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EXPERIMENT SIMULATION SOFTWARE (FPE 5.1)

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ABSTRACT

This document describes the software required to automate the acquisition, analysis and display of the prime data for the X-ray Polarimeter Experiment (FPE 5.1). In addition, software to generate simulated input to test the experiment software is described. This work was performed under contract number NAS8-25471 for the Computation Laboratory of the George C. Marshall Space Flight Center, Huntsville, Alabama.

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SECTION 1. INTRODUCTION

This report is one of two produced during the extension of NASA study contract NAS8-25471, "Analyses of the Requirements for Computer Control and Data Processing Experiment Subsystems." A second report, SDC document TM-(L)-HU-033/004/00 entitled "Experiment Support Software Techniques Analysis (FPE 5.3A)," describes the software techniques applicable to Space Station experiment FPE 5.3A - Solar Imaging X-ray Telescope. Both reports were prepared by the System Development Corporation's Huntsville Space Projects staff.

This report describes and documents the software required to analyze the primary data of the X-ray Polarimeter Experiment (FPE 5.1). Software specifications were presented in SDC document TM-(L)-HU-033/001/00, dated October 15, 1970. A description of the experiment procedure and hardware is contained in SDC document TM-(L)-HU-033/000/00, dated May 15, 1970.

This report is presented in two parts:

1) X-ray Polarimeter Experiment Program
2) Data Generation Program

1.1 Use of Existing Software

All programs were coded in FORTRAN IV and were tested and run on the MSFC IBM 7094 computer. Where possible, use was made of existing library routines including:

QUIK3V - SC-4020 plot routine
BIT - Logical bit testing function
CTOBCD - Convert to binary routine
BIN - AND/OR routine
LAGRNG - Lagrangian interpolation routine
EVAL - Power spectrum routine
HARM - Harmonic analysis (FFT) routine

LSF - Bit manipulation routine

FLD - Bit transfer routine

RANDOM - Random number generator

PDUMP - Partial core dump

Subroutines EVAL, HARM and LSF are not standard library routines but were made available by the MSFC Computation Laboratory personnel. Brief descriptions of these three routines are included herein. Descriptions of other library routines may be found in the MSFC IBM 7094 Preliminary Reference Manual.

1.2 Description of Experiment

The X-ray polarimeter experiment hardware consists of the optics and instrumentation necessary to determine the degree of polarization of X-ray celestial sources. The polarimeter is located at the focal point of a large grazing incidence X-ray telescope. Data is collected in electronic format and is processed in real time on board the Space Station. Two types of data are considered--polarimeter and pulsar. Polarimeter data is analyzed to determine the degree of polarization and the intensity of the X-ray source. Pulsar data is analyzed to determine if an X-ray source is a pulsar, and if so, the frequency of pulsation is calculated. Analyzed data is presented in both graphic and tabular format. (For a more detailed explanation of the experiment, see SDC document TM-(L)-HU-033/000/00.)

The software described in Section 2 is limited to that required for acquisition, analysis and display of primary data. Section 3 describes the software to simulate the output of the polarimeter experiment. This simulated data serves as input to the experiment program.

SECTION 2. X-RAY POLARIMETER EXPERIMENT PROGRAM

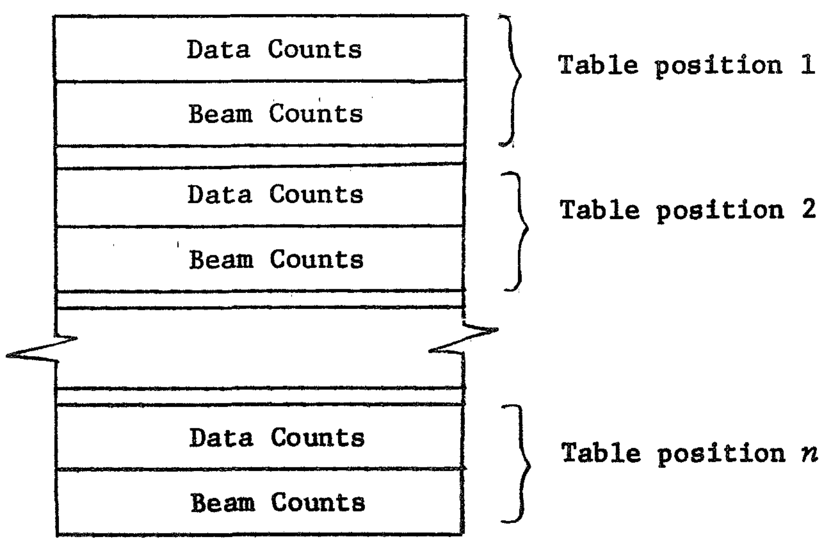
The X-ray Polarimeter Experiment Program acquires, analyzes and displays the primary data from the X-ray polarimeter and pulsar mode counter.

2.1 Input Parameters

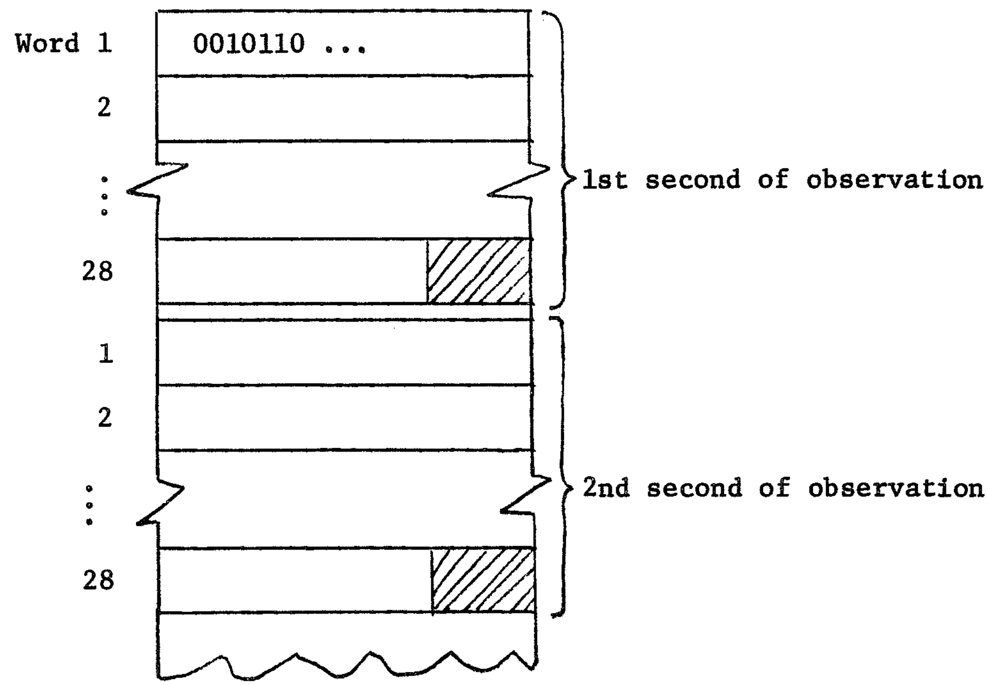
Experiment control parameters input by cards in NAMELIST format are:

NS - Number of Sources
NP - Plot Flag (1 = Plot all Levels of Intensity
0 = Plot Cumulative Only)
ID - Source Identification
RAHR - Right Ascension (Hours)
RAMIN - Right Ascension (Minutes)
DDEG - Declination (Degrees)
DMIN - Declination (Minutes)
OBSTIM - Observation Time
BTP - Beginning Table Position (Degrees)
ETP - Ending Table Position (Degrees)
TSS - Table Step Size (Degrees)

Simulated polarimeter data is input from tape (channel A5) in the following format:



Simulated pulsar data is input from tape (channel A6) in bit string format as follows:



Pulsar data is in blocks of 1000 bits--where 1 bit represents 1 millisecond of observation. The data is packed so that the entire block is stored in 28 thirty-six bit words. The least significant 8 bits of the 28th word are not used.

2.2 Program Flow

Figure 2-1 presents the general flow of the X-ray polarimeter experiment program.

2.3 Subroutines

- CAMRAV - Open SC-4020 file
- INIT - Initialize experiment parameters
- PULDAQ - Pulsar data acquisition
- PULDAN - Pulsar data analysis
- PULDDI - Pulsar data display
- POLDAQ - Polarimeter data acquisition
- POLDDP - Polarimeter data display
- SUMUP - Experiment summary
- CLEAN - Close SC-4020 file

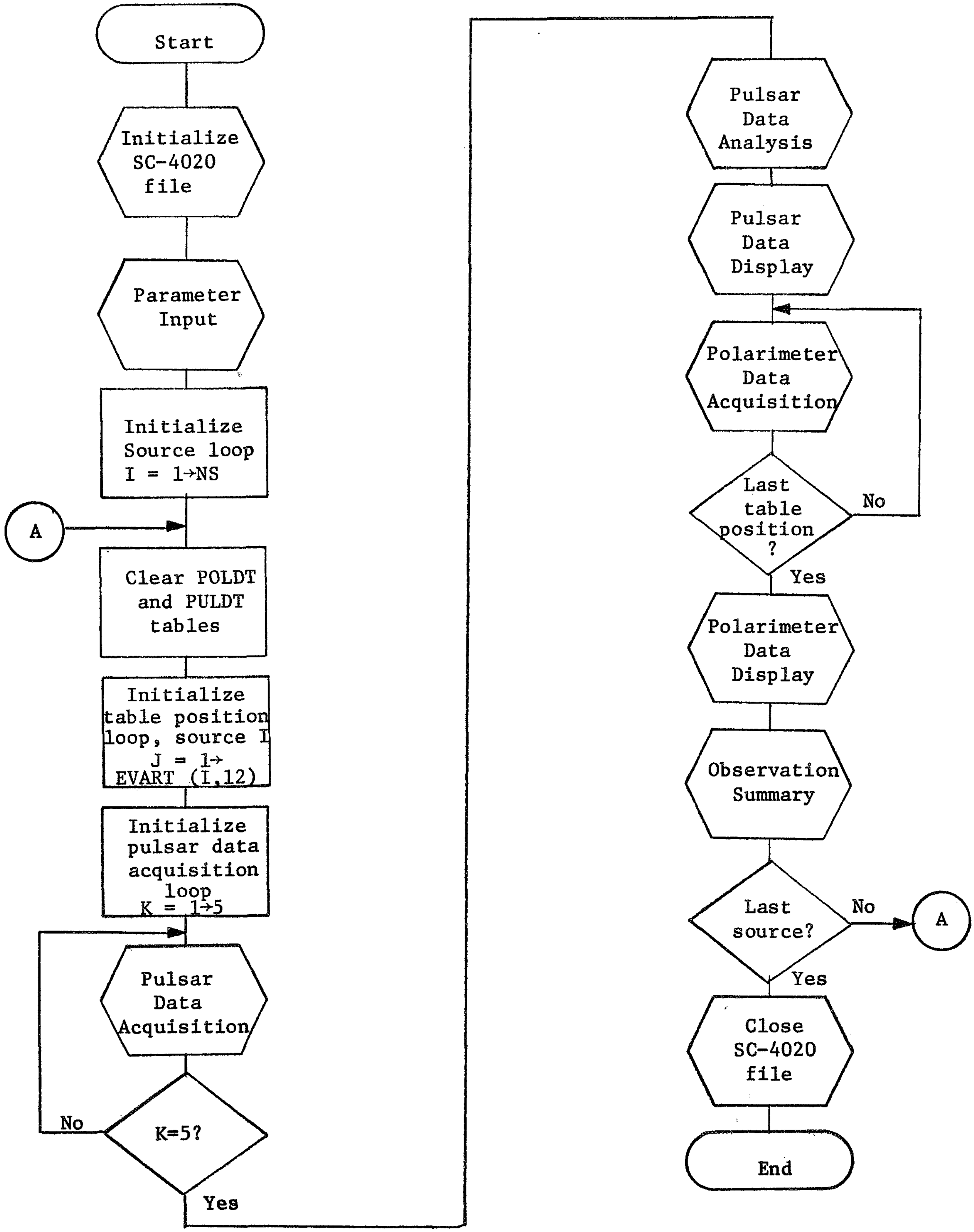


Figure 2-1. General Flow for Simulated Experiment

CAMRAV and CLEAN are part of the SC-4020 QUIK package. All other subroutines were developed as part of this contract and are documented in this section.

Subroutine INIT

Purpose: Subroutine INIT inputs all experiment control variables and initializes the experiment variable table, EVART.

Usage: CALL INIT (NS, EVART, NP)

NS - Number of sources
EVART - Experiment variable table
NP - Plot flag

Input: Input to subroutine INIT is by card in NAMELIST format.

NS - Number of Sources
NP - Plot Flag (1 = Plot all Levels of Intensity
0 = Plot Cumulative Only)
ID - Source Identification
RAHR - Right Ascension (Hours)
RAMIN - Right Ascension (Minutes)
DDEG - Declination (Degrees)
DMIN - Declination (Minutes)
OBSTIM - Observation Time
BTP - Beginning Table Position (Degrees)
ETP - Ending Table Position (Degrees)
TSS - Table Step Size (Degrees)

All of the above input items are stored in table EVART except NS and NP.

Since NAMELIST does not provide for BCD input, the source identification is input in code format as follows:

1 - Tau X-1	16 - Lup XR-1	31 - Oph XR-2
2 - Vir XR-1	17 - Nor XR-2	32 - Sco XR-3
3 - Cen XR-2	18 - Sco X-2	33 - GX 9+9
4 - Sco X-1	19 - Ara XR-1	34 - Oph XR-1
5 - Sco XR-2	20 - GX-5.6	35 - Sco XR-5
6 - GX 3+1	21 - Sgr XR-1	36 - Sco XR-6
7 - GX 5-1	22 - Ser XR-1	37 - Lyr XR-1
8 - GX 9+1	23 - Cep XR-1	38 - Sgr XR-5
9 - Sgr XR-2	24 - Leo XR-1	39 - Aql XR-1
10 - Ser XR-2	25 - Cen XR-3	40 - Cyg XR-3
11 - Cyg XR-1	26 - Cen XR-1	41 - Cyg X-3
12 - Cyg X-4	27 - Nor XR-1	42 - Vul XR-1
13 - Cyg XR-2	28 - Sco XR-4	43 - Lac XR-1
14 - Cas XR-1	29 - L7	44 - Cep XR-2
15 - Vel XR-1	30 - L8	45 - Cep XR-3

Storage: $370_{(8}$

Subroutine PULDAQ

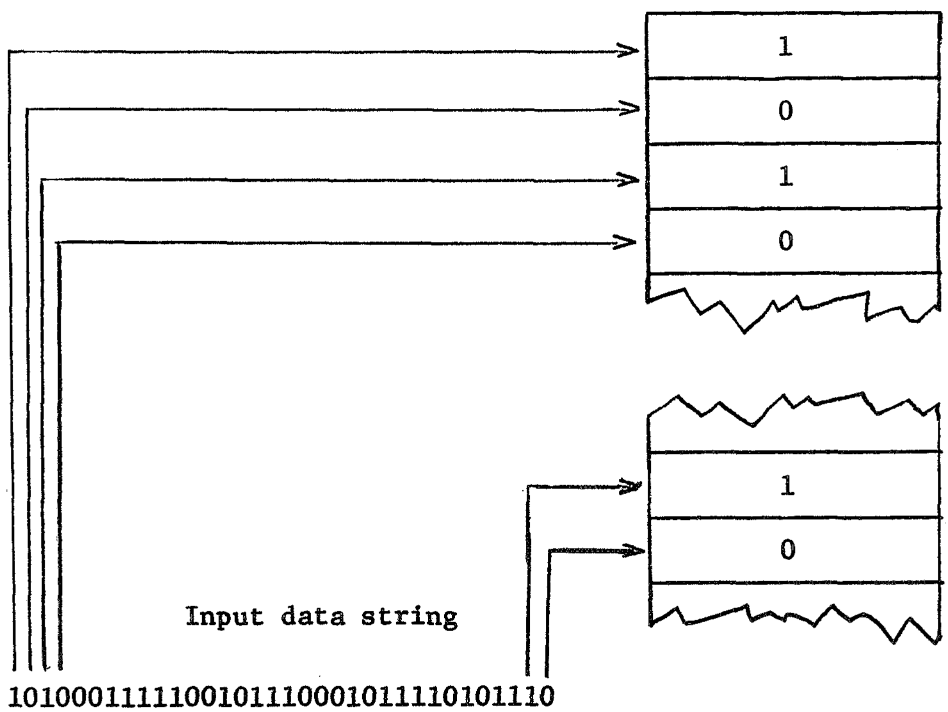
Purpose: Subroutine PULDAQ acquires pulsar data from tape and converts it from bit to word format.

Usage: CALL PULDAQ (I, PULDT)

I - Source index

PULDT - Pulsar data table

Method: Pulsar data is read from tape in string format where 1 bit represents 1 millisecond of observation. The data is unpacked to 1 bit per word to facilitate later analysis.



Subroutines: BIT (Logical bit testing routine)

Storage: 213_8

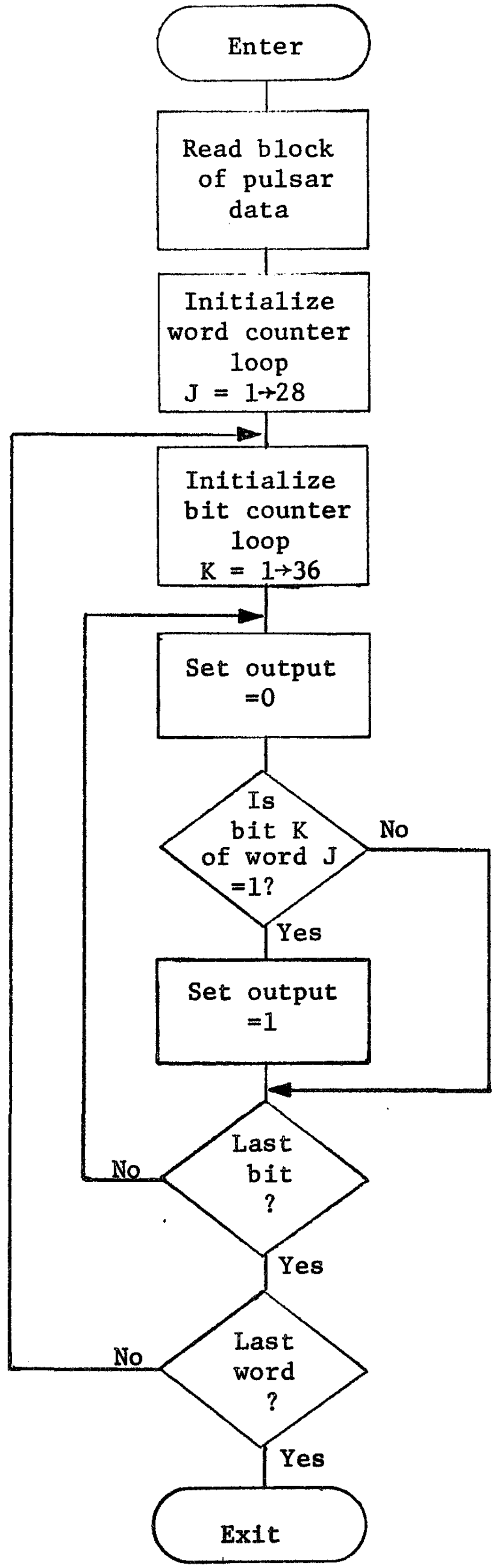


Figure 2-2. Subroutine PULDAQ

Subroutine PULDAN

Purpose: Subroutine PULDAN detects X-ray pulsations and determines the approximate pulsation period.

Usage: CALL PULDAN (I, PULDT, DUMMY, KFLAG, POWSP, TOP10, KTOP10)

I - Source index
PULDT - Pulsar data table
DUMMY - Duplicate of pulsar data table required by FFT
KFLAG - Pulsar indicator (1 = pulsar, 0 = no pulsar)
POWSP - Power spectrum of pulsar data
TOP10 - Ten highest amplitudes of power spectrum
KTOP10 - Index of 10 highest amplitudes

Method: The method used to detect pulsars and to estimate their fundamental frequency is an application of a Cooley-Tukey type Fast Fourier Transform (FFT) to obtain a power spectrum of the detected X-radiation. The pulse train of unity amplitude serves as the input to the FFT which produces cosine and sine amplitude coefficients:

$$A_r = \frac{2}{N} \sum_{k=0}^{N-1} X_k (\cos 2\pi rk/N) \qquad r = 0, 1, \ldots, N-1$$

$$B_r = \frac{2}{N} \sum_{k=0}^{N-1} X_k (\sin 2\pi rk/N) \qquad r = 0, 1, \ldots, N-1$$

where A_r and B_r are the $r^{\underline{th}}$ coefficients, X_k denotes the $k^{\underline{th}}$ sample of the time series of N samples.

From the cosine and sine amplitude coefficients, a set of power amplitudes is computed as

$$PA_r = \frac{(A_r + jB_r)(A_r - jB_r)}{T}$$

where T is the number of time increments in the sample and $j = \sqrt{-1}$

The spectrum of power amplitudes is sorted to isolate the frequencies at which the amplitudes are the highest. The 10 highest amplitudes are summed and if the resulting value is greater than 5% of the sum of all amplitudes, the source is considered a pulsar. The frequency at which the power amplitude is the greatest is the fundamental frequency of the X-ray source.

