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Simultaneous Equation Solution and
Matrix Inversion with Complex Values
1620-9.4.015

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Matrix Inversion with Complex Values
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1620 USERS GROUP PROGRAM REVIEW AND EVALUATION

(fill out in typewriter or pencil, do not use ink)

Program No. ____________ Date ____________

Program Name: ____________

1. Does the abstract adequately describe what the program is and what it does? Yes___ No___
   Comment____________

2. Does the program do what the abstract says? Yes___ No___
   Comment____________

3. Is the Description clear, understandable, and adequate? Yes___ No___
   Comment____________

4. Are the Operating Instructions understandable and in sufficient detail? Yes___ No___
   Comment____________
   Are the Sense Switch options adequately described (if applicable)? Yes___ No___
   Are the mnemonic labels identified or sufficiently understandable? Yes___ No___
   Comment____________

5. Does the source program compile satisfactorily (if applicable)? Yes___ No___
   Comment____________

6. Does the object program run satisfactorily? Yes___ No___
   Comment____________

7. Number of test cases run______. Are any restrictions as to data, size, range, etc. covered adequately in description? Yes___ No___
   Comment____________

8. Does the Program Meet the minimal standards of the 1620 Users Group? Yes___ No___
   Comment____________

9. Were all necessary parts of the program received? Yes___ No___
   Comment____________

10. Please list on the back any suggestions to improve the usefulness of the program. These will be passed onto the author for his consideration.

Please return to:

Mr. Richard L. Pratt
Data Corporation
7500 Old Xenia Pike
Dayton, Ohio 45432

Your Name ____________

Company ____________

Address ____________

User Group Code____________

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11/09/64

Simultaneous Equation Solution and Matrix Inversion With Complex Values

Author: G. S. Haralampu
New England Electric System
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Boston, Mass.

DECK KEY

* 1. Object Deck
* 2. Source Deck
* 3. Test Data Deck

* Revised → 12/07/64

Revised - November 1964

PROGRAM No. 14 AND 7014 - NEW ENGLAND ELECTRIC SYSTEM

Title: Simultaneous Equation Solution and Matrix Inversion with Complex Values

Written by: G. S. Haralampu, New England Electric System

Scope: The program has been written for the solution of a maximum of fifteen equations with fifteen unknowns for the basic 1620, with the coefficients, unknowns, and constants being complex numbers. The matrix inversion method is used for the solution of the simultaneous equations. (Note: A 25 x 25 matrix is allowed on the 7010 computer).

Machine Configuration: 20K 1620 with a 1622 card reader and punch, or 80K 7010 computer

Reference: "Numerical Mathematical Analysis" by Scarborough, Fourth Edition, Page 540.

Speed: A 4 x 4 matrix requires 20 seconds for solution. A 16 x 16 matrix requires 12 minutes for solution, on the 1620. The speed on the 7010 is approximately 12 times faster than the 1620.

Analysis: Assume the following 4 x 4 matrix is to be inverted:

Z_{11}	Z_{12}	Z_{13}	Z_{14}
Z_{21}	Z_{22}	Z_{23}	Z_{24}
Z_{31}	Z_{32}	Z_{33}	Z_{34}
Z_{41}	Z_{42}	Z_{43}	Z_{44}

All the Z's are complex numbers.

The following method was used:

A. Place the first column of a unit matrix, equal to the size of the main matrix, to the right of the main matrix. This is shown below:

Main Matrix				First Column of the Unit Matrix
Z_{11}	Z_{12}	Z_{13}	Z_{14}	1
Z_{21}	Z_{22}	Z_{23}	Z_{24}	0
Z_{31}	Z_{32}	Z_{33}	Z_{34}	0
Z_{41}	Z_{42}	Z_{43}	Z_{44}	0

B. By mathematical manipulation, obeying all the rules of matrix handling of rows and columns, obtain the first column of the unit matrix at the left of the main matrix. This will be:

First Column of the Unit Matrix	Intermediate Values of the Main Matrix			
1	Y_{12}	Y_{13}	Y_{14}	Y_{15}
0	Y_{22}	Y_{23}	Y_{24}	Y_{25}
0	Y_{32}	Y_{33}	Y_{34}	Y_{35}
0	Y_{42}	Y_{43}	Y_{44}	Y_{45}

C. Shift the intermediate values of the matrix to the left by one column and place the second column of the unit matrix to the right.

