## 5.7.3 CNVRT Subroutines

### 5.7.3.1 CNVRT

~~[illegible]~~

this subroutine will enable a programmer to perform any of 11 data conversions from a 36-bit word structure to a 32 bit ~~[illegible]~~ S/360 word. ~~given the data~~

The format of the call to this subroutine is:

CALL CNVRT(PARAM1, PARAM2, PARAM3, PARAM4, PARAM5, PARAM6)

PARAM1 - In the new package, the pointer to the address of the logical record returned to the calling program by one of the new DEBLOCK routines. In the old package, the address of the first byte of the logical record that has been read.

PARAM2 - this variable or array will contain the data after conversion.

PARAM3 - this unsigned integer constant is the number of single precision (36-bit) words ~~to be converted (each double-precision word counts as one).~~ or the number of double precision (two 36-bit) words to be converted (each double precision word counts as one).

PARAM4 - this integer constant indicates the type of conversion to be performed: ~~[illegible]~~

| Parameter Value | Conversion Performed |
|---|---|
| 1 | Single Precision 36-bit floating point to single word S/360 floating point |
| 2 | Single precision 36 bit floating point to double word S/360 floating point |
| 3 | Double precision 36 bit floating point to single word S/360 floating point |

| | |
|---|---|
| 4 | Double precision 36-bit floating point to double word floating point. |
| 5 | 36-bit fixed point to 32 bit S/360 word |
| 6 | 36 bit fixed point to single word S/360 floating point |
| 7 | 36-bit fixed point to double word S/360 floating point |
| 8 | 7090 tape BCD to S/360 EBCDIC |
| 9 | 7090 decrement to S/360 floating point |
| 10 | Move 36 bits (6 bytes) without conversion to the leftmost 36 bits of an S/360 double word |
| 11 | Move specified number of 36-bit words into data area as a contiguous bit stream (applicable to new package only) |
| >11 | Illegal. A U0768 abend will result. |

<u>Note</u>: The old package accepts only 7090 36-bit words for converting.

PARAMS - Indicates error conditions encountered during conversion

| <u>CODE</u> | <u>CONVERSION</u> |
|---|---|
| 0 | No errors. |
| 1 | A 7090 word had more than 32 significant bits ~~digits~~ in conversion (old package only) |
| 4 | First word to be converted was beyond range of the tape record. Nothing is done to data. |
| 8 | Number of words requested for conversion ran outside range of data. Conversion performed to that point. |
| 16 | Conversion #9 is not available for UNIVAC tapes. |

PARAM6 - Unsigned integer constant containing the number of the 36-bit word which is the first to be converted. Each double-precision word counts as two.

Note 1: There are only two cases where the format used in CNVRT differs between the old and new packages. The first case is where the user made a call to subroutine CMPRS in the old package. In the new package, conversion 11 in CNVRT is used instead. It moves a bit stream from the [illegible] area to the user's designated area. The results will be comparable to a call of CMPRS with PARAM4 = 2 (12 bytes compressed into 9 bytes). In order to obtain results comparable to PARAM4 = 1 in CMPRS (6 bytes compressed into 4 1/2 bytes), the user will have to call CNVRT with conversion 11 one word at a time for as many words as he desires, incrementing the first word to be converted each time. This would be a highly inefficient use of the CNVRT feature. The second case of differing formats is for the user reading a tape such as UNIVAC with 1's complement in the negative numbers. ~~The user need only use an overriding SYSLIB card to get the proper conversion for these tapes:~~

~~//SYSLIB DD DSN=SYS2.DEBLKUNV, DISP=SHR~~

~~With this case it is assumed that data is read with DBGEN only.~~
A special package for UNIVAC type tapes is ~~availab~~ available (see section 5.7.4.2). With this case it is assumed that data is read with DBGEN only

~~Note 2: A call to CNVRT can result in a U0768 abend. This occurs when the code specified in PARAM4 is greater than the 77.~~

## 5.7.3.2 CMPRS (old package only)

~~B. SUBROUTINE ABSTRACT - CMPRS (old package only)~~

The tape is read with data conversion off and each byte will contain six bits of data and two high order zero bits. The CMPRS subroutine will pull the two high order zeros out of each byte and will compress a 7094 word into 36 or 72 contiguous bits.

The call statement for the subroutine ~~will be~~ is:

CALL CMPRS (PARAM1, PARAM2, PARAM3, PARAM4, PARAM5)

PARAM1 - This integer variable contains the address of the first byte of the array of 7090 words as returned by the DEBLOCK subroutines.

PARAM2 - this variable or array will contain the data after conversi

PARAM3 - this unsigned integer constant is the number of words to be compressed.

PARAM4 - This unsigned integer constant is a code to indicate whether 36 or 72 contiguous bits are to be formed: ~~the table below lists the values for PARAM4 and their meaning~~

| Value | COMPRESSION PERFORMED |
|---|---|
| 1 | 6 bytes will be compressed into 4½ by |
| 2 | 12 bytes will be compressed into 9 byt |

PARAM5 - this unsigned integer constant is the number of the word which is to be the first to be converted

## 5.7.4 JCL

### 5.7.4.1 DD Card for Tape

The programmer must supply a DD card to intensify the tape to be read. The DD name depends on the subroutie used to read the tape:

| Subroutine Used | DD name required |
|---|---|
| DBGEN | GENTAP |
| DBFØR | FØRTAP |
| DBDCS | DCSTAP |
| DBTDCS | DBTAPE |

For example, if DBGEN is called to read the tape, the following DD card would be necessary:

```
//GO.GENTAP   DD  DSN=userid.name,UNIT=(7TRACK,
//      VOL=SER=volser,LABEL=(n,NL,,IN),DISP=(OLD,
//      DCB=(RECFM=U,BLKSIZE=blocksize,DEN=density
```

### 5.7.4.2 How to get which package

New package: No additional JCL is required (since package is in SYS2.FØRTLIB which is already in the LINKGO and LØADER procedures).

Old package: The following card must be included in SYSLIB concatenation for the LINKGO or LØADER

```
//SYSLIB  DD  DSN=SYS2.DEBLKØLD,DISP=
```

[illegible] Package: The following card must included in the SYSLIB concatenation of LINKGO or LOADER procs

```
//SYSLIB DD DSN=SYS2.DEBLKUNV,
```

Note: for this package only DBGEN is available read the tape

# 5.7.5 Tape Formats

## A~~PPENDIX A: TAPE FORMA~~TS

DBGEN: BLKSIZE of physical records provided by user in DCB of tape DD statement.

General tape:

1) No control words.
2) Logical record same size as physical record.

DBFOR:

FORTRAN tape:

1) One control word at beginning of each physical record.
2) One logical record per physical record.
3) One or more physical records per logical record.

DBDCS: (A physical record is 460 7090 words or 2070 bytes given that one 7090 word is 4-1/2 bytes of information.)

DCS tape:

1) 2 control words at beginning of each physical record.
2) One control word at beginning of each logical record.
3) One or more logical records per physical record.
4) One or more physical records per logical record.

DBFDCS: (A physical record is 460 7090 words or 2070 bytes.)

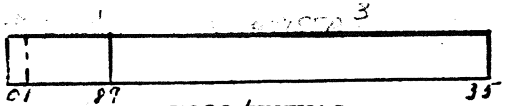
FORTRAN-DCS tape:

1) 2 control words (DCS control) at beginning of each physical record.
2) 2 control words (DCS and FORTRAN) at beginning of each logical record.
3) One or more DCS logical records per physical record.
4) One or more physical records per logical record.
5) One or more DCS logical records per FORTRAN logical record.

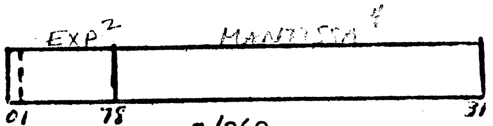
# 5.7.6 Word Formats

## (FORMATS OF 36-BIT WORDS (7090 OR UNIVAC) VS. 360 WORDS)

### 1. SINGLE PRECISION FLOATING POINT



7090/UNIVAC

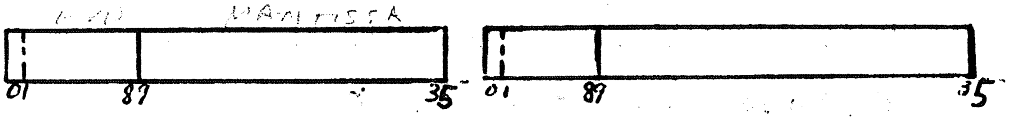


S/360

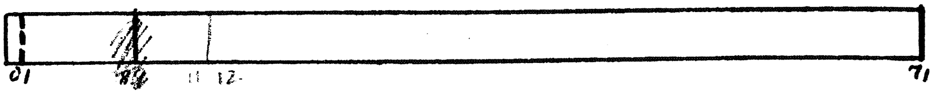
1 Exponent has excess 200 octal
2 Exponent has excess 40 hexadecimal
3 Normalized so that 1st bit is 1
4 Normalized so that 1st byte is non-zero

### 2. DOUBLE PRECISION FLOATING POINT

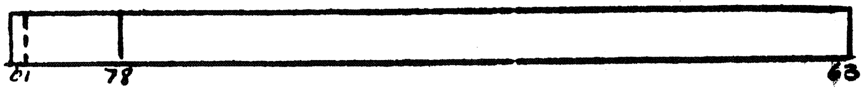
7090



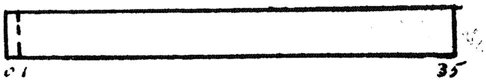
UNIVAC



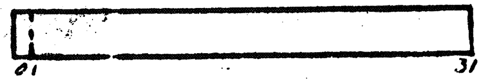
S/360



### 3. FIXED POINT

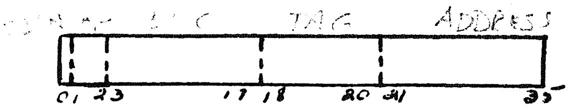


7090/UNIVAC



S/360

### 4. 7090 DECREMENT



NOTE that negative numbers are expressed differently in all three cases:

7090: Sign and magnitude; e.g. -1 = 100 000 ... 001

UNIVAC: Sign and 1's complement; e.g. -1 = 111 111 ... 110

S/360: Sign and 2's complement; e.g. -1 = 1111 1111 ... 1111

S.7.7

User abends

~~GENTAP data set~~

PARAM4 in call to CNVRT

1) GENTAP data set cannot be opened by DBGE

2) Certain types of I/O errors on a tape read by DBGEN (other than those described under PARAM3 in sect. S.7

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Please see me if
your have any
corrections!
Jenny Jacques

## Magnetic Field Processing

November 13,1979
Amended Nov. 15,1979

### Purpose

The magnetic field data for PIONEER and ISEE is to be used in the Fourier program for listing and plotting. A new data base will consist of the data averaged over a user-specified time interval which would be consistent with the "FLUX" tape which is used as input to the Fourier program. Data specific to the Fourier program's use is uncluded, as well as the original data in the input magnetic field tape for processing by other programs. All values will be averaged with a resolution of one minute, with no interpolation. All values are averaged over the interval in a simple manner: $\langle X \rangle = \Sigma X_i / N$ , where N = # of intervals included in the sum of $X_i$ .

### Description

Each input magnetic field tape is one output file. Because the volume of data is small, there will be no tape catalog, and the data most likely will be confined to one tape.

The generated data base tape will be of one averaging interval, with resolution of one minute, the resolution of the input tape. No interpolation will be done for averages of non-integral multiples of one minute due to the expected stability of the field. The times on the output tape will be event times, adjusted from the input tape ground receipt times. The program will be modular, so future changes to incorporate slightly different computations of output will be more easily made.

## Formulas

1. Distance from S/C to Earth:

$$R=(R_1^2 + R_2^2 - 2R_1R_2(\cos(A)\cos(B)\cos(C) + \sin(A)\sin(B)))^{\frac{1}{2}}$$

where : $R_1$=Distance from S/C to sun

$R_2$=Distance from Earth to sun

A = Theta for S/C

B = Theta for Earth

$C = \text{Phi}_{s/c} - \text{Phi}_{\text{Earth}}$

2. If u is the unit vector in the direction of B, and if $x=|\hat{u}|\cos\alpha$ and $y = |\hat{u}|\cos\beta$, and $z = |\hat{u}|\cos\gamma$, $|\hat{u}|= 1$, then Phi, Theta are:

$$\text{Phi} = \phi = \text{ATAN2}\ (y/x) = \text{ATAN2}\ \left(\frac{\langle\cos\beta\rangle}{\langle\cos\alpha\rangle}\right)$$

$$\text{Theta} = \theta = 90-\cos^{-1} z = 90 - \cos^{-1}(\langle\cos\gamma\rangle)$$

For PIONEER,-x=y' and y=x', x',y' are input.

## Contents

The tape will be fixed, blocked, with byte length of ~~152~~ 160 /record. It will be multi-filed with a new file beginning with each input magnetic field data tape. The following values will comprise the record:

blk = 7200

| Byte field | wd | Type | Description |
|---|---|---|---|
| 1-4 | 1 | I4 12 | Year of start of interval (i.e. 79) |
| 5-8 | 2 | I4 34 | Day of start of interval |
| 9-12 | 3 | I4 56 | Seconds of day of start of interval |
| 13-16 | 4 | I4 78 | Interval in seconds of the average |
| 17-20 | 5 | R4 | Milliseconds of data in the interval |
| 21-24 | 6 | I4 | Input tape flag:0=cruise,1=Jupiter,2=Saturn |
| 25-28 | 7 | R4 | * $\langle\cos\alpha\rangle$ in S/C spin coordinates |
| 29-32 | 8 | R4 | * $\langle\cos\beta\rangle$ in S/C spin coordinates |
| 33-36 | 9 | R4 | * $\langle\cos\gamma\rangle$ in S/C spin coordinates |

| Byte field | | Type | Description |
|---|---|---|---|
| 37-60 | 10-15 | 24*L1 | The Phi sector counts, 15° sectors |
| 61-72 | 16-18 | 12*L1 | The Theta sector counts, 15° sectors |
| 73-76 | 19 | R4 | $\langle B_x \rangle$ in desired coordinate system |
| 77-80 | 20 | R4 | $\langle B_y \rangle$ in desired coordinate system |
| 81-84 | 21 | R4 | $\langle B_z \rangle$ in desired coordinate system |
| 85-88 | 22 | R4 | $\langle B_x \rangle$ in input tape coordinates |
| 89-92 | 23 | R4 | $\langle B_y \rangle$ in input tape coordinates |
| 93-96 | 24 | R4 | $\langle B_z \rangle$ in input tape coordinates |
| 97-100 | 25 | R4 | $\langle B_x^2 \rangle$ in input tape coordinates |
| 101-104 | 26 | R4 | $\langle B_x B_y \rangle$ in input tape coordinates |
| 105-108 | 27 | R4 | $\langle B_x B_z \rangle$ in input tape coordinates |
| 109-112 | 28 | R4 | $\langle B_y^2 \rangle$ in input tape coordinates |
| 113-116 | 29 | R4 | $\langle B_y B_z \rangle$ in input tape coordinates |
| 117-120 | 30 | R4 | $\langle B_z^2 \rangle$ in input tape coordinates |
| 121-124 | 31 | R4 | $\langle \cos\alpha \rangle = B_x/B$ in input tape coordinates |
| 125-128 | 32 | R4 | $\langle \cos\beta \rangle = B_y/B$ in input tape coordinates |
| 129-132 | 33 | R4 | $\langle \cos\gamma \rangle = B_z/B$ in input tape coordinates |
| 133-136 | 34 | R4 | $\langle \lvert B \rvert \rangle$ |
| 137-140 | 35 | R4 | $\langle \lvert B^2 \rvert \rangle$ |
| 141-160 | | -- | Spare bytes |

## Coordinate system

The coordinate system used for the Fourier input is a right handed system, using X axis as the reference direction. The X axis lies in the ecliptic plane, pointing toward the Sun. The Y axis lies in the ecliptic plane, ⊥ to X axis. The

Z axis is zenith, perpendicular to the ecliptic plane

The cosines are then defined as follows:

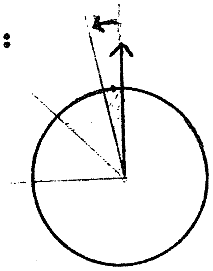
$\langle \cos \alpha \rangle = \langle B_x / |B| \rangle$

$\langle \cos \beta \rangle = \langle B_y / |B| \rangle$

$\langle \cos \gamma \rangle = \langle B_z / |B| \rangle$

where $B_x$, $B_y$, and $B_z$ are the components of the magnetic field in S/C spin coordinates.

The Phi and Theta arrays are oriented to the reference direction such that 0° is the reference direction, and thus Phi(1) for example is the sector value averaged from 0° to 15° centered on 7.5° in the counter-clockwise direction from the reference direction:



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down and analyzed as it resides in main storage. From this information, a correct solution to the storage dump problem can be made.

## E. EXTERNAL STORAGE DUMP SUMMARY

External Storage Dumps are those which occurred external to the program being executed. They are denoted by Completion Codes 001, 13 Group, 22 Group (excluding 322), and 37 Group. The following set of step-by-step procedures apply to all External Abends.

1. Determine Jobname, Stepname, and Completion Code from top of first page of storage dump.
2. Obtain detail description of Completion Code by referencing the IBM Messages and Codes Manual and/or Chapter 7 of this textbook.
3. Utilize Short Hand Method to isolate problem ddname and file.
    a. Locate valid UCB in Register 10 of SVRB.
    b. Find UCB in TIOT; associate with problem ddname.
    c. Refer to JCL listing and analyze appropriate DD Statement file.
4. Utilize Long Hand Method to isolate problem ddname and file if valid UCB occurs more than once in TIOT.
    a. Determine DCB Address from Register 2 of pertinent SVRB or Registers At Entry To Abend.
    b. Add 28 to DCB Address and locate two byte TIOT Offset in main storage. $28_{10} = 1C_{16}$
    c. Convert TIOT Offset to Decimal, subtract 24, divide by 20 truncating remainder, and add 1.
    d. Count down indicated number of lines in TIOT; associate with problem ddname.
    e. Refer to JCL listing and analyze appropriate DD Statement file.
5. Determine DCB attributes for Completion Codes relating to DCB conflicts.
    a. Determine DCB Address from Register 2 of pertinent SVRB or Registers At Entry To Abend; then add:

0 - Block Count (4 bytes)
12 - Density (1 byte)
28 - TIOT Offset (2 bytes)
3E - Maximum Blocksize (2 bytes)
4C - Address of Next Record (4 bytes)
52 - Logical Record Length (2 bytes)
5A - Physical Record Length (2 bytes)

b. Locate DCB attributes in main storage; convert to Decimal.

c. Refer to Program File Descriptions.

6. Analyze Label contents for storage dumps which occurred during Label processing.

a. Determine Label Address from Register 4 of pertinent SVRB or Registers At Entry To Abend.

b. Locate Label in main storage; compare Data Set Name and Volume Serial Number with JCL.

7. Complete thorough problem analysis. Determining the value of pertinent program variables at the time of the abend, as discussed in chapter 5, may also be of assistance.

A workshop is now provided to solidify a working knowledge of External Storage Dump debugging procedures.

Although the above procedures are specific to OS and OS/VS environments, the principle of debugging file problems resulting in external abends, and locating addresses and values in main storage can be applied to DOS applications as well. The nature of the program to be executed is of little concern. File problems resulting in external storage dumps are often encountered when attempting to execute COBOL, FORTRAN, PL1 and Assembly language programs in all application, system, and data base environments.

A Table of Offsets can optionally be obtained if a print of the Assembly Language listing is not desired. To locate Relative Address 302, compare the offset of each statement with the statement number itself. See Figure 4.18, letter 'D'. Moving to the right, an offset of 02F8 is encountered for Source Statement #27. See letter 'E'. Offset 02F8 is the closest one can come to Address 302 without exceeding it. Source Statement #28 with an offset of 0308 exceeds Address 302. See letter 'F'. Therefore, Source Statement #27 is the program instruction of interest.

Again, the principles of Internal storage dump analysis remain the same regardless of the programming language utilized. The only significant difference relates to the format of the Assembly Language listing itself.

## INTERNAL ABEND SUMMARY

Internal Storage Dumps are those which occur internal to the program being executed. They are denoted by Completion Codes 322 and the OC Group. The following set of step-by-step procedures apply to all Internal Abends.

