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APPENDIX

APPENDIX 1

SOURCE PROGRAM LISTING

```
      PROGRAM DYNAMIC EQUIVALENT
      INTEGER INDEX(250),GROUP(250),BUSP(270),BUSQ(270)
     *,TYPE(250)
     *,TRAN,SHUNT,BUSX(250),BUS,LINE,BUSTP(250),BUSTQ(250),
        * DAT
     *,NOL(270),NOT(250),STASH(250),STABUS(250),ANS(10)
      COMPLEX Z(270),Y(270),YCHAR(270),E(250),ZZ,SHUN(250),
     *,GEN(250),LOAD(250),TAPP(250),XDD(50),SUS(250),ZT(250
        * )
     *,TPQ(250),TQP(250),LOADD(250),IL(250),SHUU(250)
      REAL EE(250),EQ(250),UT1(250),UT2(250),SNT(250),SNG(5
        * 0)
     *,TAP(250)
     *,UB(250),FI(250),UBUS(250),FF,MVA
      CHARACTER*10 BUSNAME(250),NAMELP(270),NAMELQ(270)
     *,NAMETP(250),NAMETQ(250),NAMEX(250),JOB*10
      COMMON /LINEE/BUSP,BUSQ,Z,YCHAR,LINE,NOL,NL,LPQ,LQP
      COMMON /TRAN/BUSTP,BUSTQ,TRAN,TAP,SNT,UT1,UT2,ZT,FI,N
        * OT,NT
      COMMON /NODE/BUS,LOAD,LOADD,SHUN,E,EE,EQ,GEN,UBUS,NB
     *            ,STASH,IL,SHUU,STABUS
      COMMON /GEN/SNG,GBUS,XDD,H
      COMMON /GENERAL/MVA
      COMMON /COHER/INDEX,GROUP,TYPE,COGROUP
      COMMON /NAME/BUSNAME,NAMELP,NAMELQ,NAMETP,NAMETQ,NAME
        * X
      COMMON /JOBNAME/JOB,ANS
C
C
      WRITE(*,3)
    3 FORMAT(/////////////////////)
      PRINT *,'*********************************************'
      PRINT *,'*                                           *'
      PRINT *,'*     THIS  PROGRAM IS USED FOR DERIVING    *'
      PRINT *,'*  THE DYNAMIC  EQUIVALENT  FOR TRANSIENT   *'
      PRINT *,'*  STABILITY STUDIES OF POWER SYSTEM.       *'
      PRINT *,'*                                           *'
      PRINT *,'*              DEVELOPED   BY.              *'
      PRINT *,'*                                           *'
      PRINT *,'*  MR. TRAKAN DANKUL C015811 FACULTY  OF    *'
      PRINT *,'*  ELECTRICAL ENGINEERING  DEPARTMENT OF    *'
      PRINT *,'*  ENGINEERING CHULALONGKORN UNIVERSITY.    *'
      PRINT *,'*                                           *'
      PRINT *,'*          THE  THESIS IS  ADVISED   BY     *'
      PRINT *,'*  PROF. TORSTEN JOHANSSON  WHO IS  THE     *'
      PRINT *,'*  VISITING PROFESSOR FROM SWEDEN.          *'
      PRINT *,'*                                           *'
      PRINT *,'*     CO-ADVISED BY ASSOC.PROF.             *'
      PRINT *,'*  DR.SUKHUMVIT  PHOOMVUTHISARN             *'
      PRINT *,'*                                           *'
      PRINT *,'*********************************************'
      CALL DYNAMIC_AGGREGATION(GROUP,BUS,COGROUP,BUSNAME,ST
        * ABUS,LOAD)
      CALL NWTWORKL_REDUCTION
      CALL DATA_OUTPUT
      END
```

```
      SUBROUTINE DYNAMIC_AGGREGATION(GROUP,BUS,COGROUP
     *,BUSNAME,STABUS,LOAD)
      INTEGER GROUP(250),TURB(70),DTAB(70),VREG(70),TUR
     *  ,GO
     *,BUS,COGROUP,GROUPGEN(70),GOV(70),STABUS(250),ANS
     *  (10)
      COMPLEX LOAD(250)
      REAL SNG(70),UNG(70),HG(70),XD(70),XDP(70),XQ(70)
     *  ,XQP(70),D(70)
     *,TDOP(70),TQOP(70),RA(70),XA(70),SNGT,XDB(70),XQB
     *  (70),UEMIN(70)
     *,TDOB(70),TQOB(70),K(70),T1(70),T2(70),T3(70),T4(
     *  70),UEMAX(70)
     *,KH(70),KD(70),TR(70),TC(70),TW(70),KK(70),TT1(70
     *  ),TT2(70),TY(70),
     *YPMIN(70),YPMAX(70),BP(70),BT(70),TT(70),TS(70),T
     *  D(70),S10(70),
     *X10(70),S12(70),X12(70),S00(70),X00(70),S05(70),X
     *  05(70)
      CHARACTER DOC*12,DCC*30,TYPEG(70)*5,TYPEV(70)*5,T
     *  YPET(70)*5,
     *NAMEG(70)*10,NAMEV(70)*10,EQUI*15,BUSNAME(70)*10,
     *  BUSG(70)*10,
     *NAMET(70)*10,NAMEGO(70)*10,TYPEGO(70)*5,A(70)*80,
     *  JOB*10
     *,NAMED(70)*10,TYPED(70)*5
      COMMON /JOBNAME/JOB,ANS
C
      DOC ='EQGEN'
      TTT = 0
      TG = 0
      NG = 0
      DCC = JOB//'.DYNPOW'
      OPEN(UNIT=2,FILE=DCC,STATUS = 'OLD')
      DO 50 I = 1 , 50
      READ(2,55)A(I)
      TTT = TTT + 1
      IF (A(I).EQ. 'SYNCHRONOUS MACHINES') GO TO 18
50    CONTINUE
C
C
C     ****************************************
C     *                                      *
C     *    READ DATA OF SYNCHRONUS MACHINES  *
C     *                                      *
C     ****************************************
C
18    DO 60 I = 1 , 100
      READ(2,65)NAMEG(I),BUSG(I),TYPEG(I)
      IF (NAMEG(I).EQ.'END') GOTO 19
      NG = NG + 1
      READ(2,70)SNG(I),UNG(I),HG(I),D(I),VREG(I),TURB(I
     *  )
      IF (TYPEG(I).EQ.'4') THEN
      READ(2,75)XD(I),XDP(I),XQ(I)
      ELSE
      IF (TYPEG(I).EQ.'3A') THEN
```

```
      READ(2,85)XD(I),XDP(I),XQ(I),RA(I),XA(I),TDOP(I)
      ELSE
      IF (TYPEG(I).EQ.'2A') THEN
      READ(2,86)XD(I),XDP(I),XDB(I),XQ(I),XQB(I),RA(I),
     * XA(I)
     *,TDOP(I),TDOB(I),TQOB(I)
      ELSE
      IF (TYPEG(I).EQ.'1A') THEN
      READ(2,87)XD(I),XDP(I),XDB(I),XQ(I),XQP(I),XQB(I)
     * ,RA(I),XA(I)
     *,TDOP(I),TDOB(I),TQOP(I),TQOB(I)
      ELSE
      IF (TYPEG(I).EQ.'1') THEN
      TG = 1
      READ(2,387)XD(I),XDP(I),XDB(I),XQ(I),XQP(I),XQB(I
     * ),RA(I),XA(I)
     *,DTAB(I),TDOP(I),TDOB(I),TQOP(I),TQOB(I)
      ELSE
      IF (TYPEG(I).EQ.'2') THEN
      TG = 1
      READ(2,386)XD(I),XDP(I),XDB(I),XQ(I),XQB(I),RA(I)
     * ,XA(I)
     *,DTAB(I),TDOP(I),TDOB(I),TQOB(I)
      ELSE
      READ(2,385)XD(I),XDP(I),XQ(I),RA(I),XA(I),DTAB(I)
     * ,TDOP(I)
      ENDIF
      ENDIF
      ENDIF
      ENDIF
      ENDIF
      ENDIF
60    CONTINUE
19    NOV = 0
      TUR = 0
C
C     ****************************************
C     *                                      *
C     *         VOLTAGE REGULATOR            *
C     *                                      *
C     ****************************************
C
      DO 80 I = 1 , NG
      IF ( VREG(I) .NE. 0 ) THEN
        NOV = NOV + 1
      ENDIF
80    CONTINUE
C
C     ****************************************
C     *                                      *
C     *       GOVERNOR TURBINE               *
C     *                                      *
C     ****************************************
C
       NOV = 0
       TUR = 0
       GO  = 0
```

```
C
C     ****************************************
C     *                                      *
C     *    READ DATA OF VOLTAGE REGULATOR    *
C     *                                      *
C     ****************************************
C
      READ(2,100)DCC
      DO 110 I = 1 , 10
      READ(2,105)NAMEV(I),TYPEV(I)
      IF (NAMEV(I).EQ.'END') GO TO 1000
      READ(2,115)K(I),T1(I),T2(I),T3(I),T4(I)
     *,UEMIN(I),UEMAX(I)
      NOV = NOV + 1
110   CONTINUE
1000  READ(2,100)DCC
      DO 1110 I = 1 , 10
      READ(2,105)NAMET(I),TYPET(I)
      IF (NAMET(I).EQ.'END') GO TO 2000
      TUR = TUR + 1
      IF (TYPET(I).EQ.'ST1') THEN
      READ(2,1115)TR(I),KH(I),TC(I),GOV(I)
      ELSE
      READ(2,1116)TW(I),KD(I),GOV(I)
      ENDIF
1110  CONTINUE
2000  READ(2,100)DCC
      DO 2110 I = 1 , 10
      READ(2,105)NAMEGO(I),TYPEGO(I)
      IF (NAMEGO(I).EQ.'END') GO TO 3001
      GO = GO + 1
      IF (TYPEGO(I).EQ.'SG2') THEN
      READ(2,2115)KK(I),TT1(I),TT2(I),TY(I),YPMAX(I),YP
     * MIN(I)
      ELSE
      READ(2,2116)BP(I),BT(I),TT(I),TS(I),TD(I),YPMAX(I
     * ),YPMIN(I)
      ENDIF
2110  CONTINUE
3001  IF( TG .NE. 0 ) THEN
      READ(2,100)DCC
      DO 6000 I = 1 , 20
      READ(2,105)NAMED(I),TYPED(I)
      IF (NAMED(I).EQ.'END') GO TO 8001
      DT = DT + 1
      READ(2,6010)S05(I),X05(I),
     *S10(I),X10(I),S12(I),X12(I)
6010  FORMAT(/,8X,F4.2,2X,F4.2,
     */,8X,F4.2,2X,F4.2,/,8X,F4.2,2X,F4.2)
6000  CONTINUE
      ENDIF
8001  CLOSE(2)
      DO 610 I = 1 , NG
      DO 600 J = 1 , BUS
      IF ( BUSNAME(J).EQ. BUSG(I) ) THEN
      GROUPGEN(I) = GROUP(J)
      GO TO 610
```

```
      ENDIF
600   CONTINUE
610   CONTINUE
      DO 4000 II = 1 , COGROUP
      IF (ANS(II).NE. 1 ) THEN
      IF ( II .LE. 9 ) THEN
      DCC = CHAR(48+II)
      ELSE
      DCC = CHAR(59-II)//CHAR(58-II)
      ENDIF
      NG = NG + 1
      BUSG(NG) = 'BUSEQ'//DCC
      NAMEG(NG) = 'GEQ'//DCC
      HG(NG) = 0.0
      D(NG) = 0.0
      UNG(NG) = 0.0
      TDOP(NG) = 0.0
      TQOP(NG)= 0.0
      TDOB(NG) = 0.0
      TQOB(NG)= 0.0
      XD(NG) = 0.00
      XQ(NG) = 0.00
      XDP(NG) = 0.00
      XDB(NG) = 0.00
      XQP(NG) = 0.00
      XQB(NG) = 0.00
      RA(NG) = 0.00
      XA(NG) = 0.00
      N = 0
      SNGT = 0.0
      DO 25 I = 1 , NG-1
      IF (GROUPGEN(I).NE. II ) GO TO 25
4005  FORMAT(1X,A10)
      NAMEG(I) = 'DEL'
      N        = N+1
      SNGT     = SNGT + SNG(I)
      UNG(NG)  = UNG(NG) + UNG(I)
      HG(NG)   = HG(NG)  + SNG(I)*HG(I)
      D(NG)    = D(NG)   + SNG(I)*D(I)
      XD(NG)   = XD(NG)  + SNG(I)/(XD(I)*UNG(I)*UNG(I))
      XDP(NG)  = XDP(NG) + SNG(I)/(XDP(I)*UNG(I)*UNG(I)
     * )
      XDB(NG)  = XDB(NG) + SNG(I)/(XDB(I)*UNG(I)*UNG(I)
     * )
      XQ(NG)   = XQ(NG)  + SNG(I)/(XQ(I)*UNG(I)*UNG(I))
      XQB(NG)  = XQB(NG) + SNG(I)/(XQB(I)*UNG(I)*UNG(I)
     * )
      TDOP(NG) = TDOP(NG)+ SNG(I)*TDOP(I)
      TDOB(NG) = TDOB(NG)+ SNG(I)*TDOB(I)
      TQOB(NG) = TQOB(NG)+ SNG(I)*TQOB(I)
      VREG(NG) = VREG(I)
      TURB(NG) = TURB(I)
      DTAB(NG) = DTAB(I)
      XA(NG)   = XA(NG) + SNG(I)/(XA(I)*UNG(I)*UNG(I))
      TYPEG(NG)= TYPEG(I)
      IF ((TYPEG(I).EQ.'1').OR.(TYPEG(I).EQ.'1A')) THEN
      TQOP(NG) = TQOP(NG) + SNG(I)*TQOP(I)
```

```
      XQP(NG)   = XQP(NG)   + SNG(I)/(XQP(I)*UNG(I)*UNG(I
     * ))
      ENDIF
25    CONTINUE
      UNG(NG)   = UNG(NG)/N
      HG(NG)    = HG(NG)/SNGT
      D(NG)     = D(NG)/SNGT
      XD(NG)    = SNGT/(XD(NG)*UNG(NG)*UNG(NG))
      XDP(NG)   = SNGT/(XDP(NG)*UNG(NG)*UNG(NG))
      XDB(NG)   = SNGT/(XDB(NG)*UNG(NG)*UNG(NG))
      XQ(NG)    = SNGT/(XQ(NG)*UNG(NG)*UNG(NG))
      XQB(NG)   = SNGT/(XQB(NG)*UNG(NG)*UNG(NG))
      TDOP(NG)  = TDOP(NG)/SNGT
      TDOB(NG)  = TDOB(NG)/SNGT
      TQOB(NG)  = TQOB(NG)/SNGT
      XA(NG)    = SNGT/(XA(NG)*UNG(NG)*UNG(NG))
      SNG(NG)   = SNGT
      GROUPGEN(NG) = II
      TYPEG(NG)= TYPEG(I)
      IF ((TYPEG(I).EQ.'1').OR.(TYPEG(I).EQ.'1A')) THEN
      TQOP(NG)  = TQOP(NG)/SNGT
      XQP(NG)   = SNGT/(XQP(NG)*UNG(NG)*UNG(NG))
      ENDIF
      ENDIF
4000  CONTINUE
      DCC = JOB//'EQ.DYNPOW'
      OPEN(UNIT=1,FILE=DCC,STATUS='NEW')
      WRITE(1,7000)
      DO 300 I = 1 , TTT
      WRITE(1,55)A(I)
300   CONTINUE
      WRITE(1,1102)
      DO 1111 I = 1 , BUS
      IF ((STABUS(I).EQ.1).AND.(CABS(LOAD(I)) .GT. 0.01
     *  )) THEN
      WRITE(1,1101)BUSNAME
      ENDIF
1111  CONTINUE
      WRITE(1,255)
      DO 200 I = 1 , NG
      IF (NAMEG(I).NE.'DEL' ) THEN
      WRITE(1,165)NAMEG(I),BUSG(I),TYPEG(I)
      WRITE(1,170)SNG(I),UNG(I),HG(I),D(I),VREG(I),TURB
     * (I)
      IF (TYPEG(I).EQ.'4') THEN
      WRITE(1,175)XD(I),XDP(I),XQ(I)
      ELSE
      IF (TYPEG(I).EQ.'3A') THEN
      WRITE(1,186)XD(I),XDP(I),XQ(I),RA(I),XA(I),TDOP(I
     * )
      ELSE
      IF (TYPEG(I).EQ.'2A') THEN
      WRITE(1,285)XD(I),XDP(I),XDB(I),XQ(I),XQB(I),RA(I
     * ),XA(I)
     *,TDOP(I),TDOB(I),TQOB(I)
      ELSE
      IF (TYPEG(I).EQ.'1A') THEN
      WRITE(1,286)XD(I),XDP(I),XDB(I),XQ(I),XQP(I),XQB(
```

```
     * I),RA(I),XA(I)
     *,TDOP(I),TDOB(I),TQOP(I),TQOB(I)
      ELSE
      IF (TYPEG(I).EQ.'1') THEN
      WRITE(1,586)XD(I),XDP(I),XDB(I),XQ(I),XQP(I),XQB(
     * I),RA(I),XA(I)
     *,DTAB(I),TDOP(I),TDOB(I),TQOP(I),TQOB(I)
      ELSE
      IF (TYPEG(I).EQ.'2') THEN
      WRITE(1,485)XD(I),XDP(I),XDB(I),XQ(I),XQB(I),RA(I
     * ),XA(I)
     *,DTAB(I),TDOP(I),TDOB(I),TQOB(I)
      ELSE
      WRITE(1,486)XD(I),XDP(I),XQ(I),RA(I),XA(I),DTAB(I
     * ),TDOP(I)
      ENDIF
      ENDIF
      ENDIF
      ENDIF
      ENDIF
      ENDIF
      ENDIF
200   CONTINUE
      WRITE(1,255)
      WRITE(1,301)
      DO 295 I = 1 , NOV
      WRITE(1,305)NAMEV(I),TYPEV(I)
      WRITE(1,310)K(I),T1(I),T2(I),T3(I),T4(I),UEMIN(I)
     * ,UEMAX(I)
295   CONTINUE
      WRITE(1,255)
      WRITE(1,3000)
      DO 3110 I = 1 , TUR
      WRITE(1,305)NAMET(I),TYPET(I)
      IF (TYPET(I).EQ.'ST1') THEN
      WRITE(1,3115)TR(I),KH(I),TC(I),GOV(I)
      ELSE
      WRITE(1,3116)TW(I),KD(I),GOV(I)
      ENDIF
3110  CONTINUE
      WRITE(1,255)
      WRITE(1,3000)
      DO 4110 I = 1 , GO
      WRITE(1,305)NAMEGO(I),TYPEGO(I)
      IF (TYPEGO(I).EQ.'SG2') THEN
      WRITE(1,4115)KK(I),TT1(I),TT2(I),TY(I),YPMAX(I),Y
     * PMIN(I)
      ELSE
      WRITE(1,4116)BP(I),BT(I),TT(I),TS(I),TD(I),YPMAX(
     * I),YPMIN(I)
      ENDIF
4110  CONTINUE
      WRITE(1,255)
      WRITE(1,6030)
      DO 6020 I = 1 , DT
      WRITE(1,305)NAMED(I),TYPED(I)
      WRITE(1,6040)S00(I),X00(I),S05(I),X05(I),
     *S10(I),X10(I),S12(I),X12(I)
```

```
6020  CONTINUE
455   WRITE(1,255)
      WRITE(1,255)
      CLOSE(1)
2     FORMAT(A$)
55    FORMAT(A80)
65    FORMAT(A6,A6,6X,A2)
165   FORMAT(A6,A7,'TYPE=',A2)
70    FORMAT(9X,F10.5,3X,F10.5,3X,F10.5,2X,F10.5,5X,I2,
     * 7X,I2)
75    FORMAT(9X,F10.5,4X,F10.5,/,
     *       9X,F10.5)
85    FORMAT(9X,F10.5,4X,F10.5,/,
     *       9X,F10.5,/,
     *       9X,F10.5,3X,F10.5,/,
     *       11X,F8.5)
86    FORMAT(9X,F10.5,4X,F10.5,4X,F10.5,/,
     *       9X,F10.5,4X,F10.5,/,
     *       9X,F10.5,3X,F10.5,/,
     *       11X,F8.5,5X,F8.5,/,
     *       11X,F8.5)
87    FORMAT(9X,F10.5,4X,F10.5,4X,F10.5,/,
     *       9X,F10.5,4X,F10.5,4X,F10.5,/,
     *       9X,F10.5,3X,F10.5,/,
     *       11X,F8.5,5X,F10.5,/,
     *       11X,F8.5,5X,F10.5)
385   FORMAT(9X,F10.5,4X,F10.5,/,
     *       9X,F10.5,/,
     *       9X,F10.5,3X,F10.5,6X,I2,/,
     *       11X,F8.5)
386   FORMAT(9X,F10.5,4X,F10.5,4X,F10.5,/,
     *       9X,F10.5,4X,F10.5,/,
     *       9X,F10.5,3X,F10.5,6X,I2,/,
     *       11X,F8.5,5X,F8.5,/,
     *       11X,F8.5)
387   FORMAT(9X,F10.5,4X,F10.5,4X,F10.5,/,
     *       9X,F10.5,4X,F10.5,4X,F10.5,/,
     *       9X,F10.5,3X,F10.5,6X,I2,/,
     *       11X,F8.5,5X,F10.5,/,
     *       11X,F8.5,5X,F10.5)
100   FORMAT(A10)
105   FORMAT(A6,5X,A4)
115   FORMAT(8X,F7.2,4X,F5.2,4X,F5.2,4X,F5.2,
     *4X,F5.2,7X,F5.2,7X,F5.2)
120   FORMAT(8X,F7.5,7X,F7.5,7X,F7.5,6X,F7.5)
170   FORMAT(6X,'SN=',F7.2,3X,'UN=',F7.3,4X,'H=',F6.3,4
     * X,'D=',F6.3,4X,
     *'VREG=',I2,' TURB=',I2)
175   FORMAT(6X,'XD=',F7.4,3X,'XDP=',F7.4,/,
     *       6X,'XQ=',F7.4)
186   FORMAT(6X,'XD=',F7.4,3X,'XDP=',F7.4,/,
     *       6X,'XQ=',F7.4,/,
     *       6X,'RA=',F7.4,3X,'XA=',F7.4,/,
     *       6X,'TDOP=',F7.4)
285   FORMAT(6X,'XD=',F7.4,3X,'XDP=',F7.4,3X,'XDB=',F7.
     * 4,/,
     *       6X,'XQ=',F7.4,3X,'XQB=',F7.4,/,
```

```
     *       6X,'RA=',F7.4,3X,'XA=',F7.4,/,
     *       6X,'TDOP=',F7.4,1X,'TDOB=',F7.4,/,
     *       6X,'TQOB=',F7.4)
286   FORMAT(6X,'XD=',F7.4,3X,'XDP=',F7.4,3X,'XDB=',F7.
     * 4,/,
     *       6X,'XQ=',F7.4,3X,'XQP=',F7.4,3X,'XQB=',F7.
     * 4,/,
     *       6X,'RA=',F7.4,3X,'XA=',F7.4,/,
     *       6X,'TDOP=',F7.4,1X,'TDOB='F7.4,/,
     *       6X,'TQOP=',F7.4,1X,'TQOB=',F7.4)
486   FORMAT(6X,'XD=',F7.4,3X,'XDP=',F7.4,/,
     *       6X,'XQ=',F7.4,/,
     *       6X,'RA=',F7.4,3X,'XA=',F7.4,4X,'QTAB=',I2,/,
     *       6X,'TDOP=',F7.4)
485   FORMAT(6X,'XD=',F7.4,3X,'XDP=',F7.4,3X,'XDB=',F7.
     * 4,/,
     *       6X,'XQ=',F7.4,3X,'XQB=',F7.4,/,
     *       6X,'RA=',F7.4,3X,'XA=',F7.4,4X,'QTAB=',I2,* /,
     *       6X,'TDOP=',F7.4,1X,'TDOB=',F7.4,/,
     *       6X,'TQOB=',F7.4)
586   FORMAT(6X,'XD=',F7.4,3X,'XDP=',F7.4,3X,'XDB=',F7.
     * 4,/,
     *       6X,'XQ=',F7.4,3X,'XQP=',F7.4,3X,'XQB=',F7.4,/,
     *       6X,'RA=',F7.4,3X,'XA=',F7.4,4X,'QTAB=',I2,/,
     *       6X,'TDOP=',F7.4,1X,'TDOB='F7.4,/,
     *       6X,'TQOP=',F7.4,1X,'TQOB=',F7.4)
255   FORMAT('END')
301   FORMAT('REGULATOR')
305   FORMAT(A6,'TYPE=',A4)
310   FORMAT(6X,'K=',F7.2,' T1=',F5.2,' T2=',F5.2,' T3=
     * ',F5.2,
     *' T4=',F5.2,' UEMIN=',F5.2,' UEMAX=',F5.2)
1101  FORMAT(1X,A10,1X,' NO 2  MP 2  MQ 2')
1102  FORMAT('LOAD')
1115  FORMAT(9X,F7.5,3X,F6.3,3X,F6.3,4X,I2)
1116  FORMAT(9X,F7.5,3X,F6.3,4X,I2)
2115  FORMAT(8X,F7.2,4X,F5.2,4X,F5.2,4X,F5.2,
     *16X,F5.2,7X,F5.2)
2116  FORMAT(9X,F6.2,4X,F5.2,4X,F5.2,4X,F5.2,
     *4X,F5.2,7X,F5.2,7X,F5.2)
3115  FORMAT(6X,'TR=',F6.3,' KH=',F5.3,' TC=',F5.3,' GO
     * V ',I2)
3116  FORMAT(6X,'TW=',F6.3,' KD=',F5.3,' GOV ',I2)
4115   FORMAT(6X,'K=',F7.2,' T1=',F5.2,' T2=',F5.2,' TY
     * =',F5.2,
     *9X,' YPMAX=',F5.2,' YPMIN=',F5.2)
4116  FORMAT(6X,'BP=',F6.2,' BT=',F5.2,' TT=',F5.2,' TS
     * =',F5.2,
     *' TD=',F5.2,' YPMAX=',F5.2,' YPMIN=',F5.2)
3000  FORMAT('TURBINES')
6040  FORMAT(6X,'F',1X,F4.2,2X,F4.2,/,8X,F4.2,2X,F4.2,/,
     *8X,F4.2,2X,F4.2,/,8X,F4.2,2X,F4.2)
6030  FORMAT('TABLES')
7000  FORMAT('                    USING DYNAMIC EQUIVALEN
     * T VERSION 1')
      RETURN
      END
```

```
      SUBROUTINE READDATA
      INTEGER BUSP(270),BUSQ(270),BUSTP(250),GROUP(250)
     * ,INDEX(250)
     *,BUSX(250),T,M,BUS,LINE,TRAN,SHUNT,BUSTQ(250),TYP
     * E(250),COGROUP
     *,NOL(270),NOT(250),NS,NT,NL,NB,STASH(250),STABUS(
     * 250),ANS(10)
      COMPLEX Z(270),YCHAR(270),GEN(250),LOAD(250),LOAD
     * D(250)
     *,E(250),SHUN(250),ZT(250),TAPP(250),IL(250),SHUU(
     * 250)
      REAL UB(250),DUM,SN,MVA,UBUS(250),UT1(250),UT2(25
     * 0)
     *,SNT(250),FI(250),TAP(250),EE(250),EQ(250),YCH(27
     * 0)
      CHARACTER DOC*12 , DCC*4 , DOCC*2,BUSNAME(250)*10
     *,NAMELP(270)*10,NAMELQ(270)*10,NAMETP(250)*10,NAM
     * ETQ(250)*10
     *,NAMEX(250)*10,DCCC*10,JOB*10,NGOUP(20)*100
      COMMON /LINEE/BUSP,BUSQ,Z,YCHAR,LINE,NOL,NL
      COMMON /TRAN/BUSTP,BUSTQ,TRAN,TAP,SNT,UT1,UT2,ZT,
     * FI,NOT,NT
      COMMON /NODE/BUS,LOAD,LOADD,SHUN,E,EE,EQ,GEN,UBUS
     * ,NB,STABUS
     *                ,STASH,IL,SHUU
      COMMON /GEN/SNG,GBUS,XDD,H
      COMMON /GENERAL/MVA
      COMMON /COHER/INDEX,GROUP,TYPE,COGROUP
      COMMON /NAME/BUSNAME,NAMELP,NAMELQ,NAMETP,NAMETQ
      COMMON /JOBNAME/JOB,ANS
C
C
C
      DO 992 I = 1 , 20
992   NGOUP(I) = ' '
      PRINT * ,'      ENTER  FILE  NAME  WHICE HAS  '
      WRITE(*,99)'       LOAD FLOW AND MACHINE DATA : '
99    FORMAT(A$)
      READ(*,991)JOB
991   FORMAT(A10)
      DOC = 'OTRES.'//JOB
      DU = 1.0000
      WRITE(*,789)
789   FORMAT(/////////////////////////,15X,'***  DYNAM
     * IC EQUIVALENT',
     *8X,' DATA READING ***',//////////)
      OPEN (UNIT=2,FILE=DOC,STATUS='OLD')
      READ(2,3)MVA
3     FORMAT(3X,F8.5)
      DOCC = '##'
899   IF ( DOCC .NE. '**' ) THEN
      READ(2,4)DOCC
      GO TO 899
      ENDIF
4     FORMAT(A2)
      READ(2,4)DOCC
      DO 5 I = 1 , 300
```

```
      LOAD(I)= 0.000
      SHUN(I) = 0.000
      LOADD(I) = LOAD(I)
      READ(2,44)BUSNAME(I)
      IF ( BUSNAME(I).EQ. 'END' ) GO TO 45
      BUS = I
      READ(2,8)UBUS(I),EE(I),EQ(I),GEN(I),GROUP(I),K
      IF ( GROUP(I) .GE. COGROUP ) THEN
      COGROUP = GROUP(I)
      ENDIF
      E(I) = CMPLX(EE(I)*COS(EQ(I)),EE(I)*SIN(EQ(I)))
8     FORMAT(3X,F8.4,7X,F8.6,5X,E14.7,2X,E13.7,1X,E14.7
     * ,/,23X,I2,10X,I2)
44    FORMAT(A10)
      IF ( K .EQ.0 )THEN
      TYPE(I) = 4
      INDEX(I) = 2
      ELSE
      INDEX(I) = 1
      IF ( ABS(EQ(I)) .LT. 1.0E-10) THEN
      TYPE(I) = 1
      ELSE
      TYPE(I) = 2
      ENDIF
      ENDIF
      GEN(I) = GEN(I)*MVA
5     CONTINUE
45    READ(2,4)DOCC
      DO 9 J = 1 , 300
      READ(2,44)NAMELP(J)
      IF (NAMELP(J).EQ. 'END' ) GO TO 200
      READ(2,10)NAMELQ(J),NOL(J),Z(J),YCH(J)
10    FORMAT(A10,/,11X,I1,/,17x,E13.7,2X,E13.7,2X,E13.7
     * ,/)
      YCHAR(J) = CMPLX(0.000,YCH(J)/2)
      LINE = J
9     CONTINUE
200   READ(2,13)DOCC
13    FORMAT(A2,/)
      DO 18 I = 1 , 200
      READ(2,44)NAMETP(I)
      IF (NAMETP(I).EQ. 'SHUN' ) GOTO 100
      TRAN = I
      READ(2,15)NAMETQ(I),NOT(I),SNT(I),UT1(I),UT2(I),Z
     * T(I)
      READ(2,16)FI(I),TAP(I)
15    FORMAT(A10,/,11X,I1,/,3X,F8.3,7X,F8.4,7X,F8.4,6X,
     * E13.7,2X,E13.7)
16    FORMAT(1X,E14.7,3X,F8.6,//)
18    CONTINUE
100   DO 20 I = 1 , BUS
      READ(2,75)NAMEX(I)
      IF (NAMEX(I).EQ. 'END' ) GO TO 400
      DO 21 J = 1 , BUS
      IF (NAMEX(I).EQ.BUSNAME(J)) THEN
      READ(2,19)KK,STASH(J),SHUN(J)
19    FORMAT(10X,I2,23X,I2,/,2X,E13.7,2X,F10.5)
```

```
      GO TO 20
      ENDIF
21    CONTINUE
20    CONTINUE
400   DO 600 I = 1 , BUS
      READ(2,44)DCCC
      IF ( DCCC .EQ. 'END' )GO TO 800
      DO 605 J = 1 , BUS
      IF ( DCCC.EQ.BUSNAME(J)) THEN
      READ(2,22)LOAD(J)
      LOADD(J) = LOAD(J)
22    FORMAT(/,33X,F9.5,4X,F9.5,/)
801   FORMAT(' J = ',I3,5X,' LOAD =',2F10.5)
      GO TO 600
      ENDIF
605   CONTINUE
600   CONTINUE
800   CLOSE(2)
75    FORMAT(A10)
      DO 50 I = 1 , LINE
      T = 0
      DO 61 J = 1 , BUS
      IF (NAMELP(I).EQ.BUSNAME(J)) THEN
      BUSP(I) = J
      T = T + 1
      ENDIF
      IF (NAMELQ(I).EQ.BUSNAME(J)) THEN
      BUSQ(I) = J
      T = T + 1
      ENDIF
      IF ( T .EQ. 2 ) GO TO  50
61    CONTINUE
50    CONTINUE
      DO 51 I = 1 , TRAN
      T = 0
      DO 71 J = 1 , BUS
      IF (NAMETP(I).EQ.BUSNAME(J)) THEN
      BUSTP(I) = J
      T = T + 1
      ENDIF
      IF (NAMETQ(I).EQ.BUSNAME(J)) THEN
      BUSTQ(I) = J
      T = T + 1
      ENDIF
      IF ( T .EQ. 2 ) GO TO 51
71    CONTINUE
51    CONTINUE
      NL = LINE
      NT = TRAN
      NB = BUS
      WRITE(*,1000)COGROUP
1000  FORMAT('   THIS SYSTEM IS DEVICED INTO  ',I2,'
     *   AREA. ')
      PRINT *,'  ENTER (Y/N) WHICE Y FOR REDUCING    AR
     * EA. '
      PRINT *,'              WHICE N FOR NONREDUCING AR
     * EA. '
```

```
      DO 1100 I = 1 ,COGROUP
      WRITE(*,999)I
      DO 1111 J = 1 , BUS
      IF ((GROUP(J) .EQ. I ).AND.(UBUS(J) .LT. 100 )) T
     * HEN
      WRITE(*,997)BUSNAME(J)
997   FORMAT(5X,A10)
      ENDIF
1111  CONTINUE
999   FORMAT(/,'   AREA ',I2,' : DO YOU WANT TO REDUCE
     * '
     *       ,//,'     1) PASSIVE NETWORK.'
     *       ,/,'     2) GENERATOR BUSES. '
     *       ,/,'     3) 1 + 2            '
     *       ,//,'     THIS AREA HAVE GENERATOR :',/)
      WRITE(*,99)'     ANSWER : '
      READ(*,998)ANS(I)
998   FORMAT(I1)
1100  CONTINUE
      RETURN
      END
```

```
      SUBROUTINE DATA_OUTPUT
      INTEGER INDEX(250),GROUP(250),BUSP(270),BUSQ(270)
     * ,TYPE(250)
     *,TRAN,SHUNT,BUSX(250),BUS,LINE,BUSTP(250),BUSTQ(2
     * 50),NOL(270)
     *,NOT(250),STABUS(250),STASH(250),NL,NT,NB,NS
      COMPLEX Z(270),Y(270),YCHAR(270),E(250),ZZ,LOADD(
     * 250),IL(250)
     *,GEN(250),LOAD(250),TAPP(250),XDD(50),ZT(250),SHU
     * N(250),SHUU(250)
      REAL EE(250),EQ(250),UT1(250),UT2(250),SNT(250),T
     * AP(250)
     *,UB(250),FI(250),UBUS(250),FF,MVA,A,B,C,D,F
      CHARACTER DOC*20,DDC*20,DCC*7,DOCC*2,BUSNAME(250)
     * *10
     *,NAMELP(270)*10,NAMELQ(270)*10,NAMETP(250)*10
     *,NAMETQ(250)*10,NAMEX(250)*10,JOB*6
      COMMON /LINEE/BUSP,BUSQ,Z,YCHAR,LINE,NOL,NL
      COMMON /TRAN/BUSTP,BUSTQ,TRAN,TAP,SNT,UT1,UT2,ZT,
     * FI,NOT,NT
      COMMON /NODE/BUS,LOAD,LOADD,SHUN,E,EE,EQ,GEN,UBUS
     * ,NB,STABUS
     *              ,STASH,IL,SHUU
      COMMON /GENERAL/MVA
      COMMON /COHER/INDEX,GROUP,TYPE
      COMMON /NAME/BUSNAME,NAMELP,NAMELQ,NAMETP,NAMETQ,
     * NAMEX
      COMMON /JOBNAME/JOB
C
C
C
      NB = 0
      NGG = 0
      NG = 0
      DDC = JOB//'EQ.DYNPOW'
      DOC = JOB//'EQ.OPTPOW'
      DO 111 I = 1 , BUS
      IF (GEN(I) .NE. 0 ) THEN
      IF ( STABUS(I) .EQ. 1 ) THEN
      NGG = NGG + 1
      ENDIF
      IF ( STABUS(I) .LE. 2 ) THEN
      NG = NG + 1
      ENDIF
      ENDIF
      IF ( STABUS(I) .EQ. 1 ) THEN
      NB = NB + 1
      ENDIF
111   CONTINUE
      NS = 0
      DO 112 I = 1 , SHUNT
      IF ( STABUS(BUSX(I)) .EQ. 1 ) THEN
      NS = NS + 1
      ENDIF
      A  = (BUS-NB)*100/BUS
      B  = (NL-LINE)*100/NL
```

```
      C  = (NT-TRAN)*100/NT
      D  = (SHUNT-NS)*100/SHUNT
      EG = (NG-NGG)*100/NG
112   CONTINUE
      OPEN (UNIT=1,FILE='NEWLOAD.DAT',STATUS='NEW')
      DO 117 I = 1 , BUS
      IF ((STABUS(I).EQ. 1).AND.( CABS(LOAD(I)) .GT. 0.
     * 01 ))THEN
      WRITE(1,127)BUSNAME(I)
      ENDIF
117   CONTINUE
      OPEN (UNIT=2,FILE=DOC,STATUS='NEW')
      WRITE(2,100)JOB,BUS,NB,A,NL,LINE,B,NT,TRAN,C,SHUN
     * T,NS,D,NG,NGG,EG
      WRITE(2,98)
      WRITE(2,97)
      WRITE(2,1),MVA
      DO 2 I = 1 , BUS
      IF (STABUS(I) .EQ. 1 ) THEN
      WRITE(2,3)BUSNAME(I),UBUS(I),GROUP(I)
      ENDIF
2     CONTINUE
      WRITE(2,4)
      DO 5 I = 1 , LINE
      WRITE(2,6)NAMELP(I),NAMELQ(I),Z(I),2*AIMAG(YCHAR(
     * I)),NOL(I)
5     CONTINUE
      WRITE(2,7)
      DO 8 I = 1 , TRAN
      N = BUSTP(I)
      M = BUSTQ(I)
      WRITE(2,9)BUSNAME(N),BUSNAME(M),SNT(I),UT1(I),UT2
     * (I),ZT(I),NOT(I)
8     CONTINUE
      WRITE(2,10)
119   CONTINUE
      DO 11 I = 1 , BUS
      IF ((STABUS(I).EQ. 1).AND.( CABS(LOAD(I)) .GT. 0.
     * 01 ))THEN
      WRITE(2,12)BUSNAME(I),LOADD(I)
      ENDIF
11    CONTINUE
      DO 110 I = 1 , BUS
      IF ((STABUS(I).EQ. 1).AND.( CABS(LOAD(I)) .GT. 0.
     * 01 ))THEN
      WRITE(2,122)BUSNAME(I),LOAD(I)-LOADD(I)
      ENDIF
110   CONTINUE
      WRITE(2,13)
      DO 14 I = 1 , BUS
      IF ((STABUS(I).EQ. 1).AND.( CABS(SHUN(I)) .NE. 0.
     * 0 ))THEN
      WRITE(2,15)BUSNAME(I),STASH(I),SHUN(I),UBUS(I)
      ENDIF
14    CONTINUE
      WRITE(2,16)
      DO 17 I = 1 , BUS
```

```
      IF ((STABUS(I).EQ.1).OR.(INDEX(I).EQ.1)) THEN
      EQ(I) = EQ(I)*57.29578
      IF ( TYPE(I) .EQ. 1 )THEN
      WRITE(2,18)BUSNAME(I),CABS(E(I))*UBUS(I),EQ(I)
      ENDIF
      IF ( TYPE(I) .EQ. 2 )THEN
      WRITE(2,38)BUSNAME(I),REAL(GEN(I)),UBUS(I)*CABS(E
     * (I)),EQ(I)
      ENDIF
      IF ( TYPE(I) .EQ. 3 )THEN
      WRITE(2,48)BUSNAME(I),GEN(I)
      ENDIF
      ENDIF
17    CONTINUE
      DO 19 I = 1 ,TRAN
      N = BUSTP(I)
      M = BUSTQ(I)
      FI(I) = FI(I)*57.29578
      WRITE(2,20)BUSNAME(N),BUSNAME(M),TAP(I),FI(I),NOT
     * (I)
19    CONTINUE
      WRITE(2,21)
      CLOSE(2)
      CLOSE(3)
98    FORMAT('**')
99    FORMAT(A$)
97    FORMAT('CONTROL DATA',/,'EDIT 0 ',5X,'METHOD 0 ',
     * /,'END')
1     FORMAT('GENERAL',/,'  SN ',F7.2,/,'END',/,'NODE')
3     FORMAT(1X,A10,'UB',F8.3,3X,'AREA ',I3)
4     FORMAT('END',/,'LINE')
6     FORMAT(1X,A10,A10,'TYPE 12',2X,'R ',F8.5,3X,'X '
     *,F8.5,3X,'B ',F8.5,'  NO ',I1)
7     FORMAT('END',/,'TRANSFORMERS')
9     FORMAT(1X,A8,A8,'NW 2 SN ',F4.0,
     *1X,'UN1 ',F5.1,1X,'UN2 ',F5.1,1X,'ER12 ',F7.4,1X,
     *'EX12 ',F7.4,1X,'NO ',I1)
10    FORMAT('END',/,'LOAD')
12    FORMAT(1X,A8,'P ',F12.4,4X,'Q ',F12.4,' NO 1 ')
122   FORMAT(1X,A8,'P ',F12.4,4X,'Q ',F12.4,' NO 2 ')
129   FORMAT(1X,A8,'P ',F12.4,4X,'Q ',F12.4)
127   FORMAT(1X,A10,' NO 2 MP 0.5   MQ 2.2 ')
13    FORMAT('END'/'SHUNT IMPEDANCE')
15    FORMAT(1X,A8,' NCON ',I2,2X,' P ',F10.4,3X,' Q ',
     * F10.4,3X,
     *' UN ',F9.4)
16    FORMAT('END'/'POWER INSTRUCTION')
18    FORMAT(1X,A8,' TYPE NODE RTYP SW U ',F9.4,' FI ',
     * F6.2)
38    FORMAT(1X,A8,' TYPE NODE RTYP U  P ',F9.4,' U ',F
     * 9.4,' FI ',F9.4)
39    FORMAT(1X,A8,' TYPE NODE RTYP U  P ',F9.4,' U ',F
     * 9.4)
48    FORMAT(1X,A8,' TYPE NODE RTYP PQ P ',F9.4,' Q ',F
     * 9.4)
20    FORMAT(1X,A9,A8,'TYPE TREG RTYP FI TAU ',F6.4,' F
     * I ',F9.5,
```

```
     *' NO ',I1)
21    FORMAT('END',/,'END')
100   FORMAT(/,17X,'**  DYNAMIC EQUIVALENT PROGRAM VERS
     * ION 1 ** ',//,
     *'            THIS IS THE DYNAMIC EQUIVALENT DATA O
     * F JOB   :',A8,//,
     *'                      ORIGINAL       REDUCED
     * PERCENT OF ',/,
     *'                      SYSTEM         SYSTEM       R
     * EDUCTION( % )',//,
     *' BUSES                ',I3,'            ',I3,'
     *         ',F6.3,/,
     *' LINES                ',I3,'            ',I3,'
     *         ',F6.3,/,
     *' TRANSFORMER          ',I3,'            ',I3,'
     *         ',F6.3,/,
     *' SHUNT                ',I3,'            ',I3,'
     *         ',F6.3,/,
     *' GENERATOR            ',I3,'            ',I3,'
     *         ',F6.3,/)
      CLOSE(2)
      WRITE(*,300)DOC,DDC
300   FORMAT(//////////////,27X,' **  JOB COMPLETED  **
     * ',
     *//,8X,'**  LOAD FLOW DATA  IS SAVED IN FILE : ',A
     * 20,' **',
     *//,8X,'**  MACHINES  DATA  IS SAVED IN FILE : ',A
     * 20,' **',
     */////////// )
      RETURN
      END
```

```
      SUBROUTINE NETWORK_REDUCTION
      INTEGER INDEX(250),GROUP(250),BUSP(270),BUSQ(270)
     * ,TYPE(250)
     *,TRAN,SHUNT,BUSX(250),DUM(100),BUSLP(250),BUSLQ(2
     * 50),STA(250)
     *,BUS,LINE,SUMG,BUSTP(250),BUSTQ(250),BUSTTQ(250),
     * BUSTTP(250)
     *,P,NOL(270),NOT(250),BB,INDEXX(250),TT,T,N,M,GR(2
     * 50),NS,STASH(250)
     *,COGROUP,BUSPP(250),STALINE(270),STATRAN(250),STA
     * BUS(250),ANS(10)
      COMPLEX Z(270),Y(270),YCHAR(270),E(250),ZZZ,ZL(25
     * 0),ZTT(250)
     *,GEN(250),LOAD(250),ZT(250),SHUN(250),SHU(250),IL
     * (250),ILL(100),
     *SHUU(250),PQ,QP,EF(250),MVAA
     *,YBUS(70,70),YYBUS(70,70),YCH(250),LOADD(250),LO(
     * 100),YY,ZZ,FE,TA
      REAL EE(250),EQ(250),UT1(250),UT2(250),SNT(250),T
     * AP(250)
     *,UB(250),FI(250),UBUS(250),FF,MVA,TAPP(250),FQ
      CHARACTER*10 BUSNAME(250),NAMELP(270),NAMELQ(270)
     * ,NAMETP(250)
     *,NAMETQ(250),DOC*5,JOB*10
      COMMON /LINEE/BUSP,BUSQ,Z,YCHAR,LINE,NOL
      COMMON /TRAN/BUSTP,BUSTQ,TRAN,TAP,SNT,UT1,UT2,ZT,
     * FI,NOT
      COMMON /NODE/BUS,LOAD,LOADD,SHUN,E,EE,EQ,GEN,UBUS
     * ,NB,STABUS
     *              ,STASH,IL,SHUU
      COMMON /COHER/INDEX,GROUP,TYPE,COGROUP
      COMMON /GENERAL/MVA
      COMMON /NAME/BUSNAME,NAMELP,NAMELQ,NAMETP,NAMETQ
      COMMON /JOBNAME/JOB,ANS
C
C
C     ************************************************
C     * TRANSFER GENERATION AND LOAD AT COHERENT BUS  *
C     * GEN(BUS) = SUM OF GEN OF ALL COHERENT BUS     *
C     * LOAD(BUS = SUM OF LOAD OF ALL COHERENT BUS    *
C     ************************************************
C
C
      MVAA = CMPLX(100.00,0.000)
      OPEN(5,FILE='DYN.DAT',STATUS='NEW')
      OPEN(8,FILE='DYN1.DAT',STATUS='NEW')
      YY = 0.00
      DO 101 I = 1 , BUS
      GR(I) = GROUP(I)
      YY = YY + LOADD(I)
      IL(I) = 0.0000
      SHUU(I) = 0.000
101   STABUS(I) = 1
C     WRITE(*,1111)YY
1111  FORMAT(///,' TOTAL LOAD = ',2F15.5)
      DO 11 IJ = 1,COGROUP
      IF ( ANS(IJ).EQ.2 ) GO TO 11
```

```
      DO 977 K = 1 ,BUS
      LO(K) = 0.00
      SHU(K) = 0.000
      STA(K) = 1
      ILL(K) = 0
      EF(K)  = CMPLX(1.00,0.00)
      IF ( GROUP(K) .EQ. IJ )  THEN
      NB = NB + 1
      ENDIF
      IF ( GR(K) .EQ. IJ )  THEN
      STABUS(K) = 2
      ENDIF
977   CONTINUE
      DO 1 I = 1 , LINE
      N = BUSP(I)
      M = BUSQ(I)
      IF ( GROUP(N) .NE. GROUP(M)) THEN
      GR(N) = 20
      GR(M) = 20
      INDEX(N) = 4
      INDEX(M) = 4
      STABUS(N) = 1
      STABUS(M) = 1
      ENDIF
1     STALINE(I) = 1
      DO 2 I = 1 , TRAN
      N = BUSTP(I)
      M = BUSTQ(I)
      IF ((TYPE(N).LE.3).OR.(TYPE(M).LE.3)) THEN
      GR(N) = 20
      GR(M) = 20
      INDEX(N) = 3
      INDEX(M) = 3
      STABUS(N) = 1
      STABUS(M) = 1
      ENDIF
2     STATRAN(I) = 1
      NB = 0
      NBB = 0
      NTR = TRAN
      DO 5050 I = 1 , BUS
      IF ((GROUP(I).EQ.IJ).AND.(STABUS(I).EQ.1)) THEN
      NBB = NBB + 1
      ENDIF
5050  CONTINUE
5000  P = 2
      T = 0
      TT = 0
      ZZZ = 0
      NN = 0
      MMM = 0
      DO 4 J = 1 , LINE
      N = BUSP(J)
      M = BUSQ(J)
      IF (( GR(N).EQ.IJ ).OR.( GR(M).EQ.IJ )) THEN
      STALINE(J) = 2
      T = T + 1
```

```
      ZL(T) = Z(J)
      YCH(T) = YCHAR(J)
      IF ( T .NE. 1 ) THEN
      TEST = 0
      DO 20 II = 1 , P
      IF ( N .EQ. DUM(II) ) THEN
      TEST = 1
      GO TO 22
      ENDIF
20    CONTINUE
22    IF ( TEST .EQ. 1 ) THEN
      BUSLP(T) = II
      ELSE
      P = P + 1
      BUSLP(T) = P
      DUM(P) = N
      LO(P)  = LOADD(N)
      ILL(P) = CONJG(LOADD(N)/E(N))
      SHU(P) = SHUN(N)
      STA(P) = STASH(N)
      EF(P)  = E(N)
      IF ( GR(N) .NE. IJ ) THEN
      INDEXX(P) = 1
      ELSE
      INDEXX(P) = INDEX(N)
      ENDIF
      ENDIF
      TEST = 0
      DO 30 II = 1 , P
      IF ( M .EQ. DUM(II) ) THEN
      TEST = 1
      GO TO 32
      ENDIF
30    CONTINUE
32    IF ( TEST .EQ. 1 ) THEN
      BUSLQ(T) = II
      ELSE
      P = P + 1
      BUSLQ(T) = P
      DUM(P) = M
      LO(P)  = LOADD(M)
      ILL(P) = CONJG(LOADD(M)/E(M))
      SHU(P) = SHUN(M)
      STA(P) = STASH(M)
      EF(P)  = E(M)
      IF ( GR(M) .NE. IJ ) THEN
      INDEXX(P) = 1
      ELSE
      INDEXX(P) = INDEX(M)
      ENDIF
      ENDIF
      ELSE
      DUM(1) = N
      DUM(2) = M
      LO(1)  = LOADD(N)
      LO(2)  = LOADD(M)
      ILL(1) = CONJG(LOADD(N)/E(N))
```

```
      ILL(2) = CONJG(LOADD(M)/E(M))
      SHU(1) = SHUN(N)
      SHU(2) = SHUN(M)
      STA(1) = STASH(N)
      STA(2) = STASH(M)
      EF(1)  = E(N)
      EF(2)  = E(M)
      BUSLP(T) = 1
      BUSLQ(T) = 2
      IF ( GR(N).NE.IJ ) THEN
      INDEXX(1) = 1
      ELSE
      INDEXX(1) = INDEX(N)
      ENDIF
      IF ( GR(M).NE.IJ ) THEN
      INDEXX(2) = 1
      ELSE
      INDEXX(2) = INDEX(M)
      ENDIF
      ENDIF
      ENDIF
4     CONTINUE
      TT = 0
      N = 0
      M = 0
      DO 5 J = 1 , TRAN
      N = BUSTP(J)
      M = BUSTQ(J)
7000  IF (( GR(N).EQ.IJ ).OR.( GR(M).EQ.IJ )) THEN
      TEST = 0
      TT = TT + 1
      ZTT(TT) = ZT(J)
      STATRAN(J) = 2
      TAPP(TT) = TAP(J)
      DO 40 II = 1 , P
      IF ( N .EQ. DUM(II) ) THEN
      TEST = 1
      GO TO 42
      ENDIF
40    CONTINUE
42    IF ( TEST .EQ. 1 ) THEN
      BUSTTP(TT) = II
      ELSE
      P = P + 1
      BUSTTP(TT) = P
      DUM(P) = N
      LO(P)  = LOADD(N)
      ILL(P) = CONJG(LOADD(N)/E(N))
      SHU(P) = SHUN(N)
      STA(P) = STASH(N)
      EF(P)  = E(N)
      IF ( GR(N) .NE. IJ ) THEN
      INDEXX(P) = 1
      ELSE
      INDEXX(P) = INDEX(N)
      ENDIF
      ENDIF
```

```
      TEST = 0
      DO 50 II = 1 , P
      IF ( M .EQ. DUM(II) ) THEN
      TEST = 1
      GO TO 52
      ENDIF
50    CONTINUE
52    IF ( TEST .EQ. 1 ) THEN
      BUSTTQ(TT) = II
      ELSE
      P = P + 1
      BUSTTQ(TT) = P
      DUM(P) = M
      LO(P)  = LOADD(M)
      ILL(P) = CONJG(LOADD(M)/E(M))
      SHU(P) = SHUN(M)
      STA(P) = STASH(M)
      EF(P)  = E(M)
      IF ( GR(M) .NE. IJ ) THEN
      INDEXX(P) = 1
      ELSE
      INDEXX(P) = INDEX(M)
      ENDIF
      ENDIF
      ENDIF
5     CONTINUE
60    CONTINUE
70    CONTINUE
80    CONTINUE
      DO 333 II = 1 ,70
      DO 333 J = 1 ,70
      YBUS(II,J) = 0.000
      YYBUS(II,J) = 0.000
333   CONTINUE
C     ************************************************
     * *
C     *
     * *
C     *                    FORM YBUS
     * *
C     *
     * *
C     ************************************************
     * *
      DO 112 II = 1 ,T
      Y(II) = 1/ZL(II)
      N = BUSLP(II)
      M = BUSLQ(II)
      YBUS(N,N) = YBUS(N,N) +  Y(II)
      YBUS(M,M) = YBUS(M,M) +  Y(II)
      YBUS(N,M) = YBUS(N,M) -  Y(II)
      YBUS(M,N) = YBUS(M,N) -  Y(II)
      YYBUS(N,N) = YYBUS(N,N) +  Y(II) + YCH(II)
      YYBUS(M,M) = YYBUS(M,M) +  Y(II) + YCH(II)
      YYBUS(N,M) = YYBUS(N,M) -  Y(II)
      YYBUS(M,N) = YYBUS(M,N) -  Y(II)
112   CONTINUE
```

```
C     ***********************************************
C     *                                             *
C     *            FORM YBUS                        *
C     *          TRANSFORMER                        *
C     *                                             *
C     ***********************************************
      IF ( TT .GT. 0 ) THEN
      DO 31 II = 1 ,TT
      Y(II) = 1/ZTT(II)
      TA    = 1/TAP(II)
      N = BUSTTP(II)
      M = BUSTTQ(II)
      YBUS(N,N) = YBUS(N,N) + Y(II)*TA
      YBUS(M,M) = YBUS(M,M) + Y(II)*TA
      YBUS(N,M) = YBUS(N,M) - Y(II)*TA
      YBUS(M,N) = YBUS(M,N) - Y(II)*TA
      YYBUS(N,N) = YYBUS(N,N) + Y(II)*TA + TA*Y(II)*(TA
     * -1)
      YYBUS(M,M) = YYBUS(M,M) + Y(II)*TA + Y(II)*(1-TA)
      YYBUS(N,M) = YYBUS(N,M) - Y(II)*TA
      YYBUS(M,N) = YYBUS(M,N) - Y(II)*TA
31    CONTINUE
      ENDIF
C     ***********************************************
C     *                                             *
C     *            FORM YBUS                        *
C     *         SHUNT  IMPEDANCE                    *
C     *                                             *
C     ***********************************************
      DO 113 K = 1 , P
      IF (STA(K).EQ. 0 ) THEN
      YYBUS(K,K)= YYBUS(K,K)-CONJG(SHU(K))/(EF(K)*CONJG
     * (EF(K))*MVAA)
      ENDIF
113   CONTINUE
C     ***********************************************
C     *                                             *
C     *          END OF FORM YBUS                   *
C     *                                             *
C     ***********************************************
C
C      WRITE(*,778)IJ
778   FORMAT(/,15X,'*** DYNAMIC EQUIVALENT   LOAD BUS I
     * N AREA ',I2,
     *' ARE REDUCED ***',/)
C     ***********************************************
C     *                                             *
C     *          GAUSSIAN                           *
C     *         ELIMINATION                         *
C     *                                             *
C     ***********************************************
C
      SUM = 0
      YY = 0.00
```

```
      DO 6 II = 1 , P
      YY = YY + LO(II)
      IF ( INDEXX(II) .EQ. 2 ) THEN
        SUM = SUM + 1
      ENDIF
6     CONTINUE
C     WRITE(*,1111)YY
      S = P
      DO 700 II = 1 , SUM
      DO 8  J = s , 1, -1
      IF (INDEXX(J) .EQ. 2 ) THEN
         S = J
         GOTO 202
      ENDIF
8     CONTINUE
202   IF ( YBUS(S,S) .NE. 0.0 ) THEN
       DO 10 K = 1 , P
          IF ( YBUS(K,K) .NE. 0.0 ) THEN
          IF ( K .NE. S ) THEN
             YY       = YBUS(K,S)/YBUS(S,S)
             ZZ       = YYBUS(K,S)/YYBUS(S,S)
             LO(K)    = LO(K)  - LO(S)*YY
             ILL(K)   = ILL(K) - ILL(S)*ZZ
             DO 9 T = K , P
             IF ( T .NE. S ) THEN
               YBUS(K,T) = YBUS(K,T) - YY*YBUS(S,T)
               YYBUS(K,T) = YYBUS(K,T) - ZZ*YYBUS(S,T)
               YBUS(T,K) = YBUS(K,T)
               YYBUS(T,K) = YYBUS(K,T)
             ENDIF
9            CONTINUE
          ENDIF
          ENDIF
10    CONTINUE
      ENDIF
      NT = 0
      DO 735 JJ = 1 , P
      YBUS(JJ,S) = 0.0
      YBUS(S,JJ) = YBUS(JJ,S)
      YYBUS(JJ,S) = 0.0
735   YYBUS(S,JJ) = YYBUS(JJ,S)
      LO(S)  = 0.000
      ILL(S) = 0.000
      s = s - 1
700   CONTINUE
      YY = 0.0000
      DO 92 II = 1 , P
      LOADD(DUM(II)) = LO(II)
      IL(DUM(II))    = ILL(II)
      YY = YY + LO(II)
      DO 92 JJ = II+1 , P
      IF ( CABS(YYBUS(II,JJ)) .GT. 0.01) THEN
      NT = NT + 1
      NTR = NTR +1
      STATRAN(NTR) = 1
      ZT(NTR)      = -1/YYBUS(II,JJ)
      NAMETP(NTR)  = BUSNAME(DUM(II))
```

```
      NAMETQ(NTR)   = BUSNAME(DUM(JJ))
      BUSTP(NTR)    = DUM(II)
      BUSTQ(NTR)    = DUM(JJ)
      UT1(NTR)      = UBUS(DUM(II))
      UT2(NTR)      = UBUS(DUM(JJ))
      SNT(NTR)      = 100
      TAP(NTR)      = 1.00
      FI(NTR)      = 0.00
      NOT(NTR)      = 0
      ENDIF
92    CONTINUE
      DO 93 II = 1 , P
      SHUU(DUM(II)) = 0.0000
      DO 93 JJ = 1 , P
      SHUU(DUM(II)) = SHUU(DUM(II)) + YYBUS(II,JJ)
93    CONTINUE
      WRITE(5,105)IJ,NB,NBB,T,TT,NT,NG
      LL = 0
      DO 7 I = 1 , LINE
      IF (STALINE(I) .EQ. 2 ) THEN
      LL = LL + 1
      ELSE
      NAMELP(I-LL)   = NAMELP(I)
      NAMELQ(I-LL)   = NAMELQ(I)
      BUSP(I-LL)     = BUSP(I)
      BUSQ(I-LL)     = BUSQ(I)
      YCHAR(I-LL)    = YCHAR(I)
      Z(I-LL)        = Z(I)
      NOL(I-LL)      = NOL(I)
      ENDIF
7     CONTINUE
      LINE = LINE - LL
      BB = 0
      DO 77 I = 1 , BUS
      IF (STABUS(I) .EQ. 2 ) THEN
      BB = BB + 1
      ENDIF
77    CONTINUE
      BB = BUS - BB
C
C
C
      TT = 0
      DO 88 I = 1 , NTR
      IF (STATRAN(I) .EQ. 2 ) THEN
      TT = TT + 1
      ELSE
      NAMETP(I-TT) = NAMETP(I)
      NAMETQ(I-TT) = NAMETQ(I)
      BUSTP(I-TT)  = BUSTP(I)
      BUSTQ(I-TT)  = BUSTQ(I)
      ZT(I-TT)     = ZT(I)
      TAP(I-TT)    = TAP(I)
      FI(I-TT)     = FI(I)
      SNT(I-TT)    = SNT(I)
      UT1(I-TT)    = UT1(I)
      UT2(I-TT)    = UT2(I)
```

```
      NOT(I-TT)     = NOT(I)
      ENDIF
88    CONTINUE
      TRAN = NTR - TT
11    CONTINUE
      OPEN(UNIT = 1,FILE='TRAKAN6.DAT',STATUS = 'NEW')
      DO 51 I = 1 , BUS
51    LOAD(I) = 0.000
      DO 601 J = 1 ,LINE
      N = BUSP(J)
      M = BUSQ(J)
      PQ =  CONJG(E(N))*(E(N)-E(M))/Z(J)
     *       + (CABS(E(N))**2)*YCHAR(J)
      QP =  CONJG(E(M))*(E(M)-E(N))/Z(J)
     *       + (CABS(E(M))**2)*YCHAR(J)
      LOAD(N) =  LOAD(N) + PQ
      LOAD(M) =  LOAD(M) + QP
      WRITE(1,661)J,BUSNAME(N),BUSNAME(M),PQ,QP
661   FORMAT(' J = ',I3,5X,'BUSP=',A10,5X,'BUSQ=',A10,5
     * X,
     */,'FPQ=',2F12.5,5X,'FQP=',2F12.5)
601   CONTINUE
      DO 701 J = 1 ,TRAN
      N = BUSTP(J)
      M = BUSTQ(J)
      ZZ = CMPLX(TAP(J)*COS(FI(J)),TAP(J)*SIN(FI(J)))
      QP = CONJG(E(M))*(E(M)-ZZ*E(N))/(((CABS(ZZ))**2)*
     * ZT(J))
      PQ = CONJG(E(N))*(ZZ*E(N)- E(M))/(ZZ*ZT(J))
      LOAD(N) = LOAD(N) + PQ
      LOAD(M) = LOAD(M) + QP
      WRITE(1,86)J,BUSNAME(N),BUSNAME(M),PQ,QP
86    FORMAT(5X,' J = ',I3,5X,'BUSP=',A10,5X,'BUSQ=',A1
     * 0,5X,/
     *,'FPQ =',2F12.5,'FQP =',2F12.5)
701   CONTINUE
      DO 801 J = 1 , BUS
      IF (STASH(J).EQ.0) THEN
      LOAD(J) = LOAD(J) + CONJG(SHUN(J))*(E(J)*CONJG(E(
     * J)))/MVAA
      ENDIF
      LOAD(J) = GEN(J) - MVAA*CONJG(LOAD(J))
801   CONTINUE
C
C
C
C
      DO 909 IJ = 1 , COGROUP
      IF ( ANS(IJ).NE.1 ) THEN
      BUS  = BUS+1
      IF (IJ .LE. 9 ) THEN
      DOC = CHAR(48+IJ)
      ELSE
      DOC = CHAR(59-IJ)//CHAR(58-IJ)
      ENDIF
      BUSNAME(BUS) = 'BUSEQ'//DOC
      LOAD(BUS) = 0.0000
```

```
      GEN(BUS)  = 0.0000
      UBUS(BUS) = 0.0000
      FF = 0.0000
      GG = 0.0000
      EQ(BUS) = 0.0000
      NG = 0
      DO 97 K = 1 ,BUS
      IF (( GROUP(K) .EQ. IJ ).AND.(GEN(K).NE. 0.000))
     *  THEN
        STABUS(K) = 2
        LOAD(BUS) = LOAD(BUS) + LOAD(K)
        GEN(BUS)  = GEN(BUS) + GEN(K)
        UBUS(BUS) = UBUS(BUS) + UBUS(K)
        EQ(BUS)   = EQ(BUS) + EQ(K)
        FF        =  FF + CABS(E(K))
        NG        = NG + 1
        GEN(K)    = 0.000
        LOAD(K)   = 0.000
      ENDIF
97    CONTINUE
      FF = FF/NG
      EQ(BUS) = EQ(BUS)/NG
      E(BUS)=CMPLX(FF*COS(EQ(BUS)),FF*SIN(EQ(BUS)))
      EE(BUS)=CABS(E(BUS))
      UBUS(BUS) = UBUS(BUS)/NG
      STABUS(BUS) = 1
      INDEX(BUS) = 3
      GR(BUS)    = IJ
      GROUP(BUS) = IJ
      SHUN(BUS) = 0.000
      IL(BUS) =.00000
      SHUU(BUS) = 0.000
      IF ( IJ .EQ. 1 ) THEN
      TYPE(BUS)  = 1
      ELSE
      TYPE(BUS)  = 2
      ENDIF
      DO 57 J = 1 , TRAN
      N = BUSTP(J)
      M = BUSTQ(J)
      IF (( GROUP(N).EQ.IJ ).AND.( GROUP(M).EQ.IJ )) TH
     * EN
        IF (TYPE(N).LE.3 ) THEN
        BUSTP(J) = BUS
        UT1(J)   = UBUS(BUS)
        ZT(J)    = ZT(J)/((EE(N)/EE(BUS))**2)
        TAP(J)   = TAP(J)*EE(N)/EE(BUS)
        FI(J)    = EQ(N)-EQ(BUS)
        WRITE(8,808)IJ,BUSNAME(N),EE(N),EE(BUS),EE(N)/
     * EE(BUS),FI(J)
        ENDIF
        IF (TYPE(M).LE.3 ) THEN
        BUSTQ(J) = BUS
        UT1(J)   = UBUS(BUS)
        ZT(J)    = ZT(J)/((EE(M)/EE(BUS))**2)
        TAP(J)   = TAP(J)*EE(M)/EE(BUS)
        FI(J)    = EQ(M)-EQ(BUS)
```

```
          WRITE(8,808)IJ,BUSNAME(M),EE(M),EE(BUS),EE(M)/
     * EE(BUS),FI(J)
          ENDIF
        ENDIF
57      CONTINUE
808     FORMAT(' I = ',I2,' BUS = ',A10,' EBUS = ',F6.4,'
     *  EBUS = ',F6.4,
     *' TAP = ',F7.4,' FI = ',F7.4)
        ENDIF
909     CONTINUE
        DO 100 I = 1 , TRAN
        IF(ZT(I) .NE. 0.00 ) THEN
        ZZ = 1/ZT(I)
        N = BUSTP(I)
        M = BUSTQ(I)
        FF = SNT(I)
        DO 1010 J = I+1 , TRAN
        NN = BUSTP(J)
        MM = BUSTQ(J)
        IF(((N.EQ.NN).AND.(M.EQ.MM)).OR.((N.EQ.MM).AND.(M
     * .EQ.NN))) THEN
        IF ( FI(I).NE.FI(J)) GO TO 1010
        IF(ZT(J) .NE. 0.00 ) THEN
        ZZ = ZZ + 1/ZT(J)
        FF = FF  + SNT(J)
        ZT(J) = 0.0000
        SNT(J) = 0
        ENDIF
        ENDIF
1010    CONTINUE
        ZT(I) = 1/ZZ
        ENDIF
100     CONTINUE
        TT = 0
        DO 889 I = 1 , TRAN
        NOT(I) = 0
        IF (ZT(I) .EQ. 0.000 ) THEN
        TT = TT + 1
        ELSE
        NAMETP(I-TT) = NAMETP(I)
        NAMETQ(I-TT) = NAMETQ(I)
        BUSTP(I-TT)  = BUSTP(I)
        BUSTQ(I-TT)  = BUSTQ(I)
        ZT(I-TT)     = ZT(I)
        TAP(I-TT)    = TAP(I)
        FI(I-TT)    = FI(I)
        SNT(I-TT)    = SNT(I)
        UT1(I-TT)    = UT1(I)
        UT2(I-TT)    = UT2(I)
        NOT(I-TT)    = NOT(I)
        ENDIF
889     CONTINUE
        TRAN = TRAN - TT
        DO 1009 I = 1 , TRAN
        IF ( NOT(I) .EQ. 0 ) THEN
        T = 1
        N = BUSTP(I)
```

```
      M = BUSTQ(I)
      DO 1019 J = I+1 , TRAN
      IF ( NOT(J) .EQ. 0 ) THEN
      NN = BUSTP(J)
      MM = BUSTQ(J)
      IF(((N.EQ.NN).AND.(M.EQ.MM)).OR.((N.EQ.MM).AND.(M
     * .EQ.NN)))THEN
      T = T + 1
      NOT(I) = 1
      NOT(J) = T
      ENDIF
      ENDIF
1019  CONTINUE
      ENDIF
1009  CONTINUE
105   FORMAT(/,17X,'**     AREA ',I3,'              ** ',
     * //,
     *'                ORIGINAL          REDUCED       ',
     * /,
     *'                SYSTEM            SYSTEM        ',
     * //,
     *' BUSES          ',I3,'              ',I3,'     ',
     * /,
     *' LINES          ',I3,'               0         '
     * ,/,
     *' TRANSFORMER    ',I3,'              ',I3,'     ',
     * /,
     *' GENERATOR      ',I3,'               1         ',
     * /)
      CLOSE(5)
      YY = 0.000
      DO 102 I = 1 , BUS
102   YY = YY + LOADD(I)
      RETURN
      END
```

