```
1000 REM ************************************************************************
1010 REM *    Main Routine to Solved a Set of Ordinary Referential             *
1020 REM * Equations in The Form of                                            *
1030 REM *         dx(t)/dt = Ax(t) + Bu(t),     x(0)=x0                       *
1040 REM *         y(t)=Cx(t)                                                   *
1050 REM * Where                                                              *
1060 REM *         x(t) is an N-Dimensional Vecter                              *
1070 REM *         u(t) is an M-Dimensional Vecter                              *
1080 REM *         y(t) is an L-Dimensional Vecter                              *
1090 REM *         A    is an N*N Dimensional system coefficient Matrix         *
1100 REM *         B    is an N*M Dimensional system coefficient Matrix         *
1110 REM *         C    is an L*N Dimensional system coefficient Matrix         *
1120 REM * Input are :                                                         *
1130 REM *               x(0)= The Initial Value                                *
1140 REM *               u(0)= The Control Inputs                               *
1150 REM * Output are :                                                        *
1160 REM *               y(t)  The Output of The System                         *
1170 REM * Parameter  :                                                        *
1180 REM *               Tau is The sampling Inputval                           *
1190 REM *               Limit is The Number of Data Solved                     *
1200 REM ************************************************************************
1210 REM
1220 N=4: M=1: L=1: LIMIT=50                        ' Patameter
1230 OPTION BASE 1
1240 DIM A(N,N), B(N,M), C(L,N), U(M,LIMIT), X(N), Y(L,LIMIT), H(N,N),
     PIVOT(2,N),XX(N), P(N,N), Q(N,M)
1250 INPUT "TAU, UMAG, T1,T2";TAU,UMAG,T1,T2     'Input Parameter
1260 LPRINT
1270 LPRINT "                      Sampling Interval TAU=";TAU
1280 LPRINT "    Magnitude of Step Control Input UMAG=";UMAG
1290 LPRINT "                                Parameter T1=";T1
1300 LPRINT "                                Parameter T2=";T2
1310 '
1320 '-- Generation Of Control Input U(k),k=1,2,･･･,LIMIT -------
1330 FOR I=1 TO M
1340     FOR K=1 TO LIMIT
1350         U(I,K)=UMAG
1360 NEXT K,I
1370 '
1380 '-- Set Of Initial Value Of The Stae Valiables -------------
1390 FOR I=1 TO N
1400     X(I)=0
1410 NEXT I
1420 '
1430 '-- Generation Of The A Matrix A(N,N) ----------------------
1440 FOR I=1 TO N
1450     FOR J=1 TO N
1460         A(I,J)=0
1470 NEXT J,I
1480 '
1490 A(1,1)=-1/T1:                                  A(1,4)=(T2/T1-1)/T1
1500 A(2,1)=20   : A(2,2)=-4 :                  A(2,4)=-20*T2/T1
1510               A(3,2)=48 : A(3,3)=-16
1520                           A(4,3)=1
1530 '
1540 '--Generation Of B Matrix B(N,M) ---------------------------
1550 FOR I=1 TO N
1560     FOR J=1 TO M
1570         B(I,J)=0
1580 NEXT J,I
1590 '
1600 B(1,1)=-A(1,4)
1610 B(2,1)=-A(2,4)
1620 '
```

