the ionosphere as well as the solar wind is a significant source of energetic magnetospheric plasma. The energetic ion mass spectrometer is a high-sensitivity (10^{-2} cm^2-ster) high-resolution analyzer designed to measure the ionic composition over the mass-per-unit-charge region from 1 to 138 AMU in the energy-per-unit-charge range from zero to 17 keV. A schematic diagram of one of the spectrometers is shown in Figure 1. It consists of an entrance collimation section, a retarding potential analyzer, a curved-plate electrostatic energy analyzer and a set of energy analyzer detectors followed by a combined electrostatic-magnetic mass analyzer system with associated detector. The experiment consists of two complete spectrometers which are referred to throughout this document as Sensor A and Sensor B. The two sensors are required outside the magnetosphere to provide adequate elevation angle coverage. Inside the magnetosphere it is planned to devote one sensor to measurements of the cold plasma.

The spectrometers have 2 basic modes of ion energy analysis. After passing through the retarding potential analyzer (RPA), all ions are accelerated by a 3-kV potential before entering the curved plate electrostatic analyzer (ESA) section. In the cold plasma mode of operation, the RPA potential is programmable to any one of 32 values covering the range between 0 and approximately 100 volts. In this mode, the ESA plate potentials are set to transmit the ions with energies between 3.0 keV and about 3.15 keV so that the combination of the RPA and ESA pass ions whose energies prior to the acceleration section were between the RPA setting and 150 eV per unit charge. In the normal mode of operation, the RPA voltage is fixed and the ESA plate potential is controllable in 32 steps. Depending on the RPA setting, this covers the range from the RPA level to the maximum energy.

For each energy setting, the total mass range of the spectrometer, from less than one AMU to greater than 138 AMU is covered in 64 steps on the mass analyzer plate voltages. Thus, the entire mass energy range of the instrument includes 4096 combinations of voltages. Because large sections of the mass range are expected to be void of measurable fluxes much of the time and relatively coarse energy resolution is adequate for many studies, it is desirable to have the capability of wide latitude in selecting the sub-set of these 4096 possibilities to be covered during any given period. To accomplish this, each sensor is controlled by a command reprogrammable 1024 x 6-bit random access memory which permits nearly random selection of the mass-energy combinations to be covered. This memory can be programmed for optimum coverage in each region of the environment covered during each orbit.

ALGORITHM FOR PROCESSING THE POOL DATA FROM THE PLASMA COMPOSITION EXPERIMENT

The total cold plasma ion density will be derived from the Lockheed Plasma Composition Experiment while the instrument is operating in a retarding potential analyzer/ion mass spectrometer mode. In general, at least one of the two sensor heads of the instrument will be operating in this mode within the earth's magnetosphere. Specifically, operation in this mode will begin in the vicinity of the magnetopause inbound and will continue through instrument saturation at the high density levels of the inner plasmasphere. After perigee the instrument will be again turned on for measurement of cold ion density from the inner plasmasphere across the plasma trough to the vicinity of the magnetopause outbound.

The analysis routine begins with the data sorting required to identify and select points taken in the direction of maximum flow and following this, makes a determination of the relation between this maximum flow direction and the spacecraft velocity vector. A detected difference between these two directions will be assumed to be due to the presence of a significant bulk flow in the plasma.

The program then solves for density in the expression

$$\text{Particle Count Rate} = F(T)\, N\, V_S \cos\theta$$

where

$F(T)$ is a temperature dependent geometric factor describing the fraction of ambient ions which reach the detector

θ is the angle between the instrument normal direction and the direction of the maximum flow

T is the ion temperature

N is the ambient odd ion density (ions/cm^3)

V_S is the velocity of incoming flow (taken to be the satellite velocity)

The above analysis applies only to the routine "quick-look" calculations in the data pool tape. This analysis is subject to uncertainties introduced by bulk motion of the plasma relative to the spacecraft, spacecraft charging and particle focusing effects caused by the spacecraft sheath in regions of large Debye length (of the order of one meter or more). All of these uncertainties will be addressed in the more detailed analysis which will be carried out using the full information from the experiment's operation. The necessary inflexibility and automatic nature of the "quick-look" analysis does not allow these more involved portions of the analysis to be accomplished.

