A Low Order Nonlinear Dynamic Model for Drum Boiler-Turbine-Alternator Units

Bell, R.D.; Åström, Karl Johan

1979

Document Version:
Publisher's PDF, also known as Version of record

Link to publication

Citation for published version (APA):
Bell, R. D., & Åström, K. J. (1979). *A Low Order Nonlinear Dynamic Model for Drum Boiler-Turbine-Alternator Units*. (Technical Reports TFRT-7162). Department of Automatic Control, Lund Institute of Technology (LTH).

Total number of authors:
2

STATE ESTIMATION IN POWER NETWORKS III
PROGRAM description

A.J.M. van OVERBECK

Report 7404(C) April 1974
Lund Institute of Technology
Division of Automatic Control

STATE ESTIMATION IN POWER NETWORKS III

Program description

A.J.M. van Overbeek

ABSTRACT.

This report gives a description of the programs developed to compare the three state estimation methods. It is intended for future users of these programs.

This work has been done as partial fullfillment of the requirements for the Masters Degree in Electrical Engineering at the Eindhoven University of Technology, Eindhoven, The Netherlands.

Contents

1. Introduction

In order to compare the three methods mentioned in /1/*) 41 subroutines and four mainprograms were written. The purpose of this report is to give a description of these programs for future users.

First a general description is given of the simulation program and the way the data exchange between the different subroutines is organized in common blocks. After a detailed description of these common blocks all subroutines are presented in chapter 4. The last chapter consists of the program listings and two tables showing the relationships between the various subroutines and programs.

The 41 routines and four programs consist of 5630 source-cards. All programming is done in Fortran on the Univac 1108 of the computing center of Lund University.

*) See chapter 6: References

2. Simulation, general

The purpose of the simulationprograms is to compare and test the three different methods on the following:

1. errors in the network model used by the estimator
2. the influence of measurement accuracy and bias
3. the influence of the choice of measurement system

How is this implemented in the simulation program?
Fig. 2.1 gives a simplified flow diagram of the main program. The power demand is chosen as the control variable for the true state, since this is closest to reality. In the data read part (part 1 in fig. 2.1) the load pattern is read. The true state is calculated from the power demand by means of a conventional Newton-Raphson load-flow. The load flow program needs as input net bus injections. Therefore there is first done an economic load dispatch to divide the active demand over the generators. The dispatch program needs generator data, these are supplied in the common block /GEN/.
The reactive demand is divided over the generators in the same ratio as the active demand. This means that all generators are operated at the same cos ϕ. From the true state the other true variables are calculated. These consist of the types in the following table. These type numbers are used in all routines and programs

type	variable
1	bus voltage
2	line current at A-end of line
3	line current at B-end of line
4	line flow at A-end of line
5	line flow at B-end of line
6	bus injection

Table 2.1 variable types

Flow diagram:

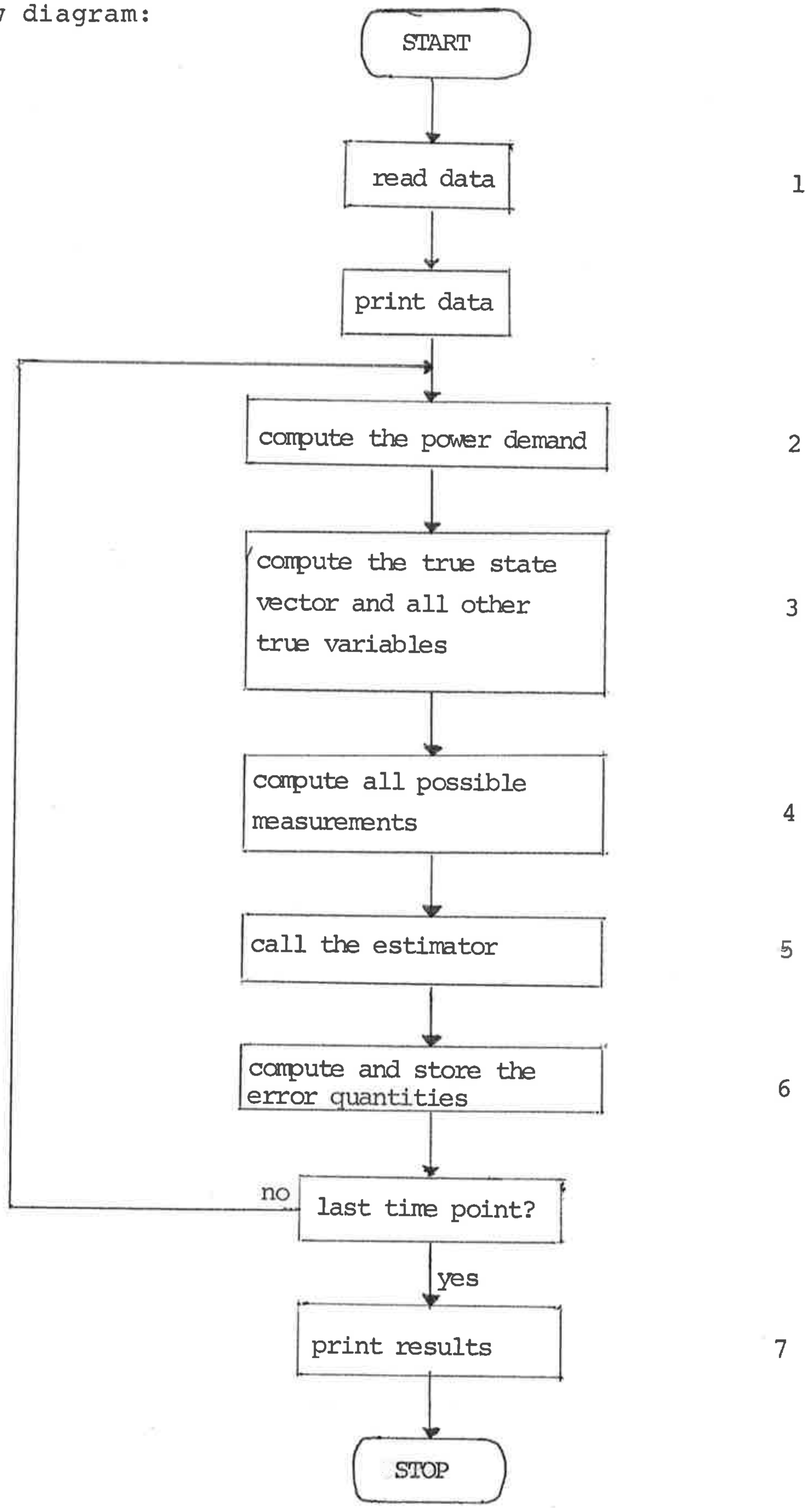


Figure 2.1 Mainprogram for simulation

The true variables are stored in the common block /TRUE/. In all these calculations the true network parameters and structure are used. These are stored in /TNET/. With the true variables given, the measurements are computed (4 in fig. 2.1). All possible measurements are always computed. These are stored in the common block /MSM/. Which measurements are used by the estimator is determined by a mask vector. This has the advantage that for two different measurement systems the same values are generated for those measurements used by both systems. The mask vector and the information on the order of the measurements (necessary for method B) are stored in /MSI/. The measurements are computed by adding bias and noise to the true values. The noise is generated by a random number generator. The noise amplitude for each measurement is given by: $\alpha \times$ (full scale value) + $\beta \times$ (true value). In this way we can introduce both an absolute (α) and relative (β) error. The α, full scale and β values, the bias and the noise amplitude computed from these quantities are stored in /METT/.
The estimator (5 in fig. 2.1) is not treated in detail here.
It makes use of its own network data: /ENET/.
The estimate and the other variables computed from the estimate are stored in /EST/. All three methods try to minimize the loss function

$$J = \{\underline{y} - g(\underline{x})\}^T W \{\underline{y} - g(\underline{x})\}$$

The weighting factors plus the α, β and full scale values for each measurement used by the estimator are stored in /METE/.
So the only coupling between true and estimated values occurs through the common blocks /MSM/ and /MSI/. The error quantities (6 in fig. 2.1): the estimation error, the lineflow error and the measurement index are stored in /EVAL/.
Now we can say which data have to be read in (1)

- true network data
- generator data
- load data
- true meter data
- measurement information

- estimator meter data
- estimator parameters.

The next chapter describes all common blocks while chapter 4 presents all subroutines as they occur in the simulation program and the three simulation programs (one for each method) and the program to plot the results.
The last chapter consists of the program listings.

3. The common blocks

The following dimension parameters are used in the common blocks:

MG	maximum number of generators.
MB	maximum number of buses.
ML	maximum number of lines.
MMB	2MB
MML	2ML

The common block/TNET/: true network parameters.

```
COMMON /TNET/ NBT,NLT,LTAT(ML),LTBT(ML),YAAT(ML),ZABT(ML),YBBT(ML)
```

NBT	number of buses
NLT	number of lines
LTAT(I)	A-end of line I is connected to bus LTAT(I)
LTBT(I)	B-end of line I is connected to bus LTBT(I)
YAAT(I)	shunt admittance at A-end of line I
ZABT(I)	series impedance of line I
YBBT	shunt admittance at B-end of line I

The common block/TRUE/: the true variables.

```
COMMON /TRUE/ XT(MB),YT2(ML),YT3(ML),YT4(ML),YT5(ML),YT6(MB)
```

XT(I)	busvoltage I (state)
YT2(I)	line current at A-end of line I
YT3(I)	line current at B-end of line I
YT4(I)	lineflow at A-end of line I
YT5(I)	lineflow at B-end of line I
YT6(I)	businjection at bus I

all variables are complex.

The common block/GEN/: the gener[illegible]ameters.

```
[illegible],PMIN(MG),PMAX(MG)
```

NG	number of generators
NGB(I)	generator I is connected to bus I
A1(I)	coefficients of the generator

A2(I) cost function: $c = a_1 + a_2 P^2_{gen}$

PMIN(I) min generated active power for generator I

PMAX(I) max generated active power for generator I

The common block/METT/: true meter information.

```
 COMMON /METT/ BIAS1(MB),BIAS2(ML),BIAS3(ML),BIAS4(MML),
X              BIAS5(MML),BIAS6(MMB),WN1(MB),WN2(ML),WN3(ML),
X              WN4(MML),WN5(MML),WN6(MMB),ALFT1(MB),ALFT2(ML),
X              ALFT3(ML),ALFT4(MML),ALFT5(MML),ALFT6(MMB),
X              FST1(MB),FST2(ML),FST3(ML),FST4(MML),
X              FST5(MML),FST6(MMB),BETT1(MB),BETT2(ML),BETT3(ML),
X              BETT4(MML),BETT5(MML),BETT6(MMB)
```

BIASX(I) bias for type X measurement

WNX(I) weighting factor for type X measurement noise

ALFTX(I) α value for type X measurement

FSTX(I) full scale value for type X measurement

BETTX(I) β value for type X measurement.

The α, full scale and β values are used by the subroutine CAWN to compute the measurement noise weighting factors. The BIAS and WN values are used by the subroutine ALLMSM to compute the measurements.

The common block/MSM/: all possible measurements.

```
 COMMON /MSM/ YM1(MB),YM2(ML),YM3(ML),YM4(MML),YM5(MML),YM6(MMB)
```

YMX(I) type X measurement

The common block/MSI/: measurement system information.

```
 COMMON /MSI/ MSK1(MB),MSK2(ML),MSK3(ML),MSK4(ML),MSK5(ML),
X             MSK6(MB),NM,NTYP(MM),NMSM(MM)
```

MSKX(I) mask vector for type X measurement

For type 1, 2, and 3 measurements ("modulus measurements") element I = 1 means that the corresponding measurement in /MSM/ is used by the estimator and element I = 0 that the measurement is not used. For type 4, 5, 6 measurements ("power measurements") the meaning of the maskvector elements is given in the following table:

element

0	measurement is not used
1	only active measurement is used
2	only reactive measurement is used
3	both active and reactive measurement are used.

NM number of measurements used by the estimator. active and reactive power measurements are counted separately

NTYP(I) measurement I is of type NTYP(I)

NMSM(I) measurement I is the NMSM(I)-th measurement of type NTYP(I)

examples:

NTYP(I)	NMSMT(I)	
1	5	voltage measurement at bus 5
3	4	line current measurement at B-end of line 4
4	5	active lineflow measurement at A-end of line 3
4	6	reactive lineflow measurement at A-end of line 3

The measurement order information stored in NTYP(I) and NMSM(I) is used by method B.
From this information the subroutine RDMSM computes the mask-vectors.

The common block/RES/: the residues.

```
 COMMON /RES/ RES1(MB),RES2(ML),RES3(ML),RES4(MML),RES5(MML),
X             RES6(MMB)
```

RESX(I) The residue $y - g(\underline{x})$ for measurement I of type X.

The common block/METE/: estimator meter information.

```
 COMMON  /METE/  WF1(MB),WF2(ML),WF3(ML),WF4(MML),WF5(MML),
X                WF6(MMB),ALFE1(MB),ALFE2(ML),ALFE3(ML),ALFE4(MML),
X                ALFE5(MML),ALFE6(MMB),FSE1(MB),FSE2(ML),FSE3(ML),
X                FSE4(MML),FSE5(MML),FSE6(MMB),BETE1(MB),BETE2(ML),
X                BETE3(ML),BETE4(MML),BETE5(MML),BETE6(MMB)
```

WFX(I) weighting factor for measurement I of type X

ALFEX(I), FSEX(I), BETEX(I) — see corresponding T variables in /METT/

The weighting factors WFX(I) are computed from the α, full scale and β values by the subroutine CAWF.

The common block/ENET/: estimator network d

```
                                 ...,ZABE(ML),YBBE(ML)
```

Estimator network data. See /TNET/.

The common block/EST/: all estimated variables.

```
COMMON /EST/ XE(MB),YE2(ML),YE3(ML),YE4(ML),YE5(ML),YE6(MB)
```

All complex estimated variables. See /TRUE/.

The common block/JAC/: the Jacobian.

```
 COMMON /JAC/ AJAC1(MB,2),AJAC2(ML,4),AJAC3(ML,4),AJAC4(MML,4),
X             AJAC5(MML,4),AJAC6(MMB,MMB)
```

The jacobian. Only the non-zero jacobian elements are stored for type 1, 2, 3, 4 and 5 measurements.

type 1: voltage measurement

AJAC1(I,1) element $\frac{\delta V}{\delta e}$

AJAC1(I,2) element $\frac{\delta V}{\delta f}$

type 2 + 3: line current measurement

X = 2 or 3

AJACX(I,1) element $\frac{\delta|I_{ab}|}{\delta e_a}$

AJACX(I,2) element $\frac{\delta|I_{ab}|}{\delta f_a}$

AJACX(I,3) element $\frac{\delta|I_{ab}|}{\delta e_b}$

AJACX(I,4) element $\frac{\delta|I_{ab}|}{\delta f_b}$

type 4 + 5: lineflow measurement

X = 4 or 5

I odd .. = P_{ab}

I even .. = Q_{ab}

AJACX(I,1) element $\frac{\delta ..}{\delta e_a}$

AJACX(I,2) element $\frac{\delta ..}{\delta f_a}$

AJACX(I,3) element $\frac{\delta ..}{\delta e_b}$

AJACX(I,4) element $\frac{\delta ..}{\delta f_b}$

type 6: bus injection measurement

AJAC6(I,J) all jacobian elements for a bus injection measurement are stored.

<u>The common block/MAT/: Matrices for method A.</u>

```
COMMON /MAT/ A(MMB,MMB),T(MMB,MMB)
```

A(I,J) matrix G^TWG

T(I,J) triangularized version of A(I,J)

This common block is only used by method A.

The common block /VAR/: diagonal P-matrices for method B.

```
COMMON /VAR/ COV(MMB),PNEW(MMB)
```

COV(I) covariance for statevariable I in method B

example: cov(3) = covariance of real part of bus voltage 2.

PNEW(I) new covariance for statevariable I.

This common block is only used by method B.

The common block /MAT/: matrices for method C.

```
COMMON /MAT/ A(MB,MB),T(MB,MB)
```

A(I,J) matrix B^TDB of method C

T(I,J) triangularized version of A.

This common block is only used by method C.

The common block /EVL/: evaluation parameters.

```
      COMMON /EVL/ EE(MTMX1),EEM(MTMX1,2),AEE,EEMT(2),EEMMT(3)
     X             EL(MTMX1),ELM(MTMX1,2),AEL,ELMT(2),ELMMT(3)
     X             EM(MTMX1),AEM,EMMT(2)
```

EE(I) estimation error at timepoint I

EEM(I,1) maximum element in EE(I)

EEM(I,2) place of EEM(I,1)

two examples: EEM(I,2) = 4: imaginary part of bus voltage 2, EEM(I,2) = 5: real part of bus voltage 3.

AEE average estimation error

EEMT(1) maximum estimation error

EEMT(2) time point of maximum estimation error.

EEMMT(1) maximum element in all estimation errors

EEMMT(2) place of EEMMT(1). See EEM(I,2)

EEMMT(3) time point of EEMMT(1)

EL(I) lineflow error at time point I

ELM(I,1) maximum element in EL(I)

ELM(I,2) place of ELM(I,1)

ELM(I,2) positive means at A-end of line, negative at B-end of line examples: ELM(I,2) = 3: active flow at A-end of line 2. ELM(I,2) = -4: reactive flow at B-end of line 2.

AEL	average lineflow error
ELMT(1)	maximum lineflow error
ELMT(2)	time point of ELMT(1)
ELMMT(1)	maximum element in all lineflow errors
ELMMT(2)	place of ELMMT(2). See ELM(I,2)
ELMMT(3)	time point of ELMMT(3).
EM(I)	measurement index at time point I
AEM	average measurement index
EMMT(1)	maximum measurement index
EMMT(2)	time point of EMMT(1)

4. The subroutines and mainprograms.

In this chapter there is given a short description of each subroutine. If necessary a flow diagram and further comments are included. The subroutines are presented about in the order as they occur in the simulation program in the following sections:

4.1 The subroutines PRENET and PRTNET.
4.2 The data read routines (part 1 in fig. 2.1).
4.3 The subroutine CASDB (part 2 in fig. 2.1).
4.4 The subroutines for computing all true variables (part 3 in fig. 2.1).
4.5 The subroutines for computing the measurements (part 4 in fig. 2.1).
4.6 The jacobian routines (used by estimator A and B).
4.7 The routines and mainprogram for method A.
4.8 The routines and mainprogram for method B.
4.9 The routines and mainprogram for method C.
4.10 The subroutine EVAL.
4.11 The plot program.

Chapter 5 starts with two tables giving the relationships between the various routines and programs.

4.1 The subroutines PRENET and PRTNET.

SUBROUTINE PRENET

Prints the estimator network data stored in the common block /ENET/.

SUBROUTINE PRTNET

Prints the true network data stored in the common block /TNET/.

4.2 The data read routines.

SUBROUTINE RDTNET (IPRINT, IERR)

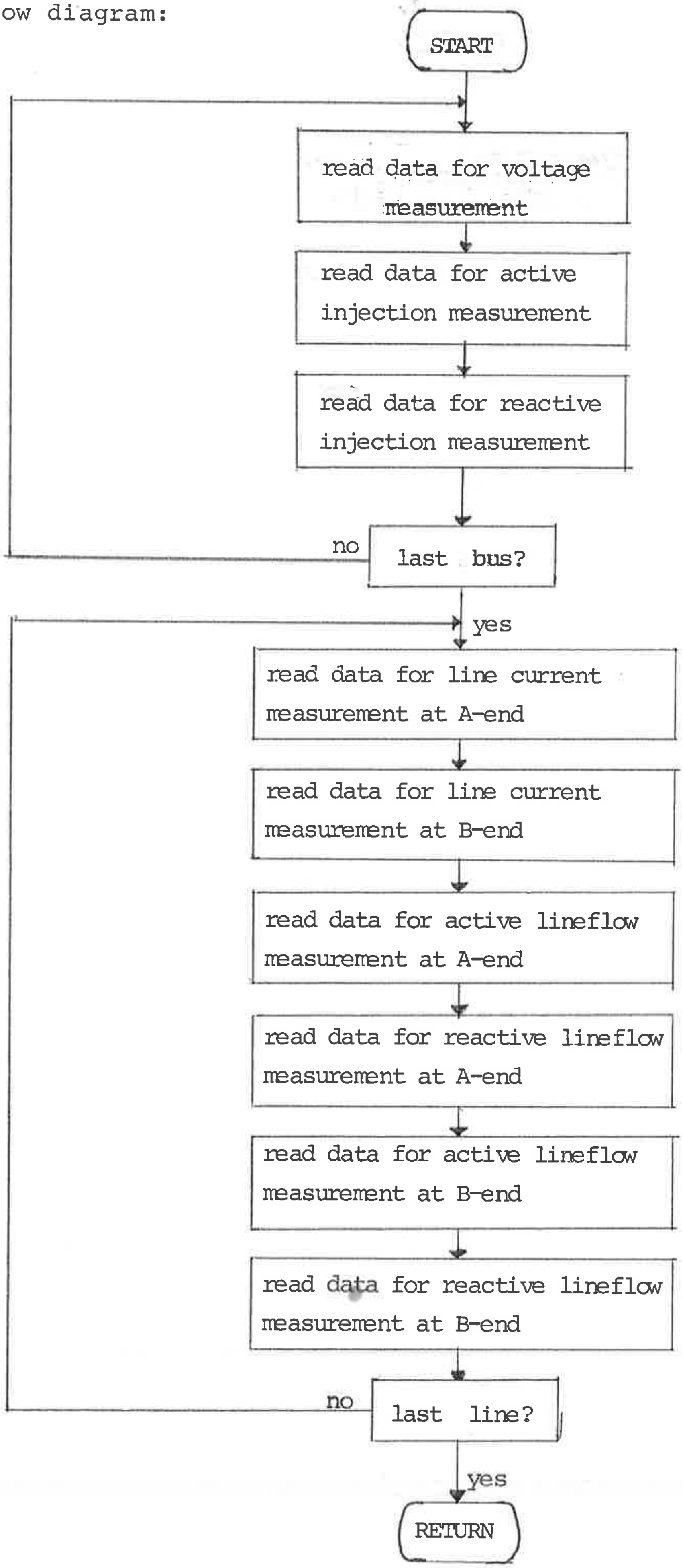
Reads the true network data into the common block /TNET/ and prints the read data.

SUBROUTINE RDMETT (IPRINT)

Reads for all possible measurements the bias, α, full scale and β values into the common block /METT/ and prints the read data.

flow diagram:

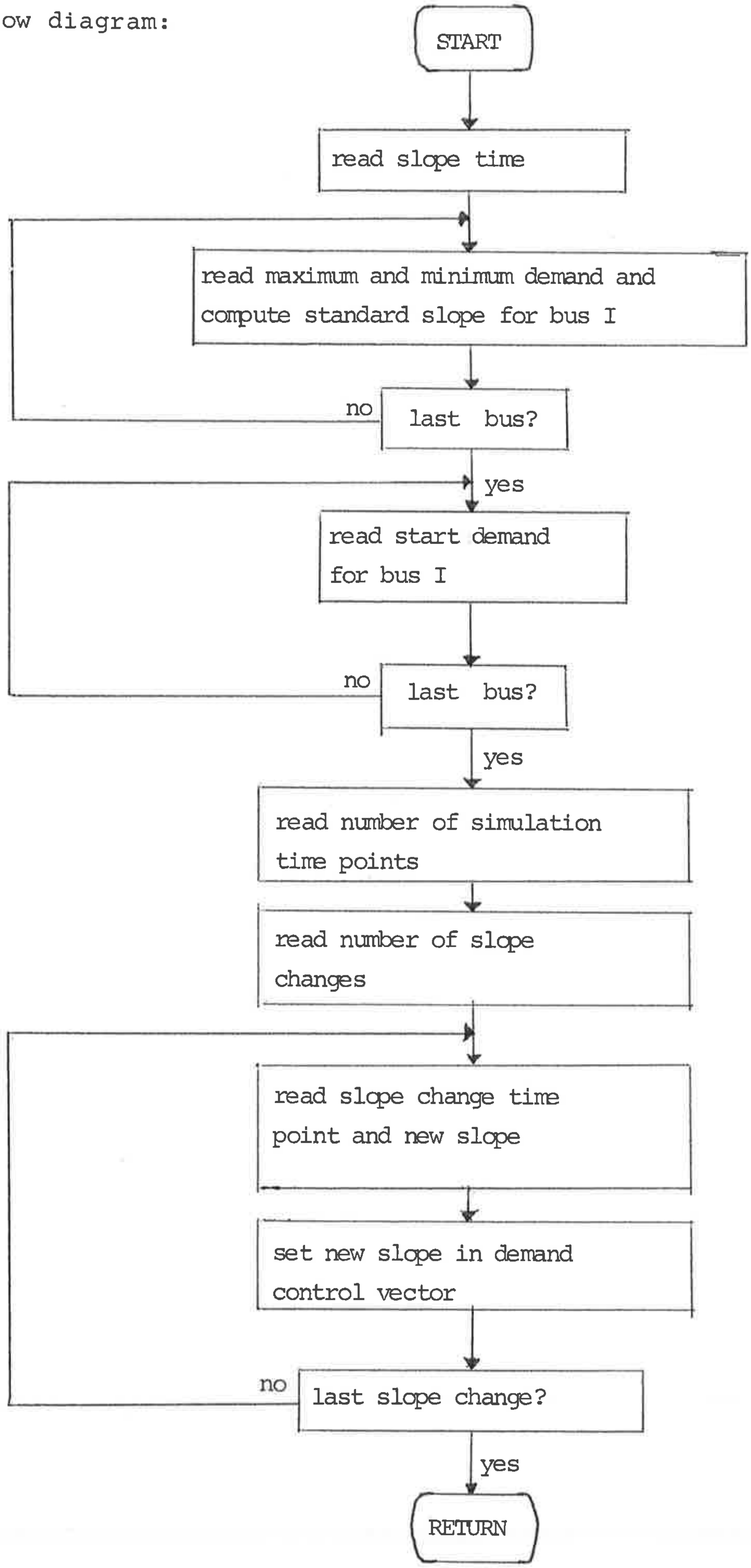
Flow diagram:



SUBROUTINE RDGEN (IPRINT, IERR)
Reads the generator data into the common block /GEN/ and prints the read data.

SUBROUTINE RDLD (IPRINT, IERR)
Reads and prints the demand data necessary for the subroutine CASDB to compute at each time point the new load demand.
Flow diagram:

Flow diagram:



comments:

The subroutine CASDB computes the new load demand at time point K + 1 for bus I as load (K+1) = load (K) + U(K+1)× standard slope (I). U(K+1) is the demand control vector element. The standard slope for bus I is defined as :

$$\frac{\text{maximum demand - minimum demand}}{\text{slope time}}$$

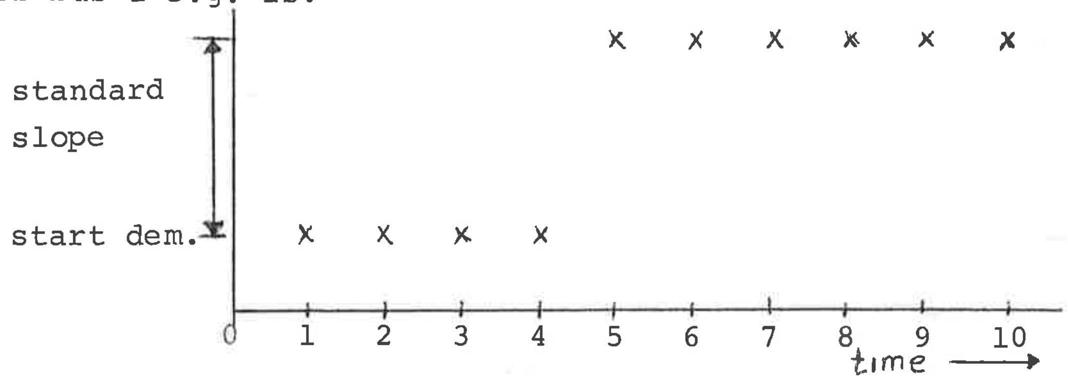
example: simulation time = 10

nr of slope changes = 2

slope change time point	new slope
5	1.0
6	0.0

Then U is: 0.0 0.0 0.0 0.0 1.0 0.0 0.0 0.0 0.0 0.0

The load for bus 1 e.g. is:



SUBROUTINE RDENET (IPRINT, IERR)

Reads estimator network data into the common block /ENET/ and prints the read data

SUBROUTINE RDMETE (IPRINT)

Reads for all possible measurements the α, full scale and β values into the common block /METE/

flowdiagram: see the subroutine RDMETT

SUBROUTINE RDMSM (IPRINT, IERR)

Reads which of all possible measurements are to be used by the estimator and in which order they are to be processed. This data is read into NM, NTYP(I) and NMSM(I) in the common block /MSI/. From this data the mask vectors are computed. Active and reactive measurements are treated separately. See the description of the common block /MSI/ in the previous chapter.

4.3 The subroutine CASDB.

SUBROUTINE CASDB (SDB, SSL, U, IPRINT)

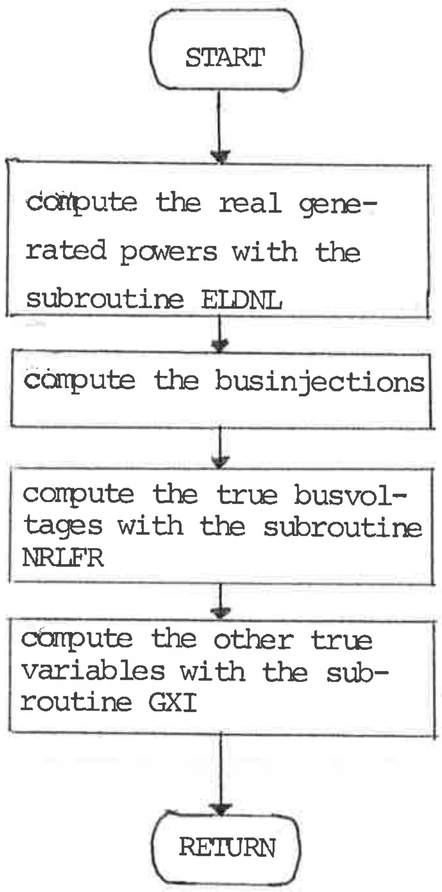
Computes the new load demand for all buses given the old demand, the standard slopes and the demand control vector element. See the subroutine RDLD.

