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OPTIMIZATION OF THE
IEEE 118-BUS POWER SYSTEM**

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OF THE IEEE 118-BUS POWER SYSTEM

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Abstract

A single-line diagram and brief description of the IEEE 118-bus system is provided in this report. The system is extensively used in the application and verification of various analytical methods and computerized algorithms for power network analysis and planning. The complex Lagrangian method is employed to evaluate sensitivities of different network functions. These sensitivities have been verified by small perturbations about the nominal point. A minimum-loss problem is formulated and solved using the optimization package MINOS/AUGMENTED.

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I. INTRODUCTION

The IEEE 118-bus system [1] is a standard, average size test network. It has been extensively used in a variety of steady-state analysis and planning studies. The power transmission network of the system comprises transmission lines, tap-changing-under-load transformers and phase-shifting transformers [2,3]. At some of the nodes, the static load is specified, which may be used as a means of controlling a given network function.

A single-line diagram of the system is provided which indicates load and generator buses, and their interconnections through transmission elements. The diagram is useful for investigating expansion plans, fault and contingency analysis, and real-time operations [4]. The generator bus with widest P, Q limits and/or largest generation is generally chosen to represent the slack bus and is declared as the last bus of the system.

The load flow problem of the system may be formulated in complex, rectangular or polar mode and can be solved by using an appropriate package [5-9]. In order to evaluate sensitivities of a real network function, various packages [5-7] can be used and the sensitivities supplied to gradient-type optimization routines. However, in this report we have presented the results obtained from the package XLF3 [6], which is capable of handling the complex turns ratio of phase-shifting transformers. The package can provide sensitivities w.r.t. bus-type control variables and adjustable control parameters of transmission elements, including the turns ratio and internal impedance of the transformers. A minimum-loss problem of the system is formulated and solved using the optimization package MINOS/AUGMENTED [10]. The various data files and the computer program listing are included in the Appendix.

II. GENERAL DESCRIPTION

The IEEE 118-bus system shown in Fig. 1 consists of load buses ($n_L = 64$), generator buses ($n_G = 53$) and a slack bus, usually indexed as the last bus ($n = 118$). The power transmission network of the system comprises lines ($n_T = 170$), tap-changing-under-load transformers ($n_t = 7$) and phase-shifting transformers ($n_p = 2$). At some of the buses ($n_s = 14$), switchable shunt reactors/capacitors are provided. The buses with zero demand ($n_d = 10$) are considered as load buses and are included in n_L .

The power system has been frequently investigated as a standard test network in large scale optimal power flow and planning studies [11]. The load flow problem has been formulated and solved by implementing different algorithms [5-9] from a flat voltage profile of the system. We describe data files which are relevant to package XLF3. These files are available under the charge RJWBAND [12] and can be accessed by the following commands

```
/GET, B118FVA/GR.
```

```
/GET, B118FVB/GR.
```

The difference between these files lies only in the values of the control variables associated with some of the generator buses listed in Table I and it appears that B118FVB is an optimized version of B118FVA. The solution files are also available under the same charge, namely, B118SVA and B118SVB, respectively. All the values in these various files are in the per unit system.

III. SENSITIVITY EVALUATION USING PACKAGE XLF3

The package XLF3 [6] has been designed to handle the load flow equations in complex mode and provide sensitivities of a general real function with respect to network controls listed in Table II. However, it is the user's responsibility to supply the right-hand-side vector of the adjoint system of a function of interest. We present some examples to illustrate the use of this package.

Example 1

We consider the voltage magnitude at a load bus ($\ell = 35$) given by

$$f_1 = |V_{35}| = (V_{35} V_{35}^*)^{1/2}. \quad (1)$$

The non-zero element of $df_1/d\mathbf{V}$ is given by

$$\frac{df}{dV_{35}} = \frac{0.5 V_{35}^*}{|V_{35}|}. \quad (2)$$

The sensitivities of this function with respect to several control variables are provided in Table III.

Example 2

Another network state associated with a load bus is the bus voltage angle and we consider a function given by

$$f_2 = \delta_{16} = \tan^{-1} \left[\frac{V_{16} - V_{16}^*}{j(V_{16} + V_{16}^*)} \right]. \quad (3)$$

The function is dependent on complex voltage V_{16} and its conjugate, hence the only non-zero element of $df_2/d\mathbf{V}$ is given by

$$\frac{df_2}{dV_{16}} = -j \frac{0.5}{V_{16}}. \quad (4)$$

The sensitivities of f_2 with respect to various control variables are provided in Table IV.

Example 3

Next, we consider reactive power at a generator bus ($g = 72$) given by

$$f_3 = Q_{72} = \frac{S_{72} - S_{72}^*}{2j}. \quad (5)$$

Using Fig. 1 (page 55), we write the current injected at this bus in the form

$$I_{72} = Y_{72,72} V_{72} + Y_{72,24} V_{24} + Y_{72,71} V_{71} \quad (6)$$

and the function f_3 can be expressed as

$$f_3 = \frac{V_{72} I_{72}^* - V_{72}^* I_{72}}{2j}. \quad (7)$$

The variables involved in (7) are complex voltages at buses 24, 71 and 72 and their complex conjugates. Hence the non-zero elements of vector $df_3/d\mathbf{V}$ are given by

$$\frac{df_3}{dV_{24}} = j0.5 Y_{72,24} V_{72}^* , \quad (8)$$

$$\frac{df_3}{dV_{71}} = j0.5 Y_{72,71} V_{72}^* , \quad (9)$$

and

$$\frac{df_3}{dV_{72}} = j0.5 [(Y_{72,72} - Y_{72,72}^*) V_{72}^* - (Y_{72,24}^* V_{24}^* + Y_{72,71}^* V_{71}^*)] . \quad (10)$$

The sensitivities of this function are provided in Table V.

Example 4

The real power at the slack bus ($n = 118$) is considered in this example, which can be expressed in the form

$$f_4 = P_n = \frac{S_n + S_n^*}{2} . \quad (11)$$

From Fig. 1, the various buses connected to the slack bus are 47, 49, 68, 70, 75 and 77. Using an expression for the injected current similar to (6), we can express the non-zero elements of $df_4/d\mathbf{V}$ in a straightforward manner. These elements are

$$\frac{df_4}{dV_k} = 0.5 \left(Y_{nk} V_n^* + \delta_{kn} \sum_{i=1}^n Y_{ni}^* V_i^* \right) \quad (12)$$

where

$$\delta_{kn} = \begin{cases} 0 & \text{for } k \neq n \\ 1 & \text{for } k = n \end{cases}$$

The sensitivities of this function are provided in Table VI.

We have considered δ_g ($g = 72$) and Q_n also, in a manner similar to Examples 2 and 3, respectively. Their sensitivities are displayed in Tables VII and VIII. These results have been verified by small perturbations about the nominal point.

IV. FORMULATION AND SOLUTION OF A MINIMUM-LOSS PROBLEM

The minimum-loss problem of a power system is a constrained minimization problem where the cost function is the total transmission active power loss in the system. The problem is routinely solved with multiple objectives [11,13]. For an n-node system, the function is given by

$$f = \sum_{i=1}^n P_i, \quad (13)$$

where P_i is the net real power injected at the i th node [14]. The load flow equations are included as equality constraints and the bounds on other system variables \mathbf{x} and/or \mathbf{u} are represented as inequality constraints. The problem, in general, is stated as

minimize f

subject to

$$\mathbf{h}(\mathbf{x}, \mathbf{u}) = \mathbf{0}$$

and

$$\mathbf{g}(\mathbf{x}, \mathbf{u}) \geq \mathbf{0}.$$

We consider the generator-bus control variables with the bounds

$$0.9 \leq |V_g| \leq 1.1$$

$$0 \leq P_g \leq 1.30 P_{g(\text{nominal})}$$

for all g . The specifications for the problem are displayed in Table IX. The results from the optimization package MINOS/AUGMENTED are summarized in Table X. A brief description of the package and computer program listing are provided in the Appendix.

V. CONCLUSIONS

The IEEE 118-bus system has been described briefly. The complex Lagrangian method has been employed to evaluate sensitivities of various network functions. The control variables considered are load bus real and reactive powers, generator bus voltage magnitudes and real powers, line conductances and susceptances, turns ratios and internal impedances of

phase-shifting and tap-changing-under-load transformers. The sensitivities have been verified by small perturbations about the nominal point. A minimum-loss problem for the system has been formulated and solved by an optimization package, which is capable of verifying the objective gradients. Any other optimization problem may be attempted in a similar way. For corridor selection or line contingency the single-line diagram may prove quite useful.

VI. REFERENCES

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APPENDIX

MINOS/AUGMENTED (ALIAS MINOS VERSION 4.0)

This is a general purpose nonlinear programming system developed by Murtagh and Saunders [10]. The system is especially designed for solving large-scale optimization problems involving sparse linear and nonlinear constraints [11].

The solution process consists of a sequence of "major iterations". At the start of each major iteration, the nonlinear constraints are linearized at the current point and the cost function is modified. This includes a quadratic penalty function and an estimation of the Lagrange multipliers for the linearized constraints. The linearly constrained subproblems are then solved in a sequence of "minor iterations" using the reduced-gradient algorithm shown in Fig. 2 (page 56).

The data for an optimal power flow problem is supplied by means of the SPECS file, the MPS file and the power network data file.

DESCRIPTION OF THE FILES

Unit Number	Description
1	SPECS data containing a list of keywords and values defining various optimization parameters. MPS data containing linear objectives and constraints, inequalities and right-hand-sides of constraints, upper and lower bounds for variables and constraints, and the definition of the starting point.
3	B118SVB describing the transmission elements and the load flow solution of the IEEE 118-bus system. All the values contained in this file are in the per unit system.
6	Output file containing listing of the SPECS and MPS data, parameters, iteration log, solution and error messages.
9	Scratch file used during input of the SPECS file and for storing ROW and COLUMN names from the MPS data.
10	OLD BASIS FILE intended for restarting the solution of the problem at a point reached by an earlier run ("warm start").
11	NEW BASIS FILE stored for a subsequent run of the problem.

Computer program listing

	PROGRAM MAIN(DDA, B118F, OUTPUT, SCRTCH, BASISF, TAPE1=DDA, TAPE4=B118F,	A	1
	1TAPE6=OUTPUT, TAPE9=SCRTCH, TAPE10=BASISF)	A	2
	DIMENSION W(10000)	A	3
	COMMON /MNCFG/ LCOUNT	A	4
	LCOUNT=1	A	5
	LW=10000	A	6
	CALL MINOS1 (W, LW, 1, 6, 9)	A	7
	STOP	A	8
	END	A	9
C		B	1
C		B	2
	SUBROUTINE CALCFG (MODE, N, X, F, G, NSTATE, NPROG)	B	3
	COMPLEX V(118), DLX(118), DSX(236), YT(476)	B	4
	INTEGER BTYP(118), JRYT(119), IGYT(1000), LBINP(179), LBOUT(179), OTPT	B	5
	DIMENSION X(106), G(106), BCV(236), WS(25000)	B	6
	COMMON /XLF3ID/ ITEL, TIMEL, VEPS, IDER, ILOAD, IADJ	B	7
	COMMON /MNCFG/ LCOUNT	B	8
C		B	9
C		B	10
C		B	11
C		B	12
C		B	13
	IF (LCOUNT.GT.1) GO TO 30	B	14
	NB=118	B	15
	INPT=4	B	16
	OTPT=6	B	17
	LWS=25000	B	18
	IP=0	B	19
	NTL=179	B	20
	NYT=NB+2*NTL	B	21
	IFLAG=0	B	22
	IMODE=1	B	23
	IDER=1	B	24
	IWRITE=0	B	25
	PWL=0.0	B	26
	N1=NB-1	B	27
	CALL FORMPR (LBINP, LBOUT, BTYP, YT, JRYT, IGYT, BCV, V, WS, LWS, NB, NTL, NLB	B	28
	1, IP, INPT, OTPT, IFLAG, IWRITE)	B	29
	IF (IFLAG.GE.0) GO TO 10	B	30
	WRITE (OTPT, 90) IFLAG	B	31
	STOP	B	32
10	DO 20 I=1, N1	B	33
	IF (BTYP(I).NE.0) GO TO 20	B	34
	JP=2*I-1	B	35
	PWL=PWL+BCV(JP)	B	36
20	CONTINUE	B	37
30	J=0	B	38
	PWG=0.0	B	39
	NG=53	B	40
	DO 40 I=1, N1	B	41
	IF (BTYP(I).EQ.0) GO TO 40	B	42
	J=J+1	B	43
	I2=2*I	B	44
	R=X(J)	B	45
	V(I)=V(I)*(R/BCV(I2))	B	46
	BCV(I2)=R	B	47
	BCV(I2-1)=X(NG+J)	B	48
	PWG=PWG+BCV(I2-1)	B	49
40	CONTINUE	B	50
	CALL LFNCM (NB, NLB, NYT, JRYT, IGYT, BTYP, YT, V, BCV, WS, LWS, DSX, IMODE, IF	B	51
	LAG, OTPT, IWRITE)	B	52
	IF (IFLAG.GE.0) GO TO 50	B	53
	WRITE (OTPT, 100) IFLAG	B	54
	STOP	B	55
C			

Computer program listing (continued)

50	LCOUNT=LCOUNT+1	B	56
	FS=0.0	B	57
	KK=JRYT(NB+1)-JRYT(NB)	B	58
	DO 60 J=1, KK	B	59
	KJ=JRYT(NB)+J-1	B	60
	KA=ICYT(KJ)	B	61
	AV=CONJG(YT(KJ))*V(KA)	B	62
	FS=FS+REAL(V(NB)*AV)	B	63
60	CONTINUE	B	64
	F=PWL+PWG+FS	B	65
	WRITE (OTPT, 110) PWL, PWG, F	B	66
	DO 70 I=1, NB	B	67
	J=2*I-1	B	68
	DLX(I)=DSX(J)	B	69
70	CONTINUE	B	70
	LK=0	B	71
	DO 80 K=1, N1	B	72
	IF (BTYP(K).EQ.0) GO TO 80	B	73
	LK=LK+1	B	74
	LP=LK+NG	B	75
	CALL DERIVX (LBINP, LBOUT, LG, LB, LTAP, BTYP, V, NB, K, L2, DLX, NTL, 1, G(LP)	B	76
	1, G(LK))	B	77
80	CONTINUE	B	78
	RETURN	B	79
90	FORMAT (//, 1X, "RETURN FLAG FROM FORMPR: ", I3)	B	80
100	FORMAT (//, 1X, "RETURN FLAG FROM LFNCM: ", I3)	B	81
110	FORMAT (//, 5X, "PWL: ", F7.2, 2X, "PWG: ", F7.2, 2X, "LOSS: ", F10.6)	B	82
	END	B	83

Computer program listing (continued)

C		C	1
C		C	2
	SUBROUTINE FORMMU (V, AI, NB, DS, DSL, IDER, YT, JRYT, ICYT, BTYP, NYT, OTPT)	C	3
	COMPLEX V(1), AI(1), DS(1), DF(1:18), YT(1), DSL	C	4
	INTEGER JRYT(1), ICYT(1), BTYP(1), IDER, OTPT	C	5
	N=NB-1	C	6
	DO 10 I=1, NB	C	7
	DS(I)=(0., 0.)	C	8
	DF(I)=(0., 0.)	C	9
	DF(N+I)=(0., 0.)	C	10
10	CONTINUE	C	11
	DO 40 I=1, NB	C	12
	IF (BTYP(I).EQ.0) GO TO 40	C	13
	KJ=JRYT(I+1)-JRYT(I)	C	14
	DO 30 J=1, KJ	C	15
	J1=JRYT(I)+J-1	C	16
	DF(ICYT(J1))=DF(ICYT(J1))+0.5*YT(J1)*CONJG(V(I))	C	17
	IF (BTYP(ICYT(J1)).EQ.0) GO TO 30	C	18
	DO 20 K=1, KJ	C	19
	J2=JRYT(I)+K-1	C	20
	DF(ICYT(J1))=DF(ICYT(J1))+0.5*CONJG(YT(J2)*V(ICYT(J2)))	C	21
20	CONTINUE	C	22
30	CONTINUE	C	23
40	CONTINUE	C	24
	DSL=0.	C	25
	DO 50 I=1, N	C	26
	J=2*I-1	C	27
	K=J+1	C	28
	DS(J)=DF(I)	C	29
	DS(K)=CONJG(DF(I))	C	30
50	CONTINUE	C	31
	RETURN	C	32
	END	C	33

TABLE I
CONTROL VARIABLES ASSOCIATED WITH GENERATOR BUSES

Control Variable	Bus Indices
P_g and $ V_g $	6, 31, 32, 34, 36, 76, 105, 110
P_g only	1, 15, 18, 19, 55, 56, 62, 70, 74, 77, 85, 87, 103, 104, 116
$ V_g $ only	10, 12, 27, 25, 66

TABLE II
PRACTICAL CONTROL VARIABLES OF A POWER NETWORK

Variable	Description
P_ℓ	demand real power
Q_ℓ	demand reactive power
P_g	generator real power
$ V_g $	generator bus voltage magnitude
V_{n1}	real component of the slack bus voltage
G_t	line conductance of a transmission line
B_t	line susceptance of a transmission line
G_{sh}	shunt conductance of a transmission line
B_{sh}	shunt susceptance of a transmission line
a_1	real component of the complex turns ratio
a_2	imaginary component of the complex turns ratio
$ a $	magnitude of the complex turns ratio
ϕ	phase angle of the complex turns ratio
R_t	resistance of a phase-shifting transformer
X_t	reactance of a phase-shifting transformer

