ESD-TR-65-20

A FORTRAN PROGRAM WHICH AIDS IN GENERATING MUTUAL INTERFERENCE CHARTS

Technical Report

No. ESD-TR-65-20

November 1965

Department of Defense
ELECTROMAGNETIC COMPATIBILITY ANALYSIS CENTER
A Joint Military Facility

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Published by
Electromagnetic Compatibility Analysis Center
U.S. Navy Marine Engineering Laboratory
Annapolis, Maryland 21402

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ERRATA

A Fortran Program Which Aids in Generating Mutual Interference Charts, ESD-TR-65-20, published by Electromagnetic Compatibility Analysis Center, November 1965.

Page 3-1, last paragraph, should read as follows:

The printed output consists of: receiver number, transmitter number, data on card 3, data on card 6, data on card 4, and the maximum values of P and HQ followed by the table of incompatible frequencies. In this table are listed the receiver and transmitter frequencies and the values of P and HQ. A sample printout is given in APPENDIX II.

ABSTRACT

This technical report presents a program for generating data for mutual interference charts and discusses the uses of such charts. Several examples are included.

KEY TERMS

FORTRAN
MUTUAL INTERFERENCE MATRIX
INTERFERENCE
PREDICTION

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SECTION 1

INTRODUCTION

Transmitters radiate energy at harmonic frequencies as well as at the fundamental frequency. Receivers ususally have a number of spurious responses as well as the tuned response. As a result of these unintentional emissions and responses, mutual interference may occur between two nonassociated equipments (interfering transmitter and victim receiver) even though their tuned frequencies are widely separated. Normally, interference resulting from a transmitter harmonic passing through a spurious response of a receiver occurs only when the two equipments are operated at the same site or are in close proximity to one another. To prevent the possibility of mutual interference in these cases, one should assign tuned frequencies to the equipments so that none of the transmitter harmonics are coincident in frequency with any of the spurious responses of the receiver.

The Electromagnetic Compatibility Analysis Center (ECAC) has implemented a mutual interference chart (MIC) generator that can be used as an aid in making frequency assignments for a particular transmitter and receiver (specified by nomenclature). The generator computes, for a given tuned frequency of the receiver, all of the tuned frequencies of the transmitter that may cause its fundamental or harmonics to be in frequency coincidence with one of the spurious responses of the receiver. The data resulting from the computations can be plotted in the form of a chart, in which the abscissa is the tuned frequency of the transmitter and the ordinate is the tuned frequency of the receiver. The plots on the chart show which tuned frequencies result in one of the receiver responses being coincident in frequency with either the fundamental or harmonic of the transmitter. It should be pointed out that even though an emission is coincident with one of the responses, the received signal may not be of sufficient amplitude to be detected or to cause interference, since signal level is not determined by the MIC generator. Some inference can be made, however, by considering the order of the interaction (see SECTION 2). It is also necessary to establish guardbands to take into account side band energy strong enough to interact with the receiver responses.

Two of the significant features of the mutual interference chart generator are:

1. Tables of incompatible frequencies can be produced for all transmitter-receiver combinations (by nomenclature). These tables can then be used to form charts which will aid in making

frequency assignments in situations where transmitter harmonics and receiver spurious responses must be taken into consideration.

2. The program has been written in FORTRAN, and thus can be used with any computer having a FORTRAN capability.

The mutual interference chart generator described in this report is a very useful tool that can be used by organizations involved in making frequency assignments and having a suitable computer available. Since the ratio of channel bandwidth to frequency spectrum for HF is very small, the charts must be quite large if adequate resolution is to be had. This makes their use somewhat awkward in this frequency range.

A technique that is commonly used to circumvent this problem is to plot an MIC containing only the "allocated set" of frequencies. That is, rather than plot all channels, only those channels available are placed on the chart.

As illustrated in Figure 1-1, the frequency set f_1, f_2, f_3, ... f_N represents the available set. The entries in the matrix are the same as with a standard MIC.