Subroutines: EVAL (Power spectrum density)

Storage: $225_{(8}$

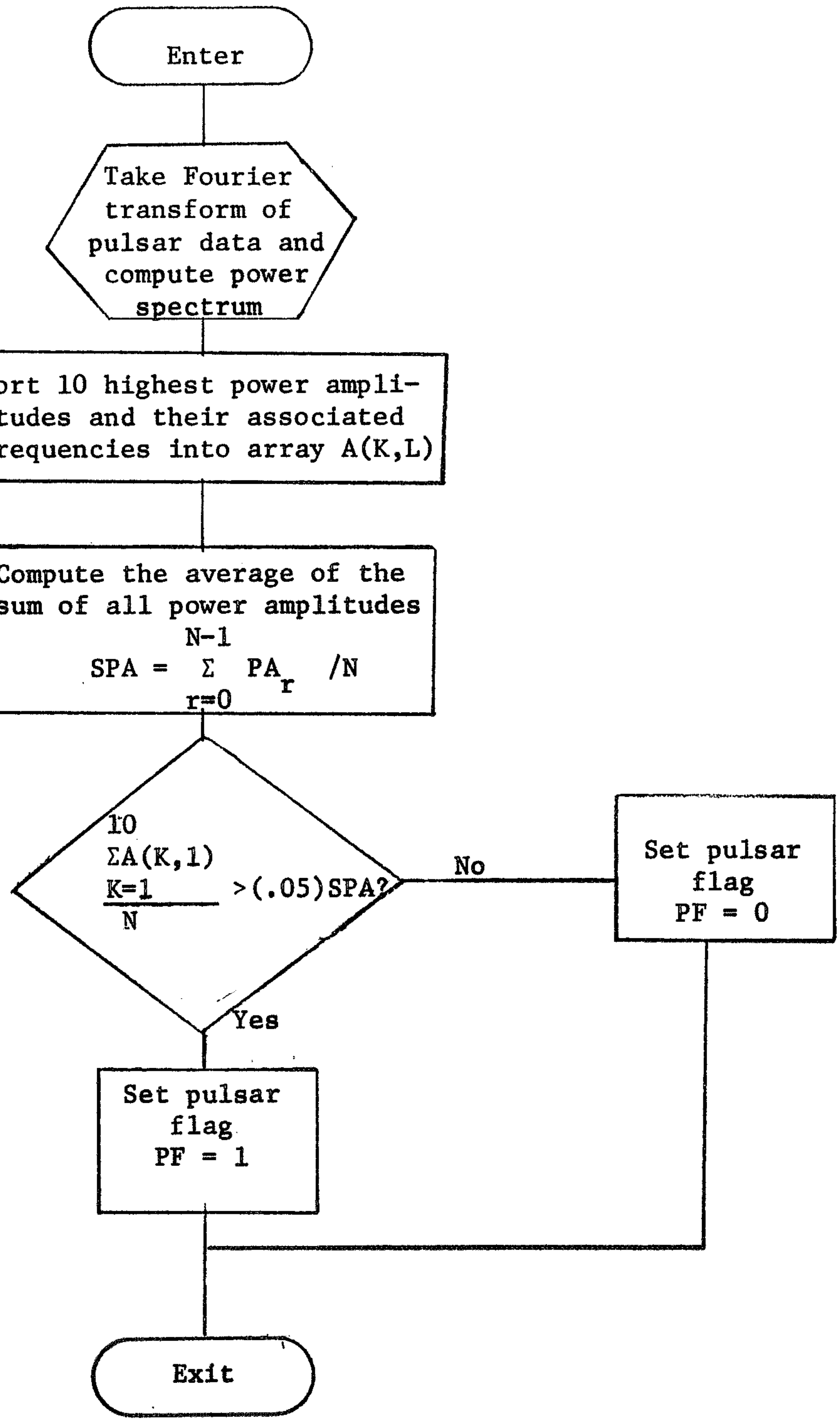


Figure 2-3. Subroutine PULDAN

Subroutine EVAL

Purpose: Subroutine EVAL calculates the power spectrum using the real and imaginary arrays.

Usage: CALL EVAL (X1, X2, N, SR, Y1)

X1 - Input data for the first data array.

X2 - Input data for the second data array.

N - The number of points in the X1 and X2 arrays where $N \leq 2^{12}$. If N is not a power of 2, the value of N will be set to a negative value on error return and the routine will not calculate the power spectrum.

SR - The sample rate for the data.

Y1 - The cross power spectrum array containing N spectral estimates.

Subroutines: HARM (Subroutine HARM is an IBM Share routine which has been converted to the IBM-7094.)

LSF (The subroutine LSF is a bit manipulation routine with entry points IRS and INVERT.)

Restrictions:

1. Subroutine EVAL removes the mean from the X1 and X2 data arrays before the cross power spectrum is calculated.
2. After a successful call to EVAL, the data is destroyed in the X1 and X2 data arrays.
3. A flag can be set in the routine to aid in program checkout by printing the power spectrum for each data array.
4. If the contents of X1 and X2 data arrays contain the same data, the Y1 array will be a single power spectrum.

Storage: $501_{(8}$

Subroutine LSF

Purpose: Subroutine LSF moves a string of bits left, right, or produces a mirror image for N bits where N $\leq$ 32.

Usage: CALL LSF (IWORD, NBITS)

IWORD - The routine will move a string of bits in IWORD to the left.

NBITS - The number of places to move the string of bits in IWORD.

Entry Point II

CALL IRS (IWORD, NBITS)

IWORD - The entry IRS will move a string of bits in IWORD to the right.

NBITS - The number of places to move the string of bits in IWORD.

Entry Point III

CALL INVERT (IWORD, NBITS)

IWORD - The entry will invert a string of bits to produce a mirror image.

NBITS - The number of bits in IWORD to invert.

Storage: $216_{(8}$

Subroutine PULDDI

Purpose: Subroutine PULDDI presents the analyzed pulsar data in graphic form.

Usage: CALL PULDDI (I, EVART, POWSP, TOP10, KTOP10, X, Y, DOMFRQ)

I - Source index
EVART - Experiment variable table
POWSP - Power spectrum of pulsar data
TOP10 - Amplitude of 10 highest frequencies
KTOP10 - Index of 10 highest amplitudes
X - Working storage array
Y - Working storage array
DOMFRQ - Dominant frequency

Output: The SC-4020 plotter is used as the output device for plots of the power spectrum of the pulsar data. See Figure 2-7.

Subroutines: CTOBCD (Convert to BCD)
QUIK3V (SC-4020 plot routine)

Storage: $411_{(8}$

Subroutine POLDAQ

Purpose: Subroutine POLDAQ acquires from tape, edits and maintains cummulative totals of the polarimeter data.

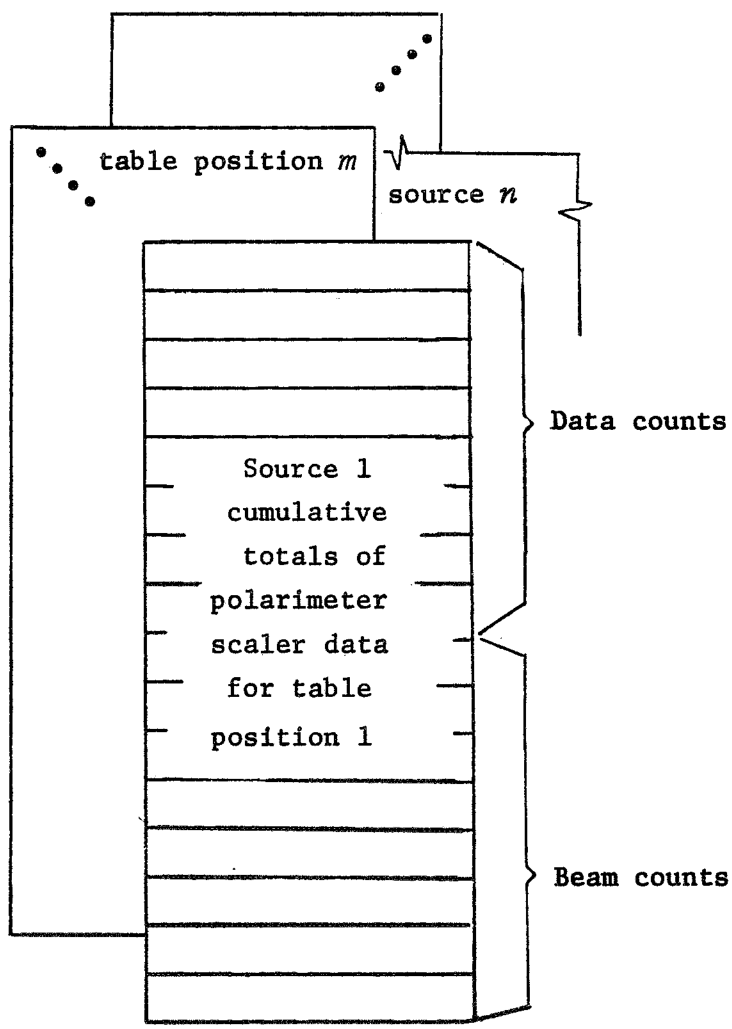
Usage: CALL POLDAQ (I, J, POLDT)

I - Source index

J - Polarimeter table position index

POLDT - Polarimeter data table

Method: Polarimeter data is read from tape, extraneous bits stripped off and the resulting values stored in table POLDT as follows:



Subroutines: BIN (AND operator)

Storage: $174_{(8}$

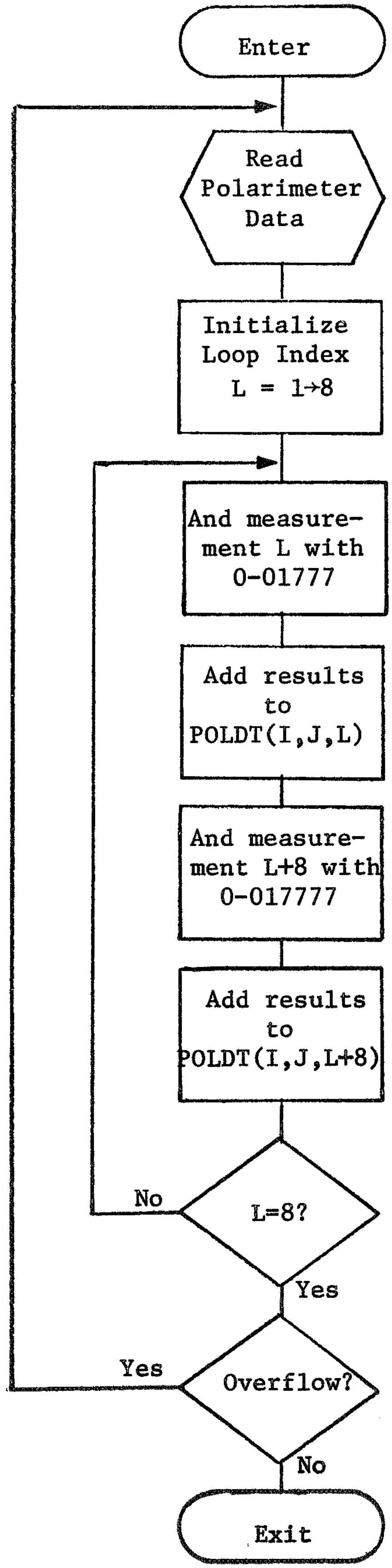


Figure 2-4. Subroutine POLDAQ

Subroutine POLDDP

Purpose: Subroutine POLDDP formats and presents the polarimeter data in graphic form.

Usage: CALL POLDDP (I, POLDT, EVART, NP, DEGPOL, PM)

I - Source index
POLDT - Polarimeter data table
EVART - Experiment variable table
NP - Plot flag
DEGPOL - Degree of polarization
PM - Angle of maximum polarization

Method: Degree of polarization is calculated as

$$D = \frac{\text{max} - \text{min}}{\text{max} + \text{min}} \times 100.$$

Angle of maximum polarization is determined by interpolation.

Output: The SC-4020 is used as the output device. See Figure 2-8.

Subroutines: CTOBCD (Convert to BCD)
LAGRNG (Lagrangian interpolation)
QUIK3V (SC-4020 plot routine)

Storage: $1075_{(8}$

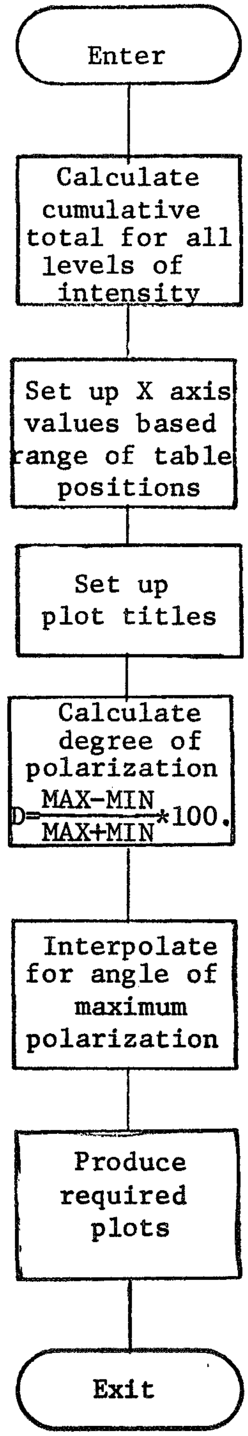


Figure 2-5. Subroutine POLDDP

Subroutine SUMUP

Purpose: Subroutine SUMUP outputs a summary of the total observation of each source.

Usage: CALL SUMUP (I, EVART, POLDT, TOP10, KTOP10, DEGPOL, PM, KFLAG, DOMFRQ)

- I - Source index
- EVART - Experiment variable table
- POLDT - Polarimeter data table
- TOP10 - Ten highest amplitudes of power spectrum
- KTOP10 - Index of ten highest amplitudes
- DEGPOL - Degree of polarization
- PM - Angle of maximum polarization
- KFLAG - Pulsar indicator
- DOMFRQ - Dominant frequency

Output: See Figures 2-20 through 2-23.

Storage: $624_{(8}$

2.4 Sample Input

Card input for 4 sample X-ray sources is presented in Figure .

```
$DATA
 $NAM1                    Number of Sources and Plot Flag
 NS = 4
 NP = 1$
 $NAM2                    Source 1
 ID = 2
 RAHR = 12.
 RAMIN = 30.7
 DDEG = 12.
 DMIN = 30.
 OBSTIM = 20.
 BTP = 0.
 ETP = 350.
 TSS = 10.$
 $NAM2                    Source 2
 ID = 18
 RAHR = 16.
 RAMIN = 53.
 DDEG = -40.
 DMIN = 0.
 OBSTIM = 10.
 TSS = 10.$
 $NAM2                    Source 3
 ID = 21
 RAHR = 17.
 RAMIN = 48.
 DDEG = -30.
 DMIN = 0.
 OBSTIM = 20.
 TSS = 10.$
 $NAM2                    Source 4
 ID = 13
 RAHR = 21.
 RAMIN = 42.6
 DDEG = 38.
 DMIN = 5.
 OBSTIM = 15.
 BTP = 0.
 ETP = 175.
 TSS = 5.$
 $END
```

Figure 2-6. Sample Experiment Program Input

2.5 Sample Output

Output for 4 sample X-ray sources is presented in Figures 2-7 through 2-19.

