Geconcerteerde Akties Oceanografie
Technisch Rapport Benthos 81/05

A Program executing Maximum Entropy Spectral Analysis .

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Introduction.

Maximum entropy spectral analysis (MESA) is a recently developed method for the spectral analysis of time series. In contrast to the "classical" methods of analysis (the power spectrum method of Blackmann & Tukey (1959) and the periodogram) it has the major advantage that it minimizes assumptions about the unavailable data (i.e. the values of the time function before and after the period where the data are available). MESA has been shown to be superior to classical methods, since it has a greater resolution for low frequency components (Ulrych 1972,1973,1974; Kirk et al. 1979). This effect is most pronounced for short time series.

This paper presents a computer program for the calculation of MESA spectra on a HP-9825 A desk-top calculator. It is our intention to use it in the analysis of biological time series as a tool in monitoring strategies. MESA has the tremendous advantage over other methods that it can resolve for periodicities which have the same length as the time series itself so that far fewer data points are necessary, with great savings in terms of sampling effort.

As an example, the analysis of a time series of abundance of the copepod *Tachidius discipes* is included

Although written in HPL the program could easily be translated into BASIC. The original FORTRAN program is available from the literature.

Basic elements of MESA.

For a detailed mathematical treatment of this method, the reader is referred to Kirk, Rust and Van Winkle (1979). We will only briefly summarize here the nessecary formula's underlying the algorithms that were used in the computer program.
The basic problem is to find "the spectrum which corresponds to the most random time series whose autocorrelation function agrees with given values". Formally, one looks for a real positive function P(f) maximizing the entropy function

$$I = \int_{-f_M}^{f_M} \ln P(f)\, df \qquad (1)$$

under the constraints that

$$\rho_k = \int_{-f_M}^{f_M} P(f) \exp(i2\pi f k \Delta t)\, df \qquad (2)$$

where $-M \leqslant k \leqslant M$, $M \leqslant N$, N the number of observations, ρ_k the autocorrelation with time lag $k\Delta t$, $i = \sqrt{-1}$ and $f_M = 1 / 2\Delta t$ is the Nyquist frequency.
One can show that a solution to the problem is provided by the expression

$$P(f) = \frac{P_M \Delta t}{\left| 1 + \sum_{m=1}^{M} a_m e^{-i2\pi f m \Delta t} \right|^2} \qquad (3)$$

where

$$\begin{bmatrix} \rho_0 & \rho_1 & \cdots & \rho_M \\ \rho_{-1} & \rho_0 & \cdots & \rho_{M-1} \\ \vdots & & & \\ \rho_{-M} & \rho_{-M+1} & & \rho_0 \end{bmatrix} \begin{bmatrix} 1 \\ a_1 \\ \vdots \\ a_M \end{bmatrix} = \begin{bmatrix} P_M \\ 0 \\ \vdots \\ 0 \end{bmatrix} \qquad (4)$$

Furthermore, if we put

$$\hat{x}_t = \sum_{s=1}^{M} (-a_s)\, x_{t-s} \qquad (5)$$

where x_i represents an element of the original time series $x_0, x_1, \ldots\ldots, x_{N-1}$, then $\hat{x}_t$ is a linear prediction of x_t from the previous elements of the time series. Similarly, , a backward prediction (from the following elements in the series) can be applied. Calling

$$e_t = x_t - \hat{x}_t = \sum_{s=0}^{M} a_s x_{t-s} \qquad (6)$$

the "forward prediction error", and , symmetrically,

$$h_t = \sum_{s=0}^{M} a_s x_{t-M+s} \qquad (7)$$

the "backward prediction error"; it can be shown that

$$P_M = E\,\{e_t^2\} = E\,\{h_t^2\} \qquad (8)$$

for a M-length linear predictor mith the coefficients a_i (i = 1 to M) chosen so as to minimise the squared prediction error.
("E" stands for the expected value operator)
Furthermore it is shown that the values a_i in equations 6 and 7 are identical to those in the matrix equation 4.

The algorithm used in the computer program is based on the following procedure. First a linear prediction filter with length 1 is applied; the coefficient a_1, which will be called here a_{11}(indicating that it is the first coefficient in a filter with length 1) is calculated. Next a filter with length 2 is applied, yielding the values of the coefficients a_{12} and a_{22}. The procedure is repeated until an M-length filter produces the values of $a_{1,M}$, $a_{2,M}$, ...,$a_{M,M}$. Using these coefficients, the values of P_M and ρ_M are calculated at each step. The actual formula's used in each step are:

$$a_{M,M} = -2 \sum_{j=0}^{(n-1)-M} p_{jM}\, q_{jM} \Bigg/ \sum_{j=0}^{(n-1)-M} (p_{jM}^2 + q_{jM}^2) \qquad (8)$$

with $p_{jM} = p_{j,M-1} + a_{M-1,M-1}\, q_{j,M-1}$ (9)

and $q_{jM} = q_{j+1,M-1} + a_{M-1;M-1}\, p_{j+1,M-1}$ (10)

where $p_{j1} \equiv x_j$ and $q_{j1} = x_{j+1}$ $(j = 0,1,\ldots\ldots,n-2)$ (11)

are starting values, relating all calculations to the data. Once $a_{M,M}$ is calculated, all other values $a_{i,M}$ are derived from the expression:

$$a_{i,M} = a_{i,M-1} + a_{M,M}\, a_{M-i,M-1} \quad (i = 1,2,\ldots\ldots,M-1) \qquad (12)$$

P_M can be derived form the equations:

$$P_0 = \rho_0 = (1 / (n-1)) \sum_{j=0}^{n-1} x_j x_j \quad \text{and} \qquad (13)$$

$$P_M = P_{M-1}\,(1 - a_{MM}^2) \qquad (14)$$

The autocorrelation function values are calculated at each step as :

$$\rho_j = \sum_{s=1}^{M} - a_s\, \rho_{j-s} \qquad (15)$$

where the value of ρ_0 is estimated as given above.

The coefficients thus calculated allow for the computation of the power spectrum (eq. 3). Two problems still remain to be solved now: which value of M to chose, and how to determine the relative importance of the different peaks in the spectrum. The first problem has not yet been completely resolved from a theoretical point of view. It has been proposed to use the "Final Prediction Error", FPE, defined by :

$$FPE(M) = Q \cdot P_M$$

where

$$Q = \begin{cases} \frac{n+M}{n-M} & \text{if the time series is not detrended} \\ \frac{n+M+1}{n-(M+1)} & \text{if the mean is removed} \\ \frac{n+M+2}{n-(M+2)} & \text{if the series is linearly detrended.} \end{cases}$$

The value of M to be used should then be chosen so, that the FPE is at a minimum. This is, however, not always possible. Kirk, Rust & Van Winkle (1979) advise to use a M-value close to half the number of data points, and, if possible, to take a value where the FPE shows a sudden drop.

To determine the relative importance of the different peaks, it is necessary to have an estimate of the surface under these peaks. This is done by numerical integration of the power spectrum curve: at each frequency for which the P(f) value has been calculated the integral of P(f) is calculated over an integration width of approximately f_M / (M/2 + 1), where f_M is the Nyquist frequency

The computer program.

The computer program presented in this report has been developped for a Hewlett-Packard 9825 A desk-top calculator, and makes also use of the HP-9871A printer-plotter and the HP-9877A external tape memory.

The input consists of the data points of the time series (which should be equally-spaced), the number of data points, and the highest value of M for which the autocorrelation function values and the FPE should be calculated. When the FPE as a function of M has been plotted one can enter the values of M at which power spectra are to be calculated.

The output consists of :

- a plot of $_M$ as a function of M
- a table of these values
- a table of FPE(M)
- a plot of FPE (M)
- a plot of P(f)
- a plot of the integrated spectrum
- a table of the ten most important peaks in the power spectrum
- (if desired) a full table of P(f) and the integrated spectrum

With the available memory size of 24 K, a maximum of around 350 data points can be treated. However, the calculation time is very long, and the program is designed so that the longest calculations (over 1 hr. for a 200 data series) can be done at night or in the abscence of the operator. Therefore it has been divided into three blocks, called "Day 1 Jobs","Night Jobs", and "Day 2 Jobs" respectively.

"Day 1 Jobs" contain the following operations:

- the data of time series 1 are entered
- the autocorrelation and FPE values are calculated (± 15 min. for a 200 data series)
- output of autocorrealtion and FPE
- enter appropiate values of M for the power spectrum calculations
- enter data of time series 2
- etc.

In "Night Jobs" the power spectra and integrated spectra of the time series are calculated and recorded on data cartridges.

"Day 2 Jobs" gives the output of the power spectra and integrated spectra that have been calculated during the night.

(Appendix 1 gives the program listings of all programs involved in the operations.

(It will be noted that the numerical integration of the spectrum curve is performed by fitting a cubic natural spline function through the spectrum points in the integration interval, and by integrating this curve. This proved to be superior to the application of Simpson's rule, since the occuring peaks are very sharp. However, the process is very time-consuming, and we presently look for more efficient integration methods.)

Appendix 2 gives an example of the complete output of a MESA calculation. The time series in question consisted of 184 data points, which were logaritmically transformed (by taking $\log (x_i+1)$) prior to the operation.

The data were taken from Heip(1978) and Herman (1978).

References.