4.4 The subroutines for computing all true variables.

SUBROUTINE TRUEV (SDB, IPRINT, IERR)

Computes all true variables from the load demand

flow diagram:



1

comments:
ad 1. the subroutine ELDNL distributes the total active demand over all generators. The total reactive demand is distrubuted over the generators in the same ratio as the active demand.

SUBROUTINE ELDNL (A1, A2, PMIN, PGEN, PMAX, PDEM, EPS, NG, IPRINT, IERR)
Performs an economic load dispatch neglecting linelosses by minimizing the generator cost function with a Lagrange multiplier method and taking into account minimum and maximum generated power restrictions.

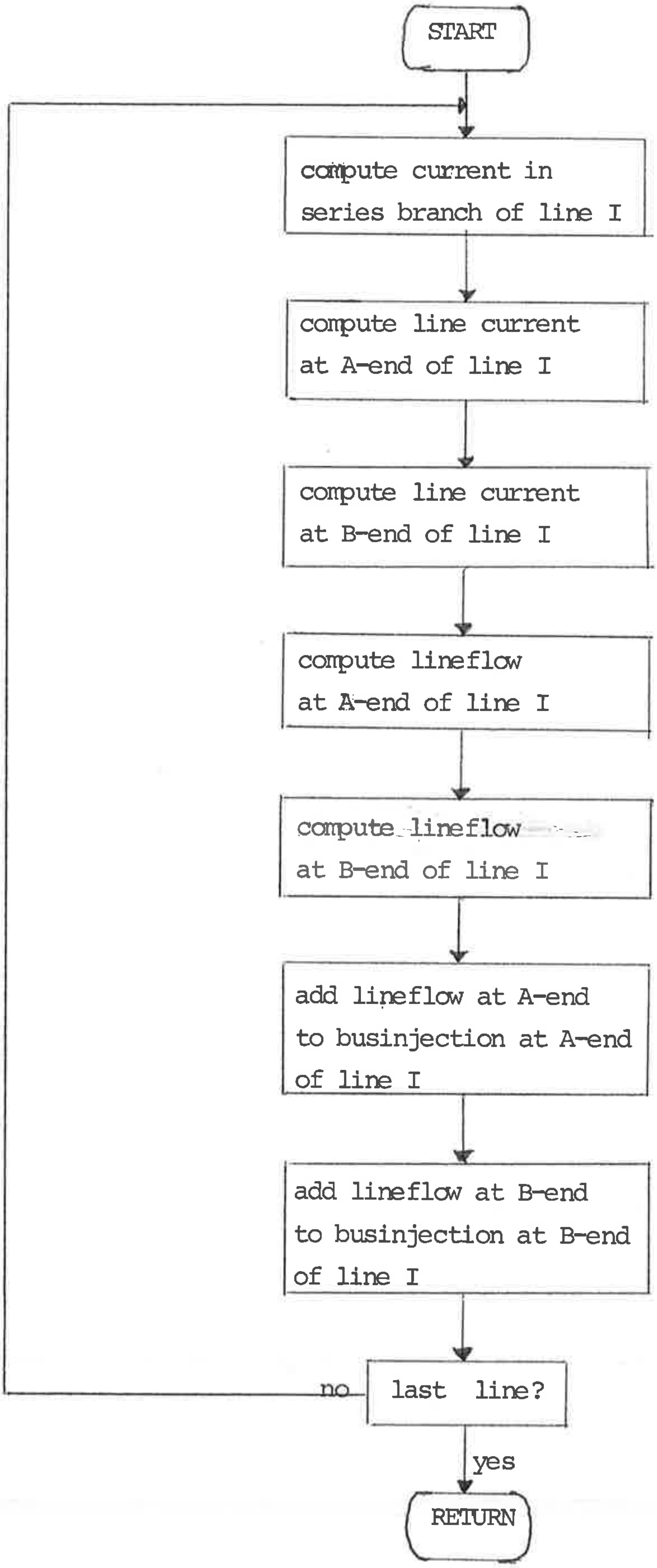
SUBROUTINE NRLFR (NB, NL, LTA, LTB, YAA, ZAB, YBB, SINJ, VB, EPS, IS, MAXIT, IPRINT, JFAIL)
Performs a conventional Newton-Raphson load flow to compute the true bus voltages. The subroutine TRUEV assumes that bus NB is the slack-bus.

SUBROUTINE DECOM (A, NN, IA, EPS, ISING)
SUBROUTINE SOLVB (B, X, NN, NNB, IA)
Solves the linear system of equations A × X = B by means of Gauss decomposition of matrix A (DECOM) and forward and backward substitution (SOLVB).
These routines are used in NRLFR and are taken form the program library of the Division of Automatic Control of the Lund Institute of Technology.

SUBROUTINE MPRI (A, M, N, IA, IND, IFORM, IERR)
Prints a matrix.
The routine is used in NRLFR and a few other routines. It is also taken from the above mentioned program library.

SUBROUTINE GXT (IPRINT, IERR)
Computes all other true variables from the true state.
Flow diagram:

Flow diagram:



4.5 The subroutines for computing the measurements.

SUBROUTINE CAWN (IPRINT)

Computes for all possible measurements the measurement noise weighting factors WN:

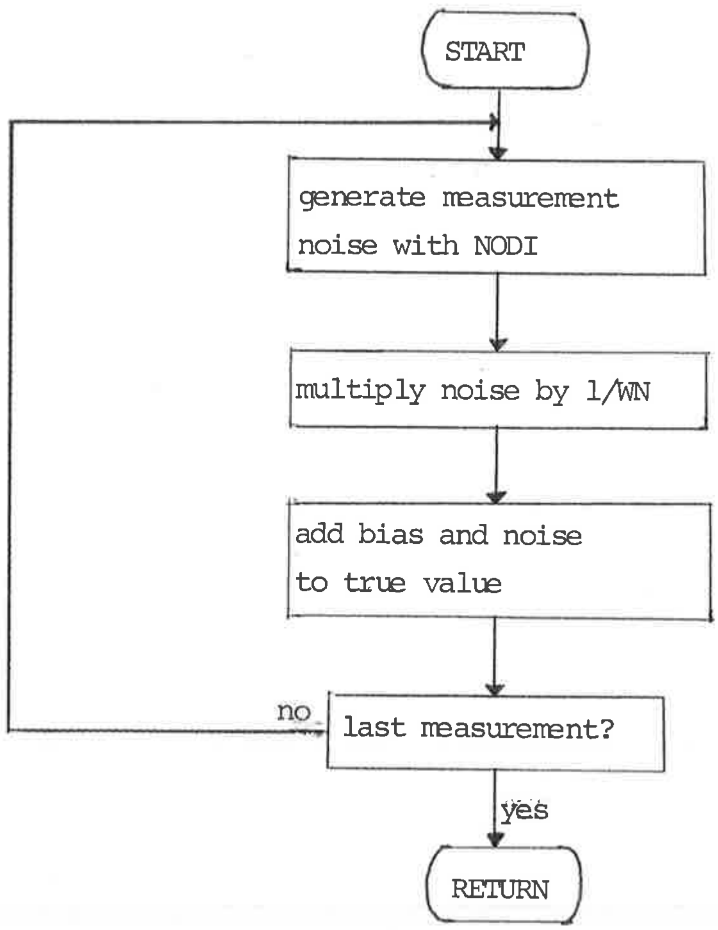
$$WN = \frac{1}{\alpha \times \text{full scale} + \beta \times \text{true value}}$$

The computed weighting factors are stored in the common block /METT/.

SUBROUTINE ALLMSM (NODD, IPRINT)

Computes all possible measurements.

flow diagram:



1

comments: for type 4, 5 and 6 the active and reactive measure. ments are treated separately.

ad 1. the subroutine NODI needs an odd number to generate random numbers. This is supplied by NODD in the subroutine call to ALLMSM. A good start value for NODD = 19. This must be supplied at the first call to ALLMSM. Successive calls to ALLMSM make use of the value of NODD upon exit of the previous call.

SUBROUTINE NODI (NODD, GAUSS)

function: to provide a random number from a standard normal N(0,1) probability distribution.

The routine is taken from the program library of the Division of Automatic Control and is used in ALLMSM.

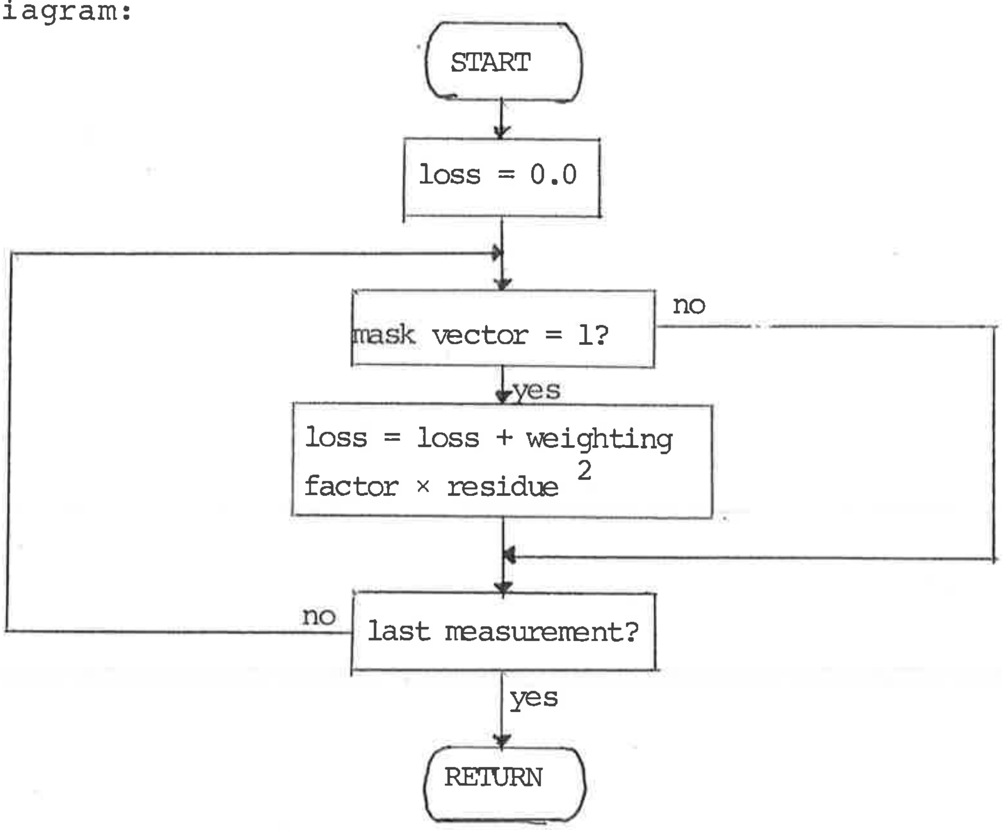
Some routines used by all methods.

FUNCTION ALOSS (IPRINT)

function: to calculate the loss function $\{\underline{y} - g(\underline{\hat{x}})\}^T W \{\underline{y} - g(\underline{\hat{x}})\}$

It is assumed that the matrix W is diagonal and that the residues $\underline{y} - g(\underline{\hat{x}})$ are given.

flow diagram:



comments: for type 4, 5, and 6 active and reactive measurements are treated separately; dependent on the value of the mask vector the active or reactive or both measurements are used in the calculation of the loss function.

SUBROUTINE CARES (IPRINT, IERR)
Computes the residues from the estimated state and the measurements. Before the residues first all estimated variables are computed with the subroutine GXT. The computed residues are stored in the common block /RES/.

SUBROUTINE PRRES
Prints the residues as stored in /RES/, the corresponding used measurements and estimated values.

SUBROUTINE CAWF (IPRINT)
Computes the weighting factors WF for all possible measurements. Only the weighting factors of the measurements processed by the estimator are used in the calculations of the loss function.

SUBROUTINE PRWF
prints all weighting factors as stored in the common block /METE/.

4.6 The jacobian routines.

The following four routines make use of the formula's given in the Appendix of /1/ for rectangular coordinates. These routines are used by both method A and B.

SUBROUTINE JACV (U, DU, IR, ID, IERR)
Computes the two non zero jacobian elements for a voltage measurement.

SUBROUTINE JACI (VA, UB, ZAB, YAA, DI, IR, ID, IERR)
Computes the four non zero jacobian elements for a line current measurement.

SUBROUTINE JACLF (M, UA, UB, ZAB, YAA, DP, IRP, DQ, IRQ, ID, IERR)
Computes the non zero jacobian elements for an active, reactive or both lineflow measurements dependent on the value of the mask vector.

SUBROUTINE JACBI (M, IA, DPI, IRP, DQI, IRQ, ID, IERR)
Computes the jacobian row(s) for an active, a reactive or both bus injection measurements, dependent on the value of the mask vector. The row(s) are calculated by computing the jacobian elements of all lineflow measurements at the bus concerned.

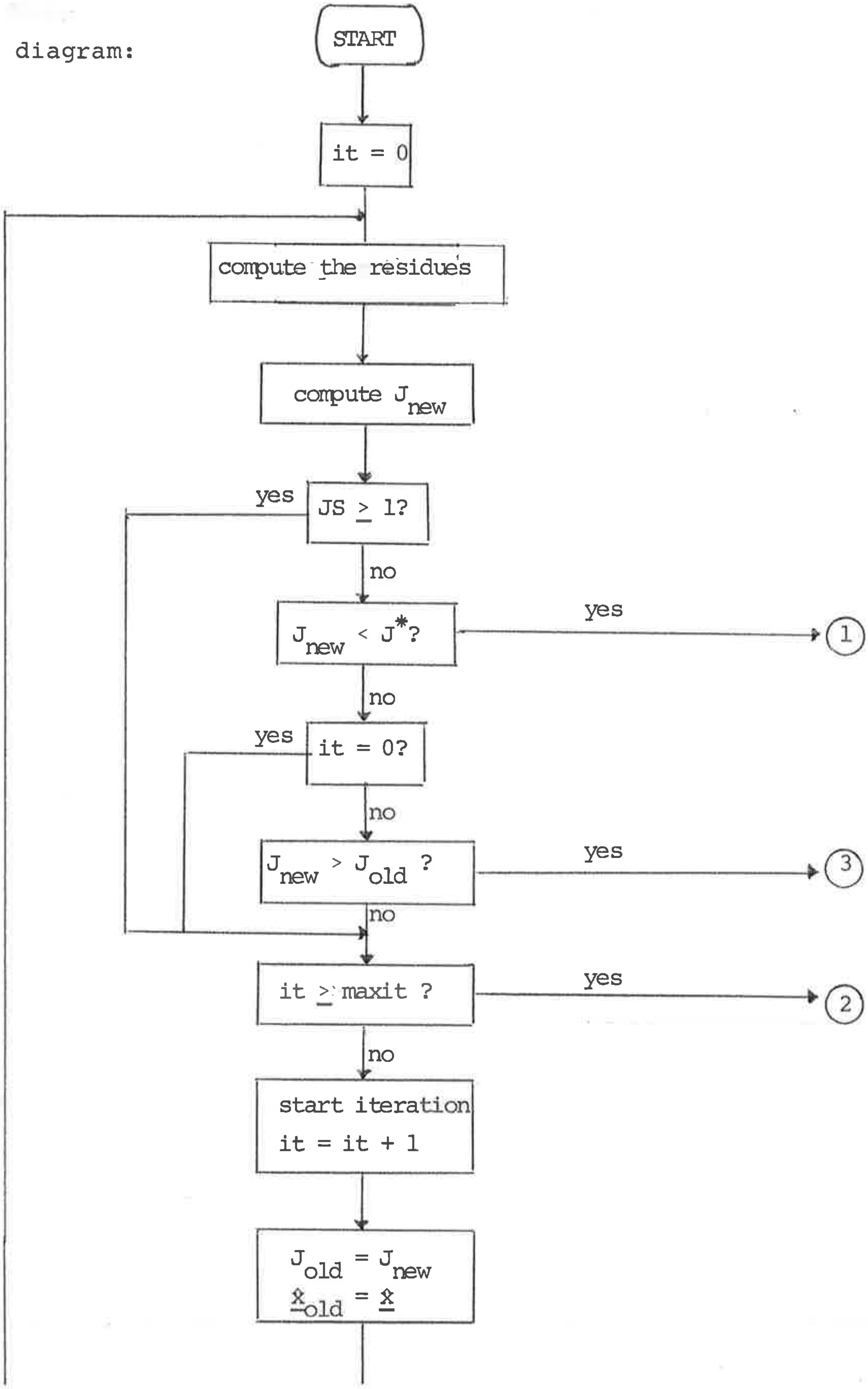
SUBROUTINE CAJAC (IPRINT, IERR)
Computes the jacobian for method A using the previous four routines. Only the jacobian elements of the measurements used by estimator A are computed.

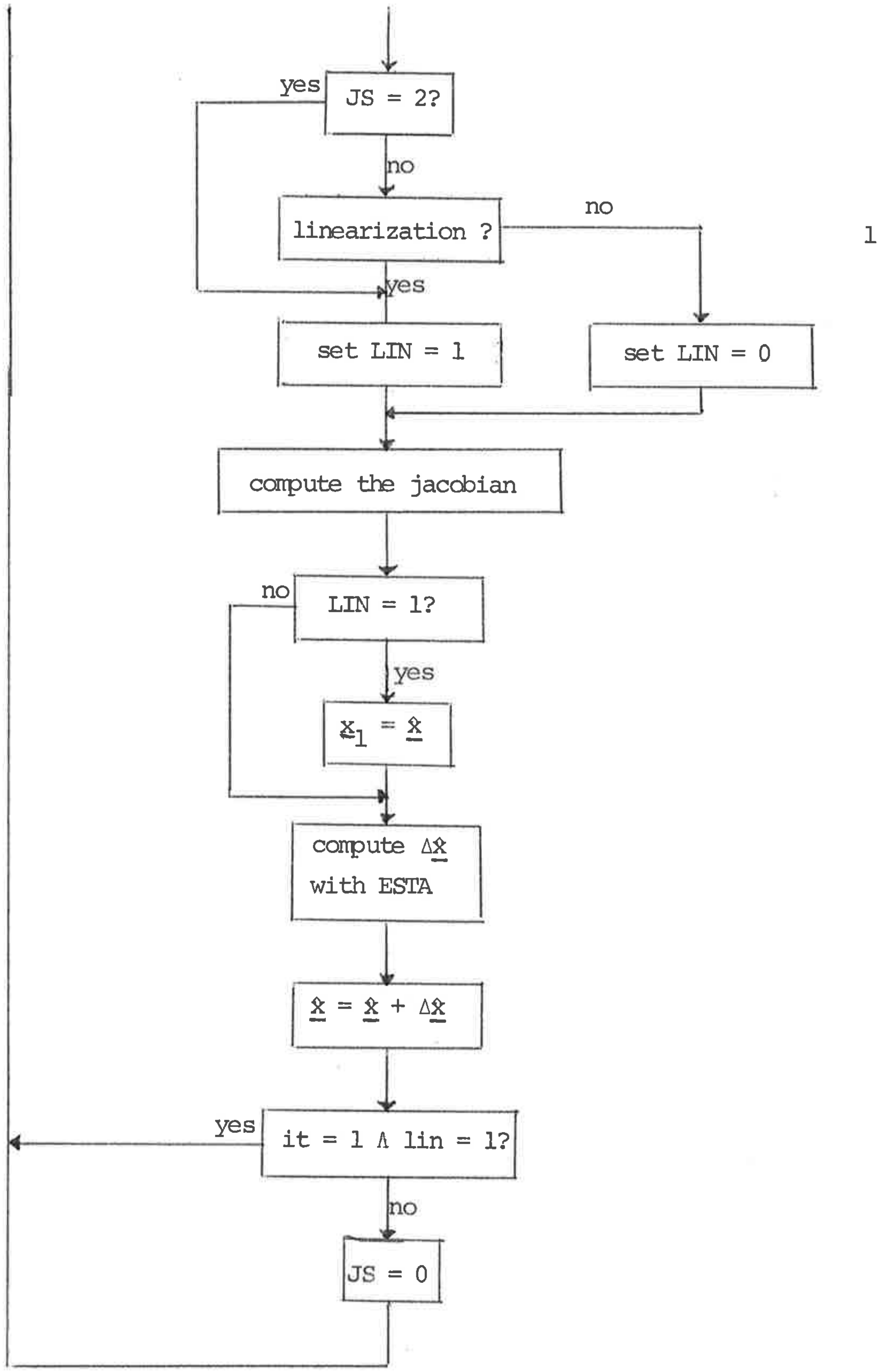
SUBROUTINE PRJAC
Prints the jacobian as stored in the common block /JAC/.

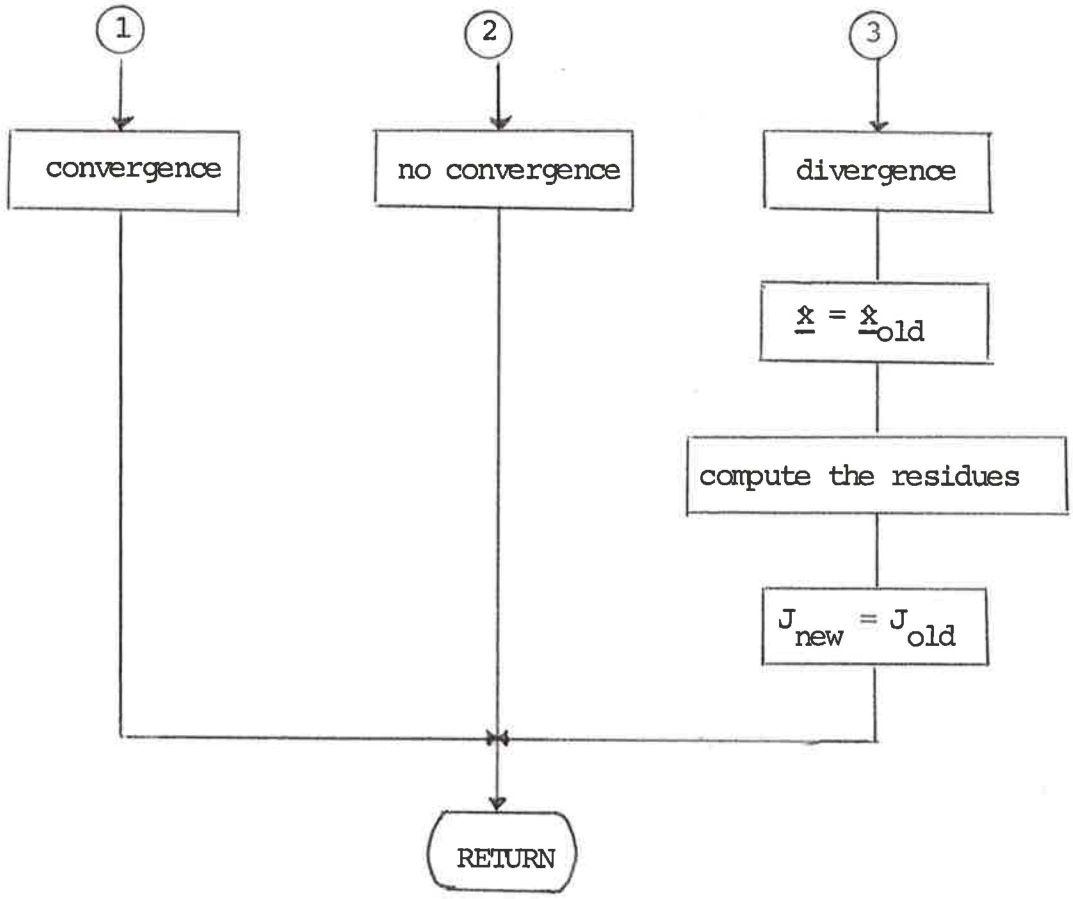
4.7 The routines and mainprogram for method A.

SUBROUTINE ADMA (MAXIT, JS, CRLOSS, XL, CRLIN, IEXIT, TIME, IPRINT)
Main routine for method A.
Flow diagram:

Flow diagram:




JS = 2?
yes
no
linearization ?
no
1
yes
set LIN = 1
set LIN = 0
compute the jacobian
LIN = 1?
no
yes
$\underline{x}_1 = \underline{\hat{x}}$
compute $\Delta\underline{\hat{x}}$
with ESTA
$\underline{\hat{x}} = \underline{\hat{x}} + \Delta\underline{\hat{x}}$
it = 1 ∧ lin = 1?
yes
no
JS = 0


1
2
3
convergence
no convergence
divergence
x = x_old
compute the residues
J_new = J_old
RETURN

2

comments:

ad 1. The linearization decision is made by computing the norm of the vector $\underline{x}_1 - \hat{\underline{x}}$, where $\underline{x}_1$ is the last linearization point. When this norm comes over a critical value (CRLIN in the subroutine call) a linearization is done around the present estimate.
The estimator can operate in various modes determined by JS

JS	mode
0	Normal operation, iterate till loss function is less than the critical loss J^* (CRLOSS in the subroutine call) or till the maximum number of iterations (MAXIT). Linearize if necessary.
1	Iterate at least once irrespective of the value of the loss function. Upon exit JS = 0.
2	Linearize in two iterations (if maxit permits this). Upon exit (MAXIT $\geq$ 2) is JS = 0.

Table 4-1 Estimator modes for method A.

Examples:
JS = 2, MAXIT = 3: Start up of the estimator from e.g. flat voltage. In the first iteration a linearization is made around the flat voltage profile. In the second around the estimate obtained after the first iteration.
JS = 0, MAXIT = 1: Normal operation under normal conditions.

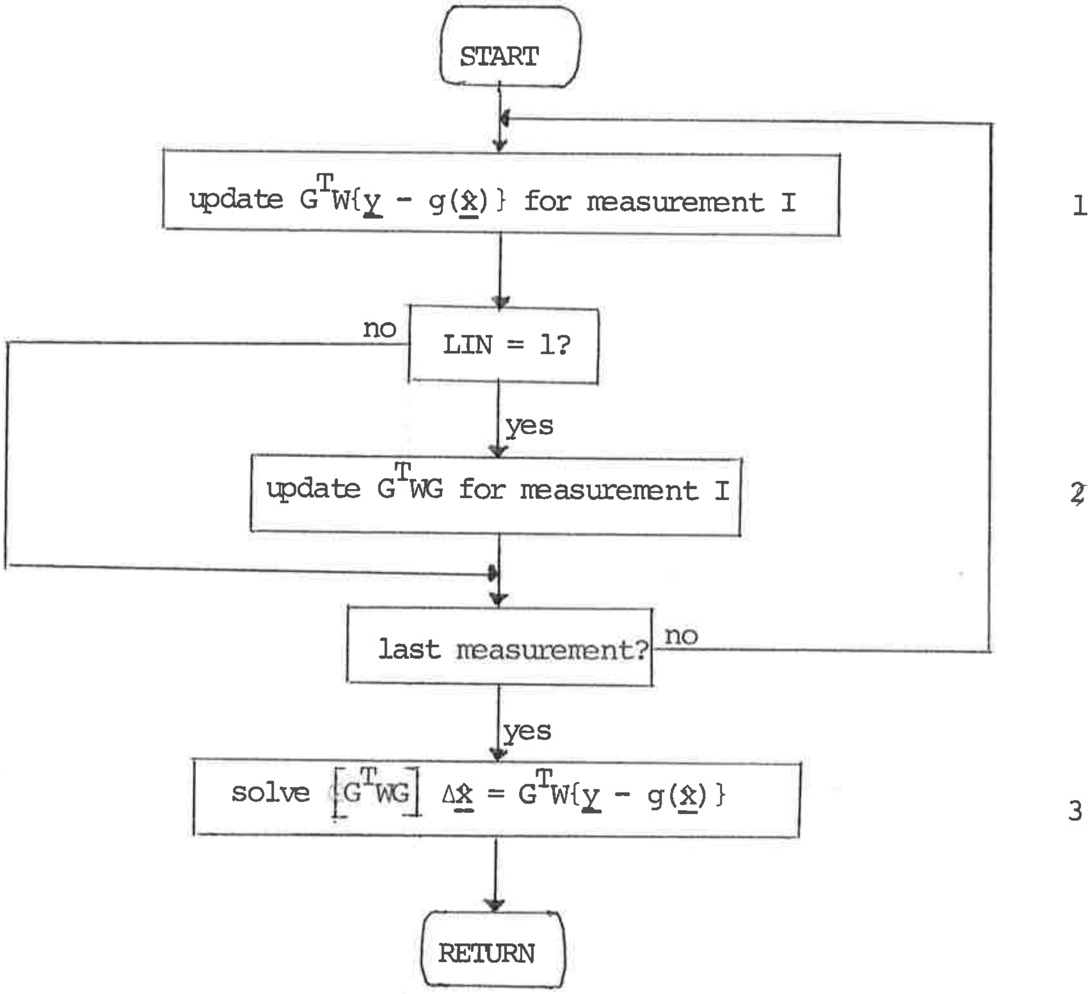
Ad 2. When after an iteration the loss function has increased the divergence exit is taken. The estimate is set equal to the estimate after the previous iteration. The residues are calculated again and the loss is set equal to the loss after the previous iteration.

SUBROUTINE ESTA (LIN, DX, IPRINT, IERR)
Performs one iteration of method A by solving

$$\left[G^T(\underline{x}_1)WG(\underline{x}_1)\right] \Delta\hat{\underline{x}} = G^T(\hat{\underline{x}})W\{\underline{y} - g(\hat{\underline{x}})\}$$

It is assumed that the jacobian G and the residues $\underline{y} - g(\hat{\underline{x}})$ are available in the common blocks /JAC/ and /RES/.
Flow diagram:

Flow diagram:



comments:

ad 1. See subroutine UPDBA

ad 2. See subroutine UPDAA

ad 3. This is done by the subroutines DESYM and SOLVS. A mistake in the present realization is that DESYM is also called when there is no linearization (LIN = 0). This means that G^TWG is decomposed every time ESTA is called. See the item on computing times in /2/.