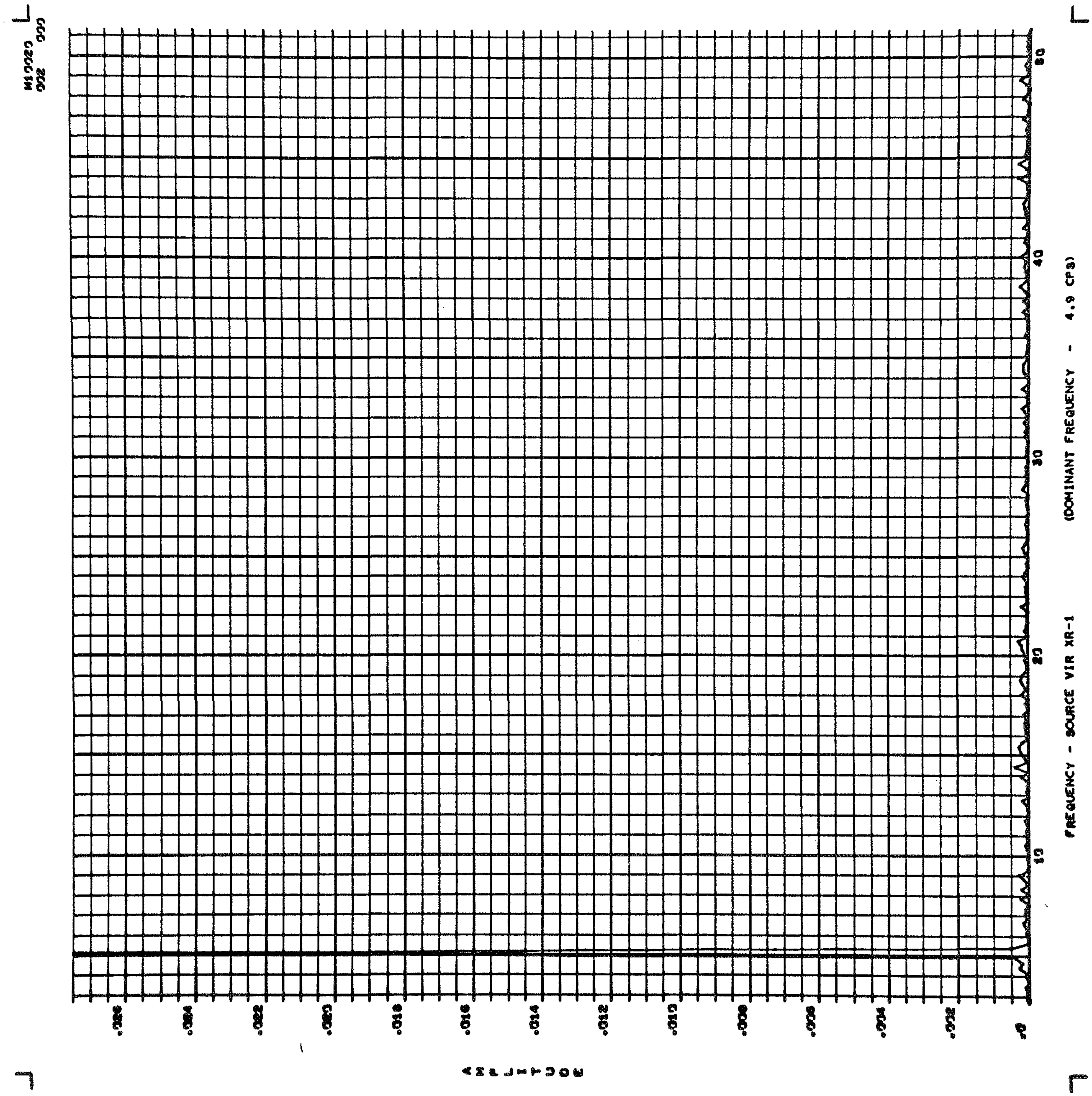


Figure 2-7. Power Spectrum of Pulsar Data - Source 1

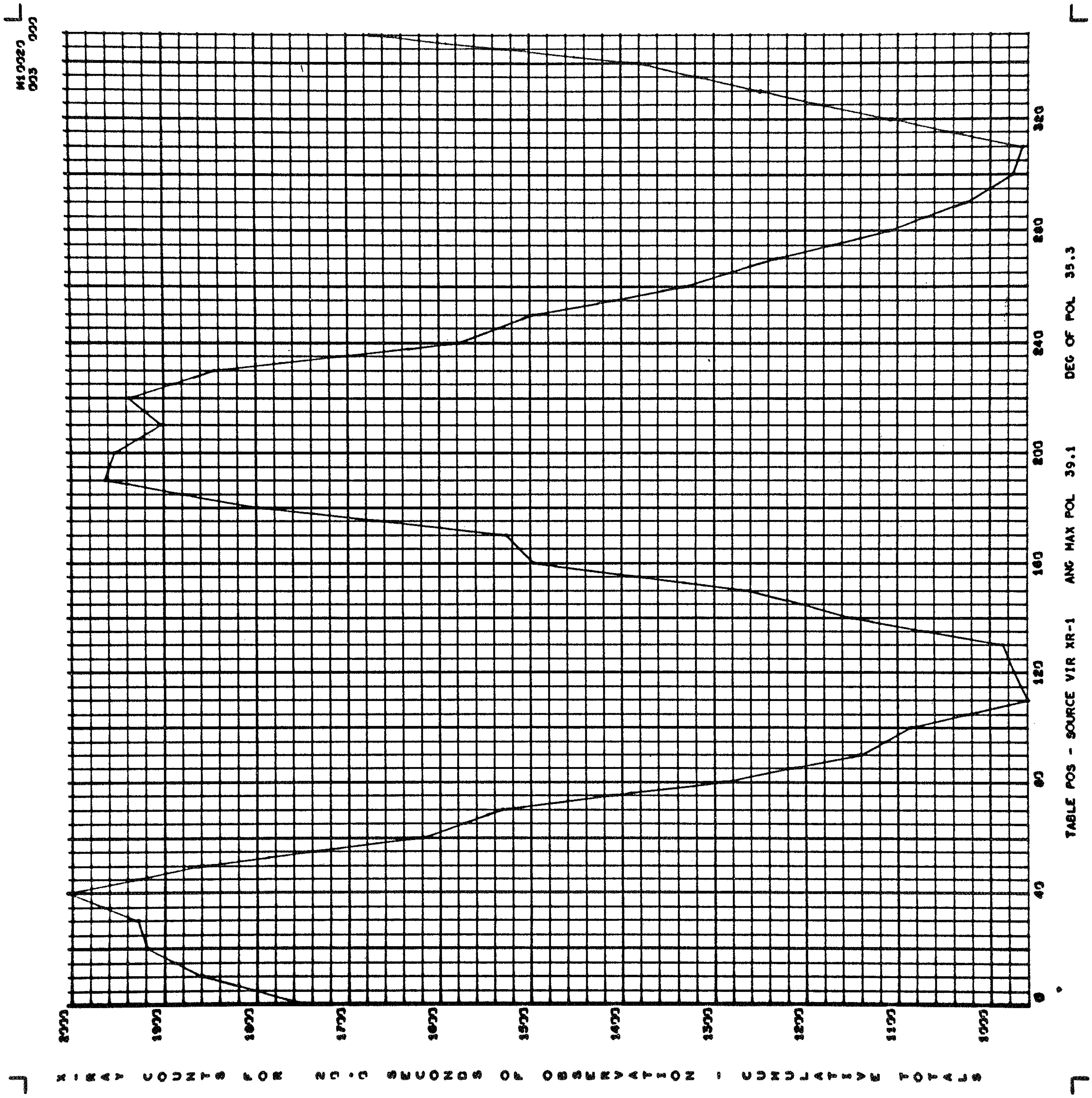


Figure 2-8. Cummulative Totals of Polarimeter Data Counts - Source 1

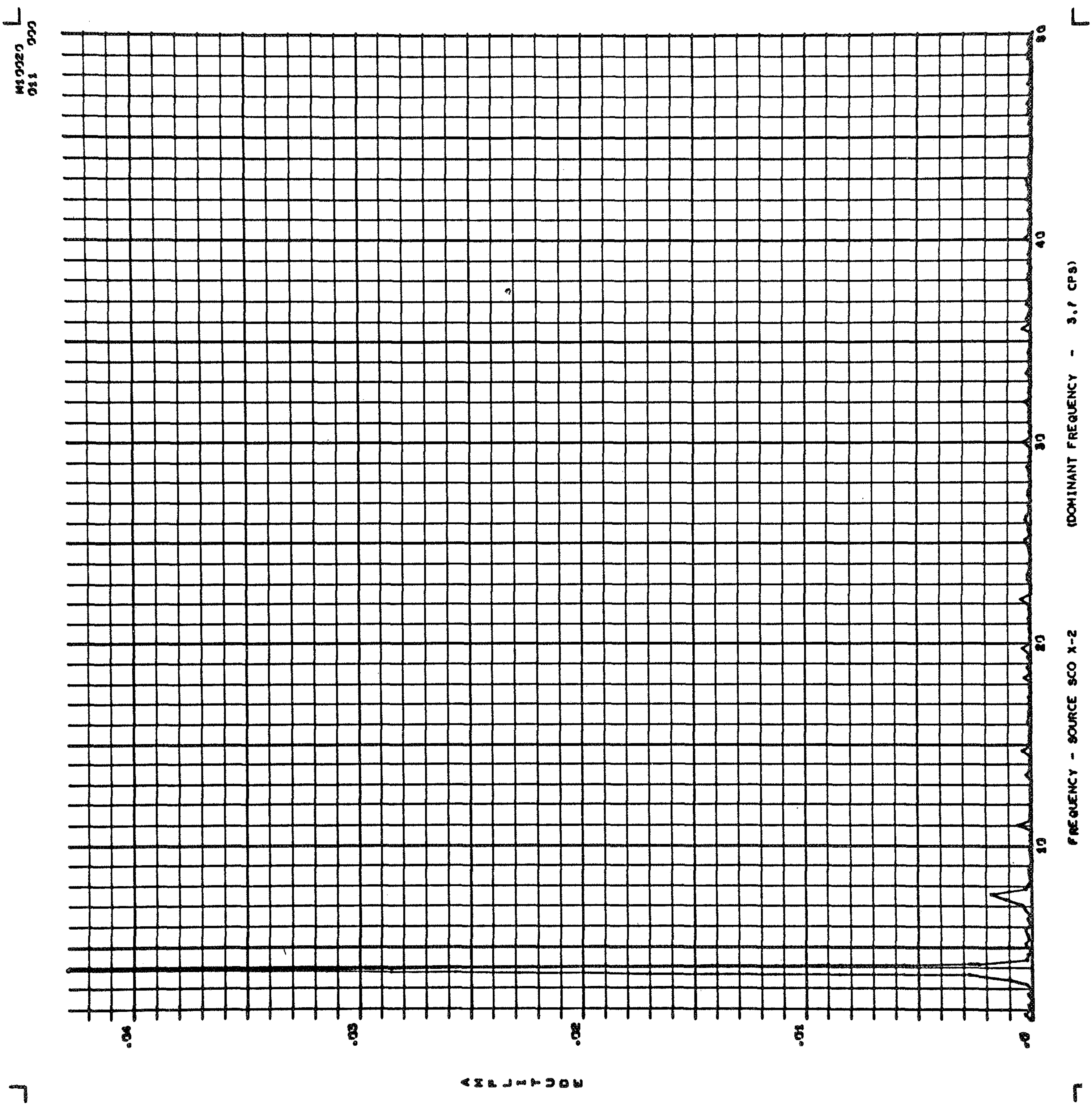


Figure 2-9. Power Spectrum of Pulsar Data - Source 2

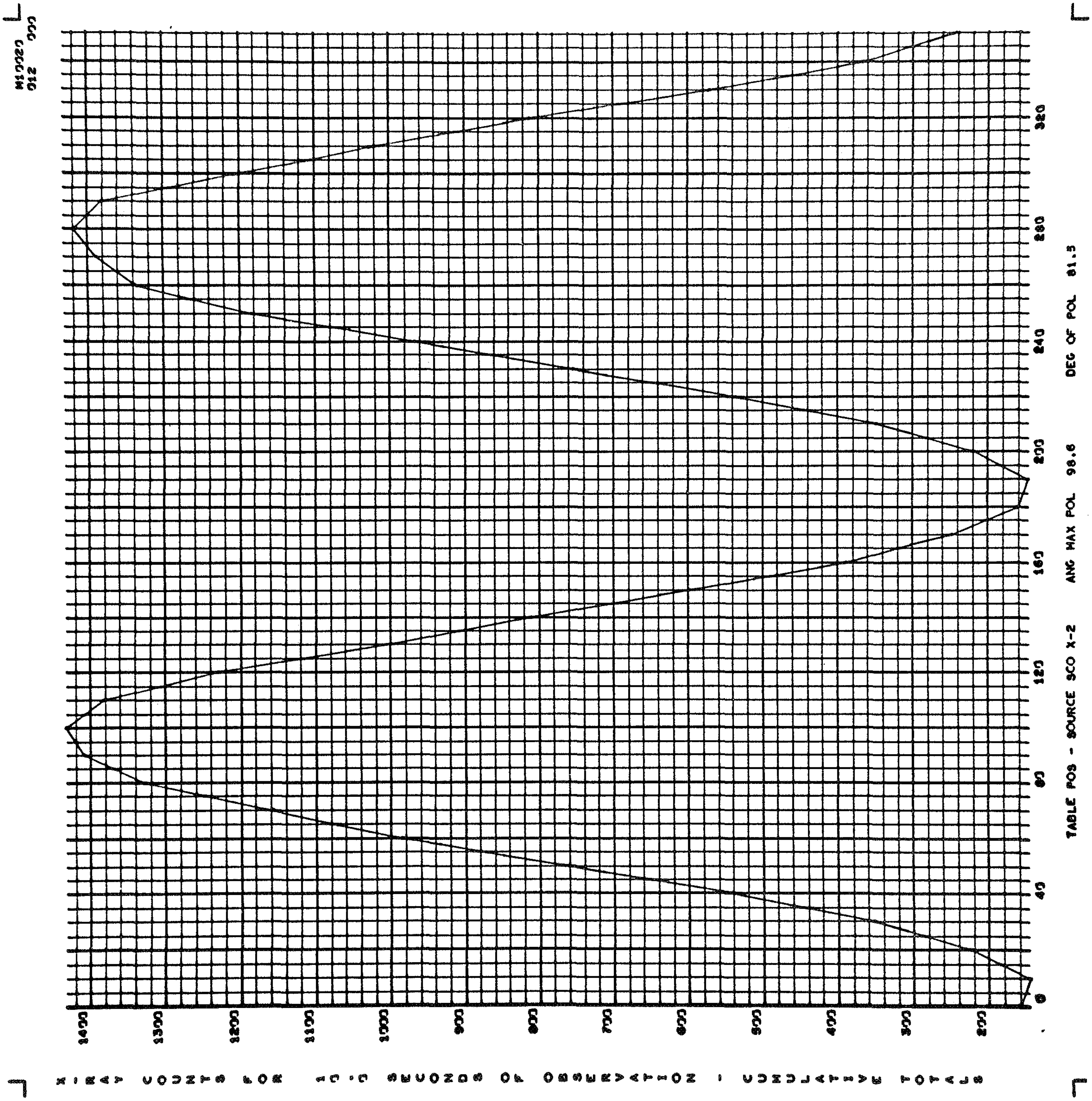


Figure 2-10. Cummulative Totals of Polarimeter Data Counts - Source 2

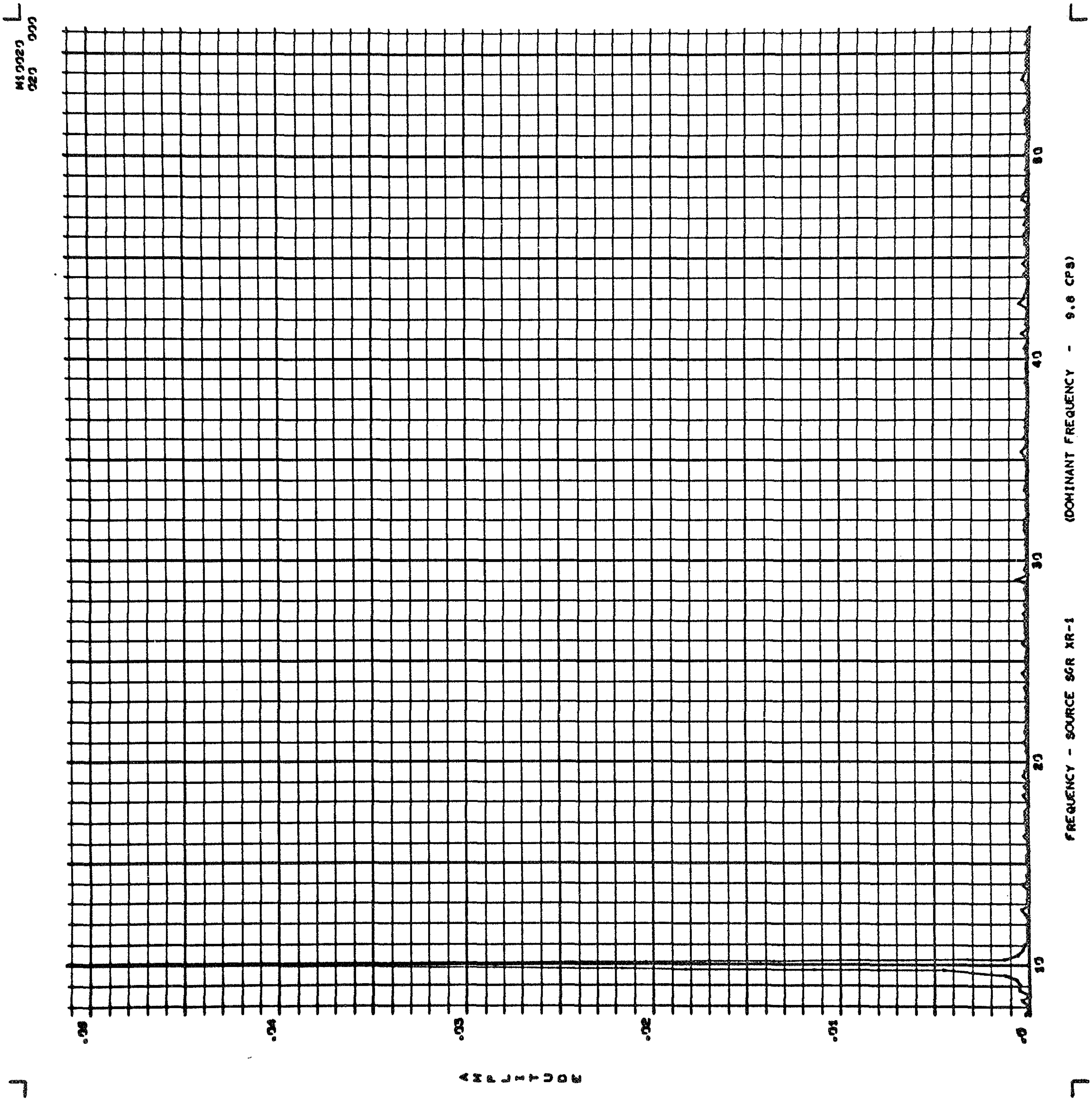


Figure 2-11. Power Spectrum of Pulsar Data - Source 3

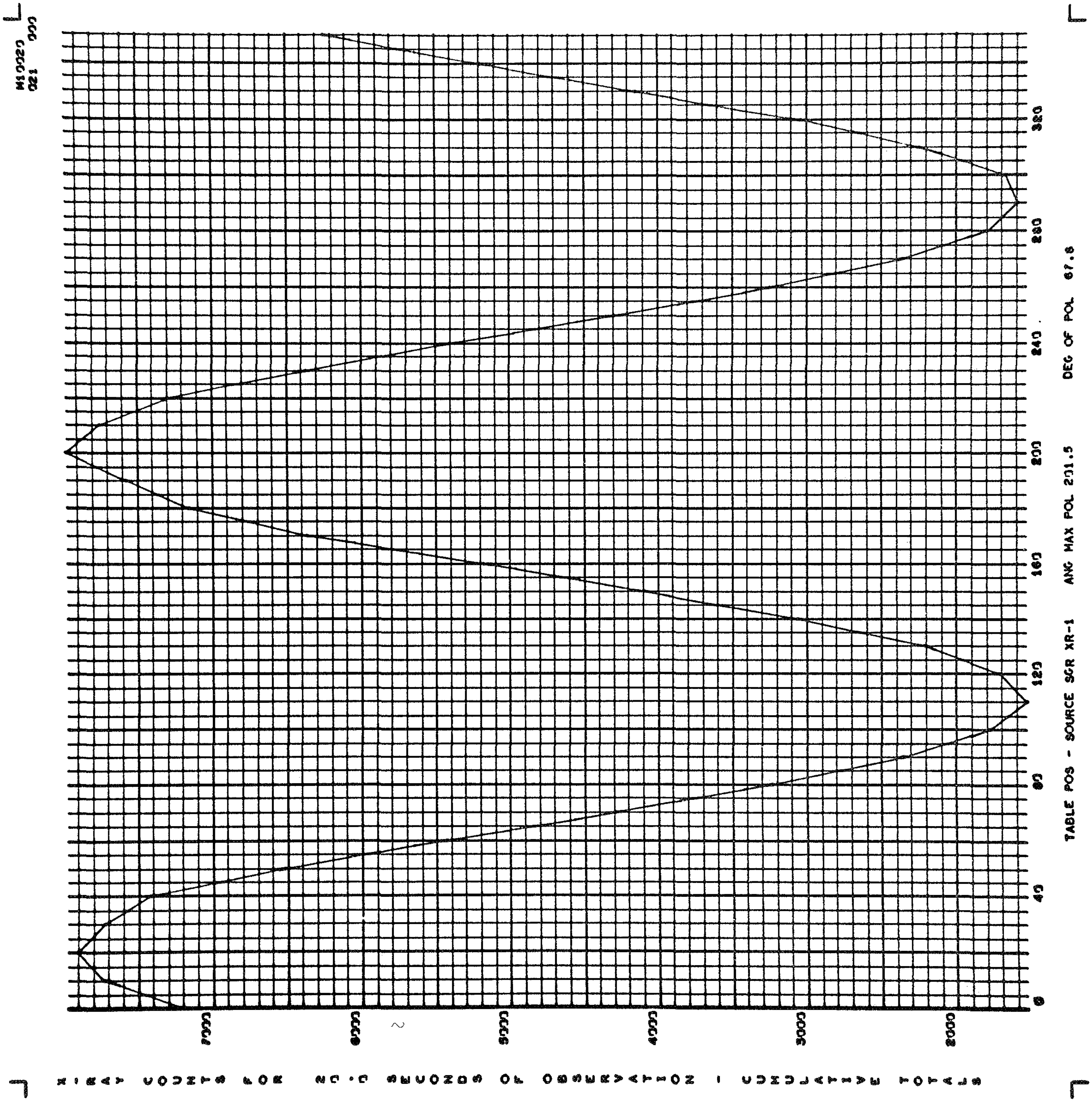


Figure 2-12. Cummulative Totals of Polarimeter Data Counts - Source 3

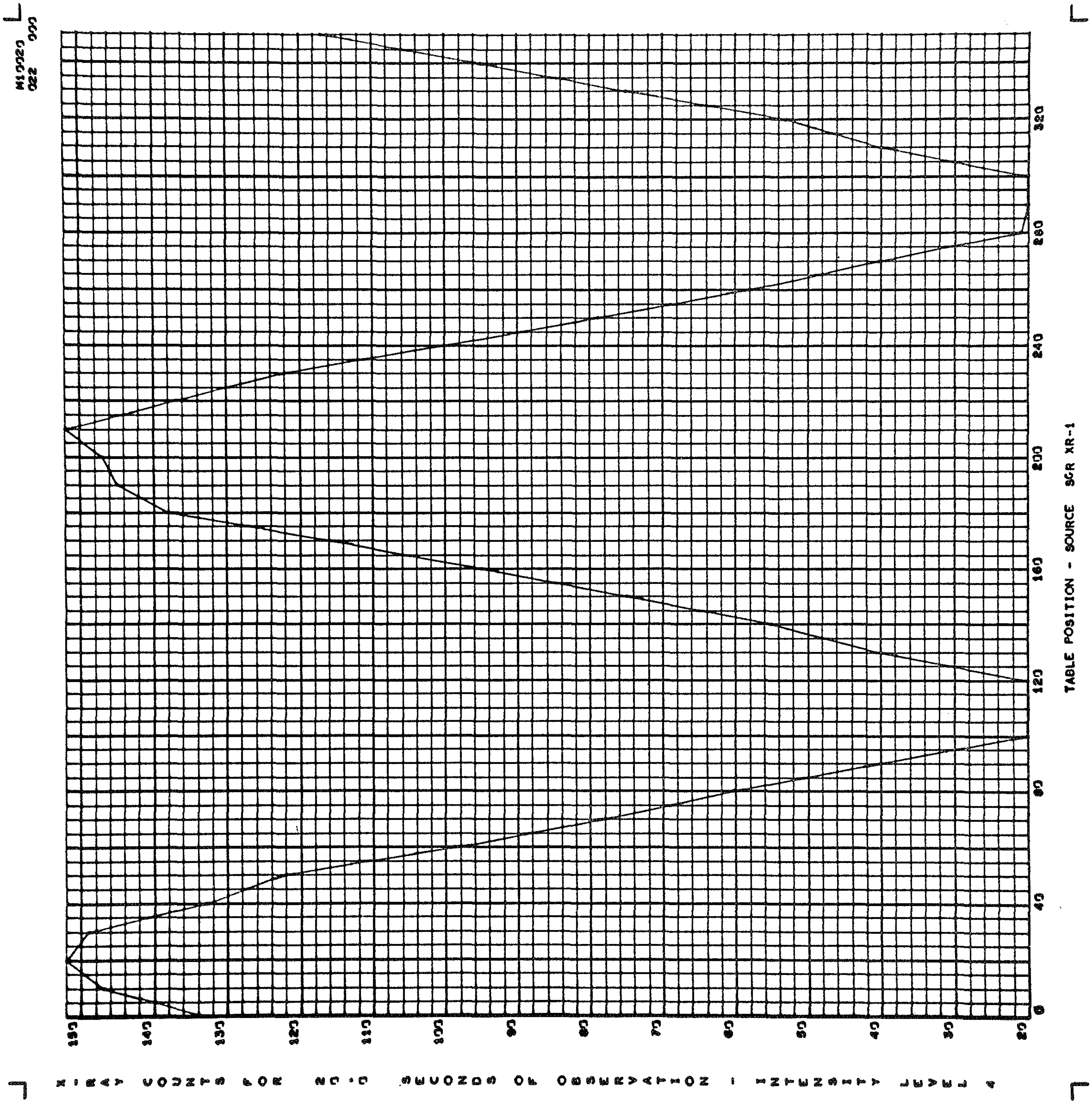


Figure 2-13. Intensity Level 4, Polarimeter Data Counts - Source 3

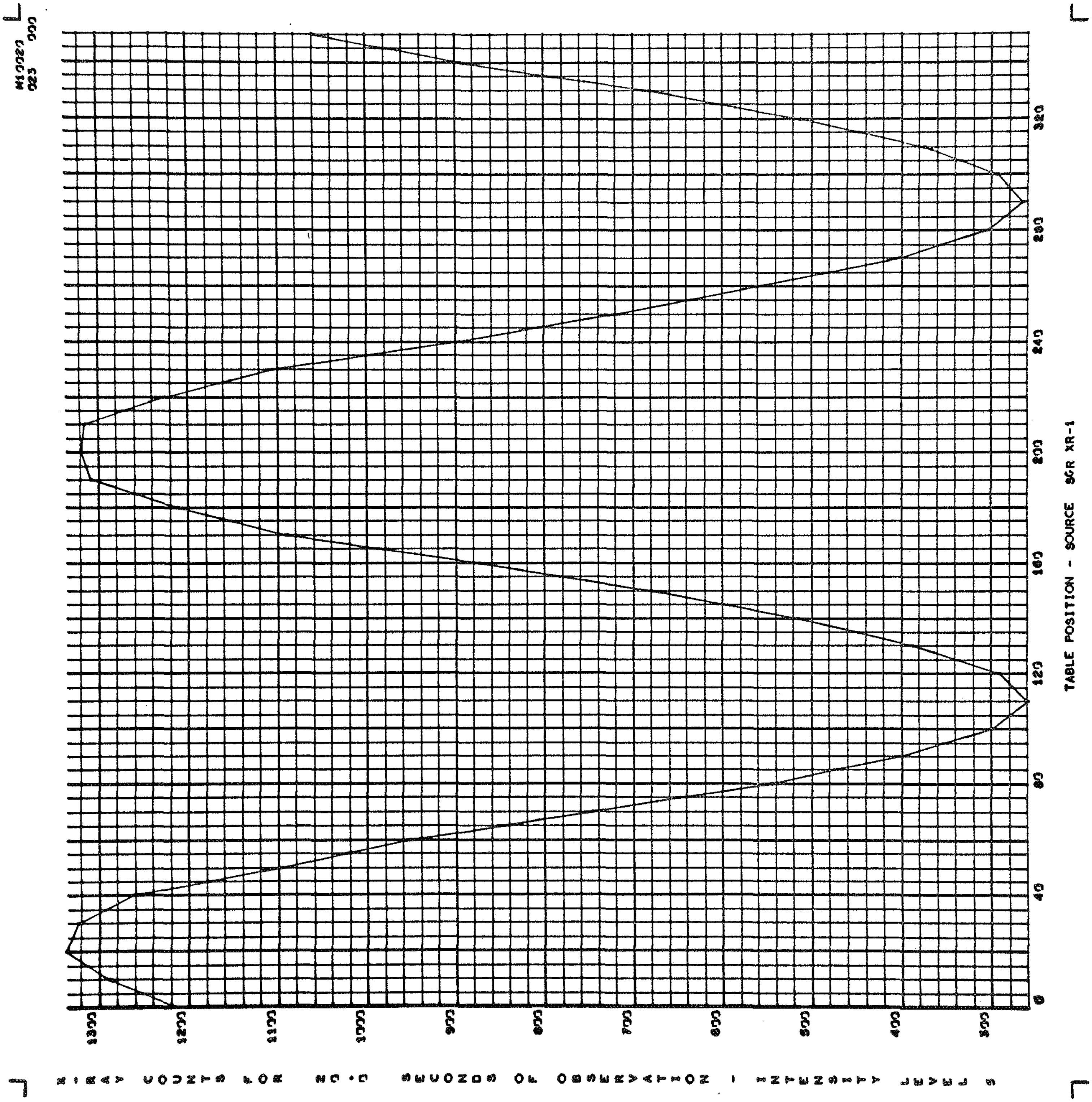


Figure 2-14. Intensity Level 5, Polarimeter Data Counts - Source 3

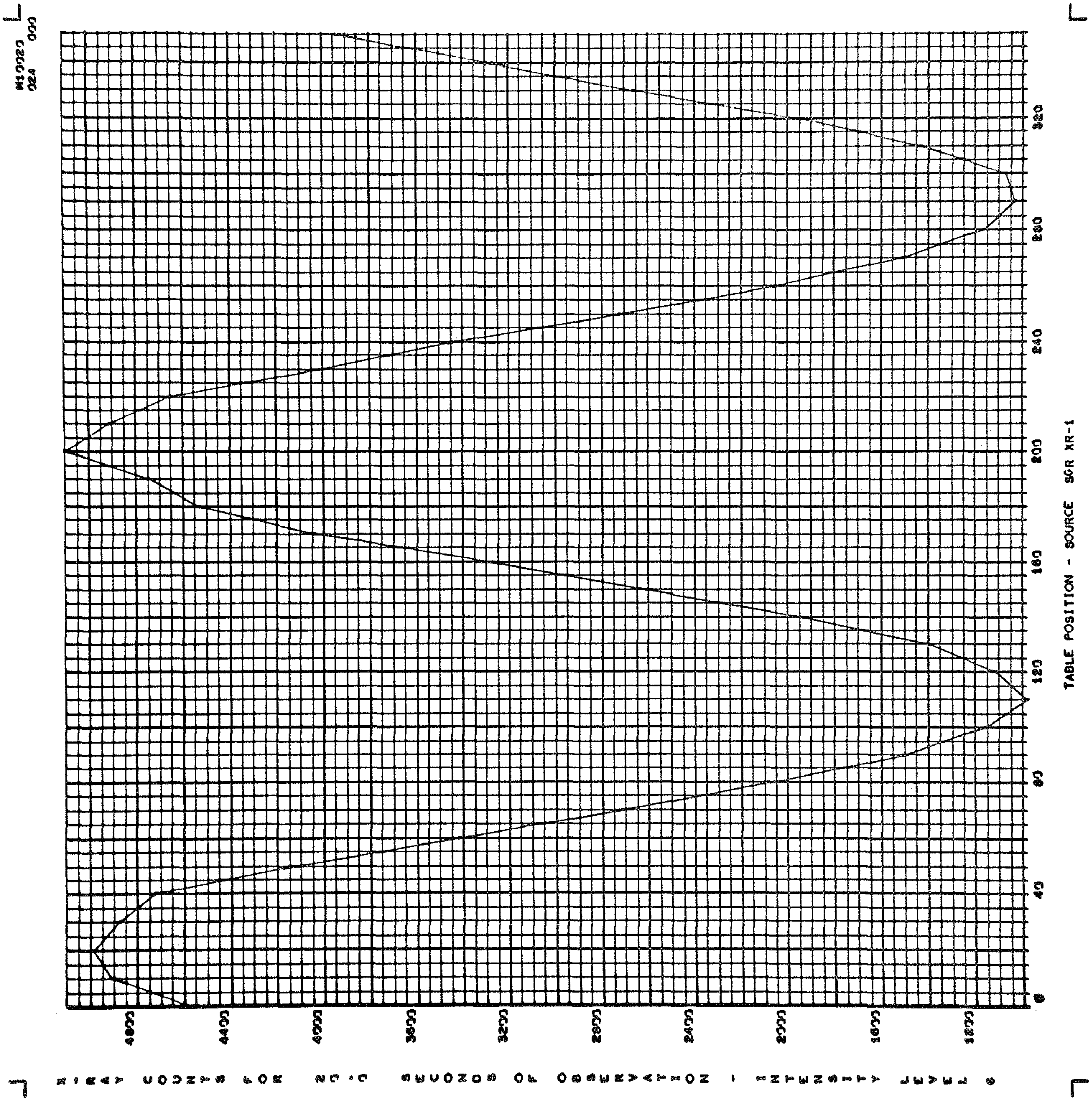


Figure 2-15. Intensity Level 6, Polarimeter Data Counts - Source 3

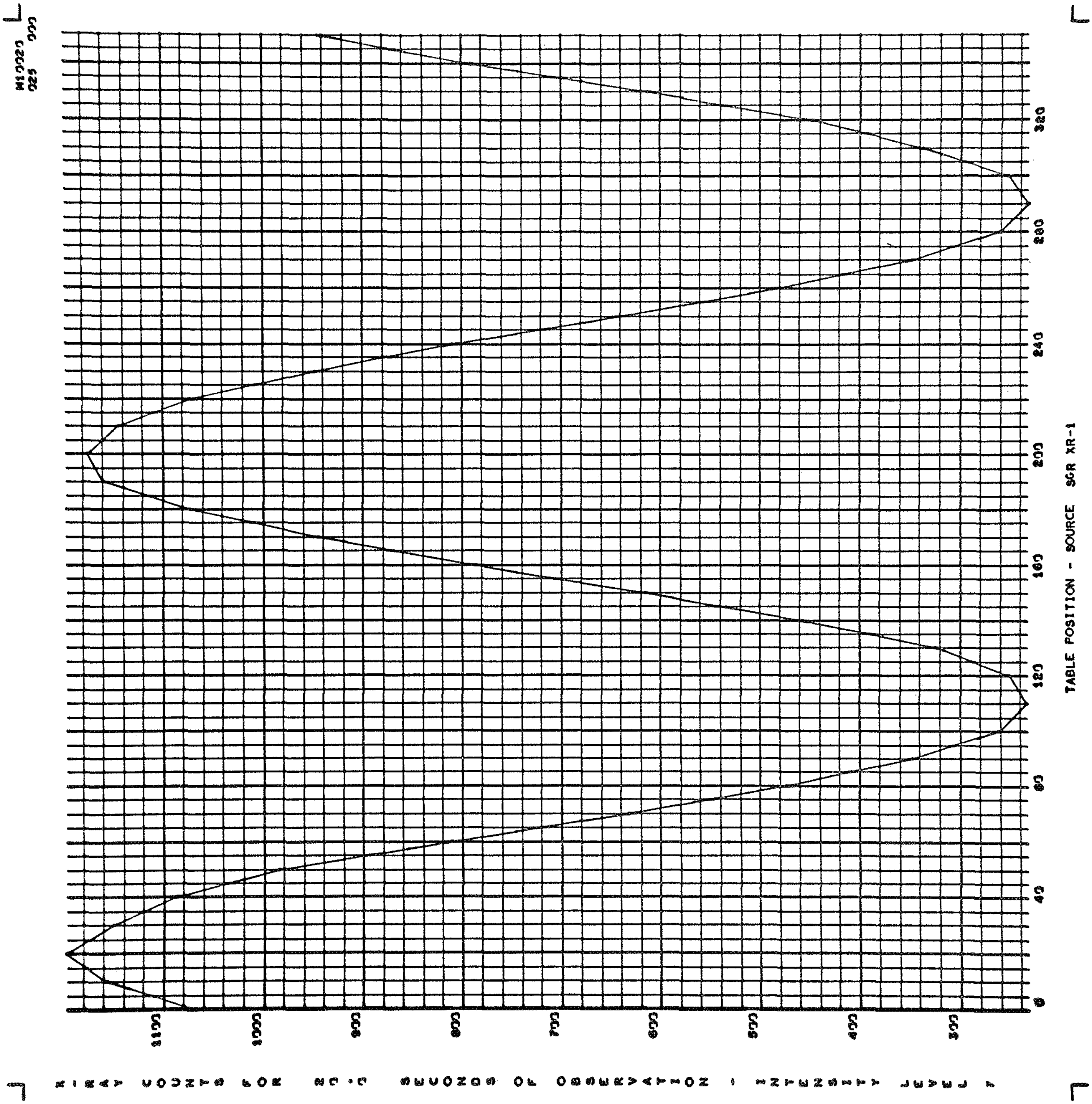