図 2.33(1)　BASIC による $\left\{ \begin{array}{l} \dfrac{\mathrm{d}\boldsymbol{x}(t)}{\mathrm{d}t} = \boldsymbol{A}\boldsymbol{x}(t) + \boldsymbol{B}\boldsymbol{u}(t) \\ \boldsymbol{x}(0) = \boldsymbol{x}_0,\ \boldsymbol{y}(t) = \boldsymbol{C}\boldsymbol{x}(t) \end{array} \right\}$ の解法ルーチン

```
1630 '-- Generation Of C Matrix C(L,N) ---------------------------
1640 FOR I=1 TO L
1650     FOR J=1 TO N
1660         C(I,J)=0
1670 NEXT J,I                                    '  C(0,0,0,・・・,1)
1680 FOR I=1 TO L
1690     C(I,N)=1
1700 NEXT I
1710 '
1720 '-- Print Out A,B,C ----------------------------------------
1730 LPRINT: LPRINT "    A MATRIX"
1740 FOR I=1 TO N
1750     FOR J=1 TO N
1760         LPRINT USING " ##.####^^^^";A(I,J) ;
1770     NEXT J: LPRINT
1780 NEXT I
1790 LPRINT: LPRINT "    B MATRIX"
1800 FOR I=1 TO N
1810     FOR J=1 TO M
1820         LPRINT USING " ##.####^^^^";B(I,J) ;
1830     NEXT J: LPRINT
1840 NEXT I
1850 LPRINT :LPRINT "    C MATRIX"
1860 FOR I=1 TO L
1870     FOR J=1 TO N      '
1880         LPRINT USING " ##.####^^^^";C(I,J) ;
1890     NEXT J: LPRINT
1900 NEXT I
1910 '
1920 '*****
1930 '*  Sampling Time                              Tau
1940 '*  Number of Solutions                        Limit
1950 '*  Sequence of Control Inputs                 U(k),k=1,2,・・・,Limit
1960 '*  Initial Condition of State Variable        x(0)
1970 '*  Matric                                     A,B,C
1980 '*  Have Been Set. Next The State Equation Will Be Solved
1990 '*        By Using The Subroutine TRAN
2000 '*****
2010 '
2020 GOSUB 3000                          ' TRAN
2030 '
2040 '-- The State Equation Has Been Solved. --------------------
2050 '        Print Out The Output Solution Y(L,LIMIT)
2060 FOR I=1 TO L
2070     LPRINT: LPRINT"OUTPUT NUMBER=";I
2080     FOR K=1 TO LIMIT
2090         LPRINT USING " ##.#####       ";Y(I,K) ;
2100     NEXT K :LPRINT
2110 NEXT I
2120 END
2130 '
2140 '
3000 REM ************************************
3010 REM *  SUBROUTINE TRAN                 *
3020 REM * Dimension of                     *
3030 REM *      A(N,N), B(N,M), C(L,N)      *
3040 REM *      U(M,LIMIT), X(N)            *
3050 REM *      Y(L.LIMIT),P(N,N)           *
3060 REM *      Q(N,M), H(N,N), XX(N)       *
3070 REM ************************************
3080 '
3090 '-- -(TAU/2)*A ----------------------------
3100 TT= -.5*TAU
```

図 2.33(2)　BASIC による $\left\{ \begin{array}{l} \dfrac{\mathrm{d}\boldsymbol{x}(t)}{\mathrm{d}t} = \boldsymbol{A}\boldsymbol{x}(t) + \boldsymbol{B}\boldsymbol{u}(t) \\ \boldsymbol{x}(0) = \boldsymbol{x}_0,\ \ \boldsymbol{y}(t) = \boldsymbol{C}\boldsymbol{x}(t) \end{array} \right\}$ の解法ルーチン

```
3110 FOR I=1 TO N
3120     FOR J=1 TO N
3130         H(I,J)= TT*A(I,J)
3140 NEXT J,I
3150 '
3160 '-- I-(TAU/2)*A ---------------------------
3170 FOR I=1 TO N
3180     H(I,I)=1+H(I,I)
3190 NEXT I
3200 '
3210 '-- Inverse of [I-(TAU/2)*A] --------------
3220 GOSUB 4000                    ' Invers H Matrix
3230 '
3240 '-- TAU*[I-(TAU/2)*A]^(-1) ----------------
3250 FOR I=1 TO N
3260     FOR J=1 TO N
3270         H(I,J)=TAU*H(I,J)
3280 NEXT J,I
3290 '
3300 '-- A*TAU*[I-(TAU/2)*A]^(-1) --------------
3310 FOR I=1 TO N
3320     FOR J=1 TO N
3330         P(I,J)=0
3340         FOR K=1 TO N
3350             P(I,J)=P(I,J)+A(I,K)*H(K,J)
3360 NEXT K,J,I
3370 '
3380 '-- I+A*[I-(TAU/2)*A]^(-1) ----------------
3390 FOR I=1 TO N
3400     P(I,I)=1+P(I,I)
3410 NEXT I
3420 '
3430 '-- Q=TAU*[I-(TAU/2)*A]^(-1)*B -------------
3440 FOR I=1 TO N
3450     FOR J=1 TO M
3460         Q(I,J)=0
3470         FOR K=1 TO N
3480             Q(I,J)=Q(I,J)+H(I,K)*B(K,J)
3490 NEXT K,J,I
3500 '
3510 '-- CALCULATION OF SOLUTION ---------------
3520 '
3530 FOR I=1 TO L
3540     Y(I,1)=0
3550 NEXT I
3560 FOR II=2 TO LIMIT
3570     FOR I=1 TO N
3580         XX(I)=0
3590         FOR J=1 TO N
3600             XX(I)=XX(I)+P(I,J)*X(J)
3610     NEXT J,I
3620     FOR I=1 TO N
3630         SUM=0
3640         FOR J=1 TO M
3650             SUM=SUM+Q(I,J)*U(J,I)
3660         NEXT J
3670         X(I)=XX(I)+SUM
3680     NEXT I
3690     FOR I=1 TO L
3700         Y(I,II)=0
3710         FOR K=1 TO N
3720             Y(I,II)=C(I,K)*X(K)+Y(I,II)
3730 NEXT K,I,II
```