1. Determine Jobname, Stepname, and Completion Code from top of first page of storage dump.
2. Obtain detail description of Completion Code by referencing the IBM Messages and Codes Manual and/or Chapter 7 of this textbook.
3. Calculate Relative Length into executable module.
    a. Determine Entry Point Address (EPA) from first line of Contents Directory Entry.
    b. Determine Interrupt Address (IA) from:
        i. System 360/370 OS - APSW near top of first page of storage dump.
        ii. System 370 OS/VS - PSW AT ENTRY TO ABEND at top of first page of storage dump.
    c. Subtract EPA from IA giving Relative Length into module.
4. Reference Control Section to verify and/or recalculate Relative Length.

   a. If programmer-written subroutines are not utilized and Relative Length falls within bounds of the main program, ignore Control Section information.
   b. If programmer-written subroutines are utilized and Relative Length falls within bounds of a subroutine, subtract the Origin of the subroutine from Relative Length, giving length into the called routine.
   c. If Relative Length falls outside bounds of main program and programmer-written subroutines, refer to SAVE AREA TRACE portion of storage dump. Subtract Return Address for system-provided routine from Entry Point Address of the program module which called the routine, giving length into the calling module.

5. Reference Assembly Language Listing of pertinent program module or subroutine.
   a. Locate Length calculated above.
   b. Determine appropriate Source Statement Number.

6. Reference Source Program Listing of pertinent program module or subroutine.
   a. Locate Source Statement Number.
   b. Determine actual Source Statement being executed at time of abend.

7. Complete thorough problem analysis. If necessary, determine value of pertinent variables utilizing the techniques to be covered in the next chapter.

A workshop is now provided to solidify a working knowledge of Internal Storage Dump debugging procedures.

Although the above procedures are specific to OS and OS/VS environments, the principle of debugging program problems resulting in internal abends, and locating the problem statement, can be applied to DOS applications as well. The specific language of the program being executed is of little concern. Program problems resulting in internal storage dumps are often encountered when attempting to execute COBOL, FORTRAN, PL1, and Assembly language programs in all application, system, and data base environments.

Floating Point form of data representation is utilized. FORTRAN REAL variables and COBOL USAGE COMP-1 items default to a length of four bytes. A FORTRAN Double Precision of the above or utilization of COBOL's USAGE COMP-2 defines a length of eight bytes to the above field. In other words, Internal Floating Point field lengths are not directly specified in the program itself.

Field lengths for all other forms of COBOL data representation are programmer defined via the Picture Clause. For FORTRAN programs, however, program language conventions take on more significance. All FORTRAN variables are automatically converted by the compiler to four byte fields. If the Double Precision feature is utilized, eight byte field lengths will result. Two byte fields can also be defined. In addition, Integer and Real fields are converted to Binary and Internal Floating Point, respectively, even though they may not have been originally defined as such.

In the breakdown and analysis of machine instructions to be covered in the next chapter, some COBOL variables will be found to be represented in Internal Decimal even though they were defined as External Decimal in the program. This is because the compiler generates instructions to automatically convert from the Unpacked to Packed Format prior to the execution of various test and arithmetic operations.

In summary, actual data representation of program variables as found in main storage depends upon the programming language utilized and its conventions, as well as programmer-defined fields within the program itself. The exact length of a COBOL variable can always be determined from the DMAP. FORTRAN variables are usually four bytes but can be two or eight bytes if the halfword or doubleword feature has been utilized.

## E. VARIABLE VALUE SUMMARY

After isolating the problem source statement, the value of pertinent variables should be determined. The following set of step-by-step procedures apply specifically to COBOL and FORTRAN programs; however, the principles utilized apply to all programming languages.

he next chapter.

1. Determine Pertinent Variables.

   Those variables coded directly in the problem source statement or related to the problem are considered pertinent.

2. Locate Variable Name.
   a. COBOL -- In DMAP under heading SOURCE NAME.
   b. FORTRAN -- In right-hand portion of Assembly Language Listing at or near problem statement.
3. Determine Base Register and Base Address.
   a. COBOL -- Base Register assignment in DMAP under heading BASE. Go to Register Assignment Area and note Base Register.
   b. FORTRAN -- Note Base Register (right-hand number in parentheses) to left of Variable Name in Assembly Language Listing.
   c. Obtain Base Address from appropriate register in REGS AT ENTRY TO ABEND Area just prior to the print of Main Storage.
4. Determine Displacement.
   a. COBOL -- In DMAP under heading DISPL.
   b. FORTRAN -- In Assembly Language Listing to the left of parentheses. Convert from Decimal to Hexadecimal.
5. Determine Variable Length.
   a. COBOL -- In DMAP under heading DEFINITION.
   b. FORTRAN -- Four bytes; eight bytes if Double Precision; two bytes if Halfword defined.
6. Determine Data Representation Form.
   a. COBOL -- In DMAP under heading USAGE.

      Character Format, i.e., External Decimal, for DISPLAY Variables;
      Internal Decimal for COMP-3 Variables;
      Binary for COMP Variables;

External Floating Point for DISPLAY E Picture Variables;
Internal Floating Point for COMP-1 and COMP-2 Variables.

b. FORTRAN -- From Source Program Listing.

Character Format, i.e., Unpacked Format, for Alpha Variables;
Binary for INTEGER Variables;
Internal Floating Point for REAL Variables.

7. Add Base Address to Displacement giving Address of Variable in Main Storage.

8. Page down left-hand side of the print of Main Storage and locate Address.

9. Delineate data field using appropriate Length.

10. Determine Variable Value by interpreting character string in relation to form of data representation utilized.

Although the above procedures are specific to OS and OS/VS environments, the principle of locating and interpreting pertinent program variables can be applied to DOS applications as well. The specific language of the program to be executed is of little concern. Problems resulting in storage dumps are often encountered when attempting to execute COBOL, FORTRAN, PL1, and Assembly language programs in all application, system, and data base environments.

in main storage by adding the contents of Base Register D to Displacement 209. Once this address is located, a Length of 0 + 1, or 1, would be marked off. Similarly, the value of the First Operand in the second instruction, and in this case the second character of BPFYR, can be found and interpreted by adding the contents of Base Register D to Displacement 20A. Once this address is located, a Length of 0 + 1, or 1, would be marked off.

As can be seen, a knowledge of machine instruction breakdown and analysis within an Assembly Language listing is necessary when determining the value of pertinent PL1 program variables.

## D. MACHINE INSTRUCTION SUMMARY

When appropriate listings are not available, the location, breakdown, and analysis of machine instructions should be accomplished. Op Code and Operand Values can then be determined.

1. Determine Address of Next Machine Instruction to be executed.
    a. System 360/370 OS -- Right-most three bytes of APSW.
    b. System 370 OS/VS -- Right-most three bytes of PSW AT ENTRY TO ABEND.
2. Determine Length of Machine Instruction.
    a. System 360/370 OS -- Convert left-most byte of APSW to Binary. Two left-most bits indicate Length.
        01 - 2 bytes
        10 - 4 bytes
        11 - 6 bytes
    b. System 370 OS/VS -- See 'ILC x' message to right of PSW AT ENTRY TO ABEND, where x = Length in bytes.
3. Determine Machine Instruction being executed.
    a. Locate Address in Main Storage.
    b. Back up required Number of Bytes as determined from Length.
4. Note Op Code, Function, and Format.
    a. Determine Op Code from First Byte of Machine Instruction.
    b. Determine Function from Reference Data Card.
    c. Determine Format from Reference Data Card.

5. Determine Operand Addresses.
    a. Breakdown Instruction utilizing appropriate Format.
    b. Calculate Operand Addresses utilizing appropriate Base Registers, Index Registers, and Displacements, as required.
6. Locate and Interpret Operand Value.
    a. Locate Operand Address in Main Storage except for Immediate Operands which are located in the Instruction itself.
    b. Delineate Operand using appropriate Length.

       For SS Format, Length is determined by adding one to Length Indication in Machine Instruction. For other Formats, Length equals four bytes, except for occasional Halfword (2 bytes) and Double Word (8 bytes) instruction use as determined from the Reference Data Card or the program itself.

    c. Interpret Character String based upon nature of Op Code and Data Representation techniques.

A workshop is now provided to solidify a working knowledge of Machine Instruction location, breakdown, and analysis.

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# HOW TO READ A 360 DUMP*

THIS WILL SERVE TO ANSWER MOST OFTEN ASKED QUESTIONS ABOUT 360 DUMPS.

THESE DUMPS CONTAIN MUCH USELESS* INFORMATION SO. IT IS NECESSARY TO IDENTIFY THOSE USEFUL ITEMS. HERE ARE SOME

THIS IS THE BEGINNING OF A TYPICAL DUMP:

```
JOB ZEFRFRE2               STEP GO                 TIME 171539    DATE 72126

COMPLETION CODE            SYSTEM = 0C6

PSW AT ENTRY TO ABEND   FFC5CC0D 4000A252

TCB   0225B8   REP      00022120    PIE      CCCC0C0C    DEB   00021EC4   TIO 0002
               MSS      02028838    PK-FLG   0C850505    FLG   000C282E   LLS 0002
               FSA      010E67EC    TCB      C0000C0C    TME   0C0C0000   JST 0002
               LTC      00CC0000    IQE      C000000C    ECB   00027090   STA 0000
               NSTAE    88C5EFEE    TCT      CC027E2C    USER  000CC000

ACTIVE RES

PRB   026CA0   RESV     00000000    APSW     8203F52E    WC-SZ-STAB C0040082   FI
               Q/TTR    00C00000    WT-LNK   C0C225E8
```

KEY TO TYPE OF ERROR THAT HAS OCCURRED

ABSOLUTE ADDRESS IN THE MACHINE WHERE IT HAPPENED (the error, that is)

USUALLY ON THE SECOND PAGE WILL BE FOUND:

ABSOLUTE BEGINNING ADDRESS OF THIS PROGRAM IN THE MACHINE

```
XL
                                                         LN          ADR

      027F28   SZ CC0C0010   NO C0C000C1              80C12ED8    00039[illegible]
      026D48   SZ 00000C10   NO C0000001              80000680    00C5798C
      032340   SZ 000C0C10   NO C0C00001              80000240    001FE1E0
      032240   SZ 00000010   NO C0C000C1              80000188    001FDC98
      032210   SZ 00000C10   NO CC0000C1              80000058    001FE808
      C27448   SZ C0000C10   NO C0C000C1              8CC003D0    00C4CC30
      03228C   SZ CC000C10   NO C00000C1              8C0000E8    001FCF18
      032430   SZ 0C000C10   NO C0C000C1              8CCC0068    001FE670
      0323A0   SZ CC00CC10   NO C0000C01              80000078    001FE4E0
      032340   SZ 0C00CC10   NO C0000C01              80000240    001FE1E0
      03231C   SZ 00000010   NO C0C00C01              8C0000C0    001FE120
      03227C   SZ 00000010   NO C0CC0C01              800000F8    001FDE20
      0322EC   SZ 0C000010   NO C0000CC1              80000070    001FE080
      032240   SZ C0000C10   NO C0000001              80000188    001FCC98
      032210   SZ CC000C10   NO 00000001              80000058    001FE808
```

* FOR A FORTRAN PROGRAMMER

Q. I WANT TO FIND THE FORTRAN STATEMENT THAT CAUSED THE ERROR.

A. 1. Compute the relative address of the error

hexadecimal numbers →

```
  03F52E   ← ABSOLUTE ADDRESS WHERE ERROR OCCURRED
- 039928   ← ABSOLUTE PROGRAM BEGINNING
    5C06   ← RELATIVE ADDRESS (IN PROGRAM) OF THE ERROR
```

2. Consult the "CONTROL SECTION" (NOT IN THE DUMP) FOR RELATIVE ADDRESSES OF PROGRAM MODULES.

(THIS ERROR OCCURRED IN SUBROUTINE "XINIT1")

3. COMPUTE RELATIVE ADDRESS WITHIN MODULE:

```
  5C06   ← ADDRESS RELATIVE TO PROGRAM BEGINNING
  3498   ← REL. ADD. OF "XINIT1"
  276E   ← REL. ADD. WITHIN "XINIT1".
```

4. Consult a compilation of the ROUTINE IN WHICH the "LIST" OPTION WAS SPECIFIED. THIS GIVES A CROSS REFERENCE OF FORTRAN STATEMENTS VS. RELATIVE ADDRESSES.

(EC FORTRAN, PARM='LIST')

```
F88-LEVEL LINKAGE ECITUR CF
          VARIABLE UPTIONS
IEW0000    ENTRY SASFET


CENTFOL SECTION

  NAME       ORIGIN   LENGTH

SASFET           00     E5E
XTRCT1          E60    1D1E
TIME           2278     1A4
FMTREQ         2020     774
XINIT1         3498    29CE
IFLCC          5E68     12C

XINIT          5F98     CA8

GETAPE         6D40     35E
WRTELF         7098     2AE
IHCECICS*      7340     E66

DRECV    *     E1A8     DEE

FREAC    *     8060     A1C

FUNITABL*      978C      CE
IHCECONF*      9E48     F41

IHCCCMF2*      A790     65C

STRANS   *     ADF0     70A
IHCFCVIH*      E500    115C
```

Q. I NEED TO KNOW WHAT THE VALUE OF A CERTAIN VARIABLE WAS WHEN I crashed.

A. 1. Compute ABSOLUTE ADDRESS OF VARIABLE DESIRED. FOR OUR EXAMPLE WE WILL FIND THE VALUE OF "NDX" IN THE FOLLOWING CODE BECAUSE IT LOOKS SUSPICIOUS.

```
            WRITE( 6, 10000 ) ICAT
      10000 FORMAT(' ENTERING XINIT1. ICAT =',I3)
            IF( ICAT .EQ. OLDCAT ) GO TO 425
            LIM = 2
            IREC = 1
            WRITE( 6, 10100 ) IREC
      10100 FORMAT(' READING TEMPLATE BLOCK',I3,'. TEMPLATE RECORDS:')
            CALL FREAD( TBUF, 20 + ICAT, LEN, &900, &910 )
            NUMTEM = TBUF(1,1)
            NDX = 1
        200 DO 400 NDX2 = LIM, 20
            WRITE( 6, 10200 ) ( TEMPLT(NDX,NDX3), NDX3 = 1, 8 )
      10200 FORMAT(10X,8Z9)
            DO 300 NDX3 = 1, 8
        300 TEMPLT(NDX,NDX3) = TBUF(NDX3,NDX2)
            IF( NDX .EQ. NUMTEM ) GO TO 450
        400 NDX = NDX + 1
            LIM = 1
            IREC = IREC + 1
            WRITE( 6, 10100 ) IREC
            CALL FREAD( TBUF, 20 + ICAT, LEN, &900, &900 )
            GO TO 200
        425 DO 450 NDX = 1, NUMTEM
        450 TEMPLT(NDX,6) = -1
            OLDCAT = ICAT
        500 NIOT = REQ(1)
            NPARMS = REQ(15) + 15
      C
```

$\underline{138}$ ← REL. ADDRESS OF "NDX" FROM SYMBOL TABLE IN THE COMPILE.
8

\+ 3498 ← REL. ADDRESS OF MODULE CONTAINING "NDX". IF NDX IS IN COMMON THIS IS THE RELATIVE ADDRESS OF THAT COMMON

$\underline{+\ 39928}$ ← ABSOLUTE PROGRAM BEGINNING ADDRESS

3CEF8

2. CONSULT DUMP.

"NDX" WAS $19_{10}$

```
3CEA0    482F2661 482F244D 540C5046 4C6F50CC   4C6F0538 28FF482E 244D5606 50CC4CCC
3CEC0    0C043170 00042688 C003CF10 0003F288   8003CEF4 0003CF10 0003F288 8003CEF4
        0        4        8        C          0        4        8        C
3CEE0    417CCC78 45C089C6 CCCC00C1 00000002   00000001 000C0280 00000013 00000014
3CF00    0C0C0008 CC74561A 580E5810 3A5E5E13   00000013 000C0000 00000000 00000000
3CF20    000C0000 [000000CC] 6[illegible]00 C0C00000   01930C00 00000000 00000000 00000000
3CF40    0CCC0C00 C000C0C0 6C0CC0A[illegible] [illegible]0020   01930C00 00000000 00000000 00000000
3CF60    0C0C0000 000C0000 000000C0 00000020   01930C00 00000000 00000000 00000000
```

fullword

3CEF0

Q. I KNOW I HAD MORE PRINTER OUTPUT THAN I GOT,
HOW DO I FIND THE REST OF IT?

A. 1. FIND THE FOLLOWING ADDRESS IN THE FIRST PART OF THE DUMP: (IN the "DATA MANAGEMENT CONTROL BLOCKS")

```
FTC6FC01        DEB   022B1C   C6C225B8 1CCC000C E8CC0000 C7CC0000     01000000 2B00000
                               18C021EC 0C0C0020 C0C8C021 00070014     00010001 0000000
                               C2C2C2C1 C3C8C3D1 C3C3C3C4 000C000C     00000000 0000000
                               CC1D036A 0C026E20 C4160000 8002A178     40024000 C9C5C9E

                CCB   05E6EC   C0C0010C 2DCCCCCC C02C00C8 000C80EE     00281C7E 0205A72
                               04C499C8 5404994C CC4C2020 00022B1C     921FDC98 01FE80
                               E8C45C70 0C05E5AC C21FE120 001FE1E0     00000039 0000000
```

ADDRESS OF PRINTER BUFFER

2. CONSULT DUMP. The PRINTER BUFFER WILL USUALLY BE NEAR THE END AND NOT IN NUMERICAL ORDER.

3. The ABSENCE OF the ABOVE LISTING IN THE DUMP INDICATES NOTHING WAS PRINTED.

GENERAL NOTES:

The "SAVE AREA TRACE" shows the SEQUENCE OF SUBROUTINE CALLS JUST BEFORE THE ERROR. IF THE VARIABLE: "RET" IN this TRACE BEGINS WITH "FF" the PROGRAM WAS NOT IN THIS ROUTINE.

---

IN the "DATA MANAGEMENT CONTROL BLOCKS" THE ACTUAL TAPE NUMBER MOUNTED FOR A TAPE LOGICAL UNIT (OR DSN) CAN BE FOUND HERE

```
                            3F4    30C02008 240C0004 00400800 D2F3E4E2
                            1DC    00000000 C4001201 0B000000 00002EA0

   UCB   0220EC   CC20FFA8 0234
                  D9F1 1C03 0C0201C
```

IN THIS CASE, 'D2F3E4E2D9F1' = K3USR1

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# VII. Multisatellite Fourier Analysis Program
# IMP-8 System Documentation

## A. Overview

The satellite-dependent (SD) IMP routines allow the IMP 8 data to be processed through the Fourier program's analysis and output procedures. The satellite-independent (SI) routines are contained in separate source and load modules from all SD code, and thus, any satellite may be linked via JCL.

This document describes the SD user input required for IMP Fourier analysis. The main document containing the SI user input must be reviewed prior to this one.

### 1. Input Required

#### a. Satellite independent namelist INPUT

(1) The RATES parameter may have the following values:

| RATES Parameter | Rate Signified |
|---|---|
| MED1 | DI E F G |
| MED2 | DI D2 E F G |
| MED3 | (DI+EI)1 E F G |
| MED4 | DI (DI+EI)1 E F G |
| LED1 | A1 B C |
| LED2 | A1 B C |
| VLET1 | DI DII F |
| VLET2 | DI DII (SUM)1D F |

(2) The parameter SATID must be 'IMP-8'.

#### b. IMP namelist IMP

&IMP ZMAG,QLED

This namelist must appear after each namelist set of the SI routines.

| Name | Type | Default | Description |
|---|---|---|---|
| ZMAG(8) | A8 | blanks | List of magnetic field tape names in order |
| QLED | L*1 | T | T=use corrected LED rates data |

#### c. Counts Tape

This is a standard label, fixed, blocked tape in the IMP counts tape format. It is provided by the tape catalog.