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0: dsp "MESA : INITIATE JOBS PROGRAM"
1: dim A$[80];ssc 1;trk 0;fdf 0;ldf 0,A$
2: enp "INITIATE DAY 1 JOBS ?",X;if flg13;cfg 13;jmp 5
3: enp "FIRST FREE FILE ON SSC 4, TRK 0",X;X-1→X
4: fti (X)→A$[5,6]
5: ssc 1;trk 0;fdf 0;rcf 0,A$
6: ssc 1;fdf 2;ldp 2
7: enp "NIGHT OR DAY 2 JOBS : FIRST FILE TO BE TREATED ?",M
8: ssc 4;trk 0;fdf M;ldf M,A$;ssc 1;trk 0;fdf 0;rcf 0,A$
9: 0→X;ent "Night jobs ?",X;if flg13;jmp 2
10: ssc 1;trk 0;fdf 8;ldp 8
11: ssc 1;trk 0;fdf 10;ldp 10
*9737
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0: dsp "MESA : DRIVER FILE"
1: dim D[4],A[4],A$[80]
2: ssc 1;trk 0;fdf 0;ldf 0,A$
3: ent "Title",A$[9,80]
4: enp "Number of data",D[1]
5: enp "Maximum M",D[2]
6: itf(A$[5,6])+2→D[3]
7: dim X[D[1]]
8: ent "data from file?",X;if not flg13;gto 15
9: for I=1 to D[1]
10: enp X[I];if flg13;cfg 13;jmp 0
11: next I
12: ent "CORRECTIONS ?",X;if flg13;jmp 4
13: enp "WHICH VALUE ?",A;if flg13;jmp 3
14: enp "CORRECT VALUE ?",B;B→X[A];jmp -1
15: ent "trk ?",A;ent "File ?",B;ssc 5;trk A;fdf B;ldf B,X[*]
16: ent "Data allready detrended?",H;if not flg13;2→D[4];gto 19
17: ent "linear detrending",C;if C=1;2→D[4];prt "Data detrended";gto "DTRN
18: ent "removing mean ?",E;if E=1;1→D[4];prt "mean removed";gto "DTRND"
19: for I=1 to 4;fti (D[I])→A$[2I-1,2I];next I
20: ssc 1;trk 0;fdf 0;rcf 0,A$
21: ssc 4;trk 0;fdf D[3]-1;mrk 1,100;rcf D[3]-1,A$
22: ssc 4;trk 0;fdf D[3];mrk 1,D[1]*8+25;rcf D[3],X[*]
23: ssc 1;trk 0;fdf 3;ldp 3
24: "DTRND":0→r0→r1→r2→r3→r4→r5→Z
25: for I=1 to D[1];X[I]→Y;I→X
26: r0+1→r0;r1+X→r1;r2+Y→r2;r3+XX→r3;r4+YY→r4;r5+XY→r5
27: next I
28: r1/r0→r1;r2/r0→r2;(r3-r0r1r1)/(r0-1)→r3
29: (r4-r0r2r2)/(r0-1)→r4;(r5-r0r1r2)/(r0-1)r3→B;r2-Br1→A
30: if D[4]=2;for I=1 to D[1];X[I]-(A+B*I)→X[I];next I
31: if D[4]=1;for I=1 to D[1];X[I]-r2→X[I];next I
32: gto 19
*23191
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0: dim D[4],A$[80];ssc 1;trk 0;fdf 0;ldf 0,A$
1: for I=1 to 4;itf(A$[2I-1,2I])→D[I];next I
2: D[2]→A;D[1]→N
3: dim X[0:N-1],P[0:N-1],Q[0:N-1],A[2,A],O[0:A],C[0:A]
4: ssc 4;trk 0;fdf D[3];ldf D[3],X[*]
5: for I=0 to N-2;X[I]→P[I];X[I+1]→Q[I];next I
6: for J=0 to N-2;P[J]*Q[J]+r1→r1;P[J]^2+Q[J]^2+r2→r2;next J
7: -2*r1/r2→A[2,1]
8: 0→r1;for I=0 to N-1;X[I]^2+r1→r1;next I;r1/(N-1)→O[0]→C[0]
9: (1-A[2,1]^2)*O[0]→O[1];C[0]*-A[2,1]→C[1]
10: 2→M
11: for J=0 to N-2;P[J]+A[2,M-1]*Q[J]→r1
12: Q[J+1]+A[2,M-1]*P[J+1]→Q[J];r1→P[J];next J
13: 0→r1→r2
14: for J=0 to N-1-M;P[J]*Q[J]+r1→r1;P[J]^2+Q[J]^2+r2→r2;next J
15: for I=1 to M;A[2,I]→A[1,I];0→A[2,I];next I
16: -2r1/r2→A[2,M]
17: for I=1 to M-1;A[1,I]+A[2,M]*A[1,M-I]→A[2,I];next I
18: O[M-1]*(1-A[2,M]^2)→O[M]
19: 0→r1;for I=1 to M;-A[2,I]*C[M-I]+r1→r1;next I;r1→C[M]
20: if (M+1→M)<A+1;gto 11
21: for I=1 to A+1;O[I-1]*((N+I-1+D[4])/(N-I+1-D[4]))→O[I-1];next I
22: ssc 4;trk 0;fdf D[3]+1;mrk 1,(A+1)*8+20;rcf D[3]+1,C[*]
23: ssc 4;trk 0;fdf D[3]+2;mrk 1,(A+1)*8+20;rcf D[3]+2,O[*]
24: ssc 1;trk 0;ldp 4
*4658
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0: dsp "MESA: PLOT AUTOCORRELATION (BURG)";6→r0;wtb 6,27,69
1: dim D[4],A$[80];ssc 1;trk 0;fdf 0;ldf 0,A$
2: for I=1 to 4;itf(A$[2I-1,2I])→D[I];next I
3: D[2]+1→A;dim R[A]
4: ssc 4;trk 0;fdf D[3]+1;ldf D[3]+1,R[*]
5: for I=2 to A;R[I]/R[1]→R[I];next I;1→R[1]
6: (int(10*min(R[*]))-1)/10→r1;1→r2;A-1→A
7: dsp "CHANGE PAPER - CONT.";stp
8: wtb 6,13;wrt 6,A$[9,len(A$)];wtb 6,13,10
9: fmt 5,c30;wrt 6.5,"Burg autocorrelation estimate";wtb 6,13
10: cll 'form'(20/2.54,15/2.54,18/2.54)
11: cll 'psiz'(10/2.54,15/2.54,3/2.54,2/2,54)
12: 5*(int(A/5)+1)→r3
13: cll 'scl'(0,r3,r1,r2)
14: cll 'xaxis'(r1,r3/5,0,r3)
15: for I=0 to r3 by r3/5;cll 'move'(I-r3/50,r1-.05);fmt 1,f3.0
16: wrt 6.1,I;next I
17: cll 'move'(3A/4,r1-.1(r2-r1));wrt 6,"Lag"
18: cll 'yaxis'(0,.1,r1,r2)
19: for I=r1 to r2 by .1;cll 'move'(0,I);cll 'space'(-5);fmt 2,f4.1
20: wrt 6.2,I;next I
21: cll 'move'(0,1)
22: for I=1 to A;cll 'fplt'(I-1,R[I]);next I
23: ssc 1;trk 0;fdf 5;ldp 5
24: "move":
25: wtb r0,27,65,int((p1-X)U/64),int((p1-X)U),int((p2-Y)V/64),int((p2-Y)V)
26: ret
27: "fplt":
28: wtb r0,27,97,int((p1-X)U/64),int((p1-X)U),int((p2-Y)V/64),int((p2-Y)V)
29: if p3=0;46→p3
30: if p3=46;wtb r0,27,82,0,0,0,6
31: wtb r0,p3;wtb r0,8
32: if p3=46;wtb r0,27,82,0,0,63,-6
33: ret
34: "psiz":
35: p1→H;p2→W
36: wtb r0,27,79,int(p4*120/64),p4*120,int(p3*96/64),p3*96
37: ret
38: "scl":
39: 120W/(p2-p1)→U
40: 96H/(p4-p3)→V
41: p1→X;p3→Y
42: ret
43: "xaxis":
44: wtb r0,27,46,95,0,5,9
45: if p3=0 and p4=0;X→p3;X+120W/U→p4
46: if p2=0;p4-p3→p2
47: wtb r0,27,65,int((p3-X)U/64),int((p3-X)U),int((p1-Y)V/64),int((p1-Y)V)
48: p3→p5;wtb r0,43;wtb r0,8
49: wtb r0,27,114,int(p2U/64),int(p2U),0,0;wtb r0,43,8;jmp (p5+p2→p5)>=p4
50: ret
51: "yaxis":
*17339
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51: "yaxis":
52: wtb r0,27,46,124,0,3,0
53: if p3=0 and p4=0;Y→p3;Y+960/V→p4
54: if p2=0;p4-p3→p2
55: wto r0,27,65,int((p1-X)U/64),int((p1-X)U),int((p3-Y)V/64),int((p3-Y)V)
56: p3→p5;wtb r0,43;wtb r0,3
57: wtb r0,27,114,0,0,int(p2V/64),int(p2V);wtb r0,43,8;jmp (p5+p2→p5)>=p4
58: ret
59: "space":
60: if p1<0;gto +2
61: wtb r0,32;jmp 2((p1-1→p1)=0)
62: wtb r0,8;jmp (p1+1→p1)=0
63: ret
64: "skip":
65: if p1<0;gto +2
66: wtb r0,10;jmp 2((p1-1→p1)=0)
67: wtb r0,27,10;jmp (p1+1→p1)=0
68: ret
69: "form":
70: wtb r0,27,77
71: wtb r0,27,84
72: if p1=0;13.2→p1;11→p2→p3
73: wtb r0,27,87,int(120*p1/64),120*p1
74: wtb r0,27,76,int(96*p2/64),96*p2
75: wtb r0,27,70,int(96*p3/64),96*p3
76: ret
*4066
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0: dsp "MESA : TABLE AUTOCORRELATION";wtb 6,27,69
1: dim D[4],A$[80];ssc 1;trk 0;fdf 0;ldf 0,A$
2: for I=1 to 4;itf(A$[2I-1,2I])→D[I];next I
3: D[2]+1→A;dim R[A]
4: ssc 4;trk 0;fdf D[3]+1;ldf D[3]+1,R[*]
5: int(A/40)+1→r3
6: fmt 1,c3,10x,z;fmt 2,c9,z;fmt 3,f3.0,8x,z;fmt 4,f11.8,10x,z
7: fmt 5,10x,c3,10x,z;fmt 6,c9;fmt 7,f3.0,8x,z;fmt 8,f11.8
8: 1→I;if r3=1;gto "LCOL"
9: r3-2→r3;wtb 6,13;dsp "CHANGE PAPER : FOR TABLE!";stp
10: if I=1;wrt 6,A$[9,len(A$)];wtb 6,13,10
11: if I=1;wrt 6,"TABLE   : AUTOCORRELATION FUNCTION VALUES";jmp 2
12: I+41→I;wrt 6,"TABLE   (Cont.)"
13: wtb 6,13,10,10,10,10;wrt 6.1,"LAG";wrt 6.2,"AUTOCORR."
14: wrt 6.5,"LAG";wrt 6.6,"AUTOCORR.";wtb 6,13,10,10
15: wrt 6.3,I-1;wrt 6.4,R[I]/R[1]
16: if I+40<=A;wrt 6.7,I+39;wrt 6.8,R[I+40]/R[1]
17: if I+40>A;wtb 6,13,10
18: if I/40#int(I/40);1+I→I;jmp -3
19: if r3=0;gto "END"
20: if r3=1;gto "LCOL"
21: gto 9
22: "LCOL":dsp "CHANGE PAPER : FOR TABLE !";stp ;wtb 6,13
23: if I=1;wrt 6,A$[9,80];wtb 6,13,10
24: if I=1;wrt 6,"TABLE   :AUTOCORRELATION FUNCTION VALUES";jmp 2
25: I+41→I;wrt 6,"TABLE   (Cont.)"
26: wtb 6,13,10,10,10,10;fmt 2,c9;fmt 4,f11.8
27: wrt 6.1,"LAG";wrt 6.2,"AUTOCORR.";wtb 6,13,10,10
28: wrt 6.3,I-1;wrt 6.4,R[I]/R[1]
29: if I<A;I+1→I;jmp -1
30: gto "END"
31: "END":ssc 1;trk 0;fdf 6;ldp 6
*16970
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0: dsp "MESA : TABLE FPE";wtb 6,27,69
1: dim D[4],A$[80];ssc 1;trk 0;fdf 0;ldf 0,A$
2: for I=1 to 4;itf(A$[2I-1,2I])→D[I];next I
3: D[2]+1→A;dim R[A]
4: ssc 4;trk 0;fdf D[3]+2;ldf D[3]+2,R[*]
5: int(A/40)+1→r3
6: fmt 1,c3,10x,z;fmt 2,c9,z;fmt 3,f3.0,7x,z;fmt 4,e12.6,10x,z
7: fmt 5,10x,c3,10x,z;fmt 6,c9;fmt 7,f3.0,7x,z;fmt 8,e12.6
8: 1→I;if r3=1;gto "LCOL"
9: r3-2→r3;wtb 6,13;dsp "CHANGE PAPER : FOR TABLE!";stp
10: if I=1;wrt 6,A$[9,len(A$)];wtb 6,13,10
11: if I=1;wrt 6,"TABLE     : FINAL PREDICTION ERROR VALUES";jmp 2
12: I+41→I;wrt 6,"TABLE    (Cont.)"
13: wtb 6,13,10,10;wrt 6.1," M ";wrt 6.2,"F.P.E.    "
14: wrt 6.5," M ";wrt 6.6,"F.P.E.    ";wtb 6,13,10
15: wrt 6.3,I-1;wrt 6.4,R[I]
16: if I+40<=A;wrt 6.7,I+39;wrt 6.8,R[I+40]
17: if I+40>A;wtb 6,13,10
18: if I/40#int(I/40);1+I→I;jmp -3
19: if r3=0;gto "END"
20: if r3=1;gto "LCOL"
21: gto 9
22: "LCOL":dsp "CHANGE PAPER : FOR TABLE !";stp ;wtb 6,13
23: if I=1;wrt 6,A$[9,len(A$)];wtb 6,13,10
24: if I=1;wrt 6,"TABLE     : FINAL PREDICTION ERROR VALUES";jmp 2
25: I+41→I;wrt 6,"TABLE    (Cont.)"
26: wtb 6,13,10,10;fmt 2,c9;fmt 4,e12.6
27: wrt 6.1," M ";wrt 6.2,"F.P.E.    ";wtb 6,13,10
28: wrt 6.3,I-1;wrt 6.4,R[I]
29: if I<A;I+1→I;jmp -1
30: gto "END"
31: "END":ent "New M-value for plot ?",X;if flg13;jmp 2
32: enp "NEW M-VALUE:",M;fti (M)→A$[3,4];ssc 1;fdf 0;rcf 0,A$
33: ssc 1;trk 0;fdf 7;ldp 7
*11223
```