Figure 2-16. Intensity Level 7, Polarimeter Data Counts - Source 3

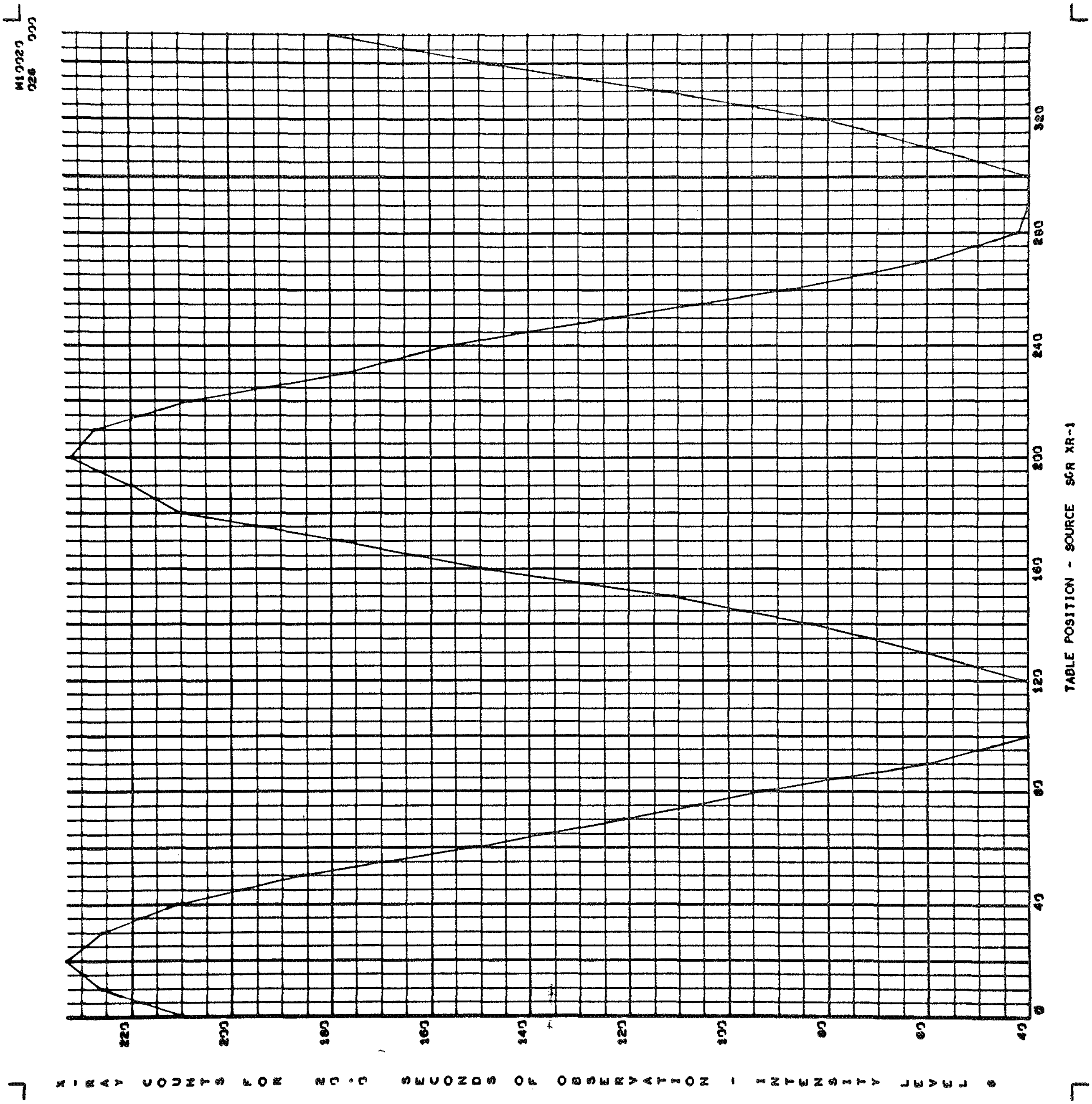


Figure 2-17. Intensity Level 8, Polarimeter Data Counts - Source 3

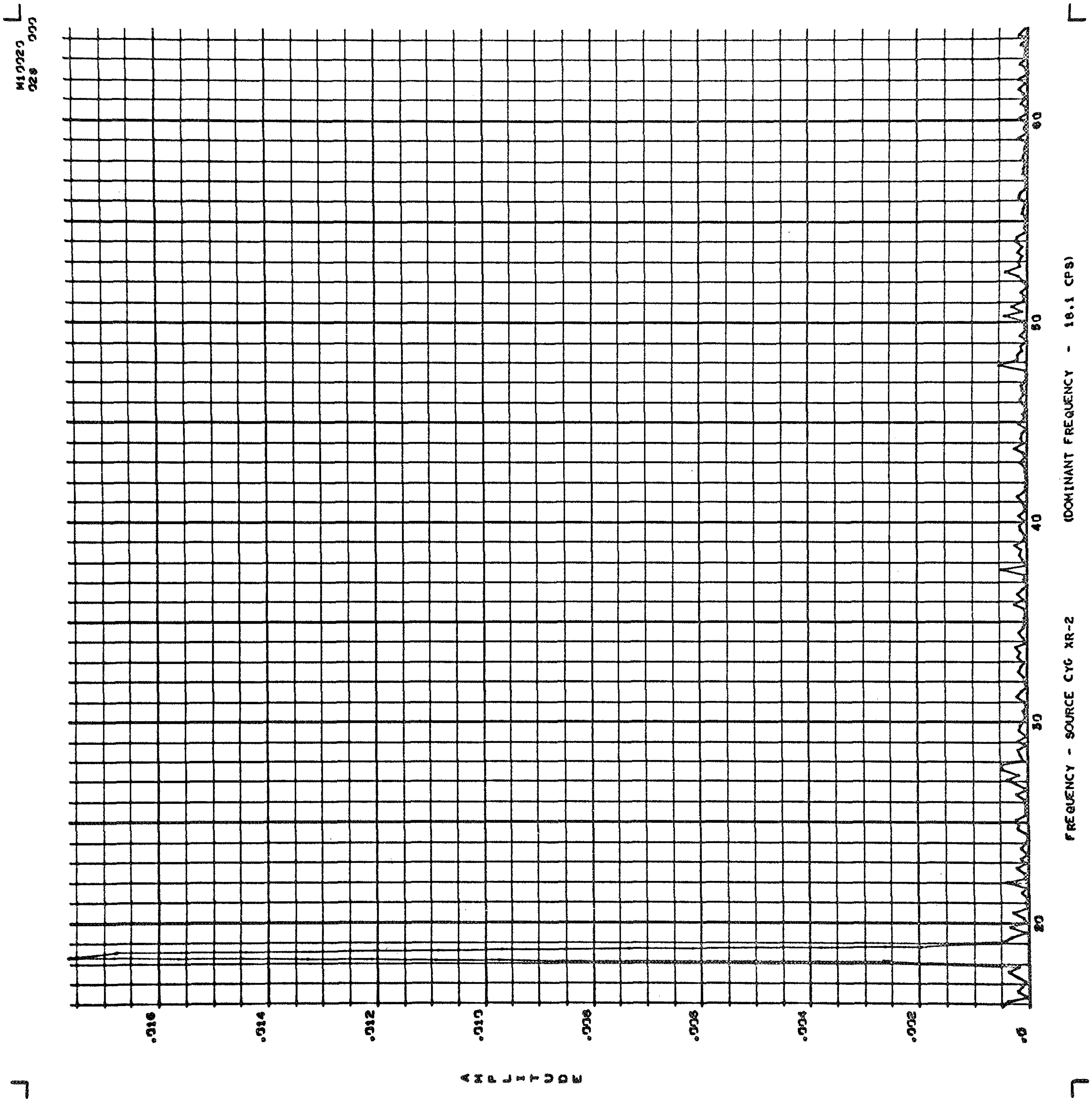


Figure 2-18. Power Spectrum of Pulsar Data - Source 4

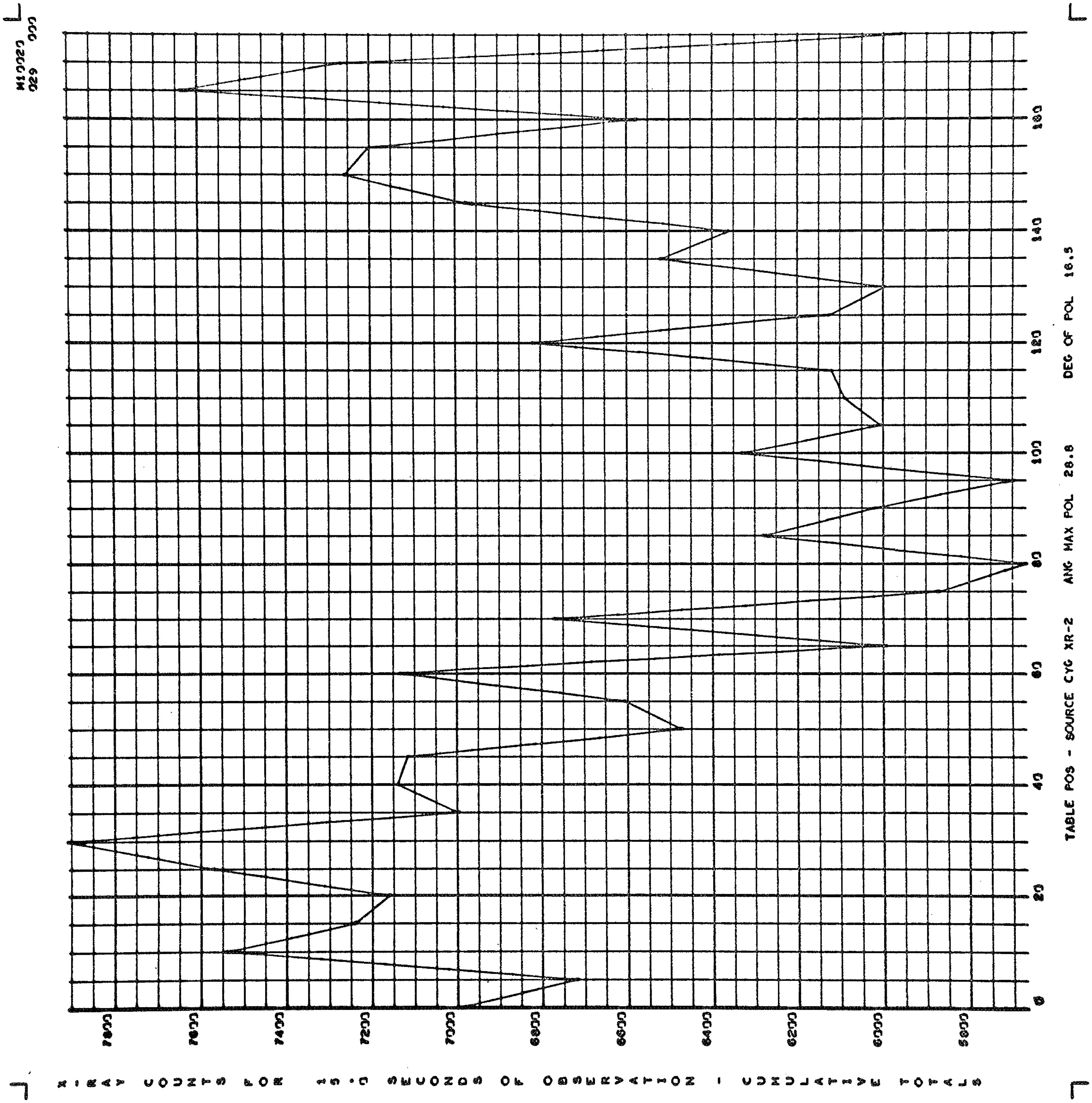


Figure 2-19. Cummulative Totals of Polarimeter Data Counts - Source 4

SUMMARY OF OBSERVATION

SOURCE - VIR XR-1

LOCATION - RIGHT ASCENSION 12. HOURS, 31. MINUTES

DECLINATION 12. DEGREES, 30. MINUTES

OBSERVATION TIME - 20. SECONDS AT EACH TABLE POSITION

X-RAY POLARIZATION

BEGINNING TABLE POSITION 0. DEGREES

ENDING TABLE POSITION 350. DEGREES

TABLE STEP SIZE 10. DEGREES

ANGLE OF MAXIMUM POLARIZATION - 39.1 DEGREES

DEGREE OF POLARIZATION - 35.3 PERCENT

X-RAY INTENSITY

	DATA COUNTS		BEAM COUNTS	
LEVEL	NUMBER	PERCENT	NUMBER	PERCENT
1	5215	9.9	3460	9.9
2	8999	17.0	6080	17.4
3	15399	29.1	10155	29.1
4	21981	41.6	14531	41.6
5	895	1.7	544	1.6
6	374	0.7	165	0.5
7	0	0.0	0	0.0
8	0	0.0	0	0.0