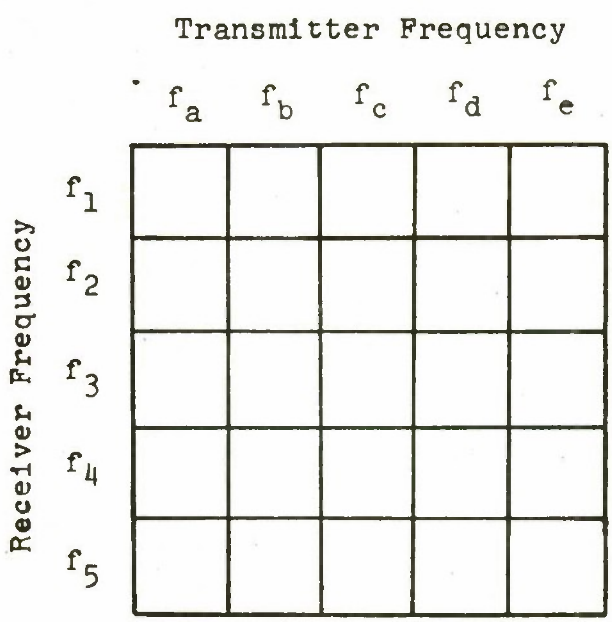

Figure 1-1. Sample Frequency Matrix

SECTION 2

MATHEMATICAL APPROACH

The MIC generator is based on the spurious response equation (2-1):

$$f_{sp} = \frac{Pf_{LO} \pm f_{IF}}{Q} \tag{2-1}$$

where

f_{sp} = an input frequency which causes a spurious response in the receiver.

f_{LO} = receiver local oscillator frequency.

f_{IF} = receiver first intermediate frequency.

P and Q are integers.

Since f_{sp} may equal a harmonic of the transmitter frequency, potential interfering fundamental frequencies may be found by:

$$f_t = \frac{f_{sp}}{H} = \frac{Pf_{LO} \pm f_{IF}}{HQ} \tag{2-2}$$

where

f_t = fundamental transmitter frequency.

H = integer representing harmonic number.

The FORTRAN program computes, for each receiver frequency, all possible solutions of equation (2-2) which are within the transmitter's tuning range. The process is repeated for several steps in receiver tuned frequency (input parameters). No levels are computed, but the significance of each response can be inferred from its order (P + HQ). As the order goes up, the responses tend to be less significant.

SECTION 3

DISCUSSION OF THE PROGRAM

Using $f_{LO} = (f_R + f_{IF})/M$, equation (2-2) can be rewritten as follows:

$$f_t = \frac{P}{HQ} \; \frac{f_R + f_{IF}}{M} \pm \frac{f_{IF}}{HQ} \qquad (3\text{-}1)$$

where f_R is the receiver tuned frequency and M is the local oscillator multiplication factor. The maximum values which P and HQ take on in a given computation are input parameters. For all combinations of values up to these maximums, the potential interfering transmitter frequencies are calculated. Those frequencies which lie within the transmitter's tuning range are printed out and all others are discarded.

The program can handle up to 100 receivers and any number of transmitters on a single run. All transmitters will be run against all receivers. The only limiting factor is the quantity of printout, since provision is made for only one tape reel. When this is filled, the program will stop.

The program itself is given in APPENDIX I. The following data cards are required as inputs:

Card No.	Format	Contents
1	2I5	Number of receivers, number of transmitters.
2	I5	Receiver identification number.
3	3E20.8,2I5	First receiver tuned frequency, tuned frequency increments, intermediate frequency, L.O. multiplication factor, number of steps.
4	2I5	Maximum value of P, maximum value of HQ.
Repeat cards 1 - 4 for all receivers.		
5	I5	Transmitter identification number.
6	2E20.8	Lowest transmitter frequency, highest transmitter frequency.
Repeat cards 5 and 6 for all transmitters.		

The printed output consists of: receiver number, transmitter number, data on card 3, data on card 6, data on card 4, and the table of incompatible frequencies. In this table are listed the receiver and transmitter frequencies and the values of P and HQ. A sample printout is given in APPENDIX II.

SECTION 4

APPLICATIONS AND SAMPLE PLOTS

As an example of the formation and use of MICs, two equipments with the following characteristics are assumed:

Equipment No. 1

Tuning range	1100-1300 mc
IF	60 mc
LO multiplication	1
Receiver identification number	11
Transmitter identification number	21

Equipment No. 2

Tuning range	200-400 mc
IF	27 mc
LO multiplication	3
Receiver identification number	12
Transmitter identification number	22

Transmitter No. 2 was run against receiver No. 1, and transmitter No. 1 was run against receiver No. 2. Receiver No. 1 was step-tuned in 50-mc increments and receiver No. 2 was step-tuned in 25-mc increments. The outputs for both runs are given in APPENDIX II and are plotted in Figures 4-1 and 4-2. Since receiver No. 2 has an LO multiplication factor of 3, spurious frequencies are computed by using the base LO frequency. This results in more potential response frequencies as can be seen from Figure 4-2. It can also be seen that each response follows a straight line as receiver and transmitter frequencies change. The slope of this line is:

$$\frac{\Delta f_t}{\Delta f_r} = \frac{P}{HQM} \qquad (4\text{-}1)$$

where all terms are as previously defined.

