เอกสารอ้างอิง

1. Bhat, M.V., and Kesavan, H.K., "Piecewise Load Flow Solution Based on Newton-Raphson Method", IEEE PAS Summer Power Meeting, San Francisco, California, Paper C-72-442-2, July, 1972.

2. Brameller, A., John, M.N., and Scott, M.R., Practical Diakoptics for Electrical Networks, Champman & Hall Ltd., 1969.

3. Elgerd, O.I., Electric Energy System Theory:An Introduction, Second Edition, McGraw-Hill, 1982.

4. Happ, H.H., Piecewise Methods and Applications to Power Systems, John Wiley & Sons, 1980.

5. Happ, H.H., and Undrill, J.M., "Automatic Sectionalization of Power System Networks for Networks Solutions,", IEEE Trans. Power Apparatus and System 90 (January/February 1971) : 46-53.

6. Happ, H.H., and Young, C.C., "Tearing Algorithms for Large Scale Network Programs", IEEE Trans. Power Apparatus and System 90 (November/December 1971) : 2639-2649.

7. Kasturi, R., and Potti, M.S.N., "Piecewise Newton-Raphson Load Flow-An Exact Method Using Ordered Elimination", IEEE Trans. Power Apparatus and System 95 (July/August 1976) : 1244-1253.

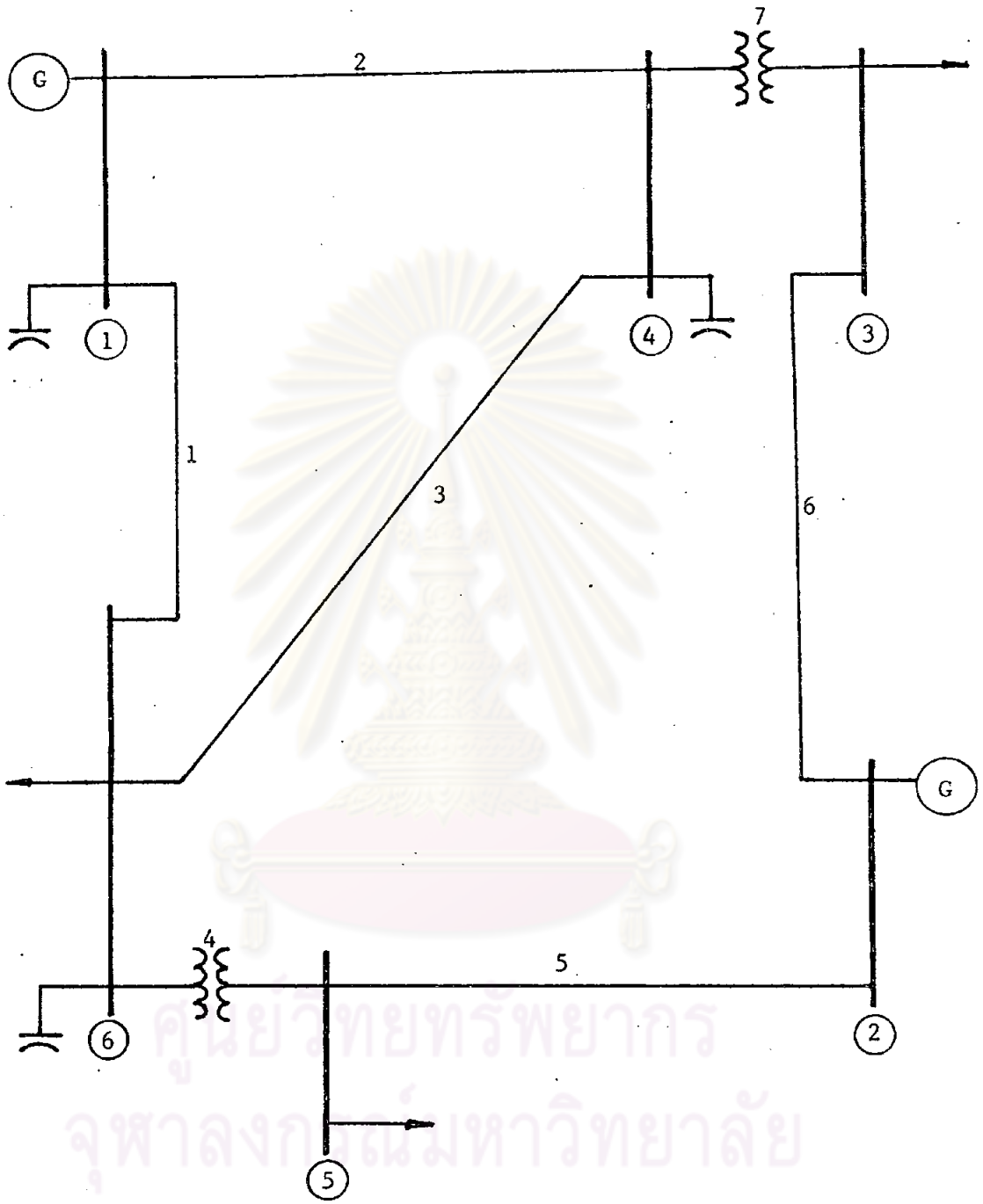
8. Kesavan, H.K., Pai, M.A., and Bhat, M.V., "Piecewise Solution of The Load Flow Problem", IEEE Trans. Power Apparatus and System 91 (July/August 1972) : 1382-1386.

9. Stagg, G.W., and El-Abiad, A.H., Computer Methods in Power System Analysis, McGraw-Hill, 1968.

ภาคผนวก ก.

ตัวอย่างการวิเคราะห์นิวตันราฟสันโหลดโฟลว์ของระบบไฟฟ้ากำลัง ตามมาตรฐาน IEEE

ก.1 ลักษณะของระบบไฟฟ้ากำลัง 6 บัส ตามมาตรฐาน IEEE



ก.2 ข้อมูลของระบบไฟฟ้ากำลัง 6 บัส

PIECEWISE LOADFLOW SOLUTION BASED ON NEWTON-RAPHSON METHOD

THE GENERAL DATA OF THE POWER SYSTEM

THE NUMBER OF BUSES = 6
THE NUMBER OF LINES = 7
THE BASE POWER =100.00MVA

THE BUS DATA OF THE POWER SYSTEM

BUS	BUS TYPE	VOLT (PU)	GENERATION MW	GENERATION MVAR	LOAD MW	LOAD MVAR	MVAR LIMIT MAX	MVAR LIMIT MIN	SHUNT CAPACITOR
1	3	1.050	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	2	1.100	25.00	0.00	0.00	0.00	500.00	-500.00	0.00
3	1	1.000	0.00	0.00	27.50	6.50	0.00	0.00	0.00
4	1	1.000	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	1	1.000	0.00	0.00	15.00	9.00	0.00	0.00	0.00
6	1	1.000	0.00	0.00	25.00	2.50	0.00	0.00	0.00

NOTE ---- BUS NUMBER 1 = LOAD BUS
BUS NUMBER 2 = VOLTAGE CONTROLLED BUS
BUS NUMBER 3 = SLACK BUS

THE LINE DATA OF THE POWER SYSTEM

LINE NO.	BUS P	BUS Q	IMPEDANCE R	IMPEDANCE X	LINE CHARGING	TRANSF. RATIO
1	1	4	0.1600	0.7400	0.0140	1.000
2	1	6	0.2460	1.0360	0.0198	1.000
3	2	3	1.4460	2.1000	0.0000	1.000
4	2	5	0.5640	1.2800	0.0000	1.000
5	4	3	0.0000	0.2660	0.0000	0.909
6	4	6	0.1940	0.8140	0.0152	1.000
7	6	5	0.0000	0.6000	0.0000	0.976

THE BUS ALLOCATION OF THE POWER SYSTEM

BUS NUMBER	SUBDIVISION NUMBER
1	1
2	2
3	1
4	1
5	2
6	2

LIST OF TIE LINES

TIE LINE NUMBER	BUS P	BUS Q
1	1	6
2	2	3
3	4	6

BUS VOLTAGES AND POWER GENERATIONS

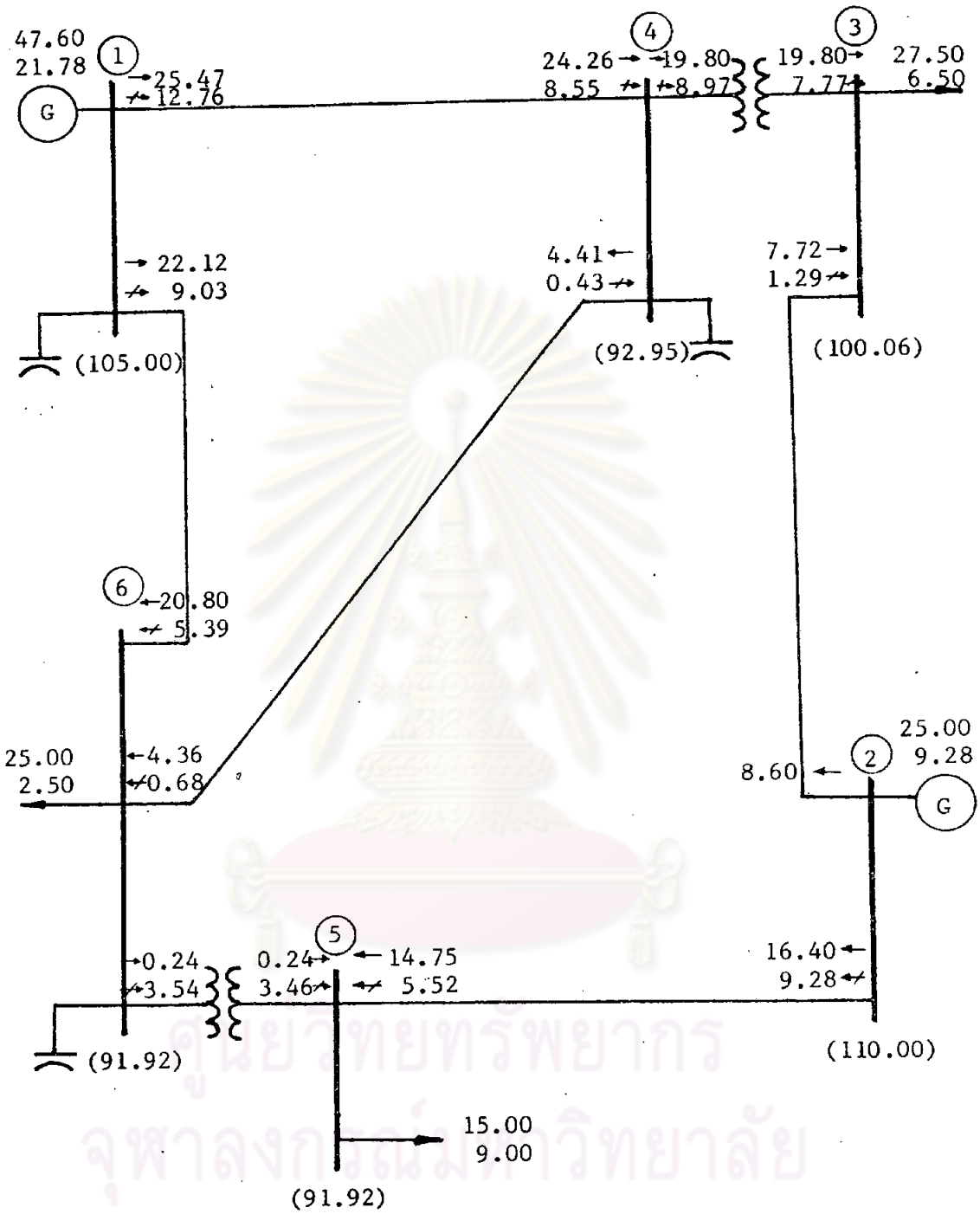
BUS NO.	BUS TYPE	BUS VOLTAGE PU	BUS VOLTAGE KV	BUS VOLTAGE DEG	GENERATION MW	GENERATION MVAR	LOAD MW	LOAD MVAR	QSTATICS MVAR
1	3	1.0500	105.00	0.00	47.60	21.78	0.00	0.00	0.00
2	2	1.1000	110.00	-3.35	25.00	9.28	0.00	0.00	0.00
3	1	1.0006	100.06	-12.79	0.00	0.00	27.50	6.50	0.00
4	1	0.9295	92.95	-9.84	0.00	0.00	0.00	0.00	0.00
5	1	0.9192	91.92	-12.31	0.00	0.00	15.00	9.00	0.00
6	1	0.9192	91.92	-12.22	0.00	0.00	25.00	2.50	0.00

LINE FLOWS

LINE NO.	BETWEEN BUS P	BETWEEN BUS Q	FLOW FROM BUS P MW	FLOW FROM BUS P MVAR	FLOW TO BUS Q MW	FLOW TO BUS Q MVAR	POWER LOSS MW	POWER LOSS MVAR	CHARGING MVAR
1	1	4	25.47	12.76	-24.26	-8.55	1.21	5.58	1.38
2	1	6	22.12	9.03	-20.80	-5.39	1.32	5.56	1.93
3	2	3	8.60	-0.00	-7.72	1.29	0.88	1.28	0.00
4	2	5	16.40	9.28	-14.75	-5.52	1.65	3.76	0.00
5	4	3	19.80	8.97	-19.80	-7.77	-0.00	1.20	0.00
6	4	6	4.41	-0.43	-4.36	-0.68	0.04	0.18	1.30
7	6	5	0.24	3.54	-0.24	-3.46	-0.00	0.09	0.00

SYSTEM TOTALS

	MW	MVAR
GENERATION	72.60	31.07
LOAD	67.50	18.00
STATIC CAPACITOR		0.00
LINE CHARGING		4.60
POWER LOSS	5.11	17.66
POWER MISMATCH	-0.02	0.01



ก.4 ผลการวิเคราะห์นิวตันราฟสันโหลดโฟลว์ โดยวิธีธรรมดา

xxx OUT PUT xxx

BUS NO.	VOLT PU.	VOLT KV	ANGLE (DEGREE)	GENERATION MW	GENERATION MVAR	DEMAND MW	DEMAND MVAR	STATIC CAP. MVAR
1	1.0500	105.00	0.0000	47.61	21.80	0.00	0.00	1.84
2	1.1000	110.00	-3.3567	25.00	9.29	0.00	0.00	0.00
3	1.0006	100.06	-12.7834	0.00	0.00	27.50	6.50	0.00
4	0.9296	92.96	-9.8351	0.00	0.00	0.00	0.00	1.27
5	0.9191	91.91	-12.3352	0.00	0.00	15.00	9.00	0.00
6	0.9191	91.91	-12.2394	0.00	0.00	25.00	2.50	1.48

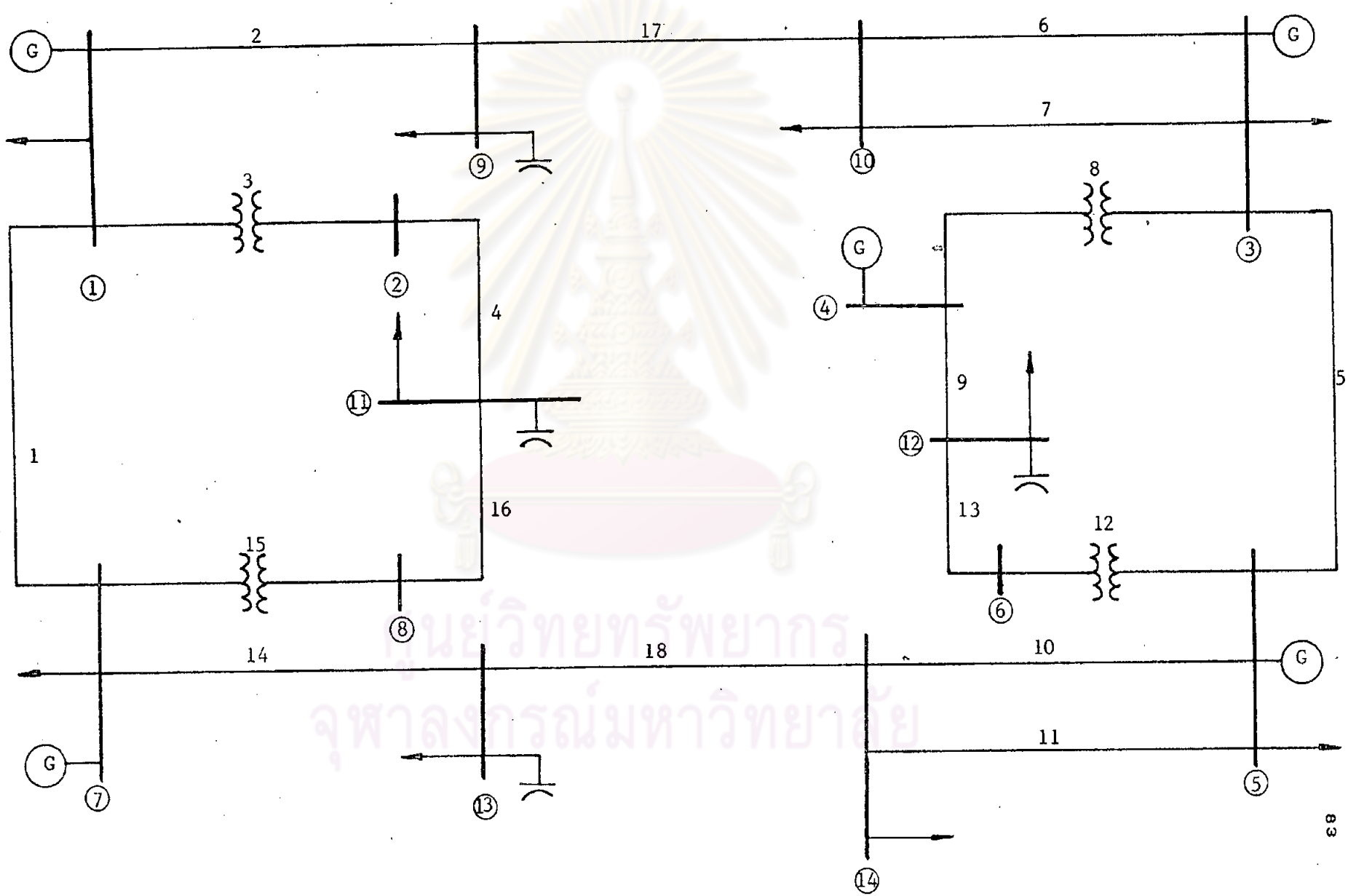
xxx LINE FLOW xxx

LINE NO.	FROM BUS P	TO BUS Q	FLOW FROM P MW	FLOW FROM P MVAR	FLOW TO Q MW	FLOW TO Q MVAR	LOSS MW	LOSS MVAR
1	1	6	22.152	10.121	-20.828	-4.547	1.323	5.574
2	1	4	25.454	13.518	-24.248	-7.943	1.205	5.575
3	4	6	4.457	0.225	-4.412	-0.038	0.045	0.188
4	2	5	16.417	9.284	-14.759	-5.521	1.658	3.763
5	2	3	8.585	0.001	-7.704	1.278	0.881	1.279

xxx SYSTEM TOTAL xxx

	MW	MVAR
GENERATION	72.61	31.08
LOAD	67.50	18.00
LINE CHARGING	0.00	0.00
STATIC CAPACITOR	0.00	4.59
LOSS	5.11	17.67
MISMATCH	0.01	0.01

ก.5 ลักษณะของระบบไฟฟ้ากำลัง 14 บัส ตามมาตรฐาน IEEE



PIECEWISE LOADFLOW SOLUTION BASED ON NEWTON-RAPHSON METHOD

THE GENERAL DATA OF THE POWER SYSTEM

THE NUMBER OF BUSES = 14
THE NUMBER OF LINES = 18
THE BASE POWER =100.00MVA

THE BUS DATA OF THE POWER SYSTEM

BUS	BUS TYPE	VOLT (PU)	GENERATION MW	GENERATION MVAR	LOAD MW	LOAD MVAR	MVAR LIMIT MAX	MVAR LIMIT MIN	SHUNT CAPACITOR
1	2	1.020	200.00	0.00	100.00	50.00	100.00	0.00	0.00
2	1	1.000	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	1	1.000	200.00	56.20	100.00	50.00	0.00	0.00	0.00
4	2	1.000	0.00	0.00	0.00	0.00	100.00	0.00	0.00
5	2	1.020	200.00	0.00	100.00	50.00	100.00	0.00	0.00
6	1	1.000	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7	3	1.040	0.00	0.00	100.00	50.00	0.00	0.00	0.00
8	1	1.000	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9	1	1.000	0.00	0.00	50.00	25.00	100.00	0.00	20.00
10	1	1.000	0.00	0.00	50.00	25.00	0.00	0.00	0.00
11	1	1.000	0.00	0.00	25.00	20.00	100.00	0.00	10.00
12	1	1.000	0.00	0.00	25.00	20.00	100.00	0.00	10.00
13	1	1.000	0.00	0.00	50.00	25.00	100.00	0.00	20.00
14	1	1.000	0.00	0.00	50.00	25.00	0.00	0.00	0.00

NOTE ----
BUS NUMBER 1 = LOAD BUS
BUS NUMBER 2 = VOLTAGE CONTROLLED BUS
BUS NUMBER 3 = SLACK BUS

THE LINE DATA OF THE POWER SYSTEM

LINE NO.	BUS P	BUS Q	IMPEDANCE R	IMPEDANCE X	LINE CHARGING	TRANSF. RATIO
1	1	7	0.0670	0.2000	0.0420	1.000
2	1	9	0.0670	0.2000	0.0420	1.000
3	2	1	0.0000	0.1200	0.0000	0.990
4	2	11	0.3500	0.4200	0.0070	1.000
5	3	5	0.0670	0.2000	0.0420	1.000
6	3	10	0.0670	0.2000	0.0420	1.000
7	3	10	0.0670	0.2000	0.0420	1.000
8	4	3	0.0000	0.1200	0.0000	0.990
9	4	12	0.3500	0.4200	0.0070	1.000
10	5	14	0.0670	0.2000	0.0420	1.000
11	5	14	0.0670	0.2000	0.0420	1.000
12	6	5	0.0000	0.1200	0.0000	0.988
13	6	12	0.3500	0.4200	0.0070	1.000
14	7	13	0.0670	0.2000	0.0420	1.000
15	8	7	0.0000	0.1200	0.0000	0.973
16	8	11	0.3500	0.4200	0.0070	1.000
17	9	10	0.0340	0.1000	0.0210	1.000
18	13	14	0.0340	0.1000	0.0210	1.000

ก.7 ผลการวิเคราะห์นิวตันราฟสันโหลดโฟลว์ โดยวิธีแยกเป็นส่วนย่อย เมื่อแบ่งระบบแบบที่ 1