X-RAY PULSATION

THIS SOURCE APPEARS TO BE A PULSAR WITH A
FREQUENCY OF 4.86 CYCLES PER SECOND

Figure 2-20. Observation Summary - Source 1

SUMMARY OF OBSERVATION

SOURCE - SCO X-2

LOCATION - RIGHT ASCENSION 16. HOURS, 53. MINUTES

DECLINATION -40. DEGREES, 0. MINUTES

OBSERVATION TIME - 10. SECONDS AT EACH TABLE POSITION

X-RAY POLARIZATION

BEGINNING TABLE POSITION 0. DEGREES

ENDING TABLE POSITION 350. DEGREES

TABLE STEP SIZE 10. DEGREES

ANGLE OF MAXIMUM POLARIZATION - 98.6 DEGREES

DEGREE OF POLARIZATION - 81.5 PERCENT

X-RAY INTENSITY

	DATA COUNTS		BEAM COUNTS	
LEVEL	NUMBER	PERCENT	NUMBER	PERCENT
1	0	0.0	24	0.1
2	1778	6.3	2513	6.5
3	11064	39.2	14851	38.3
4	7222	25.6	10030	25.9
5	5166	18.3	7131	18.4
6	2685	9.5	3814	9.8
7	302	1.1	432	1.1
8	0	0.0	0	0.0

X-RAY PULSATION

THIS SOURCE APPEARS TO BE A PULSAR WITH A
FREQUENCY OF 3.66 CYCLES PER SECOND

Figure 2-21. Observation Summary - Source 2

SUMMARY OF OBSERVATION

SOURCE - SGR XR-1

LOCATION - RIGHT ASCENSION 17. HOURS, 48. MINUTES

DECLINATION -30. DEGREES, 0. MINUTES

OBSERVATION TIME - 20. SECONDS AT EACH TABLE POSITION

X-RAY POLARIZATION

BEGINNING TABLE POSITION 0. DEGREES

ENDING TABLE POSITION 350. DEGREES

TABLE STEP SIZE 10. DEGREES

ANGLE OF MAXIMUM POLARIZATION - 201.5 DEGREES

DEGREE OF POLARIZATION - 67.8 PERCENT

X-RAY INTENSITY

	DATA COUNTS		BEAM COUNTS	
LEVEL	NUMBER	PERCENT	NUMBER	PERCENT
1	0	0.0	0	0.0
2	0	0.0	0	0.0
3	0	0.0	0	0.0
4	3112	1.8	2641	1.8
5	29012	17.0	25286	16.9
6	108626	63.5	95273	63.7
7	25519	14.9	22275	14.9
8	4822	2.8	4145	2.8

X-RAY PULSATION

THIS SOURCE APPEARS TO BE A PULSAR WITH A
FREQUENCY OF 9.77 CYCLES PER SECOND

Figure 2-22. Observation Summary - Source 3

SUMMARY OF OBSERVATION

SOURCE - CYG XR-2

LOCATION - RIGHT ASCENSION 21. HOURS, 43. MINUTES

DECLINATION 38. DEGREES, 5. MINUTES

OBSERVATION TIME - 15. SECONDS AT EACH TABLE POSITION

X-RAY POLARIZATION

BEGINNING TABLE POSITION 0. DEGREES

ENDING TABLE POSITION 175. DEGREES

TABLE STEP SIZE 5. DEGREES

ANGLE OF MAXIMUM POLARIZATION - 28.8 DEGREES

DEGREE OF POLARIZATION - 16.5 PERCENT

X-RAY INTENSITY

	DATA COUNTS		BEAM COUNTS	
LEVEL	NUMBER	PERCENT	NUMBER	PERCENT
1	208854	87.0	47137	87.8
2	29123	12.1	6288	11.7
3	2182	0.9	245	0.5
4	0	0.0	0	0.0
5	0	0.0	0	0.0
6	0	0.0	0	0.0
7	0	0.0	0	0.0
8	0	0.0	0	0.0

X-RAY PULSATION

THIS SOURCE APPEARS TO BE A PULSAR WITH A
FREQUENCY OF 18.07 CYCLES PER SECOND

Figure 2-23. Observation Summary - Source 4

2.6 Program Listing

```
C       SIMULATED X-RAY POLARIMETER EXPERIMENT
C       KEN BAUER  -  SYSTEM DEVELOPMENT CORPORATION, HUNTSVILLE, ALABAMA
C       PHONE  539-7711
C
C       THIS PROGRAM SIMULATES THE PROCESSING OF PRIME DATA FROM THE
C       X-RAY POLARIMETER ASSOCIATED WITH A PROPOSED SPACE STATION
C       EXPERIMENT - FPE 5.1.
C
        DIMENSION EVART(4,12)
        DIMENSION POLDT(4,36,16)
        DIMENSION PULDT(4097)
        DIMENSION DUMMY(4097)
        DIMENSION POWSP(4097)
        DIMENSION TOP10(10)
        DIMENSION KTOP10(10)
C
        INTEGER POLDT
C
C.....INITIALIZE SC 4020
        CALL CAMRAV(9)
C
C.....INPUT EXPERIMENT CONTROL PARAMETERS
        CALL INIT (NS,EVART,NP)
C
C.....INITIALIZE SOURCE LOOP
        DO 300 I=1,NS
C
C.....CLEAR POLDT AND PULDT TABLES
        DO 30  K=1,4
        DO 30  L=1,36
        DO 30  M=1,16
 30     POLDT(K,L,M) = 0
        DO 40  K=1,4096
 40     PULDT(K) = 0.
C
C.....INITIALIZE TABLE POSITION LOOP
        NTP = EVART(I,12)
        J = 1
C
C.....INITIALIZE PULSAR DATA ACQUISITION LOOP AND ACQUIRE DATA
        DO 100 K=1,5
 100    CALL PULDAQ (K,PULDT)
C
C.....PULSAR DATA ANALYSIS
        CALL PULDAN (I,PULDT,DUMMY,KFLAG,POWSP,TOP10,KTOP10)
C
C.....IF NO PULSAR, DO NOT PLOT
        IF (KFLAG.EQ.0) GO TO 200
C
C.....PULSAR DATA DISPLAY
        CALL PULDDI (I,EVART,POWSP,TOP10,KTOP10,PULDT,DUMMY,DOMFRQ)
C
C.....ACQUIRE POLARIMETER DATA FOR SOURCE I, TABLE POSITION J
 200    CALL POLDAQ (I,J,POLDT)
C
```

```
C.....INCREMENT TABLE POSITION
      J = J+1
      IF (J.LE.NTP) GO TO 200
C
C.....POLARIMETER DATA DISPLAY
      CALL POLDDP (I,POLDT,EVART,NP,DEGPOL,PM)
C
C.....SUMMATION FOR SOURCE I
      CALL SUMUP (I,EVART,POLDT,TOP10,KTOP10,DEGPOL,PM,KFLAG,DOMFRQ)
 300  CONTINUE
C
C.....CLOSE SC-4020 FILE
      CALL CLEAN
      STOP
      END
```

```
C.....PARAMETER INITIALIZATION SUBROUTINE
      SUBROUTINE INIT (NS,EVART,NP)
C
      DIMENSION EVART(4,12)
      DIMENSION SNAME(90)
C
      INTEGER POLOT
C
      DATA BLANKS/6H      /
      DATA SNAME/
     16H TAU X,6H-1    ,6H VIR X,6HR-1   ,6H CEN X,6HR-2   ,
     26H SCO X,6H-1    ,6H SCO X,6HR-2   ,6H GX 3+,6H1     ,
     36H GX 5-,6H1     ,6H GX 9+,6H1     ,6H SGR X,6HR-2   ,
     46H SER X,6HR-2   ,6H CYG X,6HR-1   ,6H CYG X,6H-4    ,
     56H CYG X,6HR-2   ,6H CAS X,6HR-1   ,6H VEL X,6HR-1   ,
     66H LUP X,6HR-1   ,6H NOR X,6HR-2   ,6H SCO X,6H-2    ,
     76H ARA X,6HR-1   ,6H GX -5,6H.6    ,6H SGR X,6HR-1   ,
     86H SER X,6HR-1   ,6H CEP X,6HR-1   ,6H LEO X,6HR-1   ,
     96H CEN X,6HR-3   ,6H CEN X,6HR-1   ,6H NOR X,6HR-1   ,
     16H SCO X,6HR-4   ,6H L7   ,6H      ,6H L8   ,6H      ,
     26H OPH X,6HR-2   ,6H SCO X,6HR-3   ,6H GX 9+,6H9     ,
     36H OPH X,6HR-1   ,6H SCO X,6HR-5   ,6H SCO X,6HR-6   ,
     46H LYR X,6HR-1   ,6H SGR X,6HR-5   ,6H AQL X,6HR-1   ,
     56H CYG X,6HR-3   ,6H CYG X,6H-3    ,6H VUL X,6HR-1   ,
     66H LAC X,6HR-1   ,6H CEP X,6HR-2   ,6H CEP X,6HR-3   /
C
      NAMELIST /NAM1/NS,NP
      NAMELIST /NAM2/ID,RAHR,RAMIN,DDEG,DMIN,OBSTIM,BTP,ETP,TSS
C
C     INPUT VARIABLES
C
C     NS     - NUMBER OF SOURCES
C     NP     - PLOT FLAG (1 = PLOT ALL LEVELS OF INTENSITY
C                         0 = PLOT CUMULATIVE ONLY)
C     ID     - SOURCE IDENTIFICATION
C     RAHR   - RIGHT ASCENSION (HOURS)
C     RAMIN  - RIGHT ASCENSION (MINUTES)
C     DDEG   - DECLINATION (DEGREES)
C     DMIN   - DECLINATION (MINUTES)
C     OBSTIM - OBSERVATION TIME
C     BTP    - BEGINNING TABLE POSITION (DEGREES)
C     ETP    - ENDING TABLE POSITION (DEGREES)
C     TSS    - TABLE STEP SIZE (DEGREES)
C
C     ALL INPUT VARIABLES ARE STORED IN TABLE EVART EXCEPT NS AND NP
C
C.....READ NUMBER OF SOURCES AND PLOT FLAG
      READ (5,NAM1)
C
C.....INITIALIZE SOURCE INPUT LOOP
      IF (NS.GT.4) NS = 4
      DO 100 I=1,NS
C
C.....READ PARAMETERS FOR SOURCE I
      READ (5,NAM2)
```

```
      K1 = ID*2-1
      K2 = K1+1
      EVART(I,1) = SNAME(K1)
      EVART(I,2) = SNAME(K2)
      EVART(I,3) = BLANKS
      EVART(I,4) = RAHR
      EVART(I,5) = RAMIN
      EVART(I,6) = DDEG
      EVART(I,7) = DMIN
      EVART(I,8) = OBSTIM
      EVART(I,9) = BTP
      EVART(I,10) = ETP
      EVART(I,11) = TSS
      EVART(I,12) = (ETP - BTP) / TSS + 1.0001
100   CONTINUE
      RETURN
      END
```

```
C.....PULSAR DATA ACQUISITION SUBROUTINE
      SUBROUTINE PULDAQ (I,PULDT)
C
      LOGICAL BIT
      LOGICAL X
C
      DIMENSION NIN(28)
      DIMENSION PULDT(4097)
C
      READ (10) (NIN(M),M=1,28)
      DO 100 J=1,28
      DO 100 K=1,36
      L = K-1
      X = BIT(NIN(J),L)
      N = (I-1)*1000 + (J-1)*36 + K
      PULDT(N) = 0.
      IF (X) PULDT(N) = 1.
      IF (J.EQ.28.AND.K.EQ.28) RETURN
      IF (N.EQ.4096) RETURN
  100 CONTINUE
      RETURN
      END
```

```
C.....PULSAR DATA ANALYSIS SUBROUTINE
      SUBROUTINE PULDAN (I,PULDT,DUMMY,KFLAG,POWSP,TOP10,KTOP10)
C
      DIMENSION PULDT(4097)
      DIMENSION DUMMY(4097)
      DIMENSION POWSP(4097)
      DIMENSION TOP10(10)
      DIMENSION KTOP10(10)
C
C.....SET ARRAY DUMMY = PULDT
      DO 100 K=1,4096
      DUMMY(K) = PULDT(K)
 100  CONTINUE
C
C.....TAKE FOURIER TRANSFORM OF PULSAR DATA AND COMPUTE POWER
C.....SPECTRUM DENSITY
      CALL EVAL (PULDT,DUMMY,4096,1000.,POWSP)
C
C.....CALCULATE TOTAL POWER SPECTRUM DENSITY
      TOT = 0.
      DO 200 K=2,2048
      TOT = TOT + POWSP(K)
 200  CONTINUE
C
C.....DETERMINE TOP 10 VALUES OF POWER SPECTRUM DENSITIES
      DO 400 K=1,10
      TOP10(K) = 0.
      DO 300 J=2,2048
      IF (POWSP(J).LT.TOP10(K)) GO TO 300
      TOP10(K) = POWSP(J)
      KTOP10(K) = J
 300  CONTINUE
      L = KTOP10(K)
      POWSP(L) = -POWSP(L)
 400  CONTINUE
C
C.....RESET TOP 10 VALUES IN POWER SPECTRUM
      DO 500 K=1,10
      L = KTOP10(K)
      POWSP(L) = TOP10(K)
 500  CONTINUE
C
C.....SUM TOP 10 POWER SPECTRUM DENSITIES
      SUM = 0.
      DO 600 K=1,10
      SUM = SUM + TOP10(K)
 600  CONTINUE
C
C.....CHECK FOR SUM OF TOP 10 GREATER THAN SOME PERCENTAGE OF TOTAL
      PCT = .05
      KFLAG = 0
      IF (SUM.GT.TOT*PCT) KFLAG = 1
      RETURN
      END
```

```
      SUBROUTINE EVAL(X1,X2,N,SR,Y1)
C
C                IBM 7094 FAST FOURIER CONVERSION
C
C                SUBROUTINE EVAL REMOVES THE MEAN FROM THE X1 AND X2 ARRAYS
C                AND CALLS SUBROUTINE HARM.  EVAL TAKES THE TWO ARRAYS
C                RETURNED FROM HARM AND CALCULATES THE POWER SPECTRUM.
C
C   INPUT
C
C         X1       DATA FOR CHNL NO. 1
C
C         X2       DATA FOR CHNL NO. 2
C
C         N        NUMBER OF POINTS TO TRANSFORM IN FFT
C                  IF N IS NOT A POWER OF 2, N WILL BE SET TO A NEGATIVE
C                  VALUE AND RETURN TO THE CALLING PROGRAM.
C
C         SR       SAMPLE RATE
C
C         Y1       THE POWER SPECTRUM COMPUTED FROM THE FFT
C
C         IDEBUG   IS SET TO 1 FOR DEBUG PRINT
C
C   OUTPUT
C
C         Y1       CROSS PSD
C
      DIMENSION X1(1),X2(1)
      DIMENSION M(3)
      DIMENSION Y1(1)
      IDEBUG=0
      DO 210 I=1,12
      ITEMP=2**I
      IF(N.LE.ITEMP) GO TO 212
  210 CONTINUE
  212 M(1)=I
      IF(2**M(1).EQ.N) GO TO 213
      WRITE(6,214)
  214 FORMAT(34H ***** N IS NOT A POWER OF 2 *****)
      N=-N
      GO TO 25
  213 M(2)=0
      M(3)=0
      NP=N
      ANP=NP
C
C        REMOVE MEAN FROM DATA
      T1=0.0
      T2=0.0
      DO 10 I=1,N
      T1=T1+X1(I)
   10 T2=T2+X2(I)
      T1=T1/ANP
      T2=T2/ANP
```

```
      DO 15 I=1,M
      X1(I)=X1(I)-T1
   15 X2(I)=X2(I)-T2
  217 CALL HARM(X1,X2,M)
      NDX=NP+1
      X1(NDX)=X1(1)
      X2(NDX)=X2(1)
      AN=1.0/(ANP*ANP)
      AB=AN*2.0
      T=0.0
  220 DO 20 I=1,NP
      NDX=NP-I+2
      T1=(X1(I)+X1(NDX))*.5
      T2=(X2(I)-X2(NDX))*(-.5)
      Z1=(X2(I)+X2(NDX))*.5
      Z2=(X1(NDX)-X1(I))*(-.5)
      H1=T1*Z1+T2*Z2
      H2=T1*Z2-T2*Z1
      Y1(I)=SQRT(H1*H1+H2*H2)*AB
      IF(IDEBUG.EQ.0) GO TO 20
C
C        CALCULATIONS FOR DEBUG PRINT
C
C        F         REEQUENCY
C        X1        REAL ARRAY
C        X2 IMIGINARY ARRAY
C        TEMP6     PSD CHNL 1
C        TEMP7     PSD CHNL 2
C        Y1        CROSS PSD
      TEMP6=(T1*T1+T2*T2)*AB
      TEMP7=(Z1*Z1+Z2*Z2)*AB
      F=I-1
      WRITE(6,8348) F,X1(I), X2(I),TEMP6,TEMP7,Y1(I)
 8348 FORMAT(1X,F15.2,5E16.7)
   20 CONTINUE
   25 RETURN
      END
```

```
      SUBROUTINE HARM(AR,AI,M)
C
C      HARMONIC ANALYSIS SUBROUTINE. EVALUATES COMPLEX FOURIER SERIES
C     ND=NO. OF DIMENSIONS
C     MI(I)=LOG2NI,NI=NO. OF PTS.IN I-TH DIRECTION, ORDERED SO M(1) IS M
C     AR(I)=REAL PART OF A(I1,I2,I3),I=I1+I2*N1+I3*N1*N2
C     AI(I)=IMAG. PART OF A(I1,I2,I3)
C
C     ALL ARGUMENTS ARE TO BE SET BEFORE ENTRY.  THE AR,AI ARRAYS ARE
C     REPLACED BY THE REAL AND IMAGINARY PARTS, RESP. OF THE FOURIER
C     SUM-
C                 I1*J1   I2*J2   I3*J3
C     X(J1,J2,J3)=A(I1,I2,I3)*W1*W2*W3
C     SUMMED OVER I1=0,N1-1,I2=0,N2-1,I3=0,N3-1.
C
C     WHERE WI=NI-TH ROOT OF UNITY
C     X(J1,J2,J3) IS STORED IN LOCATION K=K1+K2*N1+K3*N1*N2 WHERE
C     K1,K2,K3 ARE OBTAINED FROM J1,J2,J3 BY INVERTING THEIR BITS.
C
      DIMENSION AR(1),AI(1),M(1)
      DIMENSION W(2),T(2),N(3) ,NP(3)
C
      EQUIVALENCE (N1,N),(N2,N(2)),(N3,N(3))
C
      N1=2**M(1)
      N2=2**M(2)
      N3=2**M(3)
      NP(1)=N(1)
      NP(2)=N(1)*N(2)
      NP(3)=N(3)*NP(2)
      DO 120 ID=1,3
      MML=M(ID)
      IF(N(1)-N(ID))10,20,20
   10 WRITE(6,12)M
   12 FORMAT(27HOM(1) IS NOT LARGEST, M(I)=  3I5)
      CALL EXIT
   20 IF(MML)130,130,30
   30 IL=NP(3)-NP(ID)+1
      NBIT=MML
      JBIT=NP(ID)
      IDI=JBIT
      FN=JBIT
      ZZ=6.2831853/FN
   60 LLAST=M(ID)
      KLAST=0
      KKDI=NP(ID)
      DO 110 IL6=1,LLAST
      MML=MML-1
      JBIT=JBIT/2
      JL=JBIT-1
C     DO FOR K=0
      DO 70 I=1,IL,IDI
      JLAST=JL+I
      DO 70 J=I,JLAST
      JD=J+JBIT
```

```
      T(1)=AR(JD)
      T(2)=AI(JD)
      AR(JD)=AR(J)-T(1)
      AI(JD)=AI(J)-T(2)
      AR(J)=AR(J)+T(1)
   70 AI(J)=AI(J)+T(2)
      IF(KLAST)100,100,72
   72 KK=KKDI+1
      DO 90 K=1,KLAST
      IBIT=KK-1
      CALL IRS(IBIT,MML)
      CALL INVERT(IBIT,NBIT)
      ITDP=IBIT
      FN=ITDP
      ARG=ZZ*FN
 8050 W(1)=COS(ARG)
      W(2)=SIN(ARG)
      ILAST=IL+KK
      DO 80 I=KK,ILAST,IDI
      JLAST=JL+I
      DO 80 J=I,JLAST
      JD=J+JBIT
      T(1)=AR(JD)*W(1)-AI(JD)*W(2)
      T(2)=AR(JD)*W(2)+AI(JD)*W(1)
      AR(JD)=AR(J)-T(1)
      AI(JD)=AI(J)-T(2)
      AR(J)=AR(J)+T(1)
   80 AI(J)=AI(J)+T(2)
   90 KK=KK+KKDI
C     END OF K LOOP
  100 KKDI=KKDI/2
  110 KLAST=2*KLAST+1
C     END OF L LOOP
  120 CONTINUE
C     END OF ID LOOP
  130 CONTINUE
C     PUT IN CORRECT ORDER
      DO 40 J3=1,N3
      NBIT=M(3)
      I3=J3-1
      I2=I3
      CALL INVERT(I3,NBIT)
      JJJ=I2
      CALL LSF(JJJ,M(2))
      CALL LSF(I3,M(2))
      III=I3
      DO 40 J2=1,N2
      NBIT=M(2)
      I2=J2-1
      CALL INVERT(I2,NBIT)
      JJ=JJJ+J2-1
      CALL LSF(JJ,M(1))
      II=III+I2
      CALL LSF(II,M(1))
      NBIT=M(1)
      DO 40 J1=1,N1
```

```
      I1=J1-1
      CALL INVERT(I1,NBIT)
      J=JJ+J1
      I=II+I1+1
      IF(I-J)40,40,133
  133 T(1)=AR(I)
      T(2)=AI(I)
      AR(I)=AR(J)
      AI(I)=AI(J)
      AR(J)=T(1)
      AI(J)=T(2)
   40 CONTINUE
      RETURN
      END
```

```
      SUBROUTINE LSF(IWORD,NBITS)
C
C
C    LSF         LSF TAKES A STRING OF BITS FROM IWORD AND RESTORES
C                IN DIFFERENT BIT POSITIONS IN IWORD LEFT SHIFTED
C
C    IWORD       CONTAINS THE BIT STRING TO BE MOVED
C    NBITS       THE NUMBER OF BITS IN IWORD TO BE MOVED
C
      IA=0
      NAB=36-NBITS
      CALL FLD(IA,0,NAB,NBITS,IWORD)
      IWORD=IA
      RETURN
C
      ENTRY IRS(IWORD,NBITS)
C
C    IRS         IRS TAKES A STRING OF BITS FROM IWORD AND RESTORES
C                IN DIFFERENT BIT POSITIONS IN IWORD RIGHT SHIFTED
C
      IA=0
      NAB=36-NBITS
      CALL FLD(IA,NBITS,NAB,0,IWORD)
      IWORD=IA
      RETURN
C
      ENTRY INVERT(IWORD,NBITS)
C
C    INVERT      INVERT GIVES A MIRROR IMAGE FOR A STRING OF NBITS
C                AND RESTORES THEM IN IWORD
C
      IF(NBITS.EQ.0) GO TO 20
      I1=35
      I2=36-NBITS
      IA=0
      DO 10 I=1,NBITS
      CALL FLD(IA,I2,1,I1,IWORD)
      I1=I1-1
   10 I2=I2+1
      IWORD=IA
   20 RETURN
      END
```

```
C.....PULSAR DATA DISPLAY SUBROUTINE
      SUBROUTINE PULDDI (I,EVART,POWSP,TOP10,KTOP10,X,Y,DOMFRQ)
C
      DIMENSION EVART(4,12)
      DIMENSION POWSP(4097)
      DIMENSION TOP10(10)
      DIMENSION KTOP10(10)
      DIMENSION X(4097)
      DIMENSION Y(4097)
      DIMENSION XLAB(12),YLAB(12)
      DIMENSION DFBCD(5)
C
      DATA XLAB/72HFREQUENCY - SOURCE                         (DOMINANT FREQU
     1ENCY   -          CPS) /
      DATA YLAB/72HAMPLITUDE
     1                         /
      DATA FMT/6H(F6.1)/
C
      C = 1000. / 4096.
      NPP = 682
      NP2 = 200
      DO 200 K=1,682
      Y(K) = 0.
      DO 100 L=2,4
      M = (K-1)*3+L
      Y(K) = Y(K) + POWSP(M)
  100 CONTINUE
      FK = K
      X(K) = ((FK-1.) * C * 3.) + (2. * C)
  200 CONTINUE
C.....SET UP PLOT TITLE
      DO 300 K=1,3
      XLAB(K+3) = EVART(I,K)
  300 CONTINUE
      TOP = KTOP10(1) - 1
      DOMFRQ = TOP * C
      CALL CTOBCD (NBCDWS,DFBCD(1),FMT,1,DOMFRQ)
      XLAB(11) = DFBCD(1)
      CALL QUIK3V (-1,42,XLAB,YLAB,-NPP,X,Y)
      K1 = KTOP10(1) - 10
      IF (K1.LT.2) K1 = 2
      FK1 = K1
      DO 400 K = 1,200
      FK1C = FK1*C
      FK = K
      X(K) = FK1C + (FK-1.)*C
  400 CONTINUE
      CALL QUIK3V(-1,42,XLAB,YLAB,-NP2,X(1),POWSP(K1))
      RETURN
      END
```

```
C.....POLARIMETER DATA ACQUISITION SUBROUTINE
      SUBROUTINE POLDAQ(I,J,POLDT)
C
      DIMENSION KDATA(8)
      DIMENSION KBEAM(8)
      DIMENSION POLDT(4,36,16)
C
      INTEGER POLDT
C
      DATA KD/017777/
      DATA KB/0177777/
C
C.....INPUT POLARIMETER DATA FOR SOURCE I, TABLE POSITION J
 100  READ(8)KPOS,KOFF,(KDATA(M),M=1,8),(KBEAM(M),M=1,8)
C
C.....UNPACK POLARIMETER DATA
      DO 200 L=1,8
      CALL BIN (KDATA(L),0,36,0,KD,1)
      POLDT(I,J,L) = POLDT(I,J,L) + KDATA(L)
      CALL BIN (KBEAM(L),0,36,0,KB,1)
      POLDT(I,J,L+8) = POLDT(I,J,L+8) + KBEAM(L)
 200  CONTINUE
      IF (KOFF.EQ.1) GO TO 100
      RETURN
      END
```

```
C.....POLARIMETER DATA DISPLAY SUBROUTINE
      SUBROUTINE POLDDP (I,POLDT,EVART,NP,DEGPOL,PM)
C
      DIMENSION POLDT(4,36,16)
      DIMENSION EVART(4,12)
      DIMENSION TPOS(36)
      DIMENSION LPF(8)
      DIMENSION TPLAB(12)
      DIMENSION CTPLAB(12)
      DIMENSION CCNTLB(12)
      DIMENSION CNTLAB(12)
      DIMENSION CNT(36)
      DIMENSION TEMP(5)
      DIMENSION LEVEL(8)
      DIMENSION X(5)
      DIMENSION Y(5)
C
      REAL LEVEL
C
      INTEGER POLDT
      INTEGER CCNT
C
      DATA CNTLAB/72H  X-RAY COUNTS FOR        SECONDS OF OBSERVATION -
     1INTENSITY LEVEL       /
      DATA CCNTLB/72H  X-RAY COUNTS FOR       SECONDS OF OBSERVATION - C
     1UMULATIVE TOTALS      /
      DATA TPLAB /72HTABLE POS - SOURCE              ANG MAX POL
     1     DEG OF POL       /
      DATA CTPLAB/72HTABLE POSITION - SOURCE
     1                      /
      DATA FMT2/6H(F6.1)/
      DATA LEVEL /6H 1    ,6H 2    ,6H 3    ,6H 4    ,6H 5    ,
     16H 6    ,6H 7    ,6H 8    /
      DATA KONE/1/
      DATA KFIVE/5/
C
C.....CLEAR FLAGS FOR MULTILEVEL PLOTS
      DO 50 K=1,8
      LPF(K) = 0
 50   CONTINUE
C
C.....SET NTP = NUMBER OF TABLE POSITIONS FOR SOURCE I
      NTP = EVART(I,12)
C
C.....CALCULATE CUMULATIVE TOTALS FOR Y AXIS
      DO 100 K=1,NTP
      CCNT = 0
      DO 100 L=1,8
      CCNT = CCNT + POLDT(I,K,L)
      CNT(K) = CCNT
C
C.....SET FLAG FOR MULTILEVEL PLOTS IF THERE IS DATA FOR THAT LEVEL
      IF (POLDT(I,K,L).NE.0) LPF(L) = 1
 100  CONTINUE
C
```

```
C.....SET UP X AXIS VALUES
      TS = EVART(I,9)
      DO 200 K=1,NTP
      TPOS(K) = TS
      TS = TS + EVART(I,11)
 200  CONTINUE
C
C.....SET UP PLOT TITLES
      TIME = EVART(I,8)
      CALL CTOBCD (NBCDWS,TEMP(1),FMT2,1,TIME)
      CNTLAB(4) = TEMP(1)
      CCNTLB(4) = TEMP(1)
C
C.....CALCULATE DEGREE OF POLARIZATION
      CMIN = CNT(1)
      CMAX = CNT(1)
      KMAX = 1
      DO 250 K = 2,NTP
      IF (CNT(K).LE.CMAX) GO TO 240
      CMAX = CNT(K)
      KMAX = K
 240  CONTINUE
      IF (CNT(K).LT.CMIN) CMIN = CNT(K)
 250  CONTINUE
      DEGPOL = ((CMAX - CMIN) / (CMAX + CMIN)) * 100.
      CALL CTOBCD (NBCDWS,TEMP(1),FMT2,1,DEGPOL)
      TPLAB(12) = TEMP(1)
C
C.....CALCULATE ANGLE OF MAXIMUM POLARIZATION
      KS = KMAX-2
      IF (KMAX.LT.3) KS = 1
      IF (KMAX.GT.(NTP-2)) KS = NTP-4
      DO 260 K=1,5
      X(K) = TPOS(KS)
      Y(K) = CNT(KS)
      KS = KS+1
 260  CONTINUE
      PM = TPOS(KMAX)
      CM = CNT(KMAX)
      ARG = TPOS(KMAX)
      STEP = .01
      IF (Y(2).GT.Y(4)) STEP = -.01
      IDUM = 0
      DO 270 K=1,100
      ARG = ARG + EVART(I,11) * STEP
      CALL LAGRNG (IERR,IDUM,KONE,ARG,KFIVE,X,KFIVE,Y,ANS)
      IF (IERR.NE.0) WRITE (6,1000) ARG
 1000 FORMAT (1X,33HERROR IN INTERPOLATION  -  ARG = ,E15.7)
      IF (ANS.GT.CM) PM = ARG
      IF (ANS.GT.CM) CM = ANS
 270  CONTINUE
      CALL CTOBCD (NBCDWS,TEMP(1),FMT2,1,PM)
      TPLAB(8) = TEMP(1)
C
C.....PLOT CUMULATIVE
      TPLAB(4) = EVART(I,1)
```

```
      TPLAB(5) = EVART(I,2)
      CALL QUIK3V (-1,42,TPLAB,CCNTLB,-NTP,TPOS,CNT)
C
C.....CHECK FOR MULTIPLE PLOTS OF ALL INTENSITIES
      IF (NP.EQ.0) RETURN
C
C.....PLOT MULTIPLE PLOTS OF ALL INTENSITIES
      DO 400 K=1,8
      IF (LPF(K).EQ.0) GO TO 400
      DO 300 L=1,NTP
      CNT(L) = POLDT(I,L,K)
 300  CONTINUE
      CTPLAB(5) = EVART(I,1)
      CTPLAB(6) = EVART(I,2)
      CNTLAB(12) = LEVEL(K)
      CALL QUIK3V (-1,42,CTPLAB,CNTLAB,-NTP,TPOS,CNT)
 400  CONTINUE
      RETURN
      END
```

```
      SUBROUTINE SUMUP (I,EVART,POLDT,TOP10,KTOP10,DEGPOL,PM,KFLAG,
     1 DOMFRQ)
      DIMENSION EVART(4,12)
      DIMENSION POLDT(4,36,16)
      DIMENSION TOP10(10)
      DIMENSION KTOP10(10)
      DIMENSION N(16)
      INTEGER POLDT
      WRITE (6,1000) (EVART(I,M),M=1,11)
 1000 FORMAT (1H1,20X,22HSUMMARY OF OBSERVATION////1X,10HSOURCE  - ,
     1 3A6//1X,28HLOCATION   -  RIGHT ASCENSION,F5.0,7H HOURS,,F7.0,
     2 8H MINUTES//14X,11HDECLINATION,F9.0,9H DEGREES,,F5.0,8H MINUTES//
     3 1X,19HOBSERVATION TIME - ,F6.0,31H SECONDS AT EACH TABLE POSITION
     4 ///19H X-RAY POLARIZATION//6X,24HBEGINNING TABLE POSITION,F6.0,
     5 8H DEGREES//6X,21HENDING TABLE POSITION,F9.0,8H DEGREES//
     6 6X,15HTABLE STEP SIZE,9X,F6.0,8H DEGREES///)
      WRITE (6,1001)  PM,DEGPOL
 1001 FORMAT (6X,32HANGLE OF MAXIMUM POLARIZATION - ,F7.1,8H DEGREES///
     1 6X,25HDEGREE OF POLARIZATION - ,F7.1,8H PERCENT///
     2 1X,15HX-RAY INTENSITY//
     3 22X,11HDATA COUNTS,14X,11HBEAM COUNTS/
     4 6X,5HLEVEL,8X,6HNUMBER,4X,7HPERCENT,8X,6HNUMBER,4X,7HPERCENT//)
      DO 100 K=1,16
      N(K) = 0
      DO 100 L=1,36
      N(K) = N(K) + POLDT(I,L,K)
 100  CONTINUE
      NDT = 0
      NBT = 0
      DO 200 K=1,8
      NDT = NDT + N(K)
      K1 = K+8
      NBT = NBT + N(K1)
 200  CONTINUE
      DO 300 K=1,8
      DT = NDT
      FN = N(K)
      PD = (FN/DT)*100.
      BT = NBT
      FN = N(K+8)
      PB = (FN/BT)*100.
      K1 = K+8
      WRITE (6,1002) K,N(K),PD,N(K1),PB
 1002 FORMAT (8X,I1,9X,I6,5X,F6.1,8X,I6,5X,F6.1)
 300  CONTINUE
      WRITE (6,1003)
 1003 FORMAT (///1X,15HX-RAY PULSATION//)
      IF (KFLAG.EQ.0) WRITE (6,1004)
 1004 FORMAT (6X,42HTHIS SOURCE SOES NOT APPEAR TO BE A PULSAR)
      IF (KFLAG.NE.0) WRITE (6,1005) DOMFRQ
 1005 FORMAT (6X,41HTHIS SOURCE APPEARS TO BE A PULSAR WITH A/
     1 5X,13H FREQUENCY OF,F7.2,18H CYCLES PER SECOND)
      RETURN
      END
```

