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XLF1 - A PROGRAM FOR COMPLEX LOAD FLOW ANALYSIS BY CONJUGATE ELIMINATION

J.W. Bandler, M.A. El-Kady and H. Gupta

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Abstract

XLF1 is a package of five compiled library subroutines for solving steady-state power flow equations in the compact complex mode. A usersupplied main program provides the necessary dimensional storage and system data. The program implements the recently developed algorithm for practical complex solution of power flow equations presented by Bandler, El-Kady and Gupta. Sensitivities of system states with respect to system control variables can also be evaluated by the program using a perturbation method. The program is written in Fortran IV, documented and tested on a CYBER 170 computer. The report includes a listing of the program, a user's guide and some illustrative examples.

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I. INTRODUCTION

The computer program package called XLF1 implements the practical complex solution of power flow equations presented by Bandler, El-Kady and Gupta [1], which uses the complex notation introduced by Bandler and El-Kady [2]. The user has to provide the main program which assigns the necessary dimensional storage and reads system data if the solution of the load flow equations is required. For sensitivity analysis using a perturbation method, a different main program is needed in which the package XLF1 is called an appropriate number of times. The user can also assess transmission contingencies by the same approach, where one line at a time is taken out. Some examples of these problems are included in this report to illustrate the versatility of the program.

This package is particularly designed to solve problems of moderate size. Its 501 Fortran statements require about 7.2 K bytes of storage on the CYBER 170/730 machine when compiled using the Fortran compiler with OPT = 1. The total number of lines in the program is 839.

Fig. 1, with arrows emanating from calling subprograms and leading to called subroutines, highlights the overall organization of the program units.

II. SUBROUTINES AND VARIABLES

This section describes all the subroutines and variables that could be of interest to the user. The essential information regarding the dimensions and initialization is also provided in Table I in a condensed form. In addition, a more comprehensive explanation of various features

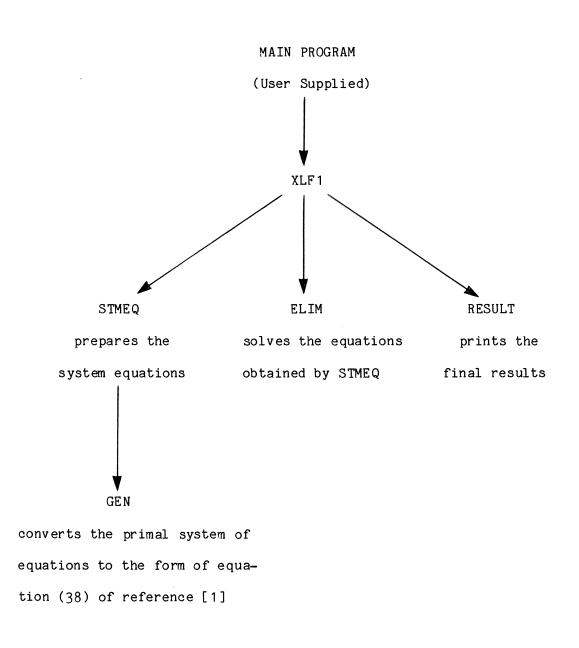


Fig. 1 Overall organization of the XLF1 package

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is included in the comment statements in the program listing.

Subroutines

- XLF1 This is the main subroutine of the XLF1 package, which is called by the user's main program. This subroutine solves the load flow problem by calling subroutines, STMEQ, ELIM and RESULT.
- ELIM This subroutine solves equations obtained by STMEQ using conjugate reduction combined with forward Gaussian elimination as introduced by Bandler and El-Kady [2].
- RESULT This subroutins prints the final results in an appropriate format.
- STMEQ This subroutine reads line data (from tape 3) and prepares the system equations to the form of equation (38) of the paper by Bandler, El-Kady and Gupta [1]. Subroutine GEN is called for this purpose.
- GEN This subroutine is called by subroutine STMEQ to convert the primal system of equations to the form of equation (38) of the paper by Bandler, El-Kady and Gupta [1].

Integer Variables

- IA,JA (IA,JA) represents a transmission line connecting buses IA and JA.
- IAC, JAC (IAC, JAC) is the transmission line whose parameters have been altered by the user.
- ICHTL = 0 if there is no alteration in the line data file required by the user. Normally, it is zero for load flow analysis.

- = 1 if parameters of one line have been altered by the user (i.e., the parameters of one line differ from the line data file and the user does not want to change the line data file). Normally, it is 1 for performing sensitivity analysis by a perturbation method.
- = 2 if one line is to be removed for contingency analysis.
- IG NGB dimensional array which stores the generator bus indices. IG(I) is the bus number of the Ith generator bus, where I = 1, ..., NGB.

IT current iteration number.

ITMAX maximum number of iterations after which program will stop. IWRITE variable to control printouts.

= 0 prints the final load flow solution only.

- = 1 prints results iteration-wise as well as the final load flow solution. Iteration wise results include bus currents, mismatches, bus voltages and correction voltage vector.
- = 2 suppresses all printouts.
- IZ N dimensional array.
 - IZ(I) = 0 if the modulus of the bus current of the Ith bus is $>10^{-6}$.
 - = I if the modulus of the bus current of the Ith bus is $<10^{-6}$.
- IZB an array to identify the zero current buses during the iteration. IZB(I) is the bus number of the Ith zero current bus (modulus of the bus current $\leq 10^{-6}$), where I = 1,...,NIZ. As NIZ is not known at the beginning, the

dimension	of	IZB	is	taken	as	equ	lal	to	the	number	of
expected	zero	curr	ent	buses	du	ring	the	so	lutio	n proce	ess.
This dime	nsion	can	be	equal	to d	or sl	ight	;ly	large	r than	the
number of	dumm	y bus	ses.								

KA

Ν

NB

KA(I) = 0 if the Ith bus is a load bus.

= 1 if the Ith bus is a generator bus.
(Note: The NBth bus is taken as the slack bus.)
NB-1
total number of buses.

N dimensional array identifying the type of bus.

NGB number of generator buses.

NIZ number of zero current buses.

Real Variables

CC altered transformer tap between buses IAC and JAC.

SHTLC altered value of half shunt susceptance of the transmission line (IAC, JAC).

TOLV tolerance over bus voltages to the accuracy the final solution is required.

Complex Variables

AI NB dimensional array of bus currents.

AK NxN matrix which is denoted by $\underset{SM}{K_{SM}}$ in equation (20) of SOC-270 [1].

BGK NGBxN matrix which is denoted by $[\overline{K}_{GL} \ \overline{K}_{GD} \ \overline{K}_{GG}]$ in equation (32) of SOC-270 [1]. These are coefficients of the conjugate of the bus voltages in the equations of the generator buses.

CV	NB dimensional array of the conjugate of V.
DS	NB dimensional array which represents mismatches as well as
	correction voltages.
S	N dimensional array of load bus powers, and generator bus
	active power and modulus of the voltage, which is
·	represented as $P_{G} + j V_{G} $. See equation (15) of SOC-270
	[1].

V NB dimensional array of bus voltages, i.e., bus voltage vector.

Y line admittance.

- YL half leakage admittance of the line.
- ZC altered impedance of line (IAC, JAC).

III. HOW TO USE THE PROGRAM

In order to use the XLF1 package, the user has to prepare the following programs and data.

Main Program

The main program must provide the dimensions and execute reading of all the system data except line data, i.e., the number of buses, the number of generator buses, the tolerance over bus voltage to the accuracy the final solution is required, the maximum number of iterations, specified bus powers, initial bus voltages, type of buses, and parameters of the transmission line where parameters have been altered by the user.

Line Data File

The line data file must be available on tape (unit) 3 arranged in free format and in the following sequence.

READ (3,*) ICODE, IA, JA, A1, A2, A3, A4, A5

where

A 1

ICODE code to identify data card.

= 4 for a transmission line without a transformer.

= 7 for a transmission line having a transformer.

IA, JA (IA,JA) represents a transmission line connecting buses IA and JA.

identifies the circuit number if ICODE = 4.

identifies the type of transformation ratio if ICODE = 7.

= 0 for fixed tap.

= 1 for real transformation ratio.

= 2 for complex transformation ratio.

A2 denotes the branch type if ICODE = 4.

series resistance of the line if ICODE = 7.

A3 series resistance of the line if ICODE = 4.

series reactance of the line if ICODE = 7.

A4 series reactance of the line if ICODE = 4.

real part of the transformation ratio if ICODE = 7.

A5 half shunt susceptance of the line if ICODE = 4.

imaginary part of the transformation ratio if ICODE = 7.

This program does not use A1 or A2 if ICODE = 4 and A5 if ICODE = 7 as the program solves the load flow equations with real transformation ratios. Line data is read by subroutine STMEQ and used for preparing

the system equations.

Dimensions and Initialization

For the purpose of dimensioning and initializations, Table I should be consulted. Note that the last bus is taken as the slack bus. Some illustrative examples have been included in this report.

TABLE I

ESSENTIAL INFORMATION ON DIMENSIONS AND INITIALIZATION FOR THE MAIN PROGRAM

Variable Name	Initialized by User	Dimensions In Main Program
IAC, JAC	Yes if ICHTL = 1 or 2	
ICHTL	Yes	
IG	No	NGB
IWRITE	Yes	
ITMAX	Yes	
IZ	No	N = NB - 1
IZB	No	Equal to or slightly greater than the number of dummy buses
КА	Yes	N
NB	Yes	
NGB	Yes	
Real Variables		
CC	Yes if ICHTL = 1	
SHTLC	Yes if ICHTL = 1	
TOLV	Yes	
Complex Variables		
AI	No	NB
AK	No	Nx N
BGK	No	NGBx N
CV	No	NB
DS	No	N
S	Yes	Ν
V	Yes	NB
ZC	Yes if ICHTL = 1	

IV. EXAMPLES

Six examples are presented in this section to illustrate the flexibility and power of XLF1. For each example, a complete listing of the main program and the output has been provided. The listing of XLF1 is given in the Appendix.

We consider 6-bus and 26-bus power systems in the examples to be described in this report. The structure and line diagrams of these power systems are shown in Figs. 2 and 3, respectively. The detailed data of the 6-bus and 26-bus power systems are tabulated by Tables II-V. All the values shown are in per unit. The computations have been performed on a CYBER 170 computer. TOLV for all examples is taken as 10^{-6} which gives an accuracy over mismatches of 10^{-12} .

Examples 1 and 2 determine the load flow solution of the 6-bus and 26-bus power systems, respectively. Example 3 deals with contingency analysis of the 26-bus power system.

The sensitivities of state variables with respect to the control variables for the 26-bus power system are determined in Examples 4-6 by perturbation. The basic formula used is

$$\frac{dF}{dt} \simeq \frac{\Delta F}{\Delta t} = \frac{F(t + \frac{\Delta t}{2}) - F(t - \frac{\Delta t}{2})}{\Delta t}, \qquad (1)$$

where Δt is very small.

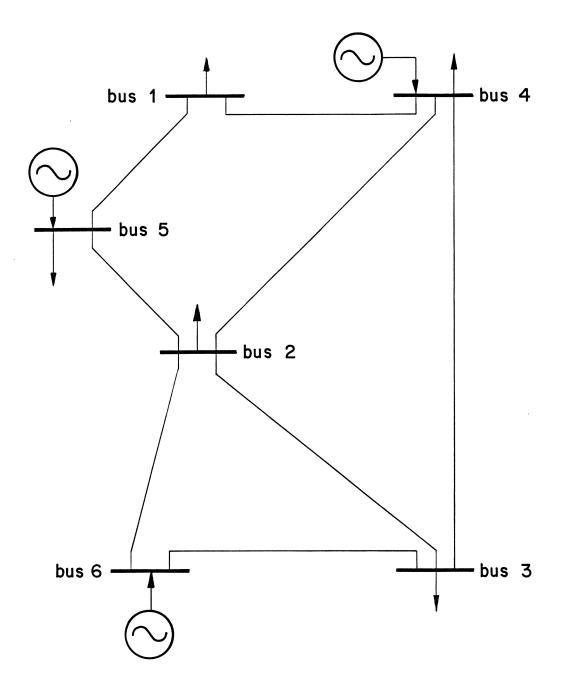


Fig. 2 6-bus power system

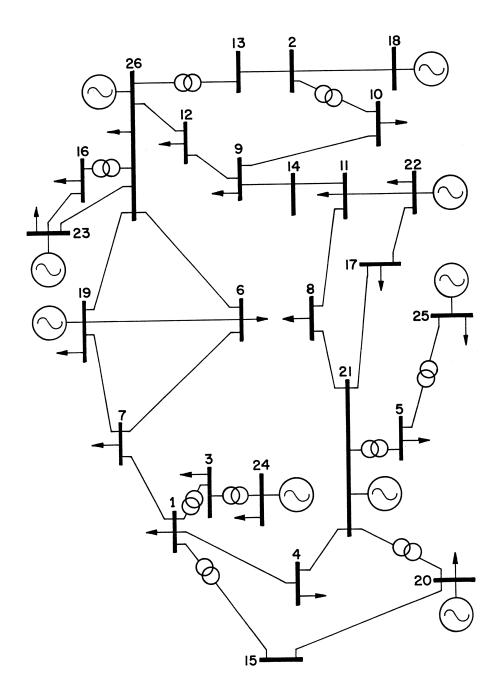


Fig. 3 26-bus power system

TABLE I	Ι
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Line No.	Terminal Buses	Resistance R _t (pu)	Reactance X _t (pu)	Number of Lines
1	1,4	0.05	0.20	1
2	1,5	0.025	0.10	2
3	2,3	0.10	0.40	1
4	2,4	0.10	0.40	1
5	2,5	0.05	0.20	1
6	2,6	0.01875	0.075	4
7	3,4	0.15	0.60	1
8	3,6	0.0375	0.15	2

LINE DATA FOR 6-BUS POWER SYSTEM

	T/	ABI	LE	Ι	Ι	Ι
--	----	-----	----	---	---	---

BUS	DATA	FOR	6-BUS	POWER	SYSTEM
000	Durn	r on	0-005	1000	010100

Bus No.	Bus Type	P _m (pu)	Q _m (pu)	^V m ∠₅m (pu)
1	load	-2.40	0	- [=
2	load	-2.40	0	- 1-
3	load	-1.60	-0.40	- /-
4	generator	-0.30	-	1.02 /-
5	generator	1.25	-	1.04 /-
6	slack	-	-	1.04 /-

TABLE IV

Line No.	Terminal Buses	Resistance R _t (pu)	Reactance X _t (pu)	1/2 Shunt Susceptance
1	13,26	0.0	0.0131	0.0
2	26,16	0.0	0.0392	0.0
3	16,23	0.0	0.4320	0.0
4	23,26	0.0	0.3140	0.0
5	2,10	0.0	0.0150	0.0
6	9,10	0.1494	0.3392	0.4120
7	9,12	0.0658	0.1494	0.0182
8	12,26	0.0533	0.1210	0.0147
9	9,14	0.0618	0.2397	0.0319
10	11,14	0.0676	0.2620	0.0349
11	19,26	0.0610	0.2521	0.0295
12	6,26	0.0513	0.1986	0.0265
13	6,19	0.0129	0.0532	0.0074
14	7,19	0.0906	0.3742	0.0437
15	6,7	0.0921	0.3569	0.0475
16	11,22	0.0513	0.2118	0.0248
17	8,11	0.0865	0.3355	0.0447
18	17,22	0.0281	0.1869	0.0237
19	8,21	0.0735	0.2847	0.0379
20	17,21	0.0459	0.3055	0.0387
21	1,4	0.0619	0.2401	0.0319
22	4,21	0.0610	0.2365	0.0315
23	20,21	0.0	0.0305	0.0
24	15,1	0.0	0.0147	0.0
25	2,13	0.0086	0.0707	0.3017
26	1,7	0.0199	0.0785	0.0404
27	15,20	0.0107	0.0617	0.4471
28	2,18	0.0074	0.0608	0.2593
29	1,3	0.0	0.0392	0.0
30	24,3	0.0	0.1450	0.0
31	5,21	0.0	0.1750	0.0
32	5,25	0.0	0.154	0.0

LINE DATA FOR 26-BUS POWER SYSTEM

TABLE V	
---------	--

Bus	Inject	ed Power	Bus Vol	tage
No.	Pm	Q _m	V _m	δ _m
1 2 3 4 5 6 7 8 9 10	-0.82 0.0 -0.57 -0.48 -0.43 -0.40 -1.11 -0.23 -0.67 -1.02	-0.21 0.0 -0.17 -0.21 -0.11 -0.10 -0.27 -0.06 -0.21 -0.27		
11 12 13 14 15 16 17 18 20 21 22 23 24 25 26	$\begin{array}{c} -0.43 \\ -0.43 \\ 0.0 \\ 0.0 \\ 0.0 \\ -1.31 \\ -0.03 \\ 2.80 \\ 1.45 \\ 2.80 \\ 1.10 \\ -0.56 \\ -0.04 \\ -0.05 \\ 0.63 \\ 0.0 \end{array}$	-0.14 -0.12 0.0 0.0 -0.30 -0.01 - - - - - -	- - - - 1.07 1.05 1.00 1.02 0.89 1.00 1.00 1.00 1.00 1.01	

BUS DATA FOR 26-BUS POWER SYSTEM

Transformer tap (a $_{\rm mm}{}^{\rm ,}{}^{\rm ,}{}^{\rm)}$ between buses m and m'

 $a_{13,26} = 1.03, a_{26,16} = 0.96, a_{2,10} = 1.03,$ $a_{20,21} = 0.97, a_{15,1} = 0.98, a_{1,3} = 0.98,$ $a_{24,3} = 0.98, a_{5,21} = 0.99, a_{5,25} = 1.03$ <u>Bus Type</u> $n_{L} = 17, n_{G} = 8$

Example 1

In this example the load flow solution of the 6-bus power system is determined by the package XLF1. The listing of the main program is given on page 18. Two input data files TL6 and BUS6 are created:

1) TL6 transmission line data file.

2) BUS6 bus data file.

Input data files TL6 and BUS6 are listed on page 19. The program output is reported on pages 20-25. The final load flow solution is reported on page 25.

С	PROGRAM MAIN(INPUT, OUTPUT, TL6, BUS6, TAPE5=BUS6, TAPE6=OUTPUT, TAPE3= 1TL6)	MN MN MN	10 20 30
-	COMPLEX V(6), CV(6), AI(6), S(5), DS(5), AK(5,5), BCK(2,5) DIMENSION KA(5), IG(2), IZ(5), IZB(2)	MN MN	40 50
C C C	THIS IS THE MAIN PROCRAM FOR SOLVING THE POWER FLOW EQUATIONS	MN MN MN	60 70 89
C C	USING THE COMPUTER PROGRAM PACKAGE CALLED XLF1	MN MN	90 100
C C	**************************************	*MN MN MN	110 120 130
	READ $(5,20)$ ND, NOD, THIAK, TUITE, TWITTE READ $(5,30)$ TOLV N=NB-1	MN MN	140 150
10	DO 10 I=1,N READ (5,40) S(I),V(I),KA(I)	MN MN MN	160 170
10	CONTINUE READ (5,50) V(NB) CALL XLF1 (V,CV,AI,S,DS,AK,BGK,KA,IG,IZ,IZB,NB,N,NGB,ITMAX,TOLV,I	MN MN CMN	180 190 200
G	1HTL, IAC, JAC, ZC, SHTLC, CC, IWRITE) STOP	MN MN MN	210 220 230
C 20 30	FORMAT (1015) FORMAT (E15.5)	MN MN	230 240 250
40 50	FORMAT (4F10.5, I5) FORMAT (2F10.5) END	MN MN MN	260 270 289-

Data File TL6 for Example 1

 $\begin{array}{l} 4,1,4,1,1,0.05,.2,0.0\\ 4,1,5,1,1,0.025,0.1,0.0\\ 4,2,3,1,1,0.1,0.4,0.0\\ 4,2,4,1,1,0.1,0.4,0.0\\ 4,2,5,1,1,0.05,0.2,0.0\\ 4,3,4,1,1,0.15,0.6,0.0\\ 4,3,6,1,1,0.0375,0.15,0.0\\ 4,2,6,1,1,0.01875,0.075,0.0\end{array}$

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Data File BUS6 for Example 1

1

6	2 7	01		
	.1E-5			
-2.4	0.0	1.0	0.0	Ø
-2.4	0.0	1.0	0.0	Ø
-1.6	-0.4	1.0	0.0	0
-0.3	1.02	1.02	0.0	1
1.25	1.04	1.04	0.0	1
1.04	0.0	•		

.

BUS NO.	BUS CURRENT(AI)		MISMATCHES(DS)		
	REAL	IMAGINARY	REAL	IMAGINARY	
1	11765E+00	.47059E+00	22824E+01	47059E+00	
2	18431E+00	.73725E+00	22157E+01	73725E+00	
3	70588E-01	.28235E+00	15294E+01	.11765E+00	
4	.43137E-01	17255E+00	34400E+00	0.	
5	.14118E+00	56471E+00	.11032E+01	0.	
BUS NO.	VOI	LTAGE	VOLTAGE CORR	ECTION VECTOR	
	REAL	IMAGINARY	REAL	IMAGINARY	
t	.99310E+00	58403E+00	68966E-02	58403E+00	
2	.10029E+01	26520E+00	.29450E-02	26520E+00	
3	.95323E+00	26781E+00	46769E-01	26781E+00	
4	.10200E+01	49117E+00	.89623E-13	49117E+00	
5	.10400E+01	41966E+00	.19307E-12	41966E+00	

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ITERATION NO. 2 OF XLF1

BUS NO.	BUS CUR	RENT(AI)	MISMATC	HES(DS)
	REAL	IMAGINARY	REAL	IMAGINARY
1	21260E+01	.71955E-01	24666E+00	.11702E+01
2	22039E+01	.46709E-01	17719E+00	.53764E+00
3	15277E+01	.43211E+00	28041E-01	.39723E+00
4	37721E+00	38270E+00	10322E+00	-,11210E+00
5	.97405E+00	41073E+00	.64619E-01	81480E-01
BUS NO.	VOI	LTAGE	VOLTAGE CORR	ECTION VECTOR
	REAL	IMAGINARY	REAL	IMAGINARY
1	.79592E+00	60185E+00	19718E+00	9 17818E-01
1 2	.79592E+00 .92797E+00	60185E+00 27936E+00	19718E+00 74973E-01	17818E-01
			74973E-01	14162E-01
2	.92797E+00	27936E+00		

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ITERATION NO. 3 OF XLF1

BUS NO.	BUS CURI	RENT(AI)	MISMATC	HES(DS)
	REAL	IMAGINARY	REAL	IMAGINARY
1	20854E+01	.12788E+01	.29499E-01	.23725E+00
2	23814E+01	.66430E+00	45576E-02	.48816E-01
3	15587E+01	.89675E+00	20810E-02	.38489E-01
샦	57253E+00	44051E+00	29869E-01	43835E-02
5	.78797E+00	12280E+01	54385E-01	29843E-02
BUS NO.	VOI	LTAGE	VOLTAGE CORRI	ECTION VECTOR
	REAL	IMAGINARY	REAL	IMAGINARY
1	.77345E+00	60028E+00	22472E-01	.15732E-02
2	.92099E+00	28255E+00	69778E-02	31901E-02
3	.86204E+00	26994E+00	84248E-02	10791E-02
4	.86636E+00	53857E+00	11572E-01	10741E-01
5	.92560E+00	47443E+00	93334E-02	12143E-01

ITERATION NO. 4 OF XLF1

BUS NO.	BUS CURI	RENT(AI)	MISMATCI	HES(DS)
	REAL	IMAGINARY	REAL	IMAGINARY
1	19421E+01	.15005E+01	.28715E-02	.52077E-02
2	23821E+01	.73029E+00	.20584E-03	.46258E-03
3	15582E+01	.95142E+00	.63372E-04	.46000E-03
4	65452E+00	49877E+00	15746E-02	11278E-03
5	.64489E+00	13834E+01	32222E-02	10848E-03
BUS NO.	VO	LTAGE	VOLTAGE CORRI	ECTION VECTOR
	REAL	IMAGINARY	REAL	IMAGINARY
1	.77301E+00	60019E+00	43554E-03	.88604E-04
2	.92085E+00	28264E+00	14201E-03	87338E-04
3	.86189E+00	26998E+00	14641E-03	38698E-04
4	.86605E+00	53885E+00	30761E-03	28122E-03
5	.92532E+00	47475E+00	28624E-03	32061E-03

ITERATION NO. 5 OF XLF1

ATCHES(DS)
IMAGINARY
05 ,19341E-05
07 .97458E-07
07 .10501E-06
0678917E-07
0583149E-07
DRRECTION VECTOR
IMAGINARY
.38893E-07
0744605E-07
0722760E-07
0613119E-06
0615056E-06
ATCHES (DS)
IMAGINARY
2.19185E-12
3.35527E-14
.23093E-13
1221316E - 13
221316E - 13

- 24 -

------_ __ __ __ __ __ __ ----LOAD FLOW SOLUTION OF 6-BUS POWER SYSTEM LOAD BUSES V(1) = .77301 - J .60019 V(2) = .92085 - J .28264V(3) = .86189 - J .26998GENERATOR BUSES Q(4) = .78656V(4) = .86605 - J .53885 Q(5) = .97796V(5) = .92532 - J .47475SLACK BUS P(6) = 6.12978 Q(6) = 1.35460

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TOTAL NUMBER OF ITERATIONS TAKEN BY XLF1 = 5 TOTAL EXECUTION TIME TAKEN BY XLF1 = .639 SECONDS

Example 2

The 26-bus power system load flow problem is solved using the package XLF1. The listing of the main program is given on page 27. Two input data files TL26 and BUS26 are created:

1) TL26 transmission line data file.