Main Matrix				Second Column of the Unit Matrix
Y_{11}	Y_{12}	Y_{13}	Y_{14}	0
Y_{21}	Y_{22}	Y_{23}	Y_{24}	1
Y_{31}	Y_{32}	Y_{33}	Y_{34}	0
Y_{41}	Y_{42}	Y_{43}	Y_{44}	0

D. Repeat "B" until we have:

Second Column of the Unit Matrix	Second Intermediate Values of the Main Matrix			
0	Y_{12}	Y_{13}	Y_{14}	Y_{15}
1	Y_{22}	Y_{23}	Y_{24}	Y_{25}
0	Y_{32}	Y_{33}	Y_{34}	Y_{35}
0	Y_{42}	Y_{43}	Y_{44}	Y_{45}

E. Repeat parts B and C until the matrix manipulation has been done for the four columns of the unit matrix. Then the values left in position

Y_{12}	Y_{13}	Y_{14}	Y_{15}
Y_{22}	Y_{23}	Y_{24}	Y_{25}
Y_{32}	Y_{33}	Y_{34}	Y_{35}
Y_{42}	Y_{43}	Y_{44}	Y_{45}

compose the inverted matrix.

F. Once the matrix is inverted, the unknowns can be found by matrix multiplication. Assume the given equations to be solved are in the form of

$$[Z] \times [I] = [E] \qquad \text{Equation 1}$$

where each bracketed symbol represents a matrix. Solving for the I's we have:

$$[I] = [Y] \times [E] \qquad \text{Equation 2}$$

where the Y matrix is the inverse of the Z matrix.

G. If the equations to be solved are as shown below,

$$Z_{11}I_1 + Z_{12}I_2 + Z_{13}I_3 + Z_{14}I_4 = E_1$$
$$Z_{21}I_1 + Z_{22}I_2 + Z_{23}I_3 + Z_{24}I_4 = E_2$$
$$Z_{31}I_1 + Z_{32}I_2 + Z_{33}I_3 + Z_{34}I_4 = E_3$$
$$Z_{41}I_1 + Z_{42}I_2 + Z_{43}I_3 + Z_{44}I_4 = E_4$$

then Equation 1 expanded is as follows:

$$\begin{bmatrix} Z_{11} & Z_{12} & Z_{13} & Z_{14} \\ Z_{21} & Z_{22} & Z_{23} & Z_{24} \\ Z_{31} & Z_{32} & Z_{33} & Z_{34} \\ Z_{41} & Z_{42} & Z_{43} & Z_{44} \end{bmatrix} \times \begin{bmatrix} I_1 \\ I_2 \\ I_3 \\ I_4 \end{bmatrix} = \begin{bmatrix} E_1 \\ E_2 \\ E_3 \\ E_4 \end{bmatrix}$$

and Equation 2 is:

$$\begin{bmatrix} I_1 \\ I_2 \\ I_3 \\ I_4 \end{bmatrix} = \begin{bmatrix} Y_{11} & Y_{12} & Y_{13} & Y_{14} \\ Y_{21} & Y_{22} & Y_{23} & Y_{24} \\ Y_{31} & Y_{32} & Y_{33} & Y_{34} \\ Y_{41} & Y_{42} & Y_{43} & Y_{44} \end{bmatrix} \times \begin{bmatrix} E_1 \\ E_2 \\ E_3 \\ E_4 \end{bmatrix}$$

