CNTL - A FORTRAN PACKAGE FOR PROCESSING CONTINGENCY SOLUTIONS OF POWER SYSTEMS

J.W. Bandler, M.A. El-Kady and G. Centkowski

SOS-83-26-L

October 1983

CNTL - A FORTRAN PACKAGE FOR PROCESSING CONTINGENCY SOLUTIONS OF POWER SYSTEMS

J.W. Bandler, M.A. El-Kady and G. Centkowski

Abstract

This document contains a listing of the package CNTL described in [1]. CNTL is a package of subroutines designed for analyzing pre-contingency and post-contingency states of a power system, i.e., power flow in lines, bus voltages at the solution and losses in the lines. The subroutines for reading and preprocessing data containing load flow solutions of a power system under different contingencies are included in the package. The package CNTL has been developed for the CDC 170/730 system with NOS 1.4 level 552 operating system and the Fortran Extended (FTN) version 4.8 compiler. The listing contains 245 lines, of which 106 are comments.

This work was supported by the Natural Sciences and Engineering Research Council of Canada under Grants A7239, A1708 and G0647.

The authors are with the Simulation Optimization Systems Research Laboratory and the Department of Electrical and Computer Engineering, McMaster University, Hamilton, Canada L8S 4L7.

M.A. El-Kady is also with Ontario Hydro, Toronto, Canada.

G. Centkowski is on leave from the Institute of Electronics Fundamentals, Technical University of Warsaw, Warsaw, Poland.

I. INTRODUCTION

CNTL [1] is a package of three Fortran subroutines for comparing pre-contingency and post-contingency states of a power system, i.e., power flow in lines, bus voltages at the solution [2] and losses in the lines. The subroutines for reading and preprocessing data containing load flow solutions of a power system under different contingencies are included in the package.

The package CNTL and its documentation have been developed for the CDC 170/730 system with the NOS 1.4 level 552 operating system [3]. At McMaster University it is available in the form of a library of binary relocatable subroutines. The library is available as a group indirect file LIBCNTL under the charge RJWBAND.

The CNTL package contains 245 lines, of which 106 are comments.

II. REFERENCES

[1] J.W. Bandler, M.A. El-Kady and G. Centkowski, "CNTL - A Fortran package for processing contingency solutions of power systems", Department of Electrical and Computer Engineering, McMaster University, Hamilton, Canada, Report SOS-83-26-U, 1983.

[2] J.W. Bandler, M.A. El-Kady and G. Centkowski, "Load flow solutions of test power systems under contingency: formatted data files", Department of Electrical and Computer Engineering, McMaster University, Hamilton, Canada, Report SOS-83-25-D, 1983.

[3] "Fortran extended version 4, reference manual", Control Data Cyber 170 series, 1974.

