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DATA PROCESSING/DISPLAY DESIGN FOR THE SPACE SHUTTLE/SPACELAB ELECTROMAGNETIC ENVIRONMENT EXPERIMENT(EEE)

Final Report

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16. Abstract

Under this contract data processing/display techniques were developed for the space shuttle/spacelab electromagnetic environment experiment (EEE). Methods of data analysis, data compression including universal coding, storage and retrieval on random access storage devices, and display were developed and implemented on the GSFC Interdata computer. The original 64 bit per frequency band representation was reduced to 10 bits through source coding/universal coding, a compression ratio of 6.4, prior to storage. Rapid encoding/decoding was achieved by the algorithms used so that rapid random access is retained.

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I. INTRODUCTION

The NASA Space Shuttle/Spacelab Electromagnetic Environment Experiment (EEE) will measure radiation in the 0.4 to 100 Ghz range for the purpose of determining earth-emitted interference levels and RF spectrum occupancy. The quantities of data involved will be very large. Therefore sophisticated methods of data compression, storage, and retrieval must be developed so that the data can be stored efficiently and retrieved rapidly in the most useful format for analysis and display. Such methods include the use of random access mass storage devices coupled with efficient data compression/reconstruction algorithums.

Under the tasks of this contract Techno-Sciences has developed and implemented a series of computer programs for the analysis, compression, storage and retrieval of a data base consisting of 28 tape files from the ATS-6 RFIME experiment. There is one mode 2 file, three mode 3 files and 24 mode 4 files. Two principal programs are now implemented on the NASA Interdata Model 5 computer using a Bryant 5 M byte disk as a random access mass storage device. One program is designed to input the tape data, output it to disk and plot the data points, if desired. The zero order or differential entropy can also be calculated. The second program is for data retrieval and anlysis. Arbitrarily chosen frequency averaged segments of any of the files on disk can be plotted at arbitrarily chosen frequency increments (in multiples of the basic input frequency increment of 10 khz for mode 4 data and 100 khz for mode 2 and 3 data). Data smoothing can also be accomplished if desired to remove noise variations by a moving quadratic least squares polynomial fit. Finally, RFI emitters can be located and printed out using any of the mode 4 files, one of the mode 3 files and either the raw mode 2 file or a smoothed mode 2 file generated using the moving average quadratic polynomial smoothing program.

The compression achieved by the present simple fixed format implementation is 2.21 over the tape storage format. An overall compression of four to one is easily achievable by variable length, compact storage methods which can be further extended to 6.4 to one using a simple universal coding/decoding algorithm.

The succeeding sections describe the data, the methods of data analysis, reduction, and coding, and the computer programs developed. Complete program flow diagrams and source listings appear in the appendices. Also appearing in the appendices is an analysis of the R-ratio as a signal detector and an analysis of the quantization effects on the data.

II. THE DATA BASE

The data used for the study were provided by Westinghouse on 2 digital 9 track magnetic tapes. A listing of the original tape and file number designations appears in Table II.1. These data are from the ATS-6 RFIME C band experiment and are formatted as shown in Table II.2 and cover the 5925 Mhz to 6425 Mhz frequency band. The principal volume of data is mode 4 which is recorded in 10 khz frequency increments. Mode 2 and mode 3 data on the other hand are recorded in 100 khz increments. Only modes 2, 3 and 4 were supplied. The contract study was concerned with these modes only.

In addition to header information each file consists of statistics measured for each frequency increment based on a linear envelope detector output. 39 12-bit quantized samples of the detector output are taken, the mean value computed and recorded as a 12-bit (magnitude without sign) number and stored in a 16 bit (2 byte) word. The sum of the squares of the sampled values is also computed, but not normalized to 39, resulting in a 12 + 12 + 6 = 30 bit number which is stored in a 32 bit (4 byte) word. For mode 4 data only, the peak value of the 39 is also recorded as a 12-bit (2 byte) number. Thus 64 bits storage per band are required.

The data are written on tape in DEC format and need to be converted to Interdata (IBM) compatible format. In particular, byte switching must be accomplished to get the most significant byte of each word in the right place and DEC floating point numbers must be converted to the Interdata (IBM) floating point format. This is accomplished by subroutines developed especially for this contract.

Some difficulty was encountered in the use of the data. The header, pulse detection, attitude, and telemetry information do not appear on the tapes in some cases. Because of the marginal interest in these quantities for this contract effort, these data were only reformatted and stored on disk and not used further except for computer printouts. Furthermore, numerous "bad points" appear, apparently due to the method of A/D conversion used. These are screened out, when required, by "R-ratio" technique used by Westinghouse. An analysis of the R-ratio appears in Appendix A.

TABLE II.1

ATS-6 RFIME Data Based Used in Study

Tape #	File #	Mode
68	201	2A
159	302	3A
159	403	4
159	407	4
159	408	4
290	304	3A
290	305	3A
290	401	4A
290	402	4A
290	403	4A
290	404	4A
290	405	4A
290	406	4A
290	407	4A
290	408	4A
290	409	4A
290	410	4A
290	411	4A
290	412	4A
290	413	4A
290	414	4A
290	415	4A
290	416	4A
290	417	4A
290	418	4A
290	419	4A
290	420	4A
290	421	4A

TABLE II.2

Digital Tape Data File Format

Modes 2 & 3

Record #1	Header
Records # 2-41	Data
Data Record:	
Bytes 0-767	128 6-byte Interlaced Mean, Sum Squares Values
Bytes 768-1133	Time, Frequency, Attitude, Telemetry Data

Mode 4

Record #1	Header
Records #2-392	Data Record
Rocord #393	Pulse Detection Data
Data Record:	
Bytes 0-1023	128 8-byte Interlaced Mean (2 byte) Sum Squares (4 bytes), Peak (2 byte) Values
Bytes 1024-1133	Time, Frequency, Attitude, Telemetry Data

III. DATA FORMATTING FOR STORAGE/RETRIEVAL

The data format described in Section II is not very effective for efficient data storage and data utilization. In particular, it seems likely that most data useage will be in decibel quantities rather than in the statistics that appear on the digital tape. It is clear that 3 quantities must be retained to preserve the 3 degrees of freedom in the mean, peak, and sum squares statistics. It is also clear that there is a correlation between the three which can be removed by a better choice of coordinates. The resulting 3 uncorrelated coordinates can then be coded more efficiently. The three quantities chosen for storage are the log of the mean, the log of the peak/mean ratio and the log of the normalized sum-of-the squares to the mean squared (inverse R-ratio). Note that for 12 bit quantization, the original data range is 1 to 2^{12} (volts) or 0 to 72.2 db for each of the 3 original quantities. On the other hand, for the selected statistics, only the log of the mean has a 72.2 db range. For the 39 points used at each frequency, the logarithms of the R-ratio and the peak/mean ratios have a maximum range of 1 to 39 or 15.9 db for the R-ratio (a power ratio) and 31.8 db for the peak/mean ratio (a voltage ratio). Furthermore, the R-ratio is primarily useful for data screening in the range of about .5 to 1 - a 3 db useable range. Points with an R-ratio less than .5 to .6 or so are rejected as "bad points".

From the analyses in Appendices A and B, based on noise considerations, it is concluded that 6 bits of quantization for the log of the mean and 4 bits for each of the other 2 quantities is sufficient to achieve a level of quantization noise which is negligible compared with the system noise. Thus a reduction in storage requirement from 64 original data bits to 14 stored data bits or 4.57 to one is achievable through quantization alone.

The presently implemented scheme uses 8 bits for each of the quantized parameters and a range of 0 to 100 db. 8 bits was chosen for ease of data manipulation as the Interdata machine is directly addressable in 8 bit bytes. Formatting at the 14 bit level can be achieved however. The 100 db range was chosen arbitrarily and can be easily changed. At any rate, the the present scheme provides a reduction from 64 data bits to 24 or 2.67 to one. The rms quantization noise is .11 db.

A Bryant 5 M byte moveable head disk is used for data storage. Each disk sector contains 256 bytes. The 128 frequencies in each tape record are stored in 3 x 128 = 384 bytes = 1.5 sectors. 0.5 sector is presently used to contain the frequency, time, attitude and telemetry values for each record and can, no doubt be compressed significantly. Because of the unreliability of the taped data, it is not known what reduction can actually be achieved. At any rate, the original 1134 bytes is presently stored in 512 bytes, a reduction of 2.21 to one.

The above considerations lead to the conclusion that a compression in excess of 4 to one can be readily attained through more efficient quantization and formatting alone.

Entropy and universal coding studies performed found that a set of 3 data points can be further reduced to an average of 10 bits or 6.4 original bits to one. A universal coding block of 128 points for each coordinate was used for the study. A simple, effective, universal coding method which achieves the 10 bit average is implemented by sending the maximum and minimum value for each of the parameters across each block together with the 128 quantized vectors, where the quantization is effected on the reduced range defined by the maximum and minimum values. Because of the reduced range, fewer bits are needed to describe values within the range, the actual number of bits depending on the range within a particular block, some blocks being more variable than others. In order to further control the range, bad data points are removed by R-ratio screening with replacement by an interpolated average value.

IV. DESCRIPTION OF THE COMPUTER PROGRAM FOR PLOTTING AND STORAGE

One of the two principal presently implemented programs on the NASA GSFC Interdata Model 5 is used for the plotting of data points, quantization studies, data formatting, and disk storage. The data is input from digital magnetic tape and optionally output to the Bryant disk as described in the previous section. A flow diagram of this program, labelled RFCAL4 , and source listing appears in Appendix C. Prior to program start, the input tape must be positioned to the start of the file to be processed. A series of commands are entered from the system teletype in response to program prompts. An example of a command sequence appears in Figure IV.1. The underlined quantities are the operator responses. The first program query after program start is whether disk output is desired. If it is, the program asks whether or not it is desired to initialize the disk pack. If it is, the data is output starting with sector #100 (sectors 0-99 are reserved for program storage). If initialize is not requested, the disk pack is searched for end of file which is designated by a zero in the first 2 bytes of the sector immediately following a data file. A data file is of fixed length using the storage format described in the last section - 80 sectors for modes 2 and 3, 782 sectors for mode 4, so that it is possible to find an empty location by a rapid scan.

After output or no output is determined, whether or not it is desired to print the record headers and/or the data points is determined. The first record header is always printed for identification/verification purposes. Figure IV.2 is an example of a small portion of the beginning of the plotter output when the printing of headers is not selected, but

COMMAND SEQUENCE FOR RFCAL4	COMMENTS
START	Start of program
Y FOR OUTPUT	Enter Y for output to disk
Y	For no output, enter N
Y TO INITIALIZE	Enter Y if this is the first file on
N	this disk pack,otherwise, enter N
P FOR PRINT DATA	Enter P if record headers are to be printed
N	
P FOR PLOT	Enter P to plot the data
N	
TAPE?,FILE?	Enter the tape and file #
290 410	I5 format
MODE?	Enter Mode
4	Format I1
BITS?	Enter quantization bits desired
8	
Z FOR ZERO ORDER ENTROPY	Enter Z for zero order entropy, for
N	differential entropy, enter anything else
STOP	Program stop
EOJ	End of job

Figure IV.1 RFCAL4 Program Command Sequence to Output Data to Bryant Disk without Plotting (Program prompts are not underlined, operator responses are underlined)

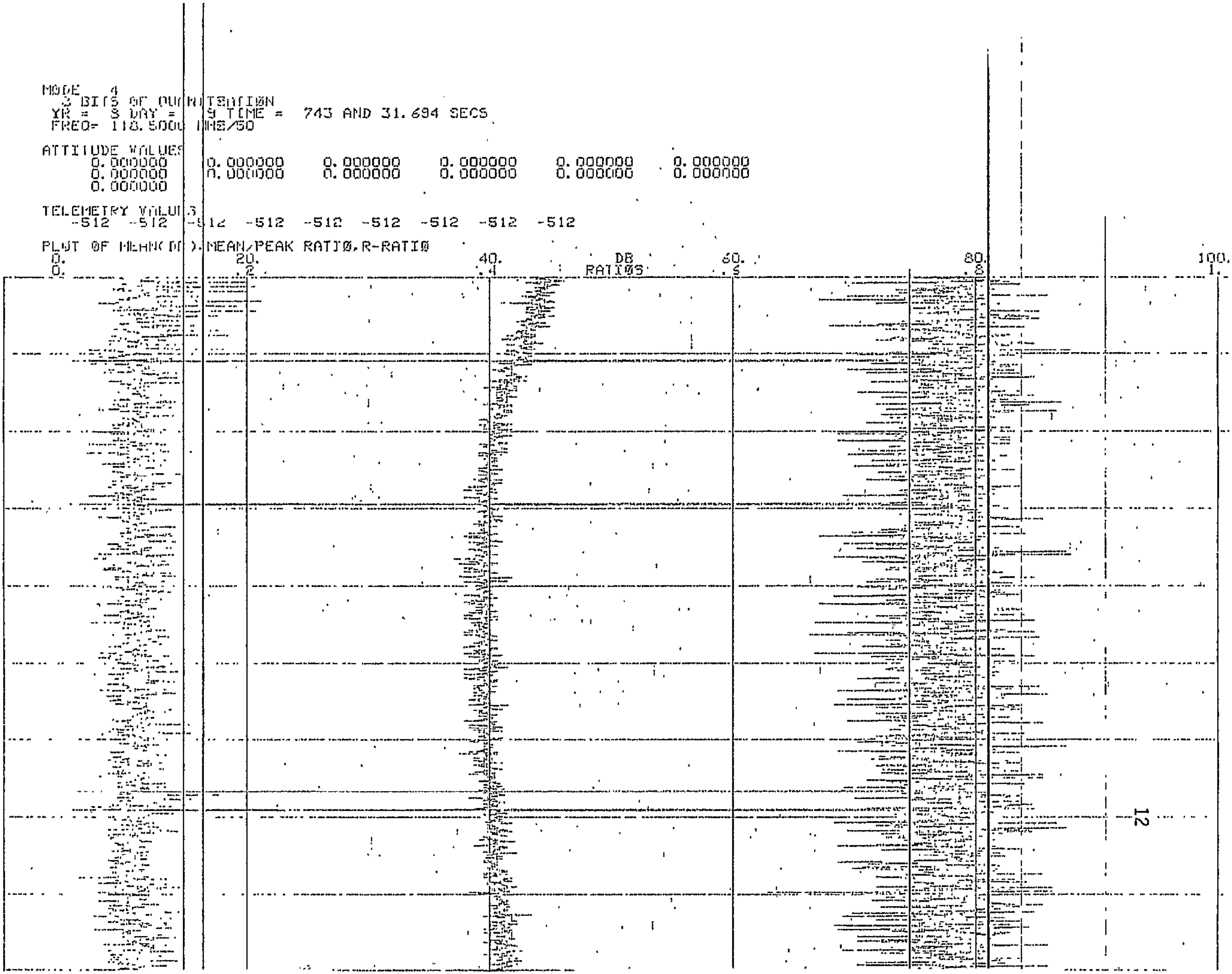

Figure IV.2. RFCAL4 Sample Plotter Output (Tape #159, File #403) plotting is selected. Note that the record attitude and telemetry information are meaningless. The plotting is on a Varian 514 plotter. The dark horizontal lines are caused by defective transistors in the plotter. Note that the log of the mean and the log of the peak/mean ratio are plotted in db between 0 and 100 db and the R-ratio is plotted as a number between 0 and one. Several bad points are seen where the R-ratio becomes very small.

The final program query prior to execution is whether zero order or differential entropy is to be calculated. Upon program termination the selected quantity is printed out and can be used in data compression studies.

V. DESCRIPTION OF THE COMPUTER PROGRAM FOR RETRIEVAL, PLOTTING AND RFI DECTECTION

The second of the two principal presently implemented programs on the NASA GSFC Interdata Model 5 is used for data retrieval and processing from the Bryant disk using the format described in earlier sections as output to disk by program RFCAL4 described in the previous section. A flow diagram and source listing of this program, labelled RFCAL5, appear in Appendix D.

Upon program start, a message is printed on the system teletype requesting an operator command (type of processing to be done). There are four commands presently implemented - "STOP", "LIST", "PLOT", and "FIND". Upon completion of the latter three commands, control returns to the start point. Thus the purpose of the first command is to stop execution to allow for exit from the program. If a non-existent command is entered, control also returns to the start point.

The second command, "LIST", provides a listing of all the data files presently on disk by designated tape and file number. There are presently one mode 2 file , three mode 3 files and 24 mode 4 files on disk. In addition, there is one smoothed mode 2 file produced by RFCAL5 for RFI emitter detection (see below).