```
0: dsp "MESA: PLOT FPE";6→r0
1: dim D[4],A$[80];ssc 1;trk 0;fdf 0;ldf 0,A$
2: for I=1 to 4;itf(A$[2I-1,2I])→D[I];next I
3: D[2]+1→A;dim R[D[1]]
4: ssc 4;trk 0;fdf D[3]+2;ldf D[3]+2,R[*]
5: for I=A+1 to D[1];0→R[I];next I
6: if R[1]=max(R[*]);0→R[1]
7: max(R[*])→r4;int(log(r4))→r3;int(r4/10^r3)→r4;10*(r4+1)→r2;0→r1
8: r3-1→r3
9: dsp "CHANGE PAPER : FOR PLOT !";stp ;wtb 6,13
10: wrt 6,A$[9,len(A$)];wtb 6,13,10
11: fmt 5,c20,z;fmt 6,f2.0,z;fmt 7,c1
12: wtb 6,13;wrt 6.5,"Final Prediction Error (*10^";wrt 6.6,r3;wrt 6.7,")"
13: cll 'form'(20/2.54,15/2.54,18/2.54)
14: cll 'psiz'(10/2.54,15/2.54,3/2.54,2/2.54)
15: 5*(int(A/5)+1)→r4
16: cll 'scl'(0,r4,r1,r2)
17: cll 'xaxis'(r1,r4/5,0,r4)
18: for I=0 to r4 by r4/5;cll 'move'(I-r4/50,r1-.05*(r2-r1));fmt 1,f3.0
19: wrt 6.1,I;next I
20: cll 'move'(A/2,-.1(r2-r1));wrt 6,"Number of filter coeff."
21: cll 'yaxis'(0,10,r1,r2)
22: for I=r1 to r2 by 10;cll 'move'(0,I);cll 'space'(-5);fmt 2,f2.0
23: wrt 6.2,I;next I
24: cll 'move'(0,r1)
25: for I=3 to A;cll 'fplt'(I-1,R[I]/10^r3);next I
26: ent "M Value for computations?",M;fti (M)→A$[3,4]
27: ssc 4;trk 0;fdf D[3]-1;rcf D[3]-1,A$
28: cfg 13;ent "ANOTHER M VALUE TO BE TRIED ?",X;if flg13;jmp 6
29: if not flg1;sfg 1;ssc 4;trk 0;fdf D[3];ldf D[3],R[*]
30: ent "M VALUE?",M;fti (M)→A$[3,4];D[3]+2→D[3];fti (D[3])→A$[5,6]
31: ssc 4;trk 0;fdf D[3]-1;mrk 1,100;rcf D[3]-1,A$
32: ssc 4;trk 0;fdf D[3];mrk 1,D[1]*8+25;rcf D[3],R[*]
33: ssc 1;trk 0;fdf 0;rcf 0,A$;jmp -5
34: ssc 1;trk 0;fdf 2;ldp 2
35: "move":
36: wtb r0,27,65,int((p1-X)U/64),int((p1-X)U),int((p2-Y)V/64),int((p2-Y)V)
37: ret
38: "fplt":
39: wtb r0,27,97,int((p1-X)U/64),int((p1-X)U),int((p2-Y)V/64),int((p2-Y)V)
40: if p3=0;46→p3
41: if p3=46;wtb r0,27,82,0,0,0,6
42: wtb r0,p3;wtb r0,8
43: if p3=46;wtb r0,27,82,0,0,63,-6
44: ret
45: "psiz":
46: p1→B;p2→W
47: wtb r0,27,79,int(p4*120/64),p4*120,int(p3*96/64),p3*96
48: ret
49: "scl":
50: 120W/(p2-p1)→U
*25272
```

```
51: 96H/(p4-p3)→V
52: p1→X;p3→Y
53: ret
54: "xaxis":
55: wtb r0,27,46,95,0,5,9
56: if p3=0 and p4=0;X→p3;X+120W/U→p4
57: if p2=0;p4-p3→p2
58: wtb r0,27,65,int((p3-X)U/64),int((p3-X)U),int((p1-Y)V/64),int((p1-Y)V)
59: p3→p5;wtb r0,43;wtb r0,8
60: wtb r0,27,114,int(p2U/64),int(p2U),0,0;wtb r0,43,8;jmp (p5+p2→p5)>=p4
61: ret
62: "yaxis":
63: wtb r0,27,46,124,0,3,0
64: if p3=0 and p4=0;Y→p3;Y+96H/V→p4
65: if p2=0;p4-p3→p2
66: wtb r0,27,65,int((p1-X)U/64),int((p1-X)U),int((p3-Y)V/64),int((p3-Y)V)
67: p3→p5;wtb r0,43;wtb r0,8
68: wtb r0,27,114,0,0,int(p2V/64),int(p2V);wtb r0,43,8;jmp (p5+p2→p5)>=p4
69: ret
70: "space":
71: if p1<0;gto +2
72: wtb r0,32;jmp 2((p1-1→p1)=0)
73: wtb r0,8;jmp (p1+1→p1)=0
74: ret
75: "skip":
76: if p1<0;gto +2
77: wtb r0,10;jmp 2((p1-1→p1)=0)
78: wtb r0,27,10;jmp (p1+1→p1)=0
79: ret
80: "form":
81: wtb r0,27,77
82: wtb r0,27,84
83: if p1=0;13.2→p1;11→p2→p3
84: wtb r0,27,87,int(120*p1/64),120*p1
85: wtb r0,27,76,int(96*p2/64),96*p2
86: wtb r0,27,70,int(96*p3/64),96*p3
87: ret
*21924
```

