

**GTTM1 – A FORTRAN PACKAGE FOR
GRADIENT ANALYSIS IN POWER SYSTEMS**

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GTTM1 - A FORTRAN PACKAGE FOR
GRADIENT ANALYSIS IN POWER SYSTEMS

J.W. Bandler, M.A. El-Kady and J. Wojciechowski

Abstract

This document contains a listing of the package GTTM1 for gradient evaluation in various power system applications. GTTM1 provides the values and the reduced gradients of a variety of functions frequently used in the optimal load flow and power system planning problems. The Tellegen theorem method is used with the aid of sparse matrix techniques for efficient gradient calculation.

The package GTTM1 has been developed for the CDC 170/815 system with the NOS 2.1 operating system and the Fortran Extended (FTN) version 4.8 compiler. The listing contains a total of 1334 lines (including 359 comments) constituting 33 subroutines.

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I. INTRODUCTION

This document contains a Fortran listing of the package GTTM1 for gradient analysis in power systems. The user manual of the package together with illustrative examples is found in [1].

The package GTTM1 implements the Tellegen theorem method for gradient calculation [2,3]. It provides the values and the reduced gradients of a variety of functions frequently used in the optimal load flow and planning problems. These functions are: load bus voltage magnitude, bus voltage argument, generator bus reactive power, current magnitude of an admittance-type element, transmission power losses, slack bus active power, cost of generation. The allowed control variables are: input and output line shunt conductance and susceptance, transmission line conductance and susceptance, bus static load, load bus active and reactive powers, generator bus active power and voltage magnitude.

The package has been developed in Fortran IV for use on the CDC 170/815 system with the NOS 2.1 operating system. The package is available at McMaster University in the form of a library of binary relocatable subroutines. The library is in the group indirect file LIBGTM1 accessible under the charge RJWBAND. The package calls the subroutine SENSIT of the package TTM1 [3]. Subsequently subroutines DERIV, FORMTE, and PQ of TTM1 and also subroutines MA28A, MA28B and MA28C of the package MA28 [4] are called. Packages TTM1 and MA28 must thus be available when GTTM1 is used. This document includes neither of these packages.

The package GTTM1 has been modularized into 33 subroutines. It contains 1334 lines of which 359 are comments.

II. REFERENCES

- [1] J.W. Bandler, M.A. El-Kady and J. Wojciechowski, "GTTM1 - A Fortran package for gradient analysis in power systems", Department of Electrical and Computer Engineering, McMaster University, Hamilton, Canada, Report SOS-83-30-U, 1983.
- [2] J.W. Bandler and M.A. El-Kady, "Exact power network sensitivities via generalized complex branch modelling", Proc. IEEE Symp. CAS (Rome, Italy, May 1982), pp. 313-316.
- [3] J.W. Bandler, M.A. El-Kady and J. Wojciechowski, "TTM1 - A Fortran implementation of the Tellegen theorem method to power system simulation and design", Department of Electrical and Computer Engineering, McMaster University, Hamilton, Canada, Report SOS-82-12-U2, 1983.
- [4] I.A. Duff, "MA28 - A set of Fortran subroutines for sparse unsymmetric linear equations", Computer Science and Systems Division, AERE Harwell, Oxfordshire, England, Report R.8730, 1980.

III. LISTING OF THE PACKAGE GRAD

<u>Subroutine</u>	<u>Number of lines</u> (source text)	<u>Number of words</u> (compiled code)	<u>Listing from page</u>
WDADJ	35	104	5
GRAD1	33	263	6
GRAD2	34	266	7
GRAD3	41	456	8
GRAD4	46	475	9
GRAD5	46	507	10
GRAD6	40	452	11
GRAD7	40	430	12
GRAD8	45	576	13
PARDER3	68	420	14
PARDER4	62	347	16
PARDER5	65	367	17
PARDER6	56	261	18
PARDER7	64	407	19
PARDER8	84	610	20
RHST1	26	147	22
RHST2	27	161	23
RHST3G	23	136	24
RHST3S	39	202	25
RHST4	50	243	26
RHST5	51	256	27
RHST6	39	216	28
RHST7	39	173	29
RHST8	39	201	30
PDR3	32	117	31
PDR4	28	201	32
PDR5	26	142	33
PDR6	29	172	34
PDR7	32	117	35
PDR8	32	131	36
WRTGR	14	132	37
CF1	35	146	38
CF5	14	65	39

C		A	1
C		A	2
C		A	3
	SUBROUTINE WDADJ (WADJ,LADJ,NB,NTL)	A	4
C		A	5
C	SUBROUTINE WDADJ DISTRIBUTES WORKSPACE VECTOR WADJ INTO	A	6
C	A FAMILY OF SUBVECTORS USED FOR GRADIENT ANALYSIS	A	7
C		A	8
	REAL WADJ(LADJ)	A	9
	COMMON /MDADJ/ JT, JICN, JICT, JIRT, JIKEEP, JIW, JCS, JRHS, JPDR/FLAG/IFL	A	10
	IAG	A	11
C		A	12
	IFLAG=0	A	13
	N1=NB+NB	A	14
	NYT=NB+NTL+NTL	A	15
	NR=N1-2	A	16
	NZ=(7*NYT)/2	A	17
	LICN=3*NZ	A	18
	LIRN=NZ+NR	A	19
	JT=1	A	20
	JICN=JT+LICN	A	21
	JICT=JICN+LICN	A	22
	JIRT=JICT+NZ	A	23
	JIKEEP=JIRT+LIRN	A	24
	JIW=JIKEEP+5*NR	A	25
	JCS=JIW+8*NR	A	26
	JRHS=JCS+N1	A	27
	JPDR=JRHS+N1	A	28
	JMAX=JPDR+NB/2+NTL-1	A	29
	IF (JMAX.LE.LADJ) RETURN	A	30
	IFLAG=-1	A	31
	WRITE (6,10) JMAX	A	32
	RETURN	A	33
10	FORMAT (///" WORKSPACE REQUIRED FOR GRADIENT ANALYSIS:",I4)	A	34
	END	A	35

C		B	1
C		B	2
C		B	3
	SUBROUTINE GRAD1 (LBINP, LBOUT, YT, JRYT, ICYT, V, BTYP, CCV, ICV, DF, F, WAD	B	4
	1J, NB, IND, NCV, MODE, IWRITE)	B	5
		B	6
C		B	7
C	SUBROUTINE GRAD1 CALCULATES VOLTAGE MODULUS OF THE INDTH BUS	B	8
C	AND ITS GRADIENTS W.R.T. CONTROL VARIABLES DEFINED BY VECTORS	B	9
C	CCV, ICV	B	10
		B	11
	INTEGER LBINP(1), LBOUT(1), JRYT(1), ICYT(1), BTYP(1), CCV(1), ICV(1)	B	12
	REAL WADJ(1), DF(1)	B	13
	COMPLEX V(1), YT(1), VB	B	14
	COMMON /MDADJ/ JT, JICN, JICT, JIRT, JIKEEP, JIW, JCS, JRHS, JPDR/FLAG/IFL	B	15
	1AG	B	16
C		B	17
	IFLAG=0	B	18
	NAV=NB+NB	B	19
	VB=V(IND)	B	20
	CALL RHST1 (VB, IND, WADJ(JRHS), NAV, IWRITE)	B	21
	IVT=1	B	22
	CALL SENSIT (LBINP, LBOUT, YT, JRYT, ICYT, V, BTYP, WADJ(JCS), WADJ(JRHS),	B	23
	1CCV, ICV, WADJ(JPDR), DF, WADJ(JT), WADJ(JIRT), WADJ(JICT), WADJ(JICN), WA	B	24
	2DJ(JIKEEP), WADJ(JIW), NB, NCV, IVT, MODE, IFLAG, 6, IWRITE-1)	B	25
	IF (IFLAG.LT.0) RETURN	B	26
	F=CABS(VB)	B	27
	IF (IWRITE.LT.3) RETURN	B	28
	WRITE (6, 10) IND, F	B	29
	CALL WRTGR (CCV, ICV, DF, NCV)	B	30
	RETURN	B	31
	10 FORMAT (// " VOLTAGE MODULUS OF BUS: ", I3, / " VALUE OF FUNCTION", 4X, E1	B	32
	13.7 / " GRADIENTS ")	B	33
	END	B	33