SUBROUTINE DESYM (A, G, N, EPS, IRANK, IA)
SUBROUTINE SOLVS (G, B, X, NN, NNB, IA)
Solves the linear system of equations $A \times X = B$ for a symmetric A matrix by triangularization (decomposition) of A (DESYM) and forward and backward substitution (SOLVS). These routines are taken from the program library of the Div. of Automatic Control of the Lund Institute of Technology.

SUBROUTINE UPDAA (INDEX, ELT, NOE, WI, A)
Updates $G^T(\underline{x}_1)WG(\underline{x}_1)$ for a measurement. The NOE non-zero elements of G that have to do with the measurement are given in the vector ELT. The NOE elements in INDEX give the corresponding places of the jacobian elements in the complete jacobian row. WI is the weighting factor for the measurement and A the matrix to be updated.

example:

NOE = 2   INDEX(1) = 1   ELT(1) = 2.0   WI = 2
           INDEX(2) = 3   ELT(2) = 4.0

matrix A before updating

0	0	0
0	0	0
0	0	0

matrix A after updating

8	0	16
0	0	0
16	0	32

In this way multiplications with zero are avoided in computing G^TWG, but this implementation also asks much computing time because of the complicated subroutine call. This can be improved by transferring a number of variables (e.g. matrix A) through common blocks.

SUBROUTINE UPDBA (INDEX, ELT, NOE, WI, B, RES)
Updates $G^T(\underline{\hat{x}}_k)W\{\underline{y} - g(\underline{\hat{x}}_k)\}$ for a measurement. Since W is diagonal only the places corresponding to non zero jacobian elements are changed in the right hand vector.

INDEX, ELT and NOE are organized in the same way as in UPDAA. WI is again the weighting factor while RES is the residue for the measurement. B is the righthand vector.

example:

NOE = 2	INDEX(1) = 1	ELT(1) = 2.0	WI = 2	RES = 0.25
	INDEX(2) = 3	ELT(2) = 4.0		

B before updating	B after updating
0	1
0	0
0	2

Concerning computing time the same can be said as for UPDAA.

Mainprogram MAINA

The three mainprograms for the three methods all are organized as sketched in fig. 2.1. The only differences are the estimator parameters read in part 1 of fig. 2.1 the initialization of the estimator at time point 0 and of course the used estimator: ADMA, ADMB and ADMC respectively.
For method A the estimator parameters that are read are given in the following table:

MAXIT	maximum number of iterations
JS	estimator mode, see ADMA, table 4-1
CRLOSS	the critical value of the loss function: J^*
CRLIN	the linearizing distance: $\Delta \underline{x}_1$

Table 4-2 Estimator parameters for ADMA

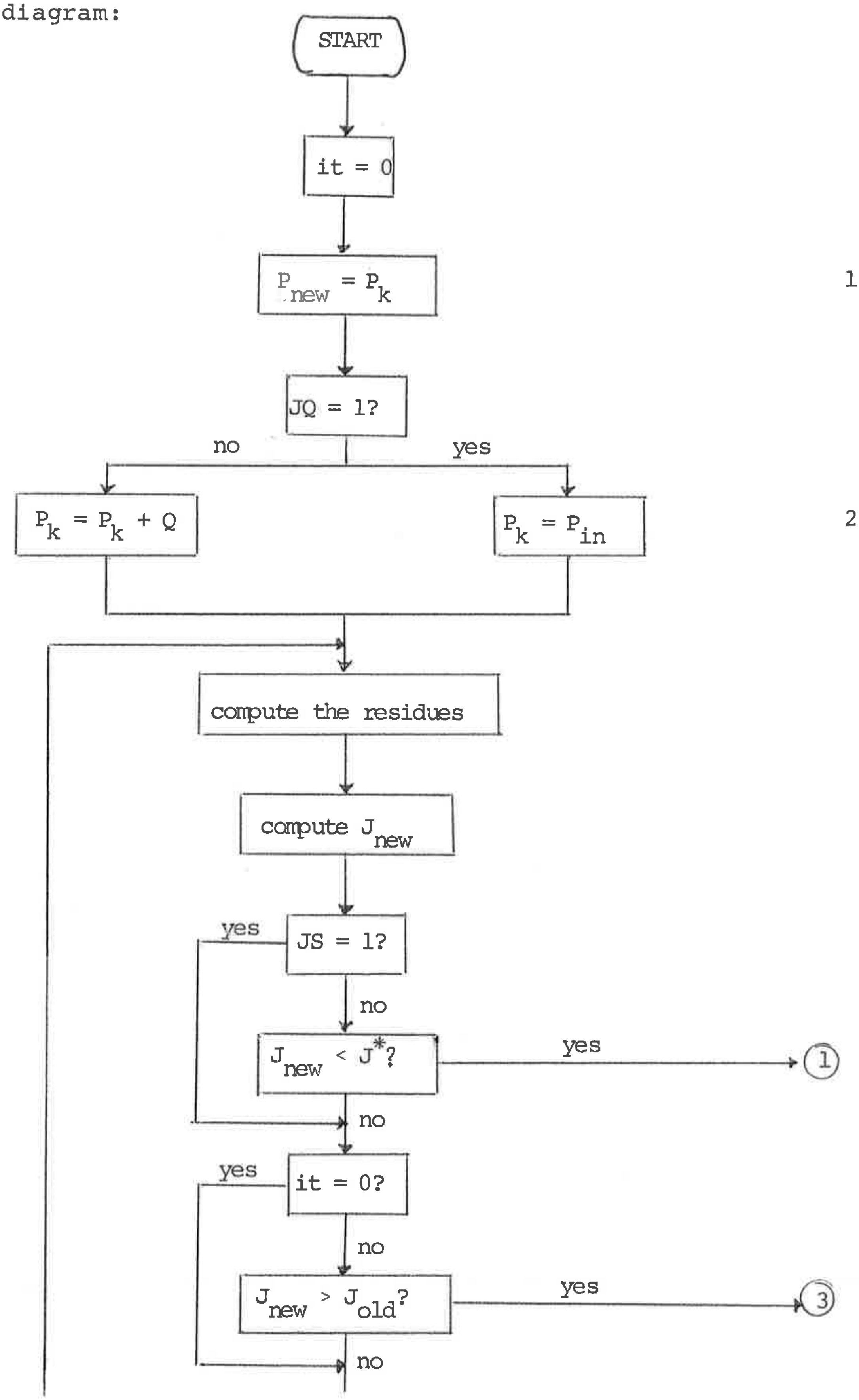
Estimator A is initialized by setting the initial estimate at t = 0 equal to the true state and linearizing around the true state in one iteration. So we know that the estimator starts with G^TWG computed at the true state.
At the end of the program all evaluation quantities are printed for all time points and the totals. See also the description of the subroutine EVAL and the common block /EVL/.

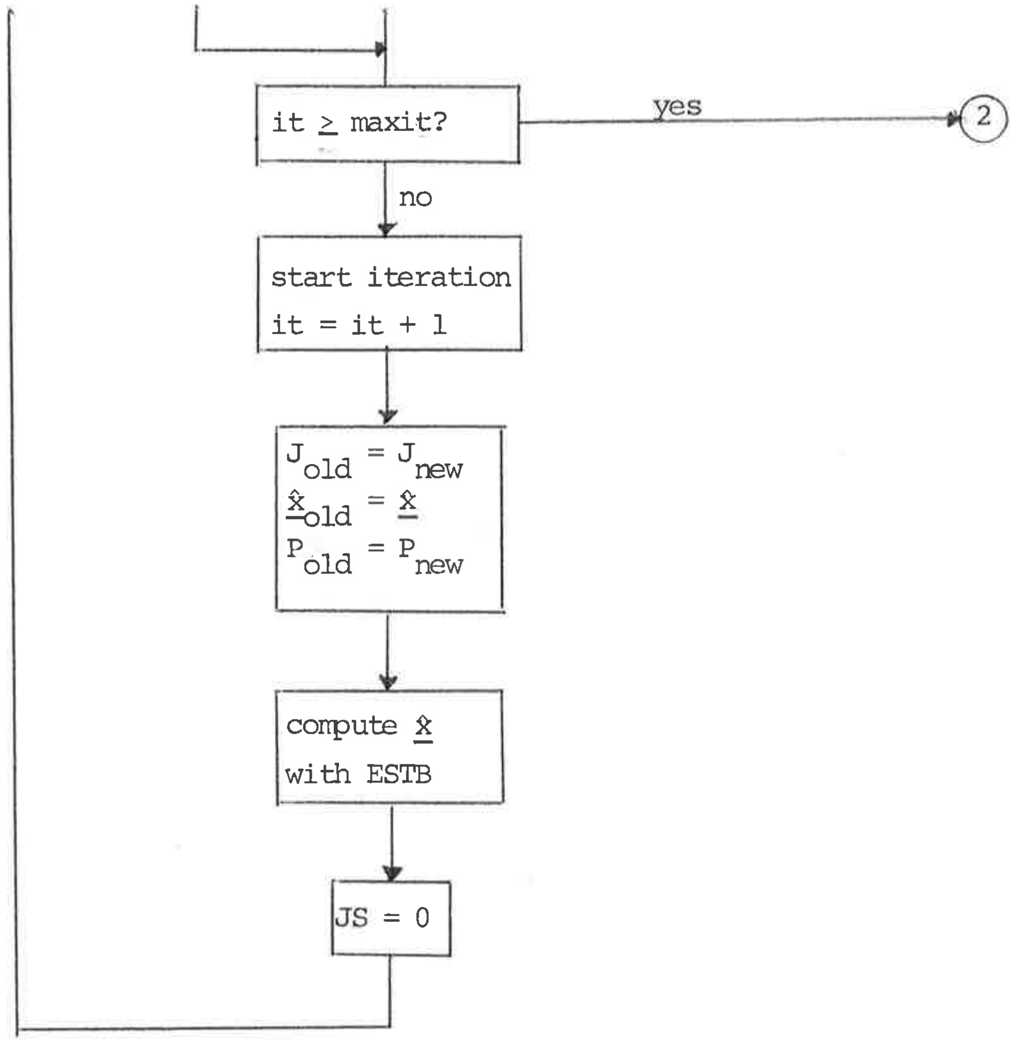
The data needed for the plotprogram (the estimation error, the lineflow error, and the measurement index for all time points) are written in internal code to a file with internal filename 1. For more details see the programlisting.

4.8 The routines and mainprogram for method B.

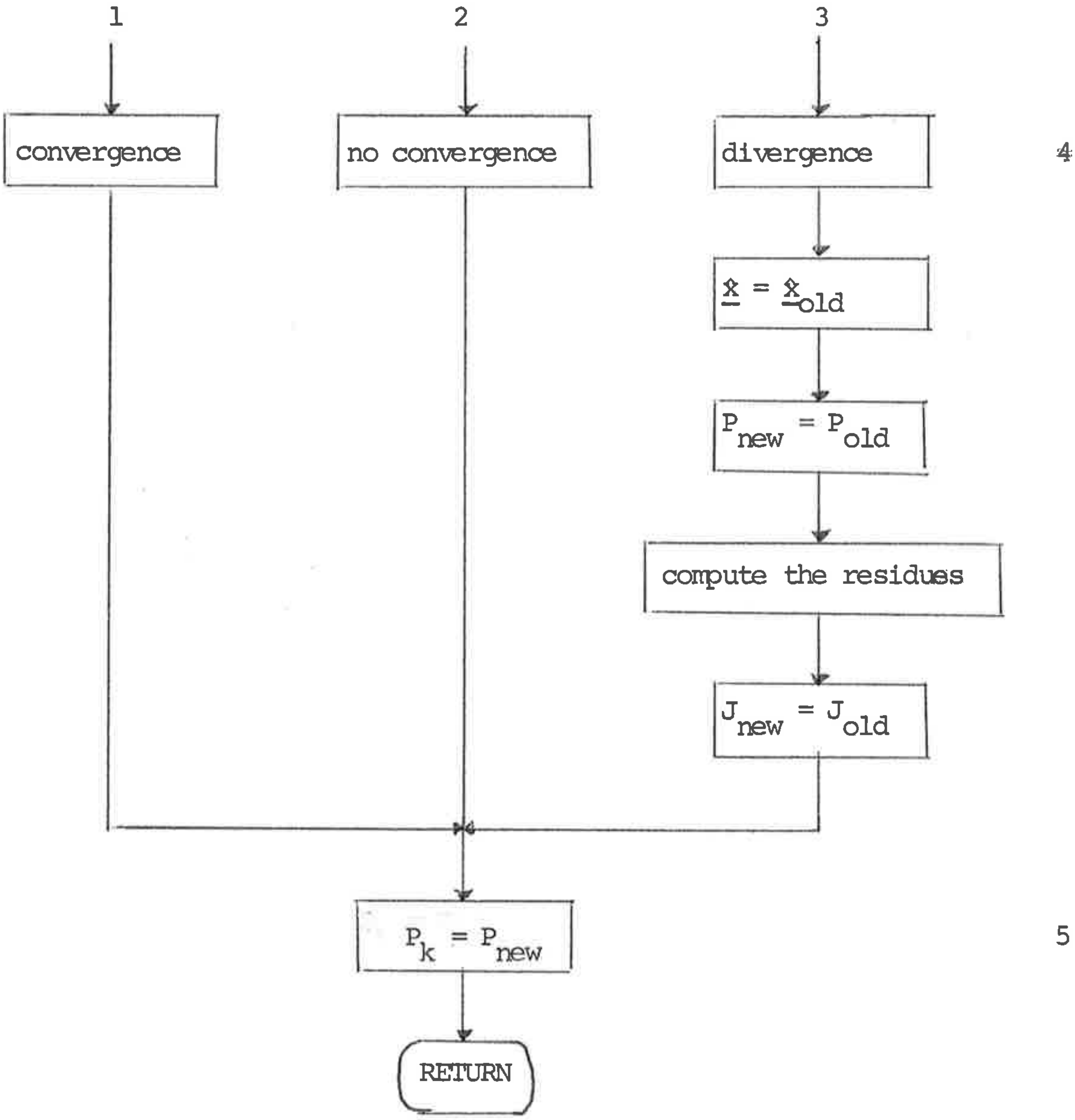
SUBROUTINE ADMB (MAXIT, JS, CRLOSS, JQ, PIN, Q, IEXIT, TIME, IPRINT)
Main routine for method B.
Flow diagram:

Flow diagram:




it ≥ maxit?
yes
2
no
start iteration
it = it + 1
J_old = J_new
x̂_old = x̂
P_old = P_new
compute x̂
with ESTB
JS = 0

3


1
2
3
convergence
no convergence
divergence
4
$\underline{\hat{x}} = \underline{\hat{x}}_{old}$
$P_{new} = P_{old}$
compute the residues
$J_{new} = J_{old}$
$P_k = P_{new}$
5
RETURN

comments:

ad 1. P_k and P_{new} are stored in the common block /VAR/ in COV(I) and PNEW(I) respectively.

ad 2. Note that the contents of P_k are not changed during iterations. So each iteration starts with the same P_k.

The estimator can operate in various modes determined by JS and JQ. They are given in the following table.

JS	mode
0	Normal operation, iterate till loss function is less than the critical loss J^* or till the maximum number of iterations.
1	Iterate at least once irrespective of the value of the loss function.

JQ	mode
0	To the final diagonal P-matrix after the previous time point a certain diagonal Q-matrix is added to be used as initial covariance for each iteration.
1	The initial covariance matrix before each iteration has all diagonal elements equal to P_{in}.

Table 4-3 Estimator modes for method B.

Ad 3. In ESTB P_{new} is computed.

Ad 4. Concerning divergence the same can be said as for ADMA, only here the covariance also has to be restored.

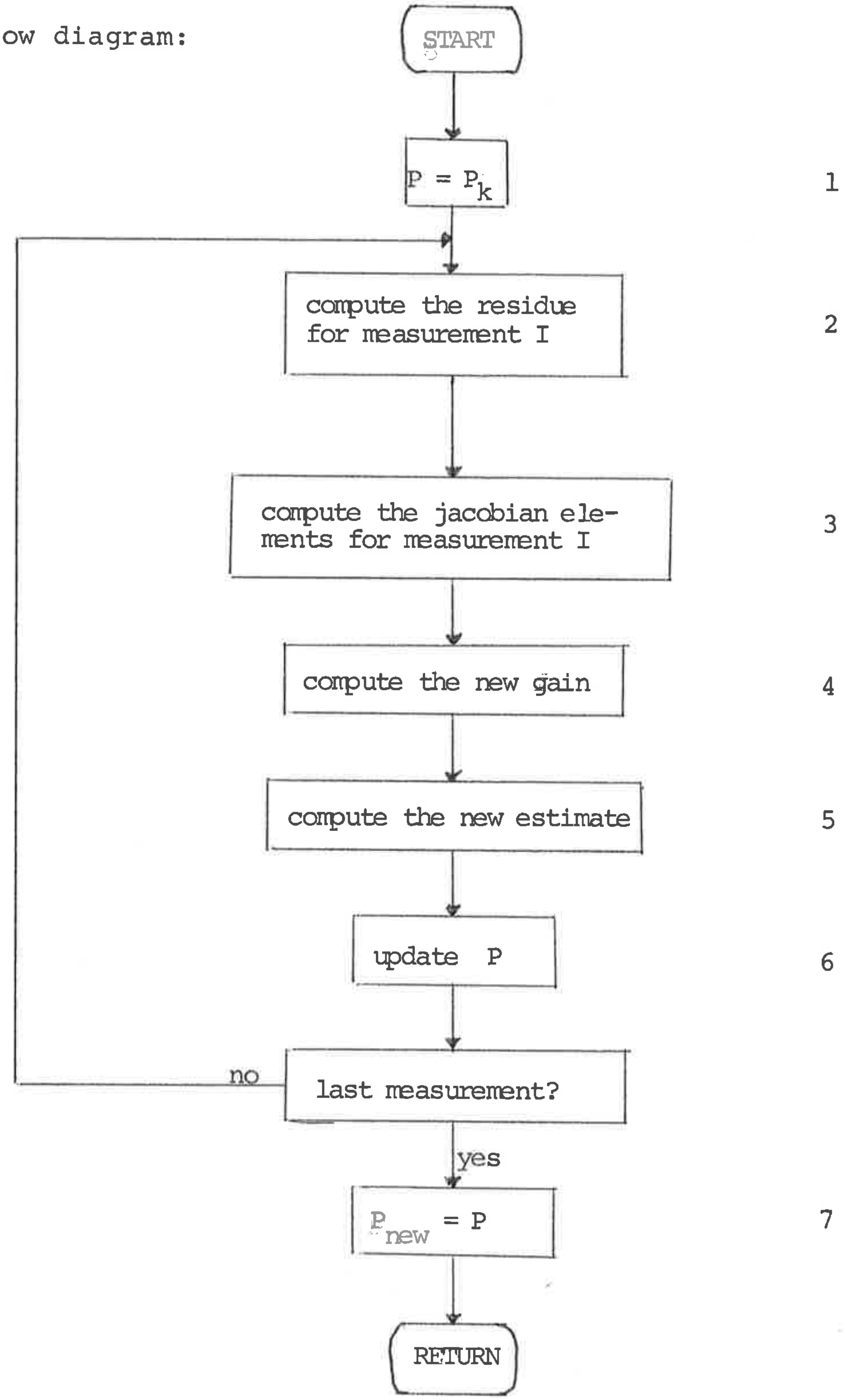
Ad 5. Note that first here P_k (COV(I) in /VAR/) is changed again after 2.

SUBROUTINE ESTB (IPRINT, IERR)

Performs one iteration of method B.

Flow diagram:

Flow diagram:



comments:

Ad 1 + 7. P_k and P_{new} are stored in the common block /VAR/ and PNEW(I) respectively.

Ad 2. The residue for each measurement is computed in ESTB. CARES can not be used in ESTB because the estimate changes during the measurement processing.

Ad 3. The jacobian routines JACV, JACI, JACLF and JACBI are used.

Ad 2 - 6. For the measurement processing use is made of the measurement order information stored in /MSI/. See the description of this common block.

Ad 4 - 6. For type 2, 3, 4 and 5 measurements only four gain elements are non-zero and only four P- and estimate elements are changed. Therefore there was written a separate subroutine for type 2 - 5 measurements: the subroutine UPDEP.

SUBROUTINE UPDEP (IA, IB, RES, WF, G, P, AK, XE)
See the comments of ESTC.

Mainprogram MAINB.

The general remarks mentioned with MAINA are also valid here. The estimator parameters read by MAINB are given in the following table:

MAXIT	maximum number of iterations
JS	mode parameters. See ADMB, table 4-3
JQ	mode parameters. See ADMB, table 4-3
CRLOSS	the critical value of the loss function J^*
PIN	the value of all diagonal elements of the initial covariance matrix when JQ = 0. See table 4-3
Q(I)	vector of elements to be added to the initial covariance matrix when JQ = 1. See table 4-3

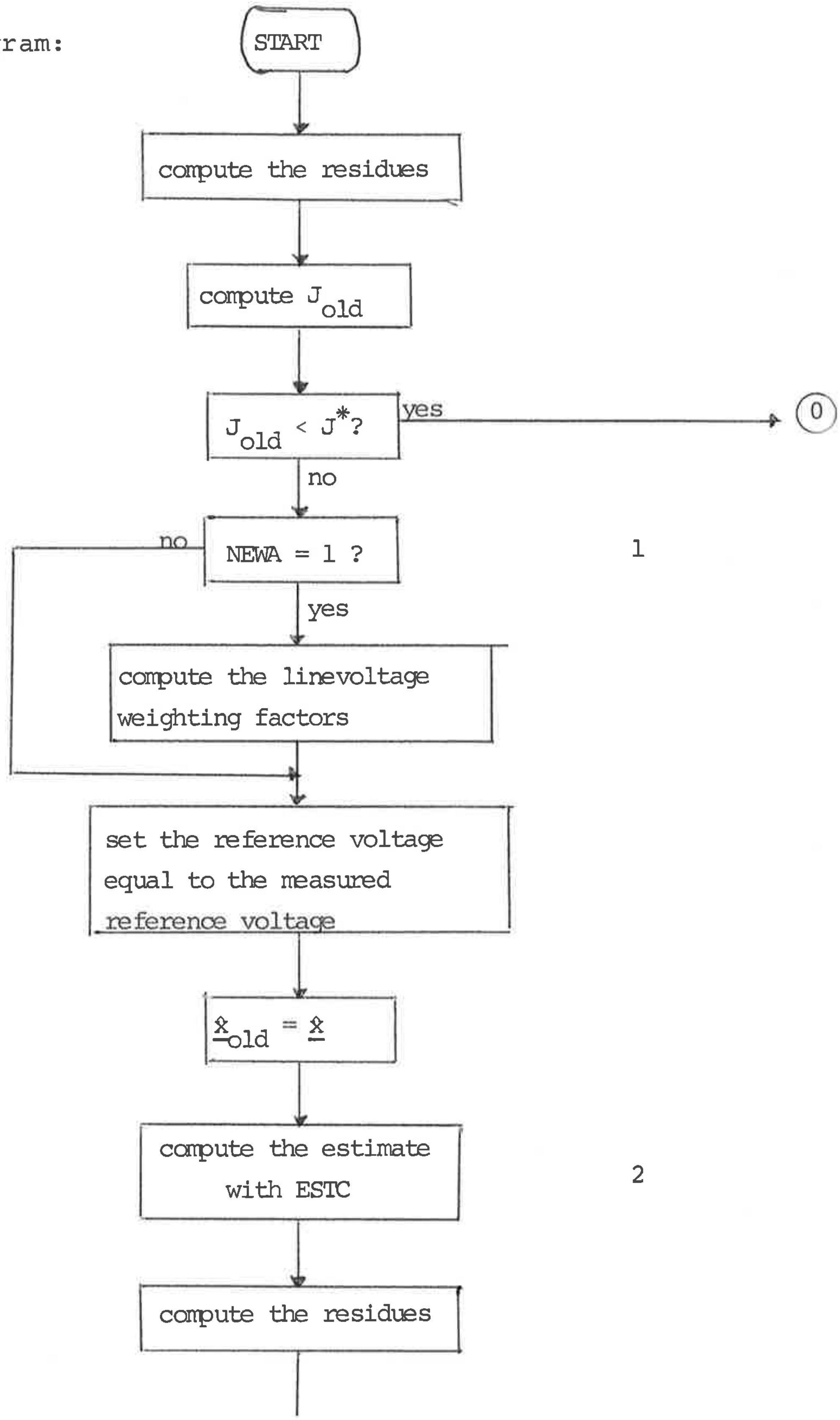
Table 4-4 Estimator parameters for ADMB.

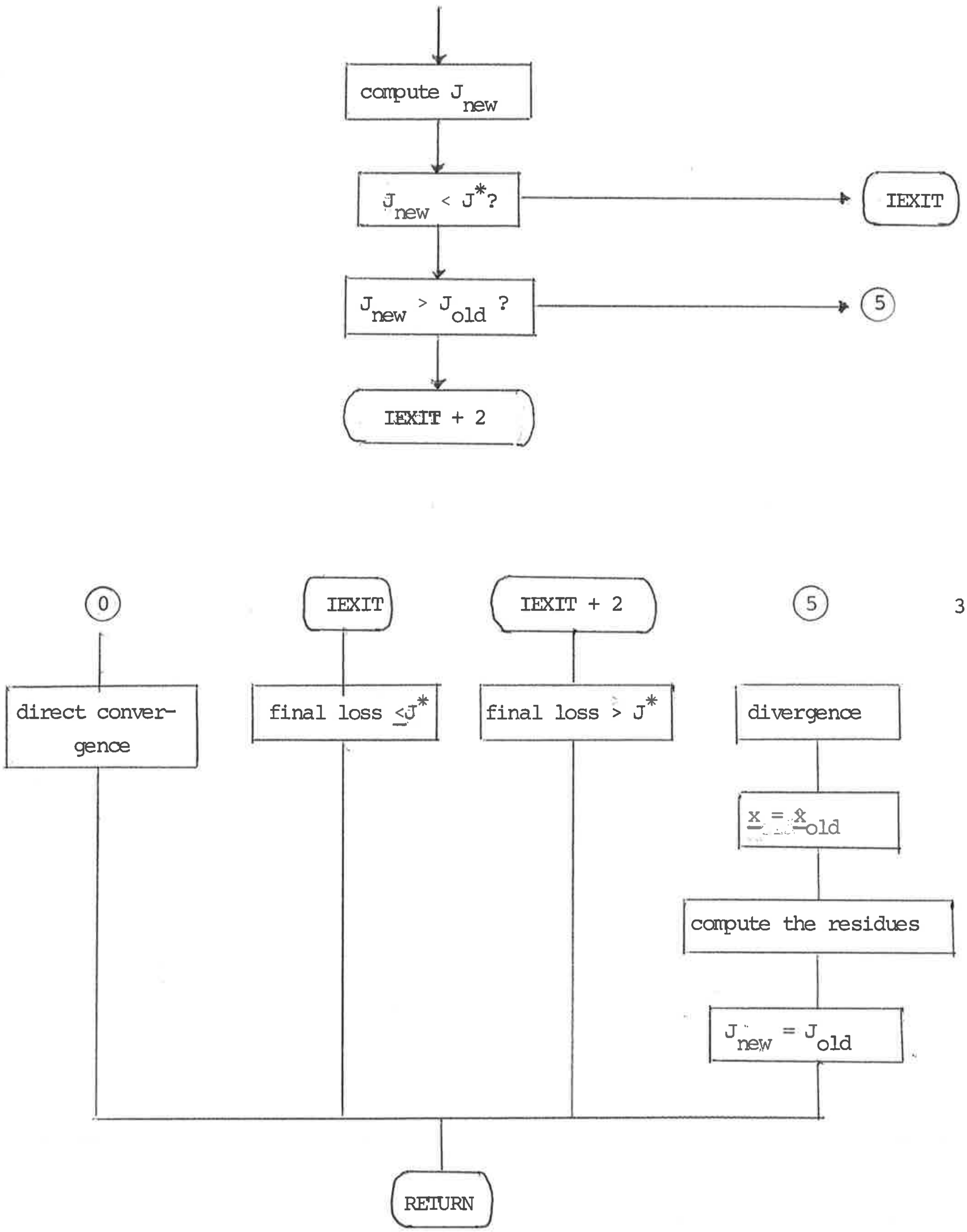
The estimator is initialized by setting the initial estimate at t = 0 equal to the true state and performing one iteration of ADMB with JS = 1, JQ = 1 and all elements of the diagonal cov. matrix equal to the value read in PIN.

4.9 The routines and mainprogram for method C.

SUBROUTINE ADMC (NEWA, CRLOSS, MAXIT, EPS, IEXIT, TIME, IPRINT)
Main routine for method C.
Flow diagram:

Flow diagram:




compute J new
J new < J*?
IEXIT
J new > J old ?
5
IEXIT + 2
0
IEXIT
IEXIT + 2
5
3
direct convergence
final loss ≤J*
final loss > J*
divergence
x = x old
compute the residues
J new = J old
RETURN

comments:

Ad 1 + 2. The subroutine ESTC needs the line voltage weighting factors. These are computed by the subroutine CAD.

Ad 2 + 3. The computation of the estimate in ESTC is done iteratively. This iteration process may or may not convergence. This is represented by IEXIT = 1 or 2 respectively. But this convergence is independent from convergence in the sense of the loss function: $J < J^*$. Therefore there are five exit possibilities. See also ESTC.

SUBROUTINE CAD (DA, DB, IPRINT).