The third command, "PLOT" allows one to plot out a selected data file from disk on the system plotter. The frequency increment in multiples of the input increment of 100 khz for modes 2 and 3 and 10 khz for mode 4 can be selected. Frequency averaged values are plotted for increments larger than the respective input frequency increments. Figure V.1 is an example of the plotted portion of a mode 4 file, plotted at frequency

TAPE = 290 FILE = 410 START SECTØR = 9804
8 BITS ØF QUANTIZATIØN
YR = 5 DAY = 139 TIME = 1432 AND 49.450 SECS
START FREQ= 5925.0000 MHZ DELTAF = 0.1000 MHZ, 10.0000 MHZ/GRID LINE

ATTITUDE VALUES
-2973.132324 12040.605469 699.020264 90618.610382 -6.784468 89386.057853
-45.897385 -110.484970 92684.143781 12086.000000 -1959.350098 -110.019302
-3.686335

TELEMETRY VALUES
-1 -1 -1 -1 -1 -1 -1 -1 -1

PLØT ØF MEAN(DB), PEAK/MEAN RATIØ(DB), R-RATIØ

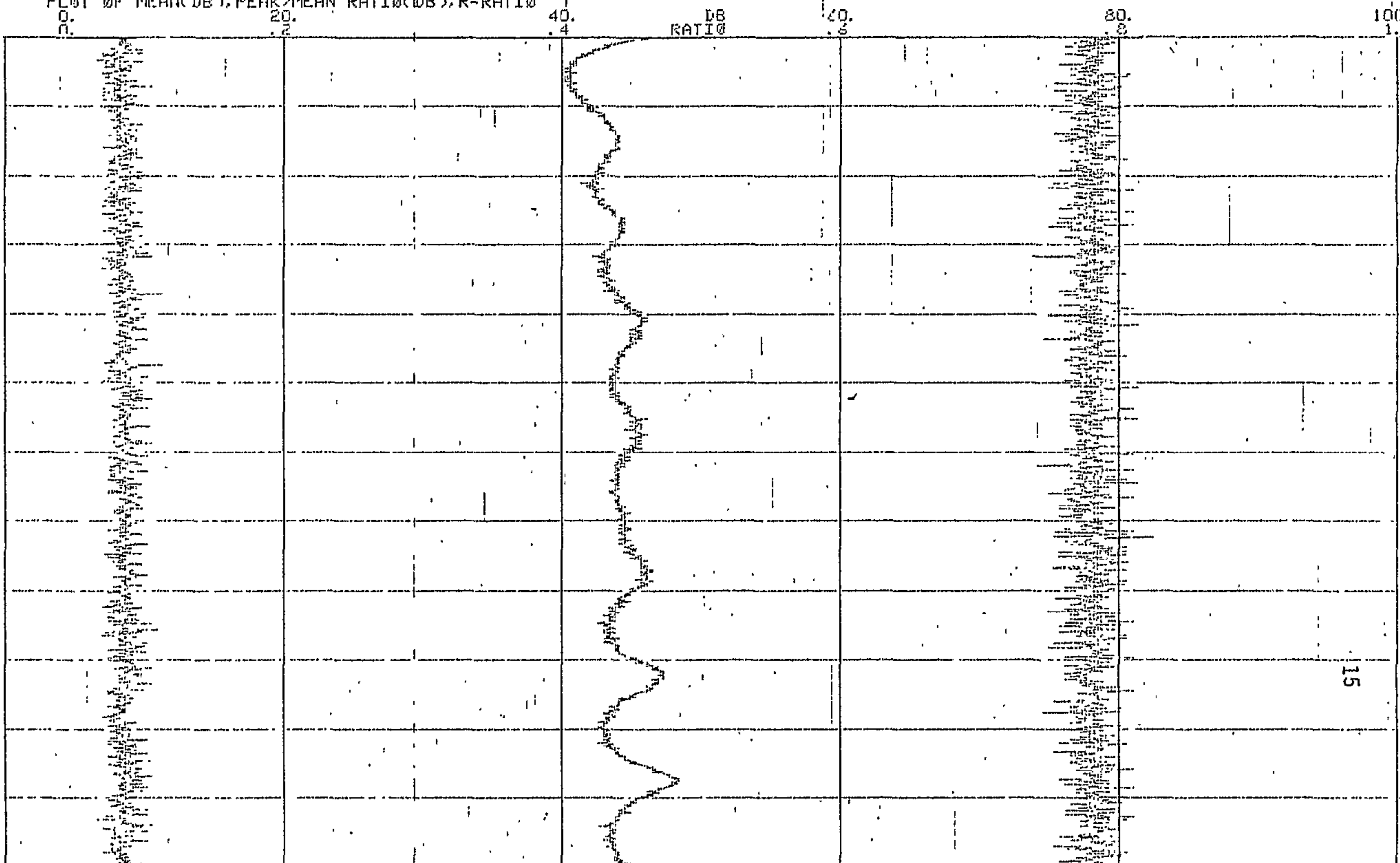

Figure V.1. Portion of a Mode 4 Plot, 100 khz per point increments of 100 khz. Because 10 input points go into one plotted point, the plotted data appear smoother than the original (compare with figure IV.1).

The plot routine can also select smoothing. In this case, a 32 point least squares quadratic polynomial is used to smooth the data. The polynomial moves 16 points at a time to provide overlap and the 16 best fit polynomial values from the center of the interval are selected for plotting (except the first and last 16 frequency points which obviously must come from the end of the interval). The 32 points with 16 points of overlap and the choice of a quadratic polynomial were selected on the basis of a compromise between accuracy of smoothing and speed of operation. Prior to smoothing, bad points are screened out by the R-ratio and replaced by an interpolated average. If desired, the smoothed values can be output to a new disk file to be used as a smoothed reference for subsequent data operations. The mode 2 file in the provided data base has been processed in this fashion. A plotted segment of this file before and after smoothing appears in figures V.2 and V.3. Note that after smoothing, much of the noise is removed. The quantizing noise in the smoothed data is at the same level as in the original, but is now obvious because of the sharp reduction in the system noise.

The final input command is to "FIND". This command requires a mode 4 file to search for RFI emitters and a mode 2 and a mode 3 file for reference. The mode 4 file is scanned sequentially. After every 10th frequency, the next mode 2 and mode 3 frequency is selected. The R-ratio for each point is checked against an input threshold and skipped if too small. If the R-ratio exceeds the threshold, the excess of the mode 4 detector output over the corresponding mode 2 reference is compared with an input threshold. If

```
TAPE = 83 FILE = 201 START SECTØR = 2526
 3 BITS ØF QUANTIZATIØN
 YR = 8 DAY = 313 TIME = 1946 AND 31.353 SECS
START FREQ= 5925.0000 MHZ DELTAF = 0.1000 MHZ, 10.0000 MHZ/GRID LINE

ATTITUDE VALUES
     0.000000    0.000000    0.000000    0.000000    0.000000    0.000000
     0.000000    0.000000    0.000000    0.000000    0.000000    0.000000
     0.000000

TELEMETRY VALUES
  -512  -512  -512  -512  -512  -512  -512  -512  -512
```

PLØT ØF MEAN(DB), PEAK/MEAN RATIØ(DB), R-RATIØ

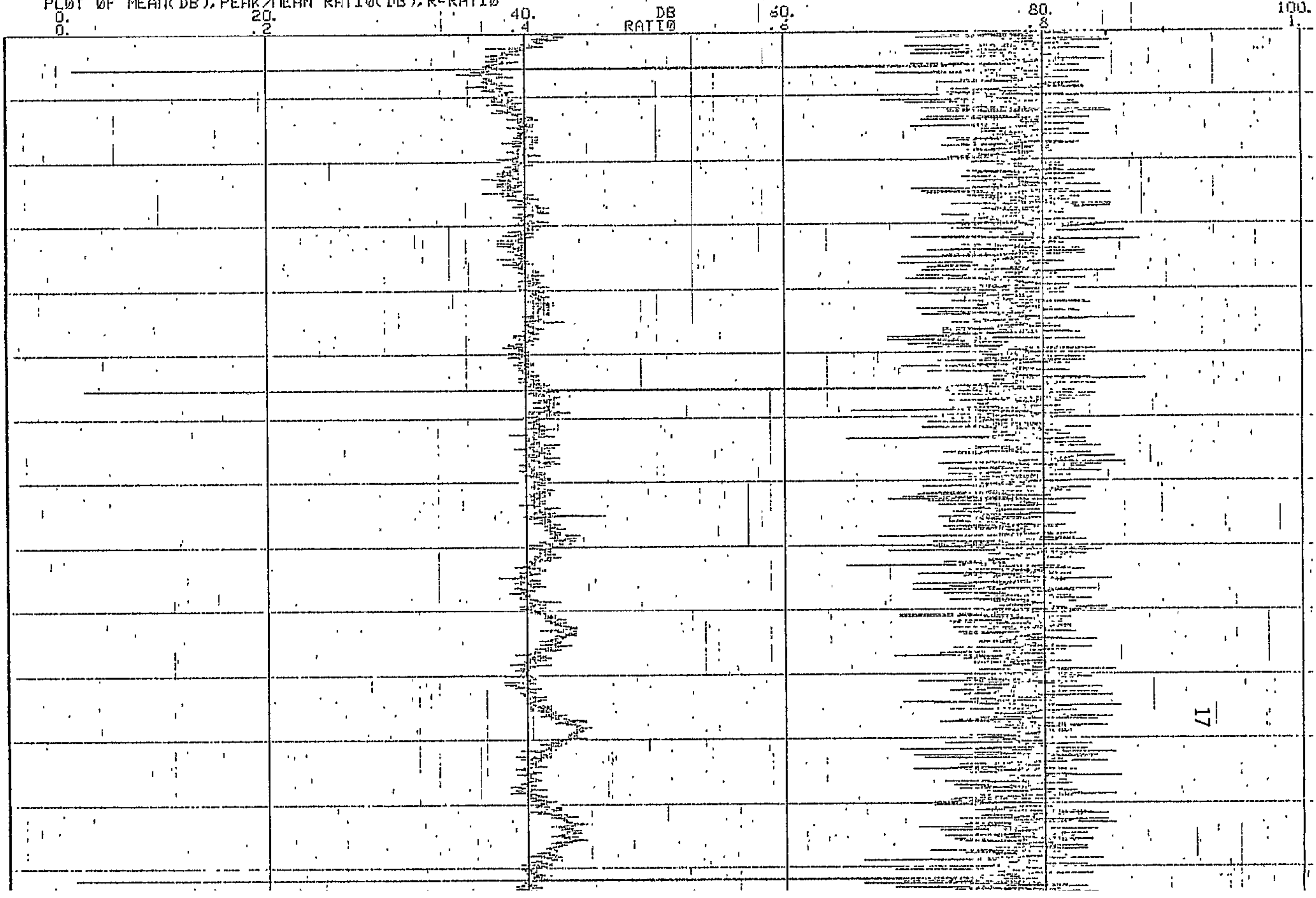

Figure V.2. Portion of Mode 2 Data, unsmoothed

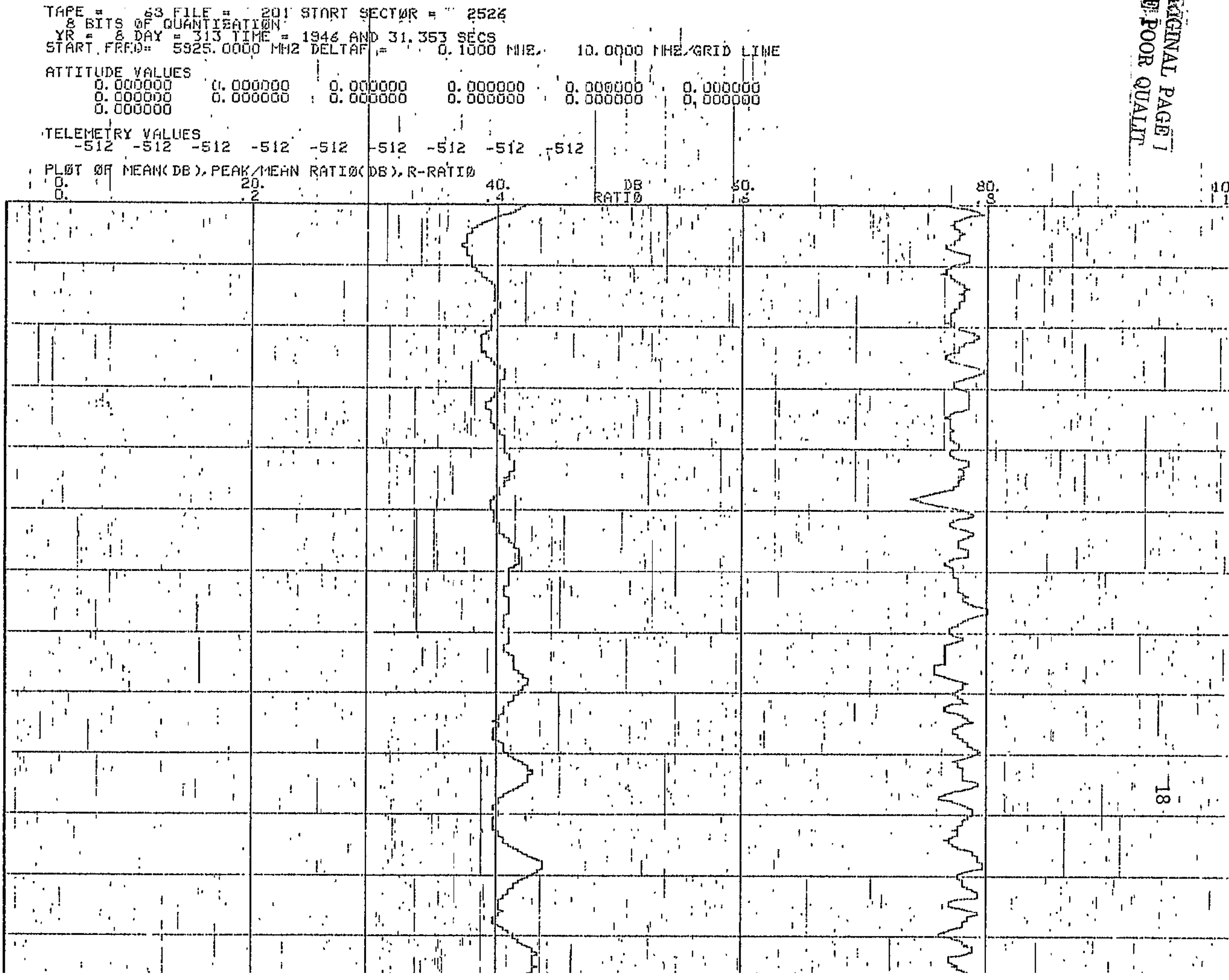

Figure V.3. Portion of Mode 2 Data, Smoothed by a Quadratic Polynomial

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the threshold is not exceeded, the program goes to the next point. If the threshold is exceeded, an RFI emitter has been detected and the RFI level is calculated using the selected mode 3 file as an absolute reference. The emitter frequency and level are printed on the system plotter, together with the R-ratio and mode 2 and 3 levels. An example of such a printout appears in figure V.4.

Program operation is very fast and is limited in speed primarily by the plotter. Hence several thresholds can be selected and tried successively.