SECTION 3. DATA GENERATION PROGRAM

The Data Generation Program simulates the output of the X-ray polarimeter and pulsar mode counter. The output of this program serves as the input to the simulated experiment program.

3.1 Input

The following parameters are input in NAMELIST format for each X-ray source to be simulated:

- NAME - Source Identification Code
- ITIME - Observation Time at Each Table Position (Seconds)
- STEP - Table Step Size (Degrees)
- BEGIN - Beginning Table Position (Degrees)
- END - Ending Table Position (Degrees)
- AMAX - Angle of Maximum Polarization (Degrees)
- DATAM - Data Count in Plane of Maximum Polarization (Average Data Counts per Second)
- DATAP - Data Count in Plane Perpendicular to Plane of Maximum Polarization (Average Data Counts per Second)
- TOTI - Total Intensity (Average Data and Beam Counts per Second)
- DEV - Desired Random Deviation of Polarimetry Data (Percentage)
- FREQ - Pulsation Frequency (Pulses per Second)
- AMP - Pulsation Wave Form Amplitude
- PHS - Pulse Height Spread (Percentages)

3.2 Program Flow

Figure 3-1 presents the flow of the Data Generation Program.

3.3 Subroutines

The following subroutines are called by the Data Generation Program:

- RANDOM - Random Number Generator
- PULSAR - Pulsar Data Generator
- OVRFLO - Polarimeter Buffer Overflow

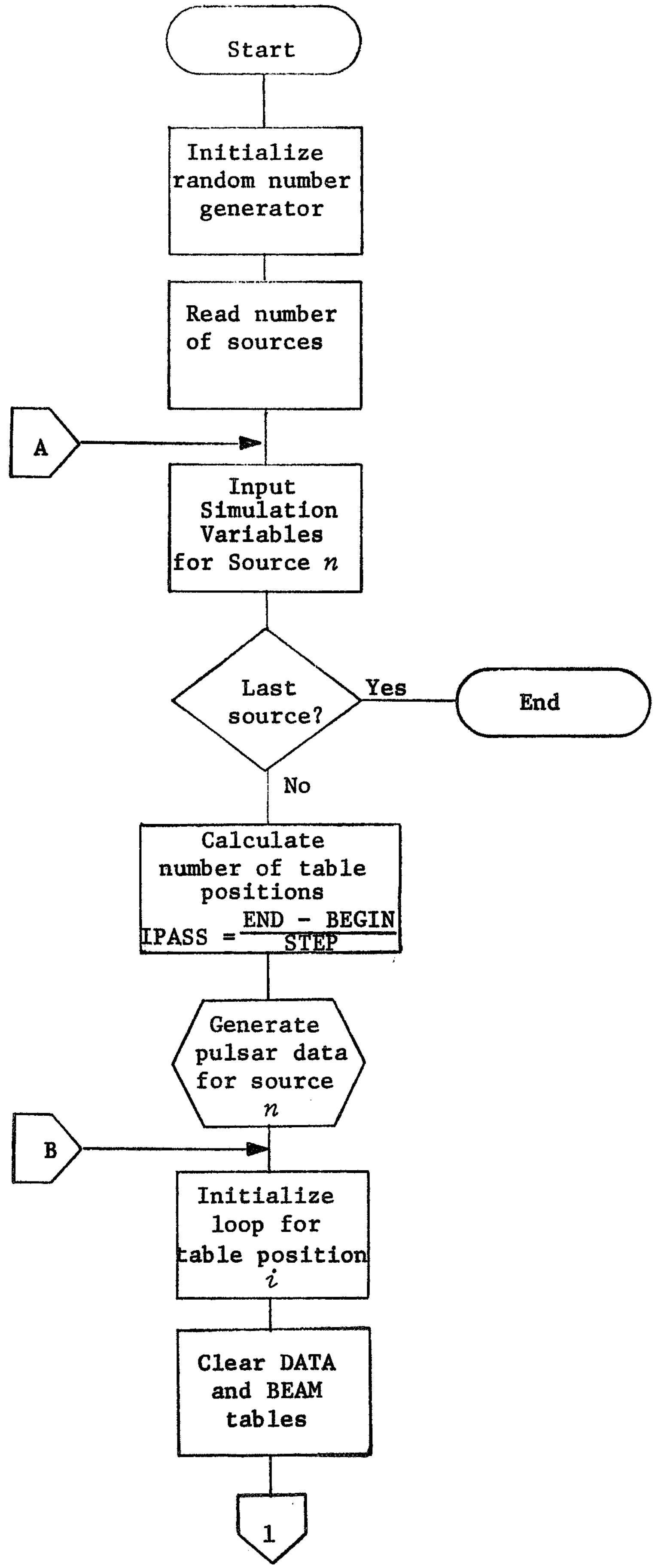


Figure 3-1. Routine DRIVER

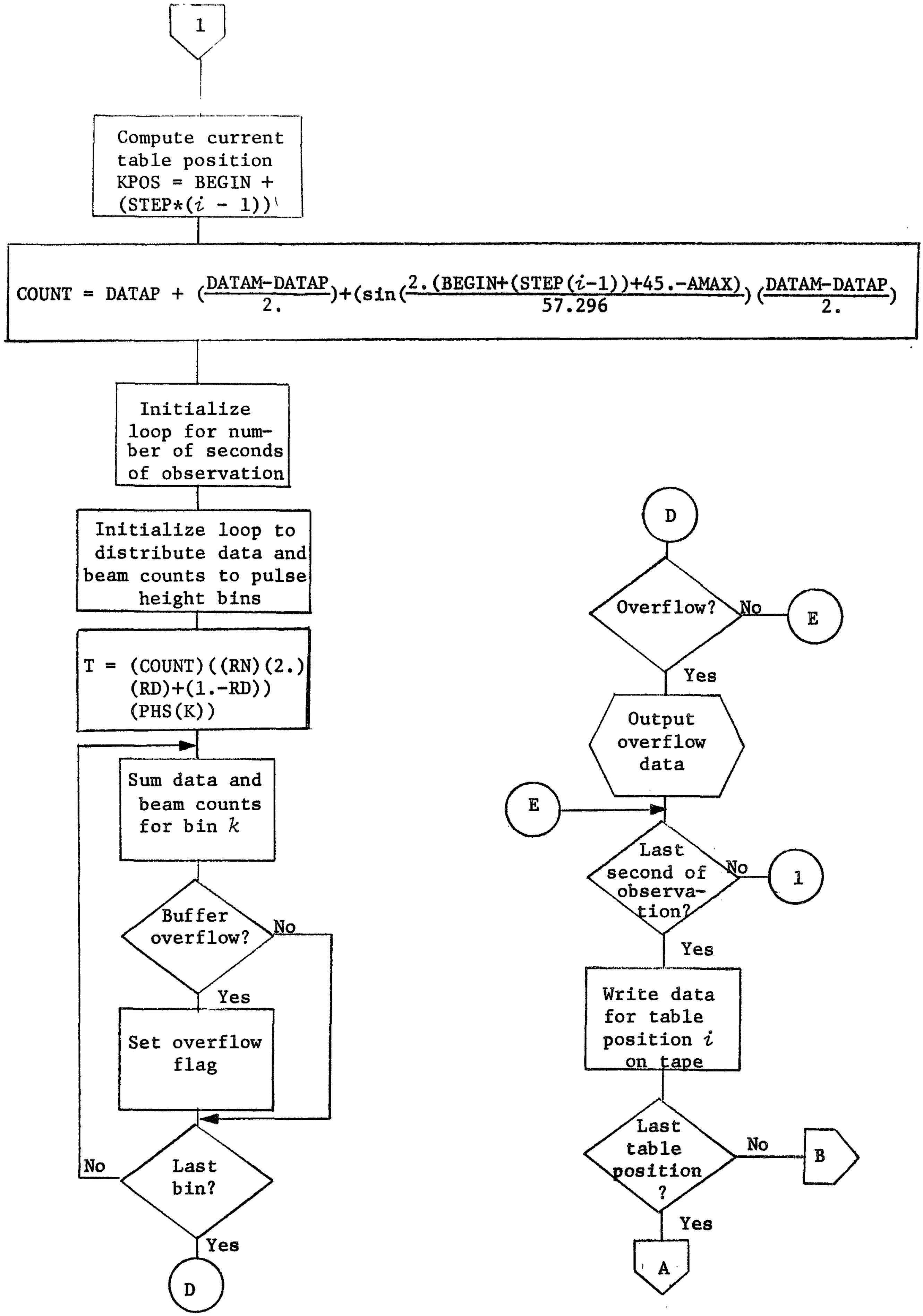


Figure 3-1. (Cont.) Routine DRIVER

Subroutine OVRFLO

Purpose: Subroutine OVRFLO outputs overflow polarimeter data and beam counts and adjust the internal counters accordingly.