THE BUS ALLOCATION OF THE POWER SYSTEM

BUS NUMBER	SUBDIVISION NUMBER
1	1
2	1
3	1
4	1
5	2
6	2
7	2
8	2
9	1
10	1
11	1
12	2
13	2
14	2

LIST OF TIE LINES

TIE LINE NUMBER	BUS P	BUS Q
1	1	7
2	3	5
3	4	12
4	8	11

THE ACCELERATING FACTOR =1.600

BUS VOLTAGES AND POWER GENERATIONS

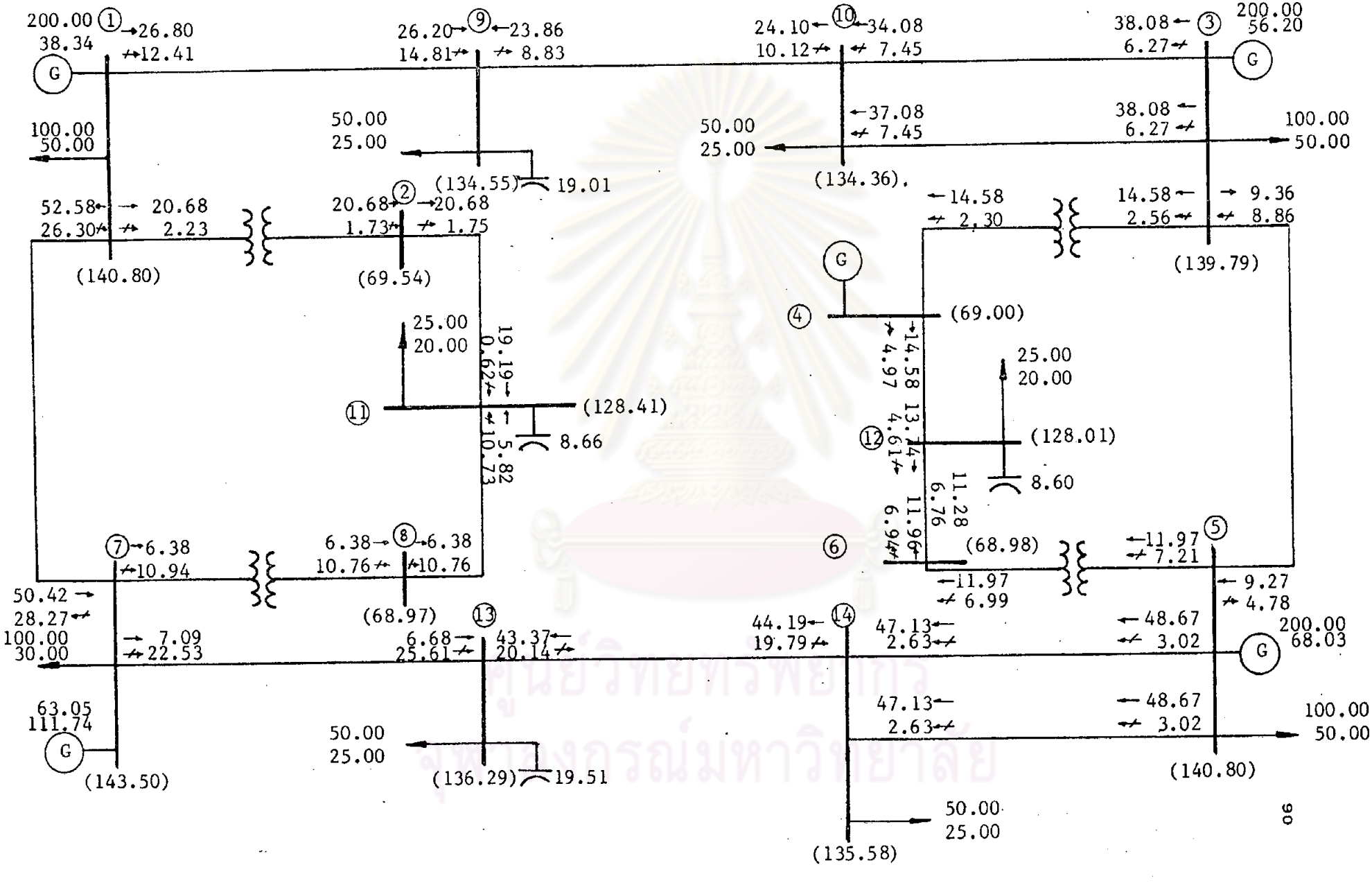
BUS	BUS	BUS VOLTAGE			GENERATION		LOAD		QSTATICS
NO.	TYPE	PU	KV	DEG	MW	MVAR	MW	MVAR	MVAR
1	2	1.0203	140.80	6.57	200.00	38.34	100.00	50.00	0.00
2	1	1.0078	69.54	5.20	0.00	0.00	0.00	0.00	0.00
3	1	1.0130	139.79	9.78	200.00	56.20	100.00	50.00	0.00
4	2	1.0000	69.00	8.80	0.00	2.67	0.00	0.00	0.00
5	2	1.0203	140.80	8.50	200.00	68.03	100.00	50.00	0.00
6	1	0.9998	68.98	7.70	0.00	0.00	0.00	0.00	0.00
7	3	1.0399	143.50	0.00	63.05	111.74	100.00	50.00	0.00
8	1	0.9995	68.97	-0.41	0.00	0.00	0.00	0.00	0.00
9	1	0.9750	134.55	4.04	0.00	0.00	50.00	25.00	19.01
10	1	0.9737	134.36	5.68	0.00	0.00	50.00	25.00	0.00
11	1	0.9305	128.41	0.33	0.00	0.00	25.00	20.00	8.66
12	1	0.9276	128.01	6.17	0.00	0.00	25.00	20.00	8.60
13	1	0.9876	136.29	0.14	0.00	0.00	50.00	25.00	19.51
14	1	0.9824	135.58	3.12	0.00	0.00	50.00	25.00	0.00

LINE FLOWS

LINE NO.	BETWEEN BUS P	BUS Q	FLOW FROM BUS P MW	FLOW FROM BUS P MVAR	FLOW TO BUS Q MW	FLOW TO BUS Q MVAR	POWER LOSS MW	POWER LOSS MVAR	CHARGING MVAR
1	1	7	52,58	-26,30	-50,42	28,27	2,15	6,43	4,46
2	1	9	26,80	12,41	-26,20	-14,81	0,60	1,79	4,18
3	2	1	-20,68	-1,73	20,68	2,23	0,00	0,50	0,00
4	2	11	20,68	1,75	-19,19	-0,62	1,49	1,79	0,66
5	3	5	9,36	-8,86	-9,27	4,78	0,09	0,26	4,34
6	3	10	38,08	6,27	-37,08	-7,45	0,99	2,96	4,15
7	3	10	38,08	6,27	-37,08	-7,45	0,99	2,96	4,15
8	4	3	-14,58	-2,30	14,58	2,56	0,00	0,26	0,00
9	4	12	14,58	4,97	-13,74	-4,61	0,84	1,01	0,65
10	5	14	48,67	3,02	-47,13	-2,63	1,54	4,60	4,21
11	5	14	48,67	3,02	-47,13	-2,63	1,54	4,60	4,21
12	6	5	-11,97	-6,99	11,97	7,21	0,00	0,23	0,00
13	6	12	11,96	6,94	-11,28	-6,76	0,69	0,82	0,65
14	7	13	7,09	22,53	-6,68	-25,61	0,41	1,23	4,32
15	8	7	-6,38	-10,76	6,38	10,94	0,00	0,18	0,00
16	8	11	6,38	10,76	-5,81	-10,73	0,58	0,69	0,65
17	9	10	-23,86	8,83	24,10	-10,12	0,24	0,70	1,99
18	13	14	-43,37	20,14	44,19	-19,79	0,81	2,39	2,04

SYSTEM TOTALS

	MW	MVAR
GENERATION	663.05	276.99
LOAD	650.00	340.00
STATIC CAPACITOR		55.78
LINE CHARGING		40.66
POWER LOSS	12.97	33.40
POWER MISMATCH	0.08	0.03



ก.8 ผลการวิเคราะห์นิวตันราฟสันโหลดโฟลว์ โดยวิธีแยกเป็นส่วนย่อย เมื่อแบ่งระบบแบบที่ 2

THE BUS ALLOCATION OF THE POWER SYSTEM

BUS NUMBER	SUBDIVISION NUMBER
1	1
2	1
3	2
4	2
5	2
6	2
7	1
8	1
9	1
10	2
11	1
12	2
13	1
14	2

LIST OF TIE LINES

TIE LINE NUMBER	BUS P	BUS Q
1	9	10
2	13	14

THE ACCELERATING FACTOR =1.600

BUS VOLTAGES AND POWER GENERATIONS

BUS NO.	BUS TYPE	BUS VOLTAGE PU	BUS VOLTAGE KV	BUS VOLTAGE DEG	GENERATION MW	GENERATION MVAR	LOAD MW	LOAD MVAR	QSTATICS MVAR
1	2	1.0203	140.80	6.56	200.00	38.36	100.00	50.00	0.00
2	1	1.0078	69.54	5.19	0.00	0.00	0.00	0.00	0.00
3	1	1.0130	139.79	9.76	200.00	56.20	100.00	50.00	0.00
4	2	1.0000	69.00	8.79	0.00	2.69	0.00	0.00	0.00
5	2	1.0203	140.80	8.48	200.00	67.91	100.00	50.00	0.00
6	1	0.9998	68.99	7.69	0.00	0.00	0.00	0.00	0.00
7	3	1.0399	143.50	0.00	63.16	111.66	100.00	50.00	0.00
8	1	0.9995	68.97	-0.41	0.00	0.00	0.00	0.00	0.00
9	1	0.9750	134.56	4.03	0.00	0.00	50.00	25.00	19.01
10	1	0.9737	134.37	5.67	0.00	0.00	50.00	25.00	0.00
11	1	0.9305	128.42	0.33	0.00	0.00	25.00	20.00	8.66
12	1	0.9276	128.01	6.16	0.00	0.00	25.00	20.00	8.60
13	1	0.9877	136.30	0.13	0.00	0.00	50.00	25.00	19.51
14	1	0.9825	135.59	3.11	0.00	0.00	50.00	25.00	0.00

LINE FLOWS

LINE NO.	BETWEEN BUS P	BUS Q	FLOW FROM BUS P MW	FLOW FROM BUS P MVAR	FLOW TO BUS Q MW	FLOW TO BUS Q MVAR	POWER LOSS MW	POWER LOSS MVAR	CHARGING MVAR
1	1	7	52,50	-26,28	-50,35	28,24	2,15	6,41	4,46
2	1	9	26,84	12,39	-26,24	-14,78	0,60	1,79	4,18
3	2	1	-20,67	-1,75	20,67	2,25	-0,00	0,50	0,00
4	2	11	20,67	1,75	-19,18	-0,62	1,49	1,78	0,66
5	3	5	9,31	-8,85	-9,23	4,77	0,09	0,26	4,34
6	3	10	38,06	6,25	-37,07	-7,43	0,99	2,96	4,15
7	3	10	38,06	6,25	-37,07	-7,43	0,99	2,96	4,15
8	4	3	-14,57	-2,29	14,57	2,55	0,00	0,26	0,00
9	4	12	14,57	4,98	-13,72	-4,62	0,84	1,01	0,65
10	5	14	48,63	2,99	-47,09	-2,60	1,54	4,60	4,21
11	5	14	48,63	2,99	-47,09	-2,60	1,54	4,60	4,21
12	6	5	-11,97	-6,94	11,97	7,17	0,00	0,22	0,00
13	6	12	11,97	6,95	-11,28	-6,77	0,69	0,83	0,65
14	7	13	7,11	22,48	-6,70	-25,58	0,41	1,23	4,32
15	8	7	-6,39	-10,76	6,39	10,93	-0,00	0,18	0,00
16	8	11	6,39	10,76	-5,82	-10,72	0,58	0,69	0,65
17	9	10	-23,82	8,80	24,06	-10,10	0,24	0,70	1,99
18	13	14	-43,29	20,08	44,10	-19,74	0,81	2,38	2,04

SYSTEM TOTALS

	MW	MVAR
GENERATION	663.16	276.81
LOAD	650.00	340.00
STATIC CAPACITOR		55.79
LINE CHARGING		40.66
POWER LOSS	12.95	33.34
POWER MISMATCH	0.21	-0.08

ก.๑ ผลการวิเคราะห์นิวตันราฟสันโหลดโฟลว์ โดยวิธีธรรมดา

xxx OUT PUT xxx

BUS NO.	VOLT PU.	VOLT KV	ANGLE (DEGREE)	GENERATION MW	GENERATION MVAR	DEMAND MW	DEMAND MVAR	STATIC CAP. MVAR
1	1.0200	140.76	6.5740	200.00	38.05	100.00	50.00	0.00
2	1.0075	69.52	5.2045	0.00	0.00	0.00	0.00	0.00
3	1.0128	139.77	9.7921	200.00	56.20	100.00	50.00	0.00
4	1.0000	69.00	8.8121	0.00	2.85	0.00	0.00	0.00
5	1.0200	140.76	8.5112	200.00	67.73	100.00	50.00	0.00
6	0.9996	68.97	7.7148	0.00	0.00	0.00	0.00	0.00
7	1.0400	143.52	0.0000	63.03	112.12	100.00	50.00	0.00
8	0.9996	68.97	-0.4122	0.00	0.00	0.00	0.00	0.00
9	0.9748	134.53	4.0539	0.00	0.00	50.00	25.00	19.01
10	0.9735	134.35	5.6957	0.00	0.00	50.00	25.00	0.00
11	0.9302	128.37	0.3428	0.00	0.00	25.00	20.00	8.66
12	0.9273	127.97	6.1907	0.00	0.00	25.00	20.00	8.61
13	0.9876	136.28	0.1461	0.00	0.00	50.00	25.00	19.51
14	0.9823	135.56	3.1370	0.00	0.00	50.00	25.00	0.00

xxx LINE FLOW xxx

LINE NO.	FROM BUS P	TO BUS Q	FLOW FROM P MW	FLOW FROM P MVAR	FLOW TO Q MW	FLOW TO Q MVAR	LOSS MW	LOSS MVAR
1	1	7	52.575	-26.510	-50.414	28.505	2.161	6.451
2	1	9	26.737	12.374	-26.141	-14.773	0.597	1.782
3	2	11	20.677	1.762	-19.188	-0.633	1.490	1.787
4	3	5	9.328	-8.776	-9.243	4.692	0.085	0.255
5	3	10	38.042	6.276	-37.051	-7.461	0.992	2.960
6	3	10	38.042	6.276	-37.051	-7.461	0.992	2.960
7	4	12	14.586	5.035	-13.740	-4.671	0.846	1.015
8	5	14	48.641	2.949	-47.101	-2.561	1.541	4.599
9	5	14	48.641	2.949	-47.101	-2.561	1.541	4.599
10	6	12	11.960	6.958	-11.271	-6.783	0.688	0.826
11	7	13	7.036	22.642	-6.621	-25.722	0.415	1.239
12	8	11	6.410	10.843	-5.827	-10.797	0.583	0.699
13	9	10	-23.861	8.788	24.099	-10.081	0.238	0.700
14	13	14	-43.385	20.241	44.199	-19.885	0.814	2.394

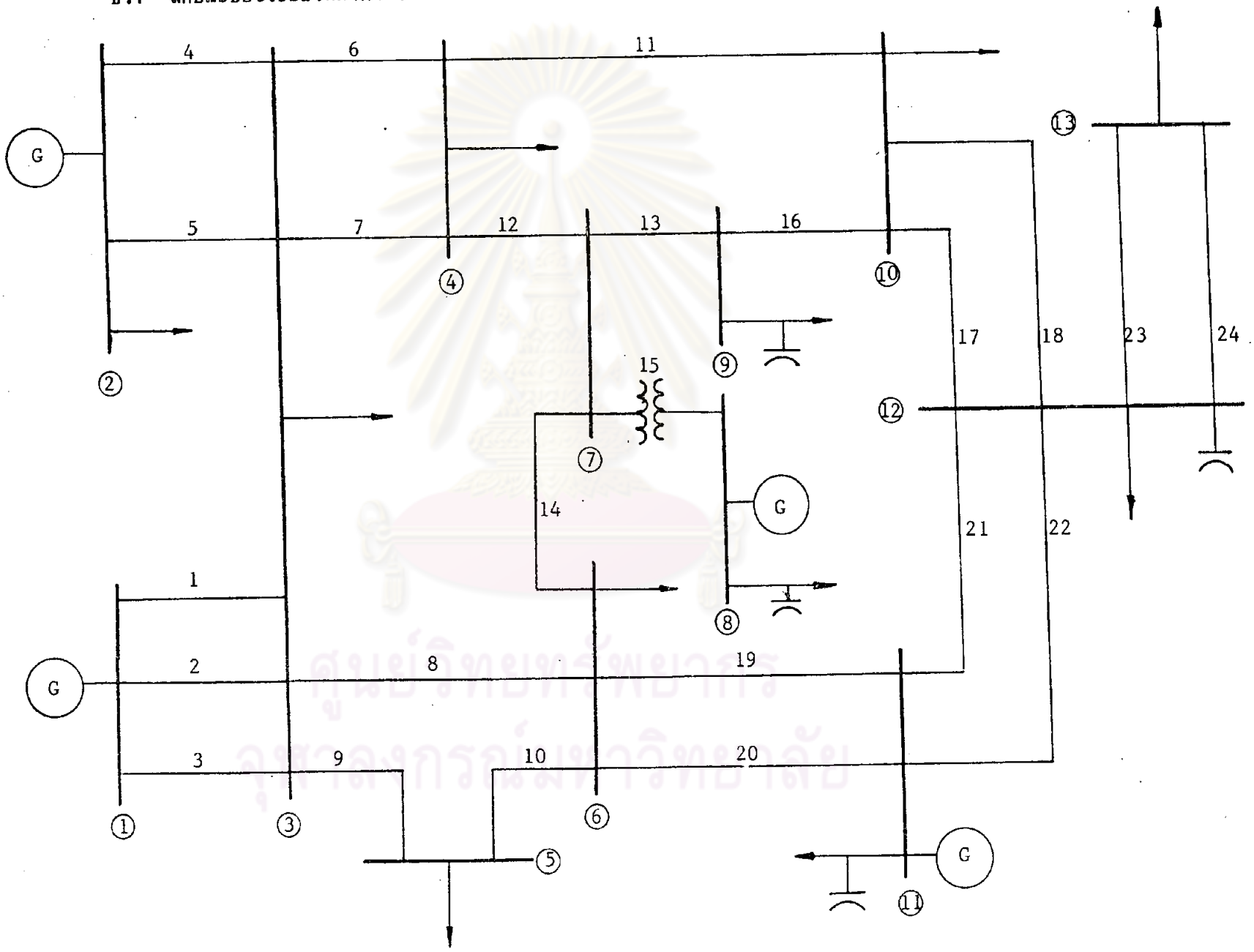
*** SYSTEM TOTAL ***

	MW	MVAR
GENERATION	663.03	276.96
LOAD	650.00	340.00
LINE CHARGING	0.00	40.65
STATIC CAPACITOR	0.00	55.79
LOSS	12.98	33.42
MISMATCH	0.05	0.03

ภาคผนวก ข.

ตัวอย่างการวิเคราะห์นิวตันราฟสันโหลดโฟลว์ของระบบไฟฟ้ากำลังส่วนหนึ่งของการไฟฟ้าฝ่ายผลิตแห่งประเทศไทย

ข.1 ลักษณะของระบบไฟฟ้ากำลังส่วนหนึ่งของการไฟฟ้าฝ่ายผลิตแห่งประเทศไทย



PIECEWISE LOADFLOW SOLUTION BASED ON NEWTON-RAPHSON METHOD

THE GENERAL DATA OF THE POWER SYSTEM

THE NUMBER OF BUSES = 13
THE NUMBER OF LINES = 24
THE BASE POWER =100.00MVA

THE BUS DATA OF THE POWER SYSTEM

BUS	BUS TYPE	VOLT (PU)	GENERATION MW	GENERATION MVAR	LOAD MW	LOAD MVAR	MVAR LIMIT MAX	MVAR LIMIT MIN	SHUNT CAPACITOR
1	3	1.087	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	2	1.087	154.00	0.00	68.00	26.80	200.00	-100.00	0.00
3	1	1.000	0.00	0.00	34.80	19.40	0.00	0.00	0.00
4	1	1.000	0.00	0.00	183.00	88.20	0.00	0.00	0.00
5	1	1.000	0.00	0.00	45.40	34.50	0.00	0.00	0.00
6	1	1.000	0.00	0.00	269.00	155.20	0.00	0.00	0.00
7	1	1.000	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8	2	1.000	163.00	0.00	331.00	260.00	200.00	-100.00	60.00
9	1	1.000	0.00	0.00	156.00	92.00	0.00	0.00	64.80
10	1	1.000	0.00	0.00	180.00	77.70	0.00	0.00	0.00
11	2	1.000	1268.00	0.00	320.50	200.70	800.00	-500.00	60.00
12	1	1.000	0.00	0.00	94.00	58.80	0.00	0.00	32.40
13	1	1.000	0.00	0.00	66.10	25.10	0.00	0.00	0.00

NOTE

BUS NUMBER 1 = LOAD BUS
BUS NUMBER 2 = VOLTAGE CONTROLLED BUS
BUS NUMBER 3 = SLACK BUS

THE LINE DATA OF THE POWER SYSTEM

LINE NO.	BUS P	BUS Q	IMPEDANCE R	IMPEDANCE X	LINE CHARGING	TRANSF. RATIO
1	1	3	0.0214	0.1623	0.3310	1.000
2	1	3	0.0214	0.1623	0.3310	1.000
3	1	3	0.0212	0.1646	0.3280	1.000
4	2	3	0.0399	0.1944	0.3750	1.000
5	2	3	0.0399	0.1944	0.3750	1.000
6	3	4	0.0129	0.0977	0.1960	1.000
7	3	4	0.0129	0.0977	0.1960	1.000
8	3	6	0.0281	0.1682	0.3410	1.000
9	3	5	0.0245	0.1875	0.3790	1.000
10	5	6	0.0081	0.0627	0.1260	1.000
11	4	10	0.0105	0.0796	0.1590	1.000
12	4	7	0.0095	0.0176	0.1430	1.000
13	7	9	0.0007	0.0052	0.0100	1.000
14	6	7	0.0018	0.0143	0.0270	1.000
15	7	8	0.0000	0.0199	0.0000	0.940
16	9	10	0.0010	0.0078	0.0160	1.000
17	10	12	0.0014	0.0113	0.0220	1.000
18	10	12	0.0014	0.0113	0.0220	1.000
19	6	11	0.0023	0.0174	0.0340	1.000
20	6	11	0.0023	0.0174	0.0340	1.000
21	11	12	0.0017	0.0136	0.0170	1.000
22	11	12	0.0017	0.0136	0.0170	1.000
23	12	13	0.0093	0.0728	0.1436	1.000
24	12	13	0.0093	0.0728	0.1436	1.000