```
0: dim D[4],A$[80];ssc 1;trk 0;fdf 0;ldf 0,A$
1: for I=1 to 4;itf(A$[2I-1,2I])→D[I];next I
2: D[2]→A;D[1]→N
3: dim X[0:N-1],P[0:N-1],Q[0:N-1],A[2,A],O[0:A],R[600],C[0:A]
4: ssc 4;trk 0;fdf D[3];ldf D[3],X[*]
5: for I=0 to N-2;X[I]→P[I];X[I+1]→Q[I];next I
6: for J=0 to N-2;P[J]*Q[J]+r1→r1;P[J]^2+Q[J]^2+r2→r2;next J
7: -2*r1/r2→A[2,1]
8: 0→r1;for I=0 to N-1;X[I]^2+r1→r1;next I;r1/(N-1)→O[0]→C[0]
9: (1-A[2,1]^2)*O[0]→O[1];C[0]*-A[2,1]→C[1]
10: 2→M
11: dsp M;for J=0 to N-2;P[J]+A[2,M-1]*Q[J]→r1
12: Q[J+1]+A[2,M-1]*P[J+1]→Q[J];r1→P[J];next J
13: 0→r1→r2
14: for J=0 to N-1-M;P[J]*Q[J]+r1→r1;P[J]^2+Q[J]^2+r2→r2;next J
15: for I=1 to M;A[2,I]→A[1,I];0→A[2,I];next I
16: -2r1/r2→A[2,M]
17: for I=1 to M-1;A[1,I]+A[2,M]*A[1,M-I]→A[2,I];next I
18: O[M-1]*(1-A[2,M]^2)→O[M]
19: 0→r1;for I=1 to M;-A[2,I]*C[M-I]+r1→r1;next I;r1→C[M]
20: if (M+1→M)<A+1;gto 11
21: M-1→M;for I=1 to 600;0→r1→r2;.5/599*(I-1)→C
22: rad;for J=1 to M;A[2,J]*cos(2πCJ)+r1→r1;A[2,J]*sin(2πCJ)+r2→r2;next J
23: (1+r1)^2+r2^2→r1;O[M]/r1→R[I]
24: next I
25: ssc 4;trk 1;fdf D[3]-1;mrk 1,4850;rcf D[3]-1,R[*]
26: ssc 1;trk 0;fdf 9;ldp 9
*1996
```

```
0: dim R[600],A[600];fxd 0
1: dim D[4],A$[80];ssc 1;trk 0;fdf 0;ldf 0,A$
2: for I=1 to 4;itf(A$[2I-1,2I])→D[I];next I
3: ssc 4;trk 1;fdf D[3]-1;ldf D[3]-1,R[*];.000001→E
4: .5/D[2]→rl;rl/.5*599→rl;int(rl)+1→rl
5: if rl/2=int(rl/2);rl+1→rl
6: if rl<5;5→rl
7: dim X[rl],Y[rl],B[2:rl-1],S[rl],G[2:rl-1];rl→N→D[4]
8: fti (D[4])→A$[7,8]
9: rl/2-.5→rl
10: for J=1+rl to 600-rl;dsp J
11: for K=-rl to rl;R[J+K]→Y[rl+1+K];next K
12: for K=-rl to rl;.5/599*(J-1)+K*(.5/599)→X[rl+1+K];next K;gsb "INT"
13: A→A[J];next J;gto 29
14: "INT":1→I;0→C;.00001→E
15: if (I+1→I)>N-1;gto +3
16: .5(X[I]-X[I-1]→X)/(X[I+1]-X[I-1]→H)→B[I]
17: 2(((Y[I+1]-Y[I])/(X[I+1]-X[I])-(Y[I]-Y[I-1])/X)/H→T)→S[I];3T→G[I];gto -
18: 0→S[1]→S[N];8-4√3→W
19: C+1→C;if C>10;E*1.1→E
20: 0→U;2→I
21: W(-S[I]-B[I]S[I-1]-(.5-B[I])S[I+1]+G[I])→T
22: if (abs(T)→H)>U;H→U
23: S[I]+T→S[I]
24: if I#N-1;I+1→I;gto -3
25: if U>=E;gto -6
26: 0→I→A
27: if (I+1→I)>N-1;ret
28: A+(.5(X[I+1]-X[I]→H)(Y[I]+Y[I+1])-(1/24)H^3(S[I]+S[I+1]))→A;gto -1
29: ssc 4;trk 0;fdf D[3]-1;rcf D[3]-1,A$
30: ssc 4;trk 1;fdf D[3];mrk 1,4850;rcf D[3],A[*]
31: ssc 4;trk 0;fdf D[3]+1;ldf D[3]+1,A$
32: ssc 1;trk 0;fdf 0;rcf 0,A$
33: ssc 1;trk 0;fdf 8;ldp 8
*28164
```

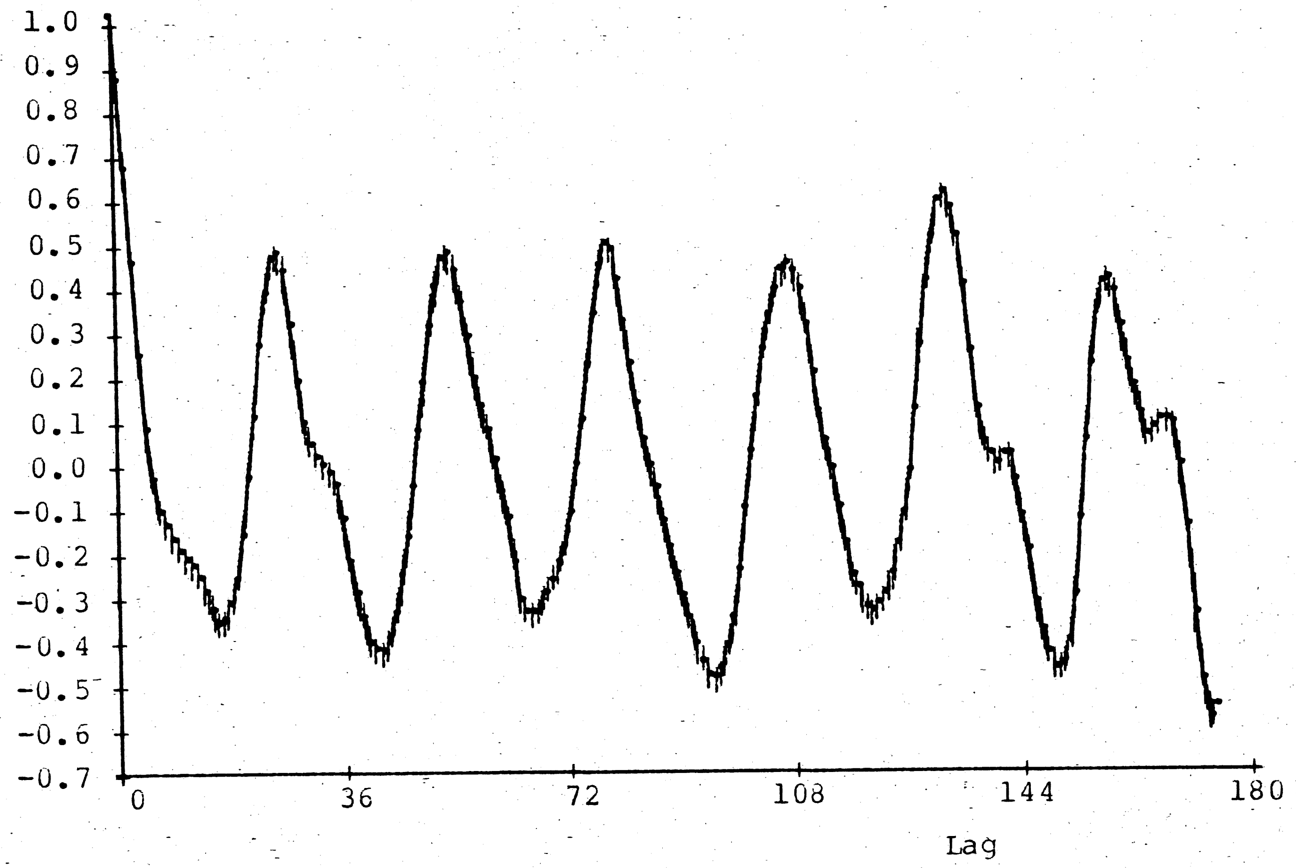
```
0: dsp "MESA: PLOTS P(f) and INTEGR. SPECTRUM";6→r0;wtb 6,27,69
1: dim D[4],A$[80];ssc 1;trk 0;fdf 0;ldf 0,A$
2: for I=1 to 4;itf(A$[2I-1,2I])→D[I];next I
3: dim R[600],P[600]
4: ssc 4;trk 1;fdf D[3]-1;ldf D[3]-1,R[*]
5: ssc 4;trk 1;fdf D[3];ldf D[3],P[*]
6: max(R[*])→r4;int(log(r4))→r3;int(r4/10^r3)→r4;10*(r4+1)→r2;0→r1
7: r3-1→r3
8: dsp "CHANGE PAPER - FOR PLOT";stp ;wtb 6,13
9: wrt 6,A$[9,len(A$)];wtb 6,13,10; if flg1;jmp 3
10: fmt 5,c17,z;fmt 6,f1.0,z;fmt 7,c1
11: wrt 6.5,"MESA VALUES (*10^";wrt 6.6,r3;wrt 6.7,")";jmp 3
12: fmt 8,c25,z,f1.0,z,c1
13: wrt 6.8,"INTEGRATED SPECTRUM (*10^",r3,")";wtb 6,13,10
14: wtb 6,13;fmt 5,"M = ",f3.0;wrt 6.5,D[2]
15: wtb 6,13;cll 'form'(25/2.54,15/2.54,18/2.54)
16: cll 'psiz'(10/2.54,20/2.54,3/2.54,2/2,54)
17: .5→r4→A
18: cll 'scl'(0,r4,r1,r2)
19: cll 'xaxis'(r1,r4/5,0,r4)
20: for I=0 to r4 by r4/5;cll 'move'(I-r4/50,r1-.05*(r2-r1));fmt 1,f3.1
21: wrt 6.1,I;next I
22: cll 'move'(3A/4,-.1(r2-r1));wrt 6,"FREQUENCY"
23: cll 'yaxis'(0,10,r1,r2)
24: for I=r1 to r2 by 10;cll 'move'(0,I);cll 'space'(-5);fmt 2,f2.0
25: wrt 6.2,I;next I
26: cll 'move'(0,r1);if flg1;jmp 2
27: for I=1 to 600;cll 'fplt'(.5/599*(I-1),P[I]/10^r3);next I;jmp 2
28: for I=1+D[4] to 600-D[4];cll 'fplt'(.5/599*(I-1),R[I]/10^r3);next I;jm
29: sfg 1;ara P→R;gto 6
30: ssc 1;trk 0;fdf 11;ldp 11
31: "move":
32: wtb r0,27,65,int((p1-X)U/64),int((p1-X)U),
```