APPENDIX 2

Block diagram of control system.

- Excitation and Voltage regulation system
- Turbine system
- Governor system

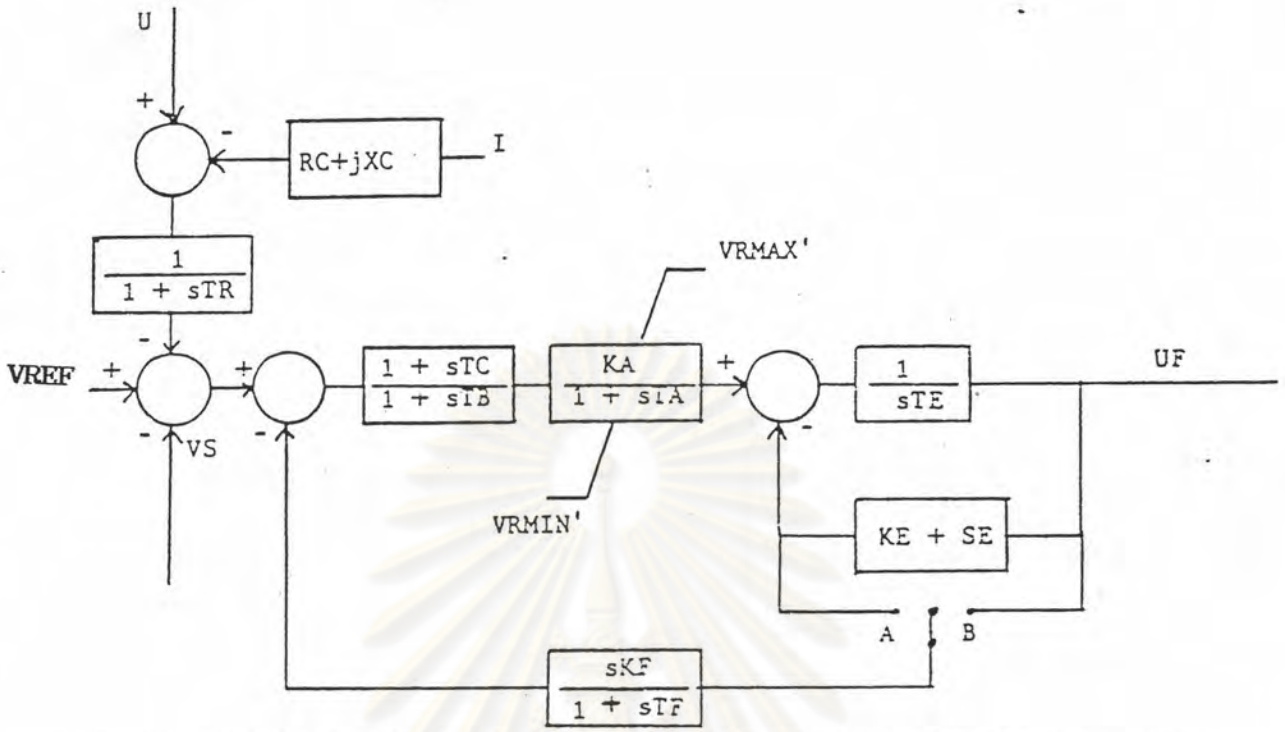


Figure A2.1 Regulator Type 1: Excitation system with DC-generator-Commutator Exciter. Source : Simpow user's manual.

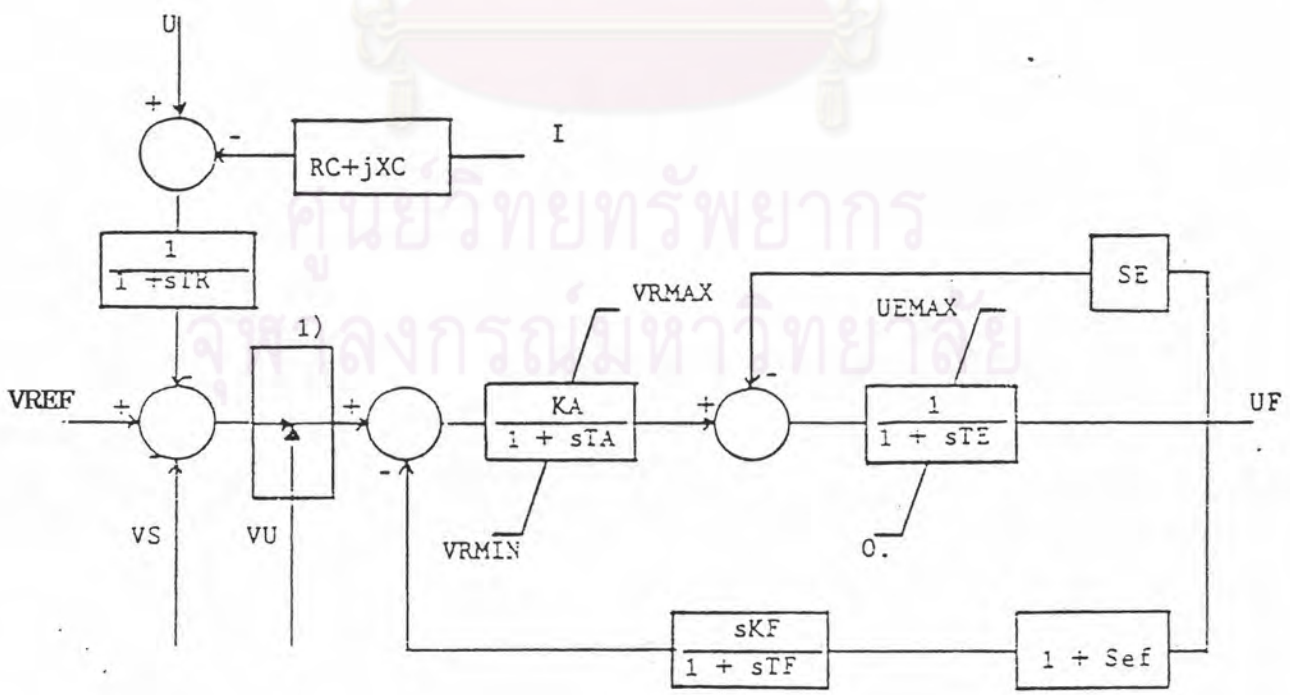


Figure A2.2 Regulator Type **12** Excitation system with Alternator rectifier Exciter. Source : Simpow user's manual.

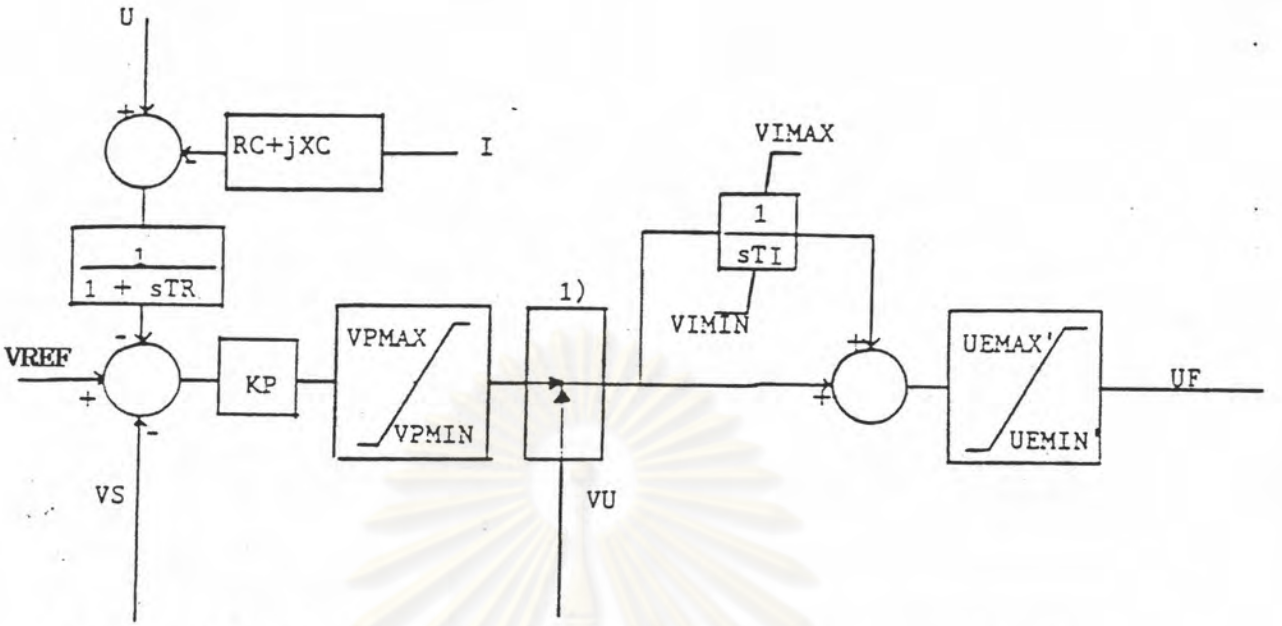


Figure A2.3 Regulator Type 15: The ASEA-excitation system with potential source rectifier Exciter. Source : Simpow user's manual.

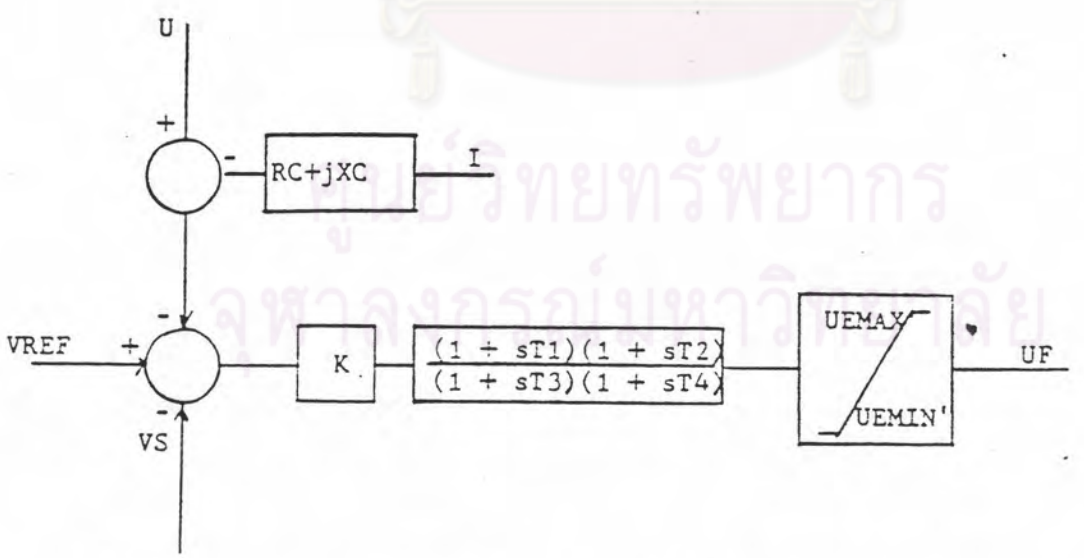


Figure A2.4 Regulator Type BBC1: Static voltage regulator. Source : Simpow user's manual.

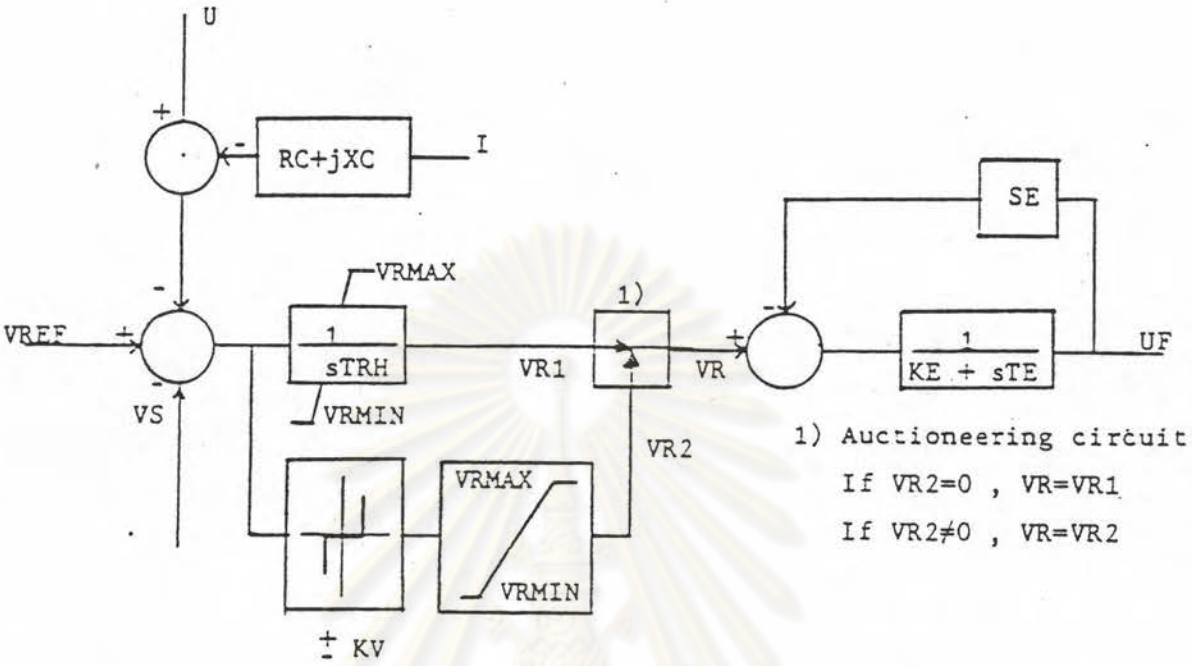


Figure A2.5 Regulator Type 4: Excitation system with DC-generator-Commutator Exciter and Non-Continuosly Acting Regulators.

Source : Simpow user's manual.

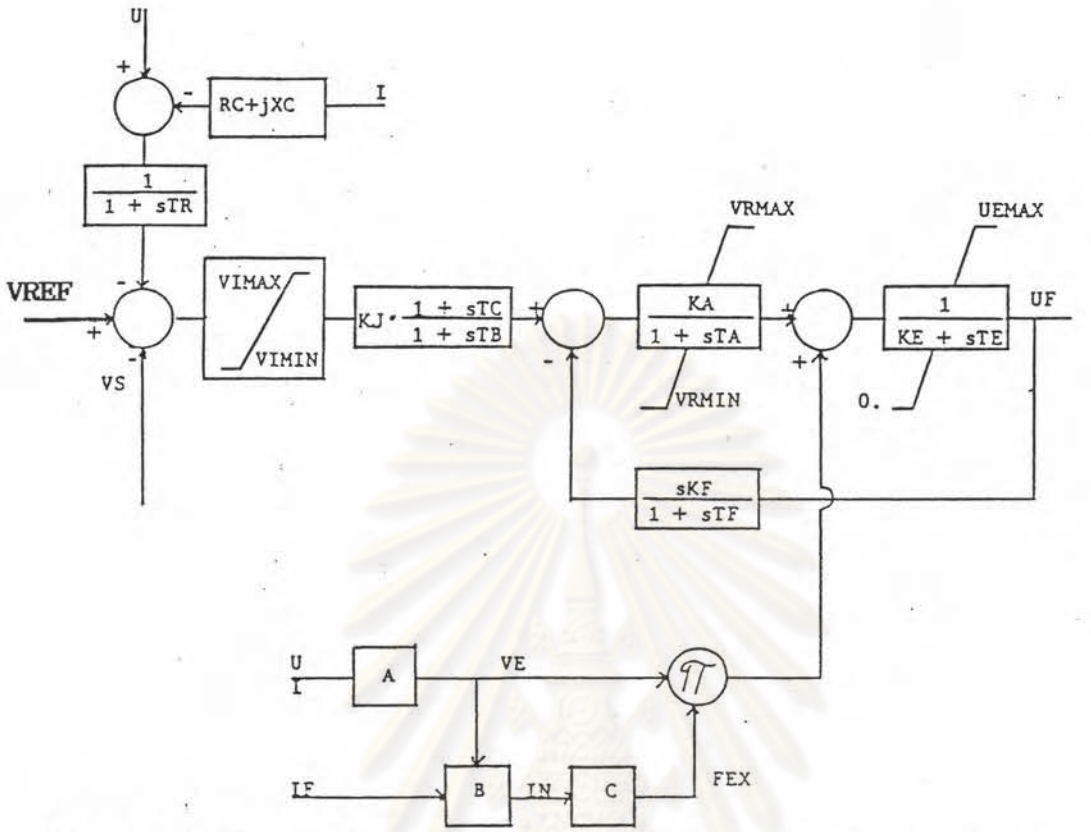


Figure A2.6 Regulator Type ST2: Excitation system with Potentia source Rectifier Exciter. Source : Simpow user's manual.

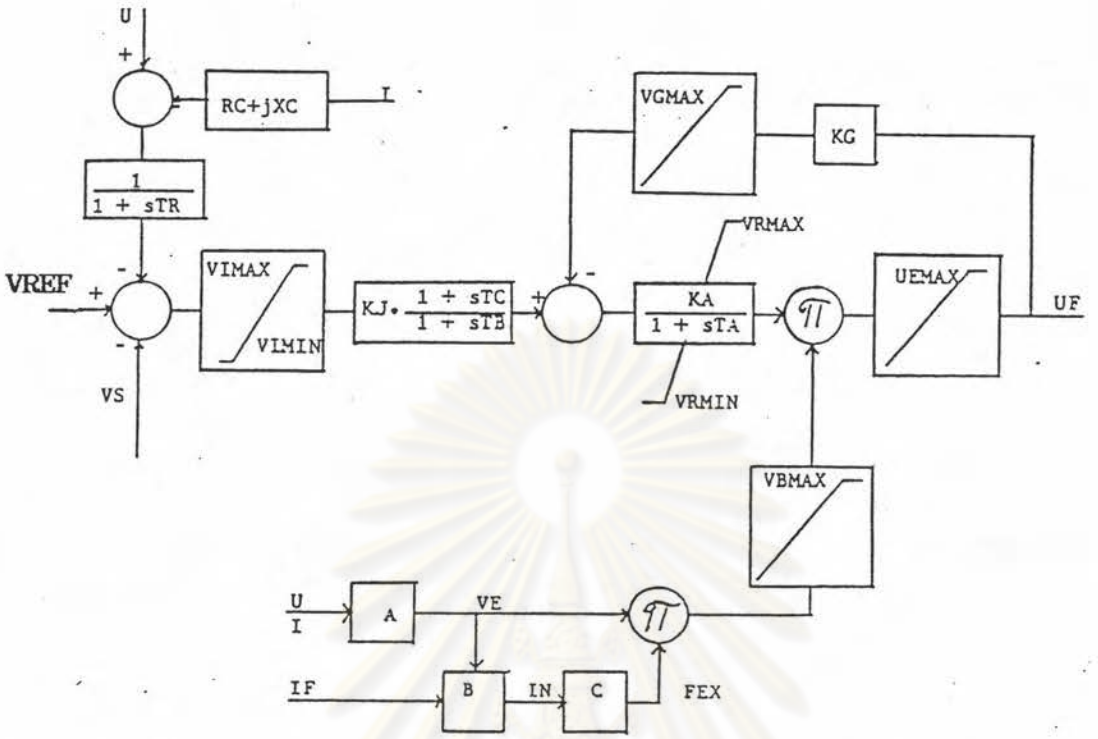


Figure A2.7 Regulator Type ST3: Excitation system with Potentia source Rectifier Exciter. Source : Simpow user's manual.

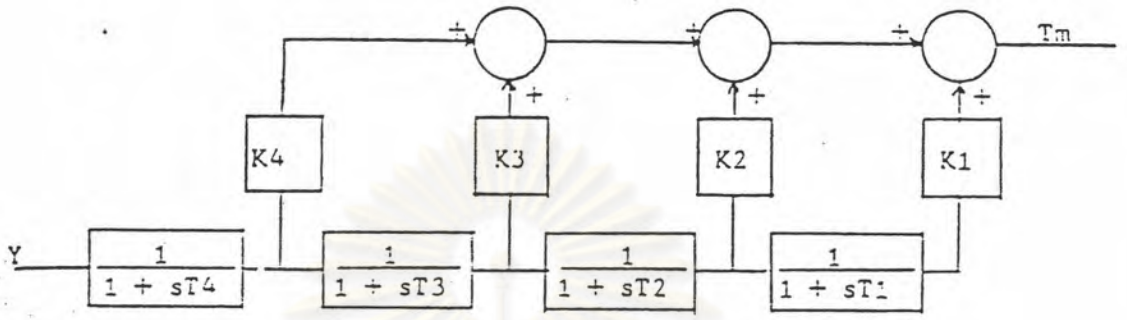


Figure A2.8 Turbine Type ST2: General steam turbine.
Source : Simpow user's manual.

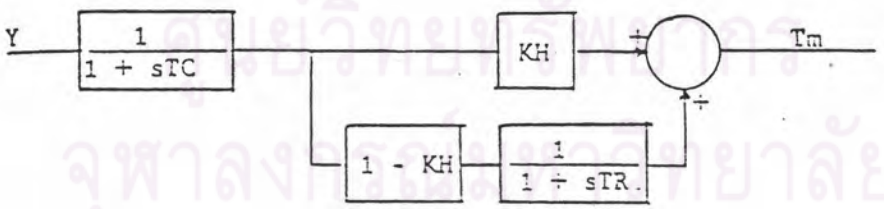


Figure A2.9 Turbine Type ST1: Approximate model of steam turbine. with single reheat. Source : Simpow user's manual.

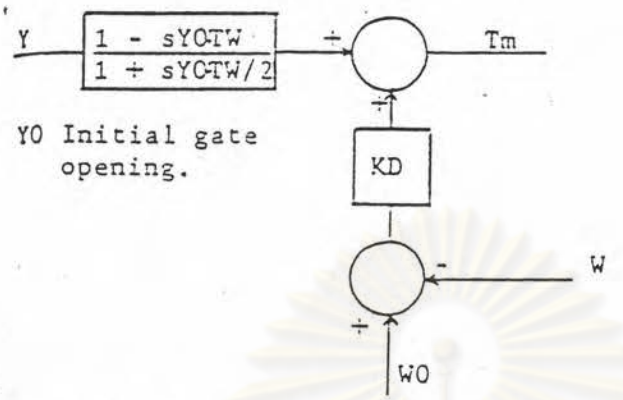


Figure A2.10 Turbine Type HT1: Classical penstock turbine.

Source : Simpow user's manual.