To aid in the interpretation of the simplified data pool density, two flags based on intermediate calculations within the analysis routine will be provided along with the density calculation. These will be set on indications of high ion temperatures and on an indication of the presence of bulk flow in the cold plasma.

Specifically, the temperature flag will be set when estimates indicate the assumption of short Debye lengths is violated and the bulk flow flag will be set when the angle between the spacecraft velocity vector and the estimated direction of maximum flow becomes sufficiently large to violate the assumption that the plasma ram velocity is equal to the spacecraft velocity.

In summary three quantities are provided - a number proportional to the cold plasma density ($E < 150\,eV$), a flag indicating a deviation from cold ion temperatures and an angle which indicates the presence of bulk flow in the cold plasma. These three quantities have been designated PLADEN, PLATEM, and PLANGL, respectively, in the data pool format.

III. Experiment Description - Williams-Keppler

A. Brief Description

The major scientific objectives of this experiment are to identify and study plasma instabilities responsible for acceleration, source, and loss mechanisms and boundary and interface phenomena throughout the orbital range of the Mother-Daughter pair. This includes studies of geomagnetic storms, substorms, and aurora along with magnetopause, magnetosheath, bow shock, and near-earth interplanetary phenomena. The use of two satellites is required for this initial attempt to uniquely separate spatial and temporal variations. Mother-Daughter observations over the planned separation distances of 100 to 5,000 km will allow not only the determination of spatial gradients but also the propagation velocity of these gradients as well as any differences of particle behavior across surfaces such as the magnetopause or interplanetary shocks. Measurements of the azimuthal asymmetry in the pitch angle distribution over the energy range stated above afford a unique determination of spatial gradients traveling with high velocities even for spacecraft separations of 100 km.

These objectives will be accomplished by flying solid state detector systems on both the Mother and Daughter spacecraft to measure detailed energy spectra and angular distributions of protons in the energy range 20 keV to 2 MeV and electrons in the energy range 20 keV to 1 MeV. In addition to the above, the Mother's instrument contains a solid state time-of-flight detector system to measure the energy spectra and pitch angle distributions of alpha particles and heavy ions in the energy range above 150 keV per nucleon. The NOAA Space Environment Laboratory is responsible for Mother instrument hardware and integration, and the Max-Planck Institute for Aeronomy is responsible for Daughter instrument hardware and integration.

Particle identification is accomplished through combinations of magnetic analysis, threshold discrimination and dE/dx by E coincidence techniques. Energy analysis is provided by the detector-preamplifier combination and associated electronics. Angular analysis is provided by a combination of satellite spin and a scan platform on the Mother spacecraft and a combination of satellite spin and various detector orientations on the Daughter spacecraft.

The basic instrumentation consists of three separate analyzing configurations of solid state detectors: (1) the proton telescope, (2) the electron spectrometer, and (3) the heavy ion telescope. The proton telescope and the electron spectrometer are mounted in the same physical structure and take advantage of a single magnet assembly.

ALGORITHM FOR PROCESSING THE POOL DATA FROM THE WILLIAMS-KEPPLER EXPERIMENT

A. EXPERIMENT DESCRIPTION

The contribution of the Medium Energy Particles Experiment (WIM) to the data pool tape will consist of data derived from the electron/proton spectrometer on the Mother spacecraft only and will exclude data from other parts of this experiment. The experiment observes particles in the energy domain essentially from 20 keV to 1 MeV for electrons and 20 keV to 2.0 MeV for protons. The "proton" sensor is actually sensitive to all positive ions with the same or slightly higher energy indicated by the passband. The use of the word "proton" implies the expected major response but this may not be true at all times or in all regions of the magnetosphere.