THE BUS ALLOCATION OF THE POWER SYSTEM

BUS NUMBER	SUBDIVISION NUMBER
1	1
2	1
3	1
4	1
5	1
6	2
7	2
8	2
9	2
10	2
11	2
12	2
13	2

LIST OF TIE LINES

TIE LINE NUMBER	BUS P	BUS Q
1	3	6
2	5	6
3	4	10
4	4	7

ข.3 ผลการวิเคราะห์นิวตันราฟสันโหลดโฟลว์ โดยวิธีแยกเป็นส่วนย่อย

THE ACCELERATING FACTOR =1.600

BUS VOLTAGES AND POWER GENERATIONS

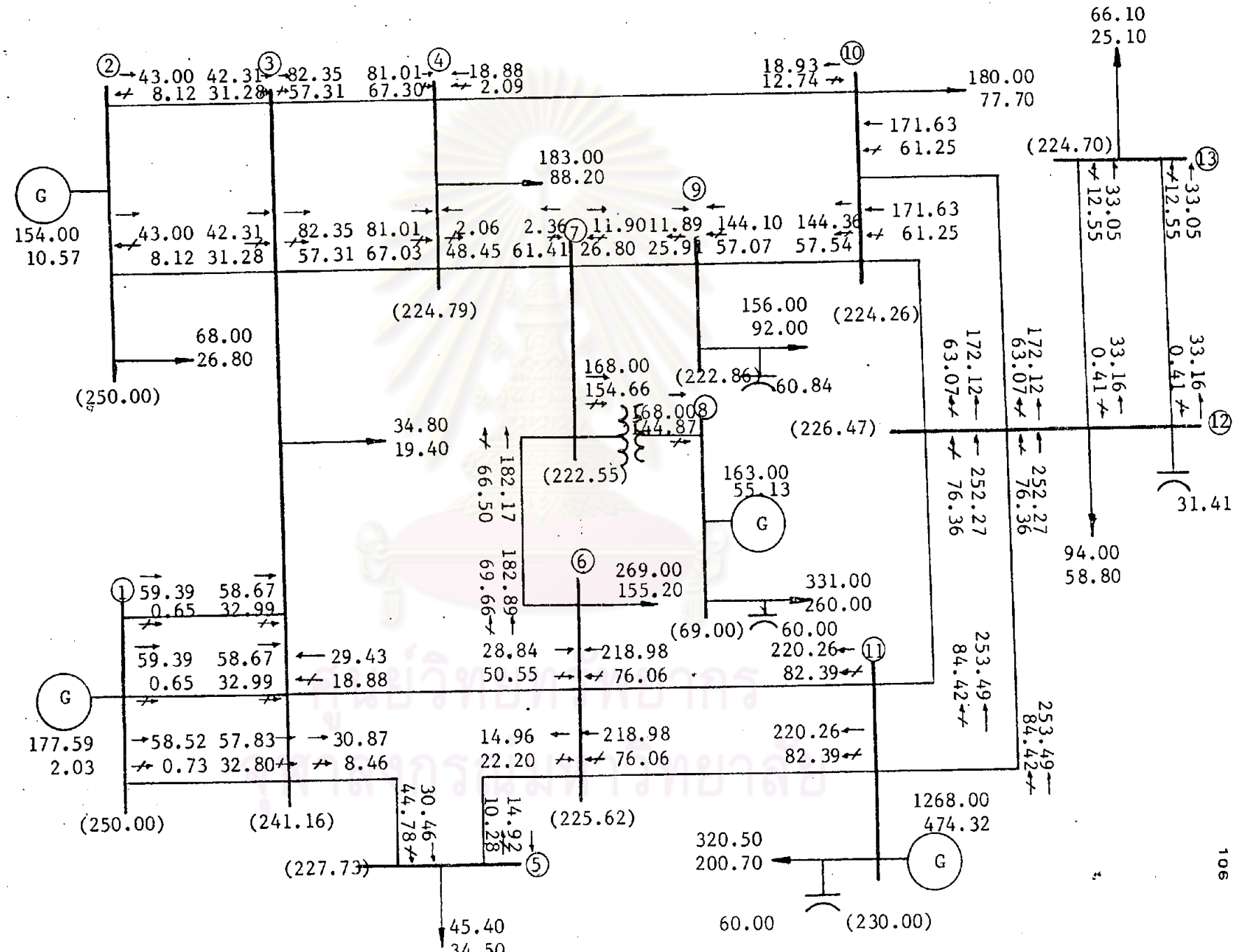
BUS NO.	BUS TYPE	BUS VOLTAGE PU	BUS VOLTAGE KV	BUS VOLTAGE DEG	GENERATION MW	GENERATION MVAR	LOAD MW	LOAD MVAR	@STATICS MVAR
1	3	1.0870	250.00	0.00	177.29	2.03	0.00	0.00	0.00
2	2	1.0870	250.00	-0.71	154.00	10.57	68.00	26.80	0.00
3	1	1.0485	241.16	-4.63	0.00	0.00	34.80	19.40	0.00
4	1	0.9773	224.79	-8.64	0.00	0.00	183.00	88.20	0.00
5	1	0.9901	227.73	-7.43	0.00	0.00	45.40	34.50	0.00
6	1	0.9810	225.62	-6.80	0.00	0.00	269.00	155.20	0.00
7	1	0.9676	222.55	-8.30	0.00	0.00	0.00	0.00	0.00
8	2	1.0000	69.00	-10.16	163.00	55.13	331.00	260.00	60.00
9	1	0.9689	222.86	-8.35	0.00	0.00	156.00	92.00	60.84
10	1	0.9750	224.26	-7.71	0.00	0.00	180.00	77.70	0.00
11	2	1.0000	230.00	-4.68	1268.00	474.32	320.50	200.70	60.00
12	1	0.9846	226.47	-6.60	0.00	0.00	94.00	58.80	31.41
13	1	0.9770	224.70	-8.00	0.00	0.00	66.10	25.10	0.00

LINE FLOWS

LINE NO.	BETWEEN BUS P	BUS Q	FLOW FROM BUS P MW	FLOW FROM BUS P MVAR	FLOW TO BUS Q MW	FLOW TO BUS Q MVAR	POWER LOSS MW	POWER LOSS MVAR	CHARGING MVAR
1	1	3	59,39	0,65	-58,67	-32,99	0,71	5,41	37,75
2	1	3	59,39	0,65	-58,67	-32,99	0,71	5,41	37,75
3	1	3	58,52	0,73	-57,83	-32,80	0,69	5,33	37,41
4	2	3	43,00	-8,12	-42,31	-31,28	0,69	3,37	42,77
5	2	3	43,00	-8,12	-42,31	-31,28	0,69	3,37	42,77
6	3	4	82,35	57,31	-81,01	-67,30	1,34	10,15	20,14
7	3	4	82,35	57,31	-81,01	-67,30	1,34	10,15	20,14
8	3	6	29,43	18,88	-28,84	-50,55	0,58	3,49	35,15
9	3	5	30,87	8,46	-30,46	-44,78	0,40	3,09	39,41
10	5	6	-14,92	10,28	14,96	-22,20	0,04	0,32	12,24
11	4	10	-18,88	-2,09	18,93	-12,74	0,04	0,32	15,15
12	4	7	-2,06	48,45	2,36	-61,41	0,30	0,56	13,52
13	7	9	11,90	-26,80	-11,89	25,91	0,01	0,05	0,94
14	6	7	182,89	69,66	-182,17	-66,50	0,72	5,72	2,56
15	7	8	168,00	154,66	-168,00	-144,87	0,00	9,79	0,00
16	9	10	-144,10	-57,07	144,36	57,54	0,25	1,99	1,51
17	10	12	-171,63	-61,25	172,12	63,07	0,49	3,93	2,11
18	10	12	-171,63	-61,25	172,12	63,07	0,49	3,93	2,11
19	6	11	-218,98	-76,06	220,26	82,39	1,28	9,67	3,34
20	6	11	-218,98	-76,06	220,26	82,39	1,28	9,67	3,34
21	11	12	253,49	84,42	-252,27	-76,36	1,22	9,73	1,67
22	11	12	253,49	84,42	-252,27	-76,36	1,22	9,73	1,67
23	12	13	33,16	-0,41	-33,05	-12,55	0,11	0,86	13,81
24	12	13	33,16	-0,41	-33,05	-12,55	0,11	0,86	13,81

SYSTEM TOTALS

	MW	MVAR
GENERATION	1762.29	542.05
LOAD	1747.80	1038.40
STATIC CAPACITOR		212.25
LINE CHARGING		401.07
POWER LOSS	14.71	116.88
POWER MISMATCH	-0.22	0.09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(224.70)
13
33.05
12.55
33.05
12.55
2
43.00 42.31
8.12 31.28
3
82.35 81.01
57.31 67.30
4
18.88
2.09
18.93
12.74
10
180.00
77.70
171.63
61.25
183.00
88.20
9
G
154.00
10.57
43.00 42.31
8.12 31.28
82.35 81.01
57.31 67.03
2.06 2.36
48.45 61.41
7
11.90 11.89
26.80 25.96
144.10 144.36
57.07 57.54
171.63
61.25
(224.79)
156.00
92.00
(224.26)
68.00
26.80
(250.00)
168.00
154.66
(222.86)
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8
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0.41
12
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19.40
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66.50
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69.66
(222.55)
163.00
55.13
G
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31.41
94.00
58.80
6
269.00
155.20
331.00
260.00
(69.00)
60.00
1
59.39 58.67
0.65 32.99
59.39 58.67
0.65 32.99
29.43
18.88
28.84
50.55
218.98
76.06
220.26
82.39
11
253.49
84.42
G
177.59
2.03
58.52 57.83
0.73 32.80
30.87
8.46
14.96
22.20
218.98
76.06
220.26
82.39
253.49
84.42
(250.00)
(241.16)
30.46
44.78
14.92
10.28
(225.62)
1268.00
474.32
320.50
200.70
G
(227.73)
5
45.40
60.00
(230.00)

ภาคผนวก ค.

โปรแกรมการวิเคราะห์นิวตันราฟสันโหลดโฟลว์โดยวิธีแยกเป็นส่วนย่อย

FORTRAN IV V02.5 PAGE 001

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      C.....................................................................
      C          PIECEWISE LOAD FLOW SOLUTION BASED ON NEWTON RAPHSON METHOD
      C.....................................................................
      C
      C.........CLASSIFY THE VARIABLES
0001        INTEGER IR,IW,NSUB,NBUS,NLINE,KMAX,OPTION(15),BUS(30)
0002        INTEGER BUSTYP(30),LINE(50),BUSP(50),BUSQ(50),ATABLE(30)
0003        INTEGER BPTL(10),BQTL(10),NOTL(30),NBIS(5),NOLS(5),NLCP(10)
0004        INTEGER BPOS(10,3),BQOS(10,3),NLB,NVCB,BUSS(10,3)
0005        REAL BASMVA,BASEKV(30),ALPHA,VOLT(30),QMAX(30),QMIN(30)
0006        REAL QSTATC(30),YLC(50),T(50),EPSLON,PPQ(50),QPQ(50)
0007        REAL PQP(50),QQP(50)
0008        COMPLEX ZS(50),Z1(10,10,3),Z2(10,10,3),Z4(10,10)
0009        COMPLEX YTIE(10),EBUS(30),GEN(30),LOAD(30),YBUS(10,10,3)
      C.........COMMON THE ARRAYS OF VARIABLES
0010        COMMON IR,IW,NSUB,NBUS,NLINE,KMAX,OPTION,BASMVA,BASEKV,ALPHA
0011        COMMON BUS,BUSTYP,LINE,BUSP,BUSQ,VOLT,QMAX,QMIN,QSTATC,YLC,T
0012        COMMON ZS,ATABLE,BPTL,BQTL,NOTL,NBIS,NOLS,NLCP,BPOS,BQOS
0013        COMMON BUSS,Z1,YBUS,Z4,YTIE,PPQ
0014        COMMON EPSLON,GEN,LOAD,QPQ,PQP,QQP,EBUS,NLB,NVCB
      C.........READ AND WRITE THE INPUT DATA OF THE POWER SYSTEM
0015        CALL STEP1
      C.........AUTOMATIC SECTIONALIZATION OF THE POWER SYSTEM
0016        CALL STEP2
      C.........PREPARE THE DATA FOR LOAD FLOW CALCULATION
0017        CALL STEP3
      C.........LOAD FLOW CALCULATION
0018        CALL STEP4
      C.........PRINT OUT THE LOAD FLOW SOLUTION
0019        CALL STEP5
0020        STOP
0021        END
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FORTRAN IV STORAGE MAP FOR PROGRAM UNIT .MAIN.

COMMON BLOCK / /, SIZE = 022362 (4729. WORDS)

NAME	TYPE	OFFSET	NAME	TYPE	OFFSET	NAME	TYPE	OFFSET
IR	I*2	000000	IW	I*2	000002	NSUB	I*2	000004
NBUS	I*2	000006	NLINE	I*2	000010	KMAX	I*2	000012
OPTION	I*2	000014	BASMVA	R*4	000052	BASEKV	R*4	000056
ALPHA	R*4	000246	BUS	I*2	000252	BUSTYP	I*2	000346
LINE	I*2	000442	BUSP	I*2	000606	BUSQ	I*2	000752
VOLT	R*4	001116	QMAX	R*4	001306	QMIN	R*4	001476
QSTATC	R*4	001666	YLC	R*4	002056	T	R*4	002366
ZS	C*8	002676	ATABLE	I*2	003516	BPTL	I*2	003612
BQTL	I*2	003636	NOTL	I*2	003662	NBIS	I*2	003756
NOLS	I*2	003770	NLCP	I*2	004002	BPOS	I*2	004026
BQOS	I*2	004122	BUSS	I*2	004216	Z1	C*8	004312
YBUS	C*8	011052	Z4	C*8	015612	YTIE	C*8	017252
PPQ	R*4	017372	EPSLON	R*4	017702	GEN	C*8	017706
LOAD	C*8	020266	QPQ	R*4	020646	PQP	R*4	021156
QQP	R*4	021466	EBUS	C*8	021776	NLB	I*2	022356
NVCB	I*2	022360						

LOCAL AND COMMON ARRAYS:

NAME	TYPE	SECTION	OFFSET	------SIZE-----	DIMENSIONS
ATABLE	I*2	.$$$$.	003516	000074 (30.)	(30)
BASEKV	R*4	.$$$$.	000056	000170 (60.)	(30)
BPOS	I*2 VEC	.$$$$.	004026	000074 (30.)	(10,3)
BPTL	I*2	.$$$$.	003612	000024 (10.)	(10)
BQOS	I*2 VEC	.$$$$.	004122	000074 (30.)	(10,3)
BQTL	I*2	.$$$$.	003636	000024 (10.)	(10)
BUS	I*2	.$$$$.	000252	000074 (30.)	(30)
BUSP	I*2	.$$$$.	000606	000144 (50.)	(50)
BUSQ	I*2	.$$$$.	000752	000144 (50.)	(50)
BUSS	I*2 VEC	.$$$$.	004216	000074 (30.)	(10,3)
BUSTYP	I*2	.$$$$.	000346	000074 (30.)	(30)
EBUS	C*8	.$$$$.	021776	000360 (120.)	(30)
GEN	C*8	.$$$$.	017706	000360 (120.)	(30)
LINE	I*2	.$$$$.	000442	000144 (50.)	(50)
LOAD	C*8	.$$$$.	020266	000360 (120.)	(30)
NBIS	I*2	.$$$$.	003756	000012 (5.)	(5)
NLCP	I*2	.$$$$.	004002	000024 (10.)	(10)
NOLS	I*2	.$$$$.	003770	000012 (5.)	(5)
NOTL	I*2	.$$$$.	003662	000074 (30.)	(30)
OPTION	I*2	.$$$$.	000014	000036 (15.)	(15)
PPQ	R*4	.$$$$.	017372	000310 (100.)	(50)
PQP	R*4	.$$$$.	021156	000310 (100.)	(50)
QMAX	R*4	.$$$$.	001306	000170 (60.)	(30)
QMIN	R*4	.$$$$.	001476	000170 (60.)	(30)
QPQ	R*4	.$$$$.	020646	000310 (100.)	(50)
QQP	R*4	.$$$$.	021466	000310 (100.)	(50)
QSTATC	R*4	.$$$$.	001666	000170 (60.)	(30)
T	R*4	.$$$$.	002366	000310 (100.)	(50)
VOLT	R*4	.$$$$.	001116	000170 (60.)	(30)
YBUS	C*8 VEC	.$$$$.	011052	004540 (1200.)	(10,10,3)
YLC	R*4	.$$$$.	002056	000310 (100.)	(50)

FORTRAN IV STORAGE MAP FOR PROGRAM UNIT .MAIN.

YTIE	C*8	.$$$$.	017252	000120 (40.)	(10)
ZS	C*8	.$$$$.	002676	000620 (200.)	(50)
Z1	C*8 VEC.	.$$$$.	004312	004540 (1200.)	(10,10,3)
Z2	C*8 VEC	$DATA	000000	004540 (1200.)	(10,10,3)
Z4	C*8 VEC	.$$$$.	015612	001440 (400.)	(10,10)

SUBROUTINES, FUNCTIONS, STATEMENT AND PROCESSOR-DEFINED FUNCTIONS:

NAME	TYPE	NAME	TYPE	NAME	TYPE	NAME	TYPE	NAME	TYPE
STEP1	R*4	STEP2	R*4	STEP3	R*4	STEP4	R*4	STEP5	R*4


```
      C.....................................................................
0001        SUBROUTINE STEP1
      C.....................................................................
      C
      C.........LIST OF VARIABLES
      C
      C          NSUB   = NUMBER OF SUBDIVISIONS
      C          NBUS   = NUMBER OF BUSES
      C          NLINE  = NUMBER OF TRANSMISSION LINES AND TRANSFORMERS
      C          KMAX   = MAXIMUM ITERATION NUMBER
      C          BASMVA = BASE POWER OF THE POWER SYSTEM
      C          BASEKV = BASE VOLTAGE OF THE POWER SYSTEM
      C          ALPHA  = ACCELERATING FACTOR
      C          EPSLON = TOLERANCE OF POWER MISMATCH
      C          OPTION = CONTROL CODE
      C          BUSNAM = NAME OF BUS
      C          BUS    = BUS NUMBER
      C          BUSTYP = TYPE OF BUS
      C          VOLT   = SPECIFIED OR INITIAL BUS VOLTAGE
      C          GEN    = REAL AND REACTIVE BUS POWER GENERATION
      C          LOAD   = REAL AND REACTIVE BUS POWER DEMAND
      C          QMAX   = MAXIMUM REACTIVE BUS POWER SOURCE
      C          QMIN   = MINIMUM REACTIVE BUS POWER SOURCE
      C          QSTATC = STATIC VAR OF CAPACITOR
      C          LINE   = LINE NUMBER OF TRANSMISSION LINE OR TRANSFORMER
      C          BUSP   = BUS P OF TRANSMISSION LINE OR TRANSFORMER
      C          BUSQ   = BUS Q OF TRANSMISSION LINE OR TRANSFORMER
      C          ZS     = SERIES IMPEDANCE OF TRANSMISSION LINE OR TRANSFORMER
      C          YLC    = LINE CHARGING ADMITTANCE
      C          T      = TURN RATIO OF TRANSFORMER
      C
      C.........CLASSIFY THE VARIABLES
0002        INTEGER IR,IW,NSUB,NBUS,NLINE,KMAX,OPTION(15)
0003        REAL    BASMVA,BASEKV(30),ALPHA,EPSLON
0004        INTEGER BUS(30),BUSTYP(30),LINE(50),BUSP(50),BUSQ(50)
0005        REAL    VOLT(30),QMAX(30),QMIN(30),QSTATC(30),YLC(50)
0006        REAL    T(50),PPQ(50),QPQ(50),PQP(50),QQP(50)
0007        COMPLEX GEN(30),LOAD(30),ZS(50),EBUS(30),YBUS(10,10,3)
0008        INTEGER ATABLE(30),BPTL(10),BQTL(10),NOTL(30),NBIS(5),NOLS(5)
0009        INTEGER NLCP(10),BPOS(10,3),BQOS(10,3),NLB,NVCB,BUSS(10,3)
0010        COMPLEX Z1(10,10,3),Z2(10,10,3),Z4(10,10),YTIE(10)
      C
      C.........COMMON THE ARRAYS OF THE VARIABLES
0011        COMMON IR,IW,NSUB,NBUS,NLINE,KMAX,OPTION,BASMVA,BASEKV,ALPHA
0012        COMMON BUS,BUSTYP,LINE,BUSP,BUSQ,VOLT,QMAX,QMIN,QSTATC,YLC,T
0013        COMMON ZS,ATABLE,BPTL,BQTL,NOTL,NBIS,NOLS,NLCP,BPOS,BQOS
0014        COMMON BUSS,Z1,YBUS,Z4,YTIE,PPQ
0015        COMMON EPSLON,GEN,LOAD,QPQ,PQP,QQP,EBUS,NLB,NVCB
      C.........SELECT THE POWER SYSTEM WHICH MUST BE STUDIED
0016        TYPE 30
0017        TYPE 31
0018        TYPE 30
0019  86    TYPE 80
0020  80    FORMAT(///T10,'SELECT THE POWER SYSTEM WHICH YOU WANT TO STUDY')
```

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0021          TYPE 81
0022  81      FORMAT(/T15,'1 = PROBLEM 1'/T15,'2 = PROBLEM 2'/T15,'3 = PROBLEM
             X3'/T15,'4 = PROBLEM 4'/T15,'5 = PROBLEM 5')
0023          TYPE 89
0024  89      FORMAT(/T10,'THE PROBLEM WHICH YOU SELECT TO STUDY IS ',$)
0025          ACCEPT 82,MPROB
0026  82      FORMAT(I1)
0027          IF(MPROB.EQ.1) GO TO 83
0029          IF(MPROB.EQ.2) GO TO 84
0031          IF(MPROB.EQ.3) GO TO 85
0033          IF(MPROB.EQ.4) GO TO 87
0035          IF(MPROB.EQ.5) GO TO 88
0037          GO TO 86
0038  83      IR=1
0039          IW=7
0040          OPEN(UNIT=1,NAME='DY1:PROB1.DAT',TYPE='OLD')
0041          GO TO 99.
0042  84      IR=2
0043          IW=7
0044          OPEN(UNIT=2,NAME='DY1:PROB2.DAT',TYPE='OLD')
0045          GO TO 99
0046  85      IR=3
0047          IW=7
0048          OPEN(UNIT=3,NAME='DY1:PROB3.DAT',TYPE='OLD')
0049          GO TO 99
0050  87      IR=4
0051          IW=7
0052          OPEN(UNIT=4,NAME='DY1:PROB4.DAT',TYPE='OLD')
0053          GO TO 99
0054  88      IR=8
0055          IW=7
0056          OPEN(UNIT=8,NAME='DY1:PROB5.DAT',TYPE='OLD')
      C.........READ THE GENERAL SYSTEM DATA
0057  99      READ(IR,10) NSUB,NBUS,NLINE,KMAX,BASMVA,ALPHA,EPSLON
0058  10      FORMAT(4I5,3F8.3)
      C.........READ CONTROL DATA
0059          READ(IR,11) (OPTION(I),I=1,15)
0060  11      FORMAT(15I1)
      C.........READ THE DATA OF EACH BUS
0061          DO 20 I=1,NBUS
0062          READ(IR,12) BUS(I),BUSTYP(I),VOLT(I),GEN(I),LOAD(I),
             X              QMAX(I),QMIN(I),QSTATC(I),BASEKV(I)
0063  12      FORMAT(2I5,9F7.3)
0064          VOLT(I)=VOLT(I)/BASEKV(I)
0065          IF(VOLT(I).EQ.0.0) VOLT(I)=1.0
0067  20      CONTINUE
      C.........READ THE TRANSMISSION LINE AND TRANSFORMER DATA
0068          DO 21 I=1,NLINE
0069          READ(IR,13) LINE(I),BUSP(I),BUSQ(I),ZS(I),YLC(I),T(I)
0070  13      FORMAT(3I5,4F10.5)
0071          IF(T(I).EQ.0.0) T(I)=1.0
0073  21      CONTINUE
      C.........WRITE THE TITLE
0074          TYPE 91
```

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0075  91    FORMAT(/////T10,'DO YOU WANT TO PRINT THE DATA? (Y OR N)',$)
0076         ACCEPT 92,MY
0077  92    FORMAT(A1)
0078         DATA MM/1HY/
0079         IF(MM.EQ.MY) IW=6
0081         WRITE(IW,30)
0082  30    FORMAT(' ','----------------------------------------------------
     X-------------------------')
0083         WRITE(IW,31)
0084  31    FORMAT(T11,'PIECEWISE LOADFLOW SOLUTION BASED ON NEWTON-RAPHSON
     XMETHOD')
0085         WRITE(IW,30)
0086         IF(OPTION(1).EQ.0) GO TO 100
     C.........WRITE THE GENERAL DATA
0088         WRITE(IW,32)
0089  32    FORMAT(///T22,'THE GENERAL DATA OF THE POWER SYSTEM')
0090         WRITE(IW,33)
0091  33    FORMAT(   T22,'----------------------------------')
0092         WRITE(IW,34)NBUS
0093  34    FORMAT(/T20,'THE NUMBER OF BUSES =',I5)
0094         WRITE(IW,35)NLINE
0095  35    FORMAT( T20,'THE NUMBER OF LINES =',I5)
0096         WRITE(IW,36)BASMVA
0097  36    FORMAT( T20,'THE BASE POWER      =',F6.2,'MVA')
     C.........WRITE THE BUS DATA
0098         WRITE(IW,40)
0099  40    FORMAT(///T25,'THE BUS DATA OF THE POWER SYSTEM')
0100         WRITE(IW,41)
0101  41    FORMAT(   T25,'--------------------------------')
0102         WRITE(IW,42)
0103  42    FORMAT( T3,':----:----:-------:-------:-------:-------:-------:-
     X------:-------:---------:')
0104         WRITE(IW,43)
0105  43    FORMAT( T3,':BUS :BUS : VOLT  :  GENERATION   :     LOAD      :
     X  MVAR LIMIT   :  SHUNT  :')
0106         WRITE(IW,44)
0107  44    FORMAT( T3,':    :    :-------:-------:-------:-------:-------:-
     X------:-------:          :')
0108         WRITE(IW,45)
0109  45    FORMAT( T3,':    :TYPE: (PU)  :  MW   : MVAR  :  MW   : MVAR  :
     X  MAX  :  MIN  :CAPACITOR:')
0110         WRITE(IW,42)
0111         DO 50 I=1,NBUS
0112         WRITE(IW,46) BUS(I),BUSTYP(I),VOLT(I),GEN(I),LOAD(I),QMAX(I),QMI
     XN(I),QSTATC(I)
0113  46    FORMAT(T3,':',T4,I3,T8,':',T10,I1,T13,':',T15,F6.3,T21,6(':',F7.
     X2),':',F8.2,T79,':')
0114         WRITE(IW,42)
0115  50    CONTINUE
0116         WRITE(IW,160)
0117  160   FORMAT(/T3,'NOTE     BUS NUMBER 1 = LOAD BUS'/
     X          T3,'----     BUS NUMBER 2 = VOLTAGE CONTROLLED BUS'/
     X          T3,'         BUS NUMBER 3 = SLACK BUS')
0118  100   IF(OPTION(2).EQ.0) GO TO 150
```