C		C	1
C		C	2
C		C	3
	SUBROUTINE GRAD2 (LBINP, LBOUT, YT, JRYT, ICYT, V, BTYP, CCV, ICV, DF, F, WAD	C	4
	1J, NB, IND, NCV, MODE, IWRITE)	C	5
C		C	6
C	SUBROUTINE GRAD2 CALCULATES VOLTAGE ARGUMENT OF THE INDTH BUS	C	7
C	AND ITS GRADIENTS W.R.T. CONTROL VARIABLES DEFINED BY VECTORS	C	8
C	CCV, ICV	C	9
C		C	10
	INTEGER LBINP(1), LBOUT(1), JRYT(1), ICYT(1), BTYP(1), CCV(1), ICV(1)	C	11
	REAL WADJ(1), DF(1)	C	12
	COMPLEX V(1), YT(1), VB	C	13
	COMMON /MDADJ/ JT, JICN, JICT, JIRT, JIKEEP, JIW, JCS, JRHS, JPDR/FLAG/IFL	C	14
	1AG	C	15
C		C	16
	IFLAG=0	C	17
	NAV=NB+NB	C	18
	VB=V(IND)	C	19
	ITYP=BTYP(IND)	C	20
	CALL RHST2 (VB, ITYP, IND, WADJ(JRHS), NAV, IWRITE)	C	21
	IVT=1	C	22
	CALL SENSIT (LBINP, LBOUT, YT, JRYT, ICYT, V, BTYP, WADJ(JCS), WADJ(JRHS),	C	23
	1CCV, ICV, WADJ(JPDR), DF, WADJ(JT), WADJ(JIRT), WADJ(JICT), WADJ(JICN), WA	C	24
	2DJ(JIKEEP), WADJ(JIW), NB, NCV, IVT, MODE, IFLAG, 6, IWRITE-1)	C	25
	IF (IFLAG.LT.0) RETURN	C	26
	F=ATAN2(AIMAG(VB), REAL(VB))	C	27
	IF (IWRITE.LT.3) RETURN	C	28
	WRITE (6, 10) IND, F	C	29
	CALL WRTRC (CCV, ICV, DF, NCV)	C	30
	RETURN	C	31
10	FORMAT (///" VOLTAGE ARGUMENT OF BUS: ", I3/" VALUE OF FUNCTION", 4X, E	C	32
	113.7/" GRADIENTS")	C	33
	END	C	34


```
C
C
SUBROUTINE GRAD3 (LBINP, LBOUT, YT, JRYT, ICYT, V, BTYP, CCV, ICV, DF, F, WAD
1J, NB, IND, NCV, MODE, IWRITE)
C
C
SUBROUTINE GRAD3 CALCULATES THE VALUE OF REACTIVE POWER AT THE
C
C
INDTH BUS AND ITS GRADIENTS W.R.T. CONTROL VARIABLES DEFINED BY
C
C
VECTORS CCV, ICV
C
C
INTEGER LBINP(1), LBOUT(1), JRYT(1), ICYT(1), BTYP(1), CCV(1), ICV(1)
REAL WADJ(1), DF(1)
COMPLEX V(1), YT(1), VB, CF5
COMMON /MDADJ/ JT, JICN, JICT, JIRT, JIKEEP, JIW, JCS, JRHS, JPDR/FLAG/IFL
1AG
Q(K)=AIMAG(CF5(V(K), YT(JRYT(K)), V, LO, ICYT(JRYT(K)), JRYT(K+1)-JRYT(
1K), 1))
C
IFLAG=0
NAV=NB+NB
VB=V(IND)
IF (IND.LT.NB) CALL RHST3G (VB, IND, WADJ(JRHS), NAV, IWRITE)
IF (IND.EQ.NB) CALL RHST3S (YT, JRYT, ICYT, V, BTYP, WADJ(JRHS), NB, IWRI
1TE)
CALL PDR3 (LBINP, LBOUT, VB, CCV, ICV, WADJ(JPDR), IND, NCV, NDR)
IVT=1
CALL SENSIT (LBINP, LBOUT, YT, JRYT, ICYT, V, BTYP, WADJ(JCS), WADJ(JRHS),
1CCV, ICV, WADJ(JPDR), DF, WADJ(JT), WADJ(JIRT), WADJ(JICT), WADJ(JICN), WA
2DJ(JIKEEP), WADJ(JIW), NB, NCV, IVT, MODE, IFLAG, 6, IWRITE-1)
IF (IFLAG.LT.0) RETURN
F=Q(IND)
K=JRYT(IND)
NYR=JRYT(IND+1)-K
CALL PARDER3 (LBINP, LBOUT, YT(K), ICYT(K), V, CCV, ICV, DF, F, IND, NCV, NYR
1)
IF (IWRITE.LT.3) RETURN
WRITE (6, 10) IND, F
CALL WRTGR (CCV, ICV, DF, NCV)
RETURN
10 FORMAT (// " REACTIVE POWER OF GENERATOR: ", I3, " VALUE OF FUNCTION",
14X, E13.7 // " GRADIENTS ")
END
D 1
D 2
D 3
D 4
D 5
D 6
D 7
D 8
D 9
D 10
D 11
D 12
D 13
D 14
D 15
D 16
D 17
D 18
D 19
D 20
D 21
D 22
D 23
D 24
D 25
D 26
D 27
D 28
D 29
D 30
D 31
D 32
D 33
D 34
D 35
D 36
D 37
D 38
D 39
D 40
D 41
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```
C
C
C      SUBROUTINE GRAD4 (LBINP,LBOUT, YT,JRYT, ICYT, V, BTYP,CCV, ICV,DF, F, WAD
1J, NB, YE, LTP, IND, NCV, MODE, IWRITE)
C
C      SUBROUTINE GRAD4 CALCULATES THE VALUE OF THE MODULUS OF CURRENT
C      OF THE INDTH ELEMENT AND ITS GRADIENTS W.R.T. VARIABLES DEFINED
C      BY VECTORS CCV,ICV. TYPE OF THE ELEMENT IS IDENTIFIED BY THE
C      PARAMETER LTP
C
C      INTEGER LBINP(1),LBOUT(1),JRYT(1),ICYT(1),BTYP(1),CCV(NCV),ICV(NCV
1)
C      REAL WADJ(1),DF(NCV)
C      COMPLEX V(NB),YT(1),YE,CURR,CF,Z1,Z2,Z3
C      COMMON /MDADJ/ JT,JICN,JICT,JIRT,JIKEEP,JIW,JCS,JRHS,JPDR/FLAG/IFL
1AG
C      CF(Z1,Z2,Z3)=Z1*(Z2-Z3)
C
C      IFLAG=0
C      NAV=NB+NB
C      GO TO (10,20,30,40), LTP
10  CURR=CF(YE,V(LBINP(IND)),V(LBOUT(IND)))
C      GO TO 50
20  CURR=CF(YE,V(LBINP(IND)),(0.,0.))
C      GO TO 50
30  CURR=CF(YE,V(LBOUT(IND)),(0.,0.))
C      GO TO 50
40  CURR=CF(YE,V(IND),(0.,0.))
50  F=CABS(CURR)
C      CALL RHST4 (LBINP,LBOUT,V,BTYP,WADJ(JRHS),YE,CURR,LTP,IND,NAV,IWRI
1TE)
C      CALL PDR4 (CCV,ICV,WADJ(JPDR),CURR,LTP,IND,NCV,NDR)
C      IVT=1
C      CALL SENSIT (LBINP,LBOUT, YT,JRYT, ICYT, V, BTYP, WADJ(JCS), WADJ(JRHS),
1CCV, ICV, WADJ(JPDR), DF, WADJ(JT), WADJ(JIRT), WADJ(JICT), WADJ(JICN), WA
2DJ(JIKEEP), WADJ(JIW), NB, NCV, IVT, MODE, IFLAG, 6, IWRITE-1)
C      IF (IFLAG.LT.0) RETURN
C      CALL PARDER4 (LBINP,LBOUT, V,CCV, ICV,DF, F, YE, LTP, IND, NCV)
C      IF (IWRITE.LT.3) RETURN
C      WRITE (6,60) IND,LTP,F
C      CALL WRTGR (CCV,ICV,DF,NCV)
C      RETURN
60  FORMAT (// " MODULUS OF CURRENT. ELEMENT INDEX", I3, "  ELEMENT TYPE
1", I2, ". "/ " VALUE OF FUNCTION", 4X, E13.7/ " GRADIENTS")
C      END
E 1
E 2
E 3
E 4
E 5
E 6
E 7
E 8
E 9
E 10
E 11
E 12
E 13
E 14
E 15
E 16
E 17
E 18
E 19
E 20
E 21
E 22
E 23
E 24
E 25
E 26
E 27
E 28
E 29
E 30
E 31
E 32
E 33
E 34
E 35
E 36
E 37
E 38
E 39
E 40
E 41
E 42
E 43
E 44
E 45
E 46
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```
C
C
C      SUBROUTINE GRAD5 (LBINP, LBOUT, YT, JRYT, ICYT, V, BTYP, CCV, ICV, DF, F, WAD
1J, NB, YE, LTP, IND, NCV, MODE, IWRITE)
C
C      SUBROUTINE GRAD5 CALCULATES THE VALUE OF THE POWER LOSSES OF
C      THE INDTH ELEMENT AND ITS GRADIENTS W.R.T. VARIABLES DEFINED
C      BY VECTORS CCV, ICV. TYPE OF THE ELEMENT IS IDENTIFIED BY THE
C      PARAMETER LTP
C
C      INTEGER LBINP(1), LBOUT(1), JRYT(1), ICYT(1), BTYP(1), CCV(NCV), ICV(NCV
1)
C      REAL WADJ(1), DF(NCV)
C      COMPLEX V(NB), YT(1), YE, CURR, CF, Z1, Z2, Z3
C      COMMON /MDADJ/ JT, JICN, JICT, JIRT, JIKEEP, JIW, JCS, JRHS, JPDR/FLAG/IFL
1AG
C      CF(Z1, Z2, Z3)=Z1*(Z2-Z3)
C
C      IFLAG=0
C      NAV=NB+NB
C      GO TO (10, 20, 30, 40), LTP
10  CURR=CF(YE, V(LBINP(IND)), V(LBOUT(IND)))
C      GO TO 50
20  CURR=CF(YE, V(LBINP(IND)), (0., 0.))
C      GO TO 50
30  CURR=CF(YE, V(LBOUT(IND)), (0., 0.))
C      GO TO 50
40  CURR=CF(YE, V(IND), (0., 0.))
50  F=CABS(CURR/YE)
C      F=F*F*REAL(YE)
C      CALL RHST5 (LBINP, LBOUT, V, BTYP, WADJ(JRHS), YE, LTP, IND, NAV, IWRITE)
C      CALL PDR5 (CCV, ICV, WADJ(JPDR), CURR, F, LTP, IND, NCV, NDR)
C      IVT=1
C      CALL SENSIT (LBINP, LBOUT, YT, JRYT, ICYT, V, BTYP, WADJ(JCS), WADJ(JRHS),
1CCV, ICV, WADJ(JPDR), DF, WADJ(JT), WADJ(JIRT), WADJ(JICT), WADJ(JICN), WA
2DJ(JIKEEP), WADJ(JIW), NB, NCV, IVT, MODE, IFLAG, 6, IWRITE-1)
C      IF (IFLAG.LT.0) RETURN
C      CALL PARDER5 (LBINP, LBOUT, V, CCV, ICV, DF, F, YE, LTP, IND, NCV)
C      IF (IWRITE.LT.3) RETURN
C      WRITE (6, 60) IND, LTP, F
C      CALL WRTGR (CCV, ICV, DF, NCV)
C      RETURN
60  FORMAT (// " MODULUS OF CURRENT. ELEMENT INDEX", I3, "  ELEMENT TYPE
1", I2, ". "/ " VALUE OF FUNCTION", 4X, E13.7/ " GRADIENTS")
C      END
C      F 1
C      F 2
C      F 3
C      F 4
C      F 5
C      F 6
C      F 7
C      F 8
C      F 9
C      F 10
C      F 11
C      F 12
C      F 13
C      F 14
C      F 15
C      F 16
C      F 17
C      F 18
C      F 19
C      F 20
C      F 21
C      F 22
C      F 23
C      F 24
C      F 25
C      F 26
C      F 27
C      F 28
C      F 29
C      F 30
C      F 31
C      F 32
C      F 33
C      F 34
C      F 35
C      F 36
C      F 37
C      F 38
C      F 39
C      F 40
C      F 41
C      F 42
C      F 43
C      F 44
C      F 45
C      F 46
```