### d. Tape Catalog

The catalog file name must be entered in the JCL for unit 25. The IMP catalog is in:

'SEIMP.DEX52CAT,DATA'

## 2. Output Generated

(See Fourier Plot Program SI Documentation)

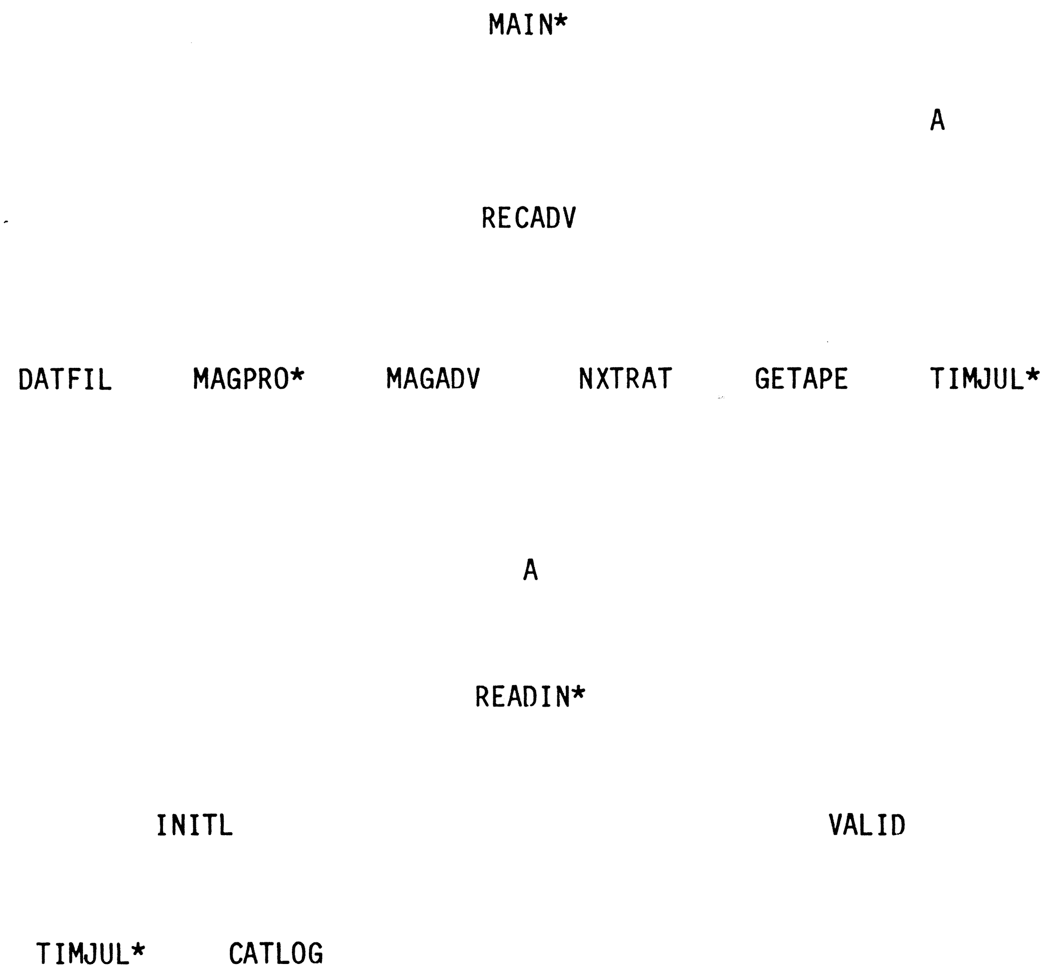
## 3. Module Documentation

| Module | Description |
|---|---|
| INITL | Initialized I/O devices, common blocks, and reads in the SD namelist PIO |
| MAGADV | Reads an averaging interval of magnetic field data |
| RECADV | Reads in one rate and magnetic field data average into the RATDAT and MAGFLD commons |
| VALID | Validates the input namelist data for the SI READIN module |
| CATLOG | Retrieves a tape name from the IMP-8 catalog.<br>This is an IMP-8 system routine. |

## 4. Program Structure

### a. Block Diagram

*=Satellite independent module



### b. Algorithm

The SI module READIN reads the SI namelist and calls VALID to validate them. Then it calls INITL to read in the SD namelist IMP and initialize the I/O devices. Control is returned to MAIN which succesively calls RECADV to accummulate one average point of sector counts and if desired, magnetic field data. RECADV reads in a flux record, stores it, and collects magnetic field data if desired (MAGPRO, MAGADV).

c. Error Handling

The following return codes and messages may be printed:
(See SI System Documentation for other handling.)

| Return Code | Description |
|---|---|
| - | 'INPUT TAPE READ ERROR, SKIP THIS RATE'<br>A tape read error on the input tape caused a volume to be skipped. |

## 5. Common Block Definitions

a. Common: /IMPUSR/ZMAG(8),QLED

| Name | Type | Description |
|---|---|---|
| ZMAG | A8 | A list of up to 8 magnetic field tapes in chronological order of use. |
| QLED | L*1 | T=use only corrected LED rates. |

b. Common: /RECORD/IBUFF(615)

| Name | Type | Description |
|---|---|---|
| IBUFF | I*4 | This buffer is used to store the input tape record. For detail on its contents see IMP-8(J) EXP52 Counts Tape Format document in the IMP-8 documentation set. |

## 6. Individual Module Documentation

All modules were designed, coded, and tested by Jenny S. Jacques, Code 664, 1980.

a. (1) Module: INITL - Initializes the I/O devices, common blocks, and reads in the IMP namelist.

(See the "Fourier Plot Program Satellite Independent System Documentation" for a basic description of .INITL. The differences of additions/deletions are described below.)

Differences or Additions/Deletions

1. There are 8 possible rates
2. A namelist IMP is read in
3. CATLOG is called to fetch input tape name.

b. (1) Module: MAGADV - Magnetic field tape advance - This routine collects the magnetic field data, within the time range passed, from the fourier magnetic field data base tape.

(2) Calling Sequence:

SUBROUTINE MAGADV (INTSEC,INTRVL,QNEW)

| Name | Type | I,0 | Description |
|---|---|---|---|
| INTSEC | I*4 | I | Averaging interval in seconds of the input data tape |
| INTRVL(2) | I*4 | I | Time range to collect the data over, in modified Julian time |

(3) Module Cross Reference:

Called by: RECADV
Calls: TIMJL2,JULTIM

(4) Common Usage:

| Common | Variables | I,0 |
|---|---|---|
| MAGFLD | BMAG,QPSECT,QTSECT,<br>COSIN,BSQR,MAGCNT,IZFILE | I,0 |
| MAGIN | all | 0 |
| IMPUSR | ZMAG | I |

(5) Significant Local Variables:

| Name | Type | Description |
|---|---|---|
| MTIME | I*4 | Modified Julian time (MJT) from magnetic field tape |
| QWAIT | L*1 | T = Interval on tape is later than current time range |
| QEOF | L*1 | T = And end of file mark was detected on the magnetic field tape |

| Name | Type | Description |
|---|---|---|
| IEND | L*1 | Ending of time range (MJT) to process |
| ITAPE | I*4 | Counter to the ZMAG tape namelist. |

(6) Logic:

Check to see if the last time left a record not used yet in the buffer (QWAIT=T). If so, skip around the FREAD. Otherwise, read in a record from the magnetic field tape. Loop, summing as many records as necessary to complete the time range. If an EOF occurs, continue to the next file. If an EOV occurs, look for the next tape name in ZMAG. If none are available, set QOFF to .true., causing further calls to simply return.

c. (1) Module: RECADV - Reads in one average of sectored counts data and, if desired, magnetic field data.

(See the "Fourier Plot Program Satellite Independent System Documentation" for a basic description or additions/deletions are described below.)

Differences or Additions/Deletions

1. RECORD is used to contain the input tape rates data records.
2. CATLOG is called to fetch a new tape name if the current one ends with time still left to process.

d. (1) Module: VALID - Validates the input satellite independent namelist values.

(See the "Fourier Plot Program Satellite Independent System Documentation" for a basic description of VALID. The differences/additions/deletions are listed below.)

Differences on Additions/Deletions

1. There are 8 possible rate ID's.
2. The rate ID's to validate are unique to IMP-8.

## 7. Program Assumptions and Restrictions

1. The flux tape requires 32K core if BUFNO = 1 in the DCB is specified.
2. The flux tape must be of the standard format for flux tapes for IMP-8.
3. The input tape catalog must be the tape catalog named in Section II. 3.

# Multisatellite Fourier Analysis Program
# IMP User's Guide

## B. Overview

The satellite-dependent (SD) IMP routines allow the IMP 8 data to be processed through the Fourier program's analysis and output procedures. The satellite-independent (SI) routines are contained in separate source and load modules from all SD code, and thus, any satellite may be linked via JCL.

This document describes the SD user input required for IMP Fourier analysis. The main document containing the SI user input must be reviewed prior to this one.

### 1. Input Required

#### a. Satellite independent namelist INPUT

(1) The RATES parameter may have the following values:

| RATES Parameter | Rate Signified |
|---|---|
| MED1 | DI E F G |
| MED2 | DI D2 E F G |
| MED3 | (DI+EI)1 E F G |
| MED4 | DI (DI+EI)1 E F G |
| LED1 | A1 B C |
| LED2 | A1 B C |
| VLET1 | DI DII F |
| VLET2 | DI DII (SUM)1D F |

(2) The parameter SATID must be 'IMP-8'.

#### b. IMP namelist IMP

&IMP ZMAG,QLED

This namelist must appear after each namelist set of the SI routines.

| Name | Type | Default | Description |
|---|---|---|---|
| ZMAG(8) | A8 | blanks | List of magnetic field tape names in order |
| QLED | L*1 | T | T=use corrected LED rates data |

c. Counts Tape

This is a standard label, fixed, blocked tape in the IMP counts tape format. It is provided by the tape catalog.

d. Tape Catalog

The catalog file name must be entered in the JCL for unit 25. The IMP catalog is in:

'SEIMP.DEX52CAT.DATA'

2. Error Handling

Only the satellite independent errors will terminate the program. See Section IV in the document: Multisatellite Fourier Analysis Program User's Guide.

3. JCL Required

1. Load module to link with SI routines:
   'SEIMP.FOURIMP.LOAD'
2. Flux catalog, unit 25:
   'SEIMP.DEX52CAT.DATA'
3. &IMP namelist for each namelist set.
4. Unit 9 defined as:

```
//FT09F001 DD DSN=IMPJDUM,DISP=SHR,UNIT=(1600,,DEFER),
//    VOL=SER=DUM1,DCB=BUFNO=1
```

## C. Sample JCL - IMP 8

# VIII. Multisatellite Fourier Analysis Program Differential Rates Routine

## A. Overview

The Multisatellite Fourier Analysis Program (MFAP) has an option to change the data before it goes into Fourier analysis. This is done via a subroutine called SUB1. (See the MFAP System Documentation Sections I.A. and IX.A.16. for a further description.) This document describes a SUB1 routine which subtracts one set of sectored counts from the next and stores this differential as a new set of counts. These counts then undergo the same analysis as before. SUB1 also changes the labels appropriately. If a succeeding rate does not exist (always the case for the last rate) or is not acceptable for analysis, the differential value can not be computed. In this case, a -2.0 is placed as a flag in the accumulation time, and the value is ignored by plotting routines.

To involk this process, SUB1 for differential rates is compiled into a load module and linked as the first SYSLIB data set. This causes the new SUB1 to override the dummy (simply returns) SUB1 in the Fourier load module, and thus be used to create differential sectored rates.

### 1. JCL Required

a. SYSLIB DD DSN=SB#PR.FOURDIF.LOAD,DISP=SHR as the first SYSLIB data set.

b. Same JCL as for the sectored rates.

# Multisatellite Fourier Analysis Program
# Anisotropy Check Routine

## B. Overview

The Multisatellite Fourier Analysis Program (MFAP) has an option to alter the data after Fourier analysis. This is done via a subroutine called SUB2. (See the MFAP System Documentation Sections I.A. and IX.A.16. for a further description.) This document describes a SUB2 routine which performs a check on the Fourier analysis anisotropy values. If a value is less than twice its deviation, it is negated. This flags the plotting routines to ignore the value, and the listing shows the negative anisotropy.

### 1. JCL Required

a. SYSLIB DD DSN=SB#PR.FOURCHK.LOAD,DISP=SHR as the first SYSLIB data set.

b. Same JCL as for the sectored rates.

C. Sample JCL - SUB1, SUB2

This example is for PIONNER. The SUB1 routine to be used is the file 'SEJSS.FOURIER.DIFFRNTL.LOAD'

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Damdrich
~~A. Stands~~
N. Lal

5/8/79

PIONEER F 10?

## Fourier Program

This paper is intended to outline all requirements of the Fourier analysis program, with such detail as is required to understand the entire scope of each function within the program. In addition, a priority list is made according to date for each function to ensure that the most essential requirements will be fulfilled by encounter. Please study this paper carefully and make comments concerning additions, deletions and corrections by COB Friday (May 11), at which time program design will begin.

### Overall Purpose.

This program is to accept sectored rates data (cnts/sec) from the PIONEER F Cosmic Ray experiment, perform a modified Fourier analysis on it, and generate printouts, plots and tapes, as described later in this paper. The program is to be effectively modularized such that specific functions--i.e., Fourier analysis, averaging, etc.--will be separate subroutines, and thus may be used by other systems.

The program is to be used by the scientist, generating no output which contributes or modifies the existing PIONEER F system.

### Data Input.

There are two sources of data input:

(1) Flux data base with catalog (15 min. averages).

(2) Encyclopedia or Rates tape with catalog (no averages). This may require trend checking. ~~with~~ w/wo input parm

### User Input.

The user will input parameters in a namelist format as follows (the functions are described later in this paper):

| | Option | Function Which Uses It |
|---|---|---|
| (1) | Averaging time | Data Collection |
| (2) | Start, stop time | Data collection, tape generation |
| (3) | Plot start, stop times | All plots |
| (4) | Rates desired (max # of rates TBD later) | All functions |
| (5) | Which output is desired (printout, plots, tapes) | -- |
| (6) | Vertical and horizontal plot scales | All plots |
| (7) | Calcomp or 4060 option | All plots |
| (8) | Polar plot options | Polar plot |

(T) Which go to tape

## Output Generated.

Any combination of the following outputs may be specified:

(1) Printout of Fourier results. + flow parameter (A(1)/accT * G) instead of Ao + DA

(2) Printout of rates and their times.

(3) Rates plot of ~~rates~~ flux (cnts/sec) vs. time. This is a semi-log plot on the 4060 plotter with option to convert to Calcomp plotter. Defaults are as follows:

  (a) Vertical axis: 4 decades such that max point is included.

  (b) Horizontal axis: 4 averaging intervals per centimeter.

(4) Parameters plot of Fourier results vs. time. This is a double plot, the top part being the Fourier result ($100 \cdot A_n/A_o$) (see Fourier analysis description later in this paper), and the bottom part being $\phi_n$, both vs. the same time scale as in Plot #3.

The ($A_n/A_o \cdot 100$) will be 2/3 of the plot, vertical scale being 0-120 with 6 tick marks.

The $\phi_n$ plot will be 1/3 of the plot, vertical scale being:

$$\left.\begin{array}{l} \phi_1 : 0\text{-}360 \\ \phi_2 : 0\text{-}180 \\ \phi_3 : 0\text{-}120 \end{array}\right\} \text{with 3 tick marks}$$

(5) Polar plots of normalized sector counts, normalized to a fixed scale. This function will use the polar plot options as already exist in a previously written program for PIONEER. Sample output is attached. JM

(6) Standard Rates Tape. This is a non-label, 9-track, 1600-BPI tape with the following format:

1 file = one run of this program.
1 record = fixed # of logical records.
1 logical record = time, followed by the desired parameters and their errors in floating point format.

Maximum # of parameters is TBD later. The first n logical records will contain header information. n will be determined later, but will be fixed.

input var.

(7) Sector Counts Tape. This is a non-label, 9-track, 1600-BPI tape with the following format:

1 file = one run of this program.
1 record = fixed # of logical records.
1 logical record = time, 8 sector counts.

The first logical record will contain the base time accumulation interval.

Additional Option.

It may be desired in the future to manipulate the data in various ways--e.g., include a new correction routine. This may occur at two points in the program:

(1) After data has been averaged, but before it is Fourier analyzed.

(2) After it has been Fourier analyzed, but before output has been generated.

To accommodate this flexibility, a common statement containing all data, which may be used in such a way, and a no-argument call to a subroutine contained in a separate disk-resident file at both points will be included in the program. Until this file is changed, the subroutine will simply issue a return.

Fourier Analysis.

The following is the fourier expansion of the counts: ~~expression for the rate will be used.~~

$$C_i = A_o[1 + \sum_{n=1}^{3} \zeta_n \cos n(\emptyset_i - \emptyset_n)]$$

where

$$A_o = \frac{1}{8\textcircled{G}} \sum_{i=1}^{8} C_i,$$

$$C_i = \text{sector rate},$$

$$\zeta_n = A_n/A_o,$$

$$A_n = (a_n^2 + b_n^2)^{1/2},$$

$$a_n = \frac{W_n}{4} \sum_{i=1}^{8} C_i \cos(n\theta_i),$$

FLUX. Ao / G * T

T = accumulation time

$$b_n = \frac{W_n}{4} \sum_{i=1}^{8} C_i \sin(n\theta_i),$$

$\theta_o$ = reference direction Sector o,

$\theta_i$ = angle in direction of Sector i,

$$\theta_n = \frac{1}{n} \tan^{-1}(b_n/a_n)+\theta_o,$$

n = harmonic number,

i = sector number,

$W_n$ = given weight factor, predetermined, and

G = geometric factor of counter ($cm^2$ ster).

For 8 sectors, $\theta_i$ is a multiple of 45°, so the values for cos $n\theta_i$ and sin $n\theta_i$ may be predetermined, saving CPU time. The result is then rotated through the angle $\theta_o$ so that the final answer is with respect to the north reference direction.

Standard Deviation.

$$\sigma_{A_o} = (A_o/8G)^{1/2}$$

$$\sigma_{\zeta_n} = W_n([1+D_n]/4A_o)^{1/2}$$

$$\sigma_{\emptyset_n} = W_n([1-D_n]/[4n^2\zeta_n{}^2A_o])^{1/2}$$

$$D_n = (W_n{}^2/8A_o{}^3\zeta_n{}^2)(\sum_{i=1}^{8}[(a_n{}^2-b_n{}^2)\cos 2n\theta_i + 2a_nb_n \sin 2_n\theta_i]C_i)$$

Schedule.

The following functions are scheduled to be completed by August 1:

(1) Use FLUX data base to average data.

(2) Fourier analysis and printouts.

(3) Rates, $A_n/A_o$, θ plots on 4060.

The following will then follow, listed in priority:

(1) Plots on Calcomp

(2) Angular plots

(3) First tape of rates

(4) Second tape of counts

(5) RATES tape as data base

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NUCLEAR INSTRUMENTS AND METHODS 138 (1976) 191–199; © NORTH-HOLLAND PUBLISHI

# LIMITATIONS OF THE COS APPROXIMATION AS APPLIED TO THE COSMIC-RAY ANISOTROPY

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Received 12 April 1976

A systematic study is presented of the COS approximation as applied to the class of spinning charged particle detec measure solar and galactic cosmic-ray anisotropies. This study includes the derivation of: (1) the general COS approx equations and their limitations for any harmonic component of the anisotropy, (2) the realistic errors for each component produced by the Poisson statistical fluctuations, and (3) the first order geometric smoothing effects real charged particle telescopes.

A computer simulation of the COS approximation is developed to test the reliability of the derived error relations examine effects associated with limited count rates. We find that not only is the anisotropy amplitude increased proper value at low count rates, but at any count rate an isotropic background anisotropy exists and is equal $\sim\sqrt{(3/C)} \pm \sqrt{(1/C)}$, where $C$ is the total number of counts.

## 1. Introduction

During the past decade numerous studies have been made, via spacecraft, of the solar and galactic cosmic-ray anisotropy in the 1–100 MeV energy range. Generally the studies involve particle detectors rotating perpendicular to the spacecraft spin axes which allow the incoming particle rate data to be divided into either four 90° sectors or eight 45° sectors. The individual sector count rates are then collectively fit to a COS curve which determines the amplitude and phase of any resulting anisotropy[1]). We shall call this procedure the COS approximation since the anisotropy is approximated by a simple COS curve in two dimensions.

In reviewing the literature on the cosmic-ray anisotropy, we have failed to find any systematic study concerning the validity *and* limitations of the *n*th harmonic COS approximation so widely in use. Nor have we found a suitable study discussing how to determine and extract a *valid* anisotropy from the large quantities of data that are produced by today's complicated particle detectors. Thus, the goal of this paper is to develop simple yet reliable analytic expressions for the geometric corrections and error analysis that can be applied to a large volume of data.

Various other methods of determining the charged particle anisotropy have been presented in the last few years. For an aggregate of particle detectors, each located in a slightly different position with respect to the spin axis of the spacecraft, a spherical harmonic analysis appears most reasonable[2,3]). This would allow a complete 3-dimensional determination of the charged particle anisotropy. However, if there is only one detector and the mean look angle of the det perpendicular to the spin axis of the spacecra the spherical harmonic analysis must be replac COS approximation. For modern particle that employ more than 8 sectors (usually 16 sect grey tone representation introduced by Gold is favorable. We note that the COS approxim requires only 5 sectors to determine the phy meaningful first and second harmonics of the tropic particle distribution. Thus, no new inform is gained by increasing the number of sectors a The only effects will be a reduction in the ge effects as shown in section 3, and a slightly im determination of the phase angles.