Upon completing the matrix multiplation, the unknown I's are:

$$I_1 = Y_{11}E_1 + Y_{12}E_2 + Y_{13}E_3 + Y_{14}E_4$$
$$I_2 = Y_{21}E_1 + Y_{22}E_2 + Y_{23}E_3 + Y_{24}E_4$$
$$I_3 = Y_{31}E_1 + Y_{32}E_2 + Y_{33}E_3 + Y_{34}E_4$$
$$I_4 = Y_{41}E_1 + Y_{42}E_2 + Y_{43}E_3 + Y_{44}E_4$$

USERS' GUIDE

INPUT DATA FOR THE 1620 OR THE 7010

First Card: Title of job with a minus sign in column 72. This will skip to a new page on the 407 for each separate solution.

Second Card: (Right justified in the first five columns). The number of equations to be solved. (Fixed point)

Subsequent Cards: (Floating point) The real part of the coefficient is entered in the first ten columns, and the imaginary part in the next ten columns. For example, for a three equation solution, the input is:

$$\begin{matrix} Z_{11} & Z_{12} & Z_{13} & E_1 \\ Z_{21} & Z_{22} & Z_{23} & E_2 \\ Z_{31} & Z_{32} & Z_{33} & E_3 \end{matrix}$$

and 12 cards are required.

Last Card: (Fixed point; right justified in the first five columns)

a) The value 1 if another case is to follow, and a 9999 if this was the last case.

OUTPUT

See examples in the Appendix.

LIMITATIONS

1) Largest matrix handled is a 15 x 15 for the 1620, and 25 x 25 for the 7010.

2) No zeroes allowed in the main diagonal.

3) If a larger than a 15 x 15 on the 1620 (or a 25 x 25 on the 7010) is attempted to be read in, the computer will not solve that case but will print message saying so, and then proceed to the next case.

FOR THE 7010 ONLY

Place the following card ahead of the input data:

(Columns 6-10) MON$$

(Columns 16-28) EXEQ HARA,MJB

A Matrix Inversion Subroutine has also been written for the 7010. To make use of this subroutine do the following:

A. In your main program include the statements:

1. DIMENSION R(25,26), X (25,26)

2. COMMON R,X,K

3. Read K or set K to equal size of matrix to be solved.

4. CALL MATINV(R,X,K)

B. In front of the input, include the following card before the "MON$$ EXEQ " card of your program:

(Columns 16-26) CALL MATINV

OPERATING INSTRUCTIONS

1) Clear Memory

2) Load Object program in computer with the input for all the cases to be solved.

3) When solution is completed for all the cases, the 1620 will PAUSE, and the 7010 will EXIT.

INDEX TO THE APPENDIX

INPUT DATA

APPENDIX I

```
    THIS IS A 4X4 MATRIX
     4
 0.071      .363
 -8.023     -4.031
 8.148      4.856
 8.648      6.323
 1.000      0.0
 .042       .236
 3.217      7.501
 -3.311     -7.813
 .665       2.632
 1.000      0.0
 -1.452     -5.087
 -9.569     -9.686
 8.050      4.390
 10.167     12.109
 1.00       0.0
 .097       .564
 -8.101     -4.564
 8.105      4.718
 8.715      7.022
 1.00       0.0
     1
    THIS IS A 3X3 MATRIX
     3
 .0582      .168
 .0         -.00196
 .0         -.000465
 .058       -.00502
 0.0        -.00196
 .0582      .168
 0.0        -.00196
 -.1102     .0000687
 0.0        -.000465
 0.0        -.00196
 .0582      .168
 -.1102     .0000687
  9999
```

