PROJECT APOLLO
TASK MSC/TRW E65

VHF ANTENNA SIMULATION PROGRAM FOR APOLLO MISSIONS D AND E
PROGRAM NO. HV014A USER'S MANUAL

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Prepared by Carl A. Argila
Carl A. Argila
Communication Systems
Programming Group

Approved by D A Schnebly
D. A. Schnebly, Project Leader
Communication Systems
Programming Group

Approved by W. P. Bennett
W. P. Bennett, Head
Subsystems Analysis Section

ABSTRACT

The VHF Antenna Simulation Program accepts LEM and CSM antenna pattern data (available on tape) and LEM and CSM position and attitude data (also available on tape) and simulates the LEM-CSM VHF communication links. All parameters involved in this simulation are printed as functions of mission trajectory. The polarization loss, gain product, CSM antenna gain, LEM antenna gain and range between CSM and LEM are plotted as functions of time. This simulation neglects multi-path effects (as might be caused by signal reflection from the lunar surface). This program is written in FORTRAN V for use on the SRU 1108 system.

CONTENTS

1. PROBLEM DESCRIPTION

Both the LEM (Lunar Excursion Module) and the CSM (Command Service Module have two VHF antennae each of which may be used at any time to establish a communication link between the two vehicles. The radiation patterns generated by these four antennae depends upon the frequency of the communication link ("High Frequency," 296.8 MHz and "Low Frequency," 259.7 MHz). Since the geometry of the LEM is different in the ascent and descent cases the LEM antenna patterns also depend upon the ascent/descent status of the vehicle.

We wish to develop a computer program which will simulate the CSM-LEM VHF communication links for Apollo missions D and E given the appropriate CSM and LEM antenna pattern data and the CSM and LEM trajectory data. All parameters involved in this simulation should be printed out as functions of mission trajectory and the polarization loss, gain product, CSM antenna gain, LEM antenna gain and range between the CSM and LEM should be plotted as functions of time.

2. INPUT DATA

By a <u>data case</u> we mean the simulation of the four possible communication links between the CSM and the LEM at one of the two frequencies and for a particular LEM ascent/descent status. Hence there are four possible data cases which we may consider. Each data case requires three input tapes and nine input cards. Each of the four data cases is selected by mounting the proper input tapes for that data case and by input of the proper cards.

2.1 DETAILED DESCRIPTION OF INPUT TAPES

Three input tapes are required for each data case. A trajectory tape giving the position and attitude of the CSM and LEM and various time points is mounted on unit "C." The trajectory tape is independent of the data case being considered. One of two CSM antenna patterns tapes is mounted on unit "A" depending on whether a high frequency or low frequency data case is being considered. One of four LEM antenna patterns tapes is mounted on unit "B" depending on whether a high frequency ascent, high frequency descent, low frequency ascent or low frequency descent data case is being considered.

2.1.1 <u>Trajectory Tape Format</u> - The trajectory tape is assumed to consist of one file. Each record within this file represents a specific time point. Records are assumed to be ordered on the tape by ascending time. Each record on the trajectory tape has the following format:

Word 1	Time (in seconds)
Words 2 thru 4	X, Y and Z coordinates, respectively, of the CSM
Words 5 thru 7	X, Y and Z coordinates, respectively, of the LEM
Words 8 thru 16	Direction cosine matrix of the CSM
Words 17 thru 25	Direction cosine matrix of the LEM

2.1.2 <u>CSM Antenna Patterns Tapes Format</u> - The two CSM antenna patterns tapes each consist of one file. There are 2160 records in this file representing a total of twelve antenna patterns, six for the first antenna and six for the second antenna. Each one of these twelve antenna patterns consists of 180 records of 90 words each. Each pattern is specified in a (θ,ϕ) (spherical) coordinate system with gain measurements made at two degree increments for θ ranging from 0° to 178° and ϕ ranging from 0° to 358°, hence each record represents a constant value of ϕ and each word represents a different value of θ at that particular ϕ.

Records on the CSM antenna patterns tapes are in the following order:

Records 1 thru 180	$\theta+45^\circ$	pattern for first antenna
Records 181 thru 360	$\phi+45^\circ$	pattern for first antenna
Records 361 thru 540	θ	pattern for first antenna
Records 541 thru 720	ϕ	pattern for first antenna
Records 721 thru 900	LCP	pattern for first antenna
Records 901 thru 1080	RCP	pattern for first antenna
Records 1081 thru 1260	$\theta+45^\circ$	pattern for second antenna
Records 1261 thru 1440	$\phi+45^\circ$	pattern for second antenna
Records 1441 thru 1620	θ	pattern for second antenna
Records 1621 thru 1800	ϕ	pattern for second antenna
Records 1801 thru 1980	LCP	pattern for second antenna
Records 1981 thru 2160	RCP	pattern for second antenna

From each value obtained from any of the above antenna patterns a "gain reference value" must be subtracted; the gain reference value converts the normalized gain appearing on the antenna pattern tapes to a gain in decibels.

2.1.3 LEM Antenna Patterns Tapes Format - Each of the four LEM antenna patterns tapes are in precisely the same format as the CSM antenna patterns tapes (§2.1.2, above) except for the order of the records. Records on the LEM antenna patterns tapes are in the following order:

Records 1 thru 180	ϕ	pattern for first antenna
Records 181 thru 360	θ	pattern for first antenna
Records 361 thru 540	$\theta+45^\circ$	pattern for first antenna
Records 541 thru 720	$\phi+45^\circ$	pattern for first antenna
Records 721 thru 900	RCP	pattern for first antenna

Records 901 thru 1080 LCP pattern for first antenna
Records 1081 thru 1260 ϕ pattern for second antenna
Records 1261 thru 1440 θ pattern for second antenna
Records 1441 thru 1620 $\theta+45^\circ$ pattern for second antenna
Records 1621 thru 1800 $\phi+45^\circ$ pattern for second antenna
Records 1801 thru 1980 RCP pattern for second antenna
Records 1981 thru 2160 LCP pattern for second antenna

From each value obtained from any of the above antenna patterns a "gain reference value" must be subtracted; the gain reference value converts the normalized gain appearing on the antenna pattern tapes to a gain in decibels.

2.2 DETAILED DESCRIPTION OF INPUT CARDS

2.2.1 Input Card One - Designates the frequency of the data case being considered

Field 1 - Column 1, Integer
1 indicates low frequency
2 indicates high frequency

2.2.2 Input Cards Two thru Five - Identification cards. The first card identifies the first link to be processed, the second card identifies the second link to be processed, etc.

Field 1 - Columns 1-48, Alphanumeric
Description of the cases being processed

2.2.3 Input Cards Six and Seven - Gain referance values. The first card gives the gain reference values for the CSM antenna patterns tape and the second card gives the gain referance values for the LEM antenna patterns tape.

Field 1 - Columns 1-5, Real
Gain reference value for pattern 1, first antenna
Field 2 - Columns 6-10, Real
Gain reference value for pattern 2, first antenna
Field 3 - Columns 11-15, Real
Gain reference value for pattern 3, first antenna

Field 4 - Columns 16-20, Real

Gain reference value for pattern 4, first antenna

Field 5 - Columns 21-25, Real

Gain reference value for pattern 5, first antenna

Field 6 - Columns 26-30, Real

Gain reference value for pattern 6, first antenna

Field 7 - Columns 31-35, Real

Gain reference value for pattern 1, second antenna

Field 8 - Columns 36-40, Real

Gain reference value for pattern 2, second antenna

Field 9 - Columns 41-45, Real

Gain reference value for pattern 3, second antenna

Field 10 - Columns 46-50, Real

Gain reference value for pattern 4, second antenna

Field 11 - Columns 51-55, Real

Gain reference value for pattern 5, second antenna

Field 12 - Columns 56-60. Real

Gain reference value for pattern 6, second antenna

2.2.4 Input Card Eight - Plot specification data. Determines limits to be set up for the plots.

Field 1 - Columns 1-8, Real

Left-hand time (in seconds)

Field 2 - Columns 9-16, Real

Right-hand time (in seconds)

Field 3 - Columns 17-24, Real

Bottom range (in nautical miles)

Field 4 - Columns 25-32, Real

Top range (in nautical miles)

Field 5 - Columns 33-40, Real

Bottom gain (in decibels)

Field 6 - Columns 41-48, Real

Top gain (in decibels)

2.2.5 Input Card Nine - Range specification data. Determines the time points which are to be processed from the trajectory tape for this data case.

Field 1 - Columns 1-8, Real

Minimum time (in seconds) desired.

Field 2 - Columns 9-16, Real

Maximum time (in seconds) desired.

Field 3 - Columns 17-24, Real

Time increment (in seconds). Minimum time increment between time points.

2.3 MULTIPLE CASES

Since different tapes must be assigned for each data case (See Appendix for current tape numbers), only one unique data case can be run per job. Multiple cases using the same tapes (i.e., cases at the same frequency and with the same LEM ascent/descent status) may be run simply by including additional data decks.

2.4 RESTRICTIONS

A maximum of one hundred time-points are allowed per data case.

3. OUTPUT DATA

Data output for this program is in the form of printed output and plotted output.

3.1 PRINTED OUTPUT

For the data case processed, four successive outputs appear, one for each of the four possible communication links. Each output consists of one page per time point. At each time point every parameter involved in the simulation is listed, as well as the values obtained from the three input tapes for this time point.

3.2 PLOTTED OUTPUT

For the data case processed, four successive series of plots appear, one for each of the four possible communication links. Each series of plots consists of a plot of CSM gain vs. time, LEM gain vs. time, gain product vs. time, polarization loss vs. time and range between CSM and LEM vs. time.

4. SAMPLE CASE

One data case (low frequency, ascent) is included as a sample case. A restricted time interval was considered.

4.1 SAMPLE CODING FORM

TRW SYSTEMS
HOUSTON COMPUTING CENTER
SYMBOLIC AND FORTRAN CODING FORM

DATE 5/15/68
NAME ARGILA
EXT 2964
NO OF CARDS 9

PRIORITY
PROBLEM NO H28901
SPECIAL CHARACTERS:

CARD STOCK: ☑ PLAIN Yellow
☐ FORTRAN SOURCE
☐ 7094 SYMBOLIC

PAGE 1 OF 1
KEYPUNCHED BY
VERIFIED BY

SYMBOL / C NUMBER | * | OPERATION / FORTRAN STATEMENT | ADDRESS, TAG, DECREMENT | COMMENTS | SEQUENCE

```
1
CSM ANTENNA B    LØW FREQUENCY
CSM ANTENNA A    LØW FREQUENCY
LEM ANTENNA 1    LØW FREQUENCY  ASCENT
LEM ANTENNA 2    LØW FREQUENCY  ASCENT
 5.41 5.41 5.45 5.45 3.74 3.74 5.48 5.48 5.52 5.52 3.76 3.76
 4.25 4.25 4.29 4.29 5.60 5.60 3.44 3.44 3.08 3.08 5.30 5.30
340784.0362940.0        0   120.0   -10.0 (60.0)    60.0 (10.0)
356160.0359900.0     30.0
```

* FORTRAN STATEMENT CONTINUATION

4-2

4.2 SAMPLE OUTPUT

16:12:49

XQT HV014A

```
TIME =    .35619173+06
CSM COORDINATES, X =    .31479301+04      Y =   -.67654114+03      Z =   -.15450020+04
LM COORDINATES,  X =    .31268607+04      Y =   -.75210509+03      Z =   -.15747862+04
CSM DIRECTION COSINES
   .25860495-00          .89998281-00          .35093361-00
   .90457495-00         -.35308258-00          .23890755-00
   .33892123-00          .25566309-00         -.90541081-00

LM DIRECTION COSINES
  -.59241281-00         -.78822555-00         -.16657575-00
   .32449338-00         -.42270567-00          .84618195-00
  -.73739477-00          .44722630-00          .50619024-00

LOOK ANGLES, THETAL =  95.79      PHIL =  25.01      THETAC = 178.96      PHIC = 176.11
POLARIZATION ANGLE = 118.72
AXIAL RATIOS, RC =     .1739+02      RL =    -.4419+01
TILT ANGLES, TC =, -48.76            TL = -31.59
ANGLE BETWEEN POLARIZATION ELLIPSES = -44.11
POLARIZATION LOSS =   -.3104+01
GAINC =    -.7210-00
GAINL =    -.1494+02
GAIN PRODUCT =    -.1877+02
LT =    .14333574+03
LS =    .12456573+03
RANGE BETWEEN CSM AND LM =    .83910224+02
CSM ANTENNA B   LOW FREQUENCY
LEM ANTENNA 1   LOW FREQUENCY   ASCENT
```

```
TIME =    .35631174+06
CSM COORDINATES, X =    .32889573+04     Y =  -.22542700+03     Z =  -.13735571+04
LM COORDINATES,  X =    .32777016+04     Y =  -.30377842+03     Z =  -.14085208+04
CSM DIRECTION COSINES
   .12834619-00         .90575495-00         .40390000-00
   .92533353-00        -.25588488-00         .27978697-00
   .35677034-00         .33783264-00        -.87096727-00

LM DIRECTION COSINES
  -.59241281-00        -.78822555-00        -.16657575-00
   .32449338-00        -.42270567-00         .84618195-00
  -.73739477-00         .44723630-00         .50619024-00

LOOK ANGLES, THETAL =  94.66     PHIL =  17.79     THETAC = 177.06     PHIC =-153.83
POLARIZATION ANGLE = 145.68
AXIAL RATIOS, RC =    .1739+02      RL =    .5848+01
TILT ANGLES, TC =, -81.13           TL = -48.85
ANGLE BETWEEN POLARIZATION ELLIPSES =  -2.04
POLARIZATION LOSS =   -.5975-01
GAINC =   -.7210-00
GAINL =   -.9636+01
GAIN PRODUCT =   -.1042+02
LT =   .13524953+03
LS =   .12483315+03
RANGE BETWEEN CSM AND LM =    .86533806+02
CSM ANTENNA B   LOW FREQUENCY
LEM ANTENNA 1   LOW FREQUENCY   ASCENT
```

```
TIME =    .35643174+06
CSM COORDINATES, X =    .33648241+04      Y =    .23015284+03      Z =  -.11748173+04
LM COORDINATES,  X =    .33640984+04      Y =    .15051964+03      Z =  -.12144794+04
CSM DIRECTION COSINES
  -.45327646-02         .89358490-00         .44887131-00
   .93190167-00        -.15902650-00         .32599047-00
   .36268260-00         .41978157-00        -.83201246-00

LM DIRECTION COSINES
  -.59241281-00        -.78822555-00        -.16657575-00
   .32449338-00        -.42270567-00         .84618195-00
  -.73739477-00         .44723630-00         .50619024-00

LOOK ANGLES, THETAL =  92.47     PHIL =  10.69      THETAC = 174.74     PHIC =-145.39
POLARIZATION ANGLE = 151.59
AXIAL RATIOS, RC =    .0000          RL =     .1739+02
TILT ANGLES, TC =, -90.00           TL = -15.39
ANGLE BETWEEN POLARIZATION ELLIPSES =  46.20
POLARIZATION LOSS =    -.2833+01
GAINC =    -.2497-00
GAINL =    -.1086+02
GAIN PRODUCT =    -.1394+02
LT =    .13901749+03
LS =    .12507397+03
RANGE BETWEEN CSM AND LM =    .88966584+02
CSM ANTENNA B    LOW FREQUENCY
LEM ANTENNA 1    LOW FREQUENCY    ASCENT
```

```
TIME =     .35655174+06
CSM COORDINATES, X =     .33740112+04     Y =     .68117137+03     Z =   -.95272657+03
LM COORDINATES,  X =     .33842961+04     Y =     .60185424+03     Z =   -.99646831+03
CSM DIRECTION COSINES
  -.13739841-00          .86368680-00          .48493996-00
   .92413180-00        -.64438266-01          .37660068-00
   .35651373-00          .49989279-00        -.78930673-00

LM DIRECTION COSINES
  -.59241281-00        -.78822555-00        -.16657575-00
   .32449338-00        -.42270567-00          .84618195-00
  -.73739477-00          .44723630-00          .50619024-00

LOOK ANGLES, THETAL =  90.27      PHIL =   3.68      THETAC = 172.15      PHIC =-140.77
POLARIZATION ANGLE = 154.25
AXIAL RATIOS, RC =    .1739+02      RL =    -.8724+01
TILT ANGLES, TC =, -90.00           TL = -15.67
ANGLE BETWEEN POLARIZATION ELLIPSES =  48.58
POLARIZATION LOSS =    -.3699+01
GAINC =    -.7210-00
GAINL =    -.1128+02
GAIN PRODUCT =    -.1570+02
LT =    .14098077+03
LS =    .12528562+03
RANGE BETWEEN CSM AND LM =    .91160593+02
CSM ANTENNA B    LOW FREQUENCY
LEM ANTENNA 1    LOW FREQUENCY    ASCENT
```

FORTY PAGES OF OUTPUT DELETED AT THIS POINT

```
TIME =    .35619173+06
CSM COORDINATES, X =    .31479301+04      Y =   -.67654114+03      Z =   -.15450020+04
LM COORDINATES,  X =    .31268607+04      Y =   -.75210509+03      Z =   -.15747862+04
CSM DIRECTION COSINES
   .25860495-00         .89998281-00         .35093361-00
   .90457495-00        -.35308258-00         .23890755-00
   .33892123-00         .25566309-00        -.90541081-00

LM DIRECTION COSINES
  -.59241281-00        -.78822555-00        -.16657575-00
   .32449338-00        -.42270567-00         .84618195-00
  -.73739477-00         .44723630-00         .50619024-00

LOOK ANGLES, THETAL =  96.79     PHIL =  25.01     THETAC = 178.96     PHIC = 176.11
POLARIZATION ANGLE = 118.72
AXIAL RATIOS, RC =    .1739+02     RL =    .1925+01
TILT ANGLES, TC =, -48.76          TL = -90.00
ANGLE BETWEEN POLARIZATION ELLIPSES =  77.48
POLARIZATION LOSS =   -.5404+01
GAINC =   -.7210-00
GAINL =    .2014+01
GAIN PRODUCT =   -.4111+01
LT =   .12867668+03
LS =   .12456573+03
RANGE BETWEEN CSM AND LM =   .83910224+02
CSM ANTENNA B   LOW FREQUENCY
LEM ANTENNA 2   LOW FREQUENCY   ASCENT
```

```
TIME =    .35631174+06
CSM COORDINATES, X =    .32889573+04     Y =   -.22542700+03      Z =   -.13735571+04
LM COORDINATES,  X =    .32777016+04     Y =   -.30377842+03      Z =   -.14085208+04
CSM DIRECTION COSINES
   .12834619-00          .90575495-00          .40390000-00
   .92533353-00        -.25588488-00          .27978697-00
   .35677034-00          .33783264-00        -.87096727-00

LM DIRECTION COSINES
  -.59241281-00        -.78822555-00        -.16657575-00
   .32449338-00        -.42270567-00          .84618195-00
  -.73739477-00          .44723630-00          .50619024-00

LOOK ANGLES, THETAL =  94.66     PHIL =  17.79     THETAC = 177.06     PHIC =-153.83
POLARIZATION ANGLE = 145.68
AXIAL RATIOS, RC =    .1739+02     RL =    .1925+01
TILT ANGLES, TC =, -81.13          TL =  83.79
ANGLE BETWEEN POLARIZATION ELLIPSES = 130.60
POLARIZATION LOSS =    -.2982+01
GAINC =   -.7210-00
GAINL =     .2014+01
GAIN PRODUCT =   -.1689+01
LT =    .12652245+03
LS =    .12483315+03
RANGE BETWEEN CSM AND LM =    .86533806+02
CSM ANTENNA B   LOW FREQUENCY
LEM ANTENNA 2   LOW FREQUENCY   ASCENT
```

```
TIME =    .35643174+06
CSM COORDINATES, X =    .33648241+04      Y =    .23015284+03      Z =   -.11748173+04
LM COORDINATES,  X =    .33640984+04      Y =    .15051964+03      Z =   -.12144794+04
CSM DIRECTION COSINES
  -.45327646-02        .89358490-00        .44887131-00
   .93190167-00       -.15902650-00        .32599047-00
   .36268260-00        .41978157-00       -.83201246-00

LM DIRECTION COSINES
  -.59241281-00       -.78822555-00       -.16657575-00
   .32449338-00       -.42270567-00        .84618195-00
  -.73739477-00        .44723630-00        .50619024-00

LOOK ANGLES, THETAL =  92.47     PHIL =  10.69     THETAC = 174.74     PHIC =-145.39
POLARIZATION ANGLE = 151.59
AXIAL RATIOS, RC =    .0000         RL =    .1785+01
TILT ANGLES, TC =, -90.00           TL =  70.05
ANGLE BETWEEN POLARIZATION ELLIPSES = 131.63
POLARIZATION LOSS =   -.2752+01
GAINC =   -.2497-00
GAINL =    .2932+01
GAIN PRODUCT =   -.7006-01
LT =   .12514403+03
LS =   .12507397+03
RANGE BETWEEN CSM AND LM =    .88966584+02
CSM ANTENNA B   LOW FREQUENCY
LEM ANTENNA 2   LOW FREQUENCY   ASCENT
```

```
TIME =     .35655174+06
CSM COORDINATES, X =    .33740112+04      Y =    .68117137+03      Z =   -.95272657+03
LM COORDINATES,  X =    .33842961+04      Y =    .60185424+03      Z =   -.99646831+03
CSM DIRECTION COSINES
  -.13739841-00          .86368680-00          .48493996-00
   .92413180-00         -.64438266-01          .37660068-00
   .35651373-00          .49989279-00         -.78930673-00

LM DIRECTION COSINES
  -.59241281-00         -.78822555-00         -.16657575-00
   .32449338-00         -.42270567-00          .84618195-00
  -.73739477-00          .44723630-00          .50619024-00

LOOK ANGLES, THETAL =   90.27     PHIL =    3.68     THETAC = 172.15     PHIC =-140.77
POLARIZATION ANGLE = 154.25
AXIAL RATIOS, RC =     .1739+02      RL =     .1377+01
TILT ANGLES, TC =, -90.00            TL =   53.99
ANGLE BETWEEN POLARIZATION ELLIPSES = 118.24
POLARIZATION LOSS =    -.3282+01
GAINC =    -.7210-00
GAINL =     .3708+01
GAIN PRODUCT =    -.2950-00
LT =    .12558066+03
LS =    .12528562+03
RANGE BETWEEN CSM AND LM =    .91160993+02
CSM ANTENNA B    LOW FREQUENCY
LEM ANTENNA 2    LOW FREQUENCY    ASCENT
```