With these considerations in mind, we have c out a detailed analysis of the COS approxim which is presented below. Starting with a *n*th har Fourier series, we derive in section 2 the most equations for the anisotropy $\xi$ and the phase $\theta$ able to the COS approximation. In section derive corrections to the anisotropy caused by th geometry of a particle detector, and then in the standard errors, so often overlooked, are ca To check the accuracy of the calculations and mine the effects produced by limited count computer simulation using Poisson statistics formed. The results which are presented in s show that: First, the calculations are accurate; ly, the measured anisotropy, on the average, is greater than the true anisotropy. This effect, rely to Poisson statistics, says that even if the true anisotropy is zero, the average measured tropy is greater than zero.

### Anisotropy – derivation

We start by expressing the particle distribution function $\psi$ in terms of the general expression for a Fourier series applied to a set of $r$ *equidistant data points*[5])

$$\psi(\theta_i) = A_0 + \sum_{n=1}^{2n+1\le r} A_n \cos(n\theta_i - \theta_n), \tag{1}$$

where $A_0$ = zeroth harmonic, $A_n$ = magnitude of the $n$th harmonic, and the summation is bounded by $2n+1 \le r$. Here $\theta_i$ refers to the direction of the equidistant data point $i$ while $\theta_n$ refers to the direction of intensity maximum for the $n$th harmonic. In applying eq. (1) we note that $r$ = number of sectors and $n$ = harmonic number. Thus the number of sectors limits the number of possible harmonics; i.e. four sectors allow only the first harmonic and eight sectors allow up to and including the third harmonic. Expanding eq. (1),

$$\psi(\theta_i) = A_0 + \sum_{n=1}^{2n+1\le r} [a_n \cos(n\theta_i) + b_n \sin(n\theta_i)], \tag{2}$$

where $a_n = A_n \cos(\theta_n)$ and $b_n = A_n \sin(\theta_n)$.
It follows that, for $2n+1 \le r$,

$$\theta_n = \tan^{-1}(b_n/a_n), \qquad A_n = \sqrt{(a_n^2 + b_n^2)}, \tag{3a}$$

[illegible] by definition[5])

$$\xi_n = A_n/A_0. \tag{3b}$$

We now seek expressions for $a_n$, $b_n$, and $A_0$ that will best fit the function $\psi(\theta_i)$ to the count rate data $y_i$ in each sector $i$. Using the method of least-squares, defined by[5])

$$\mu^2 = \frac{1}{r}\sum_{i=1}^{r} (y_i - \psi_i)^2. \tag{4}$$

We want to minimize $\mu^2$ with respect to each coefficient, i.e.

$$\partial\mu^2/\partial X = 0, \tag{5}$$

where $X = A_0, a_n, b_n$. After carrying out the intermediate manipulations, the results are

$$\begin{aligned} A_0 &= \frac{1}{r}\sum_{i=1}^{r} y_i, \\ a_n &= \frac{2}{r}\sum_{i=1}^{r} y_i \cos(n\theta_i), \\ b_n &= \frac{2}{r}\sum_{i=1}^{r} y_i \sin(n\theta_i), \end{aligned} \tag{6}$$

where $2n+1 \le r$. Together eqs. (3) and (6) determine $\xi_n$ for all allowable harmonics from the experimental data provided that each sector can be considered as a single point. However, in reality each sector has a finite width and can not be considered to be a single point. We now turn our attention to corrections applied to finite detector geometries.

## 3. Anisotropy corrections for finite detector geometries

We now want to derive corrections to the measured anisotropy that are due to a finite geometry detector. First, we look at the general case to demonstrate what is involved in solving the problem exactly. Then several reasonable approximations are made so that simple analytic expressions can be found for the first and second harmonics of the anisotropy. Note our aim is to find accurate corrections that avoid along numerical calculations.

Consider any charged particle detector that is located perpendicular to the spin axis of a spacecraft. Let the plane of rotation, defined by the mean look angle of the rotating detector, be divided into $p$ sectors. Then the *average* particle distribution seen in one sector is

$$\langle f(\theta,\phi)\rangle = \frac{\iint (\mathrm{d}G/\mathrm{d}\theta\mathrm{d}\phi)\, f(\theta,\phi)\, \mathrm{d}\theta\mathrm{d}\phi}{\iint (\mathrm{d}G/\mathrm{d}\theta\mathrm{d}\phi)\, \mathrm{d}\theta\mathrm{d}\phi}, \tag{7}$$

where $f(\theta,\phi)$ = particle distribution and $\mathrm{d}G/\mathrm{d}\theta\mathrm{d}\phi$ = differential geometry factor described by the spherical polar coordinates $\theta$ and $\phi$. Since eq. (1) is used to define the particle distribution function, assume

$$f'(\theta,\phi) = A_0 + \sum_{n=1} A_n \cos(n\gamma), \tag{8}$$

where $\gamma = \gamma(\theta,\phi)$ and $\gamma = 0$ lies along the mean interplanetary magnetic field. The prime indicates $f'(\theta,\phi)$ holds only in the frame of reference moving with the solar wind. The average anisotropy is determined by transforming eq. (8) from the solar wind to the spacecraft frame which gives $f(\theta,\phi)$, then eq. (7) is solved numerically for each sector. These operations can also be performed in reverse to find the real anisotropy along the interplanetary magnetic field[4,6]).

The above, although accurate, is a very complicated process. A great deal of computer time is spent essentially determining the correction to the anisotropy which is actually small for our range of interest.

We now want to derive approximate analytic relations describing the correction factor $W_n$, where $\xi_n(\text{true}) = W_n \xi_n(\text{measured})$. First, we restrict ourselves to charged particle energies above 1 MeV. Then the transformation from the solar wind to the spacecraft frame is small[4,6]) and the first order Compton-Getting anisotropy correction is adequate. Second, notice from eqs. (7) and (8), that

$$\cos(n\gamma) = W_n \langle \cos(n\gamma) \rangle .$$

Thus, $W_n$ can be determined by an average over only one general sector. Finally, assume that an "effective" opening angle, $2\alpha$, can be found such that $\mathrm{d}G/\mathrm{d}\theta\,\mathrm{d}\phi =$ constant. This is a very good approximation for small anisotropies. Combining all of the above, eq. (7) reduces to

$$\langle \cos(n\gamma) \rangle = \frac{\displaystyle\int_{\theta-\alpha}^{\theta+\alpha} \mathrm{d}\theta \int_{\phi-\pi/p-\alpha}^{\phi+\pi/p+\alpha} \mathrm{d}\phi \cos(n\gamma)}{4\alpha\,(\pi/p+\alpha)}, \qquad (9)$$

where the integration limits represent integration over one "effective" sector of length $2\pi/p$ and width $2\alpha$. The spherical polar coordinates are defined such that $\theta$ is measured from the spin axis of the spacecraft and $\phi$ is measured in the plane of rotation formed by the mean look angle of the detector. It follows that

$$\cos(\gamma) = \cos(\theta)\cos(\theta') + \sin(\theta)\sin(\theta')\cos(\phi - \phi'), \qquad (10)$$

where $(\theta', \phi')$ represent the location of the magnetic field vector. Notice the projection of $\cos(\gamma)$ onto the $\phi$-plane gives

$$\cos(\gamma) \rightarrow \sin(\theta')\cos(\phi-\phi') = \cos(\varepsilon)\cos(\phi-\phi'),$$

where $\varepsilon = \frac{1}{2}\pi - \theta'$. This implies that the $n=1$ particle distribution is reduced by a *constant* factor, $\cos(\varepsilon)$, when projected into the $\phi$-plane. By a similar manipulation and after integration in eq. (9), it can be seen that the $n=2$ particle distribution is approximately reduced by a constant factor $\cos^2(\varepsilon)$ when projected into the $\phi$-plane. Since the basic physical interest is in the first and second harmonics, we now assume $\theta' = \frac{1}{2}\pi$ and multiply eq. (9) by $\cos^n(\varepsilon)$. The final analytical expressions follow:

*Case 1: n=1*

For $\cos(\gamma) = \sin(\theta)\cos(\phi - \phi')$, eq. (9) gives

$$\langle \cos(\gamma) \rangle = \cos(\varepsilon)\left[\frac{\sin(\alpha)}{\alpha}\right]\left[\frac{\sin(\pi/p+\alpha)}{(\pi/p+\alpha)}\right]\cos(\gamma). \qquad (11)$$

This implies a correction factor of

$$W_1(\alpha, p, \varepsilon) = \left[\frac{1}{\cos(\varepsilon)}\right]\left[\frac{\alpha}{\sin(\alpha)}\right]\left[\frac{(\pi/p+\alpha)}{\sin(\pi/p+\alpha)}\right].$$

*Case 2: n=2*

For $\cos(2\gamma) = 2\cos^2(\gamma) - 1$, eq. (9) gives imately

$$\langle \cos(2\gamma) \rangle = \cos^2(\varepsilon)\,\frac{1}{2}\left[\frac{\sin(2\alpha)}{2\alpha} + 1\right] \times \left[\frac{\sin(2\pi/p + 2\alpha)}{(2\pi/p + 2\alpha)}\right],$$

where a constant term, independent of $\gamma$, o $-\sin(2\alpha)/2\alpha]$ has been neglected. This imp approximate correction factor of

$$W_2(\alpha, p, \varepsilon) = \left[\frac{1}{\cos^2(\varepsilon)}\right]\left[\frac{4\alpha}{\sin(2\alpha) + 2\alpha}\right] \times \left[\frac{(2\pi/p + 2\alpha)}{\sin(2\pi/p + 2\alpha)}\right].$$

Figs. 1 and 2 exemplify the effect of the co factor, $W_1$ from eq. (12), for various values o

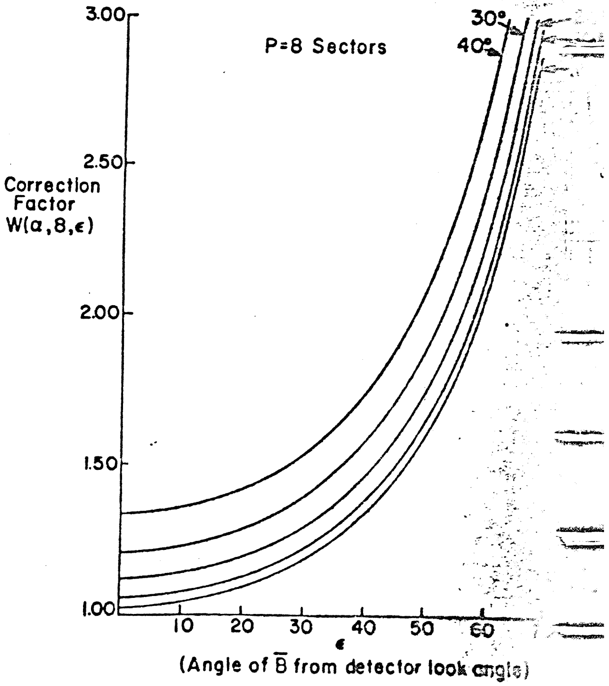

Fig. 1. Variation of correction factor was a function of between the interplanetary magnetic field and its proj the plane of rotation of the detector. Each curve re particular value of $\alpha$.

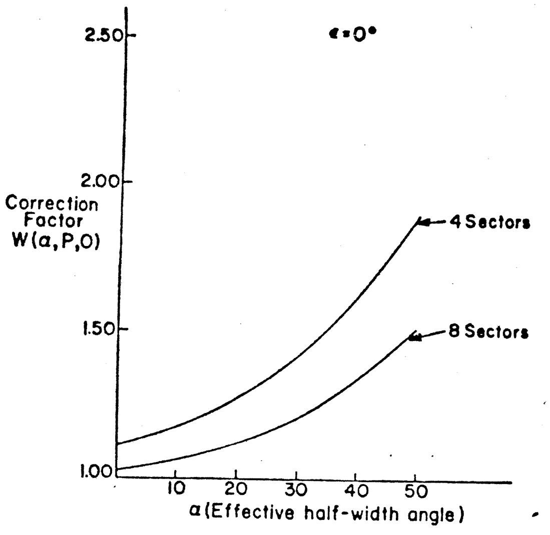

Fig. 2. Variation of correction factor $W_1$ as a function of detector effective half-width opening angle and number of sectors. The effects are purely geometrical.

and ε. In fig. 1 $W_1$ is plotted as a function of ε, the angle between the interplanetary magnetic field and its projection into the plane of rotation of the detector.

cluded in the figure is a family of curves representing various values of $\alpha$ for a fixed number of sectors, $p=8$. Notice $W_1$ is approximately constant for ε below 30° and is quite small for $\alpha$ less than 20°. Fig. 2 shows $W_1$ as a function of $\alpha$ for two commonly used values of $p$. It is clearly seen that the $p=8$ curve yields much smaller values of $W_1$, which in turn produces more accurate measured anisotropies.

As a representative example of the above analysis, consider the GSFC-UNH charged particle detectors located on the Pioneer 10 and Pioneer 11 spacecraft. The largest effective half-width angle is ~18° and $p=8$ If we assume $\varepsilon=0$, then $W_1=1.10$. Using the same values the second harmonic gives $W_2=1.47$. Thus, the first harmonic correction is very small but noticeable. The second harmonic correction is large, which implies any measured but uncorrected bidirectional anisotropy *magnitude* would be seriously undervalued.

So far we have considered the reduction in the anisotropy produced by a real detector and by a variable magnetic field. Another separate correction to the anisotropy is necessary due to a background count rate present in all real particle detectors. To derive this relationship, assume the background count rate is isotropic. Using eq. (3), the true anisotropy for any harmonic is given by

$$\xi_n(\text{true}) = \frac{A_n}{A_0(\text{true})} = \frac{A_n}{A_0 - B} = \frac{1}{1 - B/A_0}\,\xi_n(\text{measured}). \tag{15}$$

where $B=$ background count rate and $A_0=$ average measured count rate. This term, which is exact providing $B$ is isotropic, must now be added to eqs. (12) and (14) to form the most general correction factor.

In conclusion we feel that the corrections derived above are reasonable approximations to the more general case. Not only are the corrections easy to apply, they can be calculated without reference to the magnetic field data which can be added later. In practice cos(ε) is usually not included in the correction factor but is monitored individually[7]).

## 4. Standard errors

We now look for a reasonable standard error that is applicable to both the magnitude and phase of the measured anisotropy. Here, as before, the final goal is to find simple analytical expressions that will allow a confident interpretation of the data.

We start by examining the influence of the counting rate $y_i$ on the anisotropy. In order to relate the error produced by the initial data to the anisotropy as derived by the Fourier expansion, we introduce the standard definition of the variance[8])

$$\sigma_P^2 = \sum_{i=1}^{r} \left(\frac{\partial P}{\partial y_i}\right)^2 \sigma_{y_i}^2 \tag{16}$$

where $\sigma_{y_i}^2$ is the variance of $y_i$ in sector $i$, $P$ is the function of interest, and $\sigma_P^2$ is the variance of the function. In this problem $r$ represents the total number of sectors and $y_i$ is defined as the number of counts in sector $i$. This relation, as given above, is valid only if the various $y_i$ are independent of each other and if the counts per sector are high enough to use a statistical distribution. Since the cosmic-ray particles obey a Poisson statistical distribution, $\sigma_{y_i}^2 = y_i$. Then the standard variance for the amplitude and phase, for any harmonic $n$, are given by

$$\sigma_{\xi_n}^2 = \sum_{i=1}^{r} \left(\frac{\partial \xi_n}{\partial y_i}\right)^2 y_i,$$

$$\sigma_{\theta_n}^2 = \sum_{i=1}^{r} \left(\frac{\partial \theta_n}{\partial y_i}\right)^2 y_i. \tag{17}$$

Using the definition of $\xi_n$ from eq. (3),

$$\frac{\partial \xi_n}{\partial y_i} = \frac{W_n'}{A_0}\left(\frac{\partial A_n}{\partial y_i} - \frac{A_n}{A_0}\frac{\partial A_0}{\partial y_i}\right)$$

$$= \frac{2W_n'^2}{rA_0^2\xi_n}\left[a_n\cos(n\theta_i) + b_n\sin(n\theta_i) - \frac{A_0\xi_n^2}{2W_n'^2}\right], \quad (18)$$

where $W_n'$ is the correction factor discussed in the last section and $\xi_n$ is the true anisotropy. Similarly

$$\frac{\partial \theta_n}{\partial y_i} = \frac{2W_n'^2}{rA_0^2\xi_n^2}\left[a_n\sin(n\theta_i) - b_n\cos(n\theta_i)\right]. \quad (19)$$

Now combining these expressions with eq. (17) and utilizing the relationships applicable to a finite set of Fourier orthogonal functions[5]), the exact results are

$$\sigma_{\xi_n}^2 = \frac{2W_n^2}{rA_0}(1+D_n),$$

$$\sigma_{\theta_n}^2 = \frac{2W_n^2}{rA_0\xi_n^2}(1-D_n), \quad (20)$$

where

$$D_n = \frac{W_n'^2}{rA_0^3\xi_n^2}\sum_{i=1}^{r}\left[(a_n^2-b_n^2)\cos(2n\theta_i) + \right.$$

$$\left. + 2a_nb_n\sin(2n\theta_i)\right]y_i, \quad (21)$$

and $-1 \leq D_n \leq 1$. It should be pointed out that $D_n = \pm 1$ only if all the particles arrive in one sector. Of course any such distribution clearly violates the original assumption of a cosine distribution and the numerical result for $\xi_n$ would not be meaningful. Also if the distribution is isotropic, then $D_n=0$ due to the oscillating terms. These results imply that $D_n \ll 1$ when $\xi_n$ is small, which coincidentally is the only time the cosine fit can be valid. We therefore assume $D_n=0$. Now defining the total counts for all sectors as $C=rA_0$, and defining the error as the square root of the variance, we obtain the simple error expressions[7,9])

$$\sigma_{\xi_n} = W_n\sqrt{(2/C)}, \qquad \sigma_{\theta_n} = \sigma_{\xi_n}/\xi_n, \quad (22)$$

where $\xi_n$ represents the true anisotropy. Observe that the error is merely a combination of the geometrical smoothing effects which is represented entirely by $W_n'$, and the actual limited Poisson count rate represented by $C$. The phase error is also related inversely to the anisotropy magnitude but this is not unexpected since $\theta_n$ becomes undefined as $\xi_n \to 0$.

The above results allow large quantities of data to be processed to find relevant anisotropies without examining each piece of data by hand. Likewise, the errors predetermine the minimum value of $\xi_n$ that can be seen for a given count rate and for a given time period.

## 5. The background anisotropy

In order to test the effect of the count rate $C$ on the measured anisotropy and in order to test the validity of the derived error expressions as illustrated by eq. (22), we developed a computer simulation of the COS fit to the cosmic-ray anisotropy. A brief description of the simulation along with a detailed discussion of the surprising results and their implications are given below.

We begin by considering only the first harmonic of the anisotropy. Here the correction factor is set equal to one since the interest is only in the variation with respect to $C$. The simulation then consists of the following steps. First, select a perfect COS distribution of amplitude $\xi_1$ and phase $\theta_1$. Second, fit this distribution to a set number of sectors $r$ and total counts $C$.

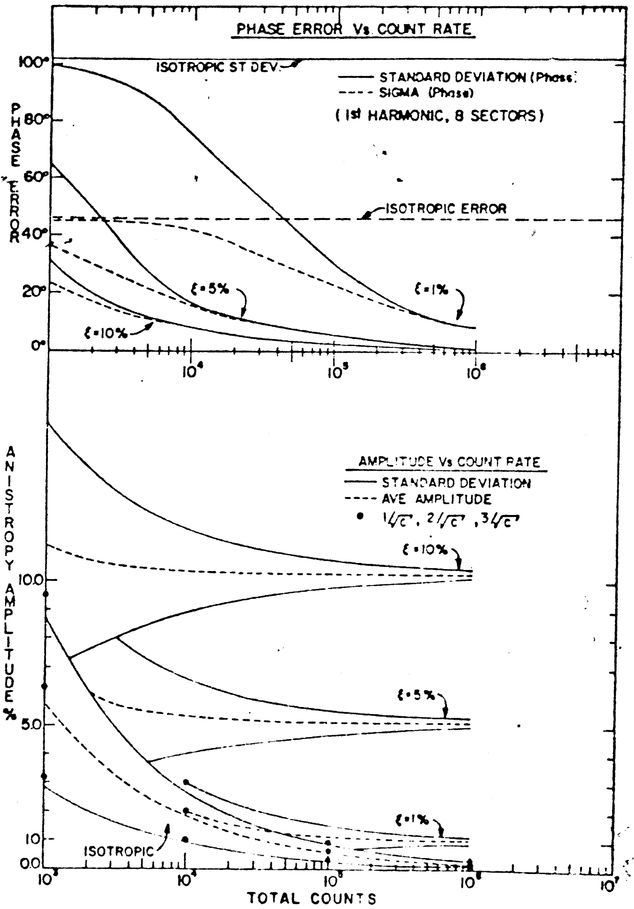

Fig. 3. Results of computer simulation of the anisotropy COS fit. Notice the finite isotropic background anisotropy.