TAPES PROCESSED: 10068/201 290/304 290/421
MODE 3 DBW = 30., NOISE THRESHOLD, 2.00 DB R-RATIO THRESHOLD =.6000

FREQ(MHZ)	RFI(DBW)	R-RATIO	MODE 2(DB)	MODE 3(DB)
5974.7930	20.9463	0.8141	40.6250	61.3281
6000.0625	22.1002	0.8180	40.6250	60.1563
6004.5234	20.4958	0.7773	40.6250	60.9375
6033.4023	20.4308	0.7691	39.8438	58.2031
6033.5039	19.8646	0.7539	39.8438	58.9844
6034.0430	19.7536	0.7734	39.8438	58.9844
6034.1133	19.8556	0.8203	39.8438	58.9844
6034.2031	19.9863	0.8672	39.8438	58.2031
6093.4727	16.9539	0.7852	40.2344	62.1094
6152.7617	21.5057	0.6828	41.7969	63.2813
6152.7734	18.5974	0.8398	41.7969	63.2813
6225.5391	18.3021	0.7539	39.4531	60.1563
6225.5781	17.9980	0.8086	39.4531	60.1563
6225.6484	18.7092	0.7422	39.4531	60.1563
6226.1680	18.7166	0.8203	39.4531	60.5469
6226.6875	17.9562	0.9164	39.8438	60.5469
6226.6992	18.6480	0.7617	39.8438	60.5469
6226.7070	17.6132	0.8438	39.8438	60.5469
6226.7461	19.2677	0.7813	39.8438	60.1563
6226.8281	21.5254	0.7969	39.8438	60.1563
6226.8398	18.9504	0.7773	39.8438	60.1563
6226.8789	19.1909	0.8047	39.8438	60.1563
6226.8867	18.5598	0.7773	39.8438	60.1563
6226.8984	19.6579	0.7227	39.8438	60.1563
6226.9063	18.9070	0.7852	39.8438	60.1563
6226.9297	18.9238	0.7148	39.8438	60.1563
6226.9375	19.0932	0.6875	39.8438	60.1563
6226.9492	18.0657	0.7305	39.8438	60.9375
6229.5961	22.0431	0.6375	39.4531	60.5469
6230.0078	26.9256	0.9805	39.4531	60.5469
6296.1367	17.5656	0.8164	39.8438	60.9375
6296.2695	17.1336	0.8242	39.8438	61.3281
6296.4683	16.6413	0.8438	39.8438	61.7188
6296.6172	17.6364	0.7969	39.8438	60.9375
6296.7266	17.4318	0.7695	39.8438	61.3281
6296.7461	17.2168	0.9086	39.8438	61.3281
6296.8086	17.6074	0.8086	40.2344	61.3281
6296.9375	17.9562	0.8164	40.2344	60.9375
6297.0463	17.6708	0.7969	40.2344	61.3281
6297.1797	17.8102	0.7656	40.2344	61.3281
6297.2461	17.9941	0.8125	40.2344	61.3281
6297.3477	17.6284	0.8047	40.2344	61.3281
6297.5977	17.7522	0.7852	40.2344	61.3281
6297.7969	18.3596	0.8906	40.2344	60.9375
6309.0391	16.7844	0.6164	40.2344	62.1094
6309.0977	17.1528	0.7500	40.2344	62.1094
6309.2383	17.0955	0.7539	40.2344	62.1094
6309.2773	17.5730	0.8066	40.2344	62.1094
6309.2891	17.1640	0.7422	40.2344	62.1094
6309.2969	17.5730	0.8066	40.2344	62.1094
6309.3398	16.4355	0.8086	40.2344	62.5000
6309.3477	16.2911	0.8359	40.2344	62.5000
6309.4570	16.7225	0.8281	40.2344	62.5000
6309.5078	16.7396	0.7539	40.2344	62.5000
6309.5391	16.1710	0.8594	40.2344	62.5000
6309.5586	17.6324	0.8008	40.2344	61.7188
6309.5977	17.0360	0.8281	40.2344	61.7188
6309.7773	17.5278	0.8203	40.2344	62.1094
6309.7891	17.2418	0.8008	40.2344	62.1094
6309.8281	16.8724	0.7969	40.2344	62.1094
6309.8789	16.8512	0.8008	40.2344	62.1094
6310.0664	16.7844	0.8164	40.2344	62.1094
6310.2969	16.9755	0.7813	40.2344	62.1094

Figure V.4. Sample RFI Emitter Detection Printout

VI. NEW TECHNOLOGY

There are no reportable new technology items resulting from the work under this contract. The following review activities were performed to determine any reportable items:

1. The key technological concepts and ideas studied and implemented under the contract effort were identified. These consisted of the methods of analysis, coding, and storage of the EEE data. The extent to which these ideas represented new techniques as versus an application of known techniques was reviewed.

2. A review of appropriate published literature to determine the uniqueness of the ideas developed under the contract was performed.

3. A meeting with the technical officer to discuss the results of the contact effort and points (1) and (2) in connection with efforts performed at GSFC and under contract with other contractors was held.

As a result of the review activities, it was concluded that there were no ideas, discoveries, or improvements or reportable items which were first conceived or reduced to practice under the contract.

VII. CONCLUSIONS

The coding, storage, and retrieval of the electromagnetic environment data was studied. A simple method of universal coding was found which can provide a 6.4 to 1 reduction in storage over the presently used, fixed format tape methods. Display, storage, retrieval, and analysis computer programs were developed and implemented on the GSFC Interdata computer. These methods provide a simple, practical and effective way of storing and analysing the EEE data.

APPENDIX A

R-RATIO ANALYSIS

The R-ratio has been proposed as a method of detecting the presence of RFI emitters. It has been determined empirically that its usefullness is questionable in this regard. This can also be shown theoretically through elementary probabilistic considerations. Let $\{R_i\}$be a set of 39 independent envelope (linear detector) observations. The R-ratio is

$$R = \frac{\left(\frac{1}{39}\sum_{i=1}^{39} R_i\right)^2}{\frac{1}{39}\sum_{i=1}^{39} R_i^2}$$

If R_i is the envelope of a pure Gaussian noise process, then R_i is Rayleigh distributed:

$$p(R_i) = \frac{R_i}{\sigma^2} \exp\left(-R_i^2 / 2\sigma^2\right)$$

where σ^2 is the power associated with the in-phase and quadrature components of the underlying Gaussian noise process.

The mean value of R_i is readily seen to be

$$E\left[R_i\right] = \sqrt{\pi/2}\,\sigma.$$

Similarly, the average value of R_i^2 is found to be

$$E\left[R_i^2\right] = 2\,\sigma^2.$$

Hence the average R-ratio is approximately

$$E\left[R\right] \approx \frac{\left(\sqrt{\pi/2}\sigma\right)^2}{\sigma^2} = \frac{\pi}{4} \approx .79.$$

For a single CW or angle-modulated signal without noise, the R-ratio is obviously $\equiv 1$. However, for amplitude modulation or multiple signal situations, an R-ratio nearer to that for Gaussian noise occurs. Consider specifically the simple situation of two equal amplitude angle-modulated signals. Then, the average value of R_i is

$$E\left[R_i\right] = \frac{1}{2\pi} \int_0^{2\pi} \left[(1+ \cos\theta)^2+(\sin\theta)^2\right]^{\frac{1}{2}} d\theta$$

$$= 4/\pi.$$

The average value of R_i^2 is

$$E\left[R_i^2\right] = 2,$$

so that average value of the R-ratio is approximately

$$E\left[R\right] \approx \frac{(4/\pi)^2}{2} = 8/\pi^2 \approx .81,$$

or almost the same as for pure noise.

For 39 points, for Gaussian noise, the standard deviation of the R-ratio is determined by the approximate expression

$$R = \frac{\frac{1}{39} \sum_{i=1}^{39} \left[(R_i - \sigma\sqrt{\pi/2}\,) + \sigma\sqrt{\pi/2}\right]^2}{\frac{1}{39} \sum_{i=1}^{39} (R_i^2 - 2\sigma^2\,) + 2\sigma^2}$$

$$\approx \pi/4 + 2\sqrt{\pi/4}\ \frac{1}{39} \sum_{i=1}^{39} (R_i/\sqrt{2}\sigma - \sqrt{\pi/4}\,)$$

$$- \pi/4\ \frac{1}{39} \sum_{i=1}^{39} (R_i^2/2\sigma^2 - 1).$$

From this, one can readily calculate

$$\mathrm{var}^{\frac{1}{2}}(R) \approx \left\{\pi/4 \;\; \frac{1}{39}\left[4 - 5\pi/4\right]\right\}^{\frac{1}{2}} = .03834,$$

which is greater than the difference between the average R-ratios for 2 equal amplitude sinusoidal emitters and noise only.

APPENDIX B

DATA QUANTIZATION ANALYSIS

As discussed in the main text, the data statistics chosen for storage/retrieval were the mean, the R-ratio and the peak/mean ratio. Because the ultimate use of the mean and peak values is in decibels, these quantities are stored in logarithmic form (log companded) on the range 1 to 2^{12}.

The mean is a 12 bit voltage value. Taking unity as the minimum, the maximum range is 0 db to 72.2 db. For 39 points the maximum range of the peak to mean ratio is 1 = 0 db to 39 = 31.8 db. The R-ratio has the maximum range of 1 to 1/39, which taken as a power quantity is 0 to -15.0 db. The R-ratio, however, is not used except in the approximate range of 1 to .5, smaller values than .5 to .6 or so being used to screen out "bad points". Hence the maximum useable range of the R-ratio is approximately 0 to -3 db.

The quantization increment must be chosen so that the quantization noise is significantly less than the receiver noise in the data. If a data range of some maximum value, M db, exists, and q quantization bits are used elementary considerations lead to a quantization one sigma error of

$$M/2^q\sqrt{12} \text{ db},$$

assuming a uniform quantizer is used.

From Appendix A, for Gaussian noise, the R-ratio has a mean + standard deviation-to-mean ratio of approximately

$$1 + \frac{.03834}{\sqrt{\pi/4}} = .184 \text{ db}$$

For M = 3 db, for negligible quantization noise,

$$3/2^q \sqrt{12} \ll .184$$

or:

$$2^q \gg 4.71.$$

Hence 4 bit or so quantization for the R-ratio suffices.

A similar analysis can be used for the mean. Following Appendix A,

$$E\left[\frac{1}{39} \sum_{i=1}^{39} Ri\right] = \sqrt{\pi/2}\ \sigma$$

$$\text{var}^{\frac{1}{2}}\left[\frac{1}{39} \sum_{i=1}^{39} Ri\right] = \left[\frac{1}{39} 2 \ \sigma^2 \left(1 - \frac{\pi}{4}\right)\right]^{\frac{1}{2}}$$

Hence the expected value of the mean plus standard deviation-to-the expected value of the mean ratio is

$$1 + \left[\frac{1 - \pi/4}{39 \ (\pi/4)}\right]^{\frac{1}{2}} = .698 \text{ db}$$

for an M = 72.2 db range,

$$72.2/2^q \sqrt{12} \gg .698$$

or:

$$2^q >> 29.9.$$

Thus 6 bit quantization suffices for the mean value.

The expected value of the peak/mean plus standard deviation-to-expected peak/mean ratio can be shown to have a value in excess of that of a single point which is

$$1 + \left[\frac{1 - \pi/4}{\pi/4}\right]^{\frac{1}{2}} = 1.826 \text{ db}$$

Hence the number of bits assigned to the peak/mean ratio for a range of 31.8 db should satisfy

$$31.8/2^q \quad \sqrt{12} << 1.826$$

or

$$2^q >> 5.03$$

Hence 4 bit quantization is sufficient for the peak/mean ratio.

Thus a total of 6 + 4 + 4 = 14 bits is sufficient for the basic quantization of each of the 3 data points at each frequency.

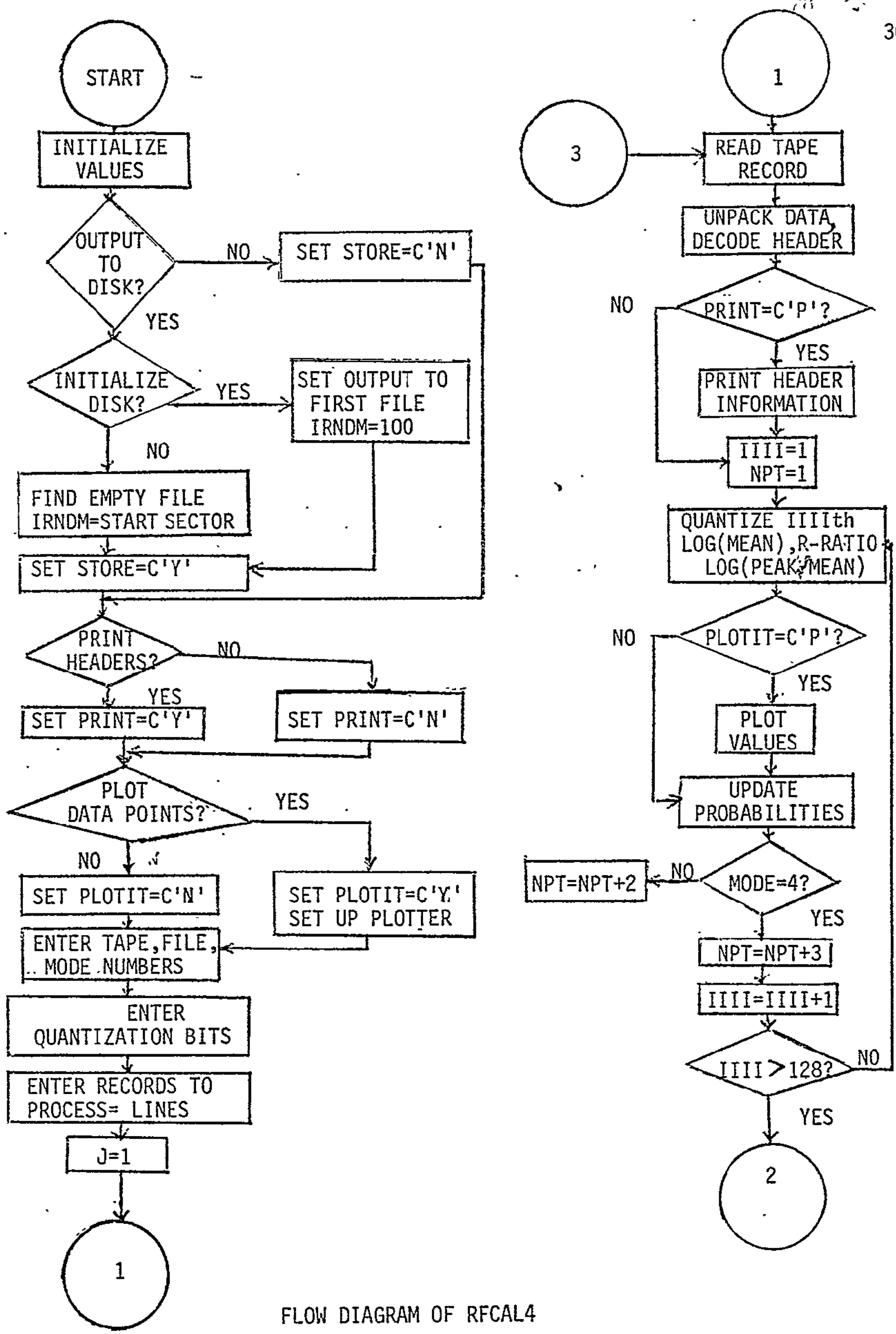
APPENDIX C

FLOW CHART AND SOURCE LISTING

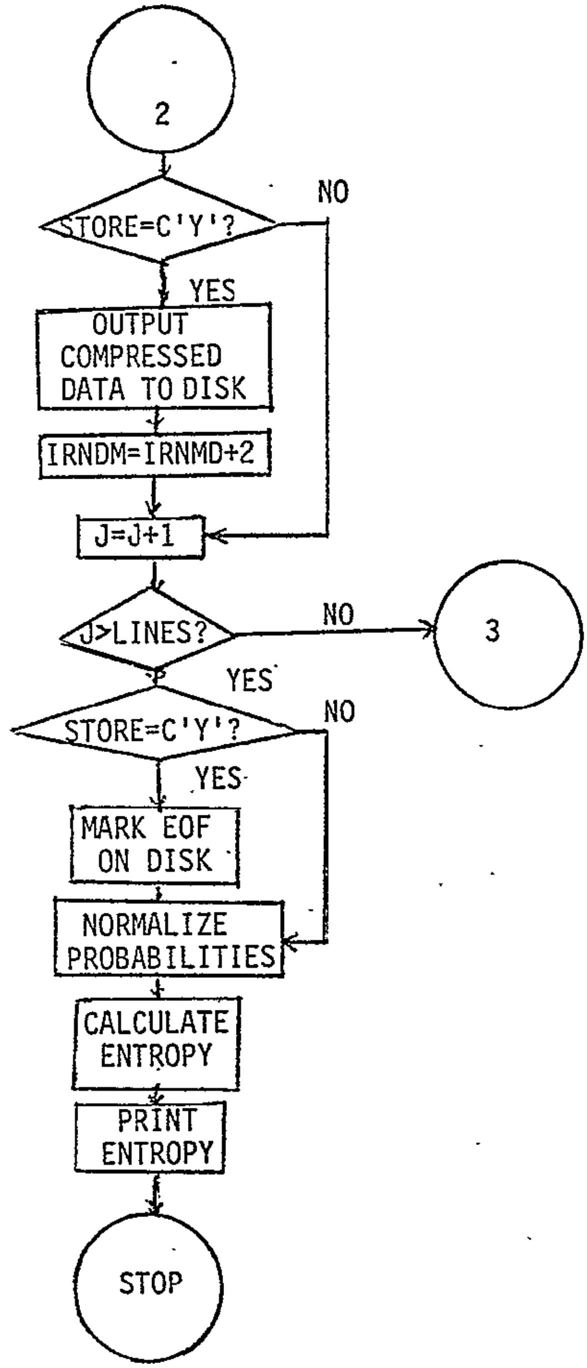
OF

STORAGE/PLOTTING PROGRAM

(RFCAL4)