図 2.33(3)　BASICによる $\left\{\begin{array}{l}\dfrac{d\boldsymbol{x}(t)}{dt}=\boldsymbol{A}\boldsymbol{x}(t)+\boldsymbol{B}\boldsymbol{u}(t)\\ \boldsymbol{x}(0)=\boldsymbol{x}_0,\ \ \boldsymbol{y}(t)=\boldsymbol{C}\boldsymbol{x}(t)\end{array}\right\}$ の解法ルーチン

```
3740 RETURN
3750 '
3760 '
4000 REM ****************************************
4010 REM *  SUBROUTINE INVERS                     *
4020 REM *        Input :                         *
4030 REM *                H(N,N) Matrix           *
4040 REM *                N Size of Matrix        *
4050 REM *                                        *
4060 REM *        Output :                        *
4070 REM *                H(N,N) Inversed         *
4080 REM ****************************************
4090 '
4100 FOR I=1 TO N
4110     IF N=I THEN 4230
4120     W=ABS(H(I,I)): W1=I
4130     FOR K=I+1 TO N
4140         IF W>=ABS(H(K,I)) GOTO 4160
4150         W1=K: W=ABS(H(K,I))
4160     NEXT K
4170     IF W=0 THEN PRINT: PRINT "CAN'T BE DONE ": END
4180     IF W1=I THEN 4230
4190     FOR J=1 TO N
4200         SWAP H(I,J),H(W1,J)
4210     NEXT J
4220     PIVOT(1,I)=I: PIVOT(2,I)=W1
4230     W=H(I,I)
4240     FOR J=1 TO N
4250         H(I,J)=H(I,J)/W
4260     NEXT J
4270     H(I,I)=1/W
4280     FOR K=1 TO N
4290         IF K=I GOTO 4350
4300         W=H(K,I)
4310         FOR J=1 TO N
4320             H(K,J)=H(K,J)-W*H(I,J)
4330         NEXT J
4340         H(K,I)=-W*H(I,I)
4350     NEXT K
4360 NEXT I
4370 '
4380 FOR I=N TO 1 STEP -1
4390     IF PIVOT(1,I)=0 THEN 4430
4400     FOR J=1 TO N
4410         SWAP H(J,PIVOT(1,I)),H(J,PIVOT(2,I))
4420     NEXT J
4430 NEXT I
4440 RETURN
```

```
                Sampling Interval TAU= .05
 Magnitude of Step Control Input UMAG= 1
                          Parameter T1= .01
                          Parameter T2= .2

  A MATRIX
-1.0000E+02  0.0000E+00  0.0000E+00  1.9000E+03
 2.0000E+01 -4.0000E+00  0.0000E+00 -4.0000E+02
 0.0000E+00  4.8000E+01 -1.6000E+01  0.0000E+00
 0.0000E+00  0.0000E+00  1.0000E+00  0.0000E+00
```

図 2.33(4)　BASICによる $\left\{ \begin{array}{l} \dfrac{\mathrm{d}\boldsymbol{x}(t)}{\mathrm{d}t} = \boldsymbol{A}\boldsymbol{x}(t) + \boldsymbol{B}\boldsymbol{u}(t) \\ \boldsymbol{x}(0) = \boldsymbol{x}_0,\ \ \boldsymbol{y}(t) = \boldsymbol{C}\boldsymbol{x}(t) \end{array} \right\}$ の解法ルーチン

```
   B MATRIX
-1.9000E+03
 4.0000E+02
 0.0000E+00
 0.0000E+00

   C MATRIX
 0.0000E+00  0.0000E+00  0.0000E+00  1.0000E+00

OUTPUT NUMBER= 1
 0.00000        0.11785        0.44811        0.82948        1.10246
 1.23531        1.24345        1.17885        1.09139        1.01726
 0.97255        0.95759        0.96350        0.97902        0.99493
 1.00601        1.01083        1.01055        1.00742        1.00358
 1.00047        0.99870        0.99819        0.99853        0.99922
 0.99989        1.00033        1.00050        1.00046        1.00031
 1.00014        1.00001        0.99994        0.99993        0.99994
 0.99997        1.00000        1.00002        1.00002        1.00002
 1.00001        1.00001        1.00000        1.00000        1.00000
 1.00000        1.00000        1.00000        1.00000        1.00000
```

図 2.33(5)　BASICによる $\left\{ \begin{array}{l} \dfrac{\mathrm{d}\boldsymbol{x}(t)}{\mathrm{d}t} = \boldsymbol{A}\boldsymbol{x}(t) + \boldsymbol{B}\boldsymbol{u}(t) \\ \boldsymbol{x}(0) = \boldsymbol{x}_0,\ \ \boldsymbol{y}(t) = \boldsymbol{C}\boldsymbol{x}(t) \end{array} \right\}$ の解法ルーチン