Third, read each sector count rate into a Poisson random number generator that is normalized to the total counts $C$. Finally, the resulting sector count rates are refit by a COS distribution as defined in eqs. (1)–(6). This process is repeated a few thousand times for each $C$ so that an average and standard deviation can be formed for both the anisotropy magnitude and phase. The results for various values of $\xi_1$ as a function of $C$ with $r = 8$ are shown in fig. 3. Observe that the average anisotropy amplitude, shown in the lower section of fig. 3, is denoted by the dashed line while the solid lines represent one standard deviation from the average. In the upper section of fig. 3, the phase error is denoted by the dashed line while the solid line represents one standard deviation from the average. The key results in fig. 3 are seen to be the following:

1) The average anisotropy amplitude accurately reproduces the initial amplitude for large values of $C$. But as $C$ decreases the average amplitude *always increases* compared to the initial amplitude.

2) For a zero initial anisotropy, i.e. isotropic conditions, there always exists a finite measured amplitude that is due entirely to Poisson statistics. In fact, our studies show that this background anisotropy follows very closely the relationship

$$\xi_{BG} \sim \sqrt{(3/C)} \pm \sqrt{(1/C)}, \qquad (23)$$

where $\sqrt{(1/C)}$ represents one standard deviation. This formula is depicted by black dots in fig. 3. The actual average calculated isotropic background amplitude is the bottom dashed curve with one standard deviation described by the solid lines. The physical consequence of these first two remarks is simple: all measured anisotropy amplitudes are biased in the upward direction.

3) The error $\sigma_{\xi_1}$, although not drawn in fig. 3, is always slightly larger than the standard deviation calculated from the simulation. The difference between the two is not large and tends to decrease with increasing $C$.

4) The error $\sigma_{\theta_1}$ converges with the standard deviation for large values of $C$, but for small values of $C$ the two curves diverge radically. The region where the breakdown occurs can be seen, from fig. 3, to be related to the area where the average anisotropy amplitude starts to increase. This region begins when the background anisotropy is no longer small compared to the actual anisotropy. Above this zone, denoted empirically by $\xi_1 \sim 2\xi_{BG}$, the phase error is accurate.

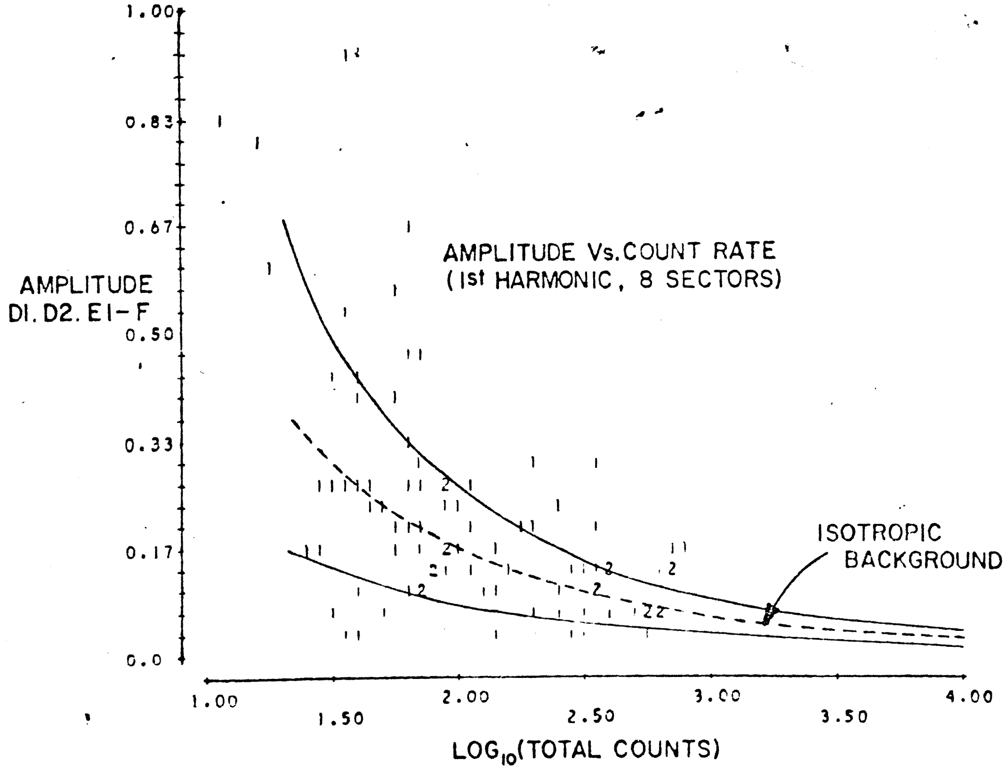

Fig. 4: Actual calculated anisotropy amplitude data from the LET-I detector on board Pioneer 10. The predicted isotropic background amplitude is shown for comparison.

To investigate the above observations in more detail, the simulation was rerun for the case of the first harmonic anisotropy divided into four sectors. If we again plot the calculated anisotropy amplitude vs the total counts $C$, the resulting curves are identical to the case of the first harmonic anisotropy that is divided into eight sectors - including the isotropic background curves. Thus, the Poisson statistical variation is independent of the number of sectors and depends only upon the total number of counts.

Rerunning the simulation for cases considering the second harmonic with four or eight sectors shows similar results to those discussed above. There appear to be no major differences between any of the observations. But this is to be expected since the derived standard error expressions are independent of both the harmonic number and the number of sectors.

Finally, in order to check the applicability of the isotropic background anisotropy, we have examined actual data from the GSFC-UNH cosmic-ray detector located on Pioneer 10 during times when the anisotropy is known to be small. A typical sample of the calculated anisotropy amplitude as a function of the total number of counts is shown in fig. 4. The average isotropic background predicted by eq. (23) is overlayed in fig. 4 as the dashed line while the solid lines represent one standard deviation from the mean. The agreement between theory and actual data is remarkable. We take this agreement as confirmation of the validity of the calculated isotropic background anisotropy.

We have also examined the Rao et al.[10]) data on the quiet time galactic cosmic-ray anisotropy in the same manner as above. The resulting data are shown in fig. 5. Clearly the anisotropy amplitude and, by association, the phase for the 45-90 MeV proton data are meaningless. Even the best 7.5-45 MeV data point, although not within one standard deviation of the mean isotropic background, is most likely influenced by it. Certainly the amplitude and phase are not as accurate as reported.

We note that Rao et al.[18]) had expressed their concern about the validity of $\xi$ for the 45-90 MeV proton energy interval and that other groups have ignored this warning and have used this information in their present-day models[11]).

For completeness, we now briefly consider the problem of correcting the measured first harmonic anisotropy amplitude so that the influence of the isotropic background anisotropy is taken into account. Since the magnitude of $\xi_{BG}$ was established by the simulation program, the problem is approached empirically. First, a measured $\xi$ curve from the simulation program is selected. Then various functions are fit to the average measured $\xi$ in an attempt to reproduce the true initial

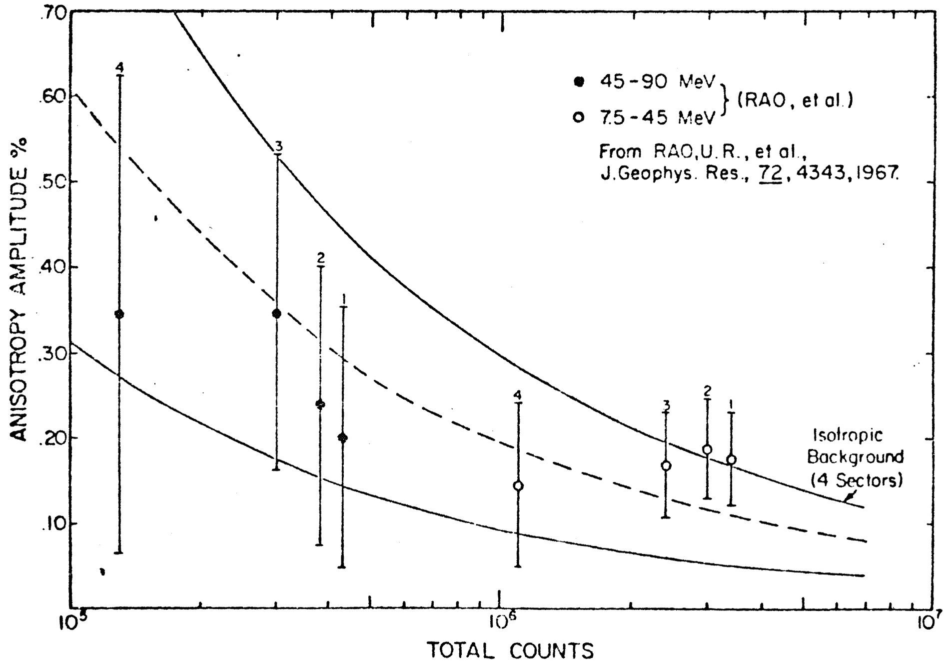

Fig. 5. Rao et al.[10]) quiet time anisotropy data compared to calculated isotropic background anisotropy. The number above each data point represents the data subset number as given in table 2 of Rao et al.[10]).

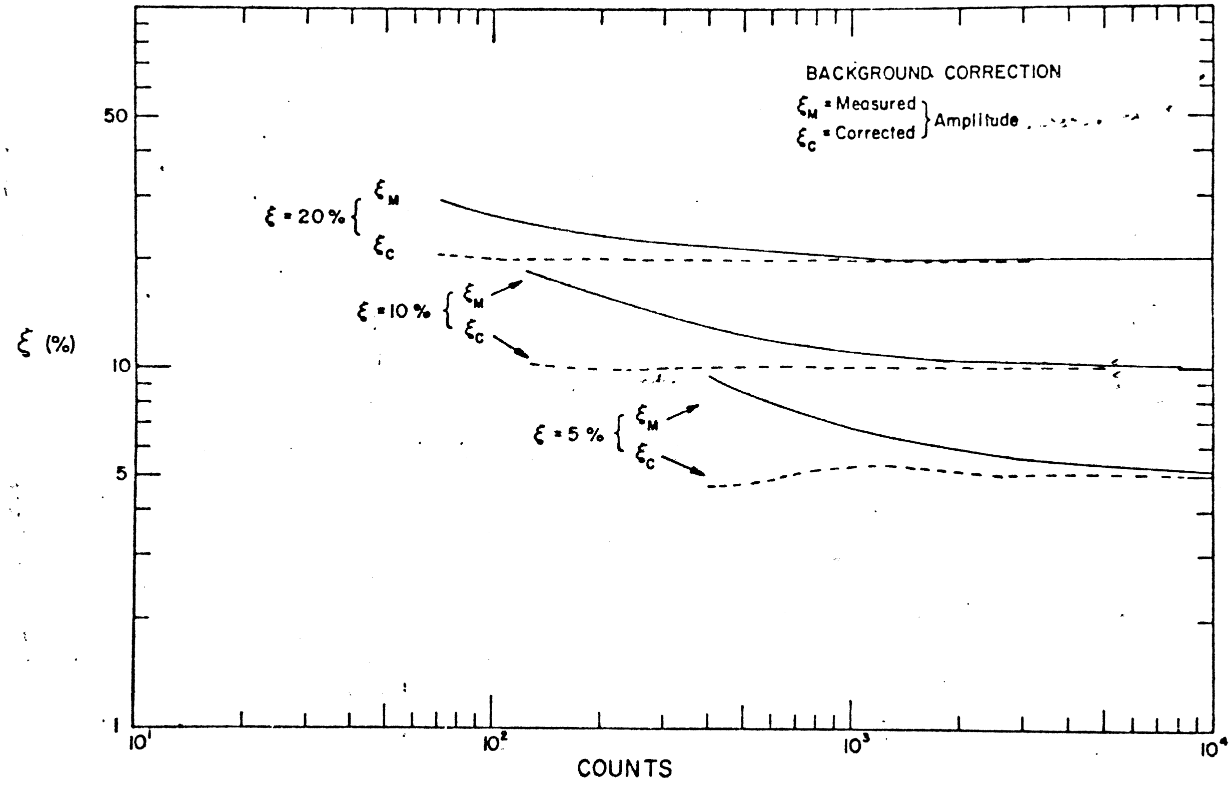

Fig. 6. The anisotropy background correction resulting from eq. (24). The $\xi$ (measured) curves are taken from the computer simulation.

anisotropy. The empirical function that best corrects the various $\xi$ curves is given by

$$\xi(\text{true}) = \begin{cases} (\xi^2 - 1/C - 35/C^{3/2})^{1/2}, & \text{for} \quad C \geq 350, \\ (\xi^2 - 2.88/C)^{1/2}, & \text{for} \quad C \leq 350, \end{cases} \tag{24}$$

where $C$ is the total number of counts and $\xi = W'_1 \xi_{\text{meas}}$, where $W'_1$ is given by eq, (12) and $\xi_{\text{meas}}$ is the actual measured anisotropy. The result of this correction can be seen in fig. 6. In practice this correction can only be used when $\xi_{\text{meas}} \gtrsim \xi_{\text{BG}}$.

## 6. Conclusions

We have presented a systematic study of the cosmic-ray anisotropy COS approximation. The initial equations derived from the Fourier series expansion for the $n$th harmonic component of the anisotropy are completely general. This includes the equations derived from the least-squares fit which allow a determination of the anisotropy for any harmonic $n$ such that $2n+1 \leq r$, where $r$ is the number of sectors. Although several assumptions were made in determining the simple analytic smoothing corrections given in section 3, we believe that they are accurate provided only that the cosmic-ray distribution can be approximated by a COS expansion and that the average energy of the particles are $\gtrsim 1$ MeV.

We conclude, after detailed investigation and implementation for more than a year, that:

1) The error expressions in eq. (22) are accurate and easy to apply to large amounts of data. We urge that they be adopted as a *standard* whenever the COS approximation is used in determining the anisotropy.
2) The isotropic background anisotropy exists and is well-described by $\xi_{\text{BG}} \sim \surd(3/C) \pm \surd(1/C)$. $\xi_{\text{BG}}$ will influence $\xi$ for low count rates.
3) Smoothing factor corrections, such as those in section 3, must be applied in any detailed comparison of the measured anisotropy with theory.
4) The three-dimensional direction of the interplanetary magnetic field must be included in any detailed analysis of the cosmic-ray anisotropy.

The authors thank Drs. J. A. Lezniak and F. C.

Roelof for their initial comments and direction in the early stages of this work.

This research is supported by the National Aeronautics and Space Administration under contract NAS 5-11276.

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# Pioneer Fourier Analysis Program.

## Data Source

Primary: 15 Min Avg Data Base

secondary: shorter averages and individual angula
distributions from encyclopedia tape

Trend Fit: with or without Trend fit. Delete all sectors if one fails; or is missing data.

## Constants for Program.

Angle of center of sector 1

PHI0 : HET 5.148721 295.1
LET I 4.363323
LET II 3.455725

Correction factor for finite solid angle, W:

| | n=1 | n=2 | n=3 |
|---|---|---|---|
| HET | 1.036 | 1.152 | 1.385 |
| LET II | 1.039 | 1.145 | 1.367 |
| LET I | 1.046 | 1.200 | 1.520 |

Geometric Factors, G

HET 0.155 $cm^2 str$. LET I 0.154 $cm^2 st$
LET II 0.0156 $cm^2 str$

## Count Times

Each sector 1/8 of a spin period. Nominal spin period is 12 seconds but there is a differenc between Pioneer 11 + 12. The period changes some with

Use default values of: 12.62 sec for Pioneer 10
11.89 sec for Pioneer 11
or get it from tape

Interval between samples depends on data rate

Computations

I Set up and sum data obtained during interva

Eliminate all sector counts if one of Them

is missing.

II. Peform Fourie Analysis

III a) Calculate Particle Flux as $\overset{F}{A(1)/(T*G)}$ and

error $DA(1)/(T*G)$.

b) Calculate flow parameter:

$$FL = \frac{A(2) + A(4)\cos 3[PHI(1) - PHI(3)]}{\boxed{A(1)} + A(3)\cos 2[PHI(1) - PHI(2)]}$$

IV Print out: $A(1)/T*G$ $DA(1)/T*G$

A) Rate ID, ~~Rate~~ ~~ΔRate~~, $100 \times A_1/A_0$, $100 \times FL$, $100 \times \Delta A_1/A_0$, $\Phi_1$, $\Delta\Phi_1$,

$100 \times A_2/A_0$ $100 \times \Delta A_2/A_0$, $\Phi_2$, $\Delta\Phi_2$, $100 \times A_3/A_0$, $100 \Delta A_3/A$

$\Phi_3$, $\Delta\Phi_3$

**Format:** Use G format for Flux and error on Flux (normally should print in F format for range 0.1 to 10,000) G8.4

For The other entries use F format with

Two significant figure after decimal point, a

max. Value of 900. F6.2

B) Optional print out of sector counts and accumulation Time.

## V Plot Options (choice of 4060, or Calcomp)

A. Polar plots of normalized sector counts
Use fixed plotting scales

B. Plot of Parameters vs Time (specifiable)

Time scale default: 4 points per 1 cm
(note 24 cm/day for 15 min. averages)

Vertical scales

1) log Rate specifiable, default 4 decades Tha
cover The maximum rate encountered duri
interval. (drop low values if necessary)

2) 100x $A_n/A_0$ range 0 – 120 with value
>120 plotted at 120 to use 2/3 of page
(or FL with $\Delta FL = DA(2)$)
$\Phi_n$ plotted in lower 1/3 of page

range $\phi_1$ 0 – 360
$\phi_2$ 0 – 180
$\phi_3$ 0 – 120

## VI Tape Options

A.) Rate Header for identifying quantities on Tape

Data: Time & each quantity at That Time plus
error in single precission floating po

If practical (?) place no limit on the number of quantities entered for each time. Limit the total record size to 1 or 2 disk tracks.

Default format: header includes up to 6 ra

1 up to 6 rates can be specified for each time, and total number of lines (96 default) can

specified total not to esceed 1 or 2 tracks.

B.) Tape of Sector Counts

Headder

Data: Time, accumulation interval, 8 sector counts

## VII Subroutine Option (?)

Supply logics necessary to request program to call a user supplied subroutine that can acces data as formated for the tape option and substitu its result into Plot program B or include its ow output program. Possible use of this option would b to merge magnetic field data and calculate a relative to the field or enter field direction To Polar plots.

Handling of Different Rates in Parallel;

Program should be able to process several rates in parallel (up to 8?). If this is desired Th work space limitations to drop (after printout) Those parameters which are not required in Th Plot Tape or subroutine options.

# Non Weighted Fourier Analysis Code

**Def. of Variables**

1) C(1 - - 8) Sector Counts = $C_i$

2) A(M-1) = $A_n$ = coefficients in Fourier Expansion

$$C_i = A_0 \left[1 + \sum_{n=1}^{\overset{3}{8}} \xi_n \cos n(\phi_i - \phi_n)\right] \quad i = 1 \cdot\cdot 8 \text{ dire sector}$$

3) W(1,2,3) = correction factor for finite sector
(default value = 1)

4) DA = standard deviation on A(1 - 4)

5) PHI = $\Phi_n$ $n = 1 - 3$

6) DPHI = standard deviation on $\Phi_n$ $n = 1 - 3$

7) PHI0 = angle between center line through 1st sector and reference direction (measu counterclockwise). In general this will have a d value for each detector on a satellite.