TABLE III

118-BUS SYSTEM: SENSITIVITIES OF /V35/

LOAD BUS QUANTITIES - TOTAL DERIVATIVES

BUS	REAL POWER	REACTIVE POWER	SHUNT CONDUCTANCE	SHUNT SUSCEPTANCE
2	.00009905	.00000016	-.00011645	.00000019
3	.00009836	.00000059	-.00012187	.00000073
5	.00009370	.00000086	-.00010849	.00000100
7	.00009681	.00000003	-.00010694	.00000003
9	.00009109	-.00000007	-.00010930	-.00000009
11	.00009752	.00000038	-.00010832	.00000042
13	.00009760	.00000070	-.00010200	.00000073
14	.00009701	-.00000008	-.00010264	-.00000009
16	.00010932	.00001527	-.00011676	.00001631
17	.00013653	.00009111	-.00013157	.00008780
20	.00008310	.00000185	-.00007261	.00000162
21	.00007464	.00000297	-.00006330	.00000252
22	.00006411	.00000332	-.00005376	.00000278
23	.00004627	.00000143	-.00003913	.00000121
28	.00007259	.00001124	-.00003117	.00000483
29	.00008166	.00000574	-.00004154	.00000292
30	.00013286	.00040267	-.00014608	.00044274
33	.00044873	.00135824	-.00041432	.00125408
35	.00223000	.00928986	-.00206657	.00860904
37	.00070672	.00287131	-.00066426	.00269880
38	.00031769	.00146331	-.00034429	.00158583
39	.00037225	.00103905	-.00034449	.00096156
41	.00004143	.00000002	-.00004120	.00000002
43	.00003584	.00000059	-.00003286	.00000054
44	.00001655	.00000082	-.00001567	.00000078
45	.00000947	.00000050	-.00000906	.00000048
47	.00000192	.00000003	-.00000198	.00000003
48	.00000182	.00000001	-.00000188	.00000001
50	-.00000005	-.00000005	.00000005	-.00000005
51	-.00000146	-.00000004	.00000136	-.00000004
52	-.00000180	-.00000001	.00000164	-.00000001
53	-.00000270	.00000001	.00000239	.00000001
57	-.00000221	-.00000005	.00000207	-.00000004
58	-.00000247	-.00000003	.00000226	-.00000002
60	-.00000858	-.00000002	.00000842	-.00000002
63	-.00000905	.00000001	.00000942	.00000001
64	-.00000977	.00000002	.00001010	.00000002
67	-.00000746	-.00000003	.00000778	-.00000004
68	-.00000402	-.00000049	.00000419	-.00000051
69	.00000363	-.00000027	-.00000328	-.00000024
71	.00001172	-.00000000	-.00001136	-.00000000
75	.00000424	-.00000004	-.00000398	-.00000003
78	.00000053	.00000003	-.00000053	.00000003
79	.00000045	.00000003	-.00000046	.00000003
81	-.00000039	-.00000012	.00000039	-.00000012
82	.00000048	.00000002	-.00000047	.00000001
83	.00000045	.00000001	-.00000044	.00000001
84	.00000040	.00000001	-.00000039	.00000001
86	.00000038	.00000000	-.00000037	.00000000
88	.00000035	.00000000	-.00000034	.00000000
93	.00000034	.00000000	-.00000033	.00000000
94	.00000034	.00000001	-.00000033	.00000001

TABLE III (continued)

95	.00000035	.00000001	-.00000034	.00000001
96	.00000037	.00000001	-.00000036	.00000001
97	.00000030	.00000001	-.00000030	.00000001
98	.00000026	-.00000000	-.00000027	-.00000000
101	.00000032	.00000000	-.00000032	.00000000
102	.00000033	.00000000	-.00000032	.00000000
106	.00000033	.00000000	-.00000031	.00000000
108	.00000033	.00000000	-.00000031	.00000000
109	.00000033	.00000000	-.00000031	.00000000
114	.00006935	.00000037	-.00005085	.00000027
115	.00006665	-.00000030	-.00004626	-.00000021
117	.00009908	.00000034	-.00010664	.00000037

 GENERATOR BUS QUANTITIES - TOTAL DERIVATIVES

BUS	REAL POWER	VOLTAGE MAGNITUDE	SHUNT CONDUCTANCE	SHUNT SUSCEPTANCE
1	.00009983	-.00008235	-.00013203	0.00000000
4	.00009757	-.00006536	-.00011806	0.00000000
6	.00009605	.00003358	-.00010629	0.00000000
8	.00009274	.00841126	-.00011018	0.00000000
10	.00008927	.00001543	-.00010317	0.00000000
12	.00009788	.00046395	-.00010812	0.00000000
15	.00009282	.01253202	-.00008733	0.00000000
18	.00010627	.00174232	-.00009999	0.00000000
19	.00009330	.00001401	-.00008598	0.00000000
24	.00003846	.00003426	-.00003185	0.00000000
25	.00003518	.00009707	-.00003310	0.00000000
26	.00002708	.00505779	-.00002762	0.00000000
27	.00006390	.00012007	-.00004328	0.00000000
31	.00008329	.00068722	-.00005106	0.00000000
32	.00007071	.00000756	-.00005377	0.00000000
34	.00004861	.04627823	-.00004471	0.00000000
36	.00019653	.87576665	-.00018225	0.00000000
40	.00004568	.03256432	-.00004298	0.00000000
42	.00002972	.00001553	-.00003596	0.00000000
46	.00000447	.00000601	-.00000447	0.00000000
49	.00000111	.00007593	-.00000115	0.00000000
54	-.00000333	-.00000148	.00000300	0.00000000
55	-.00000417	.00000175	.00000377	0.00000000
56	-.00000383	.00000016	.00000346	0.00000000
59	-.00000749	.00001973	.00000734	0.00000000
61	-.00000888	.00000937	.00000888	0.00000000
62	-.00000841	-.00000157	.00000841	0.00000000
65	-.00001186	.01582056	.00001186	0.00000000
66	-.00000658	.00005021	.00000727	0.00000000
70	.00000922	-.00000239	-.00000885	0.00000000
72	.00002432	-.00000742	-.00002335	0.00000000
73	.00001174	-.00000064	-.00001150	0.00000000
74	.00000549	-.00000034	-.00000506	0.00000000
76	.00000245	.00000693	-.00000219	0.00000000
77	.00000070	.00000307	-.00000072	0.00000000
80	.00000023	.00000317	-.00000025	0.00000000
85	.00000038	.00000043	-.00000037	0.00000000
87	.00000037	-.00000001	-.00000038	0.00000000
89	.00000033	.00000015	-.00000033	0.00000000
90	.00000034	-.00000006	-.00000034	0.00000000
91	.00000034	.00000004	-.00000032	0.00000000

TABLE III (continued)

92	.00000033	.00000012	-.00000032	0.00000000
99	.00000030	.00000004	-.00000030	0.00000000
100	.00000031	-.00000003	-.00000032	0.00000000
103	.00000032	-.00000009	-.00000033	0.00000000
104	.00000033	.00000006	-.00000031	0.00000000
105	.00000033	.00000008	-.00000031	0.00000000
107	.00000034	.00000001	-.00000031	0.00000000
110	.00000034	.00000010	-.00000032	0.00000000
111	.00000033	.00000000	-.00000032	0.00000000
112	.00000035	-.00000010	-.00000034	0.00000000
113	.00010545	.00291366	-.00010335	0.00000000
116	-.00000379	-.00001049	.00000379	0.00000000

 LINE QUANTITIES - TOTAL DERIVATIVES

LINE INDEX	ELEMENT	LINE CONDUCTANCE	LINE SUSCEPTANCE
1	1, 2	-.00000054	-.00000003
2	1, 3	-.00000025	-.00000007
3	4, 5	-.00000048	-.00000029
4	3, 5	-.00000103	-.00000045
5	5, 6	-.00000012	-.00000008
6	6, 7	-.00000001	-.00000001
7	8, 9	-.00000142	-.00000022
9	9, 10	-.00000173	-.00000027
10	4, 11	-.00000021	-.00000002
11	5, 11	-.00000028	-.00000023
12	11, 12	.00000000	.00000000
13	2, 12	-.00000022	-.00000003
14	3, 12	-.00000048	.00000003
15	7, 12	-.00000001	-.00000001
16	11, 13	-.00000013	-.00000001
17	12, 14	-.00000008	.00000001
18	13, 15	-.00000053	-.00000001
19	14, 15	-.00000057	-.00000002
20	12, 16	.00000022	-.00000025
21	15, 17	.00000285	.00000282
22	16, 17	.00000346	-.00000286
23	17, 18	.00000256	.00000211
24	18, 19	-.00000014	.00000009
25	19, 20	-.00000029	-.00000011
26	15, 19	-.00000000	-.00000000
27	20, 21	-.00000014	-.00000018
28	21, 22	-.00000014	-.00000037
29	22, 23	-.00000042	-.00000129
30	23, 24	-.00000006	.00000013
31	23, 25	-.00000050	-.00000146
33	25, 27	.00000066	-.00000519
34	27, 28	-.00000078	-.00000118
35	28, 29	-.00000057	-.00000032
37	8, 30	-.00000659	-.00001823
38	26, 30	-.00009281	.00000251
39	17, 31	-.00001350	.00001787
40	29, 31	-.00000045	-.00000030
41	23, 32	.00000053	-.00000196
42	31, 32	.00000030	-.00000013
43	27, 32	-.00000046	-.00000009
44	15, 33	-.00000799	-.00001474

TABLE III (continued)

45	19, 34	-.00000005	.00000055
46	35, 36	.00002108	.00000145
47	35, 37	-.00015942	-.00007755
48	33, 37	.00002908	.00001908
49	34, 36	-.00000057	-.00000023
50	34, 37	.00006981	.00004792
52	37, 39	.00011004	.00004258
53	37, 40	.00023966	.00006523
54	30, 38	-.00003273	-.00001336
55	39, 40	.00002433	-.00000088
56	40, 41	.00000007	.00000007
57	40, 42	.00000150	.00000028
58	41, 42	.00000089	-.00000001
59	43, 44	.00000026	-.00000062
60	34, 43	-.00000003	.00000009
61	44, 45	.00000002	-.00000020
62	45, 46	.00000007	-.00000022
63	46, 47	.00000003	-.00000007
64	46, 48	.00000004	-.00000009
65	47, 49	.00000000	-.00000002
66	42, 49	-.00000342	-.00000725
67	76, 69	-.00000000	-.00000002
68	45, 49	.00000025	-.00000081
69	48, 49	.00000000	-.00000001
70	49, 50	-.00000003	.00000003
71	49, 51	-.00000014	.00000013
72	51, 52	-.00000000	.00000000
73	52, 53	-.00000001	-.00000000
74	53, 54	.00000001	-.00000002
75	49, 54	-.00000030	.00000012
76	75, 69	-.00000001	.00000001
77	54, 55	.00000000	.00000002
78	54, 56	.00000000	.00000001
79	55, 56	.00000000	.00000000
80	56, 57	-.00000003	.00000000
81	50, 57	-.00000006	.00000004
82	56, 58	-.00000001	-.00000001
83	51, 58	-.00000001	.00000000
84	54, 59	.00000017	-.00000010
85	56, 59	.00000016	-.00000016
86	12, 117	-.00000007	-.00000004
87	55, 59	.00000015	-.00000015
88	59, 60	.00000001	-.00000004
89	59, 61	.00000006	-.00000010
90	60, 61	.00000002	-.00000001
91	60, 62	.00000000	.00000000
92	61, 62	.00000000	-.00000001
94	63, 64	.00000000	-.00000002
96	38, 65	-.00025136	.00002791
97	64, 65	-.00000001	-.00000009
98	49, 66	.00000029	-.00000096
99	68, 116	.00000001	-.00000001
100	62, 66	-.00000005	.00000012
101	62, 67	-.00000001	.00000002
103	66, 67	-.00000001	.00000004
104	65, 68	-.00000009	-.00000053
105	47, 118	.00000003	-.00000007
106	49, 118	.00000001	-.00000001
108	118, 70	.00000044	-.00000041
109	24, 70	.00000178	.00000111
110	70, 71	-.00000001	-.00000001
111	24, 72	.00000072	.00000058
112	71, 72	.00000005	.00000000
113	71, 73	-.00000000	-.00000000
114	70, 74	-.00000008	.00000008

TABLE III (continued)

115	70, 75	-.000000003	.000000003
116	118, 75	.000000025	-.000000021
117	74, 75	.000000001	-.000000002
118	76, 77	.000000009	-.000000016
119	118, 77	.000000001	.000000004
120	75, 77	.000000011	-.000000038
121	77, 78	-.000000000	.000000000
122	78, 79	.000000000	-.000000000
123	77, 80	.000000001	-.000000003
124	114, 115	-.000000009	.000000002
125	79, 80	.000000000	-.000000001
126	68, 81	.000000009	.000000023
128	77, 82	-.000000001	-.000000001
129	82, 83	-.000000000	-.000000000
130	83, 84	-.000000000	-.000000000
131	83, 85	-.000000001	-.000000001
132	84, 85	-.000000000	-.000000000
133	85, 86	-.000000000	-.000000000
134	86, 87	-.000000000	-.000000000
135	85, 88	-.000000000	-.000000000
136	85, 89	-.000000001	-.000000001
137	88, 89	-.000000000	-.000000000
138	89, 90	-.000000000	-.000000000
139	27, 115	-.000000005	-.000000005
140	90, 91	-.000000000	-.000000000
141	89, 92	-.000000000	-.000000000
142	32, 114	-.000000004	-.000000000
143	91, 92	.000000000	-.000000000
144	92, 93	-.000000000	-.000000000
145	92, 94	-.000000001	-.000000000
146	93, 94	-.000000000	-.000000000
147	94, 95	-.000000000	-.000000000
148	80, 96	.000000001	-.000000000
149	82, 96	.000000000	-.000000000
150	94, 96	-.000000000	-.000000000
151	80, 97	.000000000	-.000000000
152	80, 98	.000000000	-.000000000
153	80, 99	.000000000	.000000000
154	92, 100	-.000000000	.000000000
155	94, 100	.000000000	-.000000000
156	95, 96	-.000000000	-.000000000
157	96, 97	.000000000	.000000000
158	98, 100	-.000000000	.000000000
159	99, 100	-.000000000	.000000000
160	100, 101	-.000000000	.000000000
161	92, 102	-.000000000	.000000000
162	101, 102	-.000000000	.000000000
163	100, 103	-.000000000	-.000000000
164	100, 104	-.000000000	-.000000000
165	103, 104	-.000000000	-.000000000
166	103, 105	-.000000000	-.000000000
167	100, 106	-.000000000	-.000000000
168	104, 105	-.000000000	-.000000000
169	105, 106	-.000000000	-.000000000
170	105, 107	-.000000000	-.000000000
171	105, 108	-.000000000	-.000000000
172	106, 107	-.000000000	-.000000000
173	108, 109	-.000000000	-.000000000
174	103, 110	-.000000000	-.000000000
175	109, 110	-.000000000	-.000000000
176	110, 111	-.000000000	-.000000000
177	110, 112	-.000000000	-.000000000
178	17, 113	.000000074	-.000000058
179	32, 113	-.000000507	-.000000055

TABLE III (continued)

 TCUL TRANSFORMER QUANTITIES - TOTAL DERIVATIVES

ELEMENT	TURNS RATIO	INTERNAL RESISTANCE	INTERNAL REACTANCE
8, 5	-.00003960	-.00114937	-.00011288
26, 25	-.00000563	-.00001109	-.00015337
30, 17	.00821560	.01729376	.00663096
38, 37	-.03326443	-.08252525	-.01498019
66, 65	-.00000031	-.00038844	-.00000795
118, 68	.00000874	-.00007395	-.00013815
81, 80	-.00000351	.00000892	.00000381

 PHASE SHIFTER QUANTITIES - TOTAL DERIVATIVES

ELEMENT	TURNS RATIO MAGNITUDE	TURNS RATIO PHASE ANGLE	INTERNAL RESISTANCE	INTERNAL REACTANCE
63, 59	-.00000160	-.00003913	.00000597	-.00005252
64, 61	.00000065	-.00003323	-.00000397	-.00000146

TABLE IV

118-BUS SYSTEM: SENSITIVITIES OF DELTA(16)