FLOW DIAGRAM OF RFCAL4



FLOW DIAGRAM OF RFCAL4 (continued)

```
C LAB=RFCAL4
C THIS PRØGRAM IS WRITTEN TØ INPUT RFIME DATA,
C DECØDE THE FØRMATTED DATA THRU SUBRØUTINE
C RFIME, PLØT THE DATA ØN THE VARIAN 514 PLØTTER
C AND QUANTIZE THE VALUES TO AN INPUT NUMBER
C ØF BITS. MEAN(DB).MEAN/PEAK RATIØ(WHEN AVAILABLE)
C R-RATIØ ARE QUANTISED. THE P-RATIØ IS BETWEEN
C 0 AND 1. THE PEAK/MEAN RATIØ AND
C THE MEAN IS BETWEEN 0&100 DB
C QUANTIZED VALUES ARE PLØTTED. MAX BITS IS
C 15. DIFFERENTIAL ENTRØPY ØR 0 ØRDER
C ENTRØPY ØF THE DATA IS CALCULATED
C ØN BITS LE 10.
C DATA CAN BE ØUTPUTTED TØ DISK
C FØR THE TAPE&FILE NØ., THE MØDE NØ.,
C GMT,FREQ.ATTITUDE & TELEMETRY
C DATA, AND THE DATA PØINTS.
C DISK HAS LØG REC ØF 512 BYTES. THUS
C 1128 ØRIGINAL BYTES GØ INTØ 512
C BYTES. 8 BIT QUANT IS USED FØR ØUTPUT.
C DATA STARTS AT SECTØR 100 SØ ØNE CYL
C IS AVAILABLE FØR THE USUAL FØRMAT
C THE FILES ARE PACKED BY 391 RECØRDS
C FØR MØDE 4, 40 RECØRDS FØR MØDES 2&3.
C THE START ØF THE LAST SECTØR IS ZERØ TØ
C DENØTE END. DATA STARTS FRØM THERE UNLESS
C INITIALIZE IS SELECTED.
C
      IMPLICIT INTEGER*2 (I-N)
      DIMENSIØN PDR(2048),PDP(2048)
      DIMENSIØN INP(564),ATITUD(13),PDM(2048)
      DIMENSIØN ITELEM(9),IFREQ(2),IGMT(5)
      DIMENSIØN IPLØT(10),IGD(10)
      DIMENSIØN IØUT(628)
      EQUIVALENCE (IØUT(1),NTAPE),(IØUT(2),NFILE),(IØUT(3),MØDE),
     1 (IØUT(65),INP(1))
      EQUIVALENCE (IØUT(4),IGMT(1)),(IØUT(9),IFREQ(1)),
     1 (IØUT(11),ATITUD(1)),(IØUT(37),ITELEM(1))
      DATA IGD(1),IGD(2),IGD(3),IGD(4),IGD(5),IGD(6)/1,201,401,
     1 601,801,1001/
C READ.WRITE.RANDØM FUNCTIØNS
      DATA IREAD,IWRITE/76,44/
      DATA PEE,ZEE,WHY/1HP,1HZ,1HY/
      IMX=101
      TWØ16=2.**16
C SET QUANTISATIØN PARAMS
      XQUANT=(2.**15)/100.
      RQUANT=2.**15
C ZERØ PRØBABILITY ARRAY
      DØ 24 I=1,2048
      PDR(I)=0.
      PDP(I)=0.
24    PDM(I)=0.
      LASTM=0
      LASTR=0
      LASTP=0
      WRITE(0,34)
34    FØRMAT(15H Y FØR ØUTPUT    )
      READ(0,6) STØRE
      IF(STØRE.NE.WHY) GØ TØ 103
C FIND IF INITIALIZING
      WRITE(0,104)
104   FØRMAT(16HY TØ INITIALIZE  )
      READ(0,6) CLEAR
      IRNDM=100
      IF(CLEAR.EQ.WHY) GØ TØ 103
105      CALL SVC1(IREAD,15,ISTAT,IØUT,512,IRNDM)
      IF(IØUT(1).EQ.0) GØ TØ 103
      INC=80
      IF(MØDE.EQ.4)INC=2*391
      IRNDM=IRNDM+INC
      GØ TØ 105
103   CØNTINUE
C  GET HEADER IN
      CALL RFIME(INP)
C FIND IF PRINT ØF HEADER STUFF IS WANTED
      WRITE(0,5)
5     FØRMAT(17H P FØR PRINT DATA)
      READ(0,6) PRINT
6     FØRMAT(A1)
C FIND IF PLØT ØF PØINTS IS WANTED
      WRITE(0,30)
30    FØRMAT(11H P FØR PLØT)
      READ(0,6) PLØTIT
C FIND TAPE.FILE
      WRITE(0,41)
41    FØRMAT(16H TAPE?.FILE?(I5))
      READ(0,21)NTAPE,NFILE
C FIND MØDE
      WRITE(0,10)
10    FØRMAT(10H MØDE?(I1))
      READ(0,11) MØDE
11    FØRMAT(16I1)
      INC=4
C SPACING ØF DATA DEPENDS ØN MØDE
      IF(MØDE.LE.3.ØR.MØDE.EQ.13) INC=3
C PEAKS DØNT APPEAR IN THESE MØDES
C      SET UP PLØTTER
      CALL SET514(INC-1,IGD,6,0,0,100)
      CALL PLT514(IPLØT,0,0,0)
```

```
C SET NUMB ØF RECS TØ DØ
      LINES=40
      IF(INC.EQ.4)LINES=391
C GET BITS QUANTIZATION IF NØ ØUTPUT
      IBITS=8
      IF(STØRE.EQ.WHY) GØ TØ 37
      WRITE(0,22)
22    FØRMAT(10H BITS?(I5))
      READ(0,21) IBITS
21    FØRMAT(10I5)
37    CØNTINUE
C FIND SHIFT RELATIVE TØ 15 BITS
      IQUANT=2**(15-IBITS)
C FIND IF ZERØ ØRDER ØR DIFF ENTRØPY IS WANTED
      WRITE(0,31)
31    FØRMAT(20H Z FØR 0 ØRDER ENTPY   )
      READ(0,6) ENTPY
      DØ 4 J=1,LINES
C GET INPUT RECØRD IN ARRAY INP
      CALL RFIME(INP)
C SWITCH BYTES IN ARRAY
      CALL SWITCH(INP)
C UNPACK TIME,FREQUENCY,ATTITUDE VALUES
C IGMT(1)=YR,IGMT(2)=DAY,IGMT(3)=HR-MIN,IGMT(4)=SEC
C IGMT(5)=THØUSANDS ØF SECS
C IFREQ(1)=MHZ/50,IFREQ(2)=10,000'S ØF MHZ/50
C ATITUD(I),I=1,13 HAS ATTITUDE PARAMETERS AS PER
C DATA ACQUISITIØN USER'S MANUAL. TELEMETRY VALUES
C MUST BE MØVED FRØM INPUT ARRAY TØ ITELEM
C PRINT ØN FIRST REC ØNLY WHEN PLØT IS WANTED
      DØ 35 I=1,9
35    ITELEM(I)=INP(I+548)
      CALL PARAMS(IGMT,IFREQ,ATITUD,INP)
      IF(PRINT.NE.PEE.AND.J.NE.1) GØ TØ 40
      IF(PLØTIT.EQ.PEE.AND.J.NE.1) GØ TØ 40
      WRITE(3,19) MØDE,LINES
19    FØRMAT(6HOMØDE ,I3,I6,8H RECØRDS)
      WRITE(3,23) IBITS
23    FØRMAT(1H ,I2,21H BITS ØF QUANTIZATIØN)
      WRITE(3,7) IGMT
7     FØRMAT(5H YR =,I3,6H DAY =,I4,7H TIME =,I5,4H AND,I3,
     1 1H.,I3,5H SECS)
      WRITE(3,8) IFREQ
8     FØRMAT(7H FREQ= ,I3,1H.,I4,7H MHZ/50)
      WRITE(3,13)
13    FØRMAT (16HOATTITUDE VALUES)
      WRITE(3,9) ATITUD
9     FØRMAT(1H ,6F12.6)
      WRITE(3,14)
14    FØRMAT(17HOTELEMETRY VALUES)
      WRITE(3,15) ITELEM
15    FØRMAT(1H ,10I6)
      IF(PLØTIT.NE.PEE) GØ TØ 40
C SET UP PLØT
      WRITE(3,16)
16    FØRMAT(45HOPLØT ØF MEAN(DB),PEAK/MEAN RATIØ(DB),R-RATIØ)
      WRITE(3,17)
17    FØRMAT(3H 0.,17X,3H20.,22X,3H40.,
     1 10X,3H DB,9X,3H60.,22X,3H80.,21X,4H100.)
      WRITE(3,18)
18    FØRMAT(3H 0.,16X,3H .2,22X,3H .4,9X,7HRATIØ  ,6X,
     1 3H .6,22X,3H .8,22X,3H 1.)
C 128 DATA BLØCKS PER TAPE RECØRD
40    CØNTINUE
C     NPT PØINTS TØ ØUTPUT STØRE LØCATIØN
      NPT=1
C 128 DATA VALUES PER TAPE BLØCK
      DØ 1 IIII=1,128
C DATA BLØCKS SPACED BY 3 ØR 4 DEPENDING ØN MØDE
      III=INC*(IIII-1)+1
C NØW GET LØG ØF MEAN
      X=AMAXO(INP(III),1)
      IF(X.LT.0.)X=X+TWØ16
      AVG=X
      R=X*X
      X=20.*ALØG10(X)
C QUANTIZE THE MEAN
      KQ=X*XQUANT+.5
      KQ=KQ/IQUANT
C SET UP ØUTPUT
      INP(NPT)=KQ
      NPT=NPT+1
      IDF=KQ-LASTM+1024
      LASTM=KQ
      IF(ENTPY.EQ.ZEE)LASTM=0
      PDM(IDF)=PDM(IDF)+1.
C NØW GØ BACK FØR PLØT
      X=KQ*IQUANT
      X=X/XQUANT
      K=10.*X+1.5
      IPLØT(1)=K
      X=AMAXO(INP(III+1),1)
      IF(X.LT.0.)X=X+TWØ16
      Y=INP(III+2)
      IF(Y.LT.0.)Y=Y+TWØ16
      X=(TWØ16*X+Y)/39.
C R RATIØ= MEAN SQUARED/SUM SQUARES LE 1.
      R=R/X
C QUANTIZE R-RATIØ
      IRQ=R*RQUANT+.5
```