III. LISTING OF THE CNTL PACKAGE

Subroutine	Number of lines (source text)	Number of words (compiled code)	Description (page of [1])	Listing (page)
CONTI	148	641	4	4
CORDAT	54	117	6	7
COFDAT	43	113	7	8

```
                                                                        A    1
 SUBROUTINE CONTI (LBINP,LBOUT,LINPG,LINPB,LG,LB,LOUTG,LOUTB,LTAP,V     A    2
1,VCB,NB,NTL,NLIN,OTPT)                                                 A    3
                                                                        A    4
   SUBROUTINE CONTI CALCULATES AND COMPARES POWER FLOW IN               A    5
   TRANSMISSION LINES BEFORE AND AFTER A CONTINGENCY                    A    6
                                                                        A    7
   LBINP,LBOUT     VECTORS OF LENGTH NTL. LBINP(K),LBOUT(K) CONTAIN     A    8
                   INDICES OF BUSES INCIDENT WITH THE KTH               A    9
                   TRANSMISSION LINE                                    A   10
   LINPG,LINPB     VECTORS OF LENGTH NTL. LINPG(K),LINPB(K) CONTAIN     A   11
                   THE INPUT SHUNT CONDUCTANCE AND SUSCEPTANCE OF       A   12
                   THE KTH TRANSMISSION LINE                            A   13
   LG,LB           VECTORS OF LENGTH NTL. LG(K),LB(K) CONTAIN THE       A   14
                   CONDUCTANCE AND SUSCEPTANCE OF THE KTH               A   15
                   TRANSMISSION LINE                                    A   16
   LOUTG,LOUTB     VECTORS OF LENGTH NTL. LOUTG(K),LOUTB(K) CONTAIN     A   17
                   THE OUTPUT SHUNT CONDUCTANCE AND SUSCEPTANCE OF      A   18
                   THE KTH TRANSMISSION LINE                            A   19
   LTAP            VECTOR OF LENGTH NTL. LTAP(K) CONTAINS THE KTH       A   20
                   LINE TRANSFORMER RATIO                               A   21
   V               COMPLEX VECTOR OF LENGTH NB. IT CONTAINS THE         A   22
                   VALUES OF THE BUS VOLTAGES (IN RECTANGULAR           A   23
                   COORDINATES) OF THE POWER SYSTEM                     A   24
   NB              NUMBER OF BUSES OF THE POWER SYSTEM                  A   25
   VCB             COMPLEX VECTOR OF LENGTH NB. IT CONTAINS THE         A   26
                   VALUES OF THE BUS VOLTAGES (IN RECTANGULAR           A   27
                   COORDINATES) OF THE POWER SYSTEM UNDER A             A   28
                   CONTINGENCY                                          A   29
   NTL             NUMBER OF TRANSMISSION LINES                         A   30
   NLIN            INDEX OF A LINE WHICH IS REMOVED                     A   31
   OTPT            INDEX OF THE OUTPUT UNIT                             A   32
                                                                        A   33
 INTEGER LBINP(1),LBOUT(1),OTPT                                         A   34
 REAL LINPG(1),LINPB(1),LG(1),LB(1),LOUTG(1),LOUTB(1),LTAP(1)           A   35
 COMPLEX V(1),VCB(1),YA(2,2),C,C1,C2,PPREC1,PPREC2,PAFTC1,PAFTC2,Y,     A   36
1Y1,Y2                                                                  A   37
                                                                        A   38
 K1=LBINP(NLIN)                                                         A   39
 K2=LBOUT(NLIN)                                                         A   40
 WRITE (OTPT,120) NB                                                    A   41
 WRITE (OTPT,50) NLIN,K1,K2                                             A   42
 WRITE (OTPT,40)                                                        A   43
 WRITE (OTPT,70)                                                        A   44
 WRITE (OTPT,60)                                                        A   45
 WRITE (OTPT,80)                                                        A   46
                                                                        A   47
   COMPUTE AND COMPARE THE POWER FLOW IN LINES                          A   48
                                                                        A   49
 DO 20 I=1,NTL                                                          A   50
                                                                        A   51
   COMPUTE THE ADMITTANCE MATRIX OF THE ITH LINE MODEL                  A   52
                                                                        A   53
 K1=LBINP(I)                                                            A   54
 K2=LBOUT(I)                                                            A   55
 Y=CMPLX(LG(I),LB(I))                                                   A   56
 Y1=CMPLX(LINPG(I),LINPB(I))                                            A   57
 Y2=CMPLX(LOUTG(I),LOUTB(I))                                            A   58
 YA(1,1)=Y/(LTAP(I)**2)+Y1                                              A   59