LOAD BUS QUANTITIES - TOTAL DERIVATIVES

BUS	REAL POWER	REACTIVE POWER	SHUNT CONDUCTANCE	SHUNT SUSCEPTANCE
2	-.17004450	-.00022678	.19990486	-.00026660
3	-.16517760	-.00154336	.20466065	-.00191228
5	-.15085955	-.00288223	.17467750	-.00333728
7	-.16416226	-.00011855	.18134223	-.00013096
9	-.13798225	.00010987	.16556147	.00013183
11	-.16455509	-.00096888	.18278521	-.00107622
13	-.15956008	-.00139056	.16675593	-.00145327
14	-.16132857	.00017468	.17068619	.00018481
16	-.19349642	.01156403	.20566509	.01235104
17	-.12980846	.00024684	.12509119	.00023787
20	-.12200850	-.00118895	.10660604	-.00103885
21	-.11633030	-.00187642	.09865636	-.00159134
22	-.10881770	-.00182630	.09124807	-.00153143
23	-.09567220	.00015568	.08091344	.00013167
28	-.11862603	-.01719199	.05093224	-.00738140
29	-.12139957	-.00844459	.06176421	-.00429634
30	-.12158165	-.00034963	.13368097	-.00038443
33	-.11692359	-.00082672	.10795679	-.00076332
35	-.09812601	-.00014064	.09093473	-.00013034
37	-.09606682	-.00057761	.09029480	-.00054290
38	-.09615255	-.00139144	.10420347	-.00150794
39	-.09049899	-.00021838	.08374947	-.00020209
41	-.08317900	-.00010038	.08271288	-.00009982
43	-.08468981	-.00079960	.07763642	-.00073300
44	-.06228493	-.00109815	.05897483	-.00103979
45	-.05372558	-.00082840	.05139862	-.00079252
47	-.03856793	-.00009069	.03962460	-.00009318
48	-.04420204	.00007228	.04557622	.00007453
50	-.04440502	-.00005403	.04414491	-.00005371
51	-.04537017	-.00030608	.04216586	-.00028446
52	-.04566885	-.00038316	.04158248	-.00034887
53	-.04549152	-.00031960	.04037242	-.00028364
57	-.04522025	-.00003640	.04228302	-.00003403
58	-.04557317	-.00019357	.04162787	-.00017681
60	-.04462843	-.00000285	.04381798	-.00000279
63	-.04427382	.00005373	.04607659	.00005592
64	-.04398174	.00003879	.04545264	.00004008
67	-.04372070	-.00006254	.04560684	-.00006524
68	-.01556129	-.00170291	.01620574	-.00177343
69	-.01019663	.00032812	.00921737	.00029661
71	-.02537478	.00000526	.02459197	.00000510
75	-.01082898	.00002076	.01016950	.00001949
78	-.00689754	-.00000107	.00589488	-.00000107
79	-.00699079	-.00000261	.00707858	-.00000264
81	-.00837206	-.00033484	.00843875	-.00033751
82	-.00672598	-.00001419	.00658555	-.00001389
83	-.00661609	-.00001577	.00641823	-.00001530
84	-.00636378	-.00002890	.00614488	-.00002791
86	-.00623045	-.00000773	.00609758	-.00000757
88	-.00613200	-.00001539	.00596558	-.00001498
93	-.00657049	-.00004965	.00638689	-.00004827
94	-.00677080	-.00005113	.00663971	-.00005014

TABLE IV (continued)

95	-.00687267	-.00007449	.00660455	-.00007159
96	-.00689983	-.00002596	.00678883	-.00002554
97	-.00705296	-.00002152	.00720989	-.00002200
98	-.00710363	-.00001280	.00745547	-.00001344
101	-.00664400	-.00004183	.00655808	-.00004129
102	-.00641902	-.00002136	.00630364	-.00002097
106	-.00723845	-.00002522	.00669352	-.00002332
108	-.00727259	-.00000349	.00679071	-.00000325
109	-.00729888	-.00000479	.00682667	-.00000448
114	-.11501101	-.00037927	.08433162	-.00027810
115	-.11499961	.00027173	.07981071	.00018858
117	-.17197993	-.00059382	.18510176	-.00063912

GENERATOR BUS QUANTITIES - TOTAL DERIVATIVES

BUS	REAL POWER	VOLTAGE MAGNITUDE	SHUNT CONDUCTANCE	SHUNT SUSCEPTANCE
1	-.16864784	.12509301	.22303677	0.00000000
4	-.16031869	.07598613	.19398562	0.00000000
6	-.16048881	-.09418939	.17761361	0.00000000
8	-.14048292	-.09256091	.16690776	0.00000000
10	-.13523171	-.02337012	.15627714	0.00000000
12	-.16988644	.06810404	.18765674	0.00000000
15	-.13306648	-.02461094	.12520225	0.00000000
18	-.12990834	.01178972	.12223076	0.00000000
19	-.12819095	-.02508307	.11814078	0.00000000
24	-.08038872	-.01338589	.06656990	0.00000000
25	-.10222827	.07463352	.09618658	0.00000000
26	-.10710285	-.05546703	.10925562	0.00000000
27	-.11377505	-.12336634	.07706314	0.00000000
31	-.12064950	-.16822855	.07396888	0.00000000
32	-.11469247	.04292284	.08721032	0.00000000
34	-.09881130	-.02513507	.09087487	0.00000000
36	-.09838763	-.00209501	.09124164	0.00000000
40	-.08634587	-.04851760	.08124283	0.00000000
42	-.07298901	.03807867	.08831671	0.00000000
46	-.04532843	-.00994466	.04532843	0.00000000
49	-.04357308	-.03553857	.04533343	0.00000000
54	-.04473967	-.02040926	.04037755	0.00000000
55	-.04537859	-.00127024	.04095418	0.00000000
56	-.04543225	-.01126374	.04100261	0.00000000
59	-.04448383	.01270422	.04359860	0.00000000
61	-.04369507	-.00189306	.04369507	0.00000000
62	-.04411181	-.00336958	.04411181	0.00000000
65	-.04381775	.01130705	.04381775	0.00000000
66	-.04288425	.01444673	.04736999	0.00000000
70	-.02021980	.00334027	.01941909	0.00000000
72	-.05130689	.01550358	.04927514	0.00000000
73	-.02541390	.00139906	.02490816	0.00000000
74	-.01319955	-.00078124	.01216471	0.00000000
76	-.00872368	-.01061712	.00779046	0.00000000
77	-.00653193	.00179628	.00666322	0.00000000
80	-.00716980	.00592125	.00775486	0.00000000
85	-.00619969	-.00171268	.00607632	0.00000000
87	-.00618038	.00009392	.00630461	0.00000000
89	-.00600183	-.00285452	.00600183	0.00000000
90	-.00635504	.00099664	.00622857	0.00000000
91	-.00634211	-.00070728	.00609097	0.00000000

TABLE IV (continued)

92	-.00629957	-.00316871	.00619918	0.00000000
99	-.00596451	-.00059770	.00710449	0.00000000
100	-.00680736	.00176040	.00708237	0.00000000
103	-.00699914	.00186472	.00713982	0.00000000
104	-.00712495	-.00123734	.00670387	0.00000000
105	-.00719867	-.00173291	.00670358	0.00000000
107	-.00743021	-.00015765	.00670576	0.00000000
110	-.00733342	-.00215990	.00694276	0.00000000
111	-.00721170	-.00008292	.00692611	0.00000000
112	-.00765684	.00209474	.00735363	0.00000000
113	-.12865611	.07413741	.12609585	0.00000000
116	-.01472948	-.03701321	.01472948	0.00000000

 LINE QUANTITIES - TOTAL DERIVATIVES

LINE INDEX	ELEMENT	LINE CONDUCTANCE	LINE SUSCEPTANCE
1	1, 2	.00072068	-.00002128
2	1, 3	.00044607	.00016863
3	4, 5	.00076860	.00072441
4	3, 5	.00187849	.00140359
5	5, 6	-.00002045	.00034290
6	6, 7	.00001404	.00003894
7	8, 9	.00215505	.00034056
9	9, 10	.00261381	.00040744
10	4, 11	.00013343	.00004121
11	5, 11	.00021992	.00083843
12	11, 12	-.00001562	.00000054
13	2, 12	.00031368	-.00000389
14	3, 12	.00046336	-.00022771
15	7, 12	.00001681	.00006289
16	11, 13	.00038850	-.00008257
17	12, 14	.00029473	-.00008539
18	13, 15	.00181285	.00021238
19	14, 15	.00216074	.00008636
20	12, 16	-.00034539	-.00026892
21	15, 17	.00019938	.00012977
22	16, 17	.00355844	.00270863
23	17, 18	.00017894	.00000633
24	18, 19	.00003606	-.00001184
25	19, 20	.00022597	.00006975
26	15, 19	.00006052	-.00000836
27	20, 21	.00013761	.00012163
28	21, 22	.00020623	.00026155
29	22, 23	.00074405	.00095938
30	23, 24	.00016813	-.00022402
31	23, 25	.00234369	-.00083895
33	25, 27	.00529030	.00208711
34	27, 28	.00256780	.00185821
35	28, 29	.00044175	.00033818
37	8, 30	.00111587	-.00036679
38	26, 30	.00568870	.00303790
39	17, 31	.00654881	.00003103
40	29, 31	.00049442	.00041328
41	23, 32	.00034520	.00158554
42	31, 32	.00051207	.00006208
43	27, 32	.00033950	.00001198
44	15, 33	.00016801	-.00012449

TABLE IV (continued)

45	19, 34	.00004682	-.00036008
46	35, 36	.00000030	.00000062
47	35, 37	.00005104	.00005083
48	33, 37	-.00011045	.00043633
49	34, 36	.00000021	-.00000066
50	34, 37	.00004251	.00006731
52	37, 39	.00041598	-.00035306
53	37, 40	.00063791	-.00082183
54	30, 38	.00034254	-.00080685
55	39, 40	.00001107	-.00008595
56	40, 41	.00000333	-.00005482
57	40, 42	-.00042706	-.00023808
58	41, 42	-.00027319	.00001360
59	43, 44	-.00024781	.00071439
60	34, 43	.00003230	-.00010178
61	44, 45	.00001264	.00023529
62	45, 46	-.00003866	.00036186
63	46, 47	-.00005827	.00017760
64	46, 48	.00004540	.00003904
65	47, 49	.00006696	-.00013752
66	42, 49	.00624982	.00745759
67	76, 69	.00000589	.00002877
68	45, 49	.00017446	.00098892
69	48, 49	.00001413	.00001250
70	49, 50	.00002984	.00002108
71	49, 51	.00016487	.00010484
72	51, 52	.00000625	.00000334
73	52, 53	.00000910	-.00000044
74	53, 54	.00004322	.00002272
75	49, 54	.00016796	.00003092
76	75, 69	.00001303	-.00000979
77	54, 55	.00002040	.00001292
78	54, 56	.00001773	.00001305
79	55, 56	.00000010	-.00000007
80	56, 57	.00001002	.00000009
81	50, 57	.00003558	.00001610
82	56, 58	.00000507	-.00000025
83	51, 58	.00000187	-.00000010
84	54, 59	.00009118	.00000640
85	56, 59	.00013048	.00004235
86	12, 117	.00012599	.00006325
87	55, 59	.00013869	.00004123
88	59, 60	.00006221	-.00000535
89	59, 61	.00024938	.00005939
90	60, 61	.00005987	.00003554
91	60, 62	.00001620	.00001013
92	61, 62	.00001529	.00000778
94	63, 64	.00003114	.00000783
96	38, 65	.00425352	.00827618
97	64, 65	.00009115	.00000766
98	49, 66	.00064719	.00008580
99	68, 116	.00005259	-.00002329
100	62, 66	.00021202	.00007702
101	62, 67	.00002601	.00000608
103	66, 67	.00009351	.00003870
104	65, 68	-.00033100	-.00191627
105	47, 118	-.00061533	-.00134391
106	49, 118	-.00044343	-.00030488
108	118, 70	-.00097060	.00090724
109	24, 70	-.00365267	-.00227970
110	70, 71	.00002329	.00001840
111	24, 72	-.00147601	-.00119674
112	71, 72	-.00011269	-.00000080
113	71, 73	.00000140	.00000012
114	70, 74	.00015040	-.00014449

TABLE IV (continued)

115	70, 75	.00010224	-.00005128
116	118, 75	-.00062681	.00054109
117	74, 75	-.00001653	.00003581
118	76, 77	-.00003840	.00020287
119	118, 77	-.00011987	-.00040493
120	75, 77	-.00005936	.00046024
121	77, 78	-.00000263	.00000287
122	78, 79	.00000182	-.00000110
123	77, 80	.00005253	-.00004083
124	114, 115	.00006163	-.00001282
125	79, 80	.00003852	-.00001060
126	68, 81	.00026135	.00043878
128	77, 82	.00001624	-.00000989
129	82, 83	.00000850	.00000373
130	83, 84	.00002769	.00001621
131	83, 85	.00006790	.00004236
132	84, 85	.00000896	.00000623
133	85, 86	.00000044	.00000025
134	86, 87	.00000699	.00000160
135	85, 88	.00002001	.00000389
136	85, 89	.00010443	.00002587
137	88, 89	.00003323	.00000966
138	89, 90	.00007659	.00003980
139	27, 115	.00006750	.00002362
140	90, 91	.00000080	.00000003
141	89, 92	.00006162	.00003011
142	32, 114	.00002723	.00000622
143	91, 92	.00000097	.00000040
144	92, 93	.00003006	.00001792
145	92, 94	.00009283	.00005377
146	93, 94	.00001736	.00000965
147	94, 95	.00000490	.00000279
148	80, 96	.00002943	.00000205
149	82, 96	.00000121	-.00000200
150	94, 96	.00001062	.00000520
151	80, 97	.00000968	.00000006
152	80, 98	.00000314	-.00000022
153	80, 99	.00001431	.00000320
154	92, 100	.00011583	.00006183
155	94, 100	.00000700	.00000164
156	95, 96	.00000201	.00000093
157	96, 97	.00000585	.00000123
158	98, 100	.00001786	.00001433
159	99, 100	.00000377	.00000416
160	100, 101	.00001628	.00000700
161	92, 102	.00000618	.00000355
162	101, 102	.00002099	.00001198
163	100, 103	.00001611	.00000976
164	100, 104	.00005477	.00002757
165	103, 104	.00001653	.00000473
166	103, 105	.00002772	.00001101
167	100, 106	.00009219	.00004960
168	104, 105	.00000205	.00000126
169	105, 106	.00000064	.00000040
170	105, 107	.00001847	.00001163
171	105, 108	.00000224	.00000121
172	106, 107	.00001216	.00000780
173	108, 109	.00000032	.00000016
174	103, 110	.00005701	.00003015
175	109, 110	.00000126	.00000039
176	110, 111	.00000524	.00000333
177	110, 112	.00002486	.00001721
178	17, 113	.00000472	-.00000824
179	32, 113	.00326372	.00022165

TABLE IV (continued)

 TCUL TRANSFORMER QUANTITIES - TOTAL DERIVATIVES

ELEMENT	TURNS RATIO	INTERNAL RESISTANCE	INTERNAL REACTANCE
8, 5	.15728958	2.09872439	1.32748228
26, 25	-.00338858	.06192167	-.09225462
30, 17	.00260407	.51773397	.46390182
38, 37	-.01970519	.42832154	-.01171692
66, 65	-.00005529	.35640225	-.00140456
118, 68	.02834040	-.27926646	-.53712202
81, 80	-.01040391	.02071155	.00604562

 PHASE SHIFTER QUANTITIES - TOTAL DERIVATIVES

ELEMENT	TURNS RATIO MAGNITUDE	TURNS RATIO PHASE ANGLE	INTERNAL RESISTANCE	INTERNAL REACTANCE
63, 59	.00153998	.00534627	.08272414	.00679456
64, 61	.00139301	-.01065389	-.00051509	-.00062186

TABLE V

118-BUS SYSTEM: SENSITIVITIES OF Q(72)

LOAD BUS QUANTITIES - TOTAL DERIVATIVES

BUS	REAL POWER	REACTIVE POWER	SHUNT CONDUCTANCE	SHUNT SUSCEPTANCE
2	.00675185	.00001138	-.00793750	.00001337
3	.00672169	.00003767	-.00332840	.00004667
5	.00643395	.00005334	-.00744975	.00006176
7	.00660856	.00000148	-.00730016	.00000163
9	.00628953	-.00000501	-.00754665	-.00000601
11	.00667157	.00002521	-.00741067	.00002800
13	.00676077	.00004775	-.00706567	.00004990
14	.00670851	-.00000514	-.00709763	-.00000544
16	.00671003	.00004612	-.00716669	.00004926
17	.00674686	.00000606	-.00650168	.00000584
20	.00785019	-.00005073	-.00685918	-.00004432
21	.00855627	-.00006921	-.00725633	-.00005870
22	.00932341	-.00006386	-.00781806	-.00005355
23	.01049993	.00008420	-.00888017	.00007121
28	.00875689	.00121795	-.00375978	.00052293
29	.00844075	.00058273	-.00429439	.00029647
30	.00636963	-.00003398	-.00700351	-.00003736
33	.00598132	.00003709	-.00552261	.00003424
35	.00511930	.00000578	-.00474413	.00000536
37	.00499931	.00002075	-.00469893	.00001951
38	.00501518	.00004979	-.00543510	.00005396
39	.00470754	.00000789	-.00435645	.00000730
41	.00432457	.00000520	-.00430034	.00000517
43	.00441941	.00004201	-.00405134	.00003851
44	.00323895	.00005772	-.00306682	.00005465
45	.00278831	.00004340	-.00266754	.00004152
47	.00199604	.00000473	-.00205072	.00000486
48	.00228718	-.00000373	-.00235829	-.00000384
50	.00229603	.00000276	-.00228258	.00000274
51	.00234492	.00001579	-.00217931	.00001468
52	.00236012	.00001980	-.00214894	.00001803
53	.00235030	.00001653	-.00208583	.00001467
57	.00233663	.00000185	-.00218485	.00000173
58	.00235469	.00000999	-.00215084	.00000913
60	.00230144	.00000013	-.00225965	.00000013
63	.00228277	-.00000277	-.00237572	-.00000288
64	.00226715	-.00000199	-.00234297	-.00000206
67	.00225531	.00000321	-.00235261	.00000335
68	.00075018	.00009534	-.00078124	.00009929
69	-.00120538	.00008039	.00108962	.00007267
71	-.03075567	-.09925416	.02980685	-.09619217
75	-.00138486	.00001002	.00130052	.00000941
78	-.00029533	-.00000907	.00029522	-.00000907
79	-.00027561	-.00000808	.00027907	-.00000818
81	-.00007786	.00002388	.00007848	.00002407
82	-.00027596	-.00000445	.00027020	-.00000436
83	-.00026625	-.00000371	.00025828	-.00000360
84	-.00024761	-.00000244	.00023909	-.00000236
86	-.00023824	-.00000030	.00023316	-.00000029
88	-.00022845	-.00000091	.00022225	-.00000088
93	-.00023420	-.00000241	.00022766	-.00000234
94	-.00024002	-.00000316	.00023537	-.00000310

