

**WARDEQ - A FORTRAN IMPLEMENTATION
OF THE WARD TYPE POWER EQUIVALENTS**

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Abstract

This document contains a listing of the computer package WARDEQ described in [2]. WARDEQ is a package of forty subroutines for power systems reduction using the Ward type load flow equivalents. The package has been developed for the CDC 170/730 system with the NOS 1.4 level 552 operating system and the Fortran Extended (FTN) version 4.8 compiler. The listing contains a total of 2783 lines, of which 1229 are comments.

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I. INTRODUCTION

WARDEQ is a package of forty Fortran subroutines for power systems reduction using external equivalents. The package implements five Ward type equivalent methods [1] and it also performs a contingency analysis of the reduced power system. The user's manual of the WARDEQ package together with illustrative examples are found in [2].

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

To perform a contingency analysis of the reduced power system the package calls appropriate subroutines of the TTM1 [3] and the MA28 [4] packages, and therefore these packages must be available when the contingency analysis option is performed.

II. REFERENCES

- [1] J.W. Bandler, M.A. El-Kady and G. Centkowski, "Review of the Ward class of external equivalents for power systems", Department of Electrical and Computer Engineering, McMaster University, Hamilton, Canada, Report SOS-83-23-R, 1983.
- [2] J.W. Bandler, M.A. El-Kady and G. Centkowski, "WARDEQ - A Fortran implementation of the Ward type power equivalents", Department of Electrical and Computer Engineering, McMaster University, Hamilton, Canada, Report SOS-83-24-U, 1983.
- [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.S. 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 WARDEQ PACKAGE

<u>Subroutine</u>	<u>Number of lines</u> (source text)	<u>Number of words</u> (compiled code)	<u>Description</u> (page of [2])	<u>Listing</u> (page)
ASUB	132	364		5
BELONG	18	34		7
CHNGAD	31	47		7
CHNGC	22	31		7
CHNGI	14	14		8
CHNGJ	21	24		8
CHNGP	24	30		8
CHNUMB	66	104		9
EQBCV	171	445		10
EQCCC	61	240		12
EQCOMP	275	1412		13
EQCONTI	148	501	18	17
EQCURR	19	35		20
EQDDD	48	65		20
EQDEIE	107	355	44	22
EQDRC1	71	113		23
EQEXEQ	183	736	46	24
EQFORM	128	454	49	27
EQINBR	70	121		29
EQMOSO	41	47		30
EQINRC	43	111		31
EQREAD	154	774	52	31
EQREEY	21	31		35
EQREMS	30	31		35
EQWAES	48	53		35
EQWARD	146	531	8	36
EQWEES	164	433		38
GAUSEL	41	76		41
INTERV	53	61		41
MOVE	36	41		42

<u>Subroutine</u>	<u>Number of lines</u> (source text)	<u>Number of words</u> (compiled code)	<u>Description</u> (page of [2])	<u>Listing</u> (page)
NOTE	14	25		43
ORDEVE	65	55		43
PRINAD	24	125		44
PRINTNC	43	236		44
RDATA	32	67	53	45
SETBIN	14	27		46
SETBIT	12	13		46
SETVEC	108	241		46
SPAMAT	72	117		48
ZERO	13	12		49

C		A	1
C		A	2
	SUBROUTINE ASUB (N,NEXT,NEL,JRYT,ICYT,YT,V,AK,NCOL,NROW,IFLAG,IWRITE)	A	3
		A	4
		A	5
C		A	6
C	THIS SUBROUTINE PERFORMS GAUSSIAN ELIMINATION OF THE "NEXT"	A	7
C	EQUATIONS FOR THE SYSTEM OF "N" LINER EQUATIONS DESCRIBED BY	A	8
C	THE MATRIX WHICH IS STORED IN SPARSE FORM (VECTORS JRYT,ICYT,YT)	A	9
C	AFTER PERFORMING THE ELIMINATION THE REDUCED SYSTEM OF THE	A	10
C	EQUATIONS IS STORED IN THE COEFFICIENT MATRIX (VECTORS AK,NROW,	A	11
C	NCOL)	A	12
C		A	13
C	N NUMBER OF EQUATIONS	A	14
C	NEXT NUMBER OF EQUATIONS FOR WHICH THE ELIMINATION IS	A	15
C	PERFORMED	A	16
C	NEL NUMBER OF NONZERO ELEMENTS OF THE COEFFICIENT MATRIX	A	17
C	V VECTOR OF LENGTH N. A RIGHT HAND SIDE VECTOR	A	18
C	IFLAG RETURN FLAG. FOR SUCCESSFUL RETURN IFLAG=0	A	19
C		A	20
	INTEGER ICYT(1),JRYT(1),NCOL(1),NROW(1)	A	21
	COMPLEX YT(1),V(1),AK(1),Y	A	22
C		A	23
C	THE DESCRIPTION OF THE SYSTEM OF EQUATIONS IS PRINTED OUT BY	A	24
C	THE SUBROUTINE PRINTNC	A	25
C		A	26
	IOTP=6	A	27
	IF (IWRITE.EQ.4) CALL PRINTNC (NEL,NROW,NCOL,AK,IOTP)	A	28
	NN=N	A	29
	NYT=NEL	A	30
	DO 80 I1=1,NEXT	A	31
C		A	32
C	IN THIS LOOP THE ELIMINATION OF THE "NEXT" ROWS FROM THE MATRIX	A	33
C	DESCRIBING THE SYSTEM OF EQUATIONS (VECTORS YT,JRYT,ICYT)	A	34
C	IS PERFORMED	A	35
C		A	36
	I=1	A	37
C		A	38
C	MODIFY THE VALUE OF THE ELEMENTS IN THE ITH ROW	A	39
C		A	40
	J1=JRYT(I)+1	A	41
	J2=JRYT(I+1)-1	A	42
	J0=J1-1	A	43
	L=0	A	44
	Y=YT(J0)	A	45
	V(I)=V(I)/Y	A	46
	IF (J1-1.EQ.J2) GO TO 70	A	47
	DO 10 K=J0,J2	A	48
C		A	49
C	STORE THE NEW VALUE OF THE ELEMENTS FROM THE ITH ROW IN THE	A	50
C	VECTOR AK	A	51
C		A	52
	YT(K)=YT(K)/Y	A	53
	L=L+1	A	54
	AK(L)=YT(K)	A	55
	10 CONTINUE	A	56
	DO 60 J3=J1,J2	A	57
C		A	58
C	IN THIS LOOP THE ROWS WITH THE ITH NONZERO ELEMENT ARE	A	59
C	DETERMINED AND MODIFIED	A	60
C		A	61
	J=ICYT(J3)	A	62
	K1=JRYT(J)+1	A	63
	K2=JRYT(J+1)-1	A	64
	DO 20 K=K1,K2	A	65
	IF (ICYT(K).EQ.1) GO TO 30	A	65

20	CONTINUE	A 66
	IFLAG=-10	A 67
	WRITE (6,130) IFLAG	A 68
	RETURN	A 69
30	CONTINUE	A 70
	Y=YT(K)	A 71
	L=0	A 72
C		A 73
C	MODIFY THE VALUE OF THE ELEMENTS OF THE ITH ROW	A 74
C		A 75
	DO 40 K=J0,J2	A 76
	L=L+1	A 77
	YT(K)=AK(L)*Y	A 78
40	CONTINUE	A 79
C		A 80
C	MODIFY THE JTH ROW	A 81
C		A 82
	V(J)=V(J)/Y	A 83
	CALL SETVEC (N, NYT, JRYT, ICYT, YT, I, J, NEL, IFLAG)	A 84
	V(J)=V(J)-V(I)	A 85
	IF (IFLAG.GE.0) GO TO 50	A 86
	RETURN	A 87
50	CONTINUE	A 88
60	CONTINUE	A 89
70	CONTINUE	A 90
C		A 91
C	REMOVE THE ITH ROW FROM THE MATRIX DESCRIBING THE SYSTEM OF	A 92
C	EQUATIONS (VECTORS YT, JRYT, ICYT)	A 93
C		A 94
	CALL MOVE (N, NYT, YT, JRYT, ICYT)	A 95
C		A 96
80	CONTINUE	A 97
C		A 98
C	END OF THE ELIMINATION	A 99
C		A 100
C	FORM THE COEFFICIENT MATRIX (VECTORS AK, NROW, NCOL) FROM THE	A 101
C	VECTORS YR, JRYT, ICYT	A 102
C		A 103
	NEL=0	A 104
	DO 90 I=1,N	A 105
	J1=JRYT(I)	A 106
	NEL=NEL+1	A 107
	AK(NEL)=YT(J1)	A 108
	NROW(NEL)=I	A 109
	NCOL(NEL)=I	A 110
90	CONTINUE	A 111
	IF (N.EQ.1) RETURN	A 112
	DO 110 I=1,N	A 113
	J1=JRYT(I)+1	A 114
	J2=JRYT(I+1)-1	A 115
	IF (J1-1.EQ.J2) GO TO 110	A 116
	DO 100 J=J1,J2	A 117
	NEL=NEL+1	A 118
	NROW(NEL)=I	A 119
	NCOL(NEL)=ICYT(J)	A 120
	AK(NEL)=YT(J)	A 121
100	CONTINUE	A 122
110	CONTINUE	A 123
	N=NN	A 124
	IF (IWRITE.NE.4) RETURN	A 125
	WRITE (6,120)	A 126
	CALL PRINTNC (NEL, NROW, NCOL, AK, IOTP)	A 127
120	FORMAT (1H /" EXTERNAL DESCRIPTION OF THE SYSTEM "/)	A 128
130	FORMAT (2X, "IFLAG FROM ASUB IFLAG= ",13,3X, "AN ERROR IN THE MATRIX	A 129
	1 ICYT")	A 130

	RETURN	A 131
	END	A 132-
C		B 1
C		B 2
	LOGICAL FUNCTION BELONG(IEL, IB)	B 3
C		B 4
C	THIS LOGICAL FUNCTION CHECKS IF THE ELEMENT IEL HAS BEEN	B 5
C	CODED IN THE VECTOR IB	B 6
C		B 7
	INTEGER IB(1)	B 8
C		B 9
	BELONG= .FALSE.	B 10
	IX=(IEL-1)/50	B 11
	IY= IEL-IX*50	B 12
	J= IX+1	B 13
	K=0	B 14
	CALL SETBIT (K, IY)	B 15
	BELONG=OR(IB(J), K .EQ. IB(J)	B 16
	RETURN	B 17
	END	B 18-
C		C 1
C		C 2
	SUBROUTINE CHNGAD (N, NEL, JRYT, IGYT, YT, NROW, NCOL, AK, NEWNU)	C 3
C		C 4
C	THIS SUBROUTINE CHANGES A BUS ADMITTANCE MATRIX STORED IN A	C 5
C	SPARSE FORM (VECTORS YT, JRYT, IGYT) TO THE FORM OF A COEFFICIENT	C 6
C	MATRIX AK (VECTORS AK, NROW, NCOL) AND PERFORMS RENUMBERING OF THE	C 7
C	INDICES STORED BY THE VECTORS NROW, NCOL ACCORDING TO THE NEW	C 8
C	INDICES STORED BY THE VECTOR NEWNU	C 9
C		C 10
C	NEL NUMBER OF NONZERO ELEMENTS OF THE BUS ADMITTANCE	C 11
C	MATRIX	C 12
C	N NUMBER OF BUSES	C 13
C		C 14
	INTEGER NROW(1), NCOL(1), NEWNU(1), JRYT(1), IGYT(1)	C 15
	COMPLEX YT(1), AK(1)	C 16
C		C 17
	NEL=0	C 18
	DO 20 I=1, N	C 19
	J1=JRYT(I)	C 20
	J2=JRYT(I+1)-1	C 21
	DO 10 J=J1, J2	C 22
	NEL=NEL+1	C 23
	K= IGYT(J)	C 24
	NROW(NEL)=NEWNU(I)	C 25
	NCOL(NEL)=NEWNU(K)	C 26
	AK(NEL)=YT(J)	C 27
10	CONTINUE	C 28
20	CONTINUE	C 29
	RETURN	C 30
	END	C 31-
C		D 1
C		D 2
	SUBROUTINE CHNGC (NB, CVEKT, NEWNUM, CAUX)	D 3
C		D 4
C	THIS SUBROUTINE CHANGES THE ORDER OF NB ELEMENTS STORED IN	D 5
C	THE VECTOR CVEKT ACCORDING TO THE NEW INDICES STORED BY THE	D 6
C	VECTOR NEWNUM	D 7
C		D 8
C	CVEKT AN AUXILIARY VECTOR	D 9
C		D 10
	INTEGER NEWNUM(1)	D 11
	COMPLEX CAUX(1), CVEKT(1)	D 12
C		D 13
	DO 10 I=1, NB	D 14

	CAUX(I)=CVEKT(I)	D 15
10	CONTINUE	D 16
	DO 20 I=1,NB	D 17
	K=NEWNUM(I)	D 18
	CVEKT(K)=CAUX(I)	D 19
20	CONTINUE	D 20
	RETURN	D 21
	END	D 22-
C		E 1
C		E 2
	SUBROUTINE CHNGI (N,IVEKT,NEWNUM	E 3
C		E 4
C	THIS SUBROUTINE RENUMBERS INDICES STORED IN THE VECTOR IVEK	E 5
C	ACCORDING TO THE NEW INDICES STORED BY THE VECTOR NEWNUM	E 6
C		E 7
	INTEGER NEWNUM(1),IVEKT(1)	E 8
C		E 9
	DO 10 I=1,N	E 10
	IVEKT(I)=NEWNUM(IVEKT(I))	E 11
10	CONTINUE	E 12
	RETURN	E 13
	END	E 14-
C		F 1
C		F 2
	SUBROUTINE CHNGJ (N,IVEKT,NEWNUM,IAUX)	F 3
C		F 4
C	THIS SUBROUTINE CHANGES THE ORDER OF N ELEMENTS STORED IN	F 5
C	THE VECTOR IVEKT ACCORDING TO THE NEW INDICES STORED BY THE	F 6
C	VECTOR NEWNUM	F 7
C		F 8
C	IAUX AN AUXILIARY VECTOR	F 9
C		F 10
	INTEGER IVEKT(1),NEWNUM(1),IAUX(1)	F 11
C		F 12
	DO 10 I=1,N	F 13
	IAUX(I)=IVEKT(I)	F 14
10	CONTINUE	F 15
	DO 20 I=1,N	F 16
	K=NEWNUM(I)	F 17
	IVEKT(K)=IAUX(I)	F 18
20	CONTINUE	F 19
	RETURN	F 20
	END	F 21-
C		G 1
C		G 2
	SUBROUTINE CHNGP (NB,BVEKT,NEWNUM,RAUX)	G 3
C		G 4
C	THIS SUBROUTINE CHANGES THE ORDER OF 2*NB ELEMENTS STORED IN	G 5
C	THE VECTOR BVEKT ACCORDING TO THE NEW INDICES STORED BY THE	G 6
C	VECTOR NEWNUM	G 7
C		G 8
C	RAUX AN AUXILIARY VECTOR	G 9
C		G 10
	REAL BVEKT(1),RAUX(1)	G 11
	INTEGER NEWNUM(1)	G 12
C		G 13
	J=2*NB	G 14
	DO 10 I=1,J	G 15
	RAUX(I)=BVEKT(I)	G 16
10	CONTINUE	G 17
	DO 20 I=1,NB	G 18
	K=NEWNUM(I)	G 19
	BVEKT(2*K-1)=RAUX(2*I-1)	G 20
	BVEKT(2*K)=RAUX(2*I)	G 21
20	CONTINUE	G 22

	RETURN	C	23
	END	C	24-
C		H	1
C		H	2
	SUBROUTINE CHNUMB (NB,NINTE,NBOUND,NRET,IBINTE,IBOUND,IBRET,NEWNUM	H	3
	1,IOLDNU)	H	4
C		H	5
C	THIS SUBROUTINE DETERMINES NEW INDICES FOR THE BUSES OF THE	H	6
C	POWER SYSTEM. THE NEW INDICES ARE STORED IN THE VECTOR	H	7
C	NEWNUM. THE OLD INDICES W.R.T. THE NEW INDICES ARE STORED IN	H	8
C	THE VECTOR IOLDNU.	H	9
C		H	10
C	NB NUMBER OF BUSES	H	11
C	NINTE NUMBER OF INTERNAL BUSES	H	12
C	NBOUND NUMBER OF BOUNDARY BUSES	H	13
C	NRET NUMBER OF RETAINED BUSES	H	14
C	IBOUND,IBRET VECTORS THAT CONTAIN THE CODED INDICES OF BUSES	H	15
C	BELONGING TO THE BOUNDARY AND RETAINED BUSES,	H	16
C	RESPECTIVELY	H	17
C		H	18
	INTEGER IBINTE(1),IBRET(1),IBOUND(1),NEWNUM(1),IOLDNU(1)	H	19
	LOGICAL BELONG	H	20
C		H	21
	NEXT=NB-NRET-NBOUND-NINTE	H	22
	NCEXT=0	H	23
	NCRET=NEXT	H	24
	NCBOUN=NEXT+NRET	H	25
	NCINTE=NCBOUN+NBOUND	H	26
C		H	27
C	CALCULATE NEW INDICES OF BUSES	H	28
C		H	29
	DO 40 I=1,NB	H	30
	IF (IBINTE(I).EQ.1) GO TO 30	H	31
	IF (BELONG(I,IBRET)) GO TO 10	H	32
	IF (BELONG(I,IBOUND)) GO TO 20	H	33
C		H	34
C	CALCULATE A NEW INDEX FOR THE ITH BUS OF THE EXTERNAL SYSTEM	H	35
C		H	36
	NCEXT=NCEXT+1	H	37
	NEWNUM(I)=NCEXT	H	38
	IOLDNU(NCEXT)=I	H	39
	GO TO 40	H	40
	10 CONTINUE	H	41
C		H	42
C	CALCULATE A NEW INDEX FOR THE RETAINED BUS	H	43
C		H	44
	NCRET=NCRET+1	H	45
	NEWNUM(I)=NCRET	H	46
	IOLDNU(NCRET)=I	H	47
	GO TO 40	H	48
	20 CONTINUE	H	49
C		H	50
C	CALCULATE A NEW INDEX FOR THE BOUNDARY BUS	H	51
C		H	52
	NCBOUN=NCBOUN+1	H	53
	NEWNUM(I)=NCBOUN	H	54
	IOLDNU(NCBOUN)=I	H	55
	GO TO 40	H	56
	30 CONTINUE	H	57
C		H	58
C	CALCULATE A NEW INDEX FOR THE ITH BUS OF THE INTERNAL SYSTEM	H	59
C		H	60
	NCINTE=NCINTE+1	H	61
	NEWNUM(I)=NCINTE	H	62
	IOLDNU(NCINTE)=I	H	63

