

Data Set Catalog # 180

Explorer 34 IMP-F,
Merged Plasma 67-051A-08B
Magnetic Field 67-051A-11A

} 13 tapes

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1. INTRODUCTION:

The documentation for this data set was originally on paper, kept in NSSDC's Data Set Catalogs (DSCs). The paper documentation in the Data Set Catalogs have been made into digital images, and then collected into a single PDF file for each Data Set Catalog. The inventory information in these DSCs is current as of July 1, 2004. This inventory information is now no longer maintained in the DSCs, but is now managed in the inventory part of the NSSDC information system. The information existing in the DSCs is now not needed for locating the data files, but we did not remove that inventory information.

The offline tape datasets have now been migrated from the original magnetic tape to Archival Information Packages (AIP's).

A prior restoration may have been done on data sets, if a requestor of this data set has questions; they should send an inquiry to the request office to see if additional information exists.

2. ERRATA/CHANGE LOG:

NOTE: Changes are made in a text box, and will show up that way when displayed on screen with a PDF reader.

When printing, special settings may be required to make the text box appear on the printed output.

Version	Date	Person	Page	Description of Change
01				
02				

3 LINKS TO RELEVANT INFORMATION IN THE ONLINE NSSDC
INFORMATION SYSTEM:

<http://nssdc.gsfc.nasa.gov/nmc/>

[NOTE: This link will take you to the main page of the NSSDC Master Catalog. There you will be able to perform searches to find additional information]

4. CATALOG MATERIALS:

- a. Associated Documents To find associated documents you will need to know the document ID number and then click here.
<http://nssdcftp.gsfc.nasa.gov/miscellaneous/documents/>

- b. Core Catalog Materials

IMP-F

3 MIN. PLASMA PARAMETERS

20 SEC. MAG FLD VECTORS

67-051A-08B

67-051A-11A

THESE DATA SETS HAVE BEEN RESTORED. ORIGINALLY THERE WERE 13 9-TRACK, 800 BPI TAPES. SIX OF THESE TAPES ARE DATA SET 67-051A-08B AND DATA SET 67-051A-11A IS CONTAINED ON ALL 13 TAPES. THERE ARE TWO RESTORED TAPES. THE DR TAPES ARE 3480 CARTRIDGES AND THE DS TAPES ARE 9-TRACK, 6250 BPI. THE ORIGINAL TAPES WERE CREATED ON AN IBM 360 COMPUTER. THE DR AND DS NUMBERS ALONG WITH THE CORRESPONDING D NUMBERS AND TIME SPANS ARE AS FOLLOWS:

DR#	DS#	D#	FILES	TIME SPAN	DATA SET	
DR000960	DS000960	D009980	1	05/24/67 - 07/06/67	08B & 11A	(a)
		D009981	2	07/06/67 - 08/19/67	08B & 11A	
		D009982	3	08/19/67 - 10/01/67	08B & 11A	
		D009983	4	11/13/67 - 12/26/67	08B & 11A	(b)
		D009984	5	10/01/67 - 11/13/67	08B & 11A	
		D009985	6	12/27/67 - 02/08/68	08B & 11A	
		D009986	7	02/08/68 - 03/22/68	11A	
		D009987	8	03/22/68 - 05/04/68	11A	
DR000961	DS000961	D009988	1	05/04/68 - 06/16/68	11A	
		D009989	2	06/17/68 - 07/30/68	11A	
		D009990	3	07/30/68 - 09/11/68	11A	(c)
		D009991	4	09/11/68 - 10/24/68	11A	(d)
		D009992	5	10/25/68 - 12/07/68	11A	

(a) D009980 - 1 error, record 1, File 1

(b) D009983 - 1 error, record 12, File 1

(c) D009990 - 1 error, record 2, File 1

(d) D009991 - 1 error, record 129, File 1

67-051A-08B & 11A

EXPLORER 34 IMP-F

This data set consists of thirteen (13), 9 track, 800 BPI, Binary magnetic tapes made on the IBM/360. Each tape has one file and contains about 10 orbits per reel. See following sheet for data format information.

<u>D#</u>	<u>C#</u>	<u>START</u>	<u>STOP</u>	<u>DATA SET</u>
D-09980	C-07244	May 24, 1967	July 6, 1967	8B & 11A
D-09981	C-07245	July 6, 1967	August 19, 1967	8B & 11A
D-09982	C-07246	August 19, 1967	October 1, 1967	8B & 11A
D-09983	C-07247	November 13, 1967	December 26, 1967	8B & 11A
D-09984	C-07248	October 1, 1967	November 13, 1967	8B & 11A
D-09985	C-07249	December 27, 1967	February 8, 1968	8B & 11A
D-09986	C-07250	February 8, 1968	March 22, 1968	11A
D-09987	C-07251	March 22, 1968	May 4, 1968	11A
D-09988	C-07252	May 4, 1968	June 16, 1968	11A
D-09989	C-07253	June 17, 1968	July 30, 1968	11A
D-09990	C-07254	July 30, 1968	September 11, 1968	11A
D-09991	C-07255	September 11, 1968	October 24, 1968	11A
D-09992	C-07256	October 25, 1968	December 7, 1968	11A

COMPOSITE IMP-F MAGNETIC FIELD TAPES

Each composite IMP-F magnetic field tape combines ten orbits of specified data fields transferred without revision from individual orbits of phase II magnetic field data. In addition for orbits 1-58 composite tapes also contain specified fields of spectrum information transferred without revision from Dr. Ogilvie's working spectrum tapes.

Spectrum data is of two types - alpha and proton. In general each type of spectrum record appears once in a series of nine magnetic field records. Alpha and proton data never appear in the same record. A complete description of the composite tape record and the specific sources of information are listed below. Data transferred from magnetic field tapes appear in record words 1-21 inclusive; proton data when recorded appears in record words 22-26 inclusive; alpha data when recorded appears in words 22 and 24. "999.0" is inserted whenever the field is not applicable to the record. Record word 27 indicates the type of data to expect from record words 22-26, i.e., 0 indicates no spectrum data, 1 indicates proton data, 2 indicates alpha data.

Tapes are generated using FORTRAN IV for IBM OS/360 GSFC model 75J. Tapes are unlabelled, 9-track written in binary at 800 BPI. The record form is variable blocked. Each record consists of 27 words plus a 4 byte record control word yielding a record length of 112 bytes. The blocking factor of 280 plus a 4 byte block control word yields a block size of 31364 bytes.

COMPOSITE WORD NO.	FORMAT	MAG FLD WORD NO.	SPECTRUM WORD NO.	DATA DESCRIPTION
1	I	26	-	Year
2	I	27	1*	Decimal day (600 - 1)
3	I	28	2,3,4**	Milliseconds in day
4	I	30	-	Data quality
5	I	35	-	Pseudo sequence count
6	F	102	-	X solar ecliptic satellite position
7	F	103	-	Y solar ecliptic satellite position
8	F	104	-	Z solar ecliptic satellite position
9	F	106	-	X solar magnetosphere satellite position
10	F	107	-	Y solar magnetosphere satellite position
11	F	108	-	Z solar magnetosphere satellite position
12	F	117	-	Geomagnetic latitude sun position
13	F	194	-	Total field average $\frac{1}{3} \sum F_i$ 1 payload
14	F	195	-	Total field average $F = \sqrt{\bar{x}^2 + \bar{y}^2 + \bar{z}^2}$ 2 payload
15	F	248	-	Theta average solar ecliptic
16	F	249	-	Phi average solar ecliptic
17	F	250	-	Standard deviation of X solar ecliptic
18	F	251	-	Standard deviation of Y solar ecliptic
19	F	252	-	Standard deviation of Z solar ecliptic
20	F	298	-	Theta average solar magnetospheric
21	F	299	-	Phi average solar magnetospheric

* Calendar day for spectrum data.

** Hours, minutes, seconds for spectrum data.

<u>COMPOSITE WORD NO.</u>	<u>FORMAT</u>	<u>MAG FLD WORD NO.</u>	<u>SPECTRUM WORD NO.</u>	<u>DATA DESCRIPTION</u>
22	F	-	29	Density
23	F	-	30	Temperature
24	F	-	31	Velocity
25	F	-	35	Ratio of bulk velocity to thermal speed
26	F	-	51	Flow direction
27	I	-	32	Flag (0, no spectrum data; 1, proton data included; 2, alpha data included)

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IMP F & G PHASE II MAGNETIC FIELD ANALYSIS

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IMP F & G PHASE II
MAGNETIC FIELD ANALYSIS

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Part 1

Abstract

As implied in the title, the Phase II Magnetic Field Analysis is the second major step in the processing of the magnetic field data from IMP-F and G. The Phase I Analysis has been described in detail in a companion publication (see Reference 1). In summary the Phase I Analysis has converted the raw X, Y, Z, sensor data as received on the Magnetic Field Experiment Tape into vector measurements of the ambient magnetic field observed by the experiment. These data are computed for four frames of reference - Apparent, Payload, Solar Ecliptic and Solar Magnetospheric. In addition sequence statistics are computed for the last three coordinate systems. These computed data are saved on the Binary Summary Tape written by the Phase I Analysis. These Summary Tapes are used as input to the utility sort program and the sorted version of the tape is used as input to the Phase II Analysis where additional data editing and analysis are performed.

The major functions of this process are as follows:

- 1) Elimination of redundant sequences.
- 2) Creation of hourly average cards for SE, SM or Solar Magnetic (GM) coordinates.
- 3) Detail plots of Payload, SE or SM coordinates.
- 4) Spectral analysis of the data from the autocorrelation computer.
- 5) Production of a Nonredundant Binary Summary Tape.

The Nonredundant Binary Summary Tape and/or hourly
average cards are used as input to subsequent analysis programs,
e.g., Spectral Analysis, Simultaneous Plots.

Part II

Introduction

The Phase II Analysis uses the Binary Summary Tapes produced by the Phase I Analysis (see Reference 1 and Appendix B) for each orbit as input to the utility sort program. These Binary Summary Tapes contain overlapping data originally on the IMP F Magnetic Field Experimenter Tape for the orbit and the sort arranges these telemetry sequences in chronological order with respect to time (overlapping sequences are arranged contiguously).

The following major functions are performed by the Phase II Analysis after sorting is completed:

- 1) Elimination of redundant sequences using redundancy criteria.
- 2) Hourly averages for SE, SM and Solar Magnetic (GM) coordinates are computed and punched on hourly average cards along with the appropriate trajectory information for the coordinate system.
- 3) At the end of each file the detail measurements from the Payload, SE and SM coordinates are formatted for plotting on the SC 4020 plotter.
- 4) The data from the autocorrelation computer are analyzed.
- 5) A new Nonredundant Binary Summary tape is produced.

The switching vector card is used to determine what coordinate system(s) are to be used in the hourly average computations and the detail SC 4020 plotting. In Table 1 check marks indicate what is available in the different frames of reference.

FRAME OF REFERENCE	HOURLY AVERAGE CARDS	SC 4020 DETAIL PLOTS*
Payload		✓
SE	✓	✓
SM	✓	✓
GM	✓	

TABLE II-1

In summary the Phase II Analysis produces four different outputs using three different types of output media:

- 1.) Magnetic Tape
 - a.) SC 4020 plot tape
 - b.) Nonredundant Binary Summary Tape
- 2.) Hourly average cards
- 3.) The power spectrum and refined autocorrelation information from the analysis of the autocorrelation computer data are printed on the high speed line printer.

*Only one of the three frames of reference can be plotted per program run because only one SC 4020 plot tape is available.

Part III

General Description of Processing

The following explanation is divided into 8 numbered sections corresponding to the numbering on the left-hand side of the blocks in the flowchart which is located at the end of Part III:

1) Initialization

Reads the switching vector and calibration cards (see Appendix A) and performs the initialization functions.

2) Tape Read

In preparation for application of the redundancy criteria two sequences are read and stored in memory so that, if redundant, a comparison between the two can be made. The integer variable "P" will be used to point to the better of the two sequences (if redundant) and is now set equal to 1. A comparison is now made between the pseudo-sequence count from the two sequences. If equal the program proceeds to the next Section if unequal the program proceeds to Section 4.

3) Redundancy Criteria

The following criteria are used to decide which of the two sequences is prime.

a) Number of Good Vector Measurements and Standard Deviation.

Let N_1 equal the number of good vector measurements in sequence 1 and N_2 equal the number of good vector measurements in sequence 2 ($N_1, N_2 \leq 8$). Let SD_1 equal the total field standard deviation from sequence 1 and SD_2 from sequence 2.

TABLE III-1

LOGIC	USE SEQUENCE		
	1	2	P
$N_1 > N_2$ and $SD_1 \leq SD_2$	✓		1
$N_2 > N_1$ and $SD_2 \leq SD_1$		✓	2
$(N_1 > N_2 \text{ and } SD_1 > SD_2)$ or $(N_2 > N_1 \text{ and } SD_2 > SD_1)$	Use redundancy criteria b		

b) Data Quality Flag

Let DQ_1 equal the data quality flag from sequence 1 and

let DQ_2 equal the data quality flag from sequence 2.

TABLE III-2

LOGIC	USE SEQUENCE		
	1	2	P
$DQ_1 < 6$ and $DQ_2 = 6$	✓		1
$DQ_1 = 6$ and $DQ_2 < 6$		✓	2
$DQ_1 > DQ_2$	✓		1
$DQ_1 < DQ_2$		✓	2
$DQ_1 = DQ_2$	Use redundancy criteria c		

c) Good Vector Measurements

TABLE III-3

LOGIC	USE SEQUENCE		
	1	2	P
$N_1 > N_2$	✓		1
$N_2 > N_1$		✓	2
$N_1 = N_2$	✓		1

4) Computation of Hourly Averages

The following hourly averages are computed and punched in the hourly average cards.

TABLE III-4

Frame of Reference	Magnitude	Azimuthal Angle	Polar Angle
Solar Ecliptic	$\frac{1}{n} \sum TF_i$	$\tan^{-1} \left[\frac{\frac{1}{n} \sum y_i}{\frac{1}{n} \sum x_i} \right]$	$\tan^{-1} \left[\frac{\frac{1}{n} \sum z_i}{\left(\left(\frac{1}{n} \sum x_i \right)^2 + \left(\frac{1}{n} \sum y_i \right)^2 \right)^{1/2}} \right]$
Solar Magnetospheric			
Solar Magnetic			

All summations in Table III-4 extend from the start of the hour to the end of the hour. Trajectory data punched in the card are for the middle of the hour.

NOTES:

- 1) Averages do not include data computed when the X, Y and/or Z sensors are saturated or data set to 999.0*.
 - 2) Averages will not be computed if $n \leq 360$. Where n is the summation index in Table III-4.
- #### 5) Storage of Detail Data

The detail data for Payload, Solar Ecliptic and Solar Magnetospheric frames of reference are stored until 400 sequences have been processed; at this time the "PLTALL" Subroutine is "CALLED". The "PLTALL" Subroutine is described in Section 7.

*Results from noisy data.

6) Analysis of the Data from the Autocorrelation Computer

The "ACC" Subroutine is "CALLED" and a conversion of the output of the autocorrelation computer to power spectrum is performed. A more complete description of the autocorrelation computer is contained in Appendix C and Reference 2. This Section deals just with the computations performed by ground processing software and not the on-board computer.

6.1) Presentation of the Autocorrelation Computer

Output on the IMP-F Binary Summary Tape

6.1.1) A raw lag appears on the Binary Summary Tape as two 32 bit words.