APPENDIX II

```
07070 C      PROGRAM NUMBER 14**NOV 1,1964
07070 C      SIMULTANEOUS EQUATION SOLUTION USING MATRIX INVERSION METHOD
07070 C      COMPLEX NUMBERS ARE USED
07070 C      WRITTEN BY G.S.HARALAMPU - NEW ENGLAND ELECTRIC SYSTEM
07070 C      SIZE IS LIMITED TO A 15X15 MATRIX
07070        DIMENSION R(15,16),X(15,16),ER(15),EI(15),TR(15),TI(15)
07070   1000 FORMAT(I5)
07092   1001 FORMAT(2F10.4,2I5)
07130   1002 FORMAT   (/46H   THE INVERTED MATRIX ELEMENTS ARE AS FOLLOWS)
07252   1003 FORMAT(// 46H   THE SIMULTANEOUS EQUATION SOLUTIONS FOLLOW )
07384   1004 FORMAT(48HMATRIX LARGER THAN 15X15.NEXT CASE TO BE SOLVED.)
07504   1005 FORMAT(30H   REAL        IMAG      ROW  COL)
07588   1006 FORMAT(27H   REAL        IMAG    ELEMENT)
07666   1007 FORMAT(42H   AN ELEMENT ON THE MAIN DIAGONAL IS ZERO)
07774   1008 FORMAT(49H                                                 )
07896   1009 FORMAT(36X,35X,1H-)
07936     55 READ 1008
07948 C      READ IN THE SIZE OF THE MATRIX
07948        READ 1000,K
07972        IF(K-16)103,101,101
08040    103 DO 50 I=1,K
08052        DO 30 J = 1, K
08064     30 READ    1001, R(I,J),X(I,J)
08256     50 READ    1001, ER(I),EI(I)
08376 C      READ IN THE LAST CODE CARD. 1 FOR MORE CASES TO FOLLOW, AND 9999
08376 C      FOR THE LAST CASE
08376        READ 1000,NCODE
08400        KX = K + 1
08436        DO 33 I = 1, K
08448        DO 48 L=1,K
08460        R(L, KX) = 0.0
08544     48 X(L, KX) = 0.0
08664        R(I,KX)=1.0
08748        IY = 1
08772        IF(R(I,I))34,31,34
08852     31 IF(X(I,I))34,100,34
08932     34 T1=R(I,I)*R(I,I)+X(I,I)*X(I,I)
09112        T1R=R(I,I)
09160        T1X=X(I,I)
09208        DO 35 J=1,KX
09220        WR=(R(I,J)*T1R+X(I,J)*T1X)/T1
09436        WI=(X(I,J)*T1R-R(I,J)*T1X)/T1
09664        R(I, J) = WR
09748     35 X(I, J) = WI
09868        IX =0
09892        IY = 2
09916        IF(I-K)37,38,37
09984     38 MX=I-1
T0020        MY=1
T0044        GO TO 39
T0052     37 MY = I + 1
T0088        MX = K
T0112     39 DO 40 L = MY, MX
T0124        IX = IX +1
```



```
T0160        T1 = R(L, I)
T0208        T2 = X(L, I)
T0256        DO 40 J=1,KX
T0268        WR = R(I, J)*T1 - X(I, J)*T2
T0484        WI = R(I, J)*T2 + X(I, J)*T1
T0688        R(L, J) = R(L, J) - WR
T0844     40 X(L,J)=X(L,J)-WI
T1072        IY = 3
T1096        IF(I-1)45,44,45
T1164     45 IF((K-1)-IX)38,44,38
T1244     44 DO 46 L = 1, K
T1256        DO 46 J = 1, K
T1268        NU = J + 1
T1304        R(L,J)=R(L,NU)
T1448     46 X(L, J) = X(L, NU)
T1664     33 CONTINUE
T1700        DO 53 I=1,K
T1712        TR(I)=0.0
T1760        TI(I)=0.0
T1808        DO 53 J=1,K
T1820        T1=R(I,J)*ER(J)-X(I,J)*EI(J)
T2084        T2=X(I,J)*ER(J)+R(I,J)*EI(J)
T2336        TR(I)=TR(I)+T1
T2420     53 TI(I)=TI(I)+T2
T2576        PUNCH 1009
T2588        PUNCH 1008
T2600        PUNCH 1002
T2612        PUNCH 1005
T2624        DO 49 I=1,K
T2636        DO 49 J = 1, K
T2648     49 PUNCH    1001, R(I,J),X(I,J),I,J
T2900        PUNCH 1003
T2912        PUNCH 1006
T2924        DO 201 I=1,K
T2936    201 PUNCH    1001, TR(I),TI(I),I
T3068    202 IF(NCODE-1)102,55,102
T3136    102 PAUSE
T3148        PAUSE
T3160    100 PRINT 1007
T3172        GO TO 202
T3180    101 PRINT 1004
T3192        DO 2000 I=1,K
T3204        DO 2001 J=1,K
T3216   2001 READ 1001,W,Z
T3288   2000 READ 1001,W,Z
T3360        READ 1000,NCODE
T3384        GO TO 202
T3392        END
                                            T9999 SIN         T9989 SINF
T9979 COS                                   T9969 COSF        T9959 ATAN
T9949 ATANF          T9939 EXP              T9929 EXPF        T9919 LOG
T9909 LOGF           T9899 SQRT             T9889 SQRTF       T9879 SIGN
T9869 SIGNF          T9859 ABS              T9849 ABSF        T9839 R        T7449
```