2) BUS26 bus data file.

These files are found on page 28 and are also used as the input data files for Examples 3-6. The program output is presented on pages 29-36. The final load flow solution is reported on page 36.

С	PROGRAM MAIN(INPUT, OUTPUT, TL26, BUS26, TAPE5=BUS26, TAPE6=OUTPUT, 1TAPE3=TL26)	MN MN	10 20	
_	COMPLEX V(26),CV(26),AI(26),S(25),BS(25),AK(25,25),BGK(8,25),ZC DIMENSION KA(25), IG(8), IZ(25), IZB(6)	MN MN MN	30 40 50	
C C C	THIS IS THE MAIN PROCRAM FOR SOLVING THE POWER FLOW EQUATIONS	MN MN	60 70	
C C C	USING THE COMPUTER PROCRAM PACKAGE CALLED XLF1	MIN MIN MIN	80 90 100	
C C	***************************************	**MN MN	110	
	READ (5,20) NB, NGB, ITMAX, ICHTL, IWRITE READ (5,30) TOLV	MIN MIN	130 140	
	N=NB-1 DO 10 I=1.N	MN	150	
10	READ (5,40) S(I),V(I),KA(I) CONTINUE	MN	160 170	
	READ (5,50) V(NB) CALL XLF1 (V, CV, AI, S, DS, AK, BGK, KA, IG, IZ, IZB, NB, N, NGB, ITMAX, TOLV,	MN MN	180 190	
	IFTL, IAC, JAC, ZC, SHTLC, CC, IWRITE) STOP	MN	200 210	
C 20	FORMAT (1015)	MN MN	220 230	
30	FORMAT (E15.5)	MN MN	240 250	
40 50	FORMAT (4F10.5, I5) FORMAT (2F10.5) END	MN MN	260 270	
		MN	280-	

`

Data File TL26 for Examples 2-6

4,16,23,1,1,0.0,0.432,0.0 7,2,10,1,0.0,0.0150,1.03,0.0 4,9,10,1,1,0.1494,0.3392,0.4120 4,9,12,1,1,0.0658,0.1494,0.0182 4,9,14,1,1,0.0618,0.2397,0.0319 4, 11, 14, 1, 1, 0.0676, 0.2620, 0.0349 4,6,19,1,1,0.0129,0.0532,0.0074 4,7,19,1,1,0.0906,0.3742,0.0437 4,6,7,1,1,0.0921,0.3569,0.0475 4, 11, 22, 1, 1, 0.0513, 0.2118, 0.0248 4,8,11,1,1,0.0865,0.3355,0.0447 4, 17, 22, 1, 1, 0. 0281, 0. 1869, 0. 0237 4,8,21,1,1,0.0735,0.2847,0.0379 4, 17, 21, 1, 1, 0.0459, 0.3055, 0.0387 4, 1, 4, 1, 1, 0.0619, 0.2401, 0.0319 4,4,21,1,1,0.0610,0.2365,0.0315 7,20,21,1,0.0,0.0305,0.97,0.0 7, 15, 1, 1, 0.0, 0.0147, 0.89, 0.0 4,2,13,1,1,0.0086,0.0707,0.3017 4, 1, 7, 1, 1, 0.0199, 0.0785, 0.0404 4, 15, 20, 1, 1, 0.0107, 0.0617, 0.4471 4,2,18,1,1,0.0074,0.0608,0.2593 7,1,3,1,0.0,0.0392,.98,0.0 7,24,3,1,0.0,0.1450,0.98,0.0 7,5,21,1,0.0,0.1750,0.99,0.0 7,5,25,1,0.0,0.1540,1.03,0.0 7,13,26,1,0.0,0.0131,1.03,0.0 7,26,16,1,0.0,0.0392,0.96,0. 4,23,26,1,1,0.0,0.3140,0.0 4, 12, 26, 1, 1, 0.0533, 0.1210, 0.0147 4, 19, 26, 1, 1, 0.0610, 0.2521, 0.0295 4,6,26,1,1,0.0513,0.1986,0.0265

Data File BUS26 for Examples 2-6

26	8 7	01		
-0.82	0.1E-5 -0.21	1.0	0.0	
0.0	0.0	1.0	0.0	
-0.57	-0.17	1.0	0.0	
-0.48	-0.21	1.0	0.0	
-0.43	-0.11	1.0	0.0	
-0.40	-0.1	1.0	0.0	
-1.11	-0.27	1.0	0.0	
-0.23	-0.06	1.0	0.0	
-0.67	-0.21	1.0	0.0	
-1.02	-0.27	1.0	0.0	
-0.43	-0.14	1.0	0.0	
-0.43	-0.12	1.0	0.0	
0.0	0.0	1.0	0.0	
	0.0	1.0	0.0	
0.0				
0.0	0.0	1.0	0.0	
-1.31	-0.30	1.0	0.0	
-0.03	-0.01	1.0	0.0	
2.80	1.07	1.07	0.0	
1.45	1.05	1.05	0.0	
2.89	1.0	1.0	0.0	
1.10	1.02	1.02	0.0	
-0.56	0.89	0.89	0.0	
-0.04	1.0	1.0	0.0	
-0.05	1.0	1.0	0.0	
0.63	1.0	1.0	0.0	
1.01	0.0			

ITERATION NO. 1 OF XLF1

BUS NO.	BUS CURI	RENT(AI)	MISMATC	HES(DS)
	REAL	IMACINARY	REAL	IMAGINARY
1	0.	.79489E+01	82000E+00	77389E+01
2	13308E+00	.35807E+01	.13808E+00	35807E+01
3	0.	.66136E+00	57000E+00	49136E+00
4	20452E-01	.14269E+00	45955E+00	.67308E-01
5	0.	.24076E+00	43000E+00	13076E+00
6	22743E+00	.10163E+01	17257E+00	91626E+00
7	30560E-01	.25782E+00	10794E+01	.12181E-01
8	17003E-01	.14846E+00	21300E+00	88460E-01
9	0.	.46210E+00	67000E+00	25210E+00
10	0.	15297E+01	10200E+01	.17997E+01
11	.11882E+00	38618E+00	54882E+00	.52618E+00
12	30489E-01	.10211E+00	39951E+00	.17886E-01
13	0.	.32014E+01	0.	32014E+01
14	0.	.66800E-01	0.	66800E-01
15	0.	89999E+01	. 0.	.89999E+01
16	0.	.13287E+01	13100E+01	10287E+01
17	.76912E-01	44912E+00	10691E+00	.45912E+00
18	.1380SE+00	85706E+00	.26523E+01	0.
19	.28207E+00	10791E+01	.11533E+01	0.
20	0.	.77729E-01	.28000E+01	0.
21	.47073E-01	.20281E+00	.10520E+01	0.
22	20535E+00	.11093E+01	37724E+00	0.
23	0.	.31847E-01	40000E-01	0.
24	0.	14362E+00	50000E-01	0.
25	0.	18913E+00	.63000E+00	0.
BUS NO.	VOLTAGE		VOLTAGE CORRI	ECTION VECTOR
	V01			
	REAL	IMAGINARY	REAL	IMAGINARY
1		IMAGINARY .11125E+00	REAL .91134E-01	
2	REAL	IMAGINARY	REAL	.11125E+00
2 3	REAL . 10911E+01	IMAGINARY .11125E+00	REAL .91134E-01	.11125E+00 .10522E+00
2 3 4	REAL . 10911E+01 . 10893E+01	IMAGINARY . 11125E+00 . 10522E+00 . 87430E-01 . 13888E+00	REAL .91134E-01 .89329E-01	.11125E+00 .10522E+00 .87430E-01
2 3 4 5	REAL . 10911E+01 . 10893E+01 . 10902E+01	IMAGINARY . 11125E+00 . 10522E+00 . 87430E-01	REAL .91134E-01 .89329E-01 .90207E-01	. 1 1 125E+00 . 10522E+00 . 87430E-0 1 . 13888E+00
21 33 44 55 6	REAL . 10911E+01 . 10893E+01 . 10902E+01 . 10237E+01 . 10112E+01 . 10407E+01	IMAGINARY . 11125E+00 . 10522E+00 . 87430E-01 . 13988E+00 . 30226E+00 . 68812E-01	REAL .91134E-01 .99329E-01 .90207E-01 .23677E-01 .11166E-01 .40694E-01	.11125E+00 .10522E+00 .87430E-01 .13888E+00 .30226E+00
2 2 4 5 6 7	REAL . 10911E+01 . 10893E+01 . 10902E+01 . 10237E+01 . 10112E+01 . 10407E+01 . 10556E+01	IMAGINARY . 11125E+00 . 10522E+00 . 87430E-01 . 13588E+00 . 30226E+00 . 68812E-01 . 45791E-01	REAL .91134E-01 .89329E-01 .90207E-01 .23677E-01 .11166E-01 .40694E-01 .55594E-01	.11125E+00 .10522E+00 .87430E-01 .13888E+00 .30226E+00 .68812E-01 .45791E-01
21 3 4 5 6 7 8	REAL . 10911E+01 . 10893E+01 . 10902E+01 . 10237E+01 . 10112E+01 . 10407E+01 . 10556E+01 . 97005E+00	IMAGINARY . 11125E+00 . 10522E+00 . 87430E-01 . 13888E+09 . 30226E+00 . 68812E-01 . 45791E-01 . 85915E-01	REAL .91134E-01 .9329E-01 .90207E-01 .23677E-01 .11166E-01 .40694E-01 .55594E-01 29952E-01	.11125E+00 .10522E+00 .87430E-01 .1388E+00 .30226E+00 .68812E-01 .45791E-01 .85915E-01
21 73 44 55 66 72 83 9	REAL . 10911E+01 . 10893E+01 . 10902E+01 . 10237E+01 . 10112E+01 . 10407E+01 . 10556E+01 . 97005E+00 . 99168E+00	IMAGINARY .11125E+00 .10522E+00 .87430E-01 .13888E+00 .30226E+00 .68812E-01 .45791E-01 .85915E-01 93390E-01	REAL .91134E-01 .89329E-01 .90207E-01 .23677E-01 .11166E-01 .40694E-01 .55594E-01 29952E-01 83165E-02	.11125E+00 .10522E+00 .87430E-01 .13888E+00 .30226E+00 .68812E-01 .45791E-01 .85915E-01 93390E-01
2 3 4 5 6 7 8 9 10	REAL . 10911E+01 . 10893E+01 . 10902E+01 . 10237E+01 . 10112E+01 . 10407E+01 . 10556E+01 . 97005E+00 . 99168E+00 . 10591E+01	IMAGINARY . 11125E+00 . 10522E+00 . 87430E-01 . 13888E+00 . 30226E+00 . 68812E-01 . 45791E-01 . 85915E-01 93390E-01 . 81652E-01	REAL .91134E-01 .89329E-01 .90207E-01 .23677E-01 .11166E-01 .40694E-01 .55594E-01 29952E-01 83165E-02 .59099E-01	.11125E+00 .10522E+00 .87430E-01 .13888E+00 .30226E+00 .63812E-01 .45791E-01 .85915E-01 93390E-01 .81652E-01
2 3 4 5 6 7 8 9 10 11	REAL . 10911E+01 . 10893E+01 . 10902E+01 . 10237E+01 . 10112E+01 . 10407E+01 . 10556E+01 . 97005E+00 . 99168E+00 . 10591E+01 . 92594E+00	IMAGINARY . 11125E+00 . 10522E+00 . 87430E-01 . 13888E+00 . 30226E+00 . 68812E-01 . 45791E-01 . 85915E-01 93390E-01 . 81652E-01 54603E-01	REAL .91134E-01 .89329E-01 .90207E-01 .23677E-01 .11166E-01 .40694E-01 .55594E-01 29952E-01 83165E-02 .59099E-01 74064E-01	.11125E+00 .10522E+00 .87430E-01 .13888E+00 .30226E+00 .68812E-01 .45791E-01 .85915E-01 93390E-01 .81652E-01 54603E-01
2 3 4 5 6 7 8 9 10 11 12	REAL . 10911E+01 . 10893E+01 . 10902E+01 . 10237E+01 . 10112E+01 . 10407E+01 . 10556E+01 . 97005E+00 . 99168E+00 . 90594E+00 . 98315E+00	IMAGINARY .11125E+00 .10522E+00 .87430E-01 .13288E+00 .30226E+00 .68812E-01 .45791E-01 .85915E-01 93390E-01 .81652E-01 54603E-01 67568E-01	REAL .91134E-01 .99329E-01 .90207E-01 .23677E-01 .11166E-01 .40694E-01 .55594E-01 29952E-01 390952E-01 74064E-01 74064E-01 16850E-01	$\begin{array}{c} .11125E+00\\ .10522E+00\\ .97430E-01\\ .13888E+00\\ .30226E+00\\ .68912E-01\\ .45791E-01\\ .85915E-01\\ .85915E-01\\ .81652E-01\\ .81652E-01\\54603E-01\\67568E-01\end{array}$
2 3 4 5 6 7 8 9 10 11 12 13	REAL . 10911E+01 . 10893E+01 . 10902E+01 . 10237E+01 . 10112E+01 . 10407E+01 . 10556E+01 . 97005E+00 . 99168E+00 . 10591E+01 . 92594E+00 . 98315E+00 . 10522E+01	IMAGINARY .11125E+00 .10522E+00 .87430E-01 .13988E+00 .30226E+00 .68812E-01 .45791E-01 .85915E-01 93390E-01 .81652E-01 54603E-01 67568E-01 .17227E-01	REAL .91134 E -01 .99329 E -01 .90207 E -01 .23677 E -01 .11166 E -01 .40694 E -01 .55594 E -01 29952 E -01 83165 E -02 .59099 E -01 74064 E -01 .52159 E -01	$\begin{array}{c} .11125E+00\\ .10522E+00\\ .87430E-01\\ .3838BE+00\\ .30226E+00\\ .30226E+00\\ .63812E-01\\ .45791E-01\\ .85915E-01\\93390E-01\\ .81652E-01\\54603E-01\\54603E-01\\ .17227E-01\end{array}$
2 3 4 5 6 7 8 9 10 11 12 13 14	REAL . 10911E+01 . 10893E+01 . 10902E+01 . 10237E+01 . 10112E+01 . 10407E+01 . 10407E+01 . 10556E+01 . 97005E+00 . 99168E+00 . 10594E+00 . 98315E+00 . 10522E+01 . 96810E+00	IMAGINARY . 11125E+00 . 10522E+00 . 87430E-01 . 13988E+00 . 30226E+00 . 68812E-01 . 45791E-01 . 85915E-01 93390E-01 . 81652E-01 54603E-01 67568E-01 . 17227E-01 76881E-01	REAL .91134E-01 .99292E-01 .90207E-01 .23677E-01 .11166E-01 .40694E-01 .55594E-01 29952E-01 83165E-02 .59099E-01 74064E-01 16850E-01 .52159E-01 31902E-01	$\begin{array}{c} .11125E+00\\ .10522E+00\\ .97430E-01\\ .3888E+00\\ .30226E+00\\ .30226E+00\\ .68812E-01\\ .45791E-01\\ .85915E-01\\93390E-01\\ .81652E-01\\54603E-01\\67568E-01\\ .17227E-01\\76881E-01\end{array}$
2 3 4 5 6 7 8 9 10 11 12 13 14 15	REAL . 10911E+01 . 10893E+01 . 10902E+01 . 10237E+01 . 10112E+01 . 10407E+01 . 10407E+01 . 10556E+01 . 97005E+00 . 99168E+00 . 10591E+01 . 92594E+00 . 98315E+00 . 10522E+01 . 96810E+00 . 97892E+00	IMAGINARY . 11125E+00 . 10522E+00 . 87430E-01 . 13288E+00 . 30226E+00 . 68812E-01 . 45791E-01 . 85915E-01 93390E-01 . 81652E-01 54603E-01 . 17227E-01 76881E-01 . 14122E+00	REAL .91134E-01 . $992929E-01$.90207E-01 .23677E-01 .11166E-01 .40694E-01 .55594E-01 29952E-01 83165E-02 .59099E-01 74064E-01 .52159E-01 .31902E-01 21975E-01	$\begin{array}{c} .11125E+00\\ .10522E+00\\ .87430E-01\\ .1388E+00\\ .30226E+00\\ .30226E+00\\ .68812E-01\\ .45791E-01\\ .85915E-01\\93390E-01\\ .81652E-01\\54603E-01\\54603E-01\\ .17227E-01\\ .17227E-01\\ .14122E+00\end{array}$
2 3 4 5 6 7 8 9 10 11 12 13 14 15 16	REAL . 10911E+01 . 10893E+01 . 10902E+01 . 10237E+01 . 10237E+01 . 10407E+01 . 10407E+01 . 10556E+01 . 97005E+00 . 90168E+00 . 10591E+01 . 92594E+00 . 10522E+01 . 96810E+00 . 97022E+00 . 10388E+01	IMAGINARY . 11125E+00 . 10522E+00 . 87430E-01 . 13988E+00 . 30226E+00 . 68812E-01 . 45791E-01 . 85915E-01 . 93990E-01 . 81652E-01 . 17227E-01 . 76881E-01 . 14122E+00 47073E-01	REAL .91134E-01 .89329E-01 .90207E-01 .23677E-01 .11166E-01 .40694E-01 .55594E-01 29952E-01 83165E-02 .59099E-01 74064E-01 .52159E-01 .31902E-01 21975E-01 .38823E-01	.11125E+00 .10522E+00 .87430E-01 .13888E+00 .30226E+00 .68812E-01 .45791E-01 .85915E-01 93390E-01 .81652E-01 54603E-01 .17227E-01 .76881E-01 .14122E+00 47073E-01
2 3 4 5 6 7 8 9 10 11 12 13 4 15 16 17	REAL . 10911E+01 . 10893E+01 . 10902E+01 . 10237E+01 . 10112E+01 . 10407E+01 . 10556E+01 . 97005E+00 . 99168E+00 . 10591E+01 . 92594E+00 . 98315E+00 . 10522E+01 . 96810E+09 . 97592E+00 . 10388E+01 . 94734E+00	IMAGINARY . 11125E+00 .10522E+00 .87430E-01 .13988E+00 .30226E+00 .68812E-01 .45791E-01 .85915E-01 93390E-01 .81652E-01 .81652E-01 .17227E-01 .76881E-01 .14122E+00 47073E-01 .85223E-01	REAL .91134E-01 .89329E-01 .90207E-01 .23677E-01 .11166E-01 .40694E-01 .55594E-01 29952E-01 74064E-01 74064E-01 16850E-01 .52159E-01 31902E-01 31902E-01 32823E-01 52663E-01	$\begin{array}{c} .11125E+00\\ .10522E+00\\ .97430E-01\\ .138B8E+00\\ .30226E+00\\ .63812E-01\\ .45791E-01\\ .457915E-01\\ .85915E-01\\ .81652E-01\\ .81652E-01\\ .76881E-01\\ .17227E-01\\ .76881E-01\\ .14122E+60\\ .47073E-01\\ .85223E-01\end{array}$
2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18	REAL . 10911E+01 . 10893E+01 . 10902E+01 . 10237E+01 . 10112E+01 . 10407E+01 . 10556E+01 . 97005E+00 . 99168E+00 . 99168E+00 . 98315E+00 . 10522E+01 . 96810E+00 . 97592E+00 . 10388E+01 . 94734E+00 . 10700E+01	IMAGINARY . 11125E+00 . 10522E+00 .87430E-01 . 13988E+00 .30226E+00 .68812E-01 .45791E-01 .85915E-01 93390E-01 .81652E-01 .76881E-01 .17227E-01 .76881E-01 .14122E+00 47073E-01 .85223E-01 .28787E+00	REAL .91134E-01 .89329E-01 .90207E-01 .23677E-01 .11166E-01 .40694E-01 .55594E-01 29952E-01 39099E-01 .74064E-01 .16850E-01 .52159E-01 .31902E-01 .38523E-01 .38523E-01 .38523E-01 .23821E-13	$\begin{array}{c} .11125E+00\\ .10522E+00\\ .37430E-01\\ .1388BE+00\\ .30226E+00\\ .30226E+00\\ .68912E-01\\ .45791E-01\\ .85915E-01\\ .81652E-01\\ .81652E-01\\ .54603E-01\\ .7227E-01\\ .76881E-01\\ .14122E+00\\47073E-01\\ .85223E-01\\ .85222E-01\\ .8522E-01\\ .8522E-01$
2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19	REAL . 10911E+01 . 10893E+01 . 10902E+01 . 10902E+01 . 10112E+01 . 10112E+01 . 10407E+01 . 10556E+01 . 97005E+00 . 99168E+00 . 98315E+00 . 10592E+01 . 96810E+00 . 97892E+00 . 1038E+01 . 94734E+00 . 10700E+01 . 10500E+01	IMAGINARY . 11125E+00 . 10522E+00 .87430E-01 .13288E+00 .30226E+00 .68812E-01 .45791E-01 .85915E-01 93390E-01 .81652E-01 .54603E-01 .17227E-01 .76881E-01 .14122E+00 .47073E-01 .85223E-01 .28787E+00 .11543E+00	REAL .91134E-01 .89329E-01 .90207E-01 .236777E-01 .11166E-01 .40694E-01 .55594E-01 29952E-01 83165E-02 .59099E-01 74064E-01 16850E-01 .52159E-01 .31902E-01 .31975E-01 .3823E-01 52663E-01 .23821E-13 66919E-13	$\begin{array}{c} .11125E+00\\ .10522E+00\\ .87430E-01\\ .13888E+00\\ .30226E+00\\ .30226E+00\\ .68812E-01\\ .45791E-01\\ .85915E-01\\93390E-01\\ .81652E-01\\54603E-01\\ .17227E-01\\54603E-01\\ .17227E-01\\ .14122E+00\\ .47073E-01\\ .85223E-01\\ .28787E+00\\ .11543E+00\\ \end{array}$
2 3 4 5 6 7 8 9 10 11 23 4 5 6 7 8 9 10 11 23 4 5 6 7 8 9 10 11 23 4 5 6 7 8 9 10 11 23 4 5 6 7 8 9 10 11 23 4 5 6 7 8 9 10 11 23 10 12 10 12 10 10 10 10 10 10 10 10 10 10 10 10 10	REAL . 10911E+01 . 10893E+01 . 10902E+01 . 10237E+01 . 10112E+01 . 10407E+01 . 10407E+01 . 10556E+01 . 97005E+00 . 99168E+00 . 98315E+00 . 10594E+00 . 96810E+00 . 9732E+00 . 10388E+01 . 94734E+00 . 10700E+01 . 10500E+01 . 10900E+01	IMAGINARY . 11125E+00 . 10522E+00 . 87430E-01 . 13988E+00 . 30226E+00 . 68812E-01 . 45791E-01 . 85915E-01 93390E-01 . 81652E-01 . 7688E-01 . 17227E-01 76881E-01 . 14122E+00 47073E-01 . 85223E-01 . 28787E+00 . 11543E+00 . 28304E+00	REAL .91134E-01 .99329E-01 .90207E-01 .23677E-01 .23677E-01 .40694E-01 .55594E-01 29952E-01 83165E-02 .59099E-01 74064E-01 .52159E-01 .31902E-01 21975E-01 .3823E-01 23821E-13 .66919E-13 15987E-12	$\begin{array}{c} .11125E+00\\ .10522E+00\\ .97430E-01\\ .3888E+00\\ .30226E+00\\ .30226E+00\\ .68812E-01\\ .45791E-01\\ .85915E-01\\93390E-01\\ .81652E-01\\54603E-01\\ .54603E-01\\ .76881E-01\\ .17227E-01\\ .76881E-01\\ .14122E+00\\47073E-01\\ .85223E-01\\ .28787E+00\\ .11543E+00\\ .28304E+00\\ \end{array}$
2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 7 8 9 20 21	REAL . 10911E+01 . 10893E+01 . 10902E+01 . 10237E+01 . 10112E+01 . 10407E+01 . 10407E+01 . 10556E+01 . 97005E+00 . 99168E+00 . 10594E+00 . 10522E+01 . 96810E+00 . 1038BE+01 . 94734E+00 . 10500E+01 . 10900E+01 . 10200E+01	IMAGINARY . 11125E+00 . 10522E+00 . 87430E-01 . 13988E+00 . 30226E+00 . 68812E-01 . 45791E-01 . 85915E-01 93390E-01 . 81652E-01 . 17227E-01 . 17227E-01 . 17227E-01 . 17227E-01 . 14122E+00 47073E-01 . 85232E-01 . 28787E+00 . 11543E+00 . 28304E+00 . 27365E+00	REAL .91134E-01 .99329E-01 .90207E-01 .23677E-01 .11166E-01 .40694E-01 .55594E-01 29952E-01 83165E-02 .59099E-01 74064E-01 .52159E-01 .52159E-01 .31902E-01 .31902E-01 .32823E-01 .52663E-01 .23921E-13 .66919E-13 .15987E-12 .11239E-12	$\begin{array}{c} .11125E+00\\ .10522E+00\\ .97430E-01\\ .3888E+00\\ .30226E+00\\ .30226E+00\\ .68812E-01\\ .45791E-01\\ .85915E-01\\93390E-01\\ .81652E-01\\54603E-01\\ .81652E-01\\67568E-01\\ .17227E-01\\ .17227E-01\\ .17227E-01\\ .28703E+00\\ .28707E+00\\ .11543E+00\\ .28304E+00\\ .27365E+00\\ \end{array}$
2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 9 20 21 22	REAL . 10911E+01 . 10893E+01 . 10902E+01 . 10237E+01 . 10112E+01 . 10407E+01 . 10407E+01 . 10556E+01 . 97005E+00 . 99168E+00 . 10591E+01 . 96810E+00 . 97892E+00 . 10388E+01 . 94734E+00 . 10500E+01 . 10500E+01 . 10200E+01 . 10200E+01 . 29000E+00	IMAGINARY . 11125E+00 .10522E+00 .87430E-01 .13988E+00 .30226E+00 .68812E-01 .45791E-01 .85915E-01 .9390E-01 .81652E-01 .17227E-01 .76881E-01 .14122E+00 47073E-01 .85223E-01 .28787E+00 .11543E+00 .28304E+00 .27365E+00 31489E-01	REAL .91134E-01 .89329E-01 .90207E-01 .23677E-01 .11166E-01 .40694E-01 .55594E-01 29952E-01 83165E-02 .59099E-01 74064E-01 16850E-01 .52159E-01 31902E-01 .32923E-01 .38823E-01 .39828E-12 .10458E-12	93399E-01 .81652E-01 54603E-01 .7227E-01 .76881E-01 .14122E+00 47073E-01 .85223E-01 .28787E+00 .11543E+00 .28304E+00 .27365E+00 31489E-01
2 3 4 5 6 7 8 9 10 11 12 13 4 15 16 17 18 9 20 1 22 23	REAL . 10911E+01 . 10893E+01 . 10902E+01 . 10237E+01 . 10237E+01 . 10112E+01 . 10407E+01 . 10556E+00 . 99168E+00 . 10591E+01 . 92594E+00 . 98315E+00 . 10522E+01 . 96810E+00 . 10388E+01 . 94734E+00 . 10700E+01 . 10200E+01 . 10200E+01 . 0900E+00 . 10000E+01	IMAGINARY . 11125E+00 .10522E+00 .87430E-01 .13988E+00 .30226E+00 .68812E-01 .45791E-01 .85915E-01 93390E-01 .81652E-01 .81652E-01 .17227E-01 .76881E-01 .17227E-01 .276881E-01 .15438E+00 .28787E+00 .11543E+00 .27365E+00 .27365E+00 .31489E-01 26931E-01	REAL .91134E-01 .89329E-01 .90207E-01 .23677E-01 .11166E-01 .40694E-01 .55594E-01 29952E-01 83165E-02 .59099E-01 74064E-01 16850E-01 .52159E-01 31902E-01 .32923E-01 .38233E-01 .38233E-01 .38232E-01 .39362E-12 .10458E-12 .10458E-12 .10458E-12	$\begin{array}{c} .11125E+00\\ .10522E+00\\ .87430E-01\\ .13838E+00\\ .30226E+00\\ .30226E+00\\ .30226E+01\\ .45791E-01\\ .45791E-01\\ .45791E-01\\ .85915E-01\\93390E-01\\ .81652E-01\\ .76881E-01\\ .17227E-01\\ .17227E-01\\ .14122E+00\\ .47073E-01\\ .85223E-01\\ .28767E+00\\ .11543E+00\\ .28304E+00\\ .27365E+00\\ .31489E-01\\26931E-01\end{array}$
2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 7 8 9 20 21 22	REAL . 10911E+01 . 10893E+01 . 10902E+01 . 10237E+01 . 10112E+01 . 10407E+01 . 10407E+01 . 10556E+01 . 97005E+00 . 99168E+00 . 10591E+01 . 96810E+00 . 97892E+00 . 10388E+01 . 94734E+00 . 10500E+01 . 10500E+01 . 10200E+01 . 10200E+01 . 29000E+00	IMAGINARY . 11125E+00 .10522E+00 .87430E-01 .13988E+00 .30226E+00 .68812E-01 .45791E-01 .85915E-01 .9390E-01 .81652E-01 .17227E-01 .76881E-01 .14122E+00 47073E-01 .85223E-01 .28787E+00 .11543E+00 .28304E+00 .27365E+00 31489E-01	REAL .91134E-01 .89329E-01 .90207E-01 .23677E-01 .11166E-01 .40694E-01 .55594E-01 29952E-01 83165E-02 .59099E-01 74064E-01 16850E-01 .52159E-01 31902E-01 .32923E-01 .38823E-01 .39828E-12 .10458E-12	$\begin{array}{c} .11125E+00\\ .10522E+00\\ .87430E-01\\ .13838E+00\\ .30226E+00\\ .30226E+00\\ .68812E-01\\ .45791E-01\\ .85915E-01\\93390E-01\\ .81652E-01\\54603E-01\\ .81652E-01\\ .76881E-01\\ .17227E-01\\ .14122E+00\\47073E-01\\ .85223E-01\\ .28787E+00\\ .11543E+00\\ .28304E+00\\ .27365E+00\\31489E-01\end{array}$