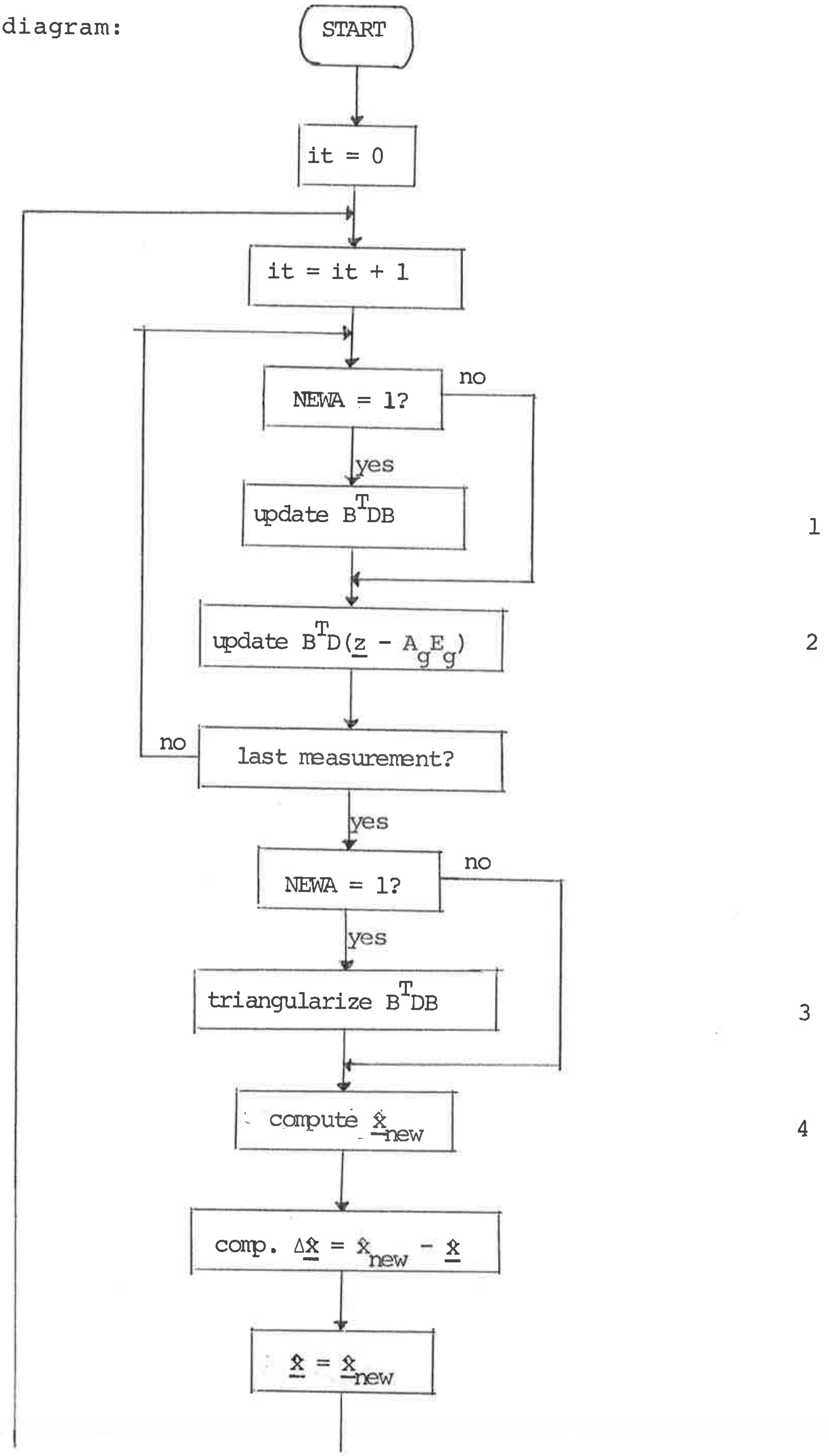
Computes the linevoltage weighting factors for the active line-flow measurements. Only the active weighting factors are used since method C assumes that both the active and reactive measurement are available.

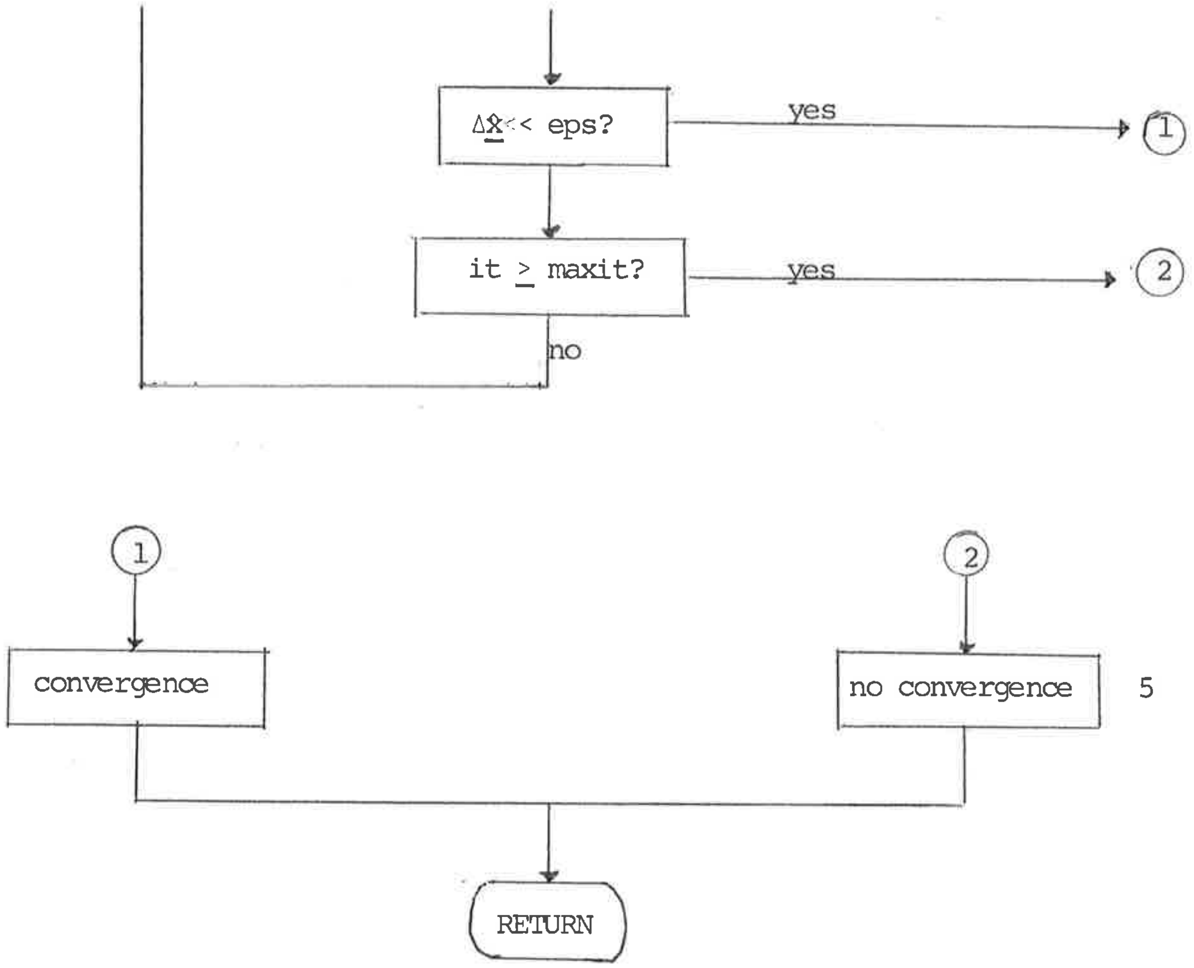
SUBROUTINE ESTC (NR, DA, DB, MAXIT, EPS, NEWA, IEXIT, TIME, IPRINT)

Basis routine for method C.

Flow diagram:

Flow diagram:




Δx < eps?
yes
1
it ≥ maxit?
yes
2
no
1
2
convergence
no convergence
5
RETURN

comments:

Ad 1 + 2. The updating of B^TDB is done by the subroutine UPDAC. It is assumed that the linevoltage weighting factors D are already calculated. The updating of the righthand side vector $B^TD(\underline{z} - A_gE_g)$ is done by UPDBC. Note that B and D are real and that $\underline{z} - A_gE_g$ is complex.

Ad 3 + 4. The triangularization is done by DESYM. The solution of $[B^TDB]\hat{E}_{new} = B^TD(\underline{z} - A_gE_g)$ is done by solving the two sets of equations, one for the real parts of $\hat{\underline{E}}$ and one for the imaginary parts, by SOLVS. Note that the dimension of B^TDB is about half of the corresponding G^TWG-matrix in ESTA.

Ad 5. See the comments on IEXIT in ADMC.

ESTC is written to have more than one reference voltage in E_g but ADMC uses ESTC with only one reference voltage.

SUBROUTINE UPDAC (IA, IB, DA)

Updates the matrix B^TDB for a complex lineflow measurement. The subroutine functions in the same way as UPDAA. Note that in this routine the matrix to be updated is given in the common block /MAT/.

SUBROUTINE UPDBC (CB, IA, IB, NR, XEA, XEB, ZL, YA, CYM, CLV, DA)

Updates $B^TD(\underline{z} - A_gE_g)$ for a complex lineflow measurement. The subroutine computes the complex linevoltage CLV from the complex lineflow measurement CYM. It functions in the same way as UPDBA. The only difference is the implementation of the term $-B^TDA_gE_g$. Also here E_g may consist of more than one reference voltage.

See ESTC.

Mainprogram MAINC.

The general remarks in MAINA are also valid here.

The estimator parameters read by MAINC for ADMC are:

NEWA	If NEWA = 1 a new B^TDB matrix is computed. This is only necessary when there has been a change in network structure. So normal operation is NEWA = 0.
MAXIT	Maximum number of iterations for ESTC.
CRLOSS	The critical loss J^* for ADMC.
EPS	Convergence criterion for ESTC.

Table 4-5 Estimator parameters for ADMC.

The estimator is initialized by setting the initial estimate at time point 0 equal to the true state. An estimate with method C is done in which B^TDB is calculated. Direct convergence is avoided by setting $J^* = 1.0$.

4.10 The subroutine EVAL.

SUBROUTINE EVAL (K, IPRINT)

The subroutine computes the following quantities at a time point:

- the estimation error.
- the maximum element in the estimation error.
- the lineflow error.
- the maximum element in the lineflow error.
- the measurement index.

It updates the following quantities:

- the average estimation error.
- the maximum estimation error.
- the maximum element in all estimation errors.
- the average lineflow error.
- the maximum lineflow error.
- the maximum element in all lineflow errors.
- the average measurement index.
- the maximum measurement index.

All these quantities are stored in /EVL/. The average values AEE, AEL and AEM are updated by adding the corresponding computed errors. To obtain the real average values AEE, AEL and AEM have to be divided by the number of time points. For the organization of the evaluation data see the description of EVL.

4.11 The plotprogram.

Mainprogram PLT.

This program is used to plot a number of plots from either MAINA, MAINB or MAINC. It is build around the plotroutine RITA from the program library from the Div. of Automatic Control of the Lund Institute of Technology.
For each plot the data is read from an internal file with internal filename 10+ plotnumber. So if there have to be plotted 4 plots the plotdata have to be supplied to PLT in files with names 11, 12, 13, and 14 respectively.

5. The program listings.

The chapter starts with a table showing the relationships between the routines and mainprograms. The remainder consists of the program listings of the subroutines ordered alphabetically and the listings of the four mainprograms.

ROUTINE/PROGRAM	CALLS:					
ADMA	ALOSS	CAJAC	CARES	ESTA	PRRES	PRWF
ADMB	ALOSS	CARES	ESTB	PRRES	PRWF	
ADMC	ALOSS	CAD	CARES	ESTC	PRRES	
ALLMSM	NODI					
ALOSS	PRRES					
CAD						
CAJAC	JACBI	JACI	JACLF	JACB	PRENET	PRJAC
CARES	GXE	PRRES				
CASDB						
CAWF						
CAWN						
DECOM[1)]						
DESYM[1)]						
ELDNL						
ESTA	DESYM	MPRI	PRJAC	PRRES	SOLVS	UPDAA
	UPDBA					
ESTB	JACBI	JACI	JACLF	JACV	UPDEP	
ESTC	DESYM	MPRI	SOLVS	UPDAC	UPDBC	
EVAL						
GXE	PRENET					
GXT	PRTNET					
JACBI	JACLF					
JACI						
JACLF						
JACV						
MPRI[1)]						
NODI[1)]						
NRLFR	DECOM	MPRI	SOLVB			

[1)] program library Div. of Autom. Control, Lund Institute of Techn.

Table 5-1 Relationships between routines and programs (Part 1 of 4).

PRENET						
PRJAC						
PRRES						
PRTNET						
PRWF						
RDENET	PRENET					
RDGEN						
RDLD						
RDMETE						
RDMETT						
RDMSM						
RDTNET	PRTNET					
SOLVB[1]						
SOLVS[1]						
TRUEV	ELDNL	GXT	NRLFR			
UPDAA						
UPDAC						
UPDBA						
UPDBC						
UPDEP						
MAINA	ADMA	ALLMSM	CASDB	CAWF	CAWN	EVAL
	RDENET	RDGEN	RDLD	RDMETE	RDMETT	RDMSM
	RDTNET	TRUEV				
MAINB	ADMB	ALLMSM	CASDB	CAWF	CAWN	EVAL
	RDENET	RDGEN	RDLD	RDMETE	RDMETT	RDMSM
	RDTNET	TRUEV				
MAINC	ADMC	ALLMSM	CASDB	CAWF	CAWN	EVAL
	RDENET	RDGEN	RDLD	RDMETE	RDMETT	RDMSM
	RDTNET	TRUEV				
PLT	PLOT	PLOTS	RITA			

[1] program library Div. of Autom. Control, Lund Institute of Techn.

Table 5-1 Relationships between routines and programs (Part 2 of 4).

ROUTINE	CALLED BY:					
ADMA	MAINA					
ADMB	MAINB					
ADMC	MAINC					
ALLMSM	MAINA	MAINB	MAINC			
ALOSS	ADMA	ADMB	ADMC			
CAD	ADMC					
CAJAC	ADMA					
CARES	ADMA	ADMB	ADMC			
CASDB	MAINA	MAINB	MAINC			
CAWF	MAINA	MAINB	MAINC			
CAWN	MAINA	MAINB	MAINC			
DECOM[1)]	NRLFR					
DESYM[1)]	ESTA	ESTC				
ELDNL	TRUEV					
ESTA	ADMA					
ESTB	ADMB					
ESTC	ADMC					
EVAL	MAINA	MAINB	MAINC			
GXE	CARES					
GXT	TRUEV					
JACBI	CAJAC	ESTB				
JACI	CAJAC	ESTB				
JACLF	CAJAC	ESTB	JACBI			
JACV	CAJAC	ESTB				
MPRI[1)]	ESTA	ESTC	NRLFR			
NODI[1)]	ALLMSM					
NRLFR	TRUEV					
PRENET	CAJAC	GXE	RDENET			
PRJAC	CAJAC	ESTA				
PRRES	ADMA	ADMB	ADMC	ALOSS	CARES	ESTA

[1)] program library Div. of Autom. Control, Lund Institute of Techn.

Table 5-1 Relationships between routines and programs
(Part 3 of 4).

PRTNET	RDTNET		
PRWF	ADMA	ADMB	
RDENET	MAINA	MAINB	MAINC
RDGEN	MAINA	MAINB	MAINC
RDLD	MAINA	MAINB	MAINC
RDMETE	MAINA	MAINB	MAINC
RDMETT	MAINA	MAINB	MAINC
RDMSM	MAINA	MAINB	MAINC
RDTNET	MAINA	MAINB	MAINC
SOLVB[1)]	NRLFR		
SOLVS[1)]	ESTA	ESTC	
TRUEV	MAINA	MAINB	MAINC
UPDAA	ESTA		
UPDAC	ESTC		
UPDBA	ESTA		
UPDBC	ESTC		
UPDEP	ESTB		

[1)] program library Div. of Autom. Control, Lund Institute of Techn.

Table 5-1 Relationships between routines and programs (Part 4 of 4).

Table 5-2: The program listings (part 2 of 2).