Expansion:

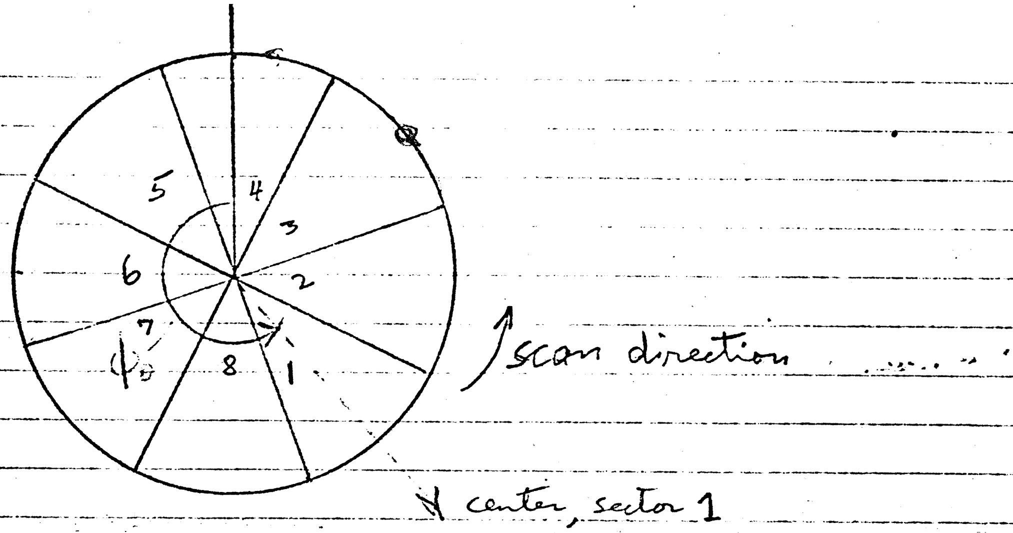
$$C_i = A_0 + LA1 \cos\phi_i + LB_1 \sin\phi_i + LA2 \cos 2\phi_i + LB2 \sin 2\phi_i + LA3 \cos 3\phi_i + LB_3 \sin 3\phi_i$$

where $\phi_i$ = angle in direction of observation refe to 1st sector so that $\phi_1 = 0$

**Notice:** for 8 sectors $\phi_i$ is a multiple of 45°, Th

The only values are: 0, .7071068, 1, -.7071068

$\uparrow$ cos 45°
sin 45°



After the LA's and LB's have been calculated

✓ calculate $\xi_n = \sqrt{LA_n^2 + LB_n^2}/A_0$ ($LA_1 = LA1$ etc)

✓ $\phi_n = \frac{1}{n}\tan^{-1}\frac{LB_n}{LA_n} + \phi_0$ to reference direction

✓ $A_0 = \frac{1}{8}\sum_{i=1}^{8} \boxed{C_i}$

✓ $LA_n = \frac{1}{4}\sum_{i=1}^{8} C_i \cos n\phi_i$ $LB_n = \frac{1}{4}\sum_{i=1}^{8} C_i \sin n\phi_i$

Standard Deviation

$$\sigma_{A_0} = \sqrt{A_0/8}$$

$$\sigma_{\xi_n} = \frac{W_n}{2\sqrt{A_0}}\sqrt{1 + D_n}$$

$$\sigma_{\phi_n} = \frac{W_n}{2n\,\xi_n\sqrt{A_0}}\sqrt{1 - D_n}$$ in radians

$$= \frac{180\,W_n}{\pi\sqrt{A_0}\;n\;\xi_n}\sqrt{1 - D_n}$$ in degree

$$D_n = \frac{W_n^2}{\quad} \sum^{8} [(LA_i^2 - LB_i^2)\cos 2n\phi_i$$

From The above expression we get.

$$D_1 = \frac{W_1^2}{8A_0^3\,\xi_1^2}\Big\{(LA_1^2 - LB_1^2)\big[C(1)+C(5)-C(3)-C(7)\big] + 2\,LA_1\,LB_1\big[C(2)+C(6)-C(4)-C(8)\big]\Big\}$$

an(2

$$D_2 = \frac{W_2^2}{8A_0^3\,\xi_2^2}\,(LA_2^2 - LB_2^2)\big[C(1)+C(3)+C(5)+C(7) - C(2)-C(4)-C(6)-C(8)\big]$$

an(3

$$D_3 = \frac{W_3^2}{8A_0^3\,\xi_3^2}\Big\{(LA_3^2 - LB_3^2)\big[C(1)+C(5)-C(3)-C(7)\big] + 2\,LA_3\,LB_3\boxed{\big[C(2)+C(6)-C(4)-C(8)\big]}\Big\}$$

an(4)

$$-C(2)-C(6)+C(4)+C(8$$

In following code Do loops were not used in order to minimize running Time.

$$(a^2-b^2)\cos 2n\phi + 2ab$$

$$\overset{6\ \phi}{\sin 2n\phi} \qquad \phi$$

```
Subroutine   FOURIE(C, PHI0, W, A, DA, PHI, DPH

      DIMENSION  C(8), W(3), A(4), DA(4), PHI(3), DPHI(3)
        T = 57.29578
        Z = 0.7071068

2A0 = A(1) = (C(1) + C(2) + C(3) + C(4) + C(5) + C(6) + C(7) + C(8))/ 8

      LA1 = C(1) - C(5) + (C(2) - C(4) - C(6) + C(8)) * Z

      LB1 = C(3) - C(7) + (C(2) + C(4) - C(6) - C(8)) * Z

      LA2 = C(1) - C(3) + C(5) - C(7)

      LB2 = C(2) - C(4) + C(6) - C(8)

      LA3 = C(1) - C(5) + (C(4) - C(2) + C(6) - C(8)) * Z

      LB3 = C(7) - C(3) + (C(2) + C(4) - C(6) - C(8)) *

degrees
      PHI(1) = AMOD(((ATAN2(LB1/LA1) + PHI0)*T, 360) ~~+ 360~~
                             LB  LA
      PHI(2) = AMOD(((ATAN2(LA2/LB2)/2 + PHI0) * T, 180) ~~+ 180~~ , 1
                             LB  LA
      PHI(3) = AMOD(((ATAN2(LA3/LB3)/3   + PHI0) * T, 120) ~~+ 360~~ , +

      A(2) = (SQRT (LA1**2 + LB1**2))/ A0 * W(1)   /4

      A(3) = (SQRT (LA2**2 + LB2**2))/ A0 * W(2)   /4

      A(4) = (SQRT (LA3**2 + LB3**2))/ A0 * W(3)   /4

σA0 = DA(1) = SQRT(A(1)/8.W)
```

```
      D1 ← 2*SQRT A(1)                          ?
      M2 = T/ ~~SQRT A(1)~~ ?    1/2      D1
      D2 = 8*A(1)**3   .2768
      D = (LA1**2-LB1**2)x(C(1)+C(5)-C(3)-C(7))
      D = W(1)**2/D2/A(2)**2x(D+2xLA1xLB1x(C(2)+C(6)
                                   -C(4)-C(8)))
$\sigma_{S_1}$      DA(2) = W(1)/D1*SQRT(1+D)
                      ?
$\sigma_{\phi_1}$      DPHI(1) = W(1)*M2/A(2) * SQRT(1-D)   T to convert
      D = C(1)+C(3)+C(5)+C(7)-C(2)-C(4)-C(6)-C(8)
      D = W(2)**2/D2/A(3)**2 *(LA$\overset{2}{3}$**2-LB$\overset{2}{3}$**2)*D
$\sigma_{S_2}$      DA(3) = W(2)/D1 * SQRT(1+D)
$\sigma_{\phi_2}$      DPHI(2) = W(2)*M2/2/A(3)*SQRT(1-D)
      D = (LA3**2-LB3**2)(C(1)+C(5)-C(3)-C(7))
      D = W(3)**2/D2/A(4)**2*(-2*LA3*LB3*(C(2)+C(6)-
                              -C(4)-C(8))+D)
$\sigma_{S_3}$      DA(4) = W(3)/D1 * SQRT(1+D)
                          ?
$\sigma_{\phi_3}$      DPHI(3) = W(3)*MULT/3/A(4) *SQRT(1-D)

      RETURN
      END
```

$\sqrt{A}\cdot\sqrt{B} = \sqrt{A\cdot B}$

$$\text{DeVA} = \frac{W(1)\cdot SQ\left(1+\frac{D(1)}{4\cdot A\phi}\right)}{2\cdot}$$

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9/10/80

# Multisatellite Fourier Analysis Program
# Anisotropy Check Routine

## Overview

The Multisatellite Fourier Analysis Program (MFAP) has an option to alter the data after Fourier analysis. This is done via a subroutine called SUB2. (See the MFAP System Documentation Sections I.A. and IX.A.16. for a further description.) This document describes a SUB2 routine which performs a check on the Fourier analysis anisotropy values. If a value is less than twice its deviation, it is negated. This flags the plotting routines to ignore the value, and the listing shows the negative anisotropy.

## JCL Required

1. SYSLIB DD DSN=SBPIO.FOURCHK.LOAD,DISP=SHR data set.

2. Same JCL as for the sectored rates.

Sample JCL - SUB1, SUB2

This example is for PIONEER. The SUB1 routine to be used is in file 'SEJSS.FOURIER.DIFFRNTL.LOAD'.

```
//         DD DSN=SEJSS.FOURIER.SI.LOAD,DISP=SHR

// EXEC LOADER,REGION=270K,PARM='SIZE=260K,EP=MAIN'
//*--- FOR DOCUMENTATION ON LINKING INTO THE PROPER SATELLITE,
//*    QED THE FILE 'SEJSS.MULTISAT.FOURIER(DOC)'
//*---
//SYSLIB DD DSN=SEJSS.FOURIER.DIFFRNTL.LOAD,DISP=SHR

//         DD DSN=SEJSS.FOURIER.PIONEER.LOAD,DISP=SHR
```

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# VII. Multisatellite Fourier Analysis Program
## IMP-8 System Documentation

## A. Overview

The satellite-dependent (SD) IMP routines allow the IMP 8 data to be processed through the Fourier program's analysis and output procedures. The satellite-independent (SI) routines are contained in separate source and load modules from all SD code, and thus, any satellite may be linked via JCL.

This document describes the SD user input required for IMP Fourier analysis. The main document containing the SI user input must be reviewed prior to this one.

### 1. Input Required

#### a. Satellite independent namelist INPUT

(1) The RATES parameter may have the following values:

| RATES Parameter | Rate Signified |
|---|---|
| MED1 | DI E F G |
| MED2 | DI D2 E F G |
| MED3 | (DI+EI)1 E F G |
| MED4 | DI (DI+EI)1 E F G |
| LED1 | A1 B C |
| LED2 | A1 B C |
| VLET1 | DI DII F |
| VLET2 | DI DII (SUM)1D F |

(2) The parameter SATID must be 'IMP-8'.

#### b. IMP namelist IMP

&IMP ZMAG,QLED

This namelist must appear after each namelist set of the SI routines.

| Name | Type | Default | Description |
|---|---|---|---|
| ZMAG(8) | A8 | blanks | List of magnetic field tape names in order |
| QLED | L*1 | T | T=use corrected LED rates data |

#### c. Counts Tape

This is a standard label, fixed, blocked tape in the IMP counts tape format. It is provided by the tape catalog.

d. Tape Catalog

The catalog file name must be entered in the JCL for unit 25. The IMP catalog is in:

'SEIMP.DEX52CAT,DATA'

## 2. Output Generated

(See Fourier Plot Program SI Documentation)

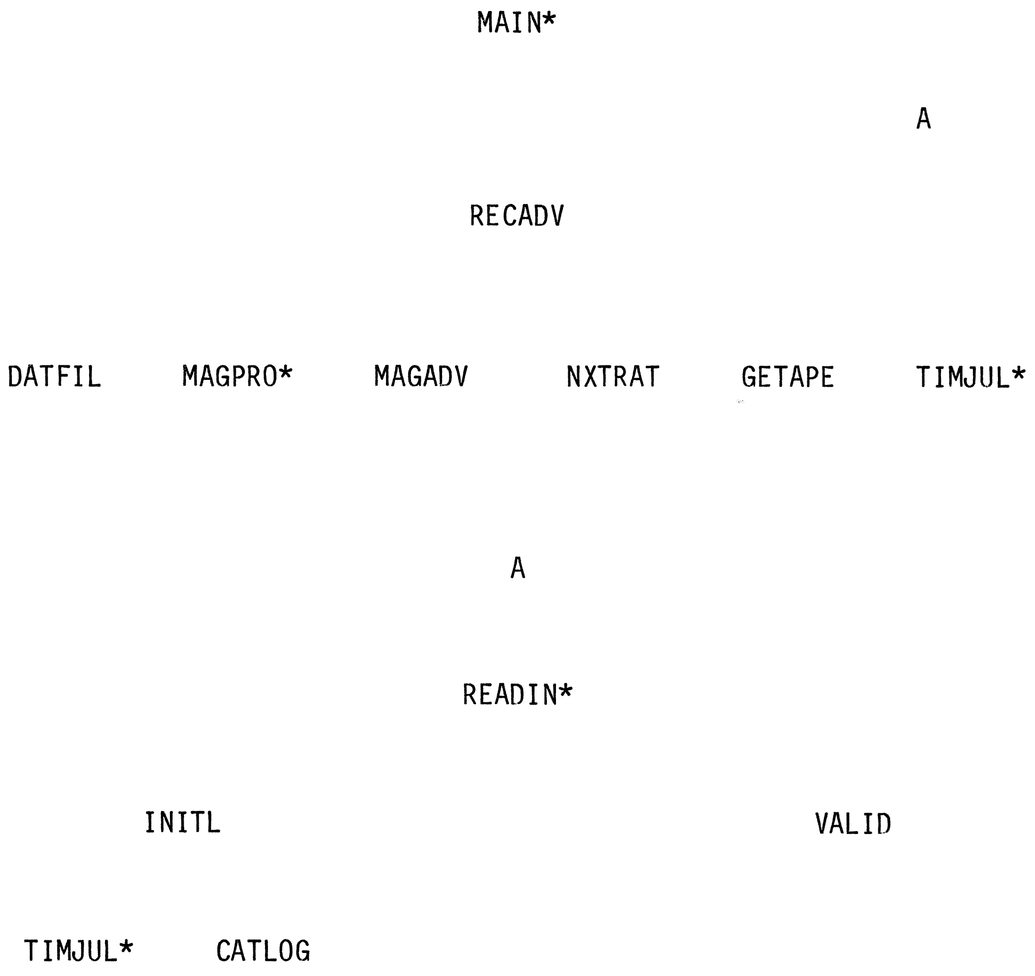
## 3. Module Documentation

| Module | Description |
|---|---|
| INITL | Initialized I/O devices, common blocks, and reads in the SD namelist PIO |
| MAGADV | Reads an averaging interval of magnetic field data |
| RECADV | Reads in one rate and magnetic field data average into the RATDAT and MAGFLD commons |
| VALID | Validates the input namelist data for the SI READIN module |
| CATLOG | Retrieves a tape name from the IMP-8 catalog.<br>This is an IMP-8 system routine. |

## 4. Program Structure

### a. Block Diagram

*=Satellite independent module



### b. Algorithm

The SI module READIN reads the SI namelist and calls VALID to validate them. Then it calls INITL to read in the SD namelist IMP and initialize the I/O devices. Control is returned to MAIN which succesively calls RECADV to accummulate one average point of sector counts and if desired, magnetic field data. RECADV reads in a flux record, stores it, and collects magnetic field data if desired (MAGPRO, MAGADV).

### c. Error Handling

The following return codes and messages may be printed: (See SI System Documentation for other handling.)

| Return Code | Description |
|---|---|
| - | 'INPUT TAPE READ ERROR, SKIP THIS RATE'<br>A tape read error on the input tape caused a volume to be skipped. |

## 5. Common Block Definitions

a. Common: /IMPUSR/ZMAG(8),QLED

| Name | Type | Description |
|---|---|---|
| ZMAG | A8 | A list of up to 8 magnetic field tapes in chronological order of use. |
| QLED | L*1 | T=use only corrected LED rates. |

b. Common: /RECORD/IBUFF(615)

| Name | Type | Description |
|---|---|---|
| IBUFF | I*4 | This buffer is used to store the input tape record. For detail on its contents see IMP-8(J) EXP52 Counts Tape Format document in the IMP-8 documentation set. |

## 6. Individual Module Documentation

All modules were designed, coded, and tested by Jenny S. Jacques, Code 664, 1980.

a. (1) Module: INITL - Initializes the I/O devices, common blocks, and reads in the IMP namelist.

(See the "Fourier Plot Program Satellite Independent System Documentation" for a basic description of .INITL. The differences of additions/deletions are described below.)

Differences or Additions/Deletions

1. There are 8 possible rates
2. A namelist IMP is read in
3. CATLOG is called to fetch input tape name.

b. (1) Module: MAGADV - Magnetic field tape advance - This routine collects the magnetic field data, within the time range passed, from the fourier magnetic field data base tape.

(2) Calling Sequence:

SUBROUTINE MAGADV (INTSEC,INTRVL,QNEW)

| Name | Type | I,0 | Description |
|---|---|---|---|
| INTSEC | I*4 | I | Averaging interval in seconds of the input data tape |
| INTRVL(2) | I*4 | I | Time range to collect the data over, in modified Julian time |

(3) Module Cross Reference:

Called by: RECADV
Calls: TIMJL2,JULTIM

(4) Common Usage:

| Common | Variables | I,0 |
|---|---|---|
| MAGFLD | BMAG,QPSECT,QTSECT,<br>COSIN,BSQR,MAGCNT,IZFILE | I,0 |
| MAGIN | all | 0 |
| IMPUSR | ZMAG | I |

(5) Significant Local Variables:

| Name | Type | Description |
|---|---|---|
| MTIME | I*4 | Modified Julian time (MJT) from magnetic field tape |
| QWAIT | L*1 | T = Interval on tape is later than current time range |
| QEOF | L*1 | T = And end of file mark was detected on the magnetic field tape |

| Name | Type | Description |
|---|---|---|
| IEND | L*1 | Ending of time range (MJT) to process |
| ITAPE | I*4 | Counter to the ZMAG tape namelist. |

(6) Logic:

Check to see if the last time left a record not used yet in the buffer (QWAIT=T). If so, skip around the FREAD. Otherwise, read in a record from the magnetic field tape. Loop, summing as many records as necessary to complete the time range. If an EOF occurs, continue to the next file. If an EOV occurs, look for the next tape name in ZMAG. If none are available, set QOFF to .true., causing further calls to simply return.

c. (1) Module: RECADV - Reads in one average of sectored counts data and, if desired, magnetic field data.

(See the "Fourier Plot Program Satellite Independent System Documentation" for a basic description or additions/deletions are described below.)

Differences or Additions/Deletions

1. RECORD is used to contain the input tape rates data records.
2. CATLOG is called to fetch a new tape name if the current one ends with time still left to process.

d. (1) Module: VALID - Validates the input satellite independent namelist values.

(See the "Fourier Plot Program Satellite Independent System Documentation" for a basic description of VALID. The differences/additions/deletions are listed below.)

Differences on Additions/Deletions

1. There are 8 possible rate ID's.
2. The rate ID's to validate are unique to IMP-8.

## 7. Program Assumptions and Restrictions

1. The flux tape requires 32K core if BUFNO = 1 in the DCB is specified.
2. The flux tape must be of the standard format for flux tapes for IMP-8.
3. The input tape catalog must be the tape catalog named in Section II. 3.

# Multisatellite Fourier Analysis Program
# IMP User's Guide

## B. Overview

The satellite-dependent (SD) IMP routines allow the IMP 8 data to be processed through the Fourier program's analysis and output procedures. The satellite-independent (SI) routines are contained in separate source and load modules from all SD code, and thus, any satellite may be linked via JCL.

This document describes the SD user input required for IMP Fourier analysis. The main document containing the SI user input must be reviewed prior to this one.

### 1. Input Required

#### a. Satellite independent namelist INPUT

(1) The RATES parameter may have the following values:

| RATES Parameter | Rate Signified |
|---|---|
| MED1 | DI E F G |
| MED2 | DI D2 E F G |
| MED3 | (DI+EI)1 E F G |
| MED4 | DI (DI+EI)1 E F G |
| LED1 | A1 B C |
| LED2 | A1 B C |
| VLET1 | DI DII F |
| VLET2 | DI DII (SUM)1D F |

(2) The parameter SATID must be 'IMP-8'.

#### b. IMP namelist IMP

&IMP ZMAG,QLED

This namelist must appear after each namelist set of the SI routines.

| Name | Type | Default | Description |
|---|---|---|---|
| ZMAG(8) | A8 | blanks | List of magnetic field tape names in order |
| QLED | L*1 | T | T=use corrected LED rates data |

c. Counts Tape

This is a standard label, fixed, blocked tape in the IMP counts tape format. It is provided by the tape catalog.

d. Tape Catalog

The catalog file name must be entered in the JCL for unit 25. The IMP catalog is in:

'SEIMP.DEX52CAT.DATA'

2. Error Handling

Only the satellite independent errors will terminate the program. See Section IV in the document: Multisatellite Fourier Analysis Program User's Guide.

3. JCL Required

1. Load module to link with SI routines:
   'SEIMP.FOURIMP.LOAD'

2. Flux catalog, unit 25:
   'SEIMP.DEX52CAT.DATA'

3. &IMP namelist for each namelist set.

4. Unit 9 defined as:

```
//FT09F001 DD DSN=IMPJDUM,DISP=SHR,UNIT=(1600,,DEFER),
//    VOL=SER=DUM1,DCB=BUFNO=1
```

### C. Sample JCL - IMP 8

# VIII. Multisatellite Fourier Analysis Program Differential Rates Routine

## A. Overview

The Multisatellite Fourier Analysis Program (MFAP) has an option to change the data before it goes into Fourier analysis. This is done via a subroutine called SUB1. (See the MFAP System Documentation Sections I.A. and IX.A.16. for a further description.) This document describes a SUB1 routine which subtracts one set of sectored counts from the next and stores this differential as a new set of counts. These counts then undergo the same analysis as before. SUB1 also changes the labels appropriately. If a succeeding rate does not exist (always the case for the last rate) or is not acceptable for analysis, the differential value can not be computed. In this case, a -2.0 is placed as a flag in the accumulation time, and the value is ignored by plotting routines.