```
0: dsp "MESA : TABLE P(f) + INTEGR.P(f)";wtb 6,27,69
1: dim D[4],A$[80];ssc 1;trk 0;fdf 0;ldf 0,A$
2: for I=1 to 4;itf(A$[2I-1,2I])→D[I];next I
3: dim R[600],P[600]
4: ssc 4;trk 1;fdf D[3]-1;ldf D[3]-1,R[*]
5: ssc 4;trk 1;fdf D[3];ldf D[3],P[*]
6: fmt 1,c3,5x,c9,5x,c6,8x,c12,5x,c14
7: fmt 6,f3.0,5x,z;fmt 7,f9.7,5x,z;fmt 8,f7.3,7x,z;fmt 9,e12.6,7x,z
8: fmt 0,e12.6;fmt 2,"M = ",f3.0;sfg 1;sfg 2
9: dsp "INSERT PAPER";stp ;wtb 6,13
10: wrt 6,A$[9,len(A$)];wtb 6,13,10
11: wrt 6,"TABLE     : MESA + INTEGR. MESA VALUES";wtb 6,13,10
12: wrt 6.2,D[2];wtb 6,13,10,10,10,10
13: for I=1 to 200;if not flg1;jmp 6
14: if flg2;cfg 2;jmp 3
15: dsp "CHANGE PAPER";stp
16: wtb 6,13;wrt 6,"TABLE     (Cont.)";wtb 6,13,10,10,10,10,10
17: wrt 6.1," I ","FREQUENCY","PERIOD","MAX. ENTROPY","INTEGR.SPECTR."
18: cfg 1;wtb 6,13,10,10,10
19: wrt 6.6,I*3;wrt 6.7,.5/599*(I*3-1)
20: if I=1;wrt 6.8,0;jmp 2
21: wrt 6.8,1/(.5/599*(I*3-1))
22: wrt 6.9,P[I*3];wrt 6,P[I*3]
23: if I/40=int(I/40);sfg 1
24: next I
25: ssc 4;trk 0;fdf D[3]+1;ldf D[3]+1,A$
26: ssc 1;trk 0;fdf 0;rcf 0,A$
27: ssc 1;trk 0;fdf 10;ldp 10
*31501
```