Both plots in Figures 4-1 and 4-2 are of the one receiver-one transmitter type. If both equipments are transceivers (transmit and receive on the same frequency), Figures 4-1 and 4-2 are combined into one plot, producing Figure 4-3. In using either type of curve, it is necessary to remember that the lines represent incompatible frequency assignments. For example, from Figure

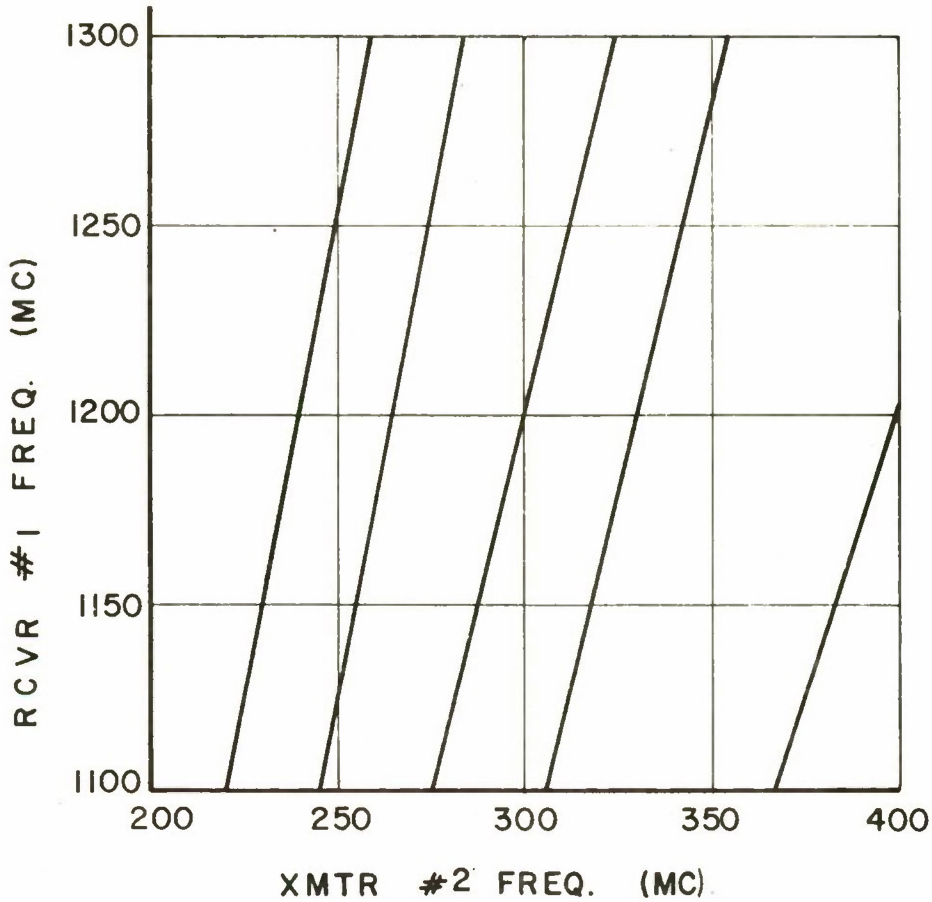

Figure 4-1. Mutual Interference Chart for Transmitter No. 2 versus Receiver No. 1