6.1.1.1) The fractional portion appears as a separate 32 bit word. Bit 8 of the 32 bit word is the sign bit. Bits 1-7 are magnitude.

6.1.1.2) The exponent appears as a separate 32 bit word the four low order bits are the transmitted exponent, no sign information is necessary.

6.1.2) The average appears on the tape as one 32 bit word; the 12th bit is the sign, the other 11 bits are magnitude.

6.2) Reconstruction of the Autocorrelation Output by
the Ground Computer Programs

6.2.1) Reconstruction of the average by the "ACC"
Subroutine. The 12th bit of the 32 bit
word containing the average on the Tape
determines the sign of the average. If
the 12th bit = 1 the average is negative
and the following algorithm is used to
convert it to its true value:

$$\text{AVERAGE} = - (\text{AVERAGE} - 2048) * 16 - 7.5$$

The subtraction of 2048 is necessary to remove
the contribution of the sign bit from the
magnitude. If bit 12 = 0: $\text{AVERAGE} = \text{AVERAGE} * 16 + 7.5$; where the addition or subtraction
of 7.5 is used to improve the estimate of
the average because of the 4 bit truncation
involved.

6.2.2) Reconstruction of the Raw Lags

6.2.2.1) Reconstruction of fraction by the
"ACC" Subroutine.

The 8th bit of the 32 bit word
containing the fractional portion
of the raw lag determines the sign
of the fraction.

- a) If the 8th bit = 1 the raw lag is negative and the following algorithm is used to obtain the correct sign:

$$\text{FRAC} = - \text{FRAC}$$

Note that in the case where the fraction is negative the sign bit has already contributed the additional 128 required because bit 8 of the true (non-compressed) fraction was not transmitted (See Appendix C Section III) unless $\text{EXP} = 0$ in which case this additional 128 must be removed from the fraction.

- b) If bit 8 = 0 the fraction is positive and it is not necessary to change the sign but because bit 8 of the true (non-compressed) fraction is not transmitted (See Appendix C Section III) it is necessary to add the equivalent of this bit back into the fraction, unless the exponent $\text{EXP} = 0$ in which case this adjustment is not required.

$$\text{FRAC} = \text{FRAC} + 128$$

6.2.2.2) Scaling with the Exponent

The next step is to scale the fraction using the 32 bit word containing the exponent (EXP). Due to the logarithmic compression algorithm the exponent is one greater than its true value:

$$\text{RAW LAG} = \text{FRAC} * (2^{*(\text{EXP}-1)})$$

If $\text{EXP} > 1$ truncation of bits during compression has taken place and a correction of half the value of the bits truncated is added or subtracted to the RAW LAG to obtain an improved estimate.

$$\text{RAW LAG} = \text{RAW LAG} \pm 0.5 * ((2.0^{*(\text{EXP}-1)}) - 1.0)$$

When the process of reconstruction is complete each raw lag, which started as two 32 bit words, has been stored as one 32 bit floating point word in the computer memory.

6.3) Conversion of these Data to the Refined Autocorrelation Function

We have now computed the value of the Raw Lagged Products. Before the autocorrelation function is transformed to obtain the power spectrum it is necessary to compute the Refined Lagged Products

from the Raw Lagged Products and the Average this is done in the "PS" Subroutine using the following algorithm:

$$\text{Refined Lag (L)} = \frac{\text{Raw Lag (L)}}{240-L} - \left(\frac{\text{Average}}{240} \right)^2$$

where L = 0-8

6.4) Computation of the Power Spectrum

The ten estimates of the power spectrum are computed from the Refined Lagged Products in the "PS" Subroutine using the following algorithm:

$$P(K) = \frac{\delta K}{9} \left\{ \sum_{L=1}^8 \left(1 + \cos \frac{L\pi}{9} \right) * \left(\cos \frac{KL\pi}{9} \right) * (\text{Refined Lag (L)}) + \text{Refined Lag (0)} \right\}$$

where P(K) is computed for K = 0,1,2,3,4,5,6,7,8,9

$\delta K = \frac{1}{2}$ for K = 0 or K = 9

$\delta K = 1$ for K = 1,2,3,4,5,6,7,8

and $\left(1 + \cos \frac{L\pi}{9} \right)$ represents the hanning window in the time (Lag) domain.

7) SC 4020 Plotting of the Detail Data

The switching vector card determines which if any of the three possible coordinate systems will be plotted by the "PLTALL" Subroutine. The "PLTALL" Subroutine is used to format the detail (2.566 sec.) data from 400 telemetry sequences for the selected

coordinate system for the SC 4020 plotter. Specifically the following parameters are plotted:

1. Total field, F (TF1)
2. Azimuthal angle, ϕ
3. Polar angle, θ

The "PLTALL" Subroutine is designed to plot a block of detail data (approximately 2.3 hours of data) each time the subroutine is entered such that each SC 4020 frame displays 1 hour of data in two $\frac{1}{2}$ -hour sweeps across the frame. Each frame is labeled with the following information:

1. Coordinate System (Payload, SE, SM)
2. Orbit Number
3. Decimal Day of Year and $\frac{1}{2}$ Hour Periods covered
4. Experimenter Tape Number
5. Analysis Date
6. Trajectory Flag
7. Trajectory Data in the Appropriate Coordinate System
8. Saturation of Sensors When it Occurs

7.1) Description of Processing

The Subroutine, using the time array for the file, i.e., times for channel zero frame zero of each sequence, operates on the corresponding data array from each Decimal Day separately.* During each Decimal

*In a two hour file it is only possible to have data from two different Decimal Days.

Day the time array is searched in $\frac{1}{2}$ -hour sweeps starting at 0 hours for time (and thus data) falling in these $\frac{1}{2}$ -hour time intervals. When data is found in a specific interval the indices IB and IE are used to indicate the point in the data array where plotting should begin and end respectively, for this particular $\frac{1}{2}$ -hour interval. After IB and IE are defined, but before the data are plotted, the routine determines if the SC 4020 frame should be advanced and a new grid drawn. This will be necessary if the data to be plotted occur in a $\frac{1}{2}$ -hour interval which starts at the beginning of the hour, otherwise it is unnecessary to generate a new grid. Frame advance and grid construction are done with the "GDA" Subroutine. The "PLTALL" Subroutine now uses IB and IE to set the limits for the DO LOOP which plots the following data from each sequence during this $\frac{1}{2}$ -hour time interval.

- a) Computed first is the value for the abscissa which represents the measurement time normalized to the $\frac{1}{2}$ -hour interval.
- b) The detail field, F, $\emptyset$, θ are plotted.

In addition:

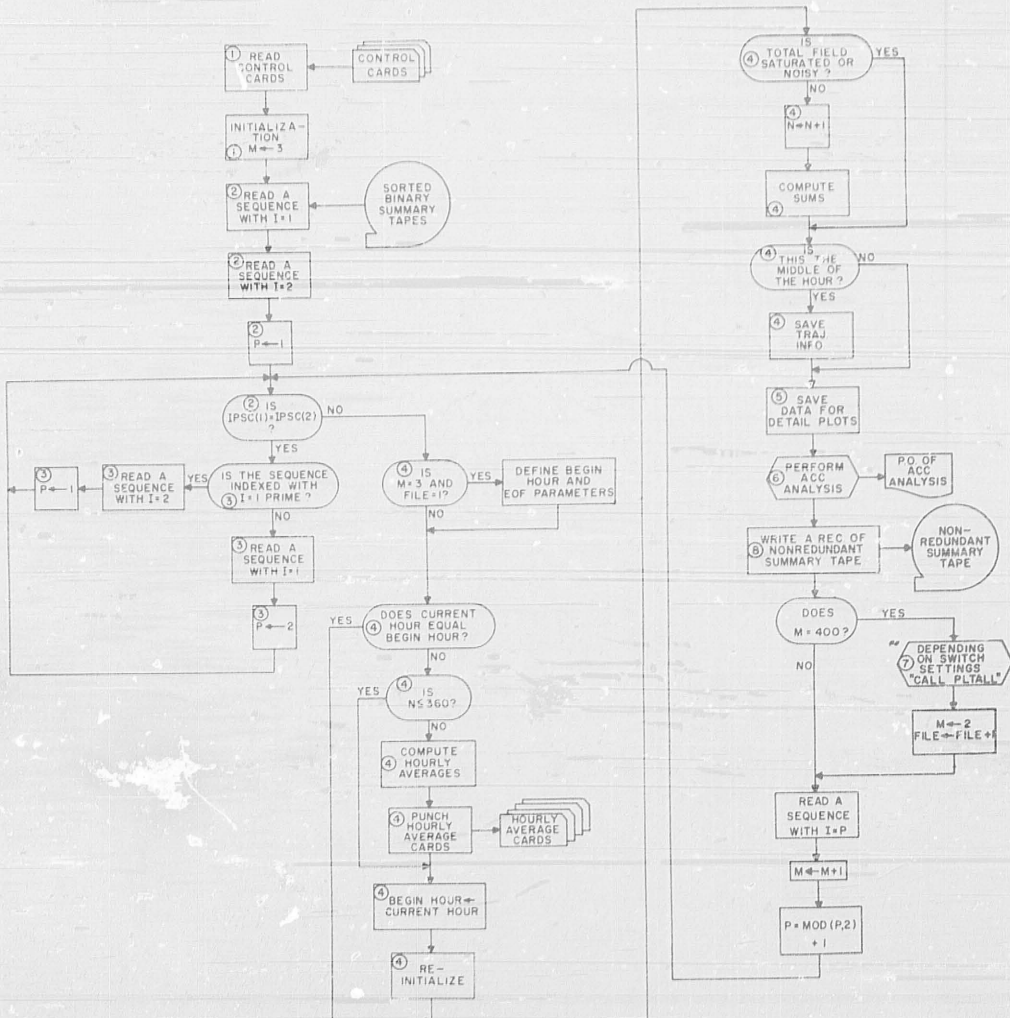
- a) Once per frame the appropriate trajectory data for the coordinate system are printed out in an X, Y, Z presentation.

b) The abscissa is labeled with the $\frac{1}{2}$ -hour period being plotted.

8) Generation of the Nonredundant Binary Summary Tape

A Binary Summary Tape record is written in the same format as the input tape record. As a result of Section 3 redundant sequences are not included on this tape. These Nonredundant Binary Summary Tapes from each orbit comprise the permanent tape library for the IMP-F magnetic field experiment.

PHASE II ANALYSIS FLOWCHART



PART IV

References

1. Mish, William H., IMP F and G Phase I Magnetic Field Analysis, X-612-67-602, Greenbelt, Maryland, Goddard Space Flight Center, November 17, 1967 (Revised March 1968).
2. Ness, Norman F., A Proposal for the Magnetic Field Experiment for IMP'S H and J, X-612-66-461, Greenbelt, Maryland, Goddard Space Flight Center, September 1966.

APPENDIX A

<u>CARD NO.</u>	<u>FORTRAN FORMAT</u>	<u>FUNCTION</u>
A	80 (I1)	Switching Vector (See rest of Appendix for functional breakdown)
B	3(F10.0)	Calibration Coefficients for low range
C	3(F10.0)	Calibration Coefficients for high range
D (Hourly Average Card)	I2 F5.1 F5.1 F5.1 F5.1 I2 I3 I2 F5.1 F5.0 F5.0 I4 18X 2A4 F4.0	Orbit Number Radial Distance X Y Z Year Decimal Day Hour F θ Ø No. of points in summation Coordinate system and satellite identification Geomagnetic latitude of sun

APPENDIX A (continued)

PHASE II

SWITCHING VECTOR CONTROL CARD A

Card Column & Subscript of s	State	Action
1	0	Hourly Average Cards in SE Coordinates Desired
	1	No SE Hourly Average Cards
2	0	Hourly Average Cards in SM Coordinates Desired
	1	No SM Hourly Average Cards
3	0	Hourly Average Cards in Solar Magnetic Coordinates Desired
	1	No Solar Magnetic Hourly Average Cards
4	0	4020 Plots of Detail Payload Coordinates
	1	No Plots
5	0	4020 Plots of Detail SE Coordinates
	1	No Plots
6	0	4020 Plots of Detail SM Coordinates
	1	No Plots
7	0	Autocorrelation Computer data will be analyzed
	1	No data from the autocorrelation computer will be analyzed.
8	0	4020 Plot of Autocorrelation Functions
	1	No Plots

APPENDIX B

IMP F SUMMARY TAPE FORMAT

<u>Item No.</u>	<u>Identification</u>	<u>Format</u>
1	Satellite I. D.	I
2	Orbit Number	I
3	Telemetry Recording Station Number	I
4	Analog Tape Number	I
5	Analog-To-Digital Line I. D.	I
6	Day of Year (Start)	I
7	Milliseconds of Day	I
8	Day of Year (Stop)	I
9	Milliseconds of Day	I
10	Average Sequence Time (Milliseconds) This File	I
11	Quick Look Data Flag	I
12	Orbit/No Orbit Data Flag	I
13	Decom Process Date Year	I
14	Decom Process Date Month	I
15	Decom Process Date Day	I
16	Decom Process Date Hour	I
17	Orbit Tape I. D. Reel Number	I
18	Orbit Tape Date of Generation Year	I
19	Orbit Tape Date of Generation Month	I

<u>Item No.</u>	<u>Identification</u>	<u>Format</u>
20	Orbit Tape Date of Generation Day	I
21	Average Spin Period in Milliseconds	I
22	Year of Start Time	I
23	Year of Stop Time	I
24	Experimenter Tape Number	A4
25	Analysis Date	A4
26	Year of Frame 0, Channel 0	I
27	Day of Frame 0, Channel 0 (Decimal Day)	I
28	Milliseconds of Day	I
29	Time Quality Flag	I
30	Data Quality Flag for this Sequence	I
31	Experimenter On/Off Flags (Frame 4, Channel 2)	I
32	Orbit Data Flag	I
33	Analog Calibration Flag (Channel 1, Frame 4)	I
34	Pseudo-Sequence Count Quality Flag	I
35	Pseudo-Sequence Count	I
36	Sequence I. D. Quality Flag	I
37	Sequence I. D.	I
38	Satellite Clock	I
39	Average Frame Time in Milliseconds	I
40	PP21 (Bellows Temperature)	I

<u>Item No.</u>	<u>Identification</u>	<u>Format</u>
41	PP7 (+11.7 Volt Line)	I
42	Frame Number (1)	I
43	X Apparent	F
44	Y Apparent	F
45	Z Apparent	F
46	Frame Number (3)	I
47	X Apparent	F
48	Y Apparent	F
49	Z Apparent	F
50	Frame Number (5)	I
51	X Apparent	F
52	Y Apparent	F
53	Z Apparent	F
54	Frame Number (7)	I
55	X Apparent	F
56	Y Apparent	F
57	Z Apparent	F
58	Frame Number (9)	I
59	X Apparent	F
60	Y Apparent	F
61	Z Apparent	F

<u>Item No.</u>	<u>Identification</u>	<u>Format</u>
62	Frame Number (11)	I
63	X Apparent	F
64	Y Apparent	F
65	Z Apparent	F
66	Frame Number (13)	I
67	X Apparent	F
68	Y Apparent	F
69	Z Apparent	F
70	Frame Number (15)	I
71	X Apparent	F
72	Y Apparent	F
73	Z Apparent	F
74	Frame 8, Channel 1a, 1b, 2a	I
75	Frame 8, Channel 2b	I
76	Frame 8, Channel 3a, 3b	I
77	Frame 8, Channel 4a	I
78	Frame 8, Channel 4b, 5a	I
79	Frame 8, Channel 5b	I
80	Frame 8, Channel 6a, 6b	I
81	Frame 8, Channel 7a	I
82	Frame 8, Channel 7b, 8a	I