C		G	1
C		G	2
C		G	3
	SUBROUTINE GRAD6 (LBINP,LBOUT,LINPG,LINPB,LG,LB,YT,JRYT,ICYT,V,BTYP	G	4
	1P,CCV,ICV,DF,F,WADJ,NB,NCV,MODE,IWRITE)	G	5
C		G	6
C	SUBROUTINE GRAD6 CALCULATES THE VALUE OF TRANSMISSION POWER LOSSES	G	7
C	AND ITS GRADIENTS W.R.T. CONTROL VARIABLES DEFINED BY VECTORS CCV,	G	8
C	ICV	G	9
		G	10
	INTEGER LBINP(1),LBOUT(1),JRYT(1),ICYT(1),BTYP(1),CCV(1),ICV(1)	G	11
	REAL LINPG(1),LINPB(1),LG(1),LB(1),WADJ(1),DF(1)	G	12
	COMPLEX V(1),YT(1),CF5	G	13
	COMMON /MDADJ/ JT,JICN,JICT,JIRT,JIKEEP,JIW,JCS,JRHS,JPDR/FLAG/IFL	G	14
	1AG	G	15
	F(K)=REAL(CF5(V(K),YT(JRYT(K)),V,LO,ICYT(JRYT(K)),JRYT(K+1)-JRYT(K	G	16
	1),1))	G	17
C		G	18
	IFLAG=0	G	19
	NAV=NB+NB	G	20
	CALL RHST6 (YT,JRYT,ICYT,V,BTYP,WADJ(JRHS),NAV,IWRITE)	G	21
	CALL PDR6 (LBINP,LBOUT,LINPG,LINPB,LG,LB,V,CCV,ICV,WADJ(JPDR),NCV,	G	22
	1NDR)	G	23
	IVT=1	G	24
	CALL SENSIT (LBINP,LBOUT,YT,JRYT,ICYT,V,BTYP,WADJ(JCS),WADJ(JRHS),	G	25
	1CCV,ICV,WADJ(JPDR),DF,WADJ(JT),WADJ(JIRT),WADJ(JICT),WADJ(JICN),WA	G	26
	2DJ(JIKEEP),WADJ(JIW),NB,NCV,IVT,MODE,IFLAG,6,IWRITE-1)	G	27
	IF (IFLAG.LT.0) RETURN	G	28
	F=0.	G	29
	DO 10 I=1,NB	G	30
	F=F+P(I)	G	31
10	CONTINUE	G	32
	CALL PARDER6 (LBINP,LBOUT,YT,JRYT,ICYT,V,CCV,ICV,DF,NCV)	G	33
	IF (IWRITE.LT.3) RETURN	G	34
	WRITE (6,20) F	G	35
	CALL WRTGR (CCV,ICV,DF,NCV)	G	36
	RETURN	G	37
20	FORMAT (// " TRANSMISSION POWER LOSSES " / " VALUE OF FUNCTION " , 4X , E13	G	38
	1.7 / " GRADIENTS ")	G	39
	END	G	40

C		H	1
C		H	2
C		H	3
	SUBROUTINE GRAD7 (LBINP, LBOUT, YT, JRYT, ICYT, V, BTYP, CCV, ICV, DF, F, WAD	H	4
	1J, NB, IND, NCV, MODE, IWRITE)	H	5
		H	6
C	SUBROUTINE GRAD7 CALCULATES THE VALUE OF ACTIVE POWER AT THE INDTH	H	7
C	BUS AND ITS GRADIENTS W.R.T. CONTROL VARIABLES DEFINED BY VECTORS	H	8
C	CCV, ICV	H	9
C		H	10
	INTEGER LBINP(1), LBOUT(1), JRYT(1), ICYT(1), BTYP(1), CCV(1), ICV(1)	H	11
	REAL WADJ(1), DF(1)	H	12
	COMPLEX V(1), YT(1), VB, CF5	H	13
	COMMON /MDADJ/ JT, JICN, JICT, JIRT, JIKEEP, JIW, JCS, JRHS, JPDR/FLAG/IFL	H	14
	1AG	H	15
	P(K)=REAL(CF5(V(K), YT(JRYT(K)), V, LO, ICYT(JRYT(K)), JRYT(K+1)-JRYT(K	H	16
	1), 1))	H	17
		H	18
C	IFLAG=0	H	19
	NAV=NB+NB	H	20
	VB=V(IND)	H	21
	CALL RST7 (YT, JRYT, ICYT, V, BTYP, WADJ(JRHS), NB, IWRITE)	H	22
	CALL PDR7 (LBINP, LBOUT, VB, CCV, ICV, WADJ(JPDR), IND, NCV, NDR)	H	23
	IVT=1	H	24
	CALL SENSIT (LBINP, LBOUT, YT, JRYT, ICYT, V, BTYP, WADJ(JCS), WADJ(JRHS),	H	25
	1CCV, ICV, WADJ(JPDR), DF, WADJ(JT), WADJ(JIRT), WADJ(JICT), WADJ(JICN), WA	H	26
	2DJ(JIKEEP), WADJ(JIW), NB, NCV, IVT, MODE, IFLAG, 6, IWRITE-1)	H	27
	IF (IFLAG.LT.0) RETURN	H	28
	F=P(IND)	H	29
	K=JRYT(IND)	H	30
	NYR=JRYT(IND+1)-K	H	31
	CALL PARDER7 (LBINP, LBOUT, YT(K), ICYT(K), V, CCV, ICV, DF, F, IND, NCV, NYR	H	32
	1)	H	33
	IF (IWRITE.LT.3) RETURN	H	34
	WRITE (6, 10) IND, F	H	35
	CALL WRTGR (CCV, ICV, DF, NCV)	H	36
	RETURN	H	37
10	FORMAT (// " ACTIVE POWER OF GENERATOR: ", I3 / " VALUE OF FUNCTION ", 4X	H	38
	1, E13.7 / " GRADIENTS ")	H	39
	END	H	40

C		I	1
C		I	2
C		I	3
	SUBROUTINE GRAD8 (LBINP, LBOUT, YT, JRYT, ICYT, V, BTYP, CCV, ICV, C, D, DF, F	I	4
	1, WADJ, NB, NCV, MODE, IWRITE)	I	5
C		I	6
C	SUBROUTINE GRAD8 DETERMINES THE COST OF GENERATION AND ITS	I	7
C	GRADIENTS W.R.T. CONTROL VARIABLES DEFINED BY VECTORS CCV, ICV	I	8
C		I	9
	INTEGER LBINP(1), LBOUT(1), JRYT(1), ICYT(1), BTYP(1), CCV(1), ICV(1)	I	10
	REAL C(1), D(1), WADJ(1), DF(1)	I	11
	COMPLEX V(1), YT(1), CF5	I	12
	COMMON /MDADJ/ JT, JICN, JICT, JIRT, JIKEEP, JIW, JCS, JRHS, JPDR/FLAG/IFL	I	13
	1AG	I	14
	P(K)=REAL(CF5(V(K), YT(JRYT(K)), V, LO, ICYT(JRYT(K)), JRYT(K+1)-JRYT(K	I	15
	1), 1))	I	16
C		I	17
	IFLAG=0	I	18
	NAV=NB+NB	I	19
	PN=P(NB)	I	20
	J=0	I	21
	F=0.	I	22
	DO 10 I=1, NB	I	23
	IF (BTYP(I).EQ.0) GO TO 10	I	24
	J=J+1	I	25
	F=F+(C(J)+D(J)*P(I))*P(I)	I	26
10	CONTINUE	I	27
	CALL RHST8 (YT, JRYT, ICYT, V, BTYP, WADJ(JRHS), C(J), D(J), PN, NAV, IWRITE	I	28
	1)	I	29
	CALL PDR8 (LBINP, LBOUT, V(NB), CCV, ICV, WADJ(JPDR), C(J), D(J), PN, NB, NC	I	30
	1V, NDR)	I	31
	IVT=1	I	32
	CALL SENSIT (LBINP, LBOUT, YT, JRYT, ICYT, V, BTYP, WADJ(JCS), WADJ(JRHS),	I	33
	1CCV, ICV, WADJ(JPDR), DF, WADJ(JT), WADJ(JIRT), WADJ(JICT), WADJ(JICN), WA	I	34
	2DJ(JIKEEP), WADJ(JIW), NB, NCV, IVT, MODE, IFLAG, 6, IWRITE-1)	I	35
	IF (IFLAG.LT.0) RETURN	I	36
	CALL PARDER8 (LBINP, LBOUT, YT, JRYT, ICYT, V, BTYP, CCV, ICV, C, D, DF, NB, J,	I	37
	1NCV)	I	38
	IF (IWRITE.LT.3) RETURN	I	39
	WRITE (6, 20) F	I	40
	CALL WRITGR (CCV, ICV, DF, NCV)	I	41
	RETURN	I	42
20	FORMAT (// " COST OF GENERATION" / " VALUE OF FUNCTION", 4X, E13.7 / " GR	I	43
	1ADIENTS")	I	44
	END	I	45