40	CONTINUE	H	64
	RETURN	H	65
	END	H	66-
C		I	1
C		I	2
	SUBROUTINE EQBCV (N,NLB,NEXT,NFIC,BTYP,BCV,V,NBCV,YT,JRYT,ICYT,OLD	I	3
	1NU,IBINTE,NRB,OTPT,IWRITE)	I	4
C		I	5
C	THIS SUBROUTINE DETERMINES THE NEW VALUES OF BUS CONTROL	I	6
C	VARIABLES FOR THE REDUCED SYSTEM	I	7
C		I	8
C	N NUMBER OF BUSES	I	9
C	NLB NUMBER OF LOAD BUSES	I	10
C	NEXT NUMBER OF EXTERNAL BUSES	I	11
C	NFIC NUMBER OF FICTITIOUS BUSES	I	12
C	JRYT VECTOR OF LENGTH N+1. IT CONTAINS ROW INDICES OF	I	13
C	A SPARSE BUS ADMITTANCE MATRIX	I	14
C	ICYT VECTOR OF LENGTH JRYT(N+1)-1. IT CONTAINS COLUMN	I	15
C	INDICES OF A SPARSE BUS ADMITTANCE MATRIX	I	16
C	YT A SPARSE BUS ADMITTANCE MATRIX	I	17
C	BTYP VECTOR OF BUS TYPES (0 LOAD BUS, 1 GENERATOR BUS,	I	18
C	2 SLACK BUS)	I	19
C	V COMPLEX BUS VOLTAGES (RECTANGULAR COORDINATES)	I	20
C	BCV REAL VECTOR OF LENGTH 2*N. IT CONTAINS NOMINAL	I	21
C	VALUES OF BUS CONTROL VARIABLES	I	22
C	NBCV AUXILIARY VECTOR OF LENGTH 2*N	I	23
C	OLDNU VECTOR OF LENGTH N. IT CONTAINS THE OLD INDICES OF	I	24
C	BUSES W.R.T. NEW INDICES	I	25
C	IBINTE VECTOR OF LENGTH N. IBINTE(K) IS EQUAL TO 1 IF THE	I	26
C	KTH BUS BELONGS TO THE INTERNAL POWER SYSTEM	I	27
C	NRB VECTOR OF LENGTH NLB. IT CONTAINS INDICES OF THE	I	28
C	FICTITIOUS BUSES	I	29
C	OTPT INDEX OF THE OUTPUT UNIT	I	30
C	IWRITE PARAMETER THAT CONTROLS OUTPUT	I	31
C		I	32
	INTEGER BTYP(1),JRYT(1),ICYT(1),OLDNU(1),IBINTE(1),NRB(1),OTPT	I	33
	REAL BCV(1),NBCV(1)	I	34
	COMPLEX V(1),YT(1),YI,EQCURR	I	35
C		I	36
	NEX=N-NEXT	I	37
C		I	38
C	MODIFICATION OF THE VECTOR V OF THE INITIAL BUS VOLTAGES	I	39
C		I	40
	DO 10 I=1,NEX	I	41
	J=NEXT+I	I	42
	V(I)=V(J)	I	43
10	CONTINUE	I	44
C		I	45
	IF (NFIC.EQ.0) GO TO 30	I	46
C		I	47
C	DETERMINE THE INITIAL BUS VOLTAGES FOR THE FICTITIOUS BUSES	I	48
C		I	49
	K=NEX+NFIC	I	50
	V(K)=V(NEX)	I	51
	DO 20 I=1,NFIC	I	52
	K=NEX+I-1	I	53
	J=NRB(I)	I	54
	V(K)=V(J)	I	55
20	CONTINUE	I	56
C		I	57
	30 CONTINUE	I	58
C		I	59
C	CALCULATE AND STORE THE NEW BUS CONTROL VARIABLES IN THE VECTOR	I	60
C	NBCV	I	61
C		I	62

	K=NEX-1	I 63
	IF (NFIC.EQ.0) K=NEX	I 64
	DO 60 I=1,K	I 65
	IK=I+NEXT	I 66
	IF (BTYP(IK).EQ.2) GO TO 60	I 67
	J=OLDNU(IK)	I 68
	IF (IBINTE(J).EQ.1) GO TO 50	I 69
C		I 70
C	CALCULATE THE CURRENT INJECTED IN THE ITH BUS	I 71
C		I 72
	YI=EQCURR(V, YT, JRYT, ICYT, I)	I 73
C		I 74
C	REAL POWER	I 75
C		I 76
	NBCV(2*I-1)=REAL(V(I)*CONJG(YI))	I 77
	IF (BTYP(IK).NE.0) GO TO 40	I 78
C		I 79
C	REACTIVE POWER	I 80
C		I 81
	NBCV(2*I)=AIMAG(V(I)*CONJG(YI))	I 82
	GO TO 60	I 83
40	CONTINUE	I 84
C		I 85
C	MODULUS OF THE BUS VOLTAGE	I 86
C		I 87
	NBCV(2*I)=BCV(2*IK)	I 88
	GO TO 60	I 89
50	CONTINUE	I 90
	NBCV(2*I-1)=BCV(2*IK-1)	I 91
	NBCV(2*I)=BCV(2*IK)	I 92
60	CONTINUE	I 93
	IF (BTYP(N).NE.2) GO TO 70	I 94
	NBCV(2*NEX-1)=BCV(2*N-1)	I 95
	NBCV(2*NEX)=BCV(2*N)	I 96
	GO TO 80	I 97
70	CONTINUE	I 98
	IF (NFIC.EQ.0) GO TO 80	I 99
	K=NEX+NFIC	I 100
C		I 101
C	CALCULATE THE CURRENT INJECTED IN THE KTH BUS	I 102
C		I 103
	YI=EQCURR(V, YT, JRYT, ICYT, K)	I 104
C		I 105
C	REAL POWER	I 106
C		I 107
	NBCV(2*NEX-1)=REAL(V(K)*CONJG(YI))	I 108
C		I 109
C	MODULUS OF THE BUS VOLTAGE	I 110
C		I 111
	NBCV(2*NEX)=CABS(V(K))	I 112
80	CONTINUE	I 113
C		I 114
C	THE NEW BUS CONTROL VARIABLES ARE STORED IN THE MATRIX BCV	I 115
C		I 116
	DO 90 I=1,NEX	I 117
	BTYP(I)=BTYP(I+NEXT)	I 118
	BCV(2*I-1)=NBCV(2*I-1)	I 119
	BCV(2*I)=NBCV(2*I)	I 120
90	CONTINUE	I 121
C		I 122
C	DETERMINE THE BUS CONTROL VARIABLES FOR THE FICTITIOUS BUSES	I 123
C		I 124
	IF (NFIC.EQ.0) GO TO 110	I 125
	K=NEX+NFIC	I 126
	BTYP(K)=BTYP(NEX)	I 127

	BCV(2*K-1)=BCV(2*NEX-1)	I	128
	BCV(2*K)=BCV(2*NEX)	I	129
	DO 100 I=1,NFIC	I	130
	K=NEX+I-1	I	131
	J=NRB(I)	I	132
	BTYP(K)=1	I	133
	BCV(2*K-1)=0.0	I	134
	BCV(2*K)=CABS(V(J))	I	135
100	CONTINUE	I	136
110	CONTINUE	I	137
C		I	138
C	CALCULATE THE NUMBER OF THE BUSES N AND THE NUMBER OF THE LOAD	I	139
C	BUSES NLB OF THE REDUCED SYSTEM	I	140
C		I	141
	N=NEX+NFIC	I	142
	NLB=0	I	143
	DO 120 I=1,N	I	144
	IF (BTYP(I).NE.0) GO TO 120	I	145
	NLB=NLB+1	I	146
120	CONTINUE	I	147
	NB=N	I	148
C		I	149
	IF (IWRITE.LT.3) RETURN	I	150
C		I	151
C	PRINT OUT THE RESULTS	I	152
C		I	153
	WRITE (OTPT,150)	I	154
	DO 140 I=1,N	I	155
	IF (I.GT.NEX-1.AND.I.LT.N) GO TO 130	I	156
	K=NEXT+I	I	157
	IF (I.EQ.N) K=K-NFIC	I	158
	J=OLDNU(K)	I	159
	WRITE (OTPT,160) J,BTYP(I),V(I),BCV(2*I-1),BCV(2*I)	I	160
	GO TO 140	I	161
130	CONTINUE	I	162
	WRITE (OTPT,170) I,BTYP(I),V(I),BCV(2*I-1),BCV(2*I)	I	163
140	CONTINUE	I	164
150	FORMAT (1H /,43X,"BASE CASE"/,21X,"VECTOR OF BUS VOLTAGES"/,3X,"B	I	165
	1US",2X,"BTYP",7X," RECTANGULAR COORDINATES",7X,"VECTOR OF BUS CONT	I	166
	2ROL VARIABLES"/)	I	167
160	FORMAT (2X,214,6X,2(E13.5,2X),2(4X,E13.5,2X))	I	168
170	FORMAT (1X,"F",214,6X,2(E13.5,2X),2(4X,E13.5,2X))	I	169
	RETURN	I	170
	END	I	171-
C		J	1
C		J	2
	SUBROUTINE EQCCC (NLIN,NTL,LBINP,LBOUT,LINPG,LINPB,LG,LB,LOUTG,LOU	J	3
	1TB,LTAP,JRYT,ICYT,YT,NB,NFIC,NEXT,NEL,IFLAG)	J	4
C		J	5
C	THIS SUBROUTINE REMOVES THE NLINTH LINE FROM THE POWER SYSTEM	J	6
C	DESCRIBED BY AN ADMITTANCE MATRIX (VECTORS YT,JRYT,ICYT) AND	J	7
C	LINE PARAMETERS (MATRICES LBINP,LBOUT,LINPG,LINPB,LB,LG,LOUTG,	J	8
C	LOUTB,LTAP)	J	9
C		J	10
	INTEGER LBINP(1),LBOUT(1),JRYT(1),ICYT(1)	J	11
	REAL LINPG(1),LINPB(1),LB(1),LG(1),LOUTG(1),LOUTB(1),LTAP(1)	J	12
	COMPLEX YT(1),Y,D1,D2	J	13
C		J	14
	IFLAG=0	J	15
	IF (NLIN.EQ.0) RETURN	J	16
	IF (NLIN.GT.NTL) GO TO 10	J	17
	R=1.0	J	18
	R1=0.0	J	19
C	KB=NB-NFIC	J	20
		J	21

C	DETERMINE INDICES OF BUSES INCIDENT WITH THE NLINTH LINE	J	22
C	I=LBINP(NLIN)	J	23
	J=LBOUT(NLIN)	J	24
	I1=I-NEXT	J	25
	J1=J-NEXT	J	26
	IF (I1.EQ.KB) I1=NB	J	27
	IF (J1.EQ.KB) J1=NB	J	28
		J	29
C	DETERMINE A POSITION OF INDICES (I1,J1) AND (J1,I1) IN THE	J	30
C	MATRIX ICYT	J	31
C	CALL EQDDD (I1,J1,JRYT,ICYT,IY1,JY1,IFLAG)	J	32
	IF (IFLAG.LT.0) RETURN	J	33
	Y=CMPLX(LG(NLIN),LB(NLIN))	J	34
	D1=CMPLX(LINPG(NLIN),LINPB(NLIN))	J	35
	D2=CMPLX(LOUTG(NLIN),LOUTB(NLIN))	J	36
	ID=JRYT(I1)	J	37
	JD=JRYT(J1)	J	38
		J	39
C	CHANGE VALUES OF ELEMENTS OF THE ADMITTANCE MATRIX	J	40
C	YT(ID)=YT(ID)-R*(Y/(LTAP(NLIN)**2)+D1)	J	41
C	YT(JD)=YT(JD)-R*(Y+D2)	J	42
	YT(IY1)=-R1*Y/LTAP(NLIN)	J	43
	YT(JY1)=-R1*Y	J	44
		J	45
C	MODIFY THE VECTORS YT,JRYT,ICYT	J	46
C	IF (IY1.GT.JY1) CALL EQREEY (I1,IY1,NB,NEL,JRYT,ICYT,YT)	J	47
	CALL EQREEY (J1,JY1,NB,NEL,JRYT,ICYT,YT)	J	48
	IF (JY1.GT.IY1) CALL EQREEY (I1,IY1,NB,NEL,JRYT,ICYT,YT)	J	49
	RETURN	J	50
	10 CONTINUE	J	51
	IFLAG=-10	J	52
	WRITE (6,20) IFLAG	J	53
	20 FORMAT (2X,"IFLAG FROM EQCCC IFLAG= ",I3,3X,"THE INDEX OF THE LINE	J	54
	1 IS GREATER THAN THE NUMBER OF ALL LINES")	J	55
	RETURN	J	56
	END	J	57
		J	58
C	SUBROUTINE EQCOMP (LBINP,LBOUT,LINPG,LINPB,LG,LB,LOUTG,LOUTB,LTAP,	K	1
C	1BV,V,VCB,NB,NTL,NLIN,MODE3,NBOUND,JBOUND,NRET,JRET,JBINTE,JOLDNU,N	K	2
	2EXT,NFIC,ICONT,INPT,OTPT,IFLAG)	K	3
		K	4
		K	5
		K	6
C	SUBROUTINE EQCOMP CALCULATES AND COMPARES POWER FLOWS IN	K	7
C	TRANSMISSION LINES OF THE UNREDUCED POWER SYSTEM AND THE REDUCED	K	8
C	POWER SYSTEM UNDER A CONTINGENCY	K	9
		K	10
	ALL THE ARGUMENTS OF THIS SUBROUTINE ARE DESCRIBED IN THE	K	11
	SUBROUTINE EQCONTI	K	12
		K	13
C	INTEGER LBINP(1),LBOUT(1),JBOUND(1),JRET(1),JOLDNU(1),JBINTE(1),OT	K	14
	1PT	K	15
	REAL LINPG(1),LINPB(1),LG(1),LB(1),LOUTG(1),LOUTB(1),LTAP(1)	K	16
	COMPLEX V(1),VCB(1),V1,V2,V3,V4,DV1,DV2,Y,C,C1,CN1,F,F1,FIN,PI	K	17
	INF,BV(1)	K	18
		K	19
C	READ A LOAD FLOW SOLUTION OF THE UNREDUCED SYSTEM WITH THE	K	20
C	NLINTH LINE REMOVED	K	21
C		K	22
	IKLIN=0	K	23
	10 CONTINUE	K	24
	READ (INPT,*) NULIN	K	25

	IKLIN=IKLIN+1	K 26
	IF (IKLIN.GT.NTL) GO TO 200	K 27
	DO 20 I=1,NB	K 28
	READ (INPT,*) K,R1,R2,R3,R4	K 29
	VCB(I)=CMPLX(R1,R2)	K 30
	20 CONTINUE	K 31
	IF (NULIN.NE.NLIN) GO TO 10	K 32
C		K 33
C	END OF READING	K 34
C		K 35
	WRITE (OTPT,250)	K 36
C		K 37
C	PRINT OUT THE TITLE	K 38
C		K 39
	NBI=NB-NEXT	K 40
	GO TO (30,40,50,60,70), MODE3	K 41
30	WRITE (OTPT,280) NBI	K 42
	GO TO 80	K 43
40	WRITE (OTPT,290) NBI	K 44
	GO TO 80	K 45
50	WRITE (OTPT,300) NBI	K 46
	GO TO 80	K 47
60	WRITE (OTPT,310) NBI	K 48
	GO TO 80	K 49
70	CONTINUE	K 50
	WRITE (OTPT,320) NBI	K 51
80	CONTINUE	K 52
	WRITE (OTPT,260) (JBOUND(I),I=1,NBOUND)	K 53
	DO 90 I=1,NBOUND	K 54
	JBINTE(JBOUND(I))=1	K 55
90	CONTINUE	K 56
	IF (NRET.EQ.0) GO TO 110	K 57
	WRITE (OTPT,270) (JRET(I),I=1,NRET)	K 58
	DO 100 I=1,NRET	K 59
	JBINTE(JRET(I))=1	K 60
100	CONTINUE	K 61
110	CONTINUE	K 62
	IF (NLIN.NE.0) GO TO 120	K 63
	WRITE (OTPT,340)	K 64
	GO TO 130	K 65
120	CONTINUE	K 66
	K1=LBINP(NLIN)	K 67
	K2=LBOUT(NLIN)	K 68
	WRITE (OTPT,330) NLIN,K1,K2	K 69
130	CONTINUE	K 70
	WRITE (OTPT,380)	K 71
	WRITE (OTPT,240)	K 72
	WRITE (OTPT,350)	K 73
	WRITE (OTPT,360)	K 74
C		K 75
C	COMPUTE AND COMPARE THE POWER FLOW IN ALL LINES FOR THE	K 76
C	UNREDUCED AND THE REDUCED POWER SYSTEM	K 77
C		K 78
	DO 140 I=1,NTL	K 79
C		K 80
C	I IS THE INDEX OF A LINE	K 81
C		K 82
	IF (I.EQ.NLIN) GO TO 140	K 83
	K1=LBINP(I)	K 84
	K2=LBOUT(I)	K 85
	IF (JBINTE(K1).EQ.0.OR.JBINTE(K2).EQ.0) GO TO 140	K 86
C		K 87
C	COMPUTE THE CURRENT FLOWING IN ITH LINE OF THE REDUCED SYSTEM	K 88
C		K 89
	V1=V(K1)/(LTAP(I))**2	K 90