BUS NO.	BUS CURI	RENT(AI)	MISMATC	HES(DS)
	REAL	IMAGINARY	REAL	IMAGINARY
1	17043E+01	51442E+00	.10968E+01	.58170E+00
2	36443E+00	33439E+00	.43217E+00	.32591E+00
3	62782E+00	.11034E+00.	.10481E+00	51841E-02
4	49933E+00	.20378E+00	.28543E-02	67955E-01
5	50277E+00	.10731E+00	.45950E-01	15048E+00
6	46068E+00	.42994E-01	.76465E-01	.23557E-01
7	11201E+01	.25427E+00	.60735E-01	49694E-01
8	24326E+00	.62986E-01	.56648E-03	21999E-01
9	62684E+00	.21384E+00	28398E-01	.56476E-01
	89509E+00	.36041E+00	10144E+00	18479E+00
10				
11	44229E+00	.10491E+00	14743E-01	.67010E-01
12	42361E+00	.12378E+00	51603E-02	.26928E-01
13	55151E-01	16698E+00.	.60904E-01	.17474E+00
14	.51357E-02	.21310E-02.	48080E-02	24579E-02
15	.12710E+01	19778E+00	12152E+01	.37293E+00
16	12475E+01	.24842E+00	24202E-02	.10066E+00
17	.12326E-01	70973E-02.	41072E-01	.17774E-01
18	.28474E+01	.95101E+00	52048E+00	38046E-01
19	.14996E+01	.13157E+00	13975E+00	63259E-02
20	.27780E+01	.11892E+00	11659E-01	39284E-01
21	.10240E+01	.48196E+00	76389E-01	36071E-01
22	58997E+00	.43659E+00	21182E-01	55687E-03
23	39142E-01	.12171E+00	.24202E-02	36257E-03
24	38464E-01	.49120E+00	50991E-01	32208E-02
25	.70607E+00	11874E+00.	28312E-01	77847E-01
BUS NO.	VOI	LTAGE	VOLTAGE CORR	ECTION VECTOR
	REAL	IMAGINARY	REAL	IMAGINARY
1	.10355E+01	.77923E-01	55642E-01	33325E-01
$\hat{2}$.10646E+01	.94546E-01	24728E-01	10675E-01
3	.10446E+01	.55841E-01	45566E-01	31589E-01
4	.98733E+00	.99447E-01	36345E-01	39437E-01
5	.97364E+00	.26109E+00	3752SE-01	41163E-01
6	.10327E+01	.55887E-01	79912E-02	12925E-01
7	.10152E+01	.18735E-01	40392E-01	27056E-01
8	.94518E+00	.42347E-01	24863E-01	43569E-01
9	.96252E+00	10840E+00	29164E-01	15009E-01
10	.10372E+01	.69525E-01	21900E-01	12127E-01
11	.90016E+00	97256E-01	25777E-01	42653E-01
12	.96761E+00	73915E-01	15539E-01	63472E-02
13	.10464E+01	.15751E-01	57856E-02	14754E-02
14	.94038E+00	10597E+00	27718E-01	29090E-01
			48064E-01	
15	.92996E+00 .10353E+01	.98296E-01		42929E-01 45460E-04
16		47118E-01	35476E-02	
17	.93338E+00	.30755E-01	13954E-01	54468E-01
18	.10398E+01	.25357E+00.	30171E-01	34300E-01
19	.10456E+01	.97181E-01	48577E-02	18250E-01
20	.97065E+00	.24250E+00	29353E-01	40541E-01
21	.99397E+00	.23148E+00.	26032E-01	42171E-01
22	.88755E+00	84881E-01	24463E-02	53393E-01
23	.99965E+00	26551E-01	35248E-03	.37931E-03
24	.99936E+00	.48009E-01	63549E-03	32315E-01
25	.93595E+00	.35282E+00	64051E-01	49371E-01

ITERATION NO. 3 OF XLF1

BUS NO.	BUS CUR	RENT(AI)	MISMATCHES(DS)	
	REAL	IMAGINARY	REAL	IMAGINARY
1	86737E+00	.12985E+00.	.68038E-01	.79575E-02
2	11058E-01	50874E-02	.12253E-01	.43706E-02
3	55663E+00	.13410E+00	.39943E-02	11663E-02
4	50098E+00	.16365E+00	16426E-02	13939E-02
5	44005E+00	.16961E-02	19938E-02	65449E-02
6	39240E+00	.76195E-01	.97474E-03	61716E-03
7	10986E+01	.24656E+00.	.66109E-03	89363E-03
8	24517E+00	.52678E-01	49655E-03	17309E-03
9	66350E+00	.29002E+00	.74213E-04	.27719E-02
10	99258E+00	.19611E+00	41275E-02	24159E-02
11	45999E+00	.20162E+00	.36687E-02	.32478E-02
12	43251E+00	.15647E+00	.69234E-04	.56448E-03
13	52350E-03	84945E-03	.56116E-03	.88060E-03
14	.20239E-03	10938E-03	20191E-03	.81407E-04
15	.61949E-01	56564E-01	52050E-01	.58691E-01
16	12496E+01	.34632E+00	31521E-05	.34740E-03
17	32508E-01	.68183E-02	.13235E-03	.26362E-02
18	.24627E+01	.98481E+00	10449E-01	29870E-03
19	.13941E+01	42010E-01	36276E-02	14858E-03
20	.28975E+01	39174E-01	29033E-02	48085E-03
21	.10497E+01	.27862E+00	79053E-02	56601E-03
22	59539E+00	.26145E+00	93643E-02	16033E-02
23	36951E-01	.11544E+00	.31521E-05	68334E-07
24	48216E-01	.17510E+00	10221E-01	51703E-03
$\frac{2}{25}$.64498E+00	.60618E-01	.49424E-02	23989E-03
US NO.	VOLTAGE		NOLTAGE CODD	ECTION VECTOR
		114012	VULIAGE COM	DULION VEGLOI
	REAL		REAL	
i	REAL	IMAGINARY	REAL	IMAGINARY
12	REAL	IMAGINARY	REAL	IMAGINARY
2	REAL . 10328E+01 . 10644E+01	IMAGINARY .77296E-01 .94340E-01	REAL 27257E-02 23480E-03	IMAGINARY 62686E-03 20652E-03
2 3	REAL . 10328E+01 . 10644E+01 . 10424E+01	IMAGINARY .77296E-01 .94340E-01 .54953E-01	REAL 27257E-02 23480E-03 22730E-02	IMAGINARY 62686E-03 20652E-03 88746E-03
2 3 4	REAL . 10328E+01 . 10644E+01 . 10424E+01 . 98591E+00	IMAGINARY .77296E-01 .94340E-01 .54953E-01 .97877E-01	REAL 27257E-02 23480E-03 22730E-02 14230E-02	IMAGINARY 62686E-03 20652E-09 88746E-09 15704E-02
2 3 4 5	REAL . 103282+01 . 106442+01 . 104242+01 . 985912+00 . 974082+00	IMAGINARY .77296E-01 .94340E-01 .54953E-01 .97877E-01 .25983E+00	REAL 27257E-02 23480E-03 22730E-02 14230E-02 .43886E-03	IMAGINARY 62686E-03 20652E-03 88746E-03 15704E-02 12683E-02
2 3 4 5 6	REAL . 103282+01 . 106442+01 . 104242+01 . 98591E+00 . 974082+00 . 103242+01	IMAGINARY .77296E-01 .94340E-01 .54953E-01 .97877E-01 .25983E+00 .55420E-01	REAL 27257E-02 23480E-03 22730E-02 14230E-02 .43885E-03 25775E-03	IMAGINARY 62686E-03 20652E-03 88746E-03 15704E-02 12683E-02 46682E-03
2 3 4 5 6 7	REAL . 103282+01 . 106442+01 . 104242+01 . 985912+00 . 974082+00 . 103242+01 . 101322+01	IMAG INARY .77296E-01 .94340E-01 .54953E-01 .97877E-01 .25983E+00 .55420E-01 .18063E-01	REAL 27257E-02 23480E-03 22730E-02 14230E-02 .43886E-03 25775E-03 20112E-02	IMAGINARY 62686E-03 20652E-03 88746E-03 15704E-02 12683E-02 46682E-03 67208E-03
234 567 8	REAL . 103282+01 . 106442+01 . 104242+01 . 98591E+00 . 97408E+00 . 103242+01 . 101322+01 . 944122+00	IMAG INARY .77296E-01 .94340E-01 .54953E-01 .97877E-01 .25983E+00 .55420E-01 .18063E-01 .40274E-01	REAL 27257E-02 23480E-03 22730E-02 14230E-02 .43886E-03 25775E-03 20112E-02 10625E-02	IMAGINARY 62686E-03 20652E-03 88746E-03 15704E-02 12683E-02 46682E-03 67208E-03 67208E-03
2345 6789	REAL . 103282+01 . 106442+01 . 104242+01 . 98591E+00 . 974082+00 . 103242+01 . 101322+01 . 944122+00 . 961382+00	IMAG INARY .77296E-01 .94340E-01 .54953E-01 .97877E-01 .55420E-01 .18063E-01 .40274E-01	REAL 27257E-02 23480E-03 22730E-02 .14230E-02 .43886E-03 25775E-03 20112E-02 10625E-02 11424E-02	IMAGINARY 62686E-09 20652E-09 88746E-09 15704E-02 12683E-09 46682E-09 67208E-09 20724E-02 36898E-09
2 3 4 5 6 7 8 9 10	REAL . 10328E+01 . 10644E+01 . 10424E+01 . 98591E+00 . 97408E+00 . 10324E+01 . 10132E+01 . 94412E+00 . 96138E+00 . 10370E+01	IMAGINARY .77296E-01 .94340E-01 .54953E-01 .97877E-01 .25983E+00 .55420E-01 .18063E-01 .40274E-01 .10877E+00 .69245E-01	REAL 27257E-02 23480E-03 22730E-02 .14230E-02 .43886E-03 25775E-03 20112E-02 10625E-02 11424E-02 22753E-03	IMAGINARY 62686E-03 20652E-03 88746E-03 15704E-02 12683E-03 46682E-03 67208E-03 20724E-02 36898E-03 28031E-03
2 3 4 5 6 7 8 9 10 11	REAL . 103282+01 . 106442+01 . 104242+01 . 985912+00 . 974082+00 . 103242+01 . 101322+01 . 944122+00 . 961382+00 . 103702+01 . 898232+00	IMAGINARY .7296E-01 .94340E-01 .54953E-01 .97877E-01 .25983E+00 .55420E-01 .18063E-01 .40274E-01 .69245E-01 .99212E-01	REAL 27257E-02 23480E-03 22730E-02 .14230E-02 .43886E-03 25775E-03 20112E-02 10625E-02 11424E-62 22753E-03 19335E-02	IMAGINARY 62686E-03 20652E-03 83746E-03 15704E-02 12683E-03 46682E-03 67208E-03 20724E-02 36898E-03 28031E-03 19559E-02
2 3 4 5 6 7 8 9 10 11 12	REAL . 103282+01 . 106442+01 . 104242+01 . 98591E+00 . 974082+00 . 103242+01 . 101322+01 . 944122+00 . 961382+00 . 103702+01 . 898232+00 . 967052+00	IMAGINARY .77296E-01 .94340E-01 .54953E-01 .97877E-01 .25983E+00 .55420E-01 .18063E-01 .40274E-01 .69245E-01 99212E-01 74064E-01	REAL 27257E-02 23480E-03 22730E-02 14230E-02 .43886E-03 25775E-08 20112E-02 10625E-02 11424E-02 22758E-03 19335E-02 56566E-03	IMAGINARY 62686E-03 20652E-03 83746E-03 15704E-02 12683E-03 46682E-03 67208E-03 20724E-02 36898E-03 28031E-03 19559E-02 14949E-03
2 3 4 5 6 7 8 9 10 11 12 13	REAL . 103282+01 . 106442+01 . 104242+01 . 98591E+00 . 974082+00 . 103242+01 . 101322+01 . 944122+00 . 961382+00 . 103702+01 . 898232+00 . 967052+00 . 104632+01	IMAGINARY .77296E-01 .94340E-01 .54953E-01 .97877E-01 .25983E+00 .55420E-01 .18063E-01 .40274E-01 .69245E-01 99212E-01 74064E-01 .15720E-01	REAL 27257E-02 23480E-03 22730E-02 .14230E-02 .43886E-03 25775E-03 20112E-02 10625E-02 11424E-02 22758E-03 19335E-02 56566E-03 44690E-04	IMAGINARY 62686E-03 20652E-03 88746E-03 15704E-02 12683E-03 46682E-03 26724E-02 36898E-03 28031E-03 19559E-02 14949E-03 31281E-04
2 3 4 5 6 7 8 9 10 11 12 13 14	REAL . 10322E+01 . 10644E+01 . 10424E+01 . 92591E+00 . 97408E+00 . 10324E+01 . 10132E+01 . 94412E+00 . 96132E+00 . 10370E+01 . 89822E+00 . 10463E+01 . 93882E+00	IMAGINARY .77296E-01 .94340E-01 .54953E-01 .97877E-01 .25983E+00 .55420E-01 .18063E-01 .40274E-01 .40274E-01 .0877E+00 .69245E-01 .99212E-01 .15720E-01 .15720E-01	REAL 27257E-02 23480E-03 22730E-02 .43886E-03 25775E-03 20112E-02 10625E-02 11424E-02 2753E-03 19335E-02 56566E-03 44690E-04 15560E-02	IMAGINARY 62686E-03 20652E-03 88746E-03 12683E-02 46682E-03 67208E-03 20724E-02 36898E-03 28031E-03 19559E-02 14949E-03 31281E-04 11553E-02
2 3 4 5 6 7 8 9 10 11 12 13 14 15	REAL . 10322E+01 . 10644E+01 . 10424E+01 . 98591E+00 . 97408E+00 . 10324E+01 . 10132E+01 . 94412E+00 . 96133E+00 . 10370E+01 . 89823E+00 . 10463E+01 . 93832E+00 . 92725E+00	IMAGINARY .77296E-01 .94340E-01 .54953E-01 .97877E-01 .25983E+00 .55420E-01 .18063E-01 .40274E-01 .40274E-01 .69245E-01 .99212E-01 .15720E-01 .15720E-01 .10713E+09 .97015E-01	REAL 27257E-02 23480E-03 22730E-02 14230E-02 .43885E-03 25775E-03 20112E-02 10625E-02 11424E-02 22753E-03 19335E-02 56566E-03 44690E-04 15560E-02 26157E-02	IMAGINARY 62686E-03 20652E-03 88746E-03 12683E-02 46682E-03 67208E-03 20724E-02 36898E-03 28931E-04 19559E-02 14949E-03 31281E-04 11553E-02 12809E-02
2 3 4 5 6 7 8 9 10 11 12 13 14 15 16	REAL . 10322E+01 . 10644E+01 . 10424E+01 . 98591E+00 . 97408E+00 . 10324E+01 . 10132E+01 . 94412E+00 . 96138E+00 . 10370E+01 . 99823E+00 . 96705E+00 . 10463E+01 . 93882E+00 . 92725E+00 . 10353E+01	IMAGINARY .77296E-01 .94340E-01 .54953E-01 .25933E-00 .55420E-01 .18063E-01 .40274E-01 .40274E-01 .69245E-01 .99212E-01 .74064E-01 .15720E-01 .10713E+00 .97015E-01	REAL 27257E-02 23480E-03 22730E-02 14230E-02 .43886E-03 25775E-03 20112E-02 10625E-02 11424E-02 2753E-03 19335E-02 56566E-03 44690E-04 15560E-02 26157E-02 12217E-04	IMAGINARY 62686E-03 20652E-03 88746E-03 15704E-02 12683E-02 46682E-03 20724E-02 36898E-03 20724E-02 36898E-03 28031E-03 19559E-02 14949E-03 31281E-04 11553E-02 12809E-02 48982E-07
2 3 4 5 6 7 8 9 10 11 12 13 14 5 16 17	REAL 103282+01 106442+01 104242+01 985912+00 974082+00 103242+01 101322+01 944122+00 961382+00 103702+01 898232+00 104632+01 938322+00 927252+00 103532+01 931772+00	IMAGINARY .77296E-01 .94340E-01 .54953E-01 .97877E-01 .25983E+00 .55420E-01 .18063E-01 .40274E-01 .40274E-01 .69245E-01 .69245E-01 .15720E-01 .15720E-01 .10713E+09 .97015E-01 .27814E-01	REAL 27257E-02 23480E-03 22730E-02 .14230E-02 .43886E-03 25775E-03 20112E-02 10625E-02 11424E-62 22753E-03 19335E-02 56566E-03 44690E-04 15560E-02 26157E-02 12217E-04 16156E-02	IMAGINARY 62686E-03 20652E-03 88746E-03 15704E-02 12683E-02 46682E-03 20724E-02 36896E-03 20724E-02 36896E-03 19559E-02 14949E-03 11555E-02 12809E-02 48982E-07 29408E-02
2 3 4 5 6 7 8 9 10 11 12 13 14 5 16 17 18	REAL . 103282+01 . 10644E+01 . 10424E+01 . 98591E+00 . 97408E+00 . 10324E+01 . 10132E+01 . 94412E+00 . 96138E+00 . 10370E+01 . 93832E+00 . 10463E+01 . 93832E+00 . 10353E+01 . 93177E+00 . 10397E+01	IMAGINARY .77296E-01 .94340E-01 .54953E-01 .97877E-01 .25983E+00 .55420E-01 .18063E-01 .40274E-01 .40274E-01 .69245E-01 .99212E-01 .15720E-01 .15720E-01 .10713E+00 .97015E-01 .27814E-01 .27814E-01 .25282E+00	REAL 27257E-02 23480E-03 22730E-02 14230E-02 .43886E-03 25775E-03 20112E-02 10625E-02 11424E-62 22753E-03 19335E-02 56566E-03 44690E-04 15560E-02 26157E-02 12217E-04 16156E-02 12538E-03	IMAGINARY 62686E-03 20652E-03 85746E-03 15704E-02 12683E-03 20724E-02 46682E-03 20724E-02 36898E-03 2931E-03 19559E-02 14949E-03 31281E-04 11553E-02 12809E-02 48982E-07 29408E-02 74664E-03
2 3 4 5 6 7 8 9 10 11 12 13 14 5 6 7 13 14 5 17 18 19	REAL . 103282+01 . 106442+01 . 104242+01 . 98591E+00 . 974082+00 . 103242+01 . 101322+01 . 944122+00 . 961382+00 . 96705E+00 . 10463E+01 . 93822E+00 . 92735E+00 . 10353E+01 . 93177E+00 . 10397E+01 . 10455E+01	IMAGINARY .77296E-01 .94340E-01 .54953E-01 .97877E-01 .25983E+00 .55420E-01 .18063E-01 .40274E-01 .10877E+00 .69245E-01 .99212E-01 .15720E-01 .15720E-01 .15720E-01 .97015E-01 .27814E-01 .27814E-01 .25282E+00 .96581E-01	REAL 27257E-02 23480E-03 22730E-02 .43886E-03 25775E-08 20112E-02 10625E-02 11424E-02 22758E-03 2935E-03 44690E-04 15560E-02 26157E-02 12217E-04 16156E-02 12538E-03 93486E-04	IMAGINARY 62686E-03 20652E-03 88746E-03 15704E-02 12683E-03 67208E-03 20724E-02 36898E-03 28031E-03 28031E-03 19559E-02 14949E-03 31281E-04 11553E-02 48982E-07 29408E-03 29408E-03 59968E-03
2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 7 18 19 20	REAL 103282+01 106442+01 104242+01 98591E+00 974082+00 10324E+01 10132E+01 94412E+00 96138E+00 10370E+01 89823E+00 96705E+00 10463E+01 93882E+00 92725E+00 10353E+01 93177E+00 10397E+01 10455E+01 97058E+00	IMAGINARY .77296E-01 .94340E-01 .54953E-01 .97877E-01 .25983E+00 .55420E-01 .18063E-01 .40274E-01 .40274E-01 .69245E-01 .99212E-01 .74064E-01 .15720E-01 .15720E-01 .10713E+00 .97015E-01 .25282E+00 .96581E-01 .24080E+00	REAL 27257E-02 23480E-03 22730E-02 .43886E-03 25775E-03 20112E-02 10625E-02 11424E-02 22758E-03 2935E-02 56566E-03 44690E-04 15560E-02 12217E-04 16156E-02 12538E-03 93426E-04 70239E-04	IMAGINARY 62686E-03 20652E-03 88746E-03 15704E-02 12683E-03 67208E-03 20724E-02 36898E-03 28031E-03 28031E-03 19559E-02 14949E-03 31281E-04 11553E-02 12809E-02 48982E-07 29408E-02 74664E-03 59968E-03 17027E-02
2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 8 9 20 21	REAL . 103282+01 . 106442+01 . 104242+01 . 92591E+00 . 974082+00 . 103242+01 . 101322+01 . 944122+00 . 961382+00 . 967052+00 . 104532+00 . 927252+00 . 103532+01 . 931772+00 . 103532+01 . 931772+01 . 104552+01 . 970582+00 . 993842+00	IMAGINARY .77296E-01 .94340E-01 .54953E-01 .97877E-01 .25983E+00 .55420E-01 .18063E-01 .40274E-01 .40274E-01 .99212E-01 .74064E-01 .15720E-01 .10713E+09 .97015E-01 .27814E-01 .27814E-01 .25282E+00 .96581E-01 .24080E+00 .22952E+00	REAL 27257E-02 23480E-03 22730E-02 .43886E-03 25775E-03 20112E-02 10625E-02 11424E-02 22758E-03 19335E-02 56566E-03 44690E-04 15560E-02 26157E-02 12217E-04 16156E-02 12538E-03 93426E-04 70239E-04 12532E-03	IMAGINARY 62686E-03 20652E-03 88746E-03 15704E-02 12683E-03 67208E-03 20724E-02 36898E-03 28031E-03 19559E-02 14949E-03 31281E-04 11553E-02 12809E-02 48982E-07 29468E-02 74664E-03 59968E-03 17027E-02 19574E-02
2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 9 20 22 22	REAL . 103282+01 . 106442+01 . 104242+01 . 92591E+00 . 974082+00 . 103242+01 . 101322+01 . 944122+00 . 961382+00 . 103702+01 . 998232+00 . 104632+01 . 938222+00 . 103532+01 . 931772+00 . 103532+01 . 931772+00 . 103532+01 . 931772+00 . 103532+01 . 931772+00 . 103532+01 . 931772+00 . 103532+01 . 970582+00 . 993342+00 . 885602+00	IMAG I NARY .77296E-01 .94340E-01 .54953E-01 .97877E-01 .25983E+00 .55420E-01 .40274E-01 .40274E-01 .40274E-01 .99212E-01 .99212E-01 .15720E-01 .15720E-01 .15720E-01 .27814E-01 .27814E-01 .25282E+00 .96551E-01 .24080E+00 .22952E+00 .22952E+00	REAL 27257E-02 23480E-03 22730E-02 14230E-02 .43886E-03 25775E-03 20112E-02 10625E-02 11424E-02 22753E-03 19335E-02 56566E-03 44690E-04 15560E-02 26157E-02 12217E-04 16156E-02 12538E-03 92486E-04 70239E-04 12532E-03 19545E-02	IMAGINARY 62686E-03 20652E-03 88746E-03 12683E-02 12683E-03 67208E-03 20724E-02 36898E-03 2893E-03 19559E-02 14949E-03 31281E-04 11553E-02 12809E-02 48982E-07 29408E-02 74664E-03 59968E-03 59968E-03 59968E-03 59968E-03 59968E-03 59968E-03 59968E-03 59968E-03 17027E-02 19574E-02 35954E-02
2 3 4 5 6 7 8 9 10 11 12 14 15 16 17 18 19 20 21	REAL . 103282+01 . 106442+01 . 104242+01 . 92591E+00 . 974082+00 . 103242+01 . 101322+01 . 944122+00 . 961382+00 . 967052+00 . 104532+00 . 927252+00 . 103532+01 . 931772+00 . 103532+01 . 931772+01 . 104552+01 . 970582+00 . 993842+00	IMAGINARY .77296E-01 .94340E-01 .54953E-01 .97877E-01 .25983E+00 .55420E-01 .18063E-01 .40274E-01 .40274E-01 .99212E-01 .74064E-01 .15720E-01 .10713E+09 .97015E-01 .27814E-01 .27814E-01 .25282E+00 .96581E-01 .24080E+00 .22952E+00	REAL 27257E-02 23480E-03 22730E-02 .43886E-03 25775E-03 20112E-02 10625E-02 11424E-02 22758E-03 19335E-02 56566E-03 44690E-04 15560E-02 26157E-02 12217E-04 16156E-02 12538E-03 93426E-04 70239E-04 12532E-03	IMAGINARY 62686E-03 20652E-03 83746E-03 15704E-02 12683E-02 46682E-03 20724E-02 46682E-03 20724E-02 36898E-03 28031E-03 19559E-02 14949E-03 31281E-04 11558E-02 12809E-02 48982E-07 29408E-02 74664E-03 59968E-03 17027E-02 19574E-02 35954E-02 .40871E-06 21570E-02