C		J	1
C		J	2
C		J	3
	SUBROUTINE PARDER3 (LBINP, LBOUT, YR, ICYR, V, CCV, ICV, DF, F, INB, NCV, NYR	J	4
	1)	J	5
C		J	6
C	SUBROUTINE PARDER3 CALCULATES PARTIAL DERIVATIVES OF THE INBTH BUS	J	7
C	REACTIVE POWER W.R.T. CONTROL VARIABLES DEFINED BY VECTORS CCV, ICV	J	8
C		J	9
	INTEGER LBINP(1), LBOUT(1), ICYR(NYR), CCV(NCV), ICV(NCV)	J	10
	REAL DF(NCV)	J	11
	COMPLEX V(1), YR(NYR), VB, VR, CF5	J	12
C		J	13
	VB=V(INB)	J	14
	RV=CABS(VB)	J	15
	DO 110 J=1, NCV	J	16
	L=CCV(J)	J	17
	M=ICV(J)	J	18
C		J	19
C	LINPG LINPB LG LB LOUTG LOUTB P Q MODV ARGV BSTL	J	20
	GO TO (110, 10, 20, 20, 110, 50, 110, 110, 60, 60, 100), L	J	21
C		J	22
C	PARTIAL DERIVATIVE W.R.T. INPUT SHUNT SUSCEPTANCE	J	23
C		J	24
	10 IF (LBINP(M).EQ. INB) DF(J)=DF(J)-RV*RV	J	25
	GO TO 110	J	26
C		J	27
C	PARTIAL DERIVATIVE W.R.T. TRANSMISSION LINE ADMITTANCE	J	28
C		J	29
	20 IF (LBINP(M).NE. INB) GO TO 30	J	30
	K=LBOUT(M)	J	31
	GO TO 40	J	32
	30 IF (LBOUT(M).NE. INB) GO TO 110	J	33
	K=LBINP(M)	J	34
	40 IF (L.EQ. 3) DF(J)=DF(J)+AIMAG(CONJG(VB)*V(K))	J	35
	IF (L.EQ. 4) DF(J)=DF(J)+REAL(CONJG(VB)*V(K))-RV*RV	J	36
	GO TO 110	J	37
C		J	38
C	PARTIAL DERIVATIVE W.R.T. OUTPUT SHUNT SUSCEPTANCE	J	39
C		J	40
	50 IF (LBOUT(M).EQ. INB) DF(J)=DF(J)-RV*RV	J	41
	GO TO 110	J	42
C		J	43
C	PARTIAL DERIVATIVES W.R.T. BUS VOLTAGE MODULUS AND ARGUMENT	J	44
C		J	45
	60 IF (M.NE. INB) GO TO 70	J	46
	IF (L.EQ. 9) DF(J)=DF(J)-RV*AIMAG(YR(1))+F/RV	J	47
	IF (L.EQ. 10) DF(J)=DF(J)-RV*RV*REAL(YR(1))+REAL(CF5(VB, YR, V, K, ICYR	J	48
	1, NYR, 1))	J	49
	GO TO 110	J	50
	70 IND=0	J	51
	DO 80 K=2, NYR	J	52
	IF (ICYR(K).NE. M) GO TO 80	J	53
	IND=K	J	54
	GO TO 90	J	55
	80 CONTINUE	J	56
	90 IF (IND.EQ. 0) GO TO 110	J	57
	VR=V(ICYR(IND))	J	58
	IF (L.EQ. 9) DF(J)=DF(J)+AIMAG(VB*CONJG(YR(IND)*VR))/CABS(VR)	J	59
	IF (L.EQ. 10) DF(J)=DF(J)-REAL(VB*CONJG(YR(IND)*VR))	J	60
	GO TO 110	J	61
C		J	62
C	PARTIAL DERIVATIVE W.R.T. BUS STATIC LOAD	J	63
C		J	64
	100 IF (M.EQ. INB) DF(J)=DF(J)-RV*RV	J	65

110 CONTINUE
RETURN
END

J 66
J 67
J 68

C		K	1
C		K	2
C		K	3
	SUBROUTINE PARDER4 (LBINP,LBOUT,V,CCV,ICV,DF,F,YE,LTP,INL,NCV)	K	4
C		K	5
C	SUBROUTINE PARDER4 CALCULATES PARTIAL DERIVATIVES OF THE MODULUS	K	6
C	OF CURRENT OF THE INLTH ELEMENT W.R.T. CONTROL VARIABLES DEFINED	K	7
C	BY VECTORS CCV,ICV. TYPE OF THE ELEMENT IS IDENTIFIED BY THE	K	8
C	PARAMETER LTP.	K	9
C		K	10
	INTEGER LBINP(1),LBOUT(1),CCV(NCV),ICV(NCV)	K	11
	REAL DF(NCV)	K	12
	COMPLEX V(1),YE,V1,V2	K	13
C		K	14
	DO 110 J=1,NCV	K	15
	L=CCV(J)	K	16
	M=ICV(J)	K	17
C		K	18
C	LINPG LINPB LG LB LOUTG LOUTB P Q MODV ARGV BSTL	K	19
	GO TO (10,20,10,20,10,20,110,110,30,30,20), L	K	20
C		K	21
C	PARTIAL DERIVATIVE W.R.T. CONDUCTANCE	K	22
C		K	23
	10 IF (M.EQ.INL) DF(J)=DF(J)+REAL(1./YE)*F	K	24
	GO TO 110	K	25
C		K	26
C	PARTIAL DERIVATIVE W.R.T. SUSCEPTANCE	K	27
		K	28
	20 IF (M.EQ.INL) DF(J)=DF(J)-AIMAG(1./YE)*F	K	29
	GO TO 110	K	30
C		K	31
C	PARTIAL DERIVATIVE W.R.T. BUS VOLTAGE MODULUS AND ARGUMENT	K	32
C		K	33
	30 GO TO (40,60,70,80), LTP	K	34
	40 IF (LBINP(INL).NE.M) GO TO 50:	K	35
	V1=V(LBINP(INL))	K	36
	V2=V1*CONJG(V(LBOUT(INL)))	K	37
	GO TO 90	K	38
	50 IF (LBOUT(INL).NE.M) GO TO 110	K	39
	V1=V(LBOUT(INL))	K	40
	V2=V1*CONJG(V(LBINP(INL)))	K	41
	GO TO 90	K	42
	60 IF (LBINP(INL).NE.M) GO TO 110	K	43
	V1=V(LBINP(INL))	K	44
	V2=(0.,0.)	K	45
	GO TO 90	K	46
	70 IF (LBOUT(INL).NE.M) GO TO 110	K	47
	V1=V(LBOUT(INL))	K	48
	V2=(0.,0.)	K	49
	GO TO 90	K	50
	80 IF (INL.NE.M) GO TO 110	K	51
	V1=V(INL)	K	52
	V2=(0.,0.)	K	53
	90 R1=REAL(YE*CONJG(YE))/F	K	54
	IF (L.EQ.10) GO TO 100	K	55
	R2=CABS(V1)	K	56
	DF(J)=DF(J)+(R2-REAL(V2)/R2)*R1	K	57
	GO TO 110	K	58
	100 DF(J)=DF(J)+AIMAG(V2)*R1	K	59
	110 CONTINUE	K	60
	RETURN	K	61
	END	K	62

C		L	1
C		L	2
C		L	3
	SUBROUTINE PARDERS (LBINP,LBOUT,V,CCV,ICV,DF,F,YE,LTP,INL,NCV)	L	4
C		L	5
C	SUBROUTINE PARDERS CALCULATES PARTIAL DERIVATIVES OF THE POWER	L	6
C	LOSSES OF THE INLTH ELEMENT W.R.T. CONTROL VARIABLES DEFINED	L	7
C	BY VECTORS CCV, ICV. TYPE OF THE ELEMENT IS IDENTIFIED BY THE	L	8
C	PARAMETER LTP.	L	9
	INTEGER LBINP(1),LBOUT(1),CCV(NCV),ICV(NCV)	L	10
	REAL DF(NCV)	L	11
	COMPLEX V(1),YE,V1,V2	L	12
C		L	13
	DO 150 J=1,NCV	L	14
	L=CCV(J)	L	15
	M=ICV(J)	L	16
C		L	17
C	LINP LINPB LG LB LOUTG LOUTB P Q MODV ARGV BSTL	L	18
	GO TO (10,150,10,150,10,150,150,150,70,70,150), L	L	19
C		L	20
C	PARTIAL DERIVATIVE W.R.T. LINE PARAMETERS	L	21
C		L	22
	10 IF (M.NE.INL) GO TO 150	L	23
	GO TO (20,30,40,50), LTP	L	24
	20 R1=CABS(V(LBINP(INL))-V(LBOUT(INL)))	L	25
	GO TO 60	L	26
	30 R1=CABS(V(LBINP(INL)))	L	27
	GO TO 60	L	28
	40 R1=CABS(V(LBOUT(INL)))	L	29
	GO TO 60	L	30
	50 R1=CABS(V(INL))	L	31
	60 DF(J)=DF(J)+R1*R1	L	32
	GO TO 150	L	33
C		L	34
C	PARTIAL DERIVATIVE W.R.T. BUS VOLTAGE MODULUS AND ARGUMENT	L	35
C		L	36
	70 GO TO (80,100,110,120), LTP	L	37
	80 IF (LBINP(INL).NE.M) GO TO 90	L	38
	V1=V(LBINP(INL))	L	39
	V2=V1*CONJG(V(LBOUT(INL)))	L	40
	GO TO 130	L	41
	90 IF (LBOUT(INL).NE.M) GO TO 150	L	42
	V1=V(LBOUT(INL))	L	43
	V2=V1*CONJG(V(LBINP(INL)))	L	44
	GO TO 130	L	45
	100 IF (LBINP(INL).NE.M) GO TO 150	L	46
	V1=V(LBINP(INL))	L	47
	V2=(0.,0.)	L	48
	GO TO 130	L	49
	110 IF (LBOUT(INL).NE.M) GO TO 150	L	50
	V1=V(LBOUT(INL))	L	51
	V2=(0.,0.)	L	52
	GO TO 130	L	53
	120 IF (INL.NE.M) GO TO 150	L	54
	V1=V(INL)	L	55
	V2=(0.,0.)	L	56
	130 IF (L.EQ.10) GO TO 140	L	57
	R2=CABS(V1)	L	58
	DF(J)=DF(J)+2.*REAL(YE)*(R2-REAL(V2)/R2)	L	59
	GO TO 150	L	60
	140 DF(J)=DF(J)+2.*AIMAG(V2)*REAL(YE)	L	61
	150 CONTINUE	L	62
	RETURN	L	63
	END	L	64
		L	65