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V2=V(K2)/LTAP(I)
DV1=V1-V2
Y=CMPLX(LG(I),LB(I))
C=DV1*Y
C1=V(K1)*CMPLX(LINPG(I),LINPB(I))
C THE CURRENT FLOWING IN THE ITH LINE OF THE REDUCED SYSTEM
CNI=C+C1
C COMPUTE THE CURRENT FLOWING IN THE ITH LINE OF THE UNREDUCED
C SYSTEM
V3=VCB(K1)/(LTAP(I))**2
V4=VCB(K2)/LTAP(I)
DV2=V3-V4
F=DV2*Y
F1=VCB(K1)*CMPLX(LINPG(I),LINPB(I))
C THE CURRENT FLOWING IN THE ITH LINE OF THE UNREDUCED SYSTEM
FIN=F+F1
C THE POWER INJECTED IN THE ITH LINE OF THE REDUCED SYSTEM
PIN=V(K1)*CONJG(CNI)
PINR=REAL(PIN)
PINIM=AIMAG(PIN)
C THE POWER INJECTED IN THE ITH LINE OF THE UNREDUCED SYSTEM
PINF=VCB(K1)*CONJG(FIN)
PINFR=REAL(PINF)
PINFIM=AIMAG(PINF)
C COMPARE RESULTS
X1=PINFR-PINR
X2=PINFIM-PINIM
X3=(100.0*X1)/PINFR
X4=(100.0*X2)/PINFIM
X5=(100.0*X1)/CABS(PINF)
X7=(100.0*CABS(PINF-PIN))/CABS(PINF)
WRITE (OTPT,370) I,K1,K2,PINFR,PINFIM,PINR,PINIM,X1,X2,X3,X4,X7
140 CONTINUE
C COMPUTE AND COMPARE THE CHANGES OF THE BUS VOLTAGES
C CORRESPONDING TO A CHANGE IN OPERATING CONDITIONS IN THE
C INTERNAL PART OF THE UNREDUCED AND REDUCED POWER SYSTEMS
WRITE (OTPT,390)
WRITE (OTPT,420)
C DO 160 I=1,NB
IF (JBINTE(I).EQ.0) GO TO 160
C=VCB(I)-V(I)
X1=REAL(VCB(I))
X2=AIMAG(VCB(I))/X1
X3=REAL(V(I))
X4=AIMAG(V(I))/X3
X5=ATAN(X2)
X6=ATAN(X4)
X6=X5-X6
IF (X5.NE.0.0) X7=100.0*X6/X5
X=CABS(C)

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K 91
K 92
K 93
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K 153
K 154
K 155

	IF (X5.NE.0.0) GO TO 150	K 156
	WRITE (OTPT,440) I,X,X6	K 157
	GO TO 160	K 158
150	CONTINUE	K 159
	WRITE (OTPT,440) I,X,X6,X7	K 160
160	CONTINUE	K 161
	IF (ICONT.GT.1) RETURN	K 162
C		K 163
C	COMPARE THE CHANGES OF THE BUS VOLTAGES CORRESPONDING TO A	K 164
C	CHANGE IN OPERATING CONDITIONS IN THE INTERNAL PART OF THE	K 165
C	UNREDUCED SYSTEM WITH THE LOAD FLOW SOLUTION FOR THE BASE CASE	K 166
C		K 167
	WRITE (OTPT,400)	K 168
	WRITE (OTPT,430)	K 169
C		K 170
	DO 180 I=1,NB	K 171
	IF (JBINTE(I).EQ.0) GO TO 180	K 172
	C=VCB(I)-BV(I)	K 173
	X1=REAL(VCB(I))	K 174
	X2=AIMAG(VCB(I))/X1	K 175
	X3=REAL(BV(I))	K 176
	X4=AIMAG(BV(I))/X3	K 177
	X5=ATAN(X2)	K 178
	X6=ATAN(X4)	K 179
	X6=X5-X6	K 180
	IF (X5.NE.0.0) X7=100.0*X6/X5	K 181
	X=CABS(C)	K 182
	IF (X5.NE.0.0) GO TO 170	K 183
	WRITE (OTPT,440) I,X,X6	K 184
	GO TO 180	K 185
170	CONTINUE	K 186
	WRITE (OTPT,440) I,X,X6,X7	K 187
180	CONTINUE	K 188
C		K 189
C	COMPUTE THE POWER FLOW IN THE LINES FOR THE BASE CASE	K 190
C		K 191
	WRITE (OTPT,410)	K 192
	WRITE (OTPT,230)	K 193
C		K 194
	DO 190 I=1,NTL	K 195
	K1=LBINP(I)	K 196
	K2=LBOU(T(I))	K 197
	IF (JBINTE(K1).EQ.0.OR.JBINTE(K2).EQ.0) GO TO 190	K 198
C		K 199
C	COMPUTE THE CURRENT FLOWING IN THE ITH LINE	K 200
C		K 201
	V1=BV(K1)/(LTAP(I))**2	K 202
	V2=BV(K2)/LTAP(I)	K 203
	DV1=V1-V2	K 204
	Y=CMPLX(LG(I),LB(I))	K 205
	C=DV1*Y	K 206
	C1=BV(K1)*CMPLX(LINPG(I),LINPB(I))	K 207
C		K 208
C	THE CURRENT FLOWING IN THE ITH LINE	K 209
C		K 210
	CNI=C+C1	K 211
C		K 212
C	THE POWER INJECTED IN THE ITH LINE	K 213
C		K 214
	PIN=BV(K1)*CONJG(CNI)	K 215
	PINR=REAL(PIN)	K 216
	PINIM=AIMAG(PIN)	K 217
	WRITE (OTPT,220) I,K1,K2,PINR,PINIM	K 218
190	CONTINUE	K 219
	RETURN	K 220

	200 CONTINUE	K 221
C		K 222
C	THE LACK OF THE LOAD FLOW SOLUTION FOR THE LINE WHICH IS	K 223
C	DECLARED	K 224
C		K 225
	IFLAG=-10	K 226
	WRITE (OTPT,210) IFLAG	K 227
	RETURN	K 228
	210 FORMAT (2X,"RETURN FLAG FROM EQCOMP IFLAG= ",I3)	K 229
	220 FORMAT (2X,3(I4,2X),2(F8.3,3X))	K 230
	230 FORMAT (//,2X,"LINE LINE ",7X," POWER FLOW ",/,4X,"NO",2X,"	K 231
	1FROM",4X,"TO",7X,"P",10X,"Q")	K 232
	240 FORMAT (2X,"P - REAL POWER ; Q - REACTIVE POWER ; S - COMPLEX P	K 233
	OWER")	K 234
	250 FORMAT (///,2X,"RESULTS OF CONTINGENCY ANALYSIS:TEST USING EXTERNA	K 235
	1L EQUIVALENTS",//)	K 236
	260 FORMAT (//,2X,"BOUNDARY BUSES: ",20(I4,1X))	K 237
	270 FORMAT (/,2X,"RETAINED BUSES: ",20(I4,1X))	K 238
	280 FORMAT (2X,"THE SOLUTION FOR ",I4,1X,"BUS-SYSTEM";" USING STANDARD	K 239
	1 WARD METHOD")	K 240
	290 FORMAT (2X,"THE SOLUTION FOR ",I4,1X,"BUS-SYSTEM";" USING STANDARD	K 241
	1 WARD METHOD WITH BUFFER ZONE")	K 242
	300 FORMAT (2X,"THE SOLUTION FOR ",I4,1X,"BUS-SYSTEM";" USING EXTENDED	K 243
	1 WARD METHOD")	K 244
	310 FORMAT (2X,"THE SOLUTION FOR ",I4,1X,"BUS-SYSTEM";" USING SIMPLIFI	K 245
	ED EXTENDED WARD METHOD")	K 246
	320 FORMAT (2X,"THE SOLUTION FOR ",I4,1X,"BUS-SYSTEM";" USING STANDARD	K 247
	1 WARD METHOD WITH SHUNTS IN THE EXTERNAL SYSTEM")	K 248
	330 FORMAT (//,2X,"OUTAGE LINE: ",I4,2X,"FROM: ",I4," TO: ",I4)	K 249
	340 FORMAT (//,2X,"THE SOLUTION FOR THE BASE CASE")	K 250
	350 FORMAT (//,2X,"LINE LINE ",3X,"UNREDUCED SYSTEM",3X,"REDUCED	K 251
	1 SYSTEM",10X,"DEVIATIONS",6X,"(DEVIA.P)/P",6X,"(DEVIA.Q)/Q",6X,"MO	K 252
	2D(DEVIA.S)/MOD(S)")	K 253
	360 FORMAT (4X,"NO",2X,"FROM",4X,"TO",6X," P",7X," Q ",6X,"P ",5X,"	K 254
	1Q",10X," P",6X," Q",7X,"ERROR IN %",7X,"ERROR IN %",8X,"ERROR IN	K 255
	2%")	K 256
	370 FORMAT (2X,3(I4,2X),4(F7.3,2X),3X,2(F7.3,2X),6X,3(F7.2,10X))	K 257
	380 FORMAT (/,2X,"THE POWER FLOW IN LINES CORRESPONDING TO A CHANGE IN	K 258
	1 OPERATING CONDITIONS IN THE INTERNAL "/,2X,"PART OF THE UNREDUCED	K 259
	2 AND REDUCED SYSTEM")	K 260
	390 FORMAT ("1",1X,"THE CHANGES OF THE BUS VOLTAGES CORRESPONDING TO A	K 261
	1 CHANGE IN OPERATING CONDITIONS IN THE INTERNAL "/,2X,"PART OF THE	K 262
	2 UNREDUCED AND REDUCED SYSTEM")	K 263
	400 FORMAT ("1",1X,"THE CHANGES OF THE BUS VOLTAGES CORRESPONDING TO A	K 264
	1 CHANGE IN OPERATING CONDITIONS IN THE INTERNAL "/,2X,"PART OF THE	K 265
	2 UNREDUCED SYSTEM W.R.T SOLUTION FOR THE BASE CASE")	K 266
	410 FORMAT (/,2X,"THE POWER FLOW IN TRANSMISSION LINES FOR THE BASE CA	K 267
	1SE")	K 268
	420 FORMAT (//1X,"MODULUS OF THE BUS VOLTAGE ERROR",2X,//4X,"BUS",6X,"	K 269
	1VALUE",23X,"DEVIATION OF ANGLE",3X,"ANGLE ERROR IN %")	K 270
	430 FORMAT (//1X,"MODULUS OF THE CHANGE OF THE BUS VOLTAGE ",2X,//4X,"	K 271
	1BUS",6X,"VALUE",23X,"THE CHANGE OF ANGLE",3X,"THE CHANGE OF ANGLE	K 272
	2IN %")	K 273
	440 FORMAT (3X,I4,3X,F8.4,32X,2(F7.3,12X))	K 274
	END	K 275-
C		L 1
C		L 2
	SUBROUTINE EQCONTI (INB,NB,NLB,NEXT,NFIC,NBOUND,JBOUND,NRET,JRET,B	L 3
	1TYP,BCV,V,NEWNUM,JOLDNU,JBINTE,YT,JRYT,ICYT,LBINP,LBOUT,NTL,MODE3,	L 4
	2NEL,NLIN,LINPG,LINPB,LG,LB,LOUTG,LOUTB,LTAP,BV,ITEL,TOLV,T,WSP,LWS	L 5
	3P,ICONT,IFLAG,INPT,OTPT,IFOREG,IWRITE,IWRITE)	L 6
C		L 7
C		L 8
C	SUBROUTINE EQCONTI PERFORMS A CONTINGENCY ANALYSIS OF THE	L 9
C	REDUCED POWER SYSTEM	L 10

C	INB	NUMBER OF BUSES IN THE UNREDUCED POWER SYSTEM	L 11
C	NBEQ	NUMBER OF BUSES IN THE REDUCED POWER SYSTEM	L 12
C	NLBE	NUMBER OF LOAD BUSES IN THE REDUCED POWER SYSTEM	L 13
C	NEXT	NUMBER OF BUSES BELONGING TO THE EXTERNAL POWER SYSTEM	L 14
C			L 15
C	NFIC	NUMBER OF FICTITIOUS BUSES	L 16
C	NBOUND	NUMBER OF BOUNDARY BUSES	L 17
C	JBOUND	VECTOR OF LENGTH NBOUND. IT CONTAINS BOUNDARY BUSES	L 18
C	NRET	NUMBER OF RETAINED BUSES	L 19
C	JRET	VECTOR OF LENGTH NRET. IT CONTAINS RETAINED BUSES	L 20
C	BTPY	VECTOR OF BUS TYPES (0 LOAD BUS, 1 GENERATOR BUS, 2 SLACK BUS) OF THE REDUCED POWER SYSTEM	L 21
C			L 22
C	BCV	VECTOR OF LENGTH 2*NB. IT CONTAINS NOMINAL VALUES OF BUS CONTROL VARIABLES OF THE REDUCED POWER SYSTEM	L 23
C			L 24
C			L 25
C	V	COMPLEX BUS VOLTAGES (RECTANGULAR COORDINATES) OF THE REDUCED POWER SYSTEM	L 26
C			L 27
C	NEWNUM	VECTOR OF LENGTH NB. IT STORES THE NEW INDICES OF BUSES	L 28
C			L 29
C	IOLDNU	VECTOR OF LENGTH NB. IT STORES THE OLD INDICES OF BUSES W.R.T. NEW INDICES	L 30
C			L 31
C	IBINTE	VECTOR OF LENGTH NB. IT STORES BUSES OF THE INTERNAL POWER SYSTEM	L 32
C			L 33
C	YT	THE SPARSE BUS ADMITTANCE MATRIX	L 34
C	JRYT	VECTOR OF LENGTH NB+1. IT CONTAINS ROW INDICES OF THE SPARSE BUS ADMITTANCE MATRIX	L 35
C			L 36
C	ICYT	VECTOR OF LENGTH JRYT(NB+1)-1. IT CONTAINS COLUMN INDICES OF THE SPARSE ADMITTANCE MATRIX	L 37
C			L 38
C	LBINP,LBOUT	VECTORS OF LENGTH NTL. LBINP(K),LBOUT(K) CONTAIN INDICES OF BUSES INCIDENT WITH THE KTH LINE	L 39
C			L 40
C	NTL	NUMBER OF TRANSMISSION LINES	L 41
C	MODE3	TYPE OF AN EQUIVALENT :	L 42
C		1 - STANDARD WARD EQUIVALENT WITHOUT SHUNTS	L 43
C		2 - STANDARD WARD EQUIVALENT WITH BUFFER ZONE	L 44
C		3 - EXTENDED WARD EQUIVALENT	L 45
C		4 - SIMPLIFIED EXTENDED WARD EQUIVALENT	L 46
C		5 - STANDARD WARD EQUIVALENT WITH SHUNTS IN THE EXTERNAL SYSTEM	L 47
C			L 48
C	NEL	NUMBER OF NONZERO ELEMENTS OF THE BUS ADMITTANCE MATRIX	L 49
C			L 50
C	NLIN	THE INDEX OF A LINE TO BE REMOVED	L 51
C	LINPG,LINPB	VECTORS OF LENGTH NTL. LINPG(K),LINPB(K) CONTAIN THE INPUT SHUNT CONDUCTANCE AND SUSCEPTANCE OF THE KTH LINE	L 52
C			L 53
C			L 54
C	LG,LB	VECTORS OF LENGTH NTL. LG(K),LB(K) CONTAIN THE CONDUCTANCE AND SUSCEPTANCE OF THE KTH TRANSMISSION LINE	L 55
C			L 56
C			L 57
C	LOUTG,LOUTB	VECTORS OF LENGTH NTL. LOUTG(K),LOUTB(K) CONTAIN THE OUTPUT SHUNT CONDUCTANCE AND SUSCEPTANCE OF THE KTH TRANSMISSION LINE	L 58
C			L 59
C			L 60
C	LTAP	VECTOR OF LENGTH NTL. LTAP(K) CONTAINS THE KTH LINE TRANSFORMER RATIO	L 61
C			L 62
C	BV	COMPLEX VECTOR. IT CONTAINS THE VALUES OF THE BUS VOLTAGES (IN RECTANGULAR COORDINATES) OF THE UNREDUCED SYSTEM	L 63
C			L 64
C			L 65
C	ITEL	THE NUMBER OF ITERATIONS	L 66
C	TOLV	REQUIRED ACCURACY OF THE LOAD FLOW SOLUTION	L 67
C	T	TOTAL ITERATION TIME	L 68
C	WSP	REAL VECTOR. WORKSPACE	L 69
C	LWSP	THE LENGTH OF THE WORKSPACE	L 70
C	ICONT	IT CONTROLS THE MODE OF A WORK	L 71
C		0 ONLY LOAD FLOW SOLUTION IS PERFORMED	L 72
C		1 THE BUS VOLTAGES OF THE UNREDUCED SYSTEM ,BEFORE AND AFTER OUTAGE ARE COMPARED	L 73
C			L 74
C		2 ONLY POWER FLOW IN LINES BEFORE AND AFTER OUTAGE	L 75