<u>Item No.</u>	<u>Identification</u>	<u>Format</u>
83	Frame 8, Channel 8b	I
84	Frame 8, Channel 9a, 9b	I
85	Frame 8, Channel 10a	I
86	Frame 8, Channel 10b, 11a	I
87	Frame 8, Channel 11b	I
88	Frame 8, Channel 12a, 12b	I
89	Frame 8, Channel 13a	I
90	Frame 8, Channel 13b, 14a	I
91	Frame 8, Channel 14b	I
92	Frame 8, Channel 15a, 15b	I
93	0A SCAN (Spin-Axis-Sun-Angle)	F
94	0A1 (Sun Time)	F
95	0A2 (Spin Period)	F
96	0A3 (Earth Time)	F
97	0A4 (Earth Width)	F
98	Day of Orbit Data	I
99	Milliseconds of Day of Orbit Data	I
100 - 142	Items 231-273 (Trajectory Data) from IMP F Experimenter Tape Format	F
143	X Payload	F
144	Y Payload	F
145	Z Payload	F

<u>Item No.</u>	<u>Identification</u>	<u>Format</u>
146	ALPHA Payload	F
147	PSI Payload	F
148	Total Field Payload	F
191	X Average Payload	F
192	Y Average Payload	F
193	Z Average Payload	F
194	TOTAL FIELD AVERAGE 1 Payload	F
195	TOTAL FIELD AVERAGE 2 Payload	F
196	ALPHA Average Payload	F
197	PSI Average Payload	F
198	Standard Deviation of X Payload	F
199	Standard Deviation of Y Payload	F
200	Standard Deviation of Z Payload	F
201	Standard Deviation of Total Field 1 Payload	F
202	Standard Deviation of Total Field 2 Payload	F
203	Component Ratio Payload	F
204	Total Field Ratio Payload	F
205	X Solar Ecliptic	F
206	Y Solar Ecliptic	F
207	Z Solar Ecliptic	F
208	THETA Solar Ecliptic	F
209	PHI Solar Ecliptic	F

For Frames
1, 3, 5, 7, 9, 11, 13, 15

For Frames
1, 3, 5, 7, 9, 11, 13, 15

<u>Item No.</u>	<u>Identification</u>	<u>Format</u>
245	X Average Solar Ecliptic	F
246	Y Average Solar Ecliptic	F
247	Z Average Solar Ecliptic	F
248	THETA Average Solar Ecliptic	F
249	PHI Average Solar Ecliptic	F
250	Standard Deviation of X Solar Ecliptic	F
251	Standard Deviation of Y Solar Ecliptic	F
252	Standard Deviation of Z Solar Ecliptic	F
253	Component Ratio Solar Ecliptic	F
254	Total Field Ratio Solar Ecliptic	F
255	X Solar Magnetospheric	F
256	Y Solar Magnetospheric	F
257	Z Solar Magnetospheric	F
258	THETA Solar Magnetospheric	F
259	PHI Solar Magnetospheric	F
295	X Average Solar Magnetospheric	F
296	Y Average Solar Magnetospheric	F
297	Z Average Solar Magnetospheric	F
298	THETA Average Solar Magnetospheric	F
299	PHI Average Solar Magnetospheric	F
300	Standard Deviation of X Solar Magnetospheric	F

For Frames
1, 3, 5, 7, 9, 11, 13, 15

<u>Item No.</u>	<u>Identification</u>	<u>Format</u>
301	Standard Deviation of Y Solar Magnetospheric	F
302	Standard Deviation of Z Solar Magnetospheric	F
303	Component Ratio Solar Magnetospheric	F
304	Total Field Ratio Solar Magnetospheric	F
305	Celestial Inertial Orientation of Spin Axis for X	F
306	Celestial Inertial Orientation of Spin Axis for Y	F
307	Celestial Inertial Orientation of Spin Axis for Z	F

End of tape is indicated by an EOF mark. Files are not separated by any logical type of EOF record. This is a 9 track IBM 360 binary tape (999.0 indicates bad data). All words are single precision (i.e. 4 bytes in length).

APPENDIX C

Autocorrelation Computer Computations and Analysis

I) Introduction

This Appendix describes in detail:

- (1) The computations performed by the IMP F autocorrelation computer.
- (2) The manner in which these data are compressed and transmitted.
- (3) The presentation of these data on the IMP F experimenter tape.
- (4) The reconstruction of these data by the ground computer programs.
- (5) Conversion of these data to the refined autocorrelation function.
- (6) Computation of the power spectrum.

The IMP F autocorrelation computer performs direct computations of the first nine raw lagged products and average of the autocorrelation function with a sampling rate of 0.080 seconds. The computer operates separately for one sequence on one axis of data from the triaxial magnetometer. The axes are alternately switched between parallel to the spin axis (Z axis) and perpendicular to the spin axis (Y axis) every sequence so that the complete directional spectrum of the magnetic field fluctuations can be studied.

II) Computations Performed by the Autocorrelation Computer

Sampling of the 8 bit output of the Y or Z axis sensor begins in frame 9 channel 0 of one sequence and continues through frame 7 channel 15 of the next sequence with an 0.080 second separation between samples. Let $X_1, X_2, \dots, X_{240}$ represent the time series being sampled. The following ten quantities are computed by the autocorrelation computer.

$$1) \quad \text{AVERAGE} = \frac{1}{240} \sum_{i=1}^{240} X_i$$

$$2-10) \quad \text{RAW LAG (L)} = \sum_{i=1}^{240-L} X_i X_{i+L} \quad \text{where } L = 0, 1, 2, 3, 4, 5, 6, 7, 8$$

These parameters are computed to a precision of 16 bits (with sign) for the average and 23 bits (with sign) for the raw lags. These data are stored in a 23 bit register in the spacecraft whose bits, for purposes of the following discussion, will be numbered starting from the right from 1 through 23 (See Figure 1). The MSB (bit 23) is the sign bit (0 = +; 1 = -).

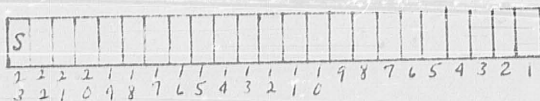


Figure 1

III) Data Compression and Transmission

Before transmission these data are compressed using the following algorithms.

A) Compression of the Raw Lags.

The following logarithmic algorithm is used to compress the raw lags. This generates a 7 bit fraction and 4 bit exponent.

- 1) If bits 8 through 22 are all equal to zero transmit bits 1 through 7 as the fraction and zero as the exponent.

Also transmit the sign for a total of 12 bits.

- 2) If bits 9 through 22 are all equal to zero and bit 8 equals 1 transmit bits 1 through 7 as the fraction and 1 as the exponent. Also transmit the sign for a total of 12 bits.
- 3) If bits 9 through 22 are not all equal to zero shift right n times until bits 9 through 22 are equal to zero. Transmit bits 1 through 7 as the fraction and $n + 1$ as the exponent. Also transmit the sign for a total of 12 bits.

The raw lag products are readout in frame 8 channels 2b through 15b (see Figure 2). The 4 bit exponent is readout first from LSB to MSB followed by the seven bit fraction from LSB to MSB followed by the sign bit for a total of 12 bits so, for instance, the transmission of lag 8 requires three half channels* (channel 2b through 3b). Raw lag 7 through raw lag 0 are readout in an analogous fashion respectively and require channels 4a through 15b

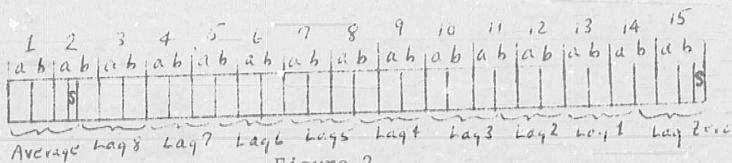


Figure 2

B) Compression of the Average.

In the case of the average, bits 5 through 15 and bit 23 (sign bit) are transmitted (total of 12 bits). The average is readout

*There are 4 bits per half channel.

+Y is readout in sequences with even sequence ID's
Z is readout in sequences with odd sequence ID's

in frame 8 channels 1a, 1b, 2a (see Figure 2). The magnitude is readout first from LSB to the MSB followed by the sign for a total of 12 bits.

IV) Presentation of the Autocorrelation Computer Output on the IMP F Experimenter Tape.

A) A raw lag appears on the Magnetic Field Experimenter Tape as two 32 bit words

- 1) The fractional portion appears as a separate 32 bit word. Bit 8 of the 32 bit word is the sign bit. Bits 1-7 are magnitude.
- 2) The exponent appears as a separate 32 bit word the four low order bits are the transmitted exponent, no sign information is necessary.

B) The average appears on the Experimenter Tapes as one 32 bit word the 12th bit of this 32 bit word is the sign, the other 11 bits are magnitude.

V) Reconstruction of the Autocorrelation Output by the Ground Computer Programs

A) Reconstruction of the Average

The 12th bit of the 32 bit word containing the average on the Experimenter Tape determines the sign of the average. If the 12th bit = 1 the average is negative and the following algorithm is used to convert it to its true value:

$$\text{AVERAGE} = - (\text{AVERAGE} - 2048) * 16 - 7.5$$

The subtraction of 2048 is necessary to remove the contribution

of the sign bit from the magnitude. If bit 12 = 0:
 $AVERAGE = AVERAGE * 16 + 7.5$; where the addition or subtraction
of 7.5 is used to improve the estimate of the average because
of the 4 bit truncation involved.

B) Reconstruction of the Raw Lags

1) Reconstruction of Fraction

The 8th bit of the 32 bit word (FRAC) containing the fractional
portion of the raw lag determines the sign of the fraction.

- a) If the 8th bit = 1 the raw lag is negative and the
following algorithm is used to obtain the correct sign:

$$FRAC = - FRAC$$

Note that in the case where the fraction is negative
the sign bit has already contributed the additional 128
required because bit 8 of the true (non-compressed) fraction
was not transmitted (See Section III) unless $EXP = 0$ in
which case this additional 128 must be removed
from the fraction.

- b) If bit 8 = 0 the fraction is positive and it is not
necessary to change the sign but because bit 8 of the
true (non-compressed) fraction is not transmitted
(See Section III) it is necessary to add the equivalent
of this bit back into the fraction, unless the exponent
(EXP) = 0 in which case this adjustment is not required.

$$FRAC = FRAC + 128$$

2) Scaling with the Exponent

The next step is to scale the fraction using the 32 bit word containing
the exponent (EXP). Note that due to the logarithmic compression
algorithm the exponent is one greater than its true value:

$$RAW\ LAG = FRAC * (2^{**} (EXP-1))$$

If $EXP > 1$ truncation of bits during compression has taken place and a correction of half the value of the bits truncated is added or subtracted to the RAW LAG to obtain an improved estimate.

$$RAW\ LAG = RAW\ LAG \pm 0.5 * ((2.0 ** (EXP - 1)) - 1.0)$$

When the process of reconstruction is complete each raw lag, which started as two 32 bit words, has been stored as one 32 bit floating point word in the computer memory.

VI) Conversion of these Data to the Refined Autocorrelation Function

We have now computed the value of the Raw Lagged Products. Before the autocorrelation function is transformed to obtain the power spectrum it is necessary to compute the Refined Lagged Products from the Raw Lagged Products and the Average using the following algorithm:

$$Refined\ Lag\ (L) = \frac{Raw\ Lag\ (L)}{240-L} - \left(\frac{Average}{240} \right)^2$$

where $L = 0, 1, 2, 3, 4, 5, 6, 7, 8$

VII) Computation of the Power Spectrum

The ten estimates of the power spectrum are computed from the Refined Lagged Products using the following algorithm:

$$P(K) = \frac{\delta_K}{9} \left\{ \sum_{L=1}^8 \left(1 + \cos \frac{L\pi}{9} \right) * \left(\cos \frac{KL\pi}{9} \right) * (Refined\ Lag\ (L)) + Refined\ Lag\ (0) \right\}$$

where $P(K)$ is computed for $K = 0, 1, 2, 3, 4, 5, 6, 7, 8, 9$

$$\delta_K = \frac{1}{2} \text{ for } K = 0 \text{ or } K = 9$$

$$\delta_K = 1 \text{ for } K = 1, 2, 3, 4, 5, 6, 7, 8$$

and $\left(1 + \cos \frac{L\pi}{9} \right)$ represents the hanning window in the time (Lag) domain.

APPENDIX D

DESCRIPTION OF SC 4020 DETAIL PLOTS

PLOTS

The detail plotting routine plots the following parameters as a function of time for the Payload, SE and SM coordinate systems.

1. Total field (TF1)
2. ϕ ($0 - 360^\circ$)
3. θ ($\pm 90^\circ$)

Each frame of the plot displays 1 hour of data in two $\frac{1}{2}$ -hour sweeps across the frame. If trajectory information is on the experimenter tape it is displayed every hour in the proper coordinate system in units of R_E . The following characters are used in the plotting:

Parameter, P	Range of P	Characters	Identification of Range on Abscissa
Total Field	$0 \leq P < 25$	●	1
	$25 \leq P < 50$	●	2
	$50 \leq P < 75$	●	3
	$75 \leq P < 100$	●	4
	$100 \leq P < 125$	●	5
	$125 \leq P < 150$	●	6
ϕ	$0 \leq P < 360$	●	
θ	$-90 \leq P \leq +90$	●	
Special Characters	Saturation	S	

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IMP F AND G PHASE I MAGNETIC FIELD ANALYSIS

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NOVEMBER 17, 1967

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**GODDARD SPACE FLIGHT CENTER
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PHASE I MAGNETIC
FIELD ANALYSIS

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IMP F AND G
PHASE I MAGNETIC
FIELD ANALYSIS

William Mish

PART I

ABSTRACT

This paper describes the Phase I Analysis Program developed to analyse the magnetic field data from the GSFC magnetic field experiment flown on IMP F and to be flown on IMP G.

The Phase I Analysis converts the raw X, Y, Z sensor data as received on the Magnetic Field Experiment Tape into vector measurements of the ambient magnetic field observed by the experiment. These data are computed for four frames of reference — Apparent, Payload, Solar Ecliptic and Solar Magnetospheric. In addition 20.45 second (sequence) statistics are computed for the last three coordinate systems and SC 4020 plots of these statistics as a function of time can be obtained. Finally a summary tape is produced containing detailed data and sequence statistics as well as the output from the autocorrelation computer, trajectory data and identification information. This summary tape provides the input to the Phase II analysis which is currently under development.

PART II

INTRODUCTION

1. INSTRUMENTATION

IMP F was launched from the Western Test Range May 24, 1967 at 1405:54Z into a "Polar" orbit (Apogee = 214,382 Km; Perigee = 242 Km; Inclination = 67.12°). The magnetic field experiment consists of fluxgate magnetometer sensors mounted remotely from the spacecraft on two booms in a triaxial configuration such that the ambient magnetic field can be measured in three orthogonal directions. The Z sensor is located on a separate boom opposite the X-Y set. A flipper mechanism is included to rotate the Z sensor by 180° approximately every 4 days to provide in-flight zeros for this axis. The spin modulation which appears in the X and Y sensor data provides the necessary information to determine the zero levels of these sensors. In addition approximately every hour a 10γ on-board calibration field is applied to each of the sensors to calibrate sensitivity. Each sensor has a dual range of $\pm 32\gamma$ and $\pm 128\gamma$.