C		M	1
C		M	2
C		M	3
	SUBROUTINE PARDER6 (LBINP, LBOUT, YT, JRYT, ICYT, V, CCV, ICV, DF, NCV)	M	4
C		M	5
C	SUBROUTINE PARDER6 CALCULATES PARTIAL DERIVATIVES OF TRANSMISSION	M	6
C	POWER LOSSES W.R.T. CONTROL VARIABLES DEFINED BY VECTORS CCV, ICV	M	7
C		M	8
	INTEGER LBINP(1), JRYT(1), LBOUT(1), ICYT(1), CCV(NCV), ICV(NCV)	M	9
	REAL DF(NCV)	M	10
	COMPLEX YT(1), V(1), VB	M	11
C		M	12
	DO 90 J=1, NCV	M	13
	L=CCV(J)	M	14
	M=ICV(J)	M	15
C		M	16
C	LINPG LINPB LG LB LOUTG LOUTB P Q MODV ARGV BSTL	M	17
	GO TO (10, 90, 20, 90, 30, 90, 90, 90, 50, 50, 90), L	M	18
C		M	19
C	PARTIAL DERIVATIVE W.R.T. LINE INPUT SHUNT CONDUCTANCE	M	20
C		M	21
	10 VB=V(LBINP(M))	M	22
	GO TO 40	M	23
C		M	24
C	PARTIAL DERIVATIVE W.R.T. LINE CONDUCTANCE	M	25
C		M	26
	20 VB=V(LBINP(M))-V(LBOUT(M))	M	27
	GO TO 40	M	28
C		M	29
C	PARTIAL DERIVATIVE W.R.T. LINE OUTPUT SHUNT CONDUCTANCE	M	30
C		M	31
	30 VB=V(LBOUT(M))	M	32
	40 DF(J)=DF(J)+REAL(VB*CONJG(VB))	M	33
	GO TO 90	M	34
C		M	35
C	PARTIAL DERIVATIVES W.R.T. BUS VOLTAGE MODULUS AND ARGUMENT	M	36
C		M	37
	50 K1=JRYT(M)+1	M	38
	K2=JRYT(M+1)-1	M	39
	R=0.	M	40
	VB=V(M)	M	41
	IF (L.EQ.10) GO TO 70	M	42
	VM=CABS(VB)	M	43
	DO 60 K=K1, K2	M	44
	R=R+REAL(YT(K))*REAL(VB*CONJG(V(ICYT(K))))	M	45
	60 CONTINUE	M	46
	R=VM*REAL(YT(K1-1))+R/VM	M	47
	DF(J)=DF(J)+R+R	M	48
	GO TO 90	M	49
	70 DO 80 K=K1, K2	M	50
	R=R-REAL(YT(K))*AIMAG(VB*CONJG(V(ICYT(K))))	M	51
	80 CONTINUE	M	52
	DF(J)=DF(J)+R+R	M	53
	90 CONTINUE	M	54
	RETURN	M	55
	END	M	56

C		N	1
C		N	2
C		N	3
C	SUBROUTINE PARDER7 (LBINP, LBOUT, YR, ICYR, V, CCV, ICV, DF, F, INB, NCV, NYR	N	4
	1)	N	5
C		N	6
C	SUBROUTINE PARDER7 CALCULATES PARTIAL DERIVATIVES OF THE INBTH	N	7
C	BUS ACTIVE POWER W.R.T. CONTROL VARIABLES DEFINED BY VECTORS	N	8
C	CCV, ICV	N	9
		N	10
	INTEGER LBINP(1), LBOUT(1), ICYR(NYR), CCV(NCV), ICV(NCV)	N	11
	REAL DF(NCV)	N	12
	COMPLEX V(1), YR(NYR), VB, VR, CF5	N	13
C		N	14
	VB=V(INB)	N	15
	RV=CABS(VB)	N	16
	DO 100 J=1, NCV	N	17
	L=CCV(J)	N	18
	M=ICV(J)	N	19
C		N	20
C	LINPG LINPB LG LB LOUTG LOUTB P Q MODV ARGV BSTL	N	21
C	GO TO (10, 100, 20, 20, 50, 100, 100, 100, 60, 60, 100), L	N	22
C		N	23
C	PARTIAL DERIVATIVE W.R.T. LINE INPUT SHUNT CONDUCTANCE	N	24
C		N	25
	10 IF (LBINP(M).EQ. INB) DF(J)=DF(J)+RV*RV	N	26
	GO TO 100	N	27
C		N	28
C	PARTIAL DERIVATIVE W.R.T. TRANSMISSION LINE ADMITTANCE	N	29
C		N	30
	20 IF (LBINP(M).NE. INB) GO TO 30:	N	31
	K=LBOUT(M)	N	32
	GO TO 40	N	33
	30 IF (LBOUT(M).NE. INB) GO TO 100	N	34
	K=LBINP(M)	N	35
	40 IF (L.EQ. 3) DF(J)=DF(J)-REAL(CONJG(VB)*V(K))+RV*RV	N	36
	IF (L.EQ. 4) DF(J)=DF(J)+AIMAG(CONJG(VB)*V(K))	N	37
	GO TO 100	N	38
C		N	39
C	PARTIAL DERIVATIVE W.R.T. LINE OUTPUT SHUNT CONDUCTANCE	N	40
C		N	41
	50 IF (LBOUT(M).EQ. INB) DF(J)=DF(J)+RV*RV	N	42
	GO TO 100	N	43
C		N	44
C	PARTIAL DERIVATIVES W.R.T. BUS VOLTAGE MODULUS AND ARGUMENT	N	45
C		N	46
	60 IF (M.NE. INB) GO TO 70	N	47
	IF (L.EQ. 9) DF(J)=DF(J)+RV*REAL(YR(1))+F/RV	N	48
	IF (L.EQ. 10) DF(J)=DF(J)-RV*RV*AIMAG(YR(1))-AIMAG(CF5(VB, YR, V, K, IC	N	49
	1YR, NYR, 1))	N	50
	GO TO 100	N	51
	70 IND=0	N	52
	DO 80 K=2, NYR	N	53
	IF (ICYR(K).NE. M) GO TO 80	N	54
	IND=K	N	55
	GO TO 90	N	56
	80 CONTINUE	N	57
	90 IF (IND.EQ. 0) GO TO 100	N	58
	VR=V(ICYR(IND))	N	59
	IF (L.EQ. 9) DF(J)=DF(J)+REAL(VB*CONJG(YR(IND)*VR))/CABS(VR)	N	60
	IF (L.EQ. 10) DF(J)=DF(J)+AIMAG(VB*CONJG(YR(IND)*VR))	N	61
	100 CONTINUE	N	62
	RETURN	N	63
	END	N	64

C		0	1
C		0	2
C		0	3
	SUBROUTINE PARDERS (LBINP, LBOUT, YT, JRYT, ICYT, V, BTYP, CCV, ICV, C, D, DF	0	4
	1, NB, NG, NCV)	0	5
C		0	6
C	SUBROUTINE PARDERS DETERMINES PARTIAL DERIVATIVES OF THE COST OF	0	7
C	GENERATION W.R.T. CONTROL VARIABLES DEFINED BY VECTORS CCV, ICV	0	8
		0	9
	INTEGER LBINP(1), LBOUT(1), JRYT(1), ICYT(1), BTYP(1), CCV(NCV), ICV(NCV	0	10
	1)	0	11
	REAL C(NG), D(NG), DF(1)	0	12
	COMPLEX V(1), YT(1), VB, VR, CF5	0	13
	DER(A1, A2, A3, X) = (A1 + 2.*A2*A3*X)*X	0	14
	P(K) = REAL(CF5(V(K), YT(JRYT(K))), V, LO, ICYT(JRYT(K)), JRYT(K+1) - JRYT(K	0	15
	1), 1))	0	16
	Q(K) = AIMAG(CF5(V(K), YT(JRYT(K))), V, LO, ICYT(JRYT(K)), JRYT(K+1) - JRYT(0	17
	1K), 1))	0	18
C		0	19
	VB = V(NB)	0	20
	RV = CABS(VB)	0	21
	RV2 = RV*RV	0	22
	CN = C(NG)	0	23
	DN = D(NG)	0	24
	PN = P(NB)	0	25
	K1 = JRYT(NB) + 1	0	26
	K2 = JRYT(NB + 1) - 1	0	27
	DO 130 J = 1, NCV	0	28
	L = CCV(J)	0	29
	M = ICV(J)	0	30
C		0	31
C	LINP LINPB LG LB LOUTG LOUTB P Q MODV ARGV BSTL	0	32
	GO TO (10, 130, 20, 20, 50, 130, 60, 130, 90, 90, 130), L	0	33
C		0	34
C	PARTIAL DERIVATIVE W.R.T. LINE INPUT SHUNT CONDUCTANCE	0	35
C		0	36
	10 IF (LBINP(M).EQ.NB) DF(J) = DF(J) + DER(CN, DN, PN, RV2)	0	37
	GO TO 130	0	38
C		0	39
C	PARTIAL DERIVATIVE W.R.T. TRANSMISSION LINE ADMITTANCE	0	40
C		0	41
	20 IF (LBINP(M).NE.NB) GO TO 30	0	42
	K = LBOUT(M)	0	43
	GO TO 40	0	44
	30 IF (LBOUT(M).NE.NB) GO TO 130	0	45
	K = LBINP(M)	0	46
	40 IF (L.EQ.3) DF(J) = DF(J) + DER(CN, DN, PN, RV2 - REAL(CONJG(VB)*V(K)))	0	47
	IF (L.EQ.4) DF(J) = DF(J) + DER(CN, DN, PN, AIMAG(CONJG(VB)*V(K)))	0	48
	GO TO 130	0	49
C		0	50
C	PARTIAL DERIVATIVE W.R.T. LINE OUTPUT SHUNT CONDUCTANCE	0	51
C		0	52
	50 IF (LBOUT(M).EQ.NB) DF(J) = DF(J) + DER(CN, DN, PN, RV2)	0	53
	GO TO 130	0	54
	60 I = 0	0	55
	N1 = NB - 1	0	56
	DO 70 IC = 1, N1	0	57
	IF (BTYP(IC).EQ.0) GO TO 70	0	58
	I = I + 1	0	59
	IF (IC.EQ.M) GO TO 80	0	60
	70 CONTINUE	0	61
	80 DF(J) = DF(J) + C(I) + 2.*D(I)*P(M)	0	62
	GO TO 130	0	63
C		0	64
C	PARTIAL DERIVATIVES W.R.T. BUS VOLTAGE MODULUS AND ARGUMENT	0	65