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```
      IRQ=IRQ/IQUANT
C SET UP ØUTPUT
      INP(NPT)=IRQ
      NPT=NPT+1
      IDF=IRQ-LASTR+1024
      LASTR=IRQ
      IF(ENTPY.EQ.ZEE)LASTR=0
      PDR(IDF)=PDR(IDF)+1.
C SHIFT BACK FØR PLØT
      R=IRQ*IQUANT
      R=R/RQUANT
C SKIP PEAK IF NØT IN THIS MØDE
      IF(INC.EQ.3) GØ TØ 12
      X=AMAX0(INP(III+3),1)
      IF(X.LT.0.)X=X+TW016
C PKRAT=MEAN/PEAK RATIØ
      PKRAT=20.*ALØG10(X/AVG)
C QUANTIZE PEAK RATIØ
      IPKRAT=PKRAT*XQUANT+.5
      IPKRAT=IPKRAT/IQUANT
C SET UP ØUTPUT
      INP(NPT)=IPKRAT
      IDF=IPKRAT-LASTP+1024
      LASTP=IPKRAT
      IF(ENTPY.EQ.ZEE) LASTP=0
      PDP(IDF)=PDP(IDF)+1.
C DE-QUANTIZE FØR PLØT
      PKRAT=IPKRAT*IQUANT
      PKRAT=PKRAT/XQUANT
      IPLØT(3)=PKRAT*10.+1.5
C INCREMENT ØUTPUT CØUNTER WHETHER ØR NØT
C PEAK DATA EXISTS
12    NPT=NPT+1
      IR=1000.*R+1.5
      IPLØT(2)=IR
      IF(PLØTIT.EQ.PEE) CALL PLT514(IPLØT,INC-1,1,1)
1     CØNTINUE
C PUT ØUT VALUES IF DESIRED
      IF(STØRE.NE.WHY) GØ TØ 4
C PACK BYTES IN
      CALL PACK(INP(1),384)
C ØUTPUT DATA
      CALL SVC1(IWRITE,15,ISTAT,IØUT,512,IRNDM)
      IRNDM=IRNDM+2
      IF (ISTAT.EQ.0) GØ TØ 4
      WRITE(0,101) ISTAT
101   FØRMAT(10HDISK STAT=,I6)
      PAUSE 1
4     CØNTINUE
      IØUT(1)=0
      IF(STØRE.EQ.WHY)CALL SVC1(IWRITE,15,ISTAT,IØUT,512,IRNDM)
      IF(ISTAT.EQ.0) GØ TØ 102
      WRITE(0,101) ISTAT
      PAUSE 2
102   CØNTINUE
C GET PRØBS,ENTRØPY
      SM=0.
      SR=0.
      SP=0.
      DØ 25 I=1,2048
      SM=SM+PDM(I)
      SR=SR+PDR(I)
25    SP=SP+PDP(I)
      HM=0.
      HR=0.
      HP=0.
      DØ 26 I=1,2048
      IF(PDM(I).EQ.0.) GØ TØ 27
      PDM(I)=PDM(I)/SM
      HM=HM+PDM(I)*ALØG(PDM(I))
27    IF(PDR(I).EQ.0.)GØ TØ 28
      PDR(I)=PDR(I)/SR
      HR=HR+PDR(I)*ALØG(PDR(I))
28    IF(PDP(I).EQ.0.) GØ TØ 26
      PDP(I)=PDP(I)/SP
      HP=HP+PDP(I)*ALØG(PDP(I))
26    CØNTINUE
      HM=-HM/ALØG(2.)
      HR=-HR/ALØG(2.)
      HP=-HP/ALØG(2.)
      IF(ENTPY.EQ.ZEE)WRITE(3,32)
      IF(ENTPY.NE.ZEE)WRITE(3,33)
32    FØRMAT(19H ZERØ ØRDER ENTRØPY)
33    FØRMAT(22H DIFFERENTIAL ENTRØPY )
      WRITE(3,29) HM,HR,HP
29    FØRMAT(15H MEAN ENTRØPY= ,F12.6,19H R-RATIØ ENTRØPY = ,
     1 F12.6,15H PEAK ENTRØPY =,F12.6)
      STØP
      END
  .U      0000R   EXT  FUNC
  PDR     113CR   REAL VAR
  PDP     313CR   REAL VAR
  INP     518CR   INT2 VAR
  ATITUD  5150R   REAL VAR
  ITELEM  5184R   INT2 VAR
  IFREQ   514CR   INT2 VAR
  IGMT    5142R   INT2 VAR
  IØUT    513CR   INT2 VAR
  NTAPE   513CR   INT2 VAR
  NFILE   513ER   INT2 VAR
```

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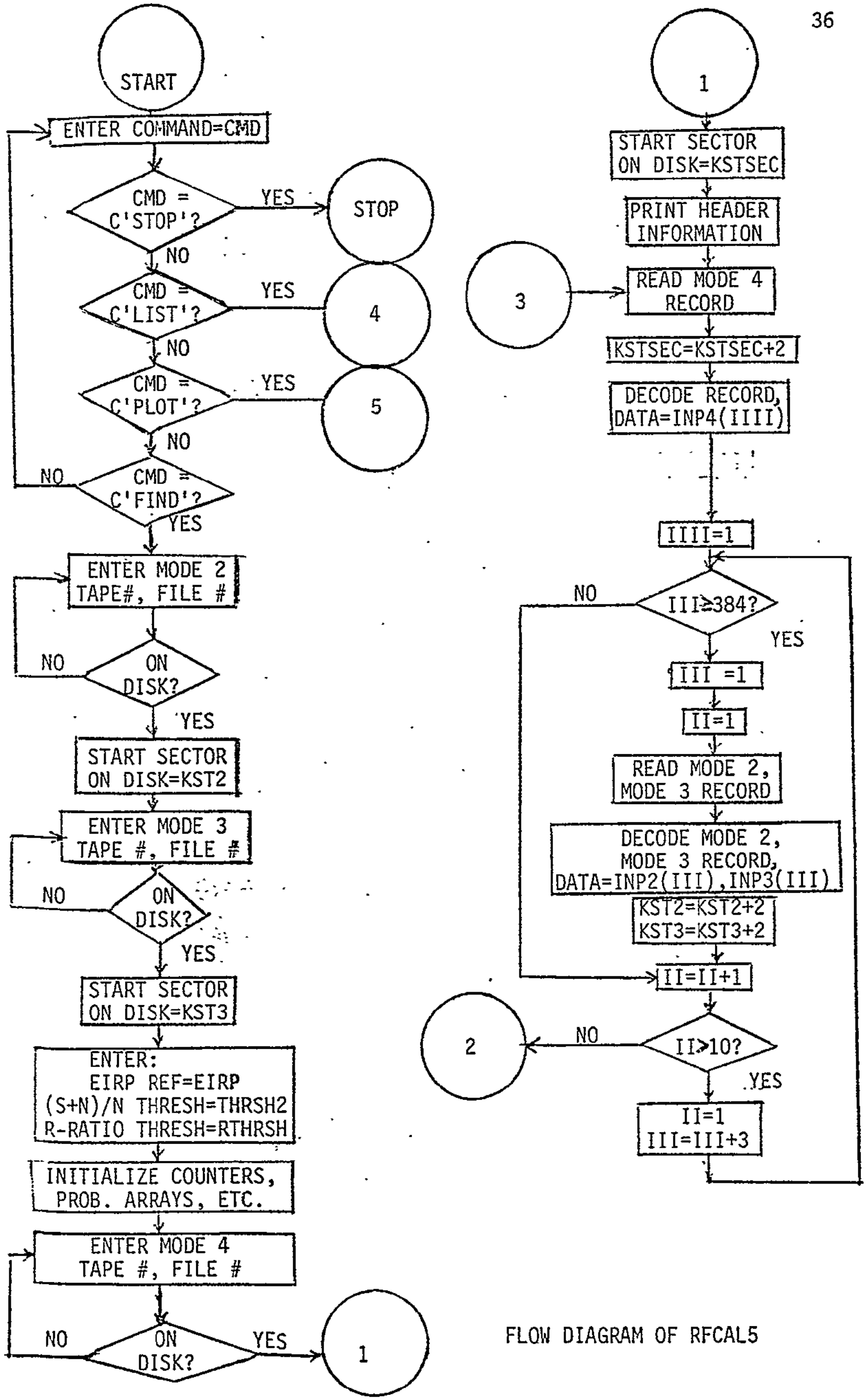
APPENDIX D

FLOW CHART AND SOURCE LISTING

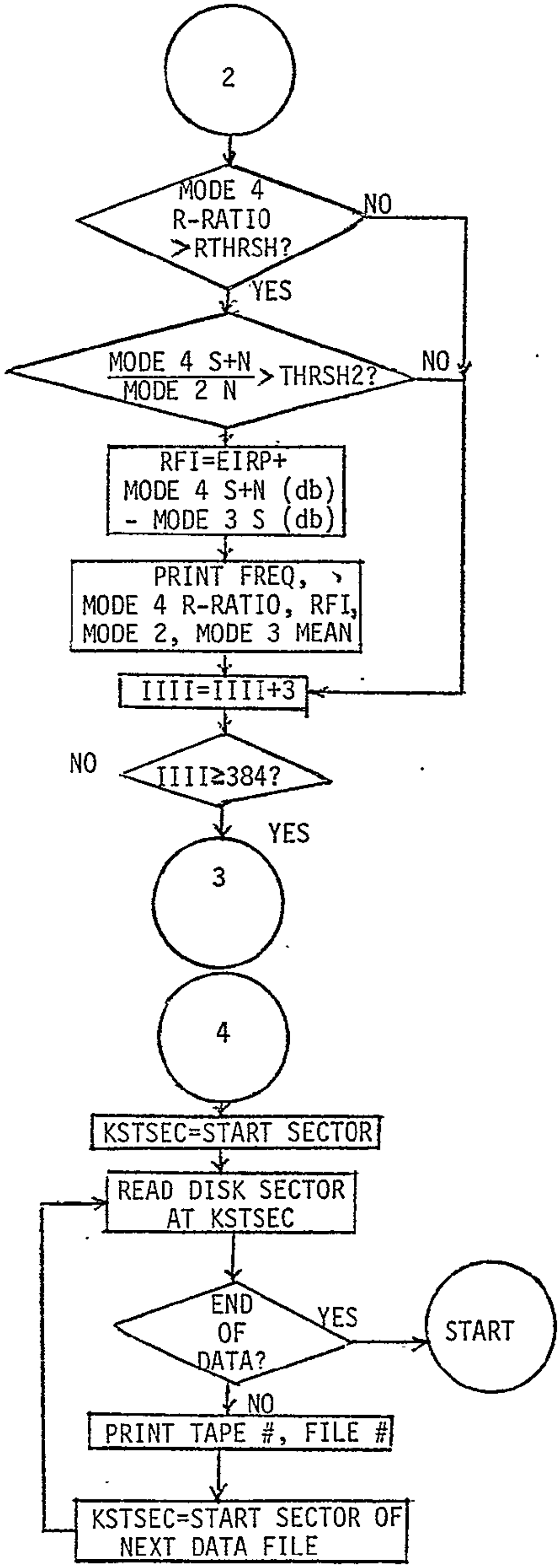
OF

RETRIEVAL/PLOTTING/RFI DETECTION PROGRAM

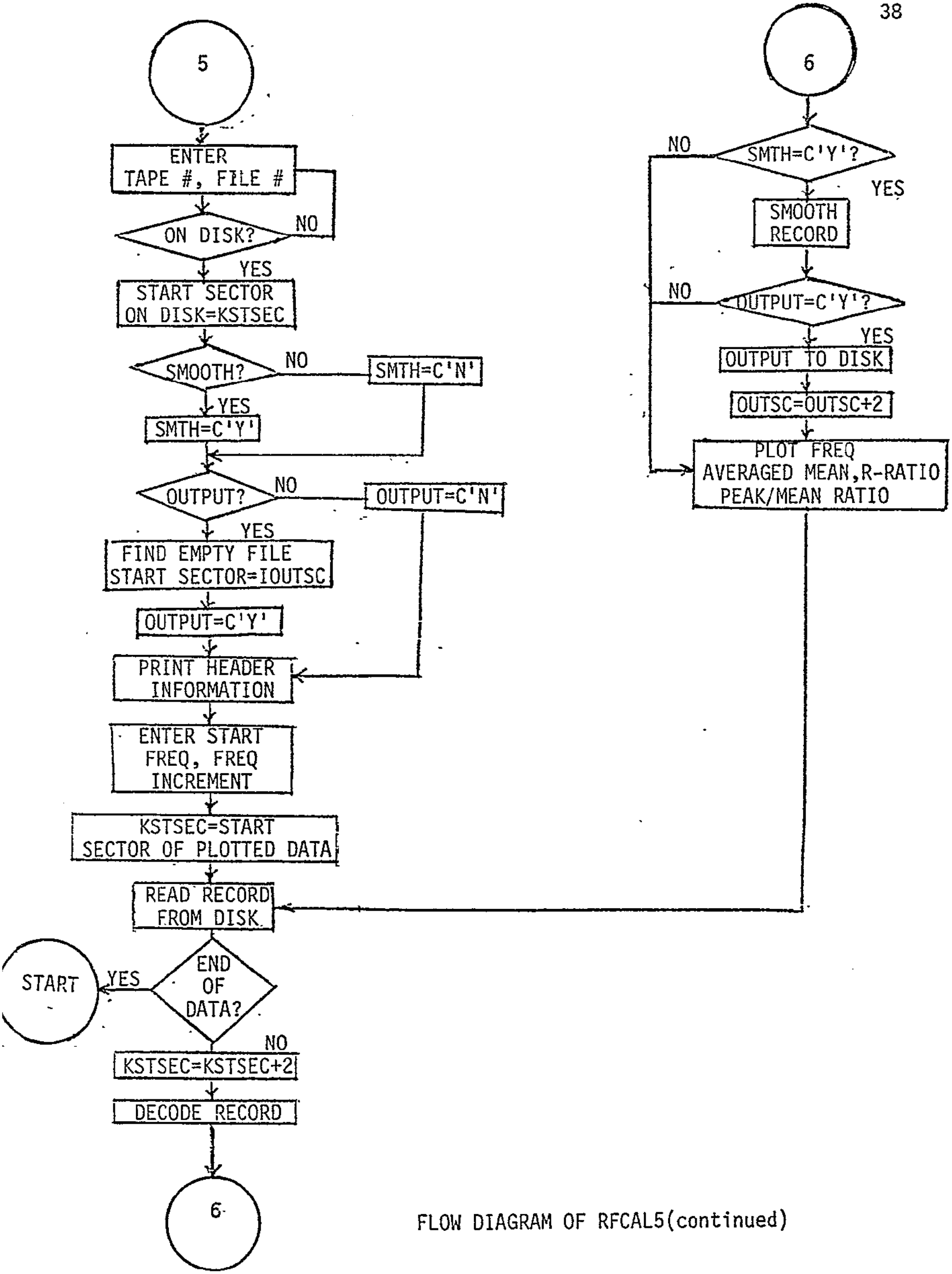
(RFCAL5)



FLOW DIAGRAM OF RFCAL5



FLOW DIAGRAM OF RFCAL5(continued)



FLOW DIAGRAM OF RFCAL5(continued)

```
C LAB=RFCAL5
C THIS PRØGRAM IS WRITTEN TØ INPUT RFIME DATA.
C IN CØMPRESSED FØRM BY RFCAL4 ØN DISK
C PLØT THE DATA ØN THE VARIAN 514 PLØTTER
C INPUT DATA IS QUANTIZED TØ 6 BITS. ØN RECØNSTRUCTIØN,
C THE R-RATIØ IS BETWEEN
C 0 AND 1. THE PEAK/MEAN RATIØ AND
C THE MEAN ARE BETWEEN 0&100 DB
C DIFFERENTIAL ENTRØPY ØR 0 ØRDER
C ENTRØPY ØF THE DATA IS CALCULATED
C DISK HAS LØG REC ØF 512 BYTES. THUS
C 1128 ØRIGINAL BYTES GØ INTØ 512
C BYTES.
C DATA STARTS AT SECTØR 100 SØ ØNE CYL
C IS AVAILABLE FØR THE USUAL FØRMAT
C THE FILES ARE PACKED BY 351 RECØRDS
C FØR MØDE 4. 40 RECØRDS FØR MØDES 2&3.
C THE START ØF THE LAST SECTØR IS ZERØ TØ
C DENØTE END.
C
      IMPLICIT INTEGER*2 (I-N)
      DIMENSIØN PDR(1024),PDP(1024)
      DIMENSIØN INP4(564),ATITUD(13),PDM(1024)
      DIMENSIØN ITELEM(9),IFREQ(2),IGMT(5),CMDS(8)
      DIMENSIØN IPLØT(10),IGD(10)
      DIMENSIØN INP2(564),INP3(564)
      DIMENSIØN IRD4(628),IRD2(628),IRD3(628)
      DIMENSIØN INPSAV(96),INP5(564)
      EQUIVALENCE (IRD4(41),INP5(1))
      EQUIVALENCE (INP2(1),IRD2(65)),(INP3(1),IRD3(65))
      EQUIVALENCE (IRD4(1),NTAPE),(IRD4(2),NFILE),(IRD4(3),MØDE),
     1 (IRD4(65),INP4(1))
      EQUIVALENCE (IRD4(4),IGMT(1)),(IRD4(9),IFREQ(1)),
     1 (IRD4(11),ATITUD(1)),(IRD4(37),ITELEM(1))
      DATA IGD(1),IGD(2),IGD(3),IGD(4),IGD(5),IGD(6)/1,201,401,
     1 601,801,1001/
      DATA NSTART,NSMØTH/100,32/
      DATA CMDS(1),CMDS(2),CMDS(3),MAXCMD/4HLIST,4HPLØT,4HFIND,4/
      DATA CMDS(4)/4HSTØP/
      DATA IREAD,IWRITE/76,44/
      DATA PEE,ZEE,WHY/1HP,1HZ,1HY/
      DATA TWØ16,XQUANT,RQUANT,IBITS,IQUANT/65536.,327.68,32768.,8,128/
54    WRITE(0,50)
50    FØRMAT(12HCØMMAND?(A4))
      READ(0,51) CMD
51    FØRMAT(A4)
      DØ 52 ICMD=1,MAXCMD
      IF(CMD.EQ.CMDS(ICMD)) GØ TØ 53
52    CØNTINUE
      WRITE(0,55)
55    FØRMAT(9HNØT FØUND)
      GØ TØ 54
53    GØ TØ (101,102,103,104),ICMD
C LIST FILES ØN DISK
101   IRNDM=NSTART
56    CALL SVC1(IREAD,15,ISTAT,IRD4,6,IRNDM)
      IF(NTAPE.EQ.0) GØ TØ 54
      WRITE(3,66) NTAPE,NFILE,IRNDM
      IRNDM=IRNDM+702*MAXO(MØDE,3)-2026
      GØ TØ 56
C
C PRINT ØUT EMMITERS
103   WRITE(0,57)
57    FØRMAT(11HMØDE 2 REF?)
      READ(0,21) NTREF2,NFREF2
      IRNDM=NSTART
58    CALL SVC1(IREAD,15,ISTAT,IRD4,6,IRNDM)
      IF(NTAPE.EQ.0) GØ TØ 35
      IF(NTREF2.EQ.NTAPE.AND.NFREF2.EQ.NFILE) GØ TØ 59
      IRNDM=IRNDM+702*MAXO(MØDE,3)-2026
      GØ TØ 58
59    KST2=IRNDM
      WRITE(0,60)
60    FØRMAT(11HMØDE 3 REF?)
      READ (0,21)NTREF3,NFREF3
      IRNDM=NSTART
61    CALL SVC1(IREAD,15,ISTAT,IRD4,6,IRNDM)
      IF(NTAPE.EQ.0) GØ TØ 35
      IF(NTREF3.EQ.NTAPE.AND.NFREF3.EQ.NFILE)GØ TØ 62
      IRNDM=IRNDM+702*MAXO(3,MØDE)-2026
      GØ TØ 61
62    KST3=IRNDM
      WRITE(0,71)
71    FØRMAT(32HEIRP REF(DB),NTHRESH(DB),RTHRESH)
      READ(0,43)EIRP,THRSH2,RTHRSH
C EIRP= EIRP ØF MØDE 3 REF,NTHRESH=THRESHØLD ABØVE NØISE,RTHRSH
C = R-RATIØ THRESHØLD
      NTHRSH=255.*THRSH2/100.+.5
      IRTHSH=255.*RTHRSH+.5
C GET QUANTIZED EQUIVALENTS
102   CØNTINUE
C ZERØ PRØBABILITY ARRAY
      DØ 24 I=1,1024
      PDR(I)=0.
      PDP(I)=0.
24    PDM(I)=0.
```

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```
      LASTM=0
      LASTR=0
      LASTP=0
6     FØRMAT(A1)
C FIND TAPE,FILE
38    WRITE(0,41)
41    FØRMAT(16H TAPE?,FILE?(I5))
      READ(0,21)NTPIN,NFLIN
21    FØRMAT(15I5)
C FIND IT ØN DISK
      IRNDM=NSTART
C START SECTØR
34    CALL SVC1(IREAD,15,ISTAT,IRD4,6,IRNDM)
      IF(NTAPE.EQ.0) GØ TØ 35
C NØT FØUND IF ZERØ ENCØUNTERED
      IF(NTAPE.EQ.NTPIN.AND.NFLIN.EQ.NFILE) GØ TØ 36
      IDINC=80
      IF(MØDE.EQ.4)IDINC=782
      IRNDM=IRNDM+IDINC
      GØ TØ 34
35    WRITE(0,37)
37    FØRMAT(19HTAPE&FILE NØT FØUND)
      GØ TØ 38
36    KSTSEC=IRNDM
      IF(ICMD.EQ.2)GØ TØ 70
C BRANCH ØN PLØT CØMMAND
C ELSE FIND EMMITERS MØDE
      II=10
      III=384
CIII PØINTS TØ MØDE2&3 DATA& INCREMENTS AT 1/10 RATE
      IFRQD=-25001
C STARTING FREQ INCREMENT
C PUT ØUT HEADER INFØ
      WRITE(3,76)NTREF2,NFREF2,NTREF3,NFREF3,NTPIN,NFLIN
76    FØRMAT(18H1TAPES PRØCESSED: ,3(I5,1H/,I3))
      WRITE(3,77) EIRP,THRSH2,RTHRSH
77    FØRMAT(13HMØDE 3 DBW = ,F5.0,18H, NØISE THRESHØLD,F5.2,3H DB,
     1 20H R-RATIØ THRESHØLD = ,F5.4)
      WRITE(3,78)
78    FØRMAT(13H    FREQ(MHZ),4X,8HRFI(DBW),4X,7HR-RATIØ,5X,
     1 10HMØDE 2(DB) ,2X,10HMØDE 3(DB) )
73    CALL SVC1(IREAD,15,ISTAT,IRD4,512,KSTSEC)
      KSTSEC=KSTSEC+2
      IF(NTAPE.NE.NTPIN.ØR.NFILE.NE.NFLIN) GØ TØ 54
C QUIT ØN END
      CALL UNPACK(INP4,384)
      DØ 74 IIII=1,384,3
      IFRQD=IFRQD+1
      II=II+1
      IF(II.LE.10) GØ TØ 72
      II=0
C II CØUNTS FØR MØDE 2&3DATA
      III=III+3
C III PØINTS TØ NEXT VALUE
      IF(III.LT.384)GØ TØ 72
      CALL SVC1(IREAD,15,ISTAT,IRD2,512,KST2)
      CALL UNPACK(INP2,384)
C NEW MØDE 2&3DATA
      CALL SVC1(IREAD,15,ISTAT,IRD3,512,KST3)
      CALL UNPACK(INP3,384)
      KST2=KST2+2
      KST3=KST3+2
      III=1
72    CØNTINUE
C GØ THRU MØDE 4 DATA
      IRQ=INP4(IIII+1)
      IF(IRQ.LT.IRTHSH) GØ TØ 74
C TEST FØR NØISE
      KQ=INP4(IIII)
      IF(KQ-INP2(III).LT.NTHRSH)GØ TØ 74
C ØTHER TEST FØR NØISE
      X=(KQ-INP3(III))*IQUANT
C RECØNSTRUCT EIRP
      X=X/XQUANT
      X=X+EIRP
      R=FLØAT(IRQ*IQUANT)/RQUANT
      R3=FLØAT(INP3(III+1)*IQUANT)/RQUANT
C ADJUST FRØM MEAN TØ PØWER
      X=X+10.*ALØG10(R3/R)
      X2=FLØAT(INP2(III)*IQUANT)/XQUANT
      X3=FLØAT(INP3(III)*IQUANT)/XQUANT
      FREQ=6175.+.01*FLØAT(IFRQD)
      WRITE(3,75) FREQ,X,R,X2,X3
75    FØRMAT(1H ,5F12.4)
74    CØNTINUE
      GØ TØ 73
70    IBLK=-9+MAX0(MØDE,3)+37
C INCREMENTS ARE 100 KHZ FØR MØDE 2,3,10 KHZ FØR MØDE 4
      XBLK=FLØAT(IBLK)*.01
C XBLK=FREQ INCR IN MHZ
      WRITE(0,42)
42    FØRMAT(16HFREQ,DELTAF(MHZ):)
      READ(0,43) SFREQ,DELTF
43    FØRMAT(6F5.2)
C kF=NUMB ØF BLØCKS FØRWARD
C FØR MØDE 4 DATA
```