The second portion of the experiment is an autocorrelation computer which performs direct computations of the first nine lagged products of the autocorrelation function with a sampling rate of 0.080 seconds. This permits the study of magnetic field fluctuations extending to 12.5 cps. The autocorrelation computer operates separately for one sequence on one axis of data from the triaxial magnetometers. The axes are alternately switched between parallel to the spin axis and perpendicular to the spin axis every sequence so that the complete directional spectrum of the magnetic field fluctuations can be studied.

2. TELEMETRY

The telemetry from the spacecraft is coherent digital PFM. The basic unit of telemetry is a 20.45 second sequence consisting of a 16 channel by 16 frame array with a channel length of .080 seconds. Commutated in the odd numbered frames* are the detail measurements from the X, Y and Z magnetometers each digitized to a precision of 8 bits. These data appear in channels 1, 2 and 3. In addition frame 8 uses channels 1 through 15 for transmission of 120 bits of output from the autocorrelation computer. The telemetry is digitized by the F-9A Data Processing System using correlation detectors for the detection of the PFM signals. (See Reference 4.)

*Frames and channels are numbered from 0 through 15.

3. PHASE I ANALYSIS

The primary purpose of the Phase I analysis is to convert the raw X, Y, Z sensor data as received on the Magnetic Field Experimenter Tape into vector measurements of the ambient magnetic field observed by the experiment. These data are computed for four different frames of reference -- Apparent, Payload, Solar Ecliptic and Solar Magnetospheric. In addition sequence (20.45 second) statistics are computed for the last three coordinate systems. The program has been written so that a great deal of flexibility is available in the calculation and display of these data both on the printer and plotting on the SC 4020 plotter as shown in Table 1. (Check marks (✓) indicate what is available in the different frames of reference.)

Table 1

Frame of Reference	Detail Printed Output	Sequence Printed Output	SC 4020 Sequence Plots
Raw	✓		
Apparent	✓		
Payload	✓	✓	✓
Solar Ecliptic	✓	✓	✓
Solar Magnetospheric	✓	✓	✓

The above options are selected through the use of a switching vector card.

In addition to the various printed outputs and SC 4020 displays, a binary summary tape is generated which contains the detail data and sequence statistics for the frames of reference as well as identification information, trajectory and the output from the autocorrelation computer.

4. PROGRAM DESIGN

The Program is designed such that the data from an entire file (approximately 2 hours of data) are read into core storage before any rotations are performed. The Main Program computes the Apparent Coordinates from the raw data for the file, stores the autocorrelation computer output, trajectory and identification

information on the disk, rotates the apparent data into three different coordinate systems and performs all the printing of these rotated data. All the rotated detailed data for the file remain in core storage after they are computed.

The statistical computations for the three different coordinate systems use this detail data, and are performed by the Statistics Subroutine. These statistics are stored in three different files (one per coordinate system) on the disk as they are computed. However, the statistics for the particular coordinate system currently being computed also remain in core storage so that they will be available to the SC 4020 plot routines, which can be called by the Statistics Subroutine. All printing of the statistics is done by the Statistics Subroutine. Finally, the detail data and statistics for the three coordinate systems, the apparent coordinates, trajectory, autocorrelation computer output, and ID information are gathered together and written on a Binary Summary Tape. There is one file of data on the Binary Summary Tape for each file of data on the Experimenter Tape.

This Summary Tape provides the input to the Phase II Analysis currently under development.

In preparation for subsequent analysis of these data by other investigators Appendix H, Characteristics of the IMP F Spacecraft and Magnetic Field Experiment That Should Be Considered in Subsequent Analysis, should be reviewed to aid in the interpretation of the results.

PART III

GENERAL DESCRIPTION OF PROCESSING

The following explanation is broken into 8 numbered sections whose numbers correspond to the numbering in the upper left hand corner of the blocks in the flowchart which is located at the end of this Section.

1. INPUT ROUTINE

a. The following control cards are read in at the beginning of the program. Formats are described in Appendix B.

CARD #	FUNCTION	VARIABLES
A	Experimenter tape # and analysis date	EXTNO, ANADTE
B	Switching vector	S(I), I = 1,80
C	Calibration coefficients for low range	AI(1,I), I = 1,3 BI(1,I), I = 1,3 CI(1,I), I = 1,3
D	Calibration coefficients for high range	AI(2,I), I = 1,3 BI(2,I), I = 1,3 CI(2,I), I = 1,3
E	Correction to zero and Z dependent zero for low range	ZDZ(1,I), I = 1,2 ZDS(1,I), I = 1,2
F	Correction to zero and Z dependent zero for high range	ZDZ(2,I), I = 1,2 ZDS(2,I), I = 1,2
G	File interval to be processed	IFLBG, IFLEND
H	Right Ascension and Declination in Celestial Interital Coordinates of the spin axis of the spacecraft	RACI, DECCI

b. The XCI, YCI and ZCI components of the spin axis unit vector are computed using the following equations.

$$XCI = \cos (DECCI) * \cos (RACI)$$

$$YCI = \cos (DECCI) * \sin (RACI)$$

$$ZCI = \sin (DECCI)$$

c. The header record for the file is now read from the experimenter tape (See Appendix C) and pertinent definitions and the file count are printed out. The switching vector card controls the degree of analysis performed and determines printing and SC 4020 plotting status.

2. CALIBRATION TO APPARENT FIELD VALUES (PROCESS ONE FILE)

The Phase I Analysis performs the following operations as it makes a pass through each file on the experiment tape.

a. A physical record is read from the experimenter tape containing three telemetry sequences (see Appendix C) along with the trajectory data* associated with channel zero frame zero of the middle sequence.

b. If S_2 is equal to zero the raw data from these three sequences are printed otherwise the printing of the raw data is suppressed.

c. The theoretical magnetic field which is included as part of the trajectory information in Solar Ecliptic Coordinates is rotated to Solar Magnetospheric Coordinates and is converted to a two angle presentation.

$$\begin{bmatrix} XT \\ YT \\ ZT \end{bmatrix}_{SM} = \begin{bmatrix} \text{Rotation Matrix to} \\ \text{go from SE to SM} \\ \text{coordinates from} \\ \text{Experimenter Tape} \end{bmatrix} \begin{bmatrix} XT \\ YT \\ ZT \end{bmatrix}_{SE}$$

*In the case of quick-look data no trajectory data is included on the Experimenter Tape.

$$PSI = \tan^{-1} \frac{YT}{XT}$$

$$FPER = (XT^2 + YT^2)^{1/2}$$

$$ALPHA = \tan^{-1} \frac{ZT}{FPER}$$

This angle presentation is calculated for both coordinates systems.

d. Computes a refined spin period for each of the three telemetry sequences in the physical record using the following algorithm:

$$\Delta T = \left[(t_3 + t_{s/s_3}) - (t_1 + t_{s/s_1}) \right]$$

$$N = \left[\frac{\Delta T}{AVSPIN} + 0.5 \right] \text{ Truncated to an integer}$$

$$\text{Refined Spin Period} = \frac{\Delta T}{N}$$

Where

t_3 = Time for channel zero frame zero of the oldest sequence in the physical record

t_{s/s_3} = See sun time for the older sequence

t_1 = Time for channel zero frame zero of the younger sequence in the physical record.

t_{s/s_1} = See sun time for the younger sequence

AVSPIN = Average spin period for the file.

This results in a spin period that is averaged over approximately 16 spacecraft revolutions. If the refined spin period differs by more than 5 milliseconds from AVSPIN the average spin period for the file is used, since the t_{s/s_3} or t_{s/s_1} may be in error.

e. Checks whether the magnetometers are in the low or high range and converts the sensor outputs D_1 , D_2 , and D_3 , to field values using the following set of equations. (Where $I = 1$ for the low range and $I = 2$ for the high range.)

$$ZA = AI(I,3) + BI(I,3)*D_3 + CI(I,3)*D_3^2$$

If the Z axis is in the "down" position the sign of ZA is reversed (this rotates ZA to Payload Coordinates)

$$ZA = -ZA$$

$$YA^* = AI(I,2) + BI(I,2)*D_2 + CI(I,2)*D_2^2 + ZDZ(I,2) + ZDS(I,2)*ZA$$

$$XA = AI(I,1) + BI(I,1)*D_1 + CI(I,1)*D_1^2 + ZDZ(I,1) + ZDS(I,1)*ZA$$

The calibration coefficients $AI(I,K)$, $BI(I,K)$, $CI(I,K)$ for the three axes (K) and two ranges (I) have been determined by performing least squares parabolic fits to the pre-launch calibration data, i.e., counts vs gammas. This calibration data is contained in Appendix G.

The zero corrections, $ZDZ(I,K)$ for the X and Y axes (both ranges) are calculated each orbit by a calibration program that is run separately prior to the Phase I Analysis (see Reference 1). The values of $ZDZ(I,K)$ represent an adjustment applied to the calibration coefficients $AI(I,K)$, which are the zero levels of the instruments.

The zero correction to the Z axis is made by direct adjustment of the $AI(I,3)$ coefficients.

*If $D_2 > 170$ counts, and the sensors are in the High Range YA is computed as:

$$YA = AI(I,2) + BI(I,2)*170.0 + CI(I,2)*170.0^2 + ZDZ(I,2)$$

$$- 1.3583*(D_2 - 170.0) + ZDS(I,2)*ZA$$

The Z dependent zeros, ZDS(I,K) for the X and Y axes (both ranges) are also calculated each orbit by the above mentioned Program. This correction compensates for the fact that the X-Y sensor set, which is mounted on a separate boom from the Z sensor, is not quite perpendicular to that sensor thus a small Z dependence is observed in the X and Y sensor data which must be compensated.

The constants AI, BI, CI, ZDZ, and ZDS are read in on Control Cards C, D, E, and F.

f. XA is now adjusted to compensate for the fact that D₁ and D₂ are not sampled orthogonally using the following equation $XA = (XA - YA \sin \Delta) / \cos \Delta$ where $\Delta = (0.080 / \text{Refined Spin Period}) * 2\pi$. In addition if the 10 γ calibration field was on during this sequence it is removed from XA, YA and ZA. If the calibration field is on:

$$XA = XA + 10.85\gamma$$

$$YA = YA + 10.97\gamma$$

$$\left. \begin{array}{l} ZA = ZA + 10.32\gamma \\ ZA = ZA - 10.32\gamma \end{array} \right\} \begin{array}{l} \text{if Z axis is "up"} \\ \text{if Z axis is "down"} \end{array}$$

As XA, YA, and ZA are computed they replace D₁, D₂, and D₃ in the Experimenter Tape record which is written on the disk along with the refined spin period for the sequence as the file is processed.

A printout of XA, YA, and ZA will also be produced if S₃ has been set to zero. Note that at the end of Section 2 all information originally on the Experimenter Tape in this file, with the exception of D₁, D₂, and D₃ has been transferred to the disk. (D₁, D₂, and D₃ have been replaced with XA, YA and ZA.) The refined spinperiod (or the average spinperiod for the file) for each sequence is also on the disk.

3. ROTATION TO PAYLOAD COORDINATES (PROCESS ONE FILE)

The Program now rotates XA, YA, and ZA into the nonrotating (fixed) Payload Coordinate System using the following rotation matrix. The derivation of this matrix is found in Appendix D.

$$\begin{bmatrix} \text{XP} \\ \text{YP} \\ \text{ZP} \end{bmatrix} = \begin{bmatrix} -\sin \gamma_i + \cos \gamma_i & 0 \\ \cos \gamma_i + \sin \gamma_i & 0 \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} \text{XA} \\ \text{YA} \\ \text{ZA} \end{bmatrix}$$

the angle γ_i has been computed in Section 2 and is defined by the following formula:

$$\gamma_i = \left[\frac{(t_i - t_{s/s})}{\text{Refined Spin Period}} \right] * 2\pi + \psi_o - \psi_1$$

where

t_i is the time for i th vector measurement of the field.

$t_{s/s}$ is the time the OA sensor saw the sun. (See Sun Time.)

ψ_o is the angular offset of sensor from the OA sensor and is equal to -22.5° .

ψ_1 is the phase shift of the sensors at the spin frequency. (ψ_1 is approximately the same for all three sensors but is a function of the range that the sensor is in)

Range	ψ_1 in degrees
Low	$7.153 \log_{10} \left[\frac{1}{\text{Refined Spin Period}} \right] + 6.108$
High	0.5

After rotation to payload coordinates it is necessary to make an adjustment to the measured field in the ZP direction resulting from the fact that the Z sensor is not quite perpendicular to the X-Y sensor set. This adjustment is made by solving the following equation for F_Z .

$$F'_Z = F_Z \cos \beta \quad F'_\perp \sin \beta \cos [\gamma_i - (\psi + \phi_o)]$$

where

F'_Z = field measured by Z sensor.

$F'_\perp \sin \beta = (\text{XP}^2 + \text{YP}^2)^{1/2} \sin \beta$ = the projection of the perpendicular field on the Z axis. β is a function of the Z axis position.

$\cos [\gamma_i - (\psi + \phi_o)]$ = Demodulates the projection of the perpendicular field on the Z axis.

ψ = Azimuthal angle of $F_{\perp}$.

ϕ_o = Correction. This correction is a function of the Z axis position.

4. DATA EDIT ON 2250 DISPLAY AND PRINTING OF PAYLOAD DATA

XP, YP, and ZP for the file are stored in core so that these data can be displayed on the 2250 Display and edited (this feature is currently not implemented and is not included in the flow chart). These data can be printed if S_4 has been set to zero.

5. PAYLOAD COORDINATE STATISTICS

Next, sequence averages and variances can be computed for XP, YP, ZP, Total Field, α_p , ψ_p using the following formulas applied to the data from each telemetry sequence:

$$\overline{XP} = \frac{1}{n} \sum_{i=1}^n XP_i : \text{similar expressions for } \overline{YP} \text{ and } \overline{ZP} \quad (5.1)$$

$$\overline{TFP1} = \frac{1}{n} \sum_{i=1}^n (XP_i^2 + YP_i^2 + ZP_i^2)^{1/2}; \quad \overline{TFP2} = (\overline{XP^2} + \overline{YP^2} + \overline{ZP^2})^{1/2} \quad (5.2a,b)$$

$$\hat{\sigma}_{XP} = \left[\frac{1}{(n-1)} \sum_{i=1}^n (XP_i - \overline{XP})^2 \right]^{1/2} : \text{similar expressions for } \hat{\sigma}_{YP} \text{ and } \hat{\sigma}_{ZP} \quad (5.3)$$

$$\hat{\sigma}_{TFP2} = \left[\frac{1}{n-1} \sum_{i=1}^n (TFP_i - \overline{TFP2})^2 \right]^{1/2}; \quad \hat{\sigma}_{TFP1} = \frac{1}{3} (\hat{\sigma}_{XP} + \hat{\sigma}_{YP} + \hat{\sigma}_{ZP}) \quad (5.4a,b)$$

$$\overline{\alpha_p} = \tan^{-1} \left(\frac{\overline{ZP}}{\sqrt{\overline{XP^2} + \overline{YP^2}}} \right) \quad (5.5)$$

$$\bar{\psi}_p = \tan^{-1} \left(\frac{\bar{Y}_P}{\bar{X}_P} \right) \quad (5.6)$$

Component Ratio:

$$\text{CRATIO} = (\hat{\sigma}_{XP} + \hat{\sigma}_{YP} + \hat{\sigma}_{ZP}) / 3(\overline{\text{TFP2}}) \quad (5.7)$$

Total Field Ratio:

$$\text{TRATIO} = \hat{\sigma}_{\text{TFP1}} / \overline{\text{TFP1}} \quad (5.8)$$

Summations extend over the number of good data points in a sequence. If S_5 is set to zero printouts of payload sequence statistics will be produced otherwise no printout is produced.