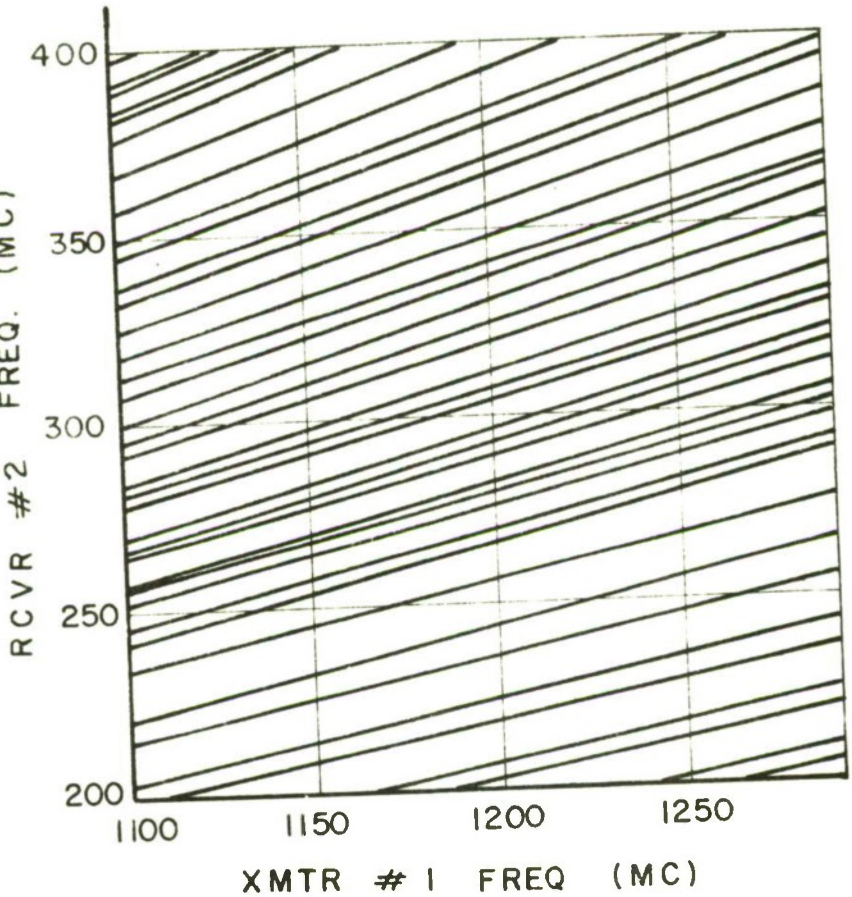

Figure 4-2. Mutual Interference Chart for Transmitter No. 1 versus Receiver No. 2