Table 5-2: The program listings (part 1 of 2).

```
      SUBROUTINE ADMA(MAXIT,JS,CRLOSS,XL,CRLIN,IEXIT,TIME,IPRINT)
C
C     MAIN ROUTINE FOR ESTIMATORS OF METHOD A
C     IT IS ASSUMED THAT BUS NB IS THE SLACK BUS
C
C     AUTHOR, TON VAN OVERBEEK 1974-02-08
C
C     MAXIT              MAXIMUM NUMBER OF ITERATIONS
C     JS=0               NORMAL OPERATION:  ITERATE TILL CONVERGENCE
C                        OR MAXIT, LINEARIZE IF NECESARRY
C     JS=1               ITERATE AT LEAST ONCE, IRRESPECTIVE OF
C                        THE VALUE OF THE LOSS FUNCTION
C     JS=2               LINEARIZE, IF MAXIT .GE. 2 IN TWO ITERATIONS
C     CRLOSS             CONVERGENCE CRITERION:  VALUE OF THE LOSS FUNCTION
C     XL(*)              VECTOR CONTAINING LAST LINEARIZATION POINT
C     CRLIN              LINEARIZATION CRITERION:  DISTANCE
C                        BETWEEN ESTIMATE AND XL
C     IEXIT=-3           ERROR IN ESTA
C     IEXIT=-2           ERROR IN CAJAC
C     IEXIT=-1           ERROR IN NB OR NL
C     IEXIT= 1           CONVERGENCE WITHIN MAXIT ITERATIONS
C     IEXIT= 2           NO CONVERGENCE AFTER MAXIT ITERATIONS
C     IEXIT= 3           DIVERGENCE:  THE LOSS FUNCTION INCREASES
C                        IN THE N-TH ITERATION.  XE CONTAINS THE
C                        ESTIMATE AFTER N - 1 ITERATIONS
C     TIME               TOTAL TIME IN MSECS
C     IPRINT=5           NO PRINTOUT
C     IPRINT=4           INITIAL VALUES OF THE ESTIMATE, THE RESIDUES
C                        AND IF JS .EQ. 0 THE LOSS FUNCTION.
C                        LINEARIZATION ITERATION NUMBERS.
C                        THE RESULTS:  NUMBER OF ITERATIONS, TOTAL TIME
C                        THE ESTIMATE, THE LOSS FUNCTION AND THE RESIDUES.
C     IPRINT=3           SAME + INPUT DATA:  MAXIT, JS, CRLOSS, CRLIN
C                        AND THE WEIGHTING FACTORS
C     IPRINT=2           SAME + IN EACH ITERATION:  DX, THE ESTIMATE,
C                        THE LOSS FUNCTION AND THE ITERATION TIME
C     IPRINT=1           SAME + IN EACH ITERATION THE JACOBIAN AND
C                        THE RESIDUES
C     IPRINT=0           SAME + IN EACH ITERATION THE A- AND T-MA-
C                        TRICES AND THE B-VECTOR
C
C     SUBROUTINE REQUIRED
C               ALOSS
C                 PRRES
C               CAJAC
C                 JACBI
C                   JACLF
C                 JACI
C                 JACLF
C                 JACV
C                 PRENET
C                 PRJAC
```

```
C               CARES
C                 GXE
C                   PRENET
C                 PRRES
C               ESTA
C                 DESYM
C                 MPRI
C                 PRJAC
C                 PRRES
C                 SOLVS
C                 UPDAA
C                 UPDBA
C               PRRES
C               PRWF
C
      PARAMETER MB=10,ML=13
      PARAMETER MMB=2*MB,MML=2*ML,MBL=MB+MML,MM=3*MBL
C
      COMPLEX YAA,ZAB,YBB,XE,YE2,YE3,YE4,YE5,YE6,XO(MB),XL(MB),CDX(MB)
C
      DIMENSION DX(MMB),PR(9)/'(1H0,',0,0,'VERGEN',
     1           'CE AFT','ER,I5,','11H IT','ERATIO','NS)'/
C
      INTEGER TIME,TBEG,TEND,TBIT,TEIT,TIT
C
      COMMON /EST/ XE(MB),YE2(ML),YE3(ML),YE4(ML),YE5(ML),YE6(MB)
     X       /ENET/ NB,NL,LTA(ML),LTB(ML),YAA(ML),ZAB(ML),YBB(ML)
     X       /MSM/ YM1(MB),YM2(ML),YM3(ML),YM4(MML),YM5(MML),YM6(MMB)
     X       /METE/ WF1(MB),WF2(ML),WF3(ML),WF4(MML),WF5(MML),
     X              WF6(MMB),ALFE1(MB),ALFE2(ML),ALFE3(ML),ALFE4(MML),
     X              ALFE5(MML),ALFE6(MMB),FSE1(MB),FSE2(ML),FSE3(ML),
     X              FSE4(MML),FSE5(MML),FSE6(MMB),BETE1(MB),BETE2(ML),
     X              BETE3(ML),BETE4(MML),BETE5(MML),BETE6(MMB)
      COMMON /RES/ RES1(MB),RES2(ML),RES3(ML),RES4(MML),RES5(MML),
     X             RES6(MMB)
     X       /MAT/ A(MMB,MMB),T(MMB,MMB)
     X       /MSI/ MSK1(MB),MSK2(ML),MSK3(ML),MSK4(ML),MSK5(ML),
     X             MSK6(MB),NM,NTYP(MM),NMSM(MM)
     X       /JAC/ AJAC1(MB,2),AJAC2(ML,4),AJAC3(ML,4),AJAC4(MML,4),
     X             AJAC5(MML,4),AJAC6(MMB,MMB)
C
      EQUIVALENCE (CDX,DX)
C
C     CHECK NB AND NL
C
      IF (NB) 20,20,10
   10 IF (NB-MB) 40,40,20
   20 IEXIT=-1
      WRITE(6,30) NB
   30 FORMAT(13H0NB IN ADMA =,I5)
      RETURN
C
   40 IF (NL) 60,60,50
```

```
   50 IF (NL-ML) 80,80,60
   60 IEXIT=-1
      WRITE(6,70) NL
   70 FORMAT(13H0NL IN ADMA =,I5)
      RETURN
C
C     INITIALIZATION
C
   80 IT=0
      IF (IPRINT-5) 90,150,150
   90 WRITE(6,100)
  100 FORMAT(19H0PRINTOUT FROM ADMA/1X,18(1H*)/
     F15H0INITIAL VALUES/1X,14(1H-))
      IF (IPRINT-4) 110,130,150
  110 WRITE(6,120) MAXIT,JS,CRLOSS,CRLIN
  120 FORMAT(20H0INPUTDATA:  MAXIT =,I5,6H   JS =,I2,
     F10H   CRLOSS =,F10.5,9H  CRLIN =,F10.5)
      CALL PRWF
  130 WRITE(6,140)(I,XE(I),I=1,NB)
  140 FORMAT(17H0INITIAL ESTIMATE/14H0BUSNR
     F,10HRE(XE)
     F,6HIM(XE)//
     F(I5,5X,2F10.5))
  150 TBEG=MSCPU(X)
      TBIT=TBEG
C
C     LAST PART OF THE ITERATION, ALSO USED FOR INITIALIZATION
C     CALCULATION OF THE RESIDUES AND THE LOSS FUNCTION
C
  160 CALL CARES(2,IE)
      IF (IPRINT-4) 170,170,190
  170 IF (IT) 180,180,190
  180 CALL PRRES
  190 IF (IT .EQ. 0 .AND. JS .GT. 0) GO TO 240
      FLOSSN=ALOSS(2)
      IF (IPRINT-4) 200,200,240
  200 IF (IT) 220,220,210
  210 IF (IPRINT-2) 220,220,240
  220 WRITE(6,230) FLOSSN
  230 FORMAT(20H0THE LOSS FUNCTION =,F15.5)
  240 TEIT=MSCPU(X)
      TIT=TEIT-TBIT
      IF (IPRINT .LE. 2) WRITE(6,250) IT,TIT
  250 FORMAT(22H0TIME FOR ITERATION NR,I4,4H  IS,I5,6H MSECS)
C
C     CONVERGENCE OR MAXIT ?
C
      IF (JS) 260,260,270
  260 IF (FLOSSN-ABS(CRLOSS)) 520,264,264
  264 IF (IT) 270,270,268
  268 IF (FLOSSN-FLOSSO) 270,270,530
  270 IF(IT .GE. MAXIT) GO TO 525
C
```

```
C     HERE STARTS THE ITERATION
C
      IT=IT+1
      IF (IPRINT-2) 280,280,300
  280 WRITE(6,290) IT
  290 FORMAT(13H0ITERATION NR,I5/1X,17(1H*))
  300 FLOSSO=FLOSSN
      DO 305 I=1,NB
  305 XO(I)=XE(I)
      TBIT=MSCPU(X)
      IF (JS-2) 310,340,340
C
C     LINEARIZATION ?
C
  310 XEL=0.0
      DO 320 I=1,NB
  320 XEL=XEL+CABS(XE(I)-XL(I))**2
      XEL=SQRT(XEL)
      IF (XEL-ABS(CRLIN)) 330,340,340
  330 LIN=0
      GO TO 380
  340 LIN=1
      IF (IPRINT-4) 350,350,380
  350 WRITE(6,370) IT
  370 FORMAT(27H0LINEARIZATION IN ITERATION,I5)
C
C     CALCULATION OF IPRJ(=IPRINT IN THE SUBROUTINE CAJAC)
C     AND IPRA(=IPRINT IN THE SUBROUTINE ESTA)
C
  380 IPRJ=IPRINT+1
      IPRA=IPRJ
      IF (IPRINT .EQ. 2) IPRJ=1
      IF (IPRINT .EQ. 0) IPRA=0
C
C     CALCULATION OF THE JACOBIAN
C
      CALL CAJAC(IPRJ,IERR)
      IF (IERR) 410,410,390
  390 IEXIT=-2
      WRITE(6,400) IT
  400 FORMAT(28H0ERROR IN CAJAC IN ITERATION,I5)
      RETURN
C
C     ESTIMATE DX
C
  410 IF (LIN) 440,440,420
  420 DO 430 I=1,NB
  430 XL(I)=XE(I)
  440 CALL ESTA(LIN,DX,IPRA,IERR)
      IF (IERR) 470,470,450
  450 IEXIT=-3
      WRITE(6,460) IT
  460 FORMAT(27H0ERROR IN ESTA IN ITERATION,I5)
      RETURN
```

```
C
  470 DO 480 I=1,NB
  480 XE(I)=XE(I)+CDX(I)
      IF (IPRINT-2) 490,490,510
  490 WRITE(6,500)(I,XE(I),I=1,NB)
  500 FORMAT(13H0THE ESTIMATE/14H0BUSNR
     F,10HRE(XE)
     F,6HIM(XE)//
     F(I5,5X,2F10.5))
  510 IF (IT .EQ. 1 .AND. LIN .EQ. 1) GO TO 160
      JS=0
      GO TO 160
C
C     END OF ESTIMATION, PRINTOUT OF THE RESULTS
C
  520 IEXIT=1
      GO TO 535
  525 IEXIT=2
      GO TO 535
  530 IEXIT=3
  535 TEND=MSCPU(X)
      TIME=TEND-TBEG
      IF (IEXIT .LT. 3) GO TO 540
      PR(2)='/1H+,'
      PR(3)=' 16HDI'
      DO 538 I=1,NB
  538 XE(I)=XO(I)
      CALL CARES(2,IE)
      FLOSSN=FLOSSO
      GO TO 548
  540 IF (IEXIT .LT. 2) GO TO 542
      PR(2)='3HNO ,'
      GO TO 545
  542 PR(2)='/1H+,'
  545 PR(3)='17HCON'
  548 IF (IPRINT-5) 550,990,990
  550 WRITE(6,560)
  560 FORMAT(19H0ESTIMATION RESULTS/1X,18(1H-))
      WRITE(6,PR) IT
      WRITE(6,570) TIME
  570 FORMAT(13H0TOTAL TIME =,I5,6H MSECS)
      WRITE(6,500)(I,XE(I),I=1,NB)
      WRITE(6,580) FLOSSN
  580 FORMAT(20H0THE LOSS FUNCTION =,F15.5)
      CALL PRRES
C
  990 RETURN
      END
```

```
      SUBROUTINE ADMB(MAXIT,JS,CRLOSS,JQ,PIN,Q,IEXIT,TIME,IPRINT)
C
C     MAIN ROUTINE FOR ESTIMATORS OF METHOD B
C     IT IS ASSUMED THAT BUS NB IS THE SLACK BUS
C
C     AUTHOR, TON VAN OVERBEEK 1974-03-05
C
C     MAXIT          MAXIMUM NUMBER OF ITERATIONS
C     JS=0           NORMAL OPERATION:  ITERATE TILL CONVERGENCE
C                    OR MAXIT
C     JS=1           ITERATE AT LEAST ONCE, IRRESPECTIVE OF
C                    THE VALUE OF THE LOSS FUNCTION
C     CRLOSS         CONVERGENCE CRITERION:  VALUE OF THE LOSS FUNCTION
C     JQ=1           THE COV MATRIX HAS DIAGONAL ELEMENTS PIN BEFORE
C                    EACH ITERATION
C     JQ=0           THE COV MATRIX HAS DIAGONAL ELEMENTS
C                    COV(I,I) + Q(I) BEFORE EACH ITERATION
C     PIN            VALUE OF ALL DIAGONAL ELEMENTS OF THE INITIAL
C                    COV MATRIX WHEN JQ = 0, USUALLY LARGE
C     Q(*)           VECTOR CONTAINING THE ELEMENTS TO BE ADDED TO THE
C                    DIAGONAL ELEMENTS OF THE COV MATRIX WHEN JQ = 1
C     IEXIT= 1       CONVERGENCE WITHIN MAXIT ITERATIONS
C     IEXIT= 2       NO CONVERGENCE AFTER MAXIT ITERATIONS
C     IEXIT= 3       DIVERGENCE:  THE LOSS FUNCTION INCREASES
C                    IN THE N-TH ITERATION.  XE CONTAINS THE
C                    ESTIMATE AFTER N - 1 ITERATIONS
C     IEXIT=-1       ERROR IN NB, NL OR NM
C     IEXIT=-2       ERROR IN ESTB
C     TIME           TOTAL TIME IN MSECS
C     IPRINT=4       NO PRINTOUT
C     IPRINT=3       THE INITIAL ESTIMATE AND COV.
C                    THE RESULTS:  NUMBER OF ITERATIONS, TOTAL TIME
C                    THE ESTIMATE AND COV, THE LOSS FUNCTION AND
C                    THE RESIDUES
C     IPRINT=2       SAME + INPUT DATA:  MAXIT, JS, CRLOSS, JQ, THE
C                    WEIGHTING FACTORS AND IF JQ .EQ. 0 PIN ELSE
C                    THE Q-VECTOR
C     IPRINT=1       SAME + AT EACH ITERATION PRINTOUT FROM ESTB
C     IPRINT=0       SAME + AT EACH ITERATION PRINTOUT FROM ESTB
C
C     SUBROUTINE REQUIRED
C               ALOSS
C                 PRRES
C               CARES
C                 GXE
C                   PRENET
C                 PRRES
C               ESTB
C                 JACBI
C                   JACLF
C                 JACI
C                 JACLF
C                 JACV
C                 UPDEP
```

```
C                    PRRES
C                    PRWF
C
      PARAMETER MB=10,ML=13
      PARAMETER MMB=2*MB,MML=2*ML,MM=3*(MB+MML)
C
      COMPLEX YAA,ZAB,YBB,XE,YE2,YE3,YE4,YE5,YE6,XO(MB)
C
      DIMENSION POLD(MMB),Q(1),PR(9)/'(1H0,','0,0,'VERGEN',
     1           'CE AFT','ER,I5,',','11H IT','ERATIO','NS)'/
C
      INTEGER TIME,TBEG,TEND,TBIT,TEIT,TIT
C
      COMMON /EST/ XE(MB),YE2(ML),YE3(ML),YE4(ML),YE5(ML),YE6(MB)
     X       /ENET/ NB,NL,LTA(ML),LTB(ML),YAA(ML),ZAB(ML),YBB(ML)
     X       /MSM/ YM1(MB),YM2(ML),YM3(ML),YM4(MML),YM5(MML),YM6(MMB)
     X       /METE/ WF1(MB),WF2(ML),WF3(ML),WF4(MML),WF5(MML),
     X              WF6(MMB),ALFE1(MB),ALFE2(ML),ALFE3(ML),ALFE4(MML),
     X              ALFE5(MML),ALFE6(MMB),FSE1(MB),FSE2(ML),FSE3(ML),
     X              FSE4(MML),FSE5(MML),FSE6(MMB),BETE1(MB),BETE2(ML),
     X              BETE3(ML),BETE4(MML),BETE5(MML),BETE6(MMB)
      COMMON /MSI/ MSK1(MB),MSK2(ML),MSK3(ML),MSK4(ML),MSK5(ML),
     X             MSK6(MB),NM,NTYP(MM),NMSM(MM)
     X       /RES/ RES1(MB),RES2(ML),RES3(ML),RES4(MML),RES5(MML),
     X             RES6(MMB)
     X       /VAR/ COV(MMB),PNEW(MMB)
C
C     CHECK NB, NL AND NM
C
      IF (NB) 20,20,10
   10 IF (NB-MB) 40,40,20
   20 IEXIT=-1
      WRITE(6,30) NB
   30 FORMAT(13H0NB IN ADMB =,I5)
      RETURN
C
   40 IF (NL) 60,60,50
   50 IF (NL-ML) 80,80,60
   60 IEXIT=-1
      WRITE(6,70) NL
   70 FORMAT(13H0NL IN ADMB =,I5)
      RETURN
C
   80 IF (NM) 100,100,90
   90 IF (NM-MM) 120,120,100
  100 IEXIT=-1
      WRITE(6,110) NM
  110 FORMAT(13H0NM IN ADMB =,I5)
      RETURN
C
C     INITIALIZATION
C
  120 NNB=2*NB
```

```
      NNB1=NNB-1
      IT=0
C
      IF (IPRINT-3) 130,130,220
  130 WRITE(6,140)
  140 FORMAT(19H0PRINTOUT FROM ADMB/1X,18(1H*)/
     F15H0INITIAL VALUES/1X,14(1H-))
      IF (IPRINT-2) 150,150,220
  150 WRITE(6,160) MAXIT,JS,CRLOSS,JQ
  160 FORMAT(12H0INPUT DATA:/8H0MAXIT =,I5,6H  JS =,I2,
     F10H  CRLOSS =,F10.5,6H  JQ =,I3)
      IF (JQ) 190,190,170
  170 WRITE(6,180) PIN
  180 FORMAT(6H0PIN =,F10.5)
      GO TO 210
  190 WRITE(6,200)(I,Q(2*I-1),Q(2*I),I=1,NB)
  200 FORMAT(14H0BUSNR
     F,10HQREAL
     F,5HQIMAG//(I5,5X,2E10.3))
  210 CALL PRWF
C
      DO 215 I=1,NNB
  215 PNEW(I)=COV(I)
  220 IF (JQ .GE. 1) GO TO 240
      DO 230 I=1,NNB1
  230 COV(I)=COV(I)+Q(I)
      GO TO 260
  240 DO 250 I=1,NNB1
  250 COV(I)=PIN
  260 COV(NNB)=0.0
C
      IF (IPRINT-3) 270,270,300
  270 WRITE(6,280)
  280 FORMAT(1H0,19HINITIAL EST AND COV/
     F14H0BUSNR
     F,10HRE(XE)
     F,15HIM(XE)
     F,10HPREAL
     F,5HPIMAG/)
      WRITE(6,290)(I,XE(I),COV(2*I-1),COV(2*I),I=1,NB)
  290 FORMAT(I5,5X,2F10.5,5X,2F10.5)
C
  300 TBEG=MSCPU(X)
      TBIT=TBEG
C
C     LAST PART OF THE ITERATION, ALSO USED FOR INITIALIZATION
C     CALCULATION OF THE RESIDUES AND THE LOSS FUNCTION
C
  310 CALL CARES(2,IE)
      IF (IPRINT-3) 320,320,340
  320 IF (IT) 330,330,340
  330 CALL PRRES
  340 FLOSSN=ALOSS(2)
```

```
      IF (IPRINT-3) 350,350,390
  350 IF (IT) 370,370,360
  360 IF (IPRINT-1) 370,370,390
  370 WRITE(6,380) FLOSSN
  380 FORMAT(20H0THE LOSS FUNCTION =,F15.5)
  390 TEIT=MSCPU(X)
      TIT=TEIT-TBIT
      IF (IPRINT .LE. 1) WRITE(6,400) IT,TIT
  400 FORMAT(22H0TIME FOR ITERATION NR,I5,4H  IS,I5,6H MSECS)
C
C     CONVERGENCE OR MAXIT ?
C
      IF (JS) 410,410,420
  410 IF (FLOSSN-ABS(CRLOSS)) 510,420,420
  420 IF (IT) 440,440,430
  430 IF (FLOSSN-FLOSSO) 440,440,530
  440 IF (IT .GE. MAXIT) GO TO 520
C
C     HERE STARTS THE ITERATION
C
      IT=IT+1
      IF (IPRINT-1) 450,450,465
  450 WRITE(6,460) IT
  460 FORMAT(13H0ITERATION NR,I5/1X,17(1H*))
  465 FLOSSO=FLOSSN
      DO 470 I=1,NB
  470 XO(I)=XE(I)
      DO 475 I=1,NNB
  475 POLD(I)=PNEW(I)
      TBIT=MSCPU(X)
C
C     COMPUTE THE ESTIMATE
C
      CALL ESTB(IPRINT,IERR)
      IF (IERR) 500,500,480
  480 WRITE(6,490) IT
  490 FORMAT(27H0ERROR IN ESTB IN ITERATION,I5)
      IEXIT=-2
      RETURN
C
  500 JS=0
      GO TO 310
C
C     END OF ESTIMATION, PRINTOUT OF THE RESULTS
C
  510 IEXIT=1
      GO TO 540
  520 IEXIT=2
      GO TO 540
  530 IEXIT=3
  540 TEND=MSCPU(X)
      TIME=TEND-TBEG
      IF (IEXIT .LT. 3) GO TO 560
```

```
      PR(2)='/1H+,'
      PR(3)=' 16HDI'
      DO 550 I=1,NB
  550 XE(I)=XO(I)
      DO 555 I=1,NNB
  555 PNEW(I)=POLD(I)
      CALL CARES(2,IE)
      FLOSSN=FLOSSO
      GO TO 590
  560 IF (IEXIT .LT. 2) GO TO 570
      PR(2)='3HNO '
      GO TO 580
  570 PR(2)='/1H+,'
  580 PR(3)='17HCON'
  590 DO 595 I=1,NNB
  595 COV(I)=PNEW(I)
C
      IF (IPRINT-4) 600,990,990
  600 WRITE(6,610)
  610 FORMAT(19H0ESTIMATION RESULTS/1X,18(1H-))
      WRITE(6,PR) IT
      WRITE(6,620) TIME
  620 FORMAT(13H0TOTAL TIME =,I5,6H MSECS)
      WRITE(6,630)
  630 FORMAT(1H0,23X,17HFINAL EST AND COV/
     F14H0BUSNR
     F,10HRE(XE)
     F,15HIM(XE)
     F,10HPREAL
     F,5HPIMAG/)
      DO 640 I=1,NB
      I2=2*I
      I1=I2-1
  640 WRITE(6,650) I,XE(I),COV(I1),COV(I2)
  650 FORMAT(I5,2(5X,2F10.5))
      WRITE(6,660) FLOSSN
  660 FORMAT(20H0THE LOSS FUNCTION =,F15.5)
      CALL PRRES
C
  990 RETURN
      END
```

```
      SUBROUTINE ADMC(NEWA,CRLOSS,MAXIT,EPS,IEXIT,TIME,IPRINT)
C
C     MAINROUTINE FOR METHOD C.  IT IS ASSUMED THAT THERE IS ONLY
C     ONE REFERENCE VOLTAGE:  THE VOLTAGE AT BUS NB
C
C     AUTHOR, TON VAN OVERBEEK 1974-03-14
C
C     NEWA=1          NEW LINEVOLTAGE WEIGHTING FACTORS AND A NEW
C                     A-MATRIX ARE CALCULATED
C     NEWA=0          NO NEW WEIGHTING FACTORS AND MATRIX ARE CALCULATED
C     CRLOSS          CONVERGENCE CRITERION
C                     IF THE INITIAL LOSS .LE. CRLOSS THEN ESTC
C                     IS NOT CALLED
C     MAXIT           MAXIMUM NUMBER OF ITERATIONS FOR ESTC
C     EPS             CONVERGENCE CRITERION FOR ESTC
C     IEXIT=-3        ERROR IN MASKVECTOR FOR VOLTAGE MEASUREMENT
C     IEXIT=-2        DECOMPOSITION OF A HAS FAILED IN ESTC
C     IEXIT=-1        ERROR IN NB OR NL
C     IEXIT= 0        INITIAL LOSS .LE. CRLOSS
C     IEXIT= 1        CONVERGENCE OF ESTC, FINAL LOSS .LT. CRLOSS
C     IEXIT= 2        NO CONVERGENCE OF ESTC, FINAL LOSS .LT. CRLOSS
C     IEXIT= 3        CONVERGENCE OF ESTC, FINAL LOSS .GT. CRLOSS
C     IEXIT= 4        NO CONVERGENCE OF ESTC, FINAL LOSS .GT. CRLOSS
C     IEXIT= 5        DIVERGENCE:  THE LOSS FUNCTION INCREASES
C                     THE ESTIMATE IS SET EQUAL TO THE INITIAL ESTIMATE
C     IPRINT=4        NO PRINTOUT
C     IPRINT=0-3      SEE ESTC
C                     THE INITAL AND FINAL RESIDUES AND LOSS FUNCTION
C                     ARE ALSO PRINTED
C
C     SUBROUTINE REQUIRED
C               ALOSS
C                 PRRES
C               CAD
C               CARES
C                 GXE
C                   PRENET
C                 PRRES
C               ESTC
C                 DESYM
C                 MPRI
C                 SOLVS
C                 UPDAC
C                 UPDBC
C               PRRES
C
      PARAMETER MB=10,ML=13
      PARAMETER MMB=2*MB,MML=2*ML,MM=3*(MB+MML)
C
      INTEGER TIME,TBEG,TEND
C
      DIMENSION DA(ML),DB(ML),PR(6)/'(13HOF','INAL L','OSS .','0,
     1         '7H CRL','OSS)'/
```

```
C
      COMPLEX YAA,ZAB,YBB,XE,YE2,YE3,YE4,YE5,YE6,XEO(MB)
C
      COMMON /EST/ XE(MB),YE2(ML),YE3(ML),YE4(ML),YE5(ML),YE6(MB)
     X       /ENET/ NB,NL,LTA(ML),LTB(ML),YAA(ML),ZAB(ML),YBB(ML)
     X       /MSM/ YM1(MB),YM2(ML),YM3(ML),YM4(MML),YM5(MML),YM6(MMB)
     X       /METE/ WF1(MB),WF2(ML),WF3(ML),WF4(MML),WF5(MML),WF6(MMB)
     X       /MSI/ MSK1(MB),MSK2(ML),MSK3(ML),MSK4(ML),MSK5(ML),
     X             MSK6(MB),NM,NTYP(MM),NMSM(MM)
     X       /RES/ RES1(MB),RES2(ML),RES3(ML),RES4(MML),RES5(MML),
     X             RES6(MMB)
     X       /MAT/ A(MB,MB),T(MB,MB)
C
C     CHECK NB AND NL
C
      IF (NB) 20,20,10
   10 IF (NB-MB) 40,40,20
   20 IEXIT=-1
      WRITE(6,30) NB
   30 FORMAT(13H0NB IN ADMC =,I5)
      RETURN
C
   40 IF (NL) 60,60,50
   50 IF (NL-ML) 80,80,60
   60 IEXIT=-1
      WRITE(6,70) NL
   70 FORMAT(13H0NL IN ADMC =,I5)
      RETURN
C
C     CALCULATE THE INITAL RESIDUES AND LOSS FUNCTION
C
   80 TBEG=MSCPU(X)
      CALL CARES(2,IE)
      FLOSSO=ALOSS(2)
C
      IF (IPRINT-3) 90,90,120
   90 WRITE(6,100) CRLOSS
  100 FORMAT(19H0PRINTOUT FROM ADMC/1X,18(1H*)/
     F15H0INITIAL VALUES/1X,14(1H-)/9H0CRLOSS =,F10.5)
      CALL PRRES
      WRITE(6,110) FLOSSO
  110 FORMAT(20H0THE LOSS FUNCTION =,F15.5)
C
C     DIRECT CONVERGENCE ?
C
  120 IF (FLOSSO-ABS(CRLOSS)) 130,130,170
  130 IEXIT=0
      TEND=MSCPU(X)
      TIME=TEND-TBEG
C
      IF (IPRINT-3) 140,140,990
  140 WRITE(6,150)(I,XE(I),I=1,NB)
  150 FORMAT(19H0DIRECT CONVERGENCE/
```

```
     F1H0,15X,12HTHE ESTIMATE/
     F14H0BUSNR
     F,10HRE(XE)
     F,6HIM(XE)//
     F(I5,5X,2F10.5))
      WRITE(6,160) TIME
  160 FORMAT(22H0TOTAL TIME FOR ADMC =,I5,6H MSECS)
      GO TO 990
C
C     CALCULATE THE LINEVOLTAGE WEIGHTING FACTORS IF NECESARRY
C     AND COMPUTE THE ESTIMATE
C
  170 IF (NEWA) 190,190,180
  180 CALL CAD(DA,DB,IPRINT+1)
  190 IF (MSK1(NB)) 200,200,220
  200 IEXIT=-3
      WRITE(6,210) NB,MSK1(NB)
  210 FORMAT(13H0ERROR IN MSK,5X,5HMSK1(,I5,3H) =,I5)
      GO TO 990
C
  220 DO 230 I=1,NB
  230 XEO(I)=XE(I)
      XE(NB)=CMPLX(YM1(NB),0.0)
      NR=1
      CALL ESTC(NR,DA,DB,MAXIT,EPS,NEWA,IEXIT,TIME,IPRINT)
      IF (IEXIT) 990,240,240
C
C     CALCULATE THE FINAL RESIDUES AND LOSS FUNCTION
C
  240 CALL CARES(2,IE)
      FLOSSN=ALOSS(2)
      IF (FLOSSN-ABS(CRLOSS)) 250,250,260
  250 PR(4)='3HLE.,'
      GO TO 280
C
  260 IF (FLOSSN-FLOSSO) 270,270,300
  270 IEXIT=IEXIT+2
      PR(4)='3HGT.,'
C
  280 IF (IPRINT-3) 290,290,350
  290 WRITE(6,PR)
      GO TO 350
C
  300 IEXIT=5
      DO 310 I=1,NB
  310 XE(I)=XEO(I)
      IF (IPRINT-3) 320,320,340
  320 WRITE(6,330)(I,XE(I),I=1,NB)
  330 FORMAT(11H0DIVERGENCE/1H0,15X,12HTHE ESTIMATE/
     F14H0BUSNR
     F,10HRE(XE)
     F,6HIM(XE)//
     F(I5,5X,2F10.5))
```

```
  340 CALL CARES(2,IE)
      FLOSSN=FLOSSO
C
  350 TEND=MSCPU(X)
      TIME=TEND-TBEG
      IF (IPRINT-3) 360,360,990
  360 WRITE(6,110) FLOSSN
      WRITE(6,160) TIME
C
  990 RETURN
      END
```

```
      SUBROUTINE ALLMSM(NODD,IPRINT)
C
C     COMPUTES ALL POSSIBLE MEASUREMENTS BY ADDING NOISE AND
C     BIAS TO THE TRUE VALUES
C
C     AUTHOR, TON VAN OVERBEEK  1974-01-16
C
C     NODD            PARAMETER FOR THE SUBROUTINE NODI.
C                     AT FIRST CALL OF ALLMSM NODD MUST EQUAL AN ODD
C                     INTEGER(E.G. 19).  NODD IS RETURNED CONTAINING A