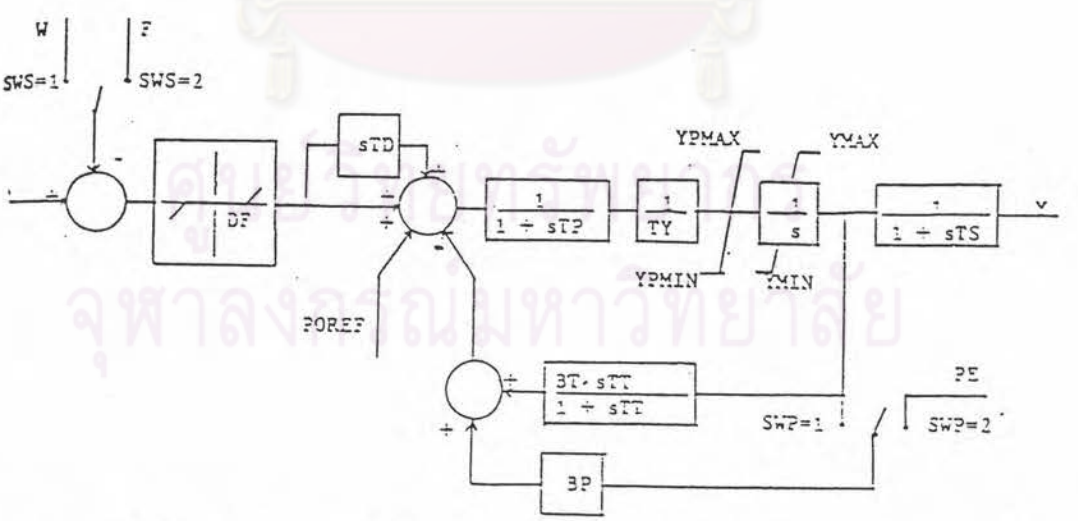


Figure A2.11 Governor Type ST2: General speed-governing model.

Source : Simpow user's manual.

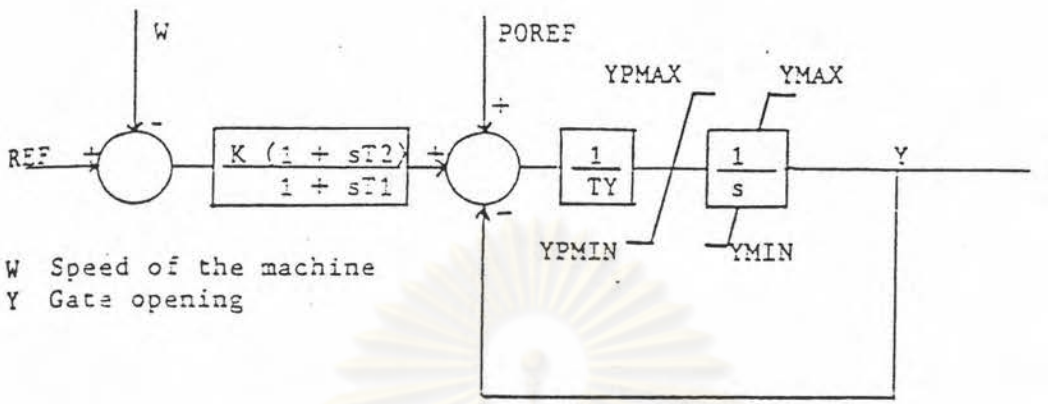


Figure A2.12 Governor Type SG2: Approximate speed-governing model (steam turbine). Source : Simpow user's manual.

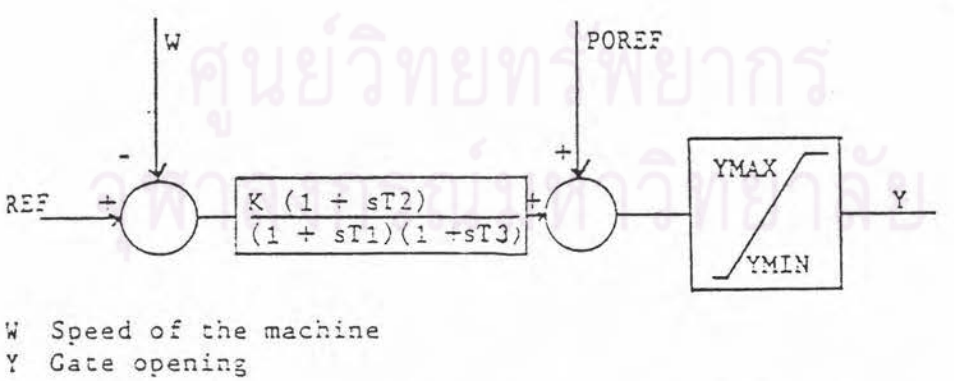


Figure A2.13 Governor Type SG3: Approximate speed-governing model (hydro turbine). Source : Simpow user's manual.

APPENDIX 3

The solution of transient stability studies of the actual system and the reduced system.

SYMBOLS USES IN APPENDIX 3

SYMBOL	DESCRIPTION
NODE XXXX U POS. KV	Positive sequence voltage of XXXX bus in kilovolt.
LINE XXXX YYYY 1 P1 POWER MW	Positive sequence power flows on line no 1 from XXX bus to YYY bus in maggawatt.
SYNC XXXX TETA DEGREES RELATIVE TO YYYY	Rotor angle movement of XXXX generator relative to rotor angle of YYYY generator in degrees.
SYNC XXXX SPEED PU.	Frequency of generator XXXX in per unit.
XXXX , YYYY	NAME OF COMPONENT

Table A3 The symbols used in appendix 3

APPENDIX 3.1

Test case no. 1: The three phase fault occured at bus NCO-230. The fault is cleared after 120 ms.

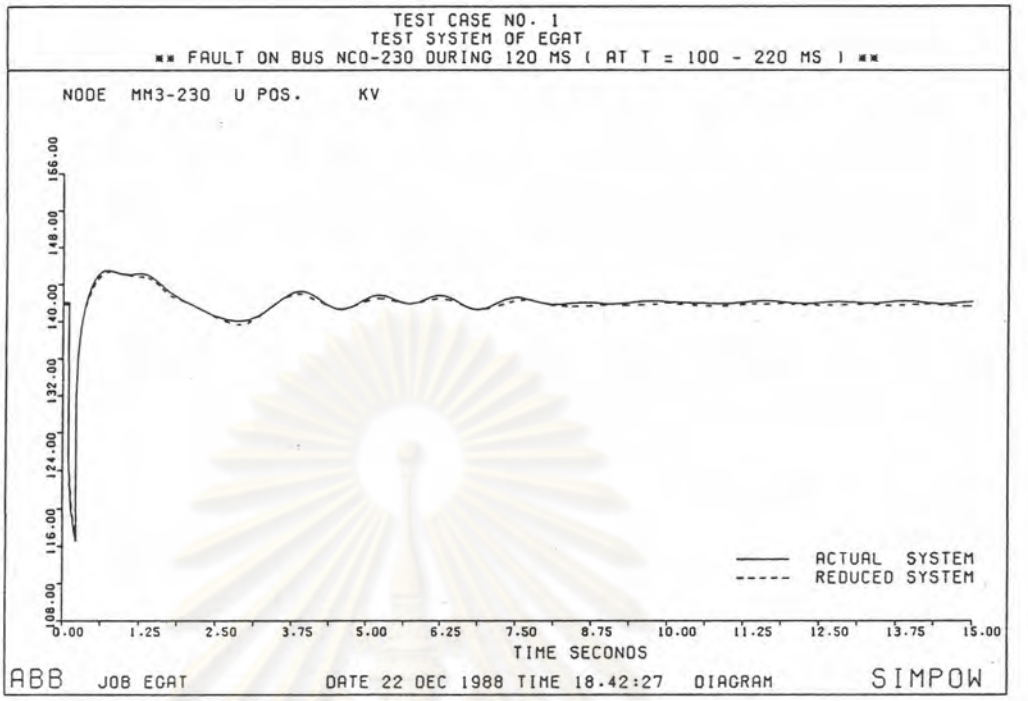


Figure A3.1.1

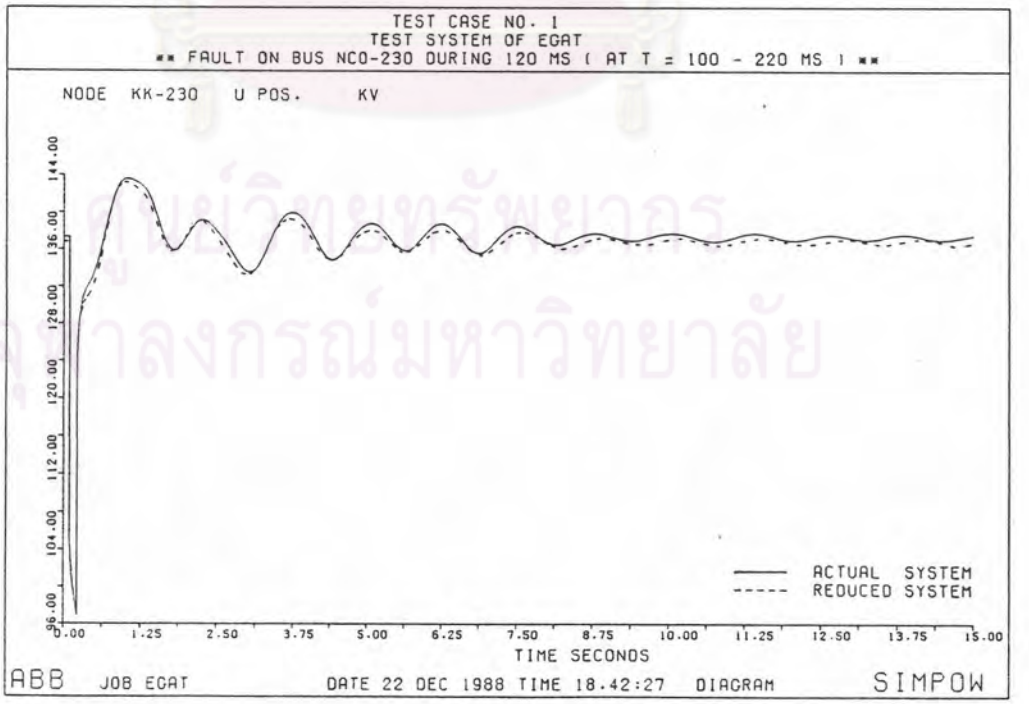


Figure A3.1.2

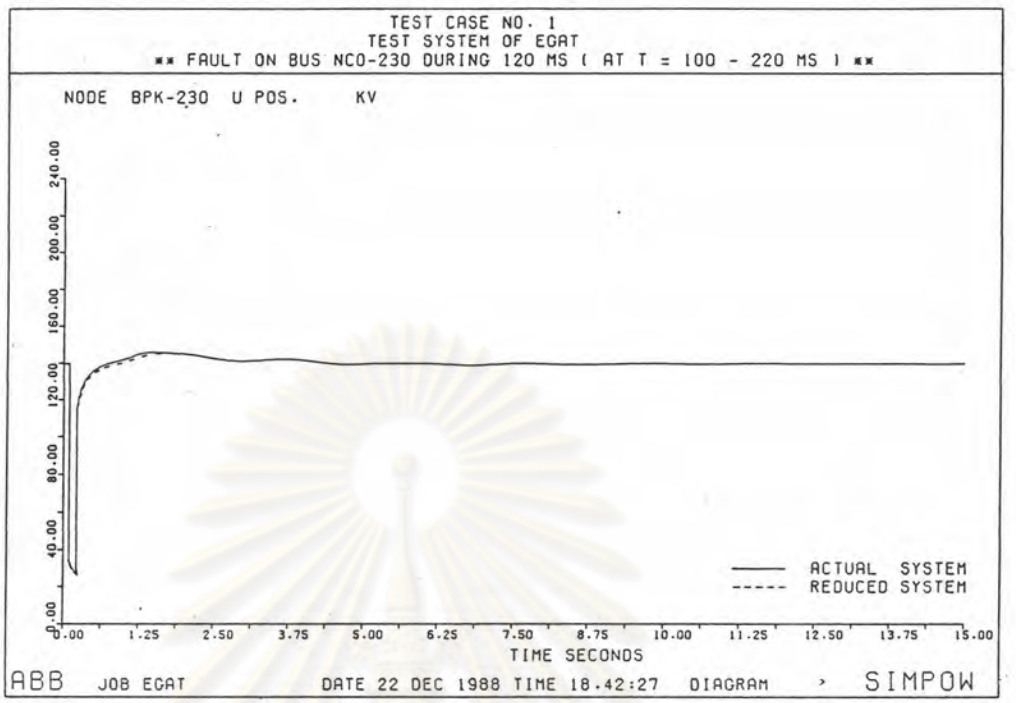


Figure A3.1.3

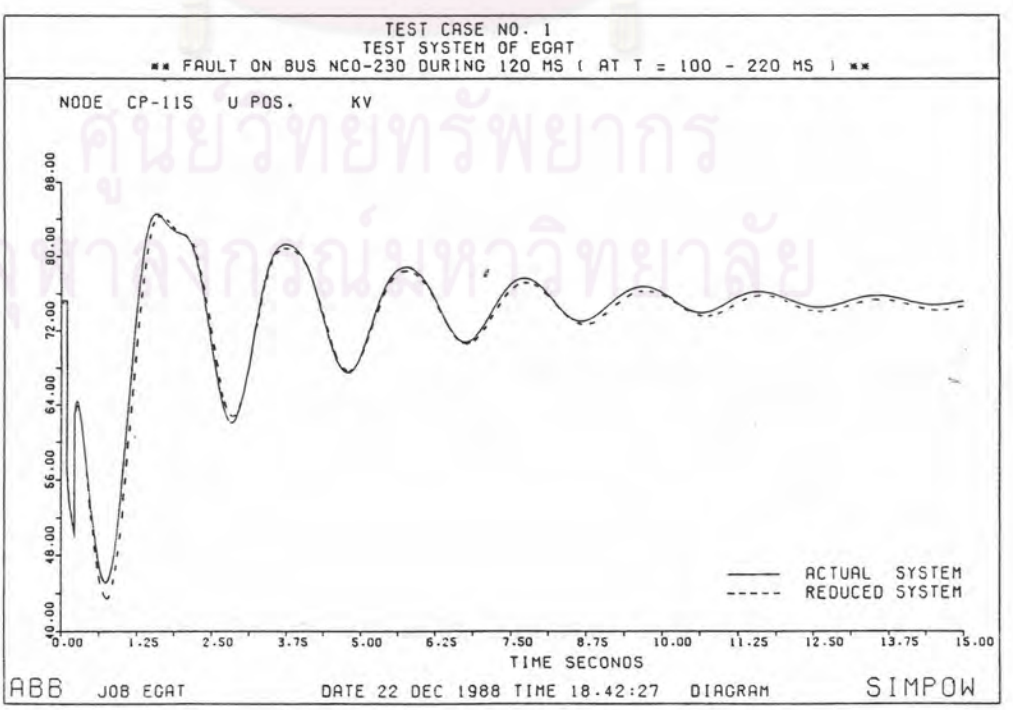


Figure A3.1.4

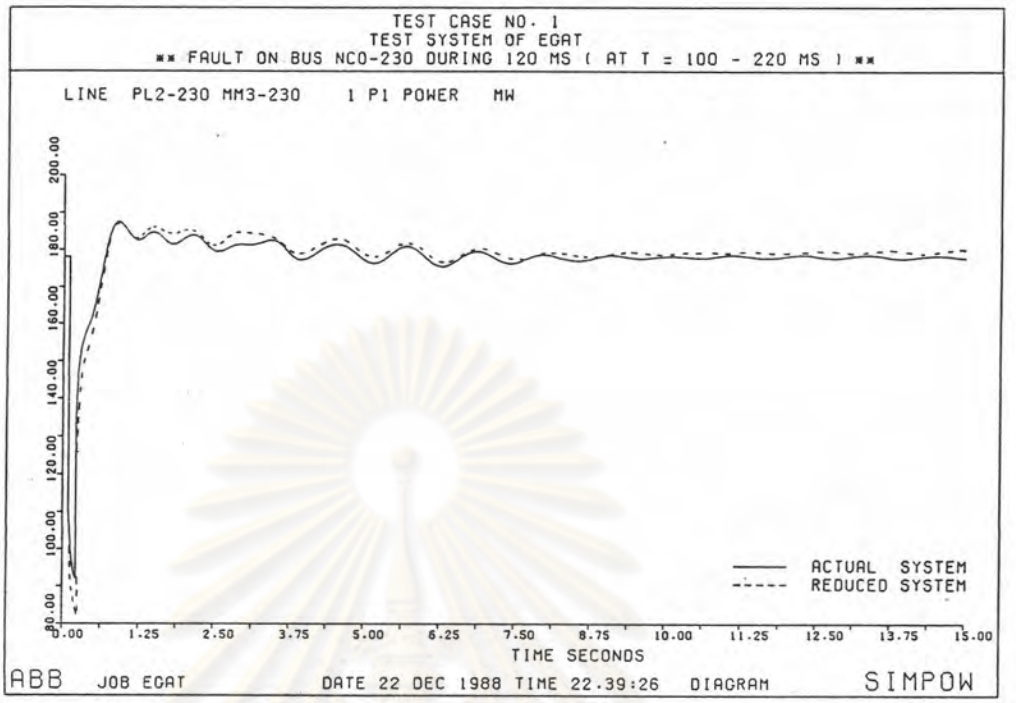


Figure A3.1.5

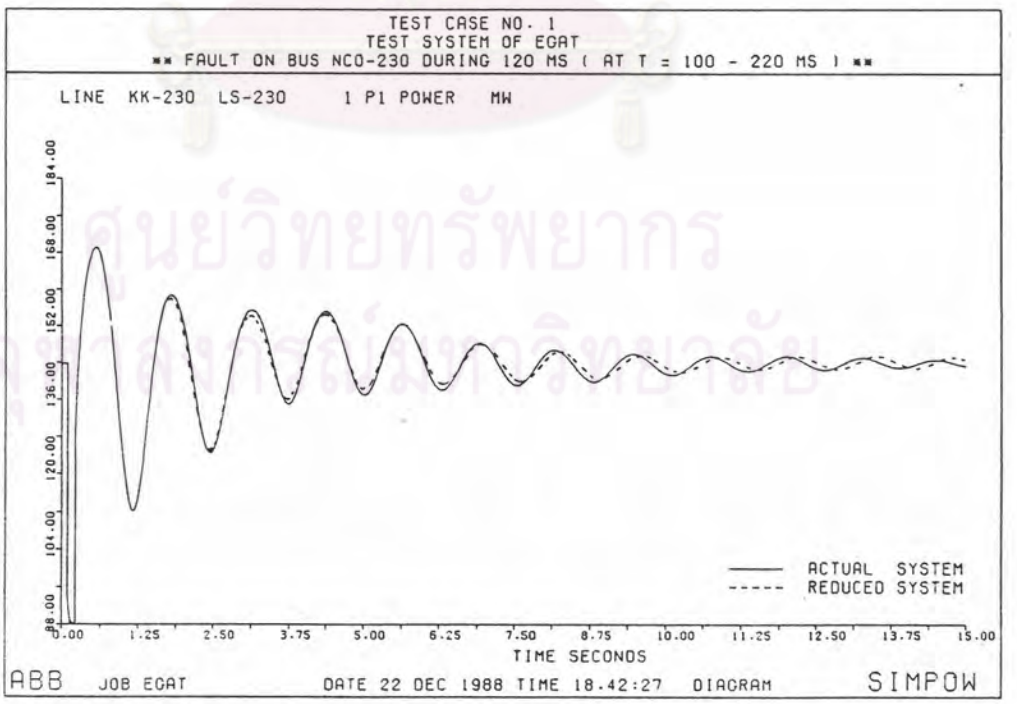


Figure A3.1.6

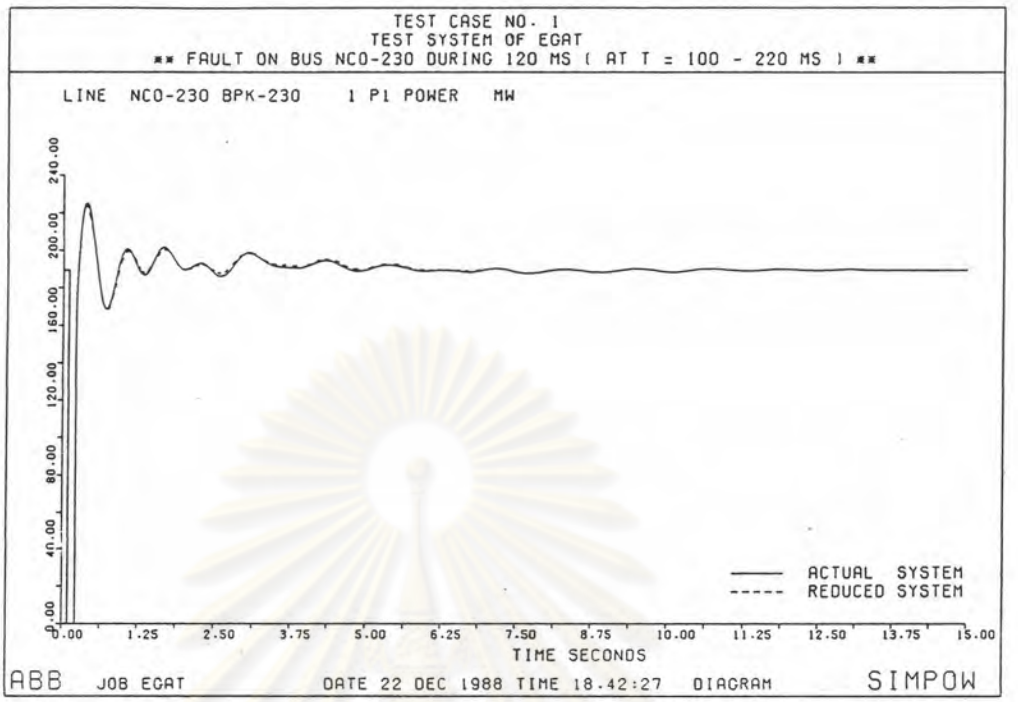


Figure A3.1.7

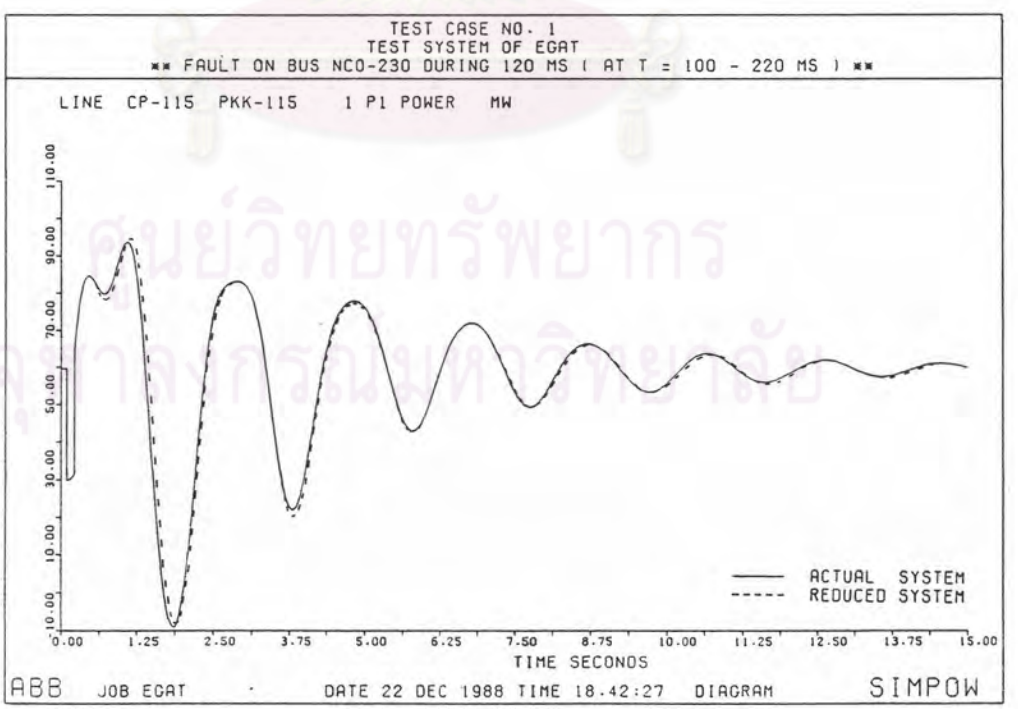


Figure A3.1.8

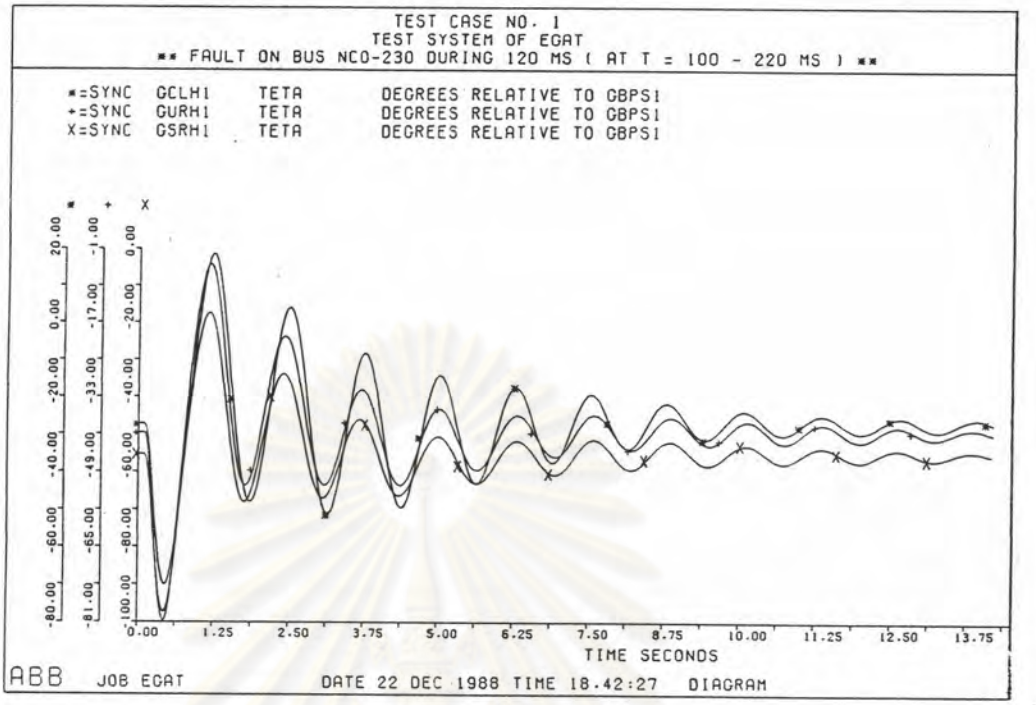
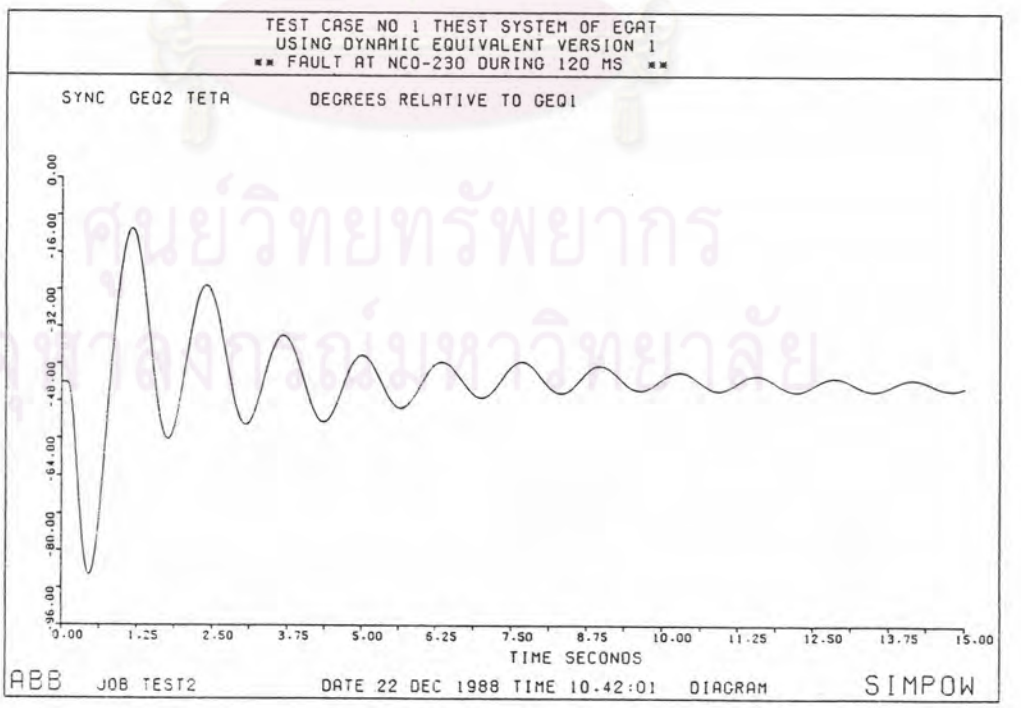


Figure A3.1.9



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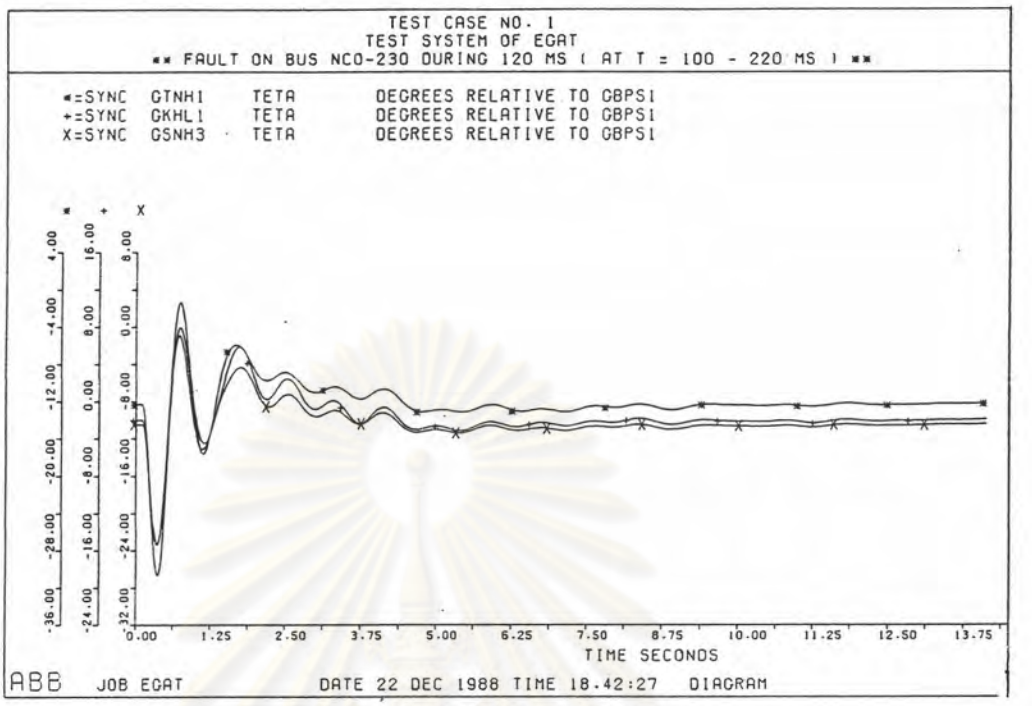


Figure A3.1.11

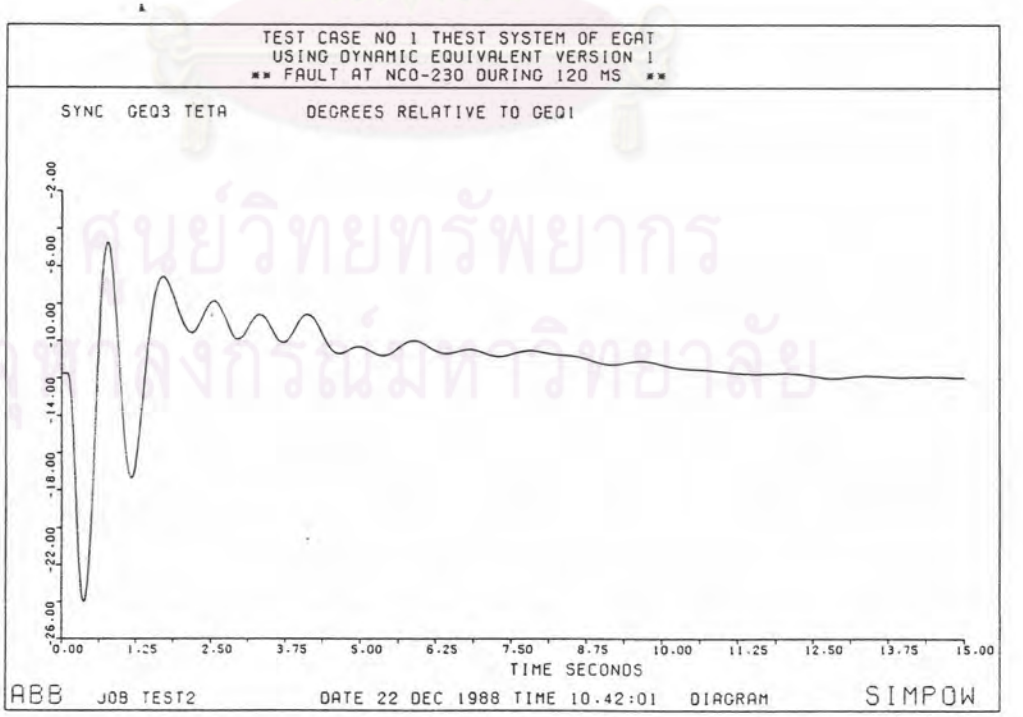


Figure A3.1.12

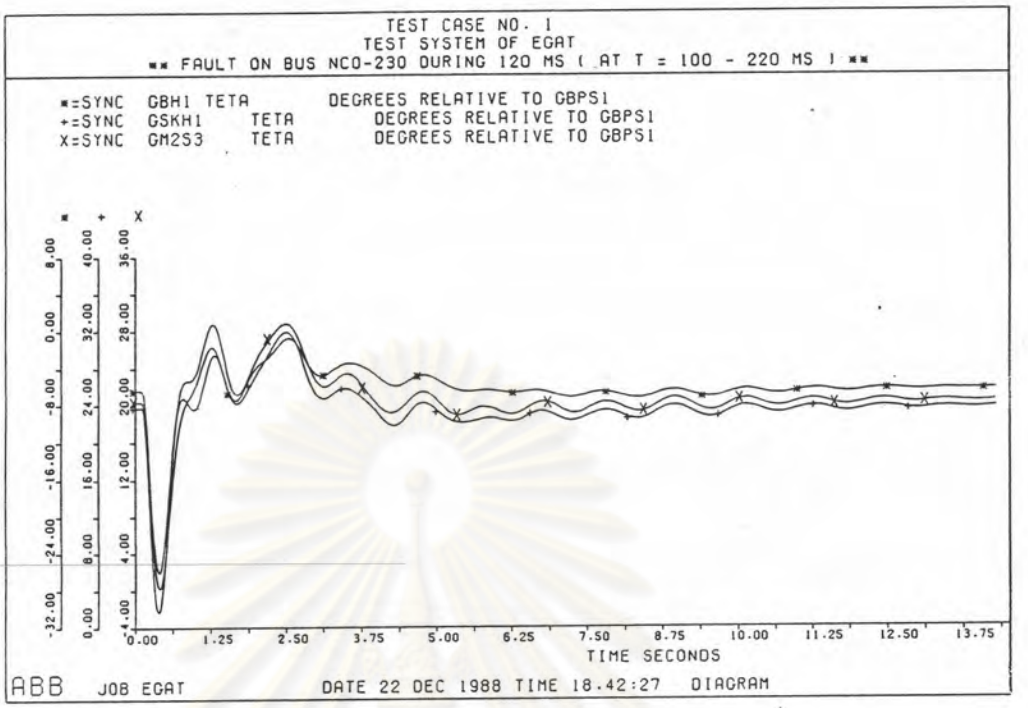


Figure A3.1.13

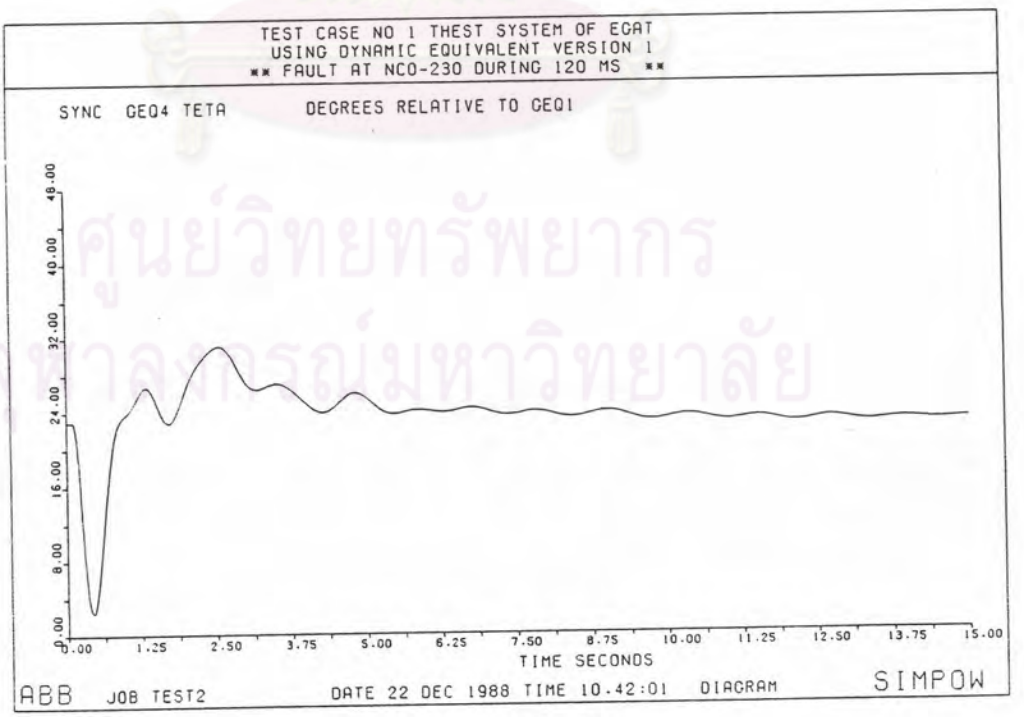
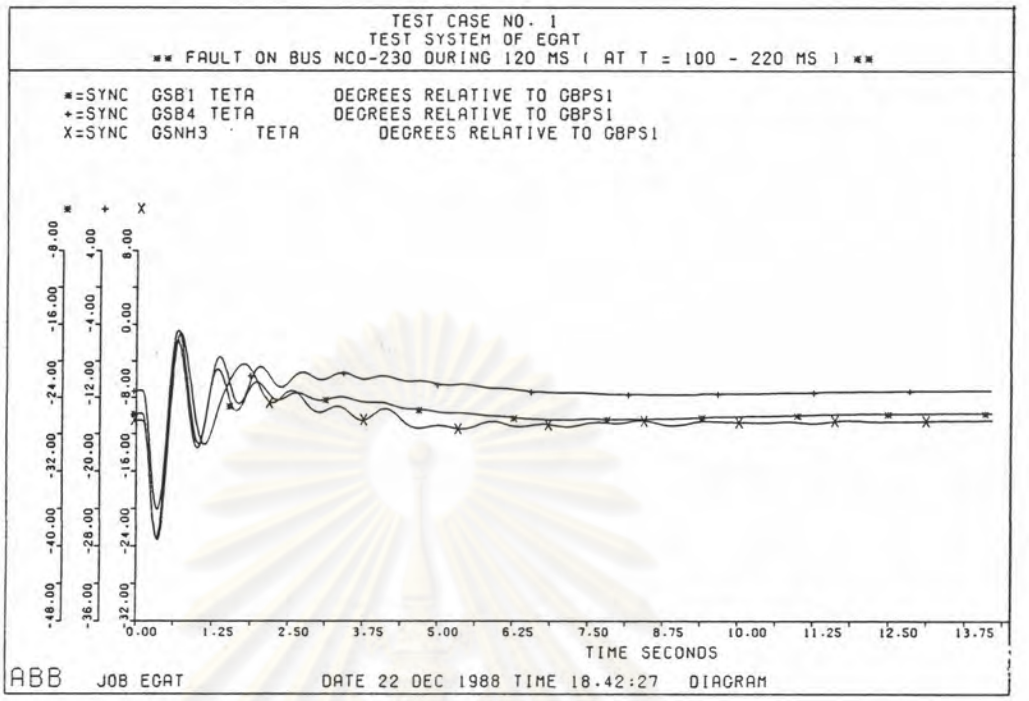


Figure A3.1.14



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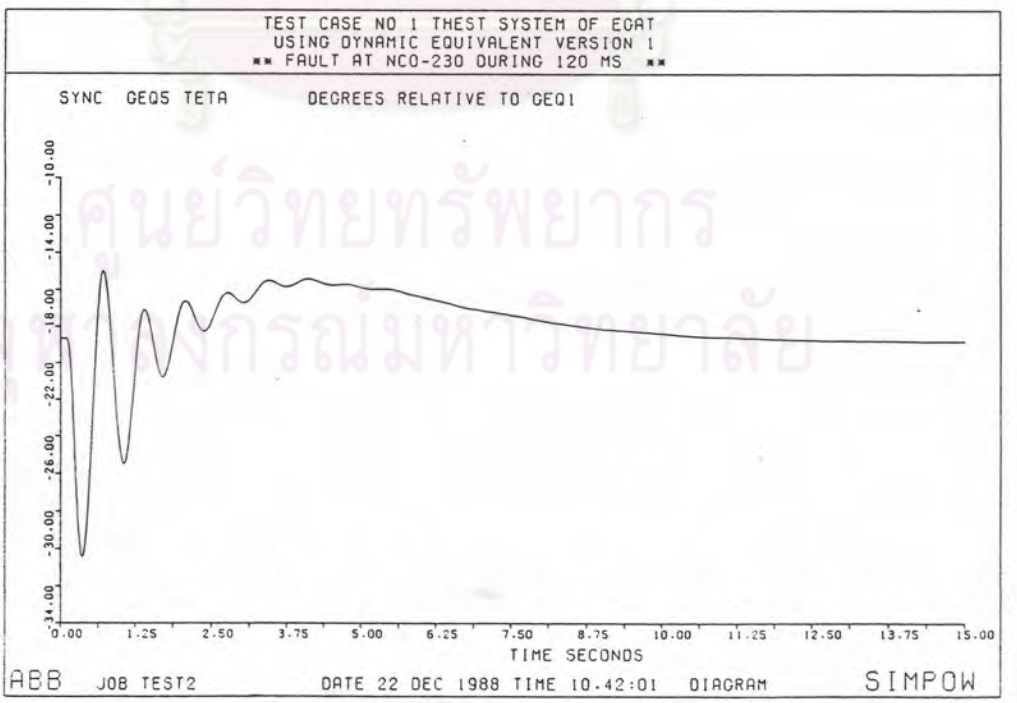

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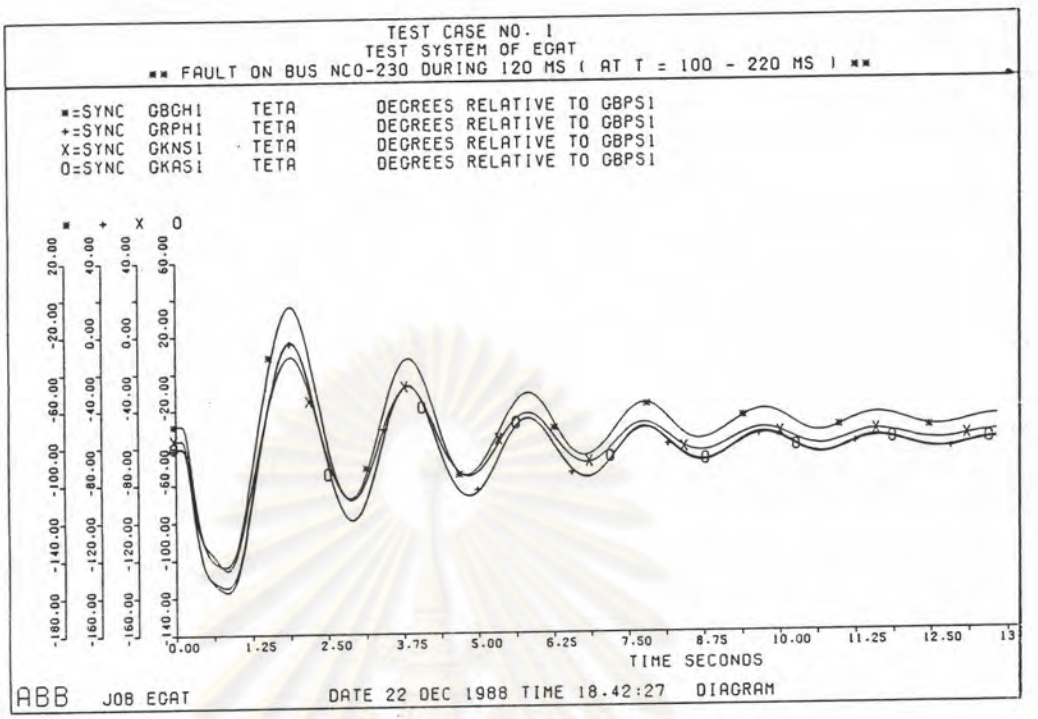

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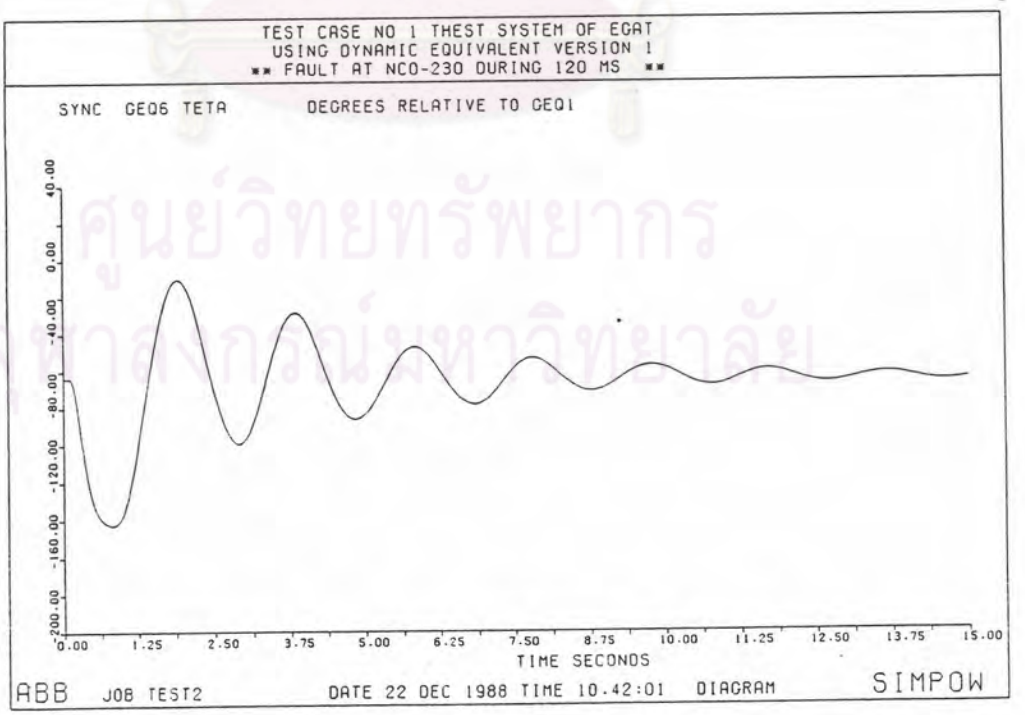


Figure A3.1.18

APPENDIX 3.2

Test case no 2: The three phase fault occured on line no 2 which link between bus PL2-230 and bus MM3-230 near bus PL2-230. The fault is cleared by permanent disconnection the line after 150 ms..