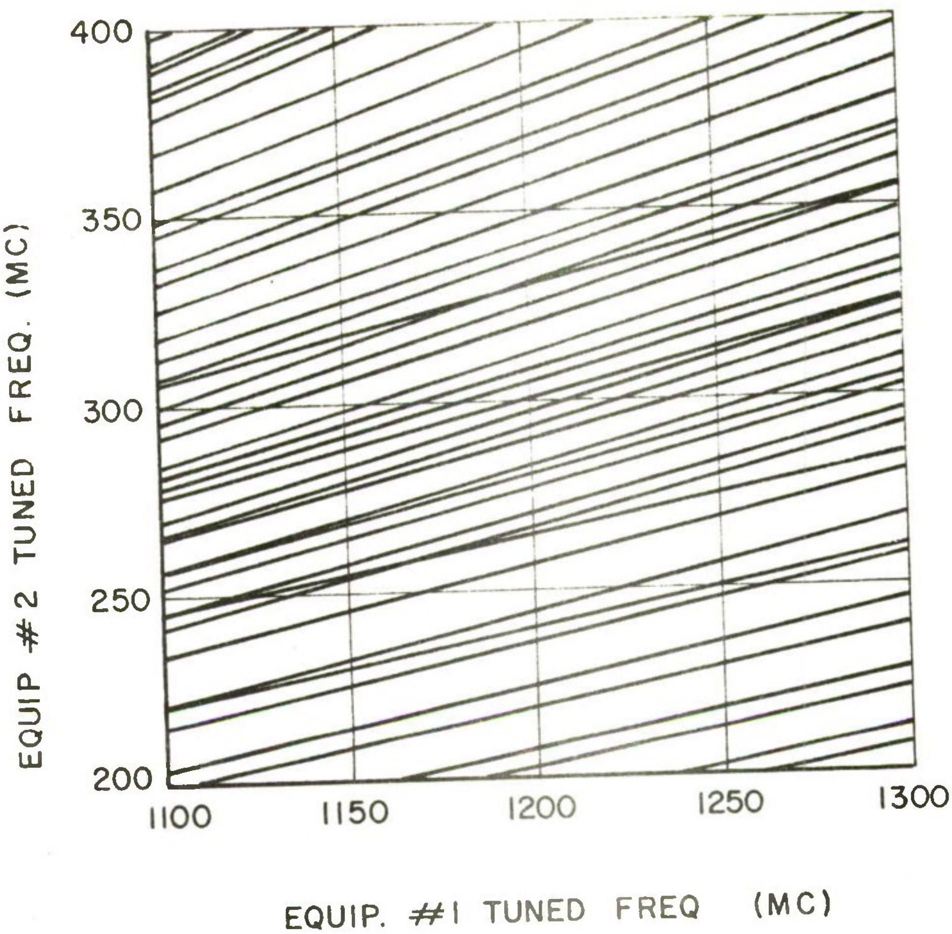

Figure 4-3. Mutual Interference Chart for Two Transceivers

4-1, transmitter No. 2 should not be tuned to 300 mc if receiver No. 1 is tuned to 1200 mc. Frequency assignments should be made by finding a pair of frequencies in an area with as few lines as possible. An example from Figure 4-3 is to tune equipment No. 1 to 1200 mc and equipment No. 2 to 250 mc.

APPENDIX I

LISTING OF THE MIC GENERATION PROGRAM

```
C      MIC  GENERATION
       DIMENSION NRCQ(100),FRQ(100),DELFQ(100),FIFQ(100),MQ(100),NCQ(100)
      1 ,MPQ(100),MHQ(100)
    1 FORMAT (3E20.8,2I5)
    2 FORMAT (2E20.8)
    3 FORMAT (2I5)
   11 FORMAT (/14X2HFT,18X2HFR,8X1HP,3X2HHQ/)
   20 FORMAT (I5)
   19 FORMAT (I5/, 3E20.8,2I5/,2I5)
      READ (5,3) NRX,NTX
      READ (5,19)(NRCQ(J),FRQ(J),DELFQ(J),FIFQ(J),MQ(J),NCQ(J),MPQ(J),
     1 MHQ(J), J=1,NRX)
      DO 18 JN=1,NTX
      READ (5,20) NTC
      READ (5,2) FTL,FTH
      DO 17 JK=1,NRX
      NRC= NRCQ(JK)
      FR=FRQ(JK)
      DELF = DELFQ(JK)
      FIF = FIFQ(JK)
      M= MQ(JK)
      NC= NCQ(JK)
      MP=MPQ(JK)
      MH=MHQ(JK)
      WRITE (6,20) NRC
      WRITE(6,20) NTC
      WRITE (6,1) FR,DELF,FIF,M,NC
      WRITE (6,2) FTL,FTH
      WRITE (6,3)MP,MH
      WRITE (6,11)
      AM=M
      F2=(FR+FIF)/AM.
      DO 10  I=0,NC
      G=I
      F1 = G*DELF/AM
      FLO =F1+F2
      FRD=FR+G*DELF
      DO 10  J=0,MP
      P=J
      FSP = ABS(P*FLO + FIF)
      FSN = ABS(P*FLO - FIF)
      DO  9  L=1,MH
      H=L
      FTP = FSP/H
      FTN = FSN/H
      IF (FTP - FTL) 6,4,4
    4 IF (FTP - FTH) 5,5,6
    5 FORMAT (2E20.8,2I5)
      WRITE (6,5)FTP,FRD,J,L
    6 IF(FTN-FTL)9,7,7
    7 IF (FTN-FTH)8,8,9
    8 WRITE (6,5)FTN,FRD,J,L
    9 CONTINUE
   .0 CONTINUE
   17 CONTINUE
   18 CONTINUE
      STOP
```

APPENDIX II

SAMPLE OUTPUT

PAGE 1 PRINTS LIST

11
22

.11000000+04	.50000000+02	.60000000+02	1	4
.20000000+03	.40000000+03			

8 5

FT	FR	P	HQ
.36666666+03	.11000000+04	1	3
.30500000+03	.11000000+04	1	4
.27500000+03	.11000000+04	1	4
.24400000+03	.11000000+04	1	5
.22000000+03	.11000000+04	1	5
.38333333+03	.11499999+04	1	3
.31750000+03	.11499999+04	1	4
.28749999+03	.11499999+04	1	4
.25400000+03	.11499999+04	1	5
.23000000+03	.11499999+04	1	5
.40000000+03	.12000000+04	1	3
.33000000+03	.12000000+04	1	4
.30000000+03	.12000000+04	1	4
.26400000+03	.12000000+04	1	5
.23999999+03	.12000000+04	1	5
.34250000+03	.12500000+04	1	4
.31250000+03	.12500000+04	1	4
.27400000+03	.12500000+04	1	5
.25000000+03	.12500000+04	1	5
.35500000+03	.13000000+04	1	4
.32500000+03	.13000000+04	1	4
.28399999+03	.13000000+04	1	5
.26000000+03	.13000000+04	1	5