C		0	66
90	IF (M.NE.NB) GO TO 100	0	67
	IF (L.EQ.9) DF(J)=DF(J)+DER(CN, DN, PN, RV*REAL(YT(K1-1))+PN/RV)	0	68
	IF (L.EQ.10) DF(J)=DF(J)+DER(CN, DN, PN, -Q(NB)-RV2*AIMAG(YT(K1-1)))	0	69
	GO TO 130	0	70
100	IND=0	0	71
	DO 110 K=K1, K2	0	72
	IF (ICYT(K).NE.M) GO TO 110	0	73
	IND=K	0	74
	GO TO 120	0	75
110	CONTINUE	0	76
120	IF (IND.EQ.0) GO TO 130	0	77
	VR=V(ICYT(IND))	0	78
	IF (L.EQ.9) DF(J)=DF(J)+DER(CN, DN, PN, REAL(VB*CONJG(YT(IND)*VR))/CA	0	79
	1BS(VR))	0	80
	IF (L.EQ.10) DF(J)=DF(J)+DER(CN, DN, PN, AIMAG(VB*CONJG(YT(IND)*VR)))	0	81
130	CONTINUE	0	82
	RETURN	0	83
	END	0	84

C		P	1
C		P	2
C		P	3
	SUBROUTINE RHST1 (VB, INB, RHS, NAV, IWRITE)	P	4
C		P	5
C	SUBROUTINE RHST1 FORMS THE RIGHT HAND SIDE VECTOR RHS OF THE	P	6
C	ADJOINT EQUATIONS FOR THE MODULUS OF VOLTAGE OF THE INBTH BUS	P	7
C		P	8
	REAL RHS(NAV)	P	9
	COMPLEX VB, VA	P	10
C		P	11
	DO 10 J=1,NAV	P	12
	RHS(J)=0.	P	13
10	CONTINUE	P	14
	J2= INB+INB	P	15
	J1=J2-1	P	16
	VA=CABS(VB)/VB	P	17
	RHS(J1)=REAL(VA)	P	18
	RHS(J2)=AIMAG(VA)	P	19
	IF (IWRITE.LT.4) GO TO 20	P	20
	WRITE (6,30)	P	21
	WRITE (6,40) (M,RHS(M),M=1,NAV)	P	22
20	RETURN	P	23
30	FORMAT (// " RHS VECTOR OF ADJOINT EQUATIONS" /)	P	24
40	FORMAT (5(2X,14, ":", " ,E13.7))	P	25
	END	P	26

C		Q	1
C		Q	2
C		Q	3
	SUBROUTINE RHST2 (VB, ITYP, INB, RHS, NAV, IWRITE)	Q	4
C		Q	5
C	SUBROUTINE RHST2 FORMS THE RIGHT HAND SIDE VECTOR RHS OF THE	Q	6
C	ADJOINT OF VOLTAGE EQUATIONS FOR THE ARGUMENT OF THE INBTH BUS	Q	7
C		Q	8
	REAL RHS(NAV)	Q	9
	COMPLEX VA, VB	Q	10
C		Q	11
	DO 10 J=1, NAV	Q	12
	RHS(J)=0.	Q	13
10	CONTINUE	Q	14
	J2= INB+INB	Q	15
	J1=J2-1	Q	16
	VA=(-1., 0.)	Q	17
	IF (ITYP.EQ.0) VA=(0., -1.)/VB	Q	18
	RHS(J1)=REAL(VA)	Q	19
	RHS(J2)=AIMAG(VA)	Q	20
	IF (IWRITE.LT.4) GO TO 20	Q	21
	WRITE (6,30)	Q	22
	WRITE (6,40) (M, RHS(M), M=1, NAV)	Q	23
20	RETURN	Q	24
30	FORMAT (// " RHS VECTOR RHS OF ADJOINT EQUATIONS" /)	Q	25
40	FORMAT (5(2X, I4, ":", "E13.7))	Q	26
	END	Q	27

C		R	1
C		R	2
C		R	3
	SUBROUTINE RHST3G (VB, INB, RHS, NAV, IWRITE)	R	4
C		R	5
C		R	6
C	SUBROUTINE RHST3 FORMS THE RIGHT HAND SIDE VECTOR RHS OF THE	R	7
C	ADJOINT EQUATIONS FOR THE REACTIVE POWER OF THE INBTH GENERATOR	R	8
	REAL RHS(NAV)	R	9
	COMPLEX VB	R	10
C		R	11
	DO 10 J=1,NAV	R	12
	RHS(J)=0.	R	13
10	CONTINUE	R	14
	RHS(INB+INB)=-REAL(VB*CONJG(VB))	R	15
	IF (IWRITE.LT.4) GO TO 20	R	16
	WRITE (6,30)	R	17
	WRITE (6,40) (M, RHS(M), M=1, NAV)	R	18
20	RETURN	R	19
30	FORMAT (// " RHS VECTOR OF ADJOINT EQUATIONS" /)	R	20
40	FORMAT (5(2X, I4, ":", E13.7))	R	21
	END	R	22
		R	23

C		S	1
C		S	2
C		S	3
	SUBROUTINE RHST3S (YT,JRYT,ICYT,V,BTYP,RHS,NB,IWRITE)	S	4
C		S	5
C	SUBROUTINE RHST3S FORMS THE RIGHT HAND SIDE VECTOR RHS OF THE	S	6
C	ADJOINT EQUATIONS FOR THE REACTIVE POWER OF THE SLACK BUS	S	7
C		S	8
	INTEGER JRYT(1),ICYT(1),BTYP(NB)	S	9
	REAL RHS(1)	S	10
	COMPLEX YT(1),V(NB),Z,ZZ	S	11
C		S	12
	NAV=NB+NB	S	13
	NR=NAV-2	S	14
	DO 10 J=1,NR	S	15
	RHS(J)=0.0	S	16
10	CONTINUE	S	17
	Z=CONJG(V(NB))	S	18
	RHS(NAV-1)=AIMAG(Z)	S	19
	RHS(NAV)=-REAL(Z)	S	20
	K1=JRYT(NB)+1	S	21
	K2=JRYT(NB+1)-1	S	22
	DO 30 L=K1,K2	S	23
	IBUS=ICYT(L)	S	24
	LL=IBUS+IBUS	S	25
	ZZ=YT(L)*Z*(0.,1.)	S	26
	IF (BTYP(IBUS).EQ.1) GO TO 20	S	27
	RHS(LL-1)=REAL(ZZ)	S	28
	RHS(LL)=AIMAG(ZZ)	S	29
	GO TO 30	S	30
20	RHS(LL-1)=AIMAG(ZZ*V(IBUS))	S	31
30	CONTINUE	S	32
	IF (IWRITE.LT.4) GO TO 40	S	33
	WRITE (6,50)	S	34
	WRITE (6,60) (M,RHS(M),M=1,NAV)	S	35
40	RETURN	S	36
50	FORMAT (// " RHS VECTOR OF ADJOINT EQUATIONS" /)	S	37
60	FORMAT (5(2X,14," :",E13.7))	S	38
	END	S	39

C		T	1
C		T	2
C		T	3
	SUBROUTINE RHST4 (LBINP,LBOUT,V,BTYP,RHS,YE,CURR,LTP,INL,NAV,IWRITE)	T	4
		T	5
		T	6
C	SUBROUTINE RHST4 FORMULATES RHS VECTOR OF THE ADJOINT EQUATIONS	T	7
C	FOR THE MODULUS OF CURRENT OF THE INLTH ELEMENT. TYPE OF THE	T	8
C	ELEMENT IS IDENTIFIED BY THE PARAMETER LTP.	T	9
C		T	10
	INTEGER LBINP(1),LBOUT(1),BTYP(1)	T	11
	REAL RHS(NAV)	T	12
	COMPLEX V(1),CURR,YE,VA	T	13
C		T	14
	DO 10 J=1,NAV	T	15
	RHS(J)=0.	T	16
	10 CONTINUE	T	17
	IF (CURR.EQ.(0.,0.)) GO TO 100	T	18
	J2=0	T	19
	GO TO (20,30,40,50), LTP	T	20
	20 J1=LBINP(INL)	T	21
	J2=LBOUT(INL)	T	22
	GO TO 60	T	23
	30 J1=LBINP(INL)	T	24
	GO TO 60	T	25
	40 J1=LBOUT(INL)	T	26
	GO TO 60	T	27
	50 J1=INL	T	28
	60 VA=CONJG(CURR)*YE/CABS(CURR)	T	29
	I=0	T	30
	J=J1	T	31
	70 IF (BTYP(J).EQ.2) GO TO 90	T	32
	K=J+J	T	33
	IF (BTYP(J).EQ.1) GO TO 80	T	34
	RHS(K-1)=REAL(VA)	T	35
	RHS(K)=AIMAG(VA)	T	36
	GO TO 90	T	37
	80 RHS(K-1)=AIMAG(V(J)*VA)	T	38
	90 I=I+1	T	39
	IF (I.EQ.2.OR.J2.EQ.0) GO TO 100	T	40
	J=J2	T	41
	VA=-VA	T	42
	GO TO 70	T	43
	100 IF (IWRITE.LT.4) GO TO 110	T	44
	WRITE (6,120)	T	45
	WRITE (6,130) (I,RHS(I),I=1,NAV)	T	46
	110 RETURN	T	47
	120 FORMAT (// " RHS VECTOR OF ADJOINT EQUATIONS" /)	T	48
	130 FORMAT (5(2X,I4," :",E13.7))	T	49
	END	T	50