To involk this process, SUB1 for differential rates is compiled into a load module and linked as the first SYSLIB data set. This causes the new SUB1 to override the dummy (simply returns) SUB1 in the Fourier load module, and thus be used to create differential sectored rates.

### 1. JCL Required

a. SYSLIB DD DSN=SB#PR.FOURDIF.LOAD,DISP=SHR as the first SYSLIB data set.

b. Same JCL as for the sectored rates.

# Multisatellite Fourier Analysis Program
# Anisotropy Check Routine

## B. Overview

The Multisatellite Fourier Analysis Program (MFAP) has an option to alter the data after Fourier analysis. This is done via a subroutine called SUB2. (See the MFAP System Documentation Sections I.A. and IX.A.16. for a further description.) This document describes a SUB2 routine which performs a check on the Fourier analysis anisotropy values. If a value is less than twice its deviation, it is negated. This flags the plotting routines to ignore the value, and the listing shows the negative anisotropy.

### 1. JCL Required

a. SYSLIB DD DSN=SB#PR.FOURCHK.LOAD,DISP=SHR as the first SYSLIB data set.

b. Same JCL as for the sectored rates.

## C. Sample JCL - SUB1, SUB2

This example is for PIONNER. The SUB1 routine to be used is the file 'SEJSS.FOURIER.DIFFRNTL.LOAD'

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Bob,

The old load modules for IMP8 are:

SETBS.IMP8.LOAD 2 replaces SB#IM.FOURIMP8.LOAD
SETBS.IMFOURSI.LOAD 3 replaces SB#PR.FOURSI.LOAD

You may want to copy them to your own user id.
(Remember to change them in your jcl file).

Teresa

GF typ 3.28
Other 2.37

sb#pr. [illegible]
fourier.save
(Imp8)

MED gravity factor
wrong (by factor 10
in Summer?) -

NOTE: NEEDS ADDTOLIB.LOAD (needs relink?)

7/11/80

# Multisatellite Fourier Analysis Program
# User's Guide

## I. Overview

The Fourier Program is divided into two groups:

1. Satellite independent code (SI) which performs the analysis.
2. Satellite dependent code (SD) which reads in alluser and satellite data and prepares it for the SI code.

The SI load modules are contained in 'SEJSS.FOURIER.SI.LOAD' and the SD load modules are located according to their name as follows:

| Satellite | SI Load Module |
|---|---|
| PIONEER F,G (sectored) | 'SEJSS.FOURIER.PIONEER.LOAD' |
| PIONEER F,G (PHA) | 'SEJSS.FOURIER.PIOPHA.LOAD' |
| ISEE 3 | 'SEJSS.FOURIER.ISEE3.LOAD' |
| IMP8 | 'SEJSS.FOURIER.IMP.LOAD' |
| HELIOS A,B | 'SEJSS.FOURIER.HELIOS.LOAD' |

Both the SI and SD load modules are specified in the JCL as described later in this document. Documentation for user input, output, error handling, and JCL in the SD routines is documented separately for each satellite.

## II. Input Required

A. Namelist parameters for five namelists as follows:

1. Namelist: INPUT

| Name | Type | Default | Description |
|---|---|---|---|
| FROM(6) | I4 | 0 | Beginning time for analysis in year (1978=78), month, day, hour, minute, second. |
| TO(6) | I4 | 0 | Ending time for analysis in year (1978=78), month, day, hour, minute, second. |
| NUMAVG | I4 | 1 | The number of input intervals (volumes) to average into one point. |
| RATES(6) | A8 | blanks | Names for the rates to be processed. |
| FPARMS(9) | A8 | blanks | The run parameters which specify those Fourier parameters to output on plots or tapes. |

| Name | Type | Default | Description |
|---|---|---|---|
| | | | Choices are:<br>'A0'=flux<br>'A1','A2','A3'=anisotropy harmonics 1-3<br>'PHI1','PHI2','PHI3'=Angle PHI for harmonics 1-3<br>'FLOW'=flow parameter<br>'MAG'=magnetic field data |

**The plots are determined by A0,A1,A2, and A3, A0=do flux plot, A1,A2,A3=anisotropy plots for the first, second, and third harmonics. All other FPARMS parameters are used for the tape option.

| | | | |
|---|---|---|---|
| SATID | A16 | blanks | EBCDIC satellite name. |
| INTSEC | I4 | 900 | Number of seconds per input interval. |
| QPRINT | L1 | F | T=print FOURIER results. |
| QPLOT | L1 | F | T=there will be plots made. |
| QTAPES | L1 | F | T=there will be tapes created. |
| QMAGNT | L1 | F | T=process magnetic field data. |

2. Namelist: PRINTR

| Name | Type | Default | Description |
|---|---|---|---|
| IPRINT | I4 | 1 | 1=print only Fourier results<br>2=print counts and accumulation times in addition to Fourier results. |

3. Namelist: PLOTS

| Name | Type | Default | Description |
|---|---|---|---|
| DEVICE | I4 | 1 | 1=Create SD4060 plot tape.<br>2=Create CalComp plot tape. |
| PLTDEN | I4 | 4 | Plot point density in points/sm. ? The plot is 24 cm long. |
| QRATPL | L1 | F | Create a rate (flux) plot. |
| QANIPL | L1 | F | Create an anisotropy and angle plot. |

| Name | Type | Default | Description |
|---|---|---|---|
| QPOLPL | L1 | F | Create polar (cm) plots. |
| QBARR | L1 | F | Include error bars on the flux or anisotropy plots if they are being created. |
| IHARMS | I4 | 0 | 0 = Do no anisotropy arrows on cam plots<br>1 = do first anisotropy dash arrow only<br>2 = do second anisotropy solid line only<br>3 = do both 1 and 2 |
| FLMIN | R4 | data adjusted | Flux plot minimum if automatic scaling not desired. |
| FLMAX | R4 | data adjusted | Flux plot maximum if automatic scaling is not desired. |

4. Namelist: TAPES

This must be used if and only if QTAPES=T in the INPUT namelist.

| Name | Type | Default | Description |
|---|---|---|---|
| QRTAPE | L1 | F | Create a tape of Fourier parameters. |
| IRFILE | I4 | 1 | Start file number of Fourier tape. |
| ZRVOL | A8 | blank | Volume-serial name of the tape to be used for Fourier output. |
| QSTAPE | L1 | F | Create a tape of counts and accumulation time. |
| ISFILE | I4 | 1 | Start file number of counts tape. |
| ZSVOL | A8 | blank | Volume-serial names of the tape to be used for counts output. |

5. Namelist: MAGNT

This must be used if and only if QMAGNT=T in the INPUT namelist.

| Name | Type | Default | Description |
|---|---|---|---|
| IHISTS | I4 | 0 | 0 = do no magnetic field histograms<br>1 = do the phi histogram only<br>2 = do the theta histogram only<br>3 = do both phi and theta histograms |
| ZMVOL | A8 | blank | Magnetic field data base tape name. |
| IZFILE | I4 | I | Start file number on magnetic field data base tape. |

----NOTE----

The INPUT determines which of the other four namelists are to be used. These other four namelist must appear in the order listed. The set of namelist describing the characteristics of the job run may be repeated any number of times with varying parameters. This allows several plots with different rate combinations. All parameters except SATID, RATES, and FPARMS default to the last value used in the previous namelist set.

B. Tape input is required as follows:

1. Plot Tape

This is a 7-track 556 BPI tape to be used for SD4060 of Calcomp plots if desired.

2. Rates Input Data

This is satellite dependent (SD).

3. Fourier Tape

This is a tape used for Fourier parameter output if QTAPES=T in the INPUT namelist and QRTAPE=T in the TAPES namelist, device unit 10 is used for this tape.

4. Counts Tape

This is a tape for the counts and accumulation time output, only when QTAPES=T in the INPUT namelist and QSTAPE=T in the TAPES namelists. Device until 11 is used for this tape.

### 5. Magnetic Field Data Base Tape

This is a tape created for the Fourier program which contains the magnetic field data as described in documentation on the Fourier MAGDBG documentation.

### C. Subroutine Substitution

There are two positions one may insert any subroutine by JCL methods:

1. SUB1 - This subroutine is called before the Fourier routine so that the data may be altered before Fourier analysis.

2. SUB2 - This subroutine is called after Fourier analysis so that the data may be altered before being output in some form.

If a SYSLIB card pointing to an object module with SUB1 and/or SUB2 as members are inserted before the SYSLIB card pointing to the Fourier program object modules, then the program will accept the new SUB1, SUB2 routines. If this card is not inserted, then the dummy SUB1, SUB2 routines, which merely return control, are used.

Ex:

No Substitution:

```
//SYSLIB   DD  DSN=SEJSS.FOURIER.SI.LOAD,DISP=SHR
//         DD  DSN-SYS1.FORTLIB,DISP=SHR
//         DD  DSN=SYS2.FORTLIB.DISP=SHR
//         DD  DSN-SYS2.WOLFPLOT,DISP=SHR
```

Substitution: (USRID.PROG.LOAD has member SUB1)

```
//SYSLIB   DD  DSN=USRID.PROG.LOAD,DISP=SHR
//         DD  DSN=SEJSS.FOURIER.SI.LOAD,DISP=SHR
//         DD  DSN=SYS1.FORTLIB,DISP=SHR
//         DD  DSN=SYS2,FORTLIB,DISP=SHR
//         DD  DSN=SYS2.WOLFPLOT,DISP=SHR
```

## III. Output Generated

### Automatic Output

1. The input namelist data is printed.

2. A summary of how many plot tape files were created is printed.

User Option Output

| Output | Namelist: option flag |
|---|---|
| 1. Fourier Parameter Printout | INPUT: QPRINT=T<br>PRINT: IPRINT=1 |
| 2. Fourier Parameter and Counts Printout | INPUT: QPRINT=T<br>PRINT: IPRINT=2 |
| 3. Flux or Rates | INPUT: QPLOTS=T<br>PLOTS: QRATPL=T |
| 4. Anisotropy Plots | INPUT: QPLOTS=T<br>PLOTS: QANIPL=T |
| 5. Polar or Cam Plots | INPUT: QPLOTS=T<br>PLOTS: QPOLPL=T |
| 6. Tape of Fourier Parameters | INPUT: QTAPES=T<br>TAPES: QRTAPE=T |
| 7. Tape of Counts and Accumulation Time | INPUT: QTAPES=T<br>TAPES: QSTAPE=T |

## IV. Running the Program

The following steps must be done to submit a run.

Step 1

Hang all required tapes in the slots and determine the namelist parameters to be used.

Step 2

Edit the TSO file which contains the JCL and namelists to run the job. Change:

1. The JOBCARD
2. Plot tapes VOL=SER names
3. Namelist parameters to suit the desired input and output.
4. All SD unit DD card specifications as required by the particular satellite.

Step 3

Submit the job using:

1. `SUB^*' if still in edit mode.
2. `SUB^name' if the file has been renamed and saved under a new file name.

---If still in edit and the file is not renamed, end the edit session with END^N command.---

## V. Error Handling

### Return Code

1 The namelist parameters are checked to ensure typing errors were not introduced. The program stop will return code of 1 if any parameters are not valid.

- If there is an I/O error while creating the anisotropy plots, the message:

  'RECORD # OF HARMONIC # SKIPPED, I/O DISK ERR.'

7 If there is a timing problem the message:

'JULTIM HAS BAD TIMES'

is issued and the program stops with a return code of 7. Consult person who maintains the program.

- When an I/O error is encountered while creating polar plots, the message:

  'DISK READ ERROR IN POLAR ROUTINE'

  is used and the program continues. Some data will be missing.

- When an I/O error is encountered while creating flux plots, the message:

  'RECORD # SKIPPED DUE TO I/O ERROR FROM DISK'

  is issued, and the program continues. Some data will be missing on the flux plot.

## VI. JCL Required

The JCL is contained in the file 'SEJSS.MULTISAT.FOURIER(JCL)'. This file contains only that JCL required for the SI routines. Comment cards indicate where SD JCL is to be included.

Bob

7/11/80

# Multisatellite Fourier Analysis Program
# IMP User's Guide

## I. Overview

The satellite-dependent (SD) IMP routines allow the IMP 8 data to be processed through the Fourier program's analysis and output procedures. The satellite-independent (SI) routines are contained in separate source and load modules from all SD code, and thus, any satellite may be linked via JCL.

This document describes the SD user input required for IMP Fourier analysis. The main document containing the SI user input must be reviewed prior to this one.

## II. Input Required

### 1. Satellite independent namelist INPUT

a. The RATES parameter may have the following values:

| RATES Parameter | Rate Signified |
|---|---|
| MED1 | DI E F ¬G |
| MED2 | DI ¬D2 E ¬F ¬G |
| MED3 | (DI+EI)1 E ¬F ¬G |
| MED4 | DI ¬(DI+EI)1 E ¬F ¬G |
| LED1 | A1 ¬B ¬C |
| LED2 | A1 B ¬C |
| VLET1 | DI DII ¬F |
| VLET2 | DI DII (SUM)1D ¬F |

b. The parameter SATID must be 'IMP-8'.

### 2. IMP namelist IMP

&IMP ZMAG,QLED

This namelist must appear after each namelist set of the SI routines.

| Name | Type | Default | Description |
|---|---|---|---|
| ZMAG(8) | A8 | blanks | List of magnetic field tape names in order |
| QLED | L*1 | T | T=use corrected LED rates data |

3. Counts Tape

This is a standard label, fixed, blocked tape in the IMP counts tape format. It is provided by the tape catalog.

4. Tape Catalog

The catalog file name must be entered in the JCL for unit 25. The IMP catalog is in:

'K3.SBJPH.SB016.DEX52CAT'

## III. Error Handling

Only the satellite independent errors will terminate the program. See Section IV in the document: Multisatellite Fourier Analysis Progrm User's Guide.

## IV. JCL Required

1. Load module to link with SI routines:
   'SEJSS.FOURIER.IMP.LOAD'
2. Flux catalog, unit 25:
   'K3.SBJPH.SB016.DEX52CAT'
3. &IMP namelist for each namelist set.
4. Unit 9 defined as:

```
//FT09F001 DD DSN=IMPJDUM,DISP=SHR,UNIT=(1600,,DEFER),
//    VOL=SER=DUM1,DCB=BUFNO=1
```

INTSEC should not exceed 1 day
For IMP, product of INTSEC + NUMAVG is used

Bob-

Here is the σI documentation. The only other thing you really need is definition of rates & a sample file:

| RATES ~~my~~ names | Description |
|---|---|
| MED1 | DI E F ¬G |
| MED2 | DI-D2 E¬F G |
| MED3 | (DI+EI)1 E ¬F ¬G |
| MED4 | DI ¬(DI+EI)1 E ¬F ¬G |
| ~~MEF~~ | |
| LED1 | A1 ¬B ¬C |
| LED2 | A1 B ¬C |
| VLET1 | DI DII ¬F |
| VLET2 | DI DII $\Sigma_1$D ¬F |

This file is in

'SEJSS.MULTISAT.FOURIER(IMPJCL)'

if you want to copy it.

Jenny

Also, it has to be NONUM before you submit it.
Also, change the JOBCARD.

Imp-J (8) 15.36 sec Summary Tapes
6250 BPI, den = 4

| Orbit | Decom | DD Start-Stop | | ("FP" Prefix) Tape # |
|---|---|---|---|---|
| 1-5 | 1-12 | 73302- | 73351 | 2040 |
| 5-6 | 13-16 | 351- | 364 | 2779 |
| 6-7 | 16-18 | 74 000- | 74 009 | 2975 |
| 7-11 | 18-30 | 009- | 057 | 2027 |
| 11-14 | 30-42 | 057- | 106 | 3459 |
| 14-19 | 42-54 | 106- | 155 | 3039 |
| 19-23 | 54-66 | 155- | 204 | 2837 |
| 23-27 | 67-78 | 204- | 253 | 7450 |
| 27-31 | 79-90 | 253- | 301 | 4768 |
| 31-35 | 91-102 | 301- | 349 | 2025 |
| 35-36 | 103-106 | 349- | 364 | 2135 |
| 37-40 | 107-118 | 75 000- | 75 048 | 5128 |
| 41-44 | 119-130 | 048- | 096 | 2043 |
| 45-48 | 131-142 | 096- | 142 | 2035 |
| 48-52 | 142-154 | 142- | 191 | 5130 |
| 52-56 | 155-166 | 191- | 239 | 6090 |
| 57-60 | 167-178 | 239- | 288 | 6114 |
| 60-64 | 179-191 | 288- | 337 | 2751 |
| 64-67 | 191-198 | 337- | 364 | 6120 |
| 67-71 | 198-210 | 76 000- | 76 049 | 2191 |
| 71-75 | 211-222 | 049- | 097 | 6118 |
| 75-79 | 223-234 | 097- | 146 | 2752 |
| 79-82 | 235-246 | 146- | 194 | 6115 |
| 83-86 | 247-257 | 194- | 237 | 6117 |
| 86-90 | 257-269 | 237- | 286 | 6116 |
| 90-94 | 269-281 | 286- | 335 | 6119 |
| 94-97 | 282-289 | 335- | 365 | 2221 |
| 97-101 | 290-301 | 77 000- | 77 048 | 7497 |
| 101-105 | 301-313 | 048- | 096 | 7498 |
| 105-109 | 313-325 | 096- | 146 | 7499 |
| 109-113 | 326-337 | 146- | 195 | 5875 |
| 113-117 | 338-349 | 195- | 243 | 6330 |
| 117-121 | 350-361 | 243- | 291 | 6338 |
| 121-125 | 361-373 | 291- | 340 | 6339 |
| 125-127 | 374-379 | 340- | 364 | 6340 |
| 127-131 | 380-392 | 78 000- | 78 052 | 2541 |
| 131-135 | 393-403 | 052- | 095 | 2542 |
| 135-138 | 403-414 | 095- | 141 | 2543 |
| 139-143 | 415-427 | 141- | 193 | 2576 |
| 143-147 | 428-439 | 193- | 242 | 2577 |
| 147-151 | 440-451 | 242- | 290 | 2578 |
| 151-155 | 452-463 | 290- | 339 | 2579 |
| 155-157 | 464-469 | 339- | 364 | 2580 |
| 157-161 | 470-482 | 79 000- | 79 051 | 2581 |
| 161-165 | 483-494 | 051- | 100 | 2582 |
| 165-169 | 495-506 | 100- | 148 | 2589 |
| 169-173 | 507-518 | 148- | 197 | 2593 |
| 173-177 | 519-530 | 197- | 245 | 2594 |
| 177-181 | 531-542 | 245- | 294 | 2596 |
| 181-185 | 543-554 | 294- | 342 | 2603 |
| 185-187 | 555-560 | 342- | 364 | 2606 |
| 187-191 | 560-572 | 80 000- | 80 050 | 2268 |
| 191-195 | 573-584 | 050- | 098 | 2822 |
| 195-198 | 585-595 | 098- | 143 | 3152 |

phylis Bldg 8
#147

XRPAH.MVS.
CLIST(IMPJPH2)

| Orbit | Decom | OD Start - Stop |  | (FP Prefix) Tape # |
|---|---|---|---|---|
| 199-202 | 596-607 | 80143- | 80192 | 7384 |
| 203-205 | 608-615 | 192- | 224 | 7387 |
| 205-209 | 616-627 | 224- | 273 | 2053 |
| 209-213 | 628-639 | 273- | 321 | 2054 |
| 213-217 | 640-650 | 321- | 365 | 2125 |
| 217-221 | 650-662 | 81 000- | 81049 | 2193 |
| 221-225 | 663-674 | 049- | 098 | 2441 |

|  |  |
|---|---|
| 81/098–147 | FP 2470 |
| 147 - 195 | 2524 |
| 195 - 240 | 2530 |
| 240 - 288 | 2531 |
| 288 - 337 | 2598 |
| 337 - 364 | 3024 |

| | |
|---|---|
| 82/000 - 049 | FP 3030 |

NOTE: All day nos listed here assume
JAN 1 = day 0

---

**IMP 7**

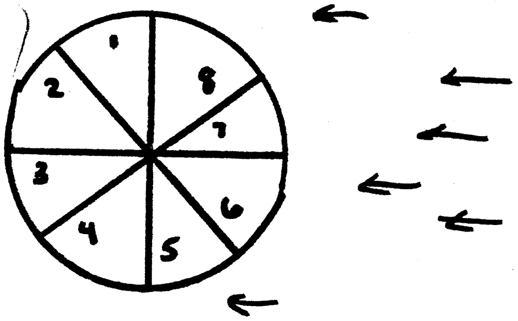
| | |
|---|---|
| 1972 data | FP 7515 (FP7588) |
| 1973 data | FP 7506 (FP7507) |