If S_7 is set to zero plots of payload sequence statistics will be produced otherwise no plots are produced.

6. ROTATION TO SOLAR ECLIPTIC COORDINATES (PROCESS ONE FILE)

XP, YP, and ZP for the file are rotated to Solar Ecliptic Coordinates using the following rotation matrix. The derivation of this matrix is found in Appendix E.

$$\begin{bmatrix} \text{XSE} \\ \text{YSE} \\ \text{ZSE} \end{bmatrix} = \begin{bmatrix} \cos A & 0 & \sin A \\ -\sin A \sin D & \cos D & \cos A \sin D \\ -\sin A \cos D & -\sin D & \cos A \cos D \end{bmatrix} \begin{bmatrix} \text{XP} \\ \text{YP} \\ \text{ZP} \end{bmatrix}$$

To compute the matrix elements first compute the unit spin axis vector in Celestial Inertial Coordinates: (This computation has been performed in Section 1.)

$$\text{XCI} = \cos(\text{DECCI}) * \cos(\text{RACI})$$

$$\text{YCI} = \cos(\text{DECCI}) * \sin(\text{RACI})$$

$$\text{ZCI} = \sin(\text{DECCI})$$

Then rotate the spin axis to Solar Ecliptic coordinates:

$$\begin{bmatrix} \text{SESX} \\ \text{SESY} \\ \text{SESZ} \end{bmatrix} = \begin{bmatrix} \text{Rotation Matrix to go} \\ \text{from Celestial} \\ \text{Inertial to Solar} \\ \text{Ecliptic obtained from} \\ \text{Trajectory information on} \\ \text{Experimenter Tape} \end{bmatrix} \begin{bmatrix} \text{XCI} \\ \text{YCI} \\ \text{ZCI} \end{bmatrix}$$

Then compute:

$$\cos A = \left((\text{SESY})^2 + (\text{SESZ})^2 \right)^{1/2}$$

$$\sin A = \text{SESX}$$

$$\cos D = \text{SESZ} / \cos A$$

$$\sin D = \text{SESY} / \cos A$$

S_8 and S_{10} determine printout and plot status for SE values.

Sequence averages and variances can be computed for XSE, YSE, ZSE, Total Field, θ_{se} , ϕ_{se} , CRATIO, and TRATIO using an analogous set of formulas to the set given in Section 5. S_9 and S_{11} , determine printout, and plot status for sequence statistics.

7. ROTATION TO SOLAR MAGNETOSPHERIC

XSE, YSE, and ZSE which are still in core are next rotated to Solar Magnetospheric Coordinates using the following rotation matrix:

$$\begin{bmatrix} \text{XSM} \\ \text{YSM} \\ \text{ZSM} \end{bmatrix} = \begin{bmatrix} \text{Rotation Matrix to go from SE to} \\ \text{SM obtained from Trajectory} \\ \text{Information on the Experimenter Tape} \end{bmatrix} \begin{bmatrix} \text{XSE} \\ \text{YSE} \\ \text{ZSE} \end{bmatrix}$$

S_{13} and S_{15} determine printout and plot status of SM values.

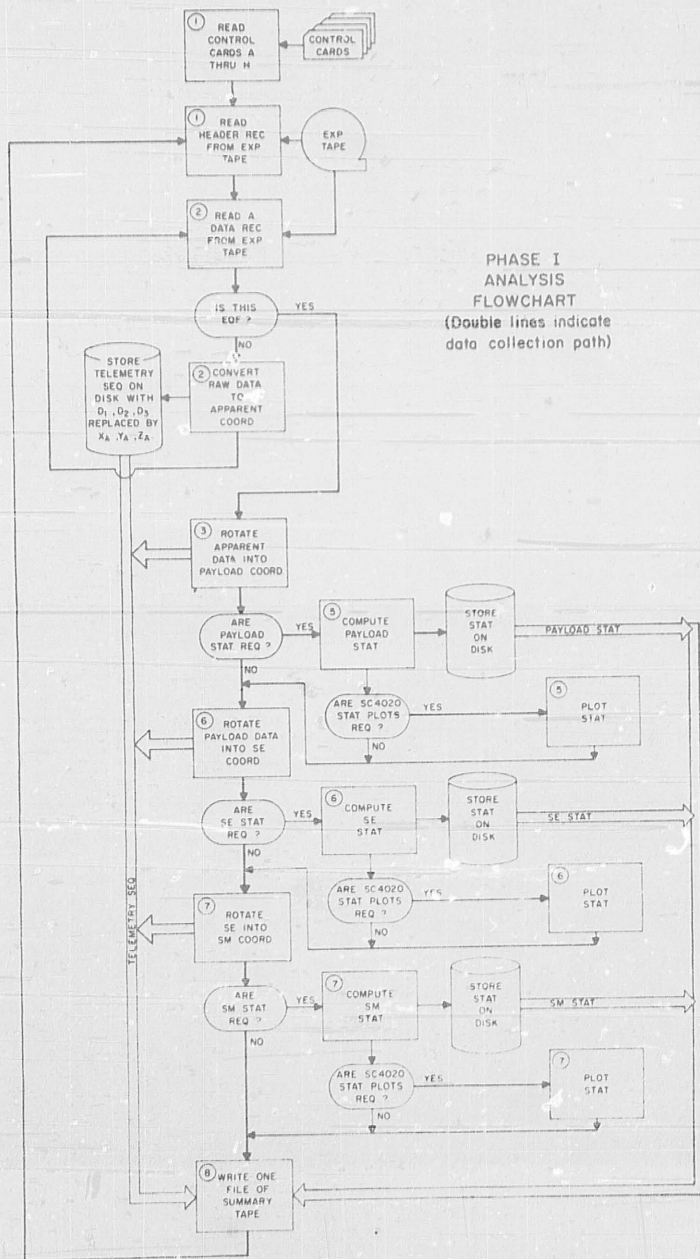
Sequence averages and variances are computed for XSM, YSM, ZSM, Total Field, θ_{sm} , ϕ_{sm} , CRATIO, and TRATIO using an analogous set of formulas to the set given in Section 5. S_{14} and S_{16} , determine printout, and plot status of SM sequence statistics.

8. GENERATION OF SUMMARY TAPE (PROCESS ONE FILE)

The Program now builds a summary tape record for each telemetry sequence which contains: (see Appendix C):

1. ID information.
2. The original telemetry sequence including the output from the autocorrelation computer with the exception that XA, YA, ZA has replaced D_1 , D_2 , D_3 .
3. The trajectory data for the sequence.
4. The Payload, SE, and SM detail data and statistics for the sequence and refined spin period.

There is one file of data on this Summary Tape for every file of data on the original experimenter tape and all overlapping data are still present. There is one set of Summary Tapes for each Experimenter Tape.



PART IV

REFERENCES

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3. IMP-F Time Correction & Decommutation System Volume I and II, Prepared for NASA Goddard Space Flight Center by Wolf Research and Development Corp., May 23, 1967.
4. Sos, John Y., F-9A Data Processing System Description, Greenbelt, Md., Goddard Space Flight Center, September 30, 1965.

APPENDIX A

DICTIONARY OF TERMS

1. S Switching Vector
2. XCI }
3. YCI } Spin axis unit vector in Celestial Inertial Coordinates
4. ZCI }
5. D₁ Detected output of X sensor
6. D₂ Detected output of Y sensor
7. D₃ Detected output of Z sensor
8. XA D₁ rotated into the standard rotating coordinate system
9. YA D₂ rotated into the standard rotating coordinate system
10. ZA D₃ rotated into the standard rotating coordinate system
11. XP XA in payload coordinates
12. YP YA in payload coordinates
13. ZP ZA in payload coordinates
14. AI Constant term of calibration coefficients
15. BI Linear term of calibration coefficients
16. CI Second degree term of calibration coefficients
17. ZDZ Correction to zero level
18. ZDS Z dependent zero level
19. γ_i $(t_i - t_{s/s}) / (\text{Refined Spin Period}) * 2\pi + \psi_0$

20. t_i Time for the orthogonal sample $D1_i, D2_i, D3_i$
21. $t_{s/s}$ Time the OA Sensor saw the sun
22. ψ_o The angular offset of sensor = -22.5°
23. $\overline{TFP1}, \overline{TFP2}$ Average total field in payload coordinates for a sequence
24. $\overline{\alpha_p}$ Average angle of field vector measured from Z axis for a sequence
25. $\overline{\psi_p}$ Average angle of field vector in X-Y plane for a sequence
26. $\hat{\sigma}_{XP}$ Variance of XP for a sequence
27. $\hat{\sigma}_{YP}$ Variance of YP for a sequence
28. $\hat{\sigma}_{ZP}$ Variance of ZP for a sequence
29. A See Appendix E
30. D See Appendix E
31. XSE XA in SE coordinates
32. YSE YA in SE coordinates
33. ZSE ZA in SE coordinates
34. RACI Rt. Ascension of spin axis in Celestial Interl Coordinates
35. DECCI Declination of spin axis in Celestial Interl Coordinates
36. $\overline{TFSE1}, \overline{TFSE2}$ Average total field in SE for a sequence
37. $\overline{\theta_{se}}$ Average angle of field vector measured from Z axis in SE for a sequence
38. $\overline{\phi_{se}}$ Average angle of field vector in X-Y plane in SE for a sequence
39. $\hat{\sigma}_{XSE}$ Variance of XSE for a sequence
40. $\hat{\sigma}_{YSE}$ Variance of YSE for a sequence

41. $\hat{\sigma}_{ZSE}$ Variance of ZSE for a sequence
42. XSM XA in SM coordinates
43. YSM YA in SM coordinates
44. ZSM ZA in SM coordinates
45. $\overline{TFSM1}, \overline{TFSM2}$ Average total field in SM for a sequence
46. $\overline{\theta}_{sm}$ Average angle of field vector measured from Z axis for a sequence
47. $\overline{\phi}_{sm}$ Average angle of field vector in X-Y plane for a sequence
48. $\hat{\sigma}_{XSM}$ Variance of XSM for a sequence
49. $\hat{\sigma}_{YSM}$ Variance of YSM for a sequence
50. $\hat{\sigma}_{ZSM}$ Variance of ZSM for a sequence

APPENDIX B

Card#	Fortran Format	Function
A	2 (A4)	Experimenter Tape# and Analysis Date
B	80 (I1)	Switching Vector (See rest of this Appendix for a functional breakdown.)
C	9 (F8.0)	Calibration Coefficients for low range
D	9 (F8.0)	Calibration Coefficients for high range
E	6 (F10.0)	Correction to zero and z dependent zero for low range
F	6 (F10.0)	Correction to zero and z dependent zero for high range
G	2 (I5)	File interval to be processed
H	2 (F10.0)	Right Ascension and Declination in Celestial Inertial Coordinates of the spin axis of the spacecraft

APPENDIX B (Cont.)

SWITCHING VECTOR CONTROL CARD B

Card Column & Subscript of s	State	Action
1	0	Reserved
	1	
2	0	Printout of the Detail Raw Data
	1	No Printout of Detail Raw Data
3	0	Printout of the Detail Apparent Field Values
	1	No Printout of Detail Apparent Field Values
4	0	Printout of the Detail Payload Field Values
	1	No Printout of Detail Payload Field Values
5	0	Printout of Sequence Statistics in Payload Coordinates
	1	No Printout
6	0	4020 Plots of Detail Payload Coordinates
	1	No Plots
7	0	4020 Plots of Sequence Statistics in Payload Coordinates
	1	No Plots
8	0	Printout of the Detail SE Field Values
	1	No Printout

Card Column & Subscript of s	State	Action
9	0	Printout of the SE Sequence Statistics
	1	No Printout
10	0	Reserved
	1	
11	0	4020 Plot of SE Sequence Statistics
	1	No Plot
12	0	Reserved
	1	
13	0	Printout of Detail SM Field Values
	1	No Printout
14	0	Printout of SM Sequence Statistics
	1	No Printout
15	0	Reserved
	1	
16	0	4020 Plot of SM Sequence Statistics
	1	No Plot
17	0	Reserved
	1	

Card Column & Subscript of s	State	Action
18	0	
	1	
19	0	
	1	
20	0	
	1	
21	0	
	1	
22	0	
	1	
23	0	
	1	
24	0	
	1	
25*	0	RACI, DECCI To Be Used
	1	RACI, DECCI Are Not To Be Used
26	0	
	1	

*S₂₅ must be set equal to zero if rotation to SE and/or SM is desired.

APPENDIX C

IMP F EXPERIMENTER BINARY TAPE ID RECORD FORMAT

<u>Word No.</u>	<u>Identification</u>	<u>Format</u>
1	Experimenter ID	I
2	Satellite ID	I
3	Orbit number	I
4	Telemetry Recording Station Number	I
5	Analog tape number	I
6	Analog-to-digital line ID	I
7	Day of Year	I
8	Milliseconds of Day	I
9	Day of Year	I
10	Milliseconds of Day	I
11	Average sequence time (milliseconds) for this file	I
12	Quick look data flag	I
13	Orbit/no orbit data flag	I
14	Decom process date year	I
15	Decom process date month	I
16	Decom process date day	I
17	Decom process date hour	I
18	Orbit tape ID reel number	I
19	Orbit tape date of generation year	I
20	Orbit tape date of generation month	I
21	Orbit tape date of generation day	I
22	Average spin period in milliseconds	I
23	Year of start time of file	
24	Year of stop time of file	
25 - 40	Room for expansion	

Orbit/No Orbit Data Flag for Experimenter Tape ID Records

- 0 = no orbit data included on this file. Fill characters are used in orbit item locations.
- 1 = "final" orbit data included on this file.
- 2 = preliminary orbit data included on this file.
- 3 = predicted orbit data included on this file.

Quick-Look Data Flag for Experimenter Tape ID Records

- 0 = no sequence clock corrections, no frame time corrections

- applied to this file, there data is "quick-look".
- 1 = Phase I sequence clock corrections and frame time corrections have been applied to this file, but final correction have not been made, therefore, data is "quick-look".
 - 2 = Phase I and Phase II sequence and frame time corrections have been made to data on this file.

Sequence Data Quality Flag

The F9 program uses the computed signal-to-noise ratio to determine the probability of error per sequence. The sequence data quality flags on F9 digitized intermediate data tapes have these meanings:

Flag	Data Quality
0	Probability of one or more errors in each 100 samples, category 1.
1	Probability of one or more errors in each 100 samples, category 2.
2	Probability of one or more errors in each 100 samples, category 3.
3	Probability of one or more errors in each 330 samples.
4	Probability of one or more errors in each 500 samples.
5	Probability of one or more errors in each 1000 samples.
6	(fill character) Data quality is undetermined for this partial sequence.

Data quality flags on a sequence basis are computed by the F8 processing program. From the number of errors in the satellite clock and in the sync oscillator, an assumption is made about the quality of the entire sequence. The F8 assigned sequence quality flags have these meanings:

Flag	Data Quality
0	Undetermined
1	Poor quality
2	Fair quality
3	Good Quality
6	Fill character, undetermined data quality

APPENDIX C (Cont.)