C                     NEW ODD INTEGER WHICH IS USED BY REPEATED CALLS
C     IPRINT=1        NO PRINTOUT
C     IPRINT=0        TRUE VALUES,BIAS,NOISE,AND MEASUREMENTS ARE PRINTED
C
C     SUBROUTINE REQUIRED
C             NODI
C
      PARAMETER MB=10,ML=13
      PARAMETER MMB=2*MB,MML=2*ML
C
      COMPLEX XT,YT2,YT3,YT4,YT5,YT6
C
      COMMON /TNET/ NB,NL
     1       /TRUE/ XT(MB),YT2(ML),YT3(ML),YT4(ML),YT5(ML),YT6(MB)
     2       /MSM/ YM1(MB),YM2(ML),YM3(ML),YM4(MML),YM5(MML),YM6(MMB)
     3       /METT/ BIAS1(MB),BIAS2(ML),BIAS3(ML),BIAS4(MML),
     4              BIAS5(MML),BIAS6(MMB),WN1(MB),WN2(ML),WN3(ML),
     5              WN4(MML),WN5(MML),WN6(MMB)
C
C     MODULUS MEASUREMENTS,TYPE 1,2,3
C
      IF (IPRINT .GE. 1) GO TO 20
      WRITE(6,10)
   10 FORMAT(21H1PRINTOUT FROM ALLMSM/1X,20(1H*)//
     F14H MSMNR
     F,10HTRUE
     F,12HBIAS
     F,8HWN
     F,10HNOISE
     F,3HMSM/)
C
C     TYPE 1
C
   20 IF (IPRINT-1) 25,35,35
   25 IT=1
      WRITE(6,30) IT
   30 FORMAT(5H0TYPE,I2/)
   35 DO 60 I=1,NB
      YT=CABS(XT(I))
      CALL NODI(NODD,ERR)
      ERR=ERR/WN1(I)
      YM1(I)=YT+BIAS1(I)+ERR
      IF (IPRINT-1) 40,60,60
```

```
   40 WRITE(6,50) I,YT,BIAS1(I),WN1(I),ERR,YM1(I)
   50 FORMAT(I5,5X,2F10.5,F10.2,2F10.5)
   60 CONTINUE
C
C     TYPE 2
C
      IF (IPRINT-1) 61,65,65
   61 IT=2
      WRITE(6,30) IT
   65 DO 80 I=1,NL
      YT=CABS(YT2(I))
      CALL NODI(NODD,ERR)
      ERR=ERR/WN2(I)
      YM2(I)=YT+BIAS2(I)+ERR
      IF (IPRINT-1) 70,80,80
   70 WRITE(6,50) I,YT,BIAS2(I),WN2(I),ERR,YM2(I)
   80 CONTINUE
C
C     TYPE 3
C
      IF (IPRINT-1) 81,85,85
   81 IT=3
      WRITE(6,30) IT
   85 DO 100 I=1,NL
      YT=CABS(YT3(I))
      CALL NODI(NODD,ERR)
      ERR=ERR/WN3(I)
      YM3(I)=YT+BIAS3(I)+ERR
      IF (IPRINT-1) 90,100,100
   90 WRITE(6,50) I,YT,BIAS3(I),WN3(I),ERR,YM3(I)
  100 CONTINUE
C
C     ACTIVE AND REACTIVE MEASUREMENTS,TYPE 4,5,6
C
      IF (IPRINT .GE. 1) GO TO 120
      WRITE(6,110)
  110 FORMAT(/1H0,33X
     F,53HACTIVE
     F,8HREACTIVE/
     F14HOMSMNR
     F,10HTRUE
     F,12HBIAS
     F,8HWN
     F,10HNOISE
     F,15HMSM
     F,10HTRUE
     F,12HBIAS
     F,8HWN
     F,10HNOISE
     F,3HMSM/)
```

```
C
C     TYPE 4
C
      IF (IPRINT-1) 115,120,120
  115 IT=4
      WRITE(6,30) IT
  120 DO 150 I=1,NL
      I1=2*I-1
      I2=2*I
      YTR=REAL(YT4(I))
      YTI=AIMAG(YT4(I))
      CALL NODI(NODD,ERRR)
      CALL NODI(NODD,ERRI)
      ERRR=ERRR/WN4(I1)
      ERRI=ERRI/WN4(I2)
      YM4(I1)=YTR+BIAS4(I1)+ERRR
      YM4(I2)=YTI+BIAS4(I2)+ERRI
      IF (IPRINT-1) 130,150,150
  130 WRITE(6,140) I,YTR,BIAS4(I1),WN4(I1),ERRR,YM4(I1),
     1                 YTI,BIAS4(I2),WN4(I2),ERRI,YM4(I2)
  140 FORMAT(I5,2(5X,2F10.5,F10.2,2F10.5))
  150 CONTINUE
C
C     TYPE 5
C
      IF (IPRINT-1) 161,165,165
  161 IT=5
      WRITE(6,30) IT
  165 DO 170 I=1,NL
      I1=2*I-1
      I2=2*I
      YTR=REAL(YT5(I))
      YTI=AIMAG(YT5(I))
      CALL NODI(NODD,ERRR)
      CALL NODI(NODD,ERRI)
      ERRR=ERRR/WN5(I1)
      ERRI=ERRI/WN5(I2)
      YM5(I1)=YTR+BIAS5(I1)+ERRR
      YM5(I2)=YTI+BIAS5(I2)+ERRI
      IF (IPRINT-1) 160,170,170
  160 WRITE(6,140) I,YTR,BIAS5(I1),WN5(I1),ERRR,YM5(I1),
     1                 YTI,BIAS5(I2),WN5(I2),ERRI,YM5(I2)
  170 CONTINUE
C
C     TYPE 6
C
      IF (IPRINT-1) 181,185,185
  181 IT=6
      WRITE(6,30) IT
  185 DO 190 I=1,NB
      I1=2*I-1
      I2=2*I
      YTR=REAL(YT6(I))
      YTI=AIMAG(YT6(I))
```

```
      CALL NODI(NODD,ERRR)
      CALL NODI(NODD,ERRI)
      ERRR=ERRR/WN6(I1)
      ERRI=ERRI/WN6(I2)
      YM6(I1)=YTR+BIAS6(I1)+ERRR
      YM6(I2)=YTI+BIAS6(I2)+ERRI
      IF (IPRINT-1) 180,190,190
  180 WRITE(6,140) I,YTR,BIAS6(I1),WN6(I1),ERRR,YM6(I1),
     1                YTI,BIAS6(I2),WN6(I2),ERRI,YM6(I2)
  190 CONTINUE
C
      RETURN
      END
```

```
      FUNCTION ALOSS(IPRINT)
C
C     CALCULATES THE LOSS FUNCTION GIVEN THE RESIDUES AND THE WEIGHTING
C     FACTORS
C
C     AUTHOR, TON VAN OVERBEEK 1974-01-23
C
C     IPRINT=2        NO PRINTOUT
C     IPRINT=1        THE VALUE OF THE LOSS FUNCTION IS PRINTED
C     IPRINT=0        SAME + THE USED MEASUREMENTS, THE CORRESPONDING
C                     ESTIMATED VALUES AND THE RESIDUES
C
C     SUBROUTINE REQUIRED
C             PRRES
C
      PARAMETER MB=10,ML=13
      PARAMETER MMB=2*MB,MML=2*ML,MBL=MB+MML,MMBL=2*MBL
C
      DIMENSION WFA(MBL),WFB(MMBL),MSKA(MBL),MSKB(MBL),RESA(MBL),
     1          RESB(MMBL)
C
      COMPLEX XE,YE2,YE3,YE4,YE5,YE6,YEA(MBL),YEB(MBL)
C
      COMMON /ENET/ NB,NL
     1       /EST/ XE(MB),YE2(ML),YE3(ML),YE4(ML),YE5(ML),YE6(MB)
     2       /METE/ WF1(MB),WF2(ML),WF3(ML),WF4(MML),WF5(MML),WF6(MMB)
     3       /MSI/ MSK1(MB),MSK2(ML),MSK3(ML),MSK4(ML),MSK5(ML),MSK6(MB)
     4       /RES/ RES1(MB),RES2(ML),RES3(ML),RES4(MML),RES5(MML),
     5             RES6(MMB)
     6       /MSM/ YM1(MB),YM2(ML),YM3(ML),YM4(MML),YM5(MML),YM6(MMB)
C
      EQUIVALENCE (YEA,XE),(YEB,YE4),(WFA,WF1),(WFB,WF4),(MSKA,MSK1),
     1            (MSKB,MSK4),(RESA,RES1),(RESB,RES4)
C
      ALOSS=0.0
      DO 60 I=1,MBL
      I2=2*I
      I1=I2-1
      IF (MSKA(I)) 20,20,10
   10 ALOSS=ALOSS+(WFA(I)*RESA(I))**2
   20 MSB=MSKB(I)
      IF (MSB) 60,60,30
   30 IF (MSB-2) 40,50,40
   40 ALOSS=ALOSS+(WFB(I1)*RESB(I1))**2
      IF (MSB-1) 60,60,50
   50 ALOSS=ALOSS+(WFB(I2)*RESB(I2))**2
   60 CONTINUE
C
C     PRINTOUT
C
      IF (IPRINT-2) 70,990,990
   70 WRITE(6,80)
   80 FORMAT(20H0PRINTOUT FROM ALOSS/1X,19(1H*))
```

```
      IF (IPRINT-1) 90,100,990
   90 CALL PRRES
  100 WRITE(6,110) ALOSS
  110 FORMAT(20H0THE LOSS FUNCTION =,F15.5)
C
  990 RETURN
      END
```

```
      SUBROUTINE CAD(DA,DB,IPRINT)
C
C     HELPROUTINE FOR ESTC
C     CALCULATES THE WEIGHTING FACTORS DA(*) AND DB(*) FOR THE
C     LINEVOLTAGES FROM THE ORIGINAL WEIGHTING FACTORS WF4(*) AND
C     WF5(*) FOR THE LINE FLOW MEASUREMENTS.  SINCE METHOD C ASSUMES
C     COMPLEX LINE FLOW MEASUREMENTS ONLY THE WEIGHTING FACTORS FOR
C     THE ACTIVE MEASUREMENTS ARE USED
C
C     AUTHOR, TON VAN OVERBEEK 1974-03-11
C
C     DA(*)           WEIGHTING FACTOR FOR LINEVOLTAGE AT A-END
C     DB(*)           WEIGHTING FACTOR FOR LINEVOLTAGE AT B-END
C     IPRINT=1        NO PRINTOUT
C     IPRINT=0        THE ORIGINAL AND COMPUTED WEIGHTING FACTORS
C                     ARE PRINTED
C
C     SUBROUTINE REQUIRED
C              NONE
C
      PARAMETER MB=10,ML=13
      PARAMETER MMB=2*MB,MML=2*ML
C
      COMPLEX YAA,ZAB,YBB
C
      DIMENSION DA(1),DB(1)
C
      COMMON /ENET/ NB,NL,LTA(ML),LTB(ML),YAA(ML),ZAB(ML),YBB(ML)
     X         /METE/ WF1(MB),WF2(ML),WF3(ML),WF4(MML),WF5(MML),WF6(MMB)
C
      IF (NL) 20,20,10
   10 IF (NL-ML) 40,40,20
   20 WRITE(6,30) NL
   30 FORMAT(12H0NL IN CAD =,I5)
      RETURN
C
   40 IF (IPRINT) 50,50,70
   50 WRITE(6,60)
   60 FORMAT(18H0PRINTOUT FROM CAD/1X,17(1H*)/
     F14H0 LINE
     F,11HWF4
     F,14HDA
     F,11HWF5
     F,2HDB/)
C
   70 DO 100 I=1,NL
      WF4A=WF4(2*I-1)
      WF5A=WF5(2*I-1)
      ZLM2=CABS(ZAB(I))**2
      DA(I)=WF4A/ZLM2
      DB(I)=WF5A/ZLM2
C
```

```
      IF (IPRINT) 80,80,100
   80 WRITE(6,90) I,WF4A,DA(I),WF5A,DB(I)
   90 FORMAT(I5,2(5X,F10.5,F10.2))
C
  100 CONTINUE
C
      RETURN
      END
```

```
      SUBROUTINE CAJAC(IPRINT,IERR)
C
C     CALCULATES THE JACOBIAN FOR ESTIMATION METHOD A GIVEN THE
C     ESTIMATE AND ESTIMATOR NETWORK DATA
C
C     AUTHOR, TON VAN OVERBEEK 1974-01-28
C
C     IPRINT=2        NO PRINTOUT
C     IPRINT=1        THE JACOBIAN IS PRINTED
C     IPRINT=0        SAME + ESTIMATE AND ESTIMATOR NETWORK DATA
C     IERR=1          ERROR IN JACV, JACI, JACLF OR JACBI
C     IERR=0          NO ERROR
C
C     SUBROUTINE REQUIRED
C               JACBI
C                 JACLF
C               JACI
C               JACLF
C               JACV
C               PRENET
C               PRJAC
C
      PARAMETER MB=10,ML=13
      PARAMETER MMB=2*MB,MML=2*ML
C
      COMPLEX YAA,ZAB,YBB,YA,ZL,YB,X,XA,XB
C
      COMMON /ENET/ NB,NL,LTA(ML),LTB(ML),YAA(ML),ZAB(ML),YBB(ML)
     1       /EST/ X(MB)
     2       /MSI/ MSK1(MB),MSK2(ML),MSK3(ML),MSK4(ML),MSK5(ML),MSK6(MB)
     3       /JAC/ AJAC1(MB,2),AJAC2(ML,4),AJAC3(ML,4),AJAC4(MML,4),
     4             AJAC5(MML,4),AJAC6(MMB,MMB)
C
      IF (IPRINT-2) 10,50,50
   10 WRITE(6,20)
   20 FORMAT(20H0PRINTOUT FROM CAJAC/1X,19(1H*))
      IF (IPRINT) 30,30,50
   30 CALL PRENET
      WRITE(6,40)(I,X(I),I=1,NB)
   40 FORMAT(13H0THE ESTIMATE/1X,12(1H-)/14H0BUSNR
     F,10HRE(XE)
     F,6HIM(XE)//(I5,5X,2F10.5))
C
C     TYPE 1 AND 6
C
   50 DO 110 I=1,NB
      IF (MSK1(I)) 90,90,60
   60 CALL JACV(X(I),AJAC1,I,MB,IERR)
      IF (IERR) 90,90,70
   70 WRITE(6,80) I
   80 FORMAT(16H0ERROR AT BUS NR,I5)
      RETURN
```

```
C
   90 IF (MSK6(I)) 110,110,100
  100 CALL JACBI(MSK6(I),I,AJAC6,2*I-1,AJAC6,2*I,MMB,IERR)
      IF (IERR) 110,110,70
  110 CONTINUE
C
C     TYPE 2, 3, 4 AND 5
C
      DO 210 I=1,NL
      IA=LTA(I)
      IB=LTB(I)
      XA=X(IA)
      XB=X(IB)
      YA=YAA(I)
      ZL=ZAB(I)
      YB=YBB(I)
      I2=2*I
      I1=I2-1
      IF (MSK2(I)) 150,150,120
  120 CALL JACI(XA,XB,ZL,YA,AJAC2,I,ML,IERR)
      IF (IERR) 150,150,130
  130 WRITE(6,140) I,IA,IB
  140 FORMAT(17H0ERROR AT LINE NR,I5,7H  LTA =,I5,7H  LTB =,I5)
      RETURN
C
  150 IF (MSK3(I)) 170,170,160
  160 CALL JACI(XB,XA,ZL,YB,AJAC3,I,ML,IERR)
      IF (IERR) 170,170,130
C
  170 IF (MSK4(I)) 190,190,180
  180 CALL JACLF(MSK4(I),XA,XB,ZL,YA,AJAC4,I1,AJAC4,I2,MML,IERR)
      IF (IERR) 190,190,130
C
  190 IF (MSK5(I)) 210,210,200
  200 CALL JACLF(MSK5(I),XB,XA,ZL,YB,AJAC5,I1,AJAC5,I2,MML,IERR)
      IF (IERR) 210,210,130
C
  210 CONTINUE
C
      IF (IPRINT-2) 220,990,990
  220 CALL PRJAC
C
  990 RETURN
      END
```

```
      SUBROUTINE CARES(IPRINT,IERR)
C
C     CALCULATES THE RESIDUES GIVEN THE MEASUREMENTS AND THE ESTIMATED
C     STATE.  WHEN THE MASK VECTOR ELEMENTS FOR TYPE 4, 5 AND 6 MEA-
C     SUREMENTS ARE 1 OR 2 THE RESIDUES FOR BOTH THE ACTIVE AND REACTIVE
C     MEASUREMENT ARE COMPUTED
C
C     AUTHOR, TON VAN OVERBEEK 1974-01-23
C
C     IPRINT=2         NO PRINTOUT
C     IPRINT=1         THE USED MEASUREMENTS, THE CORRESPONDING ESTIMATED
C                      VALUES AND THE RESIDUES ARE PRINTED
C     IPRINT=0         SAME + ESTIMATOR NETWORK DATA
C     IERR=1           ERROR IN NB OR NL
C     IERR=0           NO ERROR
C
C     SUBROUTINE REQUIRED
C             GXE
C               PRENET
C             PRRES
C
      PARAMETER MB=10,ML=13
      PARAMETER MMB=2*MB,MML=2*ML,MBL=MB+MML,MMBL=2*MBL
C
      DIMENSION YMA(MBL),MSKA(MBL),MSKB(MBL),RESA(MBL)
C
      COMPLEX YAA,ZAB,YBB,XE,YE2,YE3,YE4,YE5,YE6,YEA(MBL),YEB(MBL),
     1        YMB(MBL),RESB(MBL)
C
      COMMON /ENET/ NB,NL,LTA(ML),LTB(ML),YAA(ML),ZAB(ML),YBB(ML)
     1       /EST/ XE(MB),YE2(ML),YE3(ML),YE4(ML),YE5(ML),YE6(MB)
     2       /MSM/ YM1(MB),YM2(ML),YM3(ML),YM4(MML),YM5(MML),YM6(MMB)
     3       /MSI/ MSK1(MB),MSK2(ML),MSK3(ML),MSK4(ML),MSK5(ML),
     4             MSK6(MMB)
     5       /RES/ RES1(MB),RES2(ML),RES3(ML),RES4(MML),RES5(MML),
     6             RES6(MMB)
C
      EQUIVALENCE (YEA,XE),(YEB,YE4),(YMA,YM1),(YMB,YM4),
     1            (MSKA,MSK1),(MSKB,MSK4),(RESA,RES1),(RESB,RES4)
C
      IF (IPRINT-2) 10,30,30
   10 WRITE(6,20)
   20 FORMAT(20H0PRINTOUT FROM CARES/1X,19(1H*))
   30 DO 40 I=1,MBL
      RESA(I)=0.0
   40 RESB(I)=(0.0,0.0)
      CALL GXE(IPRINT,IERR)
      IF (IERR-1) 50,990,990
C
   50 DO 90 I=1,MBL
      IF (MSKA(I)) 70,70,60
   60 RESA(I)=YMA(I)-CABS(YEA(I))
   70 IF (MSKB(I)) 90,90,80
```

```
   80 RESB(I)=YMB(I)-YEB(I)
   90 CONTINUE
C
      IF (IPRINT-2) 100,990,990
  100 CALL PRRES
C
  990 RETURN
      END
```

```
      SUBROUTINE CASDB(SDB,SSL,U,IPRINT)
C
C     COMPUTES THE NEW LOAD DEMAND GIVEN THE OLD DEMAND, THE
C     STANDARD SLOPES AND THE LOAD CONTROL VECTOR ELEMENT U
C     ACCORDING TO:  SDB(*) = SDB(*) + U*SSL(*)
C
C     AUTHOR, TON VAN OVERBEEK 1974-02-11
C
C     SDB(*)            COMPLEX LOAD DEMAND AT BUS *
C     SSL(*)            COMPLEX STANDARD SLOPE FOR BUS *
C     U                 LOAD CONTROL VECTOR ELEMENT, SEE SUBROUTINE RDLD
C     IPRINT=1          NO PRINTOUT
C     IPRINT=0          THE VALUE OF U, THE STANDARD SLOPES AND
C                       THE NEW LOAD DEMAND ARE PRINTED
C
C     SUBROUTINE REQUIRED
C              NONE
C
      COMPLEX SDB(1),SSL(1)
C
      COMMON /TNET/ NB
C
      DO 10 I=1,NB
   10 SDB(I)=SDB(I)+U*SSL(I)
      IF (IPRINT) 20,20,99
   20 WRITE(6,30) U
   30 FORMAT(20H0PRINTOUT FROM CASDB/1X,19(1H*)/
     F4H0U =,F10.5)
      WRITE(6,40)(I,SSL(I),SDB(I),I=1,NB)
   40 FORMAT(13H0BUSNR
     F,10HRE(SSL)
     F,16HIM(SSL)
     F,10HPDEM
     F,4HQDEM//
     F(I5,5X,2F10.5,5X,2F10.5))
C
   99 RETURN
      END
```

```
      SUBROUTINE CAWF(IPRINT)
C
C     COMPUTES THE WEIGHT FACTORS WF FOR THE ESTIMATORS:
C     WF=1/(ALFA*FULL SCALE VALUE + BETA*MEASUREMENT)
C
C     AUTHOR, TON VAN OVERBEEK  1974-01-21
C
C     IPRINT=1        NO PRINTOUT
C     IPRINT=0        ALFA, FULL SCALE, BETA, MEASUREMENT AND WF
C                     VALUES ARE PRINTED
C
C     SUBROUTINE REQUIRED
C             NONE
C
      PARAMETER MB=10,ML=13
      PARAMETER MMB=2*MB,MML=2*ML
C
      COMMON /ENET/ NB,NL
     1       /METE/ WF1(MB),WF2(ML),WF3(ML),WF4(MML),WF5(MML),
     2              WF6(MMB),ALFE1(MB),ALFE2(ML),ALFE3(ML),ALFE4(MML),
     3              ALFE5(MML),ALFE6(MMB),FSE1(MB),FSE2(ML),FSE3(ML),
     4              FSE4(MML),FSE5(MML),FSE6(MMB),BETE1(MB),BETE2(ML),
     5              BETE3(ML),BETE4(MML),BETE5(MML),BETE6(MMB)
     6       /MSM/ YM1(MB),YM2(ML),YM3(ML),YM4(MML),YM5(MML),YM6(MMB)
C
      DO 10 I=1,NB
      I2=2*I
      I1=I2-1
      WF1(I)=1/(ALFE1(I)*FSE1(I)+BETE1(I)*YM1(I))
      WF6(I1)=1/(ALFE6(I1)*FSE6(I1)+BETE6(I1)*YM6(I1))
   10 WF6(I2)=1/(ALFE6(I2)*FSE6(I2)+BETE6(I2)*YM6(I2))
      DO 20 I=1,NL
      I2=2*I
      I1=I2-1
      WF2(I)=1/(ALFE2(I)*FSE2(I)+BETE2(I)*YM2(I))
      WF3(I)=1/(ALFE3(I)*FSE3(I)+BETE3(I)*YM3(I))
      WF4(I1)=1/(ALFE4(I1)*FSE4(I1)+BETE4(I1)*YM4(I1))
      WF4(I2)=1/(ALFE4(I2)*FSE4(I2)+BETE4(I2)*YM4(I2))
      WF5(I1)=1/(ALFE5(I1)*FSE5(I1)+BETE5(I1)*YM5(I1))
   20 WF5(I2)=1/(ALFE5(I2)*FSE5(I2)+BETE5(I2)*YM5(I2))
C
C     PRINTOUT
C
      IF (IPRINT-1) 30,990,990
   30 WRITE(6,40)
   40 FORMAT(19H0PRINTOUT FROM CAWF/1X,18(1H*)/
     F14H0MSMNR
     F,6HALFA
     F,14HFULL SCALE
     F,10HBETA
     F,12HMSMT
     F,2HWF/
     F,7H0TYPE 1/)
     F,14H0MSMNR
```

```
      WRITE(6,50)(I,ALFE1(I),FSE1(I),BETE1(I),YM1(I),WF1(I),I=1,NB)
   50 FORMAT(I5,5X,4F10.5,F10.2)
      WRITE(6,60)
   60 FORMAT(7HOTYPE 2/)
      WRITE(6,50)(I,ALFE2(I),FSE2(I),BETE2(I),YM2(I),WF2(I),I=1,NL)
      WRITE(6,70)
   70 FORMAT(7HOTYPE 3/)
      WRITE(6,50)(I,ALFE3(I),FSE3(I),BETE3(I),YM3(I),WF3(I),I=1,NL)
      WRITE(6,80)
   80 FORMAT(/1H0,33X
     F,53HACTIVE
     F,8HREACTIVE/
     F,14HOMSMNR
     F,6HALFA
     F,14HFULL SCALE
     F,10HBETA
     F,12HMSMT
     F,13HWF
     F,6HALFA
     F,14HFULL SCALE
     F,10HBETA
     F,12HMSMT
     F,2HWF/
     F,7HOTYPE 4/)
      DO 90 I=1,NL
      I2=2*I
      I1=I2-1
   90 WRITE(6,100) I,ALFE4(I1),FSE4(I1),BETE4(I1),YM4(I1),WF4(I1),
     1                ALFE4(I2),FSE4(I2),BETE4(I2),YM4(I2),WF4(I2)
  100 FORMAT(I5,2(5X,4F10.5,F10.2))
      WRITE(6,110)
  110 FORMAT(7HOTYPE 5/)
      DO 120 I=1,NL
      I2=2*I
      I1=I2-1
  120 WRITE(6,100) I,ALFE5(I1),FSE5(I1),BETE5(I1),YM5(I1),WF5(I1),
     1                ALFE5(I2),FSE5(I2),BETE5(I2),YM5(I2),WF5(I2)
      WRITE(6,130)
  130 FORMAT(7HOTYPE 6/)
      DO 140 I=1,NB
      I2=2*I
      I1=I2-1
  140 WRITE(6,100) I,ALFE6(I1),FSE6(I1),BETE6(I1),YM6(I1),WF6(I1),
     1                ALFE6(I2),FSE6(I2),BETE6(I2),YM6(I2),WF6(I2)
C
  990 RETURN
      END
```

```
      SUBROUTINE CAWN(IPRINT)
C
C     COMPUTES THE STANDARD DEVIATIONS WN FOR THE MEASUREMENT
C     NOISE:  WN=1/(ALFA*FULL SCALE VALUE + BETA*TRUE MEASUREMENT)
C
C     AUTHOR, TON VAN OVERBEEK  1974-01-21
C
C     IPRINT=1          NO PRINTOUT
C     IPRINT=0          ALFA, FULL SCALE, BETA, TRUE MEASUREMENT AND WN
C                       VALUES ARE PRINTED
C
C     SUBROUTINE REQUIRED
C             NONE
C
      PARAMETER MB=10,ML=13
      PARAMETER MM3=2*MB,MML=2*ML
C
      COMPLEX XT,YT2,YT3,YT4,YT5,YT6
C
      DIMENSION YA1(MB),YA2(ML),YA3(ML),YR4(ML),YI4(ML),
     1          YR5(ML),YI5(ML),YR6(MB),YI6(MB)
C
      COMMON /TNET/ NB,NL
     1       /METT/ BIAS1(MB),BIAS2(ML),BIAS3(ML),BIAS4(MML),
     2              BIAS5(MML),BIAS6(MMB),WN1(MB),WN2(ML),WN3(ML),
     3              WN4(MML),WN5(MML),WN6(MMB),ALFT1(MB),ALFT2(ML),
     4              ALFT3(ML),ALFT4(MML),ALFT5(MML),ALFT6(MMB),
     5              FST1(MB),FST2(ML),FST3(ML),FST4(MML),
     6              FST5(MML),FST6(MMB),BETT1(MB),BETT2(ML),BETT3(ML),
     7              BETT4(MML),BETT5(MML),BETT6(MMB)
     8       /TRUE/ XT(MB),YT2(ML),YT3(ML),YT4(ML),YT5(ML),YT6(MB)
C
      DO 10 I=1,NB
      I2=2*I
      I1=I2-1
      YA1(I)=CABS(XT(I))
      YR6(I)=REAL(YT6(I))
      YI6(I)=AIMAG(YT6(I))
      WN1(I)=1/(ALFT1(I)*FST1(I)+BETT1(I)*YA1(I))
      WN6(I1)=1/(ALFT6(I1)*FST6(I1)+BETT6(I1)*YR6(I))
   10 WN6(I2)=1/(ALFT6(I2)*FST6(I2)+BETT6(I2)*YI6(I))
      DO 20 I=1,NL
      I2=2*I
      I1=I2-1
      YA2(I)=CABS(YT2(I))
      YA3(I)=CABS(YT3(I))
      YR4(I)=REAL(YT4(I))
      YI4(I)=AIMAG(YT4(I))
      YR5(I)=REAL(YT5(I))
      YI5(I)=AIMAG(YT5(I))
      WN2(I)=1/(ALFT2(I)*FST2(I)+BETT2(I)*YA2(I))
      WN3(I)=1/(ALFT3(I)*FST3(I)+BETT3(I)*YA3(I))
      WN4(I1)=1/(ALFT4(I1)*FST4(I1)+BETT4(I1)*YR4(I))
```

```
      WN4(I2)=1/(ALFT4(I2)*FST4(I2)+BETT4(I2)*YI4(I))
      WN5(I1)=1/(ALFT5(I1)*FST5(I1)+BETT5(I1)*YR5(I))
   20 WN5(I2)=1/(ALFT5(I2)*FST5(I2)+BETT5(I2)*YI5(I))
C
C     PRINTOUT
C
      IF (IPRINT-1) 30,990,990
   30 WRITE(6,40)
   40 FORMAT(19H0PRINTOUT FROM CAWN/1X,18(1H*)/
     F14H0MSMNR
     F,6HALFA
     F,14HFULL SCALE
     F,8HBETA
     F,14HTRUE MSM
     F,2HWN/
     F,7H0TYPE 1/)
     F,14H0MSMNR
      WRITE(6,50)(I,ALFT1(I),FST1(I),BETT1(I),YA1(I),WN1(I),I=1,NB)
   50 FORMAT(I5,5X,4F10.5,F10.2)
      WRITE(6,60)
   60 FORMAT(7H0TYPE 2/)
      WRITE(6,50)(I,ALFT2(I),FST2(I),BETT2(I),YA2(I),WN2(I),I=1,NL)
      WRITE(6,70)
   70 FORMAT(7H0TYPE 3/)
      WRITE(6,50)(I,ALFT3(I),FST3(I),BETT3(I),YA3(I),WN3(I),I=1,NL)
      WRITE(6,80)
   80 FORMAT(/1H0,33X
     F,53HACTIVE
     F,8HREACTIVE/
     F,14H0MSMNR
     F,6HALFA
     F,14HFULL SCALE
     F,8HBETA
     F,14HTRUE MSM
     F,13HWN
     F,6HALFA
     F,14HFULL SCALE
     F,8HBETA
     F,14HTRUE MSM
     F,2HWN/
     F,7H0TYPE 4/)
      DO 90 I=1,NL
      I2=2*I
      I1=I2-1
   90 WRITE(6,100) I,ALFT4(I1),FST4(I1),BETT4(I1),YR4(I),WN4(I1),
     1             ALFT4(I2),FST4(I2),BETT4(I2),YI4(I),WN4(I2)
  100 FORMAT(I5,2(5X,4F10.5,F10.2))
      WRITE(6,110)
  110 FORMAT(7H0TYPE 5/)
      DO 120 I=1,NL
      I2=2*I
      I1=I2-1
  120 WRITE(6,100) I,ALFT5(I1),FST5(I1),BETT5(I1),YR5(I),WN5(I1),
     1             ALFT5(I2),FST5(I2),BETT5(I2),YI5(I),WN5(I2)
```

```
      WRITE(6,130)
  130 FORMAT(7H0TYPE 6/)
      DO 140 I=1,NB
      I2=2*I
      I1=I2-1
  140 WRITE(6,100) I,ALFT6(I1),FST6(I1),BETT6(I1),YR6(I),WN6(I1),
     1                ALFT6(I2),FST6(I2),BETT6(I2),YI6(I),WN6(I2)
C
  990 RETURN
      END
```

```
      SUBROUTINE ELDNL(A1,A2,PMIN,PGEN,PMAX,PDEM,EPS,NG,IPRINT,IERR)
C
C     COMPUTES A SOLUTION TO
C
C     ************************************
C     * THE ECONOMIC LOAD DISPATCH PROBLEM *
C     * NEGLECTING THE TRANSMISSION LOSSES *
C     ************************************
C
C     REFERENCE, L.K. KIRCHMAYER, 'ECONOMIC OPERATIONS OF POWER SYSTEMS'
C
C     AUTHOR, STURE LINDAHL 1972-03-12
C     REVISED FOR SEIPS,TON VAN OVERBEEK 1974-01-11
C
C     A1(I)            COEFFICIENTS IN THE GENERATOR COST FUNCTION
C     A2(I)            F(PG)=A1(I)*PG(I)+A2(I)*PG(I)**2
C     PMIN(I)          MINIMUM PERMISSIBLE ACTIVE POWER AT GENERATOR I
C     PGEN(I)          COMPUTED ACTIVE POWER AT GENERATOR I
C     PMAX(I)          MAXIMUM PERMISSIBLE ACTIVE POWER AT GENERATOR I
C     PDEM             TOTAL DEMAND OF ACTIVE POWER
C     EPS              THE ITERATION IS TERMINATED WHEN
C                      THE POWER MISMATCH IS LESS THAN EPS*PDEM
C     NG               NUMBER OF GENERATORS
C     IPRINT=0         MAXIMUM PRINTOUT FROM ELDNL
C     IPRINT=1         INPUT DATA AND RESULTS ARE PRINTED
C     IPRINT=2         NO PRINTOUT
C     IERR=0           A SOLUTION HAS BEEN COMPUTED
C     IERR=1           ERROR IN NG
C     IERR=2           TOTAL DEMAND OUTSIDE LOAD BOUNDARIES
C
C     SUBROUTINE REQUIRED
C              NONE
C
      DIMENSION A1(1),A2(1),PMIN(1),PGEN(1),PMAX(1)
C
      DATA LP/6/
C
      IF(NG) 10,10,30
   10 WRITE(LP,20) NG
   20 FORMAT(4H NG=,I5,9H IN ELDNL)
      IERR=1
      GO TO 990
C
   30 IF(IPRINT-1) 40,40,100
   40 WRITE(LP,50)
   50 FORMAT(20H0PRINTOUT FROM ELDNL/1X,19(1H*)/)