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BUS CURI	RENT(AI)	MISMATO	HES(DS)
REAL	IMAGINARY	REAL	IMAGINARY
$\begin{array}{c}80487E+00\\34891E-05\\55390E+00\\50304E+00\\44023E+00\\44023E+00\\39150E+00\\10999E+01\\24588E+09\\66371E+00\\99658E+00\\45596E+00\\45596E+00\\45261E+00\\47431E-07\\ .15019E-06\\ .12082E-03\\12496E+01\\32497E-01\\ .24543E+01\\ .13915E+01\\ .29053E+01\\ .10443E+01\\ \end{array}$	$\begin{array}{c} .14310E+00\\ .71921E-06\\ .13399E+00\\ .13399E+00\\ .16306E+00\\ .245031E-02\\ .75843E-01\\ .24687E+00\\ .53061E-01\\ .29352E+00\\ .1933E+00\\ .1933E+00\\ .15722E+00\\ .15722E+00\\ .15722E+00\\ .3165E-03\\ .34665E+00\\ .97571E-02\\ .93193E+00\\ .50496E-01\\ .82196E-01\\ .27077E+00\\ .\end{array}$	$\begin{array}{c} .17268E-03\\ .36464E-05\\ .60395E-05\\ -38624E-05\\ -376313E-05\\ .67263E-07\\ -25423E-07\\ .45574E-07\\ .10579E-05\\ -15487E-05\\ .16788E-04\\ .55514E-07\\ .40964E-07\\18844E-06\\89566E-04\\11575E-10\\ .86592E-05\\53801E-05\\53801E-05\\72697E-04\\16060E-04\\ \end{array}$	30514E-05 10883E-05 28963E-05 .24092E-05 .29550E-05 51076E-06 .15432E-05 .18621E-05 .40760E-05 .59871E-06 .10365E-05 .43878E-06 .21536E-07 .40314E-06 .22654E-03 .41517E-08 .47182E-05 22616E-06 16469E-05 17287E-05 72644E-05
36949E-01 57460E-01 .64919E+00	.11541E+00. .16208E+00. .63623E-01.	.11565E-10 31917E-04 .19057E-05	78160E-13 22784E-05 14176E-06
	REAL $\& 0487E+00$ $34891E-05$ $55390E+00$ $50304E+00$ $44023E+00$ $39150E+00$ $10999E+01$ $24588E+00$ $66371E+00$ $45596E+00$ $43261E+00$ $47431E-07$. $15019E-06$. $12082E-03$ $12496E+01$ $32497E-01$. $24543E+01$. $13915E+01$. $29053E+01$. $10443E+01$ $66624E+00$ $36949E-01$ $57460E-01$	$\begin{array}{cccccccccccccccccccccccccccccccccccc$	REALIMAGINARYREAL $\& 0487E + 00$.14310E + 00.1.17268E - 03 $34891E - 05$.71321E - 06.1.36464E - 05 $55390E + 00$.13329E + 00.1.60395E - 05 $55390E + 00$.13329E + 00.1.60395E - 05 $55390E + 00$.16306E + 00.1.386624E - 05 $44023E + 00$ $45031E - 02.1$.77313E - 05 $39150E + 00$.75843E - 01.1.67263E - 07 $10999E + 01$.24687E + 00.1.45574E - 07 $66371E + 00$.29352E + 00.1.10579E - 05 $99658E + 00$.19233E + 00.1.10579E - 05 $45596E + 00$.20622E + 00.1.1678BE - 04 $43261E + 00$.15722E + 00.1.157514E - 07 $47431E - 07$.21343E - 07.1.49964E - 07.15019E - 06.44655E - 06.1.18984E - 06.12082E - 0323165E - 03.1.89566E - 04.12082E - 0323165E - 03.1.89566E - 04.12092E - 0323165E - 01.1.53301E - 05.24543E + 01.93193E + 00.1.31902E - 05.24543E + 01.93193E + 00.1.31902E - 05.29053E + 01.52196E - 01.1.72697E - 04.10443E + 01.27077E + 00.1.11565E - 10.36949E - 01.11541E + 00.1.11565E - 10.57460E - 01.16208E + 00.1.31917E - 04

THE BUS CURRENT IS ZERO FOR THE FOLLOWING BUSES

13 14

BUS NO.

VOLTAGE VOLTAGE CORRECTION VECTOR

	REAL	IMAGINARY	REAL	IMAGINARY
1	.10328E+01	.77289E-01	86757E-05	65399E-05
2	.10644E+01	.94339E-01.	26058E-06	38691E-06
3	.10424E+01	.54945E-01	74236E-05	76573E-05
4	.98590E+00	.97867E-01	49306E-05	98786E-05
5	.97408E+00	.25981E+00	.21858E-05	12744E-04
6	.10324E+01	.55418E-01	66120E-06	28475E-05
7	.10132E+01	.18057E-01	68443E-05	58559E-05
8	.94412E+00	.40265E-01	29788E-05	95887E-05
9	.96137E+00	10877E+00.	26970E-05	12666E-05
10	.10370E+01	.69245E-01	34396E-06	47334E-06
11	.89822E+00	99219E-01	59829E-05	65459E-05
12	.96704E+00	74065E-01	12836E-05	56266E-06
13	.10463E+01	.15720E-01	36344E-07	66894E-07
14	.93882E+00	10713E+00.	43722E-05	38159E-05
15	.92734E+00	.97007E-01	84887E-05	77093E-05
16	.10353E+01	47118E-01	14589E-09	53359E-13
17	.93176E+00	.27204E-01	57954E-05	10182E-04
18	.10397E+01	.25282E+00	10729E-06	51593E-06
19	.10455E+01	.96578E-01	.12499E-06	31457E-05
20	.97058E+00	.24078E+00	.15666E-05	11865E-04
21	.99384E+00	.22951E+00.	.10420E-05	12194E-04
22	.88559E+00	88488E-01	90720E-05	10691E-04

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24 .99895E+00 .45841E-0117549E-05 /1	1455E-04
	1600E-04

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BUS NO.	BUS CURRENT(AI)		MISMATCHES(DS)	
	REAL	IMAGINARY	REAL	IMACINARY
1	80470E+00	.14312E+00.	.15430E-08	94919E-09
2	71054E-12	.13642E-11	.62758E-12	15191E-11
3	55389E+00	.13389E+00	.38366E-10	31664E-11
4	50305E+00	.16307E+00	.49068E-10	.93181E-10
5	44024E+00	44966E-02	.10151E-09	.97775E-10
6	39150E+00	.75843E-01	.17799E-11	.24469E-12
7	11000E+01	.24688E+00	43983E-11	.11500E-09
8	24588E+00	.53065E-01	.43166E-10	.17438E-10
9	66371E+00	.29353E+00	.82636E-11	.15558E-10
10	99658E+00	.19383E+00	22737E-12	.47784E-12
11	45594E+00	.20623E+00	.13079E-09	91740E-10
12	43261E+00	.15722E+00	.58620E-13	.14264E-11
13	.71054E-14	.45475E-12	14583E-13	47570E-12
14	10658E-13	.28422E-13	.13051E-13	25541E-15
15	48766E-09	31759E-08.	.76031E-09	.28978E-08
16	12496E+01	.34665E+00	0.	74607E-18
17	32488E-01	.97629E-02	.11084E-09	58604E-10
18	.24543E+01	.98193E+00	79581E-12	.14779E-11
19	.13915E+01	50531E-01	10824E-09	47038E-11
20	.29053E+01	82384E-01	21803E-08	70507E-10
21	.10443E+01	.27073E+00	46760E-09	72156E-10
22	60627E+00	.26096E+00	.32934E-10	74806E-10
23	36949E-01	.11541E+00	0.	0.
24	57488E-01	.16204E+00	50388E-09	64553E-10
25	.64920E+00	.63609E-01	17875E-09	76149E-10

THE BUS CURRENT IS ZERO FOR THE FOLLOWING BUSES

2 13 14 15

BUS NO.	VOLTAGE		VOLTAGE CORRECTION VECTOR	
	REAL	IMAGINARY	REAL	IMAGINARY
$ \begin{array}{r} 1 \\ 2 \\ 3 \\ 4 \\ 5 \\ 6 \\ 7 \\ 9 \\ 10 \\ 12 \\ 12 \\ 14 \\ 15 \\ 16 \\ 17 \\ \end{array} $. 10328E+01 . 10644E+01 . 10424E+01 . 98590E+00 . 97408E+00 . 10324E+01 . 10132E+01 . 94412E+00 . 96137E+00 . 10370E+01 . 89822E+00 . 96704E+01 . 93882E+00 . 92734E+00 . 10353E+01 . 93176E+00	.77289E-01 .94339E-01 .54945E-01 .25981E+00 .55418E-01 .40265E-01 -10877E+00 .69245E-01 99219E-01 74065E-01 .15720E-01 10713E+00 .97007E-01 47118E-01 .27304E-01	$\begin{array}{c}11111E-09\\11839E-12\\10363E-09\\91219E-10\\29597E-10\\29597E-10\\11046E-10\\93329E-10\\46850E-10\\20826E-10\\20826E-10\\72734E-12\\50899E-10\\98863E-11\\ .56674E-13\\35585E-10\\11572E-09\\ .26212E-14\\55045E-10\\ \end{array}$	83945E-10 42640E-11 10389E-09 13754E-09 21064E-09 37867E-10 73284E-10 13962E-09 18307E-10 49967E-11 81280E-10 81637E-11 69793E-12 43725E-10 32762E-17 32762E-17 12273E-09
18 19 20 21 22	. 10397E+01 . 10455E+01 .97058E+00 .99384E+00 .88559E+00	.25282E+00 .96578E-01 .24078E+09 .22951E+09 88488E-01	.24848E-11 78912E-12 22368E-10 27511E-10 84577E-10	41402E-11 42597E-10 20266E-09 20154E-09 94063E-10

23 24 25	.99965E+00 .99895E+00 .93592E+00	-:26551E-01 .45841E-01 .35222E+00	.72607E-18 56971E-10	.27336E-16
25	.93592E+00	.35222E+00.	.15733E-11	22038E-0

.29353E+00

.19383E+00.

.20623E+00.

.15722E+00

.45475E-12.

.28422E-12.

.34665E+00.

.97629E-02.

.98193E+00.

.27073E+00

.26096E+00.

.16204E+00.

.63609E-01.

.50781E-01

.11541E+00. :

-.50531E-01 -.82384E-01

-.14211E-13.

FINAL BUS CURRENTS AND MISMATCHES

BUS NO.	BUS CURR	ENT(AI)
	REAL	IMAGINARY
1 2	80470E+00 0.	.14312E+00. 0.
3 4	55389E+00 50305E+00	.13389E+00. .16307E+00.
5	44024E+00 39150E+00	44966E-02.
7	11000E+01	.75843E-01 .24688E+00.
8	24588E+00	.53065E-01

-.66371E+00

-.99658E+00

-.45594E+00

-.43261E+00

-.71054E-14

.56843E-13 -.12496E+01

-.32488E-01

.24543E+01

.13915E+01

.29053E+01

.10443E+01

-.60627E+00

-.36949E-01

-.57488E-01

.64920E+00

.13209E+00

.35527E-14

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12

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 $\mathbf{20}$

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 $\mathbf{23}$

24

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 $\mathbf{26}$

REAL	IMAGINARY
.11369E-12 0.	.98854E-12 0.
71054E-14	.39080E-13
.35527E-14 .88818E-14	.43521E-13
.00010E-14 .58620E-13	.001/00 10
14211E-13	.90150E-13
19211E-13	
.21316E-13	82157E-14 25757E-13
.28422E-13	99476E-13
.71054E-14	26645E-13
15987E-13	97700E-14
.28594E-15	47593E-12
48578E-14	.12961E-13
80284E-13	25805E-12
.71054E-14	74607E-13
.23315E-14	38858E-14
93792E-12	.42633E-13
.35527E-13	0.
42633E-13	×0.
.71054E-14	0.
0.	0.
88818E-15	0.
22204E-15	71054E-14
10658E-13	0.

MISMATCHES(DS)

LOAD FLOW SOLUTION OF 26-BUS POWER SYSTEM LOAD BUSES V(> 2) = 1.06437 + J .09434 V(1) = 1.03276 + J .07729V(4) = .98590 + J .09787: V(3) = 1.04236 + J .05495V(216) = 1.03244 + J .05542 V(5) = .97408 + J .25981 V(7) = 1.01318 + J .01806V(-8) = .94412 + J .04026V(9) = .96137 - J .10877V(<10) = 1.03697 + J .06924 V(212) = .96704 - J .07406 V(11) = .89822 - J .09922V((14) = .93882 - J.10713 V(13) = 1.04633 + J .01572 V(16) = 1.03526 - J .04712 V(15) = .92734 + J .09701V(17) = .93176 + J .02780GENERATOR BUSES V(18) = 1.03970 + J .25282 Q(18) = -.40042Q(19) = .18722V(19) = 1.04555 + J .09658V(20) = .97058 + J .24078 Q(20) = .77951V(21) = .99384 + J .22951 Q(21) = -.02939V(22) = .88559 - J .08849 Q(22) = -.17746V(23) = .99965 - J .02655 Q(23) = -.11439V(24) = .99895 + J .04584 Q(24) = -.16451Q(25) = .16913 V(25) = .93592 + J .35222 . SLACK BUS P(26) = .13341Q(26) = -.05129

TOTAL NUMBER OF ITERATIONS TAKEN BY XLF1 = 5 TOTAL EXECUTION TIME TAKEN BY XLF1 = 4.170 SECONDS

Example 3

Here we perform a contingency analysis of the 26-bus power system. For illustration purposes, the outage of lines (2,13) and (6,7) is considered.

The package XLF1 can handle only one line outage at a time without disturbing the line data file. The listing of the appropriate main program is found on pages 38-39. The data files TL26 and BUS26 reported on page 28 are used as the input data for this program. Other input data, i.e., information about line outages, is given after the main program on page 39.

The results of contingency analysis are reported on page 40.