MAGNETIC FIELD IMP F EXPERIMENTER TAPE FORMAT

<u>Item No.</u>	<u>Identification</u>	<u>Fortran Name</u>	<u>Format</u>
1	Satellite I.D.	ID(I)	I
2	Acquisition station I.D.	IDAS(I)	I
3	Analog tape I.D.	IDAT(I)	I
4	Analog-to-digital line indicator	IDAL(I)	I
5	Year of frame 0, channel 0	IYR(I)	I
6	Day of frame 0, channel 0	INTDAY(I)	I
7	Milliseconds of day	MSEC(I)	I
8	Time quality flag	ITQF(I)	I
9	Data quality flag for this sequence	IDQF(I)	I
10	Experimenter on/off flags (frame 4, channel 2)	IXF(I)	I
11	Orbit data flag	IODF(I)	I
12	Analog calibration flag (channel 1, frame 4)	IACF(I)	I
13	Pseudo-sequence count quality flag	IPSQF(I)	I
14	Pseudo-sequence count	IPSC(I)	I
15	Sequence I.D. quality flag	IDSQF(I)	I
16	Sequence I.D.	IDS(I)	I
17	Satellite clock	ISC(I)	I
18	Average frame time in milliseconds	IAFP(I)	I

<u>Item No.</u>	<u>Identification</u>	<u>Fortran Name</u>	<u>Format</u>
19	PP 21 (Bellows temperature)	PP21(I)	F
20	PP 7 (+11.7 volt line)	PP7(I)	F
21	Frame number (1)	NF (I,J)	I
22	Mag X	D1(I,J)	I
23	Mag Y	D2(I,J)	I
24	Mag Z	D3 (I,J)	I
25	Frame number (3)		I
26	Mag X		I
27	Mag Y		I
28	Mag Z		I
29-52	Magnetometer values for frames 5, 7, 9, 11, 13, and 15 (items 25-28 repeated six times)		
53	Frame 8, channel 1a, 1b, 2a	IAVG(I)	I
54	Frame 8, channel 2b	L8EX(I)	I
55	Frame 8, channel 3a, 3b	L8FR(I)	I
56	Frame 8, channel 4a	L7EX(I)	I
57	Frame 8, channel 4b, 5a	L7FR(I)	I
58	Frame 8, channel 5b	L6EX(I)	I
59	Frame 8, channel 6a, 6b	L6FR(I)	I
60	Frame 8, channel 7a	L5EX(I)	I
61	Frame 8, channel 7b, 8a	L5FR(I)	I

<u>Item No.</u>	<u>Identification</u>	<u>Fortran Name</u>	<u>Format</u>
62	Frame 8, channel 8b	L4EX(I)	I
63	Frame 8, channel 9a, 9b	L4FR(I)	I
64	Frame 8, channel 10a	L3EX(I)	I
65	Frame 8, channel 10b, 11a	L3FR(I)	I
66	Frame 8, channel 11b	L2EX(I)	I
67	Frame 8, channel 12a, 12b	L2FR(I)	I
68	Frame 8, channel 13a	L1EX(I)	I
69	Frame 8, channel 13b, 14a	L1FR(I)	I
70	Frame 8, channel 14b	LZEX(I)	I
71	Frame 8, channel 15a, 15b	LZFR(I)	I
72	OA SCAN (spin-axis-sun-angle)	OAS(I)	F
73	OA1 (sun time)	TSS(I)	F
74	OA2 (spin period)	SPIN(I)	F
75	OA3 (earth time)	ET(I)	F
76	OA4 (earth width)	EW(I)	F
77-228	Data from two more telemetry sequences (items 1-76 repeated twice)		
229	Day or orbit data	JDOD	I
230	Milliseconds of day of orbit data	JSEC	I
231	Geomagnetic latitude satellite position	TRAJ(N),	F
232	Geomagnetic longitude satellite position	N = 1, 43	F

<u>Item No.</u>	<u>Identification</u>	<u>Fortran Name</u>	<u>Format</u>
233	X solar ecliptic satellite position		F
234	Y solar ecliptic satellite position		F
235	Z solar ecliptic satellite position		F
236	Radial distance to satellite from earth center		F
237	X solar magnetosphere satellite position		F
238	Y solar magnetosphere satellite position		F
239	Z solar magnetosphere satellite position		F
240	X solar ecliptic moon position		F
241	Y solar ecliptic moon position		F
242	Z solar ecliptic moon position		F
243	X solar magnetosphere moon position		F
244	Y solar magnetosphere moon position		F
245	Z solar magnetosphere moon position		F
246	Distance from satellite to moon		F
247	Distance from satellite to the moon which is parallel to the X axis		F
248	Geomagnetic latitude sun position		F
249	Geomagnetic longitude sun position		F
250	X theoretical geomagnetic field in <u>solar ecliptic</u>		F
251	Y theoretical geomagnetic field in <u>solar ecliptic</u>		F

<u>Item No.</u>	<u>Identification</u>	<u>Fortran Name</u>	<u>Format</u>
252	Z theoretical geomagnetic field in <u>solar ecliptic</u>		F
253	Magnitude of the theoretical geomagnetic field in <u>solar ecliptic</u>		F
254-262	Rotation matrix from solar ecliptic to solar magnetospheric		F
263-271	Rotation matrix from celestial inertial to solar ecliptic		F
272	Geocentric latitude satellite position		F
273	Geocentric longitude satellite position		F

This is a seven-track, 556 BPI, binary mode tape. All items (both integer and floating) are 32-bit, IBM 360 notation words. One four-byte control word (which gives the number of bytes in the logical record) is at the beginning of each record. Missing data is indicated by having all bits except sign bit set to "1".

APPENDIX C (Cont.)

IMP F SUMMARY TAPE FORMAT

<u>Item No.</u>	<u>Identification</u>	<u>Format</u>
1	Satellite I. D.	I
2	Orbit Number	I
3	Telemetry Recording Station Number	I
4	Analog Tape Number	I
5	Analog-To-Digital Line I. D.	I
6	Day of Year (Start)	I
7	Milliseconds of Day	I
8	Day of Year (Stop)	I
9	Milliseconds of Day	I
10	Average Sequence Time (Milliseconds) This File	I
11	Quick Look Data Flag	I
12	Orbit/No Orbit Data Flag	I
13	Decom Process Date Year	I
14	Decom Process Date Month	I
15	Decom Process Date Day	I
16	Decom Process Date Hour	I
17	Orbit Tape I. D. Reel Number	I
18	Orbit Tape Date of Generation Year	I
19	Orbit Tape Date of Generation Month	I

<u>Item No.</u>	<u>Identification</u>	<u>Format</u>
20	Orbit Tape Date of Generation Day	I
21	Average Spin Period in Milliseconds	I
22	Year of Start Time	I
23	Year of Stop Time	I
24	Experimenter Tape Number	A4
25	Analysis Date	A4
26	Year of Frame 0, Channel 0	I
27	Day of Frame 0, Channel 0 (Decimal Day)	I
28	Milliseconds of Day	I
29	Time Quality Flag	I
30	Data Quality Flag for this Sequence	I
31	Experimenter On/Off Flags (Frame 4, Channel 2)	I
32	Orbit Data Flag	I
33	Analog Calibration Flag (Channel 1, Frame 4)	I
34	Pseudo-Sequence Count Quality Flag	I
35	Pseudo-Sequence Count	I
36	Sequence I. D. Quality Flag	I
37	Sequence I. D.	I
38	Satellite Clock	I
39	Average Frame Time in Milliseconds	I
40	PP21 (Bellows Temperature)	I

<u>Item No.</u>	<u>Identification</u>	<u>Format</u>
41	PP7 (+11.7 Volt Line)	I
42	Frame Number (1)	I
43	X Apparent	F
44	Y Apparent	F
45	Z Apparent	F
46	Frame Number (3)	I
47	X Apparent	F
48	Y Apparent	F
49	Z Apparent	F
50	Frame Number (5)	I
51	X Apparent	F
52	Y Apparent	F
53	Z Apparent	F
54	Frame Number (7)	I
55	X Apparent	F
56	Y Apparent	F
57	Z Apparent	F
58	Frame Number (9)	I
59	X Apparent	F
60	Y Apparent	F
61	Z Apparent	F

<u>Item No.</u>	<u>Identification</u>	<u>Format</u>
62	Frame Number (11)	I
63	X Apparent	F
64	Y Apparent	F
65	Z Apparent	F
66	Frame Number (13)	I
67	X Apparent	F
68	Y Apparent	F
69	Z Apparent	F
70	Frame Number (15)	I
71	X Apparent	F
72	Y Apparent	F
73	Z Apparent	F
74	Frame 8, Channel 1a, 1b, 2a	I
75	Frame 8, Channel 2b	I
76	Frame 8, Channel 3a, 3b	I
77	Frame 8, Channel 4a	I
78	Frame 8, Channel 4b, 5a	I
79	Frame 8, Channel 5b	I
80	Frame 8, Channel 6a, 6b	I
81	Frame 8, Channel 7a	I
82	Frame 8, Channel 7b, 8a	I

<u>Item No.</u>	<u>Identification</u>	<u>Format</u>
83	Frame 8, Channel 8b	I
84	Frame 8, Channel 9a, 9b	I
85	Frame 8, Channel 10a	I
86	Frame 8, Channel 10b, 11a	I
87	Frame 8, Channel 11b	I
88	Frame 8, Channel 12a, 12b	I
89	Frame 8, Channel 13a	I
90	Frame 8, Channel 13b, 14a	I
91	Frame 8, Channel 14b	I
92	Frame 8, Channel 15a, 15b	I
93	0A SCAN (Spin-Axis-Sun-Angle)	F
94	0A1 (Sun Time)	F
95	0A2 (Spin Period)	F
96	0A3 (Earth Time)	F
97	0A4 (Earth Width)	F
98	Day of Orbit Data	I
99	Milliseconds of Day of Orbit Data	I
100 - 142	Items 231-273 (Trajectory Data) from IMP F Experimenter Tape Format	F
143	X Payload	F
144	Y Payload	F
145	Z Payload	F

<u>Item No.</u>	<u>Identification</u>	<u>Format</u>
146	ALPHA Payload	F
147	PSI Payload	F
148	Total Field Payload	F
191	X Average Payload	F
192	Y Average Payload	F
193	Z Average Payload	F
194	TOTAL FIELD AVERAGE 1 Payload	F
195	TOTAL FIELD AVERAGE 2 Payload	F
196	ALPHA Average Payload	F
197	PSI Average Payload	F
198	Standard Deviation of X Payload	F
199	Standard Deviation of Y Payload	F
200	Standard Deviation of Z Payload	F
201	Standard Deviation of Total Field 1 Payload	F
202	Standard Deviation of Total Field 2 Payload	F
203	Component Ratio Payload	F
204	Total Field Ratio Payload	F
205	X Solar Ecliptic	F
206	Y Solar Ecliptic	F
207	Z Solar Ecliptic	F
208	THETA Solar Ecliptic	F
209	PHI Solar Ecliptic	F

<u>Item No.</u>	<u>Identification</u>	<u>Format</u>
245	X Average Solar Ecliptic	F
246	Y Average Solar Ecliptic	F
247	Z Average Solar Ecliptic	F
248	THETA Average Solar Ecliptic	F
249	PHI Average Solar Ecliptic	F
250	Standard Deviation of X Solar Ecliptic	F
251	Standard Deviation of Y Solar Ecliptic	F
252	Standard Deviation of Z Solar Ecliptic	F
253	Component Ratio Solar Ecliptic	F
254	Total Field Ratio Solar Ecliptic	F
255	X Solar Magnetospheric	F
256	Y Solar Magnetospheric	F
257	Z Solar Magnetospheric	F
258	THETA Solar Magnetospheric	F
259	PHI Solar Magnetospheric	F
295	X Average Solar Magnetospheric	F
296	Y Average Solar Magnetospheric	F
297	Z Average Solar Magnetospheric	F
298	THETA Average Solar Magnetospheric	F
299	PHI Average Solar Magnetospheric	F
300	Standard Deviation of X Solar Magnetospheric	F

For Frames
1, 3, 5, 7, 9, 11, 13, 15

<u>Item No.</u>	<u>Identification</u>	<u>Format</u>
301	Standard Deviation of Y Solar Magnetospheric	F
302	Standard Deviation of Z Solar Magnetospheric	F
303	Component Ratio Solar Magnetospheric	F
304	Total Field Ratio Solar Magnetospheric	F
305	Celestial Inertial Orientation of Spin Axis for X	F
306	Celestial Inertial Orientation of Spin Axis for Y	F
307	Celestial Inertial Orientation of Spin Axis for Z	F

End of tape is indicated by an EOF mark. Files are not separated by any logical type of EOF record. This is a 9 track IBM 360 binary tape (999.0 indicates bad data). All words are single precision (i.e. 4 bytes in length).

APPENDIX D

TRANSFORMATION TO PAYLOAD COORDINATES

A top view of the spacecraft with the three sensors is shown in Figure 1. Note that the $+Z_A$ direction points into the page* and $+X_A$ is tangential to the spin axis. Y_A forms a right hand coordinate system.

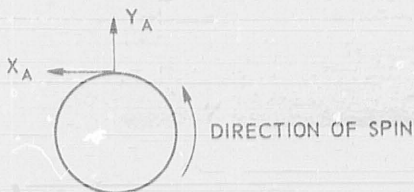


Figure 1.

Figure 2, in perspective, shows the situation when Figure 1 is turned over so that the $+Z$ direction is up.

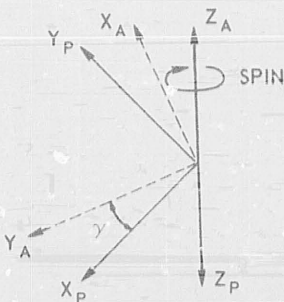


Figure 2.

Let the dotted coordinate system be the apparent coordinate system at a measurement time, t_i . Let the solid line coordinate system represent payload coordinates, (the $+X_P$ axis of which points toward the sun) thus X_P defines $t_{s/s}$, the time the optical aspect sensor saw the sun. Gamma, γ , is the angle swept out from $t_{s/s}$ to t_i by the spinning spacecraft minus 22.5° (Sun sensor-boom separation).

*This is referred to as "down" position.

Thus we get:

$$X_P = Y_A \cos \gamma - X_A \sin \gamma$$

$$Y_P = Y_A \sin \gamma + X_A \cos \gamma$$

$$Z_P = -Z_A$$

or

$$\begin{bmatrix} X_P \\ Y_P \\ Z_P \end{bmatrix} = \begin{bmatrix} -\sin \gamma & \cos \gamma & 0 \\ \cos \gamma & \sin \gamma & 0 \\ 0 & 0 & -1 \end{bmatrix} \begin{bmatrix} X_A \\ Y_A \\ Z_A \end{bmatrix}$$

APPENDIX E

TRANSFORMATION TO SOLAR ECLIPTIC COORDINATES

The solar ecliptic coordinates of the unit spin axis are defined as EPX EPY and EPZ. Now compute the following angles (see Figure 1).