FORTY PAGES OF OUTPUT DELETED AT THIS POINT

```
TIME =    .35619173+06
CSM COORDINATES, X =    .31479301+04      Y =   -.67654114+03      Z =   -.15450020+04
LM COORDINATES,  X =    .31268607+04      Y =   -.75210509+03      Z =   -.15747862+04
CSM DIRECTION COSINES
   .25860495-00         .89998281-00         .35093361-00
   .90457495-00        -.35308258-00         .23890755-00
   .33892123-00         .25566309-00        -.90541081-00

LM DIRECTION COSINES
  -.59241281-00        -.78822555-00        -.16657575-00
   .32449338-00        -.42270567-00         .84618195-00
  -.73739477-00         .44723630-00         .50619024-00

LOOK ANGLES, THETAL =   96.79      PHIL =   25.01      THETAC = 178.96      PHIC = 176.11
POLARIZATION ANGLE = 118.72
AXIAL RATIOS, RC =   -.4419+01       RL =    -.4419+01
TILT ANGLES, TC =, -56.56            TL = -31.59
ANGLE BETWEEN POLARIZATION ELLIPSES = -36.31
POLARIZATION LOSS =    -.1461+01
GAINC =    -.1805+01
GAINL =    -.1494+02
GAIN PRODUCT =    -.1821+02
LT =    .14277601+03
LS =    .12456573+03
RANGE BETWEEN CSM AND LM =    .83910224+02
CSM ANTENNA A    LOW FREQUENCY
LEM ANTENNA 1    LOW FREQUENCY    ASCENT
```

```
TIME =    .35631174+06
CSM COORDINATES, X =    .32889573+04      Y =  -.22542700+03      Z =  -.13735571+04
LM COORDINATES,  X =    .32777016+04      Y =  -.30377842+03      Z =  -.14085208+04
CSM DIRECTION COSINES
   .12834619-00          .90575495-00          .40390000-00
   .92533353-00         -.25588488-00          .27978697-00
   .35677034-00          .33783264-00         -.87096727-00

LM DIRECTION COSINES
  -.59241281-00         -.78822555-00         -.16657575-00
   .32449338-00         -.42270567-00          .84518195-00
  -.73739477-00          .44723630-00          .50619024-00

LOOK ANGLES, THETAL =   94.66     PHIL =  17.79     THETAC = 177.06     PHIC =-153.83
POLARIZATION ANGLE = 145.68
AXIAL RATIOS, RC =     .5848+01      RL =     .5848+01
TILT ANGLES, TC =, -68.89            TL = -48.85
ANGLE BETWEEN POLARIZATION ELLIPSES = -14.28
POLARIZATION LOSS =    -.2417-00
GAINC =    -.2496+01
GAINL =    -.9636+01
GAIN PRODUCT =    -.1237+02
LT =    .13720618+03
LS =    .12483315+03
RANGE BETWEEN CSM AND LM =    .86533806+02
CSM ANTENNA A   LOW FREQUENCY
LEM ANTENNA 1   LOW FREQUENCY   ASCENT
```

```
TIME =    .35643174+06
CSM COORDINATES, X =    .33648241+04      Y =    .23015284+03      Z =   -.11748173+04
LM COORDINATES,  X =    .33640984+04      Y =    .15051964+03      Z =   -.12144794+04
CSM DIRECTION COSINES
  -.45327646-02          .89358490-00          .44887131-00
   .93190167-00        -.15902650-00          .32599047-00
   .36268260-00          .41978157-00        -.83201246-00

LM DIRECTION COSINES
  -.59241281-00        -.78822555-00        -.16657575-00
   .32449338-00        -.42270567-00          .84618195-00
  -.73739477-00          .44723630-00          .50619024-00

LOOK ANGLES, THETAL =  92.47     PHIL =  10.69     THETAC = 174.74     PHIC =-145.39
POLARIZATION ANGLE = 151.59
AXIAL RATIOS, RC =     .1739+02      RL = .  .1739+02
TILT ANGLES, TC =, -83.42            TL = -15.39
ANGLE BETWEEN POLARIZATION ELLIPSES =  39.63
POLARIZATION LOSS =    -.2229+01
GAINC =    -.2721+01
GAINL =    -.1086+02
GAIN PRODUCT =    -.1581+02
LT =    .14088481+03
LS =    .12507397+03
RANGE BETWEEN CSM AND LM =    .88966584+02
CSM ANTENNA A   LOW FREQUENCY
LEM ANTENNA 1   LOW FREQUENCY   ASCENT
```

```
TIME =    .35655174+06
CSM COORDINATES, X =    .33740112+04      Y =    .68117137+03      Z =  -.95272657+03
LM COORDINATES,  X =    .33842961+04      Y =    .60185424+03      Z =  -.99646831+03
CSM DIRECTION COSINES
  -.13739841-00          .86368680-00          .48493996-00
   .92413180-00        -.64438266-01          .37660068-00
   .35651373-00          .49989279-00        -.78930673-00

LM DIRECTION COSINES
  -.59241281-00        -.78822555-00        -.16657575-00
   .32449338-00        -.42270567-00          .84618195-00
  -.73739477-00          .44723630-00          .50619024-00

LOOK ANGLES, THETAL =  90.27     PHIL =   3.68     THETAC = 172.15     PHIC =-140.77
POLARIZATION ANGLE = 154.25
AXIAL RATIOS, RC =    .1739+02     RL =  -.8724+01
TILT ANGLES, TC =,  87.07          TL = -15.67
ANGLE BETWEEN POLARIZATION ELLIPSES =  51.51
POLARIZATION LOSS =   -.4224+01
GAINC =   -.2721+01
GAINL =   -.1128+02
GAIN PRODUCT =   -.1822+02
LT =   .14350653+03
LS =   .12528562+03
RANGE BETWEEN CSM AND LM =   .91160993+02
CSM ANTENNA A   LOW FREQUENCY
LEM ANTENNA 1   LOW FREQUENCY   ASCENT
```

FORTY PAGES OF OUTPUT DELETED AT THIS POINT

```
TIME =    .35619173+06
CSM COORDINATES, X =    .31479301+04      Y =   -.67654114+03      Z =   -.15450020+04
LM COORDINATES,  X =    .31268607+04      Y =   -.75210509+03      Z =   -.15747862+04
CSM DIRECTION COSINES
   .25860495-00         .89998281-00         .35093361-00
   .90457495-00        -.35308258-00         .23890755-00
   .33892123-00         .25566309-00        -.90541081-00

LM DIRECTION COSINES
  -.59241281-00        -.78822555-00        -.16657575-00
   .32449338-00        -.42270567-00         .84618195-00
  -.73739477-00         .44723630-00         .50619024-00

LOOK ANGLES, THETAL =  96.79      PHIL =  25.01      THETAC = 178.96      PHIC = 176.11
POLARIZATION ANGLE = 118.72
AXIAL RATIOS, RC =   -.4419+01      RL =     .1925+01
TILT ANGLES, TC =, -56.56           TL = -90.00
ANGLE BETWEEN POLARIZATION ELLIPSES =  85.28
POLARIZATION LOSS =    -.1168+02
GAINC =   -.1805+01
GAINL =    .2014+01
GAIN PRODUCT =   -.1147+02
LT =   .13603601+03
LS =   .12456573+03
RANGE BETWEEN CSM AND LM =    .83910224+02
CSM ANTENNA A   LOW FREQUENCY
LEM ANTENNA 2   LOW FREQUENCY   ASCENT
```

```
TIME =    .35631174+06
CSM COORDINATES, X =    .32389573+04     Y =  -.22542700+03     Z =  -.13735571+04
LM COORDINATES,  X =    .32777016+04     Y =  -.30377842+03     Z =  -.14085208+04
CSM DIRECTION COSINES
   .12834619-00         .90575495-00         .40390000-00
   .92533353-00        -.25588488-00         .27978697-00
   .35677034-00         .33783264-00        -.87096727-00

LM DIRECTION COSINES
  -.59241281-00        -.78822555-00        -.16657575-00
   .32449338-00        -.42270567-00         .84618195-00
  -.73739477-00         .44723630-00         .50619024-00

LOOK ANGLES, THETAL =  94.66     PHIL =  17.79     THETAC = 177.06     PHIC =-153.83
POLARIZATION ANGLE = 145.68
AXIAL RATIOS, RC =    .5348+01     RL =    .1925+01
TILT ANGLES, TC =, -68.89          TL =  83.79
ANGLE BETWEEN POLARIZATION ELLIPSES = 118.36
POLARIZATION LOSS =   -.3123+01
GAINC =   -.2496+01
GAINL =    .2014+01
GAIN PRODUCT =    -.3605+01
LT =   .12843803+03
LS =   .12483315+03
RANGE BETWEEN CSM AND LM =   .86533806+02
CSM ANTENNA A   LOW FREQUENCY
LEM ANTENNA 2   LOW FREQUENCY   ASCENT
```

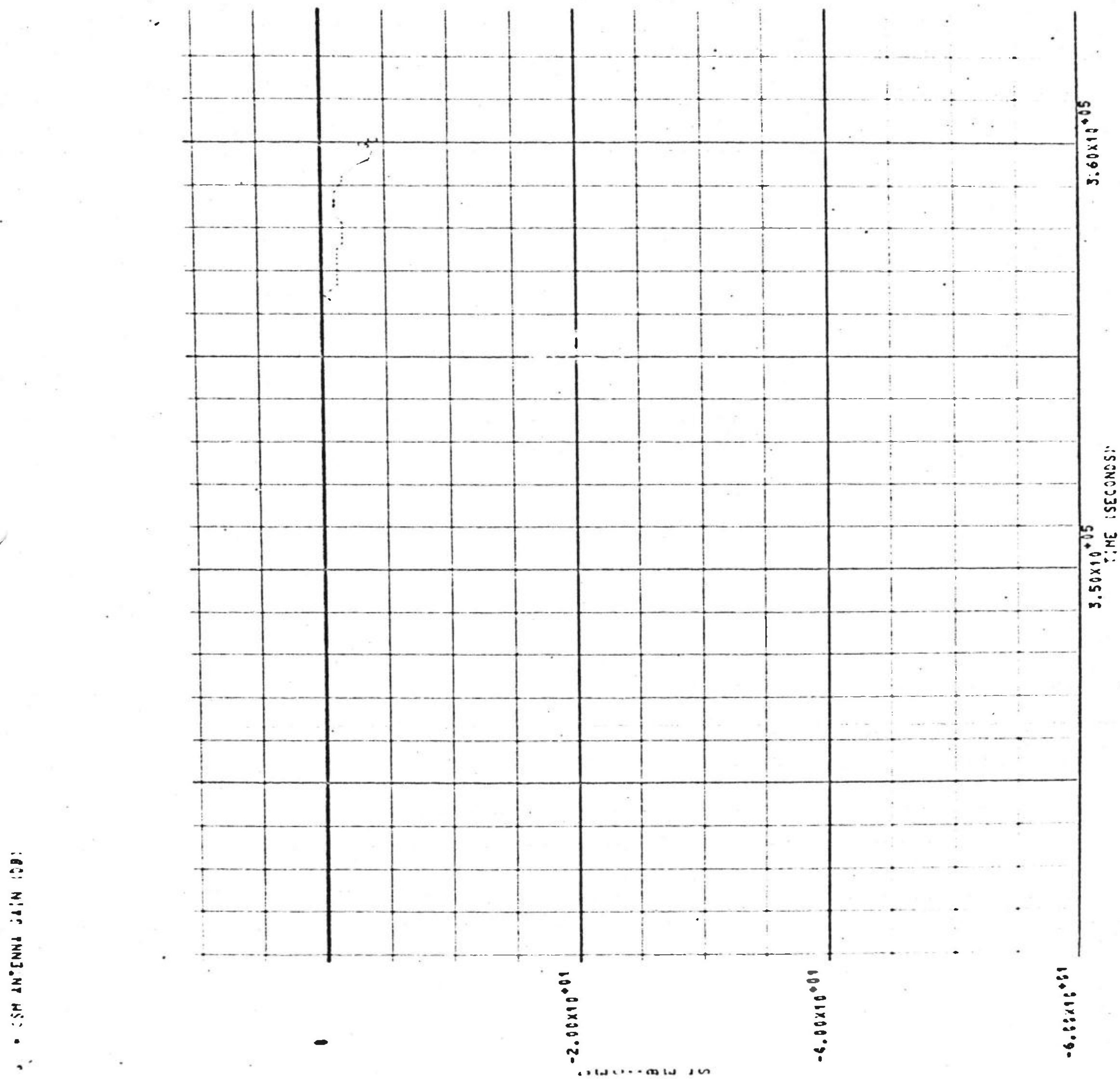
```
TIME =    .35643174+06
CSM COORDINATES, X =    .33648241+04      Y =    .23015284+03      Z =  -.11748173+04
LM COORDINATES,  X =    .33640984+04      Y =    .15051964+03      Z =  -.12144794+04
CSM DIRECTION COSINES
  -.45327646-02        .39358490-00        .44887131-00
   .93190167-00       -.15902650-00        .32599047-00
   .36268260-00        .41978157-00       -.83201246-00

LM DIRECTION COSINES
  -.59241281-00       -.78822555-00       -.16657575-00
   .32449338-00       -.42270567-00        .84618195-00
  -.73739477-00        .44723630-00        .50619024-00

LOOK ANGLES, THETAL =  92.47 .   PHIL =  10.69     THETAC = 174.74     PHIC =-145.39
POLARIZATION ANGLE = 151.59
AXIAL RATIOS, RC =    .1739+02      RL =.    .1785+01
TILT ANGLES, TC =, -83.42           TL =  70.05
ANGLE BETWEEN POLARIZATION ELLIPSES = 125.06
POLARIZATION LOSS =   -.3366+01
GAINC =   -.2721+01
GAINL =     .2932+01
GAIN PRODUCT =   -.3155+01
LT =   .12822914+03
LS =   .12507397+03
RANGE BETWEEN CSM AND LM =    .88966584+02
CSM ANTENNA A   LOW FREQUENCY
LEM ANTENNA 2   LOW FREQUENCY   ASCENT
```

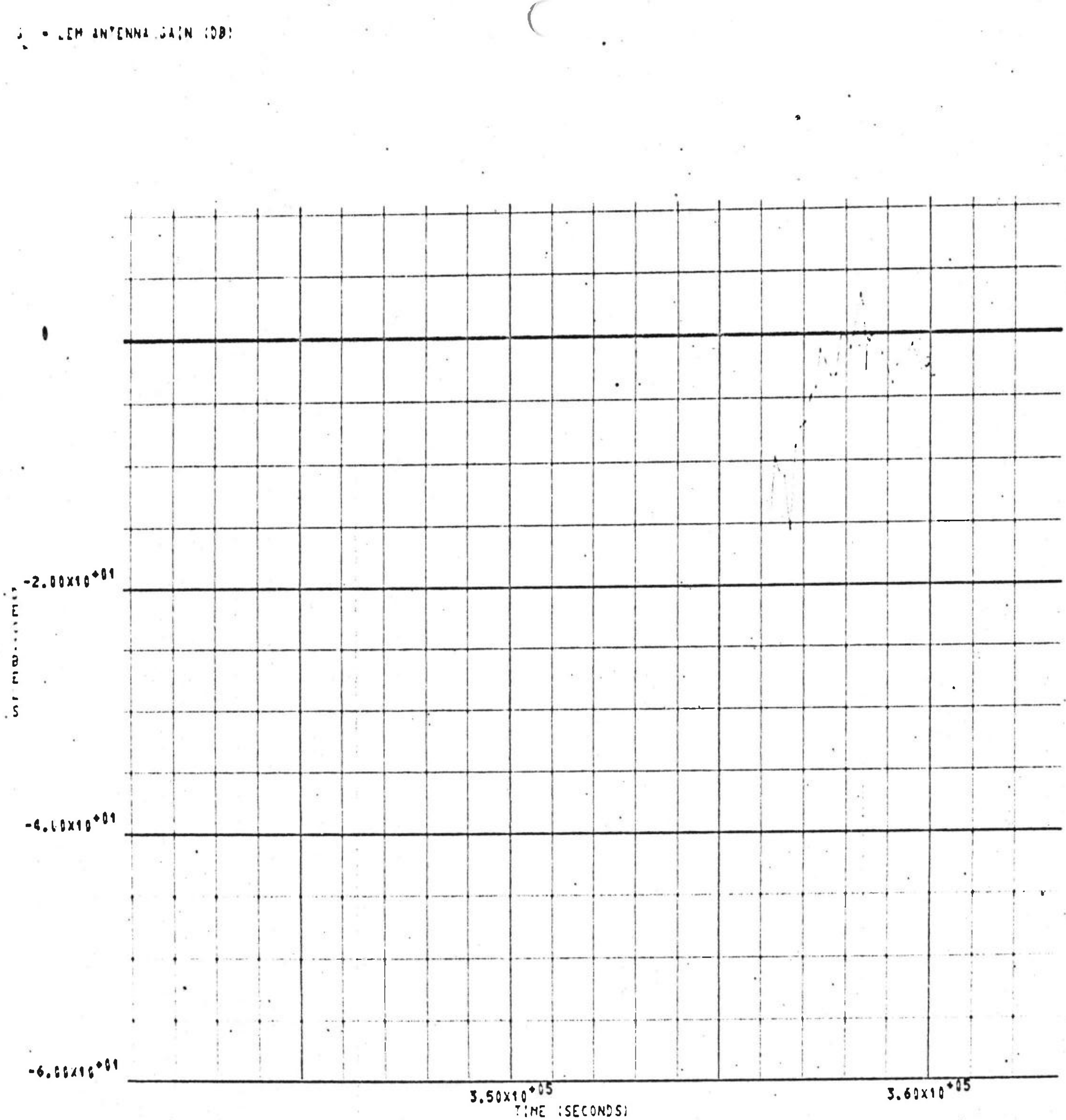
```
TIME =    .35655174+06
CSM COORDINATES, X =    .3374C112+04      Y =    .68117137+03      Z =   -.95272657+03
LM COORDINATES,  X =    .33842961+04      Y =    .60185424+03      Z =   -.99646831+03
CSM DIRECTION COSINES
  -.13739841-00         .86368680-00         .48493996-00
   .92413180-00       -.64438266-01         .37660068-00
   .35651373-00         .49989279-00       -.78930673-00

LM DIRECTION COSINES
  -.59241281-00       -.78822555-00       -.16657575-00
   .32449338-00       -.42270567-00         .84618195-00
  -.73739477-00         .44723630-00         .50619024-00

LOOK ANGLES, THETAL =  90.27     PHIL =   3.68     THETAC = 172.15     PHIC =-140.77
POLARIZATION ANGLE = 154.25
AXIAL RATIOS, RC =    .1739+02     RL =    .1377+01
TILT ANGLES, TC =,  87.07          TL =  53.99
ANGLE BETWEEN POLARIZATION ELLIPSES = -58.83
POLARIZATION LOSS =    -.3159+01
GAINC =    -.2721+01
GAINL =     .3708+01
GAIN PRODUCT =    -.2172+01
LT =    .12745755+03
LS =    .12528562+03
RANGE BETWEEN CSM AND LM =    .91160993+02
CSM ANTENNA A   LOW FREQUENCY
LEM ANTENNA 2   LOW FREQUENCY   ASCENT
```

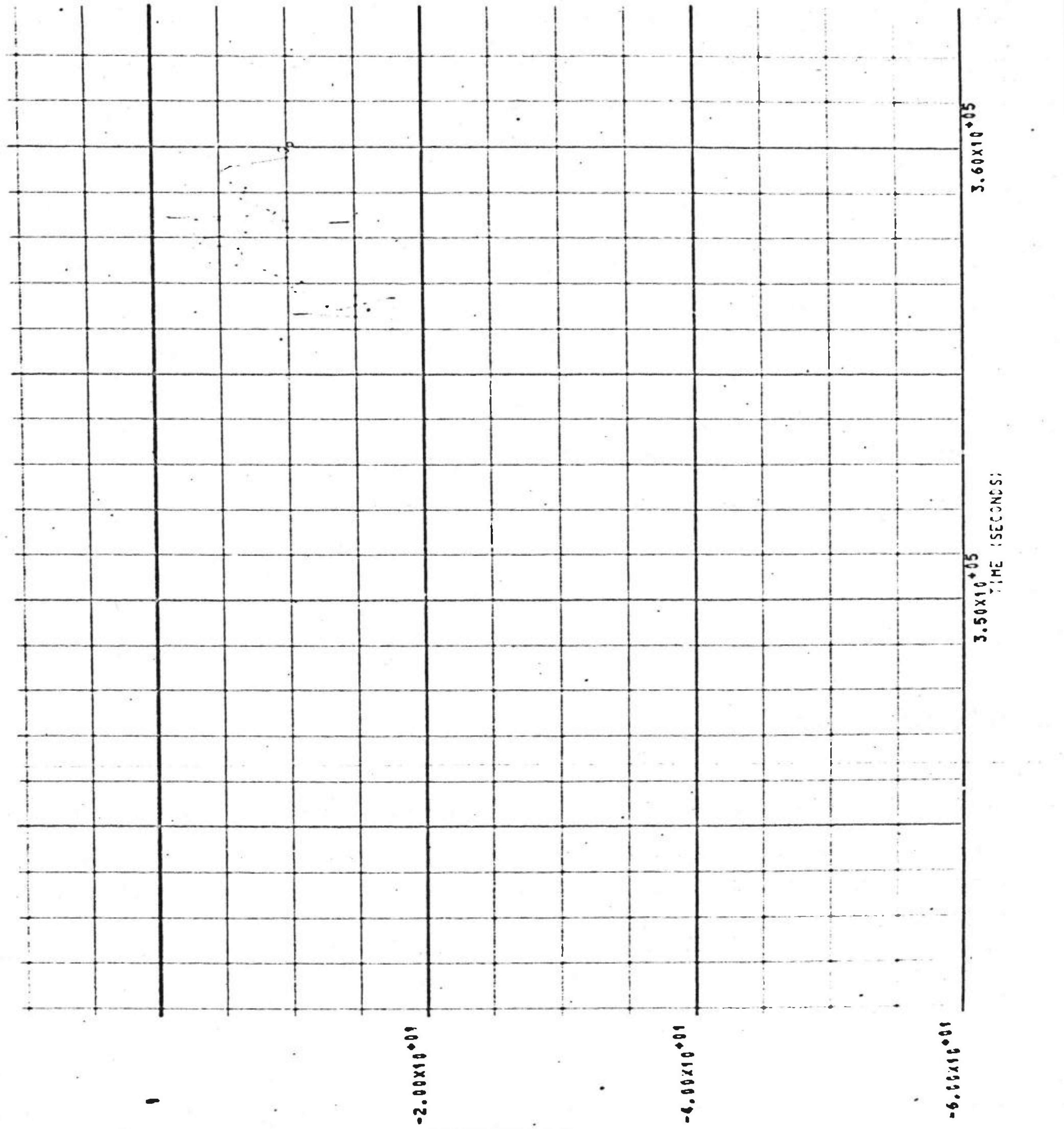
```
EXECUTION TERMINATED BY AN ATTEMPT TO READ THRU AN END OF FILE
   I/O CALLED  AT  SEQUENCE  NUMBER  00116  OF  MAIN PROGRAM
```