С		MAIN(INPUT,OUTPUT,TL26,BUS26,TAPE5=BUS26,TAPE6=OUTPUT, 26,TAPE2=INPUT)	MN	20 20
L	COMPLEX	V(26), CV(26), AI(26), S(25), DS(25), AK(25, 25), BGK(8, 25), ZC, 1	MN MN	30
~	1VO(25) DIMENSIO	N KA(25), IG(8), IZ(25), IZB(6)	MN MN	50 60
C C	THIS IS	THE MAIN PROGRAM FOR CONTINGENCY ANALYSIS IN EXAMPLE 3	MN MN	70 80
C C		E PACKAGE XLF1. EXAMPLE 3 CONSIDERS THE 26-BUS POWER	MN	90 100
C C	SYSTEM		MN MN	110 120
C C	A DESCRI	PTION OF ALL THE NEW VARIABLES USED IN THE MAIN	MN MN	
č		NOV FOLLOWS	MN MN	150
C			MN	170
C C	*******	**************************************	*MN MN	189 190
C C	DDLT4	CHANGE IN THE ARGUMENT OF THE VOLTAGE V(4) DUE TO	MN MN	200 210
C C	DDLT20	CHANGE IN THE ARGUMENT OF THE VOLTAGE V(20) DUE TO	MN MN	220 230
C		THE LINE OUTAGE	MIN	240
C C	DLT4	DELTA(4), ARGUMENT OF VOLTAGE V(4) AT THE LOAD FLOW	MN MN	250 260
C		SOLUTION OF THE ORIGINAL POWER SYSTEM	MN	270
C C	DLT20	DELTA(20), ARGUMENT OF VOLTAGE V(20) AT THE LOAD	MN MN	280 290
C		FLOW SOLUTION OF THE ORIGINAL POWER SYSTEM	MN	300
C C	D020	CHANGE IN THE REACTIVE POWER OF BUS 20 DUE TO THE	MN MN	310 320 -
C	0020	LINE OUTAGE	MN	330 330
C C	DVG	CHANGE IN THE MODULUS OF THE VOLTAGE V(6) DUE TO THE	MN	340
C	DVO	LINE OUTAGE	MN MN	350 360
C	000	DEACTIVE DOWED CHIDI LED BY DICLOG DEDODE A LINE COMAGE	MN	370
C C	Q20	REACTIVE POWER SUPPLIED BY BUS 20 BEFORE A LINE OUTAGE	PIN MN	380 390
C	VG	MODULUS OF THE VOLTAGE V(6)	MN	400
C C	*****	***************************************	MN ×MN	410
C			MN	430
C C	READING (DF THE BUS DATA FROM TAPE 5	MN MN	440 450
		60) NB, NGB, ITMAX, ICHTL, IWRITE	MN	460
	READ (5, N=NB-1		MN MN	470 480
	DO 10 I=		M	490
10	READ (5,8 CONTINUE	B0) S(I), V(I), KA(I)	MN MN	$\begin{array}{c} 500 \\ 510 \end{array}$
	READ (5,9	90) V(NB)	MN	520
С	IWRITE=2		MIN MIN	530 540
C	SOLUTION	OF THE LOAD FLOW PROBLEM BEFORE THE LINE OUTAGE	MN	550
С	CALL XLF	I (V, CV, AI, S, DS, AK, ECK, KA, IC, IZ, IZB, NB, N, NGB, ITMAX, TOLV,	MN MN	560 570
	1ICHTL, IA	C, JAC, ZC, SHTLC, CC, IWRITE)	MI	580
	DO 20 I= VO(I)=V(MIN MIN	590 600
20	CONTINUE		MIN	610
	V6=CABS() DLT4=ATAI	V(6)) N2(AIMAG(V(4)), REAL(V(4)))	MN MN	620 630
	Q20=-AIM	AG(CV(20)*AI(20))	MI	640
	A1=AIMAG	(V(20))	MN	650

	A2=REAL(V(20))	MN	660
	DLT20=ATAN2(A1, A2)	MN	
	ICHTL=2	MN	
	WRITE (6,100) NB	MN	
	WRITE (6, 110)	MIN	
C		MN	
C	READING OF THE DATA FOR THE LINE TO BE REMOVED	MN	
C		MN	
30	READ (2,*) IAC, JAC	MN	
	IF (EOF(2).NE.0) GO) TO 50	MN	
C		MN	
C	SOLUTION OF THE LOAD FLOW PROBLEM AFTER A LINE OUTAGE	MN	770
C		M	780
	CALL XLF1 (V, CV, AI, S, DS, AK, EGK, KA, IG, IZ, IZE, NB, N, NGB, ITMAX, TOLV,	. MN	790
	11CHTL, IAC, JAC, ZC, SHTLC, CC, IWRITE)	MN	800
C		MN	810
С	CALCULATION OF THE VARIOUS CHANCES DUE TO THE LINE OUTAGE	MN	
C		MIN	830
	DVG=CABS(V(G))-VG	MN	
	DDLT4=ATAN2(AIMAG(V(4)), REAL(V(4)))-DLT4	MN	850
	DQ20 = -AIMAG(CV(20) * AI(20)) - Q20	MN	860
	DDLT20=ATAN2(AIMAG(V(20)), REAL(V(20)))-DLT20	MI	870
	WRITE (6,129) IAC, JAC, DV6	MN	880
	WRITE (6,130) DDLT4	MN	890
	WRITE (6,140) D020	MN	900
	WRITE (6,150) DDLT29	MN	910
	DO 49 J=1,N	MIN	920
	$\mathbf{V}(\mathbf{J}) = \nabla \Phi(\mathbf{J})$	MN	930
40	CONTINUE	MIN	
	CO TO 30	MIN	
50	WRITE (6,160)	MIN	960
	STOP	PIN	970
C		MIN	980
60	FORMAT (1015)	MN	
70	FORMAT (E15.5)	IIII	1000
80	FORMAT (4F10.5, I5)	MN	1010
90	FORMAT (2F10.5)	MN	1020 -
100	FORMAT (1H1,/,5X, *CONTINGENCY RESULTS FOR STATES OF *, 12, *-BUS F	'OWMN	1030 🔅
	1ER SYSTEM*, /, 1X)		1040
110	FORMAT (1X, 59(*-*), //, 1X, * LINE OUTAGE STATE VARIABLE	MN	1050
	1 CHANGE IN STATE *, /, 46X, *VARIABLE*, //, 1X, 59(*-*), /, 1X)	$\mathbf{M}\mathbf{N}$	1060
120	FORMAT (6X, *(*, 12, *, *, 12, *) *, 14X, *V(6) *, 14X, F8.5, /)	MIN	1070
130	FORMAT (27X, *DELTA(4) *, 10X, F8.5, /)	MN	1080
140	FORMAT (27X, *Q(20) *, 13X, F8.5, /)	MN	1090
150	FORMAT (27K, *DELTA(20) *, 9K, F3.5, /)		1100
160	FORMAT (1X, 59(*-*))		1110
	END	MN	1120-
Inpu	t de la construcción de la constru		
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2,13 6,7

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LINE OUTAGE	STATE VARIABLE	CHANGE IN STATE VARIABLE	
(2,13)	V(6)	00027	
	DELTA(4)	.06535	
	Q(20)	.01739	÷
	DELTA(20)	.06890	
(6,7)	V(6)	.00047	
	DELTA(4)	03055	
	Q(20)	.06165	
	DELTA(20)	02989	

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Example 4

In this example, we determine by perturbation the sensitivities of $|V_6|$, δ_4 , Q_{20} and δ_{20} in the 26-bus power system with respect to the line conductances and susceptances of the lines (1,3), (1,4), (2,13) and (6,7).

The listing of the main program is given on pages 42-44. The data files TL26 and BUS26 along with line data of lines (1,3), (1,4), (2,13) and (6,7) are used as input to this program. The extra input data is reported on page 44.

The output of the program is given on pages 45-46. The formula (1) is employed for determining sensitivities. In this program, the value of Δt is 0.01. The sensitivities thus obtained by this program are comparable with those obtained by the exact method [3].

	PROGRAM MAIN(INPUT, OUTPUT, TL26, BUS26, TAPE5=BUS26, TAPE6=OUTPUT, 1TAPE3=TL26, TAPE2=INPUT)	MIN MIN	10 20
С	COMPLEX V(26), CV(26), AI(26), S(25), DS(25), AK(25, 25), BGK(8, 25), ZC,		30 40
_	1VO(25), CPX DIMENSION KA(25), IG(8), IZ(25), IZB(6)	MN MN	50 60
C C C	THIS IS THE MAIN PROCRAM FOR DETERMINING THE SENSITIVITIES OF	MN MN MN	70 30 90
Č C	THE MODULUS OF V(6), DELTA(4), Q(20), DELTA(20) W.R.T. THE LINE	MN MN	100 110
C C		MN MN	120 130
C C	(2,13) AND (6,7) USING THE PACKAGE XLF1 ALONG WITH PARAMETER	MN MN	140 150
C C	PERTURBATION	MN MN MN	160 170 180
C C C	A DESCRIPTION OF ALL THE NEW VARIABLES USED IN THE MAIN	MN MN MN	190
C C	**************************************	MN	210 220
C	NS TOTAL NUMBER OF THE LINE CONDUCTANCES (OR SUSCEPTANCES) W.R.T. THEM SENSITIVITIES ARE TO BE DETERMINED	MIN MIN MIN	230 240 250
C C C	**************************************	MN	260 270
C C	DDLT4 SENSITIVITY OF DELTA(4)	MN MN	289 290
C C C	DDLT20 SENSITIVITY OF DELTA(20)	MN MN MN	300 310 320
C C	DLT4 DELTA(4), ARGUMENT OF VOLTAGE V(4) AT THE LOAD FLOW SOLUTION OF THE ORIGINAL POWER SYSTEM		330 340
C C C	DLT20 DELTA(20), ARGUMENT OF VOLTAGE V(20) AT THE LOAD FLOW SOLUTION OF THE ORIGINAL POWER SYSTEM	MN MN MN	350 360 370
C C	DQ20 SENSITIVITY OF Q(20)	MN MN MN	380 390 400
C C C	DV6 SENSITIVITY OF V(6)	MN MN	410 420
Č C	Q20 REACTIVE POWER SUPPIED BY BUS 20 BEFORE A LINE OUTAGE		430
C C	V6 MODULUS OF THE VOLTAGE V(6)	MN MN	450 460
C C	**************************************	**MN MN MN	470 480 490
C C	READING OF BUS DATA FROM TAPE 5 READ (5,120) NB, NGB, ITMAX, ICHTL, IWRITE	MN MN	500 510
	READ (5,140) TOLV N=NB-1	MN MN	520 530
10	DO 10 I=1,N READ (5,150) S(I),V(I),KA(I) () CONTINUE	MIN MIN MIN	540 550 560
	READ (5,160) V(NB) IWRITE=2	MN MN	570 589
C C C	DETERMINATION OF THE SOLUTION OF THE LOAD FLOW PROBLEM WITH THE GIVEN CONTROL VARIABLES	MN MN MN MN	590 600 610 620
C	CALL XLF1 (V, CV, AI, S, DS, AK, BCK, KA, IG, IZ, IZB, NB, N, NGB, ITMAX, TOLV, 11CHTL, IAC, JAC, ZC, SHTLC, CC, IWRITE) DO 20 I=1,N	MIN MIN MIN MIN	620 630 640 650

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	VO(I) = V(I)	ΜN	660
20	CONTINUE	MI	670
	ICHTL=1	MIN	680
C		MN	690
ē	DETERMINATION OF THE SOLUTION OF THE LOAD FLOW PROBLEM AFTER	MN	700
č	DECREASING ONE OF THE LINE PARAMETERS BY A SMALL AMOUNT H	MN	710
č		MIN	720
u	H=0.005	MN	730
	H1=0.5/H	MN	740
	NS=4	MN	750
		MN	760
	IF (K.E. 2.2) GO 10 30	MN	770
	WRITE (6, 170)	MN	789
~ ~		MN	790
30	WRITE (6,200)	MN	890
40	WRITE (6, 189)	MN	810
	DO 110 I=1,NS	MN	820
	READ (2,*) ICODE, IAC, JAC, A1, A2, A3, A4, A5	\mathbf{M}	830
	IF (ICODE.EQ.7) GO TO 50	MN	840
	ZC=CMPLX(A3,A4)	MN	850
	SHTLC=A5 3 CC=0.0	MN	860
	CO TO 60	MN	870
50	ZC=CMPLX(A2,A3)	M	880
	CC=A4	MIN	890
60	IF (K.EQ.2) GO TO 70	MN	900
	D0 120 K=1,2 IF (K.EQ.2) C0 TO 30 WRITE (6,170) C0 TO 40 WRITE (6,200) WRITE (6,180) D0 110 I=1,NS READ (2,*) ICODE, IAC, JAC, A1, A2, A3, A4, A5 IF (ICODE.EQ.7) G0 TO 50 ZC=CMPLX(A3, A4) SHTLC=A5 S CC=0.0 C0 TO 60 ZC=CMPLX(A2, A3) CC=A4 IF (K.EQ.2) G0 TO 70 CPX=1.0/ZC+H ZC=1.0/ZC+H C0 TO 80 CPX=1.0/ZC+CMPLX(0,0,H)	MII	910
	ZC=1.0/ZC-H	$\mathbf{M}\mathbf{N}$	920
	GO TO 80	MN	930
70	CPX=1.0/ZC+CMPLX(0.0,H)	MN	940
• •	ZC=1.0/ZC-CMPLX(0.0,H)	MN	950
80	ZC=1.0/ZC	MN	960
U U			970
	1 ICHTL, IAC, JAC, ZC, SHTLC, CC, IWRITE)	MN	980
			990
	V6=CABS(V(6)) $A1=AIMAG(V(4))$ $A2=REAL(V(4))$ $DLT4=ATAN2(A1, A2)$ $Q20=-AIMAG(CV(20)*AI(20))$ $A1=AIMAG(V(20))$ $A2=REAL(V(20))$ $DLT20=ATAN2(A1, A2)$		1000
	$A_{2} = BrA(V(A))$		1010
	$\mathbf{M} = \mathbf{M} + $		1020
	DD17-AIMACAI, MZ		1030
	$(20) = - \operatorname{AIIAB}(U(20) \times \operatorname{AI}(20))$		1040
	$A_{1} - ATTAC(V(20))$		
			1050
a	DLT20=ATAN2(A1,A2)		1060
C	DEPENDENT OF THE COLUMN OF THE LOAD FLOW PROPERTY ATTEMPT	PIN	1070
C	DETERMINATION OF THE SOLUTION OF THE LOAD FLOW PROBLEM AFTER INCREASING ONE OF THE LINE PARAMETERS BY A SMALL AMOUNT H	FIN	1080
C	INCREASING ONE OF THE LINE PARAMETERS BY A SMALL AMOUNT H		
C			1100
	ZC=1.0/CPX		1110
	DO 90 J=1,N		1120
	$V(\mathbf{J}) = V \Phi(\mathbf{J})$		1130
90	CONTINUE	MN	1140
	CALL MLF1 (V, CV, AI, S, DS, AK, BGK, KA, IG, IZ, IZB, NB, N, NGB, ITMAX, TOLV,	\mathbf{M}	1150
	1 ICHTL, IAC, JAC, ZC, SHTLC, CC, IWRITE)	\mathbf{M}	1160
C		MN	1170
C	DETERMINATION OF SENSITIVITIES	MN	1180
C		MN	1190
	DV6=CABS(V(6))-V6	MN	1200
	A1 = AIMAG(V(4))	\mathbf{M}	1210
	A2=REAL(V(4))	MN	1220
	DDLT4=ATAN2(A1,A2)-DLT4	MN	1230
	BQ20 = -AIMAG(CV(20) * AI(20)) - Q20	\mathbf{M}	1240
	A1=AIMAG(V(20))		1250
	A2 = REAL(V(20))		1260
	DDLT20=ATAN2(A1,A2)-DLT20		1270
	DV6=DV6*H1		1280
	DDLT4=DDLT4*H1		1290
	B020=B020*H1		1300

	DDLT20=DDLT20*H1	1310
	DO 100 J=1.N	1320
		1330
100		1340
		1350
110		1360
		1370
120		1380
		1390
C		1400
130		1410
140	FORMAT (E15.5)	
150		1430
160	FORMAT (2F10.5)	
170	FORMAT (1H1, /, 2X, *SENSITIVITIES OF V(6), DELTA(4), Q(20), DELTA(20) MN	
		1460
180	FORMAT (1X, 59(*-*), //, 21X, *TOTAL DERIVATIVES*, //, 4X, *LINE*, 4X, 48(*M)	
	1-*),//,12X,* V(6) DELTA(4) @(20) DELTA(20)*,//,1XIN	
	,,,,,,, _	1490
190	FORMAT (/, 3X, *(*, 12, *, *, 12, *) *, F9.6, 3X, F9.6, 3X, F9.6, 3X, F9.6) MN	
200	FORMAT (1H1, /, 2X, *SENSITIVITIES OF V(6), DELTA(4), Q(20), DELTA(20) MN	
		1520
210	FORMAT (/, 1X, 59(*-*))	
		1540-
		1010

Input

 $\begin{array}{c} 7,1,3,1,0.0,0.0392,.98,0.0\\ 4,1,4,1,1,0.0619,0.2401,0.0319\\ 4,2,13,1,1,0.0921,0.3569,0.0475\\ 7,1,3,1,0.0,0.0392,0.98,0.0\\ 4,1,4,1,1,0.0619,0.2401,0.0319\\ 4,2,13,1,1,0.0926,0.0707,0.3017\\ 4,6,7,1,1,0.0921,0.3569,0.0475\\ \end{array}$

SENSITIVIT		, DELTA(4), E CONDUCTAN	Q(20), DELTA(2	20) W.R.T.		
LINE	тот	AL DERIVATI	VES			
	V(6)	DELTA(4)	Q(20)	DELTA(20)	· (+)	
(1,3)	.000019	000230	002905	000230	•••••	
(1, 4)	000063	.004666	.010103	.000448		
(2,13)	.000000	000097	000020	000102		
(6,7)	.000938	.002793	.011300	.002757		

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LINE	тот	TAL DERIVATI	VES		
	V(6)	DELTA(4)	Q(20)	DELTA(20)	- ·
(1, 3)	. 000009	000017	001328	000018	
(1,4)	.000071	.004063	010808	.000296	
(2,13)	000001	.000564	.000118	.000594	- ²
(6,7)	. 000891	005164	.012125	005050	

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SENSITIVITIES OF V(6), DELTA(4), Q(20), DELTA(20) W.R.T.

Example 5

This example deals with the evaluation of the sensitivities of $|V_6|$, δ_4 , Q_{20} and δ_{20} in the 26-bus power system with respect to the active and reactive powers of load buses 1, 2, 3 and 4.

The main program is found on pages 48-50. The data files TL26 and BUS26 are used as the input data. Other input data consists of the load bus indices, namely, 1, 2, 3 and 4, with respect to whose control variables the sensitivities are to be calculated.

The results are reported on pages 51-52. The formula (1) is employed, as before, for determining sensitivities. The value of Δt is taken as 0.002. The sensitivities thus obtained by this program are comparable with those obtained by the exact method [3].

```
PROGRAM MAIN(INPUT, OUTPUT, TL25, BUS26, TAPE5=BUS26, TAPE6=OUTPUT,
                                                                      MN
                                                                           10
    1TAPE3=TL26, TAPE2= INPUT)
                                                                      MM
                                                                           20
                                                                           30
                                                                      MN
     COMPLEX V(26), CV(26), AI(26), S(25), DS(25), AK(25, 25), BGK(8, 25), ZC,
                                                                      MN
                                                                           40
                                                                      MN
                                                                           50
    1VO(25), CPX
     DIMENSION KA(25), IG(8), IZ(25), IZB(6), INDEX(4),
                                                                      MN
                                                                           60
                                                                      MN
                                                                           70
     THIS IS THE MAIN PROGRAM FOR DETERMINING THE SENSITIVITIES OF
                                                                      MIN
                                                                           80
                                                                      MIN
                                                                           90
     THE MODULUS OF V(6), DELTA(4), Q(20), DELTA(20), W.R.T. THE
                                                                      MN
                                                                          100
                                                                      MN
                                                                          110
     ACTIVE AND REACTIVE POWERS OF THE LOAD BUSES 1, 2, 3 AND 4
                                                                      MN
                                                                          120
                                                                          130
                                                                      MN
     USING THE PACKAGE XLF1 ALONG WITH PARAMETER PERTURBATION
                                                                      MM
                                                                          140
                                                                      MN
                                                                          150
     A DESCRIPTION OF ALL THE NEW VARIABLES USED IN THE MAIN
                                                                      MN
                                                                          160
                                                                      MN
                                                                          170
     PROGRAM NOW FOLLOWS
                                                                      MN
                                                                          180
                                                                          190
                                                                      MN
     200
                                                                          210
                                                                      MN
              NS DIMENSIONAL ARRAY. THE SENSITIVITIES ARE TO BE
                                                                      MN
                                                                          220
     INDEX, NS
               DETERMINED W.R.T. THE CONTROL VARIABLES OF THESE
                                                                          230
                                                                      MN
               LOAD BUSES. NS IS THE NUMBER OF THESE BUSES
                                                                      MN
                                                                          240
                                                                      MIN
                                                                          250
     260
                                                                          270
                                                                      MN
               N DIMENSIONAL ARRAY. IT IS THE BUS VOLTAGE VECTOR
                                                                          280
                                                                      MN
     VO
               AT THE OPERATING POINT
                                                                      MN
                                                                          290
                                                                          300
                                                                      MN
     310
                                                                          320
                                                                      MN
                                                                          330
     READING OF BUS DATA FROM TAPE 5
                                                                      ΡIN
                                                                      MN
                                                                          340
     READ (5, 120) NB, NGB, ITMAX, ICHTL, IWRITE
                                                                          350
                                                                      MN
                                                                      MIN
                                                                          360
     READ (5,130) TOLV
                                                                      MN
                                                                          370
     N = NB - 1
                                                                          380
                                                                      MIN
     DO 10 I=1,N
     READ (5,140) S(1),V(1),KA(1)
                                                                      TIM
                                                                          390
                                                                      MN
                                                                          400
     CONTINUE
10
     READ (5,150) V(NB)
                                                                      MN
                                                                          410
      IWRITE=2
                                                                      MN
                                                                          420
                                                                      MN
                                                                          430
     DETERMINATION OF THE SOLUTION OF THE LOAD FLOW PROBLEM WITH
                                                                      MN
                                                                          440
     THE GIVEN CONTROL VARIABLES
                                                                      MIN
                                                                          450
                                                                      MN
                                                                          460
     CALL XLF1 (V, CV, AI, S, DS, AK, BGK, KA, IG, IZ, IZB, NB, N, NGB, ITMAX, TOLV,
                                                                      ΜN
                                                                          470
     1 ICHTL, IAC, JAC, ZC, SHTLC, CC, IWRITE)
                                                                      MN
                                                                          480
                                                                      MN
                                                                          490
     DO 20 I=1,N
                                                                          500
      VO(I) = V(I)
                                                                      MIN
     CONTINUE
                                                                      MN
                                                                          510
20
                                                                      MI
                                                                          520
     DETERMINATION OF THE SOLUTION OF THE LOAD FLOW PROBLEM AFTER
                                                                      MI
                                                                          530
     DECREASING ONE OF THE BUS CONTROL VARIABLES BY A SMALL AMOUNT H
                                                                      MN
                                                                          540
                                                                      MN
                                                                          550
     H=0.001
                                                                      MIN
                                                                          560
     H1=0.5/H
                                                                      MI
                                                                          570
                                                                      MIN
                                                                          580
     NS=4
                                                                          590
     READ (2,*) (INDEX(I), I=1, NS)
                                                                      MM
                                                                      IM
                                                                          600
     DO 110 K=1,2
     IF (K.EQ.2) GO TO 30
                                                                      MN
                                                                          610
      WRITE (6,160)
                                                                      MI
                                                                          620
     GO TO 40
                                                                      ΜI
                                                                          630
     WRITE (6,190)
                                                                      MN
                                                                          640
30
                                                                      MIN
                                                                          650
40
     WRITE (6,170)
```