The WIM data to be written on the data pool tape, however, will be particle flux observations from two energy bands, nominally 32-50 keV and 80-126 keV for both the electrons and protons. The energy passbands and absolute intensity for these channels will remain unchanged in either high or low bit rate operation (although the details of data handling will be somewhat different for the two bit rates). The above energy ranges are nominal and the exact values will be available after the sensor calibration. In the data pool format, the low range measurements are designated ELOW and PLOW, while the high range measurements are designated EHIGH and PHIGH.

The primary purpose of this experiment is to investigate the energy spectra and pitch angle distributions of electrons and protons in the energy ranges noted above. To accomplish this objective the electron spectrometer and the proton telescope are integrated into a single instrument which is mounted on a scan platform and uses magnetic focusing to separate the two species onto their respective detectors. A three-dimensional distribution function is obtained by scanning the platform and attached instruments in a plane containing the spacecraft's spin axis as the spacecraft spins at a nominal rate of 20 rpm about an axis that is nominally aligned with the ecliptic polar axis. The data are further sectored at either eight or sixteen sectors/spin depending on the current telemetry bit rate. Scanning may be carried out in an automatic mode in which one full cycle (up and down) is accomplished in 24 spins, or a manual mode in which the scan platform may be commanded to one of 14 discrete positions in 11.5° steps with respect to the spacecraft spin (Z) axis. The scan limits the telescope principal axis to 10° from the ±Z axis. A calibration position (15) is located 15° from the Z axis on the inboard side of the spacecraft.

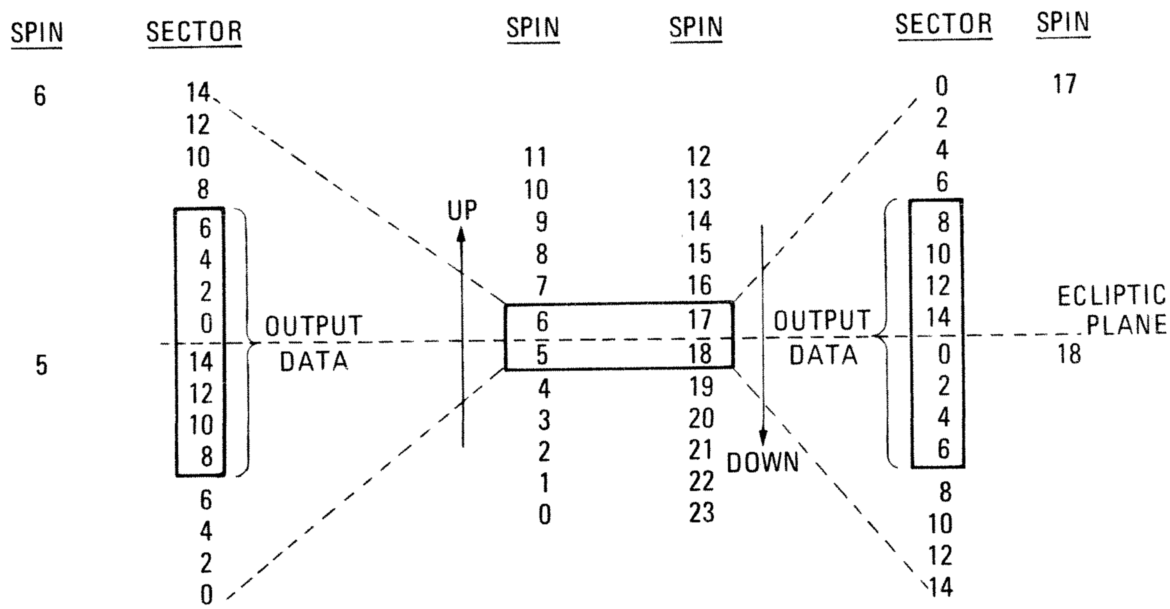
The routine experiment data are accumulated using the "623-C", 19 bit to eight bit floating point processor/accumulator hybrid. The measured data consists of read-outs of particle counts/energy range/scan position/sector. The particle counts that are recorded span the range one to 507,900 for the sensed number of physical events that occur within a counting period.