      WRITE(LP,60)
   60 FORMAT(26H GENERATOR CHARACTERISTICS/1X,25(1H-)/
     110H GENERATOR
     2,15H          PMIN
     3,15H          PMAX
     4,15H            A1
```

```
    5,15H          A2
    6)
     DO 70 I=1,NG
  70 WRITE(LP,80) I,PMIN(I),PMAX(I),A1(I),A2(I)
  80 FORMAT(I7,2F15.1,F15.3,F15.5)
     WRITE(LP,90) PDEM
  90 FORMAT(15H TOTAL DEMAND =,F22.1)
C
C     COMPUTE MINIMUM AND MAXIMUM CAPACITY,INITIAL PGA AND PGB
C
 100 PGMIN=0.0
     PGMAX=0.0
     DO 110 I=1,NG
     PGMIN=PGMIN+PMIN(I)
 110 PGMAX=PGMAX+PMAX(I)
     PGB=PGMAX-PDEM
     PGA=PGMIN-PDEM
     IF(PGB) 130,150,150
 130 WRITE(LP,140)
 140 FORMAT(59H POWER DEMAND GREATER THAN SUM OF MAXIMUM PERMISSIBLE PO
    1WER)
     IERR=2
     GO TO 990
C
 150 IF(PGA) 200,200,160
 160 WRITE(LP,170)
 170 FORMAT(56H POWER DEMAND LESS THAN SUM OF MINIMUM PERMISSIBLE POWER
    1)
     IERR=2
     GO TO 990
C
C     SOLVE THE PROBLEM IF ONLY ONE GENERATOR
C
 200 IF(NG-1) 210,210,220
 210 PGEN(1)=PDEM
     GO TO 400
C
C     COMPUTE INCREMENTAL COST AT MAXIMUM AND MINIMUM LOAD
C     INITIAL ALA AND ALB
C
 220 ALB=A1(1)+2.0*A2(1)*PMAX(1)
     ALA=A1(1)+2.0*A2(1)*PMIN(1)
     DO 230 I=2,NG
     ALB=AMAX1(ALB,(A1(I)+2.0*A2(I)*PMAX(I)))
 230 ALA=AMIN1(ALA,(A1(I)+2.0*A2(I)*PMIN(I)))
C
C     PREPARE FIRST ITERATION
C
     ITER=0
     ALN=ALA
     PMM=PGA
```

```
C
C      HERE STARTS THE ITERATION
C
  240 ITER=ITER+1
C
C      COMPUTE A NEW LAMBDA
C
      IF(PMM) 250,250,260
  250 ALA=ALN
      PGA=PMM
      GO TO 270
  260 ALB=ALN
      PGB=PMM
  270 ALN=ALA+PGA*(ALB-ALA)/(PGA-PGB)
      ALN=AMAX1(ALN,ALA+0.1*(ALB-ALA))
      ALN=AMIN1(ALN,ALB-0.1*(ALB-ALA))
C
C      DETERMINE FEASIBLE LOADS AND POWER MISMATCH
C
      PGN=0.0
      DO 345 I=1,NG
      PGEN(I)=0.5*(ALN-A1(I))/A2(I)
      IF(PGEN(I)-PMIN(I)) 310,320,320
  310 PGEN(I)=PMIN(I)
      GO TO 340
  320 IF(PMAX(I)-PGEN(I)) 330,340,340
  330 PGEN(I)=PMAX(I)
  340 PGN=PGN+PGEN(I)
  345 CONTINUE
      PMM=PGN-PDEM
C
C      ITERATION PRINTOUT
C
      IF(IPRINT) 350,350,380
  350 WRITE(LP,360) ITER,ALN,PMM
  360 FORMAT(15H ITERATION NR =,I22/19H INCREMENTAL COST =,F18.5/
     117H POWER MISMATCH =,F20.5)
      WRITE(LP,370) (PGEN(I),I=1,NG)
  370 FORMAT(22H COMPUTED ACTIVE POWER/(7X,5F15.3))
C
C      TEST ON CONVERGENCY
C
  380 IF(EPS*PDEM-ABS(PMM)) 240,240,400
C
C      PRINTOUT OF FINAL RESULTS
C
  400 IERR=0
      IF(IPRINT-1) 410,410,990
  410 WRITE(LP,420)
  420 FORMAT(//23H RESULT OF OPTIMIZATION/1X,22(1H-)/
     110H GENERATOR,10H      PGEN)
      DO 430 I=1,NG
```

```
430 WRITE(LP,440) I,PGEN(I)
440 FORMAT(I7,F15.3)
    WRITE(LP,450) ALN,PMM
450 FORMAT(19H INCREMENTAL COST =,F18.5/
   117H POWER MISMATCH =,F20.5)
990 RETURN
    END
```

```
      SUBROUTINE ESTA(LIN,DX,IPRINT,IERR)
C
C     PERFORMS ONE ITERATION OF METHOD A BY SOLVING THE EQUATION
C     A*DX=B.  IF LIN=1 A NEW A-MATRIX IS COMPUTED.
C     A=(JACOBIAN)**T*WF*JACOBIAN.  THE RIGHT-HAND VECTOR B IS
C     COMPUTED EACH TIME ESTA IS CALLED.  B=(JACOBIAN)**T*WF*RES.
C     IT IS ASSUMED THAT THE JACOBIAN AND THE RESIDUES ARE ALREADY
C     COMPUTED AND AVAILABLE IN THE COMMON BLOCKS /JAC/ AND /RES/.
C
C     AUTHOR, TON VAN OVERBEEK 1974-02-01
C
C     LIN=1          RELINEARIZATION, A NEW A-MATRIX IS COMPUTED
C     LIN=0          NO RELINEARIZATION
C     DX             THE SOLUTION:  DX=NEW ESTIMATE - OLD ESTIMATE
C                    DX(2*NB) = 0.0 = IMAGINARY PART OF SLACKBUS VOLTAGE
C     IPRINT=4       NO PRINTOUT
C     IPRINT=3       DX IS PRINTED
C     IPRINT=2       SAME + JACOBIAN, THE USED MEASUREMENTS, THE
C                    CORRESPONDING ESTIMATED VALUES AND THE RESIDUES
C                    NOTE:  ONLY THE RESIDUES ARE USED IN THE
C                           CALCULATIONS
C     IPRINT=1       SAME + B-VECTOR
C     IPRINT=0       SAME + A- AND T-MATRICES
C     IERR=1         DECOMPOSITION OF A- IN T-MATRIX HAS FAILED
C     IERR=0         NO DECOMPOSITION ERROR
C
C     SUBROUTINE REQUIRED
C              DESYM
C              MPRI
C              PRJAC
C              PRRES
C              SOLVS
C              UPDAA
C              UPDBA
C
      PARAMETER MB=10,ML=13
      PARAMETER MMB=2*MB,MML=2*ML,MM=3*(MB+MML)
C
      COMPLEX XE,YE2,YE3,YE4,YE5,YE6,YAA,ZAB,YBB
C
      DIMENSION DX(1),INDEX(MMB),ELT(MMB),B(MMB)
C
      COMMON /ENET/ NB,NL,LTA(ML),LTB(ML),YAA(ML),ZAB(ML),YBB(ML)
     1       /EST/ XE(MB),YE2(ML),YE3(ML),YE4(ML),YE5(ML),YE6(MB)
     2       /MSM/ YM1(MB),YM2(ML),YM3(ML),YM4(MML),YM5(MML),YM6(MMB)
     3       /METE/ WF1(MB),WF2(ML),WF3(ML),WF4(MML),WF5(MML),
     4              WF6(MMB)
     5       /RES/ RES1(MB),RES2(ML),RES3(ML),RES4(MML),RES5(MML),
     6             RES6(MMB)
     7       /MAT/ A(MMB,MMB),T(MMB,MMB)
     8       /MSI/ MSK1(MB),MSK2(ML),MSK3(ML),MSK4(ML),MSK5(ML),
     9             MSK6(MB)
     1       /JAC/ AJAC1(MB,2),AJAC2(ML,4),AJAC3(ML,4),AJAC4(MML,4),
     2             AJAC5(MML,4),AJAC6(MMB,MMB)
```

```
C
      IF (IPRINT-4) 10,40,40
   10 WRITE(6,20)
   20 FORMAT(19H0PRINTOUT FROM ESTA/1X,18(1H*))
      IF (IPRINT-3) 30,40,40
   30 CALL PRRES
      CALL PRJAC
C
C     UPDATING OF A-MATRIX AND B-VECTOR
C
   40 NNB=2*NB
      DO 55 I=1,NNB
      B(I)=0.0
      IF (LIN) 55,55,45
   45 DO 50 J=1,NNB
   50 A(I,J)=0.0
   55 CONTINUE
C
C     TYPE 1
C
      DO 80 I=1,NB
      IF (MSK1(I)) 80,80,60
   60 INDEX(1)=2*I-1
      INDEX(2)=2*I
      ELT(1)=AJAC1(I,1)
      ELT(2)=AJAC1(I,2)
      CALL UPDBA(INDEX,ELT,2,WF1(I),B,RES1(I))
      IF (LIN) 80,80,70
   70 CALL UPDAA(INDEX,ELT,2,WF1(I),A)
   80 CONTINUE
C
C     TYPE 2
C
      DO 120 I=1,NL
      IF (MSK2(I)) 120,120,90
   90 IA=LTA(I)
      IB=LTB(I)
      INDEX(1)=2*IA-1
      INDEX(2)=2*IA
      INDEX(3)=2*IB-1
      INDEX(4)=2*IB
      DO 100 J=1,4
  100 ELT(J)=AJAC2(I,J)
      CALL UPDBA(INDEX,ELT,4,WF2(I),B,RES2(I))
      IF (LIN) 120,120,110
  110 CALL UPDAA(INDEX,ELT,4,WF2(I),A)
  120 CONTINUE
C
C     TYPE 3
C
      DO 160 I=1,NL
      IF (MSK2(I)) 160,160,130
  130 IA=LTA(I)
```

```
      IB=LTB(I)
      INDEX(1)=2*IB-1
      INDEX(2)=2*IB
      INDEX(3)=2*IA-1
      INDEX(4)=2*IA
      DO 140 J=1,4
  140 ELT(J)=AJAC3(I,J)
      CALL UPDBA(INDEX,ELT,4,WF3(I),B,RES3(I))
      IF (LIN) 160,160,150
  150 CALL UPDAA(INDEX,ELT,4,WF3(I),A)
  160 CONTINUE
C
C     TYPE 4
C
      DO 250 I=1,NL
      M=MSK4(I)
      IF (M) 250,250,170
  170 I2=2*I
      I1=I2-1
      IA=LTA(I)
      IB=LTB(I)
      INDEX(1)=2*IA-1
      INDEX(2)=2*IA
      INDEX(3)=2*IB-1
      INDEX(4)=2*IB
C
      IF (M-2) 210,180,180
  180 DO 190 J=1,4
  190 ELT(J)=AJAC4(I2,J)
      CALL UPDBA(INDEX,ELT,4,WF4(I2),B,RES4(I2))
      IF (LIN) 210,210,200
  200 CALL UPDAA(INDEX,ELT,4,WF4(I2),A)
C
  210 IF (M-2) 220,250,220
  220 DO 230 J=1,4
  230 ELT(J)=AJAC4(I1,J)
      CALL UPDBA(INDEX,ELT,4,WF4(I1),B,RES4(I1))
      IF (LIN) 250,250,240
  240 CALL UPDAA(INDEX,ELT,4,WF4(I1),A)
C
  250 CONTINUE
C
C     TYPE 5
C
      DO 340 I=1,NL
      M=MSK5(I)
      IF (M) 340,340,260
  260 I2=2*I
      I1=I2-1
      IA=LTA(I)
      IB=LTB(I)
      INDEX(1)=2*IB-1
      INDEX(2)=2*IB
```

```
      INDEX(3)=2*IA-1
      INDEX(4)=2*IA
C
      IF (M-2) 300,270,270
  270 DO 280 J=1,4
  280 ELT(J)=AJAC5(I2,J)
      CALL UPDBA(INDEX,ELT,4,WF5(I2),B,RES5(I2))
      IF (LIN) 300,300,290
  290 CALL UPDAA(INDEX,ELT,4,WF5(I2),A)
C
  300 IF (M-2) 310,340,310
  310 DO 320 J=1,4
  320 ELT(J)=AJAC5(I1,J)
      CALL UPDBA(INDEX,ELT,4,WF5(I1),B,RES5(I1))
      IF (LIN) 340,340,330
  330 CALL UPDAA(INDEX,ELT,4,WF5(I1),A)
C
  340 CONTINUE
C
C     TYPE 6
C
      NNB1=NNB-1
      DO 350 I=1,NNB1
  350 INDEX(I)=I
      DO 440 I=1,NNB1
      M=MSK6(I)
      IF (M) 440,440,360
  360 I2=2*I
      I1=I2-1
C
      IF (M-2) 400,370,370
  370 DO 380 J=1,NNB1
  380 ELT(J)=AJAC6(I2,J)
      CALL UPDBA(INDEX,ELT,NNB1,WF6(I2),B,RES6(I2))
      IF (LIN) 400,400,390
  390 CALL UPDAA(INDEX,ELT,NNB1,WF6(I2),A)
C
  400 IF (M-2) 410,440,410
  410 DO 420 J=1,NNB1
  420 ELT(J)=AJAC6(I1,J)
      CALL UPDBA(INDEX,ELT,NNB1,WF6(I1),B,RES6(I1))
      IF (LIN) 440,440,430
  430 CALL UPDAA(INDEX,ELT,NNB1,WF6(I1),A)
C
  440 CONTINUE
C
C     PRINTOUT
C
      IF (IPRINT) 450,450,470
  450 WRITE(6,460)
  460 FORMAT(9H0MATRIX A/1X,8(1H-)//)
      CALL MPRI(A,NNB1,NNB1,MMB,8,0,IE)
C
```

```
C     SOLVE A*DX=B
C
  470 CALL DESYM(A,T,NNB1,1.E-7,IRANK,MMB)
      IF (IRANK) 480,480,500
  480 IERR=1
      WRITE(6,490)
  490 FORMAT(34H0DECOMPOSITION OF A FAILED IN ESTA)
      RETURN
C
  500 IERR=0
      CALL SOLVS(T,B,DX,NNB1,1,MMB)
      DX(NNB)=0.0
C
C     PRINTOUT
C
      IF (IPRINT-4) 505,990,990
  505 IF (IPRINT-1) 510,530,550
  510 WRITE(6,520)
  520 FORMAT(9H0MATRIX T/1X,8(1H-)//)
      CALL MPRI(T,NNB1,NNB1,MMB,8,0,IE)
  530 WRITE(6,540)(B(I),I=1,NNB1)
  540 FORMAT(1H0,6X,8HB-VECTOR/7X,8(1H-)//(F11.3,F10.3))
  550 WRITE(6,560)(I,DX(2*I-1),DX(2*I),I=1,NB)
  560 FORMAT(14H0BUSNR
     F,10HRE(DX)
     F,6HIM(DX)//
     F(I5,5X,2F10.5))
C
  990 RETURN
      END
```

```
      SUBROUTINE ESTB(IPRINT,IERR)
C
C     PERFORMS ONE ITERATION OF METHOD B
C
C     AUTHOR, TON VAN OVERBEEK 1974-03-04
C
C     IPRINT=2          NO PRINTOUT
C     IPRINT=1          THE INITIAL ESTIMATE, COVARIANCE AND THE FINAL
C                       ESTIMATE AND COVARIANCE ARE PRINTED
C     IPRINT=0          SAME + FOR EACH MEASUREMENT THE OLD AND NEW
C                       ESTIMATE AND COVARIANCE ELEMENTS AND THE
C                       CORRESPONDING FOUR GAIN ELEMENTS
C     IERR=1            ERROR IN MASK VECTOR
C     IERR=0            NO ERROR
C
C     SUBROUTINE REQUIRED
C              JACBI
C                JACLF
C              JACI
C              JACLF
C              JACV
C              UPDEP
C
      PARAMETER MB=10,ML=13
      PARAMETER MMB=2*MB,MML=2*ML,MM=3*(MB+MML)
C
      DIMENSION G(MMB),P(MMB),PP(4),AK(MMB)
C
      COMPLEX YAA,YA,ZAB,ZL,YBB,XE,XEA,XEB,CGXE
C
      COMMON /EST/ XE(MB)
     X       /ENET/ NB,NL,LTA(ML),LTB(ML),YAA(ML),ZAB(ML),YBB(ML)
     X       /METE/ WF1(MB),WF2(ML),WF3(ML),WF4(MML),WF5(MML),WF6(MMB)
     X       /MSM/ YM1(MB),YM2(ML),YM3(ML),YM4(MML),YM5(MML),YM6(MMB)
     X       /MSI/ MSK1(MB),MSK2(ML),MSK3(ML),MSK4(ML),MSK5(ML),
     X             MSK6(MB),NM,NTYP(MM),NMSM(MM)
     X       /VAR/ COV(MMB),PNEW(MMB)
C
C     FORMAT STATEMENTS
C
   10 FORMAT(24H0TYPE MSMNR    MSM
     F,6HWEIGHT//I4,I6,2F10.5)
   20 FORMAT(24H0TYPE MSMNR    ACTIVE
     F,6HWEIGHT//I4,I6,2F10.5)
   30 FORMAT(24H0TYPE MSMNR REACTIVE
     F,6HWEIGHT//I4,I6,2F10.5)
   40 FORMAT(1H0,24X,15HOLD EST AND COV)
   50 FORMAT(14H0BUSNR
     F,10HRE(XE)
     F,15HIM(XE)
     F,10HPREAL
     F,5HPIMAG//(I5,5X,2F10.5,5X,2F10.5))
   60 FORMAT(1H0,36X,15HNEW EST AND COV/
```

```
     F,14H0BUSNR
     F,10HRE(XE)
     F,15HIM(XE)
     F,10HREGAIN
     F,15HIMGAIN
     F,10HPREAL
     F,5HPIMAG//(I5,5X,2F10.5,5X,2F10.5,5X,2F10.5))
  70 FORMAT(13H0ERROR IN MSK,5X,5HMSK =,I5,
     F7H TYPE =,I5,8H MSMNR =,I5)
C
      NNB=2*NB
      NNB1=NNB-1
      IERR=0
      DO 75 I=1,NNB1
  75  P(I)=COV(I)
      P(NNB)=0.0
      IF (IPRINT-1) 80,80,100
  80  WRITE(6,90)
  90  FORMAT(1H0,22X,19HINITIAL EST AND COV)
      WRITE(6,50)(I,XE(I),P(2*I-1),P(2*I),I=1,NB)
C
C     SEQUENTIAL PROCESSING OF MEASUREMENTS
C
 100  DO 620 I=1,NM
      IF (IPRINT .LE. 0) WRITE(6,105) I
 105  FORMAT(13H0MEASUREMENT ,I5/1X,17(1H*))
      NT=NTYP(I)
      IM=NMSM(I)
      GO TO (110,170,210,290,320,450),NT
C
C     TYPE 1
C
 110  IF (MSK1(IM)) 120,120,130
 120  WRITE(6,70) MSK1(IM),NT,IM
      IERR=1
      RETURN
C
 130  IM2=2*IM
      IM1=IM2-1
      YM=YM1(IM)
      XEA=XE(IM)
      IF (IPRINT) 140,140,150
 140  WRITE(6,10) NT,IM,YM,WF1(IM)
      WRITE(6,40)
      WRITE(6,50) IM,XEA,P(IM1),P(IM2)
 150  GXE=CABS(XEA)
      RES=YM-GXE
      CALL JACV(XEA,G,1,1,IE)
      AK1=P(IM1)*G(1)
      AK2=P(IM2)*G(2)
      DEN=AK1*G(1)+AK2*G(2)+1/WF1(IM)
      AK1=AK1/DEN
      AK2=AK2/DEN
```

```
      IF (IM .EQ. NB) AK2=0.0
      XE(IM)=XEA+CMPLX(AK1,AK2)*RES
      P(IM1)=P(IM1)*(1-AK1*G(1))
      P(IM2)=P(IM2)*(1-AK2*G(2))
      IF (IPRINT) 160,160,620
  160 WRITE(6,60) IM,XE(IM),AK1,AK2,P(IM1),P(IM2)
      GO TO 620
C
C     TYPE 2 AND 3
C
  170 IF (MSK2(IM)) 180,180,190
  180 WRITE(6,70) MSK2(IM),NT,IM
      IERR=1
      RETURN
C
  190 IA=LTA(IM)
      IB=LTB(IM)
      YA=YAA(IM)
      YM=YM2(IM)
      WF=WF2(IM)
      IF (IPRINT) 200,200,250
  200 WRITE(6,10) NT,IM,YM,WF
      GO TO 250
C
  210 IF (MSK3(IM)) 220,220,230
  220 WRITE(6,70) MSK3(IM),NT,IM
      IERR=1
      RETURN
C
  230 IA=LTB(IM)
      IB=LTA(IM)
      YA=YBB(IM)
      YM=YM3(IM)
      WF=WF3(IM)
      IF (IPRINT) 240,240,250
  240 WRITE(6,10) NT,IM,YM,WF
C
  250 IA2=2*IA
      IA1=IA2-1
      IB2=2*IB
      IB1=IB2-1
      PP(1)=P(IA1)
      PP(2)=P(IA2)
      PP(3)=P(IB1)
      PP(4)=P(IB2)
      XEA=XE(IA)
      XEB=XE(IB)
      IF (IPRINT) 260,260,270
  260 WRITE(6,40)
      WRITE(6,50) IA,XEA,PP(1),PP(2),
     1            IB,XEB,PP(3),PP(4)
  270 ZL=ZAB(IM)
      GXE=CABS((XEA-XEB)/ZL+YA*XEA)
```

```
      RES=YM-GXE
      CALL JAC1(XEA,XEB,ZL,YA,G,1,1,IE)
      CALL UPDEP(IA,IB,RES,WF,G,PP,AK,XE)
      P(IA1)=PP(1)
      P(IA2)=PP(2)
      P(IB1)=PP(3)
      P(IB2)=PP(4)
      IF (IPRINT) 280,280,620
  280 WRITE(6,60) IA,XE(IA),AK(1),AK(2),PP(1),PP(2),
     1            IB,XE(IB),AK(3),AK(4),PP(3),PP(4)
      GO TO 620
C
C     TYPE 4 AND 5
C
  290 M=MOD(IM,2)
      II=IM/2+M
      IF (MSK4(II)) 300,300,310
  300 WRITE(6,70) MSK4(II),NT,IM
      IERR=1
      RETURN
C
  310 IA=LTA(II)
      IB=LTB(II)
      YA=YAA(II)
      YM=YM4(IM)
      WF=WF4(IM)
      GO TO 350
C
  320 M=MOD(IM,2)
      II=IM/2+M
      IF (MSK5(II)) 330,330,340
  330 WRITE(6,70) MSK5(II),NT,IM
      IERR=1
      RETURN
C
  340 IA=LTB(II)
      IB=LTA(II)
      YA=YBB(II)
      YM=YM5(IM)
      WF=WF5(IM)
C
  350 MSK=2-M
      IA2=2*IA
      IA1=IA2-1
      IB2=2*IB
      IB1=IB2-1
      PP(1)=P(IA1)
      PP(2)=P(IA2)
      PP(3)=P(IB1)
      PP(4)=P(IB2)
      XEA=XE(IA)
      XEB=XE(IB)
      ZL=ZAB(II)
```

```
      CALL JACLF(MSK,XEA,XEB,ZL,YA,G,1,G,1,1,IE)
      CGXE=XEA*CONJG((XEA-XEB)/ZL+XEA*YA)
      IF (M) 390,390,360
C
C     ACTIVE MEASUREMENT
C
  360 IF (IPRINT) 370,370,380
  370 WRITE(6,20) NT,IM,YM,WF
      WRITE(6,40)
      WRITE(6,50) IA,XEA,PP(1),PP(2),
     1            IB,XEB,PP(3),PP(4)
  380 RES=YM-REAL(CGXE)
      GO TO 420
C
C     REACTIVE MEASUREMENT
C
  390 IF (IPRINT) 400,400,410
  400 WRITE(6,30) NT,IM,YM,WF
      WRITE(6,40)
      WRITE(6,50) IA,XEA,PP(1),PP(2),
     1            IB,XEB,PP(3),PP(4)
  410 RES=YM-AIMAG(CGXE)
C
  420 CALL UPDEP(IA,IB,RES,WF,G,PP,AK,XE)
      IF (IPRINT) 430,430,440
  430 WRITE(6,60) IA,XE(IA),AK(1),AK(2),PP(1),PP(2),
     1            IB,XE(IB),AK(3),AK(4),PP(3),PP(4)
  440 P(IA1)=PP(1)
      P(IA2)=PP(2)
      P(IB1)=PP(3)
      P(IB2)=PP(4)
      GO TO 620
C
C     TYPE 6
C
  450 M=MOD(IM,2)
      IA=IM/2+M
      IF (MSK6(IA)) 460,460,470
  460 WRITE(6,70) MSK6(IA),NT,IM
      IERR=1
      RETURN
C
  470 MSK=2-M
      YM=YM6(IM)
      WF=WF6(IM)
      XEA=XE(IA)
      CALL JACBI(MSK,IA,G,1,G,1,1,IE)
      CGXE=(0.0,0.0)
      DO 500 J=1,NL
      IF (LTA(J) .NE. IA) GO TO 480
      IB=LTB(J)
      YA=YAA(J)
      GO TO 490
  480 IF (LTB(J) .NE. IA) GO TO 500
```

```
      IB=LTA(J)
      YA=YBB(J)
  490 XEB=XE(IB)
      ZL=ZAB(J)
      CGXE=CGXE+XEA*CONJG((XEA-XEB)/ZL+YA*XEA)
  500 CONTINUE
      IF (M) 540,540,510
C
C     ACTIVE MEASUREMENT
C
  510 IF (IPRINT) 520,520,530
  520 WRITE(6,20) NT,IM,YM,WF
      WRITE(6,40)
      WRITE(6,50)(J,XE(J),P(2*J-1),P(2*J),J=1,NB)
  530 RES=YM-REAL(CGXE)
      GO TO 570
C
C     REACTIVE MEASUREMENT
C
  540 IF (IPRINT) 550,550,560
  550 WRITE(6,30) NT,IM,YM,WF
      WRITE(6,40)
      WRITE(6,50)(J,XE(J),P(2*J-1),P(2*J),J=1,NB)
  560 RES=YM-AIMAG(CGXE)
C
  570 DEN=0.0
      DO 580 J=1,NNB1
      AK(J)=P(J)*G(J)
  580 DEN=DEN+AK(J)*G(J)
      DEN=DEN+1/WF
      AK(NNB)=0.0
      DO 590 J=1,NB
      J2=2*J
      J1=J2-1
      AK(J1)=AK(J1)/DEN
      AK(J2)=AK(J2)/DEN
  590 XE(J)=XE(J)+CMPLX(AK(J1),AK(J2))*RES
      DO 600 J=1,NNB1
  600 P(J)=P(J)*(1-AK(J)*G(J))
      P(NNB)=0.0
      IF (IPRINT) 610,610,620
  610 WRITE(6,60)(J,XE(J),AK(2*J-1),AK(2*J),P(2*J-1),P(2*J),J=1,NB)
C
  620 CONTINUE
C
      DO 625 I=1,NNB
  625 PNEW(I)=P(I)
      IF (IPRINT-1) 630,630,990
  630 WRITE(6,640)
  640 FORMAT(1H0,23X,17HFINAL EST AND COV)
      WRITE(6,50)(J,XE(J),P(2*J-1),P(2*J),J=1,NB)
C
  990 RETURN
      END
```

```
      SUBROUTINE ESTC(NR,DA,DB,MAXIT,EPS,NEWA,IEXIT,TIME,IPRINT)
C
C     BASIS ROUTINE FOR METHOD C.  IT ESTIMATES THE BUSVOLTAGES
C     THAT DON'T BELONG TO THE REFERENCE VECTOR.  THE REFERENCE
C     VOLTAGES AND THE LINEVOLTAGE WEIGHTING FACTORS DA(*) AND DB(*)
C     ARE ASSUMED TO BE GIVEN
C
C     AUTHOR, TON VAN OVERBEEK 1974-03-12
C
C     NR                NUMBER OF COMPLEX REFERENCE VOLTAGES
C     DA(*)             WEIGHTING FACTOR FOR LINEVOLTAGE AT A-END
C     DB(*)             IDEM FOR B-END
C     MAXIT             MAXIMUM NUMBER OF ITERATIONS
C     EPS               THE ITERATING IS TERMINATED WHEN
C                       CABS(XE(IT + 1) - XE(IT)) .LE. EPS
C     NEWA=1            A NEW A-MATRIX IS CALCULATED AND DECOMPOSED
C                       IN THE FIRST ITERATION
C     NEWA=0            NO NEW A-MATRIX IS CALCULATED
C     IEXIT=-2          DECOMPOSITION OF A HAS FAILED
C     IEXIT=-1          ERROR IN NB, NL OR NR
C     IEXIT= 1          CONVERGENCE WITHIN MAXIT ITERATIONS
C     IEXIT= 2          NO CONVERGENCE AFTER MAXIT ITERATIONS
C     TIME              TOTAL TIME IN MSECS
C     IPRINT=4          NO PRINTOUT
C     IPRINT=3          INITIAL ESTIMATE, THE NUMBER OF ITERATIONS,
C                       TOTAL TIME AND THE ESTIMATE ARE PRINTED
C     IPRINT=3          SAME + THE INPUT DATA:  NR, DA, DB, MAXIT AND EPS
C     IPRINT=1          SAME + IN EACH ITERATION:  THE CALCULATED
C                       LINEVOLTAGES, THE B-VECTOR, THE ESTIMATE AND DELX
C     IPRINT=0          SAME + IN THE FIRST ITERATION THE A- AND
C                       T-MATRICES
C
C     SUBROUTINE REQUIRED
C               DESYM
C               MPRI
C               SOLVS
C               UPDAC
C               UPDBC
C
      PARAMETER MB=10,ML=13
      PARAMETER MMB=2*MB,MML=2*ML
C
      INTEGER TIME,TBEG,TEND
C
      DIMENSION DA(1),DB(1),X(MB,2),B(MB,2),
     1          PR(9)/'(1H0,',0,'17HCON','VERGEN','CE AFT',
     2          'ER,I5,','11H IT','ERATIO','NS)'/
C
      COMPLEX YAA,ZAB,YBB,XE,XEA,XEB,ZL,CYM4(ML),CYM5(ML),
     1        CLVA(ML),CLVB(ML),CB(MB),XEN(MB)
C
      COMMON /ENET/ NB,NL,LTA(ML),LTB(ML),YAA(ML),ZAB(ML),YBB(ML)
     X       /EST/ XE(MB)
```

```
     X        /MAT/ A(MB,MB),T(MB,MB)
     X        /MSM/ YM1(MB),YM2(ML),YM3(ML),YM4(MML),YM5(MML),YM6(MMB)
     X        /MSI/ MSK1(MB),MSK2(ML),MSK3(ML),MSK4(ML),MSK5(ML),MSK6(MB)
C
      EQUIVALENCE (CYM4,YM4),(CYM5,YM5)
C
C     CHECK NB, NL AND NR
C
      IF (NB) 20,20,10
   10 IF (NB-MB) 40,40,20
   20 IEXIT=-1
      WRITE(6,30) NB
   30 FORMAT(13H0NB IN ESTC =,I5)
      RETURN
C
   40 IF (NL) 60,60,50
   50 IF (NL-ML) 80,80,60
   60 IEXIT=-1
      WRITE(6,70) NL
   70 FORMAT(13H0NL IN ESTC =,I5)
      RETURN
C
   80 IF (NR) 100,100,90
   90 IF (NR-NB) 120,120,100
  100 IEXIT=-1
      WRITE(6,110) NR
  110 FORMAT(13H0NR IN ESTC =,I5)
      RETURN
C
  120 IF (IPRINT-2) 130,130,160
  130 WRITE(6,140) NR,MAXIT,EPS,NEWA
  140 FORMAT(12H0INPUT DATA:/5H0NR =,I5,5X,7HMAXIT =,I5,5X,
     F5HEPS =,E7.1,5X,6HNEWA =,I5)
      WRITE(6,150)(I,MSK4(I),DA(I),MSK5(I),DB(I),I=1,NL)
  150 FORMAT(1H0,5X,33HALL LINEVOLTAGE WEIGHTING FACTORS/
     F12H0 LINE
     F,20HMSK4     DA
     F,10HMSK5     DB//
     F(I5,I10,F10.2,I10,F10.2))
  160 IF (IPRINT-3) 170,170,190
  170 WRITE(6,180)(I,XE(I),I=1,NB)
  180 FORMAT(1H0,13X,16HINITIAL ESTIMATE/
     F14H0BUSNR
     F,10HRE(XE)
     F,6HIM(XE)//
     F(I5,5X,2F10.5))
C
C     INITIALIZATION
C
  190 IT=0
      NE=NB-NR
      IF (NEWA) 220,220,200
  200 DO 210 I=1,NE
```

```
      DO 210 J=1,NE
  210 A(I,J)=0.0
  220 TBEG=MSCPU(X)
C
C     HERE STARTS THE ITERATION
C
  230 IT=IT+1
      DO 240 I=1,NB
  240 CB(I)=(0.0,0.0)
C
C     CALCULATION OF B AND A
C
      DO 320 I=1,NL
      IA=LTA(I)
      IB=LTB(I)
      XEA=XE(IA)
      XEB=XE(IB)
      ZL=ZAB(I)
      IF (MSK4(I)-2) 280,280,250
  250 IF (NEWA) 270,270,260
  260 CALL UPDAC(IA,IB,DA(I))
  270 CALL UPDBC(CB,IA,IB,NR,XEA,XEB,ZL,YAA(I),CYM4(I),CLVA(I),DA(I))
  280 IF (MSK5(I)-2) 320,320,290
  290 IF (NEWA) 310,310,300
  300 CALL UPDAC(IB,IA,DB(I))
  310 CALL UPDBC(CB,IB,IA,NR,XEB,XEA,ZL,YBB(I),CYM5(I),CLVB(I),DB(I))
  320 CONTINUE
C
C     ITERATION PRINTOUT
C
      IF (IPRINT-1) 330,330,450
  330 WRITE(6,340) IT
  340 FORMAT(13H0ITERATION NR,I5/1X,17(1H*)/
     F1H0,21X,25HTHE COMPUTED LINEVOLTAGES/
     F13H0 LINE
     F,10HRE(LVA)
     F,15HIM(LVA)
     F,10HRE(LVB)
     F,7HIM(LVB)/)