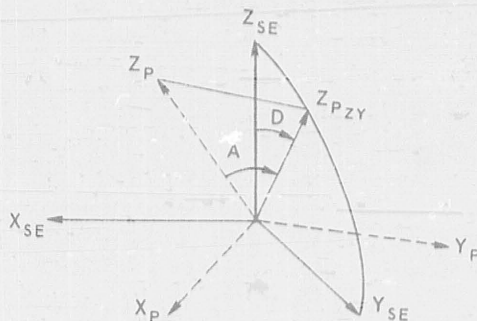


Figure 1.

$$\cos A = \frac{|\vec{Z}_{PZY}|}{Z_P} = \frac{\sqrt{(EPY)^2 + (EPZ)^2}}{\sqrt{(EPX)^2 + (EPY)^2 + (EPZ)^2}}$$

or

$$\cos A = \frac{\sqrt{(EPY)^2 + (EPZ)^2}}{\sqrt{(EPX)^2 + (EPY)^2 + (EPZ)^2}}$$

$$\sin A = \frac{EPX}{\sqrt{(EPX)^2 + (EPY)^2 + (EPZ)^2}} = \frac{EPX}{\sqrt{(EPX)^2 + (EPY)^2 + (EPZ)^2}}$$

$$\cos D = \frac{EPZ}{\sqrt{(EPY)^2 + (EPZ)^2}} \quad \text{or} \quad \cos D = \frac{EPZ}{\cos A}$$

$$\sin D = EPY / \cos A$$

If we rotate X_P into X_{SE} , Z_P must then be perpendicular to X_{SE} and consequently must lie in the $Z_{SE} - Y_{SE}$ plane: thus rotate through angle A , about Y_P axis (Z_P would then lie along Z_{PZY}). Call the new coordinates after this rotation X' , Y' , Z' . (See Figure 2.)

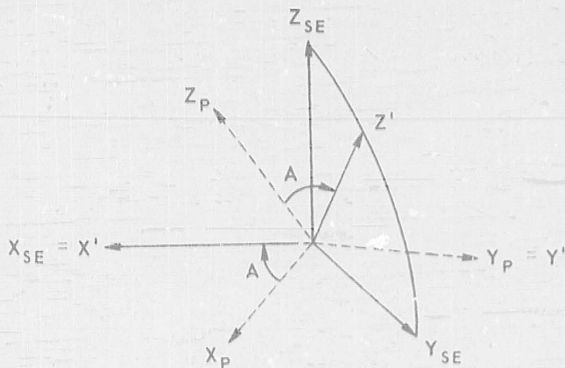


Figure 2.

$$X' = X_P \cos A + Z_P \sin A$$

$$Y' = Y_P$$

$$Z' = -X_P \sin A + Z_P \cos A$$

or

$$\begin{bmatrix} X' \\ Y' \\ Z' \end{bmatrix} = \begin{bmatrix} \cos A & 0 & \sin A \\ 0 & 1 & 0 \\ -\sin A & 0 & \cos A \end{bmatrix} \begin{bmatrix} X_P \\ Y_P \\ Z_P \end{bmatrix}$$

Then rotate about $X' = X_{SE}$ axis to get Y' into Y_{SE} and Z' into Z_{SE} . (See Figure 3.)

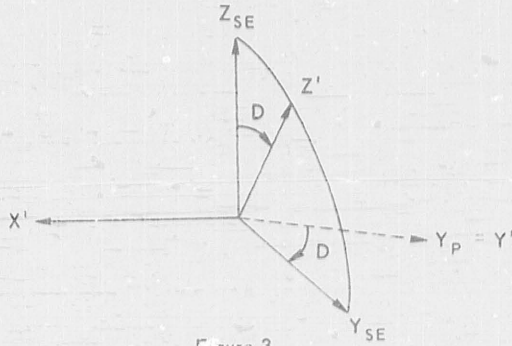


Figure 3.

$$X_{SE} = X'$$

$$Y_{SE} = Y' \cos D + Z' \sin D$$

$$Z_{SE} = -Y' \sin D + Z' \cos D$$

or

$$\begin{bmatrix} X_{SE} \\ Y_{SE} \\ Z_{SE} \end{bmatrix} = \begin{bmatrix} 1 & 0 & 0 \\ 0 & \cos D & \sin D \\ 0 & -\sin D & \cos D \end{bmatrix} \begin{bmatrix} X' \\ Y' \\ Z' \end{bmatrix}$$

Hence

$$\begin{bmatrix} X_{SE} \\ Y_{SE} \\ Z_{SE} \end{bmatrix} = \begin{bmatrix} 1 & 0 & 0 \\ 0 & \cos D & \sin D \\ 0 & -\sin D & \cos D \end{bmatrix} \begin{bmatrix} \cos A & 0 & \sin A \\ 0 & 1 & 0 \\ -\sin A & 0 & \cos A \end{bmatrix} \begin{bmatrix} X_P \\ Y_P \\ Z_P \end{bmatrix}$$

or

$$\begin{bmatrix} X_{SE} \\ Y_{SE} \\ Z_{SE} \end{bmatrix} = \begin{bmatrix} \cos A & 0 & \sin A \\ -\sin A \sin D & \cos D & \cos A \sin D \\ -\sin A \cos D & -\sin D & \cos A \cos D \end{bmatrix} \begin{bmatrix} X_P \\ Y_P \\ Z_P \end{bmatrix}$$

APPENDIX F

DESCRIPTION OF SC 4020 SEQUENCE STATISTICS

PLOTS

The sequence statistics plotting routine plots the following parameters as a function of time for the Payload, SE and SM coordinate systems.

1. Total field
 - a. Actual (TF1)
 - b. Theoretical
2. ϕ ($0 - 360^\circ$)
 - a. Actual
 - b. Theoretical
3. θ ($\pm 90^\circ$)
 - a. Actual
 - b. Theoretical
4. Standard deviation Z computed by the autocorrelation computer.
5. Standard deviation of the actual field, $\frac{1}{3} (\hat{\sigma}_x + \hat{\sigma}_y + \hat{\sigma}_z)$.

Each frame of the plot displays 6 hours of data beginning at 0, 6, 12, or 18 hours in two 3 hour sweeps across the frame. If trajectory information is on the experimenter tape it is displayed every hour in the proper coordinate system in units of R_E . The following characters are used to indicate folding of scales:

Parameter, P	Range of P	Characters
Total Field (Actual)	$0 \leq P < 25$	•
	$25 \leq P < 50$	A

Parameter, P	Range of P	Characters
	$50 \leq P < 75$	B
	$75 \leq P < 100$	C
	$100 \leq P < 125$	D
	$125 \leq P < 150$	E
	$P \geq 150$	F
Total Field (Theoretical)	$0 \leq P < 25$	U
	$25 \leq P < 50$	V
	$50 \leq P < 75$	W
	$75 \leq P < 100$	X
	$100 \leq P < 125$	Y
	$125 \leq P < 150$	Z
ϕ (Actual)	$0 \leq P < 360$	•
ϕ (Theoretical)	$0 \leq P < 360$	T
θ (Actual)	$-90 \leq P \leq +90$	•
θ (Theoretical)	$-90 \leq P \leq +90$	T
Standard deviations of 2.556 sec. and 0.080 sec. samples computed over a 20.454 sec. sequence	$0 \leq P < 5$	•
	$5 \leq P < 10$	A
	$10 \leq P < 7.2 \times 10^{75}$	B
$\log_{10} \left(\frac{SD_{0.080}}{SD_{2.556}} \right)$	$-0.60206 \leq P \leq 0.60206$	G
Special Characters	Saturation	S
	Addition of 10γ Calibration Field	K
	Heater On	H

APPENDIX F (Cont.)

SUBROUTINE PLOT

I. INTRODUCTION

This subroutine is used to plot the 20.45 second sequence statistics using the SC 4020 plotter. Specifically the following parameters are plotted:

1. Total field, F (actual sequence average, TF1)
2. Total field, F (theoretical)
3. Azimuthal angle, ϕ (actual sequence average)
4. Azimuthal angle, ϕ (theoretical)
5. Polar angle, θ (actual sequence average)
6. Polar angle, θ (theoretical)
7. Standard deviation of Z component of field for the sequence computed by the autocorrelation computer.
8. Standard deviation of total field (actual for the sequence).

$$\frac{1}{3} (\hat{\sigma}_x^2 + \hat{\sigma}_y^2 + \hat{\sigma}_z^2) .$$

The Plot Subroutine is designed to plot one file of statistics which have been computed by the Statistics Subroutine (approximately 2 hours of data) each time it is entered such that each frame displays 6 hours of data beginning at 0, 6, 12, or 18 hours in two 3-hour sweeps across the frame.

Each frame is labeled with the following information:

1. Coordinate System (Payload, SE, SM)
2. Orbit Number
3. Decimal Day of Year and 3 Hour Periods Covered
4. Experimenter Tape Number
5. Analysis Date

6. Trajectory Flag
7. Trajectory Data in the Appropriate Coordinate System (if this is production data, i.e., there is no trajectory information included with quick-look data.)
8. Saturation of Sensors When It Occurs
9. Addition of 10 γ Calibration Field When It Occurs
10. Heater On When It Occurs

II. DESCRIPTION OF PROCESSING

The Subroutine, using the time array for the file, i.e., times for channel zero frame zero of each sequence, operates on the corresponding data array from each Decimal Day separately.* During each Decimal Day the time array is searched in 3-hour sweeps starting at 0, 3, 6, 9, 12, 15, 18 and 21 hours for time (and thus data) falling in these three hour time intervals. When data is found in a specific interval the indices IB and IE are used to indicate the point in the data array where plotting should begin and end respectively, for this particular 3-hour interval. After IB and IE are defined, but before the data are plotted, the routine determines if the SC 4020 frame should be advanced and a new grid drawn. This will be necessary if the data to be plotted occurs in a three hour interval which starts at 0, 6, 12, or 18 hours, otherwise it is unnecessary to generate a new grid. Frame advance and grid construction are done with the GRD Subroutine. The Plot Subroutine now uses IB and IE to set the limits for the DO LOOP which plots the following data from each sequence during this three hour time interval.

1. Computed first is the value for the abscissa which represents the sequence time normalized to the three hour interval.
2. If there is trajectory data on the tape the theoretical magnetic field values are plotted as a function of time every 50 sequences, i.e., F , ϕ , and θ . In the appropriate coordinate system with the exception that the theoretical field is presented in SE Coordinates on the Payload Coordinate plots.
3. The actual total field sequence average, F , ϕ average, θ average, standard deviation computed by the autocorrelation computer for the

*In a two hour file it is only possible to have data from two different Decimal Days.

sequence and the standard deviation computed from the detail data for the sequence are plotted as a function of time.

In addition:

1. Every hour the appropriate trajectory data for the coordinate system are printed out.
 - a) X
 - b) Y
 - c) Z
 - d) Radial distance to satellite from Earth center
 - e) Geomagnetic latitude of Sun position
 - f) Longitude of satellite position
 - g) Latitude of satellite position
 - h) Distance of satellite from Earth-Sun line
2. The abscissa is labeled with the three hour period being plotted.

APPENDIX G

IMP-F MAGNETIC FIELD EXPERIMENT CALIBRATION

Spacecraft: IMP-F Proto-flight Date: 4/27/67 & 4/28/67 Magnetometer Serial Number: 06.

Linearity Calibration

Low Range				High Range			
Field γ	Counts (118.0)			Field γ	Counts (120.6)		
	X (2.52)	Y (2.28)	Z (2.53)		X (2.49)	Y (2.47)	Z (2.49)
0	117.7	129.8	118.3	0	120.8	122.0	121.0
5	102.3	115.1	102.2	20	104.8	106.0	104.6
10	086.1	100.7	086.8	40	088.1	090.0	088.8
15	070.8	086.1	070.2	60	072.1	074.0	072.3
20	055.6	072.0	055.0	80	056.0	058.2	055.6
25	039.8	057.8	039.1	100	040.0	042.8	039.2
30	024.1	043.8	023.5	120	023.7	027.1	021.7
35	018.0	030.0	018.0	140	018.0	018.0	018.0
0	118.1	129.8	118.2	0	121.0	121.8	121.0
-5	133.7	144.1	133.8	-20	137.0	137.1	137.0
-10	149.0	158.1	149.8	-40	152.8	152.8	153.0
-15	164.1	171.6	165.0	-60	168.0	168.0	169.0
-20	179.2	185.6	180.3	-80	184.0	183.1	184.8
-25	194.1	198.1	195.2	-100	199.3	198.1	200.7
-30	209.0	211.0	210.1	-120	215.0	213.0	216.0
-35	223.0	223.1	223.7	-140	230.0	227.1	231.0

After Deperm:

$$\left. \begin{array}{l} X_o = 2.57(116.6) \\ Y_o = 2.46(123.3) \end{array} \right\} \text{final zeros}$$

After Deperm:

$$\left. \begin{array}{l} X_o = 2.50(120.0) \\ Y_o = 2.52(119.0) \end{array} \right\} \text{final zeros}$$

IMP-F MAGNETIC FIELD EXPERIMENT CALIBRATION

Spacecraft: IMP-F Proto-flight Post Thermal-vacuum Date: 3/21/67 & 3/22/67
Magnetometer Serial Number: 06

New Booms Linearity Calibration

Low Range				High Range			
Field	Counts			Field	Counts		
γ	X (2.44)	Y (2.56)	Z (2.57)	γ	Y (2.46)	Y (2.55)	Z (2.49)
0	120.7	119.0	114.8	0	121.0	118.2	120.7
5	106.3	104.8	099.7	20	105.0	103.0	104.2
10	091.8	090.3	084.1	40	089.0	087.0	088.0
15	075.7	076.0	069.0	60	073.0	071.7	072.0
20	060.0	062.6	053.1	80	057.0	056.0	055.7
25	045.7	049.0	038.1	100	041.0	040.2	039.0
30	030.8	036.0	022.7	120	025.0	025.0	023.0
35	017.8	023.1	017.5	140	018.0	017.7	017.8
0	120.8	118.8	115.1	0	121.6	118.8	120.7
-5	136.5	133.0	130.8	-20	137.0	134.1	136.8
-10	152.1	147.0	146.0	-40	153.0	149.7	152.6
-15	165.7	160.7	161.1	-60	168.2	165.0	168.2
-20	180.3	174.0	176.0	-80	184.1	180.0	184.0
-25	194.7	186.8	190.6	-100	199.0	194.8	199.7
-30	209.5	199.0	204.8	-120	214.2	209.0	214.8
-35	223.6	211.0	218.8	-140	229.1	223.0	229.3

EXPERIMENTER FLAGS

Bit	Function	Definition
2^5	Heater	On = 1
2^4	Power	On = 1
2^3	Calibrate	On = 1
2^2	Mag. Down	Down = 0
2^1	Mag. Up	Up = 0
2^0	Range	Low = 1; High = 0

The Experimenter Flags appear in word 10 on the Magnetic Field Experimenter Tape as the six low order bits of this 32 bit word.

APPENDIX H

CHARACTERISTICS OF THE IMP F SPACECRAFT AND MAGNETIC FIELD EXPERIMENT THAT SHOULD BE CONSIDERED IN SUBSEQUENT ANALYSIS

I. Telemetry Rates

<u>Parameter</u>	<u>Value</u>
A. Sequence Period	20.454 sec.
B. Frame Period	1.278 sec.
C. Channel Period	.080 sec.

II. Spacecraft

- | | |
|--------------------------|---------------------|
| A. Spin Period | 2.580 - 2.612* sec. |
| B. Spin Axis Orientation | (See Figure 1) |

III. Characteristics of the Detail Vector Measurements Transmitted in the Odd Numbered Frames

A. Quantization

- | | |
|---------------|--|
| 1. Low Range | $64 \gamma / 200 \text{ counts} = 0.32 \gamma / \text{count}$ |
| 2. High Range | $256 \gamma / 200 \text{ counts} = 1.28 \gamma / \text{count}$ |

B. Folding Frequency for Spectrum Analysis

- i. Sampling rate is one vector measurement every two frames of telemetry, or 1 sample/2.556 sec. which gives rise to a folding frequency of approximately 0.2 cycles/sec.