The data that will appear on the data pool tape, however, will be formatted as particles/(cm^2 sec steradian keV) and will be averaged over all ecliptic longitudes for a limited interval near the ecliptic plane. It will be necessary, therefore, to extract only those data observed in or near the spin-normal plane (nominally the ecliptic), and to average these data over all complete spins, taken one spin at a time for each five-minute period. After the data have been extracted as "counts/second" for the specified energy channel, a constant multiplicative factor on the order of 1.5 to 60 will be used to convert the data to obtain the above required dimensions. Negative values indicates that proper data are not available which meet the conditions for that portion of data pool tape.

B. DETAILED MEASUREMENT PROCESSING

Data are collected spin synchronously. One full cycle of the scan platform is 24 spins which are numbered zero through 23. One full spin contains eight sectors, numbered zero through 14 by two's in the low data rate, or 16 sectors, numbered zero through 15 in the high data rate. This information is registered in the WIM telemetry and is used to identify the appropriate data pertinent to the data pool tape.

Since data pool tape measurements are to be centered on the spin-normal plane for one complete spin, data collection in the low data rate will commence with sector eight of spin five and end with sector six of spin six on the up-scan. Similarly, data collection will begin with sector eight of spin 17 and with sector six of spin 18 on the down-scan. These operations are demonstrated schematically in the following frame for the low data rate.



In the high data rate the starting sector is eight in spins five and 17 and the last sector is seven in spins six and 18.

As long as the spacecraft spin axis is maintained perpendicular to the ecliptic plane, the sample recorded for the data pool tape is within ±12° of the ecliptic. The sensor has a conical field-of-view with a 5° half angle; therefore, all WIM data samples on the tape will represent particles incident on the detectors within ±17° of the ecliptic plane.

Since each spacecraft spin takes about three seconds, one full scan cycle will take 72 seconds. In the five-minute data pool period approximately eight spins in the nominal ecliptic plane will be averaged to obtain one data point/energy band/particle species. If the data pool period happens to begin or end with an incompleted spin, meeting the other geometric conditions (i.e. in the ecliptic plane), that data will not be accepted for the data pool tape.