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```
      KF=(SFREQ-5925.)/1.28
      IF(KF.GE.0.AND.KF.LT.391) GØ TØ 44
      WRITE(0,45)
45    FØRMAT(12HØUT ØF RANGE)
      GØ TØ 36
44    KF=KF/IBLK
C BLØCK INCR ADJUSTED FØR MØDE
      IAVG=DELTF/XBLK+.5
      IAVG=MAX0(IAVG,1)
C NUMB ØF PØINTS TØ AVG MUST BE AT LEAST 1
      XAVG=IAVG
      DELTFR=XAVG*XBLK
11    FØRMAT(16I1)
C     SET UP PLØTTER
      CALL SET514(3,IGD,6,0,0,100)
C ØNE GRID LINE=100 PTS=100*DELTFR MHZ
      GRIDL=100.*DELTFR
      CALL PLT514(IPLØT,0,0,0)
C SET NUMB ØF RECS TØ DØ
C &  PLACE TØ START
      IRNDM=KSTSEC+KF+KF
C REMEMBER,IBLK=10 FØR MØDE 2,3 - IBLK=1 FØR MØDE 4.
      LINES=389/IBLK+2
      LINES=LINES-KF
C FIND IF ZERØ ØRDER ØR DIFF ENTRØPY IS WANTED
      WRITE(0,31)
31    FØRMAT(20H Z FØR 0 ØRDER ENTPY
      READ(0,6) ENTPY
      WRITE(0,80)
80    FØRMAT(12HY FØR SMØØTH)
      READ(0,6) SMTH
      ØUTPUT=0.
      IF(SMTH.NE.WHY.ØR.MØDE.NE.2) GØ TØ 92
C FIND IF SMØØTHED TØ BE ØUTPUTTED
      WRITE(0,93)
93    FØRMAT(12HY FØR ØUTPUT)
      READ (0,6) ØUTPUT
      IF(ØUTPUT.NE.WHY) GØ TØ 92
C FIND NEW TAPE NUMBER
      WRITE(0,41)
      READ(0,21) NEWTP,NEWFL
C FIND START SECTØR
      IØUTSC=IRNDM
94    CALL SVC1(IREAD,15,ISTAT,IR...,6,IØUTSC)
      IF(IRD2(1).EQ.0) GØ TØ 92
      IØUTSC=IØUTSC+702*MAX0(3,IRD2(3))-2026
      GØ TØ 94
92    NPLTAV=0
C COUNTS TØ NUMBER TØ AVERAGE FØR PLØTTING.
      MNAVG=0
      IRAVG=0
      IPKPK=0
C ZERØ AVG VALUES TØØ
      INITAT=0
C ADJUSTS SMØØTHING FØR FIRST TIME THRØUGH.
C RESET START SECTØR
      DØ 4 J=1,LINES
C GET INPUT RECØRD IN ARRAY INP4
      CALL SVC1(IREAD,15,ISTAT,IRD4,512,IRNDM)
      IRNDM=IRNDM+2
C SET FØR NEXT ACCESS
C UNPACK BYTES TØ HW
      CALL UNPACK(INP4,384)
C IGMT(1)=YR,IGMT(2)=DAY,IGMT(3)=HR-MIN,IGMT(4)=SEC
C IGMT(5)=THØUSANDS ØF SECS
C IFREQ(1)=MHZ/50,IFREQ(2)=10,000'S ØF MHZ/50
C ATITUD(I),I=1,13 HAS ATTITUDE PARAMETERS AS PER
C DATA ACQUISITIØN USER'S MANUAL.

C PRINT ØN FIRST REC ØNLY WHEN PLØT IS WANTED
      IF(J.NE.1) GØ TØ 40
      WRITE(3,66) NTAPE,NFILE,KSTSEC
66    FØRMAT(6HTAPE =,I6,7H FILE =,I6,15H START SECTØR =,I7)
      WRITE(3,23)IBITS
23    FØRMAT(1H ,I2,21H BITS ØF QUANTIZATIØN)
      WRITE(3,7) IGMT
7     FØRMAT(5H YR =,I3,6H DAY =,I4,7H TIME =,I5,4H AND,I3,
     1 1H.,I3,5H SECS)
      FREQ=50.*(FLØAT(IFREQ(1))+FLØAT(IFREQ(2))/10000.)
      WRITE(3,8) FREQ,DELTFR,GRIDL
8     FØRMAT(12HSTART FREQ= ,F10.4,4H MHZ,10H DELTAF = ,
     1 F10.4,5H MHZ,,F10.4,14H MHZ/GRID LINE )
      WRITE(3,13)
13    FØRMAT (16H0ATTITUDE VALUES)
      WRITE(3,9) ATITUD
9     FØRMAT(1H ,6F12.6)
      WRITE(3,14)
14    FØRMAT(17H0TELEMETRY VALUES)
      WRITE(3,15) ITELEM
15    FØRMAT(1H ,10I6)
C SET UP PLØT
      WRITE(3,16)
16    FØRMAT(45H0PLØT ØF MEAN(DB),PEAK/MEAN RATIØ(DB),R-RATIØ)
      WRITE(3,17)
17    FØRMAT(3H 0.,17X,3H20.,22X,3H40.,
     1 10X,3H IB,9X,3H60.,22X,3H80.,21X,4H100.)
      WRITE(3,18)
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```
18      FØRMAT(3H 0., 16X,3H .2,22X,3H .4,9X,7HRATIØ  ,6X,
     1 3H .6,22X,3H .8,22X,3H 1.)
C 128 DATA BLØCKS PER TAPE RECØRD
40      CØNTINUE
        IF(SMTH.NE.WHY) GØ TØ 81
C GET AN EXTRA BLØCK FØR ØVERLAP
        CALL SVC1(IREAD,15,ISTAT,IRD2,512,IRNDM)
        CALL UNPACK(INP2,384)
C SMØØTH VALUES
        NSM3=3*NSMØTH/2
        NSM2=NSMØTH/2
        NSM4=NSM2/2
        NSM43=3*NSM4
        DØ 90 I=1,NSM43
        II=I+384
        INP5(I)=INPSAV(I)
        INP4(II)=INP2(I)
        II=384-NSM43+I
        INPSAV(I)=INP4(II)
C SAVE FØR NEXT TIME
90      CØNTINUE
        DØ 82 IIII=1,384,NSM3
        IF(J.EQ.LINES.AND.IIII.GE.384-NSM3)INITAT=NSM2
        DØ 83 II=1,NSMØTH
        K=IIII+3*(II+NSM4-INITAT-1)
        IRD2(II)=INP5(K)
        IRD3(II)=INP5(K+1)
        IRD4(II)=INP5(K+2)
        IF(INP5(K+1).GT.128) GØ TØ 83
C FILL IN BAD ØNES
        IRD2(II)=(INP5(K-3)+INP5(K+3))/2
        IRD3(II)=(INP5(K-2)+INP5(K+4))/2
        IRD4(II)=(INP5(K-1)+INP5(K+5))/2
83      CØNTINUE
        CALL SMØØTH(IRD2,NSMØTH)
        CALL SMØØTH(IRD3,NSMØTH)
        IF(MØDE.EQ.4)CALL SMØØTH(IRD4,NSMØTH)
        DØ 84 II=1,NSM2
C INITAT=0 FIRST TIME, THEN NSM4
        III=II+INITAT
        K=IIII+3*II-3
        INP4(K)=IRD2(III)
        INP4(K+1)=IRD3(III)
        INP4(K+2)=IRD4(III)
84      CØNTINUE
        INITAT=NSM4
C NØW FIRST BLØCK IS TAKEN CARE ØF
82      CØNTINUE
        IF(ØUTPUT.NE.WHY) GØ TØ 81
C SET UP ØUTPUT
        CALL SVC1(IREAD,15,ISTAT,IRD2,512,IRNDM-2)
        DØ 95 I=1,384
C PUT IN SMØØTH VALUES
95      INP2(I)=INP4(I)
C PUT IN TAPE,FILE
        IRD2(1)=NEWTP
        IRD2(2)=NEWFL
C MUST BE MØDE 2
        IRD2(3)=2
C PACK IT
        CALL PACK(INP2,384)
        CALL SVC1(IWRITE,15,ISTAT,IRD2,512,IØUTSC)
        IØUTSC=IØUTSC+2
81      DØ 1 IIII=1,384,3
C QUANTIZED MEAN
        KQ=INP4(IIII)
        MNAVG=MNAVG+KQ
C UPDATE AVERAGE
        IDF=KQ-LASTM+512
        LASTM=KQ
        IF(ENTPY.EQ.ZEE)LASTM=0
        PDM(IDF)=PDM(IDF)+1.
C R RATIØ= MEAN SQUARED/SUM SQUARES LE 1.
C QUANTIZED R-RATIØ
        IRQ=INP4(IIII+1)
        IRAVG=IRAVG+IRQ
C UPDATE AVERAGE
        IDF=IRQ-LASTR+512
        LASTR=IRQ
        IF(ENTPY.EQ.ZEE)LASTR=0
        PDR(IDF)=PDR(IDF)+1.
C SKIP PEAK IF NØT IN THIS MØDE
        IF(MØDE.NE.4) GØ TØ 12
C PKRAT=PEAK/MEAN RATIØ
        IPKRAT=INP4(IIII+2)
        IF(IPKRAT.GE.82)IPKRAT=0
C CØRRECTIØN FØR PEAK .LT.MEAN
        IPKPK=MAX0(IPKPK,IPKRAT+KQ)
C UPDATE PEAK VALUE
        IDF=IPKRAT-LASTP+512
        LASTP=IPKRAT
        IF(ENTPY.EQ.ZEE) LASTP=0
        PDP(IDF)=PDP(IDF)+1.
12      NPLTAV=NPLTAV+1
        IF(NPLTAV.LT.IAVG)GØ TØ 1
        NPLTAV=0
```