C		IS COMPARED	L 76
C	IFLAG	RETURN FLAG FROM SUBROUTINE (SEE.REPORT SOS-83-24-U)	L 77
C	INPT	INDEX OF THE INPUT UNIT. IF (ICONT.NE.0) THE DATA	L 78
C		DESCRIBING THE UNREDUCED POWER SYSTEM IS READ FROM	L 79
C		THE UNIT INPT	L 80
C	OTPT	INDEX OF THE OUTPUT UNIT	L 81
C	IFOREQ	INDEX OF THE INPUT UNIT. IF (IFOREQ>0) THE DATA	L 82
C		DESCRIBING THE REDUCED POWER SYSTEM IS READ FROM THE	L 83
C		UNIT IFOREQ	L 84
C	IWRITE	PARAMETER THAT CONTROLS OUTPUT (SEE.REP. SOS-83-24-U)	L 85
C	IPRINT	PARAMETER THAT CONTROLS OUTPUT. IF IPRINT=1 AND	L 86
C		IFOREQ>0 THE DESCRIPTION OF THE REDUCED POWER SYSTEM	L 87
C		IS PRINTED OUT ON THE UNIT OTPT	L 88
C			L 89
C		INTEGER BTYP(1), JRYT(1), ICYT(1), LBINP(1), LBOUT(1), OTPT, JBOUND(1), J	L 90
C		IRET(1), NEWNUM(1), JOLDNU(1), JBINTE(1)	L 91
C		REAL WSP(1), BCV(1), LINPG(1), LINPB(1), LG(1), LB(1), LOUTG(1), LOUTB(1)	L 92
C		1, LTAP(1)	L 93
C		COMPLEX YT(1), V(1), BV(1)	L 94
C			L 95
C	IFLAG=0		L 96
C	WRITE (OTPT,40)		L 97
C	IF (IFOREQ.LT.0) GO TO 10		L 98
C			L 99
C		READ THE DATA DESCRIBING THE REDUCED SYSTEM	L 100
C			L 101
C		CALL EQREAD (INB,NB,NLB,NEXT,NFIC,NBOUND,JBOUND,NRET,JRET,BTYP,BCV	L 102
C		1,V,NEUNUM,JOLDNU,JBINTE,YT,JRYT,ICYT,LBINP,LBOUT,NTL,MODE3,IFOREQ,	L 103
C		2OTPT,IPRINT)	L 104
C		NEL=JRYT(NB+1)-1	L 105
C			L 106
C	10 CONTINUE		L 107
C			L 108
C		THE NLIN TH LINE WILL BE REMOVED	L 109
C			L 110
C			L 111
C		CALL EQCCC (NLIN,NTL,LBINP,LBOUT,LINPG,LINPB,LG,LB,LOUTG,LOUTB,LTA	L 112
C		1P,JRYT,ICYT,YT,NB,NFIC,NEXT,NEL,IFLAG)	L 113
C		IF (IFLAG.LT.0) RETURN	L 114
C		MODE=0	L 115
C			L 116
C		DETERMINE A LOAD FLOW SOLUTION	L 117
C		SUBROUTINE LFLFD1M IS CALLED FROM THE TTM1 LIBRARY	L 118
C			L 119
C		CALL LFLFD1M (NB,NLB,NEL,JRYT,ICYT,BTYP,YT,V,BCV,WSP,LWSP,ITEL,TOL	L 120
C		1V,T,MODE,IFLAG,OTPT,IWRITE)	L 121
C		IF (IFLAG.LT.0.OR.ICONT.EQ.0) RETURN	L 122
C			L 123
C		PREPARE DATA FOR THE SUBROUTINE EQCOMP	L 124
C			L 125
C		CALL EQMOSO (INB,NB,NFIC,NEXT,V,WSP,JOLDNU,MODE3)	L 126
C			L 127
C		RENUMBER INDICES STORED IN THE VECTORS LBINP,LBOUT	L 128
C			L 129
C		DO 20 I=1,NTL	L 130
C		LBINP(I)=JOLDNU(LBINP(I))	L 131
C		LBOUT(I)=JOLDNU(LBOUT(I))	L 132
C	20 CONTINUE		L 133
C		IFLAG1=0	L 134
C			L 135
C		PROCESS CONTINGENCY SOLUTIONS FOR THE UNREDUCED AND REDUCED	L 136
C		POWER SYSTEM	L 137
C			L 138
C		CALL EQCOMP (LBINP,LBOUT,LINPG,LINPB,LG,LB,LOUTG,LOUTB,LTAP,BV,V,W	L 139
C		1SP,INB,NTL,NLIN,MODE3,NBOUND,JBOUND,NRET,JRET,JBINTE,JOLDNU,NEXT,N	L 140

	2FIC, ICONT, INPT, OTPT, IFLAG1)	L 141
	CALL CHNG1 (NTL, LBINP, NEWNUM)	L 142
	CALL CHNG1 (NTL, LBINP, NEWNUM)	L 143
	IF (IFLAG1.LT.0) WRITE (OTPT,30) IFLAG1	L 144
30	FORMAT (2X, "IFLAG FROM EQCOMP= ", I3)	L 145
40	FORMAT (2X, "CONTINGENCY ANALYSIS OF THE REDUCED POWER SYSTEM"/)	L 146
	RETURN	L 147
	END	L 148-
C		M 1
C	COMPLEX FUNCTIONEQCURR(X, YT, JRYT, ICYT, MB)	M 2
		M 3
C		M 4
C	FUNCTION SUBPROGRAM EQCURR CALCULATES THE VALUE OF THE	M 5
C	CURRENT INJECTED INTO THE MBTH BUS FOR GIVEN VECTOR X	M 6
C	OF BUS VOLTAGES	M 7
C		M 8
	INTEGER JRYT(1), ICYT(1)	M 9
	COMPLEX X(1), YT(1)	M 10
C		M 11
	K1=JRYT(MB)	M 12
	K2=JRYT(MB+1)-1	M 13
	EQCURR=(0.0,0.0)	M 14
	DO 10 I=K1, K2	M 15
	EQCURR=EQCURR+YT(I)*X(ICYT(I))	M 16
10	CONTINUE	M 17
	RETURN	M 18
	END	M 19-
C		N 1
C		N 2
	SUBROUTINE EQDDD (I, J, IRYT, ICYT, I1, J1, IFLAG)	N 3
C		N 4
C	THIS SUBROUTINE DETERMINES FOR INDICES (I, J) A POSITION OF	N 5
C	THE JTH INDEX IN THE VECTOR ICYT AND FOR INDICES (J, I) A	N 6
C	POSITION OF THE ITH INDEX IN THE VECTOR ICYT	N 7
C		N 8
	INTEGER IRYT(1), ICYT(1)	N 9
C		N 10
	IFLAG=0	N 11
	K1=IRYT(I)+1	N 12
C		N 13
C	CALCULATE THE POSITION OF THE JTH INDEX FOR THE PAIR (I, J)	N 14
C		N 15
	K2=IRYT(I+1)-1	N 16
	DO 10 K3=K1, K2	N 17
	IF (ICYT(K3).NE.J) GO TO 10	N 18
	I1=K3	N 19
	GO TO 20	N 20
10	CONTINUE	N 21
	IFLAG=-10	N 22
	WRITE (6,50) IFLAG	N 23
	RETURN	N 24
20	CONTINUE	N 25
C		N 26
C	THE ELEMENT J IS IN THE POSITION I1	N 27
C		N 28
C	CALCULATE THE POSITION OF THE ITH INDEX FOR THE PAIR (J, I)	N 29
C		N 30
	K1=IRYT(J)+1	N 31
	K2=IRYT(J+1)-1	N 32
	DO 30 K3=K1, K2	N 33
	IF (ICYT(K3).NE.I) GO TO 30	N 34
	J1=K3	N 35
	GO TO 40	N 36
30	CONTINUE	N 37
	IFLAG=-11	N 38

```
WRITE (6,50)
RETURN
40 CONTINUE
C
C   THE ELEMENT I IS IN THE POSITION J1
C
RETURN
50 FORMAT (2X, "IFLAG FROM EQDDD IFLAG= ", I3, 3X, "AN ERROR IN THE MATRI
1X ICYT")
END
```

N	39
N	40
N	41
N	42
N	43
N	44
N	45
N	46
N	47
N	48-

C		0	1
C		0	2
	SUBROUTINE EQDEIE (NB,NTL,LBINP,LBOUT,NBOUND,JBOUND,NRET,JRET,NEWN	0	3
	1UM,IOLDNU,IBINTE,NEXT,WSP,LWSP,MODE,OTPT,IFLAG,IWRITE)	0	4
		0	5
C	THIS SUBROUTINE DIVIDES A SET OF POWER SYSTEM BUSES INTO	0	6
C	INTERNAL AND EXTERNAL BUSES, DETERMINES NEW INDICES OF THE	0	7
C	BUSES AND PARTLY PERFORMS RENUMBERING	0	8
C		0	9
C	NB NUMBER OF BUSES	0	10
C	NTL NUMBER OF TRANSMISSION LINES	0	11
C	LBINP,LBOUT VECTORS OF LENGTH NTL. LBINP(K),LBOUT(K) CONTAIN	0	12
C	INDICES OF BUSES INCIDENT WITH THE KTH LINE	0	13
C	NBOUND NUMBER OF BOUNDARY BUSES	0	14
C	JBOUND VECTOR OF LENGTH NBOUND. IT CONTAINS BOUNDARY BUSES	0	15
C	NRET NUMBER OF RETAINED BUSES	0	16
C	JRET VECTOR OF LENGTH NRET. IT CONTAINS RETAINED BUSES	0	17
C	NEWNUM VECTOR OF LENGTH NB. IT STORES THE NEW INDICES OF	0	18
C	BUSES	0	19
C	IOLDNU VECTOR OF LENGTH NB. IT STORES THE OLD INDICES OF	0	20
C	BUSES W.R.T. THE NEW INDICES	0	21
C	IBINTE VECTOR OF LENGTH NB. IBINTE(K) IS SET TO 1 IF THE KTH	0	22
C	BUS BELONGS TO THE INTERNAL POWER SYSTEM	0	23
C	NEXT NUMBER OF BUSES BELONGING TO THE EXTERNAL POWER	0	24
C	SYSTEM	0	25
C	WSP REAL WORKSPACE	0	26
C	LWSP LENGTH OF THE WORKSPACE WSP	0	27
C	MODE MODE OF AN OPERATION	0	28
C	0 - A REDUCED POWER SYSTEM IS DETERMINED	0	29
C	1 - AN EXTERNAL EQUIVALENT IS DETERMINED	0	30
C	OTPT INDEX OF THE OUTPUT UNIT	0	31
C	IFLAG RETURN FLAG:	0	32
C	0 - NORMAL RETURN	0	33
C	-2 - THE LENGTH OF THE WORKSPACE IS TOO SMALL	0	34
C	IWRITE PARAMETER THAT CONTROLS OUTPUT	0	35
C		0	36
	INTEGER LBINP(1),LBOUT(1),JBOUND(1),JRET(1),NEWNUM(1),IOLDNU(1),IB	0	37
	1INTE(1),WSP(1),OTPT	0	38
	COMPLEX V(1)	0	39
C		0	40
	IF (NBOUND.EQ.0.AND.NRET.EQ.0) RETURN	0	41
	CALL SECOND (TTM1)	0	42
C		0	43
C	DISTRIBUTE THE WORKSPACE	0	44
C		0	45
	K=(NB-1)/50+1	0	46
	JBSTOS=1	0	47
	JBOUN=JBSTOS	0	48
	JJBRET=JBSTOS+K	0	49
	IAK=JJBRET+K+1	0	50
	ITS=IAK+NB+2	0	51
	IAS=ITS+2*NTL+1	0	52
	IF (LWSP.GE.IAS+NB) GO TO 10	0	53
	IFLAG=-2	0	54
	RETURN	0	55
10	CONTINUE	0	56
	NINTE=0	0	57
C		0	58
C	SET TO ZERO THE VECTORS JBOUN,JJBRET AND IBINTE	0	59
C		0	60
	CALL ZERO (K,WSP(JBOUN))	0	61
	CALL ZERO (K,WSP(JJBRET))	0	62
	CALL ZERO (NB,IBINTE)	0	63
	NINTE=0	0	64
C		0	65

C			P	24
	J1=JRYT(I)		P	25
	J2=JRYT(I+1)-1		P	26
	DO 10 J=J1,J2		P	27
	KK=ICYT(J)		P	28
	NEL=NEL+1		P	29
	NROW(NEL)=I		P	30
	NCOL(NEL)=KK		P	31
	AK(NEL)=YT(J)		P	32
	10 CONTINUE		P	33
	20 CONTINUE		P	34
C			P	35
C	END OF THE CHANGES		P	36
C			P	37
	N=NEXT+1		P	38
	DO 40 I=N,L		P	39
C			P	40
C	IN THIS LOOP THE ROWS "N,...,L" OF THE ADMITTANCE MATRIX ARE		P	41
C	CHANGED TO THE FORM OF THE COEFFICIENT MATRIX		P	42
C			P	43
C	THE VALUES OF DIAGONAL ELEMENTS OF THE ADMITTANCE MATRIX OF THE		P	44
C	EXTERNAL SYSTEM CORRESPONDING TO THE BOUNDARY AND RETAINED BUSES		P	45
C	ARE CALCULATED		P	46
C			P	47
	J1=JRYT(I)+1		P	48
	J2=JRYT(I+1)-1		P	49
	J3=JRYT(I)		P	50
	Y=(0.0,0.0)		P	51
	DO 30 J=J1,J2		P	52
	KK=ICYT(J)		P	53
	IF (KK.GE.L) GO TO 30		P	54
	NEL=NEL+1		P	55
	NROW(NEL)=I		P	56
	NCOL(NEL)=KK		P	57
	AK(NEL)=YT(J)		P	58
	Y=Y+YT(J)		P	59
	30 CONTINUE		P	60
C			P	61
C	THE DIAGONAL ELEMENTS		P	62
C			P	63
	NEL=NEL+1		P	64
	NROW(NEL)=I		P	65
	NCOL(NEL)=I		P	66
	AK(NEL)=-Y		P	67
	YT(J3)=YT(J3)+Y		P	68
	40 CONTINUE		P	69
	RETURN		P	70
	END		P	71-
C			Q	1
C			Q	2
	SUBROUTINE EQEXEQ (NB,NLB,NFIC,JRYT,ICYT,YT,BTYP,V,BCV,NBOUND,NRET		Q	3
	1,NEXT,NEWNU,OLDNU,IBINTE,WSP,LSWSP,MODE,OTPT,IFLAG,IWRITE)		Q	4
C			Q	5
C	THIS SUBROUTINE FORMS THE BUS ADMITTANCE MATRIX OF THE REDUCED		Q	6
C	SYSTEM AND DETERMINES THE VECTOR OF BUS CONTROL VARIABLES		Q	7
C	THE REDUCED SYSTEM CONSISTS OF THE INTERNAL SYSTEM AND THE FIXED		Q	8
C	ADMITTANCE EQUIVALENT NETWORK CONNECTED TO THE INTERNAL SYSTEM		Q	9
C	AT THE BOUNDARY BUSES		Q	10
C	THE FIXED ADMITTANCE EQUIVALENT NETWORK CAN BE DETERMINED BY THE		Q	11
C	SUBROUTINE AS A WARD EQUIVALENT		Q	12
C			Q	13
C	NB	NUMBER OF BUSES	Q	14
C	NLB	NUMBER OF LOAD BUSES	Q	15
C	NFIC	NUMBER OF FICTITIOUS BUSES	Q	16
C	JRYT	VECTOR OF LENGTH NB+1. IT CONTAINS ROW INDICES OF	Q	17

C		A SPARSE BUS ADMITTANCE MATRIX	Q	18
C	ICYT	VECTOR OF LENGTH JRYT(NB+1)-1. IT CONTAINS COLUMN	Q	19
C		INDICES OF A SPARSE ADMITTANCE MATRIX	Q	20
C	YT	A SPARSE BUS ADMITTANCE MATRIX	Q	21
C	BTYP	VECTOR OF BUS TYPES (0 LOAD BUS, 1 GENERATOR BUS,	Q	22
C		2 SLACK BUS)	Q	23
C	V	COMPLEX BUS VOLTAGES (RECTANGULAR COORDINATES)	Q	24
C	BCV	VECTOR OF LENGTH 2*NB. IT CONTAINS NOMINAL VALUES OF	Q	25
C		BUS CONTROL VARIABLES	Q	26
C	NBOUND	NUMBER OF BOUNDARY BUSES	Q	27
C	NRET	NUMBER OF RETAINED BUSES	Q	28
C	NEWNU	VECTOR OF LENGTH NB. IT CONTAINS THE NEW INDICES OF	Q	29
C		BUSES	Q	30
C	OLDNU	VECTOR OF LENGTH NB. IT CONTAINS THE OLD INDICES OF	Q	31
C		BUSES	Q	32
C	IBINTE	VECTOR OF LENGTH NB. IT DETERMINES WHETHER A BUS	Q	33
C		BELONGS TO THE INTERNAL SYSTEM	Q	34
C	WSP	REAL WORKSPACE	Q	35
C	LWSP	LENGTH OF THE WORKSPACE WSP	Q	36
C	MODE	TYPE OF AN EQUIVALENT :	Q	37
C		1 - STANDARD WARD EQUIVALENT WITHOUT SHUNTS	Q	38
C		2 - STANDARD WARD EQUIVALENT WITH BUFFER ZONE	Q	39
C		3 - EXTENDED WARD EQUIVALENT	Q	40
C		4 - SIMPLIFIED EXTENDED WARD EQUIVALENT	Q	41
C		5 - STANDARD WARD EQUIVALENT WITH SHUNTS IN THE	Q	42
C		EXTERNAL SYSTEM	Q	43
C	OTPT	INDEX OF THE OUTPUT UNIT	Q	44
C	IFLAG	RETURN FLAG :	Q	45
C		-1 LENGTH OF THE WORKSPACE FOR GAUSSIAN ELIMINATION	Q	46
C		IS TOO SMALL	Q	47
C		-3 LENGTH OF THE WORKSPACE IS TOO SMALL	Q	48
C		0 NORMAL RETURN	Q	49
C	IWRITE	PARAMETER THAT CONTROLS OUTPUT	Q	50
C			Q	51
C		INTEGER JRYT(1),ICYT(1),BTYP(1),IBINTE(1),OLDNU(1),NEWNU(1),OTPT	Q	52
C		REAL BCV(1),WSP(1)	Q	53
C		COMPLEX YT(1),V(1)	Q	54
C			Q	55
C	CALL SECOND (TTM1)		Q	56
C	INB=NB		Q	57
C			Q	58
C	DISTRIBUTE THE WORKSPACE		Q	59
C			Q	60
C	NBRE=NBOUND+NRET		Q	61
C	NEL=JRYT(NB+1)-1		Q	62
C	NFIC=0		Q	63
C	IFLAG=0		Q	64
C	JAP=1		Q	65
C	JNRB=JAP+4*NBRE		Q	66
C	IAD=JNRB+NB		Q	67
C	JNROW=IAD		Q	68
C	JNCOL=IAD+NEL		Q	69
C	JITAG=JNCOL+NEL		Q	70
C	JLCOL=JITAG+4*NEL		Q	71
C	JNON=JLCOL+4*NB		Q	72
C	JCX=JNON+NB		Q	73
C	JAK=JCX		Q	74
C	JDE=JAK+2*NEL		Q	75
C	JVR=JDE+4*NB		Q	76
C	JCE=JVR+2*NB		Q	77
C	IF (JCE+4*NEL.LE.LSWSP) GO TO 10		Q	78
C	IFLAG=-3		Q	79
C	RETURN		Q	80
C	10 CONTINUE		Q	81
C	NBCV=IAD		Q	82