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      C.........WRITE THE LINE DATA
0120          WRITE(IW,60)
0121    60    FORMAT(///T25,'THE LINE DATA OF THE POWER SYSTEM')
0122          WRITE(IW,61)
0123    61    FORMAT(   T25,'--------------------------------')
0124          WRITE(IW,62)
0125    62    FORMAT(T14,':------:-----:-----:--------:--------:--------:-----
             X--:')
0126          WRITE(IW,63)
0127    63    FORMAT(T14,': LINE : BUS : BUS :    IMPEDANCE    : LINE  :TRANS
             XF.:')
0128          WRITE(IW,64)
0129    64    FORMAT(T14,':      :     :     :--------:--------:        :
             X   :')
0130          WRITE(IW,65)
0131    65    FORMAT(T14,':  NO. : P : Q :   R    :   X    :CHARGING: RATI
             XO :')
0132          WRITE(IW,62)
0133          DO 70 I=1,NLINE
0134          WRITE(IW,66) LINE(I),BUSP(I),BUSQ(I),ZS(I),YLC(I),T(I)
0135    66    FORMAT(T14,':',I4,'  :',2(I3,'  :'),3(F7.4,' :'),F6.3,' :')
0136          WRITE(IW,62)
0137    70    CONTINUE
0138    150   RETURN
0139          END
```

```
FORTRAN IV      STORAGE MAP FOR PROGRAM UNIT STEP1

LOCAL VARIABLES, .PSECT $DATA, SIZE = 004644 ( 1234. WORDS)

NAME   TYPE  OFFSET     NAME   TYPE  OFFSET     NAME   TYPE  OFFSET
I      I*2   004640     MM     I*2   004540     MPROB  I*2   004636
MY     I*2   004642

COMMON BLOCK /      /, SIZE = 022362 ( 4729. WORDS)

NAME   TYPE  OFFSET     NAME   TYPE  OFFSET     NAME   TYPE  OFFSET
IR     I*2   000000     IW     I*2   000002     NSUB   I*2   000004
NBUS   I*2   000006     NLINE  I*2   000010     KMAX   I*2   000012
OPTION I*2   000014     BASMVA R*4   000052     BASEKV R*4   000056
ALPHA  R*4   000246     BUS    I*2   000252     BUSTYP I*2   000346
LINE   I*2   000442     BUSP   I*2   000606     BUSQ   I*2   000752
VOLT   R*4   001116     QMAX   R*4   001306     QMIN   R*4   001476
QSTATC R*4   001666     YLC    R*4   002056     T      R*4   002366
ZS     C*8   002676     ATABLE I*2   003516     BPTL   I*2   003612
BQTL   I*2   003636     NOTL   I*2   003662     NBIS   I*2   003756
NOLS   I*2   003770     NLCP   I*2   004002     BPOS   I*2   004026
BQOS   I*2   004122     BUSS   I*2   004216     Z1     C*8   004312
YBUS   C*8   011052     Z4     C*8   015612     YTIE   C*8   017252
PPQ    R*4   017372     EPSLON R*4   017702     GEN    C*8   017706
LOAD   C*8   020266     QPQ    R*4   020646     PQP    R*4   021156
QQP    R*4   021466     EBUS   C*8   021776     NLB    I*2   022356
NVCB   I*2   022360

LOCAL AND COMMON ARRAYS:

NAME     TYPE    SECTION OFFSET  ------SIZE----- DIMENSIONS
ATABLE I*2       .$$$$.  003516  000074 (   30.) (30)
BASEKV R*4       .$$$$.  000056  000170 (   60.) (30)
BPOS   I*2 VEC   .$$$$.  004026  000074 (   30.) (10,3)
BPTL   I*2       .$$$$.  003612  000024 (   10.) (10)
BQOS   I*2 VEC   .$$$$.  004122  000074 (   30.) (10,3)
BQTL   I*2       .$$$$.  003636  000024 (   10.) (10)
BUS    I*2       .$$$$.  000252  000074 (   30.) (30)
BUSP   I*2       .$$$$.  000606  000144 (   50.) (50)
BUSQ   I*2       .$$$$.  000752  000144 (   50.) (50)
BUSS   I*2 VEC   .$$$$.  004216  000074 (   30.) (10,3)
BUSTYP I*2       .$$$$.  000346  000074 (   30.) (30)
EBUS   C*8       .$$$$.  021776  000360 (  120.) (30)
GEN    C*8       .$$$$.  017706  000360 (  120.) (30)
LINE   I*2       .$$$$.  000442  000144 (   50.) (50)
LOAD   C*8       .$$$$.  020266  000360 (  120.) (30)
NBIS   I*2       .$$$$.  003756  000012 (    5.) (5)
NLCP   I*2       .$$$$.  004002  000024 (   10.) (10)
NOLS   I*2       .$$$$.  003770  000012 (    5.) (5)
NOTL   I*2       .$$$$.  003662  000074 (   30.) (30)
OPTION I*2       .$$$$.  000014  000036 (   15.) (15)
PPQ    R*4       .$$$$.  017372  000310 (  100.) (50)
PQP    R*4       .$$$$.  021156  000310 (  100.) (50)
QMAX   R*4       .$$$$.  001306  000170 (   60.) (30)
QMIN   R*4       .$$$$.  001476  000170 (   60.) (30)
QPQ    R*4       .$$$$.  020646  000310 (  100.) (50)
```

FORTRAN IV STORAGE MAP FOR PROGRAM UNIT STEP1

QQP	R*4		.$$$$.	021466	000310	(100.)	(50)
QSTATC	R*4		.$$$$.	001666	000170	(60.)	(30)
T	R*4		.$$$$.	002366	000310	(100.)	(50)
VOLT	R*4		.$$$$.	001116	000170	(60.)	(30)
YBUS	C*8	VEC	.$$$$.	011052	004540	(1200.)	(10,10,3)
YLC	R*4		.$$$$.	002056	000310	(100.)	(50)
YTIE	C*8		.$$$$.	017252	000120	(40.)	(10)
ZS	C*8		.$$$$.	002676	000620	(200.)	(50)
Z1	C*8	VEC	.$$$$.	004312	004540	(1200.)	(10,10,3)
Z2	C*8	VEC	$DATA	000000	004540	(1200.)	(10,10,3)
Z4	C*8	VEC	.$$$$.	015612	001440	(400.)	(10,10)

```
      C.....................................................................
0001        SUBROUTINE STEP2
      C.....................................................................
      C
      C.........LIST OF VARIABLES
      C
      C          ATABLE = ALLOCATION TABLE
      C          RTABLE = REVISED ALLOCATION TABLE
      C          BPTL   = BUS P OF TIE LINE
      C          BQTL   = BUS Q OF TIE LINE
      C          NOTL   = NUMBER OF TIE LINES
      C          NBIS   = NUMBER OF BUSES IN SUBDIVISION
      C          NOLS   = NUMBER OF LINES IN SUBDIVISION
      C          COST   = COST OF INITIAL ALLOCATION
      C          NLCP   = NUMBER OF LINES WHICH ARE CONNECTED TO BUS P
      C          KT     = NUMBER OF INCREASED TIE LINES AFTER THE ALLOCATION OF BUS P
      C          CMIN   = MINIMUM COST OF THE ALLOCATION OF BUS P
      C          CTABLE = COST TABLE
      C          PTABLE = PREVIOUS BUS ALLOCATION TABLE
      C          BPOS   = BUS P OF LINE IN SUBDIVISION
      C          BQOS   = BUS Q OF LINE IN SUBDIVISION
      C          LINES  = LINE NUMBER IN SUBDIVISION
      C
      C.........CLASSIFY THE VARIABLES
0002        INTEGER NBPS,NN,P,NNN,M,K,Q,NOTL,C,KK,H
0003        INTEGER NBUS,NSUB,NLINE,ATABLE(30),BPTL(10),BQTL(10),NOTL(30)
0004        INTEGER NBIS(5),NOLS(5),BUSP(50),BUSQ(50),NLCP(10)
0005        INTEGER RTABLE(30),COST(30),KT(30),CMIN(30),CTABLE(30,3)
0006        INTEGER PTABLE(30,3),BPOS(10,3),BQOS(10,3)
0007        INTEGER IR,IW,KMAX,OPTION(15),BUS(30),BUSTYP(30),LINE(50)
0008        INTEGER NLB,NVCB,BUSS(10,3),BTABLE(30)
0009        REAL BASMVA,BASEKV(30),ALPHA,EPSLON,VOLT(30),QMAX(30),QMIN(30)
0010        REAL QSTATC(30),YLC(50),T(50),PPQ(50),QPQ(50),PQP(50)
0011        REAL QQP(50)
0012        COMPLEX Z1(10,10,3),Z2(10,10,3),Z4(10,10),YTIE(10)
0013        COMPLEX EBUS(30),GEN(30),LOAD(30),YBUS(10,10,3),ZS(50)
      C.........COMMON THE ARRAYS OF VARIABLES
0014        COMMON IR,IW,NSUB,NBUS,NLINE,KMAX,OPTION,BASMVA,BASEKV,ALPHA
0015        COMMON BUS,BUSTYP,LINE,BUSP,BUSQ,VOLT,QMAX,QMIN,QSTATC,YLC,T
0016        COMMON ZS,ATABLE,BPTL,BQTL,NOTL,NBIS,NOLS,NLCP,BPOS,BQOS
0017        COMMON BUSS,Z1,YBUS,Z4,YTIE,PPQ
0018        COMMON EPSLON,GEN,LOAD,QPQ,PQP,QQP,EBUS,NLB,NVCB
      C.........INITIAL COMPUTING THE NUMBER OF BUSES IN EACH SUBDIVISION
0019        NBPS=NBUS/NSUB
0020        INDEX=0
      C.........INITIAL FEASIBLE ALLOCATION
0021        NN=NSUB-1
0022        DO 201 J=1,NN
0023        DO 202 I=1,NBPS
0024        P=(J-1)*NBPS+I
0025        ATABLE(P)=J
0026  202   CONTINUE
0027  201   CONTINUE
0028        NNN=NN*NBPS+1
```

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0029          DO 203 P=NNN,NBUS
0030  203     ATABLE(P)=NSUB
      C.........SET THE RUNNING NUMBER
0031          M=1
      C.........CLEAR THE TIE LINE COUNTER
0032  250     K=0
0033          IF(INDEX.NE.999) GO TO 2250
0035          DATA MM/1HY/
0036          TYPE 2251
0037  2251    FORMAT(///T10,'DO YOU WANT TO CHANGE THE BUS ALLOCATION? (Y OR N)
             X  ',$)
0038          ACCEPT 2252,MY
0039  2252    FORMAT(A1)
0040          IF(MM.NE.MY) GO TO 2250
0042          DO 2253 II=1,NBUS
0043          TYPE 2254,II
0044  2254    FORMAT(T10,'BUS',1X,I2,1X,'IS IN SUBDIVISION  ',$)
0045          ACCEPT 2255,ATABLE(II)
0046  2255    FORMAT(I1)
0047  2253    CONTINUE
      C.........FIND THE TIE LINE
0048  2250    DO 204 I=1,NLINE
0049          P=BUSP(I)
0050          Q=BUSQ(I)
0051          IF(ATABLE(P).EQ.ATABLE(Q)) GO TO 204
      C.........COUNT THE NUMBER OF TIE LINES
0053          K=K+1
      C.........RECORD BUS P AND BUS Q OF TIE LINE
0054          BPTL(K)=P
0055          BQTL(K)=Q
0056  204     CONTINUE
      C.........OBTAIN THE NUMBER OF TIE LINES AFTER THE ALLOCATION OF BUS 1
0057          NOTL(1)=K
      C.........COMPUTE THE NUMBER OF BUSES IN EACH SUBDIVISION
0058          DO 205 J=1,NSUB
0059  205     NBIS(J)=0
0060          DO 206 J=1,NSUB
0061          DO 207 I=1,NBUS
0062          IF(ATABLE(I).NE.J) GO TO 207
      C.........COUNT THE NUMBER OF BUSES IN SUBDIVISION J
0064          NBIS(J)=NBIS(J)+1
0065  207     CONTINUE
0066  206     CONTINUE
      C.........COMPUTE THE NUMBER OF LINES IN EACH SUBDIVISION
0067          DO 208 J=1,NSUB
0068  208     NOLS(J)=0
0069          DO 209 J=1,NSUB
0070          DO 210 I=1,NLINE
0071          P=BUSP(I)
0072          Q=BUSQ(I)
0073          IF(ATABLE(P).NE.ATABLE(Q)) GO TO 210
0075          IF(ATABLE(P).NE.J)         GO TO 210
      C.........COUNT THE NUMBER OF LINES IN SUBDIVISION J
0077          NOLS(J)=NOLS(J)+1
```

```
0078        K=NOLS(J)
      C.........RECORD BUS P AND BUS Q OF LINE K IN SUBDIVISION J
0079        BPOS(K,J)=P
0080        BQOS(K,J)=Q
0081  210   CONTINUE
0082  209   CONTINUE
0083        IF(INDEX.EQ.999) GO TO 300
      C.........CLEAR THE COST TABLE
0085        DO 211 J=1,NSUB
0086        DO 212 I=1,NBUS
0087  212   CTABLE(I,J)=0
0088  211   CONTINUE
      C.........COMPUTE THE INITIAL COST
0089        DO 213 J=1,NSUB
0090  213   CTABLE(1,1)=CTABLE(1,1)+NBIS(J)**2
0091        CTABLE(1,1)=CTABLE(1,1)+NOTL(1)**2
      C.........SET THE INITIAL COST
0092        COST(M)=CTABLE(1,1)
      C.........TEST THE OPTIMUM CONDITION
0093        IF(M.EQ.1) GO TO 214
0095        IF(COST(M).LT.COST(M-1)) GO TO 214
      C.........THE INITIAL ALLOCATION IS THE OPTIMUM ALLOCATION.
      C.........REVISE THE INITIAL ALLOCATION
0097        INDEX=999
0098        DO 215 P=1,NBUS
0099  215   ATABLE(P)=RTABLE(P)
0100        GO TO 250
      C.........FIND THE OPTIMUM ALLOCATION OF BUS P
0101  214   CONTINUE
0102        DO 2230 P=1,NBUS
0103  2230  BTABLE(P)=ATABLE(P)
0104        DO 216 P=2,NBUS
0105        DO 217 J=1,NSUB
      C.........FIND THE ALLOCATION OF BUS (P-1)
0106        H=BTABLE(P-1)
      C.........ALLOCATE BUS P IN SUB. J AFTER THE ALLOCATION OF BUS (P-1)
0107        I=BTABLE(P)
0108        IF(I.EQ.J) GO TO 218
      C.........COMPUTE THE NUMBER OF LINES WHICH CONNECTED TO BUS P IN SUB. I
0110        DO 219 I1=1,NSUB
0111  219   NLCP(I1)=0
0112        DO 220 K=1,NOLS(I)
0113        IF(P.EQ.BPOS(K,I)) GO TO 221
0115        IF(P.EQ.BQOS(K,I)) GO TO 221
0117        GO TO 220
0118  221   NLCP(I)=NLCP(I)+1
0119  220   CONTINUE
      C.........COMPUTE THE NUMBER OF DECREASED TIE LINES
0120        NDTL=0
0121        DO 222 L=1,NOTL(P-1)
0122        IF(P.EQ.BPTL(L)) GO TO 223
0124        IF(P.EQ.BQTL(L)) GO TO 224
0126        GO TO 222
0127  223   Q=BQTL(L)
```


```
0128        GO TO 225
0129  224   Q=BPTL(L)
      C.....FIND THE ALLOCATION OF BUS Q
0130  225   G=BTABLE(Q)
      C.....IS BUS Q ALLOCATED IN SUBDIVISION J?
0131        IF(G.NE.J) GO TO 222
0133        NDTL=NDTL+1
0134  222   CONTINUE
      C.....COMPUTE THE INCREASED TIE LINES
0135        KT(P)=NLCP(I)-NDTL
      C.....COMPUTE THE COST OF THE ALLOCATION OF BUS P IN SUBDIVISION J
0136        CTABLE(P,J)=(NBIS(J)+1)**2+(NBIS(I)-1)**2+(NDTL(P-1)+KT(P))**2-
           X  NBIS(J)**2-NBIS(I)**2-NDTL(P-1)**2+CTABLE(P-1,H)
0137        GO TO 217
0138  218   CTABLE(P,J)=CTABLE(P-1,H)
0139  217   CONTINUE
      C.....CLEAR THE PREVIOUS BUS ALLOCATION TABLE
0140        DO 226 J=1,NSUB
0141  226   PTABLE(P,J)=0
      C.....FIND THE MINIMUM COST OF THE ALLOCATION OF BUS P
0142        CMIN(P)=CTABLE(P-1,H)
0143        K=BTABLE(P)
0144        DO 227 J=1,NSUB
0145        IF(CTABLE(P,J).GE.CMIN(P)) GO TO 227
0147        CMIN(P)=CTABLE(P,J)
0148        K=J
0149  227   CONTINUE
      C.....FORM THE PREVIOUS BUS ALLOCATION TABLE
0150        IF(P.EQ.2) GO TO 228
0152        DO 229 J=1,NSUB
0153        IF(PTABLE(P-1,J).EQ.0) GO TO 229
0155        I=J
0156  229   CONTINUE
0157        PTABLE(P,K)=I
0158        GO TO 2216
0159  228   PTABLE(P,K)=H
0160  2216  BTABLE(P)=K
0161        KK=0
0162        DO 2204 I1=1,NLINE
0163        IP=BUSP(I1)
0164        IQ=BUSQ(I1)
0165        IF(BTABLE(IP).EQ.BTABLE(IQ)) GO TO 2204
0167        KK=KK+1
0168        BPTL(KK)=IP
0169        BQTL(KK)=IQ
0170  2204  CONTINUE
0171        NOTL(P)=KK
0172        DO 2205 J1=1,NSUB
0173  2205  NBIS(J1)=0
0174        DO 2206 J1=1,NSUB
0175        DO 2207 I1=1,NBUS
0176        IF(BTABLE(I1).NE.J1) GO TO 2207
0178        NBIS(J1)=NBIS(J1)+1
0179  2207  CONTINUE
```

```
0180  2206  CONTINUE
0181        DO 2208 J1=1,NSUB
0182  2208  NOLS(J1)=0
0183        DO 2209 J1=1,NSUB
0184        DO 2210 I1=1,NLINE
0185        IP=BUSP(I1)
0186        IQ=BUSQ(I1)
0187        IF(BTABLE(IP).NE.BTABLE(IQ)) GO TO 2210
0189        IF(BTABLE(IP).NE.J1)         GO TO 2210
0191        NOLS(J1)=NOLS(J1)+1
0192        K1=NOLS(J1)
0193        BPOS(K1,J1)=IP
0194        BQOS(K1,J1)=IQ
0195  2210  CONTINUE
0196  2209  CONTINUE
0197  216   CONTINUE
      C.........RECORD THE INITIAL ALLOCATION TABLE
0198        DO 230 P=1,NBUS
0199  230   RTABLE(P)=ATABLE(P)
      C.........REPLACE THE ALLOCATION OFTHE LAST BUS IN THE INITIAL ALLO. TABLE
0200        ATABLE(NBUS)=K
      C.........FIND THE ALLOCATION OF BUS P FROM THE PREVIOUS ALLOCATION TABLE
0201        KK=NBUS-2
0202        DO 231 I=1,KK
0203        P=NBUS-I
0204        DO 232 J=1,NSUB
0205        IF(PTABLE(P+1,J).EQ.0) GO TO 232
0207        K=PTABLE(P+1,J)
0208  232   CONTINUE
      C.........REPLACE THE ALLOCATION OF BUS P IN THE INITIAL ALLOCATION TABLE
0209        ATABLE(P)=K
0210  231   CONTINUE
      C.........ADVANCE THE RUNNING NUMBER
0211        IF(M.EQ.1000) GO TO 320
0213        M=M+1
0214        GO TO 250
0215  300   IF(OPTION(3).EQ.0) GO TO 295
      C.........WRITE THE ALLOCATION TABLE
0217        WRITE(IW,270)
0218  270   FORMAT(' ',///T22,'THE BUS ALLOCATION OF THE POWER SYSTEM')
0219        WRITE(IW,271)
0220  271   FORMAT(' ',T22,'-----------------------------------')
0221        WRITE(IW,272)
0222  272   FORMAT(' ',T24,':-----------:-----------:')
0223        WRITE(IW,273)
0224  273   FORMAT(' ',T24,': BUS NUMBER : SUBDIVISION NUMBER :')
0225        WRITE(IW,272)
0226        DO 290 I=1,NBUS
0227        WRITE(IW,274) I,ATABLE(I)
0228  274   FORMAT(' ',T24,':',T29,I3,T37,':',T47,I2,T58,':')
0229        WRITE(IW,272)
0230  290   CONTINUE
0231  295   IF(OPTION(4).EQ.0) GO TO 296
      C.........WRITE THE LIST OF TIE LINES
```

```
0233        WRITE(IW,280)
0234  280   FORMAT(' ',///T32,'LIST OF TIE LINES')
0235        WRITE(IW,281)
0236  281   FORMAT(' ',T32,'-----------------')
0237        WRITE(IW,282)
0238  282   FORMAT(' ',T24,';----------------:-------:-------:')
0239        WRITE(IW,283)
0240  283   FORMAT(' ',T24,'; TIE LINE NUMBER : BUS P : BUS Q :')
0241        WRITE(IW,282)
0242        DO 291 I=1,NOTL(1)
0243        WRITE(IW,284) I,BPTL(I),BQTL(I)
0244  284   FORMAT(' ',T24,';',T33,I2,T42,':',T45,I3,T50,':',T53,I3,T58,':')
0245        WRITE(IW,282)
0246  291   CONTINUE
0247  296   IF(OPTION(5).EQ.0) GO TO 320
      C.....WRITE THE LINE OF EACH SUBDIVISION
0249        WRITE(IW,350)
0250  350   FORMAT(' ',T18,';------------:------------:-------:-------:')
0251        WRITE(IW,351)
0252  351   FORMAT(' ',T18,'; SUBDIVISION : LINE NUMBER : BUS P : BUS Q :')
0253        WRITE(IW,350)
0254        DO 310 J=1,NSUB
0255        DO 301 I=1,NOLS(J)
0256        IF(NOLS(J).NE.0) GO TO 1000
0258        L=0
0259        BPOS(I,J)=0
0260        BQOS(I,J)=0
0261        GO TO 1100
0262  1000  L=I
0263  1100  WRITE(IW,352) J,L,BPOS(I,J),BQOS(I,J)
0264  352   FORMAT(' ',T18,';',T25,I2,T32,':',T39,I2,T46,':',T50,I2,T54,
           X  ':',T58,I2,T62,':')
0265  301   CONTINUE
0266        WRITE(IW,999)
0267  999   FORMAT(' ',T18,';------------:------------:-------:-------:')
0268  310   CONTINUE
0269  320   RETURN
0270        END
```