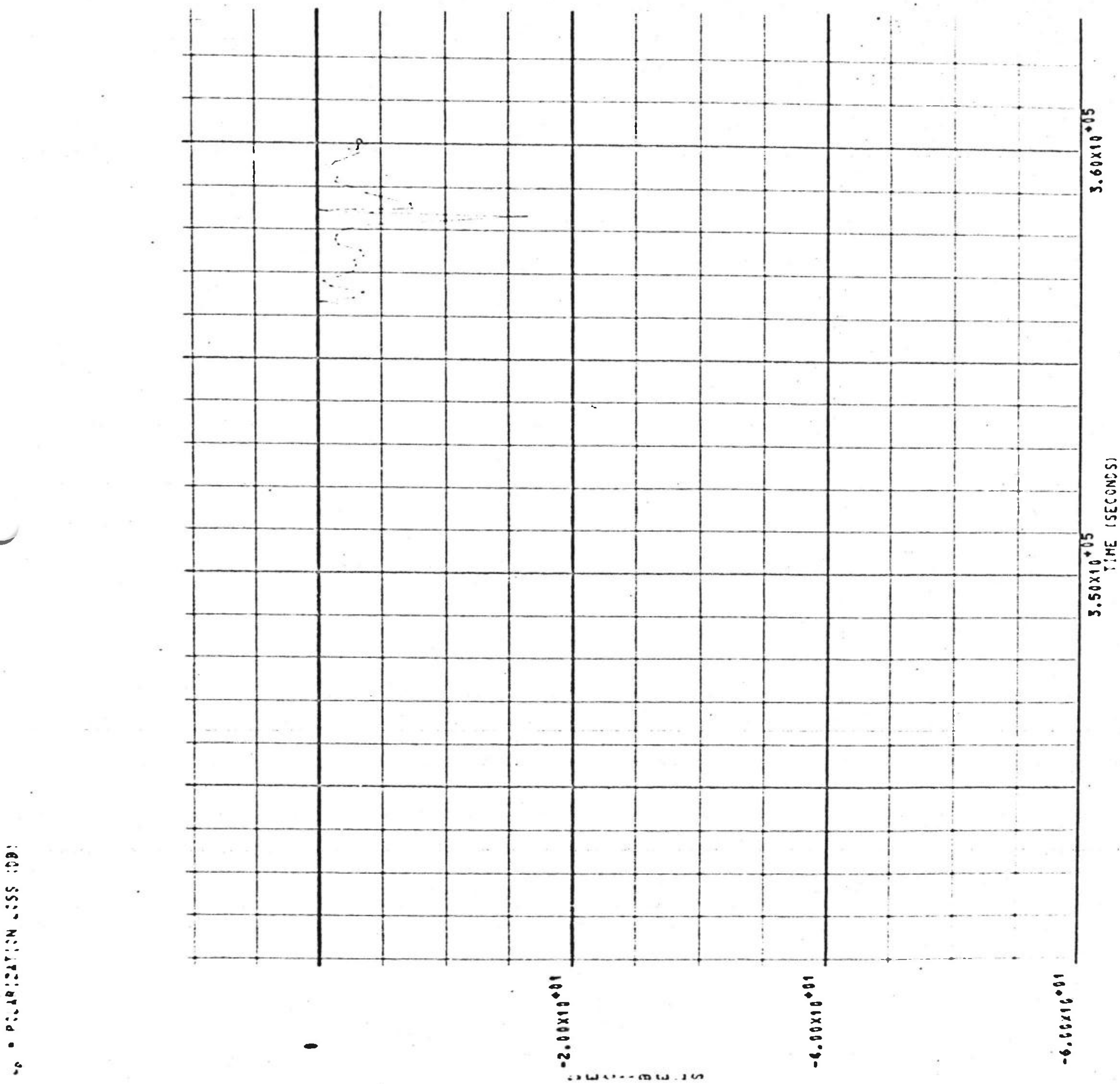
FORTY PAGES OF OUTPUT DELETED AT THIS POINT

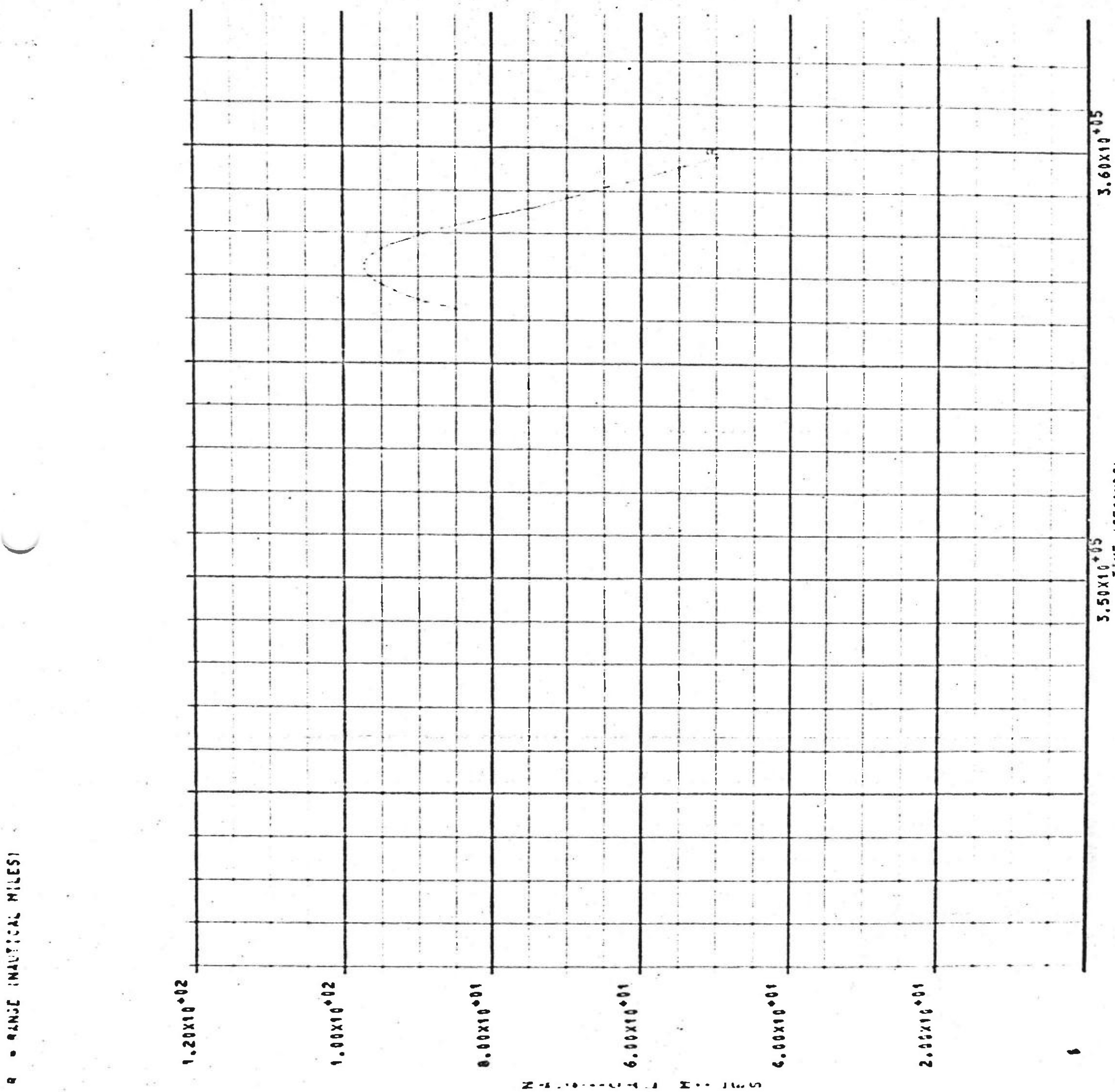
4.3 SAMPLE PLOT OUTPUT

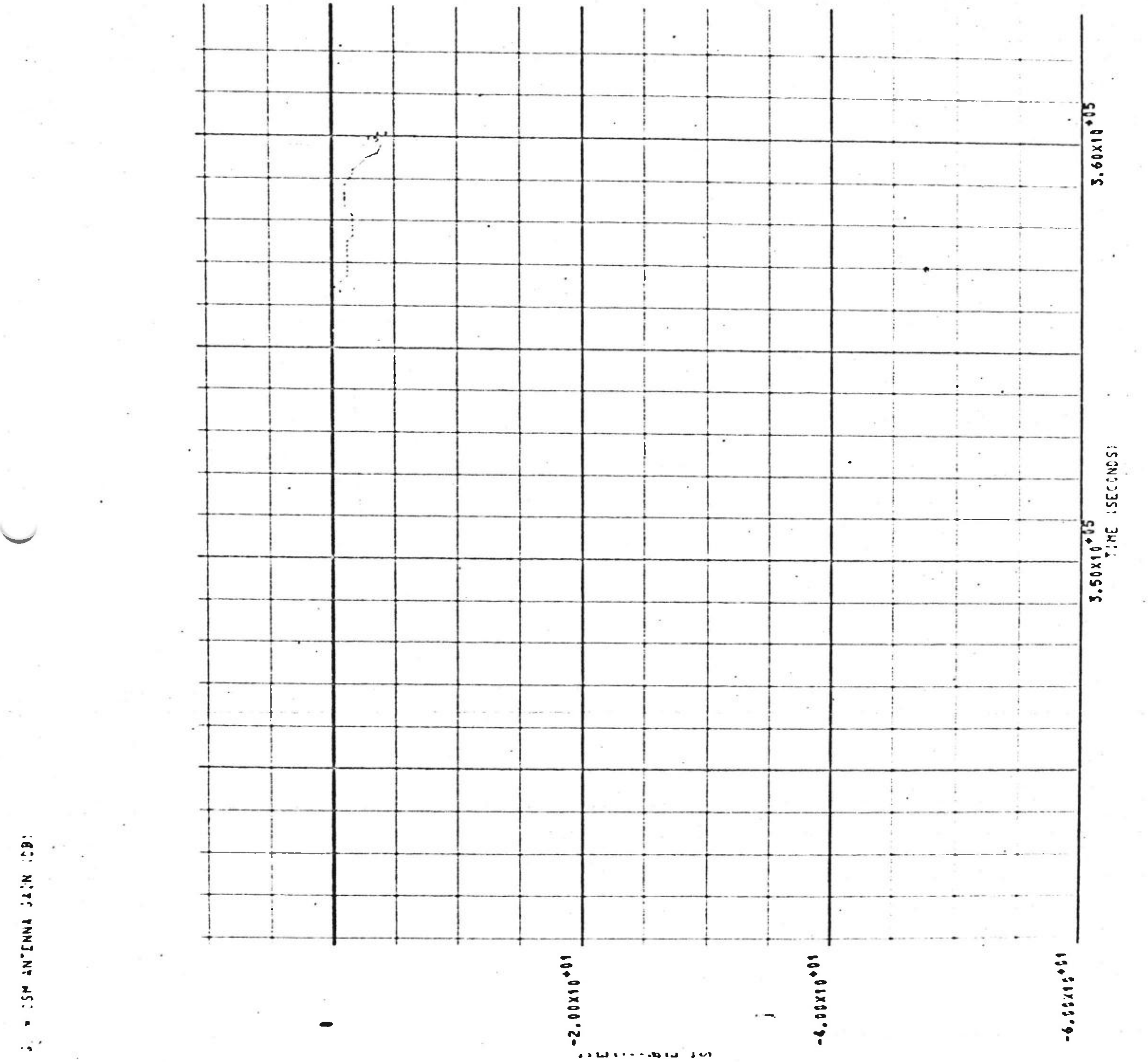


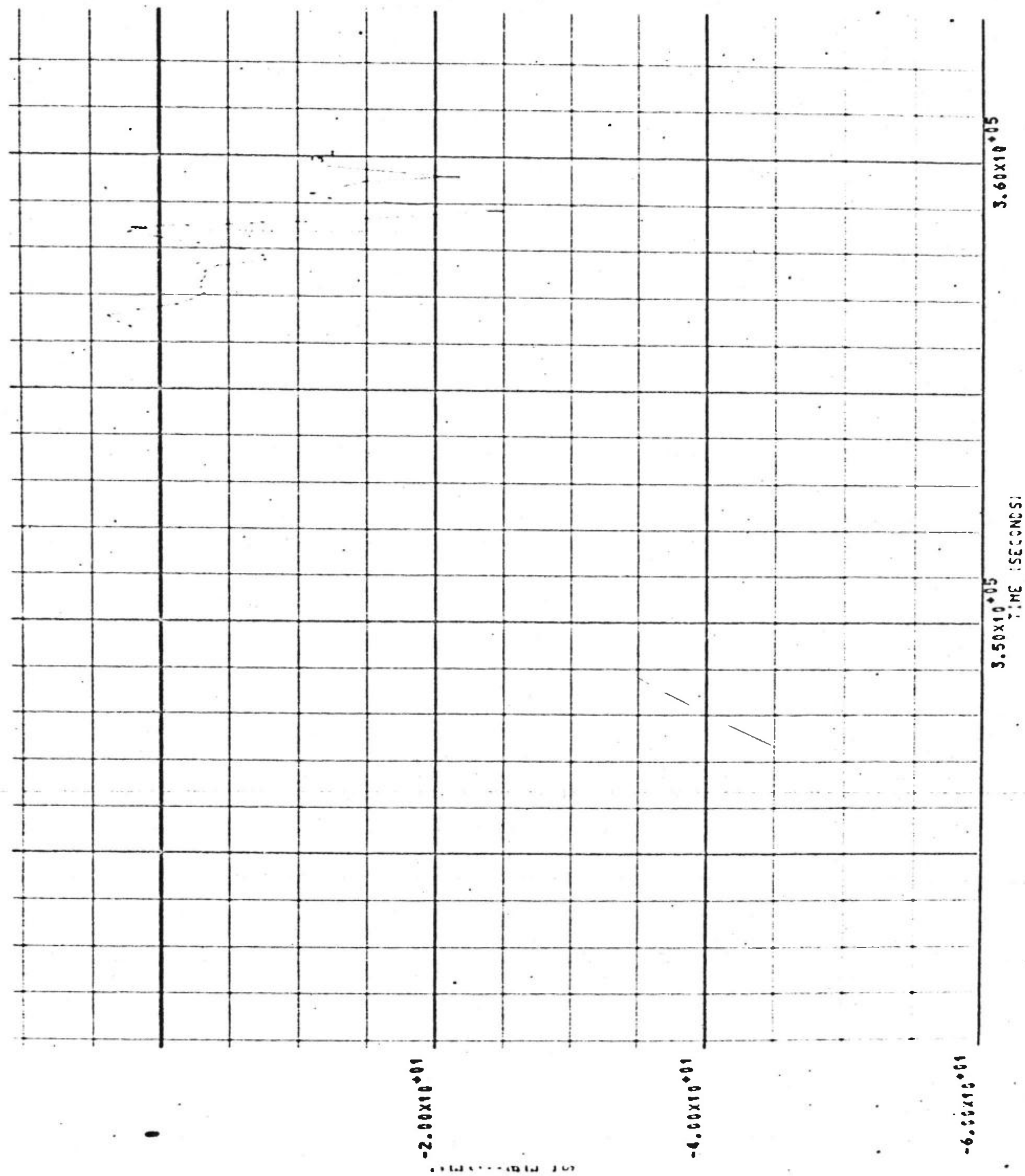

LEM ANTENNA GAIN (DB)
-2.00X10+01
-4.00X10+01
-6.00X10+01
3.50X10+05
3.60X10+05
TIME (SECONDS)