	N=4*NB	Q 83
C		Q 84
C	CHANGE THE ORDER IN THE MATRICES BTYP,BCV,V	Q 85
C		Q 86
	CALL CHNGJ (NB,BTYP,NEWNU,WSP(NBCV))	Q 87
	CALL CHNGP (NB,BCV,NEWNU,WSP(NBCV))	Q 88
	CALL CHNGC (NB,V,NEWNU,WSP(NBCV))	Q 89
C		Q 90
	DO 20 I=1,N	Q 91
	WSP(JVR-1+I)=0.0	Q 92
20	CONTINUE	Q 93
	IWSD=0	Q 94
	IF (MODE.EQ.4) IWSD=1	Q 95
	IWREMS=1	Q 96
	IF (MODE.EQ.5) IWREMS=0	Q 97
	IWESD=0	Q 98
	IF (MODE.EQ.3.OR.MODE.EQ.4) IWESD=1	Q 99
C		Q 100
C	COMPUTE THE COEFFICIENT MATRIX (VECTORS AK,NROW,NCOL)	Q 101
C		Q 102
	CALL CHNGAD (NB,NEL,JRYT,ICYT,YT,WSP(JNROW),WSP(JNCOL),WSP(JAK),NE 1WNU)	Q 103
		Q 104
C		Q 105
	INEL=NEL	Q 106
C		Q 107
C	REMOVE ALL CONDUCTANCES FROM THE EXTERNAL SYSTEM: FOR THE SIMPLIFIED WARD METHOD	Q 108
C		Q 109
C		Q 110
	IF (IWSD.EQ.1) CALL EQWAES (NEL,NEXT,WSP(JNROW),WSP(JNCOL),WSP(JAK 1))	Q 111
		Q 112
C		Q 113
C	COMPUTE A NEW ADMITTANCE MATRIX OF THE POWER SYSTEM	Q 114
C		Q 115
	CALL SPAMAT (NB,NEL,WSP(JNCOL),WSP(JNROW),WSP(JAK),JRYT,ICYT,YT)	Q 116
C		Q 117
	IF (IWESD.NE.1) GO TO 30	Q 118
C		Q 119
C	COMPUTE THE NUMBER AND VALUES OF FICTITIOUS BRANCHES	Q 120
C		Q 121
	CALL EQWEES (NB,NZ,NEXT,NBRE,NFIC,BTYP,JRYT,ICYT,YT,WSP(JNROW),WSP 1(JNCOL),WSP(JAK),WSP(JVR),WSP(JLCOL),WSP(JITAG),WSP(JCE),WSP(JNRB) 2,WSP(JAP),OTPT,IFLAG,IWRITE)	Q 122
	IF (IFLAG.LT.0) RETURN	Q 123
		Q 124
		Q 125
C		Q 126
30	CONTINUE	Q 127
C		Q 128
C	IF IWREMS=1 THE SHUNT ADMITTANCES ARE REMOVED	Q 129
C		Q 130
	IF (IWREMS.EQ.1) CALL EQREMS (NEXT,JRYT,ICYT,YT)	Q 131
C		Q 132
C	COMPUTE THE COEFFICIENT MATRIX (VECTORS WSP(AK),WSP(NROW) AND WSP(NCOL)) FOR THE EXTERNAL POWER SYSTEM AND THE ADMITTANCE MATRIX (VECTORS YT,JRYT,ICYT) OF THE INTERNAL POWER SYSTEM	Q 133
C		Q 134
C		Q 135
C		Q 136
	CALL EQDRC1 (NBRE,NEXT,NEL,JRYT,ICYT,YT,WSP(JNROW),WSP(JNCOL),WSP(1JAK))	Q 137
		Q 138
C		Q 139
	IF (IWSD.EQ.1) CALL EQWAES (NEL,NEXT,WSP(JNROW),WSP(JNCOL),WSP(JAK 1))	Q 140
		Q 141
	NB1=NBRE+NEXT	Q 142
C		Q 143
C	PERFORM GAUSSIAN ELIMINATION	Q 144
C		Q 145
	CALL GAUSEL (NB1,NEL,NEXT,WSP(JNROW),WSP(JNCOL),WSP(JAK),WSP(JVR), 1WSP(JLCOL),WSP(JITAG),WSP(JCE),IFLAG,IWRITE)	Q 146
		Q 147

C	IF (IFLAG.LT.0) RETURN	Q 148
C	ATTACH THE EXTERNAL EQUIVALENT TO THE INTERNAL POWER SYSTEM	Q 149
C	AT BOUNDARY BUSES	Q 150
C	CALL EQINRC (NB, NEXT, NBRE, NEL, JRYT, ICYT, YT, WSP(JNROW), WSP(JNCOL), W	Q 151
	ISP(JAK)	Q 152
	N=NB-NEXT	Q 153
C	ATTACH THE FICTITIOUS BRANCHES TO THE BOUNDARY BUSES	Q 154
C	(FOR THE EXTENDED AND SIMPLIFIED WARD METHOD)	Q 155
C	IF (IWESD.EQ.1) CALL EQINBR (N, NEL, NFIC, WSP(JNROW), WSP(JNCOL), WSP(Q 156
	1JNRB), WSP(JAK), WSP(JAP)	Q 157
C	CHANGE THE COEFFICIENT MATRIX (VECTORS WSP(JAK), WSP(JNROW) AND	Q 158
C	WSP(JNCOL)) TO THE FORM OF THE SPARSE MATRIX (VECTORS YT, JRYT,	Q 159
C	ICYT)	Q 160
C	CALL SPAMAT (N, NEL, WSP(JNCOL), WSP(JNROW), WSP(JAK), JRYT, ICYT, YT)	Q 161
C	CALL PRINAD (N, JRYT, ICYT, YT, IWRITE, OTPT)	Q 162
C	COMPUTE THE NEW VALUES OF THE BUS CONTROL VARIABLES OF THE	Q 163
C	REDUCED POWER SYSTEM	Q 164
C	CALL EQBCV (NB, NLB, NEXT, NFIC, BTYP, BCV, V, WSP(NBCV), YT, JRYT, ICYT, OLD	Q 165
	1INU, IBINTE, WSP(JNRB), OTPT, IWRITE)	Q 166
C	CALL SECOND (TTM2)	Q 167
	TIEL=TTM2-TTM1	Q 168
	WRITE (OTPT, 40) TIEL	Q 169
C	40 FORMAT (//, 2X, "CPU TIME FOR POWER NETWORK EQUIVALENT = ", F6.3, "SEC	Q 170
	1ONDS"//)	Q 171
	RETURN	Q 172
	END	Q 173
C		Q 174
C	SUBROUTINE EQFORM (NB, NBEQ, NLBE, NEXT, NFIC, NBOUND, JBOUND, NRET, JRET,	Q 175
	1BTYP, BCV, V, NEWNUM, OLDNUM, JBINTE, YT, JRYT, ICYT, LBINP, LBOUT, NTL, MODE,	Q 176
	20TPT, IWRITE)	Q 177
C	THE SUBROUTINE EQFORM CREATES A FORMATTED DATA FILE DESCRIBING	Q 178
C	THE REDUCED POWER SYSTEM. THE DATA IS PRINTED OUT ON THE UNIT	Q 179
C	OTPT	Q 180
C	NB NUMBER OF BUSES OF THE UNREDUCED POWER SYSTEM	Q 181
C	NBEQ NUMBER OF BUSES OF THE REDUCED POWER SYSTEM	Q 182
C	NLBE NUMBER OF LOAD BUSES OF THE REDUCED POWER SYSTEM	Q 183-
C	NEXT NUMBER OF BUSES OF THE EXTERNAL POWER SYSTEM	R 1
C	NFIC NUMBER OF FICTITIOUS BUSES	R 2
C	NBOUND NUMBER OF BOUNDARY BUSES	R 3
C	JBOUND VECTOR OF LENGTH NBOUND. IT CONTAINS BOUNDARY BUSES	R 4
C	NRET NUMBER OF RETAINED BUSES	R 5
C	JRET VECTOR OF LENGTH NRET. IT CONTAINS RETAINED BUSES	R 6
C	BTYP VECTOR OF BUS TYPES (0 LOAD BUS, 1 GENERATOR BUS,	R 7
C	2 SLACK BUS) OF THE REDUCED POWER SYSTEM	R 8
C	BCV VECTOR OF LENGTH 2*NB. IT CONTAINS NOMINAL VALUES OF	R 9
C	BUS CONTROL VARIABLES OF THE REDUCED POWER SYSTEM	R 10
C	V COMPLEX BUS VOLTAGES (RECTANGULAR COORDINATES) OF THE	R 11
C	REDUCED POWER SYSTEM	R 12
C	NEWNUM VECTOR OF LENGTH NB. IT STORES THE NEW INDICES OF	R 13
C	BUSES	R 14
C	IOLDNU VECTOR OF LENGTH NB. IT STORES THE OLD INDICES OF	R 15
C	BUSES W.R.T. THE NEW INDICES	R 16
C		R 17
C		R 18
C		R 19
C		R 20
C		R 21
C		R 22
C		R 23
C		R 24
C		R 25
C		R 26
C		R 27
C		R 28
C		R 29

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C      IBINTE      VECTOR OF LENGTH NB. IT STORES BUSES OF THE INTERNAL      R 30
C      POWER SYSTEM
C      YT          A SPARSE BUS ADMITTANCE MATRIX                          R 31
C      JRYT       VECTOR OF LENGTH NB+1. IT CONTAINS ROW INDICES OF      R 32
C      THE SPARSE BUS ADMITTANCE MATRIX
C      ICYT       VECTOR OF LENGTH JRYT(NB+1)-1. IT CONTAINS COLUMN      R 33
C      INDICES OF THE SPARSE ADMITTANCE MATRIX
C      LBINP,LBOUT VECTORS OF LENGTH NTL. LBINP(K),LBOUT(K) CONTAIN      R 34
C      INDICES OF BUSES INCIDENT WITH THE KTH LINE
C      NTL        NUMBER OF TRANSMISSION LINES                            R 35
C      MODE       TYPE OF AN EQUIVALENT :                                R 36
C      1 - STANDARD WARD EQUIVALENT WITHOUT SHUNTS                       R 37
C      2 - STANDARD WARD EQUIVALENT WITH BUFFER ZONE                     R 38
C      3 - EXTENDED WARD EQUIVALENT                                     R 39
C      4 - SIMPLIFIED EXTENDED WARD EQUIVALENT                         R 40
C      5 - STANDARD WARD EQUIVALENT WITH SHUNTS IN THE                 R 41
C      EXTERNAL SYSTEM
C      OTPT       INDEX OF THE OUTPUT UNIT                               R 42
C      IWRITE     PARAMETER THAT CONTROLS OUTPUT                       R 43
C      1 - DESCRIPTION OF THE REDUCED POWER SYSTEM IS                 R 44
C      PRINTED OUT ON THE UNIT OTPT                                    R 45
C
C      INTEGER BTYP(1),JBOUND(1),JRET(1),NEWNUM(1),OLDNUM(1),JRYT(1),ICYT
C      1(1),JBINTE(1),LBINP(1),LBOUT(1),OTPT,PAR(8)                    R 46
C      REAL BCV(1),TYPM(6),DESC(8),PL(16)                              R 47
C      COMPLEX V(1),YT(1)                                             R 48
C
C      DATA TYPM/"SWARD1", "BZWARD", "EXWARD", "SIWARD", "SWARD2", "FDWARD"/, D
C      1ESC/      NB= ", " NBEQ= ", " NLBE= ", " NEXT= ", " NFIC= ", "NBOUND
C      2= ", " NRET= ", " NTL= "/, PL/"LBINP ", "LBOUT ", "NEWNUM", "OLDNUM",
C      3"JBINTE", "BTYP", "REALV", "IMAGV", "BCV1 ", "BCV2 ", "JRYT ", " ICYT",
C      4"REAL YT", "IMAG YT", "BOUNDARY", "RETAINED"/
C
C      IF (IWRITE.NE.1) RETURN
C
C      THE PARAMETERS DESCRIBING THE REDUCED POWER SYSTEM ARE PRINTED
C      OUT ON THE UNIT OTPT
C
C      WRITE (OTPT,130) TYPM(MODE), MODE
C      PAR(1)=NB
C      PAR(2)=NBEQ
C      PAR(3)=NLBE
C      PAR(4)=NEXT
C      PAR(5)=NFIC
C      PAR(6)=NBOUND
C      PAR(7)=NRET
C      PAR(8)=NTL
C      DO 10 I=1,8
C      WRITE (OTPT,150) DESC(I),PAR(I)
C 10 CONTINUE
C
C      IF (NBOUND.EQ.0) GO TO 20
C      WRITE (OTPT,160) PL(15)
C      WRITE (OTPT,80) (JBOUND(I), I=1,NBOUND)
C 20 CONTINUE
C
C      IF (NRET.EQ.0) GO TO 30
C      WRITE (OTPT,160) PL(16)
C      WRITE (OTPT,80) (JRET(I), I=1,NRET)
C 30 CONTINUE
C
C      WRITE (OTPT,170) (PL(I), I=3,5)
C
C      DO 40 I=1,NB
C      WRITE (OTPT,100) NEWNUM(I),OLDNUM(I),JBINTE(I)