TABLE V (continued)

95	-.00024604	-.00000490	.00023644	-.00000471
96	-.00024994	-.00000407	.00024592	-.00000400
97	-.00023454	-.00000230	.00023976	-.00000235
98	-.00022553	-.00000016	.00023670	-.00000017
101	-.00023180	-.00000113	.00022880	-.00000112
102	-.00022820	-.00000052	.00022410	-.00000051
106	-.00024761	-.00000086	.00022897	-.00000080
108	-.00024878	-.00000012	.00023230	-.00000011
109	-.00024968	-.00000016	.00023353	-.00000015
114	.00895171	.00003103	-.00656383	.00002275
115	.00892118	-.00002262	-.00619138	-.00001570
117	.00674514	.00002329	-.00725978	.00002507

GENERATOR BUS QUANTITIES - TOTAL DERIVATIVES

BUS	REAL POWER	VOLTAGE MAGNITUDE	SHUNT CONDUCTANCE	SHUNT SUSCEPTANCE
1	.00681767	-.00568281	-.00901637	0.00000000
4	.00668901	-.00459932	-.00809370	0.00000000
6	.00656746	.00214048	-.00726823	0.00000000
8	.00640351	.00044036	-.00760801	0.00000000
10	.00616415	.00106526	-.00712345	0.00000000
12	.00666303	.00387428	-.00735999	0.00000000
15	.00673292	.00131378	-.00633500	0.00000000
18	.00683947	-.00018097	-.00643526	0.00000000
19	.00684098	-.00044921	-.00630465	0.00000000
24	.01307353	-5.05546216	-.01082619	0.00000000
25	.00824273	.00542402	-.00775558	0.00000000
26	.00754784	-.00375416	-.00769955	0.00000000
27	.00880370	.00828115	-.00596300	0.00000000
31	.00823751	.01173222	-.00505033	0.00000000
32	.00894399	-.00616740	-.00680086	0.00000000
34	.00516413	.00114113	-.00474936	0.00000000
36	.00513560	-.00001470	-.00476259	0.00000000
40	.00449072	.00241301	-.00422532	0.00000000
42	.00379105	-.00196037	-.00458717	0.00000000
46	.00234845	.00052102	-.00234845	0.00000000
49	.00225384	.00189230	-.00234490	0.00000000
54	.00231097	.00105424	-.00208565	0.00000000
55	.00234340	.00006694	-.00211492	0.00000000
56	.00234642	.00058253	-.00211765	0.00000000
59	.00229475	-.00064271	-.00224908	0.00000000
61	.00225297	.00010463	-.00225297	0.00000000
62	.00227485	.00017310	-.00227485	0.00000000
65	.00225716	-.00088735	-.00225716	0.00000000
66	.00221270	-.00071088	-.00244415	0.00000000
70	-.00293758	-2.75682302	.00282125	0.00000000
72	-.26818275	10.19740696	.25756271	0.00000000
73	-.01238004	-2.15000451	.01213368	0.00000000
74	-.00177394	.00007596	.00163486	0.00000000
76	-.00085502	-.00210915	.00076355	0.00000000
77	-.00033265	-.00079224	.00033933	0.00000000
80	-.00021775	-.00072914	.00023552	0.00000000
85	-.00023706	-.00015462	.00023234	0.00000000
87	-.00023632	.00000359	.00024107	0.00000000
89	-.00021937	-.00010357	.00021937	0.00000000
90	-.00023131	.00003854	.00022671	0.00000000
91	-.00022959	-.00002578	.00022050	0.00000000

TABLE V (continued)

92	-.00022615	-.00010175	.00022254	0.00000000
99	-.00023185	-.00002440	.00023651	0.00000000
100	-.00023286	.00005184	.00024227	0.00000000
103	-.00023943	.00006379	.00024424	0.00000000
104	-.00024373	-.00004233	.00022932	0.00000000
105	-.00024625	-.00005928	.00022931	0.00000000
107	-.00025417	-.00000539	.00022939	0.00000000
110	-.00025086	-.00007389	.00023750	0.00000000
111	-.00024670	-.00000284	.00023693	0.00000000
112	-.00026192	.00007166	.00025155	0.00000000
113	.000703167	-.00355590	-.00589174	0.00000000
116	.00070494	.00203399	-.00070494	0.00000000

 LINE QUANTITIES - TOTAL DERIVATIVES

LINE INDEX	ELEMENT	LINE CONDUCTANCE	LINE SUSCEPTANCE
1	1, 2	-.00003776	-.00000257
2	1, 3	-.00001698	-.00000446
3	4, 5	-.00003340	-.00001895
4	3, 5	-.00006952	-.00002774
5	5, 6	-.00000894	-.00000440
6	6, 7	-.00000065	-.00000044
7	8, 9	-.00009823	-.00001552
9	9, 10	-.00011914	-.00001857
10	4, 11	-.00001502	-.00000125
11	5, 11	-.00002029	-.00001464
12	11, 12	-.00000007	.00000008
13	2, 12	-.00001538	-.00000204
14	3, 12	-.00003448	.00000111
15	7, 12	-.00000071	-.00000060
16	11, 13	-.00000647	-.00000239
17	12, 14	-.00000281	-.00000031
18	13, 15	-.00002122	.00000225
19	14, 15	-.00002168	-.00000024
20	12, 16	-.00000112	-.00000072
21	15, 17	-.00001156	.00000062
22	16, 17	-.00002464	.00000340
23	17, 18	-.00000773	-.00000304
24	18, 19	-.00000102	-.00000001
25	19, 20	.00001874	.00000801
26	15, 19	.00000034	-.00000019
27	20, 21	.00000330	.00001435
28	21, 22	-.00000955	.00002689
29	22, 23	-.00005617	.00008630
30	23, 24	.00001978	-.00003720
31	23, 25	-.00009759	-.00028998
33	25, 27	-.00046366	-.00010140
34	27, 28	-.00024579	-.00013413
35	28, 29	-.00001109	-.00001729
37	8, 30	-.00001405	.00000215
38	26, 30	-.00025276	.00024687
39	17, 31	-.00003442	-.00000160
40	29, 31	-.00002616	-.00002727
41	23, 32	-.00016515	.00013314
42	31, 32	-.00012144	.00000736
43	27, 32	-.00002924	-.00000183
44	15, 33	-.00000789	.00000581

TABLE V (continued)

45	19, 34	-.00000259	.00002055
46	35, 36	-.00000002	-.00000004
47	35, 37	-.00000278	-.00000304
48	33, 37	.00000485	-.00002058
49	34, 36	.00000001	.00000004
50	34, 37	-.00000225	-.00000419
52	37, 39	-.00002202	.00001843
53	37, 40	-.00003397	.00004297
54	30, 38	-.00001904	.00004271
55	39, 40	-.00000064	.00000451
56	40, 41	-.00000013	.00000287
57	40, 42	.00002293	.00001247
58	41, 42	.00001463	-.00000071
59	43, 44	.00001311	-.00003764
60	34, 43	-.00000170	.00000537
61	44, 45	-.00000064	-.00001239
62	45, 46	.00000208	-.00001896
63	46, 47	.00000305	-.00000926
64	46, 48	-.00000230	-.00000212
65	47, 49	-.00000346	.00000708
66	42, 49	-.00032511	-.00038972
67	76, 69	.00000086	.00000686
68	45, 49	-.00000374	-.00005205
69	48, 49	-.00000073	-.00000066
70	49, 50	-.00000156	-.00000107
71	49, 51	-.00000863	-.00000533
72	51, 52	-.00000033	-.00000017
73	52, 53	-.00000048	.00000002
74	53, 54	-.00000223	-.00000119
75	49, 54	-.00000890	-.00000151
76	75, 69	.00000316	-.00000248
77	54, 55	-.00000105	-.00000066
78	54, 56	-.00000092	-.00000067
79	55, 56	-.00000000	.00000000
80	56, 57	-.00000054	-.00000000
81	50, 57	-.00000188	-.00000080
82	56, 58	-.00000027	.00000001
83	51, 58	-.00000010	.00000001
84	54, 59	-.00000459	-.00000041
85	56, 59	-.00000663	-.00000231
86	12, 117	-.00000494	-.00000248
87	55, 59	-.00000706	-.00000224
88	59, 60	-.00000321	.00000025
89	59, 61	-.00001285	-.00000315
90	60, 61	-.00000308	-.00000185
91	60, 62	-.00000084	-.00000052
92	61, 62	-.00000079	-.00000041
94	63, 64	-.00000161	-.00000042
96	38, 65	-.00021903	-.00043744
97	64, 65	-.00000472	-.00000046
98	49, 66	-.00003326	-.00000513
99	68, 116	-.00000284	.00000132
100	62, 66	-.00001100	-.00000390
101	62, 67	-.00000136	-.00000030
103	66, 67	-.00000484	-.00000197
104	65, 68	.00001773	.00010230
105	47, 118	.00003184	-.00006955
106	49, 118	.00002294	-.00001577
108	118, 70	-.00014101	.00013181
109	24, 70	.00102614	.00060663
110	70, 71	.00047605	-.00033672
111	24, 72	.01947245	.01157389
112	71, 72	-.00103263	-.00044275
113	71, 73	-.00048305	.00047014
114	70, 74	.00002458	-.00002395

TABLE V (continued)

115	70, 75	.00001681	-.00000855
116	118, 75	-.00008053	.00006877
117	74, 75	-.00000274	.00000594
118	76, 77	-.00002534	.00004835
119	118, 77	-.00000610	-.00002062
120	75, 77	-.00003212	.00011253
121	77, 78	.00000050	-.00000020
122	78, 79	-.00000007	.00000024
123	77, 80	-.00000221	.00000735
124	114, 115	-.00000536	.00000111
125	79, 80	-.00000039	.00000371
126	68, 81	-.00001995	-.00005223
128	77, 82	.00000189	.00000305
129	82, 83	.00000040	.00000032
130	83, 84	.00000123	.00000119
131	83, 85	.00000292	.00000297
132	84, 85	.00000036	.00000040
133	85, 86	.00000002	.00000001
134	86, 87	.00000027	.00000006
135	85, 88	.00000076	.00000049
136	85, 89	.00000380	.00000231
137	88, 89	.00000119	.00000067
138	89, 90	.00000280	.00000135
139	27, 115	-.00000539	-.00000224
140	90, 91	.00000004	.00000000
141	89, 92	.00000226	.00000069
142	32, 114	-.00000236	-.00000044
143	91, 92	.00000001	.00000003
144	92, 93	.00000113	.00000054
145	92, 94	.00000347	.00000157
146	93, 94	.00000065	.00000027
147	94, 95	.00000017	.00000017
148	80, 96	-.00000104	.00000010
149	82, 96	-.00000002	.00000029
150	94, 96	.00000046	.00000039
151	80, 97	-.00000029	.00000015
152	80, 98	-.00000006	-.00000005
153	80, 99	-.00000018	-.00000022
154	92, 100	.00000374	.00000082
155	94, 100	-.00000001	.00000007
156	95, 96	.00000012	.00000006
157	96, 97	-.00000021	-.00000008
158	98, 100	.00000050	-.00000036
159	99, 100	.00000019	-.00000003
160	100, 101	.00000045	.00000007
161	92, 102	.00000022	.00000006
162	101, 102	.00000072	.00000019
163	100, 103	.00000055	.00000033
164	100, 104	.00000187	.00000094
165	103, 104	.00000057	.00000016
166	103, 105	.00000095	.00000038
167	100, 106	.00000315	.00000170
168	104, 105	.00000007	.00000004
169	105, 106	.00000002	.00000001
170	105, 107	.00000063	.00000040
171	105, 108	.00000008	.00000004
172	106, 107	.00000042	.00000027
173	108, 109	.00000001	.00000001
174	103, 110	.00000195	.00000103
175	109, 110	.00000004	.00000001
176	110, 111	.00000018	.00000011
177	110, 112	.00000085	.00000059
178	17, 113	-.00000299	-.00000159
179	32, 113	.00009653	.00003035

TABLE V (continued)

 TCUL TRANSFORMER QUANTITIES - TOTAL DERIVATIVES

ELEMENT	URNS RATIO	INTERNAL RESISTANCE	INTERNAL REACTANCE
8, 5	-.00235004	-.07794730	-.00314597
26, 25	-.00048305	-.00385547	-.01315120
30, 17	-.00184190	-.03203304	-.02254597
38, 37	.00072892	-.02311015	.00115501
66, 65	.00000263	-.01870806	.00006691
118, 68	-.00174979	.01394040	.02570805
81, 80	.00072357	-.00196387	-.00090000

 PHASE SHIFTER QUANTITIES - TOTAL DERIVATIVES

ELEMENT	URNS RATIO MAGNITUDE	URNS RATIO PHASE ANGLE	INTERNAL RESISTANCE	INTERNAL REACTANCE
63, 59	-.00008078	-.00030459	-.00427315	-.00038912
64, 61	-.00007156	.00052723	.00002378	.00003110

TABLE VI

118-BUS SYSTEM: SENSITIVITIES OF P(SLACK)

LOAD BUS QUANTITIES - TOTAL DERIVATIVES

BUS	REAL POWER	REACTIVE POWER	SHUNT CONDUCTANCE	SHUNT SUSCEPTANCE
2	-1.03947952	-.00177566	1.22201545	-.00208747
3	-1.03650359	-.00553631	1.28426316	-.00685968
5	-.99507943	-.00749275	1.15218419	-.00867571
7	-1.01834732	-.00019391	1.12491979	-.00021421
9	-.97706650	.00077800	1.17235775	.00093350
11	-1.02768407	-.00369840	1.14153533	-.00410812
13	-1.03966842	-.00719147	1.08655543	-.00751579
14	-1.03029460	.00079850	1.09005528	.00084482
16	-1.02625936	-.00793076	1.09610291	-.00847050
17	-1.00514412	.00210844	.96861694	.00203182
20	-1.03378892	-.00481886	.90328250	-.00421052
21	-1.02839800	-.00800622	.87215461	-.00678984
22	-1.01462573	-.00777078	.85080498	-.00651611
23	-.98396251	-.00173126	.83217273	-.00146419
28	-1.03939106	-.14814200	.44626386	-.06360495
29	-1.03830689	-.07200978	.52825727	-.03663627
30	-.99846111	-.00082252	1.09782392	-.00090437
33	-1.03137677	-.00546089	.95228109	-.00504210
35	-1.02937333	-.00135593	.95393450	-.00125656
37	-1.01214317	-.00547161	.95133017	-.00514286
38	-1.00424047	-.00209184	1.08832625	-.00226699
39	-1.06103824	-.00589303	.98190477	-.00545352
41	-1.09043811	-.00198429	1.08432739	-.00197317
43	-1.05379171	-.00266810	.96602667	-.00244589
44	-1.05862891	-.00315752	1.00236860	-.00298971
45	-1.05217123	-.00584098	1.00659952	-.00558800
47	-1.01074876	.00087212	1.03844095	.00089602
48	-1.00582314	.00166684	1.03709282	.00171866
50	-1.00831807	-.00108032	1.00241173	-.00107400
51	-1.02597980	-.00681710	.95351916	-.00633563
52	-1.03175186	-.00866156	.93943248	-.00788654
53	-1.02502749	-.00728840	.90968241	-.00646825
57	-1.02032121	-.00068954	.95404743	-.00064475
58	-1.02754937	-.00431861	.93859388	-.00394475
60	-.98774534	.00000691	.96980793	.00000679
63	-.97827655	.00117697	1.01811073	.00122490
64	-.96947983	.00082415	1.00190273	.00085172
67	-.97050048	-.00131570	1.01236865	-.00137246
68	-.99648743	.01134024	1.03775544	.01180988
69	-1.04534195	.00738271	.94494950	.00667369
71	-1.02771428	.00058528	.99600932	.00056722
75	-1.03729434	.00141770	.97412348	.00133136
78	-.98254255	-.00787083	.98216371	-.00786780
79	-.97554898	-.00718252	.98779984	-.00727271
81	-.95247223	.00108283	.96005902	.00109146
82	-.94782327	-.00531094	.92803465	-.00520006
83	-.92788452	-.00483887	.90013431	-.00469416
84	-.88524430	-.00514744	.85479381	-.00497038
86	-.86312134	-.00107113	.84471339	-.00104828
88	-.84432881	-.00240672	.82141466	-.00234140
93	-.89565747	-.00731394	.87063011	-.00710956
94	-.92182880	-.00811729	.90398112	-.00796013

TABLE VI (continued)

95	-.93775867	-.01207092	.90117440	-.01160000
96	-.94397567	-.00622334	.92878907	-.00612322
97	-.94701400	-.00424413	.96808562	-.00433856
98	-.94467143	-.00149190	.99146046	-.00156579
101	-.90138107	-.00539611	.88972477	-.00532633
102	-.87449775	-.00270238	.85877839	-.00265381
106	-.97781981	-.00340679	.90420651	-.00315032
108	-.98243118	-.00047193	.91733594	-.00044066
109	-.98598247	-.00064765	.92219275	-.00060575
114	-1.02692699	-.00336525	.75299234	-.00246757
115	-1.02724262	.00240553	.71291511	.00166946
117	-1.03758854	-.00358261	1.11675511	-.00385596