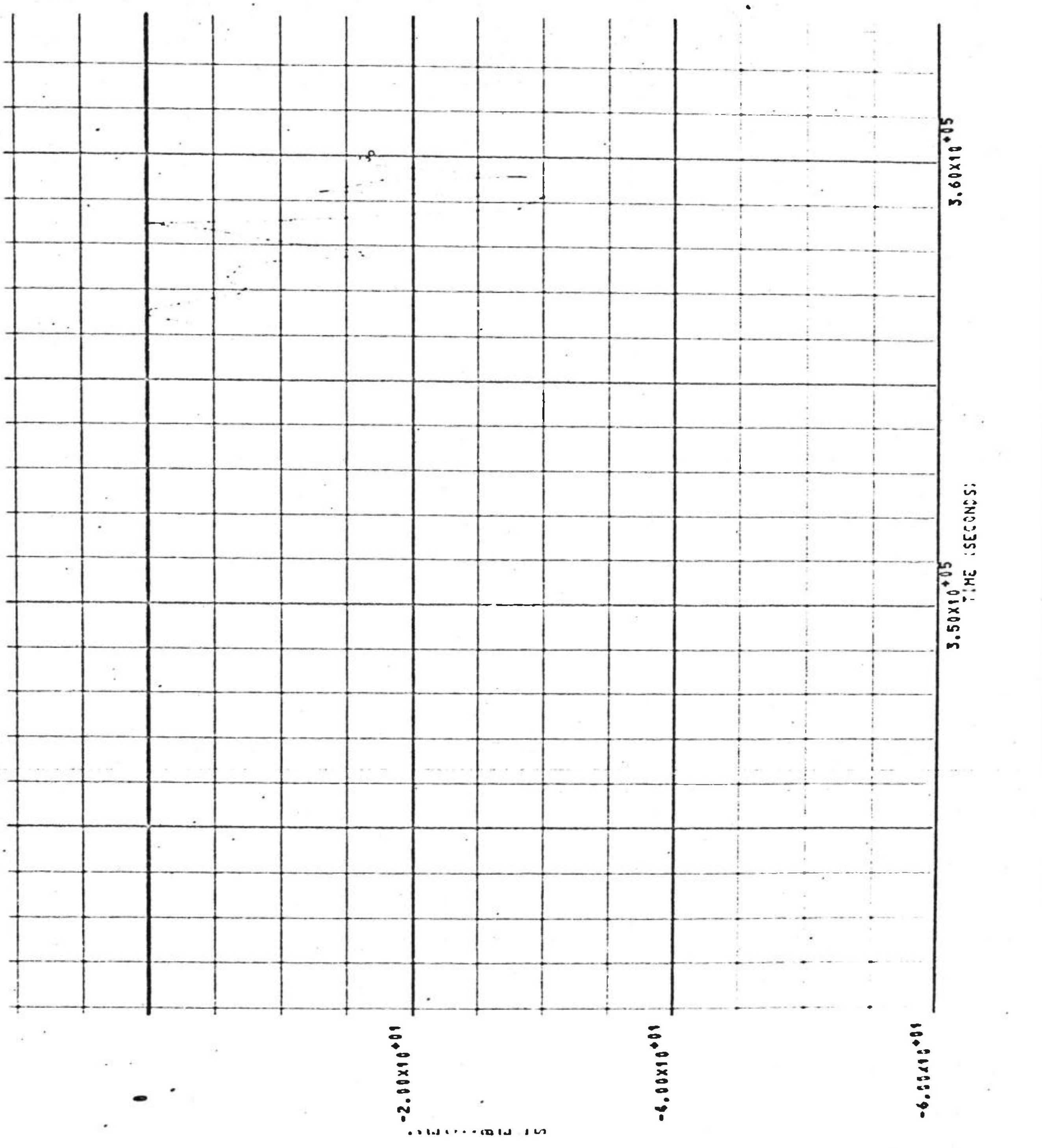

3.60X10+05
3.50X10+05
TIME (SECONDS)
-2.00X10+01
-4.00X10+01
-6.00X10+01

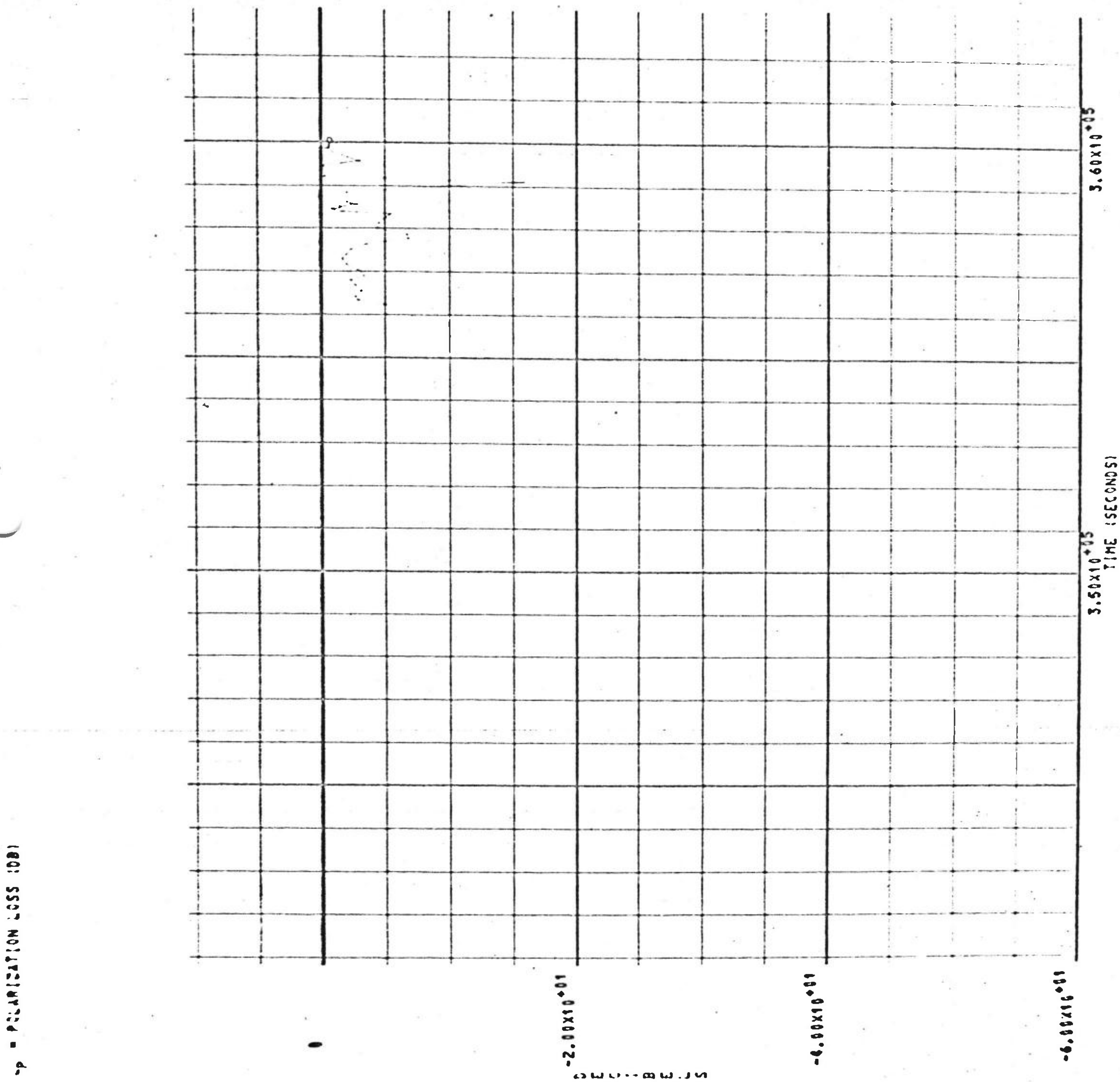

3.60X10+05
3.50X10+05
TIME (SECONDS)
-2.00X10+01
-4.00X10+01
-6.00X10+01

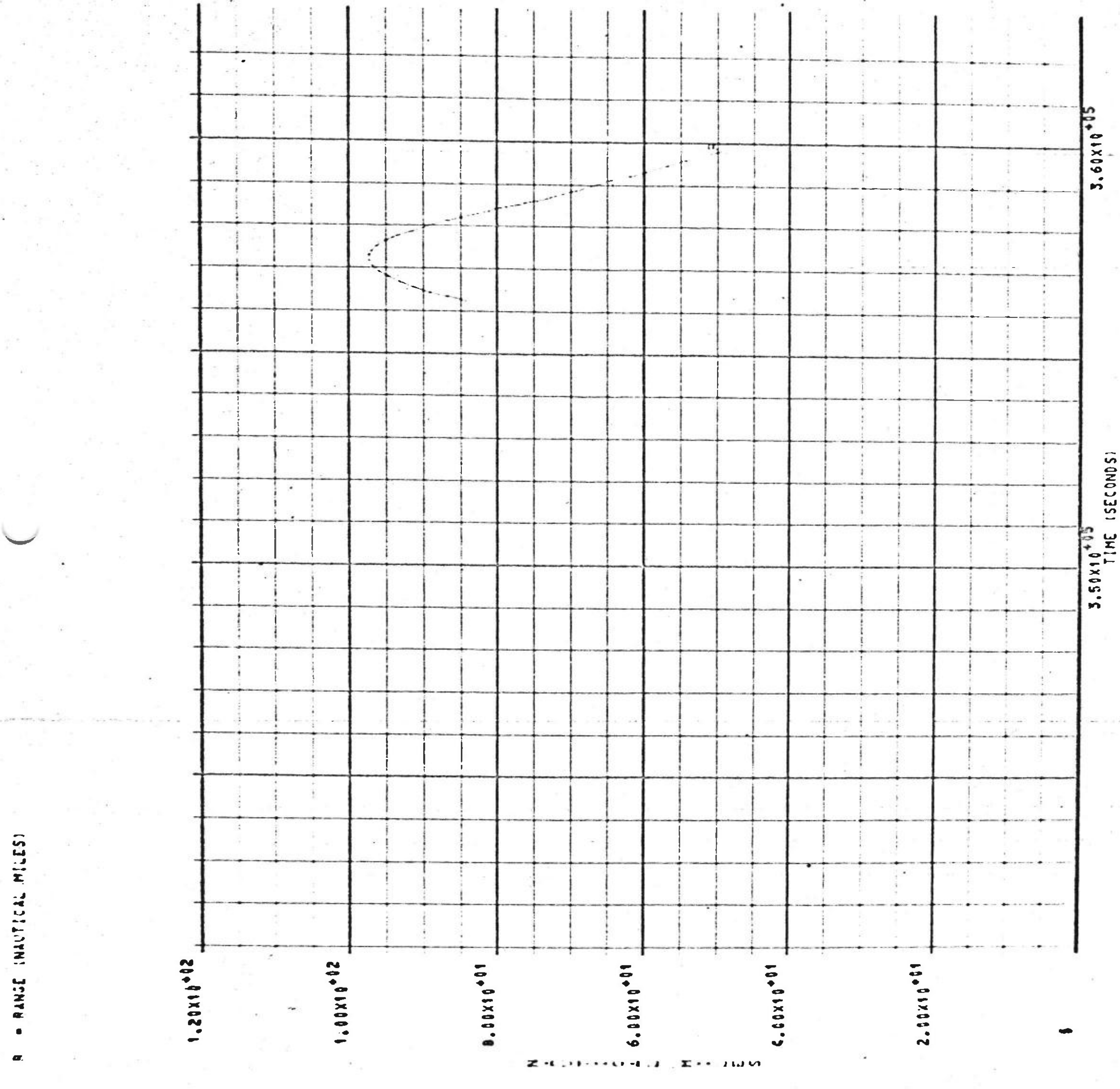

R = RANGE (NAUTICAL MILES)
1.20X10+02
1.00X10+02
8.00X10+01
6.00X10+01
4.00X10+01
2.00X10+01
3.60X10+05
3.50X10+05
TIME (SECONDS)

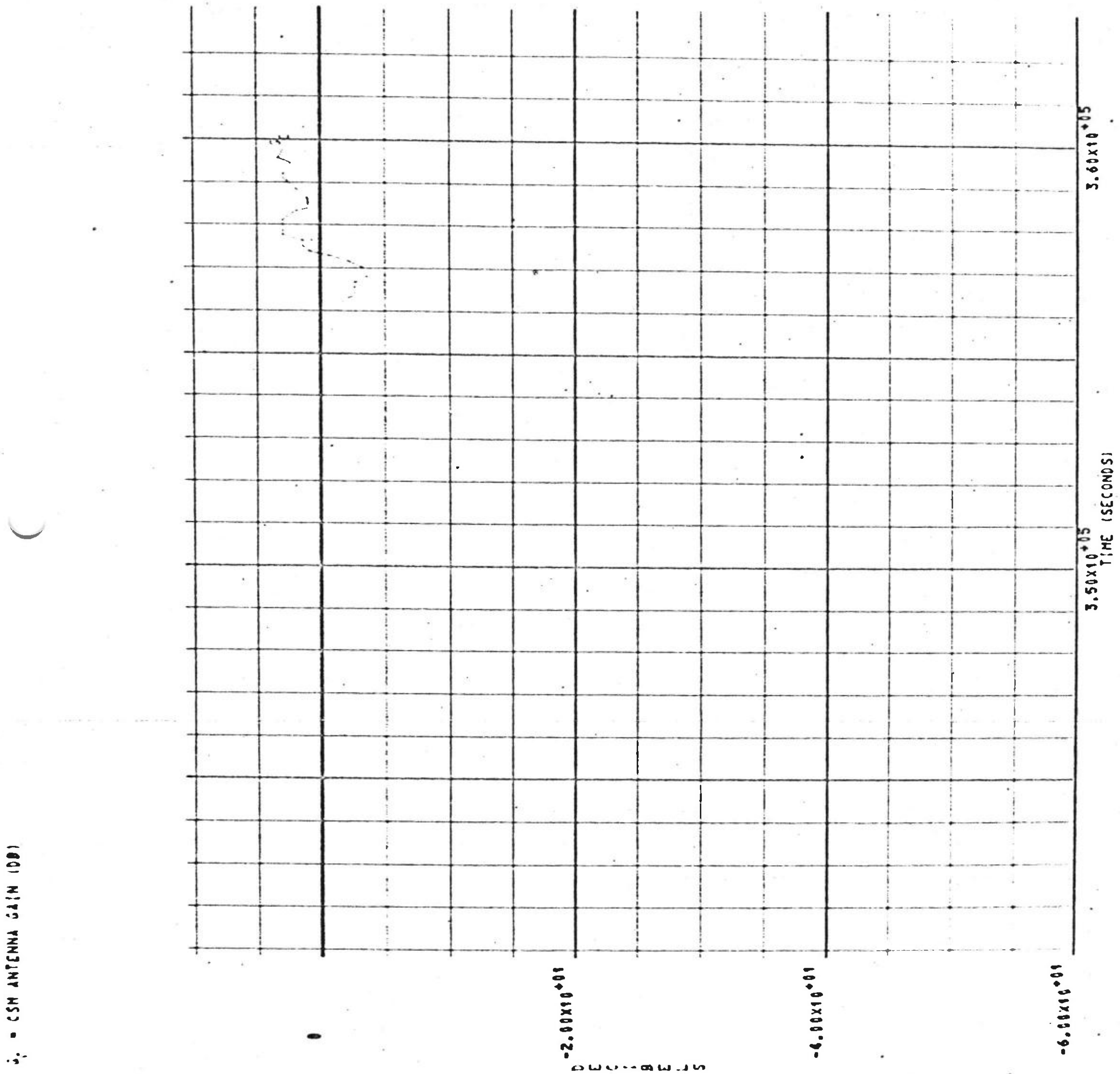

3.60X10+05
3.50X10+05
TIME (SECONDS)
-2.00X10+01
-4.00X10+01


3.60X10+05
3.50X10+05
-2.00X10+01
-4.00X10+01

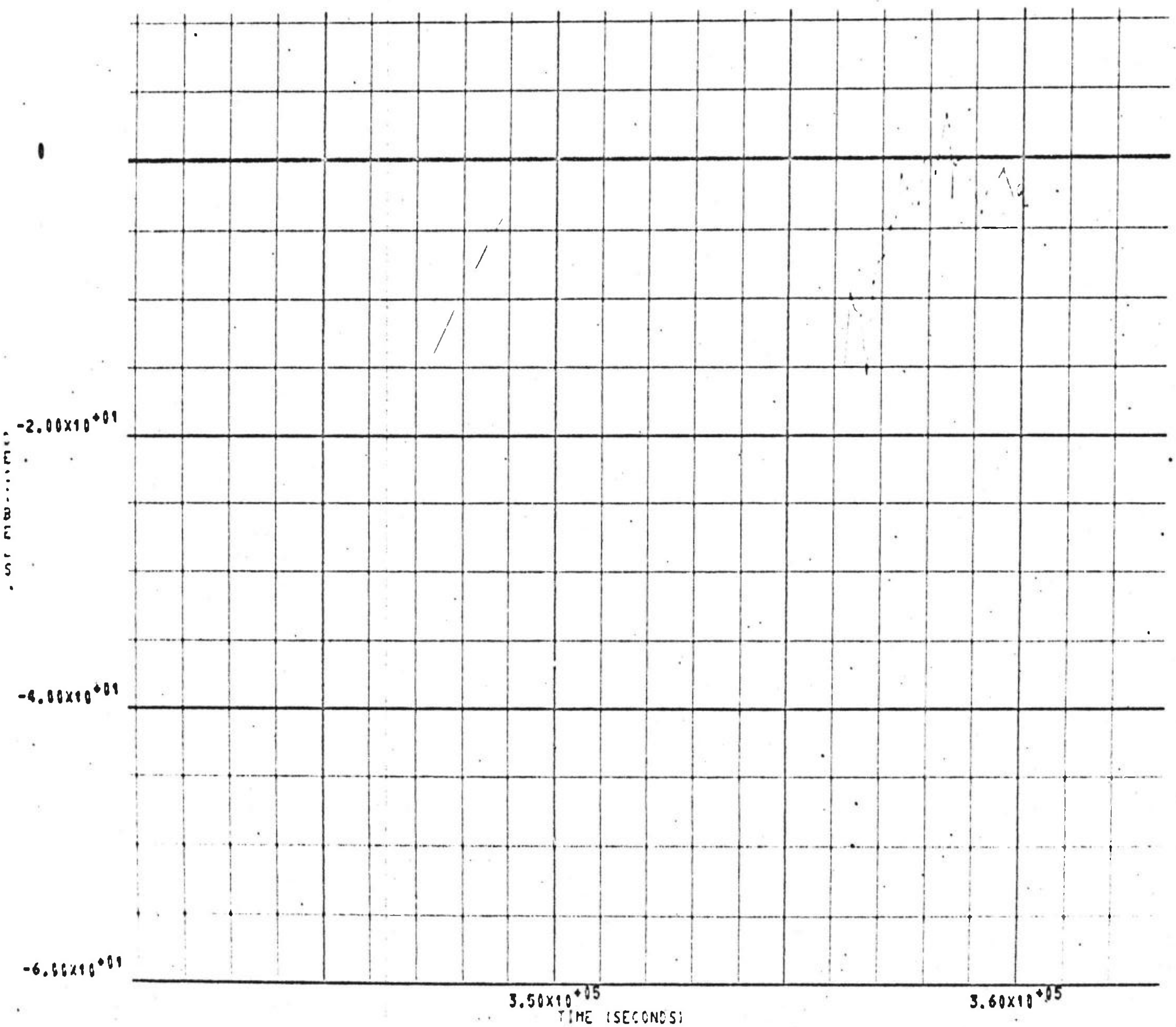

3.60X10+05
3.50X10+05
TIME (SECONDS)
-2.00X10+01
-6.00X10+01

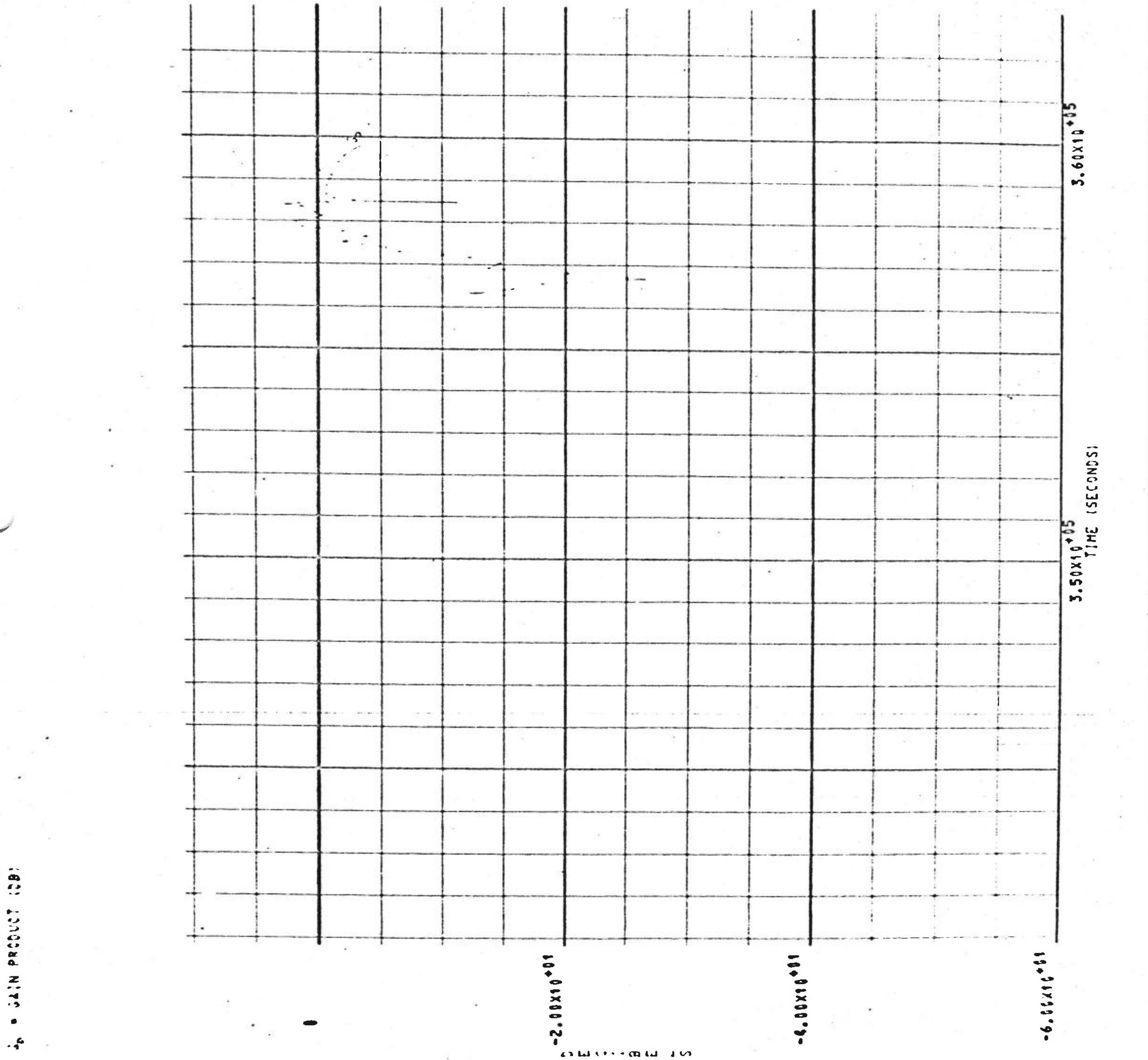

LP = POLARIZATION LOSS (DB)
-2.00X10+01
-4.00X10+01
-6.00X10+01
3.50X10+05
3.60X10+05
TIME (SECONDS)

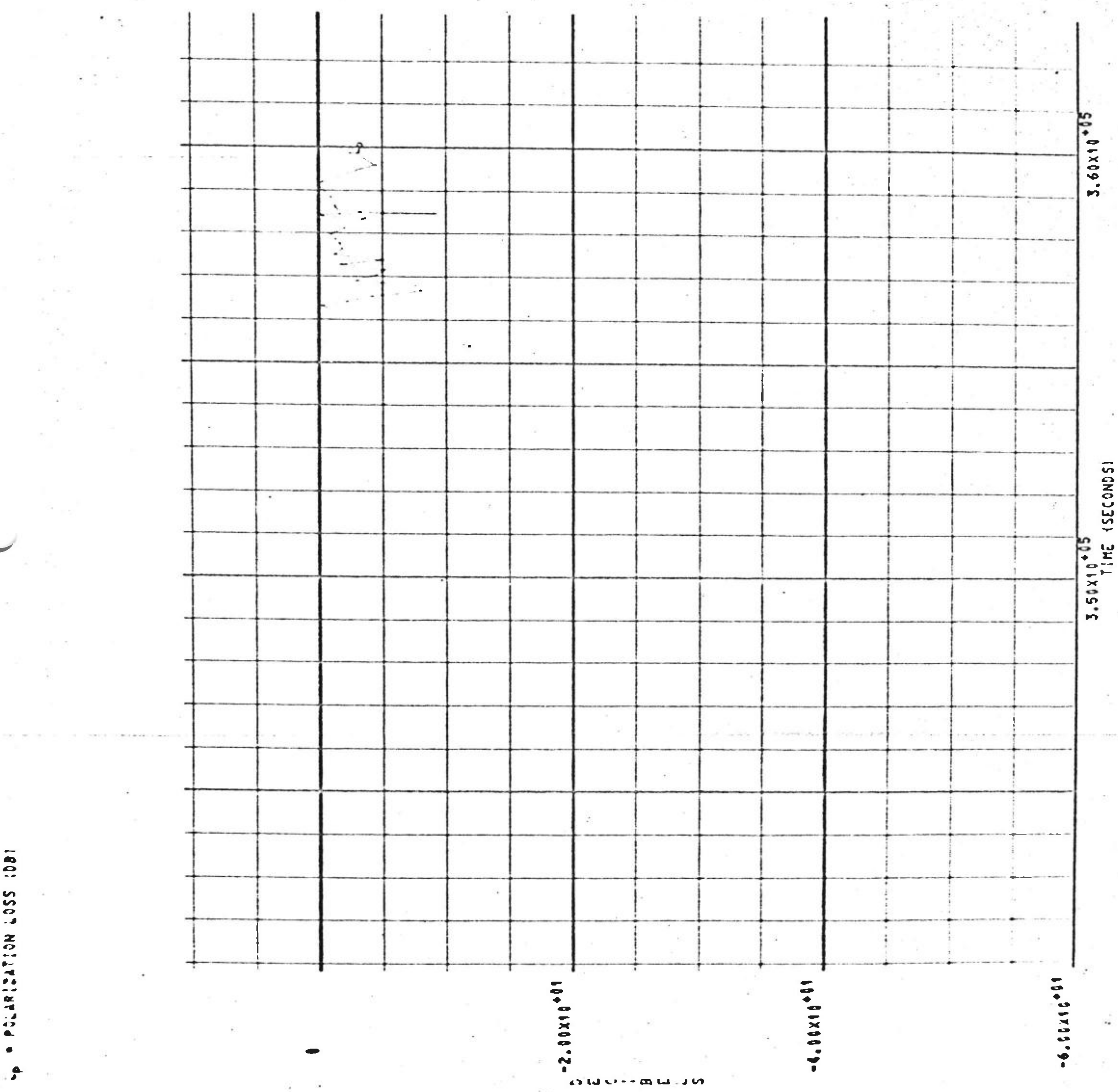

R - RANGE (NAUTICAL MILES)
1.20X10+02
1.00X10+02
8.00X10+01
6.00X10+01
4.00X10+01
2.00X10+01
0
3.50X10+05
3.60X10+05
TIME (SECONDS)