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```
              T̄7439 X        T̄5049
T̄4739 TR        T̄4599
T̄4429 T̄001              T̄4419 T̄002
T̄4389 T̄005              T̄4379 T̄006
T̄4349 T̄009              T̄4339 0̄055
T̄4309 0̄00               T̄4299 0̄103
T̄4269 I                 T̄4259 0̄030
T̄4229 KX                T̄4219 0̄00T̄
T̄4189 L                 T̄4179 0̄0000000099̄
T̄4149 0̄034              T̄4139 0̄031
T̄4109 0̄01               T̄4099 T̄1R
T̄4069 WR                T̄4059 0̄02
T̄4029 0̄000̄              T̄4019 0̄002̄
T̄3989 MX                T̄3979 MY
T̄3949 T2                T̄3939 0̄003̄
T̄3909 0̄046              T̄3899 MU
T̄3869 0̄201              T̄3859 0̄202
T̄3829 Z̄001              T̄3819 W
```

```
T̄5039 ER      T̄4899     T̄4889 EI     T̄4749
T̄4589 TI      T̄4449     T̄4439 T̄000
T̄4409 T̄003              T̄4399 T̄004
T̄4369 T̄007              T̄4359 T̄008
T̄4329 K                 T̄4319 0̄016̄
T̄4289 0̄101              T̄4279 0̄050
T̄4249 J                 T̄4239 MCODE
T̄4209 0̄033              T̄4199 0̄048
T̄4169 T̄00000000̄1        T̄4159 IY
T̄4129 0̄100              T̄4119 T1
T̄4089 T̄1X               T̄4079 0̄035
T̄4049 WI                T̄4039 IX
T̄4009 0̄037              T̄3999 0̄038
T̄3969 0̄039              T̄3959 0̄040
T̄3929 0̄045              T̄3919 0̄044
T̄3889 0̄053              T̄3879 0̄049
T̄3849 0̄102              T̄3839 Z̄000
T̄3809 Z
```

LOAD SUBROUTINES

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APPENDIX III

OUTPUT

THIS A 4X4 MATRIX

THE INVERTED MATRIX ELEMENTS ARE AS FOLLOWS

REAL	IMAG	ROW	COL
-.1862	1.0951	1	1
-.0085	.0151	1	2
-.0343	.1282	1	3
.2154	-1.2256	1	4
.2296	-1.2040	2	1
.0297	-.0935	2	2
-.0062	.0331	2	3
-.1673	1.1311	2	4
.2177	-1.1513	3	1
-.0080	-.0049	3	2
-.0056	.0339	3	3
-.1386	1.0672	3	4
.0327	-.0725	4	1
.0197	-.0779	4	2
.0054	-.0046	4	3
.0175	.0319	4	4

THE SIMULTANEOUS EQUATION SOLUTIONS FOLLOW

REAL	IMAG	ELEMENT
-.0137	.0129	1
.0858	-.1333	2
.0654	-.0551	3
.0754	-.1231	4

APPENDIX III

OUTPUT

THIS IS A 3X3 MATRIX

THE INVERTED MATRIX ELEMENTS ARE AS FOLLOWS

REAL	IMAG	ROW	COL
1.8417	-5.3149	1	1
.0385	-.0488	1	2
.0096	-.0119	1	3
.0385	-.0488	2	1
1.8422	-5.3153	2	2
.0385	-.0488	2	3
.0096	-.0119	3	1
.0385	-.0488	3	2
1.8417	-5.3149	3	3

THE SIMULTANEOUS EQUATION SOLUTIONS FOLLOW

REAL	IMAG	ELEMENT
.0748	-.3108	1
-.2049	.5882	2
-.2063	.5904	3

APPENDIX IV