GENERATOR BUS QUANTITIES - TOTAL DERIVATIVES

BUS	REAL POWER	VOLTAGE MAGNITUDE	SHUNT CONDUCTANCE	SHUNT SUSCEPTANCE
1	-1.05085695	.88278289	1.38975832	0.00000000
4	-1.03274002	.72631606	1.24961542	0.00000000
6	-1.01309495	-.31130762	1.12119623	0.00000000
8	-.99477401	-.16765971	1.18189101	0.00000000
10	-.95758960	-.16548621	1.10661448	0.00000000
12	-1.02495812	-.57140407	1.13216977	0.00000000
15	-1.02911514	-.16417657	.96829444	0.00000000
18	-1.02473321	.08126611	.96417148	0.00000000
19	-1.03008631	-.16285547	.94932754	0.00000000
24	-.99566352	-.37784815	.82450896	0.00000000
25	-.94014678	.29784197	.88458410	0.00000000
26	-.94708040	-.22066849	.96611672	0.00000000
27	-1.01662090	-1.02098617	.68358682	0.00000000
31	-1.02452778	-1.43369547	.62812671	0.00000000
32	-1.02384235	.51577121	.77851334	0.00000000
34	-1.03309319	-.19818183	.95011618	0.00000000
36	-1.03121930	-.00170362	.95632081	0.00000000
40	-1.07735109	-.76941835	1.01367964	0.00000000
42	-1.09280091	1.20554447	1.32228910	0.00000000
46	-1.02624238	-.03418192	1.02624238	0.00000000
49	-.99289190	-.10753717	1.03300474	0.00000000
54	-1.00605152	-.45903981	.90796149	0.00000000
55	-1.01802289	-.03412057	.91876564	0.00000000
56	-1.02027243	-.25627826	.92079587	0.00000000
59	-.98772868	.22923170	.96807288	0.00000000
61	-.96565508	-.07116168	.96565508	0.00000000
62	-.97650954	-.07179493	.97650954	0.00000000
65	-.95947378	-.58741967	.95947378	0.00000000
66	-.95414318	.17719736	1.05394751	0.00000000
70	-1.02678997	-.01454241	.98612908	0.00000000
72	-1.02373509	.18477763	.98319518	0.00000000
73	-1.02936740	.06473049	1.00388299	0.00000000
74	-1.04615519	-.09106652	.96413662	0.00000000
76	-1.01880956	-.45636106	.90982241	0.00000000
77	-.97575339	-.11025454	.99536603	0.00000000
80	-.94502134	.46328594	1.02213508	0.00000000
85	-.85885956	-.31347753	.84176826	0.00000000
87	-.85618483	.01301144	.87339414	0.00000000
89	-.82279192	-.39067191	.82279192	0.00000000
90	-.87038542	-.13843580	.85306475	0.00000000
91	-.86754330	-.09689593	.83318858	0.00000000

TABLE VI (continued)

92	-.86009747	-.42237198	.84639095	0.00000000
99	-.93535251	-.08412585	.95415310	0.00000000
100	-.91958426	.23064618	.95673547	0.00000000
103	-.94549171	.25189869	.96449609	0.00000000
104	-.96248697	-.16714820	.90560399	0.00000000
105	-.97244525	-.23409290	.90556533	0.00000000
107	-1.00372306	-.02129662	.90586006	0.00000000
110	-.99064835	-.29177401	.93787552	0.00000000
111	-.97420502	-.01120157	.93562650	0.00000000
112	-1.03433823	.28297138	.99337843	0.00000000
113	-1.01218632	.59507035	.99204382	0.00000000
116	-.98991217	-.10132644	.98991217	0.00000000

LINE QUANTITIES - TOTAL DERIVATIVES

LINE INDEX	ELEMENT	LINE CONDUCTANCE	LINE SUSCEPTANCE
1	1, 2	.00590656	.00043056
2	1, 3	.00260815	.00066299
3	4, 5	.00516664	.00278962
4	3, 5	.01065761	.00398199
5	5, 6	.00148031	.00058541
6	6, 7	.00010024	.00005570
7	8, 9	.01526014	.00241156
9	9, 10	.01850868	.00288514
10	4, 11	.00243326	.00018649
11	5, 11	.00326265	.00200966
12	11, 12	.00001524	-.00001326
13	2, 12	.00239749	.00033659
14	3, 12	.00547279	-.00008876
15	7, 12	.00010936	.00007262
16	11, 13	.00105326	.00033501
17	12, 14	.00046997	.00003237
18	13, 15	.00357932	-.00027068
19	14, 15	.00360946	.00005129
20	12, 16	.00027748	.00014040
21	15, 17	.00156477	.00095833
22	16, 17	.00524296	.00015987
23	17, 18	.00119052	.00068381
24	18, 19	.00010350	.00003690
25	19, 20	.00058917	.00008862
26	15, 19	.00009684	.00000167
27	20, 21	.00068423	.00014477
28	21, 22	.00160437	.00047207
29	22, 23	.00665282	.00222521
30	23, 24	.00022056	.00015701
31	23, 25	.01808139	.00563258
33	25, 27	.05163154	.01382287
34	27, 28	.02523982	.01613313
35	28, 29	.00282162	.00258893
37	8, 30	.00191931	.00011008
38	26, 30	.04509111	.01080636
39	17, 31	.03666288	.00044741
40	29, 31	.00382800	.00346351
41	23, 32	.00907316	.00322540
42	31, 32	.00822499	.00000714
43	27, 32	.00299176	.00009427
44	15, 33	.00018372	.00006606

TABLE VI (continued)

45	19, 34	.00016647	.00003685
46	35, 36	.00000311	.00000450
47	35, 37	.00057829	.00042200
48	33, 37	.00039207	.00039777
49	34, 36	.00001206	-.00000294
50	34, 37	.00054141	.00050263
52	37, 39	.00409601	.00304145
53	37, 40	.00749043	.00548200
54	30, 38	.00099281	.0019361
55	39, 40	.00058023	.00038801
56	40, 41	.00148732	.00016113
57	40, 42	.02073968	.00027539
58	41, 42	.01179285	.00020266
59	43, 44	.00148630	-.00016680
60	34, 43	.00005164	.00015476
61	44, 45	.00075570	.00016024
62	45, 46	.00196912	.00118485
63	46, 47	.00070300	.00042229
64	46, 48	.00111141	.00071345
65	47, 49	.00063839	.00048729
66	42, 49	.07566825	.02532913
67	76, 69	.00042796	.00052656
68	45, 49	.00902473	.00581086
69	48, 49	.00032770	.00025619
70	49, 50	.00075600	.00039265
71	49, 51	.00416342	.00199254
72	51, 52	.00015136	.00006770
73	52, 53	.00023664	-.00000375
74	53, 54	.00095995	.00056781
75	49, 54	.00471494	.00034883
76	75, 69	.00022150	-.00004640
77	54, 55	.00045827	.00024199
78	54, 56	.00039841	.00026789
79	55, 56	.00000214	-.00000310
80	56, 57	.00030437	-.00001148
81	50, 57	.00099611	.00023286
82	56, 58	.00013625	.00001838
83	51, 58	.00006645	-.00001405
84	54, 59	.00154831	.00045863
85	56, 59	.00247301	.00145304
86	12, 117	.00076009	.00038163
87	55, 59	.00269496	.00139602
88	59, 60	.00137881	-.00000061
89	59, 61	.00547856	.00166193
90	60, 61	.00130830	.00084056
91	60, 62	.00035914	.00021981
92	61, 62	.00033824	.00020257
94	63, 64	.00069523	.00023519
96	38, 65	.02802829	.00702976
97	64, 65	.00211074	.00043973
98	49, 66	.01382892	.00482650
99	68, 116	.00060329	.00033745
100	62, 66	.00496019	.00140336
101	62, 67	.00063534	.00008567
103	66, 67	.00214337	.00075948
104	65, 68	.00465709	.00272041
105	47, 118	-.01623909	.03516781
106	49, 118	-.01010436	.00694724
108	118, 70	-.04928826	.04607071
109	24, 70	.00864252	.00117933
110	70, 71	.00003587	.00000586
111	24, 72	.00872273	.00115516
112	71, 72	.00003774	.00000269
113	71, 73	.00005870	.00000320
114	70, 74	.00050568	.00039858

TABLE VI (continued)

115	70, 75	.00003580	.00004213
116	118, 75	-.06001283	.05186287
117	74, 75	.00028237	.00014579
118	76, 77	.01045077	.00398527
119	118, 77	-.01790627	-.06048995
120	75, 77	.01091056	.00655363
121	77, 78	.00015294	.00013303
122	78, 79	.00013732	.00008510
123	77, 80	.00366932	.00196724
124	114, 115	.00054224	-.00011293
125	79, 80	.00373985	.00205375
126	68, 81	.00433936	.00305253
128	77, 82	.00333579	.00156210
129	82, 83	.00123878	.00066976
130	83, 84	.00398308	.00272994
131	83, 85	.00967974	.00702110
132	84, 85	.00125902	.00100431
133	85, 86	.00006061	.00003436
134	86, 87	.00096888	.00022112
135	85, 88	.00276696	.00083356
136	85, 89	.01430533	.00471531
137	88, 89	.00453797	.00159628
138	89, 90	.01050243	.00536244
139	27, 115	.00060081	.00020533
140	90, 91	.00011960	.00000651
141	89, 92	.00845673	.00377322
142	32, 114	.00023978	.00005607
143	91, 92	.00011300	.00006918
144	92, 93	.00414504	.00235463
145	92, 94	.01279204	.00703739
146	93, 94	.00238901	.00125541
147	94, 95	.00066693	.00043940
148	80, 96	.00222370	.00029991
149	82, 96	.00010917	.00004053
150	94, 96	.00151984	.00088785
151	80, 97	.00077461	.00013377
152	80, 98	.00028004	.00002146
153	80, 99	.00136074	.00015063
154	92, 100	.01546150	.00724387
155	94, 100	.00072906	.00023062
156	95, 96	.00031507	.00015343
157	96, 97	.00044349	.00005868
158	98, 100	.00231605	.00121140
159	99, 100	.00056243	.00041700
160	100, 101	.00210971	.00079841
161	92, 102	.00083871	.00042762
162	101, 102	.00283913	.00142978
163	100, 103	.00217647	.00131856
164	100, 104	.00739884	.00372418
165	103, 104	.00223316	.00063963
166	103, 105	.00374464	.00148785
167	100, 106	.01245388	.00670090
168	104, 105	.00027734	.00017003
169	105, 106	.00008603	.00005338
170	105, 107	.00249511	.00157126
171	105, 108	.00030327	.00016292
172	106, 107	.00164333	.00105423
173	108, 109	.00004361	.00002148
174	103, 110	.00770122	.00407336
175	109, 110	.00017001	.00005266
176	110, 111	.00070796	.00045013
177	110, 112	.00335847	.00232533
178	17, 113	.00016967	.00002080
179	32, 113	.01319147	-.00018502

TABLE VI (continued)

TCUL TRANSFORMER QUANTITIES - TOTAL DERIVATIVES				

ELEMENT	TURNS RATIO		INTERNAL RESISTANCE	INTERNAL REACTANCE

8, 5	.31635428		11.93016310	-.08433212
26, 25	-.00481993		.52984963	-.13122324
30, 17	-.05847642		5.26626113	.33765781
38, 37	.09436520		5.15710472	.44346301
66, 65	-.00031570		9.26137851	-.00802056
118, 68	-1.67088787		-13.54335230	-36.08089473
81, 80	.03746754		.37110127	.07860824

PHASE SHIFTER QUANTITIES - TOTAL DERIVATIVES				

ELEMENT	TURNS RATIO MAGNITUDE	TURNS RATIO PHASE ANGLE	INTERNAL RESISTANCE	INTERNAL REACTANCE

63, 59	.03979616	.23901127	1.85075020	.31214901
64, 61	.02969202	-.14220260	.00022910	-.00972182

TABLE VII

118-BUS SYSTEM: SENSITIVITIES OF DELTA(72)

LOAD BUS QUANTITIES - TOTAL DERIVATIVES

BUS	REAL POWER	REACTIVE POWER	SHUNT CONDUCTANCE	SHUNT SUSCEPTANCE
2	-.05236620	-.00008825	.06156187	-.00010375
3	-.05213413	-.00029186	.06459596	-.00036163
5	-.04990566	-.00041287	.05778485	-.00047805
7	-.05125591	-.00001140	.05661996	-.00001260
9	-.04879029	.00003885	.05854225	.00004661
11	-.05174409	-.00019532	.05747652	-.00021696
13	-.05243348	-.00037012	.05479812	-.00038682
14	-.05202664	.00003989	.05504437	.00004221
16	-.05203484	-.00035847	.05557615	-.00038286
17	-.05229331	-.00004338	.05039295	-.00004181
20	-.06070851	.00038113	.05304461	.00033302
21	-.06607291	.00051863	.05603453	.00043984
22	-.07189353	.00047815	.06028565	.00040000
23	-.08081091	-.00064186	.06834471	-.00054285
28	-.06761191	-.00940733	.02902926	-.00403905
29	-.06520682	-.00450202	.03317514	-.00229049
30	-.04942150	.00025903	.05433973	.00028481
33	-.04648868	-.00028451	.04292349	-.00026270
35	-.03992053	-.00004423	.03699496	-.00004099
37	-.03899511	-.00015696	.03665215	-.00014753
38	-.03913334	-.00037535	.04241000	-.00040678
39	-.03679558	-.00006247	.03405132	-.00005781
41	-.03388383	-.00004122	.03369400	-.00004099
43	-.03456583	-.00032387	.03168701	-.00029690
44	-.02551913	-.00044466	.02416293	-.00042103
45	-.02206015	-.00033665	.02110468	-.00032207
47	-.01588485	-.00003706	.01632006	-.00003803
48	-.01820917	.00002989	.01877527	.00003082
50	-.01831156	-.00002277	.01820430	-.00002264
51	-.01872375	-.00012666	.01740138	-.00011772
52	-.01885029	-.00015814	.01716360	-.00014399
53	-.01878617	-.00013169	.01667219	-.00011687
57	-.01866945	-.00001547	.01745680	-.00001446
58	-.01881761	-.00008008	.01718856	-.00007315
60	-.01848925	-.00000141	.01815348	-.00000139
63	-.01834774	.00002230	.01909484	.000002321
64	-.01823451	.00001618	.01884434	.00001672
67	-.01810369	-.00002614	.01888469	-.00002727
68	-.00704323	-.00062030	.00733491	-.00064599
69	-.02388812	.00124118	.02159395	.00112198
71	-.07724917	.00000175	.07486603	.00000170
75	-.02655893	.00013461	.02494150	.00012641
78	-.01025270	-.00010411	.01024874	-.00010407
79	-.01012197	-.00009434	.01024909	-.00009553
81	-.00925745	-.00006372	.00933119	-.00006423
82	-.00986113	-.00006479	.00965525	-.00006343
83	-.00964086	-.00005788	.00935254	-.00005615
84	-.00917684	-.00005665	.00886118	-.00005470
86	-.00893703	-.00001109	.00874648	-.00001085
88	-.00872740	-.00002572	.00849055	-.00002503
93	-.00923130	-.00007701	.00897335	-.00007485
94	-.00949767	-.00008708	.00931379	-.00008539

TABLE VII (continued)

95	-.00966794	-.00013011	.00929077	-.00012504
96	-.00973950	-.00007213	.00958281	-.00007097
97	-.00971774	-.00004764	.00993396	-.00004870
98	-.00966607	-.00001462	.01014482	-.00001535
101	-.00927751	-.00005471	.00915754	-.00005400
102	-.00901169	-.00002723	.00884971	-.00002674
106	-.01005167	-.00003502	.00929495	-.00003238
108	-.01009908	-.00000485	.00942992	-.00000453
109	-.01013558	-.00000666	.00947984	-.00000623
114	-.06908097	-.00023926	.05065350	-.00017544
115	-.06884926	.00017436	.04778197	.00012101
117	-.05231317	-.00018063	.05630459	-.00019441

GENERATOR BUS QUANTITIES - TOTAL DERIVATIVES

BUS	REAL POWER	VOLTAGE MAGNITUDE	SHUNT CONDUCTANCE	SHUNT SUSCEPTANCE
1	-.05287806	.04408370	.06993124	0.00000000
4	-.05188204	.03569196	.06277727	0.00000000
6	-.05093831	-.01658075	.05637363	0.00000000
8	-.04967452	-.00347951	.05901830	0.00000000
10	-.04781770	-.00826363	.05525933	0.00000000
12	-.05167637	-.03001847	.05708177	0.00000000
15	-.05220858	-.01011202	.04912306	0.00000000
18	-.05301506	.00146987	.04988187	0.00000000
19	-.05302994	.00326117	.04887240	0.00000000
24	-.10039160	-.06123726	.08313428	0.00000000
25	-.06360527	-.04094207	.05984620	0.00000000
26	-.05832887	.02834294	.05950128	0.00000000
27	-.06794551	-.06397477	.04602146	0.00000000
31	-.06364771	-.09062080	.03902171	0.00000000
32	-.06901913	.04740609	.05248104	0.00000000
34	-.04026175	-.00880033	.03702796	0.00000000
36	-.04004555	.00021991	.03713700	0.00000000
40	-.03514714	-.01895325	.03306994	0.00000000
42	-.02979960	.01585844	.03605751	0.00000000
46	-.01864730	-.00404094	.01864730	0.00000000
49	-.01795693	-.01389361	.01868239	0.00000000
54	-.01848247	-.00843096	.01668043	0.00000000
55	-.01875441	-.00050621	.01692586	0.00000000
56	-.01877310	-.00464319	.01694272	0.00000000
59	-.01841872	.00543657	.01805219	0.00000000
61	-.01810734	-.00068666	.01810734	0.00000000
62	-.01827456	-.00140528	.01827456	0.00000000
65	-.01818785	.00603089	.01818785	0.00000000
66	-.01774996	.00646076	.01960663	0.00000000
70	-.05358608	-.00075787	.05146407	0.00000000
72	-.19661695	.26876117	.18883092	0.00000000
73	-.07736559	.00394989	.07582601	0.00000000
74	-.03334886	.00008135	.03073431	0.00000000
76	-.01843570	-.03457321	.01646354	0.00000000
77	-.01031083	-.00720135	.01051807	0.00000000
80	-.00964387	-.00235915	.01043081	0.00000000
85	-.00889295	-.00346903	.00371598	0.00000000
87	-.00886525	.00013473	.00904345	0.00000000
89	-.00849414	-.00403119	.00849414	0.00000000
90	-.00898303	.00143450	.00880427	0.00000000
91	-.00895052	-.00100012	.00859608	0.00000000