```
      KQ=FLØAT(MNAVG)/XAVG+.5
      X=KQ*IQUANT
      X=X/XQUANT
      IPLØT(1)=10.*X+1.5
      IRQ=FLØAT(IRAVG)/XAVG+.5
      R=IRQ+IQUANT
      R=R/RQUANT
      IPLØT(2)=1000.*R+1.5
      PKRAT=(IFKPK-KQ)*IQUANT
      PKRAT=PKRAT/XQUANT
      IPLØT(3)=PKRAT*10.+1.5
      MNAVG=0
      IRAVG=0
      IPKPK=0
      CALL PLT514(IPLØT,3,1,1)
1     CØNTINUE
4     CØNTINUE
C PUT ØUT ZERØ IF ØUTPUTTING SMØØTHED
      NTAPE=0
      IF(ØUTPUT.EQ.WHY)CALL SVC1(IWRITE,15,ISTAT,IRD4,6,IØUTSC)
C GET PRØBS,ENTRØPY
      SM=0.
      SR=0.
      SP=0.
      DØ 25 I=1,1024
      SM=SM+PDM(I)
      SR=SR+PDR(I)
25    SP=SP+PDP(I)
      HM=0.
      HR=0.
      HP=0.
      DØ 26 I=1,1024
      IF(PDM(I).EQ.0.) GØ TØ 27
      PDM(I)=PDM(I)/SM
      HM=HM+PDM(I)*ALØG(PDM(I))
27    IF(PDR(I).EQ.0.)GØ TØ 28
      PDR(I)=PDR(I)/SR
      HR=HR+PDR(I)*ALØG(PDR(I))
28    IF(PDP(I).EQ.0.) GØ TØ 26
      PDP(I)=PDP(I)/SP
      HP=HP+PDP(I)*ALØG(PDP(I))
26    CØNTINUE
      HM=-HM/ALØG(2.)
      HR=-HR/ALØG(2.)
      HP=-HP/ALØG(2.)
      IF(ENTPY.EQ.ZEE)WRITE(3,32)
      IF(ENTPY.NE.ZEE)WRITE(3,33)
32    FØRMAT(19H ZERØ ØRDER ENTRØPY)
33    FØRMAT(22H DIFFERENTIAL ENTRØPY )
      WRITE(3,29) HM,HR,HP
29    FØRMAT(15H MEAN ENTRØPY= ,F12.6,19H R-RATIØ ENTRØPY = ,
     1 F12.6,15H PEAK ENTRØPY =,F12.6)
      GØ TØ 54
104   STØP
      END
  .U        0000R   EXT FUNC
  PDR       1C1ER   REAL VAR
  PDP       2C1ER   REAL VAR
  INP4      3C9ER   INT2 VAR
  ATITUD    3C32R   REAL VAR
  ITELEM    3C66R   INT2 VAR
  IFREQ     3C2ER   INT2 VAR
  IGMT      3C24R   INT2 VAR
  IRD4      3C1ER   INT2 VAR
  INP5      3C6ER   INT2 VAR
  NTAPE     3C1ER   INT2 VAR
  NFILE     3C20R   INT2 VAR
  MØDE      3C22R   INT2 VAR
  PDM       4106R   REAL VAR
  CMDS      0020R   REAL VAR
  IPLØT     5106R   INT2 VAR
  IGD       0008R   INT2 VAR
  INP2      519AR   INT2 VAR
  IRD2      511AR   INT2 VAR
  INP3      5682R   INT2 VAR
  IRD3      5602R   INT2 VAR
  INPSAV    5AEAR   INT2 VAR
  NSTART    001CR   INT2 VAR
  NSMØTH    001ER   INT2 VAR
  MAXCMD    0040R   INT2 VAR
  IREAD     0042R   INT2 VAR
  IWRITE    0044R   INT2 VAR
  PEE       0046R   REAL VAR
  ZEE       004AR   REAL VAR
  WHY       004ER   REAL VAR
  TWØ16     0052R   REAL VAR
  XQUANT    0056R   REAL VAR
  RQUANT    005AR   REAL VAR
  IBITS     005ER   INT2 VAR
  IQUANT    0060R   INT2 VAR
  54        0062R   LABEL
  50        007AR   LABEL
  @H        0000R   EXT FUNC
  51        00B0R   LABEL
  CMD       5BAAR   REAL VAR
  52        00DER   LABEL
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```
ICMD    5BAER  INT2 VAR
53      011ER  LABEL
55      0108R  LABEL
101     0136R  LABEL
102     03E4R  LABEL
103     0182R  LABEL
104     1C14R  LABEL
IRNDM   5BB0R  INT2 VAR
56      013ER  LABEL
SVC1    0000R  EXT FUNC
ISTAT   5BB6R  INT2 VAR
66      0DE0R  LABEL
MAX0    0000R  EXT FUNC
57      01CAR  LABEL
21      04B4R  LABEL
NTREF2  5BCCR  INT2 VAR
NFREF2  5BCER  INT2 VAR
58      020ER  LABEL
35      0538R  LABEL
59      0272R  LABEL
KST2    5BD0R  INT2 VAR
60      0292R  LABEL
NTREF3  5BD2R  INT2 VAR
NFREF3  5BD4R  INT2 VAR
61      02D6R  LABEL
62      033AR  LABEL
KST3    5BD6R  INT2 VAR
71      035AR  LABEL
43      0A50R  LABEL
EIRP    5BD8R  REAL VAR
THRSH2  5BDCR  REAL VAR
RTHRSH  5BE0R  REAL VAR
NTHRSH  5BE4R  INT2 VAR
.Y      0000R  EXT FUNC
IRTHSH  5BF2R  INT2 VAR
24      0414R  LABEL
I       5BF4R  INT2 VAR
LASTM   5BFAR  INT2 VAR
LASTR   5BFCR  INT2 VAR
LASTP   5BFER  INT2 VAR
6       0452R  LABEL
38      045AR  LABEL
41      0472R  LABEL
NTPIN   5C00R  INT2 VAR
NFLIN   5C02R  INT2 VAR
34      04C6R  LABEL
36      0570R  LABEL
IDINC   5C04R  INT2 VAR
37      0550R  LABEL
KSTSEC  5C12R  INT2 VAR
70      09C6R  LABEL
II      5C18R  INT2 VAR
III     5C1ER  INT2 VAR
IFRQD   5C24R  INT2 VAR
76      05EER  LABEL
77      0646R  LABEL
78      06B6R  LABEL
73      070AR  LABEL
UNPACK  0000R  EXT FUNC
74      09B0R  LABEL
IIII    5C36R  INT2 VAR
72      0802R  LABEL
IRQ     5C3CR  INT2 VAR
KQ      5C3ER  INT2 VAR
X       5C40R  REAL VAR
.W      0000R  EXT FUNC
R       5C44R  REAL VAR
FLØAT   0000R  EXT FUNC
R3      5C50R  REAL VAR
ALØG10  0000R  EXT FUNC
X2      5C58R  REAL VAR
X3      5C5CR  REAL VAR
FREQ    5C60R  REAL VAR
75      09A0R  LABEL
IBLK    5C6CR  INT2 VAR
XBLK    5C76R  REAL VAR
42      0A0ER  LABEL
SFREQ   5C7AR  REAL VAR
DELTF   5C7ER  REAL VAR
KF      5C82R  INT2 VAR
44      0AC4R  LABEL
45      0AAAR  LABEL
IAVG    5C90R  INT2 VAR
XAVG    5C92R  REAL VAR
DELTFR  5C96R  REAL VAR
11      0B16R  LABEL
SETS14  0000R  EXT FUNC
GRIDL   5C9ER  REAL VAR
PLT514  0000R  EXT FUNC
LINES   5CA2R  INT2 VAR
31      0B96R  LABEL
ENTPY   5CA8R  REAL VAR
80      0BECR  LABEL
SMTH    5CACR  REAL VAR
OUTPUT  5CB0R  REAL VAR
92      0D46R  LABEL
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```
93      0C62R   LABEL
NEWTP   5CB4R   INT2 VAR
NEWFL   5CB6R   INT2 VAR
IØUTSC  5CB8R   INT2 VAR
94      0CF2R   LABEL
NPLTAV  5CBAR   INT2 VAR
MNAVG   5CBCR   INT2 VAR
IRAVG   5CBER   INT2 VAR
IPKPK   5CC0R   INT2 VAR
INITAT  5CC2R   INT2 VAR
4       1868R   LABEL
J       5CC4R   INT2 VAR
40      1156R   LABEL
23      0E34R   LABEL
7       0E7CR   LABEL
8       0F2AR   LABEL
13      0F98R   LABEL
9       0FD4R   LABEL
14      0FFCR   LABEL
15      1038R   LABEL
16      105ER   LABEL
17      10ACR   LABEL
18      110CR   LABEL
81      158ER   LABEL
NSM3    5CCER   INT2 VAR
NSM2    5CD0R   INT2 VAR
NSM4    5CD2R   INT2 VAR
NSM43   5CD4R   INT2 VAR
90      1242R   LABEL
82      14CAR   LABEL
83      13EAR   LABEL
K       5CD6R   INT2 VAR
SMØØTH  0000R   EXT FUNC
84      14B0R   LABEL
95      1514R   LABEL
PACK    0000R   EXT FUNC
1       1856R   LABEL
IDF     5CDCR   INT2 VAR
12      172AR   LABEL
IPKRAT  5CE2R   INT2 VAR
PKRAT   5CF0R   REAL VAR
SM      5CF4R   REAL VAR
SR      5CF8R   REAL VAR
SP      5CFCR   REAL VAR
25      18F2R   LABEL
HM      5D00R   REAL VAR
HR      5D04R   REAL VAR
HP      5D08R   REAL VAR
26      1A9ER   LABEL
27      19B2R   LABEL
ALØG    0000R   EXT FUNC
28      1A28R   LABEL
32      1B50R   LABEL
33      1B6CR   LABEL
29      1BBCR   LABEL
.S      0000R   EXT FUNC
.V      0000R   EXT FUNC

0000 ERRØRS
```

```
C $LAB= SMØØTH
C QUADRATIC SMOØTHING PRØGRAM
C MAKES BEST MS FIT TØ A QUADRATIC
C LDD 1/8/76
C
      SUBRØUTINE SMØØTH(IDAT,N)
C IDAT=INPUT AFRAY,N=NUMBER ØF PØINTS
C SMØØTHED VALLES ARE PUT BACK IN IDAT
      IMPLICIT INTEGER*2 (I-N)
      INTEGER*2 IDAT,N
      DIMENSIØN IDAT(1)
      XN=N
C XM= K BAR,XQ=(K-KBAR)**2 BAR
      XM=(XN+1.)/2.
      XQ=XM*(XN-1.)/6.
      A=0.
      B=0.
      C=0.
      DC=0.
      DØ 1 K=1,N
      X=IDAT(K)
      XK=FLØAT(K)-XM
      A=A+X
      B=B+X*XK
      XK=XK*XK-XQ
      DC=DC+XK*XK
1     C=C+X*XK
      A=A/XN
      B=B/(XQ*XN)
      C=C/DC
      DØ 2 K=1,N
      XK=FLØAT(K)-XM
      X=A+B*XK+C*(XK*XK-XQ)
2     IDAT(K)=X+SIGN(.5,X)
      RETURN
      END
  SMØØTH 0024R   FUNC/SUB
  SMØØTH 01D6R   FUNC VAR
  .Q     0000R   EXT FUNC
  .P     0000R   EXT FUNC
  IDAT   002AR   FØRM PAR
  N      002CR   FØRM PAR
  XN     01DER   REAL VAR
  .W     0000R   EXT FUNC
  XM     01E2R   REAL VAR
  XQ     01EER   REAL VAR
  A      01F6R   REAL VAR
  B      01FER   REAL VAR
  C      0202R   REAL VAR
  DC     0206R   REAL VAR
  1      00F6R   LABEL
  K      020AR   INT2 VAR
```

```
X       020CR   REAL VAR
XK      0210R   REAL VAR
FLØAT   0000R   EXT FUNC
2       0188R   LABEL
SIGN    0000R   EXT FUNC
.Y      0000R   EXT FUNC
```

0000 ERRØRS

```
[illegible]      PRØGRAM TØ DØ I/Ø UNDER FØRTRAN CØNTRØL LDD 12/75          PAGE   1
                       * CALL IS:
                       *      CALL SVC1(ICMD,LU,ISTAT,ISTART,IBYTES,IRANDØM)
                       * WHERE:
                       * ICMD= SVC1 CMD(BYTE)
                       * LU= LØG UNIT
                       * ISTAT=STATUS RETURNED
                       * ISTART= START ADDR
                       * IBYTES=BYTES TØ XFR
                       * IRANDØM= START SECTØR FØR DIRECT DISK ACCESS
                       *
                       * LDD 12/75
                       *
                       *ØPT LAB=SVC1
  0000R                        EXTRN .Ø
  0000R                        ENTRY SVC1
                       *
  0000R D090           SVC1    STM    9,REG            SAVE EM
        0052R
  0004R D19F                   LM     9,0(15)          GET ADDRS
        0000
  0008R 279E                   SIS    9,14             CK NUMB ARGS
  000AR 2336                   BES    ØK
  000CR C8B0                   LHI    11,C'33'
        3333
  0010R 41F0                   BAL    15,.Ø            SEND ERR MESS
        000OF
  0014R E130                   DC     X'E130'          QUIT
  0016R 48AA           ØK      LH     10,0(10)         GET CMD
        0000
  001AR D2A0                   STB    10,SVC
        0060R
  001ER 48BB                   LH     11,0(11)
        0000
  0022R D2B0                   STB    11,SVC+1         SET LU
        0061R
  0026R 40D0                   STH    13,SVC+4         SET START ADDR
        0064R
  002AR 4ADE                   AH     13,0(14)
        0000
  002ER 27D1                   SIS    13,1             END ADDR
  0030R 40D0                   STH    13,SVC+6         SET IT
        0066R
  0034R 48FF                   LH     15,0(15)
        0000
  0038R 40F0                   STH    15,SVC+8         SET RANDØM IF ANY
        0068R
  003CR E110                   SVC    1,SVC            DØ ØPER
        0060R
  0040R 4890                   LH     9,SVC+2          GET STAT
        0062R
  0044R 409C                   STH    9,0(12)          RETURN STAT
        0000
  0048R D190                   LM     9,REG            RESTØRE
        0052R
  004CR 4AFF                   AH     15,0(15)
        0000
  0050R 030F                   BR     15               RETURN
  0052R                REG     DS     14
  0060R 0000           SVC     DC     0,0,0,0,0
        0000
        0000
        0000
        0000
  006AR                        END
```

```
[illegible]      PRØGRAM TØ DØ I/Ø UNDER FØRTRAN CØNTRØL LDD 12/75          PAGE   2
NØ ERRØRS

* .Ø        0012R
  ØK        0016R
  REG       0052R
  SVC       0060R
* SVC1      0000R
         0000
```

ORIGINAL PAGE IS
OF POOR QUALITY

```
[illegible]        PRØGRAM TØ PACK BYTES FRØM HW FØR FØRTRAN LDD 12/75          PAGE
                    * CALL IS:
                    *      CALL PACK(ISTART,IBYTES)
                    * WHERE:
                    * ISTART=START ADDR
                    * IBYTES=NUMB OF BYTES
                    *ØPT LAB=PACK
                    *
 0000R                          EXTRN .Ø
 0000R                          ENTRY PACK
 0000R D0C0          PACK       STM    12,REG
       0038R
 0004R D1DF                     LM     13,0(15)
       0000
 0008R 27D6                     SIS    13,6          CK ARGS
 000AR 2336                     BZS    ØK
 000CR C8B0                     LHI    11,C'33'      SEND ERR MESS
       3333
 0010R 41F0                     BAL    15,.Ø
       0000F
 0014R E130                     DC     X'E130'       & QUIT
 0016R 48FF          ØK         LH     15,0(15)      BYTES
       0000
 001AR 0AFE                     AHR    15,14         END ADDR+1
 001CR 08DE                     LHR    13,14
 001ER 48CD          LØØP       LH     12,0(13)      GET HW
       0000
 0022R D2CE                     STB    12,0(14)      PACK IT
       0000
 0026R 26E1                     AIS    14,1          INCR PTRS
 0028R 26D2                     AIS    13,2
 002AR 05EF                     CLHR   14,15         CK DØNE
 002CR 2087                     BLS    LØØP
 002ER D1C0                     LM     12,REG
       0038R
 0032R 4AFF                     AH     15,0(15)
       0000
 0036R 030F                     BR     15            QUIT.
 0038R               REG        DS     8
 0040R                          END



[illegible]        PRØGRAM TØ PACK BYTES FRØM HW FØR FØRTRAN LDD 12/75          PAGE  2
NØ ERRØRS

*  .Ø       0012R
   LØØP     001ER
   ØK       0016R
*  PACK     0000R
   REG      0038R
```

ORIGINAL PAGE IS
OF POOR QUALITY

```
████████       PRØGRAM TØ UNPACK BYTES TØ HW LDD 12/75                        PAGE    1
                    * CALL IS:
                    *      CALL UNPACK(ISTART,IBYTES)
                    * WHERE:
                    * ISTART = START ADDR
                    * IBYTES= NUMB ØF BYTES
                    *   (I.E. ISTART+2+IBYTES-1 = END ADDR.
                    *      ISTART+1=FIRST UNPACKED BYTE LØC
                    *ØPT LAB=UNPACK
                    *
                    * LDD 12/75
                    *
 0000R                          EXTRN  .Ø
 0000R                          ENTRY  UNPACK
 0000R DODO         UNPACK      STM    13,REG              SAVE EM
       003AR
 0004R D1DF                     LM     13,0(15)            GET EM
       0000
 0008R 27D6                     SIS    13,6                CK ARGS
 000AR 2336                     BSS    ØK
 000CR C8B0                     LHI    11,C'33'
       3333
 0010R 41F0                     BAL    15,.Ø               SEND ERR MESS,
       0000F
 0014R E130                     DC     X'E130'             & QUIT
 0016R 4AEF         ØK          AH     14,0(15)            LAST BYTE ADDR+1
       0000
 001AR 08DE                     LHR    13,14
 001CR 4ADF                     AH     13,0(15)            LAST HW ADDR+2
       0000
 0020R 27E1         LØØP        SIS    14,1                DECR BYTE PTR
 0022R 27D2                     SIS    13,2                DECR HW PTR
 0024R D3FE                     LB     15,0(14)            GET A BYTE
       0000
 0028R 40FD                     STH    15,0(13)            STØRE HW
       0000
 002CR 05ED                     CLHR   14,13
 002ER 2087                     BLS    LØØP                CK END
 0030R D1D0                     LM     13,REG
       003AR
 0034R 4AFF                     AH     15,0(15)
       0000
 0038R 030F                     BR     15                  RETURN
 003AR              REG         DS     6
 0040R                          END
```

```
████████       PRØGRAM TØ UNPACK BYTES TØ HW LDD 12/75                        PAGE    2
NØ ERRØRS

* .Ø         0012R
  LØØP       0020R
  ØK         0016R
  REG        003AR
* UNPACK     0000R
          0000
```

ORIGINAL PAGE IS
OF POOR QUALITY