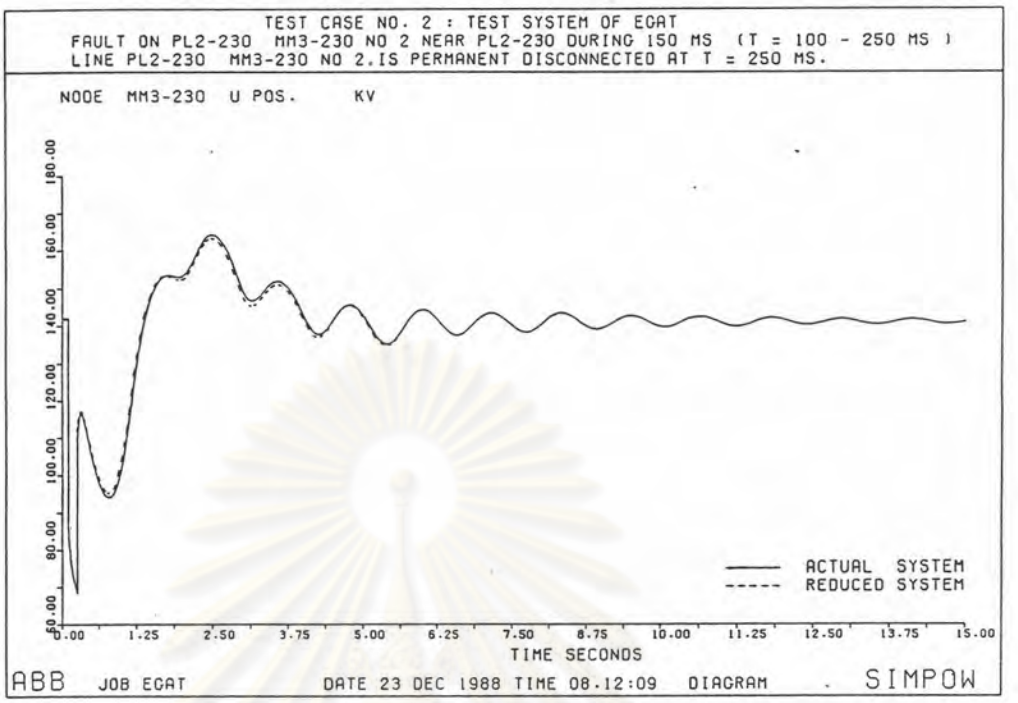


Figure A3.2.1

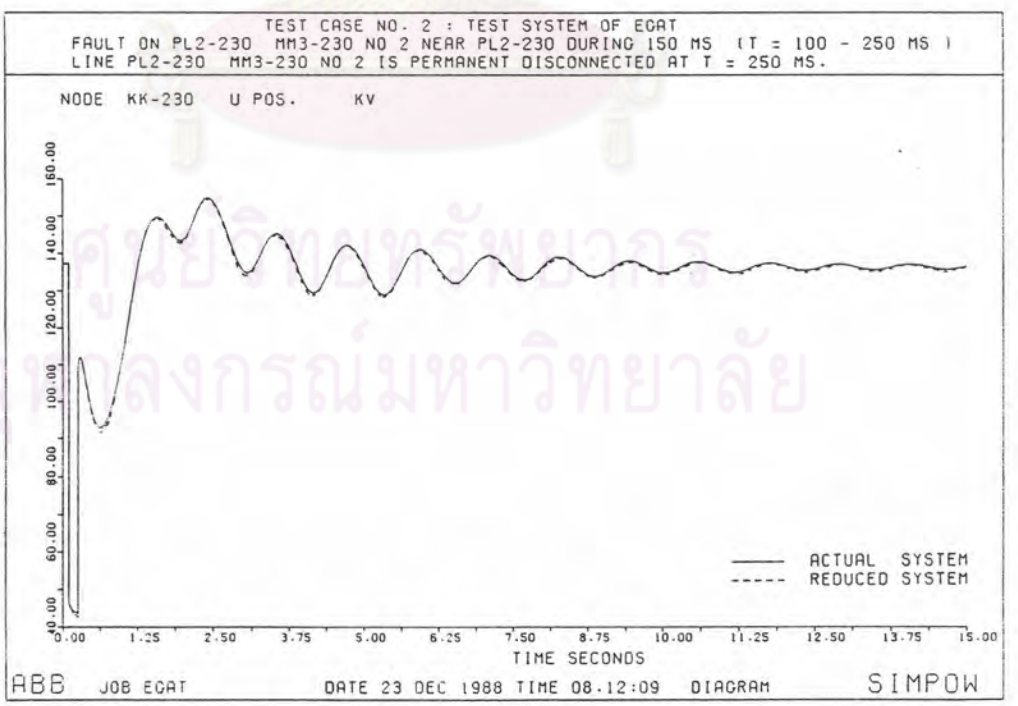
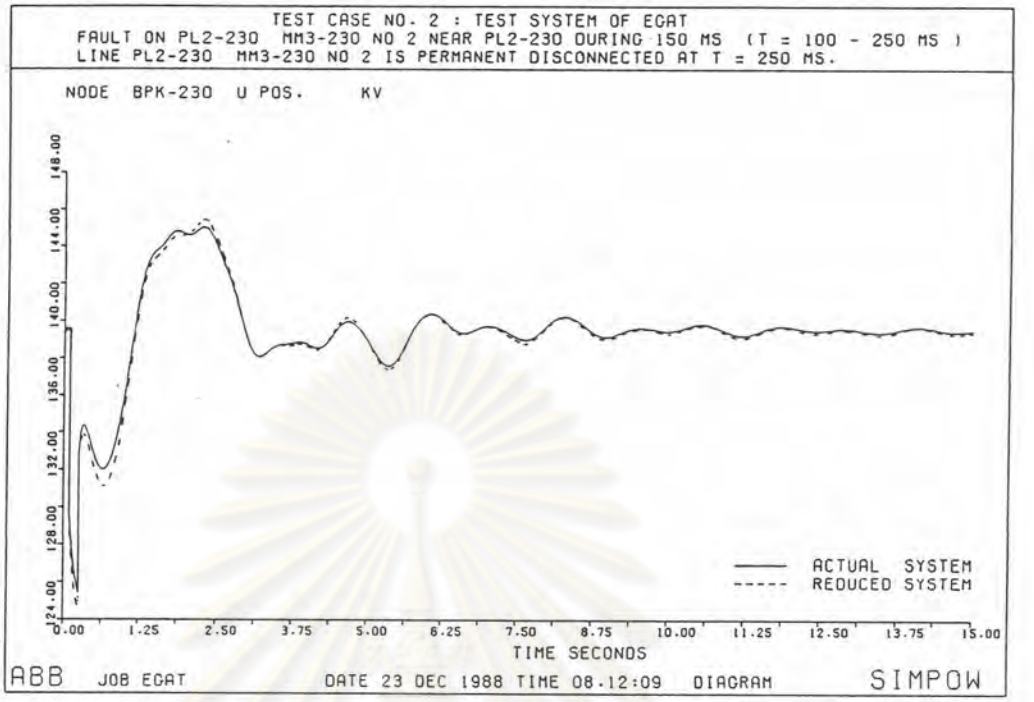


Figure A3.2.2



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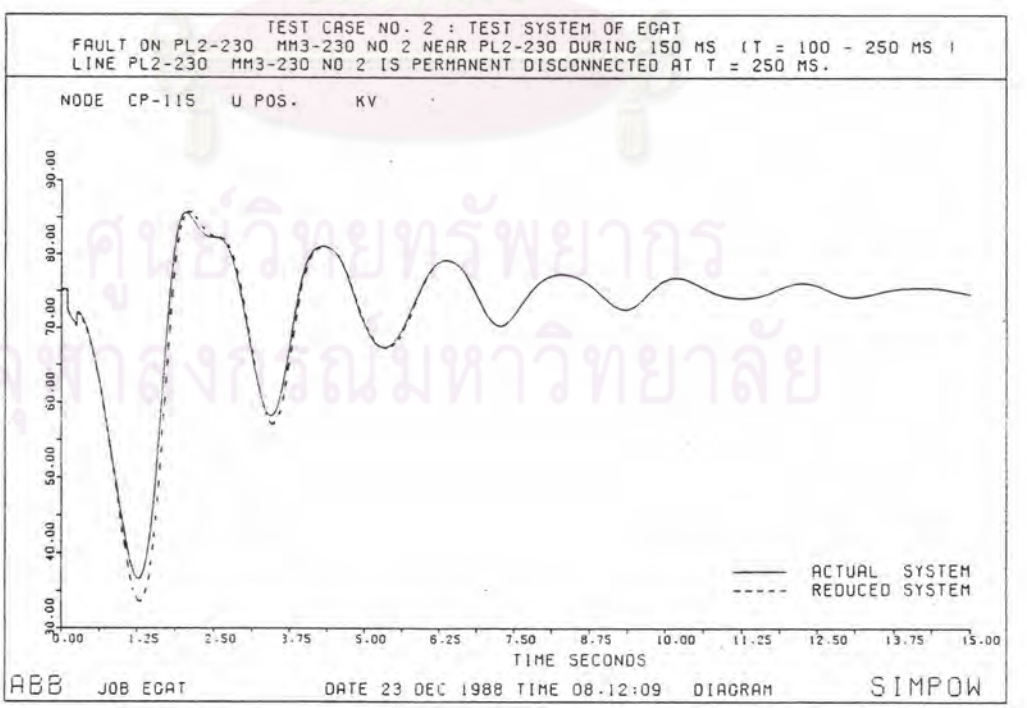

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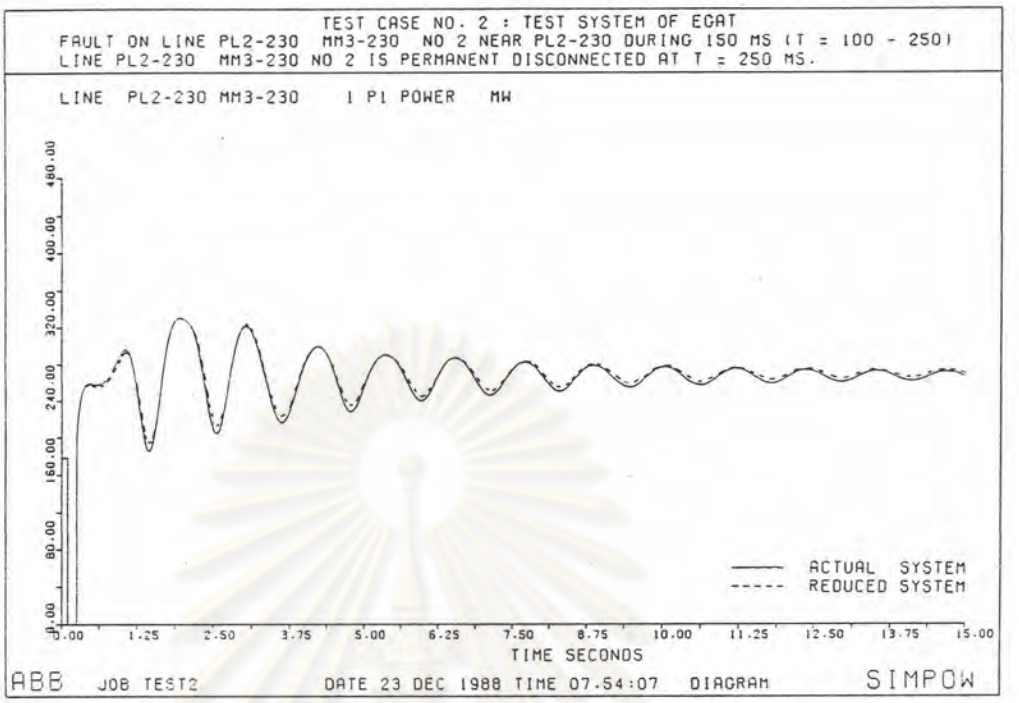

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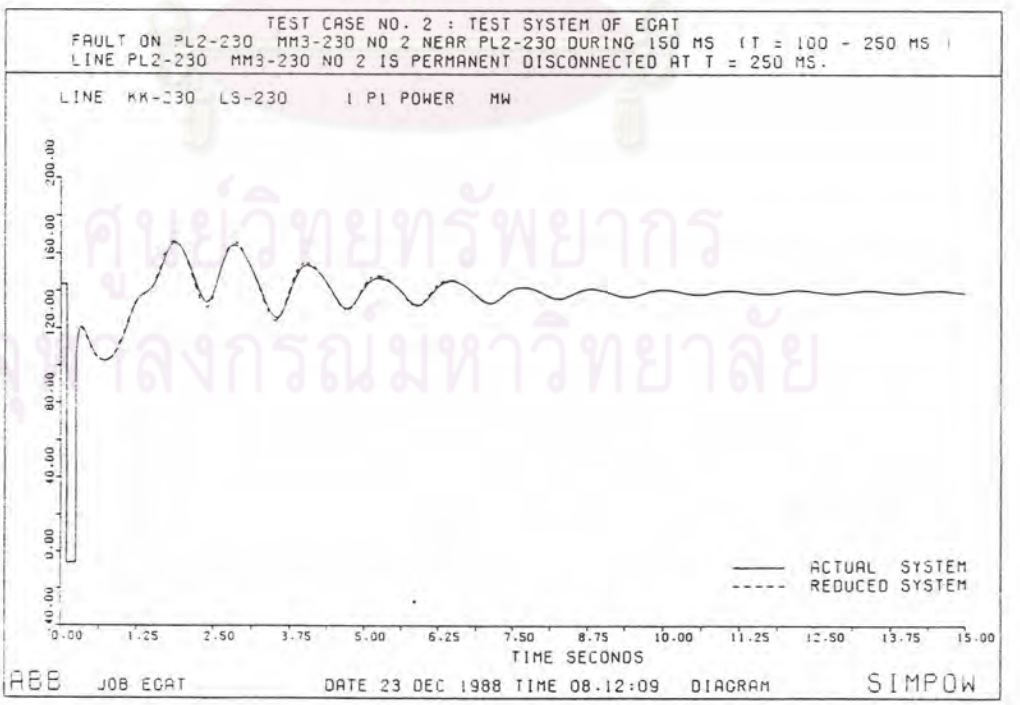
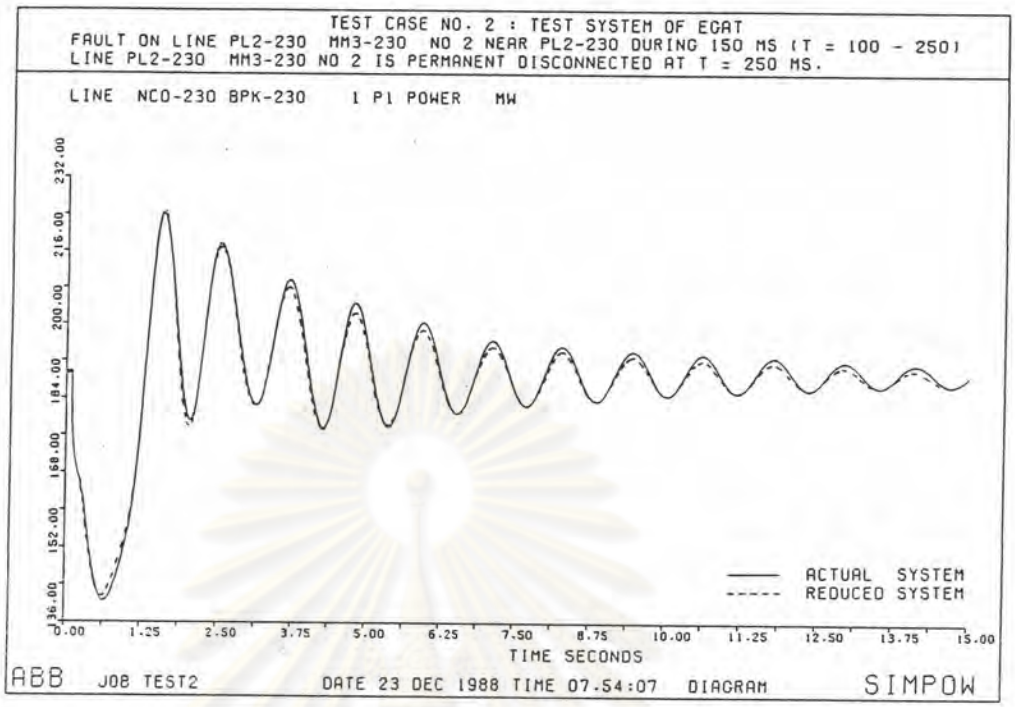


Figure A3.2.6



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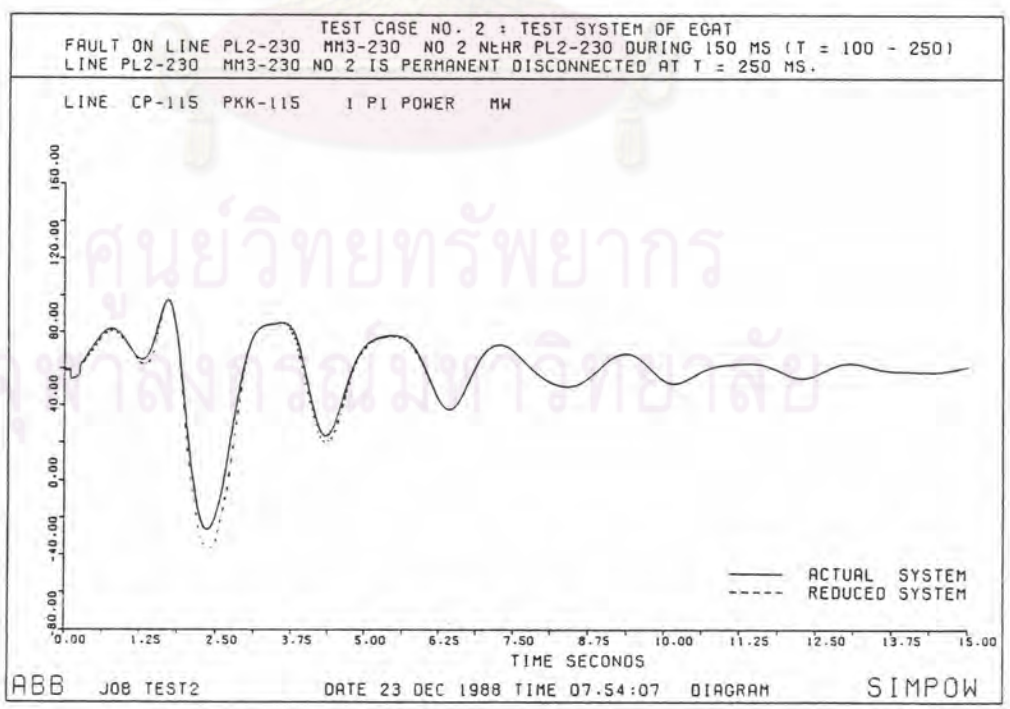

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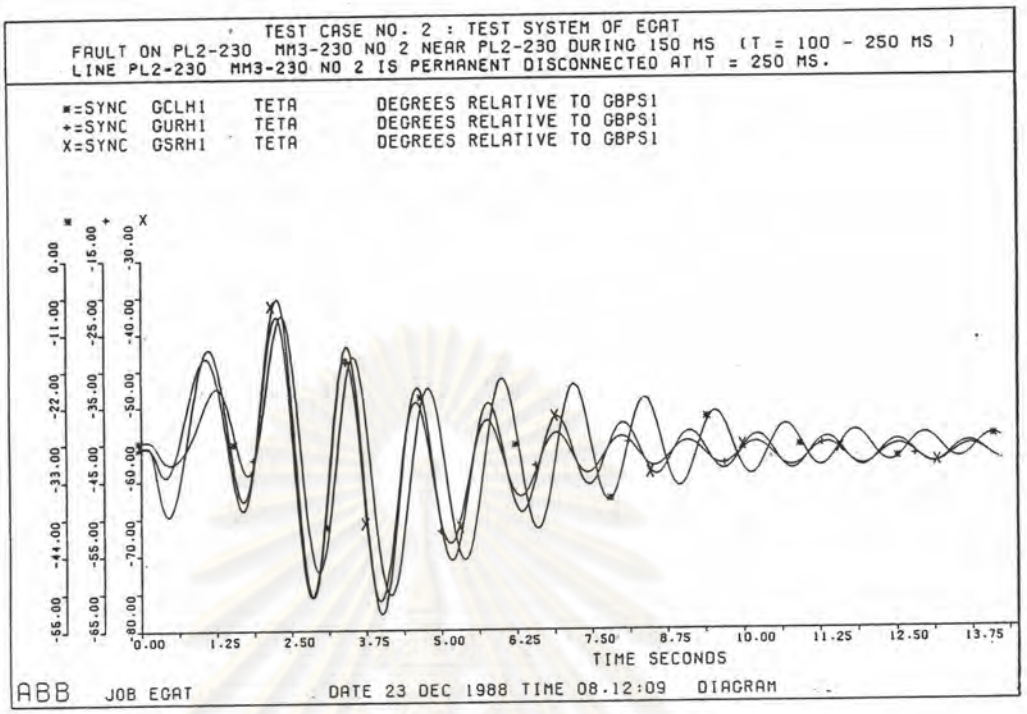

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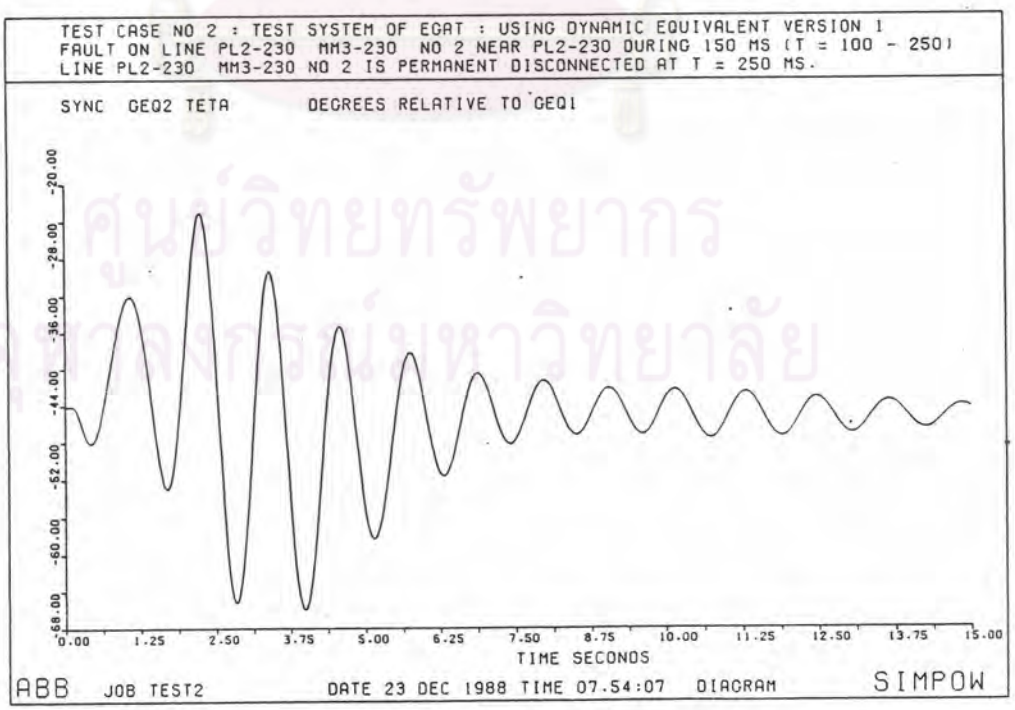

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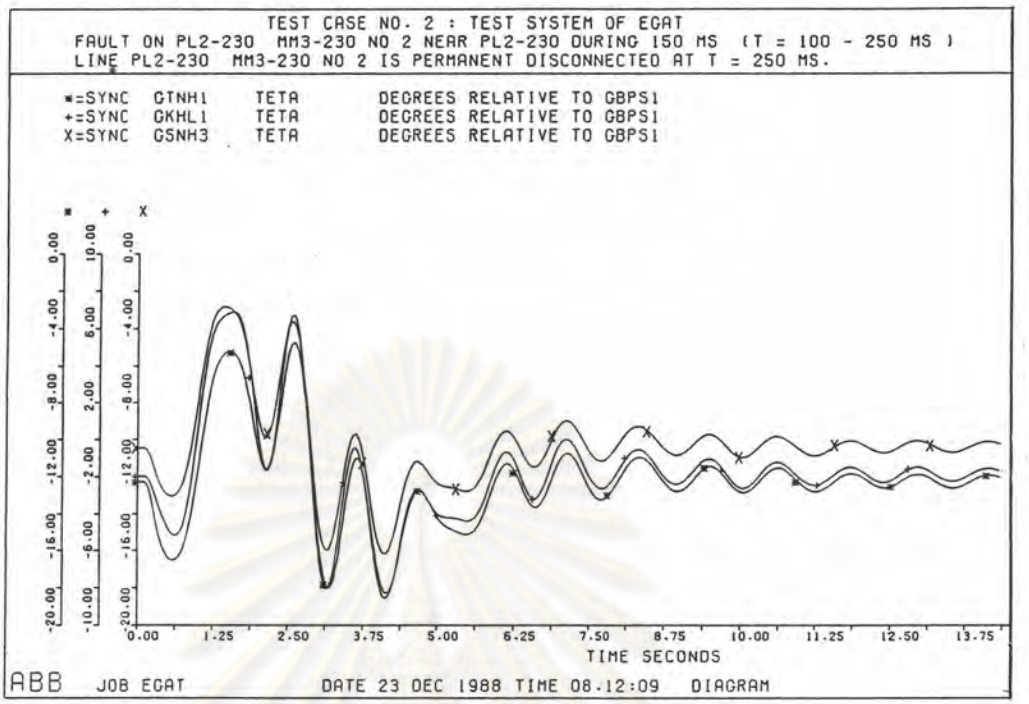
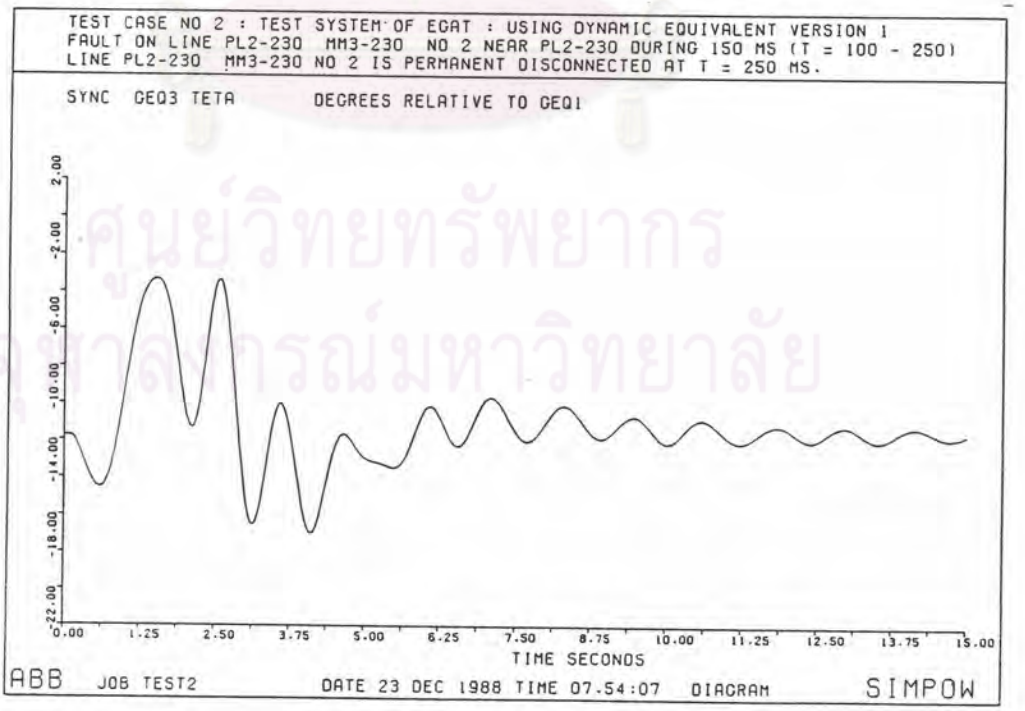


Figure A3.2.11



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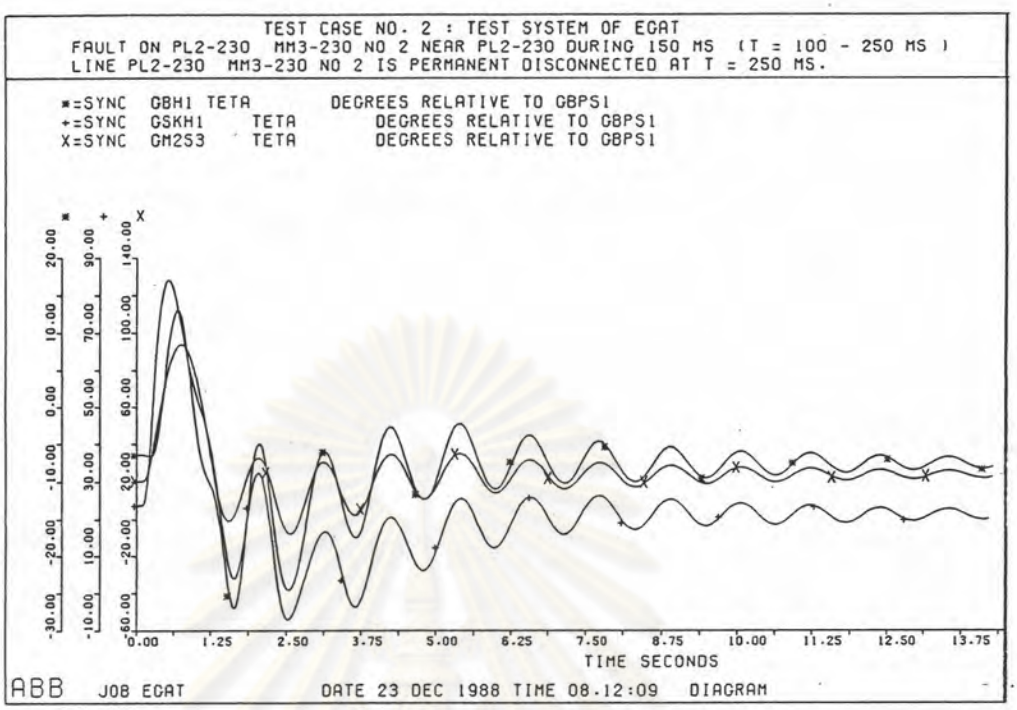
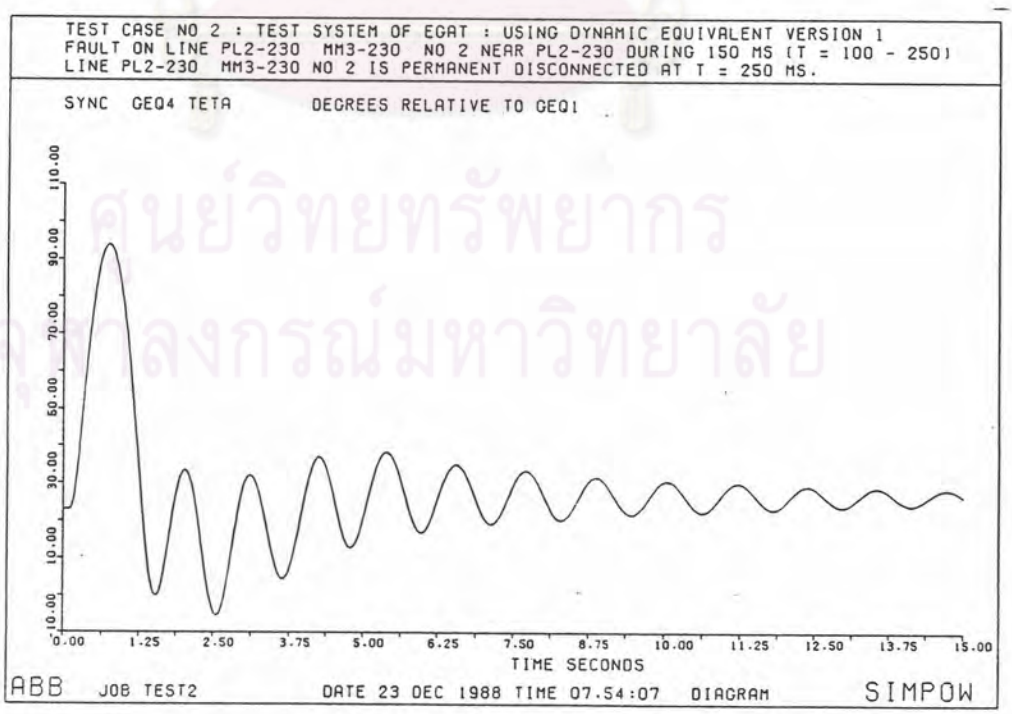


Figure A3.2.13



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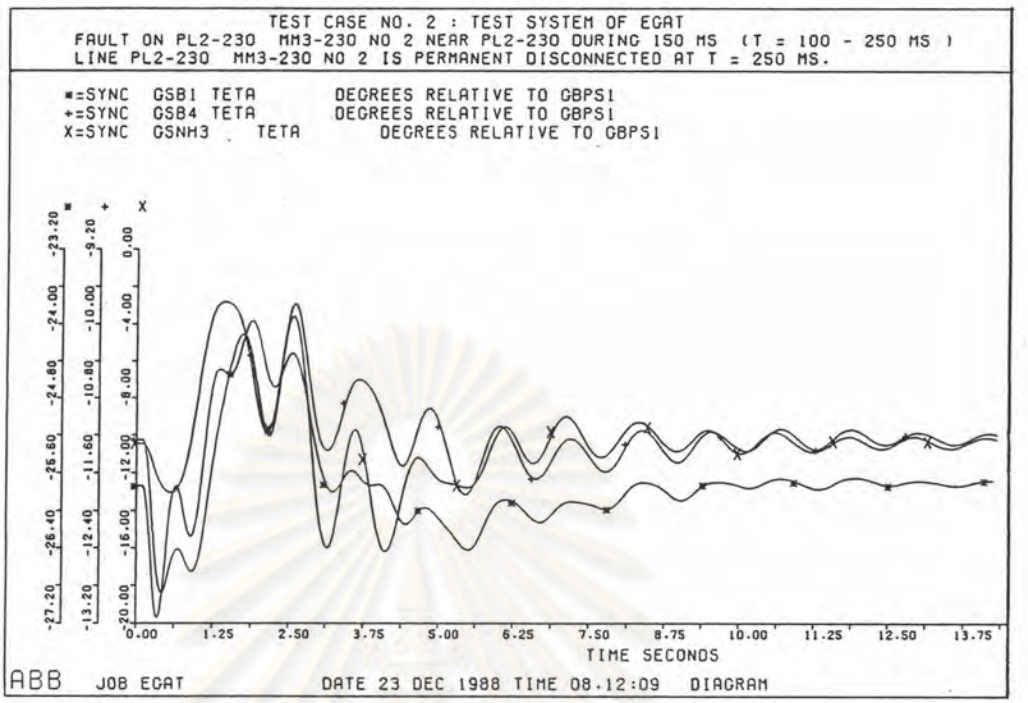
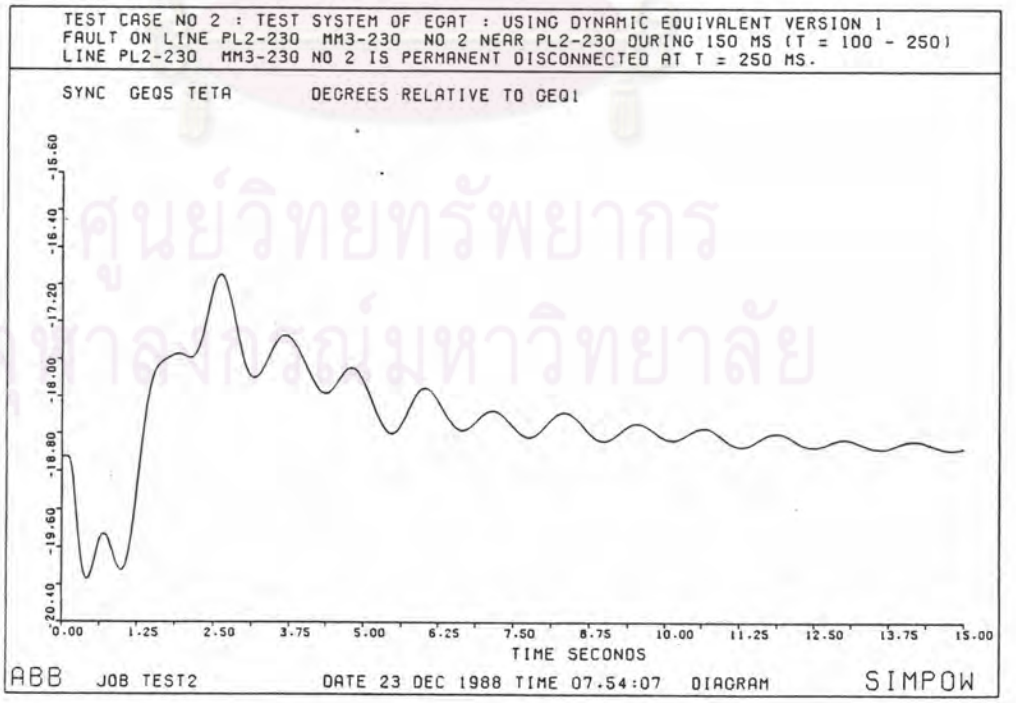


Figure A3.2.15



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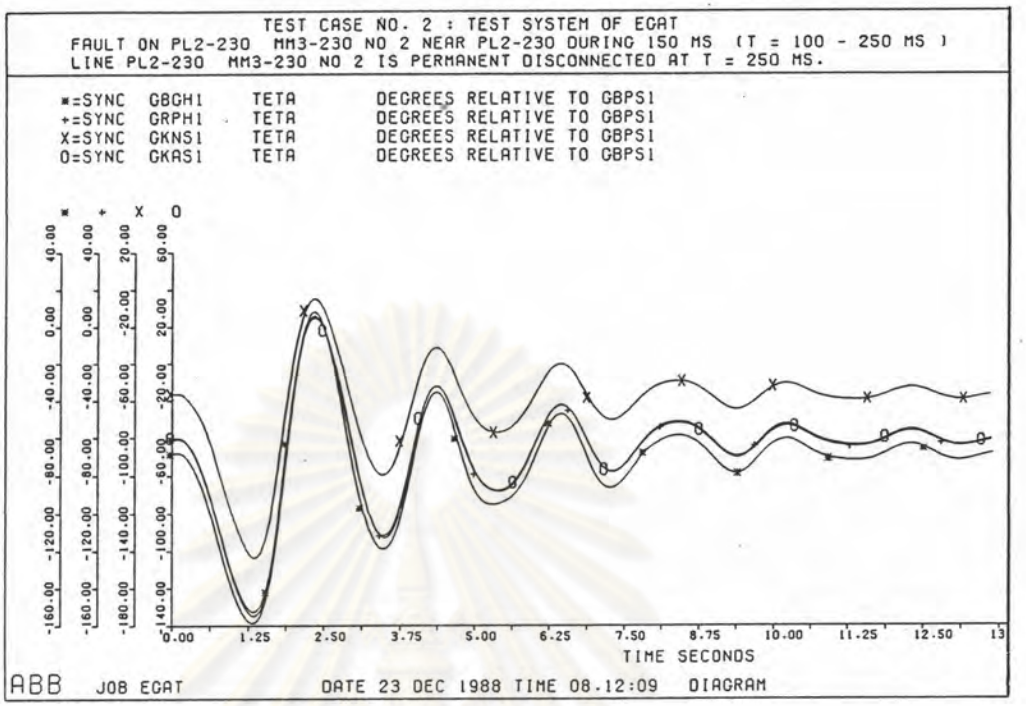

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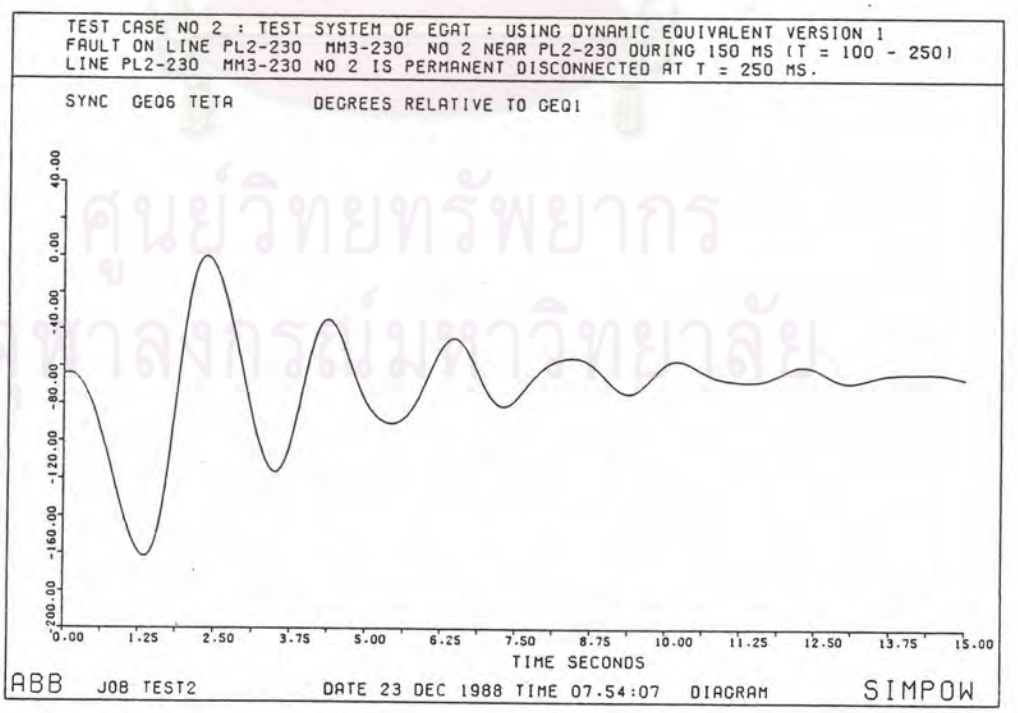


Figure A3.2.18

APPENDIX 3.3

Test case no 3: The three phase fault occured on line no 2 which link between bus CP-115 and bus PPK-115 near bus PPK-115. The fault is cleared by permanent disconnection the line after 150 ms.