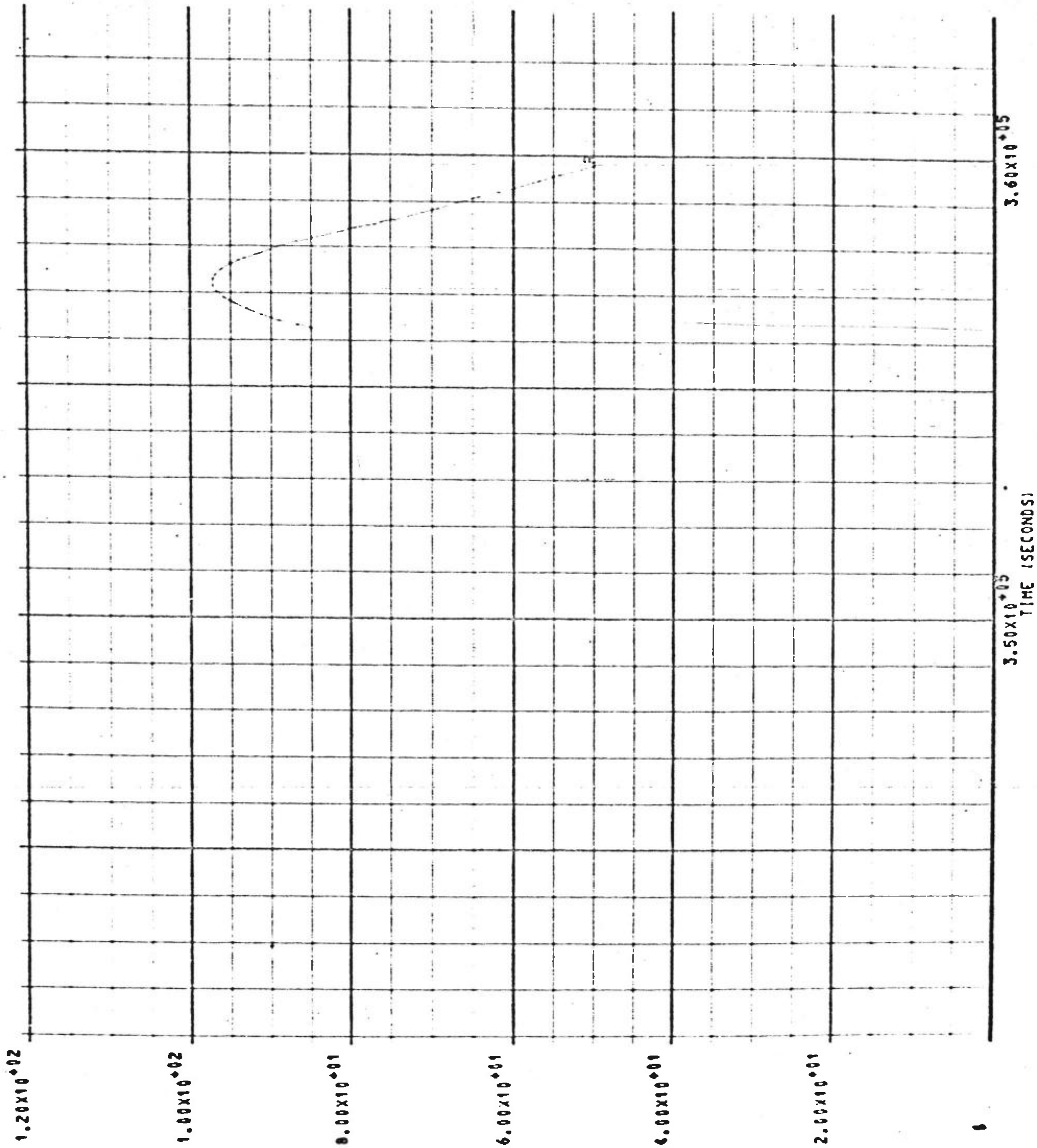

CSM ANTENNA GAIN (DB)
3.60x10+05
3.50x10+05
TIME (SECONDS)
-2.00x10+01
-4.00x10+01
-6.00x10+01

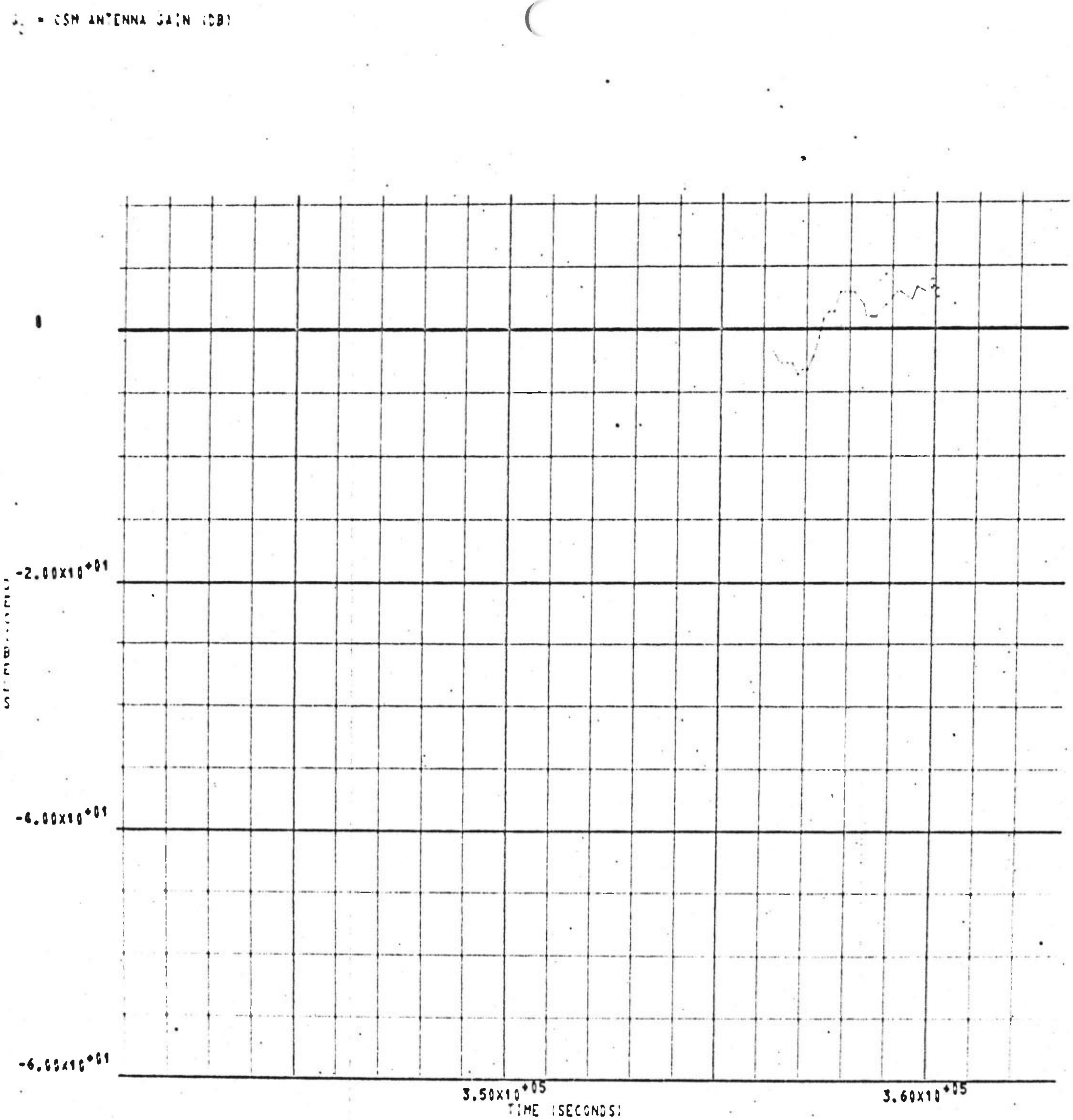
LEM ANTENNA GAIN (DB)

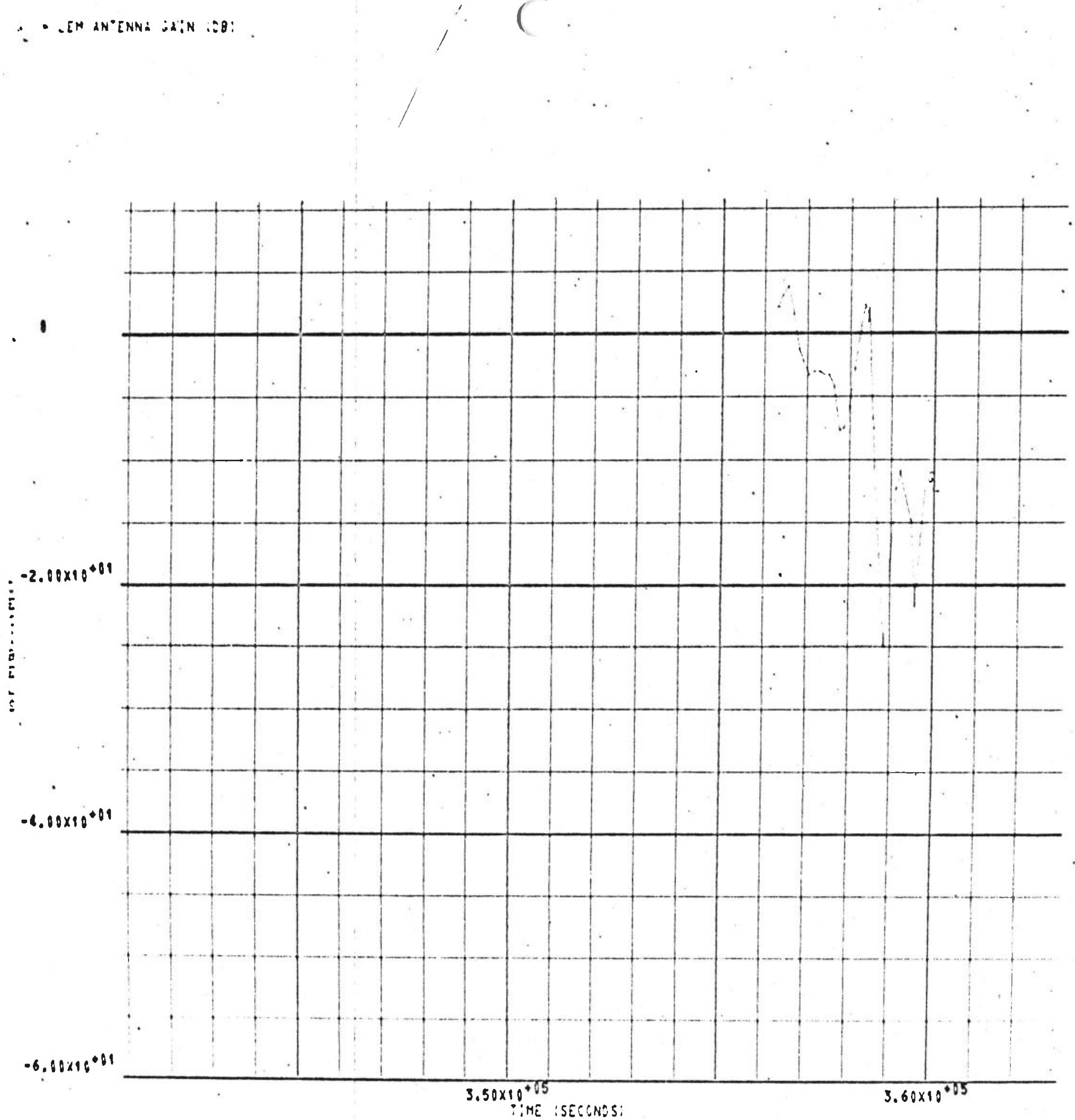


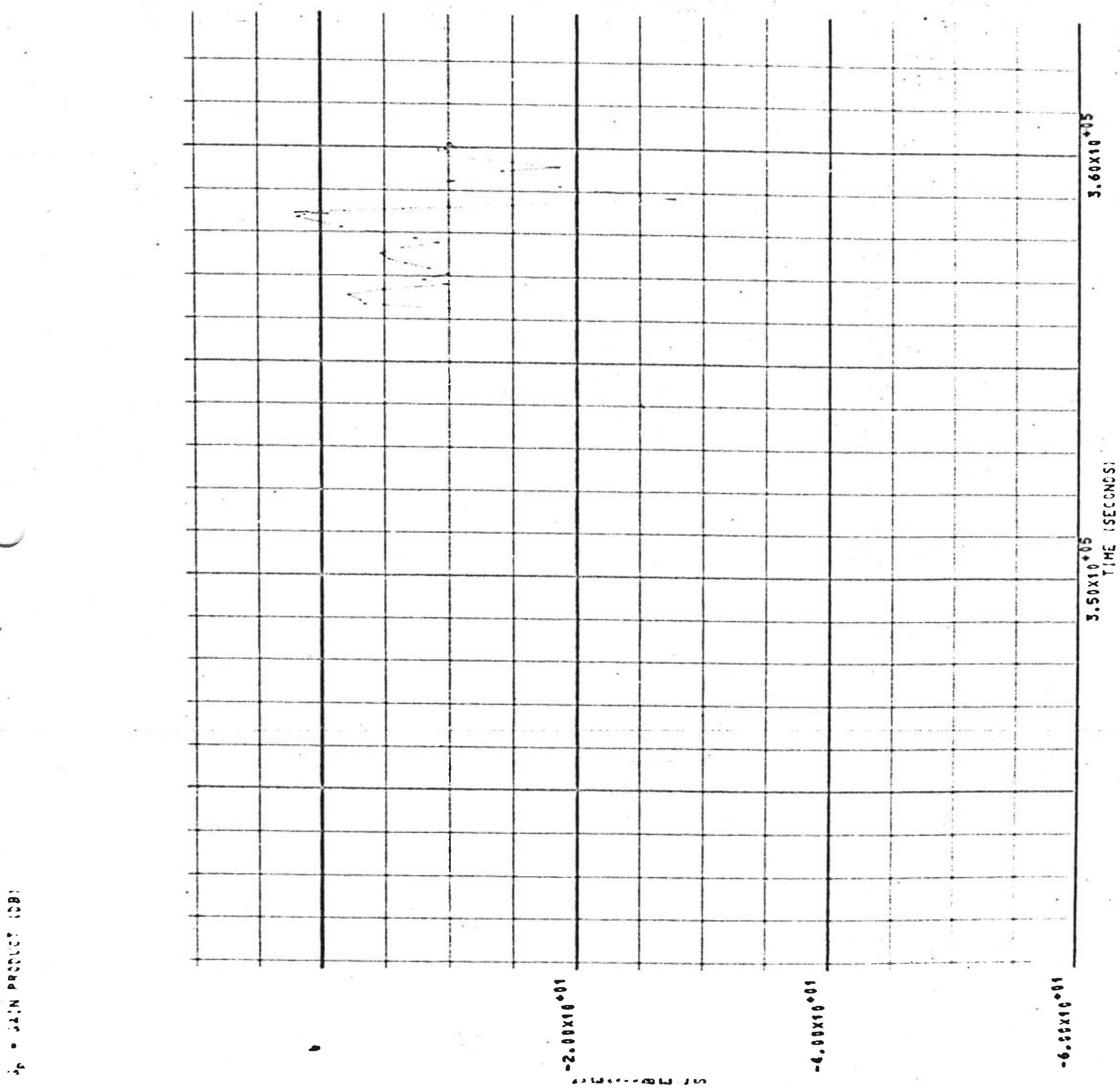

3.60X10+05
3.50X10+05
TIME (SECONDS)
-2.00X10+01
-4.00X10+01

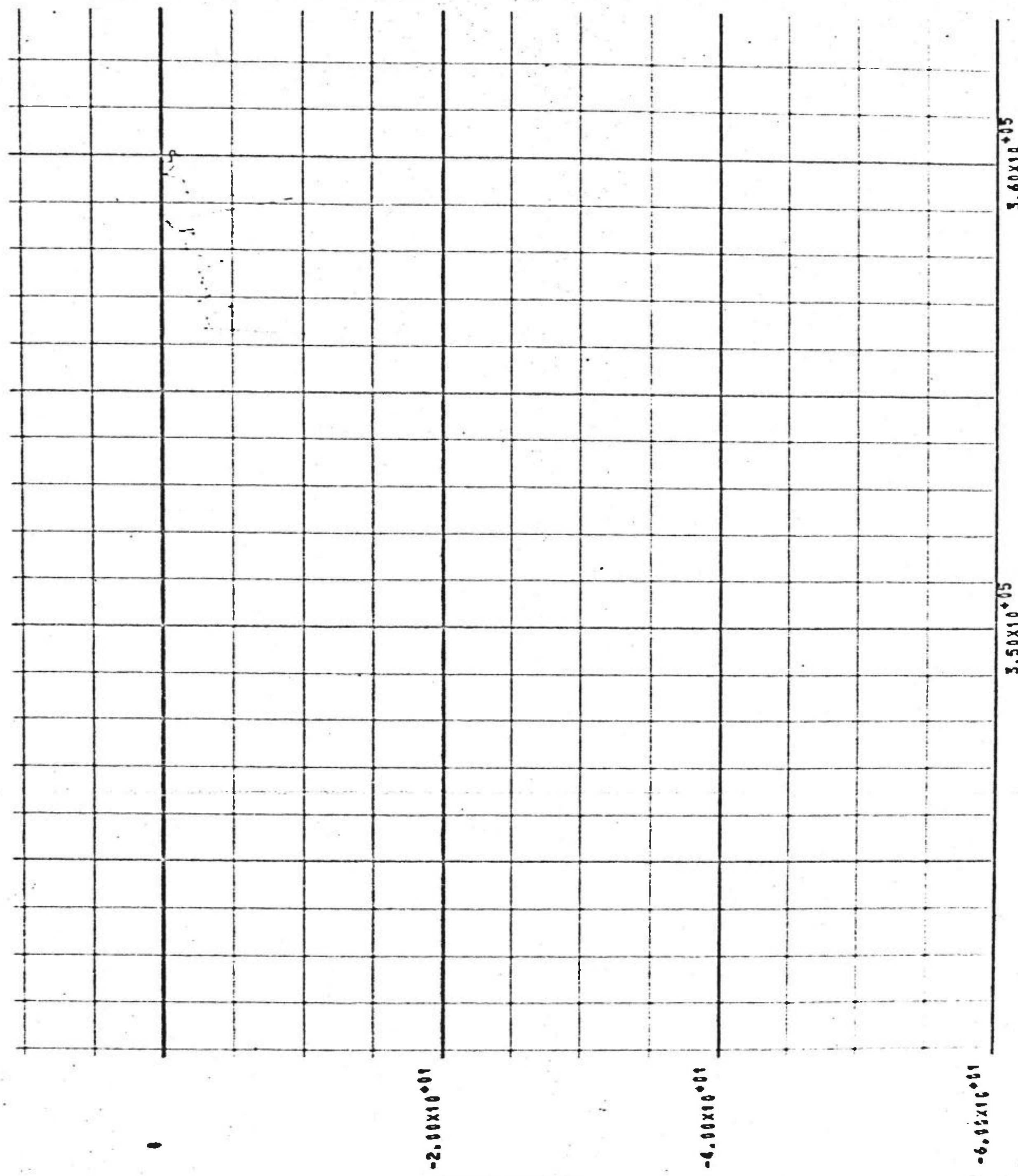

3.60X10+05
3.50X10+05
TIME (SECONDS)
-2.00X10+01
-4.00X10+01
-6.00X10+01
Lp = POLARIZATION LOSS (DB)