TABLE VII (continued)

92	-.00886888	-.00432479	.00872754	0.00000000
99	-.00959872	-.00087495	.00979166	0.00000000
100	-.00945303	.00234946	.00983493	0.00000000
103	-.00971935	.00258944	.00991471	0.00000000
104	-.00989406	-.00171823	.00930932	0.00000000
105	-.00999642	-.00240640	.00930892	0.00000000
107	-.01031795	-.00021892	.00931195	0.00000000
110	-.01018355	-.00299934	.00964106	0.00000000
111	-.01001451	-.00011515	.00961794	0.00000000
112	-.01063266	.00290885	.01021161	0.00000000
113	-.05446617	.02764613	.05388229	0.00000000
116	-.00672509	-.01391711	.00672509	0.00000000

LINE QUANTITIES - TOTAL DERIVATIVES

LINE INDEX	ELEMENT	LINE CONDUCTANCE	LINE SUSCEPTANCE
1	1, 2	.00029294	.00001996
2	1, 3	.00013172	.00003456
3	4, 5	.00025903	.00014686
4	3, 5	.00053912	.00021484
5	5, 6	.00006947	.00003400
6	6, 7	.00000501	.00000337
7	8, 9	.00076202	.00012042
9	9, 10	.00092424	.00014407
10	4, 11	.00011659	.00000967
11	5, 11	.00015750	.00011328
12	11, 12	.00000055	-.00000065
13	2, 12	.00011930	.00001585
14	3, 12	.00026762	-.00000854
15	7, 12	.00000549	.00000462
16	11, 13	.00005025	.00001845
17	12, 14	.00002183	.00000241
18	13, 15	.00016502	-.00001738
19	14, 15	.00016854	.00000192
20	12, 16	.00000879	.00000559
21	15, 17	.00008946	-.00000383
22	16, 17	.00019257	-.00002571
23	17, 18	.00005998	.00002374
24	18, 19	.00000786	.00000010
25	19, 20	-.00014196	-.00006081
26	15, 19	-.00000250	.00000141
27	20, 21	-.00002441	-.00010899
28	21, 22	.00007419	-.00020404
29	22, 23	.00043363	-.00065410
30	23, 24	-.00015016	.00028302
31	23, 25	.00075998	.00221040
33	25, 27	.00357668	.00078451
34	27, 28	.00189391	.00103581
35	28, 29	.00008707	.00013400
37	8, 30	.00010869	-.00001632
38	26, 30	.00196624	-.00186620
39	17, 31	.00029781	.00001276
40	29, 31	.00020265	.00021081
41	28, 32	.00126477	-.00100921
42	31, 32	.00093157	-.00005597
43	27, 32	.00022527	.00001402
44	15, 33	.00006024	-.00004418

TABLE VII (continued)

45	19, 34	.00001991	-.00015649
46	35, 36	.00000016	.00000029
47	35, 37	.00002186	.00002345
48	33, 37	-.00003647	.00015710
49	34, 36	-.00000008	-.00000034
50	34, 37	.00001785	.00003222
52	37, 39	.00017176	-.00013893
53	37, 40	.00026589	-.00032508
54	30, 38	.00014563	-.00032446
55	39, 40	.00000538	-.00003429
56	40, 41	.00000206	-.00002190
57	40, 42	-.00016104	-.00009532
58	41, 42	-.00010374	.00000555
59	43, 44	-.00009957	.00028845
60	34, 43	.00001306	-.00004105
61	44, 45	.00000537	.00009508
62	45, 46	-.00001522	.00014707
63	46, 47	-.00002370	.00007257
64	46, 48	.00001909	.00001521
65	47, 49	.00002764	-.00005694
66	42, 49	.00254286	.00300238
67	76, 69	.00001571	.00010664
68	45, 49	.00007440	.00039975
69	48, 49	.00000585	.00000501
70	49, 50	.00001204	.00000898
71	49, 51	.00006659	.00004453
72	51, 52	.00000254	.00000140
73	52, 53	.00000365	-.00000020
74	53, 54	.00001789	.00000919
75	49, 54	.00006625	.00001393
76	75, 69	.00004894	-.00003799
77	54, 55	.00000843	.00000550
78	54, 56	.00000733	.00000547
79	55, 56	.00000004	-.00000003
80	56, 57	.00000387	.00000008
81	50, 57	.00001405	.00000708
82	56, 58	.00000202	-.00000018
83	51, 58	.00000069	-.00000000
84	54, 59	.00003934	.00000160
85	56, 59	.00005544	.00001582
86	12, 117	.00003832	.00001924
87	55, 59	.00005871	.00001547
88	59, 60	.00002576	-.00000261
89	59, 61	.00010345	.00002344
90	60, 61	.00002486	.00001454
91	60, 62	.00000671	.00000421
92	61, 62	.00000634	.00000312
94	63, 64	.00001288	.00000304
96	38, 63	.00169050	.00332229
97	64, 65	.00003745	.00000227
98	49, 66	.00026978	.00002578
99	68, 116	.00002035	-.00000825
100	62, 66	.00008694	.00003292
101	62, 67	.00001058	.00000268
103	66, 67	.00003849	.00001636
104	65, 68	-.00012966	-.00075461
105	47, 118	-.00025845	.00055351
106	49, 118	-.00018274	.00012564
108	118, 70	-.00257225	.00240434
109	24, 70	-.00259496	-.00177338
110	70, 71	.00010568	.00008436
111	24, 72	.00737511	.00395974
112	71, 72	-.00051952	-.00000378
113	71, 73	.00000421	.00000044
114	70, 74	.00042956	-.00041653

TABLE VII (continued)

TCUL TRANSFORMER QUANTITIES - TOTAL DERIVATIVES

ELEMENT	TURNS RATIO	INTERNAL RESISTANCE	INTERNAL REACTANCE
8, 5	.01817544	.60446644	.02376171
26, 25	.00366791	.02984051	.09985931
30, 17	.01396393	.24888048	.17160778
38, 37	-.00552065	.18079691	-.00977586
66, 65	-.00002593	.14307358	-.00065885
118, 68	.00847094	-.12097567	-.24521454
81, 80	-.00218730	-.00159038	-.00417534

PHASE SHIFTER QUANTITIES - TOTAL DERIVATIVES

ELEMENT	TURNS RATIO MAGNITUDE	TURNS RATIO PHASE ANGLE	INTERNAL RESISTANCE	INTERNAL REACTANCE
63, 59	.00061895	.00181230	.03417246	.00227526
64, 61	.00058091	-.00472852	-.00025220	-.00027111

TABLE VIII

118-BUS SYSTEM: SENSITIVITIES OF Q(SLACK)

LOAD BUS QUANTITIES - TOTAL DERIVATIVES

BUS	REAL POWER	REACTIVE POWER	SHUNT CONDUCTANCE	SHUNT SUSCEPTANCE
2	.27452462	.00046932	-.32273202	.00055173
3	.27376412	.00145811	-.33920304	.00180665
5	.26286793	.00196783	-.30436995	.00227851
7	.26895780	.00005071	-.29710487	.00005601
9	.25817529	-.00020557	-.30977810	-.00024665
11	.27141782	.00097394	-.30148666	.00108183
13	.27455484	.00189680	-.28693673	.00198234
14	.27205896	-.00021099	-.28783932	-.00022323
16	.27093113	.00210681	-.28936974	.00225019
17	.26495250	-.00060335	-.25532406	-.00058142
20	.27039881	.00146062	-.23626342	.00127623
21	.26727491	.00239213	-.22666812	.00202870
22	.26167269	.00231403	-.21942320	.00194041
23	.25041903	.00028924	-.21178845	.00024462
28	.26989098	.03853616	-.11587803	.01654555
29	.27031448	.01875326	-.13752734	.00954106
30	.26396375	.00030640	-.29023236	.00033689
33	.27402769	.00143716	-.25301267	.00132694
35	.27538723	.00036428	-.25520515	.00033758
37	.27092036	.00147631	-.25464254	.00138761
38	.26870517	.00046508	-.29120405	.00050403
39	.28537201	.00163007	-.26408863	.00150850
41	.29459235	.00054290	-.29294148	.00053986
43	.28316520	.00067221	-.25958179	.00061623
44	.28638720	.00078834	-.27116729	.00074644
45	.28532944	.00155249	-.27297123	.00148525
47	.23323321	-.13242630	-.23962327	-.13605443
48	.27509010	-.00047171	-.28364228	-.00048638
50	.27671303	.00029374	-.27509215	.00029202
51	.28148052	.00186833	-.26160073	.00173638
52	.28304569	.00237627	-.25771925	.00216364
53	.28114995	.00200074	-.24951249	.00177560
57	.27988554	.00018667	-.26170590	.00017455
58	.28185450	.00118372	-.25745421	.00108125
60	.27058846	-.00000323	-.26567458	-.00000317
63	.26796349	-.00032219	-.27887463	-.00033531
64	.26550900	-.00022512	-.27438858	-.00023265
67	.26591881	.00035912	-.27739076	.00037461
68	.08532047	-.41653449	-.08989530	-.43378464
69	.22466953	-.09002805	-.20309274	-.08138195
71	.23596900	-.00013123	-.22868936	-.00012718
75	.20691230	-.15955618	-.19431142	-.14983927
78	.28173728	.00332233	-.28162865	.00332105
79	.27693291	.00299972	-.28041061	.00303739
81	.23937361	-.06240147	-.24128030	-.06289852
82	.27036260	.00197695	-.26471798	.00193567
83	.26405373	.00174543	-.25615668	.00169323
84	.25090231	.00161819	-.24227181	.00156252
86	.24412650	.00030296	-.23391997	.00029650
88	.23807977	.00071965	-.23161854	.00070012
93	.25126097	.00213047	-.24423998	.00207094
94	.25843945	.00244268	-.25343576	.00239539

TABLE VIII (continued)

95	.26320294	.00366270	-.25293474	.00351981
96	.26530976	.00213317	-.26104148	.00209885
97	.26358942	.00137972	-.26945444	.00141042
98	.26159809	.00038201	-.27455489	.00040093
101	.25224691	.00146972	-.24898495	.00145072
102	.24525115	.00072800	-.24084269	.00071491
106	.27302772	.00095125	-.25247335	.00087963
108	.27431531	.00013177	-.25613936	.00012304
109	.27530691	.00018084	-.25749549	.00016914
114	.26596537	.00086766	-.19501862	.00063621
115	.26612383	-.00061921	-.18469224	-.00042973
117	.27401213	.00094612	-.29491888	.00101830

 GENERATOR BUS QUANTITIES - TOTAL DERIVATIVES

BUS	REAL POWER	VOLTAGE MAGNITUDE	SHUNT CONDUCTANCE	SHUNT SUSCEPTANCE
1	.27754836	-.23326183	-.36705770	0.00000000
4	.27278940	-.19209743	-.33007517	0.00000000
6	.26758707	.08193711	-.29613968	0.00000000
8	.26285424	.04573480	-.31229712	0.00000000
10	.25302881	.04372727	-.29240642	0.00000000
12	.27067662	.15052194	-.29398967	0.00000000
15	.27166737	.04274834	-.25561183	0.00000000
18	.27019836	-.02228600	-.25422964	0.00000000
19	.27168123	.04644859	-.25038143	0.00000000
24	.24776948	.08740208	-.20517790	0.00000000
25	.24338342	-.09559054	-.22899946	0.00000000
26	.24691656	.07019532	-.25187959	0.00000000
27	.26343037	.26584481	-.17342903	0.00000000
31	.26693671	.37306609	-.16365596	0.00000000
32	.26512228	-.12974223	-.20159474	0.00000000
34	.27627171	.05301262	-.25408184	0.00000000
36	.27585157	.00031555	-.25581619	0.00000000
40	.29049930	.20944902	-.27333079	0.00000000
42	.29661864	-.33290088	-.35890856	0.00000000
46	.27693468	-1.03743503	-.27693468	0.00000000
49	.27254431	-5.31184352	-.28355510	0.00000000
54	.27590683	.12589230	-.24900592	0.00000000
55	.27914478	.00946223	-.25192816	0.00000000
56	.27978137	.07034002	-.25250269	0.00000000
59	.27064483	-.06180203	-.26525904	0.00000000
61	.26450949	.02005493	-.26450949	0.00000000
62	.26751426	.01961460	-.26751426	0.00000000
65	.26264575	-7.57562535	-.26264575	0.00000000
66	.26147909	-.04581207	-.28883006	0.00000000
70	.28399476	-9.09714070	-.22472857	0.00000000
72	.24399231	-.04618245	-.23433021	0.00000000
73	.28634798	-.01479410	-.23164466	0.00000000
74	.25072070	-3.75996067	-.23106420	0.00000000
76	.31029912	-1.36154709	-.27710488	0.00000000
77	.28604231	-11.10715605	-.29179176	0.00000000
80	.26044555	-1.66161004	-.28169791	0.00000000
85	.24292109	.09948215	-.23808696	0.00000000
87	.24216457	-.00368017	-.24703207	0.00000000
89	.23149079	.10982080	-.23149079	0.00000000
90	.24476250	-.03920771	-.23989173	0.00000000
91	.24380930	.02725211	-.23415446	0.00000000

TABLE VIII (continued)

92	.24148301	.11710840	-.23763474	0.00000000
99	.26037511	.02398228	-.26560865	0.00000000
100	.25676714	-.06335885	-.26714053	0.00000000
103	.26400104	-.07033538	-.26930746	0.00000000
104	.26874647	.04667127	-.25286356	0.00000000
105	.27152703	.06536363	-.25285276	0.00000000
107	.28926045	.00594646	-.25293506	0.00000000
110	.27660972	.08146940	-.26187444	0.00000000
111	.27201840	.00312771	-.26124647	0.00000000
112	.28380884	-.07901152	-.27737201	0.00000000
113	.26626341	-.15790252	-.26096477	0.00000000
116	.24691793	-7.82282275	-.24691793	0.00000000

LINE QUANTITIES - TOTAL DERIVATIVES

LINE INDEX	ELEMENT	LINE CONDUCTANCE	LINE SUSCEPTANCE
1	1, 2	-.00156134	-.00011424
2	1, 3	-.00068871	-.00017473
3	4, 5	-.00136489	-.00073477
4	3, 5	-.00281397	-.00104723
5	5, 6	-.00039253	-.00015321
6	6, 7	-.00002649	-.00001454
7	8, 9	-.00403226	-.00063722
9	9, 10	-.00489064	-.00076236
10	4, 11	-.00064448	-.00004917
11	5, 11	-.00086379	-.00052700
12	11, 12	-.00000409	.00000351
13	2, 12	-.00063363	-.00008924
14	3, 12	-.00144786	-.00002218
15	7, 12	-.00002889	-.00001888
16	11, 13	-.00027908	-.00008796
17	12, 14	-.00012473	-.00000829
18	13, 15	-.00095030	.00007027
19	14, 15	-.00095767	-.00001377
20	12, 16	-.00007486	-.00003753
21	15, 17	-.00041015	-.00026861
22	16, 17	-.00140644	-.00005245
23	17, 18	-.00031453	-.00018359
24	18, 19	-.00002661	-.00001022
25	19, 20	-.00020737	-.00004309
26	15, 19	-.00002789	-.00000002
27	20, 21	-.00019846	-.00007331
28	21, 22	-.00042569	-.00019339
29	22, 23	-.00172718	-.00081878
30	23, 24	-.00010700	.00004168
31	23, 25	-.00482098	-.00090486
33	25, 27	-.01334127	-.00362353
34	27, 28	-.00647771	-.00419329
35	28, 29	-.00076180	-.00068264
37	8, 30	-.00050310	-.00003567
38	26, 30	-.01200076	-.00358329
39	17, 31	-.01015043	-.00012137
40	29, 31	-.00100799	-.00090372
41	23, 32	-.00215211	-.00120596
42	31, 32	-.00201590	-.00001891
43	27, 32	-.00076755	-.00002209
44	15, 33	-.00003309	-.00003178

TABLE VIII (continued)