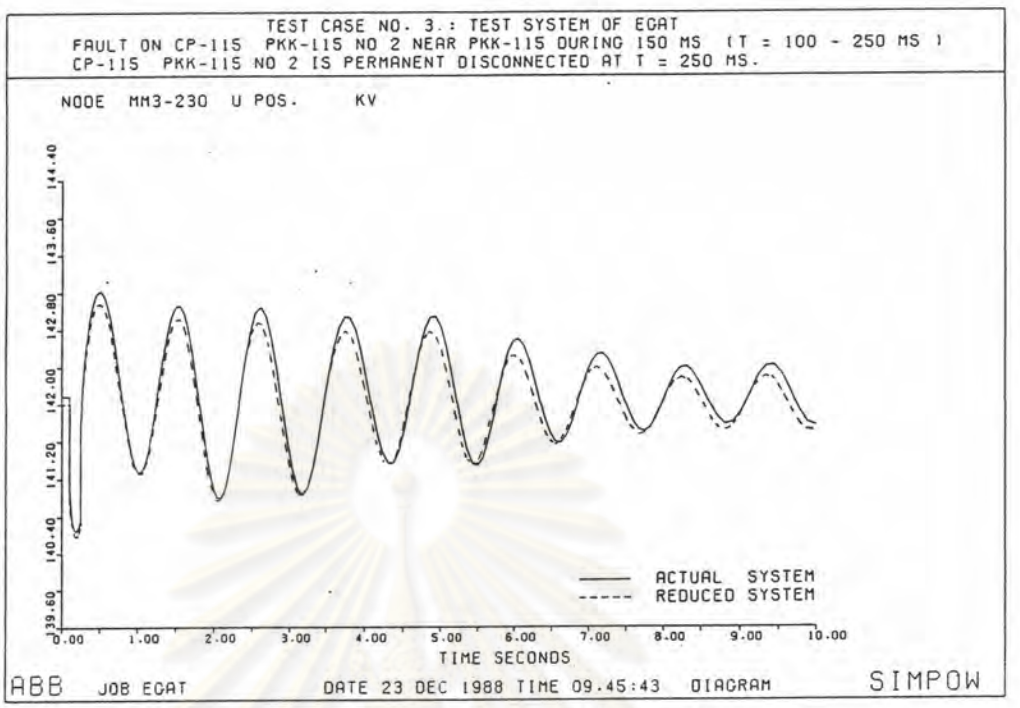


Figure A3.3.1

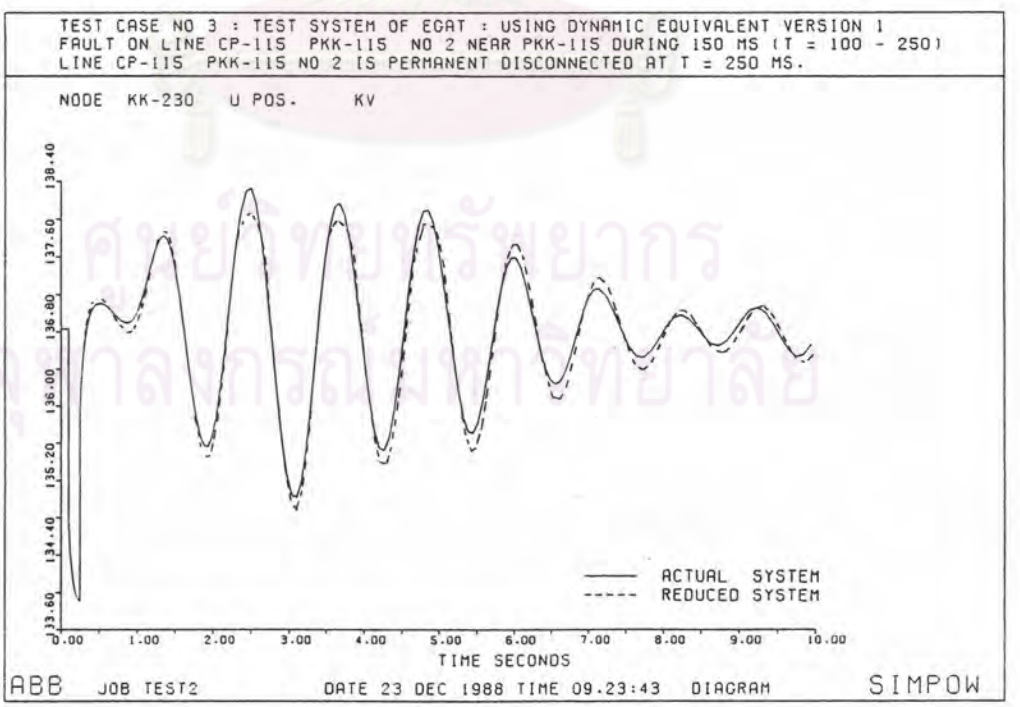


Figure A3.3.2

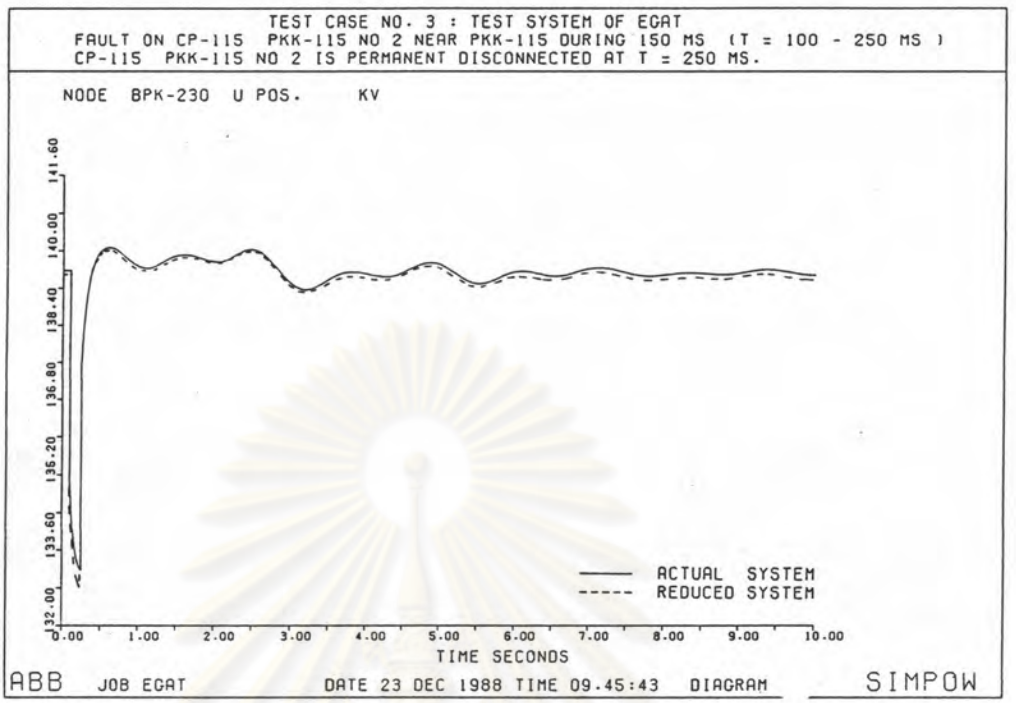


Figure A3.3.3

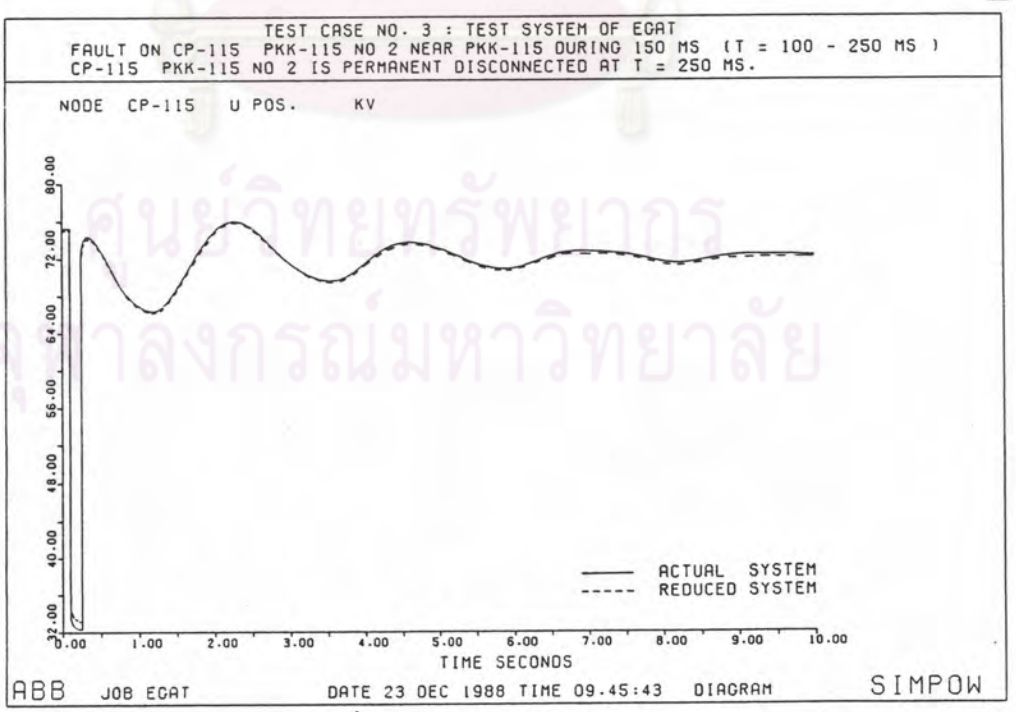


Figure A3.3.4

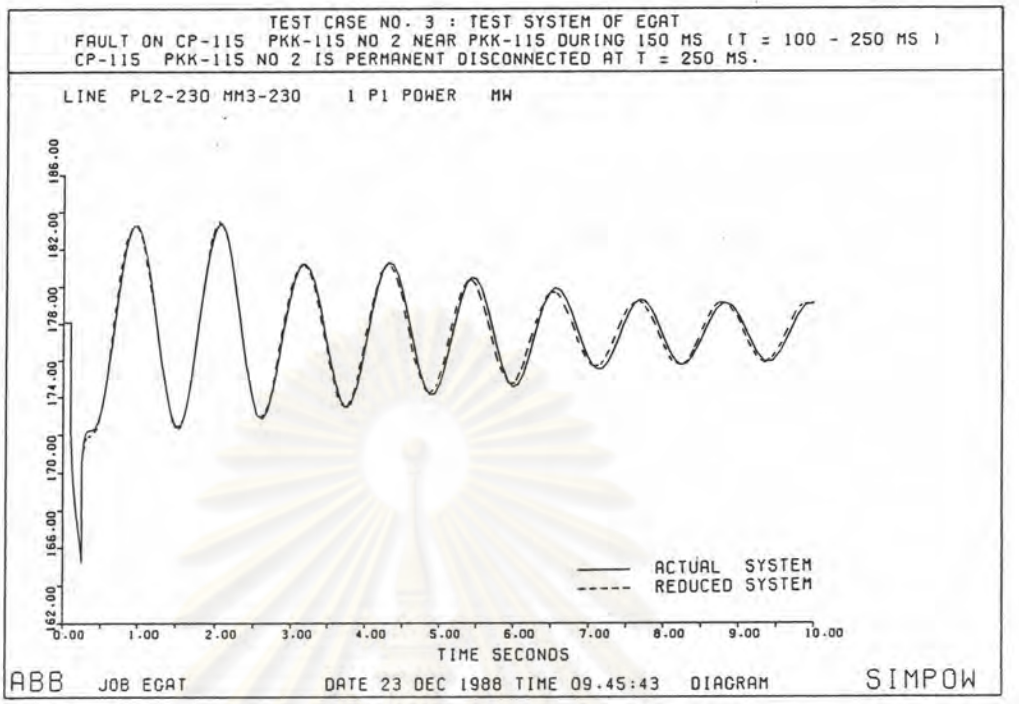


Figure A3.3.5

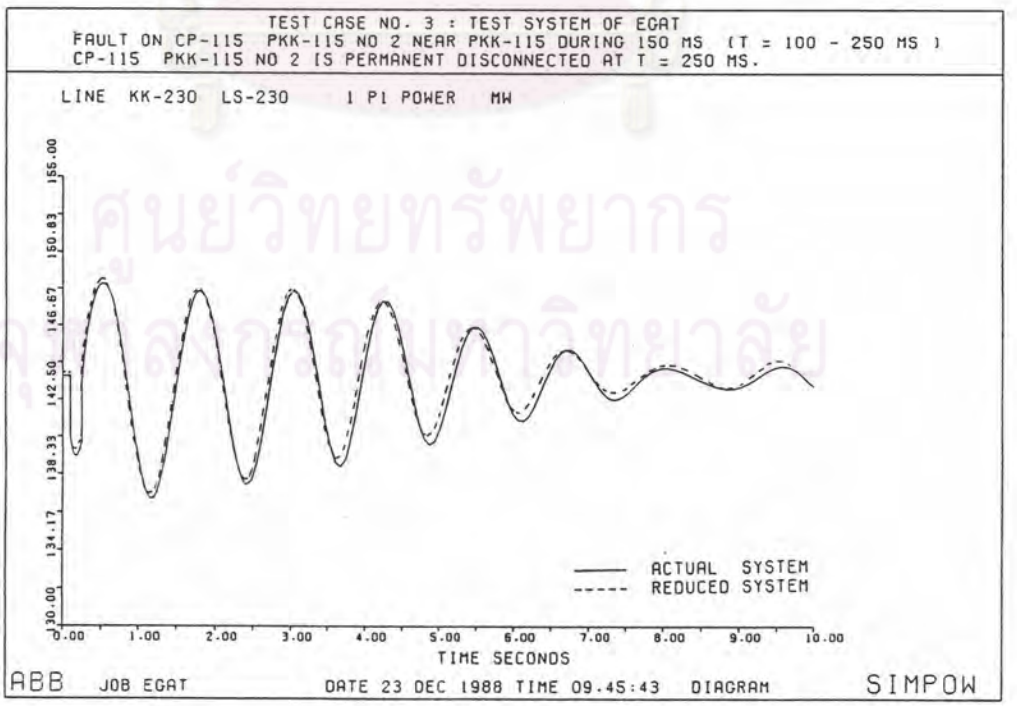


Figure A3.3.6

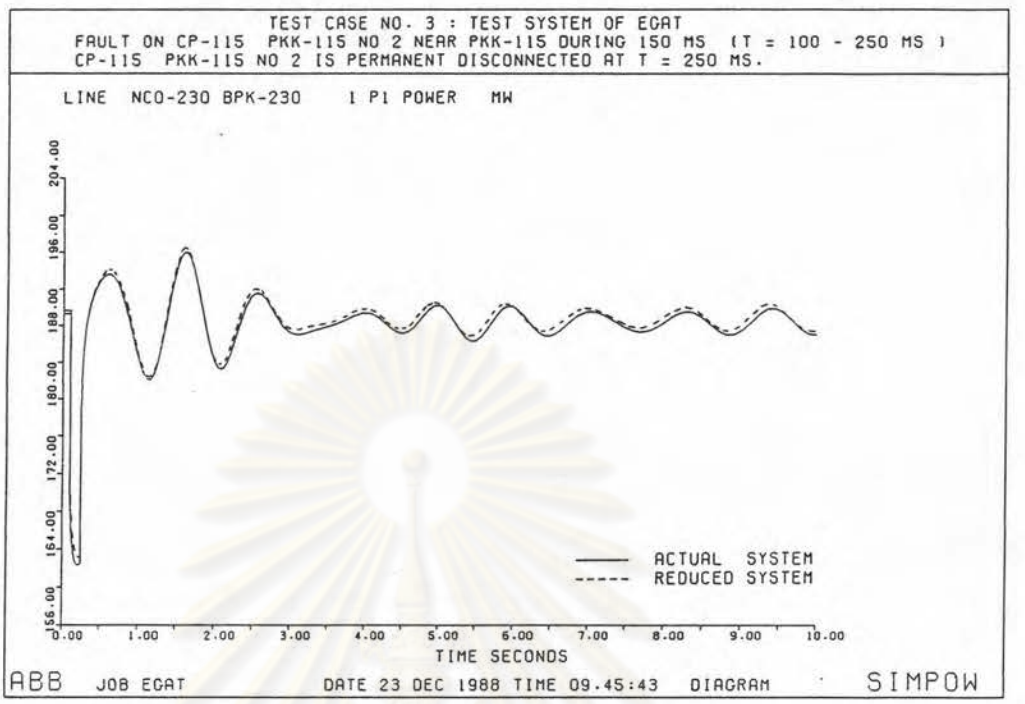


Figure A3.3.7

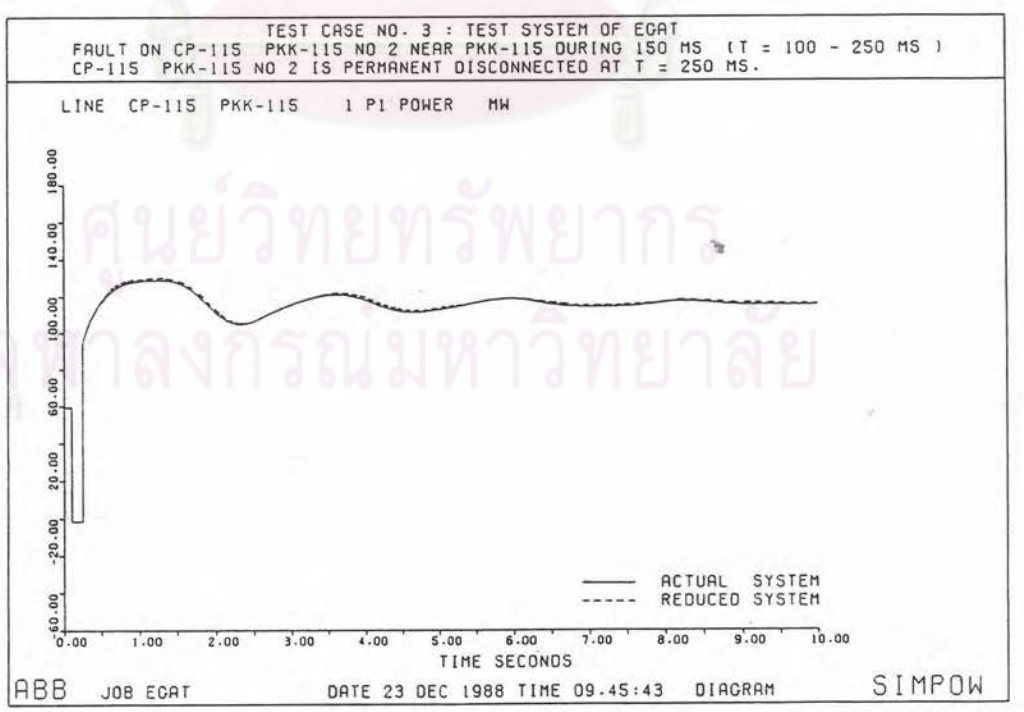


Figure A3.3.8

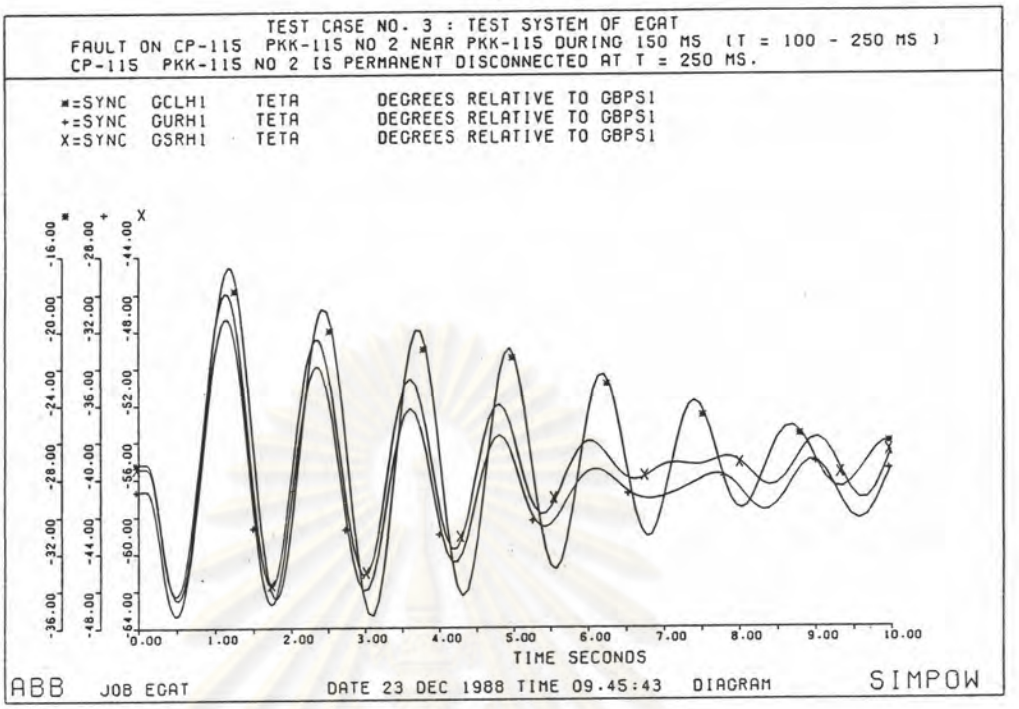


Figure A3.3.9

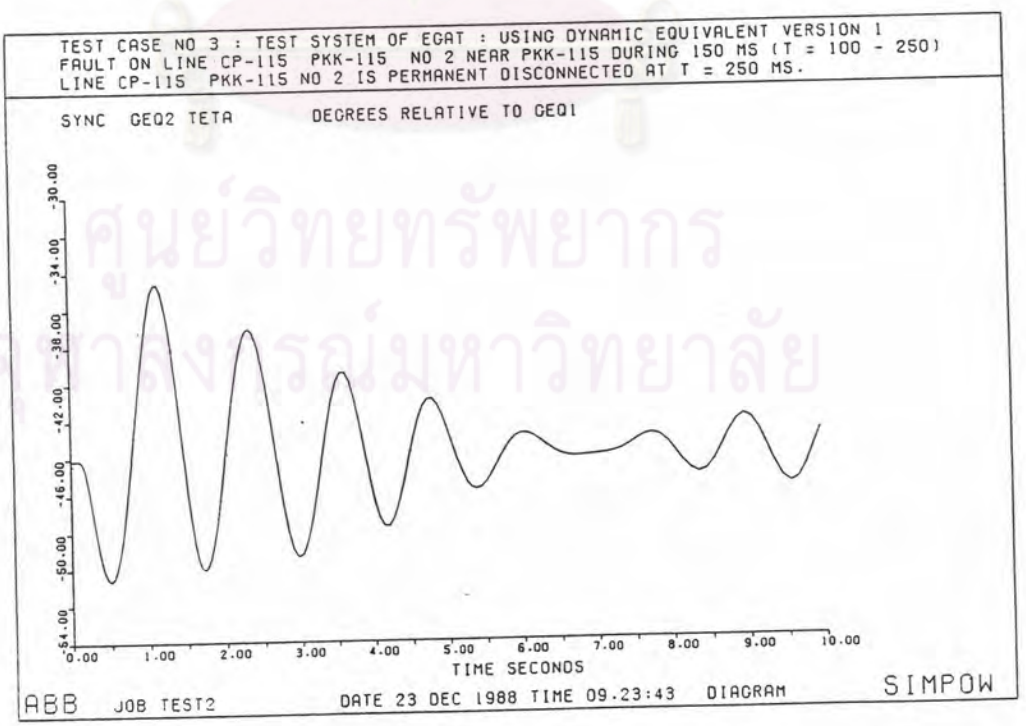


Figure A3.3.10

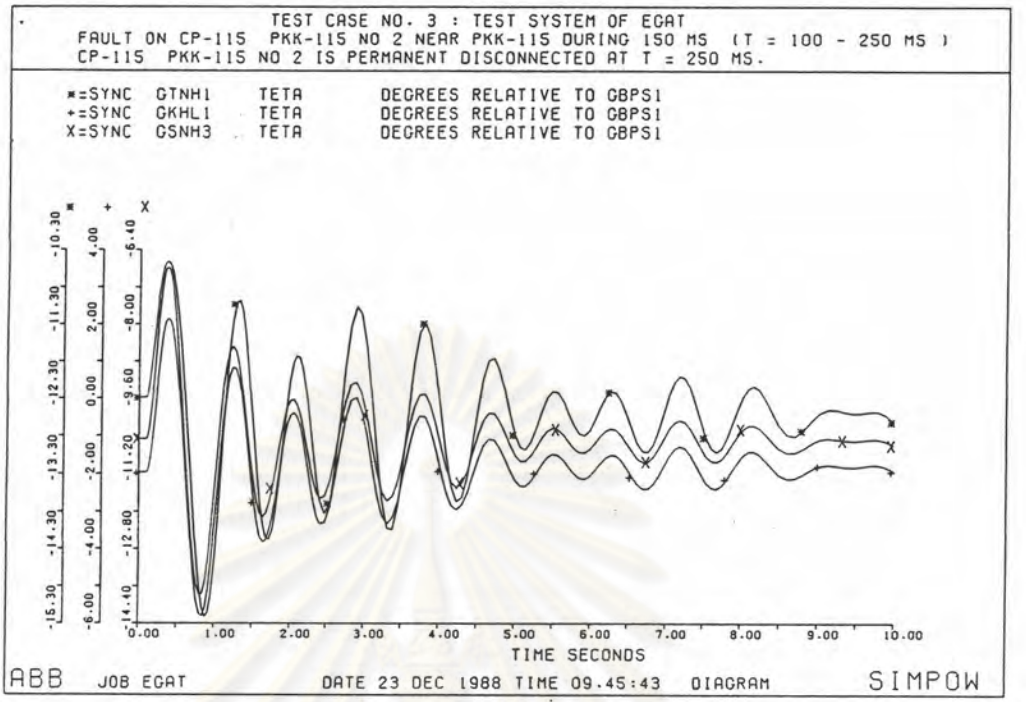


Figure A3.3.11

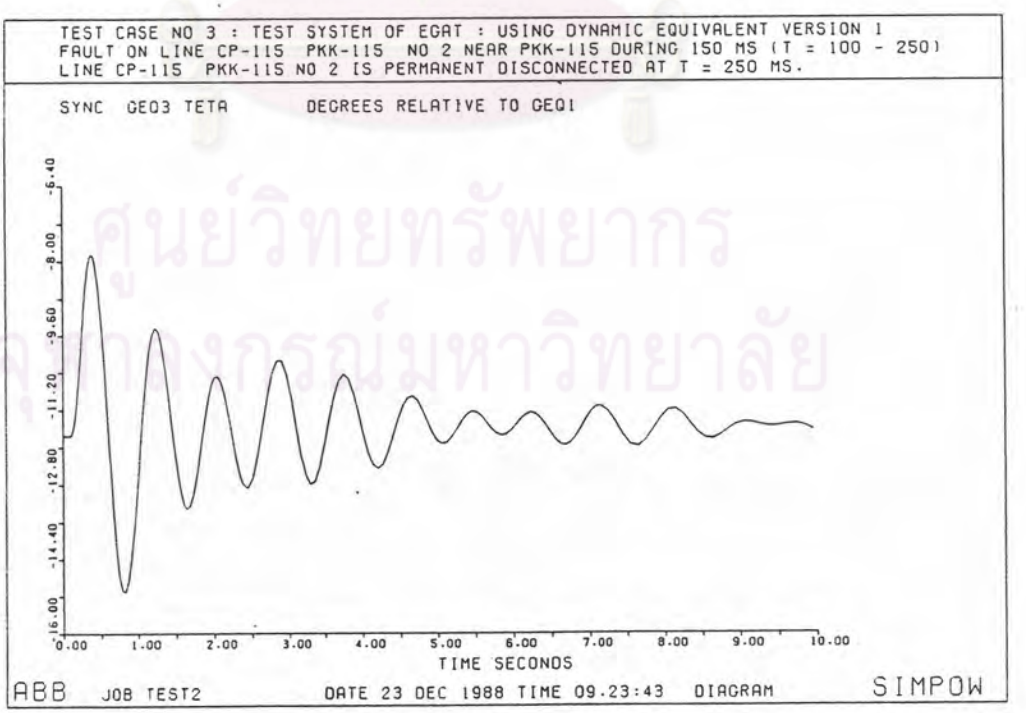


Figure A3.3.12

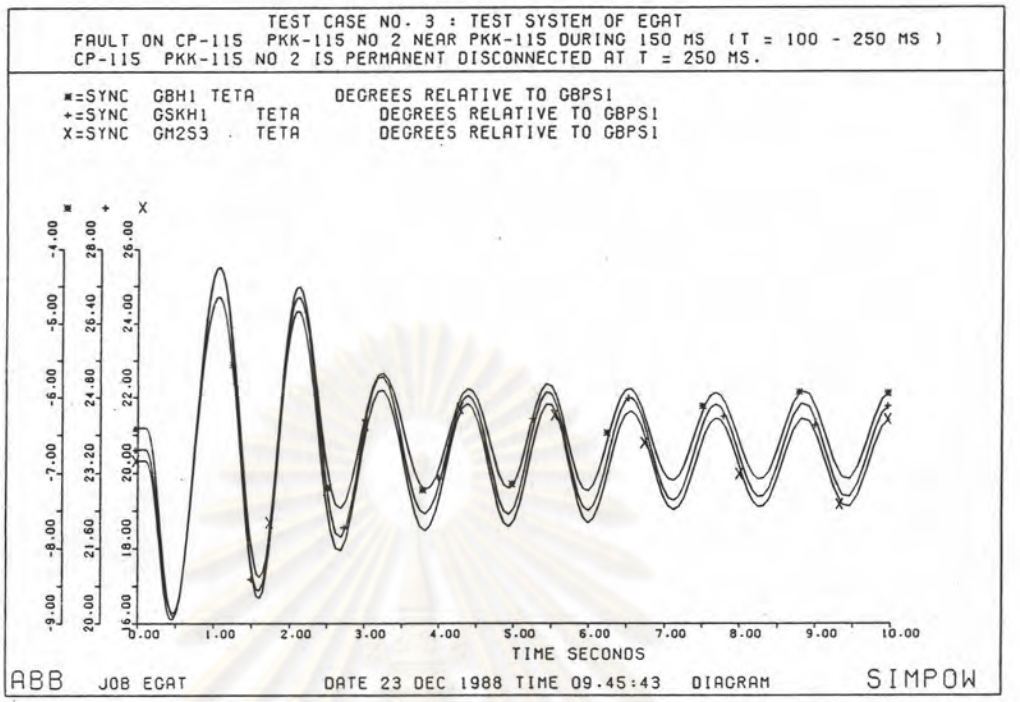


Figure A3.3.13

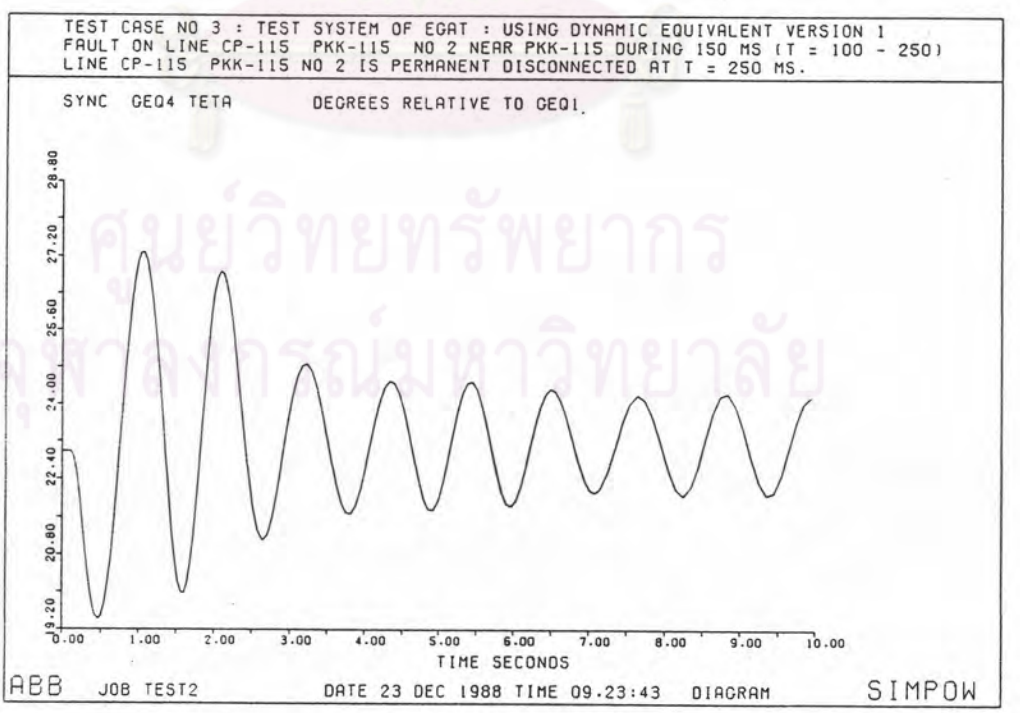


Figure A3.3.14

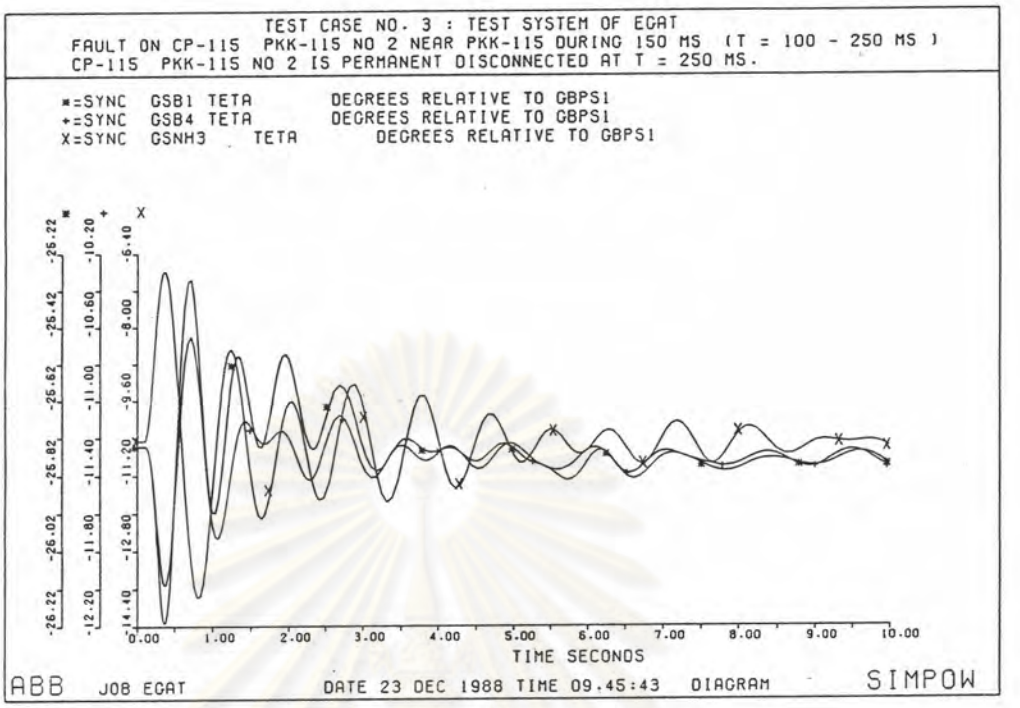


Figure A3.3.15

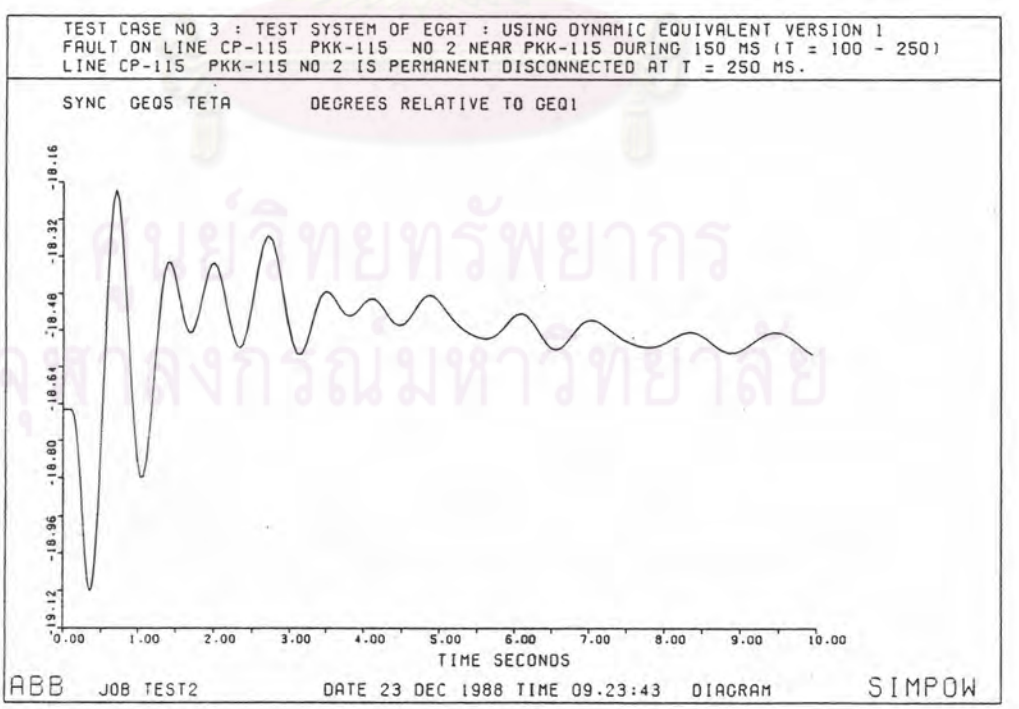


Figure A3.3.16

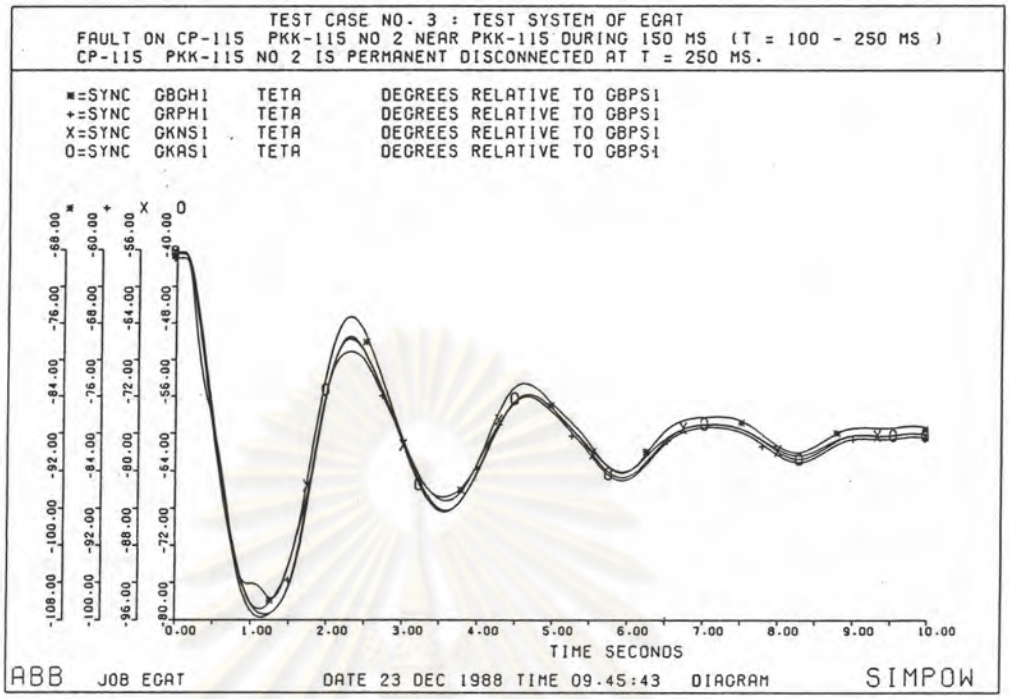


Figure A3.3.17

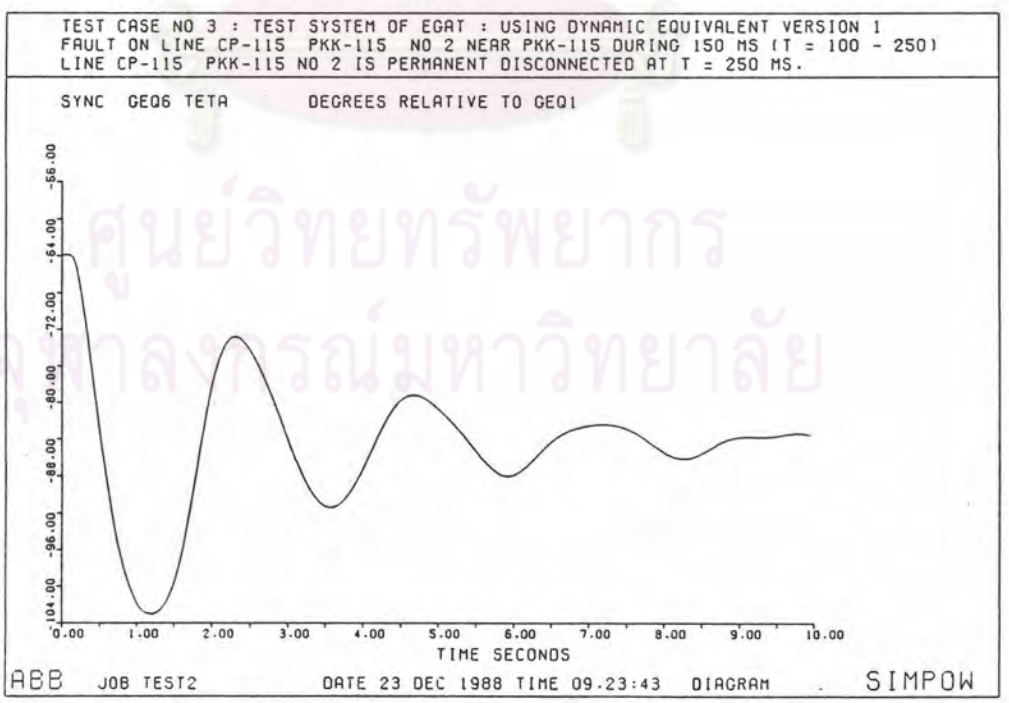


Figure A3.3.18

APPENDIX 3.4

Test case no 4: The three phase fault occured at bus BPK-S2. The fault is cleared by permanent disconnection the generator GBPS2. The generator has 680 MVA capacity. Before the fault occured; the generator had supplied 480 + j 170 MVA to the system.