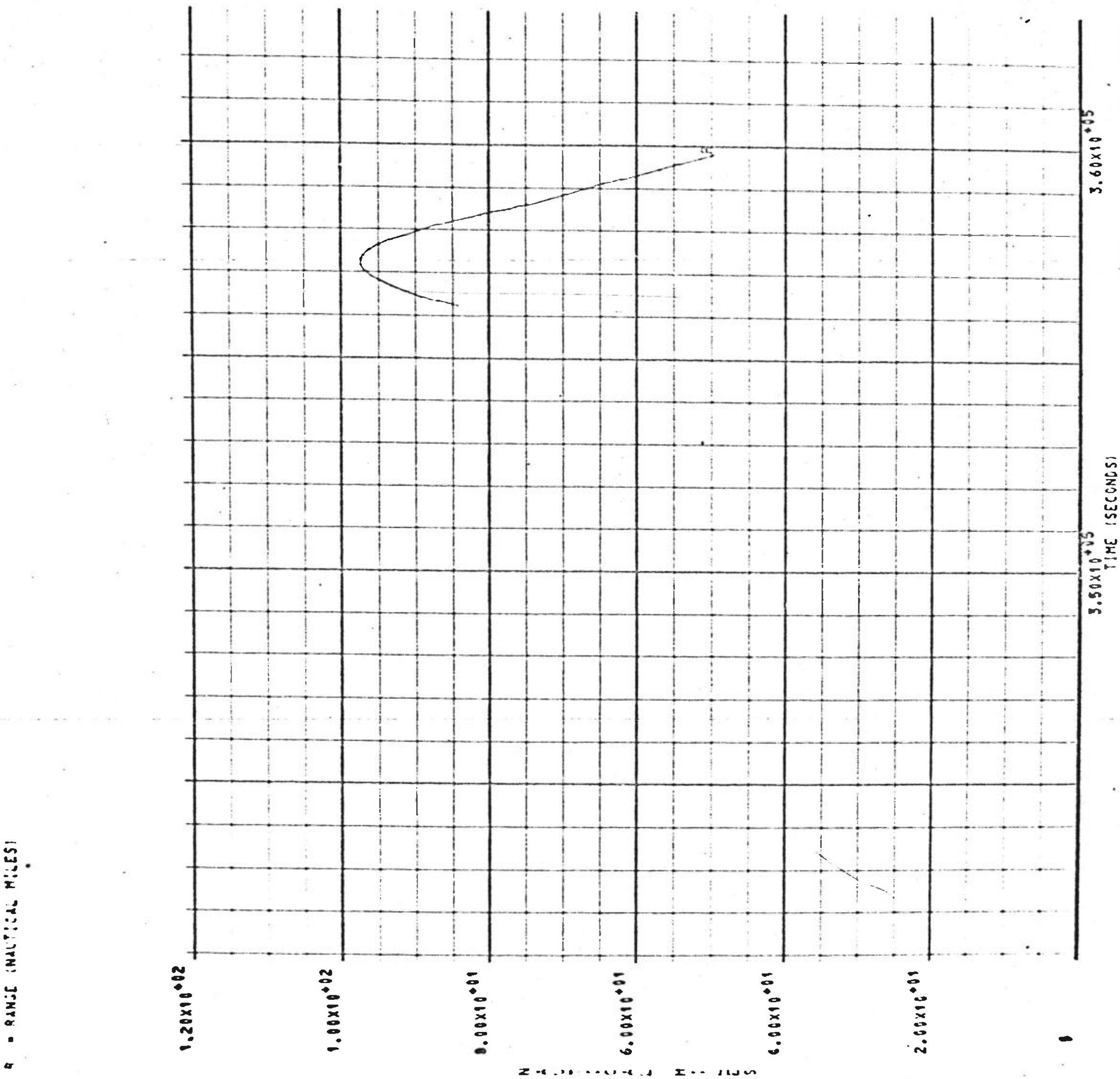

3.60X10+05
3.50X10+05
TIME (SECONDS)
1.20X10+02
1.00X10+02
8.00X10+01
6.00X10+01
4.00X10+01
2.00X10+01
0


= CSM ANTENNA GAIN (DB)
0
-2.00X10+01
-4.00X10+01
-6.00X10+01
3.50X10+05
3.60X10+05
TIME (SECONDS)


LEM ANTENNA GAIN (DB)
-2.00X10+01
-4.00X10+01
-6.00X10+01
3.50X10+05
3.60X10+05
TIME (SECONDS)


3.60X10+05
3.50X10+05
TIME (SECONDS)
-2.00X10+01
-4.00X10+01
-6.00X10+01
PRODUCT (DB)


3.60X10+05
3.50X10+05
TIME (SECONDS)
-2.00X10+01
-4.00X10+01
-6.00X10+01


R = RANGE (NAUTICAL MILES)
1.20X10+02
1.00X10+02
8.00X10+01
6.00X10+01
4.00X10+01
2.00X10+01
3.60X10+05
3.50X10+05
TIME (SECONDS)

5. OPERATING PROCEDURES

This program is written in FORTRAN V for use with the SRU 1108 system. Presently this program is in production only for the SRU 1108 system. Three input tapes are required by this program in addition to the standard input and output tapes required by the SRU 1108 system.

5.1 DECK SETUP

```
column 1
↓
$JOB etc.
∇△ASG△A=(CSM antenna patterns tape number)
∇△ASG△B=(LEM antenna patterns tape number)
∇△ASG△C=(Trajectory tape number)
∇△ASG△X=(PCF tape number)
∇△XQT△CUR
△TRW△X
△IN△X
△TRI△X
∇△XQT△HV014A
[program data
∇△EOF
```

where ∇ indicates a 7/8 punch and △ indicates one or more blank spaces/

5.2 COMPUTER RUN REQUEST

In submitting the card deck for a computer run, the run time may be estimated at approximately 5 seconds per data case per time point and the print output may be estimated at 4 pages per data case per time point. A plot output of 20 frames per data case will be generated.

Since different tapes must be assigned for each data case (see appendix for current tape numbers) only one unique data case can be run per job. Multiple cases of the same type may be run (See § 2.3).

All tapes used by this program are operated in the 800 BPI density mode.

5.2.1 Sample Run Request Form

INSTRUCTIONS FOR SCIENTIFIC COMPUTER RUNS

(DO NOT FILL IN SHADED AREAS)

PRIORITY ☐

RE-RUN ☐

TIME IN	
LEFT TRW	
RETURN TRW	
TIME OUT	

PROGRAMMER	BADGE NO.	BOX NO.	PHONE NO.	DATE (M,D,Y)
ARGILA, C.	T57659	TRW	2964	5/15/68

DIVISION CODE	PROG. NO.	PROJ. NO.	EST. TIME (MIN)	MAX. TIME (MIN)	LINES OUTPUT	SEQ. NUMBER
TRW	A025	1135P	2	3	2	

OPERATING SYSTEM				TYPE OF RUN	COMPUTER	
1108 FORTRAN V	[X]	FORTRAN FAP	☐	PROD. ☐ TEST [X]	1108 [X]	360 ☐
1108 FORTRAN IV	☐	IBSYS ☐	SYSB ☐	OTHER (EXPLAIN BELOW)	7094 ☐	
1108 COBOL	☐	OTHER			OTHER	

INPUT TAPES

UNIT	REEL	BIN NO.	DEN
A	42244		8
B	6781		8
C	2219		8
X	40179		8

OUTPUT TAPES

UNIT	REEL NO.	BIN NO.	DEN-SITY	SAVE	PROCESSING REQUIRED

WORKING TAPES

ACTUAL TIME USAGE

START

STOP

CHECK FOR	CALCOMP ☐	TAPE NO.	NO. FRAMES	PROCESSING
	4020 [X]		20	

ABNORMAL STOPS

STOP AT LOC.

SS

LOOPING – LOC.

THRU

EXCESS OUTPUT

EXCESS TIME

PROBLEM NO.	H	2	8	9	0	1
PROGRAM NAME	H	V	0	1	4	A
TOTAL TAPES						4
INPUT (100'S CARDS)						1
OUTPUT (100'S LINES)						
OUTPUT (100'S CARDS)						
RUN AT	TRW	MAC	MSD	OTHER		

PROGRAMMER'S COMMENTS:

OPERATOR'S COMMENTS:

SYSTEM OPERATOR ☐ PERIPHERAL OPERATOR ☐

SYSTEMS 7011-H (9-13-67)

6. REFERENCES

Pool, J. W., Mireles, R. Mathematical Model for VHF Antenna Coverage Analysis of Apollo Missions D and E, TRW Report 05952-H431-RO-00, February 1968.

7. PROGRAM LISTING

7.1 THE MAIN DRIVER, VHFANT

```
& FOR VHFANT,VHFANT                                                          16&12&16
UNIVAC 1108 FORTRAN V LEVEL    2206 0016 F5C16M
THIS COMPILATION WAS DONE ON 18 MAY 68 AT 16&12&16

 MAIN PROGRAM

 STORAGE USED (BLOCK, NAME, LENGTH)

       0001    *CODE    001432
       0000    *DATA    002315
       0002    *BLANK   00000C
       0003    VAR3     000014
       0004    VAR4     000014
       0005    VAR      010316
       0006    VAR5     000002
       0007    ANT      000006


 EXTERNAL REFERENCES (BLOCK, NAME)

       0010    GEOMET
       0011    CSMDAT
       0012    LMDAT
       0013    ALOG10
       0014    ARSIN
       0015    ARCOS
       0016    ANTPLT
       0017    NREW$
       0020    NRDU$
       0021    NIO1$
       0022    NIO2$
       0023    NRBU$
       0024    NEXP6$
       0025    EXP
       0026    ATAN2
       0027    COS
       0030    NWDU$
       0031    NSTOP$
```

```
STORAGE ASSIGNMENT FOR VARIABLES (BLOCK, TYPE, RELATIVE LOCATION, NAME)

0001     000322 1L      0000     002001 1000F    0000     001773 1001F    0000     001771 1002F    0000
0001     000037 125G    0001     000040 127G     0001     000060 140G     0001     000065 144G     0000
0000     001777 171F    0001     000140 173G     0001     000332 2L       0000     002160 2001F    0001
0001     000234 224G    0001     000274 276G     0001     000342 3L       0001     000127 300L     0001
0001     000417 311G    0001     000153 311L     0001     000166 312L     0001     000352 4L       0001
0001     001304 475G    0001     001077 5L       0000     002162 5001F    0001     001327 504G     0001
0001     001375 522G    0001     000006 69L      0001     000221 999L     0013 R 000000 ALOG10   0015 R
0014 R 000000 ARSIN    0000 R 001765 AS       0000 R 001766 AT       0000 R 001757 BETA     0000 R
0007 R 000004 DBB      0007 R 000005 DBT      0000 R 001660 DELTAT   0000 R 001711 ELC      0000 R
0000 R 001713 EPHC     0000 R 001744 EPHL     0000 R 001715 EPH45C   0000 R 001745 EPH45L   0000 R
0000 R 001740 ERL      0000 R 001712 ETHC     0000 R 001742 ETHL     0000 R 001714 ETH45C   0000 R
0000 R 001650 FREQ     0000 R 000000 FREQCY   0000 R 001760 G        0000 R 001763 GAINPR   0000 R
0000 R 001746 GAIN2    0003 R 000000 GNREFC   0004 R 000000 GNREFL   0000 R 001761 H        0000 I
0000 I 001703 ICSM     0000 I 001704 III      0000 I 001705 ILM      0005 I 010314 IMAXT    0000 I
0000 I 001662 IX       0000 I 001707 IZ       0000 I 001652 J        0000 I 001706 JJJ      0000 I
0000 I 001654 K        0000 I 001655 L        0000 I 001647 MX       0006 I 000001 NCSM     0006 I
0000 R 001733 PC       0000 R 000456 PHCC     0000 R 001702 PHIC     0000 R 001700 PHIL     0000 R
0000 R 001736 PL       0000 R 001764 RANGE    0007 R 000002 RB       0000 R 001734 RC       0000 R
0000 R 001735 RL       0007 R 000003 RT       0000 R 001725 R1       0000 R 001755 R2       0005 R
0005 R 000000 TAXIS    0000 R 001730 TC       0000 R 001701 THETAC   0000 R 001677 THETAL   0000 R
0000 R 000002 THETLL   0000 R 000622 TITLE    0000 R 001756 TL       0007 R 000000 TLEFT    0007 R
0000 R 001661 TST      0000 R 001657 VMAX     0000 R 001656 VMIN     0005 R 000000 WORD     0000.R
0000 R 001750 XELL     0000 R 001721 XEPHC    0000 R 001751 XEPHL    0000 R 001720 XERC     0000 R
0000 R 001722 XETHC    0000 R 001752 XETHL    0000 R 001732 XLV      0000 R 001665 XPC      0000 R
0000 R 001753 XPH45L   0000 R 001664 XPL      0000 R 001666 XTC      0000 R 001723 XTH45C   0000 R
0000 R 001663 XTL      0000 R 001646 XX       0000 R 000662 YAXES    0000 R 001731 YC       0000 R
0000 R 001672 YPC      0000 R 001670 YPL      0000 R 001671 YTC      0000 R 001667 YTL      0000 R
0000 R 001676 ZPC      0000 R 001674 ZPL      0000 R 001675 ZTC      0000 R 001673 ZTL      0000 R

0100      1*    C
0100      2*    C ************ ROLB IS THE POSITION VECTOR OF THE LM IN BASE CO-ORDINATE
0100      3*    C *          * SYSTEM. RL,PL, AND YL ARE THE ATTITUDE POSTION ANGLES OF
0100      4*    C *          * THE LM.  ROCB IS THE POSITION VECTOR OF THE CSM IN BASE
0100      5*    C *          * CO-ORDINATE SYSTEM. RC, PC, AND YC ARE THE ATTITUDE POSI-
```

```
00100      C *              * TION ANGLES OF THE CSM.
00100      C *              * THETAL, PHIL, THETAC, AND PHIC ARE THE LOOK ANGLES THAT
00100      C *              * ARE COMPUTED BY SUBROUTINE GEOMET WHICH ALSO COMPUTES THE
00100      C *              * POLARIZATION ANGLE SI.
00100      C *              * ELL,ERL,ETHL,EPHL,ETH45L,EPH45L,ELC,ERC,ETHC,EPHC,ETH45C,
00100      C ************ AND EPH45C ARE ALL POLARIZATION DATA.
00100      C
00101            DIMENSION WORD(500,43), GNREFC(12), GNREFL(12), FREQCY(2),
00101           $THETLL(500), PHLL(500), THETCC(500), PHCC(500), TITLE(4,8),
00101           $YAXES(500,5), TAXIS(500)
00103            EQUIVALENCE (TAXIS(1),WORD(1,1))
00104            COMMON/VAR3/GNREFC/VAR4/GNREFL
00105            COMMON /VAR/ WORD, IMAXT, SI
00106            COMMON/VAP5/NLM,NCSM
00107            COMMON /ANT/ TLEFT, TRITE, RB, RT, DBB, DBT
00110            XX = 57.2958
00111            FREQCY(1) = 259.7
00112            FREQCY(2) = 296.8
00113         69 REWIND 1
00114            REWIND 2
00115            REWIND 3
00116            READ(5,1002) MX
00121       1002 FORMAT(I1)
00122            FREQ = FREQCY(MX)
00123            READ(5,1003)((TITLE(I,J),J=1,8),I=1,4)
00134       1003 FORMAT(8A6)
00135            C = 2.3025851
00136            READ(5,1001) (GNREFC(K),K=1,12),(GNREFL(L),L=1,12)
00150       1001 FORMAT(12F5.2)
00151            READ(5,169) TLEFT, TRITE, RB, RT, DBB, DBT
00161        169 FORMAT(6F8.1)
00162            I = 1
00163            READ(5,171) VMIN, VMAX, DELTAT
00170        171 FORMAT(3F8.1)
00171        300 READ(3)(WORD(I,K),K=1,25)
00177            IF(WORD(I,1).LT.VMIN) GO TO 300
00201        311 TST = WORD(I,1) + DELTAT
00202            IF(TST .GT. VMAX) GO TO 999
00204            I = I + 1
00205        312 READ(3) (WORD(I,K),K=1,25)
00213            IF(WORD(I,1).LT.TST) GO TO 312
```

```
00215            IF(WORD(I,1) .GT. VMAX) GO TO 999
00217            GO TO 311
00220        999 IMAXT = I
00220      C
00220      C ************ COMPUTE LOOK ANGLES.
00220      C
00221            CALL GEOMET
00221      C
00221      C ************ CONVERT LOOK ANGLES TO NEAREST TWO DEGREE INCREMENT.
00221      C
00222            SI = SI*XX
00223            DO 25 IX = 1,IMAXT
00226            XTL = XX*WORD(IX,28)
00227            THETLL(IX) = XTL
00230            XPL = XX*WORD(IX,29)
00231            PHLL(IX) = XPL
00232            XPC = XX*WORD(IX,27)
00233            PHCC(IX) = XPC
00234            XTC = XX*WORD(IX,26)
00235            THETCC(IX) = XTC
00236            YTL = AMOD(XTL,2.0)
00237            YPL = AMOD(XPL,2.0)
00240            YTC = AMOD(XTC,2.0)
00241            YPC = AMOD(XPC,2.0)
00242            ZTL = XTL - YTL
00243            ZPL = XPL - YPL
00244            ZTC = XTC - YTC
00245            ZPC = XPC - YPC
00246            IF(YTL.LT.1.0) GO TO 1
00250            ZTL = ZTL + 2.0
00251          1 IF(YPL.LT.1.0) GO TO 2
00253            ZPL = ZPL + 2.0
00254          2 IF(YTC.LT.1.0) GO TO 3
00256            ZTC = ZTC + 2.0
00257          3 IF(YPC.LT.1.0) GO TO 4
00261            ZPC = ZPC + 2.0
00262          4 THETAL = ZTL
00263            PHIL = ZPL
00264            THETAC = ZTC
00265            PHIC = ZPC
00266            WORD(IX,26) = THETAC
```

```
00267          WORD(IX,27) = PHIC
00270          WORD(IX,28) = THETAL
00271          WORD(IX,29) = PHIL
00272       25 CONTINUE
00272    C ************ CALL SUBROUTINES LMDAT AND CSMDAT TO OBTAIN POLARIZATION
00272    C ************ DATA.  LOOK ANGLES ARE USED AS SELECTION CRITERION.
00274          ICSM = 0
00275          DO 501 III =1,2
00300          ICSM = ICSM + 1
00301          CALL CSMDAT
00302          ILM  = 0
00303          DO 500 JJJ =1,2
00306          ILM  = ILM + 1
00307          CALL LMDAT
00310          DO 703 IZ = 1,IMAXT
00313          ERC = WORD(IZ,35)
00314          ELC = WORD(IZ,34)
00315          ETHC = WORD(IZ,30)
00316          EPHC = WORD(IZ,31)
00317          ETH45C = WORD(IZ,32)
00320          EPH45C = WORD(IZ,33)
00321          GAIN1 = 10.0*ALOG10(10.0**(ERC/10.0) + 10.0**(ELC/10.0))
00322          XELC = ELC/20.0
00323          XERC = ERC/20.0
00324          XEPHC = EPHC/10.0
00325          XETHC = ETHC/10.0
00326          XTH45C = ETH45C/10.0
00327          XPH45C = EPH45C/10.0
00330          XELC = EXP(C*XELC)
00331          XERC = EXP(C*XERC)
00332          EPHC = EXP(C*XEPHC)
00333          ETHC = EXP(C*XETHC)
00334          ETH45C = EXP(C*XTH45C)
00335          EPH45C = EXP(C*XPH45C)
00336          R1 = (XERC+XELC)/(XERC-XELC)
00337          YY = ETH45C - EPH45C
00340          ZZ = ETHC - EPHC
00341          TC = .5*ATAN2(YY,ZZ)
00342          TC = XX*TC
00343          YC = ARSIN(WORD(IZ,11))
00344          XLV = WORD(IZ,8)/COS(YC)
```

```
      PC = ARCOS(XLV)
      XLV =-WORD(IZ,13)/COS(YC)
      RC = ARCOS(XLV)
      PC = XX*PC
      RC = XX*RC
      YC = XX*YC
      RL = ARSIN(WORD(IZ,20))
      XLV = WORD(IZ,17)/COS(RL)
      PL = ARCOS(XLV)
      XLV = -WORD(IZ,22)/COS(RL)
      YL = ARSIN(XLV)
      RL = XX*RL
      PL = XX*PL
      YL = XX*YL
      ERL = WORD(IZ,41)
      ELL = WORD(IZ,40)
      ETHL = WORD(IZ,36)
      ETH45L = WORD(IZ,38)
      EPHL = WORD(IZ,37)
      EPH45L = WORD(IZ,39)
      GAIN2 = 10.0*ALOG10(10.0**(ERL/10.0) + 10.0**(ELL/10.0))
      XERL = ERL/20.0
      XELL = ELL/20.0
      XEPHL = EPHL/10.0
      XETHL = ETHL/10.0
      XPH45L = EPH45L/10.0
      XTH45L = ETH45L/10.0
      XERL = EXP(C*XERL)
      XELL = EXP(C*XELL)
      ETHL = EXP(C*XETHL)
      EPHL = EXP(C*XEPHL)
      EPH45L = EXP(C*XPH45L)
      ETH45L = EXP(C*XTH45L)
      R2 = (XERL+XELL)/(XERL-XELL)
C
C ************ COMPUTE TILT ANGLE OF MAJOR AXIS (LM).
C
      YY = ETH45L - EPH45L
      ZZ = ETHL - EPHL
      TL = .5*ATAN2(YY,ZZ)
      TL = XX*TL
```

```
00413            SI = XX*WORD(IZ,43)
00414            BETA = SI + TL - TC
00414      C
00414      C ************ COMPUTE TILT ANGLE OF MAJOR AXIS (CSM).
00414      C
00415            IF(BETA.LT.0.0) BETA = BETA + 360.0
00417            IF(BETA.LE.90.0) GO TO 5
00421            BETA = BETA - 180.0
00422          5 CONTINUE
00422      C
00422      C ************ COMPUTE POLARIZATION LOSS BETWEEN LM AND CSM ANTENNAS.
00422      C
00423            G = 4.0*R2*R1/((1.0+R2*R2)*(1.0+R1*R1))
00424            H = ((1.0-R2*R2)*(1.0-R1*R1))/((1.0+R2*R2)*(1.0+R1*R1))
00425            BETA = BETA/XX
00426            RHO =10.0*ALOG10(0.5*(1.0 + G + H*COS(2.0*BETA)))
00427            GAINPR = GAIN1 + GAIN2 + RHO
00430            RANGE = WORD(IZ,42)
00431            AS = 37.8 + 20.0*ALOG10(FREQ) + 20.0*ALOG10(RANGE)
00432            AT = AS - GAINPR
00433            BETA = BETA*XX
00434            TAXIS(IZ) = WORD(IZ,1)
00435            YAXES(IZ,1) = GAIN1
00436            YAXES(IZ,2) = GAIN2
00437            YAXES(IZ,3) = GAINPR
00440            YAXES(IZ,4) = RHO
00441            YAXES(IZ,5) = RANGE
00442            WRITE(6,1000) (WORD(IZ,IT),IT=1,25),THETLL(IZ),PHLL(IZ),THETCC(IZ)
00442           *,PHCC(IZ),SI,R1,R2,TC,TL,BETA,RHO,GAIN1,GAIN2,GAINPR,AT,AS,RANGE
00471       1000 FORMAT(1H1,10X5HTIME =,E15.8/11X20HCSM COORDINATES, X =,E15.8,5X3H
00471           1Y =,E15.8,5X3HZ =,E15.8/11X20HLM COORDINATES,  X =,E15.8,5X3HY =,E
00471           215.8,5X3HZ =,E15.8/11X21HCSM DIRECTION COSINES/3(11X3(E15.8,5X)/)/
00471           311X20HLM DIRECTION COSINES/3(11X3(E15.8,5X)/)/11X21HLOOK ANGLES, T
00471           4HETAL =,F7.2,5X6HPHIL =,F7.2,5X8HTHETAC =,F7.2,5X6HPHIC =,F7.2/11X
00471           520HPOLARIZATION ANGLE =,F7.2/11X18HAXIAL RATIOS, RC =,E12.4,5X4HRL
00471           6 =,E12.4/11X13HTILT ANGLES, TC =,F7.2,10X4HTL =,F7.2/11X37HANGLE B
00471           7ETWEEN POLARIZATION ELLIPSES =,F7.2/11X19HPOLARIZATION LOSS =,E12.
00471           84/11X7HGAINC =,E12.4/11X7HGAINL =,E12.4/11X14HGAIN PRODUCT =,E12.4
00471           9,/11X4HLT =,E15.8/11X4HLS =,E15.8/11X26HRANGE BETWEEN CSM AND LM =
00471           *,E15.8)
00472            IF(ICSM.EQ.1) WRITE(6,2001) (TITLE(1,JV),JV=1,8)
```

```
00501          IF(ICSM.EQ.2) WRITE(6,2001) (TITLE(2,JV),JV=1,8)
00510          IF(ILM.EQ.1)  WRITE(6,2001) (TITLE(3,JV),JV=1,8)
00517          IF(ILM.EQ.2)  WRITE(6,2001) (TITLE(4,JV),JV=1,8)
00526     2001 FORMAT(1H ,10X8A6)
00527      703 CONTINUE
00531          CALL ANTPLT(TAXIS,YAXES,IMAXT,0,0)
00532      500 CONTINUE
00534          REWIND 2
00535      501 CONTINUE
00537     5001 FORMAT(1H ,39X3HERL13X,F6.2,6XE12.4/40X3HELL13X,F6.2,6XE12.4/40X4H
00537         *ETHL12X,F6.2,6XE12.4/40X4HEPHL12X,F6.2,6XE12.4/40X6HETH45L10X,F6.2
00537         *,6XE12.4/40X6HEPH45L10X,F6.2,6XE12.4/40X3HERC13X,F6.2,6XE12.4/40X3
00537         *HELC13X,F6.2,6XE12.4/40X4HETHC12X,F6.2,6XE12.4/40X4HEPHC12X,F6.2,6
00537         *XE12.4/40X6HETH45C10X,F6.2,6XE12.4/40X6HEPH45C10X,F6.2,6XE12.4)
00540          GO TO 69
00541          END

END OF UNIVAC 1108 FORTRAN V COMPILATION.     0 *DIAGNOSTIC* MESSAGE(S)
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7.2 SUBROUTINE GEOMET