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C
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	DO 100 I=1,NS	MII	660	
	L= INDEX(I)	MN	670	
	IF (K.EQ.2) GO TO 50	\mathbf{M}	680	
	CPX=S(L)+H	MN	690	
	S(L)=S(L)-H	MN	700	
	CO TO 60	MIN	710	
50	CPX=S(L)+CMPLX(0.0,H)	MN	720	
	S(L) = S(L) - CMPLX(0,0,H)	MN	730	
60	CALL XLF1 (V, CV, AI, S, DS, AK, BGK, KA, IG, IZ, IZB, NB, N, NGB, ITMAX, TOLV,	MI	740	
	1 ICHTL, IAC, JAC, ZĆ, SHTLC, ĆC, IVRITE)	MN	750	
	V6=CABS(V(6))	MN	760	
	A1 = AIMAG(V(4))	MI	770	
	A2 = REAL(V(4))	\mathbf{MN}	780	
	DLT4=ATAN2(A1,A2)	MI	790	
	Q20=-AIMAG(CV(20)*AI(20))	MN	800	
	A1 = AIMAG(V(20))	MIN		
	A2=REAL(V(20))	MN	820	
	DLT20=ATAN2(A1, A2)	MIA	830	
C		MN	840	
č	DETERMINATION OF THE SOLUTION OF THE LOAD FLOW PROBLEM AFTER		850	
č	INCREASING ONE OF THE BUS CONTROL VARIABLES BY A SMALL AMOUNT H	MIN	860	
č		MN	870	
u	S(L)=CPX	MIN	880	
	BO 70 J=1.N	MN	890	
	V(J) = VO(J)	MN	900	
70	CONTINUE	MN	910	
.0	CALL XLF1 (V, CV, AI, S, DS, AK, BGX, KA, IG, IZ, IZB, NB, N, NGB, ITMAX, TOLV,	MN	920	
	1 ICHTL, IAC, JAC, ZC, SHTLC, CC, IWRITE)	MN	930	
C	TIGHTE, TAG, 5AG, 2G, DHILG, GG, THUTE)	MN	940	
	DETERMINATION OF SENSITIVITIES	MN	950	
C	DETERMINATION OF SENSITIVITIES	MN		
С	DV6=CAES(V(6))-V6	MN		
		MN		
	A1 = AIMAG(V(4))		990	
	A2=REAL(V(4)) DDLT4=ATAN2(A1,A2)-DLT4		1000	
	DQ19 = AIMAG(CV(20) * AI(20)) - Q20		1010	
	A1 = AIMAG(V(20))		1020	
	A2=REAL(V(20)) DDLT20=ATAN2(A1,A2)-DLT20		1030	
			1040	
	DV6=DV6×H1		1050	
	DDLT4=DDLT4*H1		1060	
	D020=D020*H1		1070	
	DDLT20=DDLT20*H1		1080	
	$\begin{array}{c} \text{DO } & \text{SO } J=1, \text{N} \\ \text{M} & \text{M} & \text{M} & \text{M} \\ \text{M} & \text{M} & \text{M} & \text{M} \\ \text{M} & \text{M} & \text{M} \\ \text{M} & \text{M} & \text{M} & \text{M} \\ \text{M} & \text{M} & \text{M} & \text{M} & \text{M} \\ \\ \text{M} & \text{M} & \text{M} & \text{M} & \text{M} & \text{M} \\ \text{M} & \text{M} & \text{M} & \text{M} & \text{M} & \text{M} \\ \text{M} & \text{M} & \text{M} & \text{M} & \text{M} & \text{M} & \text{M} \\ \\ \text{M} & \text{M} $		1090	
00	V(J) = VO(J)		1100	
80	CONTINUE WRITE (6,120) L.DVG, DDLT4, DQ20, DDLT20		1110	
	WALLE (0, LG9) L, DVO; DDL14, D220, DDL129		1120	
	IF (K.EQ.2) GO TO 90		1130	
	S(L) = S(L) - H		1140	
0.0			1150	
90	S(L) = S(L) - CMPLX(0.0, H)		1160	
100	CONTINUE		1170	
	WRITE (6,200)		1189	
110	CONTINUE		1190	
a	STOP		1200	
C			1210	
120	FORMAT (1015)		1220	
130	FORMAT (E15.5)		1230	
140	FORMAT (4F10.5, I5)		1240	
150	FORMAT (2F10.5)	PIN	1250	
160	FORMAT (1H1,/,2X,*SENSITIVITIES OF V(6), DELTA(4),Q(20), DELTA(20)			1. C.
	1 W.R.T.*, //, 15X, *ACTIVE POWERS OF THE LOAD BUSES*, /, 1X)		1270	÷ .
170	FORMAT (1X, 59(*-*), //, 21X, *TOTAL DERIVATIVES*, //, 4X, * BUS*, 4X, 48(
	1-*, //, 11X, * V(6) DELTA(4) Q(20) DELTA(20) *, //, 1			
	2,59(*-*))	PIN	1300	

180	FORMAT (7,5X, 12,5X, F9.6,3X, F9.6,3X, F9.6,3X, F9.6) MN	1310
190	FORMAT (1H1,/,2X,*SENSITIVITIES OF V(6), DELTA(4),Q(20), DELTA(20) MN	1320
	1 W.R.T.*, //, 14X, *REACTIVE POWERS OF THE LOAD BUSES*, /, 1X) MN	1330
200	FORMAT (/, 1X, 59(*-*)) MN	1340
	END	1350-

- .

Input

1,2,3,4

ACTIVE POWERS OF THE LOAD BUSES TOTAL DERIVATIVES BUS V(6) DELTA(4) Q(20) DELTA(20) .000416 .272876 -.125585 .267582 1 .007825 .001636 2 -.000019 .008245 .000560 .272596 -.147778 .267275 3 -.000053 .404850 -.047999 4 .290383

SENSITIVITIES OF V(6) , DELTA(4), Q(20), DELTA(20) W.R.T.

Υ.

SENSITIVITIES OF	V(6)	, DELTA(4), Q(20), DELTA(20) W.R.T	•	
REACT	IVE PO	WERS OF THE LOAD BUSES		

BUS	TO	TAL DERIVAT	IVES	
DUS	V(6)	DELTA(4)	Q(20)	DELTA(20)
1	.003612	007064	559026	007722
2	000003	.001294	.000271	.001363
3	.002894	005661	447971	006188
4	.001956	025155	303855	002045

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Example 6

In this last example, we calculate the sensitivities of $|V_6|$, δ_4 , Q_{20} and δ_{20} in the 26-bus power system with respect to the active power and modulus of voltage of the generator buses 18, 19, 20 and 21.

The main program is listed on pages 54-56. The data files TL26 and BUS26 are used as the input data. Other input data consists of the generator bus indices, namely, 18, 19, 20 and 21, with respect to whose control variables the sensitivities are to be determined.

The results are reported on pages 57-58. The formula (1) is used for determining sensitivities. The value of Δt is taken as 0.002. The sensitivities obtained by this program are comparable with those obtained by the exact method [3].

С	PROGRAM MAIN(INPUT, OUTPUT, TL26, BUS26, TAPE5=BUS26, TAPE6=OUTPUT, 1TAPE3=TL26, TAPE2=INPUT)	MN MN	10 20
ŭ	COMPLEX V(26), CV(26), AI(26), S(25), DS(25), AK(25, 25), EGK(8, 25), ZC, 1V0(25), CPX		30 40
С	DIMENSION KA(25), IG(8), IZ(25), IZB(6), INDEX(4)	MIN MIN MIN	50 60 70
C C	THIS IS THE MAIN PROGRAM FOR DETERMINING THE SENSITIVITIES OF	MN MN	80
C C	THE MODULUS OF V(6), DELTA(4), Q(20), DELTA(20), W.R.T. THE ACTIVE		
C C	POWER AND MODULUS OF VOLTAGES OF THE GENERATOR BUSES 18, 19, 20		120
C	AND 21 USING THE PACKAGE XLF1 ALONG WITH PARAMETER PERTURBATION	MN	140
C		MN	150
C	A DESCRIPTION OF ALL THE NEW VARIABLES USED IN THE MAIN	MN	160
C		MN	170
C	PROGRAM NOW FOLLOWS	MN	180
C		MN	190
C	**************************************	**MN	200
C		MN	210
C	INDEX, NS DIMENSIONAL ARRAY. THE SENSITIVITIES ARE TO BE	MN	220
C	DETERMINED W.R.T. THE CONTROL VARIABLES OF THESE	MN	230
C	CENERATOR BUSES. NS IS THE NUMBER OF THESE BUSES	MN	240
C		MN	250
C	**************************************	*MN	260
C		MN	270
C	VO N DIMENSIONAL ARRAY. IT IS THE BUS VOLTAGE VECTOR	MN	280
C	AT THE OPERATING POINT	MN	290
C	***************************************	MN	300
C		*MN	310
C	READING OF BUS DATA FROM TAPE 5	FIN	320
C		MN	330 -
C	READ (5, 120) NB, NGB, ITMAX, ICHTL, IWRITE	MIN MIN	340 350
	READ (5,130) TOLV N=NB-1 DO 10 J-1 N	MN MN	360 370
10	DO 10 I=1,N	MN	380
	READ (5,140) S(I),V(I),KA(I)	MN	390
10	CONTINUE	MIN	400
	READ (5,150) V(NB)	MIN	410
C	IWRITE=2	MN	420
C		MN	430
C	DETERMINATION OF THE SOLUTION OF THE LOAD FLOW PROBLEM WITH THE GIVEN CONTROL VARIABLES	MN	440
C		MN	450
L	CALL XLF1 (V, CV, AI, S, DS, AK, EGX, KA, IG, IZ, IZE, NB, N, NGE, ITMAX, TOLV, 1 ICHTL, IAC, JAC, ZC, SHTLC, CC, IWRITE)	MN MN	460 470
	$\begin{array}{c} 1101112, 140, 340, 20, 81112, 00, 100112 \\ \hline 0020 \ I = 1, N \\ VO(I) = V(I) \end{array}$	MN MN	480 490
20	CONTINUE	MN	500
C		MN	510
C	DETERMINATION OF THE SOLUTION OF THE LOAD FLOW PROBLEM AFTER	MN	520
C	DECREASING ONE OF THE BUS CONTROL VARIABLES BY A SMALL AMOUNT H	MN	530
Ğ	H=0.001	MIN MIN	540 550
	H1=0.5/H	MN	560
	NS=4	MN	570
	READ (2,*) (INDEX(I), I=1, NS)	MN MN MN	580 590
	IF (K.EQ.2) GO TO 30 WRITE (6,160)	MIN MIN MIN	
30	GO TO 40 WRITE (6, 190)	MN MN MN	620 630 640
40	WRITE (6, 170)	MN	650

	DO 100 I=1, NS	ΡĪΝ	660
	L = INDEX(I)	MN	670
	IF (K.EQ.2) GO TO 50	MN	680
		PIN	
	CPX=S(L)+H		690
	S(L)=S(L)-표	ΓIN	700
	CO TO 60	MN	710
50	CPX=S(L)+CMPLX(0.0,H)	MN	720
	S(L) = S(L) - CMPLX(0, 0, H)	MN	730
60	CALL XLF1 (V, CV, AI, S, DS, AK, BCK, KA, IG, IZ, IZB, NB, N, NGB, ITMAX, TOLV,		740
00	1 ICHTL, IAC, JAC, ZC, SHTLC, CC, IVRITE)	MN	750
	V6=CABS(V(6))	MN	760
	A1 = AIHAG(V(4))	MN	770
	A2=REAL(V(4))	MN	789
	DLT4=ATAN2(A1,A2)	$\mathbf{M}\mathbf{N}$	790
	Q20=-AIMAG(CV(20)*AI(20))	MN	800
	A1=AIMAG(V(20))	MN	810
	A2=REAL(V(20))	MN	820
	DLT20=ATAN2(A1,A2)	MN	830
C		MIN	
	DETERMINATION OF THE SOLUTION OF THE LOAD FLOW PROBLEM AFTER		
C		MN	
C	INCREASING ONE OF THE BUS CONTROL VARIABLES BY A SMALL AMOUNT H	MN	
C		\mathbf{MN}	870
	S(L)=CPX	MN	830
	DO $70 J = 1, N$	MN	890
	V(J) = VO(J)	MN	900
70	CONTINUE	MN	910
.0	CALL XLF1 (V, CV, AI, S, DS, AK, BCK, KA, IG, IZ, IZB, NB, N, NGE, ITMAX, TOLV,		920
a	1 ICHTL, IAC, JAC, ZC, SHTLC, CC, IWRITE)	MN	930
C		MIN	940
С	DETERMINATION OF SENSITIVITIES	ΓN	950
C		MN	960
	DVG=CAES(V(G))-VG	MN	970
	A1 = A I MAG(V(4))	MN	980
	A2=REAL(V(4))	MN	
	DDLT4=ATAN2(A1,A2)-DLT4		1000
	DQ20=-AIMAG(CV(20)*AI(20))-Q20		
			1010
	A1=AIMAG(V(20))		1020
	A2=REAL(V(20))		1030
	DDLT20=ATAN2(A1,A2)-DLT20	MN	1040
	DVG=DVG*H1	\mathbf{M}	1050
	DDLT4=DDLT4*H1	MIN	1060
	B029=B020*H1	MN	1070
	DDLT20=DDLT20×H1		1080
	DO SO JEI, N		1090
	V(J) = VO(J)		1100
00			1110
80	CONTINUE		
	WRITE (6, 180) L, DV6, DDLT4, DQ20, DDLT20		1120
	IF (K.EQ.2) GO TO 90		1130
	S(L)=S(L)-H	MN	1140
	GO TO 100	MN	1150
90	S(L) = S(L) - CMPLX(0.0, H)	MN	1160
100	CONTINUE		1170
200	WRITE (6,200)		1180
110	CONTINUE		1190
110	STOP		1200
C	5101		
C			1210
120	FORMAT (1015)		1220
130	FORMAT (E15.5)		1230
140	FORMAT (4F10.5, 15)	MN	1240
150	FORMAT (2F10.5)		1250
160	FORMAT (1H1, /, 2X, *SENSITIVITIES OF V(6), DELTA(4), Q(20), DELTA(20) MN	1260
	1 W.R.T.*, //, 12X, *ACTIVE POWERS OF THE GENERATOR BUSES*, /, 1X)		1270
170	FORMAT (1X, 59(*-*), //, 21X, *TOTAL DERIVATIVES*, //, 4X, * BUS*, 4X, 48(
110	$1-*), //, 11X, * V(6) \qquad DELTA(4) \qquad Q(20) \qquad DELTA(20)*, //, 1$		
	(2,59(*-*))		1300
		1111	1000

180	FORMAT (/,5X, I2,5X, F9.6,3X, F9.6,2X, F10.6,3X, F9.6)	MN	1310
190	FORMAT (1H1,/,2X,*SENSITIVITIES OF V(6), DELTA(4),Q(20), DELTA(20)	MN	1320
	1 W.R.T.*, //, 10X, *MODULUS OF VOLTAGES OF THE GENERATOR BUSES*, /, 1X)	MN	1330
200	FORMAT (/, 1X, 59(*-*))	MN	1340
	END	MIN	1250-

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Input

18, 19, 20, 21

SENSITIVITIES OF V(6), DELTA(4), Q(20), DELTA(20) W.R.T.

ACTIVE POWERS OF THE GENERATOR BUSES

517	то	TAL DERIVAT	IVES		
BUS	V(6)	DELTA(4)	Q(20)	DELTA(20)	_
18	000918	.007196		.007583	
19	001371	.081957	004018	.080415	
20	000697	.276179	.075446	.307281	
21	000689	.281369	.058835	.296480	

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SENSITIVITIES OF V(6), DELTA(4), Q(20), DELTA(20) W.R.T. MODULUS OF VOLTAGES OF THE GENERATOR BUSES

	то	TAL DERIVAT	IVES	
BUS	 V(6)	DELTA(4)	Q(20)	DELTA(20)
18	000060	.024308	. 005083	.025614
19	.760458	037700	-1.987850	039805
20	.047441	186725	41.067219	354038
21	.008785	092272	-35.149911	219185

V. REFERENCES

- [1] J.W. Bandler, M.A. El-Kady and H. Gupta, "Practical complex solution of power flow equations", Faculty of Engineering, McMaster University, Hamilton, Canada, Report SOC-270, 1981.
- [2] J.W. Bandler and M.A. El-Kady, "Newton's load flow in complex mode", <u>Proc. European Conf. Circuit Theory and Design</u> (Hague, Netherlands, 1981), pp. 500-505.
- [3] J.W. Bandler and M.A. El-Kady, "Exact power network sensitivities via generalized complex branch modelling", Faculty of Engineering, McMaster University, Hamilton, Canada, Report SOC-258, 1980 (Revised 1981).

A PPENDI X

LISTING OF THE XLF1 PACKAGE

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Subroutine	Number of lines (source text)	Number of words (complied code)	Listing from page
XLF1	179	520	61
STMEQ	246	2434	63
GEN	152	1561	67
ELIM	107	1204	69
RESULT	155	1473	71
Total	839	7192	

	SUBROUTII	NE XLF1 (V, CV, AI, S, DS, AK, BCK, KA, IG, IZ, IZB, NB, N, NGB, ITMAX, TL, IAC, JAC, ZC, SHTLC, CC, IWRITE)	XLF	20	÷
С	COMPLEX DIMENSIO	V(1), CV(1), AI(1), S(1), DS(1), AK(N,1), BGK(NGB, 1), ZC N KA(1), IG(1), IZ(1), IZB(1)	XLF XLF XLF	40	
C C C	THIS IS	THE MAIN SUBROUTINE OF THE PACKAGE XLF1. IT GIVES THE	XLF XLF XLF	70	
C	SOLUTION	OF THE POWER SYSTEM LOAD FLOW PROBLEM USING THE	XLF	90	
C C C	METHOD P	UBLISHED IN REPORT SOC-270 OF THE FACULTY OF	XLF	100 110 120	
C C	ENGINEER	ING , MCMASTER UNIVERSITY , HAMILTON , CANADA	XLF	130	
Č C	A DESCRI	PTION OF ALL THE SUBROUTINES AND VARIABLES USED IN		150 160	
С	THIS SUB	ROUTINE NOW FOLLOWS	XLF	170	
C C	*****	**************************************	×LF ×XLF	180 190	
С С С С С С	ELIM	THIS SUBROUTINE SOLVES EQUATIONS OBTAINED BY STMEQ USING CONJUGATE REDUCTION COMBINED WITH FORWARD GAUSSIAN ELIMINATION PRESENTED BY BANDLER AND EL-KADY(2)	XLF XLF XLF XLF	200 210 220 230 240 250	
C C	RESULT	THIS WRITES FINAL RESULTS	XLF	260	÷
C	STHEQ	THIS SUBROUTINE PREPARES THE SYSTEM EQUATIONS TO	XLF XLF	$\frac{270}{280}$	
C C C		THE FORM OF EQUATION (38) OF SOC-270. IT DOES THIS BY CALLING SUBROUTINE GEN WHICH USES SECTION III OF SOC-270	XLF		≺`
C C		************************ INTEGER VARIABLES ************************************	KILF	310 320 330	4
C C C	IAC, JAC	(IAC, JAC) IS THE TRANSMISSION LINE WHOSE PARAMETERS HAVE BEEN ALTERED BY THE USER	XLF XLF		
	ICHTL	FILE REQUIRED BY THE USER = 1 IF PARAMETERS OF ONE LINE HAVE BEEN ALTERED = 2 IF ONE LINE IS TO BE REMOVED FOR CONTINGENCY ANALYSIS	XLF XLF XLF XLF XLF	370 380 390 400 410	
C C	IG	NGB DIMENSIONAL ARRAY. IG(I) IS THE BUS NUMBER OF THE ITH GENERATOR BUS	XLF	430 440	
C C C	IT	CURRENT ITERATION NUMBER		460	
C C	ITMAX	MAXIMUM NUMBER OF ITERATIONS AFTER WHICH THE PROGRAM WILL STOP	XLF.	470 480 490	
	IWRITE	= 1 ALSO PRINTS INTERMEDIATE RESULTS = 2 SUPRESSES ALL PRINTOUTS	XLF XLF XLF	520 530	
C C C C C	IZ	N DIMENSIONAL ARRAY IZ(I) = 0 IF /AI(I)/ CREATER THAN 1.0E-6 = I IF /AI(I)/ LESS THAN 1.0E-6	XLF XLF XLF XLF	550 560 570	
C C C C C C	IZB	AN ARRAY TO IDENTIFY THE ZERO CURRENT BUSES DURING THE ITERATION. THE DIMENSION OF IZB IS THE NUMBER OF EXPECTED ZERO CURRENT BUSES DURING THE SOLUTION PROCESS. THIS DIMENSION CAN BE EQUAL TO OR SLICHTLY LARGER THAN THE NUMBER OF DUMMY BUSES	XLF XLF XLF XLF XLF XLF	590 600 610 620 630	
C C	KA	N DIMENSIONAL ARRAY IDENTIFYING THE TYPE OF BUS	XLF XLF	640 650	

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С KA(I) = 0 IF THE ITH BUS IS A LOAD BUS XLF 660 С = 1 IF THE ITH BUS IS A GENERATOR BUS XLF 670 C C XLF 689 = NB-1 N XLF 690 CCCCC XLF 700 NBTOTAL NUMBER OF BUSES XLF 710 XLF 720 NUMBER OF GENERATOR BUSES NGB XLF 730 XLF 740 С NIZ NUMBER OF ZERO CURRENT BUSES XLF 750 CCCCCC XLF 760 XLF 780 CC ALTERED TRANSFORMER TAP IN TRANSMISSION LINE (IAC, JAC) XLF 790 XLF 800 ALTERED VALUE OF HALF SHUNT SUSCEPTANCE OF THE SHTLC XLF 810 C C C C TRANSMISSION LINE (IAC, JAC) XLF 820 XLF 830 TOLERANCE OVER BUS VOLTAGES TO THE ACCURACY THE TOLV XLF 840 FINAL SOLUTION IS REQUIRED XLF 850 CCCCC XLF 860 XLF 880 C NB DIMENSIONAL ARRAY OF BUS CURRENTS AI XLF 890 C C C XLF 900 AK N*N MATRIX WHICH IS DENOTED BY K IN EQUATION (20) OF XLF: 910 SM XLF 920 C C C C SOC-270 XLF 930 XLF 940 XLF 950 BGK NGE*N MATRIX WHICH IS DENOTED BY (K K K) XLF 960 GL GD GG XLF 970 IN EQUATION (32) OF SOC-270. THESE ARE COEFFICIENTS XLF 980 THE CONJUGATE OF THE VOLTAGES IN THE GENERATOR OF XLF 990 BUS EQUATIONS XLF1000 XLF1010 CPX, CPY, CPZ COMPLEX DUMMY VARIABLES IN ALL SUBROUTINES XLF1020 XLF1030 CV NB DIMENSIONAL ARRAY OF THE CONJUGATE OF V XLF 1040 XLF1050 N DIMENSIONAL ARRAY WHICH REPRESENTS MISMATCHES DS XLF1060 AS WELL AS CORRECTION VOLTAGES XLF1070 XLF1080 S N DIMENSIONAL ARRAY OF LOAD BUS POWERS, AND CENERATOR XLF1090 BUS ACTIVE POWER AND MODULUS OF VOLTAGE, WHICH IS XLF1100 REPRESENTED AS P +J/V / XLF1110 C G XLF1120 XLF1130 NB DIMENSIONAL ARRAY OF BUS VOLTAGES v 11 XLF1140 XLF1150 ALTERED IMPEDANCE OF TRANSMISSION LINE (IAC, JAC) ZC XLF1160 XLF1170 XLF1190 CALL SECOND (T1) XLF1200 TT=0XLF1210 XLF1220 CALCULATION OF THE VECTOR CV AND IDENTIFICATION OF GENERATOR XLF1230 BUSES XLF1240 XLF1250 N = NB - 1XLF1260 K=0 XLF1270 DO 10 I=1,N XLF1280 CV(I) = CONJG(V(I))XLF1290 IF (KA(I).NE.1) GO TO 10: XLF1300