```
C       PROGRAM NUMBER 14**MAY 1.1964
C       SIMULTANEOUS EQUATION SOLUTION USING MATRIX INVERSION METHOD
C       COMPLEX NUMBERS ARE USED
C       WRITTEN BY G.S.HARALAMPU - NEW ENGLAND ELECTRIC SYSTEM
C       SIZE IS LIMITED TO A 25X25 MATRIX
        DIMENSION R(25.26).X(25.26).ER(25).EI(25).TR(25).TI(25)
 1000 FORMAT(I5)
 1001 FORMAT(2F10.4.2I5)
 1002 FORMAT    (/46H   THE INVERTED MATRIX ELEMENTS ARE AS FOLLOWS)
 1003 FORMAT(///46H   THE SIMULTANEOUS EQUATION SOLUTIONS FOLLOW )
 1004 FORMAT(67H   THIS MATRIX IS GREATER THAN 25X25. THE NEXT CASE WILL
     1 BE SOLVED.)
 1005 FORMAT(30H   REAL        IMAG      ROW  COL)
 1006 FORMAT(27H   REAL        IMAG   ELEMENT)
 1007 FORMAT(42H   AN ELEMENT ON THE MAIN DIAGONAL IS ZERO)
 1008 FORMAT(1X.52H                                                    )
 3000 FORMAT(1H1)
   55 READ(1.1008)
C       READ IN THE SIZE OF THE MATRIX
        READ(1.1000) K
        IF(K.GT.25)GO TO 101
        DO 50 I=1.K
        DO 30 J = 1. K
   30 READ(1.1001) R(I.J).X(I.J)
   50 READ (1.1001) ER(I).EI(I)
C       READ IN THE LAST CODE CARD. 1 FOR MORE CASES TO FOLLOW. AND 9999
C       FOR THE LAST CASE
        READ(1.1000) NCODE
        KX = K + 1
        DO 33 I = 1. K
        DO 48 L=1.K
        R(L. KX) = 0.0
   48 X(L. KX) = 0.0
        R(I.KX)=1.0
        IY = 1
        IF(R(I.1).NE.0.0)GO TO 34
        IF(X(I.1).EQ.0.0)GO TO 100
   34 T1=R(I.1)*R(I.1)+X(I.1)*X(I.1)
        T1R=R(I.1)
        T1X=X(I.1)
        DO 35 J=1.KX
        WR=(R(I.J)*T1R+X(I.J)*T1X)/T1
        WI=(X(I.J)*T1R-R(I.J)*T1X)/T1
        R(I. J) = WR
   35 X(I. J) = WI
        IX =0
        IY = 2
        IF(I.NE.K)GO TO 37
   38 MX=I-1
        MY=1
        GO TO 39
   37 MY = I + 1
        MX = K
   39 DO 40 L = MY. MX
        IX = IX +1
        T1 = R(L. 1)
        T2 = X(L. 1)
```