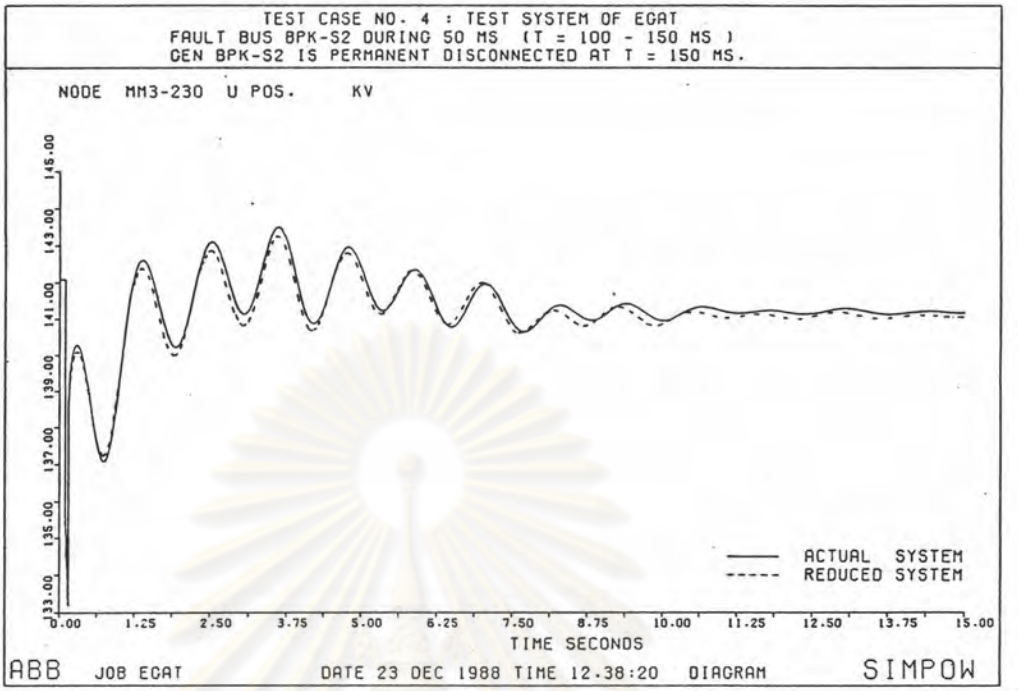


Figure A3.4.1

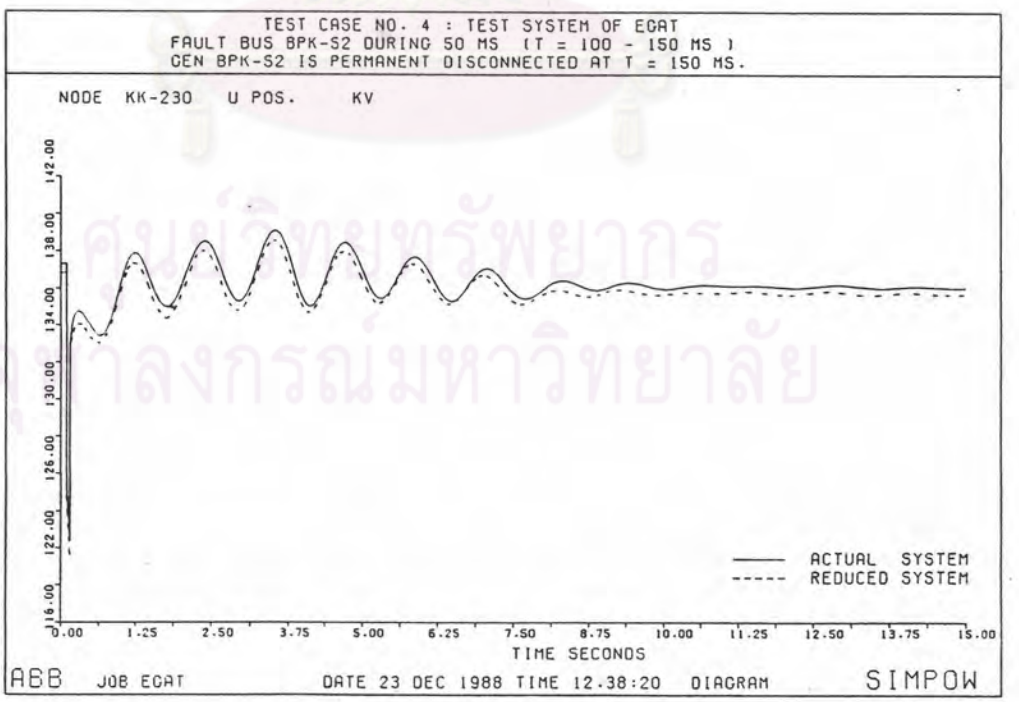


Figure A3.4.2

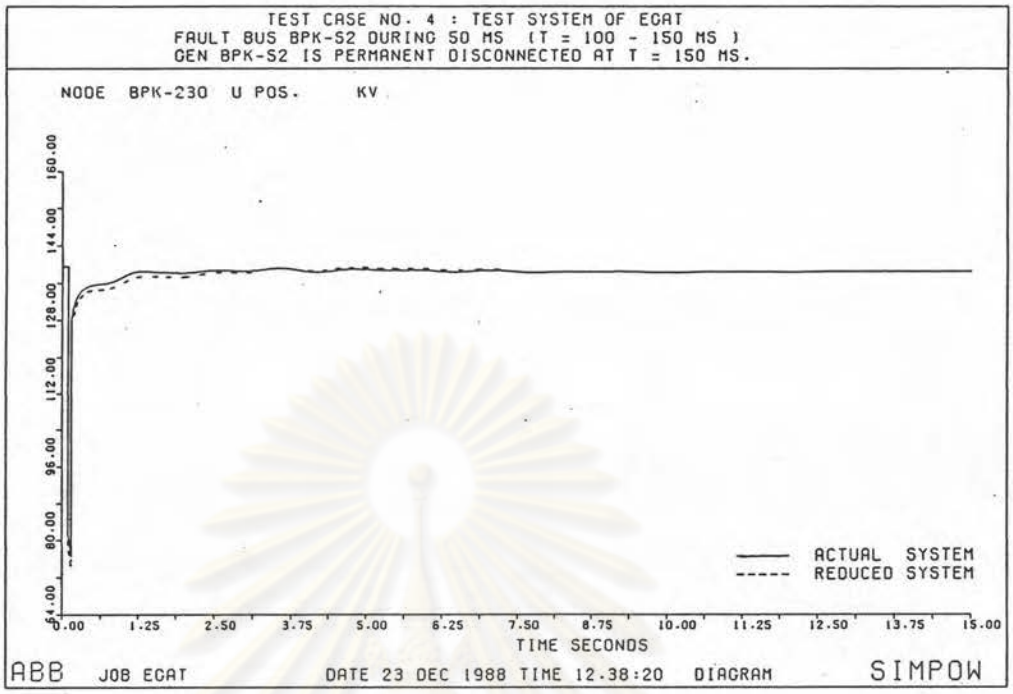


Figure A3.4.3

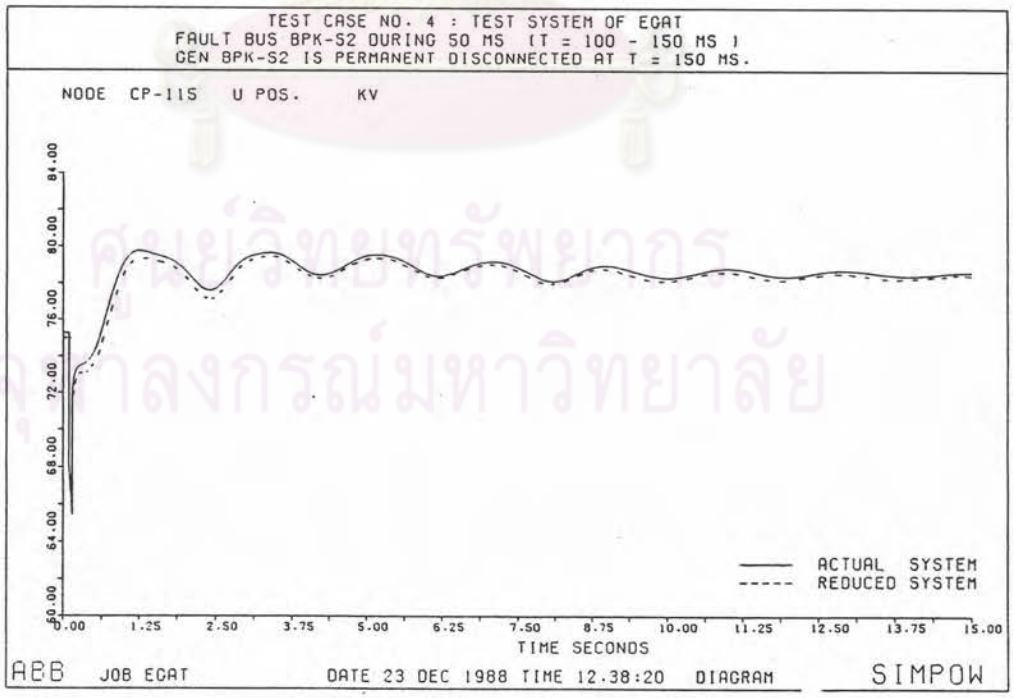


Figure A3.4.4

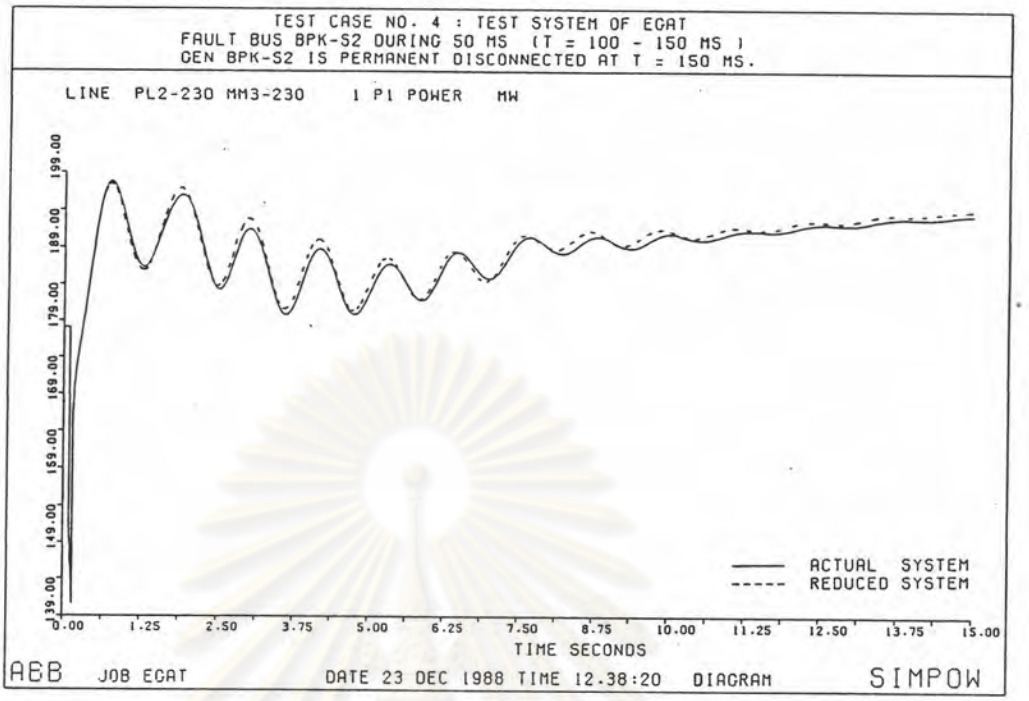


Figure A3.4.5

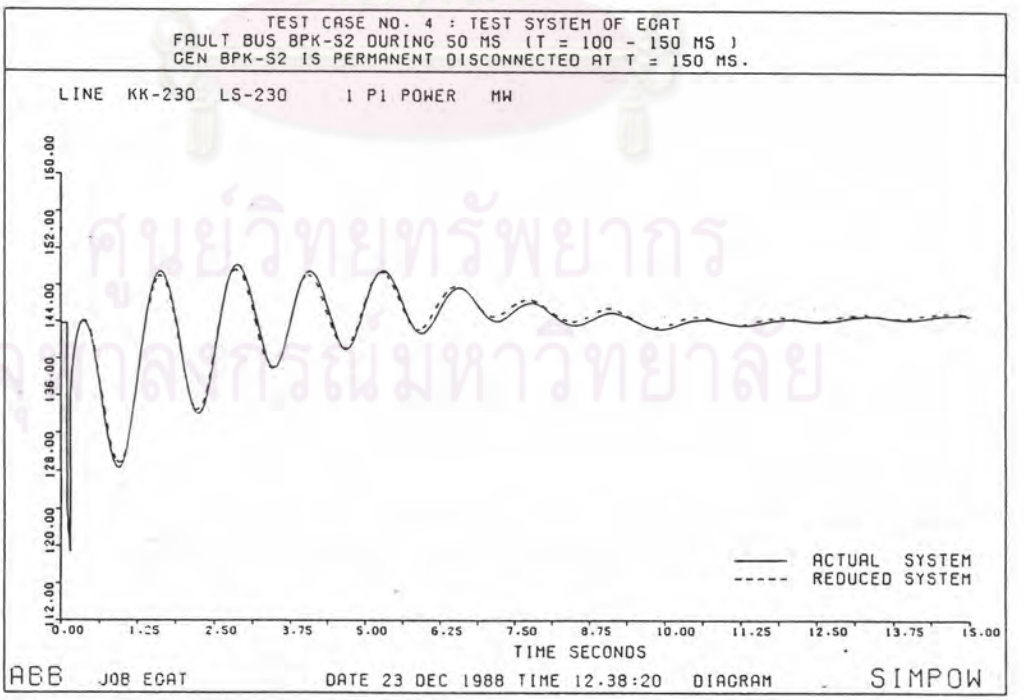


Figure A3.4.6

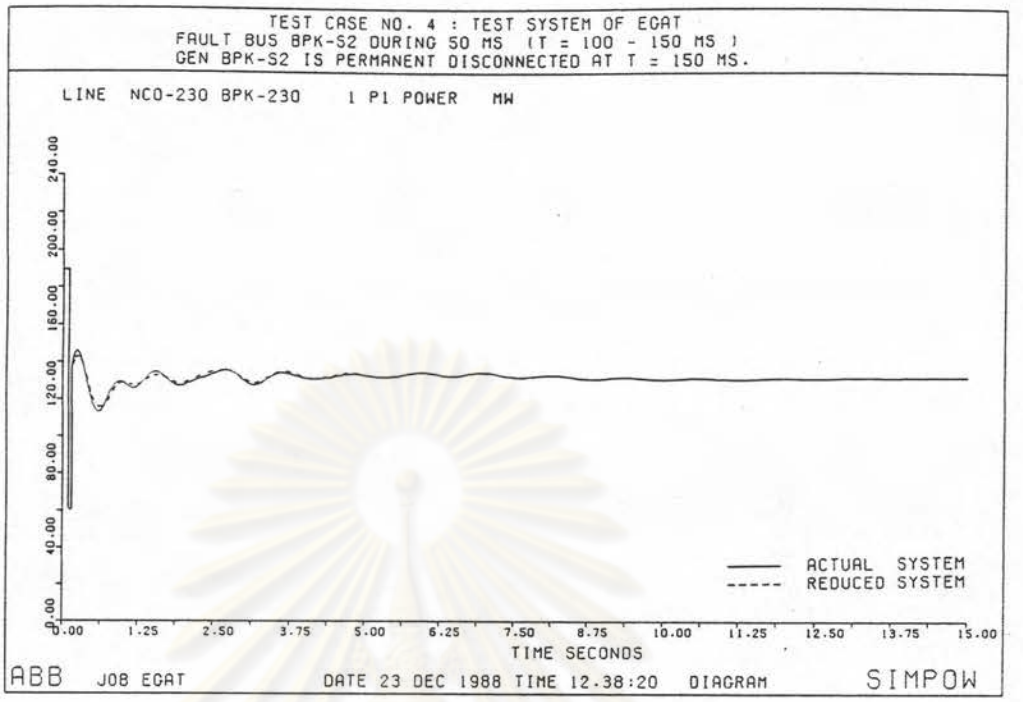


Figure A3.4.7

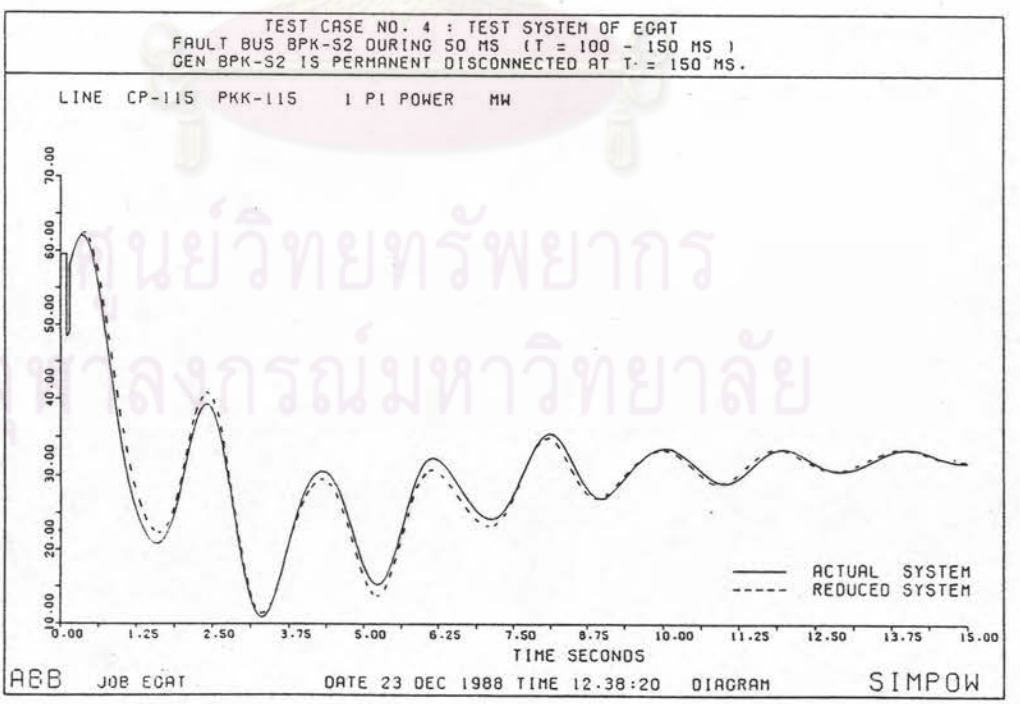


Figure A3.4.8

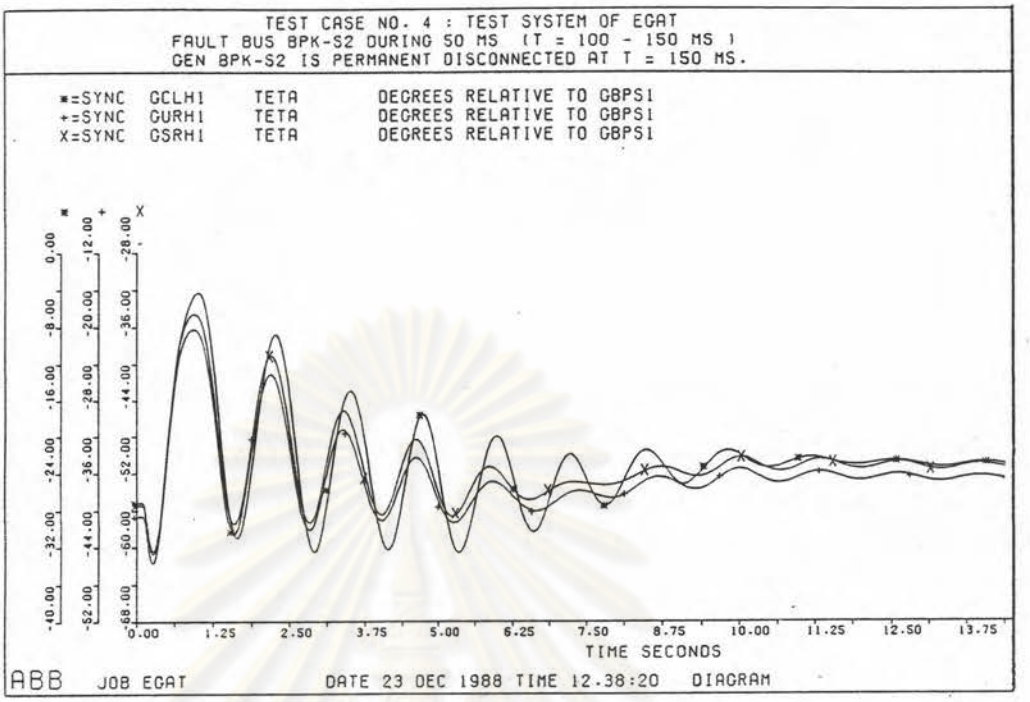


Figure A3.4.9

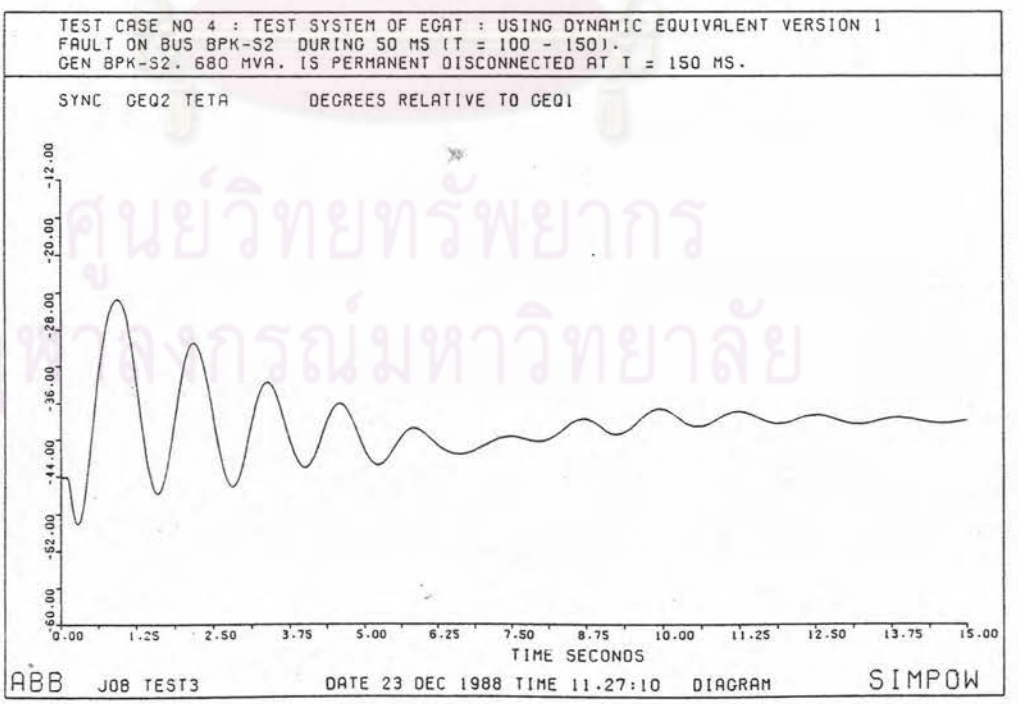


Figure A3.4.10

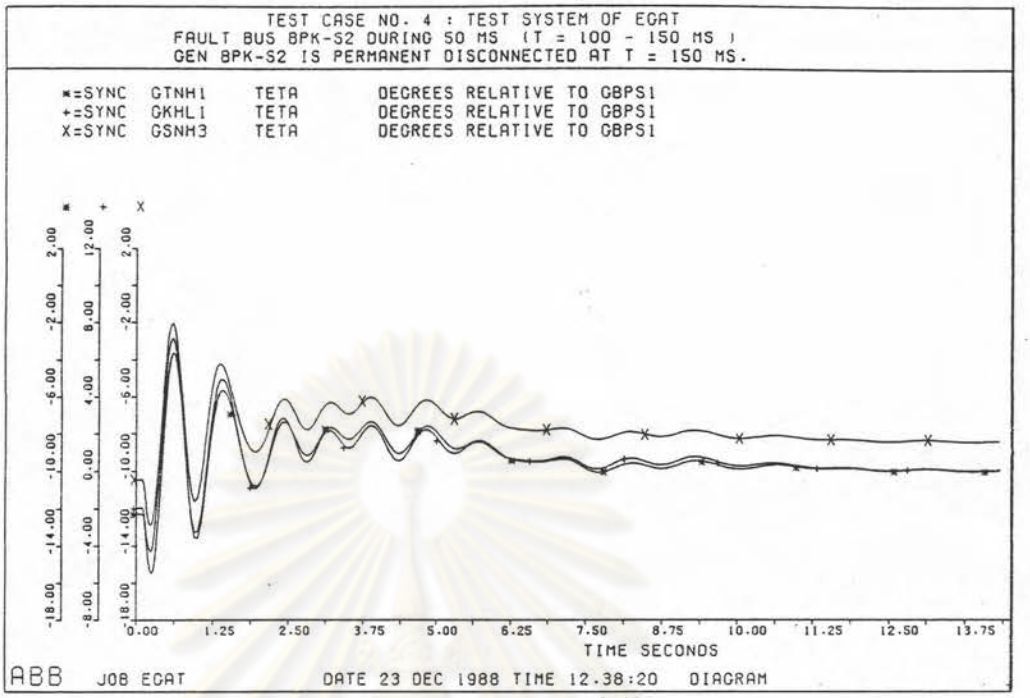


Figure A3.4.11

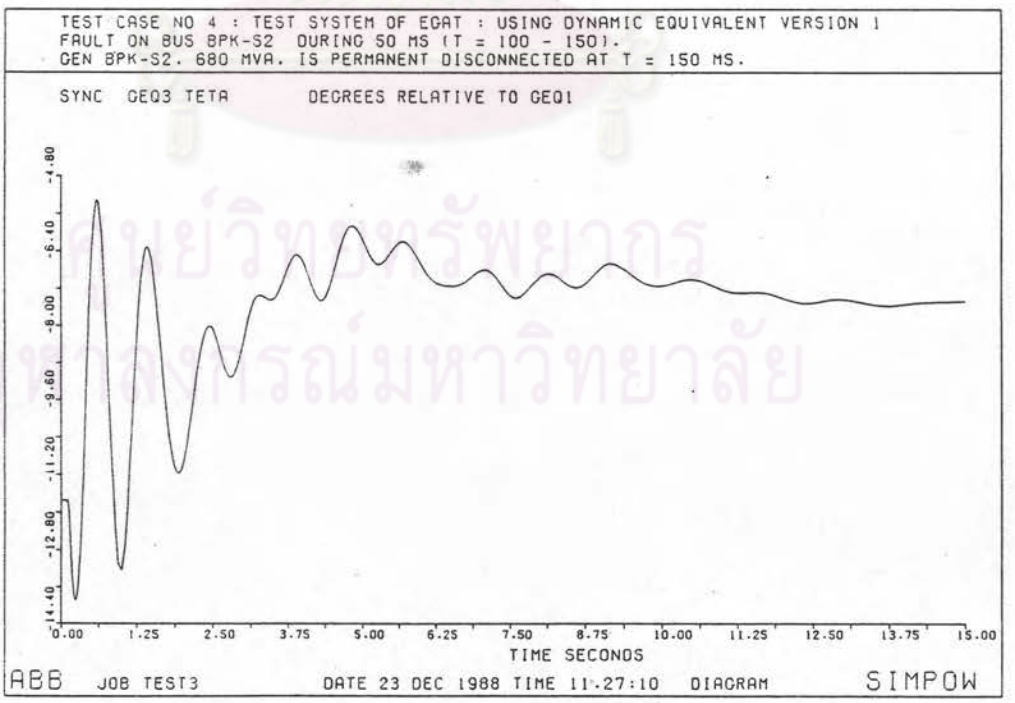


Figure A3.4.12

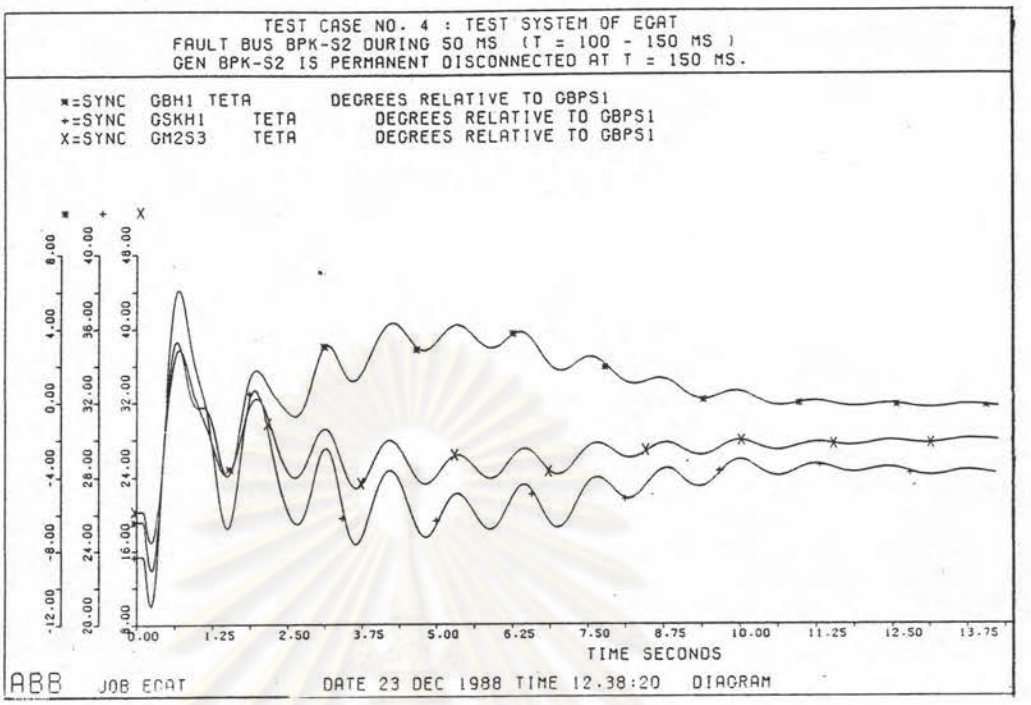


Figure A3.4.13

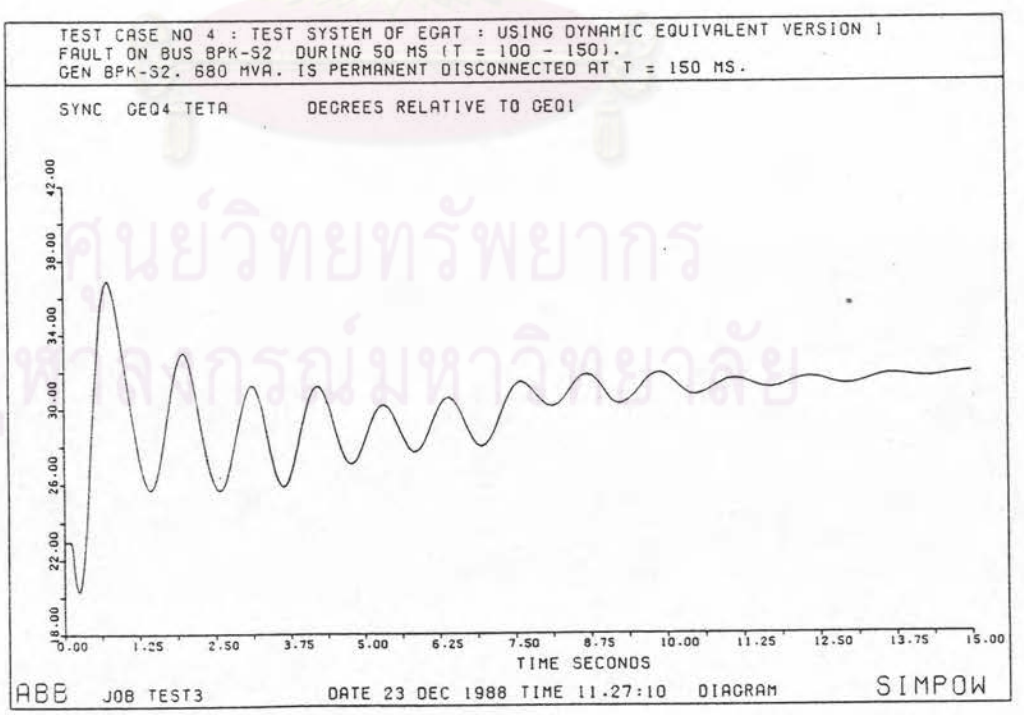


Figure A3.4.14

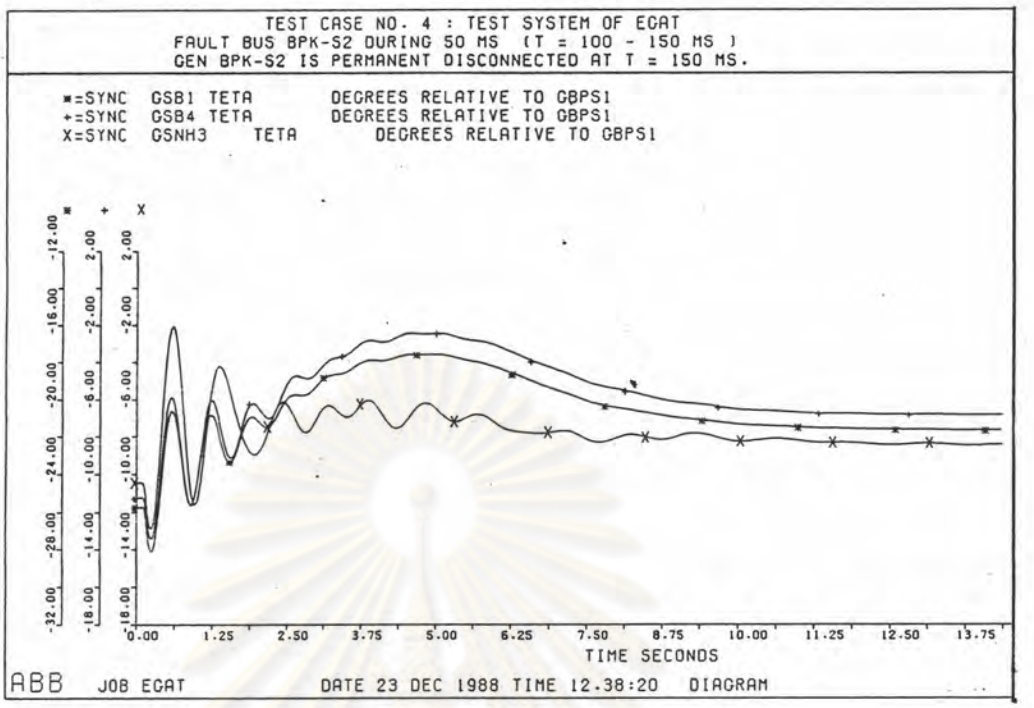


Figure A3.4.15

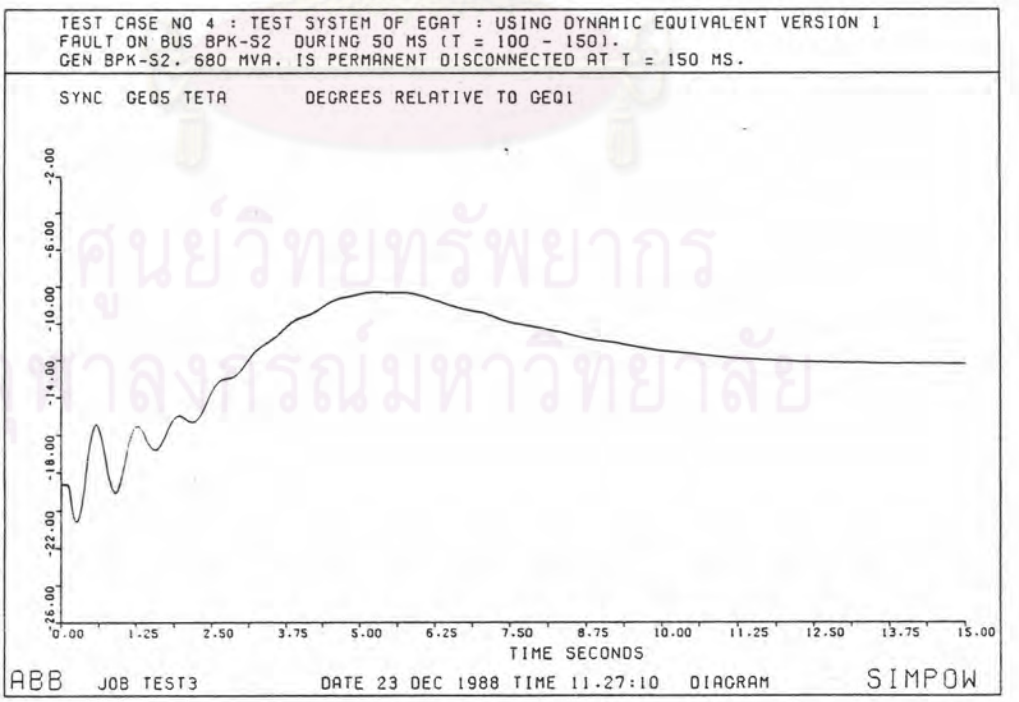


Figure A3.4.16

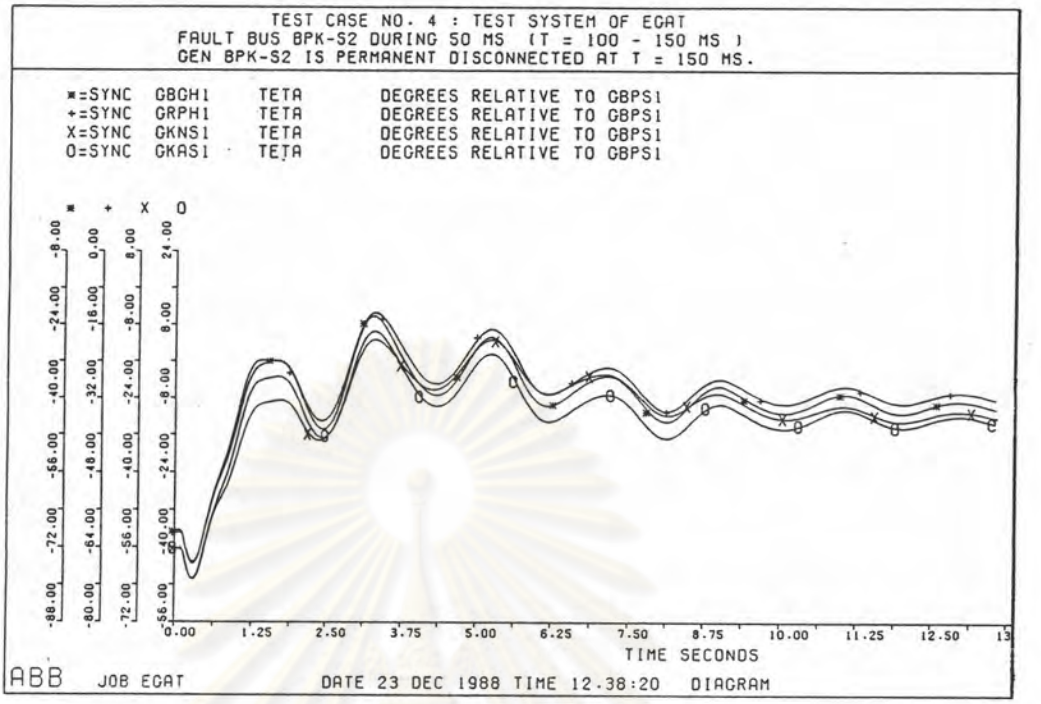


Figure A3.4.17

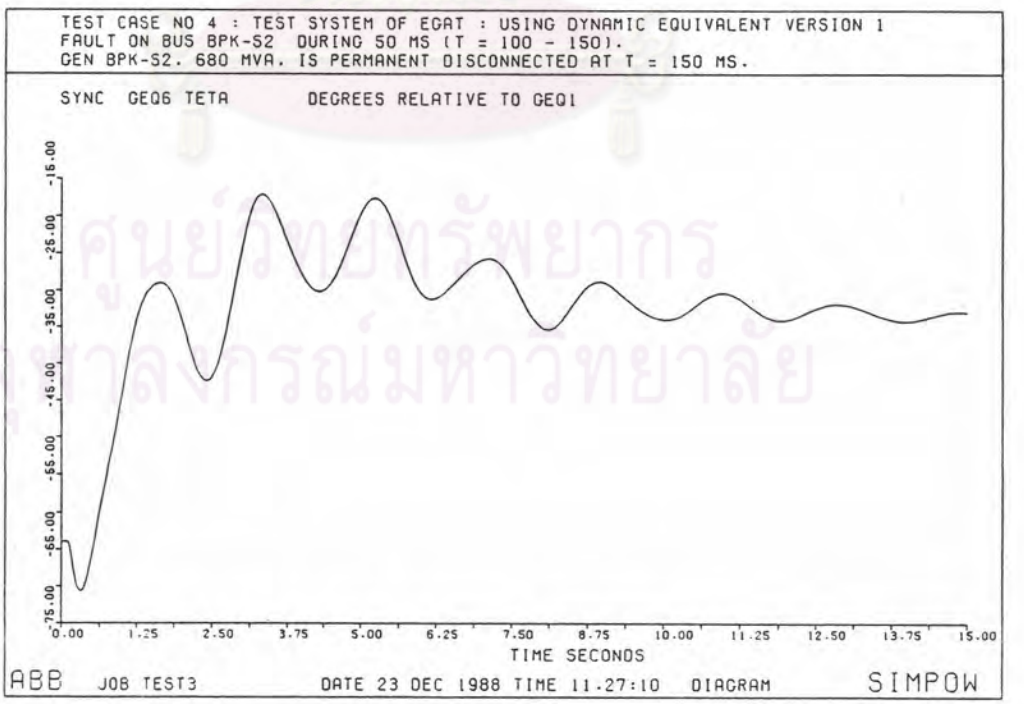


Figure A3.4.18

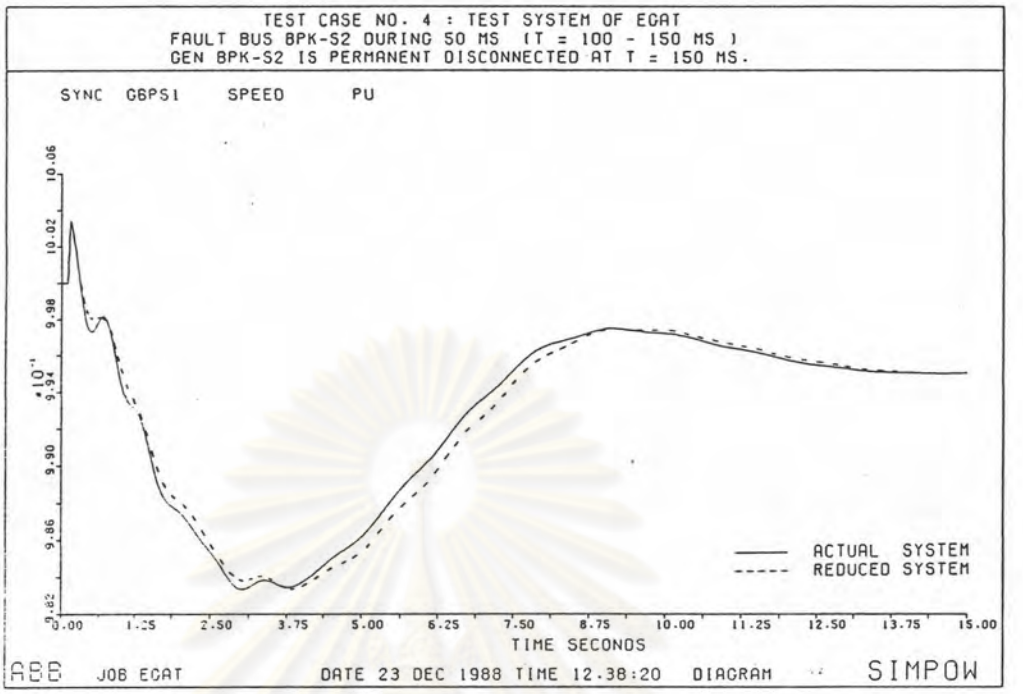


Figure A3.4.19

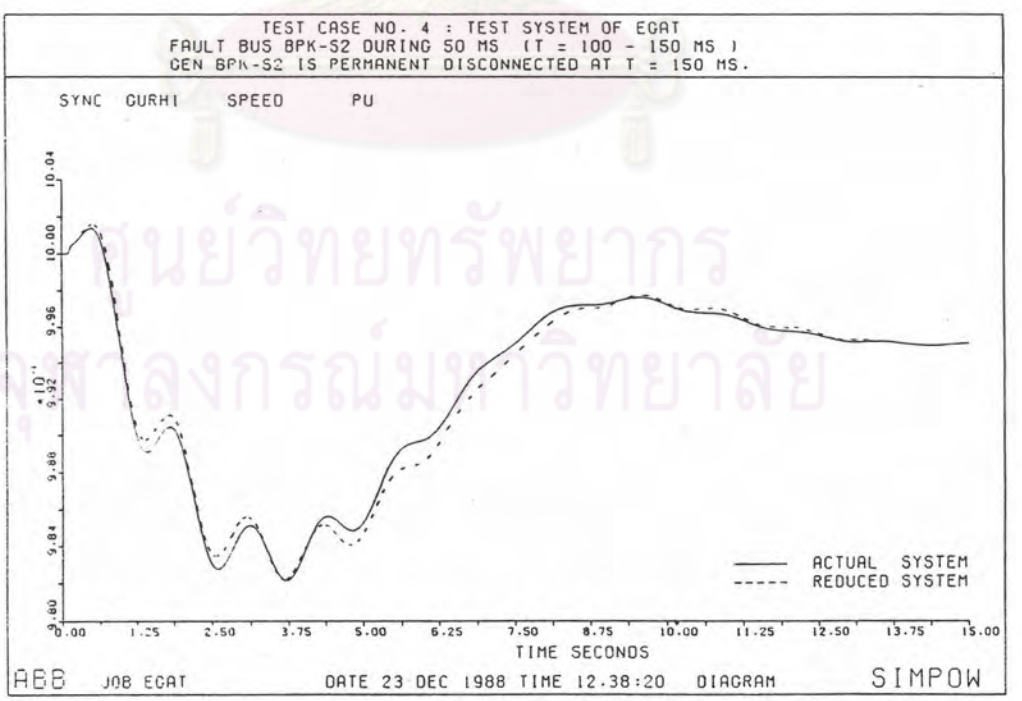


Figure A3.4.20

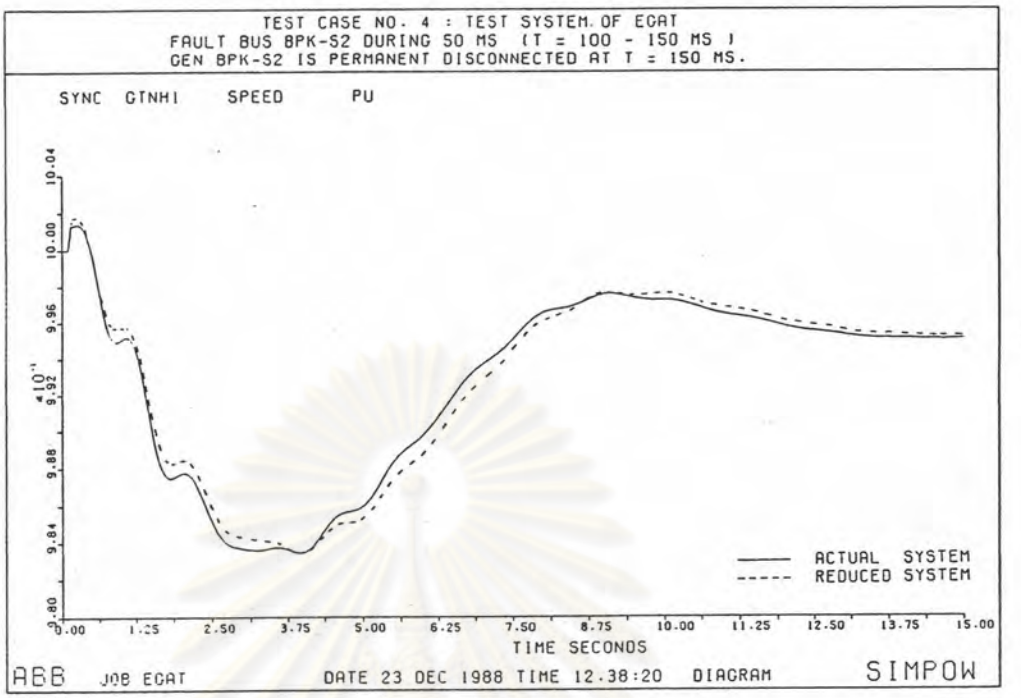


Figure A3.4.21

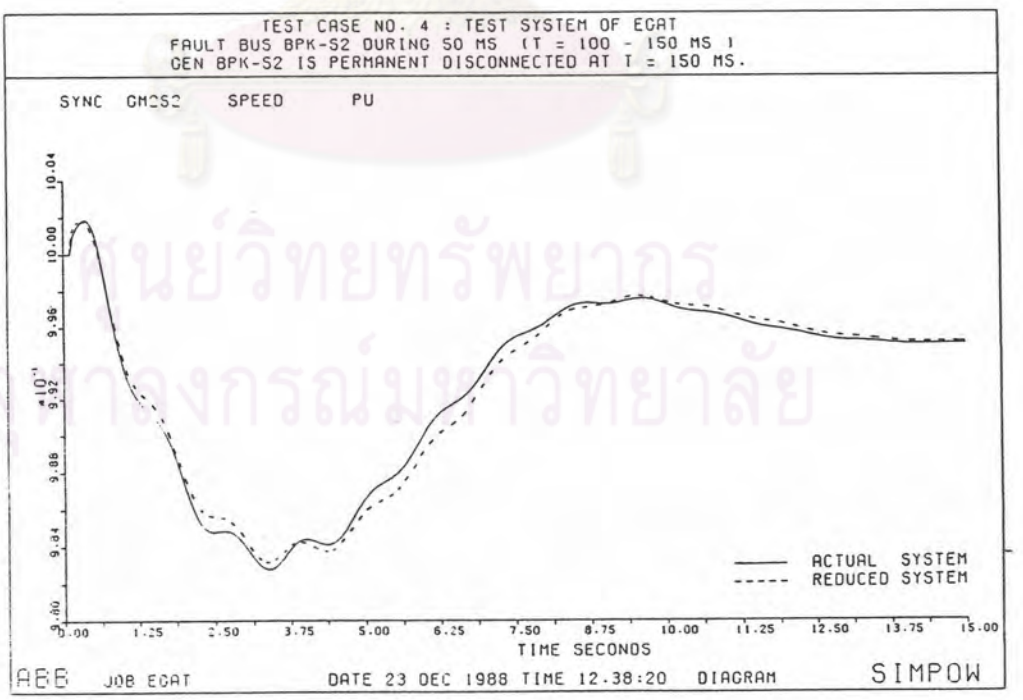


Figure A3.4.22

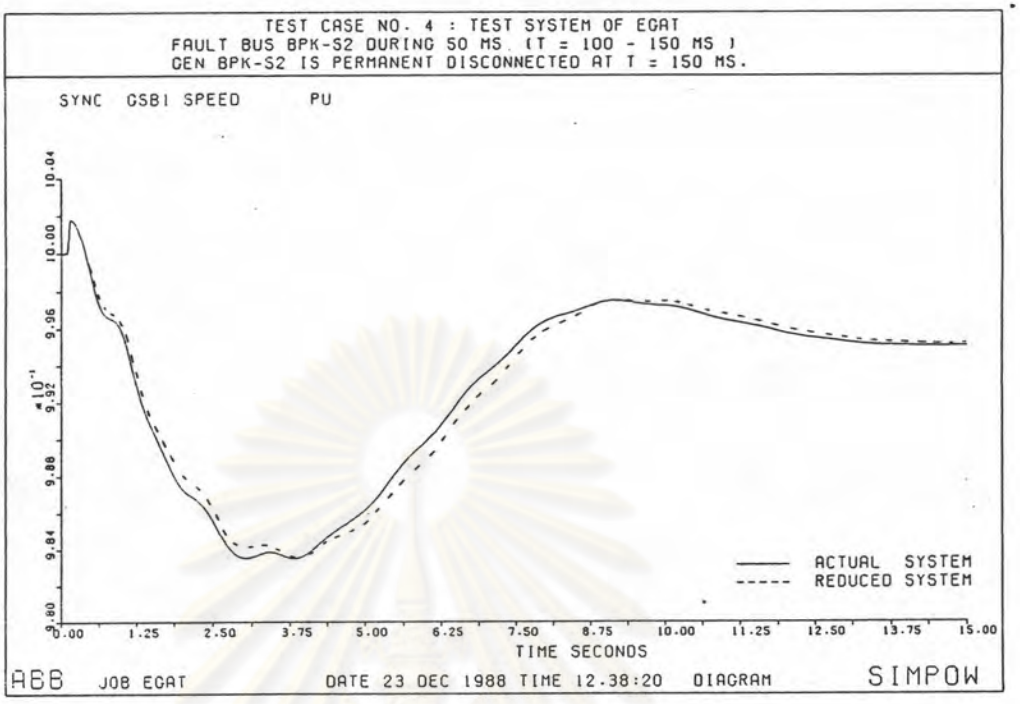


Figure A3.4.23

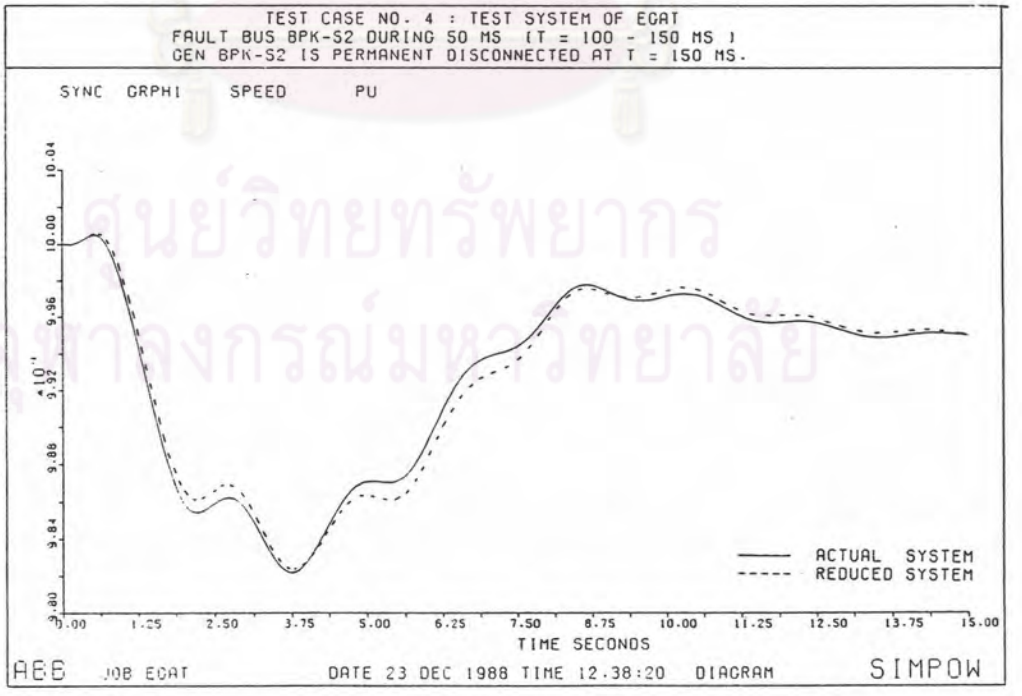


Figure A3.4.24

APPENDIX 3.5

Test case no 5: The three phase fault occured on line no 2 which link between bus CP-115 and bus PPK-115 near bus CP-115. The fault is cleared by permanent disconnection the line after 170 ms.