```
0: dsp "MESA : TABLE P(f) + INTEGR.P(f)";wtb 6,27,69
1: dim D[4],A$[80];ssc 1;trk 0;fdf 0;ldf 0,A$
2: for I=1 to 4;itf(A$[2I-1,2I])→D[I];next I
3: dim R[600],P[600]
4: ssc 4;trk 1;fdf D[3]-1;ldf D[3]-1,R[*]
5: ssc 4;trk 1;fdf D[3];ldf D[3],P[*]
6: fmt 1,c8,2x,c9,4x,c6,6x,c12,8x,c14
7: fmt 6,2x,f2.0,6x,f9.7,3x,f7.3,7x,e12.6,7x,e12.6
8: fmt 2,"M = ",f3.0;sfg 1;sfg 2;fmt 3,"INTEGR. WIDTH",f3.0
9: dsp "INSERT PAPER";stp ;wtb 6,13
10: wrt 6,A$[9,len(A$)];wtb 6,13,10
11: wrt 6,"TABLE     : MESA + INTEGR. MESA VALUES";wtb 6,13,10
12: wrt 6.2,D[2];wtb 6,13,10;wrt 6.3,D[4];wtb 6,13,10,10
13: gsb "PEAKS"
14: wrt 6.1,"PEAK NR.","FREQUENCY","PERIOD","MAX.ENTROPY","INTEGR.SPECTR."
15: wtb 6.13,10,10,10
16: for I=1 to E;wrt 6.6,I,.5/599*(B[1,I]-1)→r4,1/r4,B[2,I],P[B[1,I]]
17: wtb 6,13,10;next I
18: ssc 4;trk 0;fdf D[3]+1;ldf D[3]+1,A$
19: ssc 1;trk 0;fdf 0;rcf 0,A$
20: ssc 1;trk 0;fdf 10;ldp 10
21: "PEAKS":
22: for I=2 to 599;if R[I]>=R[I-1] and R[I]>=R[I+1];jmp 2
23: next I;jmp 4
24: if flg3;I→A[1,B];R[I]→A[2,B];B+1→B;jmp 2
25: C+1→C
26: next I
27: if not flg3;dim A[2,C];1→B;sfg 3;jmp -5
28: C→E;if C>10;10→E
29: dim B[2,E];1→B
30: 0→r0→r1;for I=1 to C
31: if A[2,I]>r0;A[2,I]→r0;I→r1
32: next I
33: A[1,r1]→B[1,B];A[2,r1]→B[2,B];0→A[2,r1];if (B+1→B)<E+1;jmp -3
34: ret
*28940
```

TACHIDIUS DISCIPES : LOG-TRANSFORMED DATA

Burg autocorrelation estimate



TACHIDIUS DISCIPES : LOG-TRANSFORMED DATA

TABLE : AUTOCORRELATION FUNCTION VALUES

LAG	AUTOCORR.	LAG	AUTOCORR.
0	1.00000000	40	-0.40787347
1	0.85481604	41	-0.42396649
2	0.65390875	42	-0.42700102
3	0.44404292	43	-0.39764097
4	0.23655976	44	-0.34394007
5	0.07139095	45	-0.25529102
6	-0.04237201	46	-0.17116843
7	-0.11355271	47	-0.05701040
8	-0.14603261	48	0.06688140
9	-0.17623110	49	0.17459074
10	-0.20121733	50	0.29990186
11	-0.22176421	51	0.39126586
12	-0.23533173	52	0.45391251
13	-0.25984909	53	0.46712639
14	-0.29221735	54	0.42548610
15	-0.33432120	55	0.35348850
16	-0.36622711	56	0.27895744
17	-0.35706145	57	0.18529726
18	-0.31946601	58	0.12307603
19	-0.26527888	59	0.06514682
20	-0.16750845	60	-0.00250495
21	-0.03819465	61	-0.07061390
22	0.09942997	62	-0.13239167
23	0.25808179	63	-0.22989207
24	0.37648765	64	-0.31379652
25	0.45463292	65	-0.34289458
26	0.46709030	66	-0.34457837
27	0.42567231	67	-0.33116111
28	0.30568991	68	-0.29570303
29	0.18104827	69	-0.27262238
30	0.08513473	70	-0.23204379
31	0.03451137	71	-0.19501089
32	0.00760233	72	-0.11800130
33	-0.01116136	73	-0.01059591
34	-0.02849852	74	0.08967343
35	-0.05234999	75	0.21390943
36	-0.12952847	76	0.33000251
37	-0.22666203	77	0.43611030
38	-0.29832647	78	0.48628210
39	-0.35114167	79	0.47264934

TABLE (Cont.)

LAG	AUTOCORR.	LAG	AUTOCORR.
80	0.40212542	120	-0.34149306
81	0.31009925	121	-0.32605188
82	0.21576194	122	-0.30334699
83	0.12667085	123	-0.25619942
84	0.04653942	124	-0.18796806
85	-0.01440212	125	-0.12275009
86	-0.06421837	126	-0.02726717
87	-0.13790738	127	0.11348397
88	-0.19888305	128	0.25795235
89	-0.25498485	129	0.39890394
90	-0.30862926	130	0.49868823
91	-0.35634917	131	0.57946142
92	-0.41433767	132	0.59816107
93	-0.45286142	133	0.56107786
94	-0.48552480	134	0.49720273
95	-0.49001666	135	0.39174271
96	-0.46917476	136	0.24307767
97	-0.41798542	137	0.11257569
98	-0.35458981	138	0.03593463
99	-0.24804698	139	0.00852216
100	-0.10834791	140	-0.01219025
101	0.01644938	141	0.01059130
102	0.13978823	142	0.00654653
103	0.24671157	143	-0.04886201
104	0.32466632	144	-0.12930521
105	0.38103277	145	-0.20800317
106	0.42743207	146	-0.32538972
107	0.43977991	147	-0.38844255
108	0.42115207	148	-0.43563351
109	0.38296511	149	-0.47430574
110	0.30052438	150	-0.46182904
111	0.19127116	151	-0.40891464
112	0.10647970	152	-0.30514537
113	0.04055760	153	-0.13497085
114	-0.02292360	154	0.03953441
115	-0.10814049	155	0.21198230
116	-0.19119455	156	0.33917911
117	-0.26133760	157	0.39578355
118	-0.29008636	158	0.40350758
119	-0.33556361	159	0.37201209

TABLE (Cont.)

LAG	AUTOCORR.
160	0.29626696
161	0.21679884
162	0.15950811
163	0.09922957
164	0.05031175
165	0.06473528
166	0.08704818
167	0.08455656
168	0.07595884
169	-0.01802485
170	-0.15563176
171	-0.35042114
172	-0.49995345
173	-0.58366964
174	-0.56033634
175	-0.48981602

TACHIDIUS DISCIPES : LOG-TRANSFORMED DATA

TABLE : FINAL PREDICTION ERROR VALUES

M	F.P.E.	M	F.P.E.
0	4.248869E-01	40	1.196778E-01
1	1.156683E-01	41	1.207751E-01
2	1.074216E-01	42	1.215434E-01
3	1.069398E-01	43	1.229533E-01
4	1.062109E-01	44	1.233158E-01
5	1.073719E-01	45	1.239881E-01
6	1.085453E-01	46	1.219023E-01
7	1.097005E-01	47	1.215594E-01
8	1.108987E-01	48	1.229153E-01
9	1.105489E-01	49	1.239243E-01
10	1.114918E-01	50	1.209314E-01
11	1.124197E-01	51	1.218394E-01
12	1.135932E-01	52	1.222128E-01
13	1.132290E-01	53	1.234573E-01
14	1.131988E-01	54	1.249396E-01
15	1.123440E-01	55	1.256604E-01
16	1.131098E-01	56	1.270316E-01
17	1.141340E-01	57	1.238696E-01
18	1.153115E-01	58	1.252158E-01
19	1.162683E-01	59	1.258567E-01
20	1.167018E-01	60	1.274025E-01
21	1.167412E-01	61	1.289720E-01
22	1.171921E-01	62	1.305376E-01
23	1.133140E-01	63	1.295777E-01
24	1.145680E-01	64	1.307558E-01
25	1.154248E-01	65	1.291830E-01
26	1.160837E-01	66	1.299053E-01
27	1.173524E-01	67	1.272989E-01
28	1.128138E-01	68	1.284053E-01
29	1.139879E-01	69	1.289135E-01
30	1.151802E-01	70	1.302965E-01
31	1.158440E-01	71	1.310196E-01
32	1.170142E-01	72	1.273475E-01
33	1.179904E-01	73	1.289768E-01
34	1.192713E-01	74	1.304327E-01
35	1.202288E-01	75	1.307754E-01
36	1.177286E-01	76	1.316946E-01
37	1.178108E-01	77	1.330394E-01
38	1.187219E-01	78	1.346103E-01
39	1.200779E-01	79	1.306315E-01

TABLE (Cont.)

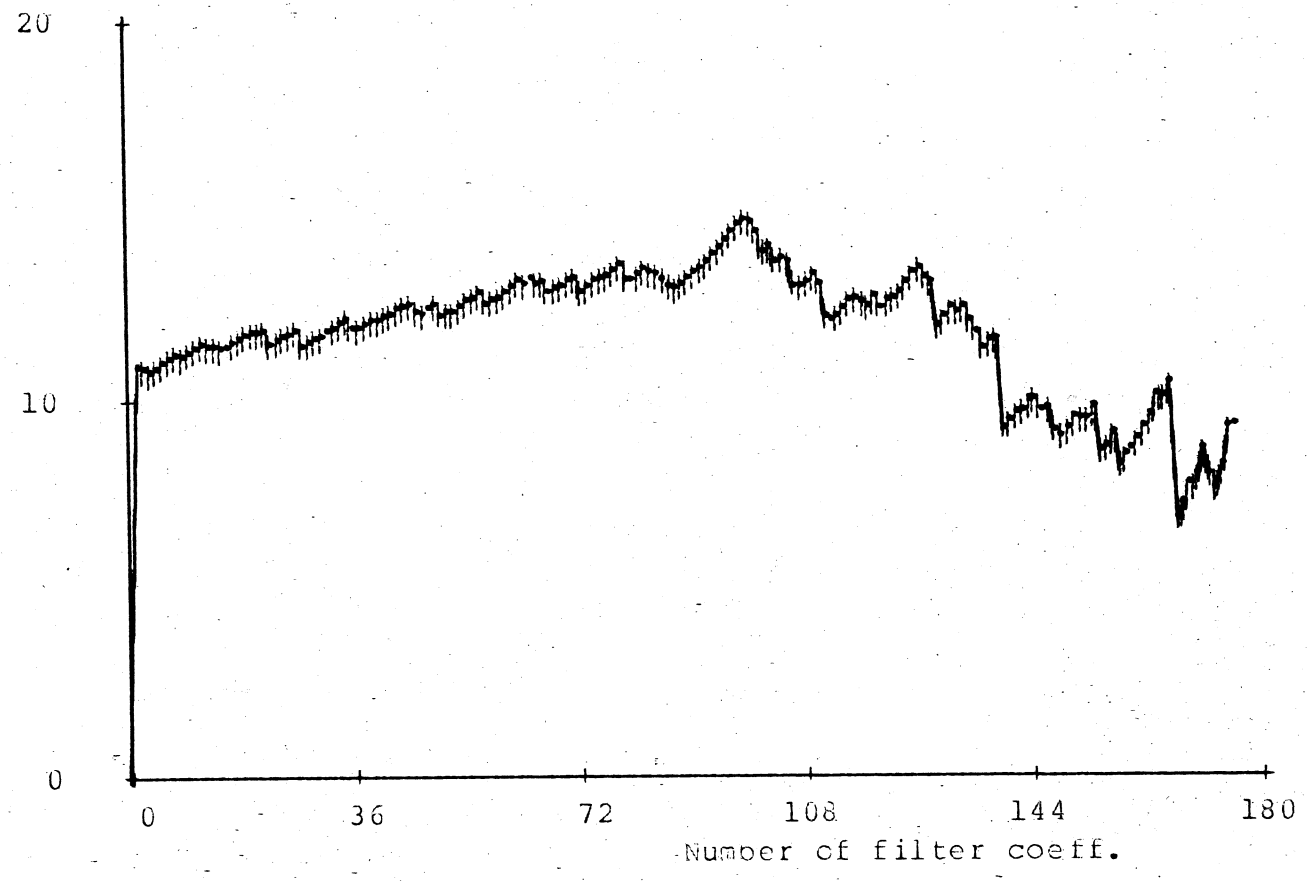
M	F.P.E.	M	F.P.E.
80	1.303344E-01	120	1.228810E-01
81	1.319775E-01	121	1.250942E-01
82	1.335781E-01	122	1.258602E-01
83	1.325543E-01	123	1.274450E-01
84	1.320795E-01	124	1.300514E-01
85	1.303614E-01	125	1.324735E-01
86	1.290555E-01	126	1.334864E-01
87	1.283688E-01	127	1.308939E-01
88	1.294887E-01	128	1.300622E-01