```
FOR GEOMET,GEOMET                                                          16&12&19
IVAC 1108 FORTRAN V LEVEL   2206 0016 F5C16M
IS COMPILATION WAS DONE ON 18 MAY 68 AT 16&12&19

 SUBROUTINE GEOMET     ENTRY POINT 000465

 STORAGE USED (BLOCK, NAME, LENGTH)

      0001    *CODE    000504
      0000    *DATA    000175
      0002    *BLANK   000000
      0003    VAR      010316


 EXTERNAL REFERENCES (BLOCK, NAME)

      0004    VECSUB
      0005    GMPRD
      0006    SQRT
      0007    ATAN2
      0010    SIN
      0011    COS
      0012    NERR3$


 STORAGE ASSIGNMENT FOR VARIABLES (BLOCK, TYPE, RELATIVE LOCATION, NAME)

 0001    000004 107G      0001    000013 114G      0001    000014 117G      0001    000100 142G      0001
 0001    000255 173G      0000 R 000033 AAA        0000 R 000022 AAL        0000 R 000105 ABC        0000 R
 0000 R 000011 ACB        0000 R 000063 ADUMMY     0000 R 000000 ALB        0000 R 000055 AXYZC      0000 R
 0000 R 000124 DC         0000 R 000127 DL         0000 I 000123 I          0000 I 000122 IA         0000 I
 0000 I 000117 IC         0000 I 000120 ID         0000 I 000116 III        0003 I 010314 IMAXT      0000 I
 0000 I 000133 L          0000 R 000126 PHIC       0000 R 000131 PHIL       0000 R 000052 RLCB       0000 R
 0000 R 000044 ROLB       0003 R 010315 SI         0000 R 000125 THETAC     0000 R 000130 THETAL     0003 R
 0000 R 000134 XX1        0000 R 000135 XY1
```

```
00101            SUBROUTINE GEOMET
00101      C
00101      C ************ THE GEOMETRY SUBROUTINE CALCULATES THE LOOK ANGLES,THETAL
00101      C *          * PHIL, THETAC, AND PHIC. IT ALSO CALCULATES THE POLARIZA-
00101      C ************ TION ANGLE SI.
00101      C
00103            DIMENSION ALB(3,3),ACB(3,3),AAL(3,3),AAA(3,3),ROLB(3),ROCB(3),RLCB
00103           *(3),AXYZC(3),AXYZL(3),ADUMMY(3,3),ACA(3,3),ABC(3,3)
00104            DIMENSION WORD(1CC,43)
00105            COMMON /VAR/ WORD, IMAXT, SI
00106            DO 100 III = 1,IMAXT
00111            IC = 8
00112            ID = 17
00113            DO 12 IB =1,3
00116            DO 11 IA =1,3
00121            ACB(IA,IB) = WORD(III,IC)
00122            ALB(IA,IB) = WORD(III,ID)
00123            IC = IC + 1
00124            ID = ID + 1
00125         11 CONTINUE
00127         12 CONTINUE
00131            ROCB(1) =WORD(III,2)
00132            ROCB(2) = WORD(III,3)
00133            ROCB(3) = WORD(III,4)
00134            ROLB(1) = WORD(III,5)
00135            ROLB(2) = WORD(III,6)
00136            ROLB(3) = WORD(III,7)
00137            CALL VECSUB(ROCB,RCLB,3,RLCB)
00140            CALL GMPRD(ALB,RLCB,AXYZL,3,3,1)
00141            DO 10 I = 1,3
00144            RLCB(I) = - RLCB(I)
00145         10 CONTINUE
00147            CALL GMPRD(ACB,RLCB,AXYZC,3,3,1)
00150            DC = SQRT(AXYZC(2)**2+AXYZC(3)**2)
00151            THETAC = ATAN2(DC,AXYZC(1))
00152            PHIC = ATAN2(AXYZC(2),-AXYZC(3))
00153            DL = SQRT(AXYZL(2)**2+AXYZL(3)**2)
00154            THETAL = ATAN2(DL,AXYZL(1))
00155            PHIL = ATAN2(-AXYZL(2),AXYZL(3))
00156            ACA(1,1) = SIN(THETAC)
```

```
00157              ACA(1,2) = 0.0
00160              ACA(1,3) = -COS(THETAC)
00161              ACA(2,1) = -COS(THETAC)*SIN(PHIC)
00162              ACA(2,2) = COS(PHIC)
00163              ACA(2,3) = -SIN(THETAC)*SIN(PHIC)
00164              ACA(3,1) = COS(THETAC)*COS(PHIC)
00165              ACA(3,2) = SIN(PHIC)
00166              ACA(3,3) = SIN(THETAC)*COS(PHIC)
00167              DO 20 K = 1,3
00172              DO 15 L = 1,3
00175           15 ABC(K,L) = ACB(L,K)
00177           20 CONTINUE
00201              AAL(1,1) = -SIN(THETAL)
00202              AAL(1,2) = -COS(THETAL)*SIN(PHIL)
00203              AAL(1,3) = COS(THETAL)*COS(PHIL)
00204              AAL(2,1) = 0.0
00205              AAL(2,2) = -COS(PHIL)
00206              AAL(2,3) = -SIN(PHIL)
00207              AAL(3,1) = COS(THETAL)
00210              AAL(3,2) = -SIN(THETAL)*SIN(PHIL)
00211              AAL(3,3) = SIN(THETAL)*COS(PHIL)
00212              CALL GMPRD(AAL,ALB,ADUMMY,3,3,3)
00213              CALL GMPRD(ADUMMY,ABC,AAL,3,3,3)
00214              CALL GMPRD(AAL,ACA,AAA,3,3,3)
00215              XX1 = AAA(1,1)
00216              XY1 = AAA(2,1)
00217              SI = ATAN2(XY1,XX1)
00220              WORD(III,26) = THETAC
00221              WORD(III,27) = PHIC
00222              WORD(III,28) = THETAL
00223              WORD(III,29) = PHIL
00224              WORD(III,42) = SQRT(RLCB(1)*RLCB(1)+RLCB(2)*RLCB(2)+RLCB(3)*RLCB(3
00224             *))
00225              WORD(III,43) = SI
00226          100 CONTINUE
00230              RETURN
00231              END

END OF UNIVAC 1108 FORTRAN V COMPILATION.     0 *DIAGNOSTIC* MESSAGE(S)
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7.3 SUBROUTINE CSMDAT

```
& FOR CSMDAT,CSMDAT                                                          16&12&21
UNIVAC 1108 FORTRAN V LEVEL   2206 0016 F5016M
THIS COMPILATION WAS DONE ON 18 MAY 68 AT 16&12&21

  SUBROUTINE CSMDAT    ENTRY POINT 000154

  STORAGE USED (BLOCK, NAME, LENGTH)

       0001   *CODE    000167
       0000   *DATA    000200
       0002   *BLANK   000000
       0003   VAR      010315
       0004   VAR3     000014
       0005   VAR1     037510

  EXTERNAL REFERENCES (BLOCK, NAME)

       0006   NRBU$
       0007   NIO1$
       0010   NIO2$
       0011   NERR2$
       0012   NERR3$

  STORAGE ASSIGNMENT FOR VARIABLES (BLOCK, TYPE, RELATIVE LOCATION, NAME)

   0001    000006 110G      0001    000015 114G      0001    000021 120G      0001    000030 126G      0001
   0001    000107 22L       0001    000113 23L       0001    000117 24L       0001    000123 25L       0001
   0001    000132 30L       0004 R 000000 GNREFC     0000 I 000152 I          0005 I 000000 IA         0003
   0000 I 000150 IY         0000 I 000151 J          0000 I 000145 K          0000 I 000147 L          0000
   0000 I 000144 NCSM       0003 R 000000 WORD       0000 R 000000 XA

00101      1*        SUBROUTINE CSMDAT
00103      2*        DIMENSION IA(90,180), WORD(100,43), GNREFC(12), XA(100)
```

```
00104          COMMON/VAR/WORD,IMAXT
00105          COMMON/VAR3/GNREFC/VAR1/IA
00105    C
00105    C ************ SELECT POLARIZATION VALUES FROM TAPE DATA.
00105    C
00106          NCSM = 0
00107          DO 10 K = 1,6
00112          NCSM = NCSM + 1
00113          DO 5 M =1,180
00116        5 READ(1) (IA(L,M),L=1,90)
00125          DO 30 IY = 1,IMAXT
00130          IF(WORD(IY,27).LT.0.0) WORD(IY,27) = 358.0 + WORD(IY,27)
00132          J = WORD(IY,26)/2.0 + 1.04
00133          I = WORD(IY,27)/2.0 + 1.04
00134          XA(IY) = IA(J,I)
00135          GO TO (21,22,23,24,25,26),K
00136       21 WORD(IY,32) = -(XA(IY)-GNREFC(NCSM))
00137          GO TO 30
00140       22 WORD(IY,33) = -(XA(IY)-GNREFC(NCSM))
00141          GO TO 30
00142       23 WORD(IY,30) = -(XA(IY)-GNREFC(NCSM))
00143          GO TO 30
00144       24 WORD(IY,31) = -(XA(IY)-GNREFC(NCSM))
00145          GO TO 30
00146       25 WORD(IY,34) = -(XA(IY)-GNREFC(NCSM))
00147          GO TO 30
00150       26 WORD(IY,35) = -(XA(IY)-GNREFC(NCSM))
00151       30 CONTINUE
00153       10 CONTINUE
00155          RETURN
00156          END

   END OF UNIVAC 1108 FORTRAN V COMPILATICN.     0 *DIAGNOSTIC* MESSAGE(S)
```

7.4 SUBROUTINE LMDAT

```
& FOR LMDAT,LMDAT                                                                    16&12&22
UNIVAC 1108 FORTRAN V LEVEL   2206 0016 F5016M
THIS COMPILATION WAS DONE ON 18 MAY 68 AT 16&12&22

  SUBROUTINE LMDAT      ENTRY POINT 000154

  STORAGE USED (BLOCK, NAME, LENGTH)

        0001    *CODE    000167
        0000    *DATA    000200
        0002    *BLANK   000000
        0003    VAR      010315
        0004    VAR4     000014
        0005    VAR1     037510


  EXTERNAL REFERENCES (BLOCK, NAME)

        0006    NRBU$
        0007    NIO1$
        0010    NIO2$
        0011    NERR2$
        0012    NERR3$


  STORAGE ASSIGNMENT FOR VARIABLES (BLOCK, TYPE, RELATIVE LOCATION, NAME)

   0001     000006 110G       0001     000015 114G       0001     000021 120G       0001     000030 126G       0001
   0001     000107 22L        0001     000113 23L        0001     000117 24L        0001     000123 25L        0001
   0001     000132 30L        0004 R 000000 GNREFL       0000 I 000151 I          0005 I 000000 IA          0003
   0000 I 000150 IY          0000 I 000152 J          0000 I 000145 K          0000 I 000147 L           0000
   0000 I 000144 NLM         0003 R 000000 WORD       0000 R 000000 XA


00101     1*          SUBROUTINE LMDAT
00103     2*          DIMENSION IA(90,180), WORD(100,43), GNREFL(12), XA(100)
```

```
00104           COMMON/VAR/WORD,IMAXT
00105           COMMON/VAR4/GNREFL/VAR1/IA
00105     C
00105     C ************ SELECT POLARIZATION VALUES FROM TAPE DATA.
00105     C
00106           NLM  = 0
00107           DO 10 K = 1,6
00112           NLM  = NLM + 1
00113           DO 5 M =1,180
00116         5 READ(2) (IA(L,M),L=1,90)
00125           DO 30 IY = 1,IMAXT
00130           IF(WORD(IY,29).LT.C.0) WORD(IY,29) = 358.0 + WORD(IY,29)
00132           I = WORD(IY,29)/2.C + 1.04
00133           J = WORD(IY,28)/2.C + 1.04
00134           XA(IY) = IA(J,I)
00135           GO TO (21,22,23,24,25,26),K
00136        21 WORD(IY,37) = -(XA(IY)-GNREFL(NLM))
00137           GO TO 30
00140        22 WORD(IY,36) = -(XA(IY)-GNREFL(NLM))
00141           GO TO 30
00142        23 WORD(IY,38) = -(XA(IY)-GNREFL(NLM))
00143           GO TO 30
00144        24 WORD(IY,39) = -(XA(IY)-GNREFL(NLM))
00145           GO TO 30
00146        25 WORD(IY,41) = -(XA(IY)-GNREFL(NLM))
00147           GO TO 30
00150        26 WORD(IY,40) = -(XA(IY)-GNREFL(NLM))
00151        30 CONTINUE
00153        10 CONTINUE
00155           RETURN
00156           END

    END OF UNIVAC 1108 FORTRAN V COMPILATION.     0 *DIAGNOSTIC* MESSAGE(S)
```

7.5 SUBROUTINE VECTOR

```
 FOR VECTOR,VECTOR                                                       16&12&23
NIVAC 1108 FORTRAN V LEVEL    2206 0016 F5016M
HIS COMPILATION WAS DONE ON 18 MAY 68 AT 16&12&23

  SUBROUTINE VECTOR     ENTRY POINT 000320

             VECCRS     ENTRY POINT 000323

             VECDOT     ENTRY POINT 000334

             VECADD     ENTRY POINT 000357

             VECSUB     ENTRY POINT 000372

             VECSCA     ENTRY POINT 000405

             VECMAG     ENTRY POINT 000430

             VECEQU     ENTRY POINT 000451


             VECTST     ENTRY POINT 000462

  STORAGE USED (BLOCK, NAME, LENGTH)

        0001    *CODE    000500
        0000    *DATA    000025
        0002    *BLANK   000000


  EXTERNAL REFERENCES (BLOCK, NAME)

        0003    SQRT
        0004    NERR3$


  STORAGE ASSIGNMENT FOR VARIABLES (BLOCK, TYPE, RELATIVE LOCATION, NAME)

   0001   000046 116G       0001   000100 126G       0001   000131 136G       0001   000155 146G       0001
```

```
00100   C
00100   C ..........................................................................
00100   C .                                                                        .
00100   C .   SUBROUTINE VECTOR                               C. ARGILA, APR, '68   .
00100   C .                                                                        .
00100   C .   DESCRIPTION-                                                         .
00100   C .      THIS PROGRAM IS A MULTIPLE ENTRY POINT SUBROUTINE WHICH PERFORMS   .
00100   C .   N-DIMENSIONAL VECTOR ARITHMETIC OPERATIONS.                          .
00100   C .                                                                        .
00100   C .   ARGUMENTS-                                                           .
00100   C .     VECCRS V1  VECTOR                                                  .
00100   C .            V2  VECTOR                                                  .
00100   C .            V3  CROSS PRODUCT V1 X V2 (V3 DISTINCT FROM V1 AND V2)      .
00100   C .     VECDOT V1  VECTOR                                                  .
00100   C .            V2  VECTOR                                                  .
00100   C .            N   DIMENSION                                               .
00100   C .            A   DOT PRODUCT V1 . V2                                     .
00100   C .     VECADD V1  VECTOR                                                  .
00100   C .            V2  VECTOR                                                  .
00100   C .            N   DIMENSION                                               .
00100   C .            V3  VECTOR SUM V1 + V2                                      .
00100   C .     VECSUB V1  VECTOR                                                  .
00100   C .            V2  VECTOR                                                  .
00100   C .            N   DIMENSION                                               .
00100   C .            V3  VECTOR DIFFERENCE V1 - V2                               .
00100   C .     VECSCA V1  VECTOR                                                  .
00100   C .            A   SCALAR                                                  .
00100   C .            N   DIMENSION                                               .
00100   C .            V2  VECTOR  =  A V1                                         .
00100   C .     VECMAG V1  VECTOR                                                  .
00100   C .            N   DIMENSION                                               .
00100   C .            A   MAGNITUDE OF VECTOR V1                                  .
00100   C .     VECEQU V1  VECTOR                                                  .
00100   C .            V2  VECTOR                                                  .
00100   C .            N   DIMENSION                                               .
00100   C .                PERFORMS THE VECTOR REPLACEMENT V1 = V2.                .
```

```
00100   C .     VECTST V1  VECTOR                                                      .
00100   C .            V2  VECTOR                                                      .
00100   C .            N   DIMENSION                                                   .
00100   C .            ACURCY  ACCURACY TO WHICH TEST IS TO BE APPLIED                 .
00100   C .            IFLAG = 0 IFF V1 .NE. V2                                        .
00100   C .                  = 1 IFF V1 .EQ. V2                                        .
00100   C .                                                                            .
00100   C .   SUBROUTINE USAGE-                                                        .
00100   C .      ABS                                                                   .
00100   C .                                                                            .
00100   C .   RESTRICTIONS-                                                            .
00100   C .      THE VECTOR CROSS PRODUCT IS DEFINED ONLY FOR THREE-DIMENSIONAL        .
00100   C .   VECTORS.  VECTORS ARE ASSUMED TO BE RECTANGULAR.                         .
00100   C ..............................................................................
00100   C
00101         SUBROUTINE VECTOR
00103         DIMENSION V1(1), V2(1), V3(1)
00104         ENTRY VECCRS(V1,V2,V3)
00106         V3(1) = V1(2)*V2(3) - V2(2)*V1(3)
00107         V3(2) = V1(3)*V2(1) - V2(3)*V1(1)
00110         V3(3) = V1(1)*V2(2) - V2(1)*V1(2)
00111         RETURN
00112         ENTRY VECDOT(V1,V2,N,A)
00114         A = 0.0
00115         DO 10 I = 1, N
00120      10 A = A + V1(I)*V2(I)
00122         RETURN
00123         ENTRY VECADD(V1,V2,N,V3)
00125         DO 20 I = 1, N
00130      20 V3(I) = V1(I) + V2(I)
00132         RETURN
00133         ENTRY VECSUB(V1,V2,N,V3)
00135         DO 30 I = 1, N
00140      30 V3(I) = V1(I) - V2(I)
00142         RETURN
00143         ENTRY VECSCA(V1,A,N,V2)
00145         DO 40 I = 1, N
00150      40 V2(I) = A*V1(I)
00152         RETURN
00153         ENTRY VECMAG(V1,N,A)
00155         A = 0.0
```

```
00156           DO 50 I = 1, N
00161        50 A = A + V1(I)**2
00163           A = SQRT(A)
00164           RETURN
00165           ENTRY VECEQU(V1,V2,N)
00167           DO 60 I = 1, N
00172        60 V1(I) = V2(I)
00174           RETURN
00175           ENTRY VECTST(V1,V2,N,ACURCY,IFLAG)
00177           DO 70 I = 1, N
00202        70 IF(ABS(V1(I) - V2(I)) .GE. ACURCY) GO TO 71
00205           IFLAG = 1
00206           RETURN
00207        71 IFLAG = 0
00210           RETURN
00211           END

END OF UNIVAC 1108 FORTRAN V COMPILATION.     0 *DIAGNOSTIC* MESSAGE(S)
```