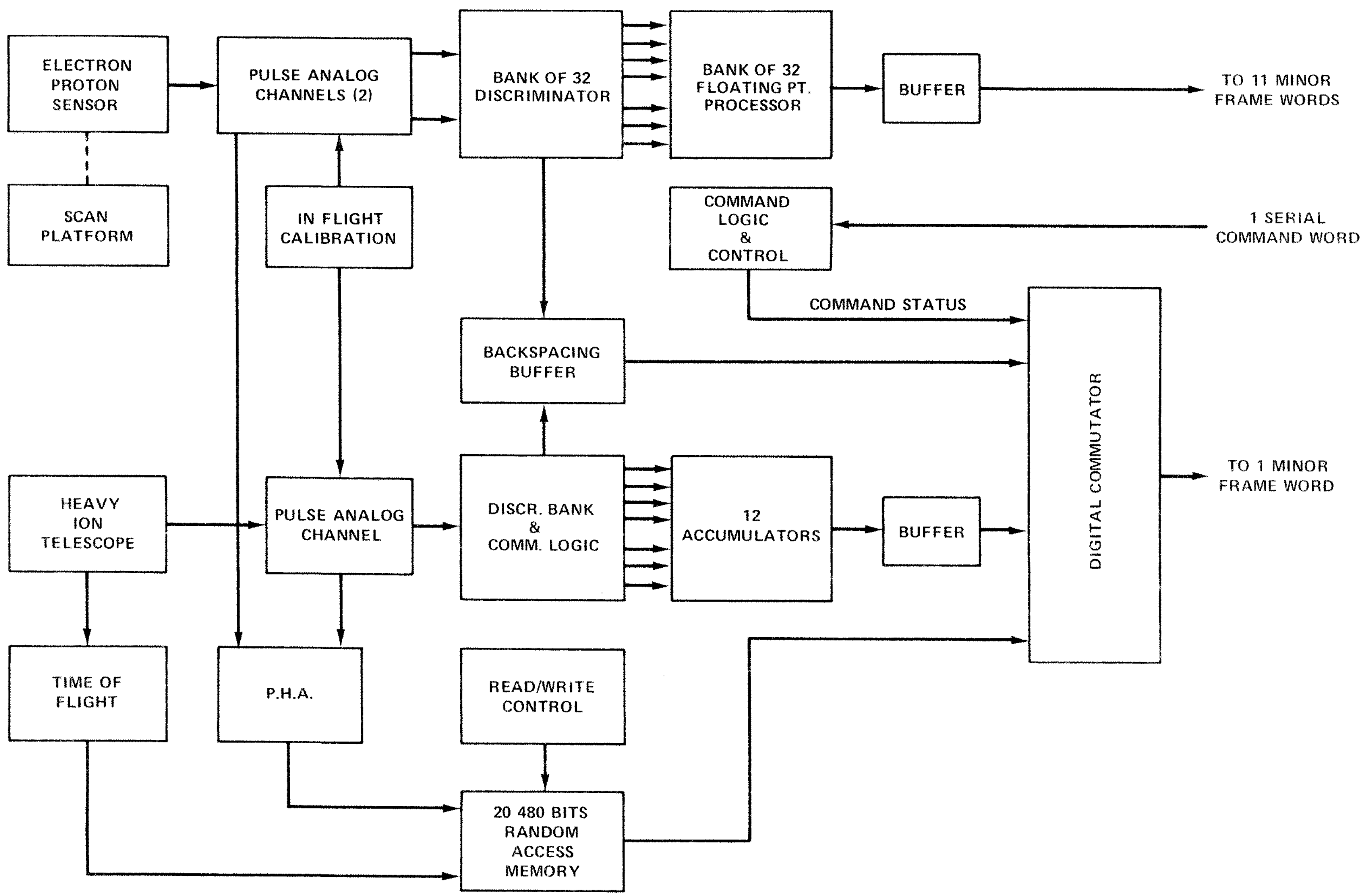
If the scan platform is in the manual mode, the data is acceptable for the data pool tape for certain discrete scan positions that correspond roughly with the ecliptic. Position number seven is nominally in the ecliptic; however, position numbers six and eight are also acceptable. The scan position is monitored at all times and is used in the generation of data pool information.

The electron/proton spectrometer normally operates with both the electron and proton detectors activated. However, it is possible for one or the other particle detectors to be turned off in which case those data cells will be filled with negative fill code, signifying that the data is unavailable.

The experiment may experience certain calibration periods, either in an automatic or a commanded mode. The automatic calibration occurs about every 17 hours, during which period the data pool tape input is a negative number set. Moreover, the commanded mode calibrations may not be automatically deleted by the algorithm and may contaminate the experiment output for about ten minutes. At present commanded calibrations are not part of any normal operation sequence and will be used only when the experimenter is examining the experiment progress using the real time data display. Unless serious problems are detected, the commanded calibration will probably be invoked on less than four days a year. On these occasions, however, several commanded calibrations may be required for which the appropriate records will be maintained.

In addition to the normal operational modes and the other qualifications as noted, the users of the data pool tape are cautioned that electronic noise associated with solid-state experiments is very dependent on the sensor temperature and the amount of radiation damage incurred by the detectors. As the ISEE mission enters its second year the data from both or either of the lowest energy channels (electrons and protons) could become badly contaminated by noise. The same is also true if the sensor operating temperature exceeds its design specifications.

If any uncertainty concerning these matters should arise, please contact the experimenter or his authorized representatives.