FORTRAN IV STORAGE MAP FOR PROGRAM UNIT STEP2

LOCAL VARIABLES, .PSECT $DATA, SIZE = 006242 (1617. WORDS)

NAME	TYPE	OFFSET	NAME	TYPE	OFFSET	NAME	TYPE	OFFSET
G	I*2	006152	H	I*2	006156	I	I*2	006164
II	I*2	006170	INDEX	I*2	006160	IP	I*2	006176
IQ	I*2	006200	I1	I*2	006172	J	I*2	006162
J1	I*2	006202	K	I*2	006144	KK	I*2	006154
K1	I*2	006204	L	I*2	006174	M	I*2	006142
MM	I*2	005764	MY	I*2	006166	NBPS	I*2	006132
NDTL	I*2	006150	NN	I*2	006134	NNN	I*2	006140
P	I*2	006136	Q	I*2	006146			

COMMON BLOCK / / , SIZE = 022362 (4729. WORDS)

NAME	TYPE	OFFSET	NAME	TYPE	OFFSET	NAME	TYPE	OFFSET
IR	I*2	000000	IW	I*2	000002	NSUB	I*2	000004
NBUS	I*2	000006	NLINE	I*2	000010	KMAX	I*2	000012
OPTION	I*2	000014	BASMVA	R*4	000052	BASEKV	R*4	000056
ALPHA	R*4	000246	BUS	I*2	000252	BUSTYP	I*2	000346
LINE	I*2	000442	BUSP	I*2	000606	BUSQ	I*2	000752
VOLT	R*4	001116	QMAX	R*4	001306	QMIN	R*4	001476
QSTATC	R*4	001666	YLC	R*4	002056	T	R*4	002366
ZS	C*8	002676	ATABLE	I*2	003516	BPTL	I*2	003612
BQTL	I*2	003636	NDTL	I*2	003662	NBIS	I*2	003756
NOLS	I*2	003770	NLCP	I*2	004002	BPOS	I*2	004026
BQOS	I*2	004122	BUSS	I*2	004216	Z1	C*8	004312
YBUS	C*8	011052	Z4	C*8	015612	YTIE	C*8	017252
PPQ	R*4	017372	EPSLON	R*4	017702	GEN	C*8	017706
LOAD	C*8	020266	QPQ	R*4	020646	PQP	R*4	021156
QQP	R*4	021466	EBUS	C*8	021776	NLB	I*2	022356
NVCB	I*2	022360						

LOCAL AND COMMON ARRAYS:

NAME	TYPE	SECTION	OFFSET	------SIZE-----	DIMENSIONS
ATABLE	I*2	.$$$$.	003516	000074 (30.)	(30)
BASEKV	R*4	.$$$$.	000056	000170 (60.)	(30)
BPOS	I*2 VEC	.$$$$.	004026	000074 (30.)	(10,3)
BPTL	I*2	.$$$$.	003612	000024 (10.)	(10)
BQOS	I*2 VEC	.$$$$.	004122	000074 (30.)	(10,3)
BQTL	I*2	.$$$$.	003636	000024 (10.)	(10)
BTABLE	I*2	$DATA	001130	000074 (30.)	(30)
BUS	I*2	.$$$$.	000252	000074 (30.)	(30)
BUSP	I*2	.$$$$.	000606	000144 (50.)	(50)
BUSQ	I*2	.$$$$.	000752	000144 (50.)	(50)
BUSS	I*2 VEC	.$$$$.	004216	000074 (30.)	(10,3)
BUSTYP	I*2	.$$$$.	000346	000074 (30.)	(30)
CMIN	I*2	$DATA	000264	000074 (30.)	(30)
COST	I*2	$DATA	000074	000074 (30.)	(30)
CTABLE	I*2 VEC	$DATA	000360	000264 (90.)	(30,3)
EBUS	C*8	.$$$$.	021776	000360 (120.)	(30)
GEN	C*8	.$$$$.	017706	000360 (120.)	(30)
KT	I*2	$DATA	000170	000074 (30.)	(30)
LINE	I*2	.$$$$.	000442	000144 (50.)	(50)

FORTRAN IV STORAGE MAP FOR PROGRAM UNIT STEP2

LOAD	C*8		.$$$$.	020266	000360	(120.)	(30)
NBIS	I*2		.$$$$.	003756	000012	(5.)	(5)
NLCP	I*2		.$$$$.	004002	000024	(10.)	(10)
NOLS	I*2		.$$$$.	003770	000012	(5.)	(5)
NOTL	I*2		.$$$$.	003662	000074	(30.)	(30)
OPTION	I*2		.$$$$.	000014	000036	(15.)	(15)
PPQ	R*4		.$$$$.	017372	000310	(100.)	(50)
PQP	R*4		.$$$$.	021156	000310	(100.)	(50)
PTABLE	I*2	VEC	$DATA	000644	000264	(90.)	(30,3)
QMAX	R*4		.$$$$.	001306	000170	(60.)	(30)
QMIN	R*4		.$$$$.	001476	000170	(60.)	(30)
QPQ	R*4		.$$$$.	020646	000310	(100.)	(50)
QQP	R*4		.$$$$.	021466	000310	(100.)	(50)
QSTATC	R*4		.$$$$.	001666	000170	(60.)	(30)
RTABLE	I*2		$DATA	000000	000074	(30.)	(30)
T	R*4		.$$$$.	002366	000310	(100.)	(50)
VOLT	R*4		.$$$$.	001116	000170	(60.)	(30)
YBUS	C*8	VEC	.$$$$.	011052	004540	(1200.)	(10,10,3)
YLC	R*4		.$$$$.	002056	000310	(100.)	(50)
YTIE	C*8		.$$$$.	017252	000120	(40.)	(10)
ZS	C*8		.$$$$.	002676	000620	(200.)	(50)
Z1	C*8	VEC	.$$$$.	004312	004540	(1200.)	(10,10,3)
Z2	C*8	VEC	$DATA	001224	004540	(1200.)	(10,10,3)
Z4	C*8	VEC	.$$$$.	015612	001440	(400.)	(10,10)

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      C.....................................................................
0001        SUBROUTINE STEP3
      C.....................................................................
      C
      C.........LIST OF VARIABLES
      C       NLB  = NUMBER OF LOAD BUS
      C          NVCB = NUMBER OF VOLTAGE CONTROLLED BUS
      C          BUSS = BUS NUMBER INDEX OF EACH SUBDIVISION
      C          BPS  = BUS P OF ELEMENT
      C          BQS  = BUS Q OF ELEMENT
      C          NPD  = BUS P OF MODIFIED LINE
      C          NQD  = BUS Q OF MODIFIED LINE
      C          ZSD  = SERIES IMPEDANCE OF MODIFIED LINE
      C          ZST  = SERIES IMPEDANCE OF TIE LINE
      C          BCS  = SHUNT ADMITTANCE AT EACH BUS
      C          YT   = SHUNT ADMITTANCE DUE TO OFF NOMINAL TURN RATIO
      C          ZRX  = SERIES IMPEDANCE OF ELEMENT
      C          Z1   = Z1 MATRIX
      C          Z2   = Z2 MATRIX
      C          Z4   = Z4 MATRIX
      C          Y4   = Y4 MATRIX
      C          YTIE = ADMITTANCE OF TIE LINE
      C
      C.........CLASSIFY THE VARIABLES
0002        INTEGER NLB,NVCB,VCBN,P,LN,LC,TLC,IP,IQ,NODE(10),IFP,IFQ
0003        INTEGER BUSS(10,3),BPS(20),BQS(20),CUTF(10)
0004        COMPLEX ZST(20),YT(30),ZRX(30),YTIE(10)
0005        COMPLEX Z1(10,10,3),Z2(10,10,3),Z4(10,10),D(10)
0006        INTEGER IR,IW,NSUB,NBUS,NLINE,KMAX,OPTION(15),BUS(30)
0007        INTEGER BUSTYP(30),LINE(50),BUSP(50),BUSQ(50),BPS1(20),BQS1(20)
0008        INTEGER ATABLE(30),BPTL(10),BQTL(10),NOTL(30),NBIS(5)
0009        INTEGER NOLS(5),NLCP(10),BPOS(10,3),BQOS(10,3),INX(10),INY(10)
0010        REAL BASMVA,BASEKV(30),ALPHA,VOLT(30),QMAX(30),QMIN(30)
0011        REAL QSTATC(30),YLC(50),T(50)
0012        REAL PPQ(50),QPQ(50),PQP(50),QQP(50),EPSLON,BCS(10)
0013        COMPLEX EBUS(30),GEN(30),LOAD(30),ZS(50),YBUS(10,10,3),YYY
0014        COMPLEX YSH,CZ,ZRX1(20),V(10)
      C.........COMMON THE ARRAYS OF VARIABLES
0015        COMMON IR,IW,NSUB,NBUS,NLINE,KMAX,OPTION,BASMVA,BASEKV,ALPHA
0016        COMMON BUS,BUSTYP,LINE,BUSP,BUSQ,VOLT,QMAX,QMIN,QSTATC,YLC,T
0017        COMMON ZS,ATABLE,BPTL,BQTL,NOTL,NBIS,NOLS,NLCP,BPOS,BQOS
0018        COMMON BUSS,Z1,YBUS,Z4,YTIE,PPQ
0019        COMMON EPSLON,GEN,LOAD,QPQ,PQP,QQP,EBUS,NLB,NVCB
      C.........ORDER THE BUS NUMBER
0020        DO 400 I=1,NSUB
0021        NLB=0
0022        NVCB=0
0023        DO 401 J=1,NBUS
0024        IF(ATABLE(J).NE.I) GO TO 401
0026        IF(BUSTYP(J).NE.1) GO TO 402
0028        NLB=NLB+1
0029        GO TO 401
0030   402  IF(BUSTYP(J).NE.2) GO TO 401
0032        NVCB=NVCB+1
```

```
0033  401   CONTINUE
0034        LBN=0
0035        VCBN=0
0036        DO 403 J=1,NBUS
0037        IF(ATABLE(J).NE.I) GO TO 403
0039        IF(BUSTYP(J).NE.1) GO TO 404
0041        LBN=LBN+1
0042        P=LBN
0043        GO TO 406
0044  404   IF(BUSTYP(J).NE.2) GO TO 405
0046        VCBN=VCBN+1
0047        P=NLB+VCBN
0048        GO TO 406
0049  405   P=NBIS(I)
0050  406   BUSS(P,I)=J
0051  403   CONTINUE
0052  400   CONTINUE
      C.....COMPUTE THE SERIES IMPEDANCE OF LINE AND THE SHUNT ADMITTANCE
0053        LC=0
0054        TLC=0
0055        DO 950 I=1,NBUS
0056        BCS(I)=0.0
0057        YT(I)=CMPLX(0.0,0.0)
0058  950   CONTINUE
0059        DO 600 I=1,NLINE
0060        M=ATABLE(BUSP(I))
0061        N=ATABLE(BUSQ(I))
0062        IP=BUSP(I)
0063        IQ=BUSQ(I)
0064        IF(M.EQ.N) GO TO 601
0066        TLC=TLC+1
0067        BPTL(TLC)=IP
0068        BQTL(TLC)=IQ
0069        ZST(TLC)=ZS(I)*T(I)
0070        YTIE(TLC)=1.0/ZST(TLC)
0071  601   YT(IP)=YT(IP)+(1.0-T(I))/T(I)**2/ZS(I)
0072        YT(IQ)=YT(IQ)+(T(I)-1.0)/T(I)/ZS(I)
0073        BCS(IP)=BCS(IP)+YLC(I)/2.0
0074        BCS(IQ)=BCS(IQ)+YLC(I)/2.0
0075  600   CONTINUE
      C.....DIVIDE AND ORDER THE ELEMENT FOR EACH SUBDIVISION
0076        DO 650 J=1,NSUB
0077        NLS=NDLS(J)+NBIS(J)
0078        DO 6650 JJ=1,NLS
0079        BPS(JJ)=0
0080  6650  BQS(JJ)=0
      C.....ORDER THE TRANSMISSION LINES AND THE TRANSFORMERS
0081        NN=0
0082        DO 651 N=1,NBIS(J)
0083        IQ=BUSS(N,J)
0084        YSH=CMPLX(0.0,BCS(IQ))+YT(IQ)+CMPLX(0.0,QSTATC(IQ))/BASMVA/
           X  VOLT(IQ)/VOLT(IQ)
0085        CZ=CMPLX(0.0,0.0)
0086        IF(YSH.EQ.CZ) GO TO 651
```

```
0088          NN=NN+1
0089          BPS(NN)=0
0090          BQS(NN)=N
0091          ZRX(NN)=1.0/YSH
0092    651   CONTINUE
0093          LC=NN
0094          IF(NOLS(J).EQ.0) GO TO 2010
0096          DO 652 M=1,NLINE
0097          MM=ATABLE(BUSP(M))
0098          NN=ATABLE(BUSQ(M))
0099          IF(MM.NE.NN) GO TO 652
0101          IF(MM.NE.J)  GO TO 652
0103          LC=LC+1
0104          DO 658 I=1,NBIS(J)
0105          IF(BUSP(M).EQ.BUSS(I,J)) BPS(LC)=I
0107          IF(BUSQ(M).EQ.BUSS(I,J)) BQS(LC)=I
0109    658   CONTINUE
0110          ZRX(LC)=ZS(M)*T(M)
0111    652   CONTINUE
0112    2010  CONTINUE
      C.....FORM Z1 MATRIX
      C.....COMPUTE THE NUMBER OF ELEMENTS
0113          NELMT=LC
      C.....FORM Z1 FROM THE FIRST ELEMENT
0114          Z1(1,1,J)=ZRX(1)
      C.....RECORD AND COUNT THE BUS WHICH HAS FORMED
0115          NODE(1)=BQS(1)
0116          K=1
0117          DO 670 N=2,NELMT
0118          IFP=0
0119          IFQ=0
0120          IF(BPS(N).EQ.0) GO TO 690
0122          DO 671 I=1,K
0123          IF(BPS(N).NE.NODE(I)) GO TO 671
0125          IFP=I
0126          GO TO 672
0127    671   CONTINUE
0128    672   CONTINUE
0129          DO 673 I=1,K
0130          IF(BQS(N).NE.NODE(I)) GO TO 673
0132          IFQ=I
0133          GO TO 674
0134    673   CONTINUE
0135    674   CONTINUE
0136          IF(IFP.EQ.0) GO TO 680
0138          IF(IFQ.EQ.0) GO TO 685
0140          L=K+1
0141          DO 675 I=1,K
0142          Z1(I,L,J)=Z1(I,IFP,J)-Z1(I,IFQ,J)
0143          Z1(L,I,J)=Z1(I,L,J)
0144    675   CONTINUE
0145          Z1(L,L,J)=Z1(IFP,L,J)-Z1(IFQ,L,J)+ZRX(N)
0146    676   CONTINUE
0147          DO 677 I=1,K
```

```
0148          DO 677 M=1,K
0149          Z1(I,M,J)=Z1(I,M,J)-(Z1(I,L,J)/Z1(L,L,J))*Z1(L,M,J)
0150    677   CONTINUE
0151          DO 678 I=1,L
0152          Z1(I,L,J)=CMPLX(0.0,0.0)
0153          Z1(L,I,J)=CMPLX(0.0,0.0)
0154    678   CONTINUE
0155          GO TO 670
0156    680   K=K+1
0157          NODE(K)=BPS(N)
0158          L=K-1
0159          DO 681 I=1,L
0160          Z1(I,K,J)=Z1(I,IFQ,J)
0161          Z1(K,I,J)=Z1(I,K,J)
0162    681   CONTINUE
0163          Z1(K,K,J)=Z1(IFQ,IFQ,J)+ZRX(N)
0164          GO TO 670
0165    685   K=K+1
0166          NODE(K)=BQS(N)
0167          L=K-1
0168          DO 686 I=1,L
0169          Z1(I,K,J)=Z1(I,IFP,J)
0170          Z1(K,I,J)=Z1(I,K,J)
0171    686   CONTINUE
0172          Z1(K,K,J)=Z1(IFP,IFP,J)+ZRX(N)
0173          GO TO 670
0174    690   CONTINUE
0175          DO 691 I=1,K
0176          IF(BQS(N).NE.NODE(I)) GO TO 691
0178          IFQ=I
0179    691   CONTINUE
0180          IF(IFQ.EQ.0) GO TO 692
0182          L=K+1
0183          DO 693 I=1,K
0184          Z1(I,L,J)=-Z1(IFQ,I,J)
0185          Z1(L,I,J)=Z1(I,L,J)
0186    693   CONTINUE
0187          Z1(L,L,J)=-Z1(IFQ,L,J)+ZRX(N)
0188          GO TO 676
0189    692   K=K+1
0190          NODE(K)=BQS(N)
0191          L=K-1
0192          DO 699 I=1,L
0193          Z1(I,K,J)=CMPLX(0.0,0.0)
0194          Z1(K,I,J)=Z1(I,K,J)
0195    699   CONTINUE
0196          Z1(K,K,J)=ZRX(N)
0197    670   CONTINUE
0198          DO 2000 M=1,NBIS(J)
0199          DO 2000 N=1,NBIS(J)
0200    2000  YBUS(M,N,J)=CMPLX(0.0,0.0)
0201          DO 2001 N=1,NELMT
0202          IP=BPS(N)
0203          IQ=BQS(N)
```

```
0204          YYY=1.0/ZRX(N)
0205          IF(IP.EQ.0) GO TO 2002
0207          YBUS(IP,IP,J)=YBUS(IP,IP,J)+YYY
0208          YBUS(IQ,IQ,J)=YBUS(IQ,IQ,J)+YYY
0209          YBUS(IP,IQ,J)=YBUS(IP,IQ,J)-YYY
0210          YBUS(IQ,IP,J)=YBUS(IQ,IP,J)-YYY
0211          GO TO 2001
0212  2002    CONTINUE
0213          YBUS(IQ,IQ,J)=YBUS(IQ,IQ,J)+YYY
0214  2001    CONTINUE
0215  650     CONTINUE
0216          IF(OPTION(6).EQ.0) GO TO 740
      C.....,WRITE Z1 MATRIX
0218          DATA BB/'BUS'/
0219          DO 700 J=1,NSUB
0220          K=NBIS(J)
0221          WRITE(IW,2911) J
0222  2911    FORMAT(' ',24X,30('-')/25X,'Z1 MATRIX FOR SUBDIVISION ',I2/25X,
             X  30('-'))
0223          WRITE(IW,2912) (BB,BUSS(I,J),I=1,K)
0224  2912    FORMAT(' ',14X,4(4X,A4,I3,11X),10(/15X,4(4X,A4,I3,11X)))
0225          DO 700 I=1,K
0226          WRITE(IW,2923) BUSS(I,J),(Z1(I,L,J),L=1,K)
0227  700     CONTINUE
0228  740     CONTINUE
      C.....,FORM Z2 MATRIX
0229          DO 750 J=1,NSUB
0230          K=NBIS(J)
0231          DO 751 IC=1,NOTL(1)
0232          DO 752 I=1,K
0233          IF(BPTL(IC).EQ.BUSS(I,J)) GO TO 753
0235          IF(BQTL(IC).EQ.BUSS(I,J)) GO TO 753
0237  752     CONTINUE
0238          GO TO 751
0239  753     IF(CUTF(IC).EQ.9999) GO TO 754
0241          DO 755 L=1,K
0242          Z2(L,IC,J)=Z1(L,I,J)
0243  755     CONTINUE
0244          CUTF(IC)=9999
0245          GO TO 751
0246  754     CONTINUE
0247          DO 756 L=1,K
0248          Z2(L,IC,J)=-Z1(L,I,J)
0249  756     CONTINUE
0250  751     CONTINUE
0251  750     CONTINUE
0252          IF(OPTION(7).EQ.0) GO TO 770
      C.....,WRITE Z2 MATRIX
0254          DO 760 J=1,NSUB
0255          K=NBIS(J)
0256          WRITE(IW,2921) J
0257  2921    FORMAT(' ',24X,30('-')/25X,'Z2 MATRIX FOR SUBDIVISION ',I2/25X,
             X  30('-'))
0258          WRITE(IW,2922) ((BPTL(I),BQTL(I)),I=1,NOTL(1))
```

```
0259  2922  FORMAT(' ',2X,'TIE LINE',4(5X,I2,'-',I2,12X),10(/15X,4(5X,I2,
             X  ,'-',I2,12X)))
0260         DO 760 L=1,K
0261         WRITE(IW,2923) BUSS(L,J),(Z2(L,IC,J),IC=1,NOTL(1))
0262  2923  FORMAT(' ',4X,'BUS',I3,4(1X,2F10.4,'J'),10(/11X,
             X  4(1X,2F10.4,'J')))
0263  760   CONTINUE
0264  770   CONTINUE
      C.........FORM Z4 MATRIX
0265         DO 7771 I=1,NOTL(1)
0266         DO 7771 J=1,NOTL(1)
0267         Z4(I,J)=CMPLX(0.0,0.0)
0268  7771  CONTINUE
0269         DO 771 J=1,NSUB
0270         K=NBIS(J)
0271         DO 772 IC=1,NOTL(1)
0272         DO 773 I=1,K
0273         IF(BPTL(IC).EQ.BUSS(I,J)) GO TO 774
0275         IF(BQTL(IC).EQ.BUSS(I,J)) GO TO 774
0277  773   CONTINUE
0278         GO TO 772
0279  774   CONTINUE
0280         IF(CUTF(IC).EQ.8888) GO TO 775
0282         DO 776 L=1,NOTL(1)
0283         Z4(IC,L)=Z4(IC,L)+Z2(I,L,J)
0284  776   CONTINUE
0285         CUTF(IC)=8888
0286         GO TO 772
0287  775   CONTINUE
0288         DO 777 L=1,NOTL(1)
0289         Z4(IC,L)=Z4(IC,L)-Z2(I,L,J)
0290  777   CONTINUE
0291  772   CONTINUE
0292  771   CONTINUE
0293         DO 778 I=1,NOTL(1)
0294         Z4(I,I)=Z4(I,I)+ZST(I)
0295  778   CONTINUE
0296         IF(OPTION(8).EQ.0) GO TO 785
      C.........WRITE Z4 MATRIX
0298         WRITE(IW,3911)
0299  3911  FORMAT(' ',34X,12('-')/35X,'Z4 MATRIX'/35X,12('-'))
0300         WRITE(IW,3912) ((BPTL(I),BQTL(I)),I=1,NOTL(1))
0301  3912  FORMAT(' ',2X,'TIE LINE',4(5X,I2,'-',I2,12X),10(/15X,
             X  4(5X,I2,'-',I2,12X)))
0302         DO 780 I=1,NOTL(1)
0303         WRITE(IW,3913) BPTL(I),BQTL(I),(Z4(I,J),J=1,NOTL(1))
0304  3913  FORMAT(' ',5X,I2,'-',I2,4(1X,2F10.4,'J'),10(/11X,
             X  4(1X,2F10.4,'J')))
0305  780   CONTINUE
0306  785   CONTINUE
0307  2500  IF(OPTION(9).EQ.0) GO TO 820
      C.........WRITE YBUS MATRIX
0309         DO 810 J=1,NSUB
0310         K=NBIS(J)
```

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0311          WRITE(IW,2941) J
0312  2941    FORMAT(' ',24X,30('-')/25X,'YBUS MATRIX FOR SUBDIVISION ',I2,
             X  /25X,30('-'))
0313          WRITE(IW,2942) ((BB,BUSS(I,J)),I=1,K)
0314  2942    FORMAT(' ',14X,4(4X,A4,I3,11X),10(/15X,4(4X,A4,I3,11X)))
0315          DO 810 I=1,K
0316          WRITE(IW,2923) BUSS(I,J),(YBUS(I,L,J),L=1,K)
0317  810     CONTINUE
0318  820     CONTINUE
0319          RETURN
0320          END
```