 YA(1,2)=-Y/LTAP(I)                                                     A   60
 YA(2,1)=-Y/LTAP(I)                                                     A   61
 YA(2,2)=Y+Y2                                                           A   62
                                                                        A   63
   COMPUTE THE CURRENT FLOWING IN THE ITH LINE (FOR THE POST            A   64
   CONTINGENCY STATE)                                                   A   65
```

```
      C1=YA(1,1)*VCB(K1)+YA(1,2)*VCB(K2)                                A  66
      C2=YA(2,1)*VCB(K1)+YA(2,2)*VCB(K2)                                A  67
                                                                        A  68
        COMPUTE THE POWER INJECTED IN THE ITH LINE (FOR THE POST        A  69
        CONTINGENCY STATE)                                              A  70
                                                                        A  71
      PPREC1=VCB(K1)*CONJG(C1)                                          A  72
      PPREC2=VCB(K2)*CONJG(C2)                                          A  73
      PRC1=REAL(PPREC1)                                                 A  74
      PIC1=AIMAG(PPREC1)                                                A  75
      PRC2=REAL(PPREC2)                                                 A  76
      PIC2=AIMAG(PPREC2)                                                A  77
      PLOS1=PRC1+PRC2                                                   A  78
      IF (NLIN.EQ.I) GO TO 10                                           A  79
                                                                        A  80
        COMPUTE THE CURRENT FLOWING IN THE ITH LINE (FOR THE BASE CASE) A  81
                                                                        A  82
      C1=YA(1,1)*V(K1)+YA(1,2)*V(K2)                                    A  83
      C2=YA(2,1)*V(K1)+YA(2,2)*V(K2)                                    A  84
                                                                        A  85
         COMPUTE THE POWER INJECTED IN THE ITH LINE (FOR THE BASE CASE) A  86
                                                                        A  87
      PAFTC1=V(K1)*CONJG(C1)                                            A  88
      PAFTC2=V(K2)*CONJG(C2)                                            A  89
      PRAC1=REAL(PAFTC1)                                                A  90
      PIAC1=AIMAG(PAFTC1)                                               A  91
      PRAC2=REAL(PAFTC2)                                                A  92
      PIAC2=AIMAG(PAFTC2)                                               A  93
      PLOS2=PRAC1+PRAC2                                                 A  94
                                                                        A  95
        COMPARE THE POWER FLOW IN THE ITH LINE                          A  96
                                                                        A  97
      XPRC1=PRC1                                                        A  98
      XPRAC1=PRAC1                                                      A  99
      IF (XPRC1.LT.0.0) XPRC1=-XPRC1+PLOS1                              A 100
      IF (XPRAC1.LT.0.0) XPRAC1=-XPRAC1+PLOS2                           A 101
      X1=-XPRC1+XPRAC1                                                  A 102
      X3=(100.0*X1)/XPRC1                                               A 103
      WRITE (OTPT,90) I,K1,K2,PRC1,PIC1,PRAC1,PIAC1,X1,X3,PLOS1,PLOS2   A 104
      GO TO 20                                                          A 105
   10 CONTINUE                                                          A 106
      WRITE (OTPT,100) I,K1,K2,PRC1,PIC1,PLOS1                          A 107
   20 CONTINUE                                                          A 108
                                                                        A 109
        COMPUTE AND COMPARE THE CHANGES OF THE BUS VOLTAGE DUE TO A     A 110
        LINE OUTAGE                                                     A 111
                                                                        A 112
      K1=LBINP(NLIN)                                                    A 113
      K2=LBOUT(NLIN)                                                    A 114
      WRITE (OTPT,110)                                                  A 115
      WRITE (OTPT,50) NLIN,K1,K2                                        A 116
      WRITE (OTPT,150)                                                  A 117
      WRITE (OTPT,140)                                                  A 118
      DO 30 I=1,NB                                                      A 119
      X1=AIMAG(VCB(I))/REAL(VCB(I))                                     A 120
      X2=AIMAG(V(I))/REAL(V(I))                                         A 121
      X3=-ATAN(X1)+ATAN(X2)                                             A 122