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	40 CONTINUE	R 95
	WRITE (OTPT,180) (PL(I),I=6,10)	R 96
	DO 50 I=1,NBEQ	R 97
	WRITE (OTPT,110) BTYP(I),V(I),BCV(2*I-1),BCV(2*I)	R 98
	50 CONTINUE	R 99
	WRITE (OTPT,170) PL(11)	R 100
	K=NBEQ+1	R 101
	WRITE (OTPT,80) (JRYT(I),I=1,K)	R 102
	K=JRYT(K)-1	R 103
	WRITE (OTPT,190) (PL(I),I=12,14)	R 104
	DO 60 I=1,K	R 105
	WRITE (OTPT,120) IGYT(I),YT(I)	R 106
	60 CONTINUE	R 107
	WRITE (OTPT,140) PL(1),PL(2)	R 108
	DO 70 I=1,NTL	R 109
	WRITE (OTPT,90) LBINP(I),LBOUT(I)	R 110
	70 CONTINUE	R 111
C		R 112
C	END OF PRINTING	R 113
C		R 114
	RETURN	R 115
	80 FORMAT (1X,10I5)	R 116
	90 FORMAT (1X,2I5)	R 117
	100 FORMAT (1X,3(1X,I5,1X))	R 118
	110 FORMAT (1X,I2,2X,4(E12.6,4X))	R 119
	120 FORMAT (1X,I5,2X,2(E12.6,2X))	R 120
	130 FORMAT (1X,A6,3X,I2)	R 121
	140 FORMAT (1X,2A6)	R 122
	150 FORMAT (1X,A8,I4)	R 123
	160 FORMAT (1X,A8)	R 124
	170 FORMAT (1X,3(A6,1X))	R 125
	180 FORMAT (1X,A4,4(5X,A5,6X))	R 126
	190 FORMAT (1X,A6,7X,A7,6X,A7)	R 127
	END	R 128-
C		S 1
C		S 2
	SUBROUTINE EQINBR (NB,NEL,NFIC,NROW,NCOL,NRB,AK,AP)	S 3
C		S 4
C	THIS SUBROUTINE ATTACHES FICTITIOUS BRANCHES TO THE	S 5
C	RELEVANT BOUNDARY BUSES	S 6
C		S 7
C	NB NUMBER OF BUSES	S 8
C	NFIC NUMBER OF FICTITIOUS BUSES	S 9
C	NEL NUMBER OF NONZERO ELEMENTS OF THE COEFFICIENT MATRIX	S 10
C	AK VECTOR OF LENGTH NEL. IT CONTAINS THE NONZERO	S 11
C	ELEMENTS OF THE COEFFICIENT MATRIX	S 12
C	NROW,NCOL VECTORS OF LENGTH NEL. THEY CONTAIN ROW AND COLUMN	S 13
C	INDICES OF THE NONZERO ELEMENTS OF THE COEFFICIENT	S 14
C	MATRIX	S 15
C	NRB VECTOR OF LENGTH NFIC. IT CONTAINS THE INDICES OF	S 16
C	BUSES INCIDENT WITH THE FICTITIOUS BRANCHES	S 17
C	AP VECTOR OF LENGTH NFIC. IT CONTAINS THE VALUES OF THE	S 18
C	FICTITIOUS BRANCHES	S 19
C		S 20
	INTEGER NROW(1),NCOL(1),NRB(1)	S 21
	COMPLEX AK(1),AP(1)	S 22
C		S 23
C	CHANGE THE ROW INDICES AND THE COLUMN INDICES OF THE COEFFICIENT	S 24
C	MATRIX AK	S 25
C		S 26
	DO 10 I=1,NEL	S 27
	IF (NROW(I).EQ.NB) NROW(I)=NROW(I)+NFIC	S 28
	IF (NCOL(I).EQ.NB) NCOL(I)=NCOL(I)+NFIC	S 29
	10 CONTINUE	S 30
C		S 31

```

C      COMPUTE THE NEW ELEMENTS OF THE COEFFICIENT MATRIX AK AND
C      THE MATRICES NROW AND NCOL                                S 32
C
C      DO 20 I=1,NFIC                                           S 33
C
C      IN THIS LOOP THE NEW DIAGONAL ELEMENTS OF THE COEFFICIENT MATRIX
C      ARE CALCULATED                                           S 34
C
C      NEL=NEL+1                                               S 35
C      NROW(NEL)=NB+I-1                                         S 36
C      NCOL(NEL)=NB+I-1                                         S 37
C      AK(NEL)=CMPLX(0.0, AIMAG(AP(I)))                          S 38
C 20 CONTINUE                                                  S 39
C
C      DO 50 I=1,NFIC                                           S 40
C
C      IN THIS LOOP THE NEW ELEMENTS OF THE COEFFICIENT MATRIX
C      ARE CALCULATED AND THE DIAGONAL ELEMENTS ARE MODIFIED  S 41
C
C      NEL=NEL+1                                               S 42
C      NROW(NEL)=NRB(I)                                         S 43
C      NCOL(NEL)=NB+I-1                                         S 44
C      AK(NEL)=-CMPLX(0.0, AIMAG(AP(I)))                        S 45
C      KK=NRB(I)                                               S 46
C      DO 30 K=1,NEL                                           S 47
C      IF (NROW(K).NE.KK) GO TO 30                               S 48
C      IF (NCOL(K).NE.KK) GO TO 30                               S 49
C      AK(K)=AK(K)+CMPLX(0.0, AIMAG(AP(I)))                    S 50
C      GO TO 40                                                 S 51
C 30 CONTINUE                                                  S 52
C 40 CONTINUE                                                  S 53
C      NEL=NEL+1                                               S 54
C      NROW(NEL)=NB+I-1                                         S 55
C      NCOL(NEL)=NRB(I)                                         S 56
C      AK(NEL)=-CMPLX(0.0, AIMAG(AP(I)))                        S 57
C 50 CONTINUE                                                  S 58
C      NB=NB+NFIC                                              S 59
C      RETURN                                                  S 60
C      END                                                    S 61
C
C
C      SUBROUTINE EQMOSO (INB,NB,NFIC,NEXT,V,AXV,JOLDNU,MODE)    S 62
C
C      THIS SUBROUTINE PREPARES DATA FOR SUBROUTINE EQCONTI.  S 63
C      IT CHANGES THE ORDER OF INB ELEMENTS STORED IN THE VECTOR V
C      ACCORDING TO THE OLD INDICES STORED BY THE VECTOR JOLDNU S 64
C
C      INB      NUMBER OF BUSES OF THE UNREDUCED POWER SYSTEM  S 65
C      NB      NUMBER OF BUSES OF THE REDUCED POWER SYSTEM     S 66
C      NEXT    NUMBER OF BUSES OF THE EXTERNAL POWER SYSTEM   S 67
C      NFIC    NUMBER OF FICTITIOUS BUSES                       S 68
C      V      COMPLEX BUS VOLTAGES (RECTANGULAR COORDINATES) OF THE
C              REDUCED POWER SYSTEM                            S 69
C      JOLDNU  VECTOR OF LENGTH INB. IT CONTAINS THE OLD INDICES OF
C              BUSES W.R.T. THE NEW INDICES                     S 70
C      AXV    AN AUXILIARY VECTOR                               T 1
C      MODE   TYPE OF AN EQUIVALENT                            T 2
C
C      INTEGER JOLDNU(1)                                       T 3
C      COMPLEX V(1)                                             T 4
C      REAL AXV(1)                                             T 5
C
C      K=2*INB                                                 T 6
C      DO 10 I=1,K                                             T 7
C      AXV(I)=0.0                                              T 8

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	10	CONTINUE	T	27
		NBF=NB-NFIC-1	T	28
		DO 20 I=1,NBF	T	29
		J=NEXT+1	T	30
		IF (MODE.NE.0) K=JOLDNU(J)	T	31
		AXV(2*K-1)=REAL(V(I))	T	32
		AXV(2*K)=AIMAG(V(I))	T	33
	20	CONTINUE	T	34
		AXV(2*INB-1)=REAL(V(NB))	T	35
		AXV(2*INB)=AIMAG(V(NB))	T	36
		DO 30 I=1,INB	T	37
		V(I)=CMPLX(AXV(2*I-1),AXV(2*I))	T	38
	30	CONTINUE	T	39
		RETURN	T	40
		END	T	41-
C			U	1
C			U	2
		SUBROUTINE EQINRC (NB,NEXT,NBRE,NEL,JRYT,ICYT,YT,NROW,NCOL,AK)	U	3
C			U	4
C		THIS SUBROUTINE LINKS AN EXTERNAL EQUIVALENT DESCRIBED BY A	U	5
C		COEFFICIENT MATRIX (VECTORS: AK,NROW,NCOL) WITH THE INTERNAL	U	6
C		SYSTEM DESCRIBED BY AN ADMITTANCE MATRIX STORED IN THE	U	7
C		SPARSE FORM (VECTORS YT,JRYT,ICYT). THE REDUCED SYSTEM IS	U	8
C		STORED IN THE COEFFICIENT MATRIX (VECTORS AK,NROW,NCOL)	U	9
C			U	10
		INTEGER JRYT(1),ICYT(1),NROW(1),NCOL(1)	U	11
		COMPLEX YT(1),AK(1)	U	12
C			U	13
C		MODIFICATION OF THE MATRIX AK AND THE MATRICES NROW AND NCOL	U	14
C			U	15
		N=NEXT+1	U	16
		NELK=NEL	U	17
		L=NEXT+NBRE	U	18
		DO 50 I=N,NB	U	19
		J1=JRYT(I)	U	20
		J2=JRYT(I+1)-1	U	21
		K1=I-NEXT	U	22
		DO 40 J=J1,J2	U	23
		KK=ICYT(J)	U	24
		K2=KK-NEXT	U	25
		IF (KK.GT.L) GO TO 20	U	26
		IF (KK.LT.N) GO TO 40	U	27
		DO 10 I1=1,NEL	U	28
		IF (K1.EQ.NROW(I1).AND.K2.EQ.NCOL(I1)) GO TO 30	U	29
	10	CONTINUE	U	30
	20	CONTINUE	U	31
		NELK=NELK+1	U	32
		NROW(NELK)=K1	U	33
		NCOL(NELK)=K2	U	34
		AK(NELK)=YT(J)	U	35
		GO TO 40	U	36
	30	CONTINUE	U	37
		AK(I1)=AK(I1)+YT(J)	U	38
	40	CONTINUE	U	39
	50	CONTINUE	U	40
		NEL=NELK	U	41
		RETURN	U	42
		END	U	43-
C			V	1
C			V	2
		SUBROUTINE EQREAD (NB,NBEQ,NLBE,NEXT,NFIC,NBOUND,JBOUND,NRET,JRET,	V	3
		1BTYP,BCV,V,NEWNUM,OLDNUM,JBINTE,YT,JRYT,ICYT,LBINP,LBOUT,NTL,MODE,	V	4
		2INPT,OTPT,IWRITE)	V	5
C			V	6
C		SUBROUTINE EQREAD READS INPUT DATA DESCRIBING THE REDUCED POWER	V	7


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C      SYSTEM FROM A FILE WHICH IS CREATED BY THE SUBROUTINE EQFORM      V  8
C      V  9
C      NB      NUMBER OF BUSES OF THE UNREDUCED POWER SYSTEM      V 10
C      NBEQ    NUMBER OF BUSES OF THE REDUCED POWER SYSTEM      V 11
C      NLBE    NUMBER OF LOAD BUSES OF THE REDUCED POWER SYSTEM  V 12
C      NEXT    NUMBER OF BUSES OF THE EXTERNAL POWER SYSTEM     V 13
C      NFIC    NUMBER OF FICTITIOUS BUSES                        V 14
C      NBOUND  NUMBER OF BOUNDARY BUSES                          V 15
C      JBOUND  VECTOR OF LENGTH NBOUND. IT CONTAINS BOUNDARY BUSES V 16
C      NRET    NUMBER OF RETAINED BUSES                          V 17
C      JRET    VECTOR OF LENGTH NRET. IT CONTAINS RETAINED BUSES V 18
C      BTYP    VECTOR OF BUS TYPES ( 0 LOAD BUS, 1 GENERATOR BUS,  V 19
C              2 SLACK BUS ) OF THE REDUCED POWER SYSTEM        V 20
C      BCV     VECTOR OF LENGTH 2*NB. IT CONTAINS NOMINAL VALUES V 21
C              OF BUS CONTROL VARIABLES OF THE REDUCED POWER   V 22
C              SYSTEM                                           V 23
C      V       COMPLEX BUS VOLTAGES (RECTANGULAR COORDINATES) OF THE V 24
C              REDUCED POWER SYSTEM                             V 25
C      NEWNUM  VECTOR OF LENGTH NB. IT STORES THE NEW INDICES OF  V 26
C              BUSES                                           V 27
C      IOLDNU  VECTOR OF LENGTH NB. IT STORES THE OLD INDICES OF  V 28
C              BUSES W.R.T. THE NEW INDICES                     V 29
C      IBINTE  VECTOR OF LENGTH NB. IT STORES BUSES OF THE INTERNAL V 30
C              POWER SYSTEM                                     V 31
C      YT      A SPARSE BUS ADMITTANCE MATRIX                    V 32
C      JRYT    VECTOR OF LENGTH NB+1. IT CONTAINS ROW INDICES OF  V 33
C              THE SPARSE BUS ADMITTANCE MATRIX                 V 34
C      ICYT    VECTOR OF LENGTH JRYT(NB+1)-1. IT CONTAINS COLUMN  V 35
C              INDICES OF THE SPARSE ADMITTANCE MATRIX         V 36
C      LBINP,LBOUT VECTORS OF LENGTH NTL. LBINP(K),LBOUT(K) CONTAIN V 37
C              INDICES OF BUSES INCIDENT WITH THE KTH LINE    V 38
C      NTL     NUMBER OF TRANSMISSION LINES                       V 39
C      MODE    TYPE OF AN EQUIVALENT :                           V 40
C              1 - STANDARD WARD EQUIVALENT WITHOUT SHUNTS     V 41
C              2 - STANDARD WARD EQUIVALENT WITH BUFFER ZONE   V 42
C              3 - EXTENDED WARD EQUIVALENT                    V 43
C              4 - SIMPLIFIED EXTENDED WARD EQUIVALENT         V 44
C              5 - STANDARD WARD EQUIVALENT WITH SHUNTS IN THE V 45
C                  EXTERNAL SYSTEM                             V 46
C      INPT    INDEX OF THE INPUT UNIT                            V 47
C      OTPT    INDEX OF THE OUTPUT UNIT                          V 48
C      IWRITE  PARAMETER THAT CONTROLS OUTPUT                   V 49
C              1 - DESCRIPTION OF THE REDUCED POWER SYSTEM IS  V 50
C                  PRINTED OUT ON THE UNIT OTPT                V 51
C              V 52
C      INTEGER BTYP(1),JBOUND(1),JRET(1),NEWNUM(1),OLDNUM(1),JRYT(1),ICYT
1(1),JBINTE(1),LBINP(1),LBOUT(1),INPT,PAR(8),OTPT      V 53
REAL BCV(1),DESC(8),PL(16)                               V 54
COMPLEX V(1),YT(1)                                       V 55
C      V 56
C      THE DATA DESCRIBING THE REDUCED POWER SYSTEM IS READ FROM THE V 57
C      UNIT INPT                                          V 58
C      V 59
C      V 60
C      READ (INPT,170) RTYP,K                              V 61
C      MODE=K                                             V 62
C      IF (IWRITE.EQ.1) WRITE (OTPT,170) RTYP,MODE      V 63
C      DO 10 I=1,8                                         V 64
C      READ (INPT,190) DESC(I),PAR(I)                    V 65
10 CONTINUE                                              V 66
IF (IWRITE.NE.1) GO TO 30                               V 67
DO 20 I=1,8                                             V 68
WRITE (OTPT,190) DESC(I),PAR(I)                         V 69
20 CONTINUE                                             V 70
30 CONTINUE                                             V 71
NB=PAR(1)                                              V 72