```
      DO 40 J=1.KX
      WR = R(I. J)*T1 - X(I. J)*T2
      WI = R(I. J)*T2 + X(I. J)*T1
      R(L. J) = R(L. J) - WR
   40 X(L.J)=X(L.J)-WI
      IY = 3
      IF(I.EQ.1)GO TO 44
      IF((K-1).NE.IX)GO TO 38
   44 DO 46 L = 1. K
      DO 46 J = 1. K
      NU = J + 1
      R(L.J)=R(L.NU)
   46 X(L. J) = X(L. NU)
   33 CONTINUE
      DO 53 I=1.K
      TR(I)=0.0
      TI(I)=0.0
      DO 53 J=1.K
      T1=R(I.J)*ER(J)-X(I.J)*EI(J)
      T2=X(I.J)*ER(J)+R(I.J)*EI(J)
      TR(I)=TR(I)+T1
   53 TI(I)=TI(I)+T2
      WRITE(3.3000)
      WRITE(3.1008)
      WRITE(3.1002)
      WRITE(3.1005)
      DO 49 I=1.K
      DO 49 J = 1. K
   49 WRITE(3.1001) R(I.J).X(I.J).I.J
      WRITE(3.1003)
      WRITE(3.1006)
      DO 201 I=1.K
  201 WRITE(3.1001) TR(I).TI(I).I
  202 IF(NCODE.EQ.1)GO TO 55
  102 CALL EXIT
  100 WRITE(3.1007)
      GO TO 202
  101 WRITE(3.1004)
      DO 2000 I=1.K
      DO 2001 J=1.K
 2001 READ (1.1001) W.Z
 2000 READ (1.1001) W.Z
      READ (1.1000) NCODE
      GO TO 202
      END
```


FORTRAN LISTING 1410-F0-970

```
      SUBROUTINEMATINV
      DIMENSIONA(25,26),B(25,26)
      COMMONA,B,M
01007 FORMAT(42H   AN ELEMENT ON THE MAIN DIAGONAL IS ZERO)
      KX=M+1
      DO33I=1,M
      DO48L=1,M
      A(L,KX)=0.0
00048 B(L,KX)=0.0
      A(I,KX)=1.0
      IY=1
      IF(A(I,1).NE.0.0)GOTO34
      IF(B(I,1).EQ.0.0)GOTO100
00034 T1=A(I,1)*A(I,1)+B(I,1)*B(I,1)
      T1R=A(I,1)
      T1X=B(I,1)
      DO35J=1,KX
      WR=(A(I,J)*T1R+B(I,J)*T1X)/T1
      WI=(B(I,J)*T1R-A(I,J)*T1X)/T1
      A(I,J)=WR
00035 B(I,J)=WI
      IX=0
      IY=2
      IF(I.NE.M)GOTO37
00038 MX=I-1
      MY=1
      GOTO39
00037 MY=I+1
      MX=M
00039 DO40L=MY,MX
      IX=IX+1
      T1=A(L,1)
      T2=B(L,1)
      DO40J=1,KX
      WR=A(I,J)*T1-B(I,J)*T2
      WI=A(I,J)*T2+B(I,J)*T1
      A(L,J)=A(L,J)-WR
00040 B(L,J)=B(L,J)-WI
      IY=3
      IF(I.EQ.1)GOTO44
      IF((M-1).NE.IX)GOTO38
00044 DO46L=1,M
      DO46J=1,M
      NU=J+1
      A(L,J)=A(L,NU)
00046 B(L,J)=B(L,NU)
00033 CONTINUE
      RETURN
00100 WRITE(3,1007)
      STOP
      END
```

APPENDIX VI