C		U	1
C		U	2
C		U	3
	SUBROUTINE RHST5 (LBINP,LBOUT,V,BTYP,RHS,YE,LTP,INL,NAV,IWRITE)	U	4
C		U	5
C	SUBROUTINE RHST5 FORMULATES RHS VECTOR OF THE ADJOINT EQUATIONS	U	6
C	FOR THE POWER LOSSES OF THE INLTH ELEMENT. TYPE OF THE ELEMENT	U	7
C	IS IDENTIFIED BY THE PARAMETER LTP	U	8
		U	9
	INTEGER LBINP(1),LBOUT(1),BTYP(1)	U	10
	REAL RHS(NAV)	U	11
	COMPLEX V(1),YE,VA	U	12
C		U	13
	DO 10 J=1,NAV	U	14
	RHS(J)=0.	U	15
10	CONTINUE	U	16
	J2=0	U	17
	GO TO (20,30,40,50), LTP	U	18
20	J1=LBINP(INL)	U	19
	J2=LBOUT(INL)	U	20
	VA=CONJG(V(J1)-V(J2))	U	21
	GO TO 60	U	22
30	J1=LBINP(INL)	U	23
	VA=CONJG(V(J1))	U	24
	GO TO 60	U	25
40	J1=LBOUT(INL)	U	26
	VA=CONJG(V(J1))	U	27
	GO TO 60	U	28
50	VA=CONJG(V(INL))	U	29
60	VA=2.*REAL(YE)*VA	U	30
	I=0	U	31
	J=J1	U	32
70	IF (BTYP(J).EQ.2) GO TO 90	U	33
	K=J+J	U	34
	IF (BTYP(J).EQ.1) GO TO 80	U	35
	RHS(K-1)=REAL(VA)	U	36
	RHS(K)=AIMAG(VA)	U	37
	GO TO 90	U	38
80	RHS(K-1)=AIMAG(V(J)*VA)	U	39
90	I=I+1	U	40
	IF (I.EQ.2.OR.J2.EQ.0) GO TO 100	U	41
	J=J2	U	42
	VA=-VA	U	43
	GO TO 70	U	44
100	IF (IWRITE.LT.4) GO TO 110	U	45
	WRITE (6,120)	U	46
	WRITE (6,130) (I,RHS(I),I=1,NAV)	U	47
110	RETURN	U	48
120	FORMAT (// " RHS VECTOR OF ADJOINT EQUATIONS"//)	U	49
130	FORMAT (5(2X,I4," :",E13.7))	U	50
	END	U	51

C		V	1
C		V	2
C		V	3
	SUBROUTINE RHST6 (YT,JRYT,ICYT,V,BTYP,RHS,NAV,IWRITE)	V	4
C		V	5
C	SUBROUTINE RHST6 FORMULATES RHS VECTOR OF THE ADJOINT	V	6
C	EQUATIONS FOR THE TRANSMISSION POWER LOSSES	V	7
		V	8
	INTEGER JRYT(1),ICYT(1),BTYP(1)	V	9
	REAL RHS(NAV)	V	10
	COMPLEX YT(1),V(1),Z	V	11
C		V	12
	N=NAV/2-1	V	13
	RHS(NAV-1)=0.	V	14
	RHS(NAV)=0.	V	15
	DO 30 I=1,N	V	16
	J1=JRYT(I)	V	17
	J2=JRYT(I+1)-1	V	18
	Z=(0.,0.)	V	19
	DO 10 J=J1,J2	V	20
	Z=Z+CONJG(V(ICYT(J)))*REAL(YT(J))	V	21
10	CONTINUE	V	22
	Z=Z+Z	V	23
	K2=I+1	V	24
	K1=K2-1	V	25
	IF (BTYP(I).EQ.1) GO TO 20	V	26
	RHS(K1)=REAL(Z)	V	27
	RHS(K2)=AIMAG(Z)	V	28
	GO TO 30	V	29
20	RHS(K1)=AIMAG(V(I)*Z)	V	30
	RHS(K2)=0.	V	31
30	CONTINUE	V	32
	IF (IWRITE.LT.4) GO TO 40	V	33
	WRITE (6,50)	V	34
	WRITE (6,60) (I,RHS(I),I=1,NAV)	V	35
40	RETURN	V	36
50	FORMAT (//" RHS VECTOR OF ADJOINT EQUATIONS"/)	V	37
60	FORMAT (5(2X,I4," :",E13.7))	V	38
	END	V	39

C		W	1
C		W	2
C		W	3
	SUBROUTINE RHST7 (YT, JRYT, ICYT, V, BTYP, RHS, NB, IWRITE)	W	4
C		W	5
C	SUBROUTINE RHST7 FORMS THE RIGHT HAND SIDE VECTOR RHS OF THE	W	6
C	ADJOINT EQUATIONS FOR THE ACTIVE POWER OF THE SLACK BUS	W	7
		W	8
	INTEGER JRYT(1), ICYT(1), BTYP(NB)	W	9
	REAL RHS(1)	W	10
	COMPLEX YT(1), V(NB), Z, ZZ	W	11
C		W	12
	NAV=NB+NB	W	13
	NR=NAV-2	W	14
	DO 10 J=1, NR	W	15
	RHS(J)=0.0	W	16
10	CONTINUE	W	17
	Z=CONJG(V(NB))	W	18
	RHS(NAV-1)=-REAL(Z)	W	19
	RHS(NAV)=-AIMAG(Z)	W	20
	K1=JRYT(NB)+1	W	21
	K2=JRYT(NB+1)-1	W	22
	DO 30 L=K1, K2	W	23
	IBUS=ICYT(L)	W	24
	LL=IBUS+IBUS	W	25
	ZZ=YT(L)*Z	W	26
	IF (BTYP(IBUS).EQ.1) GO TO 20	W	27
	RHS(LL-1)=REAL(ZZ)	W	28
	RHS(LL)=AIMAG(ZZ)	W	29
	GO TO 30	W	30
20	RHS(L-1)=AIMAG(ZZ*V(IBUS))	W	31
30	CONTINUE	W	32
	IF (IWRITE.LT.4) GO TO 40	W	33
	WRITE (6,50)	W	34
	WRITE (6,60) (I, RHS(I), I=1, NAV)	W	35
40	RETURN	W	36
50	FORMAT (// " RHS VECTOR OF ADJOINT EQUATIONS"//)	W	37
60	FORMAT (5(2X, I4, ":", E13.7))	W	38
	END	W	39

C		X	1
C		X	2
C		X	3
	SUBROUTINE RHST8 (YT, JRYT, ICYT, V, BTYP, RHS, CN, DN, PN, NAV, IWRITE)	X	4
C		X	5
C	SUBROUTINE RHST8 FORMULATES RHS VECTOR OF THE ADJOINT EQUATIONS	X	6
C	FOR THE COST OF GENERATION	X	7
		X	8
	INTEGER JRYT(1), ICYT(1), BTYP(1)	X	9
	REAL RHS(NAV)	X	10
	COMPLEX YT(1), V(1), VA, VB	X	11
C		X	12
	NB=NAV/2	X	13
	VA=CONJG(V(NB))*(CN+2*DN*PN)	X	14
	K=NAV-2	X	15
	DO 10 J=1, K	X	16
	RHS(J)=0.	X	17
10	CONTINUE	X	18
	RHS(NAV-1)=-REAL(VA)	X	19
	RHS(NAV)=-AIMAG(VA)	X	20
	J1=JRYT(NB)+1	X	21
	J2=JRYT(NB+1)-1	X	22
	DO 30 I=J1, J2	X	23
	VB=YT(I)*VA	X	24
	L=ICYT(I)	X	25
	K=L+L	X	26
	IF (BTYP(L).EQ.1) GO TO 20	X	27
	RHS(K-1)=REAL(VB)	X	28
	RHS(K)=AIMAG(VB)	X	29
	GO TO 30	X	30
20	RHS(K-1)=AIMAG(V(I)*VB)	X	31
30	CONTINUE	X	32
	IF (IWRITE.LT.4) GO TO 40	X	33
	WRITE (6,50)	X	34
	WRITE (6,60) (I,RHS(I), I=1,NAV)	X	35
40	RETURN	X	36
50	FORMAT (// " RHS VECTOR OF ADJOINT EQUATIONS"//)	X	37
60	FORMAT (5(2X, I4, ":", E13.7))	X	38
	END	X	39

C
C
C
C
C
C
C

```

SUBROUTINE PDR3 (LBINP, LBOUT, VB, CCV, ICV, PDR, INB, NCV, NDR)

SUBROUTINE PDR3 CALCULATES PARTIAL DERIVATIVES OF A BUS REACTIVE
POWER W.R.T. LINE CURRENTS

INTEGER LBINP(1), LBOUT(1), CCV(NCV), ICV(NCV)
COMPLEX PDR(1), VB
NDR=0
DO 50 J=1, NCV
L=CCV(J)
M=ICV(J)
IF (L.GT.6.AND.L.LT.11) GO TO 50
NDR=NDR+1
PDR(NDR)=(0.,0.)
IF (L.GE.7) GO TO 30
IF (L.GE.5) GO TO 20
IF (L.GE.3) GO TO 10
IF (LBINP(M).NE.INB) GO TO 50
GO TO 40
10 IF (LBINP(M).NE.INB.AND.LBOUT(M).NE.INB) GO TO 50
GO TO 40
20 IF (LBOUT(M).NE.INB) GO TO 50
GO TO 40
30 IF (M.NE.INB) GO TO 50
40 PDR(NDR)=CMPLX(0.,-1.)*CONJG(VB)
50 CONTINUE
RETURN
END
```

Y 1
Y 2
Y 3
Y 4
Y 5
Y 6
Y 7
Y 8
Y 9
Y 10
Y 11
Y 12
Y 13
Y 14
Y 15
Y 16
Y 17
Y 18
Y 19
Y 20
Y 21
Y 22
Y 23
Y 24
Y 25
Y 26
Y 27
Y 28
Y 29
Y 30
Y 31
Y 32

C		Z	1
C		Z	2
C		Z	3
C	SUBROUTINE PDR4 (CCV,ICV,PDR,CURR,LTP,INL,NCV,NDR)	Z	4
C		Z	5
C	SUBROUTINE PDR4 CALCULATES PARTIAL DERIVATIVES OF THE MODULUS	Z	6
C	OF CURRENT OF THE INLTH ELEMENT W.R.T. LINE CURRENTS	Z	7
C		Z	8
	INTEGER CCV(NCV),ICV(NCV)	Z	9
	COMPLEX PDR(1),CURR,VA	Z	10
C		Z	11
	NDR=0	Z	12
	DO 10 J=1,NCV	Z	13
	L=CCV(J)	Z	14
	M=ICV(J)	Z	15
	IF (L.GT.6.AND.L.LT.11) GO TO 10	Z	16
	NDR=NDR+1	Z	17
	PDR(NDR)=(0.,0.)	Z	18
	IF (M.NE.INL) GO TO 10	Z	19
	VA=-CONJG(CURR)/CABS(CURR)	Z	20
	IF (L.LE.2.AND.LTP.EQ.2) PDR(NDR)=VA	Z	21
	IF (L.EQ.3.OR.L.EQ.4.AND.LTP.EQ.1) PDR(NDR)=VA	Z	22
	IF (L.EQ.5.OR.L.EQ.6.AND.LTP.EQ.3) PDR(NDR)=VA	Z	23
	IF (L.EQ.11.AND.LTP.EQ.4) PDR(NDR)=VA	Z	24
10	CONTINUE	Z	25
	RETURN	Z	26
	END	Z	27
		Z	28