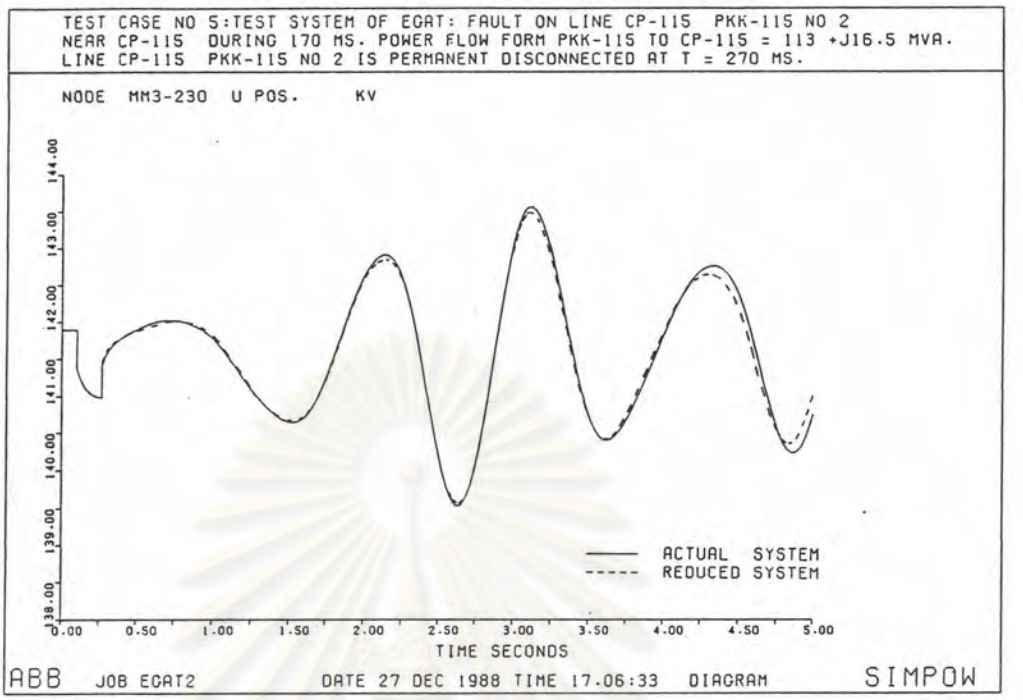


Figure A3.5.1

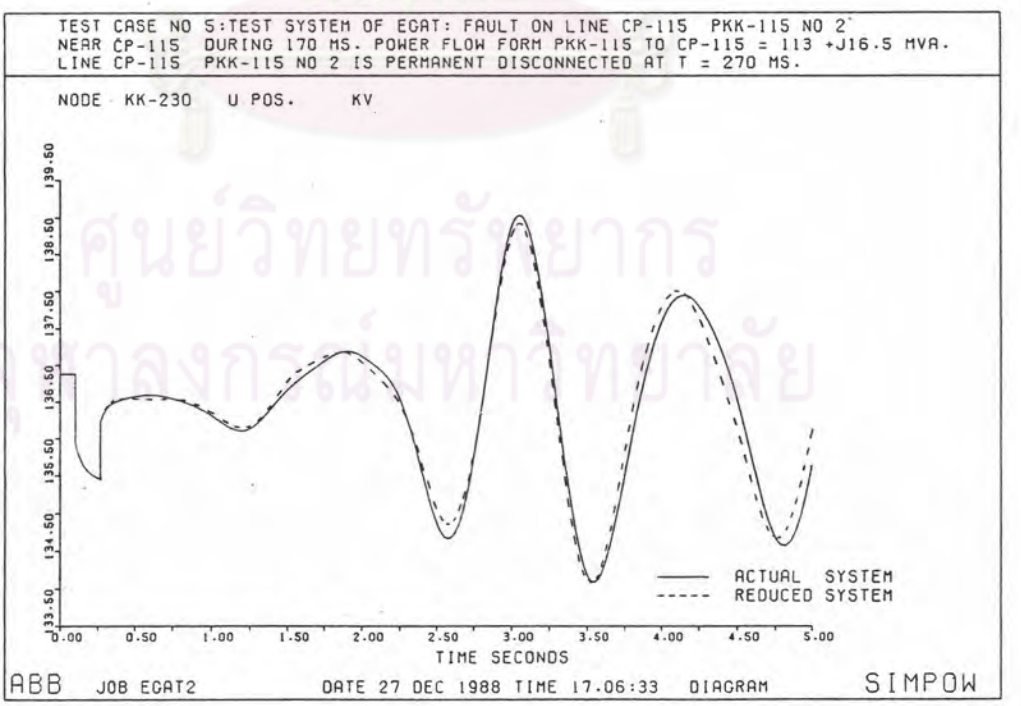


Figure A3.5.2

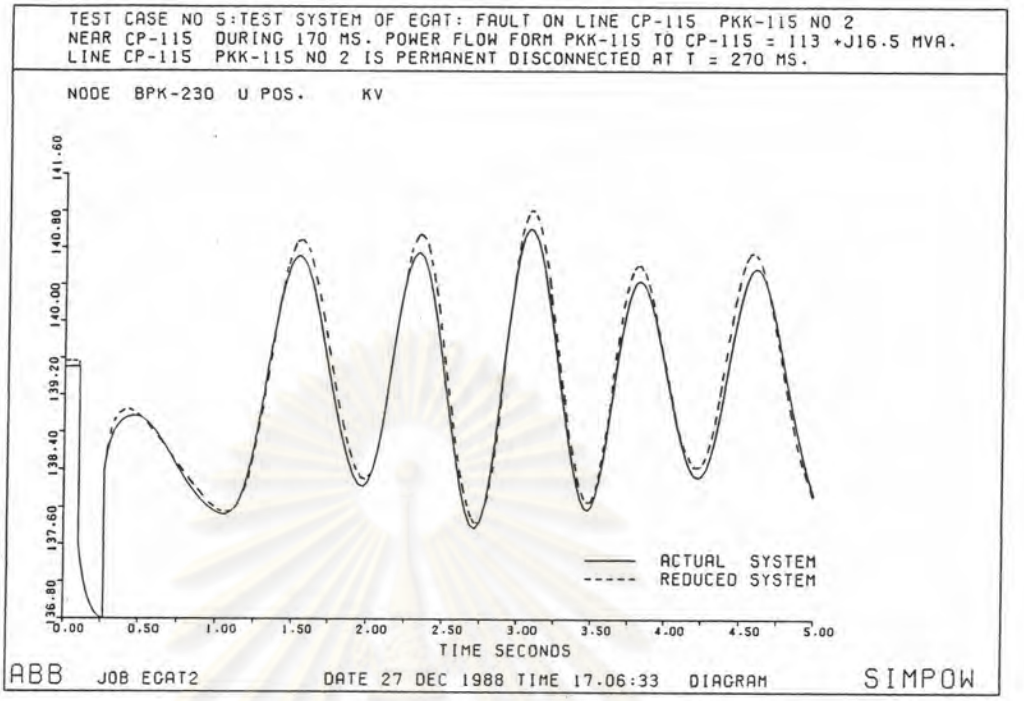


Figure A3.5.3

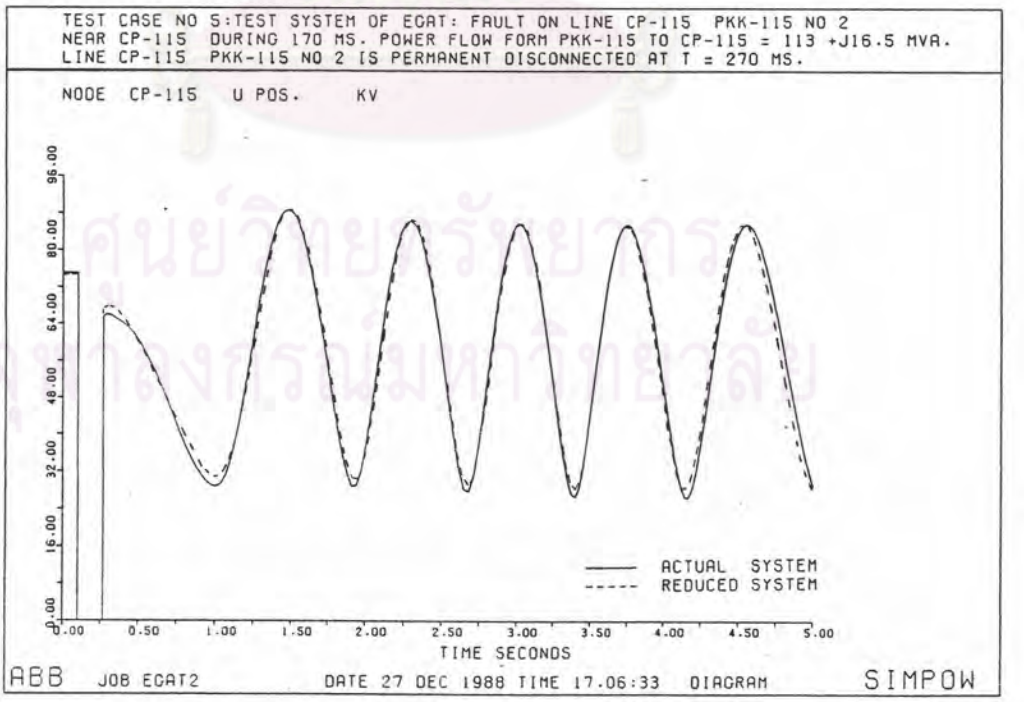


Figure A3.5.4

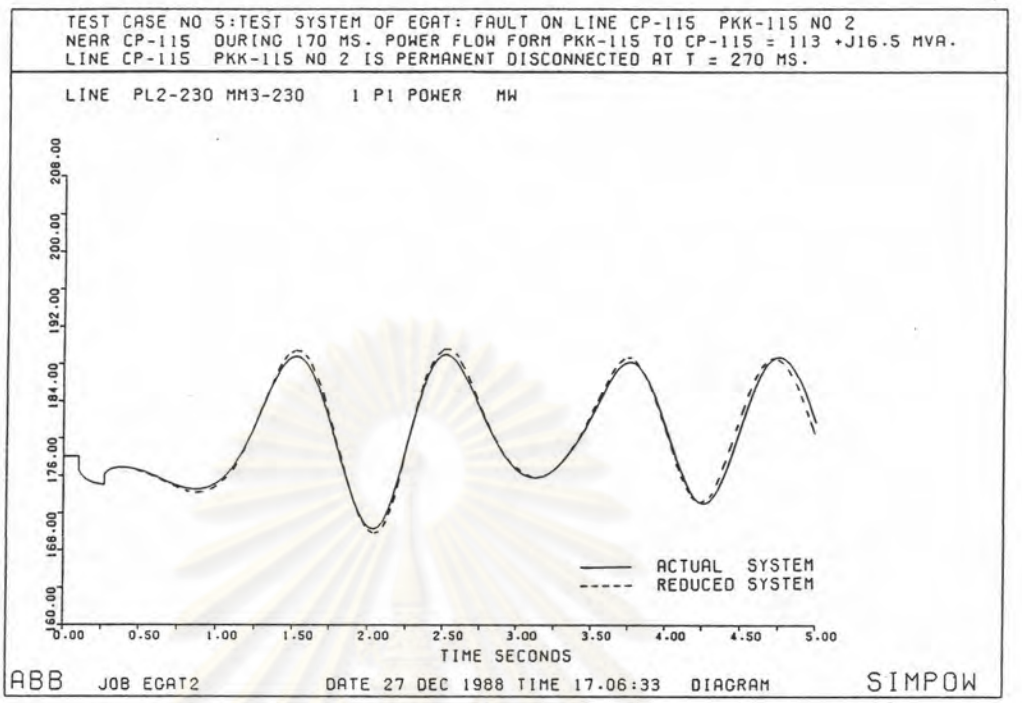


Figure A3.5.5

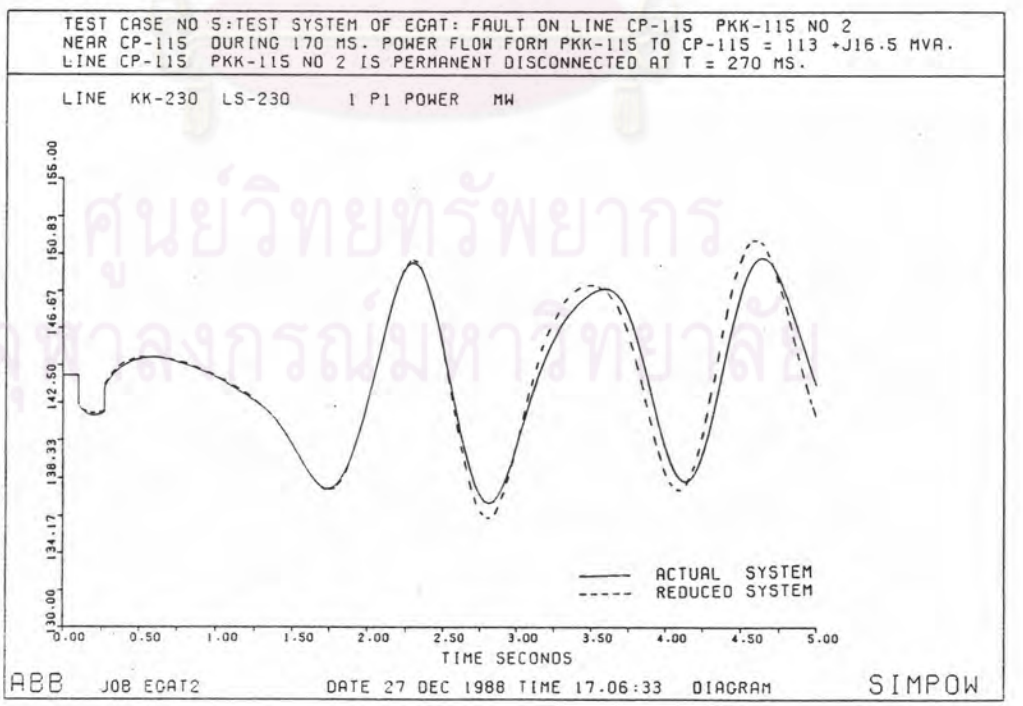


Figure A3.5.6

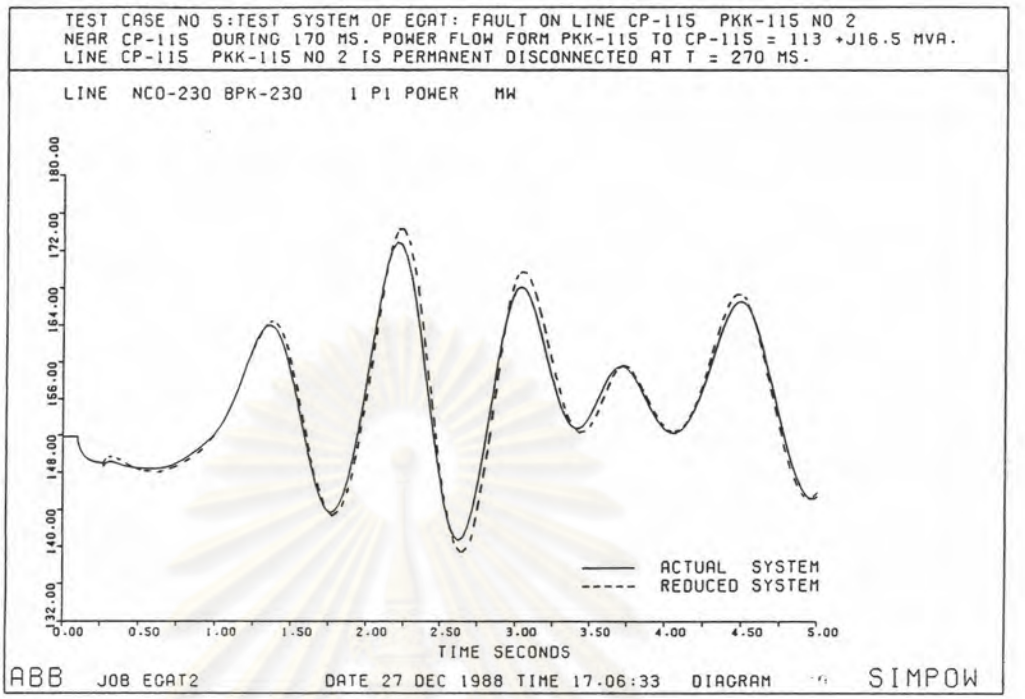


Figure A3.5.7

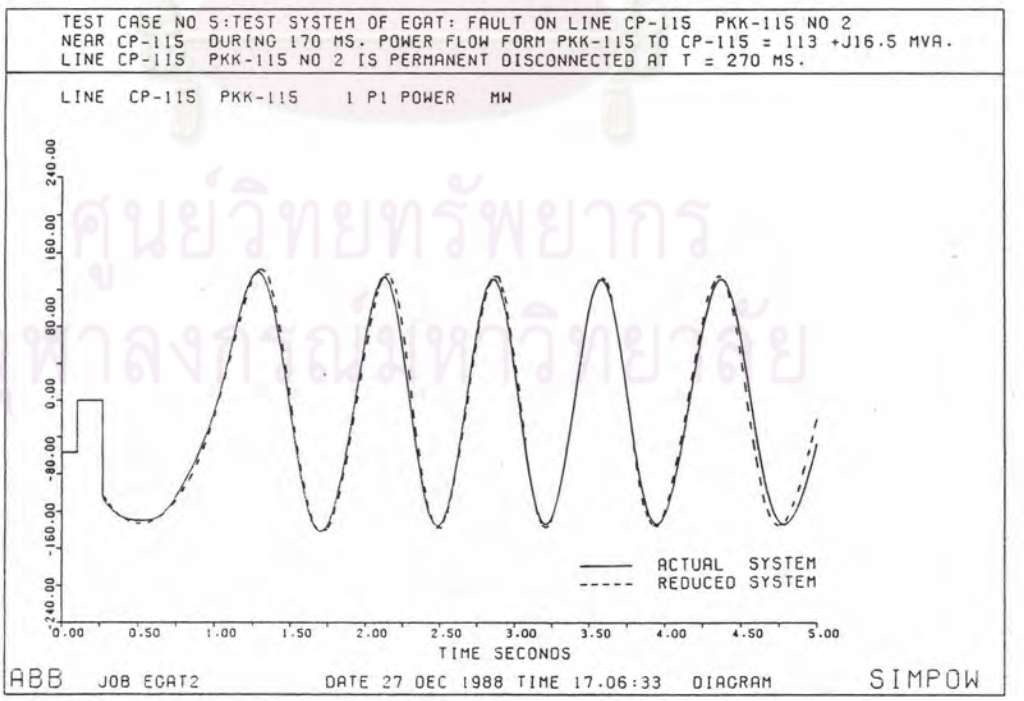


Figure A3.5.8

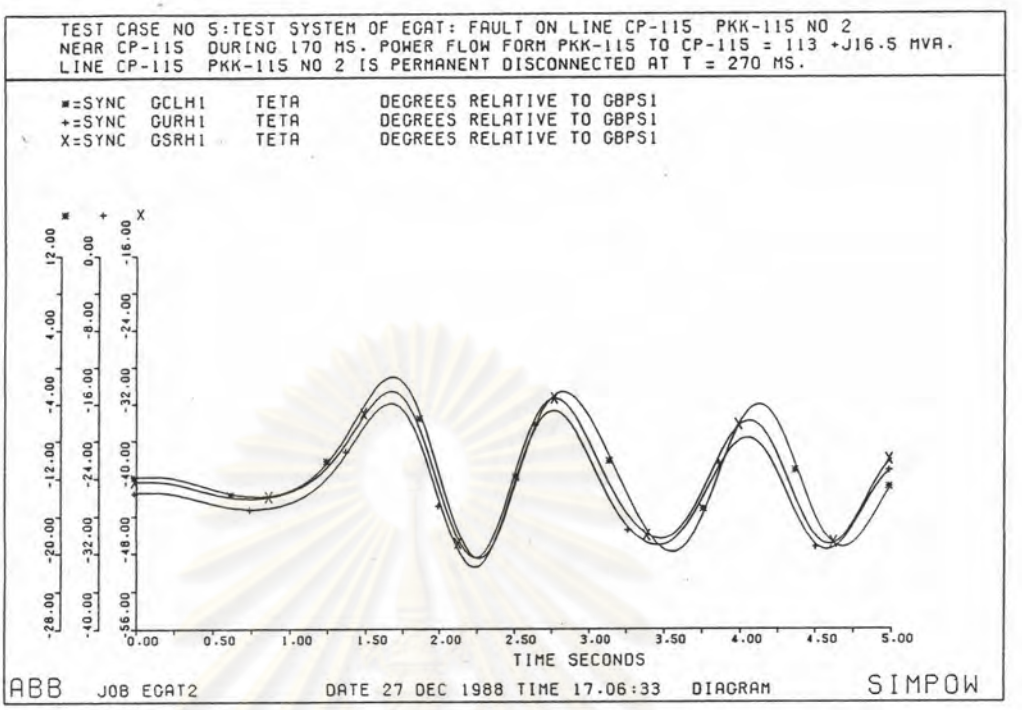


Figure A3.5.9

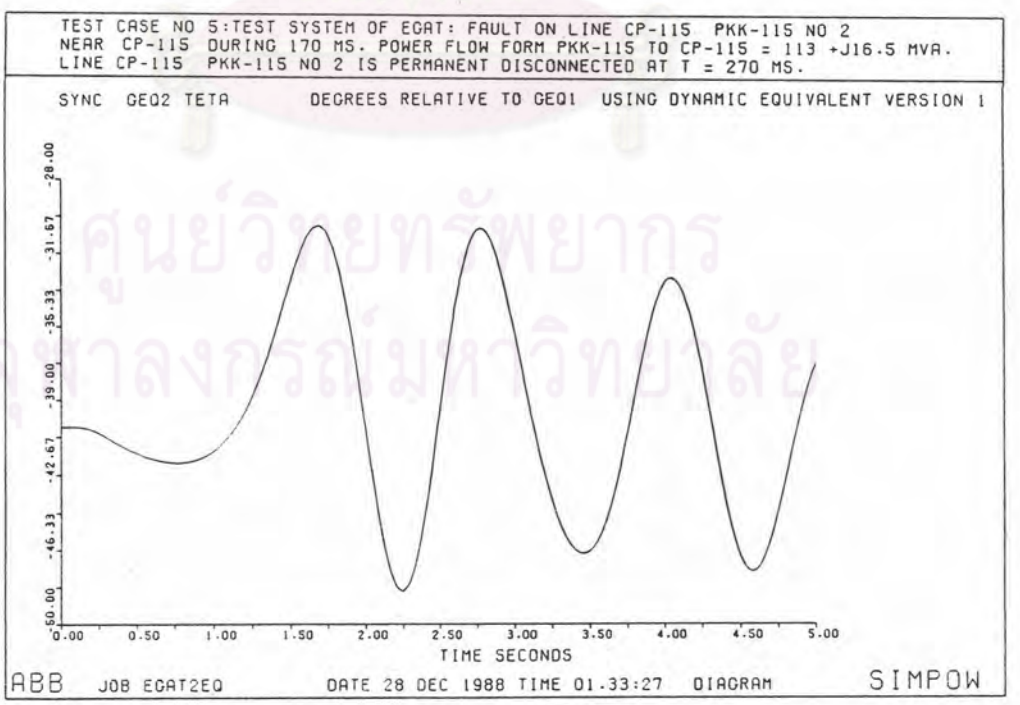


Figure A3.5.10

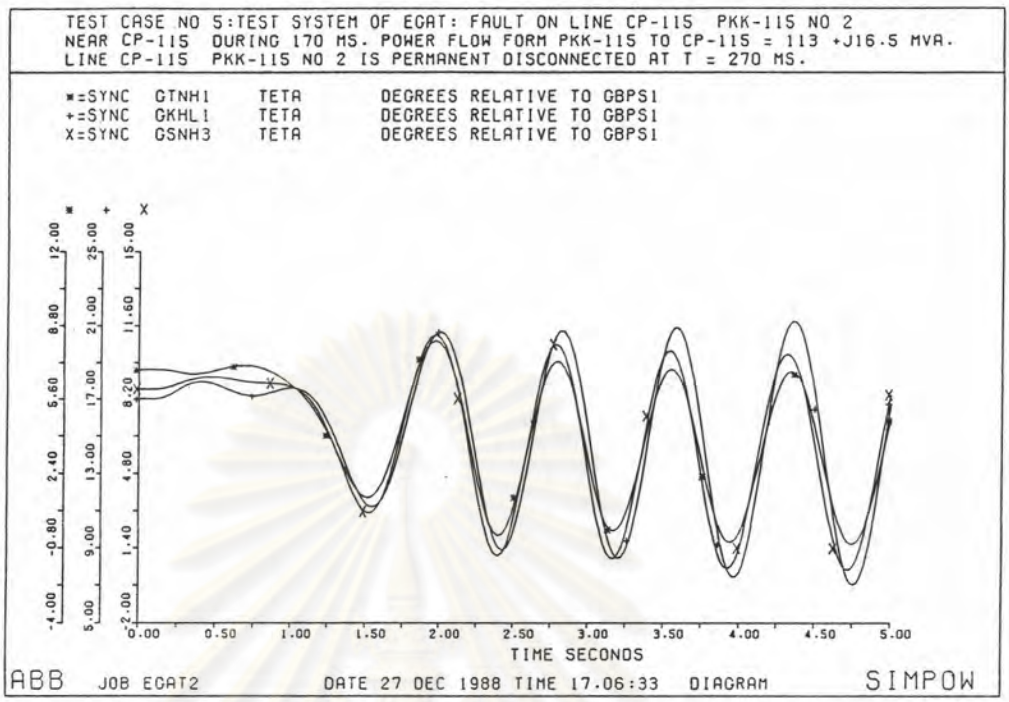


Figure A3.5.11

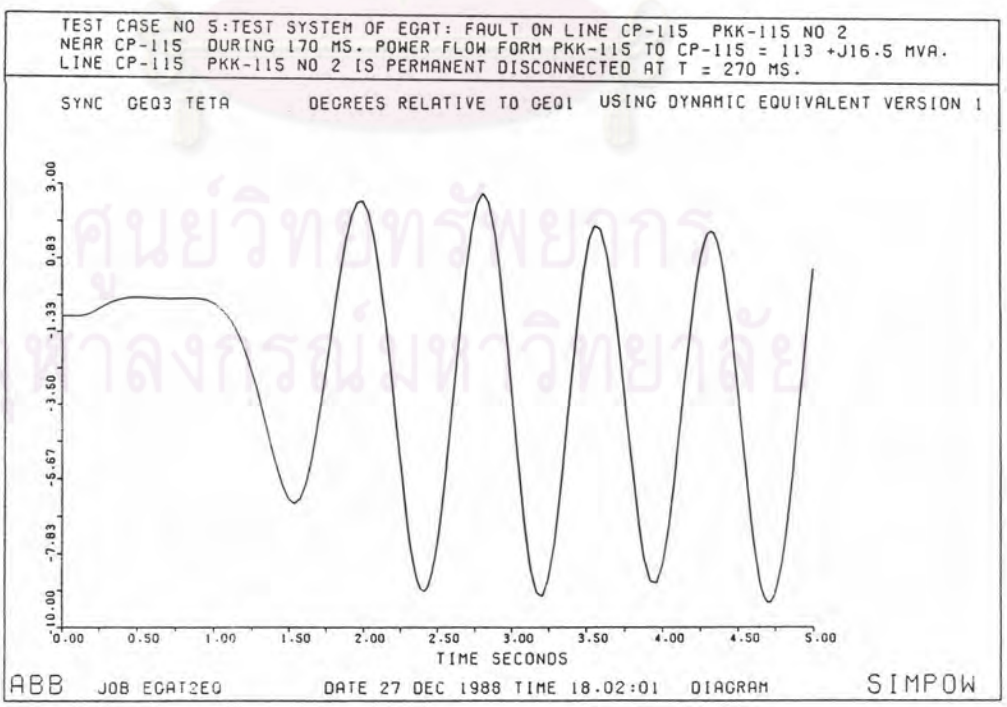


Figure A3.5.12

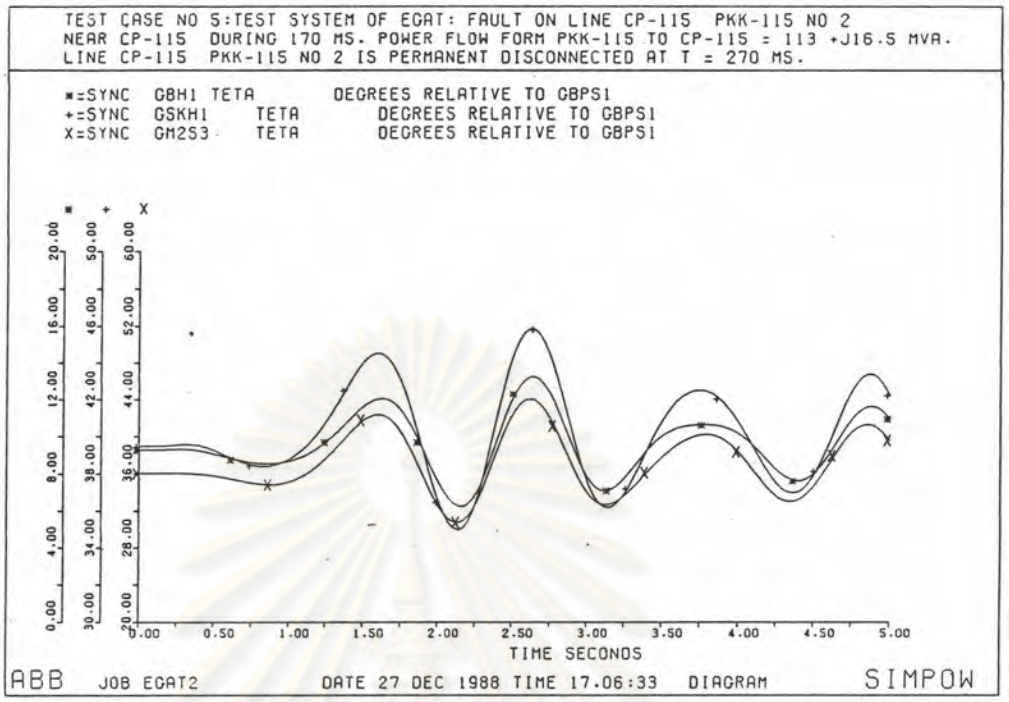


Figure A3.5.13

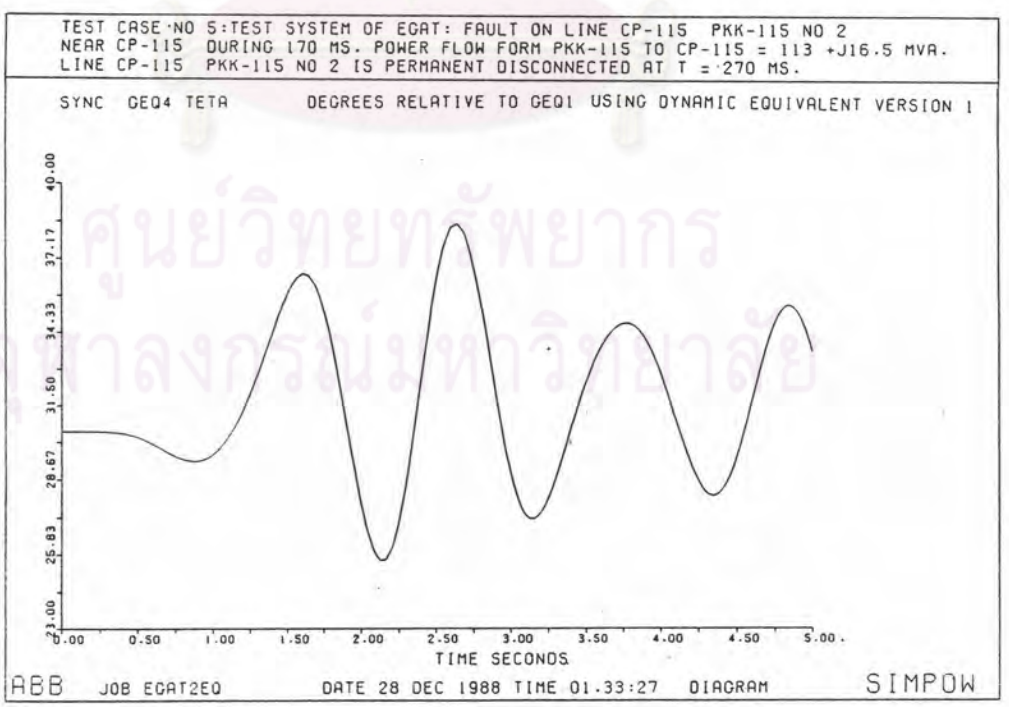


Figure A3.5.14

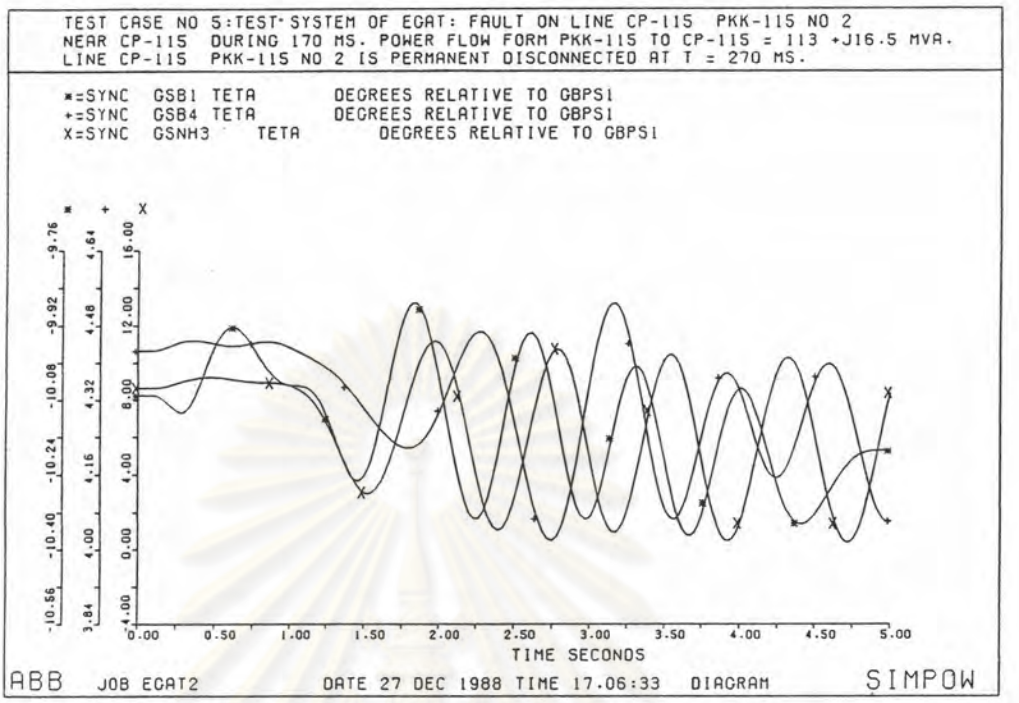


Figure A3.5.15

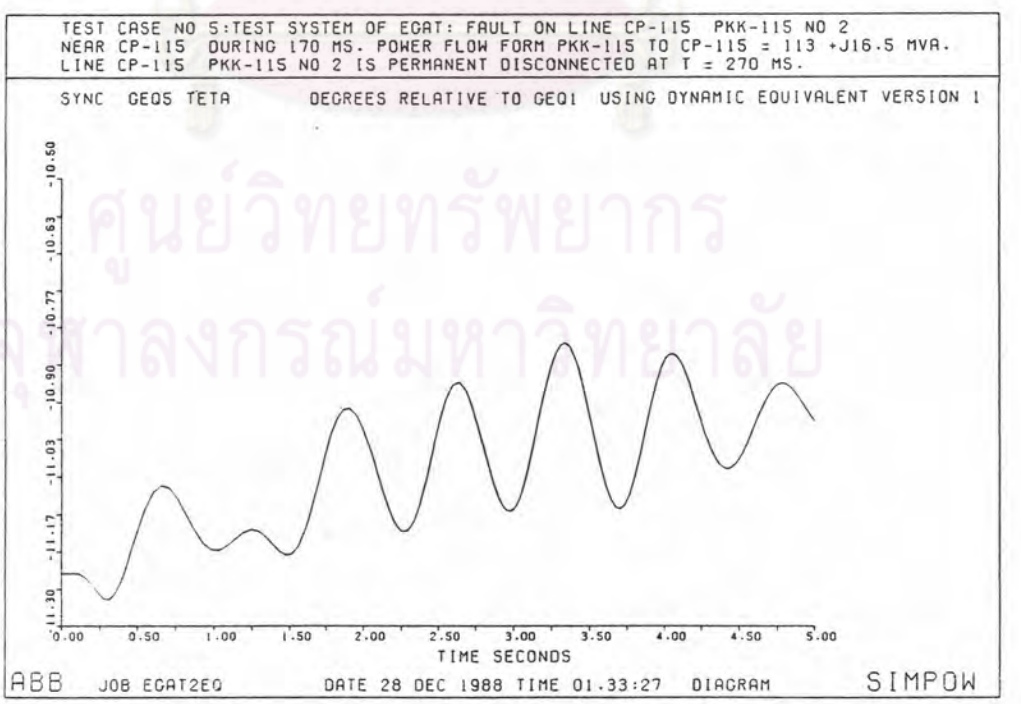


Figure A3.5.16

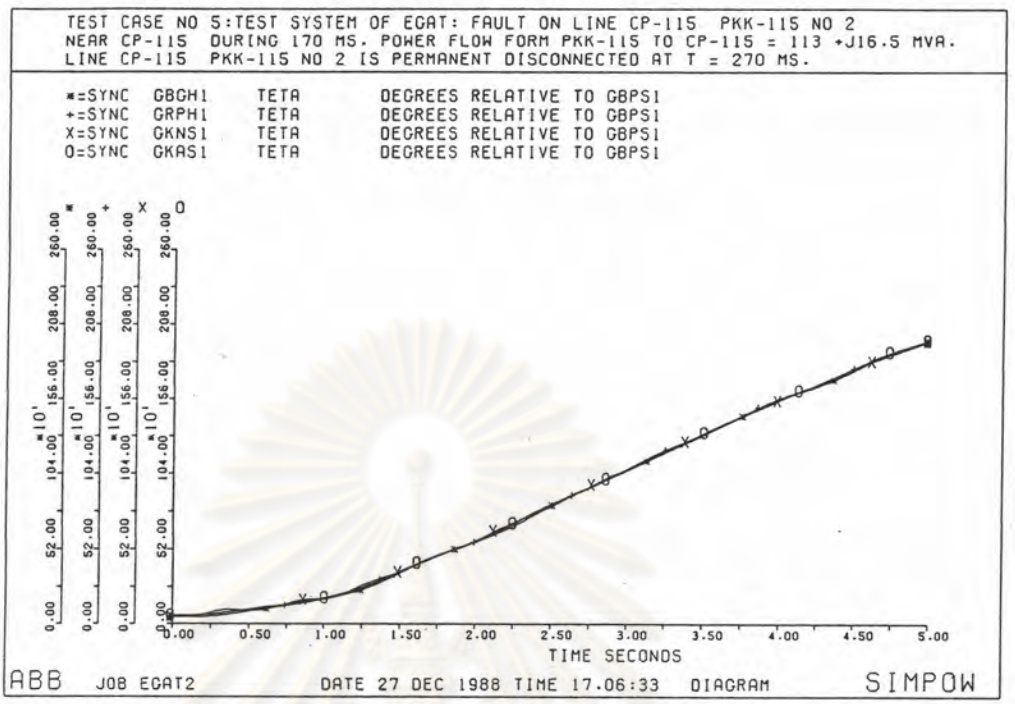


Figure A3.5.17

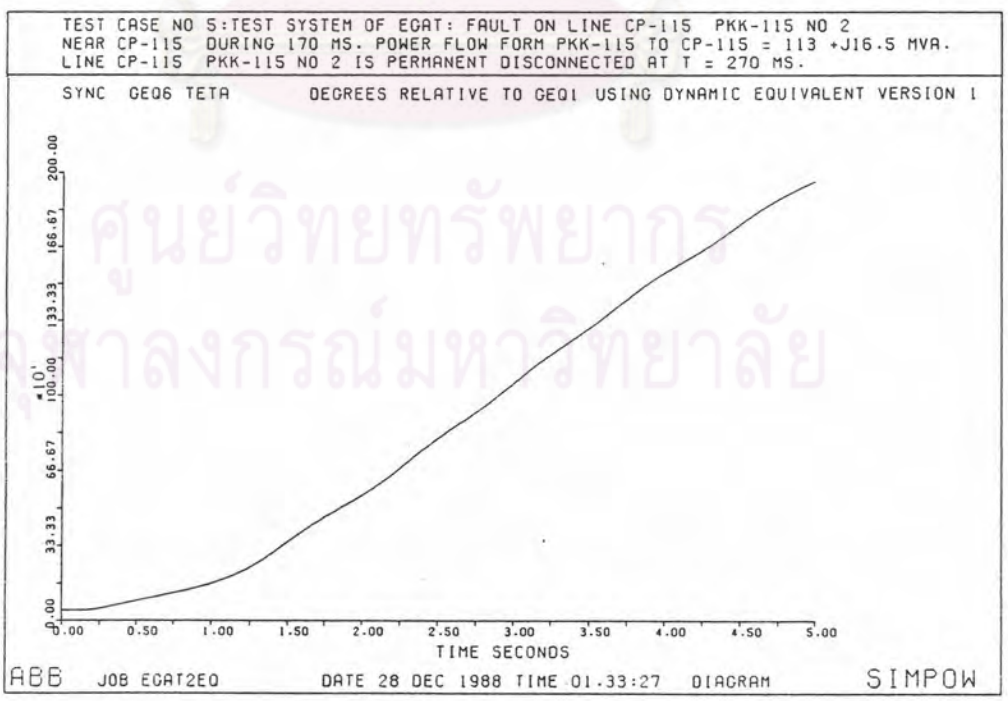


Figure A3.5.18

APPENDIX 4

The simplified single line diagram with load flow solution of actual and reduced system in case no 1. and case no. 2

SYMBOLS USES IN APPENDIX 4

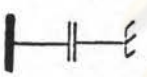
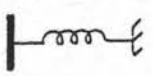
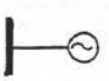
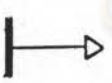
SYMBOL	DESCRIPTION
	AC-Line
	Two-winding transformer
	Load
	Shunt capacitor
	Shunt reactor
	Generator
	Power exchange to nodes without coordinates
U	Magnitude of bus voltage
FI	Phase angle of bus voltage

Table A4 The symbols used in appendix 4

- Vaule shown in figures is in per unit.
- Base power of the network is 100 MVA.

APPENDIX 4.1

The simplified single line diagram with load flow solution of actual and reduced system in case no. 1

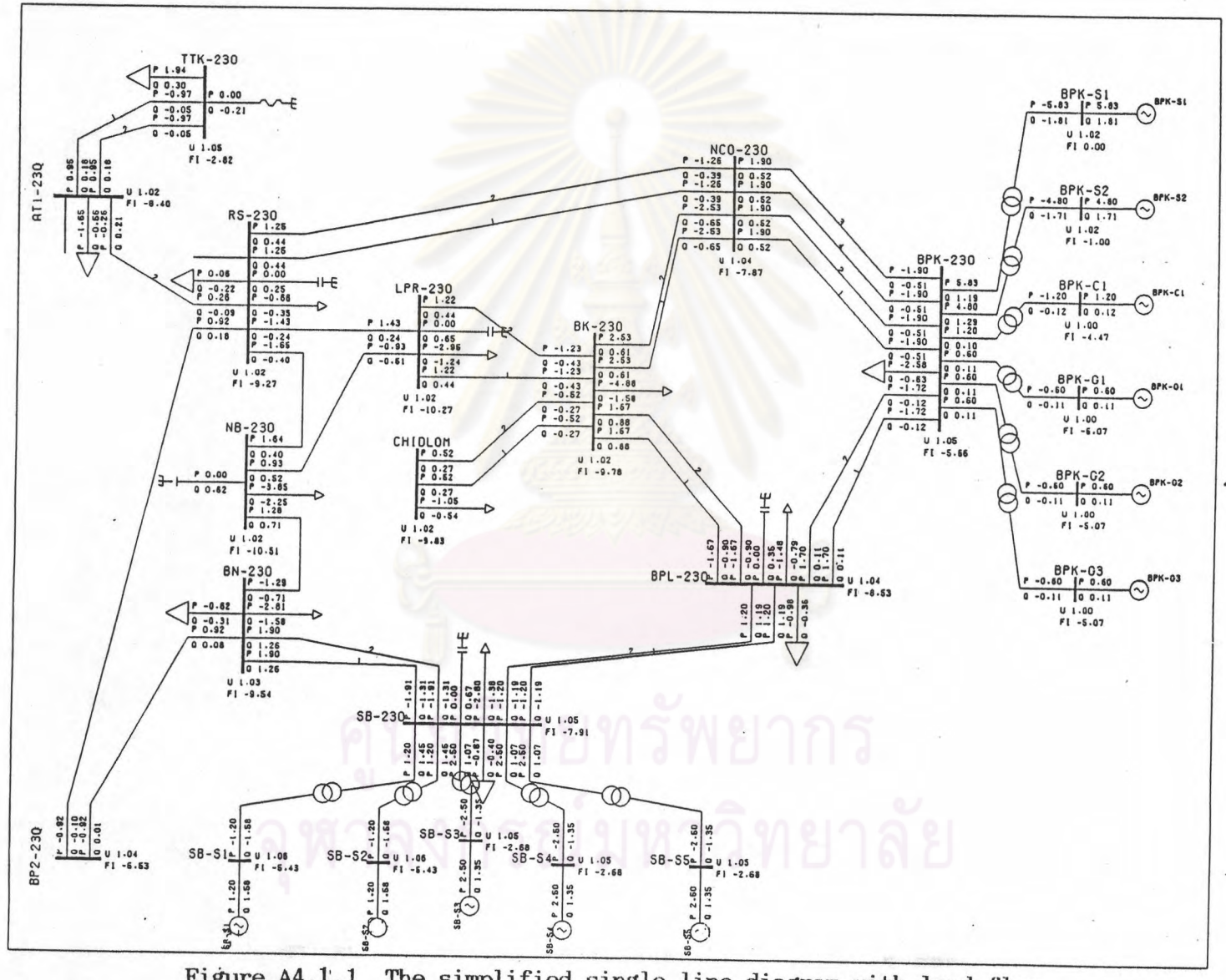


Figure A4.1.1 The simplified single line diagram with load flow solution in AREA 1 and AREA 5 of actual system.