FORTRAN IV STORAGE MAP FOR PROGRAM UNIT STEP3

LOCAL VARIABLES, .PSECT $DATA, SIZE = 007576 (1983. WORDS)

NAME	TYPE	OFFSET	NAME	TYPE	OFFSET	NAME	TYPE	OFFSET
BB	R*4	007070	CZ	C*8	007370	I	I*2	007400
IC	I*2	007430	IFP	I*2	007344	IFQ	I*2	007346
IP	I*2	007340	IQ	I*2	007342	J	I*2	007402
JJ	I*2	007414	K	I*2	007424	L	I*2	007426
LBN	I*2	007404	LC	I*2	007334	LN	I*2	007332
M	I*2	007406	MM	I*2	007420	N	I*2	007410
NELMT	I*2	007422	NLS	I*2	007412	NN	I*2	007416
P	I*2	007330	TLC	I*2	007336	VCBN	I*2	007326
YSH	C*8	007360	YYY	C*8	007350			

COMMON BLOCK / /, SIZE = 022362 (4729. WORDS)

NAME	TYPE	OFFSET	NAME	TYPE	OFFSET	NAME	TYPE	OFFSET
IR	I*2	000000	IW	I*2	000002	NSUB	I*2	000004
NBUS	I*2	000006	NLINE	I*2	000010	KMAX	I*2	000012
OPTION	I*2	000014	BASMVA	R*4	000052	BASEKV	R*4	000056
ALPHA	R*4	000246	BUS	I*2	000252	BUSTYP	I*2	000346
LINE	I*2	000442	BUSP	I*2	000606	BUSQ	I*2	000752
VOLT	R*4	001116	QMAX	R*4	001306	QMIN	R*4	001476
QSTATC	R*4	001666	YLC	R*4	002056	T	R*4	002366
ZS	C*8	002676	ATABLE	I*2	003516	BPTL	I*2	003612
BQTL	I*2	003636	NOTL	I*2	003662	NBIS	I*2	003756
NOLS	I*2	003770	NLCP	I*2	004002	BPOS	I*2	004026
BQOS	I*2	004122	BUSS	I*2	004216	Z1	C*8	004312
YBUS	C*8	011052	Z4	C*8	015612	YTIE	C*8	017252
PPQ	R*4	017372	EPSLON	R*4	017702	GEN	C*8	017706
LOAD	C*8	020266	QPQ	R*4	020646	PQP	R*4	021156
QQP	R*4	021466	EBUS	C*8	021776	NLB	I*2	022356
NVCB	I*2	022360						

LOCAL AND COMMON ARRAYS:

NAME	TYPE	SECTION	OFFSET	------SIZE-----	DIMENSIONS
ATABLE	I*2	.$$$$.	003516	000074 (30.)	(30)
BASEKV	R*4	.$$$$.	000056	000170 (60.)	(30)
BCS	R*4	$DATA	006440	000050 (20.)	(10)
BPOS	I*2 VEC	.$$$$.	004026	000074 (30.)	(10,3)
BPS	I*2	$DATA	000024	000050 (20.)	(20)
BPS1	I*2	$DATA	006250	000050 (20.)	(20)
BPTL	I*2	.$$$$.	003612	000024 (10.)	(10)
BQOS	I*2 VEC	.$$$$.	004122	000074 (30.)	(10,3)
BQS	I*2	$DATA	000074	000050 (20.)	(20)
BQS1	I*2	$DATA	006320	000050 (20.)	(20)
BQTL	I*2	.$$$$.	003636	000024 (10.)	(10)
BUS	I*2	.$$$$.	000252	000074 (30.)	(30)
BUSP	I*2	.$$$$.	000606	000144 (50.)	(50)
BUSQ	I*2	.$$$$.	000752	000144 (50.)	(50)
BUSS	I*2 VEC	.$$$$.	004216	000074 (30.)	(10,3)
BUSTYP	I*2	.$$$$.	000346	000074 (30.)	(30)
CUTF	I*2	$DATA	000144	000024 (10.)	(10)
D	C*8	$DATA	006130	000120 (40.)	(10)

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FORTRAN IV      STORAGE MAP FOR PROGRAM UNIT STEP3

EBUS    C*8       .$$$$.  021776  000360 (  120.) (30)
GEN     C*8       .$$$$.  017706  000360 (  120.) (30)
INX     I*2       $DATA   006370  000024 (   10.) (10)
INY     I*2       $DATA   006414  000024 (   10.) (10)
LINE    I*2       .$$$$.  000442  000144 (   50.) (50)
LOAD    C*8       .$$$$.  020266  000360 (  120.) (30)
NBIS    I*2       .$$$$.  003756  000012 (    5.) (5)
NLCP    I*2       .$$$$.  004002  000024 (   10.) (10)
NODE    I*2       $DATA   000000  000024 (   10.) (10)
NOLS    I*2       .$$$$.  003770  000012 (    5.) (5)
NOTL    I*2       .$$$$.  003662  000074 (   30.) (30)
OPTION  I*2       .$$$$.  000014  000036 (   15.) (15)
PFQ     R*4       .$$$$.  017372  000310 (  100.) (50)
PQP     R*4       .$$$$.  021156  000310 (  100.) (50)
QMAX    R*4       .$$$$.  001306  000170 (   60.) (30)
QMIN    R*4       .$$$$.  001476  000170 (   60.) (30)
QPQ     R*4       .$$$$.  020646  000310 (  100.) (50)
QQP     R*4       .$$$$.  021466  000310 (  100.) (50)
QSTATC  R*4       .$$$$.  001666  000170 (   60.) (30)
T       R*4       .$$$$.  002366  000310 (  100.) (50)
V       C*8       $DATA   006750  000120 (   40.) (10)
VOLT    R*4       .$$$$.  001116  000170 (   60.) (30)
YBUS    C*8 VEC   .$$$$.  011052  004540 ( 1200.) (10,10,3)
YLC     R*4       .$$$$.  002056  000310 (  100.) (50)
YT      C*8       $DATA   000430  000360 (  120.) (30)
YTIE    C*8       .$$$$.  017252  000120 (   40.) (10)
ZRX     C*8       $DATA   001010  000360 (  120.) (30)
ZRX1    C*8       $DATA   006510  000240 (   80.) (20)
ZS      C*8       .$$$$.  002676  000620 (  200.) (50)
ZST     C*8       $DATA   000170  000240 (   80.) (20)
Z1      C*8 VEC   .$$$$.  004312  004540 ( 1200.) (10,10,3)
Z2      C*8 VEC   $DATA   001370  004540 ( 1200.) (10,10,3)
Z4      C*8 VEC   .$$$$.  015612  001440 (  400.) (10,10)

SUBROUTINES, FUNCTIONS, STATEMENT AND PROCESSOR-DEFINED FUNCTIONS:

NAME   TYPE   NAME   TYPE   NAME   TYPE   NAME   TYPE   NAME   TYPE
CMPLX  C*8
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      C.....................................................................
0001        SUBROUTINE STEP4
      C.....................................................................
      C
      C.........LIST OF VARIABLES
      C         EBUSS  = BUS VOLTAGE IN SUBDIVISION
      C         EBS    = BUS VOLTAGE IN SUBDIVISION
      C         EBSM   = MAGNITUDE OF BUS VOLTAGE IN SUBDIVION
      C         EBSA   = PHASE ANGLE OF BUS VOLTAGE IN SUBDIVISION
      C         ITIE   = TIE LINE CURRENT
      C         CONVEC = CONVERGENCE VECTOR
      C         PD     = REAL BUS POWER DEMAND
      C         QD     = REACTIVE BUS POWER DEMAND
      C         PG     = REAL BUS POWER GENERATION
      C         QG     = REACTIVE BUS POWER GENERATION
      C         YBS    = BUS ADMITTANCE MATRIX OF EACH SUBDIVISION
      C         YBSM   = MAGNITUDE OF BUS ADMITTANCE MATRIX
      C         YBSA   = PHASE ANGLE OF BUS ADMITTANCE MATRIX
      C         QMAXS  = MAXIMUM LIMIT OF REACTIVE BUS POWER
      C         QMINS  = MINIMUM LIMIT OF REACTIVE BUS POWER
      C         STB    = COMPLEX POWER DELIVER TO TIE BUS
      C         PTB    = REAL POWER DELIVER TO TIE BUS
      C         QTB    = REACTIVE POWER DELIVER TO TIE BUS
      C         PCAL   = CALCULATED REAL BUS POWER
      C         QCAL   = CALCULATED REACTIVE BUS POWER
      C         DP     = REAL BUS POWER MISMATCH
      C         DQ     = REACTIVE BUS POWER MISMATCH
      C         JCB    = JACOBIAN
      C         PPQ    = REAL POWER FLOW FROM BUS P TO BUS Q
      C         QPQ    = REACTIVE POWER FLOW FROM BUS P TO BUS Q
      C         PQP    = REAL POWER FLOW FROM BUS Q TO BUS P
      C         QQP    = REACTIVE POWER FLOW FROM BUS Q TO BUS P
      C         PSLACK = REAL POWER AT SLACK BUS
      C         QSLACK = REACTIVE POWER AT SLACK BUS
      C
      C.........CLASSIFY THE VARIABLES
0002        INTEGER P,Q,CONVEC(10),PPP,NCON
0003        REAL PD(10),QD(10),PG(10),QG(10),RP,IP,YBSM(10,10),YBSA(10,10)
0004        REAL QMAXS(10),QMINS(10),PTB(10),QTB(10),EBSM(10),EBSA(10)
0005        REAL PCAL(10),QCAL(10),MAG,ANG,DP(10),DQ(10),JCB(20,20)
0006        REAL DEL(20),DEBSM(10),DEBSA(10),JII
0007        REAL PPQ(50),QPQ(50),PQP(50),QQP(50),PSLACK,QSLACK
0008        COMPLEX EP,EQ,ITIE(10),YBS(10,10),EBS(10),ITT(10)
0009        COMPLEX IT0(10),ETOSS(10),ET0S(10,3),ELPQ(10),YBUS(10,10,3)
0010        COMPLEX ICP(10),IT1(10,3),IT2(10),ET1(10),ET1S(10,3),SPQ,SQP
0011        INTEGER IR,IW,NSUB,NBUS,NLINE,KMAX,OPTION(15),BUS(30)
0012        INTEGER BUSTYP(30),LINE(50),BUSP(50),BUSQ(50),BUSS(10,3)
0013        INTEGER ATABLE(30),BPTL(10),BQTL(10),NOTL(30),NBIS(5)
0014        INTEGER NOLS(5),NLCP(10),BPOS(10,3),BQOS(10,3),NLB,NVCB
0015        REAL BASMVA,BASEKV(30),ALPHA,VOLT(30),QMAX(30),QMIN(30)
0016        REAL QSTATC(30),YLC(50),T(50),EPSLON
0017        COMPLEX ZS(50),Z1(10,10,3),Z2(10,10,3),Z4(10,10)
0018        COMPLEX YTIE(10),EBUS(30),EBUSS(10,3),GEN(30),LOAD(30)
0019        COMPLEX A(10,10),X(10),B(10),DD,EBB,EX,EY,VXX,VYY,VZZ
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      C.........COMMON THE ARRAYS OF VARIABLES
0020        COMMON IR,IW,NSUB,NBUS,NLINE,KMAX,OPTION,BASMVA,BASEKV,ALPHA
0021        COMMON BUS,BUSTYP,LINE,BUSP,BUSQ,VOLT,QMAX,QMIN,QSTATC,YLC,T
0022        COMMON ZS,ATABLE,BPTL,BQTL,NOTL,NBIS,NOLS,NLCP,BPOS,BQOS
0023        COMMON BUSS,Z1,YBUS,Z4,YTIE,PPQ
0024        COMMON EPSLON,GEN,LOAD,QFQ,PQF,QQP,EBUS,NLB,NVCB
0025        TYPE 9991
0026  9991  FORMAT(/T10,'DO YOU WANT TO CHANGE THE ACC. FACTOR ? (Y/N)',$)
0027        DATA MM/1HY/
0028        ACCEPT 9992,MY
0029  9992  FORMAT(A1)
0030        IF(MY.NE.MM) GO TO 9995
0032        TYPE 9993
0033  9993  FORMAT(/T10,'THE ACCELERATING FACTOR IS ',$)
0034        ACCEPT 9994,ALPHA
0035  9994  FORMAT(F4.2)
0036  9995  CONTINUE
      C.........INITIALIZE THE BUS VOLTAGES OF EACH SUBDIVISION
0037        DO 407 I=1,NSUB
0038        DO 408 J=1,NBIS(I)
0039        K=BUSS(J,I)
0040  408   EBUSS(J,I)=CMPLX(VOLT(K),0.0)
0041  407   CONTINUE
      C.........SET ITERATION NUMBER
0042        KKK=0
      C.........COMPUTE TIE CURRENTS
0043  471   DO 409 I=1,NOTL(1)
0044        P=BPTL(I)
0045        Q=BQTL(I)
0046        DO 4407 I1=1,NSUB
0047        DO 4408 J1=1,NBIS(I1)
0048        IF(P.NE.BUSS(J1,I1)) GO TO 4409
0050        M1=J1
0051        N1=I1
0052        GO TO 4408
0053  4409  IF(Q.NE.BUSS(J1,I1)) GO TO 4408
0055        M2=J1
0056        N2=I1
0057  4408  CONTINUE
0058  4407  CONTINUE
0059        EP=EBUSS(M1,N1)
0060        EQ=EBUSS(M2,N2)
0061        IF(N2.GT.N1) ITIE(I)=(EQ-EP)*YTIE(I)
0063        IF(N2.LT.N1) ITIE(I)=(EP-EQ)*YTIE(I)
0065  409   CONTINUE
0066        DO 4471 I=1,NSUB
0067  4471  CONVEC(I)=0
      C.........SET SUBDIVISION NUMBER
0068        L=1
      C.........LOAD DATA OF THIS SUBDIVISION
0069  457   DO 410 I=1,NBIS(L)
0070        J=BUSS(I,L)
0071        PD(I)=REAL(LOAD(J))/BASMVA
0072        QD(I)=AIMAG(LOAD(J))/BASMVA
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0073          PG(I)=REAL(GEN(J))/BASMVA
0074          QG(I)=AIMAG(GEN(J))/BASMVA
0075          QMAXS(I)=QMAX(J)
0076          QMINS(I)=QMIN(J)
0077          EBS(I)=EBUSS(I,L)
0078    410   CONTINUE
0079          DO 411 I=1,NBIS(L)
0080          DO 411 J=1,NBIS(L)
0081          YBS(I,J)=YBUS(I,J,L)
0082    411   CONTINUE
0083          NLB=0
0084          NVCB=0
0085          DO 1401 J=1,NBUS
0086          IF(ATABLE(J).NE.L) GO TO 1401
0088          IF(BUSTYP(J).NE.1) GO TO 1402
0090          NLB=NLB+1
0091          GO TO 1401
0092    1402  IF(BUSTYP(J).NE.2) GO TO 1401
0094          NVCB=NVCB+1
0095    1401  CONTINUE
      C.....COMPUTE THE REAL AND REACTIVE POWER WHICH DELIVER TO TIE BUS
0096          DO 412 I=1,NBIS(L)
0097          PTB(I)=0.0
0098          QTB(I)=0.0
0099    412   CONTINUE
0100          DO 413 I=1,NBIS(L)
0101          P=BUSS(I,L)
0102          IF(BUSTYP(P).EQ.3) GO TO 413
0104          DO 414 J=1,NOTL(1)
0105          IF(P.EQ.BPTL(J)) GO TO 415
0107          IF(P.NE.BQTL(J)) GO TO 414
0109          M=BQTL(J)
0110          N=BPTL(J)
0111          GO TO 4414
0112    415   M=BPTL(J)
0113          N=BQTL(J)
0114    4414  MM=ATABLE(M)
0115          NN=ATABLE(N)
0116          IF(MM.GT.NN) GO TO 4415
0118          AP=-REAL(EBS(I)*CONJG(ITIE(J)))
0119          PTB(I)=PTB(I)+AP
0120          AQ=-AIMAG(EBS(I)*CONJG(ITIE(J)))
0121          QTB(I)=QTB(I)+AQ
0122          GO TO 414
0123    4415  AP=REAL(EBS(I)*CONJG(ITIE(J)))
0124          PTB(I)=PTB(I)+AP
0125          AQ=AIMAG(EBS(I)*CONJG(ITIE(J)))
0126          QTB(I)=QTB(I)+AQ
0127    414   CONTINUE
0128    413   CONTINUE
      C.....COMPUTE THE REAL AND REACTIVE BUS POWER
0129          DO 416 I=1,NBIS(L)
0130          DO 416 J=1,NBIS(L)
0131          RP=REAL(YBS(I,J))
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0132          IP=AIMAG(YBS(I,J))
0133          YBSM(I,J)=CABS(YBS(I,J))
0134          YBSA(I,J)=-ATAN2(IP,RP)
0135    416   CONTINUE
0136          DO 417 I=1,NBIS(L)
0137          RP=REAL(EBS(I))
0138          IP=AIMAG(EBS(I))
0139          EBSM(I)=CABS(EBS(I))
0140    417   EBSA(I)=ATAN2(IP,RP)
0141          PPP=BUSS(NBIS(L),L)
0142          IF(BUSTYP(PPP).NE.3) NNN=NBIS(L)
0144          IF(BUSTYP(PPP).EQ.3) NNN=NBIS(L)-1
0146          IF(NNN.NE.0) GO TO 4459
0148          CONVEC(L)=9999
0149          GO TO 480
0150    4459  DO 418 I=1,NNN
0151          PCAL(I)=0.0
0152    418   QCAL(I)=0.0
0153          DO 419 I=1,NNN
0154          DO 420 J=1,NBIS(L)
0155          MAG=EBSM(I)*EBSM(J)*YBSM(I,J)
0156          ANG=EBSA(I)-EBSA(J)+YBSA(I,J)
0157          PCAL(I)=PCAL(I)+MAG*COS(ANG)
0158    420   QCAL(I)=QCAL(I)+MAG*SIN(ANG)
0159    419   CONTINUE
      C.........COMPUTE THE BUS POWER MISMATCH
0160          DMAX=0.0
0161          DO 421 I=1,NNN
0162          DP(I)=PG(I)-PD(I)-PCAL(I)-PTB(I)
0163          IF(ABS(DP(I)).GT.DMAX) DMAX=ABS(DP(I))
0165    421   CONTINUE
0166          DO 422 I=1,NLB
0167          DQ(I)=QG(I)-QD(I)-QCAL(I)-QTB(I)
0168          IF(ABS(DQ(I)).GT.DMAX) DMAX=ABS(DQ(I))
0170    422   CONTINUE
      C.........CHECK: IS THIS SOLUTION CONVERGED?
0171          IF(DMAX.LT.EPSLON) GO TO 500
      C.........FORM JACOBIAN
0173          MMM=NNN+NLB
0174          DO 423 I=1,MMM
0175          DO 423 J=1,MMM
0176    423   JCB(I,J)=0.0
0177          DO 6650 I=1,NBIS(L)
0178          DO 6651 K=1,NOTL(1)
0179          IDY=0
0180          IF(BUSS(I,L).EQ.BPTL(K)) IDY=9999
0182          IF(BUSS(I,L).EQ.BQTL(K)) IDY=9999
0184          IF(IDY.NE.9999) GO TO 6651
0186          YBS(I,I)=YBS(I,I)+YTIE(K)
0187    6651  CONTINUE
0188    6650  CONTINUE
0189          DO 4416 I=1,NBIS(L)
0190          DO 4416 J=1,NBIS(L)
0191          RP=REAL(YBS(I,J))
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0192        IP=AIMAG(YBS(I,J))
0193        YBSM(I,J)=CABS(YBS(I,J))
0194        YBSA(I,J)=-ATAN2(IP,RP)
0195  4416  CONTINUE
      C.....FORM J1 OF JACOBIAN
0196        DO 424 I=1,NNN
0197        IF(BUSTYP(PPP),NE.3) GO TO 425
0199        JCB(I,I)=-EBSM(I)*EBSM(NBIS(L))*YBSM(I,NBIS(L))*SIN(EBSA(I)+
           X  YBSA(I,NBIS(L))-EBSA(NBIS(L)))
0200  425   DO 4424 J=1,NNN
0201        IF(I.EQ.J) GO TO 4424
0203        JCB(I,J)=EBSM(I)*EBSM(J)*YBSM(I,J)*SIN(EBSA(I)+YBSA(I,J)-EBSA(J)
           X  )
0204        JCB(I,I)=JCB(I,I)-JCB(I,J)
0205  4424  CONTINUE
0206        DO 4423 K=1,NOTL(1)
0207        IQ=0
0208        IF(BUSS(I,L).EQ.BPTL(K)) IQ=BQTL(K)
0210        IF(BUSS(I,L).EQ.BQTL(K)) IQ=BPTL(K)
0212        IF(IQ.EQ.0) GO TO 4423
0214        IL=ATABLE(IQ)
0215        DO 4425 K1=1,NBIS(IL)
0216        IF(IQ.EQ.BUSS(K1,IL)) IIQ=K1
0218  4425  CONTINUE
0219        EB=CABS(EBUSS(IIQ,IL))
0220        RP=REAL(EBUSS(IIQ,IL))
0221        IP=AIMAG(EBUSS(IIQ,IL))
0222        PEB=ATAN2(IP,RP)
0223        YB=CABS(YTIE(K))
0224        RP=REAL(-YTIE(K))
0225        IP=AIMAG(-YTIE(K))
0226        PYB=-ATAN2(IP,RP)
0227        JCB(I,I)=JCB(I,I)-EBSM(I)*EB*YB*SIN(EBSA(I)+PYB-PEB)
0228  4423  CONTINUE
0229  424   CONTINUE
0230        IF(OPTION(15).EQ.0) GO TO 7777
      C.....FORM J2 OF JACOBIAN
0232        DO 426 I=1,NNN
0233        II=I+NNN
0234        IF(BUSTYP(PPP).NE.3) GO TO 4427
0236        JCB(I,II)=EBSM(NBIS(L))*YBSM(I,NBIS(L))*COS(YBSA(I,NBIS(L))+
           XEBSA(I)-EBSA(NBIS(L)))
0237  4427  DO 427 J=1,NNN
0238        IF(I.EQ.J) GO TO 427
0240        JCB(I,II)=JCB(I,II)+EBSM(J)*YBSM(I,J)*COS(EBSA(I)+YBSA(I,J)-
           X  EBSA(J))
0241  427   CONTINUE
0242        DO 428 J=1,NLB
0243        IF(I.EQ.J) GO TO 428
0245        JJ=J+NNN
0246        JCB(I,JJ)=EBSM(I)*YBSM(I,J)*COS(EBSA(I)+YBSA(I,J)-EBSA(J))
0247  428   CONTINUE
0248        JCB(I,II)=JCB(I,II)+2.0*EBSM(I)*YBSM(I,I)*COS(YBSA(I,I))
0249        DO 4428 K=1,NOTL(1)
```