89	1.309230E-01	129	1.184372E-01
90	1.326507E-01	130	1.210867E-01
91	1.333686E-01	131	1.237772E-01
92	1.351535E-01	132	1.222145E-01
93	1.371511E-01	133	1.234531E-01
94	1.391265E-01	134	1.197386E-01
95	1.408755E-01	135	1.155114E-01
96	1.429890E-01	136	1.122143E-01
97	1.451271E-01	137	1.145908E-01
98	1.463193E-01	138	1.150413E-01
99	1.458023E-01	139	9.139807E-02
100	1.433712E-01	140	9.324157E-02
101	1.379511E-01	141	9.573326E-02
102	1.396797E-01	142	9.622396E-02
103	1.352369E-01	143	9.898471E-02
104	1.364176E-01	144	9.901529E-02
105	1.350514E-01	145	9.616618E-02
106	1.290442E-01	146	9.639589E-02
107	1.286063E-01	147	9.098890E-02
108	1.297847E-01	148	8.935785E-02
109	1.319641E-01	149	9.152506E-02
110	1.293231E-01	150	9.462279E-02
111	1.211498E-01	151	9.403290E-02
112	1.200984E-01	152	9.400847E-02
113	1.208516E-01	153	9.708765E-02
114	1.229545E-01	154	8.537048E-02
115	1.251173E-01	155	8.675442E-02
116	1.256596E-01	156	9.003907E-02
117	1.246724E-01	157	8.151168E-02
118	1.237246E-01	158	8.462125E-02
119	1.260646E-01	159	8.535522E-02

TABLE (Cont.)

	F.P.E.
160	8.856923E-02
161	9.162375E-02
162	9.503619E-02
163	1.002940E-01
164	9.967473E-02
165	1.034666E-01
166	6.752189E-02
167	7.169383E-02
168	7.702143E-02
169	7.930456E-02
170	8.574941E-02
171	7.894394E-02
172	7.534708E-02
173	8.157288E-02
174	9.191779E-02
175	9.217634E-02

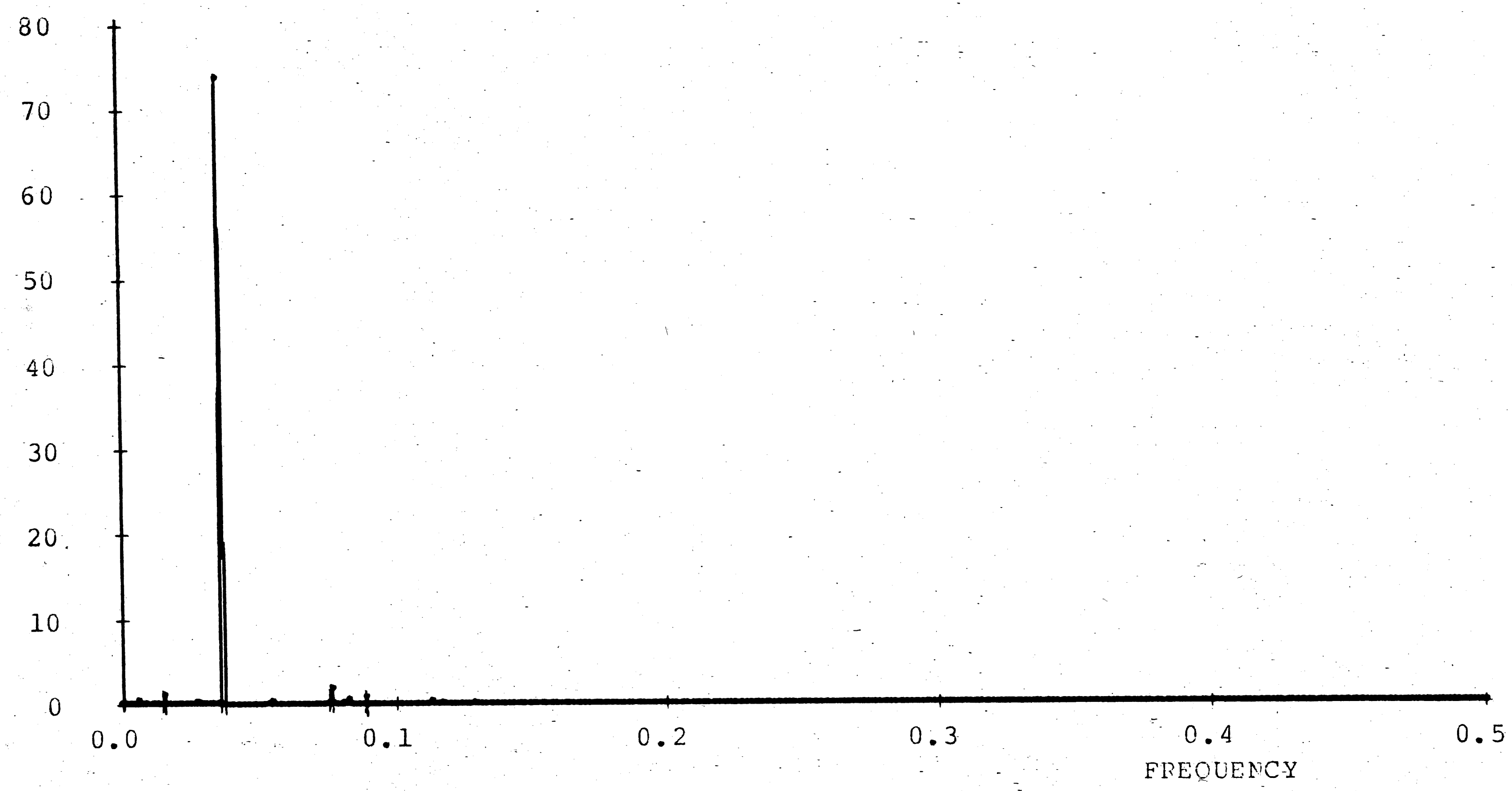
TACHIDIUS DISCIPES : LOG-TRANSFORMED DATA

Final Prediction Error (*10^-2)



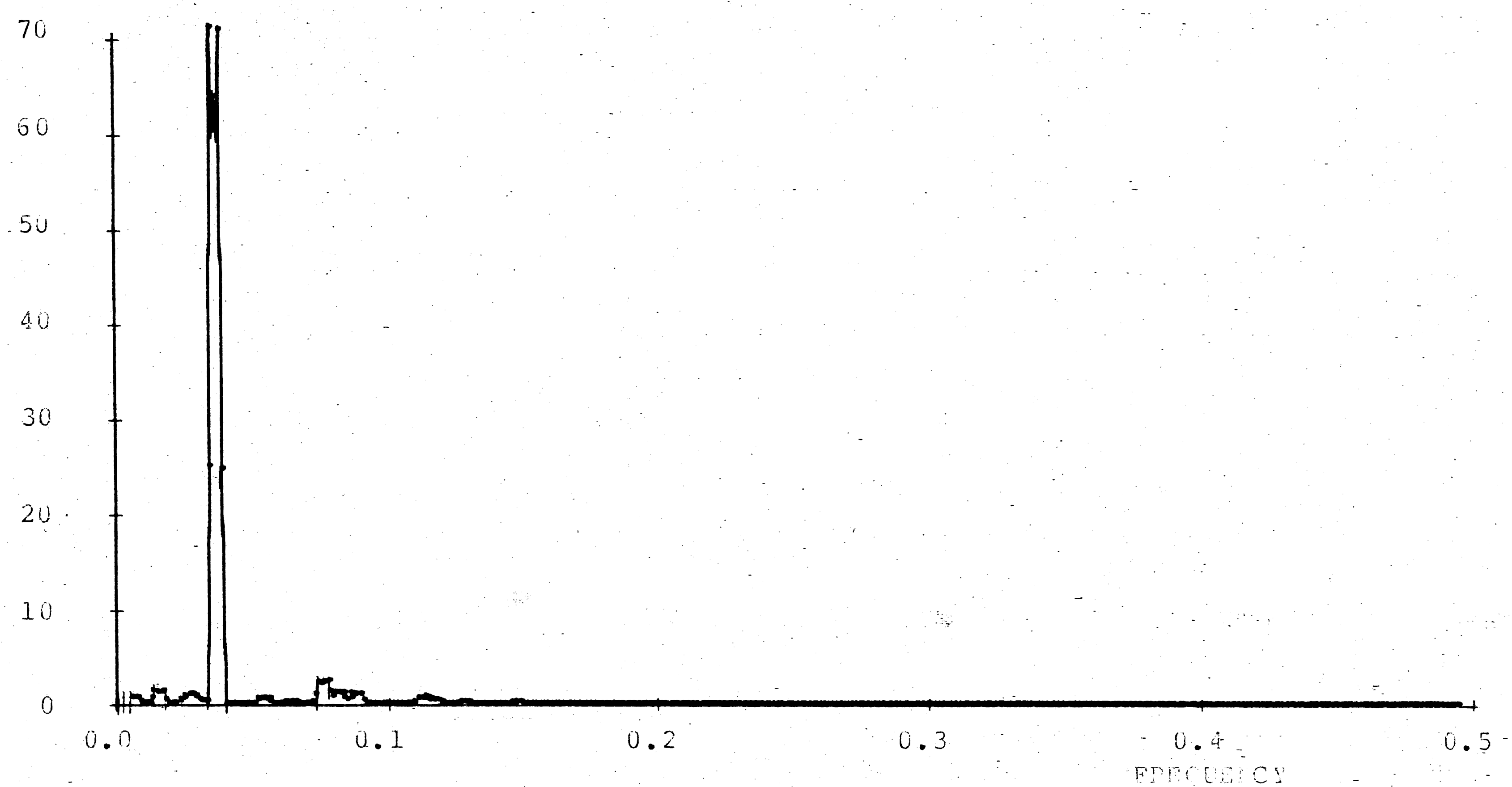
TACHIDIUS DISCIPES : LOG-TRANSFORMED DATA

MESA VALUES (*10^1)
M = 112



TACHIDIUS DISCIPES : LOG-TRANSFORMED DATA

INTEGRATED SPECTRUM (*10^$)
M = 112



TACHIDIUS DISCIPES : LOG-TRANSFORMED DATA

TABLE : MESA + INTEGR. MESA VALUES

N = 112

INTEGR. WIDTH 7

PEAK NR.	FREQUENCY	PERIOD	MAX.ENTROPY	INTEGR.SPECTR.
1	0.0375626	26.622	7.351078E 02	6.284845E-01
2	0.0767947	13.022	1.973118E 01	2.320619E-02
3	0.0158598	63.053	1.185955E 01	1.294429E-02
4	0.0893155	11.196	8.693357E 00	1.033291E-02
5	0.0826377	12.101	6.437462E 00	1.238427E-02
6	0.1135225	8.809	6.343366E 00	6.963150E-03
7	0.0066778	149.750	5.520994E 00	5.904060E-03
8	0.0550918	18.152	4.240353E 00	6.914778E-03
9	0.1293823	7.729	3.181577E 00	3.027362E-03
10	0.1185309	8.437	3.090442E 00	4.264165E-03

TACHIDIUS DISCIPES : LOG-TRANSFORMED DATA

TABLE : MESA + INTEGR. MESA VALUES

M = 112

I	FREQUENCY	PERIOD	MAX. ENTROPY	INTEGR.SPECTR.
3	0.0016694	0.000	1.268529E-02	0.000000E 00
6	0.0041736	239.600	3.773709E-02	2.209900E-03
9	0.0066778	149.750	5.520994E 00	5.904060E-03
12	0.0091820	108.909	1.060522E-01	3.017930E-03
15	0.0116861	85.571	7.689024E-02	5.842641E-04
18	0.0141903	70.471	3.662232E-01	1.353357E-02
21	0.0166945	59.900	8.077854E-01	1.250316E-02
24	0.0191987	52.087	1.279089E-01	1.035855E-03
27	0.0217028	46.077	1.381845E-01	9.301232E-04
30	0.0242070	41.310	4.802690E-01	4.377388E-03
33	0.0267112	37.437	2.884209E 00	9.828915E-03
36	0.0292154	34.229	1.577813E 00	8.295757E-03
39	0.0317195	31.526	4.659183E-01	3.123695E-03
42	0.0342237	29.220	2.861574E-01	2.306724E-03
45	0.0367279	27.227	1.679263E 00	5.933685E-01
48	0.0392321	25.489	2.308408E-01	6.979363E-01
51	0.0417362	23.960	3.125337E-02	2.698438E-04
54	0.0442404	22.604	1.458684E-02	8.463230E-05
57	0.0467446	21.393	1.320183E-02	7.356168E-05
60	0.0492487	20.305	2.131559E-02	1.377236E-04
63	0.0517529	19.323	7.251173E-02	1.433264E-03
66	0.0542571	18.431	2.433870E 00	6.741153E-03
69	0.0567613	17.618	3.010273E-01	5.959562E-03
72	0.0592654	16.873	1.133462E-01	7.123397E-04
75	0.0617696	16.189	1.334593E-01	9.495735E-04
78	0.0642738	15.558	5.676858E-01	2.544750E-03
81	0.0667780	14.975	3.299324E-01	2.302130E-03
84	0.0692821	14.434	9.028987E-02	6.140028E-04
87	0.0717863	13.930	8.540909E-02	5.588011E-04
90	0.0742905	13.461	2.689385E-01	1.017471E-02
93	0.0767947	13.022	1.973118E 01	2.320619E-02
96	0.0792988	12.611	7.962768E-01	1.315248E-02
99	0.0818030	12.224	2.489027E 00	1.237960E-02
102	0.0843072	11.861	1.049723E 00	1.118173E-02
105	0.0868114	11.519	4.327081E-01	6.404390E-03
108	0.0893155	11.196	8.693357E 00	1.033291E-02
111	0.0918197	10.891	9.169499E-02	4.077899E-03
114	0.0943239	10.602	2.470942E-02	1.679416E-04
117	0.0968280	10.328	2.168151E-02	1.493598E-04
120	0.0993322	10.067	8.128651E-02	8.046810E-04

TABLE (Cont.)

I	FREQUENCY	PERIOD	MAX. ENTROPY	INTEGR.SPECTR.
123	0.1018364	9.820	1.013725E-01	7.788575E-04
126	0.1043406	9.584	1.337511E-02	1.163146E-04
129	0.1068447	9.359	8.491292E-03	5.012638E-05
132	0.1093489	9.145	1.372526E-02	1.100881E-04
135	0.1118531	8.940	8.445191E-02	6.723645E-03
138	0.1143573	8.745	9.870925E-01	6.925214E-03
141	0.1168614	8.557	3.636335E-01	5.082535E-03
144	0.1193656	8.378	2.846422E-01	3.993249E-03
147	0.1218698	8.205	2.199788E-02	2.474840E-04
150	0.1243740	8.040	1.162025E-02	7.240103E-05
153	0.1268781	7.882	2.093604E-02	1.245066E-03
156	0.1293823	7.729	3.181577E 00	3.027362E-03
159	0.1318865	7.582	1.846973E-02	1.267404E-03
162	0.1343907	7.441	7.381512E-03	4.597034E-05
165	0.1368948	7.305	8.944996E-03	6.075638E-05
168	0.1393990	7.174	3.365909E-02	4.926254E-04
171	0.1419032	7.047	3.763979E-01	8.713017E-04
174	0.1444073	6.925	7.827645E-02	6.578523E-04
177	0.1469115	6.807	1.902646E-01	2.253814E-03
180	0.1494157	6.693	4.783053E-01	2.393514E-03
183	0.1519199	6.582	1.010241E-01	8.929909E-04
186	0.1544240	6.476	3.730186E-01	1.299580E-03
189	0.1569282	6.372	6.888025E-02	9.843525E-04
192	0.1594324	6.272	1.644838E-02	1.179323E-04
195	0.1619366	6.175	1.740563E-02	1.964854E-04
198	0.1644407	6.081	2.428277E-01	7.175399E-04
201	0.1669449	5.990	1.949382E-02	6.039812E-04
204	0.1694491	5.901	4.914162E-03	3.389354E-05
207	0.1719533	5.816	4.228367E-03	2.670133E-05
210	0.1744574	5.732	1.142513E-02	3.390421E-04
213	0.1769616	5.651	4.946740E-01	6.126928E-04
216	0.1794658	5.572	7.795691E-03	2.297077E-04
219	0.1819699	5.495	3.458465E-03	2.047751E-05
222	0.1844741	5.421	3.454034E-03	1.928230E-05
225	0.1869783	5.348	5.967537E-03	3.719695E-05