Bob

# The Fourier Plot Program

Function:

Analyzes particle flux collected into eight sectors:



Output:

1. Fourier analysis listings
2. Flux plots
3. Cam plots of the sector values
4. Anisotropy plots, first, second and third order
5. Tapes of Fourier results and/or input sector counts

Organization:

The Fourier Plot Program is divided into two parts;

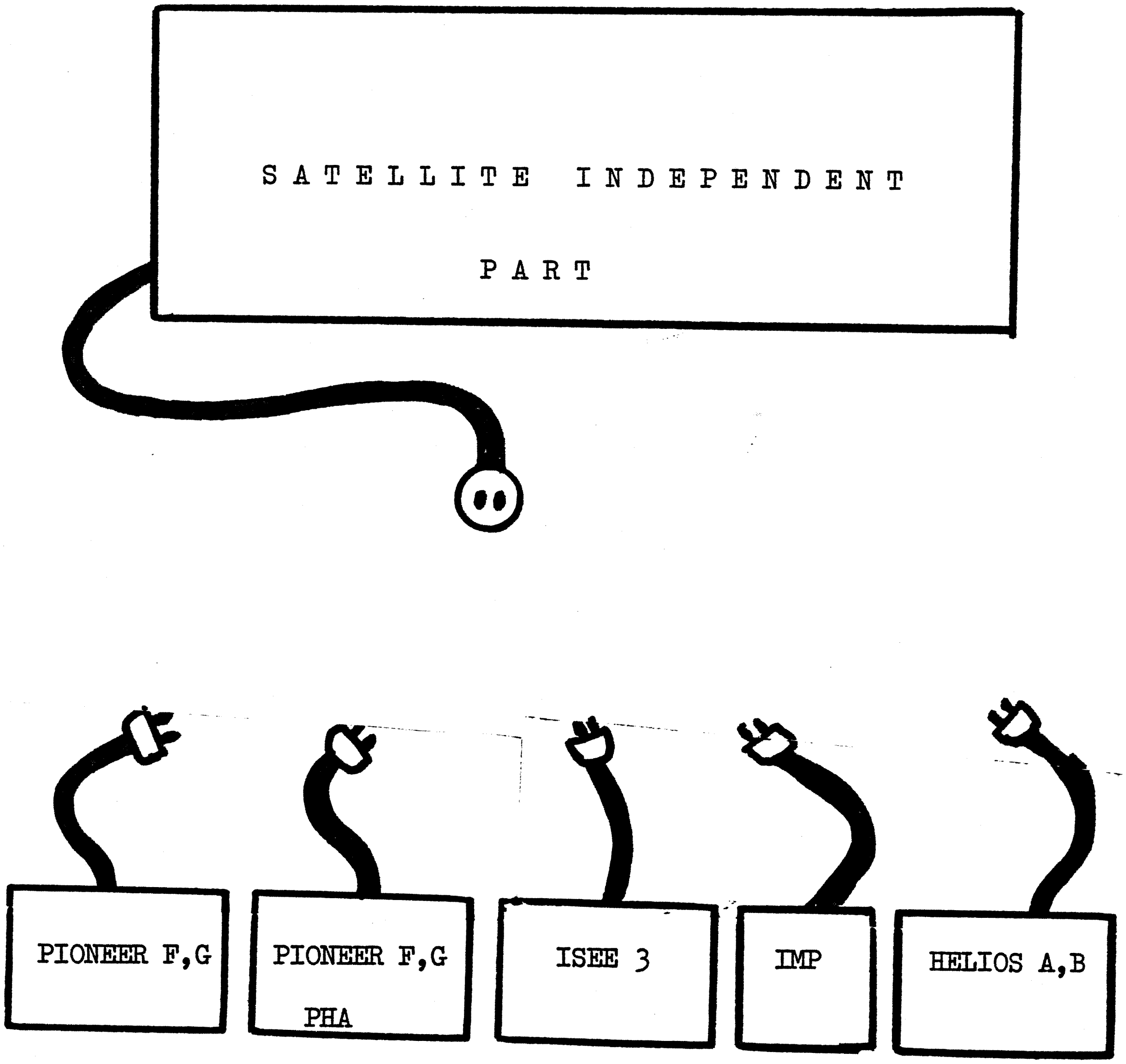
a. Satellite independent part which performs:

- Control of program flow, averaging, etc.
- Plot code
- Listing code
- Fourier analysis code
- User input parameters which are satellite independent

b. Satellite dependent part which performs:

- User input parameters which are satellite dependent
- Opens and reads the satellite dependent input counts
- Verifies all user input parameters, initializing the desired output devices and common blocks

# Multi-satellite Concept of the Fourier Plot Program



JCL dictates which satellite dependent module is "plugged into" the satellite independent code.

Note Count of 6 cam plots including $\Theta, \phi$

7/14/80

# Multi-Satellite Fourier Analysis Program
# System Documentation

## I. Overview

### A. Description

The Fourier Analysis Program analyzes sectored data from any satellite according to the article "Limitations of the COS Approximation as Applied to the Cosmic-Ray Anisotropy," *Nuclear Instruments and Methods*, #138 (1976) pages 191-199, R.D. Zwickl and W.R. Webber. This analysis calculates the first three harmonics from counts data divided into eight 45° sectors.

The following outputs may be generated:

1. Fourier listing of flux, a "flow parmeter", the anisotropies and angles, and the sectored counts. The listing may also include angle corrections to the sectors and magnetic field values.
2. Flux plots of flux vs. time.
3. Anisotropy double plots of the anisotropy values vs. time plotted above the anisotropy angles vs. time.
4. Cam plots of the sectored counts and, if desired, magnetic field cam histograms of the north-sourth and planar directions with an arrow on the rates cam plots indicating direction of field.
5. Output tape of the sector counts for use with other programs.
6. Output tape of the Fourier results for use with other programs.

All plots may be sent to either the SD4060 plotter or the Calcomp plotter.

The Fourier Analysis Program is essentially two sections:

1. Satellite-independent (SI)
2. Satellite-dependent (SD)

Thus, to incorporate a new satellite into the system, only a small subset of coding is necessary which reads in extra user parameters, validates the data, and reads in the sectored counts. How to code this is included later in "Adapting the Fourier Program to a New Data Source".

Another feature of flexibility in this program is the use of two subroutines which are called immediately prior to and after the Fourier analysis formula are used. This allows the data to be manipulated in any way before being output. The default routines extracts

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# Multi-Satellite Fourier Analysis Program
# System Documentation

## I. Overview

### A. Description

The Fourier Analysis Program analyzes sectored data from any satellite according to the article "Limitations of the COS Approximation as Applied to the Cosmic-Ray Anisotropy," Nuclear Instruments and Methods, #138 (1976) pages 191-199, R.D. Zwickl and W.R. Webber. This analysis calculates the first three harmonics from counts data divided into eight 45° sectors.

The following outputs may be generated:

1. Fourier listing of flux, a "flow parmeter", the anisotropies and angles, and the sectored counts. The listing may also include angle corrections to the sectors and magnetic field values.
2. Flux plots of flux vs. time.
3. Anisotropy double plots of the anisotropy values vs. time plotted above the anisotropy angles vs. time.
4. Cam plots of the sectored counts and, if desired, magnetic field cam histograms of the north-sourth and planar directions with an arrow on the rates cam plots indicating direction of field.
5. Output tape of the sector counts for use with other programs.
6. Output tape of the Fourier results for use with other programs.

All plots may be sent to either the SD4060 plotter or the Calcomp plotter.

The Fourier Analysis Program is essentially two sections:

1. Satellite-independent (SI)
2. Satellite-dependent (SD)

Thus, to incorporate a new satellite into the system, only a small subset of coding is necessary which reads in extra user parameters, validates the data, and reads in the sectored counts. How to code this is included later in "Adapting the Fourier Program to a New Data Source".

Another feature of flexibility in this program is the use of two subroutines which are called immediately prior to and after the Fourier analysis formula are used. This allows the data to be manipulated in any way before being output. The default routines simply return. To involk changes in this way, a routine by the same name is created in load form and JCL links it in before the Fourier program modules. Thus, these routines are used in place of the dummy routines.

## B. Formulae

### 1. Fourier formulae:

The following expression for the rate is used:

$$C_i = A_o[1 + \sum_{n=1}^{3} \zeta_n \cos n(\phi_i - \phi_n)]$$

where

$$A_o = \frac{1}{8G} \sum_{i=1}^{8} C_i ,$$

$C_i$ = sector rate,

$\zeta_n = A_n/A_o$,

$A_n = (a_n^2 + b_n^2)^{1/2}$,

$$a_n = \frac{W_n}{4} \sum_{i=1}^{8} C_i \cos(n\theta_i),$$

$$b_n = \frac{W_n}{4} \sum_{i=1}^{8} C_i \sin(n\theta_i),$$

$\theta_o$ = reference direction Sector o,

$\theta_i$ = angle in direction of Sector i,

$\theta_n = \frac{1}{n} \tan^{-1}(b_n/a_n) + \theta_o$,

n = harmonic number,

i = sector number,

$W_n$ = given weight factor, predetermined, and
G = geometric factor of counter ($cm^2$ster).

## C. Timing System

The times input by the user or from input data are in year, month, day, hour, minute, seconds. The Fourier Plot Program converts all times into one number, the "Modified Julian Time" which is in units of average intervals since January 1 of the epoch year hardcoded by the programmer. Arrays with the days for each succeeding year and days since January 1 are used in the conversion (See TIMJUL and JULTIM). For this reason, the epoch year must be a leap year -1, or the count of days will be off by 1. The formula used is:

$$\text{Modified Julian time} = A{*}B + \frac{C}{D} + C$$

where,

A = days since epoch year, Jan. 1 of epoch year = 0
B = average intervals/day
C = seconds of day
D = seconds/average interval

Thus, January 10, $1^h\ 30^m\ 0^s$ 1973, epoch year = 1971, average interval = 900 seconds is converted to $376{*}96 + \frac{5400}{900} = 36102$

## D. Input Required

1. Input sectored data set:

   This is entirely dependent on which satellite's data is processed.

2. Magnetic field tape (optional):

   This tape is described in the document "Magnetic Field Processing for the Fourier Program". The programmer may wish to use a different format and alter the MAGADV routine.

3. User namelists:

   These namelists are described in the document "Multi-Satellite Fourier Analysis Program, User's Guide".

## E. Output Generated

1. Fourier analysis listing containing:

   a. Flow parameter (see Formulae, Section IB)
   b. Flux, deviation
   c. Anisotropies, deviations
   d. Anisotropy angles, deviations
   e. Sector counts
   f. Accumulation time

   g. Magnetic field values
   h. Correction angles to sector 0 offset.

2. Flux plots of flux vs. time.

3. Anisotropy plots of anisotropy values vs. time plotted above anisotropy angles vs. time.

4. Cam plots of the sector counts containing:

   a. Cam plots
   b. Listing of Fourier parameters
   c. Average counts
   d. Magnetic field cam plots
   e. Magnetic field direction arrow overlaid on the counts cam plots
   f. Timing
   g. Direction arrow and line for the first & second order anisotrophy overlaid on the cam plot
   h. Rates label for each cam plot

5. Output tapes:

   a. There are two input tapes available from this program:

      1. Fourier parameters tape containing the results of the analysis
      2. Counts tape containing the sectored counts input to the Fourier routines

   They both are IBM variable, blocked record format, 1600 BPI. This means that four bytes are present at the start of the first record of each file, the first two of which indicate the file length in bytes (including the length words). Each record has four bytes preceeding it, the first two of which indicate the length of the record in bytes. Consult the IBM tape format manual for more detailed information.

   Each input namelist set creates a new file on the tapes.

   b. Header record format for both tapes:

   (If the JCL for a program reading this tape does not declare the tape as VB, then there is an additional four bytes for each file and 4 bytes for each record specifying the length in bytes of the file or record.)

| Bytes | Type | Description |
|---|---|---|
| 1-16 | A16 | Satellite ID, EBCDIC |
| 17-64 | 6*A8 | Rate ID's of the run. Blanks are fill. |

| Bytes | Type | Description |
|---|---|---|
| 65-136 | 9*A8 | Fourier parameters of the run. Blanks are fill. |
| 137-140 | I4 | Number of rates processed this run. (later called i) |
| 141-144 | I4 | Number of Fourier parameters stored this run. (Later called i) |
| 145-148 | I4 | Averaging interval in seconds. |
| 149-200 | — | Spare |

### C. Record structure for the Fourier parameters tape:

k=j if 'MAG' was not a FPARMS parameter. Otherwise, k=j-1

k1=i*k*2 = total R4 values; (parameter, deviation for k parameters in i rates)

| Bytes | Type | Description |
|---|---|---|
| 1-12 | 6*I2 | Year,month,day,hour,minute,second of start of interval |
| next K1*4 | R4 each | List of parameters,deviation values:<br>i * (k * (parameter,deviation)) |
| next 24 | R4 each | Magnetic field data:<br>Bytes<br>1-8 = Magnitude of field<br>9-16 = planar direction, deviation of field<br>17-24 = polar direction, deviation of field |

### D. Record structure for the Counts tape:

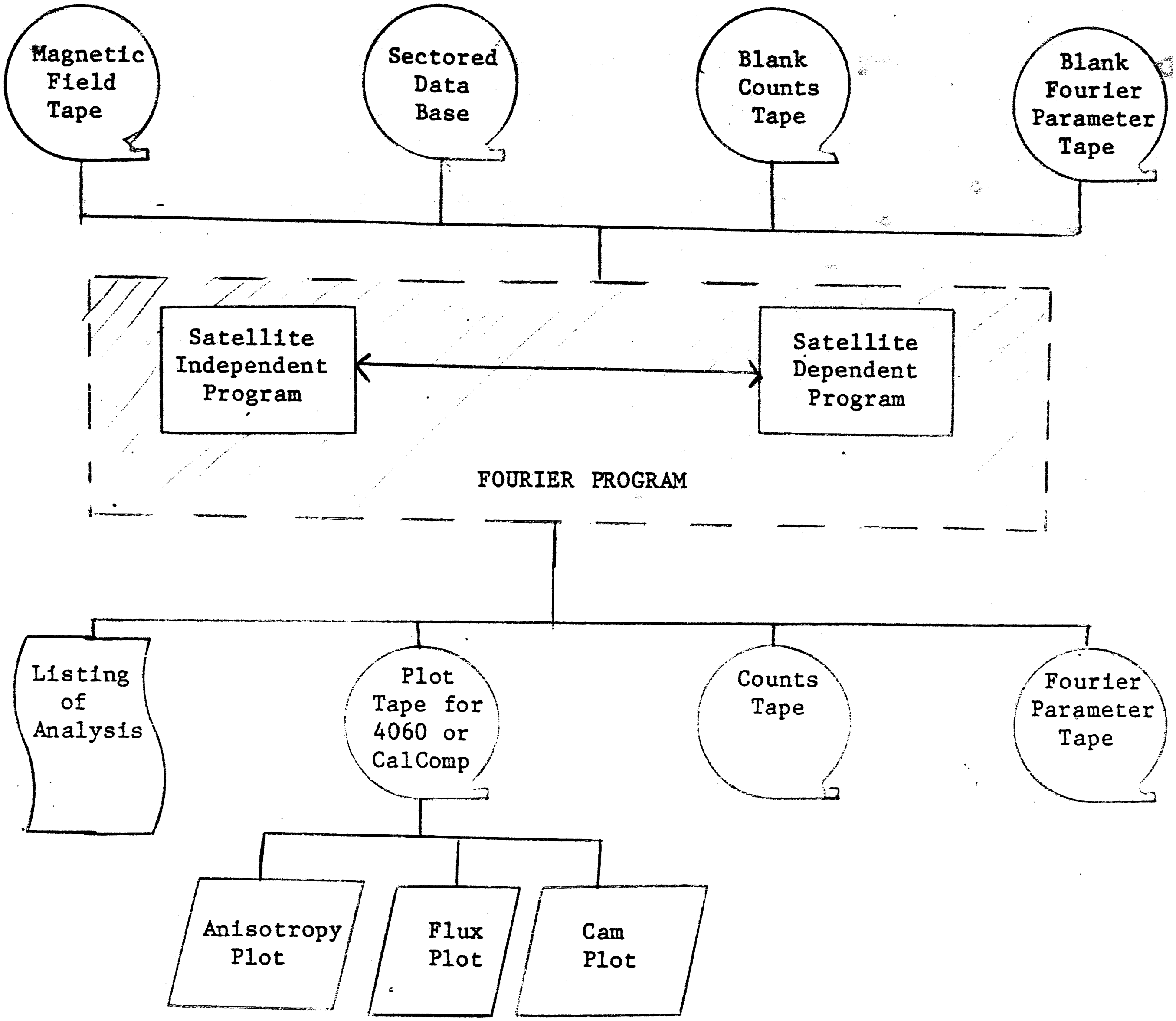
K=10*i = total # of counts data words

| Bytes | Type | Description |
|---|---|---|
| 1-12 | 6*I2 | Year,month,day,hour,minute,second of start of interval |
| next K*4 | R4 each | List of the counts data for each rate:<br>i * (accummulation time,8 counts,sum) |

### E. JCL

DCB=(BLKSIZE=7294,RECFM=VB)

## II. System Configuration



# Table of Contents

# I. Introduction

The Multi-satellite Fourier Analysis Program is a system of subroutines that may be divided into two sets:

i) The satellite independent modules (SI)

ii) The satellite dependent modules (SD)

The system is organized such that any satellite data can link into the SI modules by supplying the correct SD modules. It then receives Fourier analyzed data in the form of listings and/or plots. This saves design, coding, and testing time for all analysis, listing, and plotting routines.

It should be noted that there are two subroutines that simply return after being called. One, SUB1, is called directly before Fourier analysis, and the other, SUB2, is called immediately following analysis. This allows either subroutine to be substituted for by linking in the new load module before the SI load modules, thereby substituting in special data manipulation functions prior to or after analysis. Section 8 contains those SUB1 and SUB2 routines already devised for special uses.

This document defines all the satellite data systems developed to date: the internal code description, a user's guide, and sample JCL for running the program. The next page lists the data sets used in this system, the source, JCL and LOAD data sets. The source will be spooled to tape.

## Source

1. Source for satellite independent and dependent modules is
   MULTISAT.
   in file 'SBPIO.FOURIER.SOURCE ' with the partition names as:
   - a.SATINDEP - The satellite independent code
   - b.IMP8 - IMP 8 sectored rates
   - c.ISEE3 - ISEE 3 Cosmic Ray sectored rates
   - d.HELIOS - HELIOS A,B sectored data
   - e.PIONEER - PIONEER 10,11 sectored data
   - f.PIOPHA - PIONEER 10,11 PHA data
2. Source for the SUB1 custom modules is held in file 'SBPIO.FOURIER.SUB1 ' with partition name as:
   - a.DIFRNTL - creates rate differences, substitutes for rates
3. Source for the SUB2 custom modules is held in file 'SBPIO.FOURIER.SUB2 ' with partition name as:
   - a. ANICHK - Ensures anisotropy is within 2 * it's deviation

## JCL

1. The JCL is held in file 'SBPIO.FOURIER.JCL ' with partition names as :
   - a.JCL - This contains general JCL
   - b.PIOJCL - This contains PIONEER JCL
   - c.PHAJCL - This contains PIONEER PHA JCL
   - d.HELJCL - This contains HELIOS JCL
   - e.IMPJCL - This contains IMP 8 JCL
   - f.ISEE3JCL - This contains ISEE 3 Cosmic Ray JCL

## LOAD Modules

1. The LOAD modules are held in the user id of the satellite :
   - a.'SBPIO.FOURSI.LOAD' - Satellite independent module

b.'SBPIO.FOURPIO.LOAD' - PIONEER sectored rates

c.'SBPIO.FOURPHA.LOAD' -PIONEER PHA rates

d.'SBPIO.FOURDIF.LOAD' - PIONEER differential rates custom SUB1

e.'SBPIO.FOURCHK.LOAD' - PIONEER check on anisotropy values custom SUB2

f.'SEIMP.FOURIMP.LOAD' - IMP 8 sectored rates

g.'SDHEL.FOURHEL.LOAD' - HELIOS sectored rates

h.'SEICC.FOURICC.LOAD' - ISEE 3 Cosmic Ray sectored rates

~~FOURIER SUBT for source~~

i.'SBPIO.~~FOURDIF.LOAD~~' - Differential rates custom SUB1

ok

j.'SBPIO.FOURCHK.LOAD' - Anisotropy value check custom SUB2

* Note that the LOAD modules will be permanently on disk, but the SOURCE and JCL files may be archived by the system.