Usage: CALL OVRFLO (DATC, BEAM, KPOS)

DATC - Data count array

BEAM - Beam count array

KPOS - Table position

Storage: $207_{(8}$ locations

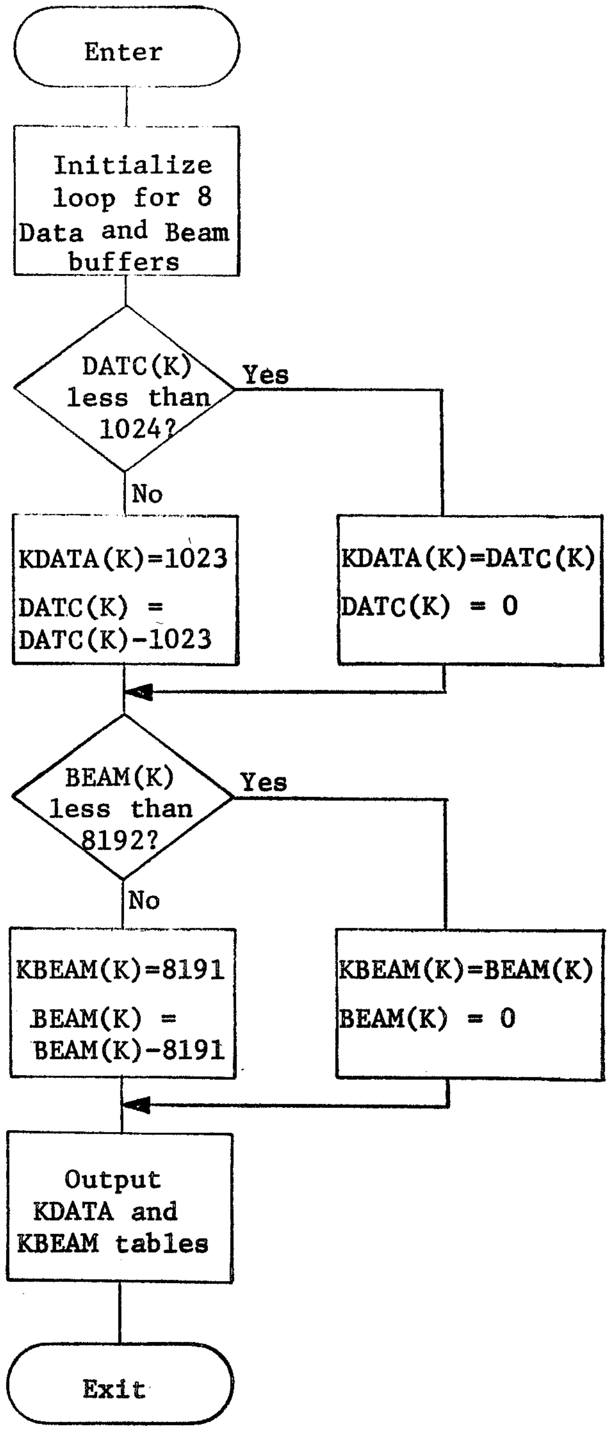


Figure 3-2. Subroutine OVRFLO

Subroutine PULSAR

Purpose: Subroutine PULSAR computes simulated pulsar data as a sinusoidal function of time modified by a normally distributed probability function.

Usage: CALL PULSAR (TOTI, FREQ, AMP)

TOTI - Total intensity of simulated source
FREQ - Frequency of simulated source
AMP - Peak amplitude of sine wave

Method: Pulsar data is generated as a sinusoidal function of time, i.e.,

$$F = \frac{AMP}{2} \sin\left(\frac{2\pi(i-1)}{P-1}\right) + RN$$

where i indicates the $i^{\underline{th}}$ millisecond of observation during period P where

$$P = (1./FREQ)1000.$$

and RN is a normally distributed random number between 0. and 1.0. F is compared against a threshold,

$$THRESH = 1. - (TOTI/1000.)$$

If F is greater than or equal to THRESH, N_i is set to 1 indicating an X-ray photon hit during millisecond i; otherwise, N_i is set to 0 indicating no hit.

Subroutines: PULOUT (Pulsar data output)
RANDOM (Random member generator)

Storage: $2160_{(8}$

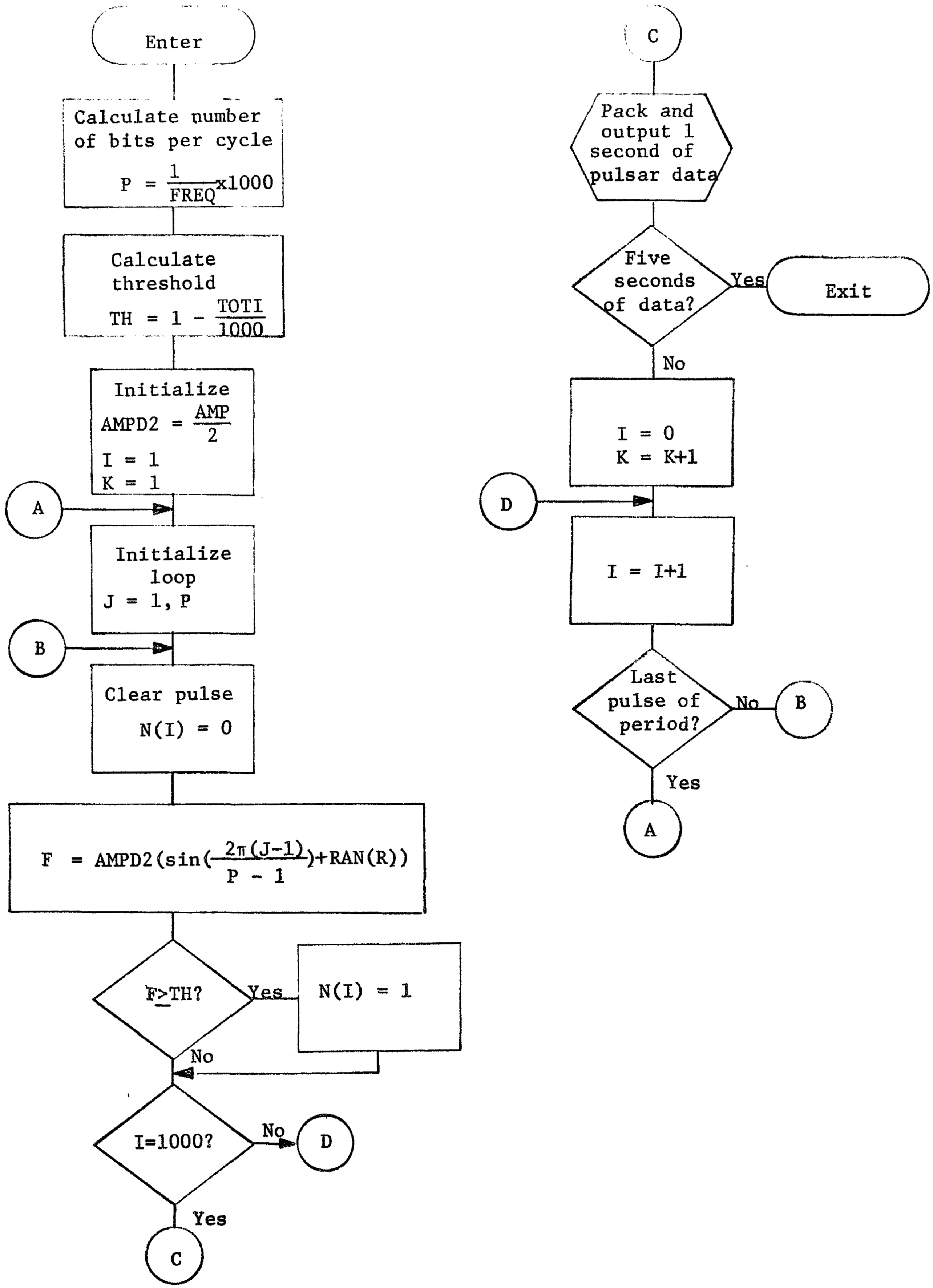


Figure 3-3. Subroutine PULSAR

Subroutine PULOUT

Purpose: Subroutine PULOUT packs and outputs the pulsar data generated by subroutine PULSAR.

Usage: CALL PULOUT (N)

N - Pulsar data array

Method: Pulsar data is packed in string format where 1 bit represents 1 millisecond of observation. All 36 bits of the computer word, which are read from left to right, are used. One second of observation is output on tape per call to subroutine PULOUT.

Subroutines: BIN (or operator)

Storage: $433_{(8}$

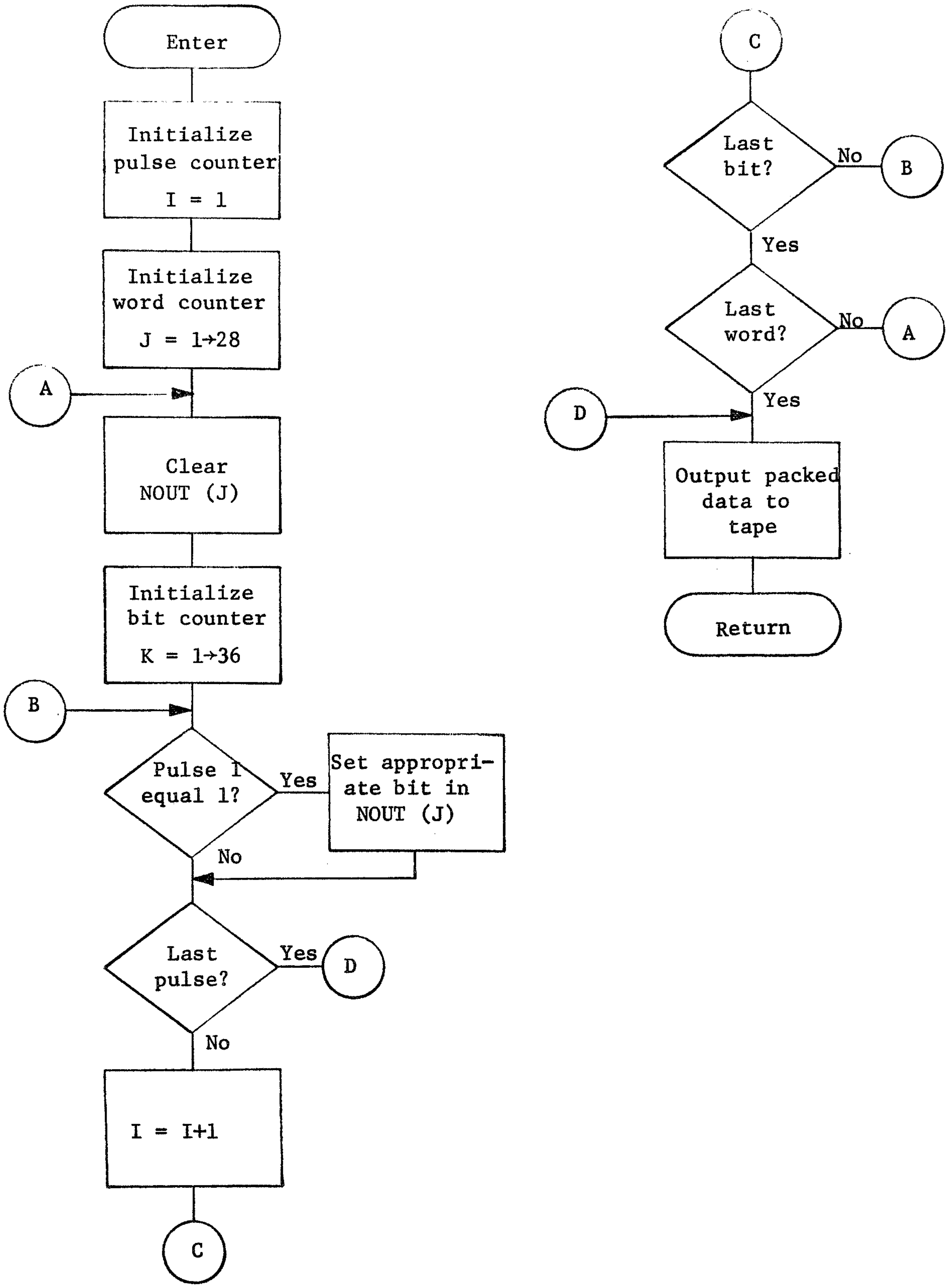


Figure 3-4. Subroutine PULOUT

3.4 Sample Input

Figure 3-5 presents the input data for 4 X-ray sources. These sample cases correspond to the sample cases presented in Section 2.

```
$DATA
 $INPUTS                                        } Number of Sources
 NS = 4$
 $INPUT
 NAME  = 2
 ITIME = 10
 STEP  = 10.
 BEGIN = 0.
 END   = 350.
 AMAX  = 27.1                                   } Source 1
 DATAM = 200.
 DATAP = 100.
 DEV   = .3
 TØTI  = 250.
 FREQ = 4.9
 PHS   = .0,.17,.29,.41,.02,.01,0.,0.
 AMP   = .5$
 $INPUT
 NAME  = 18
 ITIME = 20
 STEP  = 10.
 AMAX  = 96.
 DATAM = 75.
 DATAP = 10.                                    } Source 2
 DEV   = .2
 TØTI  = 100.
 FREQ = 3.6
 PHS   = .01,.07,.37,.25,.18,.10,.02,.0
 AMP   = 1.$
 $INPUT
 NAME  = 21
 ITIME = 20
 AMAX  = 21.
 DATAM = 400.
 DATAP = 80.
 DEV   = .1                                     } Source 3
 TØTI  = 450.
 FREQ = 9.7
 PHS   = 0.,0.,0.,.02,.17,.63,.15,.03
 AMP   = .7$
 $INPUT
 NAME  = 13
 ITIME = 15
 STEP  = 5.
```

Figure 3-5. Sample Data Generator Program Input

```
BEGIN = 0.
END   = 175.
AMAX  = 11.7
DATAM = 500.
DATAP = 400.
DEV   = .5
TØTI  = 550.
FREQ = 18.1
PHS   = .87,.12,.01,0.,0.,0.,0.,0.
AMP   = .6$
$END
```

Source 4

Figure 3-5 (cont). Sample Data Generator Program Input

3.5 Sample Output

Sample output data for two X-ray sources are presented in Figures 3-6 through 3-9.

```
LOC   06630           AC                 QP          MQ                              SI                          KEYS
                 000000000000            00     000000000014                    300000000000                000000000000
                 .00000000+00                   .00000002-38

       XR1              XR2              XR4               XR3              XR5              XR6              XR7
      77654            77774            71150             01474            00000            00005            63072
     -00124           -00004           -06630            -76304           -00000           -77773           -14706

TRAP   DCT   IOT   OFL      SENSE LIGHT   1      2      3      4       SENSE SWITCH   1      2      3      4      5      6
OFF    OFF   OFF   ON                    OFF    OFF    OFF    OFF                    OFF    OFF    OFF    OFF    OFF    OFF

06332  001010100100  000100000101  001001110000  000100110110  000011100001  001010001111  000010101101  010010010010
06342  010000000101  000000001000  010000000000  000000000000  000000000000  000000000000  000000000000  000000000000
06352  000010001000  101010011100  010100000111  001100001001  101100010001  101011011111  000011101010  110101110111
06362  110000000000  000000000000  100010000000  001000010100  000000000000  000000000000  000000000000  000000000000
06372  000000000100  000010100000  000111100010  100000001100  001001011111  011001100101  000111111010  100100100101
06402  110000101101  011101100010  000001001100  000000000100  000010001000  100000000000  000000000000  000000000000
06412  000000000000  000000001001  001000000010  011000000011  001101010000  001010011010  001000011100  010110010101
06422  110010000010  000001000000  010010000000  011000110010  000011000000  011000000000  000000000000  000000000000
06432  000000001000  000000000000  000000000000  000001100000  000010000101  010010001011  001011100100  111000000110
06442  011111100111  010000111110  110000111110  000000100000  001001010011  010000101010  000010000000  000000010000
06452  000000000000  000000000000  100001000100  000000000000
```

Figure 3-6. Pulsar Data - Source 1

POS	DATA COUNTS								BEAM COUNTS							
0	189	312	489	716	31	12	0	0	66	117	198	313	9	0	0	0
10	174	302	560	775	35	13	0	0	53	107	182	256	7	0	0	0
20	202	317	552	799	36	13	0	0	46	85	139	206	6	0	0	0
30	191	347	619	719	38	15	0	0	48	76	133	186	3	0	0	0
40	195	344	599	821	31	15	0	0	52	88	142	238	6	0	0	0
50	191	330	530	762	29	17	0	0	60	105	202	260	9	0	0	0
60	165	284	474	652	30	14	0	0	74	138	228	295	10	1	0	0
70	161	269	444	624	25	10	0	0	98	169	248	394	15	3	0	0
80	126	243	420	464	26	10	0	0	112	199	348	479	18	7	0	0
90	116	201	331	466	16	8	0	0	124	239	374	540	21	8	0	0
100	99	183	311	471	16	5	0	0	137	232	370	566	25	10	0	0
110	97	168	303	368	16	7	0	0	140	258	417	632	25	10	0	0
120	98	160	307	387	17	4	0	0	158	252	409	569	26	10	0	0
130	95	170	287	410	19	5	0	0	149	257	439	551	22	10	0	0
140	101	194	349	482	17	6	0	0	144	222	394	561	23	9	0	0
150	128	202	367	533	24	8	0	0	114	199	355	498	16	10	0	0
160	147	249	422	644	24	10	0	0	110	166	269	385	18	4	0	0
170	146	246	486	615	23	11	0	0	77	133	243	337	12	3	0	0
180	193	288	528	742	33	14	0	0	67	113	204	288	9	0	0	0
190	180	340	525	875	30	14	0	0	55	91	165	225	7	0	0	0
200	204	341	600	761	34	15	0	0	44	98	135	220	6	0	0	0
210	194	313	554	789	36	16	0	0	48	82	129	196	7	0	0	0
220	170	330	561	827	34	15	0	0	53	91	167	213	9	0	0	0
230	179	311	568	743	32	11	0	0	69	106	181	261	7	0	0	0
240	161	269	437	670	28	14	0	0	73	128	227	317	11	0	0	0
250	142	250	375	696	24	10	0	0	94	142	250	406	16	4	0	0
260	129	227	361	584	22	9	0	0	109	198	352	425	16	6	0	0
270	120	192	350	546	17	6	0	0	124	221	391	547	21	9	0	0
280	100	183	318	487	15	6	0	0	125	253	394	580	20	9	0	0
290	101	175	286	440	16	8	0	0	142	249	401	645	25	10	0	0
300	98	174	275	406	15	6	0	0	129	261	408	585	28	10	0	0
310	93	169	269	411	17	7	0	0	146	253	446	526	25	10	0	0
320	106	179	326	473	16	8	0	0	130	238	377	571	20	8	0	0
330	124	226	356	510	22	10	0	0	106	209	327	502	17	9	0	0
340	142	229	398	579	23	10	0	0	98	167	271	416	16	3	0	0
350	160	282	462	730	28	12	0	0	86	138	240	342	13	2	0	0

Figure 3-7. Polarimeter Data - Source 1

```
LOC    06630            AC                QP           MQ                            SI                                       KEYS
                   000000000000           00     000000000014                  300000000000                           000000000000
                   .00000000+00                  .00000002-38

         XR1                 XR2                 XR4                 XR3                 XR5                 XR6                 XR7
        77654               77774               71150               77767               00000               00005               63072
       -00124              -00004              -06630              -00011              -00000              -77773              -14706

  TRAP    DCT    IOT    OFL      SENSE LIGHT      1      2      3      4      SENSE SWITCH      1      2      3      4      5      6
  OFF     OFF    OFF    ON                       OFF    OFF    OFF    OFF                      OFF    OFF    OFF    OFF    OFF    OFF

06332  011111011011  011110110111  111011001111  001011001011  110110100011  000001000000  000000010010  000001000000
06342  100111001101  111111111111  001111011111  010010001000  110111011110  011000100000  000000000000  000010000000
06352  100000001011  000100001101  101111011111  111011110110  011111101010  100101100100  000000001000  010000000000
06362  010000000001  101010110110  000101111111  111111101011  110111111111  111001101111  110001000000  000000000000
06372  100011000100  000000100001  010011110100  111001110110  110111111111  111010011111  100100110001  011000100110
06402  000000000000  000001010000  010000100110  101000011111  111111111111  010111111011  110111011011  000101110001
06412  010001000000  000100010110  010100000000  100001011111  100110111001  111111111101  010011100000  011100010111
06422  101010010001  000001000000  101000000000  000101011100  010011001011  111110111110  111001111011  101010000111
06432  110010010010  100001110000  000000001001  000100000111  000000001111  010011101111  110111110111  011110110100
06442  110110010111  010101101010  100000010000  000000001000  001100010010  000111000000  011111100111  110111110101
06452  100001010101  001000010001  001101010000  000000000000
```