228	0.1894825	5.278	1.829064E-02	1.706230E-04
231	0.1919866	5.209	1.477606E-01	5.296226E-04
234	0.1944908	5.142	6.645739E-02	4.792575E-04
237	0.1969950	5.076	2.329133E-02	1.448638E-04
240	0.1994992	5.013	1.949191E-02	1.058187E-04

TABLE (Cont.)

I	FREQUENCY	PERIOD	MAX. ENTROPY	INTEGR.SPECTR.
243	0.2020033	4.950	2.582655E-02	1.363558E-04
246	0.2045075	4.890	4.095020E-02	2.270711E-04
249	0.2070117	4.831	8.348019E-02	3.887801E-04
252	0.2095159	4.773	7.641345E-02	3.535454E-04
255	0.2120200	4.717	2.459375E-02	1.585063E-04
258	0.2145242	4.661	1.698526E-02	1.004955E-04
261	0.2170284	4.608	2.985085E-02	2.628818E-04
264	0.2195326	4.555	2.152980E-01	7.602954E-04
267	0.2220367	4.504	9.700073E-02	7.158620E-04
270	0.2245409	4.454	5.763175E-02	3.856176E-04
273	0.2270451	4.404	1.521093E-01	7.753872E-04
276	0.2295492	4.356	1.738777E-01	8.218883E-04
279	0.2320534	4.309	6.816024E-02	3.845135E-04
282	0.2345576	4.263	2.729059E-02	1.578760E-04
285	0.2370618	4.218	8.644393E-03	5.522289E-05
288	0.2395659	4.174	4.927671E-03	2.843843E-05
291	0.2420701	4.131	6.064460E-03	4.184907E-05
294	0.2445743	4.089	2.431925E-02	2.366867E-04
297	0.2470785	4.047	6.348365E-02	2.703044E-04
300	0.2495826	4.007	1.270108E-02	9.703040E-05
303	0.2520868	3.967	1.437705E-02	1.199261E-04
306	0.2545910	3.928	9.413259E-02	6.317567E-04
309	0.2570952	3.890	9.734945E-02	7.068966E-04
312	0.2595993	3.852	5.862984E-02	3.304307E-04
315	0.2621035	3.815	4.214452E-02	2.175787E-04
318	0.2646077	3.779	6.500709E-03	5.480039E-05
321	0.2671119	3.744	3.438786E-03	2.101624E-05
324	0.2696160	3.709	5.532031E-03	8.005814E-05
327	0.2721202	3.675	1.172771E-01	2.184198E-04
330	0.2746244	3.641	8.141943E-03	1.510067E-04
333	0.2771285	3.608	3.357954E-03	2.199131E-05
336	0.2796327	3.576	6.026698E-03	1.462323E-04
339	0.2821369	3.544	2.791652E-01	3.489928E-04
342	0.2846411	3.513	9.419052E-03	1.895103E-04
345	0.2871452	3.483	8.466556E-03	1.793499E-04
348	0.2896494	3.452	2.218774E-01	2.820641E-04
351	0.2921536	3.423	1.878495E-03	9.229794E-05
354	0.2946578	3.394	5.918081E-04	3.791577E-06
357	0.2971619	3.365	4.729847E-04	2.726421E-06
360	0.2996661	3.337	8.227889E-04	6.535627E-06

TABLE (Cont.)

I	FREQUENCY	PERIOD	MAX. ENTROPY	INTEGR.SPECTR.
363	0.3021703	3.309	4.983471E-03	3.324708E-04
366	0.3046745	3.282	4.062309E-02	3.259123E-04
369	0.3071786	3.255	7.092686E-03	6.602998E-05
372	0.3096828	3.229	2.889647E-02	1.909414E-04
375	0.3121870	3.203	1.491327E-02	1.835087E-04
378	0.3146912	3.178	3.627811E-03	2.661037E-05
381	0.3171953	3.153	5.465922E-03	1.189226E-04
384	0.3196995	3.128	1.888875E-01	2.245135E-04
387	0.3222037	3.104	2.865733E-03	9.016265E-05
390	0.3247078	3.080	1.151969E-03	7.097875E-06
393	0.3272120	3.056	1.286448E-03	8.213182E-06
396	0.3297162	3.033	3.904644E-03	8.787435E-05
399	0.3322204	3.010	1.538765E-01	2.871870E-04
402	0.3347245	2.988	1.981189E-02	2.400501E-04
405	0.3372287	2.965	2.843138E-02	5.903496E-04
408	0.3397329	2.943	2.043504E-01	6.453676E-04
411	0.3422371	2.922	1.066867E-02	1.444384E-04
414	0.3447412	2.901	6.713644E-03	3.960797E-05
417	0.3472454	2.880	1.050792E-02	5.416295E-05
420	0.3497496	2.859	1.506016E-02	6.913039E-05
423	0.3522538	2.839	1.365125E-02	8.079776E-05
426	0.3547579	2.819	2.861359E-02	2.402970E-04
429	0.3572621	2.799	1.240175E-01	3.425441E-04
432	0.3597663	2.780	2.272951E-02	1.825794E-04
435	0.3622705	2.760	1.236407E-02	6.696701E-05
438	0.3647746	2.741	9.169030E-03	4.673887E-05
441	0.3672788	2.723	7.145229E-03	3.981805E-05
444	0.3697830	2.704	1.024008E-02	8.850296E-05
447	0.3722871	2.686	7.563476E-02	2.765505E-04
450	0.3747913	2.668	2.078866E-02	2.396624E-04
453	0.3772955	2.650	6.536845E-03	4.359341E-05
456	0.3797997	2.633	8.133579E-03	6.790191E-05
459	0.3823038	2.616	5.364771E-02	2.368873E-04
462	0.3848080	2.599	2.513922E-02	2.236517E-04
465	0.3873122	2.582	8.933585E-03	5.849886E-05
468	0.3898164	2.565	1.253779E-02	7.970235E-05
471	0.3923205	2.549	3.398192E-02	1.343836E-04
474	0.3948247	2.533	2.567457E-02	1.565611E-04
477	0.3973289	2.517	5.130371E-02	3.983425E-04
480	0.3998331	2.501	5.245464E-02	3.574349E-04

TABLE (Cont.)

I	FREQUENCY	PERIOD	MAX. ENTROPY	INTEGR.SPECTR.
483	0.4023372	2.485	5.736608E-03	5.477252E-05
486	0.4048414	2.470	3.011561E-03	1.775584E-05
489	0.4073456	2.455	3.840380E-03	2.449373E-05
492	0.4098497	2.440	1.171704E-02	7.723442E-05
495	0.4123539	2.425	3.375443E-02	1.346543E-04
498	0.4148581	2.410	2.725604E-02	1.519715E-04
501	0.4173623	2.396	3.188241E-02	1.260965E-04
504	0.4198664	2.382	8.895086E-03	6.138416E-05
507	0.4223706	2.368	4.064640E-03	2.412728E-05
510	0.4248748	2.354	4.189187E-03	2.529068E-05
513	0.4273790	2.340	1.008478E-02	7.284636E-05
516	0.4298831	2.326	3.550152E-02	1.093422E-04
519	0.4323873	2.313	9.115473E-03	6.564136E-05
522	0.4348915	2.299	4.152954E-03	2.465026E-05
525	0.4373957	2.286	4.308971E-03	3.138620E-05
528	0.4398998	2.273	2.073747E-02	2.457990E-04
531	0.4424040	2.260	1.290545E-02	2.427181E-04
534	0.4449082	2.248	1.556292E-03	1.405731E-05
537	0.4474124	2.235	8.585754E-04	5.028052E-06
540	0.4499165	2.223	1.117626E-03	6.326148E-06
543	0.4524207	2.210	2.001370E-03	7.613875E-06
546	0.4549249	2.198	8.104084E-04	4.932146E-06
549	0.4574290	2.186	4.004392E-04	2.333664E-06
552	0.4599332	2.174	4.141867E-04	2.524904E-06
555	0.4624374	2.162	1.049243E-03	2.666424E-05
558	0.4649416	2.151	5.332358E-02	9.290909E-05
561	0.4674457	2.139	2.923836E-03	6.814179E-05
564	0.4699499	2.128	1.349424E-03	8.349008E-06
567	0.4724541	2.117	2.005360E-03	1.271192E-05
570	0.4749583	2.105	5.913062E-03	2.979963E-05
573	0.4774624	2.094	9.666539E-03	5.063361E-05
576	0.4799666	2.083	1.719486E-02	2.067651E-04
579	0.4824708	2.073	2.119580E-01	4.120772E-04
582	0.4849750	2.062	2.733788E-02	2.817991E-04
585	0.4874791	2.051	3.759915E-02	1.788192E-04
588	0.4899833	2.041	1.768015E-02	1.304723E-04
591	0.4924875	2.031	2.980716E-03	2.381628E-05
594	0.4949917	2.020	1.808154E-03	1.070453E-05
597	0.4974958	2.010	2.805849E-03	1.714840E-05
600	0.5000000	2.000	6.607195E-03	0.000000E 00