45	19, 34	-.00004057	-.00005626
46	35, 36	-.00000082	-.00000114
47	35, 37	-.00015542	-.00010908
48	33, 37	-.00012058	-.00006364
49	34, 36	-.00000354	.00000066
50	34, 37	-.00014709	-.00012756
52	37, 39	-.00109197	-.00089970
53	37, 40	-.00201307	-.00164654
54	30, 38	-.00023304	-.00015268
55	39, 40	-.00016103	-.00012030
56	40, 41	-.00041655	-.00005251
57	40, 42	-.00587192	-.00010908
58	41, 42	-.00334291	-.00005500
59	43, 44	-.00043015	.00010630
60	34, 43	-.00001154	-.00005123
61	44, 45	-.00020706	-.00002430
62	45, 46	-.00050167	-.00037665
63	46, 47	-.00312875	-.00302842
64	46, 48	-.00036011	-.00006966
65	47, 49	.00320117	.00189395
66	42, 49	-.02037855	-.00610337
67	76, 69	.00200464	.00105374
68	45, 49	-.00259971	-.00126395
69	48, 49	-.00009413	-.00004980
70	49, 50	-.00020894	-.00010615
71	49, 51	-.00115040	-.00053957
72	51, 52	-.00004172	-.00001843
73	52, 53	-.00006550	.00000092
74	53, 54	-.00026304	-.00015679
75	49, 54	-.00131075	-.00008913
76	75, 69	-.00026168	-.00139515
77	54, 55	-.00012567	-.00006545
78	54, 56	-.00010926	-.00007299
79	55, 56	-.00000059	.00000088
80	56, 57	-.00008496	-.00000340
81	50, 57	-.00027688	-.00006143
82	56, 58	-.00003779	-.00000549
83	51, 58	-.00001868	.00000408
84	54, 59	-.00041516	-.00013171
85	56, 59	-.00066952	-.00040793
86	12, 117	-.00020073	-.00010078
87	53, 59	-.00073110	-.00039169
88	59, 60	-.00037776	-.00000209
89	59, 61	-.00150005	-.00046193
90	60, 61	-.00035808	-.00023130
91	60, 62	-.00009839	-.00006013
92	61, 62	-.00009266	-.00005608
94	63, 64	-.00019057	-.00006562
96	38, 65	-.00731447	-.00094151
97	64, 65	-.00058002	-.00012564
98	49, 66	-.00377889	-.00137827
99	68, 116	.00948953	-.00634097
100	62, 66	-.00136395	-.00037867
101	62, 67	-.00017319	-.00002253
103	66, 67	-.00058858	-.00020620
104	65, 68	.003049134	.00209857
105	47, 118	.00834966	-.00599467
106	49, 118	.00277360	-.00190699
108	118, 70	.01123228	-.01049904
109	24, 70	-.00065705	.00052190
110	70, 71	-.00001593	-.00000761
111	24, 72	-.00142209	.00015543
112	71, 72	.00003034	-.00000032
113	71, 73	-.00001346	-.00000075
114	70, 74	.00011840	-.00034426

TABLE VIII (continued)

115	70, 75	.00054602	.00183450
116	118, 75	.01994691	-.00114136
117	74, 75	-.00208870	-.00208039
118	76, 77	-.00240131	-.00224521
119	118, 77	.00524923	.01773264
120	75, 77	.01059150	.01387589
121	77, 78	-.00011673	-.00000011
122	78, 79	-.00002248	-.00005785
123	77, 80	-.00052574	-.00163852
124	114, 115	-.00013896	-.00002896
125	79, 80	-.00083122	-.00108083
126	68, 81	.02480702	.00295195
128	77, 82	-.00109756	-.00085795
129	82, 83	-.00035908	-.00021124
130	83, 84	-.00114746	-.00084088
131	83, 85	-.00277670	-.00214949
132	84, 85	-.00035869	-.00030420
133	85, 86	-.00001714	-.00000972
134	86, 87	-.00027404	-.00006254
135	85, 88	-.00078181	-.00027757
136	85, 89	-.00402320	-.00149434
137	88, 89	-.00127414	-.00048818
138	89, 90	-.00295525	-.00149535
139	27, 115	-.00015525	-.00005215
140	90, 91	-.00003514	-.00000218
141	89, 92	-.00238068	-.00101065
142	32, 114	-.00006148	-.00001463
143	91, 92	-.00002896	-.00002161
144	92, 93	-.00116959	-.00064791
145	92, 94	-.00360841	-.00193197
146	93, 94	-.00067353	-.00034353
147	94, 95	-.00018703	-.00013174
148	80, 96	-.00036590	-.00008703
149	82, 96	-.00002257	-.00005647
150	94, 96	-.00043670	-.00027486
151	80, 97	-.00013862	-.00005557
152	80, 98	-.00005714	-.00001350
153	80, 99	-.00029671	-.00000110
154	92, 100	-.00429010	-.00186119
155	94, 100	-.00017214	-.00006572
156	95, 96	-.00009425	-.00004688
157	96, 97	-.00007327	-.00000070
158	98, 100	-.00063260	-.00023273
159	99, 100	-.00016480	-.00009542
160	100, 101	-.00057598	-.00020159
161	92, 102	-.00023473	-.00011191
162	101, 102	-.00079331	-.00037183
163	100, 103	-.00060772	-.00036817
164	100, 104	-.00206591	-.00103987
165	103, 104	-.00062354	-.00017860
166	103, 105	-.00104558	-.00041544
167	100, 106	-.00347738	-.00187103
168	104, 105	-.00007744	-.00004748
169	105, 106	-.00002402	-.00001491
170	105, 107	-.00069669	-.00043873
171	105, 108	-.00008468	-.00004549
172	106, 107	-.00045885	-.00029436
173	108, 109	-.00001218	-.00000600
174	103, 110	-.00215034	-.00113737
175	109, 110	-.00004747	-.00001470
176	110, 111	-.00019768	-.00012568
177	110, 112	-.00093776	-.00064928
178	17, 113	-.00004047	-.00000215
179	32, 113	-.00390242	-.00001811

TABLE VIII (continued)

 TCUL TRANSFORMER QUANTITIES - TOTAL DERIVATIVES

ELEMENT	TURNS RATIO	INTERNAL RESISTANCE	INTERNAL REACTANCE
8, 5	-.08285363	-3.14965869	.03096560
26, 25	.00245608	-.13898354	.06686698
30, 17	.02056484	-1.39597706	-.04188640
38, 37	-.02798777	-1.38604289	-.12489848
66, 65	.00006910	-2.56341681	.00175539
118, 68	12.17659499	-13.80694192	8.94378299
81, 80	-2.00730714	.73661345	-.63052678

 PHASE SHIFTER QUANTITIES - TOTAL DERIVATIVES

ELEMENT	TURNS RATIO MAGNITUDE	TURNS RATIO PHASE ANGLE	INTERNAL RESISTANCE	INTERNAL REACTANCE
63, 59	-.01101140	-.06778765	-.51031594	-.08861032
64, 61	-.00811218	.03716092	-.00028551	.00258584

TABLE IX

SPECIFICATIONS FOR THE MINIMUM-LOSS PROBLEM							
BUS INDEX	VOLTAGE MAGNITUDE		REAL POWER INJECTED				
	VARIABLE INDEX	NOMINAL VALUE	VARIABLE INDEX	NOMINAL VALUE		LOWER BOUND	UPPER BOUND
				BGP	BLP		
1	1	1.150	54	.100	.510	-.510	-.380
4	2	1.100	55	.200	.900	-.900	-.640
6	3	1.052	56	.150	.520	-.520	-.323
8	4	1.090	57	.100	.500	-.500	-.370
10	5	1.075	58	4.500	0.000	0.000	5.850
12	6	1.051	59	.850	.370	-.370	.735
15	7	.970	60	.120	.900	-.900	-.744
18	8	.970	61	.100	.600	-.600	-.470
19	9	.960	62	.200	.450	-.450	-.190
24	10	.910	63	.150	.300	-.300	-.105
25	11	.970	64	2.200	0.000	0.000	2.860
26	12	1.010	65	3.140	0.000	0.000	4.082
27	13	.823	66	.120	.820	-.820	-.664
31	14	.783	67	.100	.430	-.430	-.300
32	15	.872	68	.200	.590	-.590	-.330
34	16	.959	69	.150	.590	-.590	-.395
36	17	.963	70	.100	.310	-.310	-.180
40	18	.970	71	.100	.760	-.760	-.630
42	19	1.100	72	.120	1.100	-1.100	-.944
46	20	1.000	73	.200	.280	-.280	-.020
49	21	1.020	74	2.040	.870	-.870	1.782
54	22	.950	75	.480	.130	-.130	.494
55	23	.950	76	.100	.630	-.630	-.500
56	24	.950	77	.120	.840	-.840	-.684
59	25	.990	78	1.550	2.770	-2.770	-.755
61	26	1.000	79	1.600	0.000	0.000	2.080
62	27	1.000	80	.150	.770	-.770	-.575
65	28	1.000	81	3.910	0.000	0.000	5.083
66	29	1.051	82	3.920	.390	-.390	4.706
70	30	.980	83	.500	.660	-.660	-.010
72	31	.980	84	.200	.320	-.320	-.060
73	32	.990	85	.150	.210	-.210	-.015
74	33	.960	86	.100	.680	-.680	-.550
76	34	.945	87	.100	.680	-.680	-.550
77	35	1.010	88	.120	.610	-.610	-.454
80	36	1.040	89	4.770	1.300	-1.300	4.901
85	37	.990	90	.200	.240	-.240	.020
87	38	1.010	91	.150	0.000	0.000	.195
89	39	1.000	92	6.070	0.000	0.000	7.891
90	40	.990	93	.100	1.730	-1.730	-1.600
91	41	.980	94	.120	.220	-.220	-.064
92	42	.992	95	.500	.650	-.650	0.000
99	43	1.010	96	.200	.620	-.620	-.360
100	44	1.020	97	2.520	.370	-.370	2.906
103	45	1.010	98	.500	.230	-.230	.420
104	46	.970	99	.100	.380	-.380	-.250
105	47	.965	100	.100	.310	-.310	-.180
107	48	.950	101	.120	.620	-.620	-.464
110	49	.973	102	.120	.390	-.390	-.234
111	50	.980	103	.360	0.000	0.000	.468
112	51	.980	104	.120	.800	-.800	-.644
113	52	.990	105	.120	.120	-.120	.036
116	53	1.000	106	.120	0.000	0.000	.156

TABLE X (continued)

ITERATIONS

BASIS TO BE LOADED FROM FILE 10
LOSS PRO ITR 40 EXCESS ITRN PHASE 4 OBJ 1.054911770629E+00
OBJ=OBJECT RRS=RHS RNC= BNU=BNDI N- 1 N= 100 SB= 60
NO. OF SUPER-BASICS LOADED 08

FACTORIZE 1 DEMAND 0 ITERATION 0 INFEAS 1 OBJECTV 0.

PWL: -14.33 FWC: 15.38 LOSS: 1.054912

ITN 0 -- FEASIBLE SOLUTION. OBJECTIVE = 1.054911948E+00

CHOLESKY FACTOR OF HESSIAN RESET TO 1.

ITN	PH	PF	NOPT	DJ/RG	+SBS	-SBS	-RS	STEP	PIVOT	MSPK	L	U	WINT	SINT/OBJECTIVE	RFC	MSB	RIM	B-CONDM
1	4	0	-1	3.2E-01	0	0	0	5.9E-02	0.	0.	1	1	0	1.04810820E+00	3	68	4	4
2	4	0	-1	1.5E-01	0	94	0	3.6E-02	1.2E-01	0	1	1	0	1.64102735E+00	4	67	3	3
3	4	0	-1	2.0E-01	0	67	0	4.1E-02	-6.0E-02	0	1	1	0	1.63674963E+00	5	66	3	3
4	4	0	-1	1.5E-01	0	54	0	8.2E-03	-2.6E-01	0	1	1	0	1.63197063E+00	6	65	0	0
5	4	0	-1	1.0E-01	0	101	0	1.0E-02	-4.3E-01	0	1	1	0	1.62728501E+00	7	64	0	0
6	4	0	-1	1.0E-01	0	102	0	9.7E-04	-2.2E-01	0	1	1	0	1.62699792E+00	8	63	0	0
7	4	0	-1	1.0E-01	0	76	0	2.1E-03	1.3E-01	0	1	1	0	1.62664830E+00	9	62	0	0
8	4	0	-1	1.0E-01	0	91	0	5.9E-03	3.1E-01	0	1	1	0	1.62511766E+00	10	61	0	0
9	4	0	-1	1.0E-01	0	83	0	7.2E-02	9.7E-02	0	1	1	0	1.61499378E+00	11	60	0	0
10	4	0	-1	9.5E-02	0	69	0	4.2E-02	8.4E-02	0	1	1	0	1.60782394E+00	12	59	0	0
11	4	0	-1	9.4E-02	0	76	0	6.4E-03	-5.6E-02	0	1	1	0	1.60663051E+00	13	58	0	0
12	4	0	-1	9.4E-02	0	32	0	7.0E-02	2.6E-01	0	1	1	0	1.60663051E+00	14	57	0	0
13	4	0	-1	9.4E-02	0	90	0	3.5E-02	2.6E-01	0	1	1	0	1.60663051E+00	15	56	0	0
14	4	0	-1	8.9E-02	0	61	0	2.5E-01	-3.8E-02	0	1	1	0	1.60663051E+00	16	55	0	0
15	4	0	-1	8.3E-02	0	66	0	1.8E-02	-3.6E-02	0	1	1	0	1.60663051E+00	17	54	0	0
16	4	0	-1	8.3E-02	0	100	0	1.8E-02	-6.3E-02	0	1	1	0	1.60663051E+00	18	53	0	0
17	4	0	-1	8.3E-02	0	53	0	1.9E-03	-3.9E-03	0	1	1	0	1.60663051E+00	19	52	0	0
18	4	0	-1	8.3E-02	0	62	0	5.1E-02	-5.3E-02	0	1	1	0	1.60663051E+00	20	51	0	0
19	4	0	-1	7.2E-02	0	64	0	4.0E-01	-3.6E-02	0	1	1	0	1.60663051E+00	21	50	0	0
20	4	0	-1	8.9E-02	0	68	0	9.2E-03	-5.4E-01	0	1	1	0	1.60663051E+00	22	49	0	0
21	4	0	-1	8.9E-02	0	55	0	1.4E-04	-2.8E-01	0	1	1	0	1.60663051E+00	23	48	0	0
22	4	0	-1	8.1E-02	0	99	0	1.0E-02	-2.5E-01	0	1	1	0	1.60663051E+00	24	47	0	0
23	4	0	-1	1.0E-01	0	73	0	1.1E-01	-1.8E-01	0	1	1	0	1.60663051E+00	25	46	0	0
24	4	0	-1	1.0E-02	0	83	0	5.0E-02	-3.9E-01	0	1	1	0	1.60663051E+00	26	45	0	0
25	4	0	-1	7.8E-02	0	103	0	1.2E-02	-4.5E-01	0	1	1	0	1.60663051E+00	27	44	0	0
26	4	0	-1	6.7E-02	0	56	0	2.0E-02	-1.3E-01	0	1	1	0	1.60663051E+00	28	43	0	0
27	4	0	-1	1.5E-01	0	103	0	2.0E-01	-8.6E-02	0	1	1	0	1.60663051E+00	29	42	0	0
28	4	0	-1	1.3E-01	0	103	0	1.4E-01	-1.3E-01	0	1	1	0	1.60663051E+00	30	41	0	0
29	4	0	-1	1.4E-01	0	75	0	3.3E-02	-5.7E-01	0	1	1	0	1.60663051E+00	31	40	0	0
30	4	0	-1	1.4E-01	0	15	0	1.1E-01	-5.7E-01	0	1	1	0	1.60663051E+00	32	39	0	0
31	4	0	-1	1.3E-01	0	63	0	2.0E-02	-2.3E-01	0	1	1	0	1.60663051E+00	33	38	0	0
32	4	0	-1	1.3E-01	0	59	0	1.1E-02	-3.9E-01	0	1	1	0	1.60663051E+00	34	37	0	0
33	4	0	-1	9.7E-02	0	31	0	6.3E-01	-1.7E-03	0	1	1	0	1.60663051E+00	35	36	0	0
34	4	0	-1	9.1E-02	0	90	0	8.7E-02	-4.7E-01	0	1	1	0	1.60663051E+00	36	35	0	0
35	4	0	-1	8.2E-02	0	87	0	2.1E-01	-8.0E-02	0	1	1	0	1.60663051E+00	37	34	0	0
36	4	0	-1	8.9E-02	0	20	0	4.9E-01	-3.7E-02	0	1	1	0	1.60663051E+00	38	33	0	0
37	4	0	-1	8.7E-02	0	1	0	1.3E-01	-2.0E-02	0	1	1	0	1.60663051E+00	39	32	0	0
38	4	0	-1	8.6E-02	0	96	0	2.3E-03	-9.7E-01	0	1	1	0	1.60663051E+00	40	31	0	0
39	4	0	-1	9.6E-02	0	46	0	4.2E-01	-2.6E-02	0	1	1	0	1.60663051E+00	41	30	0	0
40	4	0	-1	1.4E-01	0	18	0	2.6E-01	-4.9E-02	0	1	1	0	1.60663051E+00	42	29	0	0
41	4	0	-1	8.5E-02	0	19	0	3.6E-02	-1.1E-01	0	1	1	0	1.60663051E+00	43	28	0	0
42	4	0	-1	8.8E-02	0	14	0	1.7E-01	-3.1E-02	0	1	1	0	1.60663051E+00	44	27	0	0
43	4	0	-1	8.8E-02	0	80	0	2.5E-02	-3.2E-01	0	1	1	0	1.60663051E+00	45	26	0	0
44	4	0	-1	6.6E-02	0	2	0	4.0E-01	-9.6E-03	0	1	1	0	1.60663051E+00	46	25	0	0
45	4	0	-1	5.4E-02	0	78	0	7.7E-02	-9.7E-01	0	1	1	0	1.60663051E+00	47	24	0	0
46	4	0	-1	2.5E-02	0	43	0	5.4E-01	-0.4E-03	0	1	1	0	1.60663051E+00	48	23	0	0

TABLE X (continued)