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	K=K+1	XLF1310
10	IG(K) = I CONTINUE	XLF1320
10	CV(NB) = CONJG(V(NB))	XLF1330
20	IT = IT + 1	XLF1340
	IF (IWRITE.NE.1) GO TO 30	XLF1350 XLF1360
	WRITE (6,90) IT	XLF1370
30	CALL STMEQ (V, CV, KA, AI, IG, S, DS, AK, BGK, NGB, NB, N, IZ, NIZ, IZB, ICHTL,	XLF1380
	1 IAC, JAC, ZC, SHTLC, CC, IWRITE)	XLF1390
	CALL ELIM (AK, AI, DS, N, IZ, NIZ, IZB, IWRITE)	XLF1400
C		XLF1410
C	UPDATING OF VECTORS V AND CV	XLF1420
C		XLF 1430
	DO 40 I=1,N V(I)=V(I)+DS(I)	XLF1440
	CV(I) = CONJG(V(I))	XLF1450
40	CONTINUE	XLF1460
10	IF (IWRITE.NE.1) GO TO 60	XLF1470 XLF1480
	WRITE (6,110)	XLF1490
	WRITE (6, 120)	XLF1500
	DO 50 I=1,N	XLF1510
-	WRITE (6, 130) I, V(I), DS(I)	XLF1520
50	CONTINUE LE (LE EQ LEMAN) CO EQ CO	XLF1530
60 C	IF (IT.EQ.ITMAX) GO TO 80	XLF1540
č	CHECKING THE ACCURACY OF THE SOLUTION	XLF1550
č		XLF1560 XLF1570
	DO 70 $I=1, N$	XLF1570
	IF (CABS(DS(I)).GT.TOLV) GO TO 20	XLF1590
70	CONTINUE	XI.F1600
80	CALL RESULT (V, CV, S, DS, AI, KA, IG, NGB, NB, N, ICHTL, IAC, JAC, ZC, SHTLC,	XLF1610
	1CC, IVRITE) IF (IVRITE.EQ.2) RETURN	XLF1620
	WRITE (6,100) IT	XLF1630
	CALL SECOND (T2)	XLF1640 XLF1650
	TIME = T2 - T1	XLF1650
	WRITE (6,140) TIME	XLF1670
_	RETURN	XLF1680
C		XLF1690
90	FORMAT (1H1,* ITERATION NO. *, 12,* OF XLF1 *,/)	XLF1700
100 110	FORMAT (1H0,* TOTAL NUMBER OF ITERATIONS TAKEN BY XLF1 = *, 12, /) FORMAT (/,* BUS NO. VOLTAGE VOLTAGE COB	XLF1710
110	FORMAT (/,* BUS NO. VOLTAGE VOLTAGE CORD 1ECTION VECTOR *,/)	
120	FORMAT (* REAL IMAGINARY REAL	XLF1730
	1 IMAGINARY *,/)	XLF1740 XLF1750
130	FORMAT (1X, 15, 2X, 2E14.5, 4X, 2E14.5)	XI F1760
140	FORMAT (1X, * TOTAL EXECUTION TIME TAKEN BY XLF1 =*, F7.3, * SECONDS	XLF1770
	1%)	XLF1780
	END	XLF1790-
	SUBROUTINE STMEQ (V, CV, KA, AI, IG, S, DS, AK, BGK, NGB, NB, N, IZ, NIZ, IZB,	CEO 10
	1 ICHTL, IAC, JAC, ZC, SHTLC, CC, IWRITE)	SEQ 10 SEQ 20
C		SEQ 30
	COMPLEX V(1), CV(1), AI(1), S(1), BS(1), AK(N, 1), BGK(NGB, 1), Y, YL, CPX,	SEQ. 40
	1CPY, CPZ, ZC	SEQ 50
C	DIMENSION KA(1), IG(1), IZ(1), IZB(1)	SEQ 60
C C	THIS SUBROUTINE READS LINE DATA FROM TAPE 3 AND PREPARES THE	SEQ 70
č	THE CODRUCTINE IGADS LINE DATA FROM TAFE 3 AND PREPARES THE	SEQ 80
č	SYSTEM EQUATIONS USING SUBROUTINE GEN TO THE FORM OF EQUATION	SEQ 90 SEQ 100 -
С		SEQ 110
C	(38) OF SOC-270	SEQ 120
C		SEQ 130
С	A DESCRIPTION OF ALL THE NEW VARIABLES USED IN THIS SUBROUTINE	SEQ 140

NOW	FOLLOWS	SEQ SEQ	. 1
****	************************************	SEQ	. 1
	unnanananananananananan INTEGEN VHITHEES aaaaaaaaaaaaaaaaaaaaaaaaaaaaaaa	SEO	
IA, J	A (IA, JA) REPRESENTS A TRANSMISSION LINE CONNECTING	SEQ	
	BUSES IA AND JA	SEQ	
TCOD		OTO	
ICOD.	E CODE TO IDENTIFY DATA CARD = 4 FOR THE TRANSMISSION LINE WITHOUT TRANSFORMER	SEQ	
	= 7 FOR THE TRANSMISSION LINE WITHOUT TRANSFORMER	SEU	•
	For the newshission line having mansfolder	SEQ	
IKM	DUMMY VARIABLE	SEQ	
		SEQ	
****	**************************************		
Δ1.	IDENTIFIES THE CIRCUIT NUMBER IF ICODE = 4 IDENTIFIES THE TYPE OF TRANSFORMATION RATIO IF ICODE = 7 = 0 FOR FIX TAP	SEQ	
111	IDENTIFIES THE TYPE OF TRANSFORMATION RATIO IF	SEQ	
	ICODE = 7	SEO	
	= Ø FOR FIX TAP	SEQ	
	= 1 FOR REAL TRANSFORMATION BATIO	SEO	
	ICODE = 7 = 0 FOR FIX TAP = 1 FOR REAL TRANSFORMATION RATIO = 2 FOR COMPLEX TRANSFORMATION RATIO DENOTES BRANCH TYPE IF ICODE = 4 SERIES RESISTANCE OF THE LINE IF ICODE = 4 SERIES RESISTANCE OF THE LINE IF ICODE = 4	SEQ	
A2	DENOTES BRANCH TYPE IF ICODE = 4	SEQ	
1261	SERIES BESISTANCE OF THE LINE IF LCODE = 7	SLQ	
		SEO	
A3 👘	SERIES RESISTANCE OF THE LINE IF ICODE = 4 SERIES REACTANCE OF THE LINE IF ICODE = 7	SEQ	
	SERIES REACTANCE OF THE LINE IF ICODE = 7	SEQ	
	SERIES REACTANCE OF THE LINE IF ICODE = 4 REAL PART OF THE TRANSFORMATION RATIO IF ICODE = 7	SEQ	
A4	SERIES REACTANCE OF THE LINE IF ICODE = 4 DEAL DADT OF THE TRANSFORMATION DATIO IF LOODE - 7	SEQ	
	REAL TART OF THE TRANSFORMATION RATIO IF TODE = (SEU	
A5	HALF SHUNT SUSCEPTANCE OF THE LINE IF ICODE = 4	SEQ	
	IMAGINARY PART OF THE TRANSFORMATION RATIO IF ICODE = 7	SEQ	1
		SEQ	
	DUMMY VARIABLE	SEQ	
C	TRANSFORMER TAP BETWEEN BUSES IA AND JA	SEQ SEQ	
		SEQ	
****	**************************************	*SEQ	
*7		SEQ	
Y	LINE ADMITTANCE	SEQ	
YI.	HALF LEAKAGE ADMITTANCE OF THE LINE	SEQ SEQ	
		SEQ	
****	***************************************	*SEQ	į
T NT T // /	AT TRADION OF MADELONG AND INCODOR	SEQ	
INTT	ALIZATION OF MATRICES AND VECTORS	SEQ	
DO 20	$\mathbf{i} = \mathbf{i}, \mathbf{N}$	SEQ SEQ	
	=(0,0,0.0)	SEQ	
) J=1,N	SEQ	
	J) = (0.0, 0.0)	SEQ	
CONT		SEQ	
) J=1,NCB ((, I)=(0.0,0.0) (SEQ.	
DOK	, 1) - (0:0, 0:0)	SEQ SEQ	
DETEI	MINATION OF MATRIX AK, AND CURRENT VECTOR AI FROM LINE DATA	SEQ	
		SEQ	
REWII		SEQ	
	(3,*) ICODE, IA, JA, A1, A2, A3, A4, A5	SEQ	
1F (1	OF(3).NE.0) GOTO 280	SEQ	
		SEQ SEQ	
CHECT	WHETHER DATA IS TEMPORARILY ALTERED	6211.0.0	

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	IF (ICHTL.EQ.0) GO TO 40		SEQ 800
	IF (IA.NE.IAC) GO TO 40		SEQ 810
	IF (JA.NE.JAC) GO TO 49		SEQ 820
	IF (ICHTL.EQ.2) GO TO 30		SEQ 830
	Y=1.0/ZC		SEQ 840
	YL=CMPLX(0.0,SHTLC)		SEQ 850
	C=CC		SEQ 860
	IF (C.GT.0.0) GO TO 140		SEQ 870
	CO TO 50		SEQ 880
40	IF (ICODE.EQ.7) GO TO 139		SEQ 890
	Y=1.0/CMPLX(A3,A4)		SEQ 900
	YL=CMPLX(0.0,A5)		SEQ 910
	C=0.0		SEQ 920
50	IF (IA.EQ.NB) GO TO 220		SEQ 930 SEQ 940
a	IF (JA.EQ.NB) GO TO 220		SEQ 950
C	CONTRIBUTION TO THE CURRENTS AI(IA) AND (AI(JA) DUE TO THE	2.*	SEQ 960
C	LINE (IA, JA) WHEN C=0.0		SEQ 970
C C	LINE (IA, 5A) WHEN G-0.0		SEQ 980
u	CPX=YL+Y		SEQ 990
	AI(IA) = AI(IA) + CPX * V(IA) - Y * V(JA)		SEQ1000
	AI(JA) = AI(JA) + CPX*V(JA) - Y*V(IA)		SEQ1010
	IF (KA(IA).EQ.1) GO TO 70		SEQ1020
C			SEQ1030
č	DETERMINATION OF AK(IA, JA), AK(JA, IA) AND CONTRIBUTION TO	€ <i>1</i> 1.	SEQ1040
Ĉ	AK(IA, IA) AND AK(JA, JA) DUE TO THE LINE (IA, JA) WHEN IA	1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1	SEQ1050
ā	AND JA ARE THE LOAD BUSES, AND C=0.0		SEQ1060
C			SEQ1070
	CPY=Y*CV(IA)		SEQ1080
	AK(IA, JA) = -CPY		SEQ1090
	AK(IA, IA) = AK(IA, IA) + CPX*CV(IA)		SEQ1100
	IF (KA(JA).EQ.1) GO TO 100		SEQ1110
60	CPY=Y*CV(JA)		SEQ1120
	AK(JA, IA) = -CPY		SEQ1130
	AK(JA, JA) = AK(JA, JA) + CPY + YL * CV(JA)		SEQ1140
~	GO TO 30		SEQ1150 SEQ1160
C	DETERMINATION OF AK(IA, JA), AK(JA, IA) AND CONTRIBUTION TO	- 11	SEQ1170
C C	AK(IA, IA) AND AK(JA, JA) DUE TO THE LINE (IA, JA) WHEN IA		SEQ1189
č	AND JA ARE THE GENERATOR BUSES, AND C=0.0		SEQ1190
č			SEQ1200
70	$AK(IA, JA) = -0.5 \times CV(IA) \times Y$		SEQ1210
	DO 80 K=1, NGB		SEQ1220
	IF (IA.NE.IG(K)) GO TO 89		SEQ1230
	$BGK(K, JA) = -0.5 \times V(IA) \times CONJG(Y)$		SEQ1240
	CO TO 90		SEQ1250
80	CONTINUE	-	SEQ1260
90	AK(IA, IA) = AK(IA, IA) + CPX	-	SEQ1270
4.9.5	IF (KA(JA).NE.1) GO TO 60		SEQ1280
100	AK(JA, IA) = -0.5 * CV(JA) * Y		SEQ1290
	DO 110 K=1, NGB		SEQ1300
	IF $(JA.NE.IG(K))$ GO TO 110		SEQ1310 SEQ1320
	BCK(K, IA) =-0.5*V(JA) *CONJG(Y)		SEQ1320
110	CONTINUE		SEQ1340
120	AK(JA, JA) = AK(JA, JA) + CPX		SEQ1350
100	$\begin{array}{c} \text{ARCOA, ON - ARCOA, ON + OT R} \\ \text{GO TO 30} \end{array}$		SEQ1360
С			SEQ1370
č	CONTRIBUTION TO THE CURRENTS AI(IA) AND (AI(JA) DUE TO THE		SEQ1380
č	LINE (IA, JA) WHEN C IS POSITIVE REAL		SEQ1390
Č			SEQ1400
130	Y=1.0/CMPLX(A2,A3)		SEQ1410
	C=A4		SEQ1420
140	IF (IA.EQ.NB) GO TO 220		SEQ1430
	IF (JA.EQ.NB) GO TO 220		SEQ1440

	CPZ=Y/C		SEQ1450
	CPY=CPZ/C		SEQ1460
	$AI(IA) = AI(IA) + CPY \times V(IA) - CPZ \times V(JA)$ $AI(JA) = AI(JA) + Y \times V(JA) - CPZ \times V(IA)$		SEQ1470
	$IF (KA(IA) \cdot EQ. 1) GO TO 160$		SEQ1480 SEQ1490
С			SEQ1500
C	DETERMINATION OF AK(IA, JA), AK(JA, IA) AND CONTRIBUTION TO	271	SEQ1510
C	AK(IA,IA) AND AK(JA,JA) DUE TO THE LINE (IA,JA) WHEN IA		SEQ1520
C	AND JA ARE THE LOAD BUSES, AND C IS POSITIVE REAL		SEQ1530
С	$\Delta T (T A = T A) = - C D (T \psi C M (T A))$		SEQ1540
	AK(IA, JA) = -CPZ * CV(IA) $AK(IA, IA) = AK(IA, IA) + CPY * CV(IA)$		SEQ1550 SEQ1560
	IF (KA(JA) - EQ. 1) GO TO 190		SEQ1570
150	AK(JA, IA) = -CPZ*CV(JA)		SEQ1580
	$AK(JA, JA) = AK(JA, JA) + Y \approx CV(JA)$		SEQ1590
_	GO TO 30		SEQ1600
C			SEQ1610
C C	DETERMINATION OF AK(IA, JA), AK(JA, IA) AND CONTRIBUTION TO AK(IA, IA) AND AK(JA, JA) DUE TO THE LINE (IA, JA) WHEN IA		SEQ1620
C	AND JA ARE THE GENERATOR BUSES, AND C IS POSITIVE REAL		SEQ1630 SEQ1640
č	AND DA AND THE COMMATCH DODID, AND C IS TODITIVE TEAM		SEQ1650
160	$AK(IA, JA) = -0.5 \times CPZ \times CV(IA)$		SEQ1660
	DO 170 K=1, NGB		SEQ1670
	IF (IA.NE.IG(K)) GO TO 170		SEQ1689
	$BGK(K, JA) = -0.5 \times V(IA) \times CONJG(CPZ)$		SEQ1690
170	CO TO 189 CONTINUE		SEQ1700 SEQ1710
180	AK(IA, IA) = AK(IA, IA) + CPY		SEQ1720
	IF (KA(JA).NE.1) GO TO 150		SEQ1730
190	$AK(JA, IA) = -0.5 \times CPZ \times CV(JA)$		SEQ1740
	DO 200 K=1,NGB		SEQ1750
	IF (JA.NE.IG(K)) GO TO 200 BCK(K,IA)=-0.5*V(JA)*CONJG(CPZ)		SEQ1760
	$\frac{1}{10} = 0.5 \times 0.5 \times$		SEQ1770 SEQ1780
200	CONTINUE		SEQ1790
210	AK(JA, JA) = AK(JA, JA) + Y		SEQ1800
_	GO TO 30		SEQ1810
C	CONTRACTOR IN CURDENTIC AND ALL DUE TO STUD OF ACLE DUC		SEQ1820
C C	CONTRIBUTION IN CURRENTS AND AK DUE TO THE SLACK BUS	5 A.	SEQ1830
220	IF (C.NE.0.0) GO TO 240		SEQ1840 SEQ1850
	IKM=IA		SEQ1860
	IF (IA.GT.JA) IKM=JA		SEQ1870
	AI(IKM) = AI(IKM) + (Y+YL) *V(IKM) - Y*V(NB)		SEQ1880
	IF (KA(IKID.EQ.1) GO TO 230 AK(IKM,IKID=AK(IKM,IKID+(Y+YL)*CV(IKID))		SEQ1890
	$\mathbf{GO} \mathbf{TO} 30$		SEQ1900 SEQ1910
230	AK(IKM, IKM) = AK(IKM, IKM) + Y+ YL	-	SEQ1920
	CO TO 30		SEQ1930
240	CPY=Y/C		SEQ1940
	IF (IA.GT.JA) GO TO 260		SEQ1950
	CPZ=CPY/C $AI(IA)=AI(IA)+CPZ*V(IA)-CPY*V(NB)$		SE01960
	IF (KA(IA).EQ.1) GO TO 250		SEQ1970 SEQ1980
	AK(IA, IA) = AK(IA, IA) + CPZ * CV(IA)		SEQ1990
	CO TO 30		SE02000
250	AK(IA, IA) = AK(IA, IA) + CPZ		SEQ2010
260	GO TO 30 AI(JA)=AI(JA)+Y*V(JA)-CPY*V(NB)		SE02020
200	IF (KA(JA) - EQ. 1) GO TO 270		SEQ2030 SEQ2040
	$AK(JA, JA) = AK(JA, JA) + Y \times CV(JA)$		SEQ2050
	GO TO 30		SE02060
270	AK(JA, JA) = AK(JA, JA) + Y		SEQ2070
C	GO TO 30		SE02080
C			SEQ2090

C	CALCULATION OF AK(I,I), EGK(I,J) AND DS(I) FOR GENERATOR BUSES	SEQ2100
C		SEQ2110
280	DO 290 I=1,NGB	SE02120
	ABSV=CAES(V(IG(I)))	SEQ2130
	CPX=V(1G(1))*0.5/ABSV	SE02140
	CPY=.5*(V(IG(I))*CONJG(AK(IG(I), IG(I)))+AI(IG(I)))	SE02150
	BGK(1, IG(1))=CMPLX(0.0,1.0)*CPX+CPY AK(IG(1),IG(1))=CMPLX(0.0,1.0)*CONJG(CPX)+CONJG(CPY)	SEQ2160 SEQ2170
	BS(IG(I)) = S(IG(I)) - CMPLX(REAL(CV(IG(I))) + AI(IG(I))), ABSV)	
290	CONTINUE	SE02190
Ĉ		SE02200
C	CALCULATION OF DELTA SM FOR LOAD BUSES	SE02210
C		SE02220
	DO 300 I=1,N	SEQ2230
	IF (KA(I).EQ.1) GO TO 300	SE02240
000	DS(I) = CONJG(S(I)) - CV(I) * AI(I)	SE02250
300 C	CONTINUE	SEQ2260 SEQ2270
č	WRITING OF VECTOR AI AND DS	SEQ2280
č		SE02290
-	IF (IWRITE.NE.1) GO TO 320	SE02300
	WRITE (6,360)	SE02310
	WRITE (6,330)	SE02320
	WRITE (6,350)	SEQ2330
	DO 310 I=1,N	SEQ2340
010	WRITE (6,340) I, AI(I), DS(I)	SEQ2350
$\frac{310}{320}$	CONTINUE CALL GEN (V, CV, AI, DS, AK, BGK, IG, KA, NB, NGB, N, IZ, NIZ, IZB)	SEQ2360 SEQ2370
020	RETURN	SE02380
С		SE02390
<u>.</u> 30	FORMAT (* BUS NO. BUS CURRENT(AI) MISMATCH	ESE02400
	1S(DS) */)	SEQ2410
340	FORMAT (16,2X,2E14.5,4X,2E14.5)	SE02420
350	FORMAT (* REAL IMAGINARY REAL	SE02430
000	1 IMAGINARY *, /)	SE02440
360	FORMAT (/, 1X, 68(*-*),/)	SEQ2450 SEQ2460-
	EUD	3E@2400-
	SUBROUTINE GEN (V, CV, AI, DS, AK, BCK, IG, KA, NB, NGB, N, IZ, NIZ, IZB)	GEN 10
C		GEN 20
	COMPLEX V(1), CV(1), AI(1), DS(1), AK(N, 1), BGK(NGB, 1), CPX, CPY, CPZ	GEN 30
С	DIMENSION KA(1), IG(1), IZ(1), IM(10), II(10), IKM(5), IZB(1)	GEN 40 GEN 50
č	THIS SUBROUTINE USES SECTION 111 OF SOC-270 TO CONVERT THE	GEN 60
č		GEN 70
č	EQUATIONS TO THE FORM OF EQUATION (38) OF SOC-270	GEN 80
С		GEN 90
C	A DESCRIPTION OF ALL THE NEW VARIABLES USED IN THIS SUBROUTINE	GEN 100
C		GEN 110
C	NOW FOLLOWS	GEN 120
C C	**************************************	GEN 130 *GEN 140
C		GEN 150
C	IK, IKM IK IS THE TOTAL NUMBER OF THOSE LOAD BUSES WHOSE	GEN 160
C C	CURRENT IS ZERO AND ARE CONNECTED TO ONE OF THE GENERATOR BUSES. IKM STORES THE BUS INDECES OF	CEN 170 CEN 189
č	SUCH BUSES	GEN 180
č		GEN 200
č	IM(K), II(K) - IM(K) STORES THE INDEX OF THE GENERATOR BUS	GEN 210
С	EQUATION IN WHICH THE CONJUGATE OF THE VOLTAGE OF	GEN 220
C	ZERO CURRENT LOAD BUS II(K) IS TO BE ELIMINATED.	GEN 230
C	CASES OF ZERO CURRENT LOAD BUSES ARE FEW MOSTLY DUE	GEN 240
C C	TO DUMMY BUSES. KI IS THE NUMBER OF SUCH CASES	GEN 250 CEN 260