      X4=CABS(-VCB(I)+V(I))                                             A 123
      X5=-CABS(VCB(I))+CABS(V(I))                                       A 124
      WRITE (OTPT,130) I,X4,X5,X1,X2,X3                                 A 125
   30 CONTINUE                                                          A 126
      RETURN                                                            A 127
   40 FORMAT (2X,"P - REAL POWER  ;  Q - REACTIVE POWER  ")             A 128
   50 FORMAT (/,2X,"INDEX OF THE LINE REMOVED: ",I3,2X,"TERMINAL BUSES:" A 129
                                                                        A 130
```

```
     1,2I4)                                                                    A 131
  60 FORMAT (2X,"LINE",15X,"     BASE  CASE ",5X,"  CONTINGENCY  "," DEV      A 132
     1IATION","  RELATIVE DEVIA.",2X,"BASE CASE",3X,"CONTINGENCY")            A 133
  70 FORMAT (//,34X,"LINE  FLOWS",46X,"LINE LOSSES")                          A 134
  80 FORMAT (4X,"NO",2X,"FROM",4X,"TO",6X," P",7X," Q  ",6X,"P ",5X,"        A 135
     1Q",7X," DP   ",3X," DP/P (IN %)"/)                                      A 136
  90 FORMAT (2X,3(I4,2X),4(F7.4,2X),F7.3,7X,F7.2,11X,F6.4,3X,F6.4)            A 137
 100 FORMAT (2X,3(I4,2X),2(F7.4,2X),50X,F6.4)                                 A 138
 110 FORMAT ("1",1X,"CHANGES OF THE BUS VOLTAGES DUE TO THE LINE OUTAGE       A 139
     1 ")                                                                     A 140
 120 FORMAT ("1",1X,"CONTINGENCY ANALYSIS OF THE",I3,"-BUS POWER SYSTEM       A 141
     1 ")                                                                     A 142
 130 FORMAT (3X,I4,3X,5(F8.4,8X))                                             A 143
 140 FORMAT (4X,"BUS",3X,"MOD(VA-VB)",4X,"MOD(VA)-MOD(VB)",4X,"VB ANGLE       A 144
     1",8X,"VA ANGLE",4X,"ANGLE DEVIATION"/)                                  A 145
 150 FORMAT (2X,"VB-BUS VOLTAGE FOR A PRE-CONTINGENCY STATE ",/,2X,"VA-       A 146
     1BUS VOLTAGE FOR A POST-CONTINGENCY STATE",/)                            A 147
      END                                                                     A 148-
```

```
C                                                                       B    1
      SUBROUTINE CORDAT (NB,NLIN,V,INPT,NS,IFLAG)                       B    2
C                                                                       B    3
C       THIS SUBROUTINE SELECTS FROM THE INPT FILE THE LOAD FLOW        B    4
C       SOLUTION OF THE POWER SYSTEM WITH THE NLINTH LINE REMOVED       B    5
C                                                                       B    6
C       NB        NUMBER OF BUSES                                       B    7
C       NLIN      INDEX OF THE LINE REMOVED FROM THE POWER SYSTEM       B    8
C       V         COMPLEX VECTOR OF DIMENSION NB. IT STORES THE         B    9
C                 SOLUTION SELECTED                                     B   10
C       INPT      INDEX OF THE INPUT UNIT                               B   11
C       NS        NUMBER OF THE LOAD FLOW SOLUTIONS ON THE INPUT FILE   B   12
C       IFLAG     RETURN FLAG FROM SUBROUTINE                           B   13
C                                                                       B   14
      REAL RB(5)                                                        B   15
      COMPLEX V(1)                                                      B   16
C                                                                       B   17
      DATA RB/"  BNR","BVREAL","BVIMAG","BVMOD","BVARG"/                B   18
C                                                                       B   19
      IT=0                                                              B   20
      IFLAG=0                                                           B   21
   10 CONTINUE                                                          B   22
      IT=IT+1                                                           B   23
      IF (IT.GT.NS) GO TO 40                                            B   24
C                                                                       B   25
C       READ THE HEADER                                                 B   26
C                                                                       B   27
      READ (INPT,50) A,NB,NLINR                                         B   28
      READ (INPT,60) (RB(I),I=1,5)                                      B   29
      DO 30 I=1,NB                                                      B   30
C                                                                       B   31
C       READ THE BUS VOLTAGE                                            B   32
C                                                                       B   33
      IF (NLINR.NE.NLIN) GO TO 20                                       B   34
      READ (INPT,70) K,C1,C2,BVMOD,BVARG                                B   35