7.6 SUBROUTINE GMPRD

```
 FOR GMPRD,GMPRD                                                                    16&12&24
UNIVAC 1108 FORTRAN V LEVEL   2206 0016 F5016M
THIS COMPILATION WAS DONE ON 18 MAY 68 AT 16&12&24

  SUBROUTINE GMPRD      ENTRY POINT 00C113

  STORAGE USED (BLOCK, NAME, LENGTH)

       0001   *CODE    000145
       0000   *DATA    000047
       0002   *BLANK   000000

  EXTERNAL REFERENCES (BLOCK, NAME)

       0003   NERR3$

  STORAGE ASSIGNMENT FOR VARIABLES (BLOCK, TYPE, RELATIVE LOCATION, NAME)

   0001    000026 107G      0001    000033 113G      0001    000050 122G      0000 I 000006 I       0000
   0000 I 000001 IK         0000 I 000000 IR         0000 I 000003 J          0000 I 000004 JI      0000

00100      1*    C                                                                     GMPRD001
00100      2*    C     .................................................................GMPRD002
00100      3*    C                                                                     GMPRD003
00100      4*    C        SUBROUTINE GMPRD                                             GMPRD004
00100      5*    C                                                                     GMPRD005
00100      6*    C        PURPOSE                                                      GMPRD006
00100      7*    C           MULTIPLY TWO GENERAL MATRICES TO FORM A RESULTANT GENERAL  GMPRD007
00100      8*    C           MATRIX                                                    GMPRD008
00100      9*    C                                                                     GMPRD009
00100     10*    C        USAGE                                                        GMPRD010
00100     11*    C           CALL GMPRD(A,B,R,N,M,L)                                   GMPRD011
00100     12*    C                                                                     GMPRD012
```

```
00100    C        DESCRIPTION OF PARAMETERS                                         GMPRD013
00100    C           A - NAME OF FIRST INPUT MATRIX                                 GMPRD014
00100    C           B - NAME OF SECCND INPUT MATRIX                                GMPRD015
00100    C           R - NAME OF CUTPUT MATRIX                                      GMPRD016
00100    C           N - NUMBER CF RCWS IN A                                        GMPRD017
00100    C           M - NUMBER OF CCLUMNS IN A AND ROWS IN B                       GMPRD018
00100    C           L - NUMBER CF CCLUMNS IN B                                     GMPRD019
00100    C                                                                          GMPRD020
00100    C        REMARKS                                                           GMPRD021
00100    C           ALL MATRICES MUST BE STORED AS GENERAL MATRICES                GMPRD022
00100    C           MATRIX R CANNOT BE IN THE SAME LOCATION AS MATRIX A            GMPRD023
00100    C           MATRIX R CANNOT BE IN THE SAME LOCATION AS MATRIX B            GMPRD024
00100    C           NUMBER OF COLUMNS OF MATRIX A MUST BE EQUAL TO NUMBER OF ROWGMPRD025
00100    C           OF MATRIX B                                                    GMPRD026
00100    C                                                                          GMPRD027
00100    C        SUBROUTINES AND FUNCTION SUBPROGRAMS REQUIRED                     GMPRD028
00100    C           NONE                                                           GMPRD029
00100    C                                                                          GMPRD030
00100    C        METHOD                                                            GMPRD031
00100    C           THE M BY L MATRIX B IS PREMULTIPLIED BY THE N BY M MATRIX A GMPRD032
00100    C           AND THE RESULT IS STORED IN THE N BY L MATRIX R.               GMPRD033
00100    C                                                                          GMPRD034
00100    C     .................................................................GMPRD035
00100    C                                                                          GMPRD036
00101             SUBROUTINE GMPRD(A,B,R,N,M,L)                                     GMPRD037
00103             DIMENSION A(1),B(1),R(1)                                          GMPRD038
00103    C                                                                          GMPRD039
00104             IR=0                                                              GMPRD040
00105             IK=-M                                                             GMPRD041
00106             DO 10 K=1,L                                                       GMPRD042
00111             IK=IK+M                                                           GMPRD043
00112             DO 10 J=1,N                                                       GMPRD044
00115             IR=IR+1                                                           GMPRD045
00116             JI=J-N                                                            GMPRD046
00117             IB=IK                                                             GMPRD047
00120             R(IR)=0                                                           GMPRD048
00121             DO 10 I=1,M                                                       GMPRD049
00124             JI=JI+N                                                           GMPRD050
00125             IB=IB+1                                                           GMPRD051
00126          10 R(IR)=R(IR)+A(JI)*B(IB)                                           GMPRD052
00132             RETURN                                                            GMPRD053
```

```
00133     54*          END                                                    GMPRD054

      END OF UNIVAC 1108 FORTRAN V COMPILATION.     0 *DIAGNOSTIC* MESSAGE(S)
```

7.7 SUBROUTINE GMTRA

```
& FOR GMTRA,GMTRA                                                     16&12&25
UNIVAC 1108 FORTRAN V LEVEL   2206 0016 F5016M
THIS COMPILATION WAS DONE ON 18 MAY 68 AT 16&12&25

  SUBROUTINE GMTRA      ENTRY POINT 000C60

  STORAGE USED (BLOCK, NAME, LENGTH)

        0001    *CODE    000102
        0000    *DATA    000032
        0002    *BLANK   000000

  EXTERNAL REFERENCES (BLOCK, NAME)

        0003    NERR3$

  STORAGE ASSIGNMENT FOR VARIABLES (BLOCK, TYPE, RELATIVE LOCATION, NAME)

   0001   000017 106G       0001   000024 112G       0000 I 000001 I         0000 I 000002 IJ        0000
   0000 I 000003 J

00100      1*   C                                                                       GMTRA001
00100      2*   C       ...............................................................GMTRA002
00100      3*   C                                                                       GMTRA003
00100      4*   C          SUBROUTINE GMTRA                                             GMTRA004
00100      5*   C                                                                       GMTRA005
00100      6*   C          PURPOSE                                                      GMTRA006
00100      7*   C             TRANSPOSE A GENERAL MATRIX                                GMTRA007
00100      8*   C                                                                       GMTRA008
00100      9*   C          USAGE                                                        GMTRA009
00100     10*   C             CALL GMTRA(A,R,N,M)                                       GMTRA010
00100     11*   C                                                                       GMTRA011
00100     12*   C          DESCRIPTION OF PARAMETERS                                    GMTRA012
```

```
00100   C          A - NAME OF MATRIX TO BE TRANSPOSED                              GMTRA013
00100   C          R - NAME OF RESULTANT MATRIX                                     GMTRA014
00100   C          N - NUMBER OF RCWS CF A AND COLUMNS OF R                         GMTRA015
00100   C          M - NUMBER OF CCLUMNS OF A AND ROWS OF R                         GMTRA016
00100   C                                                                           GMTRA017
00100   C       REMARKS                                                             GMTRA018
00100   C          MATRIX R CANNOT BE IN THE SAME LOCATION AS MATRIX A              GMTRA019
00100   C          MATRICES A AND R MUST BE STORED AS GENERAL MATRICES              GMTRA020
00100   C                                                                           GMTRA021
00100   C       SUBROUTINES ANC FUNCTICN SUBPROGRAMS REQUIRED                       GMTRA022
00100   C          NONE                                                             GMTRA023
00100   C                                                                           GMTRA024
00100   C       METHOD                                                              GMTRA025
00100   C          TRANSPOSE N BY M MATRIX A TO FORM M BY N MATRIX R                GMTRA026
00100   C                                                                           GMTRA027
00100   C    ...............................................................GMTRA028
00100   C                                                                           GMTRA029
00101         SUBROUTINE GMTRA(A,R,N,M)                                             GMTRA030
00103         DIMENSION A(1),R(1)                                                   GMTRA031
00103   C                                                                           GMTRA032
00104         IR=0                                                                  GMTRA033
00105         DO 10 I=1,N                                                           GMTRA034
00110         IJ=I-N                                                                GMTRA035
00111         DO 10 J=1,M                                                           GMTRA036
00114         IJ=IJ+N                                                               GMTRA037
00115         IR=IR+1                                                               GMTRA038
00116      10 R(IR)=A(IJ)                                                           GMTRA039
00121         RETURN                                                                GMTRA040
00122         END                                                                   GMTRA041

   END OF UNIVAC 1108 FORTRAN V COMPILATION.      0 *DIAGNOSTIC* MESSAGE(S)
```

7.8 SUBROUTINE ANTPLT

```
& FOR ANTPLT,ANTPLT                                                        16&12&26
UNIVAC 1108 FORTRAN V LEVEL   2206 0016 F5016M
THIS COMPILATION WAS DONE ON 18 MAY 68 AT 16&12&26

 SUBROUTINE ANTPLT     ENTRY POINT 000336

 STORAGE USED (BLOCK, NAME, LENGTH)

      0001    *CODE    000370
      0000    *DATA    000150
      0002    *BLANK   000000
      0003    ANT      000006


 EXTERNAL REFERENCES (BLOCK, NAME)

      0004    FRAMEV
      0005    PRINTV
      0006    APRNTV
      0007    SETMIV
      0010    DXDYV
      0011    GRIDIV
      0012    PTTOPT
      0013    NXV
      0014    NYV
      0015    NERR3$


 STORAGE ASSIGNMENT FOR VARIABLES (BLOCK, TYPE, RELATIVE LOCATION, NAME)

 0001    000025 116G       0001    000047 125G       0001    000066 2L         0001    000167 4L        0001
 0000 R  000011 ANNOT      0003 R  000004 DBB        0003 R  000005 DBT        0000 R  000052 DT        0000
 0000 I  000047 I          0000 I  000055 IER        0000 I  000051 INDEX      0000 I  000063 IX1       0000
 0000 I  000066 IY1        0000 I  000065 IY2        0000 I  000050 J          0000 I  000035 LABEL     0000
 0000 I  000061 N          0000 I  000054 NT         0013 I  000000 NXV        0000 I  000062 NY        0014
 0003 R  000002 RB         0003 R  000003 RT         0003 R  000000 TL         0003 R  000001 TR        0000
 0000 R  000056 YB         0000 R  000057 YT         0000 R  000003 YTITLE
```

```
C
C ......................................................................
C .   SUBROUTINE ANTPLT                                                  .
C .   ANTENNA PLOTTING SUBRCUTINE                   C. ARGILA, APR. '68  .
C .                                                                      .
C .   DESCRIPTION-                                                       .
C .      ANTPLT IS A PLOTTING SUBROUTINE TO BE USED IN CONJUNCTION WITH THE .
C .   VHF ANTENNA SIMULATION PROGRAM.                                    .
C .                                                                      .
C .   ARGUMENTS-                                                         .
C .      TAXIS  ARRAY OF INDEPENDENT VARIABLE  - DIMENSIONED TO NPOINT.  .
C .      YAXES  ARRAY OF THE FIVE DEPENDENT VARIABLES                    .
C .                  YAXES(1,1) - FIRST LOCATION OF CSM GAIN ARRAY       .
C .                  YAXES(1,2) - FIRST LOCATION OF LEM GAIN ARRAY       .
C .                  YAXES(1,3) - FIRST LOCATION OF GAIN PRODUCT ARRAY   .
C .                  YAXES(1,4) - FIRST LOCATION OF POLARIZATION LOSS ARRAY .
C .                  YAXES(1,5) - FIRST LOCATION OF RANGE ARRAY          .
C .             DIMENSICNED TO (NPOINT,5).                               .
C .      TITLE  ARRAY OF COMMENT/DESCRIPTION CARDS.                      .
C .      K      NUMBER OF COMMENT/DESCRIPTION CARDS (0,1,...,10).        .
C .                                                                      .
C .   NAMED COMMON USAGE-                                                .
C .      ANT    TL  - MINIMUM TIME                                       .
C .             TR  - MAXIMUM TIME                                       .
C .             RB  - MINIMUM RANGE                                      .
C .             RT  - MAXIMUM RANGE                                      .
C .             DBB - MINIMUM GAIN (DB)                                  .
C .             DBT - MAXIMUM GAIN (DB)                                  .
C .                                                                      .
C .   SUBROUTINE USAGE-                                                  .
C .      PTTOPT                                                          .
C .      DD80 PLOTTING PACKAGE                                           .
C .                                                                      .
C ......................................................................
C
      SUBROUTINE ANTPLT(TAXIS,YAXES,NPOINT,TITLE,K)
      DIMENSION TAXIS(500), YAXES(500,5), TITLE(14,K), XTITLE(3),
     $YTITLE(3,2), ANNOT(4,5), LABEL(10)
```

```
00104         COMMON /ANT/ TL, TR, RB, RT, DBB, DBT
00104   C
00104   C *** LOAD DATA FOR ANNOTATION
00105         DATA (XTITLE(I),I=1,3) /6H  TIME,6H (SECO,6HNDS)  /
00107         DATA((YTITLE(I,J),I=1,3),J=1,2) /6H     D,6HECIBEL,6HS     ,6H  NA
00107        $UT,6HICAL M,6HILES  /
00111         DATA((ANNOT(I,J),I=1,4),J=1,5) /6H= CSM ,6HANTENN,6HA GAIN,6H (DB)
00111        $ ,6H= LEM ,6HANTENN,6HA GAIN,6H (DB) ,6H= GAIN,6H PRODU,6HCT (DB,
00111        $6H)     ,6H= POLA,6HRIZATI,6HON LOS,6HS (DB),6H= RANG,6HE (NAU,6HT
00111        $ICAL ,6HMILES)/
00113         DATA (LABEL(I),I=1,10) /1HG,1HC,1HG,1HL,1HG,1HP,1HL,1HP,1HR,1H /
00113   C
00113   C *** PRINT FIVE FRAMES
00115         DO 100 INDEX = 1, 5
00115   C ****** SETUP A FRAME
00120         CALL FRAMEV(2)
00120   C ****** PRINT ANNOTATIONS AND COMMENT/DESCRIPTION CARDS
00121         CALL PRINTV(18,XTITLE,459,8)
00122         IF(K .EQ. 0) GO TO 2
00124         DO 1 J = 1, K
00127       1 CALL PRINTV(80,TITLE(1,J),304,1032-16*J)
00131       2 CALL PRINTV(1,LABEL(2*INDEX-1),4,1016)
00132         CALL PRINTV(1,LABEL(2*INDEX),10,1008)
00133         CALL PRINTV(24,ANNOT(1,INDEX),28,1016)
00134         J = INDEX/5+1
00135         CALL APRNTV(0,-16,18,YTITLE(1,J),4,576)
00135   C ****** DRAW GRID
00136         CALL SETMIV(10,0,16,160)
00137         CALL DXDYV(1,TL,TR,DT,M,I,NT,20.0,IER)
00140         IF(INDEX - 5)3,4,3
00143       3 YB = DBB
00144         YT = DBT
00145         GO TO 5
00146       4 YB = RB
00147         YT = RT
00150       5 CALL DXDYV(2,YB,YT,DY,N,J,NY,20.0,IER)
00151         CALL GRID1V(2,TL,TR,YB,YT,DT,DY,M,N,-I,-J,-3,-3)
00151   C ****** PLOT CURVE
00152         CALL PTTOPT(NPOINT,TAXIS,YAXES(1,INDEX))
00152   C ****** ANNOTATE CURVE
00153         IX1 = NXV(TAXIS(NPOINT)) + 5
```

```
00154     80*              IX2 = IX1 + 5
00155     81*              IY2 = NYV(YAXES(NPOINT,INDEX))
00156     82*              IY1 = IY2 + 8
00157     83*              CALL PRINTV(1,LABEL(2*INDEX-1),IX1,IY1)
00160     84*              CALL PRINTV(1,LABEL(2*INDEX),IX2,IY2)
00161     85*          100 CONTINUE
00161     86*      C
00161     87*      C *** ADVANCE A FRAME AND RETURN
00163     88*              CALL FRAMEV(2)
00164     89*              RETURN
00165     90*              END

      END OF UNIVAC 1108 FORTRAN V COMPILATION.      0 *DIAGNOSTIC* MESSAGE(S)
```

7.9 SUBROUTINE PTTOPT

```
& FOR PTTOPT,PTTOPT                                                    16&12&27
UNIVAC 1108 FORTRAN V LEVEL   2206 0016 F5016M
THIS COMPILATION WAS DONE ON 18 MAY 68 AT 16&12&28

  SUBROUTINE PTTOPT    ENTRY POINT 000113

  STORAGE USED (BLOCK, NAME, LENGTH)

       0001    *CODE    000134
       0000    *DATA    000035
       0002    *BLANK   000000

  EXTERNAL REFERENCES (BLOCK, NAME)

       0003    LINEV
       0004    NXV
       0005    NYV
       0006    NERR3$

  STORAGE ASSIGNMENT FOR VARIABLES (BLOCK, TYPE, RELATIVE LOCATION, NAME)

   0001   000036 105G      0000 I 000000 I        0004 I 000000 NXV       0005 I 000000 NYV

00100     C
00100     C ..........................................................................
00100     C .   SUBROUTINE PTTOPT                                                    .
00100     C .   POINT-TO-POINT PLOTTING ROUTINE                                      .
00100     C .                                                                        .
00100     C .   DESCRIPTION-                                                         .
00100     C .      THIS ROUTINE ACCEPTS A SEQUENCE OF PLOT POINTS AND JOINS THEM, IN .
00100     C .   ORDER, BY STRAIGHT LINE SEGMENTS.  THIS ROUTINE IS USED IN CONJUNCTION .
00100     C .   WITH THE DD-80 PLOTTING PACKAGE.                                     .
00100     C .                                                                        .
```

```
00100    C .   ARGUMENTS-                                                  .
00100    C .      NPOINT NUMBER OF PLOT POINTS                             .
00100    C .      X      ARRAY OF ABSCISSA POINTS                          .
00100    C .      Y      ARRAY OF ORDINATE POINTS                          .
00100    C .                                                               .
00100    C .   SUBROUTINE USAGE-                                           .
00100    C .      DD-80 PLOTTING PACKAGE                                   .
00100    C .                                                               .
00100    C .................................................................
00101          SUBROUTINE PTTOPT(NPOINT,X,Y)
00103          DIMENSION X(1), Y(1)
00104          DO 1 I = 2, NPOINT
00107        1 CALL LINEV(NXV(X(I-1)),NYV(Y(I-1)),NXV(X(I)),NYV(Y(I)))
00111          RETURN
00112          END

    END OF UNIVAC 1108 FORTRAN V COMPILATION.      0 *DIAGNOSTIC* MESSAGE(S)
```

8. APPENDIX

The following is a current list of the antenna pattern tapes for use with the program HV014A and their respective formats.

8.1 CSM LOW FREQUENCY ANTENNA PATTERN TAPE (MSC TAPE No. 42244)

Polarization	Antenna	Gain Reference Value
$\theta+45^\circ$	B	5.41
$\phi+45^\circ$	B	5.41
θ	B	5.45
ϕ	B	5.45
LCP	B	3.74
RCP	B	3.74
$\theta+45^\circ$	A	5.48
$\phi+45^\circ$	A	5.48
θ	A	5.52
ϕ	A	5.52
LCP	A	3.76
RCP	A	3.76

8.2 CSM HIGH FREQUENCY ANTENNA PATTERN TAPE (MSC TAPE No. ~~5688~~ 44602)

Polarization	Antenna	Gain Reference Value
$\theta+45^\circ$	A	6.29
$\phi+45^\circ$	A	6.29
θ	A	6.19
ϕ	A	6.19
LCP	A	3.27
RCP	A	3.27
$\theta+45^\circ$	B	5.12
$\phi+45^\circ$	B	5.12
θ	B	5.10
ϕ	B	5.10
LCP	B	3.25
RCP	B	3.25

8.3 LEM LOW FREQUENCY ASCENT ANTENNA PATTERN TAPE (MSC TAPE No. 6781)

Polarization	Antenna	Gain Reference Value
ϕ	1	4.25
θ	1	4.25
$\theta+45^\circ$	1	4.29
$\phi+45^\circ$	1	4.29
RH	1	5.60
LH	1	5.60

Polarization	Antenna	Gain Reference Value
ϕ	2	3.44
θ	2	3.44
$\theta+45^\circ$	2	3.08
$\phi+45^\circ$	2	3.08
RH	2	5.30
LH	2	5.30

8.4 LEM HIGH FREQUENCY ASCENT ANTENNA PATTERN TAPE (MSC TAPE No. 37052)

Polarization	Antenna	Gain Reference Value
ϕ	1	3.51
θ	1	3.51
$\theta+45^\circ$	1	1.69
$\phi+45^\circ$	1	1.69
RH	1	4.91
LH	1	4.91
ϕ	2	3.06
θ	2	3.06
$\theta+45^\circ$	2	3.24
$\phi+45^\circ$	2	3.24
RH	2	4.19
LH	2	4.19

8.5 LEM LOW FREQUENCY DESCENT ANTENNA PATTERN TAPE (MSC TAPE No. 8356)

Polarization	Antenna	Gain Reference Value
ϕ	1	6.79
θ	1	6.79
$\theta+45^\circ$	1	3.56
$\phi+45^\circ$	1	3.56
RH	1	5.68
LH	1	5.68
ϕ	2	7.64
θ	2	7.64
$\theta+45^\circ$	2	1.58
$\phi+45^\circ$	2	1.58
RH	2	4.77
LH	2	4.77

8.6 LEM HIGH FREQUENCY DESCENT ANTENNA PATTERN TAPE (MSC TAPE No. 11105)

Polarization	Antenna	Gain Reference Value
ϕ	1	2.47
θ	1	2.47
$\theta+45^\circ$	1	2.30
$\phi+45^\circ$	1	2.30
RH	1	5.96
LH	1	5.96

Polarization	Antenna	Gain Reference Value
ϕ	2	6.04
θ	2	6.04
$\theta+45^{\circ}$	2	5.10
$\phi+45^{\circ}$	2	5.10
RH	2	6.28
LH	2	6.28