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	NBEQ=PAR(2)	V 73
	NLBE=PAR(3)	V 74
	NEXT=PAR(4)	V 75
	NFIC=PAR(5)	V 76
	NBOUND=PAR(6)	V 77
	NRET=PAR(7)	V 78
	NTL=PAR(8)	V 79
C		V 80
	IF (NBOUND.EQ.0) GO TO 40	V 81
	READ (INPT,200) PL(15)	V 82
	IF (IWRITE.EQ.1) WRITE (OTPT,200) PL(15)	V 83
	READ (INPT,120) (JBOUND(I),I=1,NBOUND)	V 84
	IF (IWRITE.EQ.1) WRITE (OTPT,120) (JBOUND(I),I=1,NBOUND)	V 85
40	CONTINUE	V 86
C		V 87
	IF (NRET.EQ.0) GO TO 50	V 88
	READ (INPT,200) PL(16)	V 89
	IF (IWRITE.EQ.1) WRITE (OTPT,200) PL(16)	V 90
	READ (INPT,120) (JRET(I),I=1,NRET)	V 91
	IF (IWRITE.EQ.1) WRITE (OTPT,120) (JRET(I),I=1,NRET)	V 92
50	CONTINUE	V 93
C		V 94
	READ (INPT,210) (PL(I),I=3,5)	V 95
C		V 96
	IF (IWRITE.EQ.1) WRITE (OTPT,210) (PL(I),I=3,5)	V 97
	DO 60 I=1,NB	V 98
	READ (INPT,140) NEWNUM(I),OLDNUM(I),JBINTE(I)	V 99
60	CONTINUE	V 100
	IF (IWRITE.NE.1) GO TO 80	V 101
	DO 70 I=1,NB	V 102
	WRITE (OTPT,140) NEWNUM(I),OLDNUM(I),JBINTE(I)	V 103
70	CONTINUE	V 104
80	CONTINUE	V 105
C		V 106
	READ (INPT,220) (PL(I),I=6,10)	V 107
	IF (IWRITE.EQ.1) WRITE (OTPT,220) (PL(I),I=6,10)	V 108
C		V 109
	DO 90 I=1,NBEQ	V 110
	READ (INPT,150) BTYP(I),V(I),BCV(2*I-1),BCV(2*I)	V 111
	IF (IWRITE.EQ.1) WRITE (OTPT,150) BTYP(I),V(I),BCV(2*I-1),BCV(2*I)	V 112
90	CONTINUE	V 113
C		V 114
	READ (INPT,210) PL(11)	V 115
	IF (IWRITE.EQ.1) WRITE (OTPT,210) PL(11)	V 116
	K=NBEQ+1	V 117
C		V 118
	READ (INPT,120) (JRYT(I),I=1,K)	V 119
	IF (IWRITE.EQ.1) WRITE (OTPT,120) (JRYT(I),I=1,K)	V 120
	K=JRYT(K)-1	V 121
C		V 122
	READ (INPT,230) (PL(I),I=12,14)	V 123
	IF (IWRITE.EQ.1) WRITE (OTPT,230) (PL(I),I=12,14)	V 124
	DO 100 I=1,K	V 125
C		V 126
	READ (INPT,160) ICYT(I),YT(I)	V 127
	IF (IWRITE.EQ.1) WRITE (OTPT,160) ICYT(I),YT(I)	V 128
100	CONTINUE	V 129
C		V 130
	READ (INPT,180) PL(1),PL(2)	V 131
	IF (IWRITE.EQ.1) WRITE (OTPT,180) PL(1),PL(2)	V 132
C		V 133
	DO 110 I=1,NTL	V 134
	READ (INPT,130) LBINP(I),LBOUT(I)	V 135
	IF (IWRITE.EQ.1) WRITE (OTPT,130) LBINP(I),LBOUT(I)	V 136
110	CONTINUE	V 137

C		V 138
C	END OF READING	V 139
C		V 140
	120 FORMAT (1X, 10I5)	V 141
	130 FORMAT (1X, 2I5)	V 142
	140 FORMAT (1X, 16, 17, 17)	V 143
	150 FORMAT (1X, 12, 2X, 4(E12.6, 4X))	V 144
	160 FORMAT (1X, 15, 2X, 2(E12.6, 2X))	V 145
	170 FORMAT (1X, A6, 3X, I2)	V 146
	180 FORMAT (1X, 2A6)	V 147
	190 FORMAT (1X, A8, I4)	V 148
	200 FORMAT (1X, A8)	V 149
	210 FORMAT (1X, 3(A6, 1X))	V 150
	220 FORMAT (1X, A4, 4(5X, A5, 6X))	V 151
	230 FORMAT (1X, A6, 7X, A7, 6X, A7)	V 152
	RETURN	V 153
	END	V 154-

C		W	1
C		W	2
	SUBROUTINE EQREEY (I1, JY1, NB, NEL, JRYT, ICYT, YT)	W	3
C		W	4
C	THIS SUBROUTINE REMOVES AN ELEMENT JY1 FROM VECTORS ICYT, YT AND	W	5
C	MODIFIES THE VECTOR JRYT	W	6
C		W	7
	INTEGER JRYT(1), ICYT(1)	W	8
	COMPLEX YT(1)	W	9
	NEL=NEL-1	W	10
	DO 10 I=JY1, NEL	W	11
	ICYT(I)=ICYT(I+1)	W	12
	YT(I)=YT(I+1)	W	13
10	CONTINUE	W	14
	K=I1+1	W	15
	N=NB+1	W	16
	DO 20 I=K, N	W	17
	JRYT(I)=JRYT(I)-1	W	18
20	CONTINUE	W	19
	RETURN	W	20
	END	W	21-
C		X	1
C		X	2
	SUBROUTINE EQREMS (NEXT, JRYT, ICYT, YT)	X	3
C		X	4
C	THIS SUBROUTINE CHANGES THE VALUE OF THE "NEXT" DIAGONAL	X	5
C	ELEMENTS OF THE ADMITTANCE MATRIX YT STORED IN THE SPARSE FORM	X	6
C	(VECTORS YT, JRYT, ICYT)	X	7
C		X	8
	INTEGER JRYT(1), ICYT(1)	X	9
	COMPLEX YT(1), Y	X	10
C		X	11
	DO 20 I=1, NEXT	X	12
	J1=JRYT(I)+1	X	13
	J2=JRYT(I+1)-1	X	14
	Y=(0.0, 0.0)	X	15
C		X	16
C	COMPUTE THE SUM OF THE ELEMENTS OF THE ITH ROW OF THE MATRIX YT	X	17
C	WITHOUT THE DIAGONAL ELEMENT	X	18
C		X	19
	DO 10 J=J1, J2	X	20
	Y=Y+YT(J)	X	21
10	CONTINUE	X	22
	J=JRYT(I)	X	23
C		X	24
C	CHANGE THE ITH DIAGONAL ELEMENT OF THE MATRIX YT	X	25
C		X	26
	YT(J)=-Y	X	27
20	CONTINUE	X	28
	RETURN	X	29
	END	X	30-
C		Y	1
C		Y	2
	SUBROUTINE EQWAES (NEL, NEXT, NROW, NCOL, AK)	Y	3
C		Y	4
C	THIS SUBROUTINE SETS TO ZERO THE REAL PART OF THE COEFFICIENTS	Y	5
C	OF THE MATRIX AK WHOSE EITHER ROW OR COLUMN INDICES ARE LESSER	Y	6
C	THAN OR EQUAL TO THE "NEXT" PARAMETER	Y	7
C		Y	8
C	NEL NUMBER OF THE NONZERO ELEMENTS OF THE MATRIX AK	Y	9
C	NEXT NUMBER OF THE EXTERNAL BUSES	Y	10
C		Y	11
	INTEGER NROW(1), NCOL(1)	Y	12
	COMPLEX AK(1)	Y	13
C		Y	14

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DO 50 I=1,NEL
IF (NROW(I).LE.NEXT.AND.NCOL(I).LE.NEXT) GO TO 40
IF (NROW(I).LE.NEXT.AND.NCOL(I).GT.NEXT) GO TO 40
IF (NCOL(I).LE.NEXT.AND.NROW(I).GT.NEXT) GO TO 10
GO TO 50
10 CONTINUE
C
C
C      FIND DIAGONAL ELEMENT
K=NROW(I)
DO 20 J=1,NEL
IF (NROW(J).EQ.K.AND.NCOL(J).EQ.K) GO TO 30
20 CONTINUE
GO TO 50
30 CONTINUE
R1=REAL(AK(I))
R=REAL(AK(J))
AI=AIMAG(AK(J))
R=R1+R
C
C
C      CHANGE THE REAL PART OF THE COEFFICIENT AK(J)
AK(J)=CMPLX(R,AI)
AK(I)=CMPLX(0.0,AIMAG(AK(I)))
GO TO 50
40 CONTINUE
X=AIMAG(AK(I))
C
C
C      SET TO ZERO THE REAL PART OF THE COEFFICIENT AK(I)
AK(I)=CMPLX(0.0,X)
50 CONTINUE
RETURN
END
C
C
C      SUBROUTINE EQWARD (NB,NLB,NTL,LBINP,LBOUT,YT,JRYT,ICYT,BTYP,V,BCV,
1NBOUND,JBOUND,NRET,JRET,NEWNUM,IOLDNU,IBINTE,NEXT,NFIC,WSP,LWSP,MO
2DE1,MODE2,MODE3,OTPT,INPT,IFLAG,IWRITE)
C
C      THIS IS THE MAIN SUBROUTINE OF THE WARDEQ PACKAGE. IT CALLS
C      SUBROUTINES EQDEIE AND EQEXEQ.CHECKS THE CORRECTNESS OF THE
C      ARGUMENTS AND SUPPLIES THE VALUE OF IFLAG
C
C      NB          NUMBER OF BUSES
C      NLB        NUMBER OF LOAD BUSES
C      NTL        NUMBER OF TRANSMISSION LINES
C      LBINP,LBOUT  VECTORS OF LENGTH NTL. LBINP(K),LBOUT(K) CONTAIN
C                   INDICES OF BUSES INCIDENT WITH THE KTH LINE
C      JRYT       VECTOR OF LENGTH NB+1. IT CONTAINS ROW INDICES OF
C                   A SPARSE BUS ADMITTANCE MATRIX
C      ICYT       VECTOR OF LENGTH JRYT(NB+1)-1. IT CONTAINS COLUMN
C                   INDICES OF A SPARSE ADMITTANCE MATRIX
C      YT         A SPARSE BUS ADMITTANCE MATRIX
C      BTYP       VECTOR OF BUS TYPES ( 0 LOAD BUS, 1 GENERATOR BUS,
C                   2 SLACK BUS )
C      V          COMPLEX BUS VOLTAGES (RECTANGULAR COORDINATES)
C      BCV        VECTOR OF LENGTH 2*NB. IT CONTAINS NOMINAL VALUES
C                   OF BUS CONTROL VARIABLES
C      NBOUND     NUMBER OF BOUNDARY BUSES
C      JBOUND     VECTOR OF LENGTH NBOUND. IT CONTAINS BOUNDARY BUSES
C      NRET       NUMBER OF RETAINED BUSES
C      JRET       VECTOR OF LENGTH NRET. IT CONTAINS RETAINED BUSES
C      NEWNUM     VECTOR OF LENGTH NB. IT STORES THE NEW INDICES OF

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C		AA	16
C	THE LOCAL RENUMBERING OF BUSES IN THE EXTERNAL POWER SYSTEM	AA	17
C	WITH GENERATOR BUSES GROUNDED. THE NEW INDICES OF THE BUSES ARE	AA	18
C	STORED IN THE VECTOR NRB	AA	19
C		AA	20
	DO 40 I=1,L	AA	21
	IF (I.GT.L) GO TO 30	AA	22
	IF (BTYP(I).NE.0) GO TO 20	AA	23
	J1=JRYT(I)+1	AA	24
	J2=JRYT(I+1)-1	AA	25
	DO 10 J3=J1,J2	AA	26
	KK=ICYT(J3)	AA	27
	IF (KK.GE.L) GO TO 10	AA	28
	IF (BTYP(KK).EQ.0) GO TO 30	AA	29
10	CONTINUE	AA	30
20	CONTINUE	AA	31
	NRB(I)=0	AA	32
	IF (I.LE.NEXT) KNEXT=KNEXT-1	AA	33
	GO TO 40	AA	34
30	CONTINUE	AA	35
	J=J+1	AA	36
	NRB(I)=J	AA	37
40	CONTINUE	AA	38
	KB=J	AA	39
		AA	40
C	END OF THE RENUMBERING	AA	41
C		AA	42
C	CALCULATE A COEFFICIENT MATRIX (VECTORS AK,NROW,NCOL) OF	AA	43
C	THE EXTERNAL POWER SYSTEM WITH THE GENERATOR BUSES GROUNDED	AA	44
C		AA	45
	NZ=0	AA	46
	DO 60 I=1,NEXT	AA	47
		AA	48
C	IN THIS LOOP "NEXT" ROWS OF THE ADMITTANCE MATRIX ARE CHANGED	AA	49
C	TO THE FORM OF THE COEFFICIENT MATRIX	AA	50
C		AA	51
	IF (NRB(I).EQ.0) GO TO 60	AA	52
	J1=JRYT(I)	AA	53
	J2=JRYT(I+1)-1	AA	54
	DO 50 J=J1,J2	AA	55
	KK=ICYT(J)	AA	56
	IF (NRB(KK).EQ.0) GO TO 50	AA	57
	NZ=NZ+1	AA	58
	NROW(NZ)=NRB(I)	AA	59
	NCOL(NZ)=NRB(KK)	AA	60
	AK(NZ)=YT(J)	AA	61
50	CONTINUE	AA	62
60	CONTINUE	AA	63
		AA	64
C	END OF THE CHANGES	AA	65
C		AA	66
	N=NEXT+1	AA	67
	DO 80 I=N,L	AA	68
		AA	69
C	IN THIS LOOP THE ROWS "N,...,L" OF THE ADMITTANCE MATRIX ARE	AA	70
C	CHANGED TO THE FORM OF THE COEFFICIENT MATRIX	AA	71
C		AA	72
C	THE VALUES OF DIAGONAL ELEMENTS OF THE ADMITTANCE MATRIX OF THE	AA	73
C	EXTERNAL SYSTEM CORRESPONDING TO THE BOUNDARY AND RETAINED BUSES	AA	74
C	ARE CALCULATED	AA	75
C		AA	76
	IF (NRB(I).EQ.0) GO TO 80	AA	77
	J1=JRYT(I)+1	AA	78
	J2=JRYT(I+1)-1	AA	79
	J3=JRYT(I)	AA	80

	Y=(0.0,0.0)	AA 81
	DO 70 J=J1,J2	AA 82
	KK=ICYT(J)	AA 83
	IF (NRB(KK).EQ.0) GO TO 70	AA 84
	IF (KK.GE.L) GO TO 70	AA 85
	NZ=NZ+1	AA 86
	NROW(NZ)=NRB(I)	AA 87
	NCOL(NZ)=NRB(KK)	AA 88
	Y=Y+YT(J)	AA 89
	AK(NZ)=YT(J)	AA 90
	70 CONTINUE	AA 91
C		AA 92
C	THE DIAGONAL ELEMENTS	AA 93
C		AA 94
	NZ=NZ+1	AA 95
	NROW(NZ)=NRB(I)	AA 96
	NCOL(NZ)=NRB(I)	AA 97
	AK(NZ)=-Y	AA 98
	80 CONTINUE	AA 99
C		AA 100
C	END OF THE CHANGES	AA 101
C		AA 102
	DO 90 I=N,L	AA 103
	IF (NRB(I).EQ.0.AND.BTYP(I).EQ.0) NRB(I)=-1	AA 104
	90 CONTINUE	AA 105
C		AA 106
C	PERFORM THE GAUSSIAN ELIMINATION	AA 107
C		AA 108
	CALL GAUSEL (KB,NZ,KNEXT,NROW,NCOL,AK,VR,LCOL,ITAG,CE,IFLAG,IWRITE	AA 109
	1) IF (IFLAG.LT.0) RETURN	AA 110
		AA 111
C		AA 112
C	CALCULATE A SPARSE ADMITTANCE MATRIX (VECTORS CE,LCOL,ITAG) OF	AA 113
C	THE EXTERNAL EQUIVALENT	AA 114
C		AA 115
	KB=KB-KNEXT	AA 116
	CALL SPAMAT (KB,NZ,NCOL,NROW,AK,LCOL,ITAG,CE)	AA 117
C		AA 118
C	CALCULATE THE NUMBER AND VALUES OF THE FICTITIOUS BRANCHES	AA 119
C		AA 120
	NFIC=0	AA 121
	DO 130 I=1,NBRE	AA 122
	J=NEXT+I	AA 123
	J1=NRB(J)	AA 124
	IF (J1.EQ.0) GO TO 130	AA 125
	NFIC=NFIC+1	AA 126
	Y=(0.0,0.0)	AA 127
	IF (J1.LT.0) GO TO 110	AA 128
	J1=LCOL(NFIC)+1	AA 129
	J2=LCOL(NFIC+1)-1	AA 130
	DO 100 J=J1,J2	AA 131
	Y=Y+CE(J)	AA 132
	100 CONTINUE	AA 133
	J=LCOL(NFIC)	AA 134
	Y=Y+CE(J)	AA 135
	NRB(NFIC)=I	AA 136
	AP(NFIC)=Y	AA 137
	GO TO 130	AA 138
	110 CONTINUE	AA 139
	J1=JRYT(J)	AA 140
	J2=J1+1	AA 141
	J3=JRYT(J+1)-1	AA 142
	DO 120 J=J2,J3	AA 143
	IF (ICYT(J).GE.L) Y=Y+YT(J)	AA 144
	120 CONTINUE	AA 145

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NRB(NFIC)=I AA 146
AP(NFIC)=YT(J1)+Y AA 147
130 CONTINUE AA 148
C THE VALUES OF THE FICTITIOUS BRANCHES ARE STORED IN THE VECTOR AA 149
C AP. THE INDICES OF THE BOUNDARY BUSES INCIDENT WITH THE AA 150
C FICTITIOUS BRANCHES ARE STORED IN THE VECTOR NRB AA 151
C AA 152
C AA 153
IF (NFIC.EQ.0) RETURN AA 154
IF (IWRITE.LT.3) RETURN AA 155
WRITE (OTPT,150) AA 156
DO 140 I=1,NFIC AA 157
WRITE (OTPT,160) I,AP(I) AA 158
140 CONTINUE AA 159
150 FORMAT (//,4X,"THE FICTITIOUS BRANCH ADMITTANCES",//,4X,"BUS",13X, AA 160
1"ADMITTANCE"/) AA 161
160 FORMAT (2X,14,4X,2(E12.5,2X)) AA 162
RETURN AA 163
END AA 164-
C AB 1
C AB 2
SUBROUTINE GAUSEL (N,NEL,NEXT,NROW,NCOL,AK,V,LCOL,ITAG,CE,IFLAG,IW AB 3
IRITE) AB 4
C AB 5
C THIS SUBROUTINE PERFORMS GAUSSIAN ELIMINATION FOR A SYSTEM OF AB 6
C LINEAR EQUATIONS DESCRIBED BY A COEFFICIENT MATRIX AK AND A AB 7
C RIGHT HAND SIDE VECTOR V. THE ELIMINATION IS PERFORMED FOR A AB 8
C NUMBER OF EQUATIONS GIVEN BY THE VARIABLE "NEXT" AB 9
C AB 10
C N NUMBER OF EQUATIONS AB 11
C NEL NUMBER OF NONZERO ELEMENTS IN THE COEFFICIENT MATRIX AB 12
C NEXT NUMBER OF EQUATIONS FOR WHICH THE ELIMINATION IS AB 13
C PERFORMED AB 14
C NROW VECTOR OF DIMENSION NEL. IT CONTAINS THE ROW INDICES AB 15
C OF ELEMENTS OF THE COEFFICIENT MATRIX AB 16
C NCOL VECTOR OF DIMENSION NEL. IT CONTAINS THE COLUMN AB 17
C INDICES OF ELEMENTS OF THE COEFFICIENT MATRIX AB 18
C AK VECTOR OF DIMENSION NEL. IT CONTAINS THE NONZERO AB 19
C ELEMENTS OF THE COEFFICIENT MATRIX AB 20
C V VECTOR OF DIMENSION NEL. RIGHT HAND SIDE VECTOR AB 21
C LCOL AUXILIARY VECTOR OF DIMENSION 2*N AB 22
C ITAG AUXILIARY VECTOR OF DIMENSION AT LEAST 2*NEL AB 23
C CE AUXILIARY VECTOR OF DIMENSION AT LEAST 2*NEL AB 24
C IWRITE PARAMETER THAT CONTROLS OUTPUT. IF IWRITE=4 THE AB 25
C COEFFICIENT MATRIX AK BEFORE AND AFTER GAUSSIAN AB 26
C ELIMINATION IS PRINTED OUT ON UNIT 6 AB 27
C IFLAG RETURN FLAG FROM GAUSEL. IFLAG=0 FOR A SUCCESSFUL AB 28
C RETURN. IFLAG=-1 IF THE LENGTH OF VECTORS ITAG AND CE AB 29
C HAVE BEEN DECLARED TOO SMALL AB 30
C AB 31
C INTEGER NROW(1),NCOL(1),LCOL(1),ITAG(1),OTPT AB 32
C COMPLEX CE(1),AK(1),V(1) AB 33
C OTPT=6 AB 34
C AB 35
C CALL SPAMAT (N,NEL,NCOL,NROW,AK,LCOL,ITAG,CE) AB 36
C AB 37