```
0250        IQ=0
0251        IF(BUSS(I,L).EQ.BPTL(K)) IQ=BQTL(K)
0253        IF(BUSS(I,L).EQ.BQTL(K)) IQ=BPTL(K)
0255        IF(IQ.EQ.0) GO TO 4428
0257        IL=ATABLE(IQ)
0258        DO 4426 K1=1,NBIS(IL)
0259        IF(IQ.EQ.BUSS(K1,IL)) IIQ=K1
0261  4426  CONTINUE
0262        EB=CABS(EBUSS(IIQ,IL))
0263        RP=REAL(EBUSS(IIQ,IL))
0264        IP=AIMAG(EBUSS(IIQ,IL))
0265        PEB=ATAN2(IP,RP)
0266        YB=CABS(YTIE(K))
0267        RP=REAL(-YTIE(K))
0268        IP=AIMAG(-YTIE(K))
0269        PYB=-ATAN2(IP,RP)
0270        JCB(I,II)=JCB(I,II)+EB*YB*COS(EBSA(I)+PYB-PEB)
0271  4428  CONTINUE
0272  426   CONTINUE
      C.....FORM J3 OF JACOBIAN
0273        DO 429 I=1,NLB
0274        II=I+NNN
0275        IF(BUSTYP(PPP).NE.3) GO TO 430
0277        JCB(II,I)=EBSM(I)*EBSM(NBIS(L))*YBSM(I,NBIS(L))*COS(EBSA(I)+
           X  YBSA(I,NBIS(L))-EBSA(NBIS(L)))
0278  430   DO 4429 J=1,NNN
0279        IF(I.EQ.J) GO TO 4429
0281        JCB(II,J)=-EBSM(I)*EBSM(J)*YBSM(I,J)*COS(EBSA(I)+YBSA(I,J)-
           X  EBSA(J))
0282        JCB(II,I)=JCB(II,I)-JCB(II,J)
0283  4429  CONTINUE
0284        DO 4430 K=1,NOTL(1)
0285        IQ=0
0286        IF(BUSS(I,L).EQ.BPTL(K)) IQ=BQTL(K)
0288        IF(BUSS(I,L).EQ.BQTL(K)) IQ=BPTL(K)
0290        IF(IQ.EQ.0) GO TO 4430
0292        IL=ATABLE(IQ)
0293        DO 4433 K1=1,NBIS(IL)
0294        IF(IQ.EQ.BUSS(K1,IL)) IIQ=K1
0296  4433  CONTINUE
0297        EB=CABS(EBUSS(IIQ,IL))
0298        RP=REAL(EBUSS(IIQ,IL))
0299        IP=AIMAG(EBUSS(IIQ,IL))
0300        YB=CABS(YTIE(K))
0301        RP=REAL(-YTIE(K))
0302        IP=AIMAG(-YTIE(K))
0303        PYB=-ATAN2(IP,RP)
0304        JCB(II,I)=JCB(II,I)+EBSM(I)*EB*YB*COS(EBSA(I)+PYB-PEB)
0305  4430  CONTINUE
0306  429   CONTINUE
0307  7777  CONTINUE
      C.....FORM J4 OF JACOBIAN
0308        DO 431 I=1,NLB
0309        II=I+NNN
```

```
0310          IF(BUSTYP(PPP),NE,3) GO TO 4432
0312          JCB(II,II)=EBSM(NBIS(L))*YBSM(I,NBIS(L))*SIN(YBSA(I,NBIS(L))+
             XEBSA(I)-EBSA(NBIS(L)))
0313  4432    DO 432 J=1,NNN
0314          IF(I,EQ,J) GO TO 432
0316          JCB(II,II)=EBSM(J)*YBSM(I,J)*SIN(EBSA(I)+YBSA(I,J)-
             X  EBSA(J))+JCB(II,II)
0317  432     CONTINUE
0318          DO 433 J=1,NLB
0319          JJ=J+NNN
0320          IF(I,EQ,J) GO TO 433
0322          JCB(II,JJ)=EBSM(I)*YBSM(I,J)*SIN(EBSA(I)+YBSA(I,J)-EBSA(J))
0323  433     CONTINUE
0324          JCB(II,II)=JCB(II,II)+2.0*EBSM(I)*YBSM(I,I)*SIN(YBSA(I,I))
0325          DO 4431 K=1,NOTL(1)
0326          IQ=0
0327          IF(BUSS(I,L),EQ,BPTL(K)) IQ=BQTL(K)
0329          IF(BUSS(I,L),EQ,BQTL(K)) IQ=BPTL(K)
0331          IF(IQ,EQ,0) GO TO 4431
0333          IL=ATABLE(IQ)
0334          DO 4434 K1=1,NBIS(IL)
0335          IF(IQ,EQ,BUSS(K1,IL)) IIQ=K1
0337  4434    CONTINUE
0338          EB=CABS(EBUSS(IIQ,IL))
0339          RP=REAL(EBUSS(IIQ,IL))
0340          IP=AIMAG(EBUSS(IIQ,IL))
0341          YB=CABS(YTIE(K))
0342          RP=REAL(-YTIE(K))
0343          IP=AIMAG(-YTIE(K))
0344          PYB=-ATAN2(IP,RP)
0345          JCB(II,II)=JCB(II,II)+EB*YB*SIN(EBSA(I)+PYB-PEB)
0346  4431    CONTINUE
0347  431     CONTINUE
      C.....COMPUTE THE CHANGE OF BUS VOLTAGES
0348          DO 434 I=1,NNN
0349  434     DEL(I)=DP(I)
0350          DO 435 I=1,NLB
0351          II=I+NNN
0352  435     DEL(II)=DQ(I)
0353          DO 436 I=1,MMM
0354          JII=JCB(I,I)
0355          DO 437 J=1,MMM
0356          JCB(I,J)=JCB(I,J)/JII
0357  437     CONTINUE
0358          DEL(I)=DEL(I)/JII
0359          DO 438 J=1,MMM
0360          IF(I,EQ,J) GO TO 438
0362          DEL(J)=DEL(J)-DEL(I)*JCB(J,I)
0363  438     CONTINUE
0364          DO 439 K=1,MMM
0365          IF(K,EQ,I) GO TO 439
0367          JII=JCB(K,I)
0368          DO 440 J=1,MMM
0369  440     JCB(K,J)=JCB(K,J)-JCB(I,J)*JII
```

```
0370  439   CONTINUE
0371  436   CONTINUE
      C.....COMPUTE THE NEW BUS VOLTAGES
0372        DO 4442 I=1,NNN
0373        DEBSA(I)=0.0
0374  4442  DEBSM(I)=0.0
0375        DO 442 I=1,NNN
0376  442   DEBSA(I)=DEL(I)
0377        DO 443 I=1,NLB
0378        J=I+NNN
0379  443   DEBSM(I)=DEL(J)
0380        DO 444 I=1,NNN
0381        EBSM(I)=EBSM(I)+DEBSM(I)
0382  444   EBSA(I)=EBSA(I)+DEBSA(I)
0383        DO 445 I=1,NBIS(L)
0384        RP=EBSM(I)*COS(EBSA(I))
0385        IP=EBSM(I)*SIN(EBSA(I))
0386        EBS(I)=CMPLX(RP,IP)
0387  445   CONTINUE
      C.....OBTAIN SOLUTION OF TORN SUBDIVISION
0388  480   DO 453 I=1,NBIS(L)
0389  453   ITT(I)=CMPLX(0.0,0.0)
0390        DO 4453 I=1,NOTL(1)
0391        P=BPTL(I)
0392        IF(ATABLE(P).NE.L) GO TO 4454
0394        DO 4455 J=1,NBIS(L)
0395        IF(P.EQ.BUSS(J,L)) M=J
0397  4455  CONTINUE
0398        MM=ATABLE(BQTL(I))
0399        IF(MM.GT.L) ITT(M)=ITT(M)+ITIE(I)
0401        IF(MM.LT.L) ITT(M)=ITT(M)-ITIE(I)
0403        GO TO 4453
0404  4454  Q=BQTL(I)
0405        IF(ATABLE(Q).NE.L) GO TO 4453
0407        DO 4456 J=1,NBIS(L)
0408        IF(Q.EQ.BUSS(J,L)) M=J
0410  4456  CONTINUE
0411        MM=ATABLE(BPTL(I))
0412        IF(MM.GT.L) ITT(M)=ITT(M)+ITIE(I)
0414        IF(MM.LT.L) ITT(M)=ITT(M)-ITIE(I)
0416  4453  CONTINUE
0417        DO 4457 I=1,NBIS(L)
0418        ETOS(I,L)=CMPLX(0.0,0.0)
0419        DO 4458 J=1,NBIS(L)
0420        ETOS(I,L)=ETOS(I,L)+Z1(I,J,L)*ITT(J),
0421  4458  CONTINUE
0422        ETOS(I,L)=EBS(I)-ETOS(I,L)
0423  4457  CONTINUE
      C.....CHECK:IS THIS THE LAST SUBDIVISION?
0424  459   L=L+1
0425        IF(L.LE.NSUB) GO TO 457
      C.....COMPUTE THE VOLTAGE ACROSS TORN SUBDIVISION
0427        DO 460 I=1,NOTL(1)
0428        P=BPTL(I)
```

```
0429          K1=ATABLE(P)
0430          DO 461 J=1,NBIS(K1)
0431          IF(P.EQ.BUSS(J,K1)) M=J
0433   461    CONTINUE
0434          Q=BQTL(I)
0435          K2=ATABLE(Q)
0436          DO 462 J=1,NBIS(K2)
0437          IF(Q.EQ.BUSS(J,K2)) N=J
0439   462    CONTINUE
0440          IF(K1.LT.K2) ELPQ(I)=ETOS(N,K2)-ETOS(M,K1)
0442          IF(K1.GT.K2) ELPQ(I)=ETOS(M,K1)-ETOS(N,K2)
0444          B(I)=ELPQ(I)
0445   460    CONTINUE
0446          DO 4460 I=1,NOTL(1)
0447          DO 4460 J=1,NOTL(1)
0448          A(I,J)=Z4(I,J)
0449   4460   CONTINUE
       C.....COMPUTE THE CLOSED PATH CURRENTS
0450          CALL GJORDA(A,ICP,B,NOTL(1))
       C.....CONVERT CLOSED PATH CURRENTS TO INJECTED TIE CURRENTS
0451          DO 463 I=1,NSUB
0452          DO 463 J=1,NBIS(I)
0453   463    IT1(J,I)=CMPLX(0.0,0.0)
0454          DO 464 I=1,NOTL(1)
0455          P=BPTL(I)
0456          K1=ATABLE(P)
0457          DO 465 J=1,NBIS(K1)
0458          IF(P.EQ.BUSS(J,K1)) M=J
0460   465    CONTINUE
0461          MM=ATABLE(BQTL(I))
0462          IF(MM.GT.K1) IT1(M,K1)=IT1(M,K1)+ICP(I)
0464          IF(MM.LT.K1) IT1(M,K1)=IT1(M,K1)-ICP(I)
0466          Q=BQTL(I)
0467          K2=ATABLE(Q)
0468          DO 466 J=1,NBIS(K2)
0469          IF(Q.EQ.BUSS(J,K2)) N=J
0471   466    CONTINUE
0472          MM=ATABLE(BPTL(I))
0473          IF(MM.GT.K2) IT1(N,K2)=IT1(N,K2)+ICP(I)
0475          IF(MM.LT.K2) IT1(N,K2)=IT1(N,K2)-ICP(I)
0477   464    CONTINUE
       C.....OBTAIN VOLTAGE CONTRIBUTIONS IN SUBDIVISION DUE TO TIE CURRENTS
0478          DO 467 L=1,NSUB
0479          DO 468 I=1,NBIS(L)
0480          IT2(I)=IT1(I,L)
0481   468    CONTINUE
0482          DO 4467 I=1,NBIS(L)
0483          ET1S(I,L)=CMPLX(0.0,0.0)
0484          DO 4468 J=1,NBIS(L)
0485          ET1S(I,L)=ET1S(I,L)+Z1(I,J,L)*IT2(J)
0486   4468   CONTINUE
0487   4467   CONTINUE
       C.....TOTAL VOLTAGE SOLUTION
0488          DO 470 I=1,NBIS(L)
```

```
0489          P=BUSS(I,L)
0490          JP=BUSS(NBIS(L),L)
0491          IF(BUSTYP(JP).NE.3) GO TO 9470
0493          VXX=ET0S(NBIS(L),L)
0494          VX=REAL(VXX)
0495          VY=AIMAG(VXX)
0496          VZ=VOLT(JP)
0497          VYY=ET1S(NBIS(L),L)
0498          VA=REAL(VYY)
0499          VB=AIMAG(VYY)
0500          VI=(VZ-VX)/VA
0501          VJ=-VY/VB
0502          VZZ=ET1S(I,L)
0503          VA1=REAL(VZZ)
0504          VB1=AIMAG(VZZ)
0505          VK=VI*VA1
0506          VL=VJ*VB1
0507          ET1S(I,L)=CMPLX(VK,VL)
0508  9470    IF(BUSTYP(P).EQ.3) GO TO 470
0510          EX=EBUSS(I,L)
0511          EBUSS(I,L)=ET0S(I,L)+ET1S(I,L)
0512          EY=EBUSS(I,L)
0513          EBUSS(I,L)=EX+ALPHA*(EY-EX)
0514  470     CONTINUE
0515  467     CONTINUE
0516          DO 4700 I=1,NOTL(1)
0517          P=BPTL(I)
0518          Q=BQTL(I)
0519          DO 4701 I1=1,NSUB
0520          DO 4702     J1=1,NBIS(I1)
0521          IF(P.NE.BUSS(J1,I1)) GO TO 4703
0523          M1=J1
0524          N1=I1
0525          GO TO 4702
0526  4703    IF(Q.NE.BUSS(J1,I1)) GO TO 4702
0528          M2=J1
0529          N2=I1
0530  4702    CONTINUE
0531  4701    CONTINUE
0532          EP=EBUSS(M1,N1)
0533          EQ=EBUSS(M2,N2)
0534          IF(N2.GT.N1) ITIE(I)=(EQ-EP)*YTIE(I)
0536          IF(N2.LT.N1) ITIE(I)=(EP-EQ)*YTIE(I)
0538  4700    CONTINUE
0539          DO 4704 L=1,NSUB
0540          DO 4444 M=1,NBIS(L)
0541          DO 4444 N=1,NBIS(L)
0542          YBS(M,N)=YBUS(M,N,L)
0543          RP=REAL(YBS(M,N))
0544          IP=AIMAG(YBS(M,N))
0545          YBSM(M,N)=CABS(YBS(M,N))
0546          YBSA(M,N)=-ATAN2(IP,RP)
0547  4444    CONTINUE
0548          DO 4470 I=1,NBIS(L)
```

```
0549          P=BUSS(I,L)
0550          IF(BUSTYP(P).NE.2) GO TO 4470
0552          EB=VOLT(P)
0553          RP=REAL(EBUSS(I,L))
0554          IP=AIMAG(EBUSS(I,L))
0555          PEB=ATAN2(IP,RP)
0556          EBB=EBUSS(I,L)
0557          RP=EB*COS(PEB)
0558          IP=EB*SIN(PEB)
0559          EBUSS(I,L)=CMPLX(RP,IP)
0560          QBS=0.0
0561          DO 447 KK=1,NBIS(L)
0562          RP=REAL(EBUSS(KK,L))
0563          IP=AIMAG(EBUSS(KK,L))
0564          PH=ATAN2(IP,RP)
0565          EM=CABS(EBUSS(KK,L))
0566          ANG=PEB+YBSA(I,KK)-PH
0567          QBS=QBS+EB*EM*YBSM(I,KK)*SIN(ANG)
0568    447   CONTINUE
0569          QTT=0.0
0570          DO 4705 J=1,NOTL(1)
0571          IF(P.EQ.BPTL(J)) GO TO 4706
0573          IF(P.NE.BQTL(J)) GO TO 4705
0575          M=BQTL(J)
0576          N=BPTL(J)
0577          GO TO 4707
0578    4706  M=BPTL(J)
0579          N=BQTL(J)
0580    4707  MM=ATABLE(M)
0581          NN=ATABLE(N)
0582          IF(MM.GT.NN) AQ= AIMAG(EBUSS(I,L)*CONJG(ITIE(J)))
0584          IF(MM.LT.NN) AQ=-AIMAG(EBUSS(I,L)*CONJG(ITIE(J)))
0586          QTT=QTT+AQ
0587    4705  CONTINUE
0588          QG(I)=(QBS+QTT)*BASMVA+AIMAG(LOAD(P))
0589          IF(QG(I).GT.QMAX(P)) GO TO 450
0591          IF(QG(I).LT.QMIN(P)) GO TO 451
0593          GO TO 452
0594    450   QG(I)=QMAX(P)
0595          EBUSS(I,L)=EBB
0596    451   QG(I)=QMIN(P)
0597          EBUSS(I,L)=EBB
0598    452   QGG=QG(I)
0599          PGG=REAL(GEN(P))
0600          GEN(P)=CMPLX(PGG,QGG)
0601    4470  CONTINUE
0602    4704  CONTINUE
      C.....CHECK: IS THE CONVERGENCE OBTAINED?
0603          KKK=KKK+1
0604          IF(KKK.LE.KMAX) GO TO 471
0606          WRITE(IW,472) KMAX
0607    472   FORMAT(' ',T10,'CONVERGENCE NOT OBTAINED IN ',I5,'ITERATIONS')
0608          GO TO 473
      C.....RECORD THE NUMBER OF CONVERGENCE AND CONVERGENCE VECTOR
```