```
[illegible]        READ RFIME TAPE INTØ FØRTRAN 5/74                                    PAGE   1
 0000R                         ENTRY RFIME,SWITCH,PARAMS
 0000R                         EXTRN .Ø
                   *
                   *   CALL IS:
                   *      CALL RFIME(INP)
                   *   INP(N) IS A FIX PT ARRAY
                   *   N.GE. 564
                   *   INP IS A 2-BYTE ARRAY
                   *
                   *   SECØND CALL IS
                   *      CALL SWITCH(INP)
                   *   ALL BYTES ARE SWITCHED IN INP TØ
                   *   FIT DEC RFIME FØRMAT
                   *
                   *   THIRD CALL IS:
                   *     CALL PARAMS(IGMT,IFREQ,ATITUD,INP)
                   *   WHERE IGMT IS A 5 DIM 2 BYTE ARRAY
                   *   IGMT(1=YR
                   *   IGMT(2)=DAY
                   *   IGMT(3)=HR-MIN
                   *   IGMT(4)=SECØNDS
                   *   IGMT(5)=THØUSANDS ØF A SEC
                   *   IFREQ IS A 2 DIM 2 BYTE ARRAY
                   *   IFREQ(1)=MHZ/50
                   *   IFREQ(2)=10 THØUSANDS ØF MHZ/50
                   *   ATITUD(I),I=1,13 = ATTITUDE DATA(FLT PT)
                   *
                   *   LDD 9/75
                   *   MØD FØR 2 BYTE 10/74
                   *   CHANGED FRØM ECKERMAN TØ RFIME 9/75
                   *
 0000R D090        RFIME   STM    9,REG              SAVE USER REGS
       01F4R
 0004R 48AF                LH     10,0(15)           CK NUMB ARGS
       0000
 0008R 27A4                SIS    10,4
 000AR 2337                BES    ØK
 000CR C8B0                LHI    11,C'33'
       3333
 0010R 41F0                BAL    15,.Ø              SEND ERR MESS
       000F
 0014R E130                SVC    3,0                & STØP
       0000
 0018R 48AF        ØK      LH     10,2(15)           GET A(INP)
       0002
 001CR 40A0                STH    10,INPUT+4         SET UP SVC
       0208R
 0020R CAA0                AHI    10,1127            END ADDR
       0467
 0024R 40A0                STH    10,INPUT+6
       020AR
 0028R E110        GØ      SVC    1,INPUT            READ TAPE IN
       0204R
 002CR 4300                LH     0,INPUT+2          CK STAT
       0206R
 0030R 4230                BNZ    NØGØ
[illegible]        READ RFIME TAPE INTØ FØRTRAN 5/74                                    PAGE   2

       01D0R
 0034R D190                LM     9,REG              RETURN IF DØNE
       01F4R
 0038R 430F                B      4(15)
       0004
                   *
 003CR D090        SWITCH  STM    9,REG
       01F4R
 0040R 48AF                LH     10,0(15)           CK NUMB ARGS
       0000
 0044R 27A4                SIS    10,4
 0046R 2335                BES    ØK1
 0048R C8E0                LHI    11,C'33'
       3333
 004CR 41F0                BAL    15,.Ø              SEND ERR MESS
       0012R
 0050R 48AF        ØK1     LH     10,2(15)           START ADDR
       0002
 0054R 24B2                LIS    11,2               BXLE INCR
 0056R C8CA                LHI    12,1126(10)        END ADDR
       0466
 005AR 48DA        LØØP    LH     13,0(10)           GET HW
       0000
 005ER 94DD                EXBR   13,13              SWITCH BYTES
 0060R 40DA                STH    13,0(10)           PUT BACK
       0000
 0064R C1A0                BXLE   10,LØØP
       005AR
 0068R D190                LM     9,REG
       01F4R
 006CR 430F                B      4(15)              RETURN
       0004
```

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```
0070R D030          PARAMS   STM   9,REG
      01F4R
0074R 48AF                   LH    10,0(15)
      0000
0078R 27AA                   SIS   10,10           CK ARGS
007AR 2337                   BZS   ØK2
007CR C880                   LHI   11,C'33'
      3333
0080R 41F0                   BAL   15,.Ø           ERR MESS
      0042R
0084R E130                   SVC   3,0             &QUIT
      0000
0088R 48EF          ØK2      LH    14,8(15)        A(INP)'
      0008
008CR 48FF                   LH    15,2(15)        A(IGMT)
      0002
0090R D3AE                   LB    10,1028(14)     YR,100'S DAYS
      0404
0094R 08BA                   LHR   11,10
0096R 90A4                   SRLS  10,4            YR'S
0098R 40AF                   STH   10,0(15)        YR STØRE
      0000
009CR C4B0                   NHI   11,X'F'         100'S DAYS
```

READ RTIME TAPE, INTØ FØRTRAN 5/74 PAGE 3

```
      000F
00A0R 4CA0                   MH    10,D10          *
      01CER
00A4R D3DE                   LB    13,1029(14)     10 DAYS,DAYS
      0405
00A8R 08CD                   LHR   12,13
00AAR 90D4                   SRLS  13,4
00ACR 0ABD                   AHR   11,13           ACCUM
00AER 4CA0                   MH    10,D10          * 10
      01CER
00B2R C4C0                   NHI   12,X'F'         GET DAY
      000F
00B6R 0ABC                   AHR   11,12           ACCUM &
00B8R 40BF                   STH   11,2(15)        STØRE DAY
      0002
00BCR 48DE                   LH    13,1026(14)     10 HR,1 HR,10 MIN,1 MIN,10 SEC
      0402
00C0R 08BD                   LHR   11,13           SAVE
00C2R 90BE                   SRLS  11,14           10 HRS
00C4R 4CA0                   MH    10,D10          * 10
      01CER
00C8R 08CD                   LHR   12,13
00CAR 90CA                   SRLS  12,10           1 HRS
00CCR C4C0                   NHI   12,X'F'
      000F
00D0R 0ABC                   AHR   11,12           ACCUM
00D2R 4CA0                   MH    10,D10          * 10
      01CER
00D6R 08CD                   LHR   12,13           10 MINS
00D8R 90C7                   SRLS  12,7
00DAR C4C0                   NHI   12,X'7'
      0007
00DER 0ABC                   AHR   11,12           ACCUM
00E0R 4CA0                   MH    10,D10          & MAKE RØØM FØR NEXT
      01CER
00E4R 08CD                   LHR   12,13
00E6R 90C3                   SRLS  12,3            1 MINS
00E8R C4C0                   NHI   12,X'F'
      000F
00ECR 0ABC                   AHR   11,12           ACCUM
00EER 40BF                   STH   11,4(15)        & STØRE HR-MIN
      0004
00F2R C4D0                   NHI   13,X'7'         10 SECS
      0007
00F6R 08BD                   LHR   11,13
00F8R 4CA0                   MH    10,D10          * 10
      01CER
00FCR 48DE                   LH    13,1024(14)     SECS,.1 SECS,.01 SECS,.001 SECS
      0400
0100R 08CD                   LHR   12,13
0102R 90CC                   SRLS  12,12
0104R 0ABC                   AHR   11,12           ACCUM SECS&
0106R 40BF                   STH   11,6(15)        STØRE
      0006
010AR 08BD                   LHR   11,13
010CR 90B8                   SRLS  11,8            .1 SECS
```

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OF POOR QUALITY

```
 010ER C480          NHI   11,X'F'
       000F
 0112R 4CA0          MH    10,D10            *10
       01CER
 0116R 93CD          LBR   12,13
 0118R 90C4          SRLS  12,4              .01 SECS
 011AR 0ABC          AHR   11,12
 011CR 4CA0          MH    10,D10
       01CER
 0120R C4D0          NHI   13,X'F'           .001 SECS
       000F
 0124R 0ABD          AHR   11,13
 0126R 40BF          STH   11,8(15)          STORE 1000'S SECS
       0008
                *  NOW GET FREQ
 012AR 48F0          LH    15,R15            RESTORE ARG PTR
       0200R
 012ER 48FF          LH    15,4(15)          A(IFREQ)
       0004
 0132R 48DE          LH    13,1030(14)       FIRST PART
       0406
 0136R C4D0          NHI   13,X'FE'          MASK GOOD PART
       00FF
 013AR 08BD          LHR   11,13             START ACCUM
 013CR 90B4          SRLS  11,4              10'S OF MHZ/50
 013ER 4CA0          MH    10,D10            MOVE OVER
       01CER
 0142R CAB0          AHI   11,100            ALWAYS 100'S = 1
       0064
 0146R C4D0          NHI   13,X'F'           1'S OF MHZ/50
       000F
 014AR 0ABD          AHR   11,13             ACCUM
 014CR 40BF          STH   11,0(15)          & STORE
       0000
 0150R 2494          LIS   9,4               SET CNTR
 0152R 48DE          LH    13,1032(14)       2D PART
       0408
 0156R 07BB          XHR   11,11             ZERO ACCUM
 0158R 4CA0     P4   MH    10,D10            MOVE OVER FOR NEXT BCD CHAR
       01CER
 015CR 08CD          LHR   12,13
 015ER 91D4          SLLS  13,4              MOVE OUT OF LEFT SIDE
 0160R C4C0          NHI   12,X'F000'
       F000
 0164R 90CC          SRLS  12,12             HERE IS BCD CHAR
 0166R 0ABC          AHR   11,12             ACCUM
 0168R 2791          SIS   9,1               REDUCE CNT
 016AR 2039          BNZS  P4
 016CR 40BF          STH   11,2(15)          STORE 10,000'S OF MHZ/50
       0002
                *  NOW GET ATTITUDE
 0170R C89E          LHI   9,1044(14)        GET START ADDR
       0414
 0174R 48F0          LH    15,R15            RESTORE ARG PTR
       0200R
 0178R 48FF          LH    15,6(15)          A(ATTITUD)
```



```
       0006
 017CR D3A9     P7   LB    10,1(9)           GET MSP FRAC
       0001
 0180R C6A0          OHI   10,X'80'          SET HIDDEN 1
       0080
 0184R 48B9          LH    11,2(9)           LSP
       0002
 0188R 48C9          LH    12,0(9)
       0000
 018CR C4C0          NHI   12,X'3F80'        SET EXP
       3F80
 0190R 08DC     P5   LHR   13,12             TEST HIDDEN ZEROES
 0192R C4D0          NHI   13,X'0180'
       0180
 0196R 2337          BZS   P6                ZERO MEANS DONE
 0198R CAC0          AHI   12,X'80'          ADD 1 TO ZERO
       0080
 019CR EAA0          RRL   10,1              DIVIDE DOWN FRAC
       0001
 01A0R 4300          B     P5
       0190R
 01A4R 90C1     P6   SRLS  12,1              EXP/2 FOR 16'S REP
 01A6R 06AC          OHR   10,12             OR IN ANS
 01A8R 48C9          LH    12,0(9)           NOW GET SIGN
       0000
 01ACR C4C0          NHI   12,X'C000'
       C000
 01B0R 06AC          OHR   10,12
 01B2R 40AF          STH   10,0(15)          SET ANS
       0000
 01B6R 40BF          STH   11,2(15)
       0002
 01BAR 26F4          AIS   15,4              INCR OUT PTR
 01BCR 2694          AIS   9,4               INCR IN PTR
 01BER C59E          CLHI  9,1096(1          TEST DONE
       0448
```

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```
01C2R 4280              BL     P7
      017CR
01C6R D190              LM     9,REG
      01F4R
01CAR 430F              B      10(15)                RETURN
      000A
01CER 000A        D10   DC     10
01D0R E120        NOGØ  SVC    2,UNPAK               UNPACK &
      01E0R
01D4R E120              SVC    2,LIST                PRINT STAT
      01E4R
01D8R E120              SVC    2,PAUSE               WAIT
      0202R
01DCR 4300              B      GØ                    TRY AGAIN
      0028R
01E0R 0006        UNPAK DC     6,MESS
      01F0R
01E4R 0007        LIST  DC     7,12,C'I/Ø ERR '
```

READ RFIME TAPE INTØ FØRTRAN 5/74. PAGE 6

```
      000C
      492F
      4F20
      4552
      5220
01F0R             MESS  DS     4
01F4R             REG   DS     14
0200R             R15   EQU    *-2
0202R 0001        PAUSE DC     1
0204R 4801        INPUT DC     X'4801',0,0,0   LU 1 RD IN
      0000
      0000
      0000
020CR                   END
```

READ RFIME TAPE INTØ FØRTRAN 5/74. PAGE 7

```
NØ ERRØRS

.Ø      0082R
D10     01CER
GØ      0028R
INPUT   0204R
LIST    01E4R
LØØP    005AR
MESS    01F0R
NØGØ    01D0R
ØK      0018R
ØK1     0050R
ØK2     0028R
P4      0158R
P5      0190R
P6      01A4R
P7      017CR
PARAMS  0070R
PAUSE   0202R
R15     0200R
REG     01F4R
RFIME   0000R
SWITCH  003CR
UNPAK   01E0R
P4      0158R
```

ORIGINAL PAGE IS
OF POOR QUALITY

```
               * OUTPUTS RFIME DATA UNDER FØRTRAN
               * CALL. CALL IS:
               *      CALL RFØUT(IØUT)
               * WHERE:
               * IØUT IS A 448 HW ARRAY. THE 1ST 64
               * HW ARE HEADER INFØ. THE LAST 384 HW ARE
               * BYTE DATA TØ BE CØMPRESSED TØ 384 BYTES FØR
               * A TOTAL ØF 512 BYTES WHICH IS ØUTPUT ØN
               * LU 2. THE HEADER INFØ IS 1 HW FØR TAPE NØ.,
               * 1 HW FØR FILE NØ., ØNE HW FØR MØDE NØ.,
               * 10 BYTES ØF GMT DATA
               * 4 BYTES ØF FREQUENCY DATA
               * 52 BYTES ØF ATTITUDE DATA
               * & 18 BYTES ØF TELEMETRY DATA
               *
               * LDD 10/75
               *
               * LAB=RFØUT
0000R                          ENTRY RFØUT
0000R                          EXTRN .Ø
0000R D0B0     RFØUT    STM    11,REG
      007ER
0004R D1DF              LM     13,0(15)        GET ARGS
      0000
0008R 27D4              SIS    13,4            CK RIGHT NUMBER
000AR 2335              BES    ØK
000CR C8B0              LHI    11,C'33'
      3333
0010R 41F0              BAL    15,.Ø           SEND ERR MESS
      0000F
0014R 40E0     ØK       STH    14,DATØUT+4     SET ADDRS
      007AR
0018R C8CE              LHI    12,128(14)      FIRST INPUT HW
      0080
001CR CAE0              AHI    14,511          LAST ØUTPUT ADDR
      01FF
0020R 40E0              STH    14,DATØUT+6     LAST ØUT ADDR SET
      007CR
0024R 08BC              LHR    11,12
0026R 48DC     LU       LH     13,0(12)        GET HW
      0000
002AR D2DB              STB    13,0(11)        STØRE AS BYTE
      0000
002ER 26B1              AIS    11,1            INCR ØUT ADDR
0030R 26C2              AIS    12,2            IN TØØ
0032R 05EB              CLHR   14,11           CK DØNE
0034R 2287              BNLS   LUP
0036R E110              SVC    1,DATØUT        ØUTPUT ØN LU 2
      0076R
003AR 48D0              LH     13,DATØUT+2     CK STAT
      0078R
003ER 41F0              BAL    15,CKIT
      004AR
0042R D1B0              LM     11,REG
      007ER
0046R 430F              B      4(15)           RETURN
      0004
004AR 433F     CKIT     BZ     0(15)           RETURN IF ZERØ
      0000
004ER E120              SVC    2,UNPAK         ELSE UNPACK STAT
      005ER
0052R E120              SVC    2,MESS          SHØW IT
      0062R
0056R E120              SVC    2,PAUSE         WAIT
      0074R
005AR 430F              B      -12(15)         TRY AGAIN
      FFF4
005ER 0006     UNPAK    DC     6,MS
      0070R
0062R 0007     MESS     DC     7,14,C'I/Ø STAT '
      000E
      492F
      4F20
      5354
      4154
      2020
0070R          MS       DS     4
0074R 0001     PAUSE    DC     1
0076R 3802     DATØUT   DC     X'3802',0,0,0
      0000
      0000
      0000
007ER          REG      DS     10
0082R                   END
```

NØ ERRØRS

```
 .Ø       0012R
 CKIT     004AR
 DATØUT   00[illegible]6R
 LUP      0026P
 MESS     0062R
 MS       0070R
 ØK       0014R
 PAUSE    0074R
 REG      007ER
 PFØUT    0030R
 UNPAK    005ER
 .D       0012R
```