C CALL ASUB (N,NEXT,NEL,LCOL,ITAG,CE,V,AK,NCOL,NROW,IFLAG,IWRITE) AB 38
C AB 39
C RETURN AB 40
C END AB 41-
C AC 1
C AC 2
SUBROUTINE INTERV (ISTOS,IBOUND,IBINTE,NINTE,JRGA,ICGA) AC 3
C AC 4
C THIS SUBROUTINE DETERMINES THE BUSES BELONGING TO THE INTERNAL AC 5

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C	POWER SYSTEM. THE RESULTS ARE STORED IN THE VECTOR IBINTE.	AC	6
C	IBINTE(K) IS SET TO 1 IF THE KTH BUS BELONGS TO THE INTERNAL	AC	7
C	POWER SYSTEM. THE NUMBER OF THE INTERNAL BUSES IS STORED AS THE	AC	8
C	PARAMETER NINTE	AC	9
C		AC	10
C	ISTOS AN AUXILIARY VECTOR	AC	11
C	JRGA VECTOR CONTAINS ROW INDICES OF THE ADJACENCY	AC	12
C	MATRIX	AC	13
C	ICGA VECTOR CONTAINS COLUMN INDICES OF THE ADJACENCY	AC	14
C	MATRIX	AC	15
C	IBOUND VECTOR CONTAINS THE CODED INDICES OF THE BUSES	AC	16
C	BELONGING TO THE BOUNDARY	AC	17
C		AC	18
C	INTEGER ISTOS(1), IBOUND(1), IBINTE(1), JRGA(1), ICGA(1)	AC	19
C	LOGICAL BELONG	AC	20
C		AC	21
C	ICSTOS=1	AC	22
C	NINTE=1	AC	23
C		AC	24
C	ISTOS(1) CONTAINS THE INDEX OF THE SLACK BUS	AC	25
C		AC	26
C	IBINTE(ISTOS(1))=1	AC	27
C	10 CONTINUE	AC	28
C	N=ISTOS(ICSTOS)	AC	29
C		AC	30
C	DETERMINE THE INDICES OF BUSES INCIDENT WITH THE NTH BUS	AC	31
C		AC	32
C	ICSTOS=ICSTOS-1	AC	33
C	INC1=JRGA(N)+1	AC	34
C	INC2=JRGA(N+1)	AC	35
C	DO 20 J=INC1, INC2	AC	36
C	INCJ=ICGA(J)	AC	37
C	IF (BELONG(INCJ, IBOUND)) GO TO 20	AC	38
C	IF (IBINTE(INCJ).EQ.1) GO TO 20	AC	39
C		AC	40
C	THE INCJTH BUS BELONGS TO THE INTERNAL SYSTEM	AC	41
C		AC	42
C	IBINTE(INCJ)=1	AC	43
C	NINTE=NINTE+1	AC	44
C		AC	45
C	PUT THE INDEX INCJ ONTO THE STACK (VECTOR ISTOS)	AC	46
C		AC	47
C	ICSTOS=ICSTOS+1	AC	48
C	ISTOS(ICSTOS)=INCJ	AC	49
C	20 CONTINUE	AC	50
C	IF (ICSTOS.GT.0) GO TO 10	AC	51
C	RETURN	AC	52
C	END	AC	53-
C		AD	1
C		AD	2
C	SUBROUTINE MOVE (N, NYT, YT, JRYT, ICYT)	AD	3
C		AD	4
C	THIS SUBROUTINE REMOVES THE FIRST ROW FROM A MATRIX STORED IN	AD	5
C	SPARSE FORM (VECTORS YT, JRYT, ICYT) AND MODIFIES THESE VECTORS	AD	6
C		AD	7
C	INTEGER JRYT(1), ICYT(1)	AD	8
C	COMPLEX YT(1)	AD	9
C		AD	10
C	K=2	AD	11
C		AD	12
C	MODIFY THE VECTORS ICYT AND YT	AD	13
C		AD	14
C	NEL=JRYT(K)-1	AD	15
C	NYT=NYT-NEL	AD	16
C	DO 10 I=1, NYT	AD	17

	K=NEL+1	AD 18
	ICYT(I)=ICYT(K)	AD 19
	YT(I)=YT(K)	AD 20
	10 CONTINUE	AD 21
C		AD 22
C	MODIFY THE VECTOR JRYT	AD 23
C		AD 24
	DO 20 I=2,N	AD 25
	JRYT(I)=JRYT(I+1)-NEL	AD 26
	20 CONTINUE	AD 27
C		AD 28
C	MODIFY THE VECTOR ICYT	AD 29
C		AD 30
	DO 30 I=1, NYT	AD 31
	ICYT(I)=ICYT(I)-1	AD 32
	30 CONTINUE	AD 33
	N=N-1	AD 34
	RETURN	AD 35
	END	AD 36-
C		AE 1
C		AE 2
	SUBROUTINE NOTE (IEL, IB)	AE 3
C		AE 4
C	THIS SUBROUTINE CODES THE ELEMENT IEL IN THE VECTOR IB	AE 5
C		AE 6
	INTEGER IB(1)	AE 7
C		AE 8
	IX=(IEL-1)/50	AE 9
	IY=IEL-IX*50	AE 10
	J=IX+1	AE 11
	CALL SETBIT (IB(J), IY)	AE 12
	RETURN	AE 13
	END	AE 14-
C		AF 1
C		AF 2
	SUBROUTINE ORDEVE (NB, NTL, LBINP, LBOUT, JRGA, ICCA)	AF 3
C		AF 4
C	THIS SUBROUTINE FORMS AN ADJACENCY MATRIX OF A GRAPH AND STORES	AF 5
C	IT IN A SPARSE FORM (VECTORS JRGA AND ICCA)	AF 6
C	NB NUMBER OF NODES	AF 7
C	NTL NUMBER OF EDGES	AF 8
C	LBINP, LBOUT INTEGER VECTORS OF DIMENSION NTL. LBINP(K), LBOUT(K)	AF 9
C	STORE THE NODES OF THE GRAPH INCIDENT WITH THE KTH	AF 10
C	EDGE	AF 11
C	JRGA STARTING POSITIONS OF ROWS. JRGA(K)+1 INDICATES THE	AF 12
C	FIRST POSITION OF ELEMENTS OF THE KTH ROW IN THE	AF 13
C	VECTOR ICCA	AF 14
C	ICCA STORES THE COLUMN INDICES OF NONZERO ELEMENTS OF THE	AF 15
C	ADJACENCY MATRIX.	AF 16
C		AF 17
	INTEGER LBINP(1), LBOUT(1), JRGA(1), ICCA(1)	AF 18
C		AF 19
	J=NB+1	AF 20
C		AF 21
	DO 10 I=1, J	AF 22
	JRGA(I)=0	AF 23
	10 CONTINUE	AF 24
C		AF 25
C	CALCULATE THE NUMBER OF EDGES INCIDENT WITH EACH NODE	AF 26
C		AF 27
	DO 20 I=1, NTL	AF 28
	JRGA(LBINP(I))=JRGA(LBINP(I))+1	AF 29
	JRGA(LBOUT(I))=JRGA(LBOUT(I))+1	AF 30
	20 CONTINUE	AF 31
C		AF 32

C	CALCULATE THE VECTOR JRGA	AF	33
C	NS2=JRGA(1)	AF	34
	JRGA(1)=1	AF	35
	DO 30 I=1,NB	AF	36
	NS1=JRGA(I+1)	AF	37
	JRGA(I+1)=JRGA(I)+NS2	AF	38
	NS2=NS1	AF	39
	30 CONTINUE	AF	40
		AF	41
C	CALCULATE THE VECTOR ICGA	AF	42
C	DO 40 I=1,NTL	AF	43
C	NS1=LBINP(I)	AF	44
	NS2=LBOUT(I)	AF	45
	ICGA(JRGA(NS1))=NS2	AF	46
	ICGA(JRGA(NS2))=NS1	AF	47
	JRGA(NS1)=JRGA(NS1)+1	AF	48
	JRGA(NS2)=JRGA(NS2)+1	AF	49
	40 CONTINUE	AF	50
		AF	51
		AF	52
C	MODIFICATION OF THE VECTOR JRGA	AF	53
C	NS1=JRGA(1)	AF	54
C	JRGA(1)=0	AF	55
	IX=NB+1	AF	56
	DO 50 I=2,IX	AF	57
	NS2=JRGA(I)	AF	58
	JRGA(I)=NS1-1	AF	59
	NS1=NS2	AF	60
	50 CONTINUE	AF	61
	RETURN	AF	62
	END	AF	63
		AF	64
		AF	65-
C		AG	1
C	SUBROUTINE PRINAD (N,JRYT,ICYT,YT,IWRITE,OTPT)	AG	2
		AG	3
C	THIS SUBROUTINE PRINTS OUT AN ADMITTANCE MATRIX STORED IN A	AG	4
C	SPARSE FORM (VECTORS YT,JRYT,ICYT)	AG	5
C		AG	6
	INTEGER JRYT(1),ICYT(1),OTPT	AG	7
	COMPLEX YT(1)	AG	8
		AG	9
C	IF (IWRITE.NE.3) RETURN	AG	10
	WRITE (OTPT,40)	AG	11
	DO 10 I=1,N	AG	12
	J1=JRYT(I)	AG	13
	J2=JRYT(I+1)-1	AG	14
	WRITE (OTPT,20) ICYT(J1)	AG	15
	WRITE (OTPT,30) (ICYT(J),YT(J),J=J1,J2)	AG	16
	10 CONTINUE	AG	17
	20 FORMAT (// "BUS NO.",I3)	AG	18
	30 FORMAT (3(3X,I3," ",2(1X,E13.7)))	AG	19
	40 FORMAT (// " ADMITTANCE MATRIX YT"// "IN EACH ROW OF MATRIX ", "DATA	AG	20
	1 IS IN SEQUENCE: COLUMN NUMBER,REAL(YT),IMAG(YT) ")	AG	21
	RETURN	AG	22
	END	AG	23
		AG	24-
C		AH	1
C	SUBROUTINE PRINTNC (N,NROW,NCOL,V,OTPT)	AH	2
		AH	3
C	THIS SUBROUTINE PRINTS THE NONZERO COEFFICIENTS OF A COMPLEX	AH	4
C	MATRIX V	AH	5
C		AH	6
C		AH	7
	INTEGER NROW(1),NCOL(1),OTPT	AH	8

	COMPLEX V(1)	AH	9
C	IF (N.LE.0) RETURN	AH	10
	IF (N.GT.1) GO TO 10	AH	11
	WRITE (OTPT,110)	AH	12
	WRITE (OTPT,100)	AH	13
	GO TO 30	AH	14
10	CONTINUE	AH	15
	IF (N.EQ.4.OR.N.EQ.2) GO TO 20	AH	16
	WRITE (OTPT,80)	AH	17
	WRITE (OTPT,50)	AH	18
	GO TO 30	AH	19
20	WRITE (OTPT,70)	AH	20
	WRITE (OTPT,60)	AH	21
30	N3=(N+2)/3	AH	22
	DO 40 I=1,N3	AH	23
	LI=I	AH	24
	LO=I+2*N3	AH	25
	IF (LO.GT.N) LO=I+N3	AH	26
	IF (LO.GT.N) LO=I	AH	27
	WRITE (OTPT,90) (NROW(J),NCOL(J),V(J),J=LI,LO,N3)	AH	28
40	CONTINUE	AH	29
	RETURN	AH	30
50	FORMAT (1H ,11X, " REAL IMAGINARY",18X,"REAL IM	AH	31
	AGINARY",18X,"REAL IMAGINARY",/)	AH	32
60	FORMAT (1H ,11X, " REAL IMAGINARY",18X,"REAL IM	AH	33
	AGINARY",/)	AH	34
70	FORMAT (1H , " ROW COL ",11X,"VALUE ROW COL",11X, "	AH	35
	1VALUE",/)	AH	36
80	FORMAT (1H , " ROW COL ",11X,"VALUE ROW COL",11X, "	AH	37
	1,"VALUE ROW COL ",11X,"VALUE",/)	AH	38
90	FORMAT (1X,14,15,2E15.6,215,2E15.6,215,2E15.6)	AH	39
100	FORMAT (1H ,16X,"REAL",9X,"IMAGINARY",/)	AH	40
110	FORMAT (1H , " ROW COL ",14X,"VALUE",/)	AH	41
	END	AH	42
		AH	43-
C		AI	1
C		AI	2
	SUBROUTINE RDATA (NBOUND,JBOUND,NRET,JRET,INPT)	AI	3
C		AI	4
C	THIS SUBROUTINE READS THE DATA DESCRIBING BOUNDARY AND RETAINED	AI	5
C	BUSES	AI	6
C		AI	7
	INTEGER JBOUND(1),JRET(1)	AI	8
C		AI	9
C	READ THE NUMBER OF BOUNDARY BUSES	AI	10
C		AI	11
	READ (INPT,*) NBOUND	AI	12
C		AI	13
C	READ BOUNDARY BUSES	AI	14
C		AI	15
	DO 10 I=1,NBOUND	AI	16
	READ (INPT,*) JBOUND(I)	AI	17
10	CONTINUE	AI	18
C		AI	19
C	READ THE NUMBER OF RETAINED BUSES	AI	20
C		AI	21
	READ (INPT,*) NRET	AI	22
	IF (NRET.EQ.0) RETURN	AI	23
C		AI	24
C	READ RETAINED BUSES	AI	25
C		AI	26
	DO 20 I=1,NRET	AI	27
	READ (INPT,*) JRET(I)	AI	28
20	CONTINUE	AI	29
C		AI	30

	RETURN	AI	31
	END	AI	32-
C		AJ	1
C		AJ	2
	SUBROUTINE SETBIN (NBI, JBI, IBI)	AJ	3
C		AJ	4
C	THIS SUBROUTINE CODES NBI ELEMENTS OF THE VECTOR JBI IN	AJ	5
C	THE VECTOR IBI	AJ	6
	INTEGER JBI(1), IBI(1)	AJ	7
C		AJ	8
	DO 10 I=1, NBI	AJ	9
	CALL NOTE (JBI(I), IBI)	AJ	10
	10 CONTINUE	AJ	11
	RETURN	AJ	12
	END	AJ	13
		AJ	14-
C		AK	1
C		AK	2
	SUBROUTINE SETBIT (K, I)	AK	3
C		AK	4
C	THIS SUBROUTINE SETS TO 1 THE ITH BIT IN THE WORD K	AK	5
C		AK	6
	J=1	AK	7
	I1=I-1	AK	8
	J=SHIFT(J, I1)	AK	9
	K=K.OR.J	AK	10
	RETURN	AK	11
	END	AK	12-
C		AL	1
C		AL	2
	SUBROUTINE SETVEC (N, NYT, JRYT, ICYT, YT, I, J, NEL, IFLAG)	AL	3
C		AL	4
C	IN THIS SUBROUTINE THE ITH ROW OF THE MATRIX STORED IN THE	AL	5
C	SPARSE FORM (VECTORS YT, JRYT, ICYT) IS SUBTRACTED FROM THE JTH	AL	6
C	ROW OF THIS MATRIX	AL	7
C		AL	8
	INTEGER ICYT(1), JRYT(1)	AL	9
	COMPLEX YT(1)	AL	10
C		AL	11
C		AL	12
	SUBTRACT THE ITH ROW FROM THE JTH ROW	AL	13
	I1=JRYT(I)+1	AL	14
	I2=JRYT(I+1)-1	AL	15
	J1=JRYT(J)	AL	16
	J2=JRYT(J+1)-1	AL	17
	NEL=0	AL	18
	IFLAG=0	AL	19
	NEL1=NYT	AL	20
	DO 10 J3=J1, J2	AL	21
	IF (I.EQ. ICYT(J3)) GO TO 20	AL	22
	10 CONTINUE	AL	23
	IFLAG=-10	AL	24
	WRITE (6, 160) IFLAG	AL	25
	RETURN	AL	26
	20 CONTINUE	AL	27
C		AL	28
C		AL	29
C	CALCULATE THE NUMBER OF THE NEW ELEMENTS IN THE JTH ROW	AL	30
	INEL=J3	AL	31
	DO 40 I3=I1, I2	AL	32
	I4=ICYT(I3)	AL	33
	DO 30 J3=J1, J2	AL	34
	IF (I4.EQ. ICYT(J3)) GO TO 40	AL	35
	30 CONTINUE	AL	36
	NEL=NEL+1	AL	37

	40 CONTINUE	AL 38
C		AL 39
C	MODIFY MATRICES YT, JRYT, ICYT (CHANGE THE LENGTH)	AL 40
C		AL 41
	JNEL=JRYT(J+1)-1	AL 42
	IF (NEL.EQ.0) GO TO 70	AL 43
	IF (NEL.NE.0) NEL=NEL-1	AL 44
	IF (NEL.EQ.0) GO TO 100	AL 45
	I1=NYT+1	AL 46
	I2=NEL+I1	AL 47
	J1=0	AL 48
	J2=JNEL+1	AL 49
	DO 50 J3=J2, NYT	AL 50
	J1=J1+1	AL 51
	ICYT(I2-J1)=ICYT(I1-J1)	AL 52
	YT(I2-J1)=YT(I1-J1)	AL 53
	50 CONTINUE	AL 54
	I2=N+1	AL 55
	I1=J+1	AL 56
	DO 60 I3=I1, I2	AL 57
	JRYT(I3)=JRYT(I3)+NEL	AL 58
	60 CONTINUE	AL 59
	NYT=NYT+NEL	AL 60
	GO TO 100	AL 61
	70 CONTINUE	AL 62
	NYT=NYT-1	AL 63
	DO 80 I1=INEL, NYT	AL 64
	ICYT(I1)=ICYT(I1+1)	AL 65
	YT(I1)=YT(I1+1)	AL 66
	80 CONTINUE	AL 67
	I1=J+1	AL 68
	I2=N+1	AL 69
	DO 90 I3=I1, I2	AL 70
	JRYT(I3)=JRYT(I3)-1	AL 71
	90 CONTINUE	AL 72
	JNEL=JNEL-1	AL 73
	100 CONTINUE	AL 74
	IF (NYT.LE.2*NEL) GO TO 110	AL 75
	IFLAG=-1	AL 76
	RETURN	AL 77
	110 CONTINUE	AL 78
C		AL 79
C	CALCULATE THE NEW VALUES OF THE ELEMENTS OF THE JTH ROW	AL 80
C		AL 81
	K=0	AL 82
	I1=JRYT(I)+1	AL 83
	I2=JRYT(I+1)-1	AL 84
	J1=JRYT(J)	AL 85
	J2=JRYT(J+1)-1	AL 86
C		AL 87
	DO 150 I3=I1, I2	AL 88
	I4=ICYT(I3)	AL 89
	DO 120 J3=J1, JNEL	AL 90
	IF (I4.EQ.ICYT(J3)) GO TO 140	AL 91
	120 CONTINUE	AL 92
	IF (K.EQ.NEL) GO TO 130	AL 93
	ICYT(J2-K)=I4	AL 94
	YT(J2-K)=-YT(I3)	AL 95
	K=K+1	AL 96
	GO TO 150	AL 97
	130 CONTINUE	AL 98
	ICYT(INEL)=I4	AL 99
	YT(INEL)=-YT(I3)	AL 100
	GO TO 150	AL 101
	140 CONTINUE	AL 102

	YT(J3)=YT(J3)-YT(I3)	AL 103
150	CONTINUE	AL 104
	RETURN	AL 105
160	FORMAT (2X, "IFLAG FROM SETVEC=IFLAG= ", I3, 3X, "AN ERROR IN THE MATR	AL 106
	IX ICYT")	AL 107
	END	AL 108-
C		AM 1
C		AM 2
	SUBROUTINE SPAMAT (N, NEL, NCOL, NROW, AK, JRYT, ICYT, YT)	AM 3
C		AM 4
C	THIS SUBROUTINE CHANGES THE COEFFICIENT MATRIX (VECTORS AK, NROW,	AM 5
C	NCOL) TO THE SPARSE MATRIX FORM AND STORES IT IN VECTORS YT, JRYT	AM 6
C	AND ICYT	AM 7
C		AM 8
	COMPLEX AK(1), YT(1), Y, Y1	AM 9
	INTEGER NCOL(1), NROW(1), JRYT(1), ICYT(1)	AM 10
C		AM 11
	N1=N+1	AM 12
	DO 10 I=1, N1	AM 13
	JRYT(I)=0	AM 14
10	CONTINUE	AM 15
	JRYT(I)=1	AM 16
C		AM 17
C	CALCULATE THE NUMBER OF ELEMENTS IN EACH ROW	AM 18
C		AM 19
	DO 20 I=1, NEL	AM 20
	JRYT(NROW(I)+1)=JRYT(NROW(I)+1)+1	AM 21
20	CONTINUE	AM 22
C		AM 23
C	MODIFY THE VECTOR JRYT	AM 24
C		AM 25
	DO 30 I=1, N	AM 26
	JRYT(I+1)=JRYT(I)+JRYT(I+1)	AM 27
30	CONTINUE	AM 28
C		AM 29
C	CALCULATE THE VECTORS YT, ICYT	AM 30
C		AM 31
	DO 40 I=1, NEL	AM 32
	NRWI=NROW(I)	AM 33
	NCLI=NCOL(I)	AM 34
	LCNC=JRYT(NRWI)	AM 35
	YT(LCNC)=AK(I)	AM 36
	ICYT(LCNC)=NCLI	AM 37
	JRYT(NRWI)=LCNC+1	AM 38
40	CONTINUE	AM 39
C		AM 40
C	MODIFY THE VECTORS JRYT, ICYT	AM 41
C		AM 42
	DO 50 I=1, N	AM 43
	J=N-1+2	AM 44
	JRYT(J)=JRYT(J-1)	AM 45
50	CONTINUE	AM 46
	JRYT(1)=1	AM 47
	DO 60 I=1, N	AM 48
	IF (JRYT(I).EQ.JRYT(I+1)) JRYT(I)=0	AM 49
60	CONTINUE	AM 50
	DO 90 I=1, N	AM 51
C		AM 52
C	CHANGE THE POSITION OF DIAGONAL ELEMENTS IN THE VECTOR ICYT	AM 53
C		AM 54
	J1=JRYT(I)	AM 55
	J2=JRYT(I+1)-1	AM 56
	DO 80 J=J1, J2	AM 57
	J3=ICYT(J)	AM 58
	IF (J3.EQ.I) GO TO 70	AM 59

	GO TO 80	AM 60
70	CONTINUE	AM 61
	Y=YT(J)	AM 62
	Y1=YT(J1)	AM 63
	YT(J)=Y1	AM 64
	YT(J1)=Y	AM 65
	ICYT(J)=ICYT(J1)	AM 66
	ICYT(J1)=J3	AM 67
	GO TO 90	AM 68
80	CONTINUE	AM 69
90	CONTINUE	AM 70
	RETURN	AM 71
	END	AM 72-
C		AN 1
C		AN 2
	SUBROUTINE ZERO (N, IB)	AN 3
C		AN 4
C	THIS SUBROUTINE SETS TO ZERO N ELEMENTS OF THE VECTOR IB	AN 5
C		AN 6
	INTEGER IB(1)	AN 7
C		AN 8
	DO 10 I=1,N	AN 9
	IB(I)=0	AN 10
10	CONTINUE	AN 11
	RETURN	AN 12
	END	AN 13-