Block Diagram

Table III-A-1. Energy Passbands

	Protons		Electrons	
	Passband	Range	Passband	Range
Spin Sectored (8 or 16)	Δ P1	18-25 keV	Δ E1	18-25 keV
	Δ P2	25-32	Δ E2	25-32
	Δ P3	32-40	Δ E3	32-40
	Δ P4	40-50	Δ E4	40-50
	Δ P5	50-63	Δ E5	50-63
	Δ P6	63-80	Δ E6	63-80
	Δ P7	80-100	Δ E7	80-100
	Δ P8	100-126	Δ E8	100-126
	Δ P9	126-159	Δ E9	126-159
	Δ P10	159-201	Δ E10	159-201
	Δ P11	201-253	Δ E11	201-253
	Δ P12	253-318	Δ E12	253-318
	Δ P13	318-504	Δ E13	318-400
	Δ P14	504-800	Δ E14	400-504
	Δ P15	800-1270	Δ E15	504-635
	Δ P16	1270-2000	Δ E16	635-800
12 Scan Sectored 128 Channel PHAs	18-200 keV		18-80 keV	
	18-500 keV		18-400 keV	
	500-1000 keV		400-800 keV	
	1.0-1.5 MeV			
	1.5-2.0 MeV			

	Alpha and Heavier Nuclei		
	Passband	Particle Energy	Elemental Sensitivity
36 Sec Average (In Low Data Rate)	Δ α 1	500-900 keV	Z ⩾ 2
	Δ α 2	0.9-1.25 MeV	Z ⩾ 2
	He	1.4-6.0 MeV	Z = 2
	L1	1.25-4.0 MeV	Z ⩾ 6
	M1	4.0-7.0 MeV	Z ⩾ 6
	C	4.5-46 MeV	Z = 6
	A5	> 7.0 MeV	Z ⩾ 9
	0	6.0-47 MeV	Z = 8
8/Spin Sectored	Δ α 1	500-900 keV	Z ⩾ 2
	Δ α 2	0.9-1.05 MeV	Z ⩾ 2
Multiparameter Analysis 2.7 or 10.8 Minute Average	Each Event: (1) Δ E (front el., 4.7 μ): 500 keV-8 MeV; (2) E (second el., 150 μ): 225 keV-40 MeV; (3) TOF (10 cm): 2-200 ns; (4) Mass or E_T: 3-18 AMU or 1-50 MeV; (5) ID ($\propto M^gZ$, M = Mass, Z = Charge, $0 < g < 1$); Not dependent on incident ion energy. ID distribution displayed in 64 channel PHA. Mass or E_T distributions are displayed in seven 64 channel PHAs for seven selected ID values. (16 possible sets of seven, by command.)		
	Rare Events: Δ E, E, TOF, ID stored for each of two events.		

M/D Medium Energy Particles: Instrumentation Summary

Item	Mother Instrument	Daughter Instrument
Weight	Exp. 3.2 kg DPU 2.7 kg 5.9 kg (Exclusive of Scan Platform)	3.8 kg
Power	Exp. 3.0 W DPU 5.5 W 8.5 W (Exclusive of Scan Platform)	4.5 W
Bit Rate	384; 1536 (12 words)	224; 896 (14 words)
Energy:		
Range P	20 keV–2 MeV	20 keV–2 MeV
Range E	20 keV–1 MeV	20 keV–250 keV (to 1 MeV for 90° unit)
Resolution P	~50%; 25%; 10%–1% (PHA)	~30%
Resolution E	~25%; 15%; 10%–1% (PHA)	~20%
Angular Resolution	Continuous sweep along spin axis, $\bar{s}$ 8 sectors around $\bar{s}$; 16 sectors around $\bar{s}$	4 directions with respect to $\bar{s}$ 4 sectors around $\bar{s}$; 16 sectors around $\bar{s}$
Time Resolution P and E	Complete Energy Sample: one direction 0.75 sec; 0.19 sec two dimensions 3.0 sec; 3.0 sec three dimensions 36 sec; 36 sec	Complete Energy Sample: one direction 9 sec; 0.75 sec; 3 sec; 0.19 sec two dimensions 9 sec; 0.75 sec; 3 sec; 0.19 sec three dimensions 36 sec; 3.0 sec; 12 sec; 3.0 sec
Geometric Factor	$\leqslant 10^{-2}$ cm^2 ster	$\leqslant 5\ (10)^{-2}$ cm^2 ster
Thermal:		
Operate	-40°–+30°C	-40°–+30°C
Preferred	-30°–0°C	-30°–0°C
Storage	-60°–+60°C (+40°C for detectors)	-60°–+60°C (+40°C for detectors)

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