C		AA	1
C		AA	2
C		AA	3
	SUBROUTINE PDR5 (CCV,ICV,PDR,CURR,F,LTP,INL,NCV,NDR)	AA	4
C		AA	5
C	SUBROUTINE PDR5 CALCULATES PARTIAL DERIVATIVES OF THE POWER	AA	6
C	LOSSES OF THE INLTH ELEMENT W.R.T. LINE CURRENTS	AA	7
C		AA	8
	INTEGER CCV(NCV),ICV(NCV)	AA	9
	COMPLEX PDR(1),CURR,VA	AA	10
	NDR=0	AA	11
	DO 10 J=1,NCV	AA	12
	L=CCV(J)	AA	13
	M=ICV(J)	AA	14
	IF (L.GT.6.AND.L.LT.11) GO TO 10	AA	15
	NDR=NDR+1	AA	16
	PDR(NDR)=(0.,0.)	AA	17
	IF (M.NE.INL) GO TO 10	AA	18
	VA=-2.*F/CURR	AA	19
	IF (L.LE.2.AND.LTP.EQ.2) PDR(NDR)=VA	AA	20
	IF (L.EQ.3.OR.L.EQ.4.AND.LTP.EQ.1) PDR(NDR)=VA	AA	21
	IF (L.EQ.5.OR.L.EQ.6.AND.LTP.EQ.3) PDR(NDR)=VA	AA	22
	IF (L.EQ.11.AND.LTP.EQ.4) PDR(NDR)=VA	AA	23
10	CONTINUE	AA	24
	RETURN	AA	25
	END	AA	26

C		AB	1
C		AB	2
C		AB	3
	SUBROUTINE PDR6 (LBINP, LBOUT, LINPG, LINPB, LG, LB, V, CCV, ICV, PDR, NCV, N	AB	4
	1DR)	AB	5
C		AB	6
C	SUBROUTINE PDR6 CALCULATES PARTIAL DERIVATIVES OF TRANSMISSION	AB	7
C	POWER LOSSES W.R.T. LINE CURRENTS	AB	8
C		AB	9
	INTEGER LBINP(1), LBOUT(1), CCV(1), ICV(1)	AB	10
	REAL LINPG(1), LINPB(1), LG(1), LB(1)	AB	11
	COMPLEX PDR(1), V(1)	AB	12
C		AB	13
	NDR=0	AB	14
	DO 10 J=1, NCV	AB	15
	L=CCV(J)	AB	16
	M=ICV(J)	AB	17
	IF (L.GE.7.AND.L.NE.11) GO TO 10	AB	18
	NDR=NDR+1	AB	19
	IF (L.LE.2) PDR(NDR)=-2.*CONJG(V(LBINP(M))*LINPG(M)/CPLX(LINPG(M	AB	20
	1), LINPB(M))	AB	21
	IF (L.EQ.3.OR.L.EQ.4) PDR(NDR)=-2.*CONJG(V(LBINP(M))-V(LBOUT(M))*	AB	22
	1LG(M)/CPLX(LG(M), LB(M))	AB	23
	IF (L.EQ.5.OR.L.EQ.6) PDR(NDR)=-2.*CONJG(V(LBOUT(M))*LINPG(M)/CMP	AB	24
	1LX(LINPG(M), LINPB(M))	AB	25
	IF (L.EQ.11) PDR(NDR)=(0., 0.)	AB	26
10	CONTINUE	AB	27
	RETURN	AB	28
	END	AB	29

C		AC	1
C		AC	2
C		AC	3
	SUBROUTINE PDR7 (LBINP, LBOUT, VB, CCV, ICV, PDR, INB, NCV, NDR)	AC	4
C		AC	5
C	SUBROUTINE PDR7 CALCULATES PARTIAL DERIVATIVES OF A BUS ACTIVE	AC	6
C	POWER W.R.T. LINE CURRENTS	AC	7
C		AC	8
	INTEGER LBINP(1), LBOUT(1), CCV(NCV), ICV(NCV)	AC	9
	COMPLEX PDR(1), VB	AC	10
C		AC	11
	NDR=0	AC	12
	DO 50 J=1, NCV	AC	13
	L=CCV(J)	AC	14
	M=ICV(J)	AC	15
	IF (L.GT.6.AND.L.LT.11) GO TO 50	AC	16
	NDR=NDR+1	AC	17
	PDR(NDR)=(0.,0.)	AC	18
	IF (L.GE.7) GO TO 30	AC	19
	IF (L.GE.5) GO TO 20	AC	20
	IF (L.GE.3) GO TO 10	AC	21
	IF (LBINP(M).NE.INB) GO TO 50	AC	22
	GO TO 40	AC	23
10	IF (LBINP(M).NE.INB.AND.LBOUT(M).NE.INB) GO TO 50	AC	24
	GO TO 40	AC	25
20	IF (LBOUT(M).NE.INB) GO TO 50	AC	26
	GO TO 40	AC	27
30	IF (M.NE.INB) GO TO 50	AC	28
40	PDR(NDR)=-CONJG(VB)	AC	29
50	CONTINUE	AC	30
	RETURN	AC	31
	END	AC	32

C		AD	1
C		AD	2
C		AD	3
	SUBROUTINE PDR3 (LBINP, LBOUT, VB, CCV, ICV, PDR, CN, DN, PN, NB, NCV, NDR)	AD	4
C		AD	5
C	SUBROUTINE PDR3 DETERMINES PARTIAL DERIVATIVES OF THE COST OF	AD	6
C	GENERATION W.R.T. LINE CURRENTS	AD	7
C		AD	8
	INTEGER LBINP(1), LBOUT(1), CCV(NCV), ICV(NCV)	AD	9
	COMPLEX PDR(1), VB	AD	10
C		AD	11
	NDR=0	AD	12
	DO 50 J=1, NCV	AD	13
	L=CCV(J)	AD	14
	M=ICV(J)	AD	15
	IF (L.GT.6.AND.L.LT.11) GO TO 50	AD	16
	NDR=NDR+1	AD	17
	PDR(NDR)=(0.,0.)	AD	18
	IF (L.GE.7) GO TO 30	AD	19
	IF (L.GE.5) GO TO 20	AD	20
	IF (L.GE.3) GO TO 10	AD	21
	IF (LBINP(M).NE.NB) GO TO 50	AD	22
	GO TO 40	AD	23
10	IF (LBINP(M).NE.NB.AND.LBOUT(M).NE.NB) GO TO 50	AD	24
	GO TO 40	AD	25
20	IF (LBOUT(M).NE.NB) GO TO 50	AD	26
	GO TO 40	AD	27
30	IF (M.NE.NB) GO TO 50	AD	28
40	PDR(NDR)=- (CN+2.0*DN*PN)*CONJG(VB)	AD	29
50	CONTINUE	AD	30
	RETURN	AD	31
	END	AD	32

C		AE	1
C		AE	2
C		AE	3
	SUBROUTINE WRTGR (CCV,ICV,DF,NCV)	AE	4
C		AE	5
C	SUBROUTINE WRTGR WRITES GRADIENTS OF A FUNCTION	AE	6
C		AE	7
	INTEGER CCV(NCV),ICV(NCV)	AE	8
	REAL DF(NCV),RLB(11)	AE	9
	DATA RLB/"LINPG(", "LINPB(", " LG(", " LB(", "LOUTG(", "LOUTB(", "	AE	10
	1 P(", " Q(", "MOD V(", "ARG V(", " BSTL("/	AE	11
	WRITE (6,10) (RLB(CCV(J)),ICV(J),DF(J),J=1,NCV)	AE	12
	10 FORMAT ((1X,4(3X,A6,13,"): ",1X,E13.7))	AE	13
	END	AE	14

C		AF	1
C		AF	2
C		AF	3
	COMPLEX FUNCTIONCF1(C0,Z1,Z2,LST1,LST2,N, IDAT)	AF	4
C		AF	5
C	FUNCTION SUBPROGRAM CF1 CALCULATES THE VALUE OF A COMPLEX	AF	6
C	FUNCTION	AF	7
C	CF1=C0 + Z1(LST1(1))*Z2(LST2(1)) + Z1(LST1(2))*Z2(LST2(2)) + ..	AF	8
C	.. + Z1(LST1(N))*Z2(LST2(N))	AF	9
C	OF COMPLEX ARGUMENTS	AF	10
		AF	11
	INTEGER LST1(1),LST2(1)	AF	12
C	COMPLEX Z1(1),Z2(1),C0	AF	13
		AF	14
	CF1=C0	AF	15
	IF (IDAT.GE.1) GO TO 20	AF	16
	DO 10 K=1,N	AF	17
	CF1=CF1+Z1(K)*Z2(K)	AF	18
10	CONTINUE	AF	19
	RETURN	AF	20
20	IF (IDAT.GE.2) GO TO 40	AF	21
	DO 30 K=1,N	AF	22
	CF1=CF1+Z1(K)*Z2(LST2(K))	AF	23
30	CONTINUE	AF	24
	RETURN	AF	25
40	IF (IDAT.GE.3) GO TO 60	AF	26
	DO 50 K=1,N	AF	27
	CF1=CF1+Z1(LST1(K))*Z2(K)	AF	28
50	CONTINUE	AF	29
	RETURN	AF	30
60	DO 70 K=1,N	AF	31
	CF1=CF1+Z1(LST1(K))*Z2(LST2(K))	AF	32
70	CONTINUE	AF	33
	RETURN	AF	34
	END	AF	35

C		AG	1
C		AG	2
C		AG	3
	COMPLEX FUNCTIONCF5(C0,Z1,Z2,LST1,LST2,N,IDAT)	AG	4
C		AG	5
C	FUNCTION SUBPROGRAM CF5 CALCULATES THE VALUE OF A COMPLEX	AG	6
C	FUNCTION	AG	7
C	CF5=C0*CONJG(CF1((0.,0.),Z1,Z2,LST1,LST2,N,IDAT))	AG	8
		AG	9
	INTEGER LST1(1),LST2(1)	AG	10
	COMPLEX Z1(1),Z2(1),C0,CF1	AG	11
	CF5=C0*CONJG(CF1((0.,0.),Z1,Z2,LST1,LST2,N,IDAT))	AG	12
	RETURN	AG	13
	END	AG	14