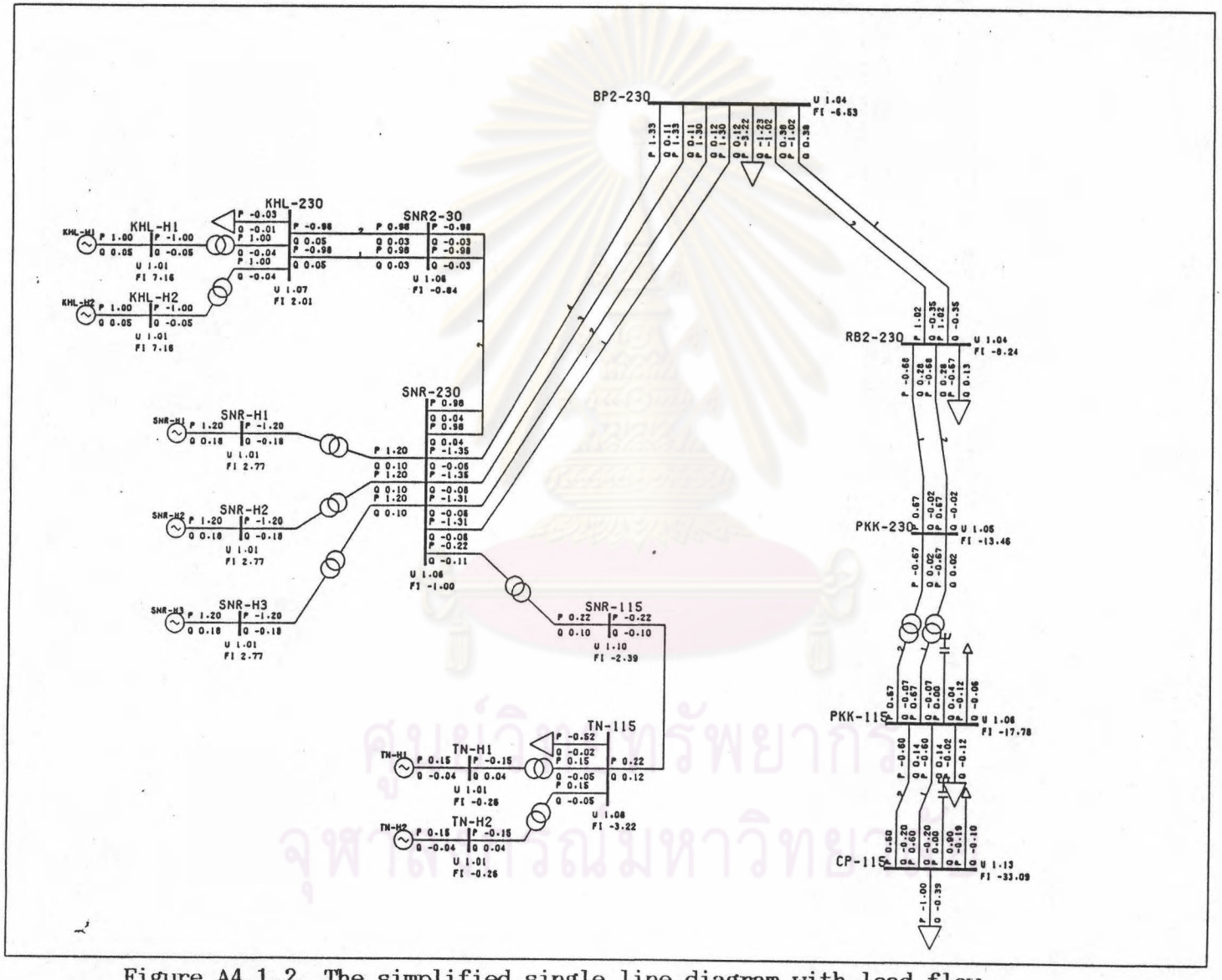


Figure A4.1.2 The simplified single line diagram with load flow solution in AREA 3 of actual system.

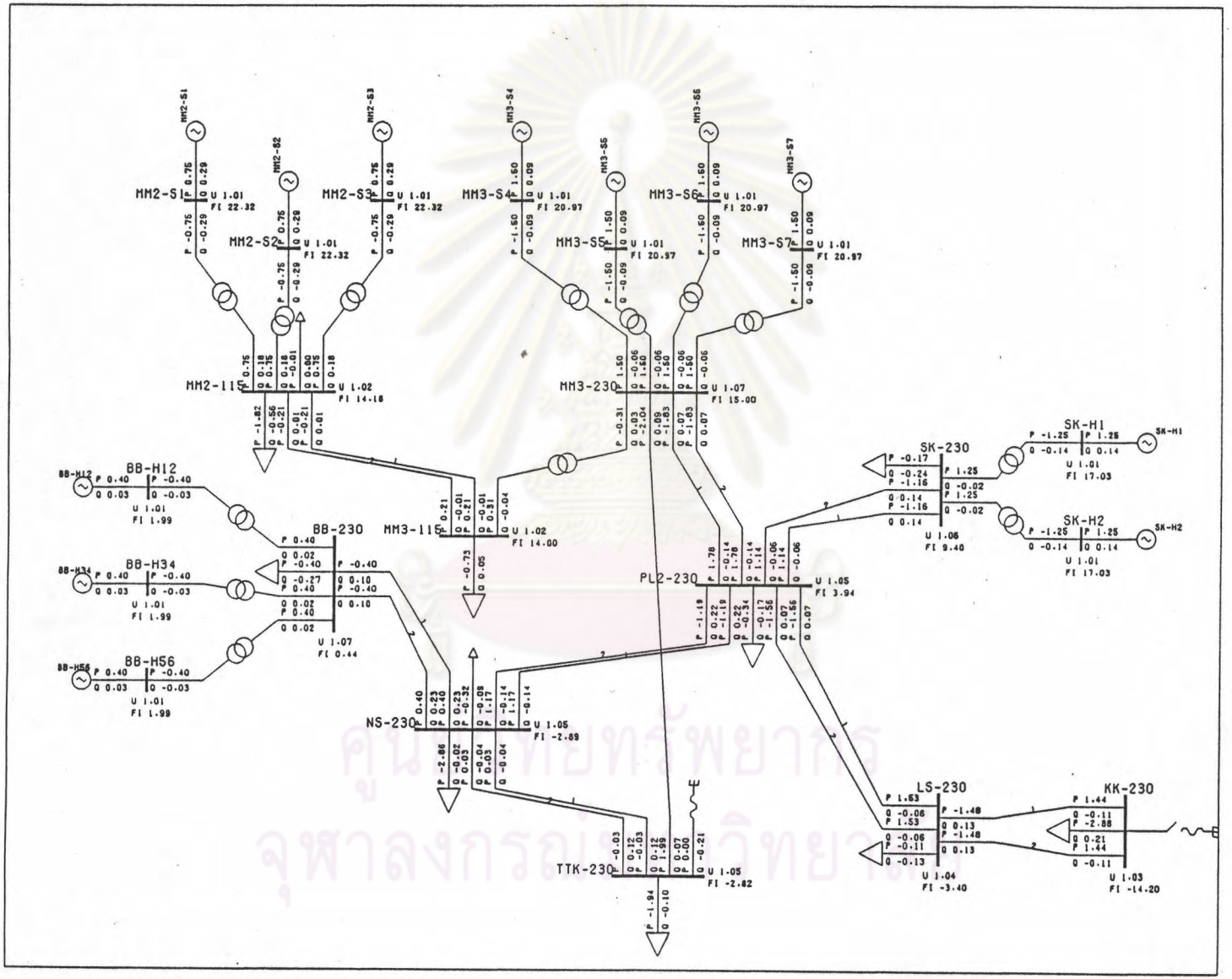


Figure A4.1.3 The simplified single line diagram with load flow solution in AREA 4 of actual system.

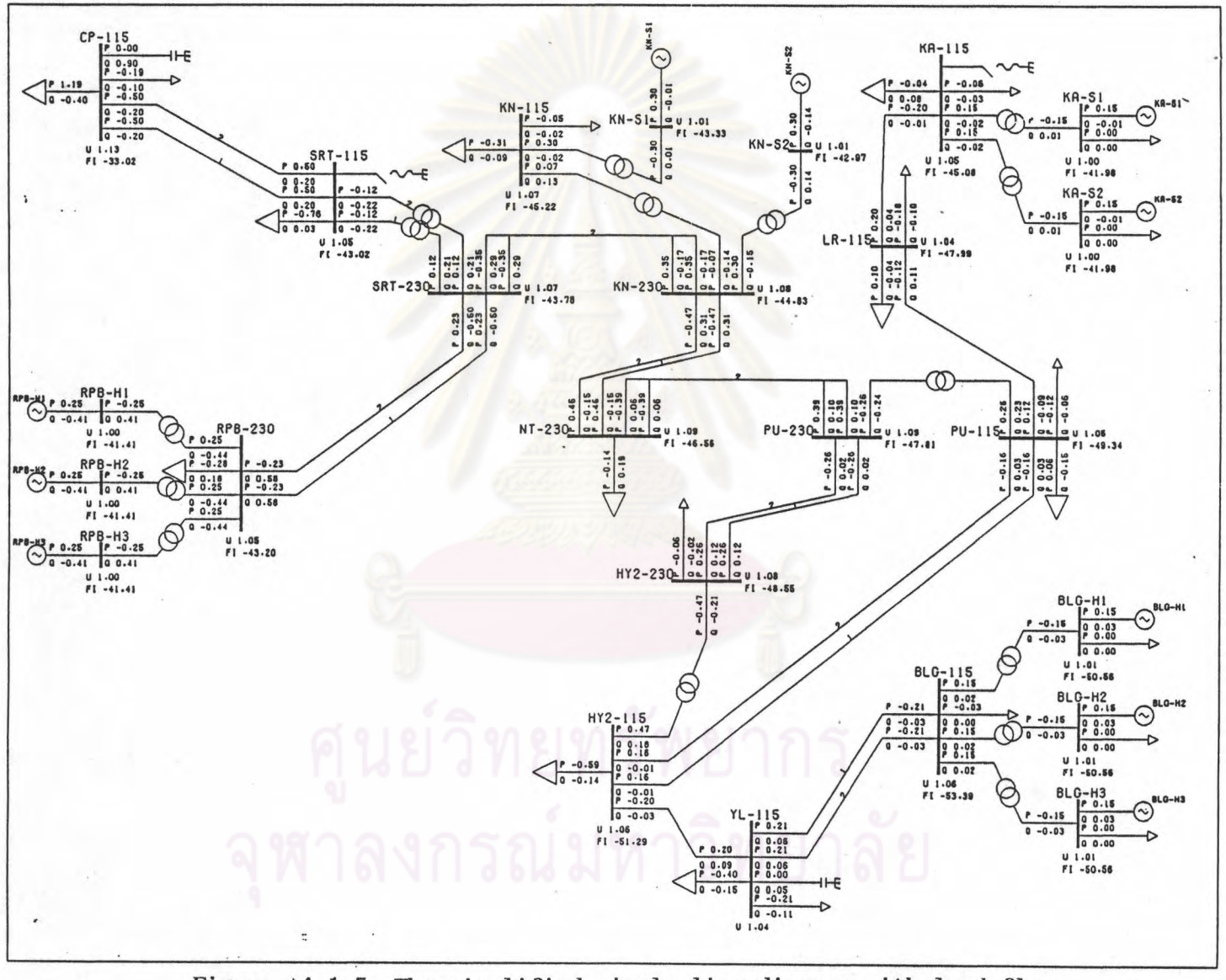


Figure A4.1.5 The simplified single line diagram with load flow solution in AREA 6 of actual system.

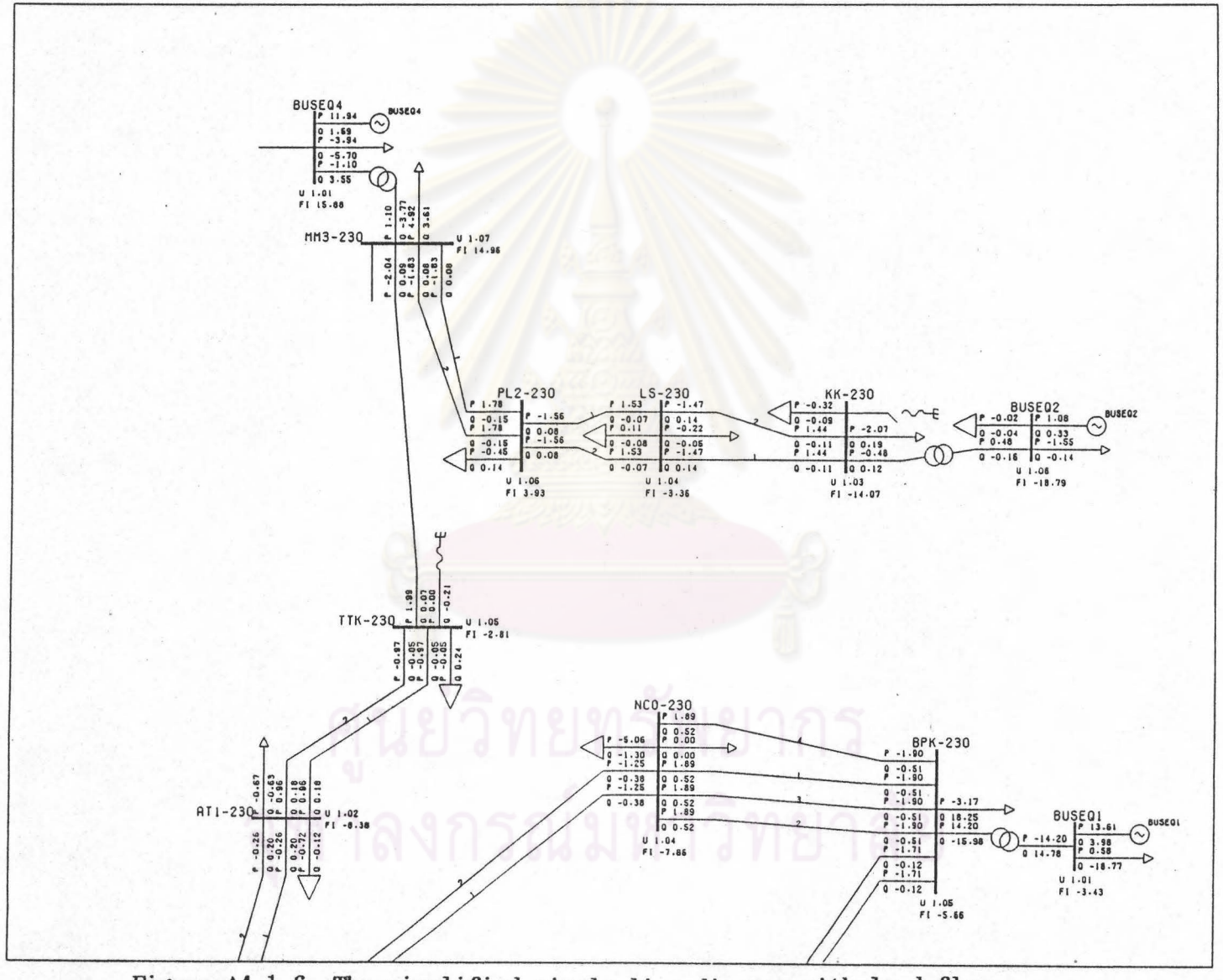


Figure A4.1.6 The simplified single line diagram with load flow solution in upper part of reduced system.

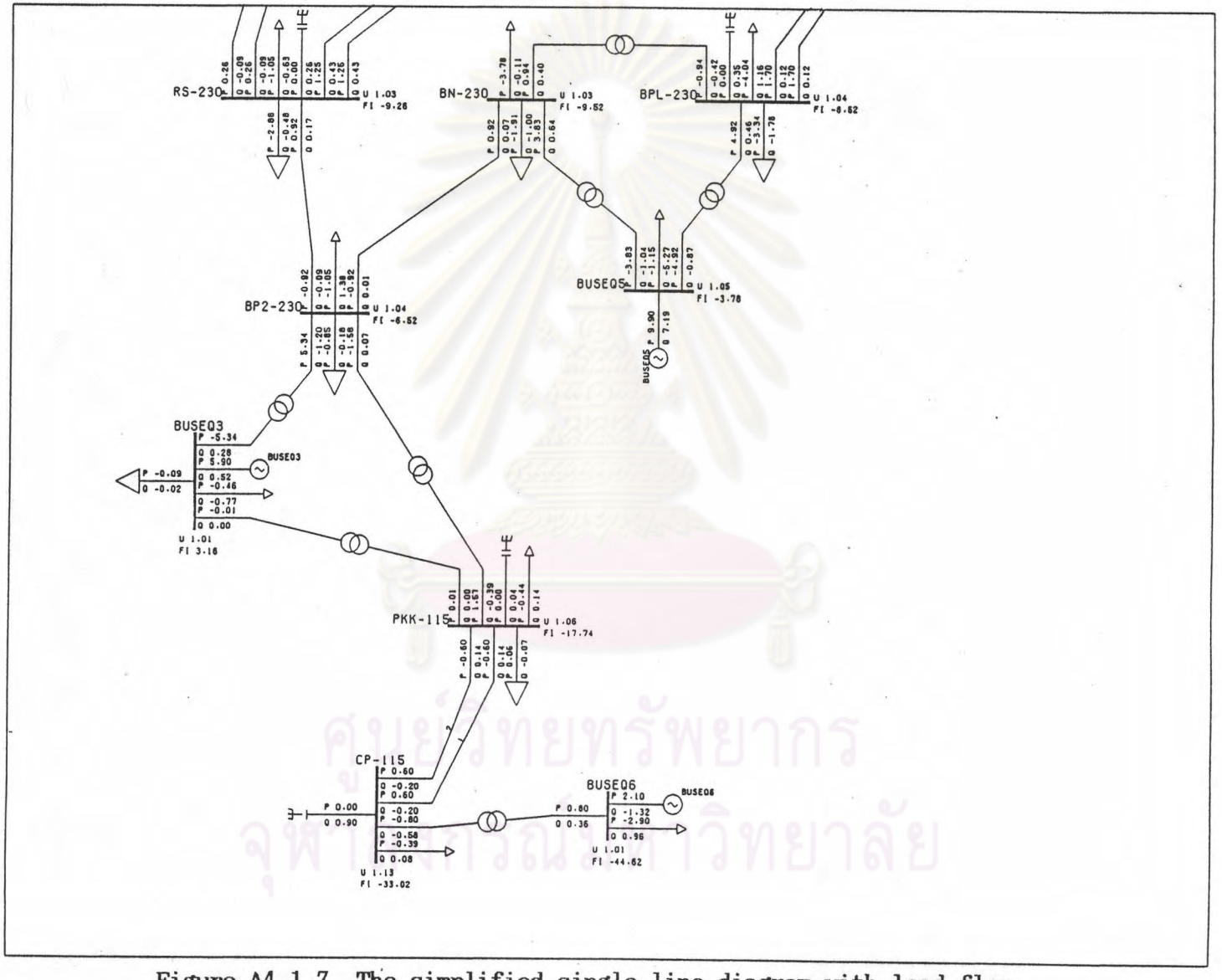


Figure A4.1.7 The simplified single line diagram with load flow solution in lower part of reduced system.

APPENDIX 4.2

The simplified single line diagram with load flow solution of actual and reduced system in case no. 2

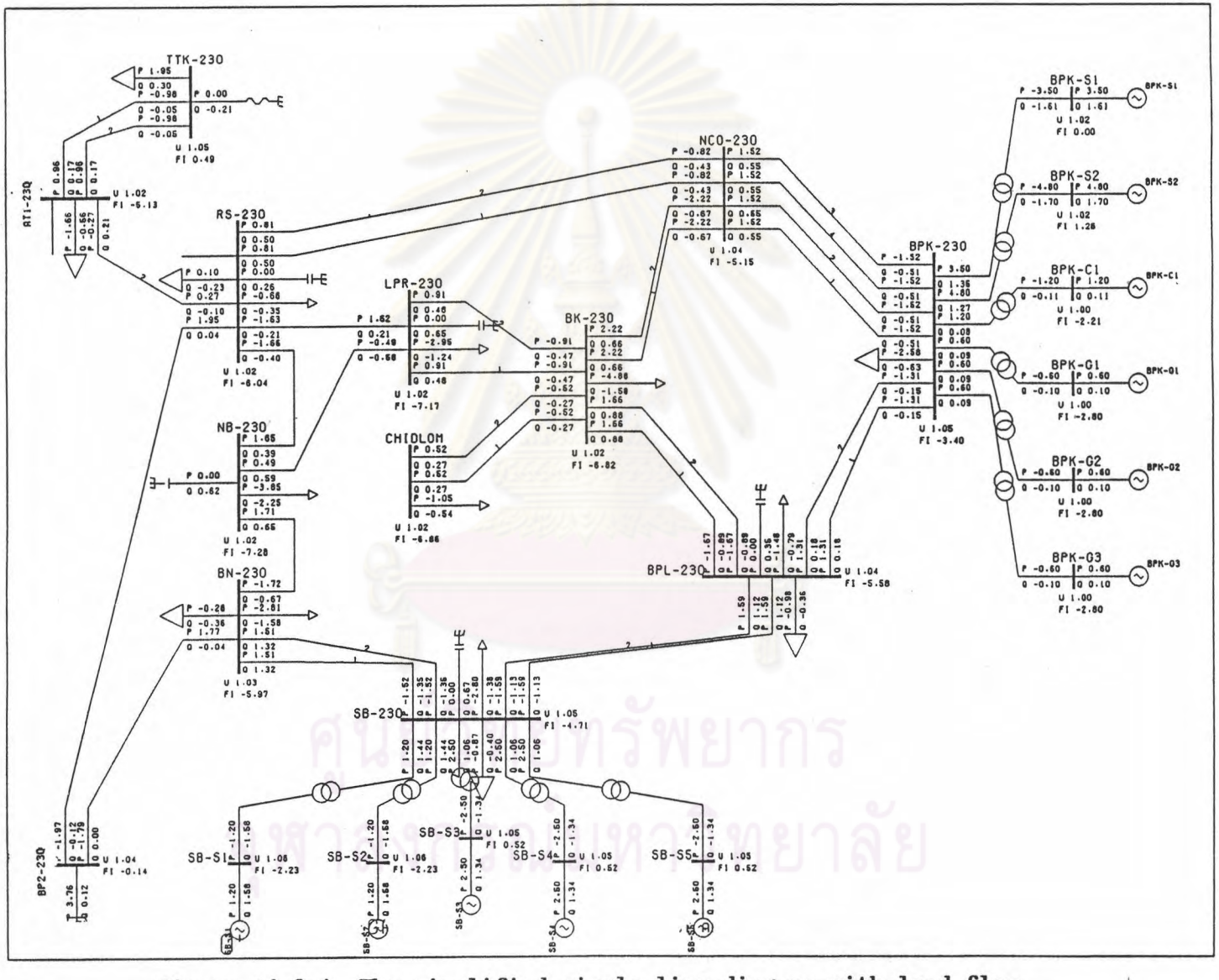


Figure A4.2.1 The simplified single line diagram with load flow solution in AREA 1 and AREA 5 of actual system.

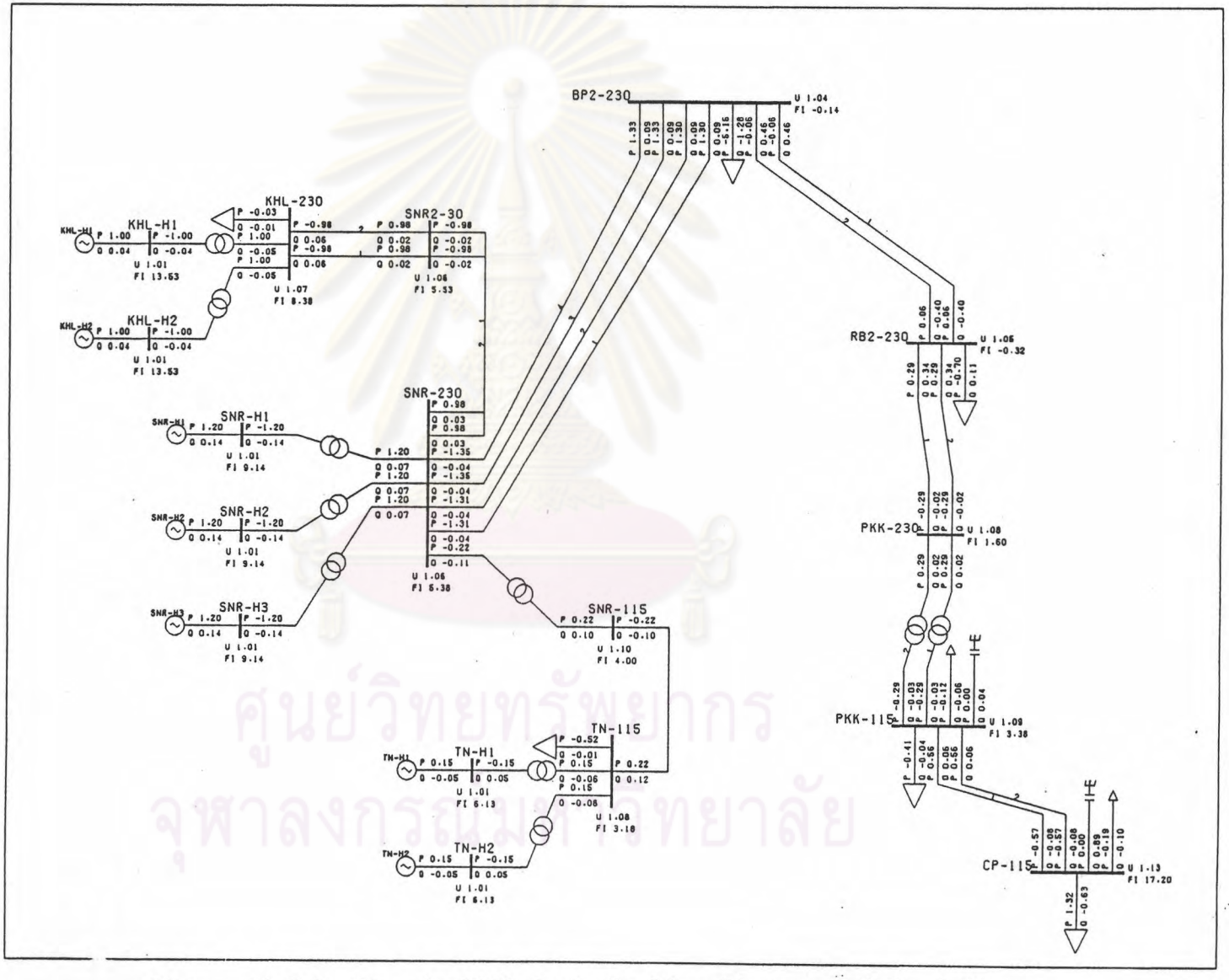


Figure A4.2.2 The simplified single line diagram with load flow solution in AREA 3 of actual system.

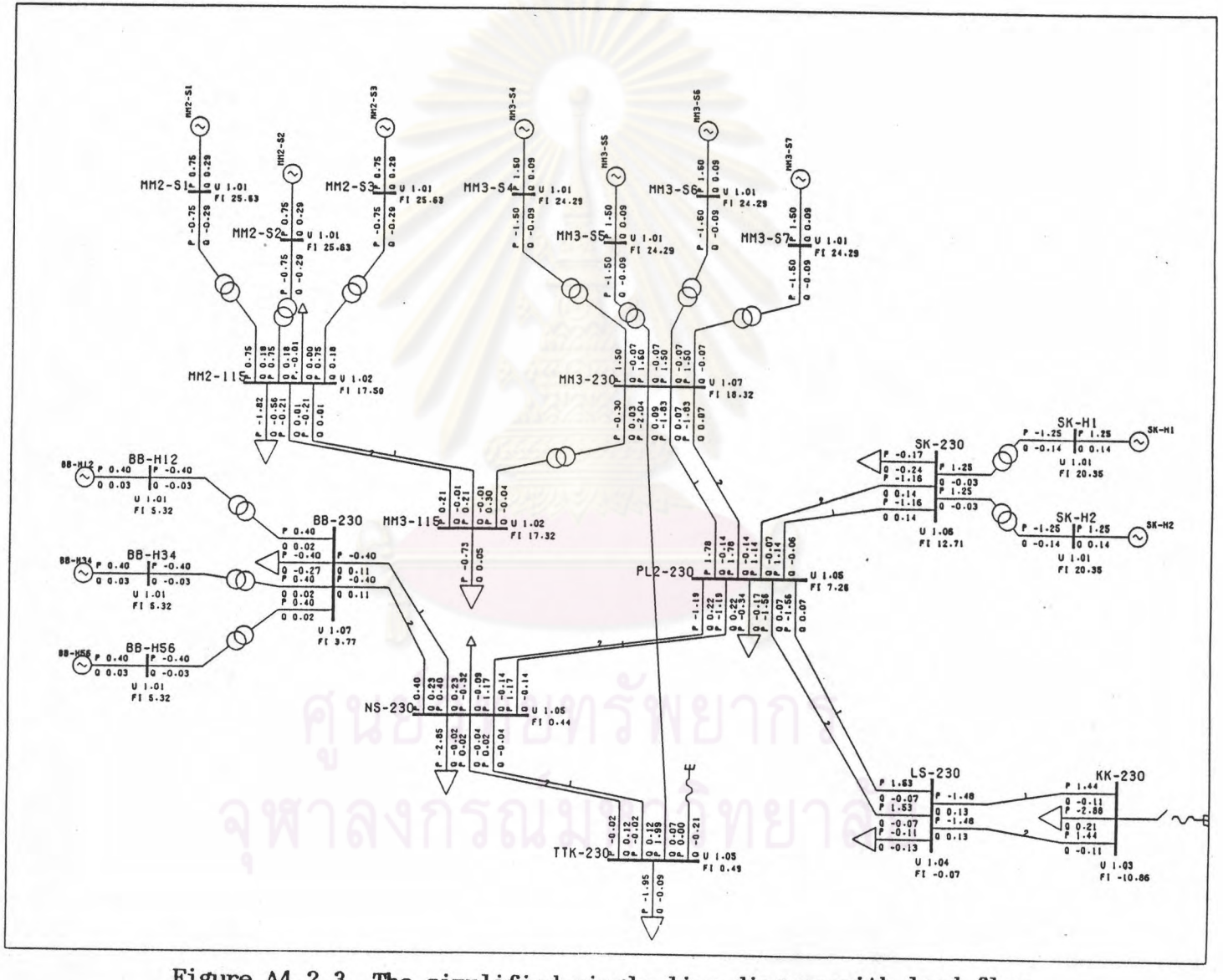


Figure A4.2.3 The simplified single line diagram with load flow solution in AREA 4 of actual system.

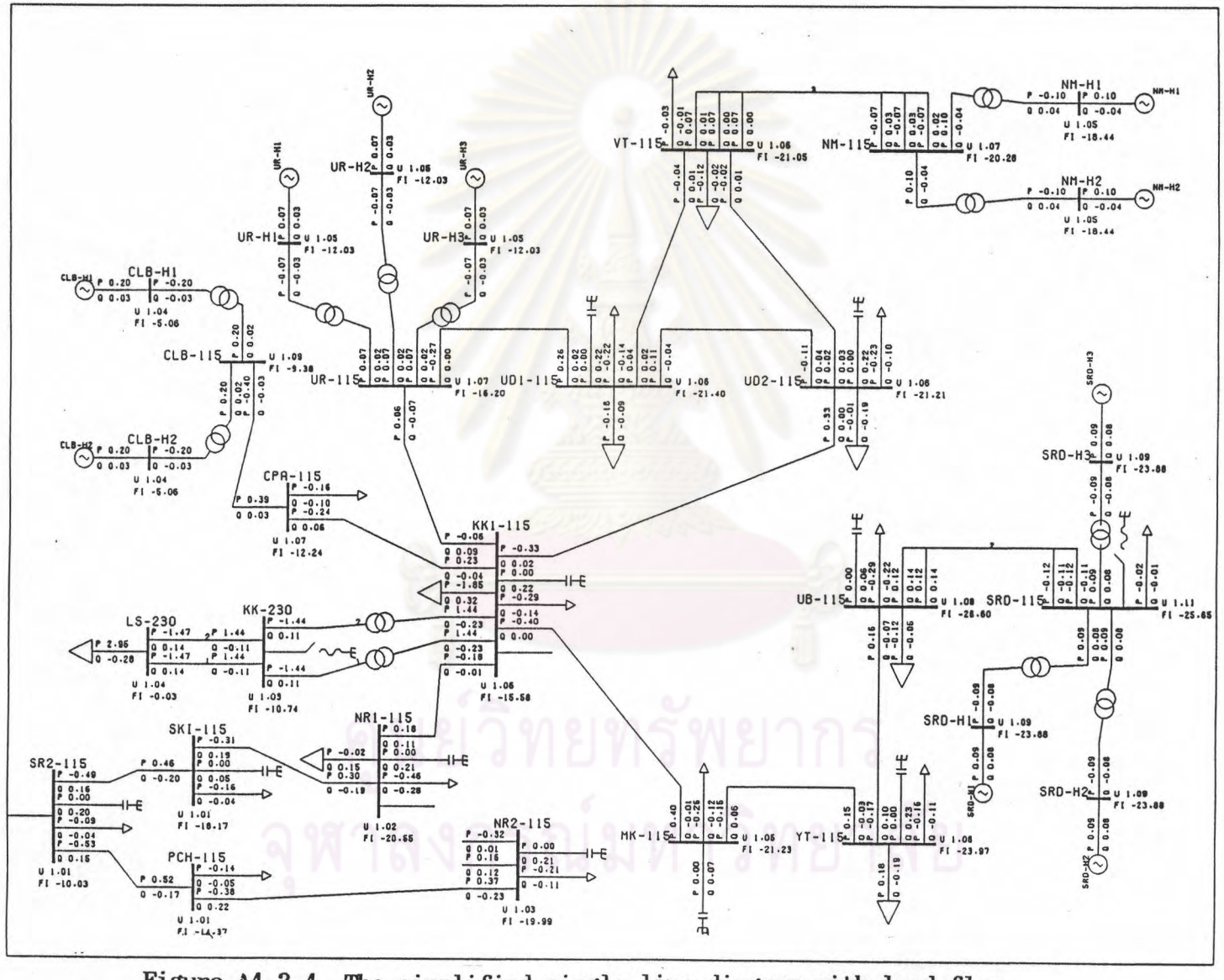


Figure A4.2.4 The simplified single line diagram with load flow solution in AREA 2 of actual system.

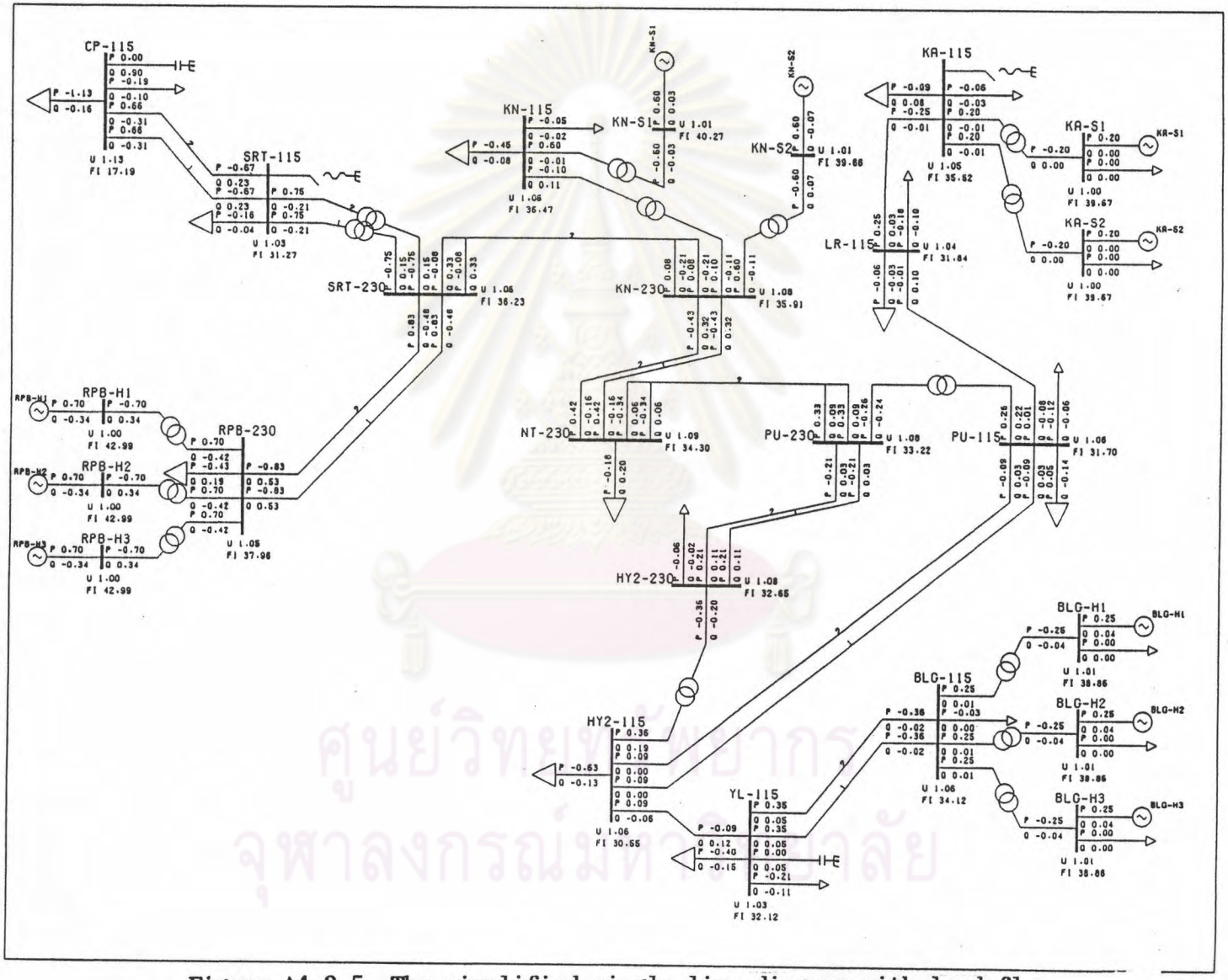


Figure A4.2.5 The simplified single line diagram with load flow solution in AREA 6 of actual system.

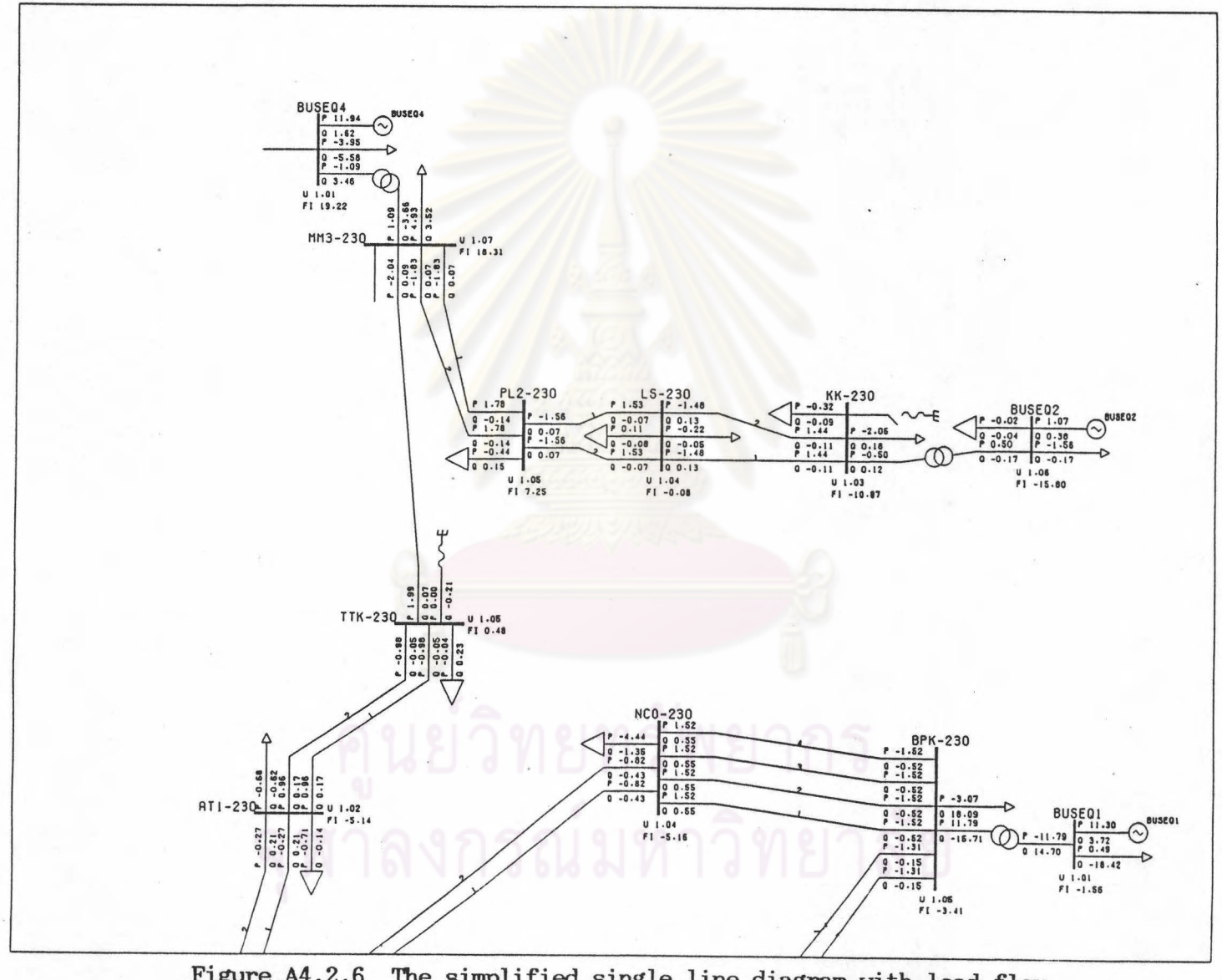


Figure A4.2.6 The simplified single line diagram with load flow solution in upper part of reduced system.

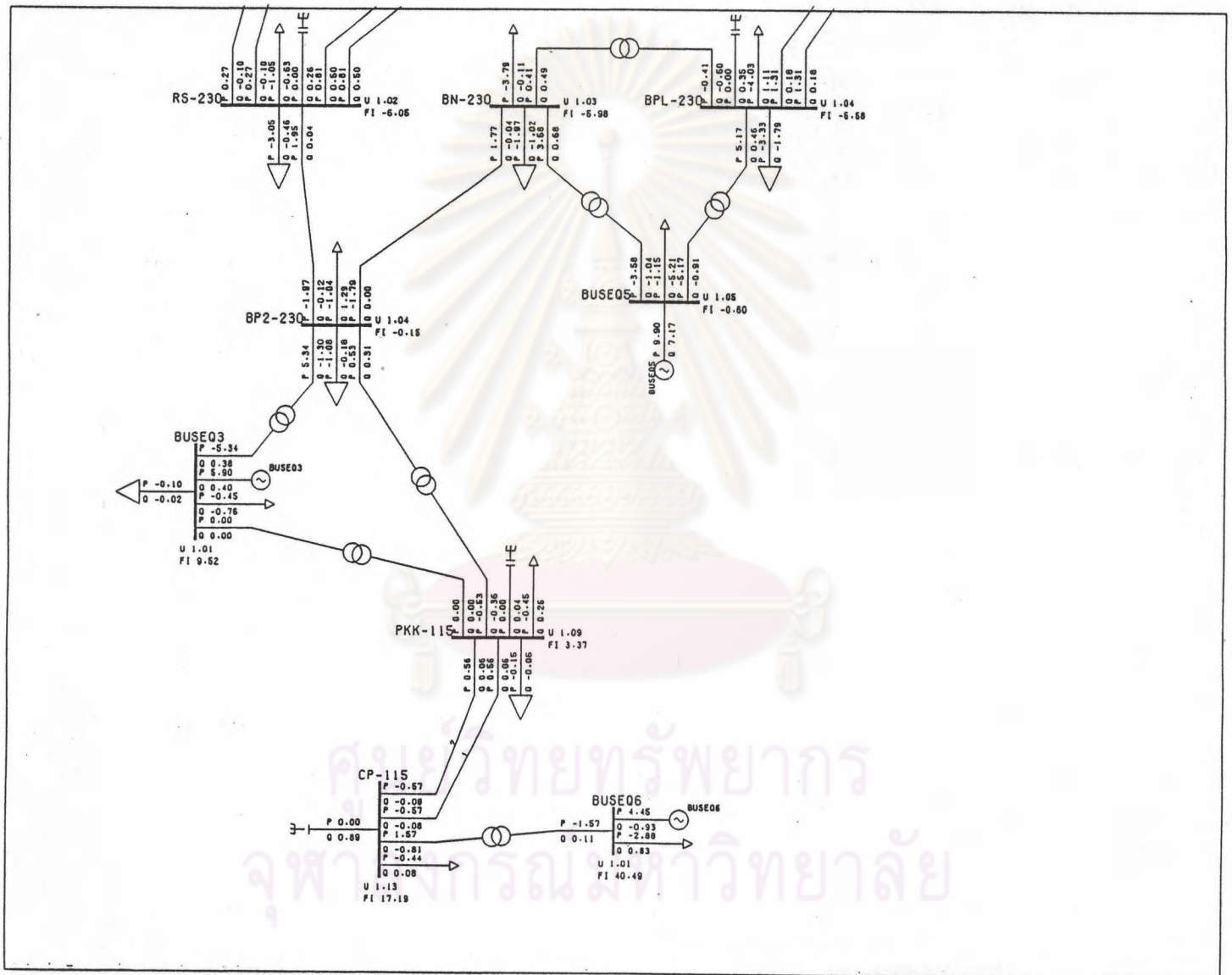


Figure A4.2.7 The simplified single line diagram with load flow solution in lower part of reduced system.

VITA

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