Figure 3-8. Pulsar Data - Source 3

POS	DATA COUNTS								BEAM COUNTS							
0	0	0	0	34	304	1023	259	49	0	0	0	5	77	285	65	10
0	0	0	0	25	245	1023	211	42	0	0	0	4	59	221	54	8
0	0	0	0	34	304	1023	276	54	0	0	0	5	77	291	68	10
0	0	0	0	27	247	1023	208	43	0	0	0	4	58	220	52	8
0	0	0	0	13	113	478	115	21	0	0	0	2	30	111	26	4
10	0	0	0	37	328	1023	286	56	0	0	0	5	47	195	43	5
10	0	0	0	30	246	1023	227	44	0	0	0	4	40	150	35	5
10	0	0	0	28	257	1023	230	46	0	0	0	4	40	153	36	4
10	0	0	0	30	260	1023	237	47	0	0	0	4	40	158	34	4
10	0	0	0	22	198	818	177	33	0	0	0	3	31	113	24	3
20	0	0	0	37	340	1023	307	61	0	0	0	4	39	152	36	5
20	0	0	0	31	279	1023	240	46	0	0	0	2	30	132	26	4
20	0	0	0	31	250	1023	238	45	0	0	0	3	33	122	28	4
20	0	0	0	30	274	1023	234	46	0	0	0	2	33	121	28	4
20	0	0	0	23	193	896	178	35	0	0	0	2	22	98	21	3
30	0	0	0	37	322	1023	287	57	0	0	0	5	47	182	39	5
30	0	0	0	31	277	1023	233	45	0	0	0	4	39	141	30	4
30	0	0	0	29	275	1023	232	47	0	0	0	4	37	141	34	4
30	0	0	0	30	256	1023	222	45	0	0	0	4	35	148	32	4
30	0	0	0	22	194	785	177	32	0	0	0	3	27	110	25	3
40	0	0	0	34	313	1023	267	54	0	0	0	5	70	266	60	10
40	0	0	0	26	255	1023	210	43	0	0	0	4	52	217	48	8
40	0	0	0	28	257	1023	214	42	0	0	0	4	55	211	49	8
40	0	0	0	32	315	1023	266	52	0	0	0	5	70	267	61	10
40	0	0	0	13	122	636	110	20	0	0	0	2	27	97	25	4
50	0	0	0	37	338	1023	297	56	0	0	0	12	122	452	109	19
50	0	0	0	24	221	1023	196	38	0	0	0	8	83	324	75	12
50	0	0	0	31	267	1023	241	47	0	0	0	10	100	389	93	16
50	0	0	0	30	270	1023	251	45	0	0	0	10	109	397	94	17
50	0	0	0	0	0	40	0	0	0	0	0	0	0	0	0	0
60	0	0	0	29	293	1023	242	44	0	0	0	18	185	670	157	29
60	0	0	0	30	281	1023	250	47	0	0	0	18	177	685	161	30
60	0	0	0	29	284	1023	244	44	0	0	0	18	168	646	160	30
60	0	0	0	10	94	350	75	16	0	0	0	6	55	221	49	10
70	0	0	0	31	299	1023	248	48	0	0	0	33	311	1146	276	53
70	0	0	0	32	290	1023	264	49	0	0	0	32	316	1146	272	53
70	0	0	0	15	158	669	120	24	0	0	0	16	153	583	138	26
80	0	0	0	30	276	1023	233	46	0	0	0	52	484	1809	416	82
80	0	0	0	30	269	1023	241	45	0	0	0	53	472	1828	412	84
80	0	0	0	0	0	12	0	0	0	0	0	0	0	0	0	0
90	0	0	0	28	285	1023	243	42	0	0	0	83	786	2921	671	131
90	0	0	0	12	116	472	105	18	0	0	0	38	319	1281	292	53
100	0	0	0	18	270	1023	236	36	0	0	0	117	1066	4101	967	182
100	0	0	0	2	29	132	25	4	0	0	0	13	119	491	101	22
110	0	0	0	20	259	979	233	40	0	0	0	134	1232	4554	1124	214
120	0	0	0	19	275	1023	238	38	0	0	0	126	1165	4333	1007	198
120	0	0	0	1	15	85	12	2	0	0	0	6	61	250	49	11
130	0	0	0	30	290	1023	242	45	0	0	0	93	838	3192	742	143
130	0	0	0	10	97	375	82	15	0	0	0	32	285	1055	244	46
140	0	0	0	29	288	1023	251	45	0	0	0	60	538	2035	470	91
140	0	0	0	26	227	919	207	38	0	0	0	47	443	1657	413	80
150	0	0	0	29	262	1023	248	42	0	0	0	36	315	1232	295	55
150	0	0	0	32	280	1023	245	46	0	0	0	36	318	1237	288	55
150	0	0	0	14	139	563	123	23	0	0	0	17	166	600	138	28
160	0	0	0	33	314	1023	274	52	0	0	0	21	220	823	199	37
160	0	0	0	30	265	1023	243	44	0	0	0	21	183	722	165	31
160	0	0	0	27	253	1023	234	45	0	0	0	19	179	718	160	33
160	0	0	0	5	41	205	36	8	0	0	0	3	31	122	27	5
170	0	0	0	35	317	1023	292	53	0	0	0	12	129	537	116	21
170	0	0	0	30	269	1023	235	45	0	0	0	10	110	425	100	19
170	0	0	0	28	282	1023	222	44	0	0	0	10	114	422	100	17
170	0	0	0	23	223	971	196	36	0	0	0	6	89	338	81	13

Figure 3-9. Polarimeter Data - Source 3

180	0	0	0	35	291	1023	266	53	0	0	0	5	78	276	66	10
180	0	0	0	35	309	1023	263	53	0	0	0	5	75	293	66	10
180	0	0	0	27	245	1023	221	42	0	0	0	4	60	216	55	8
180	0	0	0	34	302	1023	270	52	0	0	0	6	75	276	66	10
180	0	0	0	7	65	440	53	10	0	0	0	1	14	54	14	2
190	0	0	0	36	328	1023	279	54	0	0	0	5	50	188	42	5
190	0	0	0	26	271	1023	229	42	0	0	0	4	40	155	35	6
190	0	0	0	36	320	1023	297	55	0	0	0	5	48	195	43	5
190	0	0	0	31	254	1023	234	46	0	0	0	4	40	145	33	4
190	0	0	0	14	136	653	121	23	0	0	0	2	18	70	18	2
200	0	0	0	28	260	1023	239	46	0	0	0	2	31	130	29	4
200	0	0	0	30	264	1023	226	48	0	0	0	1	29	127	26	4
200	0	0	0	39	334	1023	305	59	0	0	0	2	41	156	34	5
200	0	0	0	28	257	1023	227	46	0	0	0	1	33	124	29	4
200	0	0	0	22	204	1010	178	33	0	0	0	3	24	97	19	3
210	0	0	0	37	336	1023	284	55	0	0	0	5	45	174	41	5
210	0	0	0	31	256	1023	227	45	0	0	0	4	38	145	34	4
210	0	0	0	31	258	1023	228	46	0	0	0	4	36	148	30	4
210	0	0	0	30	261	1023	230	47	0	0	0	4	38	146	32	4
210	0	0	0	23	204	826	176	34	0	0	0	3	28	100	25	3
220	0	0	0	33	298	1023	276	50	0	0	0	5	74	253	58	10
220	0	0	0	27	259	1023	222	42	0	0	0	4	57	220	46	8
220	0	0	0	36	299	1023	259	53	0	0	0	5	71	263	58	10
220	0	0	0	27	252	1023	209	41	0	0	0	4	57	220	47	8
220	0	0	0	14	117	565	107	22	0	0	0	2	28	104	26	4
230	0	0	0	31	277	1023	242	41	0	0	0	10	107	374	96	17
230	0	0	0	30	276	1023	233	47	0	0	0	10	109	398	94	16
230	0	0	0	37	331	1023	265	52	0	0	0	12	126	494	110	18
230	0	0	0	24	221	945	188	37	0	0	0	8	85	313	70	15
240	0	0	0	30	274	1023	246	46	0	0	0	18	181	661	150	29
240	0	0	0	30	275	1023	243	48	0	0	0	18	183	674	154	29
240	0	0	0	30	267	1023	238	47	0	0	0	18	182	685	160	30
240	0	0	0	10	84	374	83	15	0	0	0	6	64	235	53	10
250	0	0	0	32	290	1023	251	48	0	0	0	33	314	1168	278	50
250	0	0	0	31	285	1023	260	49	0	0	0	33	317	1185	281	50
250	0	0	0	16	147	679	129	26	0	0	0	18	155	601	136	25
260	0	0	0	31	314	1023	265	49	0	0	0	57	511	1961	471	87
260	0	0	0	27	246	1023	218	39	0	0	0	49	433	1701	367	69
260	0	0	0	0	0	11	0	0	0	0	0	0	0	0	0	0
270	0	0	0	28	282	1023	246	42	0	0	0	85	766	2884	679	131
270	0	0	0	12	120	484	102	18	0	0	0	38	314	1249	290	56
280	0	0	0	19	275	1023	234	38	0	0	0	118	1093	4009	959	188
280	0	0	0	2	29	141	27	4	0	0	0	12	126	483	100	20
290	0	0	0	20	265	1023	232	40	0	0	0	133	1243	4687	1100	208
290	0	0	0	0	0	10	0	0	0	0	0	0	0	0	0	0
300	0	0	0	20	293	1023	252	40	0	0	0	132	1253	4573	1082	202
300	0	0	0	0	0	49	0	0	0	0	0	0	0	0	0	0
310	0	0	0	30	283	1023	251	45	0	0	0	95	846	3136	762	146
310	0	0	0	10	91	412	86	15	0	0	0	32	291	1046	244	48
320	0	0	0	28	282	1023	250	45	0	0	0	59	564	2016	485	92
320	0	0	0	25	231	924	198	36	0	0	0	48	441	1709	403	77
330	0	0	0	32	267	1023	242	47	0	0	0	34	334	1242	286	52
330	0	0	0	28	272	1023	246	45	0	0	0	33	329	1202	291	53
330	0	0	0	15	143	618	126	21	0	0	0	18	157	627	142	25
340	0	0	0	34	311	1023	279	50	0	0	0	21	222	816	188	36
340	0	0	0	29	268	1023	229	45	0	0	0	19	188	715	160	31
340	0	0	0	26	271	1023	240	46	0	0	0	20	184	696	154	31
340	0	0	0	4	42	202	43	7	0	0	0	3	30	130	28	5
350	0	0	0	35	311	1023	262	54	0	0	0	12	136	508	120	21
350	0	0	0	26	268	1023	242	44	0	0	0	10	113	418	97	17
350	0	0	0	30	258	1023	237	47	0	0	0	10	112	421	98	19
350	0	0	0	24	223	674	183	35	0	0	0	8	93	337	75	13

Figure 3-9 (cont.). Polarimeter Data - Source 3

3.6 Program Listing

```
C       POLARIMETER AND PULSAR MODE COUNTER DATA SIMULATION ROUTINE
C       KEN BAUER  -  SYSTEM DEVELOPMENT CORPORATION, HUNTSVILLE, ALABAMA
C       PHONE  539-7711
C
C       THIS ROUTINE SIMULATES THE OUTPUT OF AN X-RAY POLARIMETER AND
C       PULSAR MODE COUNTER.  SEE SDC DOCUMENT TM-(L)-HU-033/000/00 FOR A
C       DESCRIPTION OF THIS SPACE BORNE EXPERIMENT.
C
C
C       INPUT VARIABLES
C
C       NAME    - SOURCE IDENTIFICATION CODE
C       ITIME   - OBSERVATION TIME AT EACH TABLE POSITION (SECONDS)
C       STEP    - TABLE STEP SIZE (DEGREES)
C       BEGIN   - BEGINNING TABLE POSITION (DEGREES)
C       END     - ENDING TABLE POSITION (DEGREES)
C       AMAX    - ANGLE OF MAXIMUM POLARIZATION (DEGREES)
C       DATAM   - DATA COUNT IN PLANE OF MAXIMUM POLARIZATION (AVERAGE DATA
C                 COUNTS PER SECOND)
C       DATAP   - DATA COUNT IN PLANE PERPENDICULAR TO PLANE OF MAXIMUM
C                 POLARIZATION (AVERAGE DATA COUNTS PER SECOND)
C       TOTI    - TOTAL INTENSITY (AVERAGE DATA AND BEAM COUNTS PER SECOND)
C       DEV     - DESIRED RANDOM DEVIATION OF POLARIMETRY DATA (PERCENTAGE)
C       FREQ    - PULSATION FREQUENCY (PULSES PER SECOND)
C       AMP     - PULSATION WAVE FORM AMPLITUDE
C       PHS     - PULSE HEIGHT SPREAD (PERCENTAGES)
C
        DIMENSION PHS(8)
        DIMENSION DATC(8)
        DIMENSION BEAM(8)
C
        INTEGER DATC
        INTEGER BEAM
C
        DATA PHS/.05,.10,.15,.20,.20,.15,.10,.05/
        DATA KZERO/0/
C
        NAMELIST /INPUTS/ NS
        NAMELIST /INPUT/NAME,ITIME,STEP,BEGIN,END,AMAX,DATAM,DATAP,
       1                 TOTI,DEV,FREQ,AMP,PHS
C
C.....INITIALIZE RANDOM NUMBER GENERATOR
        NN = 245
        CALL RNUM(NN)
C.....INPUT NUMBER OF SOURCES
        READ (5,INPUTS)
        NC = 0
C.....CHECK FOR LAST SOURCE
 10     CONTINUE
        NC = NC+1
        IF (NC.GT.NS) GO TO 400
C.....READ SIMULATION VARIABLES FROM CARDS FOR 1 X-RAY SOURCE
        READ (5,INPUT)
C.....FOR EACH TABLE POSITION
        IPASS = 1
```

```
      IF (STEP.EQ.0.) GO TO 25
      IPASS = (END - BEGIN) / STEP + 1.0001
 25   CONTINUE
      CALL PULSAR (TOTI,FREQ,AMP)
      WRITE (6,1000)
1000  FORMAT (1H1,3HPOS,22X,11HDATA COUNTS,47X,11HBEAM COUNTS/)
      DO 300 I=1,IPASS
      FI = I
      DO 50 M=1,8
      DATC (M) = 0
50    BEAM(M) = 0
      KPOS = BEGIN + (STEP * (FI - 1.))
      COUNT = DATAP + (DATAM - DATAP) / 2. + SIN(2. * (BEGIN + (STEP *
     1        (FI - 1.)) + 45. - AMAX) / 57.296) * (DATAM - DATAP) / 2.
C.....FOR EACH SECOND AT TABLE POSITION I
      DO 200 J=1,ITIME
C.....DISTRIBUTE DATA COUNTS BETWEEN THE 8 PULSE HEIGHT ANALYZER BINS
      KOF = 0
      DO 100 K=1,8
      CALL RANDOM (R)
      INT = COUNT * (R * 2. * DEV + 1. - DEV) * PHS(K)
      DATC(K) = DATC(K) + INT
      IF (DATC(K).GT.1023) KOF = 1
      CALL RANDOM (R)
      INT = (TOTI - COUNT) * (R * 2. * DEV + 1. - DEV) * PHS(K)
      BEAM(K) = BEAM(K) + INT
      IF (BEAM(K).GT.8191) KOF = 1
 100  CONTINUE
C.....IF BUFFER OVERFLOW, OUTPUT DATA
      IF (KOF.EQ.1) CALL OVRFLO (DATC,BEAM,KPOS)
 200  CONTINUE
C.....OUTPUT DATA AND BEAM COUNTS FOR TABLE POSITION I
      WRITE (8)KPOS,KZERO,(DATC(M),M=1,8),(BEAM(M),M=1,8)
      WRITE (6,2000) KPOS,(DATC(M),M=1,8),(BEAM(M),M=1,8)
 2000 FORMAT (1X,I3,8I7,3X,8I7/)
 300  CONTINUE
      GO TO 10
 400  CONTINUE
      END FILE 8
      REWIND 8
      END FILE 10
      REWIND 10
      STOP
      END
```

```
      SUBROUTINE OVFFLO (DATC,BEAM,KPOS)
C
C.....OUTPUT OVERFLOW DATA AND BEAM COUNTS
C
      DIMENSION DATC(8),BEAM(8),KDATA(8),KBEAM(8)
C
      INTEGER DATC,BEAM
C
      DATA KONE/1/
C
      DO 400 K=1,8
      IF (DATC(K).LT.1024) GO TO 100
      KDATA(K) = 1023
      DATC(K) = DATC(K) - 1023
      GO TO 200
  100 KDATA(K) = DATC(K)
      DATC(K) = 0
  200 IF (BEAM(K).LT.8192) GO TO 300
      KBEAM(K) = 8191
      BEAM(K) = BEAM(K) - 8191
      GO TO 400
  300 KBEAM(K) = BEAM(K)
      BEAM(K) = 0
  400 CONTINUE
      WRITE (8) KPOS,KONE,(KDATA(M),M=1,8),(KBEAM(M),M=1,8)
      WRITE (6,2000) KPOS,(KDATA(M),M=1,8),(KBEAM(M),M=1,8)
 2000 FORMAT (1X,I3,8I7,3X,8I7/)
      RETURN
      END
```

```
      SUBROUTINE PULSAR (TOTI,FREQ,AMP)
C
C.....COMPUTE PULSAR STRING DATA
C
      DIMENSION N(1000)
C
      INTEGER SLOTS
C
      DATA TWOPI/6.2832/
C
      SLOTS = (1./FREQ) * 1000.
      THRESH = 1. - (TOTI/1000.)
      AMPD2 = AMP/2.
      I = 1
      K = 1
 50   DO 100 J=1,SLOTS
      N(I) = 0
      X = J - 1
      S = SLOTS - 1
      CALL RANDOM(R)
      TEMP = AMPD2 * SIN((TWOPI * X) / S) + R
      IF (TEMP.GE.THRESH) N(I) = 1
      IF (I.NE.1000) GO TO 100
      CALL PULOUT (N)
      IF (K.EQ.5) RETURN
      I = 0
      K = K+1
 100  I = I+1
      GO TO 50
      END
```

```
      SUBROUTINE PULOUT (N)
C
C.....PACK PULSAR DATA AND OUTPUT TO TAPE
C
      DIMENSION N(1000),NOUT(28),NBIT(36)
      DIMENSION NPRNT(84)
C
      DATA NBIT /0400000000000,0200000000000,0100000000000,
     1 040000000000,020000000000,010000000000,04000000000,02000000000,
     2 01000000000,0400000000,0200000000,0100000000,040000000,
     3 020000000,010000000,04000000,02000000,01000000,0400000,0200000,
     4 0100000,040000,020000,010000,04000,02000,01000,0400,0200,0100,
     5 040,020,010,04,02,01/
C
      I = 1
      DO 100 J=1,28
      NOUT(J) = 0
      DO 100 K=1,36
      IF (N(I).EQ.1) CALL BIN(NOUT(J),0,36,0,NBIT(K),2)
      IF (I.EQ.1000) GO TO 200
      I = I+1
  100 CONTINUE
  200 CONTINUE
      WRITE (10) (NOUT(M),M=1,28)
      I = 1
      DO 1000 J=1,84
      NPRNT(J) = 0
      DO 1000 K= 1,12
      KT3 = K*3
      IF (N(I).EQ.1) NPRNT(J) = NPRNT(J) + NBIT(KT3)
      IF (I.EQ.1000) GO TO 2000
      I = I + 1
 1000 CONTINUE
 2000 CONTINUE
      CALL PDUMP(NPRNT(1),NPRNT(84),0)
      RETURN
      END
```

SECTION 4. SUMMARY

The X-ray polarimeter experiment of FPE 5.1 was analyzed and developed to the point where on-board operational software could be designed and implemented for the acquisition, analysis and display of primary data. The purpose of this effort was to establish some estimates of computer speed and capacity required for on-board experiment processing. Since the software was coded in FORTRAN IV and implemented on the MSFC Computation Laboratory's IBM 7094 II, estimates of on-board timing and load factors must be adjusted to take into consideration the difference in speed and capacity of future on-board computers and the IBM 7094.

Processing time required on the IBM 7094 to acquire, analyze and display the primary data for a typical observation sequence of one X-ray source is approximately 33 seconds. Since the acquisition time for simulated data is considerably faster than for actual real time data acquisition, the total processing time for data analysis and display can be spread out over the entire observation sequence. For example, a typical observation sequence of 20 seconds at each of eighteen table positions represents six minutes of elapsed time as compared to 33 seconds of processing time in the simulated mode of operation. This would indicate that the processing of the primary data can be time shared with other experiment operations.

Computer storage was utilized as follows:

Experiment modules	2,600 words
System and library routines	15,500 words
Data and working storage	14,600 words
Total	32,700 words

The Fourier analysis of the pulsar data was limited by the available core storage of the IBM 7094 to 4096 words of input--just over four seconds of observation. It would be desirable to increase the data input to 16,384 words or 16+ seconds of observation to improve the accuracy and reliability of the analysis process. This is especially desirable for weak sources or sources with a relatively long pulsation period.

This study has indicated that real time, on-board processing of primary experiment data can be beneficial not only in reducing the amount of data that must be transmitted, but also in reducing the reaction time to modify or update the experiment sequence due to unexpected events or experiment results.

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