      V(K)=CMPLX(C1,C2)                                                 B   36
      GO TO 30                                                          B   37
   20 CONTINUE                                                          B   38
      READ (INPT,70)                                                    B   39
   30 CONTINUE                                                          B   40
C                                                                       B   41
C       READ THE END OF THE SUBFILE                                     B   42
C                                                                       B   43
      READ (INPT,80) A,NB,NLINR                                         B   44
      IF (NLIN.NE.NLINR) GO TO 10                                       B   45
      RETURN                                                            B   46
   40 CONTINUE                                                          B   47
      IFLAG=-1                                                          B   48
      RETURN                                                            B   49
   50 FORMAT (/1X,A2,2I3.3/)                                            B   50
   60 FORMAT (1X,A5,2(7X,A6),2(7X,A5,1X))                               B   51
   70 FORMAT (1X,I5,2X,4(2X,E11.5))                                     B   52
   80 FORMAT (1X,A3,2I3.3)                                              B   53
      END                                                               B   54-
```

```
C                                                                       C   1
      SUBROUTINE COFDAT (NB,NLIN,V,OTPT)                                C   2
C                                                                       C   3
C       THIS SUBROUTINE CREATES A SUBFILE CONTAINING THE LOAD FLOW      C   4
C       SOLUTION OF THE POWER SYSTEM WITH THE NLINTH LINE REMOVED       C   5
C                                                                       C   6
C       NB        NUMBER OF BUSES                                       C   7
C       NLIN      THE INDEX OF THE LINE REMOVED FROM THE POWER SYSTEM   C   8
C       V         COMPLEX VECTOR OF DIMENSION NB. IT CONTAINS THE       C   9
C                 LOAD FLOW SOLUTION OF THE SYSTEM WITH THE NLINTH LINE C  10
C                 REMOVED                                               C  11
C       OTPT      INDEX OF THE OUTPUT UNIT                              C  12
C                                                                       C  13
      INTEGER OTPT                                                      C  14
      REAL RB(5)                                                        C  15
      COMPLEX V(1),C                                                    C  16
C                                                                       C  17
      DATA RB/"  BNR","BVREAL","BVIMAG","BVMOD","BVARG"/                C  18
C                                                                       C  19
C       PRINT OUT THE HEADER                                            C  20
C                                                                       C  21
      WRITE (OTPT,20) NB,NLIN                                           C  22
      WRITE (OTPT,30) (RB(I),I=1,5)                                     C  23
      DO 10 I=1,NB                                                      C  24
C                                                                       C  25
C       PRINT OUT THE BUS VOLTAGE                                       C  26
C                                                                       C  27
      BVMOD=CABS(V(I))                                                  C  28
      C=V(I)                                                            C  29
      BVARG=ATAN(AIMAG(C)/REAL(C))                                      C  30
      WRITE (OTPT,40) I,C,BVMOD,BVARG                                   C  31
   10 CONTINUE                                                          C  32
C                                                                       C  33
C       PRINT OUT THE END OF THE SUBFILE                                C  34
C                                                                       C  35
      WRITE (OTPT,50) NB,NLIN                                           C  36
C                                                                       C  37
   20 FORMAT (/1X,"CL",2I3.3/)                                          C  38
   30 FORMAT (1X,A5,2(7X,A6),2(7X,A5,1X))                               C  39
   40 FORMAT (1X,I5,2X,4(2X,E11.5))                                     C  40
   50 FORMAT (1X,"END",2I3.3)                                           C  41
      RETURN                                                            C  42
      END                                                               C  43-
```