С	KL DUMMY VARIABLE	GEN	270
C		GEN	280
C C	***************************************		
C	ELIMINATION OF THE CONJUGATE OF THE ZERO CURRENT LOAD BUS	GEN GEN	
č	VOLTAGES FROM GENERATOR BUS EQUATIONS. SEE EQUATION (32) OF	GEN	
С	SOC-270. SIMULTANEOUSLY WE ARE NORMALIZING NON ZERO CURRENT	GEN	330
C	LOAD BUS EQUATIONS W.R.T. THE CONJUGATE OF THE LOAD BUS VOLTAGES		
C	INTERATION OF INTERED VALUES	GEN	
C C	INITIALIZATION OF INTEGER VARIABLES	GEN GEN	
u	NIZ=0	GEN	
	I K= Ø	GEN	
	KL=0	GEN	
a	K1=0	GEN	
C C	DETERMINATION OF ZERO CURRENT BUSES	GEN	
č	DETENDING IN ZERO CONCENT DOSES	GEN GEN	
-	DO 40 I=1,N	GEN	
		GEN	
	IF $(KA(I), EQ. 1)$ GO TO 40	GEN	
	IF $(CABS(AI(I)), LT, 1, E-6)$ GO TO 20	GEN	
	CPX=1.0/AI(I) DO 10 J=1.N	GEN GEN	
	IF $(AK(I,J).EQ.(0.0,0.0))$ GO TO 10	GEN	
	AK(I, J) = AK(I, J) * CPX	GEN	
10	CONTINUE	GEN	
	DS(I) = DS(I) * CPX	GEN	
20	CO TO 40 IZ(I) = I	GEN	
20	NIZ=NIZ+1	GEN GEN	
	IZB(NIZ) = I	GEN	
	DO 30 M=1, NGB	GEN	
	IF (BGK(M, I).EQ.(0.0,0.0)) GO TO 30	GEN	
	K1=K1+1	GEN	
	IM(K1)=M II(K1)=I	GEN GEN	
30	CONTINUE	GEN	
	IF (K1.EQ.KL) GO TO 40	GEN	
	KL=K1	GEN	660
		CEN	
40	IKH(IK) = I CONTINUE	GEN	
	IF (IK.EQ.0) GO TO 120	GEN GEN	
С		GEN	
C	ELIMINATION OF THE CONJUGATE OF THE ZERO CURRENT LOAD BUS	GEN	720
C	VOLTAGES FROM GENERATOR BUS EQUATIONS	GEN	
С	DO 50 I=1, IK	GEN	
	DS(IKM(I)) = CONJG(DS(IKM(I)))	GEN GEN	
		GEN	
50	AK(IKH(I) , J) = CONJG(AK(IKM(I) , J))	GEN	789
	DO 80 M=1, IK	GEN	
	BO 70 I=1, IK IF (I.EQ.M) GO TO 70	GEN	
		GEN GEN	
		GEN	
	BO 60 J=1,N	GEN	
	IF (AK(IKH(M), J).EQ.(0.0,0.0)) CO TO 60)	GEN	
60	AK(IKM(I), J) = AK(IKM(I), J) + CPX*AK(IKM(M), J)	GEN	
60		GEN GEN	
70		GEN	
80		GEN	
		GEN	

	CPX=-BGK(IM(I),II(I))/AK(II(I),II(I))	.0	GEN 920
	DO 90 J=1,N IF (AK(II(I),J).EQ.(0.0,0.0)) CO TO 90		GEN 930 GEN 940
0.0	BGK(IM(I), J) = BGK(IM(I), J) + CPX*AK(II(I), J)		GEN 950
90	CONTINOL		GEN 960 GEN 970
	DS(IG(KL))=DS(IG(KL))+CPX*DS(II(I))		GEN 980
100	CONTINUE		GEN 990
	DO 110 I=1, IK DS(IKM(I))=CONJG(DS(IKM(I)))		GEN1000 GEN1010
	DO 110 J=1,N		GEN1020
110	AK(IKM(I), J) = CONJG(AK(IKM(I), J))		GEN1030
C C	CONVERT EQUATIONS TO THE FORMOOF EQUATION (37) 0	FSOC-270	GEN 1040 GEN 1050
C			GEN1060
120	DO 150 I=1, N IF $(KA(1) = 0, 1)$ CO TO 150		GEN1070
	IF (I.EQ. IZ(I)) GO TO 150		GEN1080
	D0 150 I=1,N IF (KA(I).EQ.1) C0 T0 150 IF (I.EQ.IZ(I)) C0 T0 150 D0 140 M=1,NGB IF (BCK(M,I).EQ.(0.0,0.0)) C0 T0 140 D0 130 J=1,N IF (AK(I,J).EQ.(0.0,0.0)) C0 T0 130 AK(IG(M),J)=AK(IG(M),J)-BCK(M,I)*AK(I,J) CONTINUE DS(IG(M))=ES(IG(M))-ECK(M,I)*DS(I) CONTINUE CONTINUE		GEN1109
	IF (BGK(M, I).EQ.(0.0,0.0)) GOTO 140 PO 130 J=1 N		CEN1110
	IF (AK(I,J).EQ.(0.0,0.0)) GO TO 130		GEN1120
	AK(IG(M), J) = AK(IG(M), J) - BCK(M, I) * AK(I, J)	ž	GEN1140
130	CONTINUE DS(IC(M))=DS(IC(M))-BCK(M I)*DS(I)		GEN1150 CEN1160
140	CONTINUE		GEN1170
150	CONTINUE		GENIIOU
C C	CONVERT EQUATIONS TO THE FORMOOF EQUATION (38) 0	F 60C-970	GEN1190
č			GEN1200 GEN1210
	DO 220 M=1,NGB CPX=1.0/BGK(M, IG(M)) DS(IG(M))=DS(IG(M))*CPX DO 160 J=1,N IF (AK(IG(M),J).EQ.(0.0,0.0)) GO TO 160 AK(IG(M),J)=AK(IG(M),J)*CPX CONTINUE MM=N+1 IF (MM.GT.NGB) GO TO 180 DO 170 J=MM,NGB IF (BGK(M,IG(J)).EQ.(0.0,0.0)) GO TO 170 EGK(M,IG(J))=BGK(M,IG(J))*CPX		GEN1220
	CPX=1.0/BGK(M, IG(M))		GEN1230
	DO 160 J=1.N		GEN1240 GEN1250
	IF (AK(IG(M), J).EQ.(0.0,0.0)) GO TO 160		GEN1260
160	AK(IG(M), J) = AK(IG(M), J) * CPX		GEN1270 GEN1280
100	MM= M+ 1		GEN1200
	IF (MM. GT. NGB) GO TO 180		GEN1300
	IV 170 J=MH, NGB IF (BCK(M, IC(.I)), FO, (0, 0, 0, 0)) CO TO 170		GEN1310 GEN1320
	BGK(M, IG(J)) = BGK(M, IG(J)) * CPX	· ·	GEN1330
170	CONTINUE		GEN1340
180	DO 210 I=1,NGB IF (I.EQ.M) GO TO 210		GEN 1350 GEN 1360
	IF (BGK(I, IG(M)).EQ.(0.0,0.0)) GO TO 210	4 14	GEN1370
	CPX=-BGK(I, IG(M)) DO 190 J=1,N		GEN1389
	IF (AK(IG(H), J).EQ.(0.0, 0.0)) (GO TO 190)		GEN 1390 CEN 1400
	AK(IG(I), J) = AK(IG(I), J) + CPX*AK(IG(M), J)		GEN1410
190	CONTINUE DS(IG(I))=DS(IG(I))+CPX*DS(IG(M))		GEN1420
	IF (MM.GT.NGB) GO TO 210		GEN 1430 GEN 1440
	DO 200 J=MM, NGB		GEN1450
	IF $(BCK(M, IG(J)) = BCK(0.0, 0.0))$ G0 T0 200 BCK(1, IG(J)) = BCK(1, IG(J)) + CPX*BCK(M, IG(J))		GEN1460
200	CONTINUE		CEN 1470 CEN 1480
210	CONTINUE		GEN1490
220	CONTINUE RETURN		GEN 1500 GEN 1510
	END		GEN1510
	SUBROUTINE ELIM (AK, AI, ES, N, IZ, NIZ, IZB, IWRITE)		ELM 10
С			ELN 20

10 20 ELM ELM

С

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	COMPLEX AK(N, 1), AI(1), DS(1), CPX, CPY, CPZ DIMENSION IZ(1), IZB(1)	elm 30 Elm 40
C C	THIS SUBROUTINE SOLVES THE EQUATIONS OF THE FORM OF EQUATION	ELM 50 ELM 60
C		ELM 70
C C	(38) OF SOC-270 USING CONJUGATE REDUCTION COMBINED WITH	ELM 80 ELM 90
C	FORWARD GAUSSIAN ELIMINATION PRESENTED BY BANDLER AND EL-KADY(2)	ELM:100
C C	***************************************	ELM 110 **ELM 120
C C	THIS STEP IS EXECUTED FOR ALL BUSES WHOSE BUS CURRENTS ARE ZERO	ELM 130
č		ELM 140 ELM 150
	IF (NIZ.EQ.0) GO TO 60 IF (IVRITE.NE.1) GO TO 10	ELM 160 ELM 170
	WRITE (6, 180)	ELM 189
10	WRITE (6,190) (IZB(I),I=1,NIZ) DO 50 L=1,NIZ	ELM 190 ELM 200
10	I=IZB(L)	ELM 210
	CPX=1./AK(I,I) DO 20 J=1.N	ELM 220 ELM 230
	IF (AK(1, J).EQ.(0.0,0.0)) GO TO 20	ELM 240
20	AK(I,J)=AK(I,J)*CPX CONTINUE	ELM 250 ELM 260
	DS(I) = DS(I) * CPX	ELM 270
	DO 40 J=1,N IF (J.EQ.I) GO TO 40	ELM 280 ELM 290
	IF (AK(J, I).EQ.(0.0,0.0)) GO TO 40)	ELM 300
	CPY=AK(J,I) DO 30 K=1,N	ELM 310 ELM 320
	IF (AK(I,K).EQ.(0.0,0.0)) GO TO 30	ELM 330
30	AK(J,K)=AK(J,K)-AK(I,K)*CPY CONTINUE	ELM 340 ELM 350
	DS(J) = DS(J) - DS(I) * CPY	ELM 360
40 50	CONTINUE CONTINUE	ELM 370 ELM 380
C		ELM 390
C C	CONJUGATE REDUCTION	ELM 400 ELM 410
60	DO 150 M=1,N	ELN 420
	MM=M+1 IF (M.EQ.IZ(M)) GO TO 150	ELM 430 ELM 440
	CPX=(0.0,0.0)	ELM 450
	CPY=(0.0,0.0) D0 90 I=M,N	ELM 460 ELM 470
	IF (IZ(I).EQ.I) CO TO 20 IF (AK(M,I).EQ.(0.0,0.0)) CO TO 20	ELM 480
	AI(I) = -CONJG(AK(M, I))	ELM 490 ELM 500
	IF (AK(I, M).EQ.(0.0,0.0)) GO TO 70 CPX=CPX+AI(I)*AK(I, M)	ELN 510
70	CPY=CPY+AI(I)*DS(I)	ELM 520 ELM 530
80	$\begin{array}{c} \text{G0 T0 90} \\ \text{A1(1)} = (0.0, 0.0) \end{array}$	ELM 540
90	CONTINUE	ELM 550 ELM 560
	AK(M, M) = CPX+1.0 DS(M) = CPY+CONJG(DS(M))	ELM 570 ELM 580
	IF (MM.GT.N) GO TO 150	ELM 590
	DO 110 J=NM, N CPX=(0.0,0.0)	ELN 600 ELN 610
	DO 100 I=M, N	ELM 620
	IF (AI(I).EQ.(0.0,0.0)) GD TO 100 IF (AK(I,J).EQ.(0.0,0.0)) GO TO 100	ELM 630 ELM 640
	CPX=CPX+AI(I)*AK(I,J)	ELM 650
100	CONTINUE AK(M, J)=CPX	ELM 660 ELM 670

110	CONTINUE	ELM	680
C	CAUCCIAN DODUADD DI IMINADION	ELM	
C C	GAUSSIAN FORWARD ELIMINATION	ELM ELM	
ŭ	CPX=1.0/AK(M,M)	ELM	
	DO 120 I=MM, N	ELM	730
	IF (AK(M, I).EQ. (0.0,0.0)) GO TO 120	ELM	
120	AK(M, I) = AK(M, I) *CPX	ELM	
120	DS(M) = DS(M) * CPX	ELM ELM	
	BO 140 I=MN, N	ELM	
	IF (AK(I,M).EQ.(0.0,0.0)) CO TO 140	ELM	790
	DS(I) = DS(I) - DS(M) * AK(I, M)	ELM	
	CPX=AK(I,M) DO 130 J=MM.N	ELM ELM	
		ELM	
	AK(I, J) = AK(I, J) - AK(M, J) * CPX	ELM	
130	CONTINUE	ELM	
140 150	CONTINUE	ELM	
C	CONTINUE	ELM ELM	
č	BACKWARD SUBSTITUTION	ELM	
C		ELM	
	DS(N) = DS(N) / AK(N, N)	ELM	
	N1=N-1 DO 170 I=1,N1	ELM	
	NI=N-I	ELM ELM	
	CPX=(0.0,0.0)	ELM	
	DO 160 J=1, I	ELM	960
		ELM	
	IF (AK(NI,NJ).EQ.CMPLX(0.0,0.0)) GO TO 160 CPX=DS(NJ) *AK(NI,NJ)+CPX	ELM ELM	
160	CONTINUE	ELMI	
	DS(NI)=DS(NI)-CPX	ELMI	
170	CONTINUE	ELMI	
С	RETURN	ELM1	
180	FORMAT (/,* THE BUS CURRENT IS ZERO FOR THE FOLLOWING BUSES *,/)	ELM1 ELM1	050
190	FORMAT (10110)	ELM	
	END	ELM1	070-
	SUBROUTINE RESULT (V, CV, S, DS, AI, KA, IC, NGB, NB, N, ICHTL, IAC, JAC, ZC,	RST	10
	1SHTLC, CC, IWRITE)	RST	20
C		RST	30
		RST RST	40 50
C	STERIOTOR TO(1), MA(1)	RST	60
Ċ	THIS SUBROUTINE WRITES FINAL RESULTS	RST	70
C		RST	S0
C C	***************************************		
č	CALCULATION OF BUS CURRENTS	RST RST	
C		RST	120
		RST	
	DO 10 $I=1, NB$ AI(1)=(0.0,0.0)	RST RST	
10		RST	
20	READ $(3,*)$ ICODE, IA, JA, A1, A2, A3, A4, A5	RST	170
	IF (EOF(3).NE.0) GO TO 70	RST	
	IF (ICHTL.NE.1) GO TO 30 IF (IA.NE.IAC) GO TO 30	RST RST	
	IF (JA.NE.JAC) GO TO 30	RSI	
		RST	
		RST	

	YL=CMPLX(0.0,SHTLC)	RST 240
	C=CC	RST 250
	IF (C.GT.0.0) GO TO:60	RST 260
~ ~	GO TO 40	RST 270
30	IF (ICODE.EQ.7) GO TO 50)	RST 280
	Y=1.0/CMPLX(A3,A4)	RST 290
	YL=CMPLX(0.0, A5)	RST 300
40		RST 310
40	CPX=YL+Y AI(IA)=AI(IA)+CPX*V(IA)-Y*V(JA)	RST 320
	$AI(IA) = AI(JA) + CPX \times V(JA) = I \times V(JA)$ $AI(JA) = AI(JA) + CPX \times V(JA) = Y \times V(JA)$	RST 330
	$\frac{1}{100} \frac{1}{100} \frac{1}$	RST 340
50	Y=1.0/CMPLX(A2,A3)	RST 350
	C=A4	RST 360 RST 370
60	CPZ=Y/C	RST 389
	CPY=CPZ/C	RST 390
	AI(IA) = AI(IA) + $CPY \approx V(IA) - CPZ \approx V(JA)$	RST 400
	AI(JA)=AI(JA)+Y*V(JA)-CPZ*V(IA)	RST 410
-	GO TO 20	RST 420
C		RST 430
C	WRITING OF FINAL BUS CURRENTS AND MISMATCHES	RST 440
C		RST 450
70	IF (IWRITE.NE.1) GO TO 100	RST 460
	WRITE (6,240) WRITE (6,350)	RST 470
	WRITE (6,360)	RST 489
	BO 90 I=1,N	RST 490
	IF (KA(I).EQ.1) GO TO EO	RST 500
	DS(I) = CONJG(S(I)) - CV(I) * AI(I)	RST 510 RST 520
	GO TO 90	RST 530
80	DS(I) = S(I) - CMPLX(REAL(CV(I) * AI(I)); CABS(V(I)))	RST 540
90	WRITE (6,250) I,AI(I),BS(I)	RST 550
	WRITE (6,370) NB, AI(NB)	RST 560
С		RST 570
С	WRITING OF FINAL LOAD BUS VOLTAGES	RST 530
C		RST 590
100	IF (IWRITE.EQ.2) RETURN	RST 600
	WRITE (6, 340)	RST 610
	WRITE (6,480)	RST 620
	WRITE (6,260) NB	RST 630
	WRITE (6,429) WRITE (6,270)	RST 640
	I=1	RST 650
110	ÎF (I.GT.N) GO TO 210	RST 660
	IF (KA(I).EQ.0) GO TO 120	RST 670 RST 689
	I = I + 1	RST 690
	GO TO 110	RST 700
120	J= I+1	RST 710
130	IF (J.GT.N) GO TO 190	RST 720
	IF (KA(J).EQ.0) GO TO 140	RST 730
	J=J+1	RST 740
140		RST 750
140	IF (AIMAG(V(I)).LT.0.0) GO TO 150	RST 760
	IF (AIMAG(V(J)).LT.0.0) GO TO 179 WRITE (6,220) I,V(I),J,V(J)	RST 770
	GO TO 189	RST 729
150	IF (AIMAG(V(J)).LT.0.0) GO TO 160	RST 790
190	P=REAL(V(I))	RST 890
	$Q = -\Lambda IMAG(V(I))$	RST 810 RST 820
	WRITE $(6, 330)$ I, P, Q, J, V(J)	RST 820 RST 839
	CO TO 189	RST 840
160	P=REAL(V(I))	RST 850
	Q = -AIMAG(V(I))	RST 860
	P2=REAL(V(J))	RST 870
	$\Omega_2 = -AIMAG(V(J))$	RST 889

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	WRITE (6,390) I,P,Q,J,P2,Q2	RST 290
170	GO TO 189 P2=REAL(V(J))	RST 900
160	Q2 = -AIMAG(V(J))	RST 910
	WRITE $(6, 400)$ I, V(I), J, P2, Q2	RST 920 RST 930
180	I = J + 1	RST 940
	GO TO 110	RST 950
190	IF (AIMAG(V(I)).LT.0.0) GO TO 200	RST 960
	WRITE $(6, 290)$ I, V(I)	RST 970
200	GO TO 110 IF (AIMAG(V(I)).LT.0.0) GO TO 200 WRITE (6,290) I,V(I) GO TO 210 P=REAL(V(I)) Q=-AIMAG(V(I)) WRITE (6,410) I,P,Q	RST 980
200	Q = -A I MAG(V(I))	RST 990
	WRITE (6.410) I.P.Q	RST1000 RST1010
C		RST1020
C	WRITING OF GENERATOR BUS REACTIVE POWERS AND VOLTAGES	RST1030
C		RST1040
210	WRITE (0,300)	RST1050
	$\Omega = -A \operatorname{IMAG}(CV(IG(I)) \times AI(IG(I)))$	RST1060
	IF $(AIMAG(V(IG(I))), IT, 0, 0)$ G0 T0 220	RST1070 RST1030
	WRITE (6,310) IG(I), QG, IG(I), V(IG(I))	RST1090
	GO TO 230	RST1100
220	P=REAL(V(IG(I)))	RST1110
	$W^2 = A \prod A G V (IG(1))$	RST1120
230	$\begin{array}{c} \text{CONTINIE} \\ \end{array}$	RST1120
Ĉ		RST1140 RST1150
C	WRITING OF SLACK BUS POWER	RST1160
C		RST1170
	CPX=CV(NB)*AI(NB)	RST1180
	P = REAL(UPX) O = -A IMAC(UPX)	RST1190
	WEITE (6.320)	RST1200
	<pre>WRITING OF GEMERATOR BOS REACTIVE POWERS AND VOLTAGES WRITE (6,300) D0 230 I=1,NGB GC=-AIMAG(CV(IG(I))*AI(IG(I))) IF (AIMAG(V(IG(I)).LT.0.0) GO TO 220 WRITE (6,310) IG(I),QC,IG(I),V(IG(I)) GO TO 230 P=REAL(V(IG(I))) Q=-AIMAG(V(IG(I))) WRITE (6,420) IG(I),QC,IG(I),P,Q CONTINUE WRITING OF SLACK BUS POWER CPX=CV(NB)*AI(NB) P=REAL(CPX) Q=-AIMAG(CPX) WRITE (6,220) WRITE (6,230) NB,P,NB,Q WRITE (6,430) RETURN FORMAT (/,* FINAL BUS CURRENTS AND MISMATCHES*,/) FORMAT (/16,2X,2E14.5,4X,2E14.5)</pre>	RST1210 RST1220
	WRITE (6,430)	RST1230
_	RETURN	RST1240
C	DODMAR (, , , , , , , , , , , , , , , , , ,	RST1250
$\begin{array}{c} 240 \\ 250 \end{array}$	FORMAT (/,* FINAL BUS CURRENTS AND MISMATCHES*,/) FORMAT (16,2X,2E14.5,4X,2E14.5)	RST1260
260	FORMAT (* LOAD FLOW SOLUTION OF*, 13, *-BUS POWER SYSTEM)	RST1270
		RST1290
270	FORMAT (* LOAD BUSES*,/)	BST1300
280	FORMAT (1X, *V(*, I3, *) =*, F8.5, * + J*, F7.5, 6X, *V(*, I3, *) =*, F8.5, *	
290	1+ J*,F7.5,/) FORMAT (1V WV 12 *) -* F9 5 * + 14 F7 5 ()	RST1320
300	FORMAT (1X, *V(*, I3, *) =*, F8.5, * + J*, F7.5, /) FORMAT (* GENERATOR BUSES*, /)	RST1330 RST1340
310	FORMAT (1X, *Q(*, I3, *) =*, F8.5, 17X, *V(*, I3, *) =*, F8.5, * + J*, F7.5,	/RST1350
	1)	RST1260
320	FORMAT (* SLACK BUS*,/)	RST1370
330 340	FORMAT (1X, *P(*, I3, *) =*, F8.5, 17X, *Q(*, I3, *) =*, F8.5, /) FORMAT (*1*)	RST1380
350	FORMAT (* BUS NO. BUS CURRENT(AI) MISMATCH	RST1390
	1S(DS) */)	RST1410
360	FORMAT (* REAL IMAGINARY REAL	RST1420
070	1 INAGINARY *,/)	RST1430
370 380	FORMAT (16,2X,2E14.5) FORMAT (1X,*V(*,13,*) =*,F8.5,* - J*,F7.5,6X,*V(*,13,*) =*,F8.5,*	RST1440
000	1+ J*.F7.5(/)	PST1460
390	FORMAT (1X, *V(*, I3, *) =*, F8.5, * - J*, F7.5, 6X, *V(*, I3, *) =*, F8.5.*	RST1470
		BSTIASA
400	FORMAT (1X,*V(*, I3,*) =*,F8.5,* + J*,F7.5,6X,*V(*,I3,*) =*,F8.5,* 1- J*,F7.5,/)	RST1490
410	$1 = J_{*}, F_{2}, F_{2}, F_{3}, F_{$	RST1500
420	FORMAT $(1X, *C(*, 13, *) = *, F8.5, 17X, *V(*, 13, *) = *, F8.5, * - J*, F7.5,$	RST1510
	1)	RST1520

430 FORMAT (/, 1X, 61(*-*),/) END

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RST1540 RST1550-

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XLF1 - A PROGRAM FOR COMPLEX LOAD FLOW ANALYSIS BY CONJUGATE ELIMINATION

J.W. Bandler, M.A. El-Kady and H. Gupta

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Key Words: Load flow analysis, conjugate notation, complex analysis, power systems analysis

Abstract: XLF1 is a package of five compiled library subroutines for solving steady-state power flow equations in the compact complex mode. A user-supplied main program provides the necessary dimensional storage and system data. The program implements the recently developed algorithm for practical complex solution of power flow equations presented by Bandler, El-Kady and Gupta. Sensitivities of system states with respect to system control variables can also be evaluated by the program using a perturbation method. The program is written in Fortran IV, documented and tested on a CYBER 170 computer. The report includes a listing of the program, a user's guide and some illustrative examples.

- Description: Contains Fortran program, user's manual. Source deck or magnetic tape available for \$150.00. The listing contains 839 lines, of which 338 are comments.
- Related Work: SOC-242, SOC-243, SOC-253, SOC-254, SOC-255, SOC-256, SOC-257, SOC-258, SOC-270.

Price: \$100.00.