```
      FORTRAN LISTING            1410-FO-970
      DIMENSIONR(25,26),X(25,26),ER(25),EI(25),TR(25),TI(25)
      COMMONR,X,K
01000 FORMAT(I5)
01001 FORMAT(2F10.4,2I5)
01002 FORMAT(   /46H   THE INVERTED MATRIX ELEMENTS ARE AS FOLLOWS)
01003 FORMAT(///46H   THE SIMULTANEOUS EQUATION SOLUTIONS FOLLOW )
01004 FORMAT(67H   THIS MATRIX IS GREATER THAN 25X25. THE NEXT CASE WILL BE SOLVED.
01005 FORMAT(30H   REAL       IMAG      ROW  COL)
01006 FORMAT(27H   REAL       IMAG   ELEMENT)
01007 FORMAT(42H   AN ELEMENT ON THE MAIN DIAGONAL IS ZERO)
01008 FORMAT(1X,52H                                                  )
03000 FORMAT(1H1)
00055 READ(1,1008)
C     READ IN THE SIZE OF THE MATRIX
      READ(1,1000)K
      IF(K.GT.25)GOTO101
      DO50I=1,K
      DO30J=1,K
00030 READ(1,1001)R(I,J),X(I,J)
00050 READ(1,1001)ER(I),EI(I)
C     READ IN THE LAST CODE CARD. 1 FOR MORE CASES TO FOLLOW, AND 9999
C     FOR THE LAST CASE
      READ(1,1000)NCODE
      CALLMATINV
      DO53I=1,K
      TR(I)=0.0
      TI(I)=0.0
      DO53J=1,K
      T1=R(I,J)*ER(J)-X(I,J)*EI(J)
      T2=X(I,J)*ER(J)+R(I,J)*EI(J)
      TR(I)=TR(I)+T1
00053 TI(I)=TI(I)+T2
      WRITE(3,3000)
      WRITE(3,1008)
      WRITE(3,1002)
      WRITE(3,1005)
      DO49I=1,K
      DO49J=1,K
00049 WRITE(3,1001)R(I,J),X(I,J),I,J
      WRITE(3,1003)
      WRITE(3,1006)
      DO201I=1,K
00201 WRITE(3,1001)TR(I),TI(I),I
00202 IF(NCODE.EQ.1)GOTO55
00102 CALLEXIT
00100 WRITE(3,1007)
      GOTO202
00101 WRITE(3,1004)
      GOTO102
      END
```


OUTPUT - CASE 1

THIS IS A 4X4 MATRIX

THE INVERTED MATRIX ELEMENTS ARE AS FOLLOWS

REAL	IMAG	ROW	COL
-.1862	1.0951	1	1
-.0085	.0151	1	2
-.0343	.1282	1	3
.2154	-1.2256	1	4
.2296	-1.2040	2	1
.0297	-.0935	2	2
-.0062	.0331	2	3
-.1673	1.1311	2	4
.2177	-1.1513	3	1
-.0080	-.0049	3	2
-.0056	.0339	3	3
-.1386	1.0672	3	4
.0327	-.0725	4	1
.0197	-.0779	4	2
.0054	-.0046	4	3
.0175	.0319	4	4

THE SIMULTANEOUS EQUATION SOLUTIONS FOLLOW

REAL	IMAG	ELEMENT
-.0137	.0129	1
.0858	-.1333	2
.0654	-.0551	3
.0754	-.1231	4

19/19

OUTPUT - CASE 2

THIS IS A 3X3 MATRIX

THE INVERTED MATRIX ELEMENTS ARE AS FOLLOWS

REAL	IMAG	ROW	COL
1.8417	-5.3149	1	1
.0385	-.0488	1	2
.0096	-.0119	1	3
.0385	-.0488	2	1
1.8422	-5.3153	2	2
.0385	-.0488	2	3
.0096	-.0119	3	1
.0385	-.0488	3	2
1.8417	-5.3149	3	3

THE SIMULTANEOUS EQUATION SOLUTIONS FOLLOW

REAL	IMAG	ELEMENT
.0748	-.3108	1
-.2049	.5882	2
-.2063	.5904	3