```
0609  500   CONVEC(L)=9999
      C.....CHECK: IS THE POWER SYSTEM SOLUTION CONVERGED?
0610        NCON=0
0611        DO 570 I=1,NSUB
0612        IF(CONVEC(I).NE.9999) GO TO 570
0614        NCON=NCON+1
0615  570   CONTINUE
0616        IF(NCON.NE.NSUB) GO TO 480
      C.....OBTAIN THE SOLUTION
0618        WRITE(IW,9200) KKK
0619  9200  FORMAT(////T10,'THE SOLUTION IS CONVERGED IN ',I3,'  ITERATIONS.
           X')
0620        WRITE(IW,9201) ALPHA
0621  9201  FORMAT(/T10,'THE ACCELERATING FACTOR =',F5.3)
0622        DO 501 L=1,NSUB
0623        DO 502 I=1,NBIS(L)
0624        P=BUSS(I,L)
0625        EBUS(P)=EBUSS(I,L)
0626  502   CONTINUE
0627  501   CONTINUE
      C.....COMPUTE LINE FLOWS
0628        DO 510 I=1,NLINE
0629        P=BUSP(I)
0630        Q=BUSQ(I)
0631        SPQ=CONJG(EBUS(P))*((EBUS(P)-EBUS(Q)*T(I))/(ZS(I)*(T(I)**2))+
           X  (EBUS(P)*CMPLX(0.0,YLC(I))/2.0))
0632        PPQ(I)=REAL(SPQ)
0633        QPQ(I)=-AIMAG(SPQ)
0634        SQP=CONJG(EBUS(Q))*((EBUS(Q)*T(I)-EBUS(P))/(ZS(I)*T(I))+
           X  (EBUS(Q)*CMPLX(0.0,YLC(I))/2.0))
0635        PQP(I)=REAL(SQP)
0636        QQP(I)=-AIMAG(SQP)
0637  510   CONTINUE
      C.....COMPUTE THE REAL AND REACTIVE POWER AT SLACK BUS
0638        DO 511 I=1,NBUS
0639        IF(BUSTYP(I).EQ.3) P=I
0641  511   CONTINUE
0642        PSLACK=0.0
0643        QSLACK=0.0
0644        DO 512 I=1,NLINE
0645        IF(BUSP(I).NE.P) GO TO 513
0647        PSLACK=PSLACK+PPQ(I)*BASMVA
0648        QSLACK=QSLACK+QPQ(I)*BASMVA
0649        GO TO 512
0650  513   IF(BUSQ(I).NE.P) GO TO 512
0652        PSLACK=PSLACK+PQP(I)*BASMVA
0653        QSLACK=QSLACK+QQP(I)*BASMVA
0654  512   CONTINUE
      C.....COMPUTE THE GENERATION AT SLACK BUS
0655        PSLACK=PSLACK+REAL(LOAD(P))
0656        QSLACK=QSLACK+AIMAG(LOAD(P))-QSTATC(P)
0657        GEN(P)=CMPLX(PSLACK,QSLACK)
0658  473   RETURN
0659        END
```

FORTRAN IV STORAGE MAP FOR PROGRAM UNIT STEP4

LOCAL VARIABLES, .PSECT $DATA, SIZE = 023450 (5012. WORDS)

NAME	TYPE	OFFSET	NAME	TYPE	OFFSET	NAME	TYPE	OFFSET
ANG	R*4	022210	AP	R*4	022416	AQ	R*4	022422
DD	C*8	022270	DMAX	R*4	022430	EB	R*4	022450
EBB	C*8	022300	EM	R*4	022566	EP	C*8	022230
EQ	C*8	022240	EX	C*8	022310	EY	C*8	022320
I	I*2	022362	IDY	I*2	022436	II	I*2	022470
IIQ	I*2	022446	IL	I*2	022442	IP	R*4	022200
IQ	I*2	022440	I1	I*2	022372	J	I*2	022364
JII	R*4	022214	JJ	I*2	022472	JP	I*2	022476
J1	I*2	022374	K	I*2	022366	KK	I*2	022560
KKK	I*2	022370	K1	I*2	022444	K2	I*2	022474
L	I*2	022406	M	I*2	022410	MAG	R*4	022204
MM	I*2	021424	MMM	I*2	022434	MY	I*2	022360
M1	I*2	022376	M2	I*2	022402	N	I*2	022412
NCON	I*2	022172	NN	I*2	022414	NNN	I*2	022426
N1	I*2	022400	N2	I*2	022404	P	I*2	022164
PEB	R*4	022454	PGG	R*4	022602	PH	R*4	022562
PPP	I*2	022170	PSLACK	R*4	022220	PYB	R*4	022464
Q	I*2	022166	QBS	R*4	022554	QGG	R*4	022576
QSLACK	R*4	022224	QTT	R*4	022572	RP	R*4	022174
SPQ	C*8	022250	SQP	C*8	022260	VA	R*4	022514
VA1	R*4	022534	VB	R*4	022520	VB1	R*4	022540
VI	R*4	022524	VJ	R*4	022530	VK	R*4	022544
VL	R*4	022550	VX	R*4	022500	VXX	C*8	022330
VY	R*4	022504	VYY	C*8	022340	VZ	R*4	022510
VZZ	C*8	022350	YB	R*4	022460			

COMMON BLOCK / /, SIZE = 022362 (4729. WORDS)

NAME	TYPE	OFFSET	NAME	TYPE	OFFSET	NAME	TYPE	OFFSET
IR	I*2	000000	IW	I*2	000002	NSUB	I*2	000004
NBUS	I*2	000006	NLINE	I*2	000010	KMAX	I*2	000012
OPTION	I*2	000014	BASMVA	R*4	000052	BASEKV	R*4	000056
ALPHA	R*4	000246	BUS	I*2	000252	BUSTYP	I*2	000346
LINE	I*2	000442	BUSP	I*2	000606	BUSQ	I*2	000752
VOLT	R*4	001116	QMAX	R*4	001306	QMIN	R*4	001476
QSTATC	R*4	001666	YLC	R*4	002056	T	R*4	002366
ZS	C*8	002676	ATABLE	I*2	003516	BPTL	I*2	003612
BQTL	I*2	003636	NOTL	I*2	003662	NBIS	I*2	003756
NOLS	I*2	003770	NLCP	I*2	004002	BPOS	I*2	004026
BQOS	I*2	004122	BUSS	I*2	004216	Z1	C*8	004312
YBUS	C*8	011052	Z4	C*8	015612	YTIE	C*8	017252
PPQ	R*4	017372	EPSLON	R*4	017702	GEN	C*8	017706
LOAD	C*8	020266	QPQ	R*4	020646	PQP	R*4	021156
QQP	R*4	021466	EBUS	C*8	021776	NLB	I*2	022356
NVCB	I*2	022360						

LOCAL AND COMMON ARRAYS:

NAME	TYPE	SECTION	OFFSET	------SIZE-----	DIMENSIONS
A	C*8 VEC	$DATA	017524	001440 (400.)	(10,10)
ATABLE	I*2	.$$$$.	003516	000074 (30.)	(30)

FORTRAN IV STORAGE MAP FOR PROGRAM UNIT STEP4

B	C*8	$DATA	021304	000120	(40.)	(10)
BASEKV	R*4	.$$$$.	000056	000170	(60.)	(30)
BPOS	I*2 VEC	.$$$$.	004026	000074	(30.)	(10,3)
BPTL	I*2	.$$$$.	003612	000024	(10.)	(10)
BQOS	I*2 VEC	.$$$$.	004122	000074	(30.)	(10,3)
BQTL	I*2	.$$$$.	003636	000024	(10.)	(10)
BUS	I*2	.$$$$.	000252	000074	(30.)	(30)
BUSP	I*2	.$$$$.	000606	000144	(50.)	(50)
BUSQ	I*2	.$$$$.	000752	000144	(50.)	(50)
BUSS	I*2 VEC	.$$$$.	004216	000074	(30.)	(10,3)
BUSTYP	I*2	.$$$$.	000346	000074	(30.)	(30)
CONVEC	I*2	$DATA	000000	000024	(10.)	(10)
DEBSA	R*4	$DATA	006034	000050	(20.)	(10)
DEBSM	R*4	$DATA	005764	000050	(20.)	(10)
DEL	R*4	$DATA	005644	000120	(40.)	(20)
DP	R*4	$DATA	002424	000050	(20.)	(10)
DQ	R*4	$DATA	002474	000050	(20.)	(10)
EBS	C*8	$DATA	007664	000120	(40.)	(10)
EBSA	R*4	$DATA	002234	000050	(20.)	(10)
EBSM	R*4	$DATA	002164	000050	(20.)	(10)
EBUS	C*8	.$$$$.	021776	000360	(120.)	(30)
EBUSS	C*8 VEC	$DATA	017144	000360	(120.)	(10,3)
ELPQ	C*8	$DATA	010744	000120	(40.)	(10)
ETOS	C*8 VEC	$DATA	010364	000360	(120.)	(10,3)
ETOSS	C*8	$DATA	010244	000120	(40.)	(10)
ET1	C*8	$DATA	011704	000120	(40.)	(10)
ET1S	C*8 VEC	$DATA	012024	000360	(120.)	(10,3)
GEN	C*8	.$$$$.	017706	000360	(120.)	(30)
ICP	C*8	$DATA	011064	000120	(40.)	(10)
ITIE	C*8	$DATA	006104	000120	(40.)	(10)
ITT	C*8	$DATA	010004	000120	(40.)	(10)
ITO	C*8	$DATA	010124	000120	(40.)	(10)
IT1	C*8 VEC	$DATA	011204	000360	(120.)	(10,3)
IT2	C*8	$DATA	011564	000120	(40.)	(10)
JCB	R*4 VEC	$DATA	002544	003100	(800.)	(20,20)
LINE	I*2	.$$$$.	000442	000144	(50.)	(50)
LOAD	C*8	.$$$$.	020266	000360	(120.)	(30)
NBIS	I*2	.$$$$.	003756	000012	(5.)	(5)
NLCP	I*2	.$$$$.	004002	000024	(10.)	(10)
NOLS	I*2	.$$$$.	003770	000012	(5.)	(5)
NOTL	I*2	.$$$$.	003662	000074	(30.)	(30)
OPTION	I*2	.$$$$.	000014	000036	(15.)	(15)
PCAL	R*4	$DATA	002304	000050	(20.)	(10)
PD	R*4	$DATA	000024	000050	(20.)	(10)
PG	R*4	$DATA	000144	000050	(20.)	(10)
PPQ	R*4	.$$$$.	017372	000310	(100.)	(50)
PQP	R*4	.$$$$.	021156	000310	(100.)	(50)
PTB	R*4	$DATA	002044	000050	(20.)	(10)
QCAL	R*4	$DATA	002354	000050	(20.)	(10)
QD	R*4	$DATA	000074	000050	(20.)	(10)
QG	R*4	$DATA	000214	000050	(20.)	(10)
QMAX	R*4	.$$$$.	001306	000170	(60.)	(30)
QMAXS	R*4	$DATA	001724	000050	(20.)	(10)
QMIN	R*4	.$$$$.	001476	000170	(60.)	(30)

FORTRAN IV STORAGE MAP FOR PROGRAM UNIT STEP4

QMINS	R*4		$DATA	001774	000050	(20.) (10)
QPQ	R*4		.$$$$.	020646	000310	(100.) (50)
QQP	R*4		.$$$$.	021466	000310	(100.) (50)
QSTATC	R*4		.$$$$.	001666	000170	(60.) (30)
QTB	R*4		$DATA	002114	000050	(20.) (10)
T	R*4		.$$$$.	002366	000310	(100.) (50)
VOLT	R*4		.$$$$.	001116	000170	(60.) (30)
X	C*8		$DATA	021164	000120	(40.) (10)
YBS	C*8	VEC	$DATA	006224	001440	(400.) (10,10)
YBSA	R*4	VEC	$DATA	001104	000620	(200.) (10,10)
YBSM	R*4	VEC	$DATA	000264	000620	(200.) (10,10)
YBUS	C*8	VEC	.$$$$.	011052	004540	(1200.) (10,10,3)
YLC	R*4		.$$$$.	002056	000310	(100.) (50)
YTIE	C*8		.$$$$.	017252	000120	(40.) (10)
ZS	C*8		.$$$$.	002676	000620	(200.) (50)
Z1	C*8	VEC	.$$$$.	004312	004540	(1200.) (10,10,3)
Z2	C*8	VEC	$DATA	012404	004540	(1200.) (10,10,3)
Z4	C*8	VEC	.$$$$.	015612	001440	(400.) (10,10)

SUBROUTINES, FUNCTIONS, STATEMENT AND PROCESSOR-DEFINED FUNCTIONS:

NAME	TYPE	NAME	TYPE	NAME	TYPE	NAME	TYPE	NAME	TYPE
ABS	R*4	AIMAG	R*4	ATAN2	R*4	CABS	R*4	CMPLX	C*8
CONJG	C*8	COS	R*4	GJORDA	R*4	REAL	R*4	SIN	R*4

FORTRAN IV V02.5 PAGE 001

```
0001        SUBROUTINE GJORDA(A,X,B,N)
0002        COMPLEX A(10,10),X(10),B(10),DD
0003        INTEGER N
0004        DO 550 I=1,N
0005        DD=A(I,I)
0006        DO 551 J=1,N
0007        A(I,J)=A(I,J)/DD
0008  551   CONTINUE
0009        B(I)=B(I)/DD
0010        DO 552 J=1,N
0011        IF(I.EQ.J) GO TO 552
0013        B(J)=B(J)-B(I)*A(J,I)
0014  552   CONTINUE
0015        IF(I.EQ.N) GO TO 550
0017        DO 553 K=1,N
0018        IF(K.EQ.I) GO TO 553
0020        DD=A(K,I)
0021        DO 554 J=1,N
0022        A(K,J)=A(K,J)-A(I,J)*DD
0023  554   CONTINUE
0024  553   CONTINUE
0025  550   CONTINUE
0026        DO 555 I=1,N
0027  555   X(I)=B(I)
0028        RETURN
0029        END
```

```
FORTRAN IV      STORAGE MAP FOR PROGRAM UNIT GJORDA

LOCAL VARIABLES, .PSECT $DATA, SIZE = 000050 (   20. WORDS)

NAME   TYPE  OFFSET     NAME   TYPE  OFFSET     NAME   TYPE  OFFSET
DD     C*8   000026     I      I*2   000036     J      I*2   000040
K      I*2   000042     N      I*2 à 000006

LOCAL AND COMMON ARRAYS:

NAME     TYPE   SECTION OFFSET  ------SIZE----- DIMENSIONS
A      C*8 VECà $DATA   000000  001440 (  400.) (10,10)
B      C*8    à $DATA   000004  000120 (   40.) (10)
X      C*8    à $DATA   000002  000120 (   40.) (10)
```

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FORTRAN IV     V02.5                                        PAGE 001

     C.....................................................................
0001       SUBROUTINE STEP5
     C.....................................................................
     C
     C.........CLASSIFY THE VARIABLES
0002       INTEGER IR,IW,NSUB,NBUS,NLINE,KMAX,OPTION(15),BUS(30),P,Q
0003       INTEGER BUSTYP(30),LINE(50),BUSP(50),BUSQ(50),ATABLE(30)
0004       INTEGER BPTL(10),BQTL(10),NOTL(30),NBIS(5),NOLS(5),NLCP(10)
0005       INTEGER BPOS(10,3),BQOS(10,3),NLB,NVCB,BUSS(10,3)
0006       REAL BASMVA,BASEKV(30),ALPHA,VOLT(30),QMAX(30),QMIN(30),SUMQST
0007       REAL QSTATC(30),YLC(50),T(50),EPSLON,PPQ(50),QPQ(50)
0008       REAL PQP(50),QQP(50),EPMAG,EQMAG,QCHG,PLOSS,QLOSS,SUMCHG
0009       COMPLEX ZS(50),Z1(10,10,3),Z2(10,10,3),Z4(10,10)
0010       COMPLEX YTIE(10),EBUS(30),GEN(30),LOAD(30),SUMLOS
0011       COMPLEX SUMGEN,SUMLOD,MISMAT,YBUS(10,10,3)
     C.........COMMON THE ARRAYS OF VARIABLES
0012       COMMON IR,IW,NSUB,NBUS,NLINE,KMAX,OPTION,BASMVA,BASEKV,ALPHA
0013       COMMON BUS,BUSTYP,LINE,BUSP,BUSQ,VOLT,QMAX,QMIN,QSTATC,YLC,T
0014       COMMON ZS,ATABLE,BPTL,BQTL,NOTL,NBIS,NOLS,NLCP,BPOS,BQOS
0015       COMMON BUSS,Z1,YBUS,Z4,YTIE,PPQ
0016       COMMON EPSLON,GEN,LOAD,QPQ,PQP,QQP,EBUS,NLB,NVCB
0017       IF(OPTION(10).EQ.0) GO TO 6991
     C.........WRITE THE BUS VOLTAGES AND GENERATIONS
0019       WRITE(IW,6001)
0020  6001 FORMAT(/////T24,'BUS VOLTAGES AND POWER GENERATIONS'/
          X  T24,33('-')/)
0021       WRITE(IW,6002)
0022  6002 FORMAT(' ',':-----:-----:------------------------:-----------
          X-----:----------------:--------:')
0023       WRITE(IW,6003)
0024  6003 FORMAT(' ',': BUS : BUS :        BUS VOLTAGE       :    GENERATI
          XON   :      LOAD      :QSTATICS:')
0025       WRITE(IW,6004)
0026  6004 FORMAT(' ',':     :     :--------:--------:--------:--------:---
          X-----:--------:--------:--------:')
0027       WRITE(IW,6005)
0028  6005 FORMAT(' ',': NO. :TYPE :   PU   :   KV   :   DEG  :   MW   : M
          XVAR  :   MW   :  MVAR  :  MVAR  :')
0029       WRITE(IW,6006)
0030  6006 FORMAT(' ',':-----:-----:--------:--------:--------:--------:---
          X-----:--------:--------:--------:')
0031       DO 1610 N=1,NBUS
0032       VOLTPU=CABS(EBUS(N))
0033       VOLTKV=VOLTPU*BASEKV(N)
0034       PHASE =ATAN2(AIMAG(EBUS(N)),REAL(EBUS(N)))*57.29578
0035       RATIO=VOLTPU/VOLT(N)
0036       QCAP=QSTATC(N)
0037       QSTATC(N)=RATIO*RATIO*QCAP
0038       WRITE(IW,6008) BUS(N),BUSTYP(N),VOLTPU,VOLTKV,PHASE,GEN(N),
          X  LOAD(N),QSTATC(N)
0039  6008 FORMAT(' ',':',2(I3,'  :'),F7.4,' :',7(F7.2,' :'))
0040       WRITE(IW,6006)
0041  1610 CONTINUE
0042  6991 CONTINUE
```

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FORTRAN IV      V02.5                                          PAGE 002

0043          IF(OPTION(11).EQ.0) GO TO 6992
      C.........WRITE THE LINE FLOWS
0045          SUMLOS=CMPLX(0.0,0.0)
0046          SUMCHG=0.0
0047          WRITE(IW,6011)
0048          WRITE(IW,6012)
0049          WRITE(IW,6013)
0050          WRITE(IW,6014)
0051          WRITE(IW,6015)
0052          WRITE(IW,6016)
0053  6011    FORMAT(/////T35,'LINE FLOWS'/T35,10('-')/)
0054  6012    FORMAT(' ',':----:----------:----------------:---------------
             X-:---------------:--------:')
0055  6013    FORMAT(' ',':LINE: BETWEEN  : FLOW FROM BUS P :  FLOW TO BUS Q
             X :   POWER LOSS  :CHARGING:')
0056  6014    FORMAT(' ',':    :-----:-----:--------:--------:--------:-------
             X-:-------:-------:--------:')
0057  6015    FORMAT(' ',': NO.:BUS P:BUS Q:   MW   : MVAR :   MW   : MVAR
             X:   MW  : MVAR  :  MVAR  :')
0058  6016    FORMAT(' ',':----:-----:-----:--------:--------:--------:-------
             X-:-------:-------:--------:')
0059          DO 1660 L=1,NLINE
0060          PPQ(L)=PPQ(L)*BASMVA
0061          QPQ(L)=QPQ(L)*BASMVA
0062          PQP(L)=PQP(L)*BASMVA
0063          QQP(L)=QQP(L)*BASMVA
0064          P=BUSP(L)
0065          Q=BUSQ(L)
0066          EPMAG=CABS(EBUS(P))
0067          EQMAG=CABS(EBUS(Q))
0068          QCHG=(EPMAG**2+EQMAG**2)*(YLC(L)/2.0)*BASMVA
0069          SUMCHG=SUMCHG+QCHG
0070          PLOSS=PPQ(L)+PQP(L)
0071          QLOSS=QPQ(L)+QQP(L)+QCHG
0072          SUMLOS=SUMLOS+CMPLX(PLOSS,QLOSS)
0073          WRITE(IW,6088) LINE(L),BUSP(L),BUSQ(L),PPQ(L),QPQ(L),PQP(L),
             X  QQP(L),PLOSS,QLOSS,QCHG
0074  6088    FORMAT(' ',':',I3,' :',2(I3,'  :'),4(F7.2,' :'),2(F6.2,' :'),
             X  F7.2,' :')
0075          WRITE(IW,6016)
0076  1660    CONTINUE
0077          SUMGEN=CMPLX(0.0,0.0)
0078          SUMLOD=CMPLX(0.0,0.0)
0079          SUMQST=0.0
0080          DO 920 I=1,NBUS
0081          SUMGEN=SUMGEN+GEN(I)
0082          SUMLOD=SUMLOD+LOAD(I)
0083          SUMQST=SUMQST+QSTATC(I)
0084  920     CONTINUE
0085          MISMAT=SUMGEN+CMPLX(0.0,SUMQST)+CMPLX(0.0,SUMCHG)-SUMLOD-SUMLOS
      C.........WRITE THE SYSTEM TOTALS
0086          WRITE(IW,6701)
0087  6701    FORMAT(/////T31,'SYSTEM TOTALS'/T31,'-------------'
             X//T47,'MW      MVAR')
```

```
0088          WRITE(IW,6702) SUMGEN
0089    6702  FORMAT(' ',T20,'GENERATION',T42,2F9.2)
0090          WRITE(IW,6703) SUMLOD
0091    6703  FORMAT(' ',T20,'LOAD',T42,2F9.2)
0092          WRITE(IW,6704) SUMQST
0093    6704  FORMAT(' ',T20,'STATIC CAPACITOR',T51,F9.2)
0094          WRITE(IW,6705) SUMCHG
0095    6705  FORMAT(' ',T20,'LINE CHARGING',T51,F9.2)
0096          WRITE(IW,6706) SUMLOS
0097    6706  FORMAT(' ',T20,'POWER LOSS',T42,2F9.2)
0098          WRITE(IW,6707) MISMAT
0099    6707  FORMAT(' ',T20,'POWER MISMATCH',T42,2F9.2)
0100    6992  CONTINUE
0101          RETURN
0102          END
```

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FORTRAN IV      STORAGE MAP FOR PROGRAM UNIT STEP5

LOCAL VARIABLES, .PSECT $DATA, SIZE = 004750 ( 1268. WORDS)

NAME   TYPE  OFFSET     NAME   TYPE  OFFSET     NAME   TYPE  OFFSET
EPMAG  R*4   004616     EQMAG  R*4   004622     I      I*2   004736
L      I*2   004734     MISMAT C*8   004676     N      I*2   004706
P      I*2   004606     PHASE  R*4   004720     PLOSS  R*4   004632
Q      I*2   004610     QCAP   R*4   004730     QCHG   R*4   004626
QLOSS  R*4   004636     RATIO  R*4   004724     SUMCHG R*4   004642
SUMGEN C*8   004656     SUMLOD C*8   004666     SUMLOS C*8   004646
SUMQST R*4   004612     VOLTKV R*4   004714     VOLTPU R*4   004710

COMMON BLOCK /      /, SIZE = 022362 ( 4729. WORDS)

NAME   TYPE  OFFSET     NAME   TYPE  OFFSET     NAME   TYPE  OFFSET
IR     I*2   000000     IW     I*2   000002     NSUB   I*2   000004
NBUS   I*2   000006     NLINE  I*2   000010     KMAX   I*2   000012
OPTION I*2   000014     BASMVA R*4   000052     BASEKV R*4   000056
ALPHA  R*4   000246     BUS    I*2   000252     BUSTYP I*2   000346
LINE   I*2   000442     BUSP   I*2   000606     BUSQ   I*2   000752
VOLT   R*4   001116     QMAX   R*4   001306     QMIN   R*4   001476
QSTATC R*4   001666     YLC    R*4   002056     T      R*4   002366
ZS     C*8   002676     ATABLE I*2   003516     BPTL   I*2   003612
BQTL   I*2   003636     NOTL   I*2   003662     NBIS   I*2   003756
NOLS   I*2   003770     NLCP   I*2   004002     BPOS   I*2   004026
BQOS   I*2   004122     BUSS   I*2   004216     Z1     C*8   004312
YBUS   C*8   011052     Z4     C*8   015612     YTIE   C*8   017252
PPQ    R*4   017372     EPSLON R*4   017702     GEN    C*8   017706
LOAD   C*8   020266     QPQ    R*4   020646     PQP    R*4   021156
QQP    R*4   021466     EBUS   C*8   021776     NLB    I*2   022356
NVCB   I*2   022360

LOCAL AND COMMON ARRAYS:

NAME     TYPE    SECTION OFFSET  ------SIZE----- DIMENSIONS
ATABLE I*2       .$$$$.  003516  000074 (   30.) (30)
BASEKV R*4       .$$$$.  000056  000170 (   60.) (30)
BPOS   I*2 VEC   .$$$$.  004026  000074 (   30.) (10,3)
BPTL   I*2       .$$$$.  003612  000024 (   10.) (10)
BQOS   I*2 VEC   .$$$$.  004122  000074 (   30.) (10,3)
BQTL   I*2       .$$$$.  003636  000024 (   10.) (10)
BUS    I*2       .$$$$.  000252  000074 (   30.) (30)
BUSP   I*2       .$$$$.  000606  000144 (   50.) (50)
BUSQ   I*2       .$$$$.  000752  000144 (   50.) (50)
BUSS   I*2 VEC   .$$$$.  004216  000074 (   30.) (10,3)
BUSTYP I*2       .$$$$.  000346  000074 (   30.) (30)
EBUS   C*8       .$$$$.  021776  000360 (  120.) (30)
GEN    C*8       .$$$$.  017706  000360 (  120.) (30)
LINE   I*2       .$$$$.  000442  000144 (   50.) (50)
LOAD   C*8       .$$$$.  020266  000360 (  120.) (30)
NBIS   I*2       .$$$$.  003756  000012 (    5.) (5)
NLCP   I*2       .$$$$.  004002  000024 (   10.) (10)
NOLS   I*2       .$$$$.  003770  000012 (    5.) (5)
NOTL   I*2       .$$$$.  003662  000074 (   30.) (30)
OPTION I*2       .$$$$.  000014  000036 (   15.) (15)
```

```
FORTRAN IV      STORAGE MAP FOR PROGRAM UNIT STEP5

PPQ     R*4       .$$$$.  017372  000310 (  100.) (50)
PQP     R*4       .$$$$.  021156  000310 (  100.) (50)
QMAX    R*4       .$$$$.  001306  000170 (   60.) (30)
QMIN    R*4       .$$$$.  001476  000170 (   60.) (30)
QPQ     R*4       .$$$$.  020646  000310 (  100.) (50)
QQP     R*4       .$$$$.  021466  000310 (  100.) (50)
QSTATC  R*4       .$$$$.  001666  000170 (   60.) (30)
T       R*4       .$$$$.  002366  000310 (  100.) (50)
VOLT    R*4       .$$$$.  001116  000170 (   60.) (30)
YBUS    C*8 VEC   .$$$$.  011052  004540 ( 1200.) (10,10,3)
YLC     R*4       .$$$$.  002056  000310 (  100.) (50)
YTIE    C*8       .$$$$.  017252  000120 (   40.) (10)
ZS      C*8       .$$$$.  002676  000620 (  200.) (50)
Z1      C*8 VEC   .$$$$.  004312  004540 ( 1200.) (10,10,3)
Z2      C*8 VEC   $DATA   000000  004540 ( 1200.) (10,10,3)
Z4      C*8 VEC   .$$$$.  015612  001440 (  400.) (10,10)

SUBROUTINES, FUNCTIONS, STATEMENT AND PROCESSOR-DEFINED FUNCTIONS:

NAME   TYPE   NAME   TYPE   NAME   TYPE   NAME   TYPE   NAME   TYPE
AIMAG   R*4   ATAN2   R*4   CABS    R*4   CMPLX   C*8   REAL    R*4
```

ประวัติผู้เขียน

นายสุนทร ปิยรัตนวงศ์ เกิดเมื่อวันที่ 28 กรกฎาคม พ.ศ. 2501 ณ. จังหวัดตรัง สำเร็จการศึกษาวิศวกรรมศาสตรบัณฑิต จากคณะวิศวกรรมศาสตร์ สถาบันเทคโนโลยีพระจอมเกล้าพระนครเหนือ เมื่อปี พ.ศ. 2525 หลังจากสำเร็จการศึกษาแล้วได้เข้าทำงานที่บริษัทสยามเทคโนโลยี จำกัด เป็นเวลา 1 ปี หลังจากนั้นได้มาเป็นอาจารย์ภาควิชาวิศวกรรมไฟฟ้า คณะวิศวกรรมศาสตร์ สถาบันเทคโนโลยีพระจอมเกล้าพระนครเหนือ จนถึงปัจจุบัน