47	4	1	23	1.5E-01	-49	74	0	1	1	0	6.4E-01	-3.6E-01	0	1	1	0	8.11896834E-01	49	22	3	3	7.8E+01
48	4	1	23	8.6E-02	0	0	0	1	1	0	1.6E+00	0	0	1	1	0	8.07994340E-01	51	22	4	4	1.1E+02
49	4	1	23	9.8E-02	0	0	0	1	1	0	2.4E+00	0	0	1	1	0	8.04796196E-01	54	22	4	4	2.5E+02
50	4	1	23	9.6E-02	0	0	0	1	1	0	4.0E+00	0	0	1	1	0	7.99688267E-01	56	22	4	4	2.5E+02
51	4	1	23	7.6E-02	0	97	0	1	1	0	4.7E-01	-4.2E-02	0	1	1	0	7.98694324E-01	57	21	3	3	1.8E+02
52	4	1	23	4.6E-02	0	0	0	1	1	0	1.4E+00	0	0	1	1	0	7.96717699E-01	59	21	4	4	1.8E+02
53	4	1	23	2.1E-02	0	95	0	1	1	0	3.8E+00	-3.6E-02	0	1	1	0	7.94855061E-01	61	20	3	3	2.2E+02
54	4	1	23	2.2E-02	0	0	0	1	1	0	3.9E+00	0	0	1	1	0	7.94107153E-01	64	20	4	4	2.6E+02
55	4	1	23	3.9E-02	0	0	0	1	1	0	3.1E+00	0	0	1	1	0	7.93243801E-01	66	20	4	4	2.5E+02
56	4	1	23	1.7E-02	0	0	0	1	1	0	3.1E+00	0	0	1	1	0	7.92473985E-01	68	20	4	4	2.4E+02
57	4	1	23	2.8E-02	0	0	0	1	1	0	4.4E+00	0	0	1	1	0	7.91933933E-01	72	20	4	4	3.6E+02
58	4	1	23	1.3E-02	0	0	0	1	1	0	1.7E+00	0	0	1	1	0	7.91726658E-01	74	20	4	4	3.5E+02
59	4	1	23	2.9E-02	0	79	0	1	1	0	2.0E+01	-1.2E-02	0	1	1	0	7.88734037E-01	77	19	3	3	8.5E+02
60	4	1	23	2.9E-03	0	0	0	1	1	0	1.0E+00	0	0	1	1	0	7.88493334E-01	79	19	4	4	8.8E+02
RESET X (FREQUENCY)																						
61	3	1	24	1.2E-01	49	0	0	1	1	0	1.0E+00	0	0	1	1	0	7.87942982E-01	82	20	4	4	8.8E+02
62	3	1	24	1.6E-01	46	0	0	1	1	0	1.0E+00	0	0	1	1	0	7.87447749E-01	85	21	4	4	8.8E+02
63	3	1	24	9.9E-02	30	0	0	1	1	0	1.0E+00	0	0	1	1	0	7.87112278E-01	88	22	4	4	8.8E+02
64	3	1	22	9.5E-02	22	0	0	1	1	0	1.0E+00	0	0	1	1	0	7.86569228E-01	91	23	4	4	8.9E+02
65	3	1	21	8.3E-02	14	0	0	1	1	0	1.0E+00	0	0	1	1	0	7.85947198E-01	94	24	4	4	8.9E+02
66	3	1	20	7.9E-02	37	0	0	1	1	0	1.0E+00	0	0	1	1	0	7.85565297E-01	100	26	4	4	8.9E+02
67	3	1	19	7.5E-02	15	0	0	1	1	0	1.1E+00	0	0	1	1	0	7.85382562E-01	103	27	4	4	8.9E+02
68	3	1	19	7.4E-02	42	0	0	1	1	0	1.1E+00	0	0	1	1	0	7.85216283E-01	106	28	4	4	8.9E+02
69	3	1	17	6.9E-02	18	0	0	1	1	0	1.1E+00	0	0	1	1	0	7.84997398E-01	109	29	4	4	9.0E+02
70	3	1	16	6.2E-02	19	0	0	1	1	0	1.2E+00	0	0	1	1	0	7.84275816E-01	112	30	4	4	9.0E+02
71	3	1	16	5.5E-02	43	0	0	1	1	0	1.2E+00	0	0	1	1	0	7.84095148E-01	115	31	4	4	9.0E+02
72	3	1	15	5.8E-02	1	0	0	1	1	0	1.2E+00	0	0	1	1	0	7.83875392E-01	118	32	4	4	9.0E+02
73	3	1	15	8.0E-02	45	0	0	1	1	0	1.4E+00	0	0	1	1	0	7.83730745E-01	121	33	4	4	9.2E+02
74	3	1	15	1.4E-02	0	65	0	1	1	0	3.6E+01	-1.5E-02	0	1	1	0	7.8188011E-01	124	33	3	3	4.0E+02
75	4	1	15	2.1E-03	0	0	0	1	1	0	1.0E+00	0	0	1	1	0	7.81050955E-01	126	32	4	4	4.1E+02
76	4	1	15	-4.9E-02	93	0	0	1	1	0	7.7E-02	-1.7E+00	0	1	1	0	7.74912078E-01	128	32	4	4	4.1E+02
77	3	1	14	-4.2E-02	91	0	0	1	1	0	7.6E-03	0	0	1	1	0	7.7436681E-01	131	33	4	4	6.1E+02
78	4	1	14	4.7E-02	0	106	0	1	1	0	3.6E+01	-4.5E-02	0	1	1	0	7.7433959E-01	135	33	4	4	4.6E+02
79	4	1	14	4.1E-02	0	0	0	1	1	0	1.4E+00	0	0	1	1	0	7.74019830E-01	136	32	3	3	4.3E+02
80	4	1	14	3.9E-02	0	0	0	1	1	0	1.4E+00	0	0	1	1	0	7.7364214E-01	141	32	4	4	4.6E+02
81	4	1	14	8.1E-03	0	91	0	1	1	0	1.2E+02	-1.5E-03	0	1	1	0	7.70472043E-01	130	32	3	3	5.2E+02
82	3	1	14	4.5E-02	9	0	0	1	1	0	1.6E+00	0	0	1	1	0	7.70364214E-01	144	32	4	4	5.3E+02
83	3	1	14	3.0E-02	0	0	0	1	1	0	2.7E+01	0	0	1	1	0	7.69303199E-01	147	32	4	4	5.6E+02
84	4	1	14	1.4E-03	0	0	0	1	1	0	1.1E+00	0	0	1	1	0	7.69244037E-01	149	32	4	4	5.6E+02
85	4	1	14	3.7E-02	2	0	0	1	1	0	1.0E+00	0	0	1	1	0	7.69103137E-01	151	33	4	4	5.6E+02
86	3	1	12	5.5E-02	7	0	0	1	1	0	1.0E+00	0	0	1	1	0	7.69139399E-01	153	34	4	4	5.6E+02
87	3	1	12	3.7E-02	94	0	0	1	1	0	1.7E-01	-9.4E-01	0	1	1	0	7.68664340E-01	155	34	3	3	5.6E+02
88	3	1	11	-3.7E-02	0	94	0	1	1	0	1.1E+00	0	0	1	1	0	7.68266836E-01	157	34	4	4	5.6E+02
89	4	1	11	2.6E-02	6	0	0	1	1	0	1.0E+00	0	0	1	1	0	7.68266836E-01	159	35	4	4	5.6E+02
90	3	1	10	3.7E-02	6	0	0	1	1	0	1.0E+00	0	0	1	1	0	7.68266836E-01	161	36	4	4	5.6E+02
91	3	1	9	3.4E-02	32	0	0	1	1	0	1.0E+00	0	0	1	1	0	7.68266836E-01	164	37	4	4	5.6E+02
92	3	1	8	2.7E-02	31	0	0	1	1	0	9.5E-01	0	0	1	1	0	7.68266836E-01	166	37	4	4	5.6E+02
93	4	1	7	2.7E-04	10	0	0	1	1	0	1.1E+00	0	0	1	1	0	7.68266836E-01	164	37	4	4	5.6E+02
94	3	1	6	2.4E-02	10	0	0	1	1	0	1.0E+00	0	0	1	1	0	7.68266836E-01	166	37	4	4	5.6E+02
95	3	1	6	-2.2E-02	90	0	0	1	1	0	1.0E+00	0	0	1	1	0	7.68266836E-01	166	37	4	4	5.6E+02
96	4	1	6	2.2E-04	0	0	0	1	1	0	1.3E+00	0	0	1	1	0	7.68266836E-01	168	38	4	4	5.6E+02
97	3	1	6	7.2E-04	8	0	0	1	1	0	1.0E+00	0	0	1	1	0	7.68266836E-01	170	38	3	3	5.6E+02
98	3	1	4	7.2E-03	80	0	0	1	1	0	1.0E+00	0	0	1	1	0	7.68266836E-01	172	38	4	4	5.6E+02
99	3	1	4	7.2E-03	80	0	0	1	1	0	1.0E+00	0	0	1	1	0	7.68266836E-01	174	39	4	4	5.6E+02
100	4	1	3	4.4E-03	97	0	0	1	1	0	9.4E-01	0	0	1	1	0	7.68266836E-01	176	40	4	4	5.6E+02
100	4	1	3	1.8E-03	0	0	0	1	1	0	1.2E+00	0	0	1	1	0	7.68266836E-01	179	41	4	4	1.5E+03

EXIT -- TOO MANY ITERATIONS.

NO. OF ITERATIONS	100	OBJECTIVE VALUE	7.58162598505470E-01
NO. OF MAJOR ITERATIONS	1	LINEAR OBJECTIVE	0.
OBJECTIVE FUNCN AND GRADIENT CALLS	181	NONLINEAR OBJECTIVE	7.58162598505470E-01
NORM OF X	3.924E+00	NORM OF F1	1.000E+00
NO. OF SUPERBASICS	41	NORM OF REDUCED GRADIENT	1.825E-03
EXECUTION TIME (IN SECONDS)	302.693		
ENDRUN			

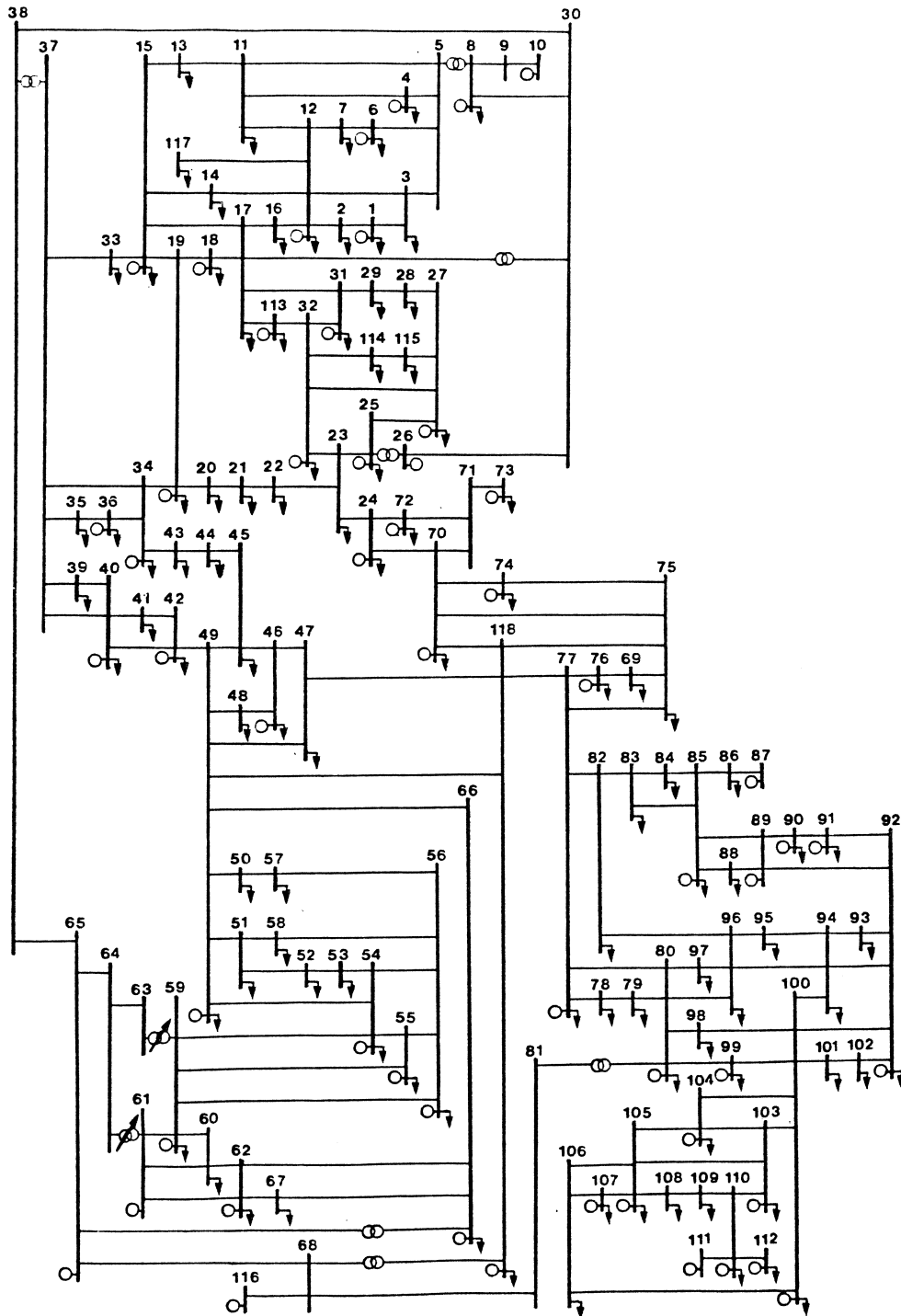


Fig. 1 The IEEE 118-bus power system.

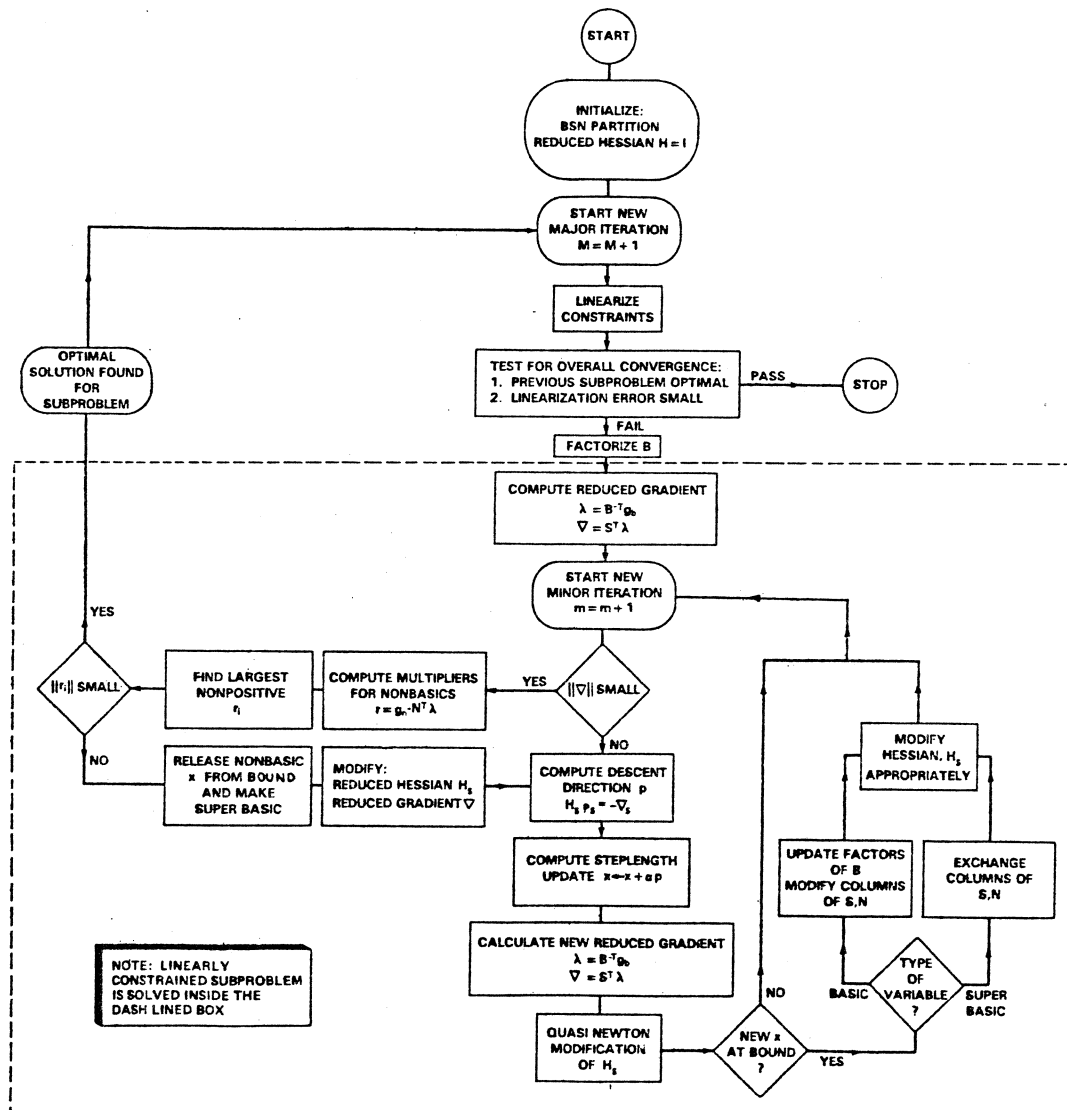


Fig. 2 An illustration of the optimization algorithm according to Burchett and Happ [11].