* Change observed from Orbit 1 through Orbit 17. Spin period will always be a function of time and larger variations than this can be expected.

SPIN AXIS ORIENTATION IMP-F

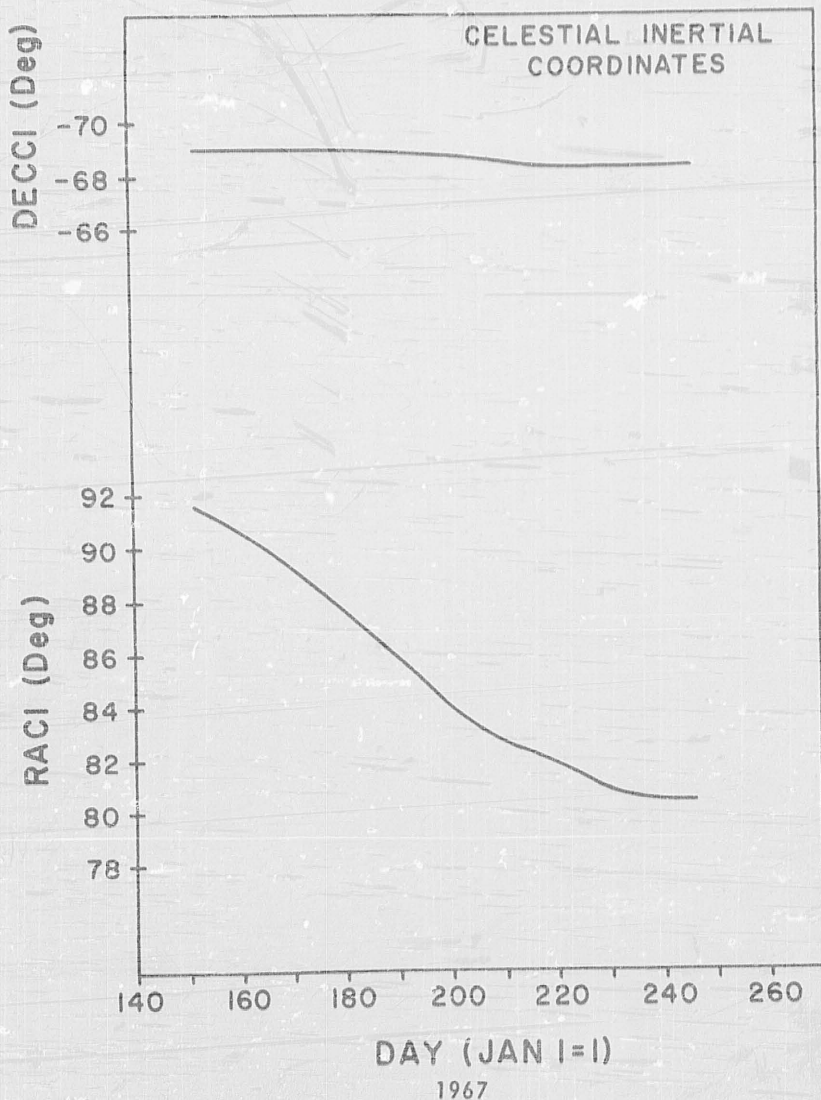


Figure 1

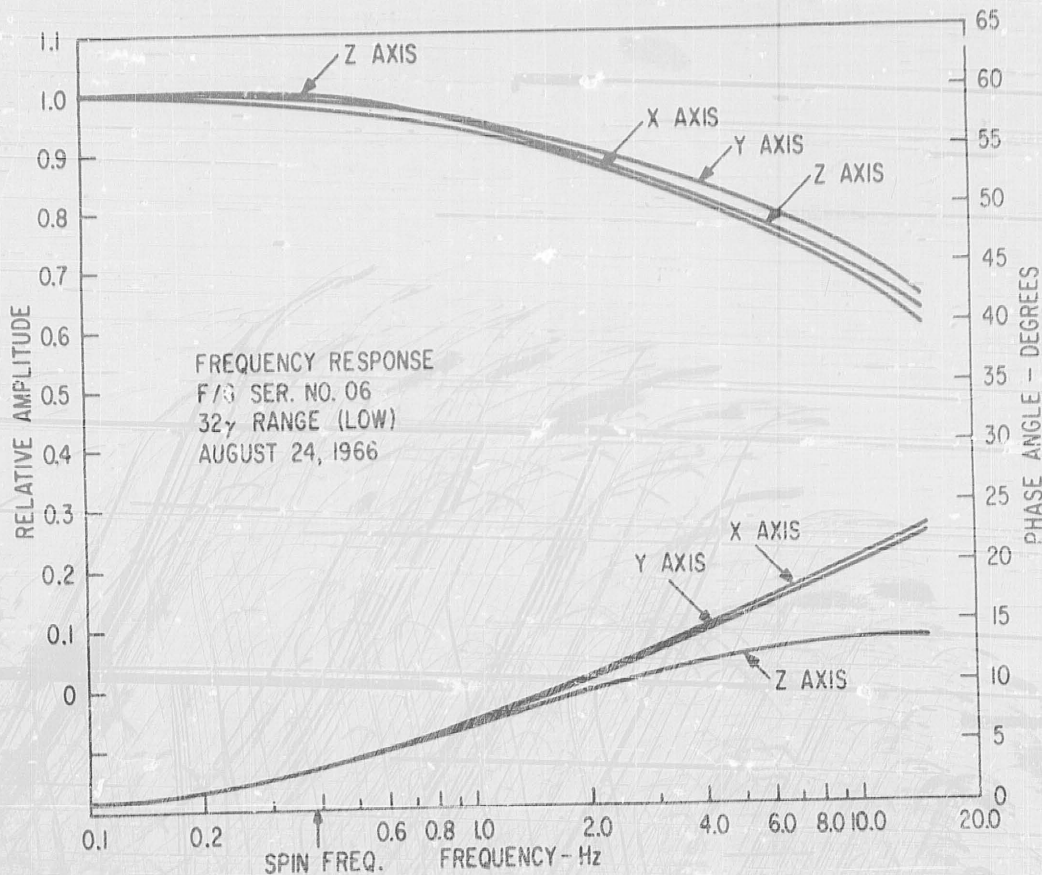


Figure 2

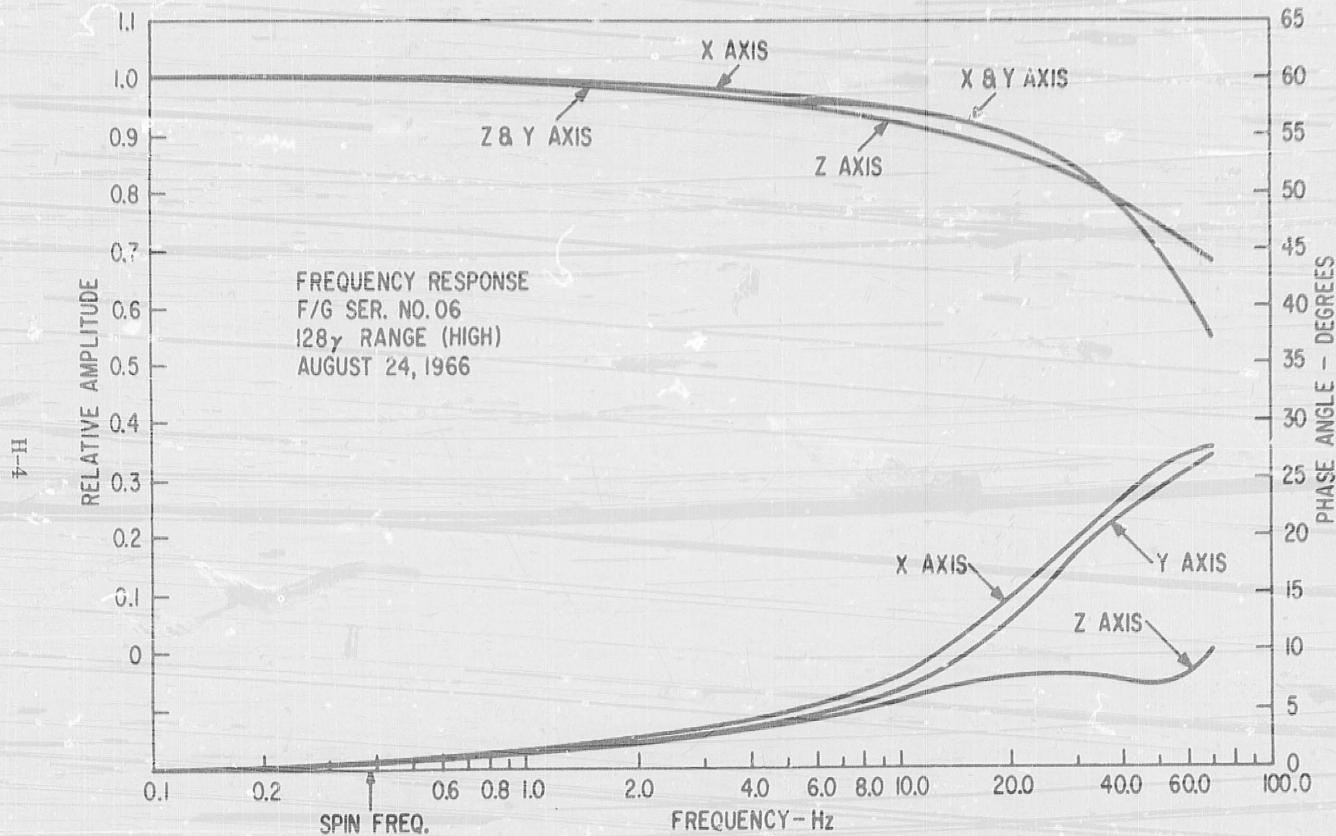


Figure 3

C. Instruments start to roll off at 12.5 cps (See Figures 2 and 3). Frequencies above 12.5 cps are attenuated at the rate of 20 DB per decade.

D. Non-Orthogonal Sampling

The X, Y, Z sensors are not sampled simultaneously but are sampled as shown in Figure 2 0.080 sec. apart.

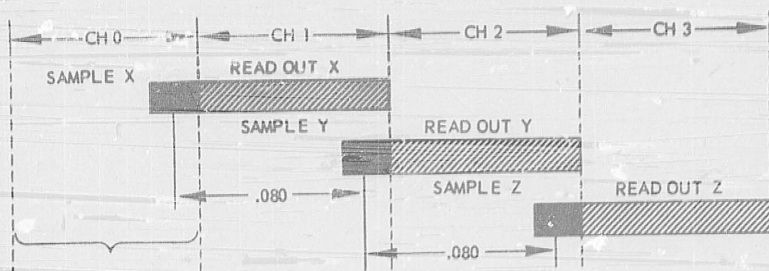


Figure 4

This requires that X be adjusted to the time at which Y is sampled using the following equation:

$$X = (X - Y \sin \Delta) / \cos \Delta$$

where

$$\Delta = 0.080 / \text{Refined Spin Period} * 2 \pi$$

IV. Characteristics of the Autocorrelation Computer Output

The input to the autocorrelation computer are the Y or Z (depending on the sequence*) 8 bit component field measurements.

The output from the autocorrelation computer consists of the following items transmitted in frame 8.

* Y is processed in sequences with even sequence ID's.
Z is processed in sequences with odd sequence ID's.

- | | |
|---------------------------|------------|
| 1) Average | - 12 bits |
| 2-10) Lag 8 through Lag 0 | - 108 bits |

These parameters are computed in the spacecraft to a precision of 16 bits (with sign) for the average and 23 bits (with sign) for the lags. These data are accumulated in 23 bit registers in the spacecraft whose bits, for purposes of the following discussion, will be numbered starting from the right from 1 through 23. The MSB (bit 23) is the sign bit. (0 = + ; 1 = -) Before transmission these data are compressed in the following fashion:

A. Compression of the Average

In the case of the average bits 5 through 15 and bit 23 (sign bit) are transmitted (total of 12 bits). On the experimenter tape the average appears as a 32 bit word the 12th bit is the sign, the other 11 bits are magnitude.

B. Compression of the Lags.

The following logarithmic algorithm is used to compress the lags. This generates an 7 bit fraction and 4 bit exponent.

1. If bits 8 through 22 are zero transmit bits 1 through 7 as the fraction and zero as the exponent. Also transmit the sign for a total of 12 bits.
2. If bits 9 through 22 are zero and bit 8 equals 1 transmit bits 1 through 7 as the fraction and 1 as the exponent. Also transmit the sign for a total of 12 bits.
3. If bits 9 through 22 are not equal to zero shift right n times until bits 9 through 22 are equal to zero transmit bits 1 through 7 as the fraction and n + 1 as the exponent. Also transmit the sign for a total of 12 bits.

C. A Lag Appears on the Experimenter Tape as Two 32 Bit Words

1. The fractional portion appears as a separate 32 bit word. Bit 8 is the sign bit. Bits 1-7 are magnitude.
2. The exponent appears as a separate 32 bit word the four low order bits of which are the transmitted exponent, no sign information is necessary.

D. Folding Frequency for Spectrum Analysis

1. Sampling rate for the autocorrelation computer is 1 sample/.080 seconds which gives a folding frequency of 6.25 cps.

V. Optical Aspect

A. Precision of Spin Period

The spacecraft computes spin period to a precision of ± 1 count = ± 2.5 milliseconds for the 400 cps counter.

The analysis program does not use the spin period as transmitted directly but rather uses the "See Sun Times" which are also quantized to ± 2.5 milliseconds and the spin period to compute a refined spin period over approximately 16 spacecraft rotations. This is the actual quantity used in the coordinate rotations unless this result differs by more than 5 milliseconds from the average spin period for the entire file. If the errors in the two "See Sun Times" used to compute the refined spin period add the precision of this quantity would be $\pm .0050 \text{ sec}/16 \text{ spins} = \pm .0003 \text{ sec/spin}$ which corresponds to $\pm .043^\circ$ of spacecraft rotation.

Handwritten:
RING
MAY 24 1967
D-9980
C-7244
MAY 24 1967
JULY 6, 1967

7A840000	00700000	00000043	0000009F
C111F842	42206490	C23D0EEB	423CD670
433E7000	433E7000	433E7000	433E7000
C0CEC765	C110145B	403AE730	C0A21B74
4018D92C	C22D1FE3	431679E7	433E7000
031E89B7	00000005	0000AE7D	40382B3F
C22B3DE5	4312BA1E	41EA3A1C	421E2CA4
00000000	00700000	00000043	0000008F
C113328C	4220668C	C24C2D7A	4243D5A5
433E7000	433E7000	433E7000	433E7000
C0C57B16	C11168E3	40382B3F	C09523CC
4042C125	C2294BC2	431474D2	433E7000
031F796A	00000005	0000AE80	40354DE8
C22709A9	4314CD75	42126930	41B9CEBD
00000000	00700000	00000043	0000008F
C11460EF	42206878	433E7000	433E7000
433E7000	433E7000	433E7000	433E7000
C08BB8BD	C112B307	40354DE8	C087C867
4022F2F5	421D0985	43133BA0	433E7000
0320591D	00000005	0000AE83	4032521F
C227E09C	4314A74B	413104F5	41572D5B
00000000	00700000	00000043	0000008F
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