PAGE 1 PRINTS LIST

12
21

.20000000+03	.25000000+02	.27000000+02	3	8
.11000000+04	.13000000+04			

24 5

FT	FR	P	HQ
.11619999+04	.20000000+03	15	1
.11080000+04	.20000000+03	15	1
.12376666+04	.20000000+03	16	1
.11836666+04	.20000000+03	16	1
.12593333+04	.20000000+03	17	1
.11189999+04	.22499999+03	13	1
.12029999+04	.22499999+03	14	1
.11489999+04	.22499999+03	14	1
.12870000+04	.22499999+03	15	1
.12329999+04	.22499999+03	15	1
.11349999+04	.25000000+03	12	1
.12273332+04	.25000000+03	13	1
.11733333+04	.25000000+03	13	1
.12656666+04	.25000000+03	14	1
.11215000+04	.25000000+03	24	2
.11343333+04	.27500000+03	11	1
.12350000+04	.27500000+03	12	1
.11809999+04	.27500000+03	12	1
.12816666+04	.27500000+03	13	1
.11208333+04	.27500000+03	22	2
.11711666+04	.27500000+03	23	2
.11441666+04	.27500000+03	23	2
.12215000+04	.27500000+03	24	2
.11945000+04	.27500000+03	24	2
.11170000+04	.30000000+03	10	1
.12260000+04	.30000000+03	11	1
.11719999+04	.30000000+03	11	1
.12809999+04	.30000000+03	12	1
.11035000+04	.30000000+03	20	2
.11579999+04	.30000000+03	21	2
.11309999+04	.30000000+03	21	2
.12125000+04	.30000000+03	22	2
.11855000+04	.30000000+03	22	2
.12669999+04	.30000000+03	23	2
.12400000+04	.30000000+03	23	2
.12944999+04	.30000000+03	24	2
.12003333+04	.32500000+03	10	1
.11463333+04	.32500000+03	10	1
.12636666+04	.32500000+03	11	1
.11281666+04	.32500000+03	19	2
.11011666+04	.32500000+03	19	2
.11868333+04	.32500000+03	20	2
.11598333+04	.32500000+03	20	2
.12454999+04	.32500000+03	21	2
.12184999+04	.32500000+03	21	2
.12771666+04	.32500000+03	22	2

P. GE 2 PRINTS LIST

.11579999+04	.34999999+03	9	1
.11039999+04	.34999999+03	9	1
.12836666+04	.34999999+03	10	1
.12296666+04	.34999999+03	10	1
.11444999+04	.34999999+03	18	2
.11174999+04	.34999999+03	18	2
.12073333+04	.34999999+03	19	2
.11803333+04	.34999999+03	19	2
.12701666+04	.34999999+03	20	2
.12431666+04	.34999999+03	20	2
.12329999+04	.37500000+03	9	1
.11789999+04	.37500000+03	9	1
.11524999+04	.37500000+03	17	2
.11254999+04	.37500000+03	17	2
.12194999+04	.37500000+03	18	2
.11924999+04	.37500000+03	18	2
.12864999+04	.37500000+03	19	2
.12594999+04	.37500000+03	19	2
.11656667+04	.40000000+03	8	1
.11116666+04	.40000000+03	8	1
.12539999+04	.40000000+03	9	1
.11521666+04	.40000000+03	16	2
.11251666+04	.40000000+03	16	2
.12233333+04	.40000000+03	17	2
.11963332+04	.40000000+03	17	2
.12944999+04	.40000000+03	18	2
.12674999+04	.40000000+03	18	2
.11002222+04	.40000000+03	23	3
.11476666+04	.40000000+03	24	3
.11296666+04	.40000000+03	24	3

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A FORTRAN PROGRAM WHICH AIDS IN GENERATING MUTUAL INTERFERENCE CHARTS

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8a. CONTRACT OR GRANT NO. AF 19(628)-5049 b. PROJECT NO. 649E c. d.	9a. ORIGINATOR'S REPORT NUMBER(S) ESD-TR-65-20 9b. OTHER REPORT NO(S) *(Any other numbers that may be assigned this report)*

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