      DO 410 I=1,NL
      WRITE(6,350) I
  350 FORMAT(I5)
      IF (MSK4(I)-2) 380,380,360
  360 WRITE(6,370) CLVA(I)
  370 FORMAT(1H+,9X,2F10.5)
  380 IF (MSK5(I)-2) 410,410,390
  390 WRITE(6,400) CLVB(I)
  400 FORMAT(1H+,34X,2F10.5)
  410 CONTINUE
      WRITE(6,420)(I,CB(I),I=1,NE)
  420 FORMAT(1H0,15X,8HB-VECTOR/16X,8(1H-)//
     F(I5,5X,2F10.2))
      IF (IT-1) 430,430,520
```

```
  430 IF (IPRINT) 440,440,450
  440 WRITE(6,445)
  445 FORMAT(9H0MATRIX-A/1X,8(1H-)/)
      CALL MPRI(A,NE,NE,NB,8,0,IE)
C
C     SOLUTION OF A*E=B
C
  450 IF (NEWA) 520,520,460
  460 CALL DESYM(A,T,NE,1.0E-7,IRANK,MB)
      IF (IRANK) 470,470,490
  470 WRITE(6,480)
  480 FORMAT(21H0DECOMPOSITION FAILED)
      IEXIT=-2
      RETURN
C
  490 IF (IPRINT) 500,500,520
  500 WRITE(6,510)
  510 FORMAT(9H0MATRIX-T/1X,8(1H-)/)
      CALL MPRI(T,NE,NE,MB,8,0,IE)
C
  520 DO 530 I=1,NE
      B(I,1)=REAL(CB(I))
  530 B(I,2)=AIMAG(CB(I))
      CALL SOLVS(T,B,X,NE,2,MB)
      DELX=0.0
      DO 540 I=1,NE
      XEN(I)=CMPLX(X(I,1),X(I,2))
      DELX=DELX+CABS(XEN(I)-XE(I))
  540 XE(I)=XEN(I)
C
      IF (IPRINT-1) 550,550,580
  550 WRITE(6,560)(I,XE(I),I=1,NB)
  560 FORMAT(1H0,15X,12HTHE ESTIMATE/
     F14H0BUSNR
     F,10HRE(XE)
     F,6HIM(XE)//
     F(I5,5X,2F10.5))
      WRITE(6,570) DELX
  570 FORMAT(7H0DELX =E10.3)
C
  580 IF (DELX-ABS(EPS)) 600,600,590
  590 IF (IT .GE. MAXIT) GO TO 610
      NEWA=0
      GO TO 230
C
C     END OF ESTIMATION, PRINTOUT OF THE RESULTS
C
  600 IEXIT=1
      PR(2)='/1H+,'
      GO TO 620
  610 IEXIT=2
      PR(2)='3HNO ,'
  620 TEND=MSCPU(X)
```

```
      TIME=TEND-TBEG
C
      IF (IPRINT-3) 630,630,990
  630 WRITE(6,640)
  640 FORMAT(19H0ESTIMATION RESULTS/1X,18(1H-))
      WRITE(6,PR) IT
      WRITE(6,650) TIME
  650 FORMAT(22H0TOTAL TIME FOR ESTC =,I5,6H MSECS)
      WRITE(6,560)(I,XE(I),I=1,NB)
C
  990 RETURN
      END
```

```
      SUBROUTINE EVAL(K,IPRINT)
C
C     THIS SUBROUTINE COMPUTES FOR TIMEPOINT K THE FOLLOWING QUANTITIES:
C           -  THE ESTIMATION ERROR
C           -  THE MAXIMUM ELEMENT IN THE ESTIMATION ERROR
C           -  THE LINE FLOW ERROR
C           -  THE MAXIMUM ELEMENT IN THE LINE FLOW ERROR
C           -  THE MEASUREMENT QUALITY INDEX
C     IT UPDATES THE FOLLOWING QUANTITIES:
C           -  THE AVERAGE ESTIMATION ERROR
C           -  THE MAXIMUM ESTIMATION ERROR
C           -  THE MAXIMUM ELEMENT IN ALL ESTIMATION ERRORS
C           -  THE AVERAGE LINE FLOW ERROR
C           -  THE MAXIMUM LINE FLOW ERROR
C           -  THE MAXIMUM ELEMENT IN ALL LINE FLOW ERRORS
C           -  THE AVERAGE MEASUREMENT QUALITY INDEX
C           -  THE MAXIMUM MEASUREMENT QUALITY INDEX
C     ALL THESE QUANTITIES ARE STORED IN THE COMMON BLOCK /EVL/
C
C     AUTHOR, TON VAN OVERBEEK 1974-02-18
C
C     K                TIME POINT
C     IPRINT=1         NO PRINTOUT
C     IPRINT=0         THE ABOVE MENTIONED QUANTITIES ARE PRINTED
C
C     SUBROUTINE REQUIRED
C              NONE
C
      PARAMETER MB=10,ML=13,MTMX=360
      PARAMETER MMB=2*MB,MML=2*ML,MBL=MB+MML,MMBL=2*MBL,MTMX1=MTMX+1
C
      DIMENSION AXE(MMB),AXT(MMB),AYE4(MML),AYT4(MML),AYE5(MML),
     1          AYT5(MML),YMA(MBL),MSKA(MBL),YMB(MMBL),MSKB(MBL)
C
      COMPLEX XE,YE2,YE3,YE4,YE5,YE6,XT,YT2,YT3,YT4,YT5,YT6,
     1        YEA(MBL),YEB(MBL),YTA(MBL),YTB(MBL),AME
C
      COMMON /EST/ XE(MB),YE2(ML),YE3(ML),YE4(ML),YE5(ML),YE6(MB)
     X       /TRUE/ XT(MB),YT2(ML),YT3(ML),YT4(ML),YT5(ML),YT6(MB)
     X       /ENET/ NB,NL
     X       /MSI/ MSK1(MB),MSK2(ML),MSK3(ML),MSK4(ML),MSK5(ML),MSK6(MB)
     X       /MSM/ YM1(MB),YM2(ML),YM3(ML),YM4(MML),YM5(MML),YM6(MMB)
     X       /EVL/ EE(MTMX1),EEM(MTMX1,2),AEE,EEMT(2),EEMMT(3),
     X             EL(MTMX1),ELM(MTMX1,2),AEL,ELMT(2),ELMMT(3),
     X             EM(MTMX1),AEM,EMMT(2)
C
      EQUIVALENCE (AXE,XE),(AXT,XT),(AYE4,YE4),(AYT4,YT4),(AYE5,YE5),
     1            (AYT5,YT5),(YEA,XE), (YTA,XT), (MSKA,MSK1),(YMA,YM1),
     2                       (YEB,YE4),(YTB,YT4),(MSKB,MSK4),(YMB,YM4)
C
      K1=K+1
C
```

```
C     ESTIMATION ERROR
C
      EE(K1)=0.0
      EEM(K1,1)=0.0
      NNB1=2*NB-1
      DO 30 I=1,NNB1
      AE=ABS(AXE(I)-AXT(I))
      E=AE**2
      EE(K1)=EE(K1)+E
      IF (EEM(K1,1)-AE) 10,10,30
   10 EEM(K1,1)=AE
      EEM(K1,2)=FLOAT(I)
      IF (EEMMT(1)-AE) 20,20,30
   20 EEMMT(1)=AE
      EEMMT(2)=FLOAT(I)
      EEMMT(3)=FLOAT(K)
   30 CONTINUE
      EE(K1)=SQRT(EE(K1))
      IF (EEMT(1)-EE(K1)) 40,40,50
   40 EEMT(1)=EE(K1)
      EEMT(2)=FLOAT(K)
   50 AEE=AEE+EE(K1)
C
C     LINE FLOW ERROR
C
      EL(K1)=0.0
      ELM(K1,1)=0.0
      NNL=2*NL
      DO 110 I=1,NNL
      AE4=ABS(AYE4(I)-AYT4(I))
      AE5=ABS(AYE5(I)-AYT5(I))
      E4=AE4**2
      E5=AE5**2
      EL(K1)=EL(K1)+E4+E5
      IF (ELM(K1,1)-AE4) 60,60,80
   60 ELM(K1,1)=AE4
      ELM(K1,2)=FLOAT(I)
      IF (ELMMT(1)-AE4) 70,70,80
   70 ELMMT(1)=AE4
      ELMMT(2)=ELM(K1,2)
      ELMMT(3)=FLOAT(K)
   80 IF (ELM(K1,1)-AE5) 90,90,110
   90 ELM(K1,1)=AE5
      ELM(K1,2)=-FLOAT(I)
      IF (ELMMT(1)-AE5) 100,100,110
  100 ELMMT(1)=AE5
      ELMMT(2)=ELM(K1,2)
      ELMMT(3)=FLOAT(K)
  110 CONTINUE
      EL(K1)=SQRT(EL(K1))
      IF (ELMT(1)-EL(K1)) 120,120,130
  120 ELMT(1)=EL(K1)
      ELMT(2)=FLOAT(K)
  130 AEL=AEL+EL(K1)
```

```
C
C     MEASUREMENT QUALITY INDEX
C
      ANOM=0.0
      DENOM=0.0
      DO 150 I=1,MBL
      IF (MSKA(I)) 150,150,140
  140 AYTA=CABS(YTA(I))
      ANOM=ANOM+(CABS(YEA(I))-AYTA)**2
      DENOM=DENOM+(YMA(I)-AYTA)**2
  150 CONTINUE
      DO 180 I=1,MBL
      AME=YEB(I)-YTB(I)
      IF (MSKB(I)-1) 180,170,160
  160 ANOM=ANOM+AIMAG(AME)**2
      DENOM=DENOM+(YMB(2*I)-AIMAG(YTB(I)))**2
      IF (MSKB(I)-2) 170,180,170
  170 ANOM=ANOM+REAL(AME)**2
      DENOM=DENOM+(YMB(2*I-1)-REAL(YTB(I)))**2
  180 CONTINUE
      EM(K1)=SQRT(ANOM/DENOM)
      IF (EMMT(1)-EM(K1)) 190,190,200
  190 EMMT(1)=EM(K1)
      EMMT(2)=FLOAT(K)
  200 AEM=AEM+EM(K1)
C
C     PRINTOUT
C
      IF (IPRINT) 210,210,990
  210 WRITE(6,220)
  220 FORMAT(19H0PRINTOUT FROM EVAL/1X,18(1H*))
C
C     ESTIMATION ERROR
C
      WRITE(6,230) EE(K1)
  230 FORMAT(17H0ESTIMATION ERROR/1X,16(1H-)//
     F6X,18HESTIMATION ERROR =,F10.7)
      I=INT(EEM(K1,2))
      M=MOD(I,2)
      J=I/2+M
      IF (M) 240,240,250
  240 ROI=4HIMAG
      GO TO 260
  250 ROI=4HREAL
  260 WRITE(6,270) EEM(K1,1),ROI,J
  270 FORMAT(6X,18HMAXIMUM ELEMENT  =,F10.7,4H IN ,A4
     F,20H PART OF BUSVOLTAGE ,I2)
      IF (K .LE. 0) GO TO 335
      AEEK=AEE/K
      WRITE(6,280) AEEK
  280 FORMAT(/6X,21HCURRENT TOTAL VALUES:/
     F6X,27HAVERAGE ESTIMATION ERROR  =,F10.7)
      KT=INT(EEMT(2))
```

```
      WRITE(6,290) EEMT(1),KT
  290 FORMAT(6X,27HMAXIMUM ESTIMATION ERROR  =,F10.7
     F,7H AT T =,I4)
      I=INT(EEMMT(2))
      M=MOD(I,2)
      J=I/2+M
      IF (M) 300,300,310
  300 ROI=4HIMAG
      GO TO 320
  310 ROI=4HREAL
  320 KT=INT(EEMMT(3))
      WRITE(6,330) EEMMT(1),KT,ROI,J
  330 FORMAT(6X,27HMAX ELEMENT IN ALL ERRORS =,F10.7
     F,7H AT T =,I4,4H IN /8X,A4,20H PART OF BUSVOLTAGE ,I2)
C
C     LINE FLOW ERROR
C
  335 WRITE(6,340) EL(K1)
  340 FORMAT(16HOLINE FLOW ERROR/1X,15(1H-)//
     F6X,17HLINE FLOW ERROR =,F10.7)
      I=INT(ELM(K1,2))
      IF (I) 350,350,360
  350 AOB=1HB
      GO TO 370
  360 AOB=1HA
  370 I=IABS(I)
      M=MOD(I,2)
      J=I/2+M
      IF (M) 380,380,390
  380 AOR=6HREACT.
      GO TO 400
  390 AOR=6HACTIVE
  400 WRITE(6,410) ELM(K1,1),AOR,AOB,J
  410 FORMAT(6X,17HMAXIMUM ELEMENT =,F10.7,4H IN ,A6
     F,9H FLOW AT ,A1,12H-END OF LINE ,I2)
      IF (K .LE. 0) GO TO 505
      AELK=AEL/K
      WRITE(6,420) AELK
  420 FORMAT(/6X,21HCURRENT TOTAL VALUES:/
     F6X,27HAVERAGE LINE FLOW ERROR   =,F10.7)
      KT=INT(ELMT(2))
      WRITE(6,430) ELMT(1),KT
  430 FORMAT(6X,27HMAXIMUM LINE FLOW ERROR   =,F10.7
     F,7H AT T =,I4)
      I=INT(ELMMT(2))
      IF (I) 440,440,450
  440 AOB=1HB
      GO TO 460
  450 AOB=1HA
  460 I=IABS(I)
      M=MOD(I,2)
      J=I/2+M
      IF (M) 470,470,480
```

```
 470 AOR=6HREACT.
     GO TO 490
 480 AOR=6HACTIVE
 490 KT=INT(ELMMT(3))
     WRITE(6,500) ELMMT(1),KT,AOR,AOB,J
 500 FORMAT(6X,27HMAX ELEMENT IN ALL ERRORS =,F10.7
    F,7H AT T =,I4,4H IN /8X,A6,9H FLOW AT ,A1,13H-END OF LINE ,I2)
C
C     MEASUREMENT QUALITY INDEX
C
 505 WRITE(6,510) EM(K1)
 510 FORMAT(20H0MEASUREMENT QUALITY/1X,19(1H-)//
    F6X,19HMEASUREMENT INDEX =,F10.7)
     IF (K .LE. 0) GO TO 990
     AEMK=AEM/K
     WRITE(6,520) AEMK
 520 FORMAT(/6X,21HCURRENT TOTAL VALUES:/
    F6X,20HAVERAGE MSMT INDEX =,F10.7)
     KT=INT(EMMT(2))
     WRITE(6,530) EMMT(1),KT
 530 FORMAT(6X,20HMAXIMUM MSMT INDEX =,F10.7
    F,7H AT T =,I4)
C
 990 RETURN
     END
```

```
      SUBROUTINE GXE(IPRINT,IERR)
C
C     COMPUTES YE FROM ESTIMATOR NETWORK DATA AND ESTIMATED STATE
C     AUTHOR: TON VAN OVERBEEK 1973-12-21
C
C     IPRINT=2       NO PRINTOUT
C     IPRINT=1       XE AND YE ARE PRINTED
C     IPRINT=0       XE,YE, AND TRUE NETWORK ARE PRINTED
C     IERR=1         ERROR IN NB OR NL
C     IERR=0         NO ERROR
C     SUBROUTINE REQUIRED
C              PRENET
C
      PARAMETER MB=10,ML=13
C
      COMPLEX YAA,ZAB,YBB,X,Y2,Y3,Y4,Y5,Y6,DI
C
      COMMON /ENET/ NB,NL,LTA(ML),LTB(ML),YAA(ML),ZAB(ML),YBB(ML)
     1        /EST/ X(MB),Y2(ML),Y3(ML),Y4(ML),Y5(ML),Y6(MB)
C
      IERR=0
      IF(NB .GT. 0 .AND. NB .LE. MB) GO TO 20
      IERR=1
      WRITE(6,10) NB
   10 FORMAT(12H0NB IN GXE =,I5)
      RETURN
C
   20 IF (NL .GT. 0 .AND. NL .LE. ML) GO TO 40
      IERR=1
      WRITE(6,30) NL
   30 FORMAT(12H0NL IN GXE =,I5)
      RETURN
C
   40 IF(IPRINT .GE. 2) GO TO 100
      WRITE(6,60)
   60 FORMAT(18H0PRINTOUT FROM GXE/1X,17(1H*))
      IF (IPRINT .GE. 1) GO TO 100
      CALL PRENET
C
  100 DO 110 I=1,NB
  110 Y6(I)=(0.0,0.0)
      DO 120 I=1,NL
      IA=LTA(I)
      IB=LTB(I)
      DI=(X(IA)-X(IB))/ZAB(I)
      Y2(I)=DI+X(IA)*YAA(I)
      Y3(I)=-DI+X(IB)*YBB(I)
      Y4(I)=X(IA)*CONJG(Y2(I))
      Y5(I)=X(IB)*CONJG(Y3(I))
      Y6(IA)=Y6(IA)+Y4(I)
      Y6(IB)=Y6(IB)+Y5(I)
  120 CONTINUE
```

```
C
      IF (IPRINT .GE. 2) GO TO 990
      WRITE(6,130)
  130 FORMAT(//14H0BUSNR
     F,10HRE(XE)
     F,10HIM(XE)
     F,10HPINJ
     F,4HQINJ/)
      WRITE(6,140)(I,X(I),Y6(1),I=1,NB)
  140 FORMAT(I5,5X,4F10.5)
      WRITE(6,150)
  150 FORMAT(20H0 LINE  A-END B-END
     F,10H RE(IAB)
     F,10H IM(IAB)
     F,10HMOD(IAB)
     F,10H RE(IBA)
     F,10H IM(IBA)
     F,10HMOD(IBA)
     F,10H  PAB
     F,10H  QAB
     F,10H  PBA
     F,5H  QBA/)
      DO 170 I=1,NL
      CMY2=CABS(Y2(I))
      CMY3=CABS(Y3(I))
      WRITE(6,160) I,LTA(I),LTB(I),Y2(I),CMY2,Y3(I),CMY3,Y4(I),Y5(I)
  160 FORMAT(I5,1X,2I6,10F10.5)
  170 CONTINUE
C
  990 RETURN
      END
```

```
      SUBROUTINE GXT(IPRINT,IERR)
C
C     COMPUTES YT FROM TRUE NETWORK DATA AND TRUE STATE
C     AUTHOR: TON VAN OVERBEEK 1973-12-21
C
C     IPRINT=2      NO PRINTOUT
C     IPRINT=1      XT AND YT ARE PRINTED
C     IPRINT=0      XT,YT, AND TRUE NETWORK ARE PRINTED
C     IERR=1        ERROR IN NB OR NL
C     IERR=0        NO ERROR
C     SUBROUTINE REQUIRED
C             PRTNET
C
      PARAMETER MB=10,ML=13
C
      COMPLEX YAA,ZAB,YBB,X,Y2,Y3,Y4,Y5,Y6,DI
C
      COMMON /TNET/ NB,NL,LTA(ML),LTB(ML),YAA(ML),ZAB(ML),YBB(ML)
     1       /TRUE/ X(MB),Y2(ML),Y3(ML),Y4(ML),Y5(ML),Y6(MB)
C
      IERR=0
      IF(NB .GT. 0 .AND. NB .LE. MB) GO TO 20
      IERR=1
      WRITE(6,10) NB
   10 FORMAT(12H0NB IN GXT =,I5)
      RETURN
C
   20 IF (NL .GT. 0 .AND. NL .LE. ML) GO TO 40
      IERR=1
      WRITE(6,30) NL
   30 FORMAT(12H0NL IN GXT =,I5)
      RETURN
C
   40 IF(IPRINT .GE. 2) GO TO 100
      WRITE(6,60)
   60 FORMAT(18H0PRINTOUT FROM GXT/1X,17(1H*))
      IF (IPRINT .GE. 1) GO TO 100
      CALL PRTNET
C
  100 DO 110 I=1,NB
  110 Y6(I)=(0.0,0.0)
      DO 120 I=1,NL
      IA=LTA(I)
      IB=LTB(I)
      DI=(X(IA)-X(IB))/ZAB(I)
      Y2(I)=DI+X(IA)*YAA(I)
      Y3(I)=-DI+X(IB)*YBB(I)
      Y4(I)=X(IA)*CONJG(Y2(I))
      Y5(I)=X(IB)*CONJG(Y3(I))
      Y6(IA)=Y6(IA)+Y4(I)
      Y6(IB)=Y6(IB)+Y5(I)
  120 CONTINUE
```

```
C
      IF (IPRINT .GE. 2) GO TO 990
      WRITE(6,130)
  130 FORMAT(//14H0BUSNR
     F,10HRE(XT)
     F,10HIM(XT)
     F,10HPINJ
     F,4HQINJ/)
      WRITE(6,140)(I,X(I),Y6(I),I=1,NB)
  140 FORMAT(I5,5X,4F10.5)
      WRITE(6,150)
  150 FORMAT(20H0 LINE   A-END B-END
     F,10H RE(IAB)
     F,10H IM(IAB)
     F,10HMOD(IAB)
     F,10H RE(IBA)
     F,10H IM(IBA)
     F,10HMOD(IBA)
     F,10H   PAB
     F,10H   QAB
     F,10H   PBA
     F,5H  QBA/)
      DO 170 I=1,NL
      CMY2=CABS(Y2(I))
      CMY3=CABS(Y3(I))
      WRITE(6,160) I,LTA(I),LTB(I),Y2(I),CMY2,Y3(I),CMY3,Y4(I),Y5(I)
  160 FORMAT(I5,1X,2I6,10F10.5)
  170 CONTINUE
C
  990 RETURN
      END
```

```
      SUBROUTINE JACBI(M,IA,DPI,IRP,DQI,IRQ,ID,IERR)
C
C     COMPUTES THE JACOBIAN ROW(S) FOR AN INJECTION MEASUREMENT
C     AT BUS IA
C
C     AUTHOR, TON VAN OVERBEEK 1974-01-24
C
C     M=1                 ACTIVE MEASUREMENT ONLY
C     M=2                 REACTIVE MEASUREMENT ONLY
C     M=3                 BOTH MEASUREMENTS
C     IA                  BUS INJECTION MEASUREMENT AT BUS IA
C     DPI                 JACOBIAN ROW FOR ACTIVE MEASUREMENT, LENGTH 2*NB
C     IRP                 ROWNR FOR DPI
C     DQI                 JACOBIAN ROW FOR REACTIVE MEASUREMENT, LENGTH 2*NB
C     IRQ                 ROWNR FOR DQI
C     ID                  DIMENSION PARAMETER
C     IERR=3              ERROR IN M
C     IERR=2              ERROR IN IA
C     IERR=1              DIMENSION ERROR
C     IERR=0              NO ERROR
C
C     SUBROUTINE REQUIRED
C                JACLF
C
      PARAMETER MB=10,ML=13
C
      COMPLEX X,YAA,ZAB,YBB
C
      DIMENSION DP(4),DQ(4),DPI(ID,1),DQI(ID,1)
C
      COMMON /EST/ X(MB)
     1       /ENET/ NB,NL,LTA(ML),LTB(ML),YAA(ML),ZAB(ML),YBB(ML)
C
      IERR=0
      IF (M) 20,20,10
   10 IF (M-3) 40,40,20
   20 IERR=3
      WRITE(6,30) M
   30 FORMAT(13H0M IN JACBI =,I5)
      RETURN
C
   40 IF (IA) 60,60,50
   50 IF (IA-NB) 80,80,60
   60 IERR=2
      WRITE(6,70) IA,NB
   70 FORMAT(14H0IA IN JACBI =,I5,5X,13HNB IN JACBI =,I5)
      RETURN
C
   80 IF (IRP) 100,100,90
   90 IF (IRP-ID) 120,120,100
  100 IERR=1
      WRITE(6,110) IRP,ID
  110 FORMAT(15H0IRP IN JACBI =,I5,5X,13HID IN JACBI =,I5)
      RETURN
```

```
C
  120 IF (IRQ) 140,140,130
  130 IF (IRQ-ID) 160,160,140
  140 IERR=1
      WRITE(6,150) IRQ,ID
  150 FORMAT(15H0IRQ IN JACBI =,I5,5X,13HID IN JACBI =,I5)
      RETURN
C
  160 NNB=2*NB
      DO 170 I=1,NNB
      DPI(IRP,I)=0.0
  170 DQI(IRQ,I)=0.0
C
      DO 230 I=1,NL
      IF (IA .EQ. LTA(I)) GO TO 180
      IF (IA .EQ. LTB(I)) GO TO 190
      GO TO 230
C
  180 IB=LTB(I)
      CALL JACLF(M,X(IA),X(IB),ZAB(I),YAA(I),DP,1,DQ,1,1,IE)
      GO TO 200
C
  190 IB=LTA(I)
      CALL JACLF(M,X(IA),X(IB),ZAB(I),YBB(I),DP,1,DQ,1,1,IE)
C
  200 IA2=2*IA
      IA1=IA2-1
      IB2=2*IB
      IB1=IB2-1
      IF (M-1) 220,220,210
  210 DQI(IRQ,IA1)=DQI(IRQ,IA1)+DQ(1)
      DQI(IRQ,IA2)=DQI(IRQ,IA2)+DQ(2)
      DQI(IRQ,IB1)=DQ(3)
      DQI(IRQ,IB2)=DQ(4)
      IF (M-2) 220,230,220
  220 DPI(IRP,IA1)=DPI(IRP,IA1)+DP(1)
      DPI(IRP,IA2)=DPI(IRP,IA2)+DP(2)
      DPI(IRP,IB1)=DP(3)
      DPI(IRP,IB2)=DP(4)
C
  230 CONTINUE
C
      RETURN
      END
```

```
      SUBROUTINE JACI(UA,UB,ZAB,YAA,DI,IR,ID,IERR)
C
C     COMPUTES THE JACOBIAN ELEMENTS FOR A LINE CURRENT MEASUREMENT
C     AT LINE END A
C
C     AUTHOR, TON VAN OVERBEEK 1974-01-24
C
C     UA                BUSVOLTAGE AT A END
C     UB                BUSVOLTAGE AT B END
C     ZAB               LINE SERIES IMPEDANCE
C     YAA               LINE SHUNT ADMITTANCE AT A END
C     DI(IR,1)          ELEMENT DI/DEA
C     DI(IR,2)          ELEMENT DI/DFA
C     DI(IR,3)          ELEMENT DI/DEB
C     DI(IR,4)          ELEMENT DI/DFB
C     IR                ROW IN DI
C     ID                DIMENSION PARAMETER
C     IERR=1            DIMENSION ERROR
C     IERR=0            NO ERROR
C
C     SUBROUTINE REQUIRED
C             NONE
C
      COMPLEX UA,UB,ZAB,YAA,Y,X
C
      DIMENSION DI(ID,1)
C
      IERR=0
      IF (IR) 20,20,10
   10 IF (IR-ID) 40,40,20
   20 IERR=1
      WRITE(6,30) IR,ID
   30 FORMAT(13H0IR IN JACI =,I5,5X,12HID IN JACI =,I5)
      RETURN
C
   40 Y=(UA-UB)/ZAB+UA*YAA
      AMY=CABS(Y)
      X=CONJG(Y)/(ZAB*AMY)
      DI(IR,3)=-REAL(X)
      DI(IR,4)=AIMAG(X)
      X=X+CONJG(Y)*YAA/AMY
      DI(IR,1)=REAL(X)
      DI(IR,2)=-AIMAG(X)
      RETURN
      END
```

```
      SUBROUTINE JACLF(M,UA,UB,ZAB,YAA,DP,IRP,DQ,IRQ,ID,IERR)
C
C     COMPUTES THE JACOBIAN ELEMENTS FOR A LINE FLOW MEASUREMENT
C     AT LINE END A
C
C     AUTHOR, TON VAN OVERBEEK 1974-01-24
C
C     M=1                ACTIVE MEASUREMENT ONLY
C     M=2                REACTIVE MEASUREMENT ONLY
C     M=3                BOTH MEASUREMENTS
C     UA                 BUSVOLTAGE AT A END
C     UB                 BUSVOLTAGE AT B END
C     ZAB                LINE SERIES IMPEDANCE
C     YAA                LINE SHUNT ADMITTANCE AT A END
C     DP(IRP,1)          ELEMENT DP/DEA
C     DP(IRP,2)          ELEMENT DP/DFA
C     DP(IRP,3)          ELEMENT DP/DEB
C     DP(IRP,4)          ELEMENT DP/DFB
C     IRP                ROW IN DP
C     DQ(IRQ,1)          ELEMENT DQ/DEA
C     DQ(IRQ,2)          ELEMENT DQ/DFA
C     DQ(IRQ,3)          ELEMENT DQ/DEB
C     DQ(IRQ,4)          ELEMENT DQ/DFB
C     IRQ                ROW IN DQ
C     ID                 DIMENSION PARAMETER
C     IERR=2             ERROR IN M
C     IERR=1             DIMENSION ERROR
C     IERR=0             NO ERROR
C
C     SUBROUTINE REQUIRED
C              NONE
C
      COMPLEX UA,UB,ZAB,YAA,CX1,CX2,CX,Y
C
      DIMENSION DP(ID,1),DQ(ID,1)
C
      IERR=0
      IF (IRP) 20,20,10
   10 IF (IRP-ID) 40,40,20
   20 IERR=1
      WRITE(6,30) IRP,ID
   30 FORMAT(15H0IRP IN JACLF =,I5,5X,13HID IN JACLF =,I5)
      RETURN
C
   40 IF (IRQ) 60,60,50
   50 IF (IRQ-ID) 80,80,60
   60 IERR=1
      WRITE(6,70) IRQ,ID
   70 FORMAT(15H0IRQ IN JACLF =,I5,5X,13HID IN JACLF =,I5)
      RETURN
C
   80 IF (M) 100,100,90
   90 IF(M-3) 120,120,100
```

```
  100 IERR=2
      WRITE(6,110) M
  110 FORMAT(13H0M IN JACLF =,I5)
      RETURN
C
  120 CX1=-UB/ZAB
      CX2=CONJG(UA)/ZAB
      Y=1/ZAB+YAA
      IF (M-1) 140,140,130
C
C     REACTIVE LINE FLOW
C
  130 CX=-2*UA*AIMAG(Y)
      DQ(IRQ,1)=-AIMAG(CX1)+REAL(CX)
      DQ(IRQ,2)=REAL(CX1)+AIMAG(CX)
      DQ(IRQ,3)=AIMAG(CX2)
      DQ(IRQ,4)=REAL(CX2)
      IF (M-2) 140,990,140
C
C     ACTIVE LINE FLOW
C
  140 CX=2*UA*REAL(Y)
      CX=CX+CX1
      DP(IRP,1)=REAL(CX)
      DP(IRP,2)=AIMAG(CX)
      DP(IRP,3)=-REAL(CX2)
      DP(IRP,4)=AIMAG(CX2)
C
  990 RETURN
      END
```

```
      SUBROUTINE JACV(U,DU,IR,ID,IERR)
C
C     COMPUTES THE JACOBIAN ELEMENTS FOR A VOLTAGE MEASUREMENT
C
C     AUTHOR, TON VAN OVERBEEK 1974-01-24
C
C     U                  BUSVOLTAGE
C     DU(IR,1)           ELEMENT DU/DE
C     DU(IR,2)           ELEMENT DU/DF
C     IR                 ROW IN DU
C     ID                 DIMENSION PARAMETER
C     IERR=1             DIMENSION ERRROR
C     IERR=0             NO ERROR
C
C     SUBROUTINE REQUIRED
C             NONE
C
      COMPLEX U,X
C
      DIMENSION DU(ID,1)
C
      IERR=0
      IF (IR) 20,20,10
   10 IF (IR-ID) 40,40,20
   20 IERR=1
      WRITE(6,30) IR,ID
   30 FORMAT(13H0IR IN JACV =,I5,5X,12HID IN JACV =,I5)
      RETURN
C
   40 X=U/CABS(U)
      DU(IR,1)=REAL(X)
      DU(IR,2)=AIMAG(X)
      RETURN
      END
```

```
      SUBROUTINE NRLFR(NB,NL,LTA,LTB,YAA,ZAB,YBB,SINJ,VB,EPS,
     1IS,MAXIT,IPRINT,JFAIL)
C
C     COMPUTES A SOLUTION TO
C
C     ******************************
C     * THE LOAD-FLOW PROBLEM USING *
C     * THE NEWTON-RAPHSON METHOD   *
C     * AND RECTANGULAR COORDINATES *
C     ******************************
C
C     REFERENCE, G.W. STAGG AND A.H. EL-ABIAD
C     'COMPUTER METHODS IN POWER SYSTEM ANALYSIS'
C     CHAPTER 8, NEW YORK, 1968
C
C     AUTHOR, STURE LINDAHL 1972-03-12
C     REVISED FOR SEIPS, TON VAN OVERBEEK 1974-01-14
C
C     YAA(*)          SHUNT ADMITTANCE AT ENDPOINT A
C     ZAB(*)          LINE IMPEDANCE BETWEEN ENDPOINT A AND B
C     YBB(*)          SHUNT ADMITTANCE AT ENDPOINT B
C     LTA(*)          ENDPOINT A OF LINE I IS CONNECTED TO BUS LTA(I)
C     LTB(*)          ENDPOINT B OF LINE I IS CONNECTED TO BUS LTB(I)
C     SINJ(*)         COMPLEX POWER INJECTION AT BUS *
C     VB(*)           COMPLEX BUSVOLTAGES
C     EPS             THE ITERATION IS TERMINATED WHEN
C                     THE MAXIMUM APPARENT POWER MISMATCH IS LESS THAN EPS
C     NB              NUMBER OF BUSSES (MAX 10)
C     NL              NUMBER OF LINES (NO MAX)
C     IS              SLACK BUS NUMBER
C     MAXIT           MAXIMUM NUMBER OF ITERATIONS
C     IPRINT=3        NO PRINTOUT
C     IPRINT=2        INPUT DATA AND THE FINAL RESULT IS PRINTED
C     IPRINT=1        SAME + APPARENT POWER MISMATCH AND
C                     BUSVOLTAGES AT EACH ITERATION
C     IPRINT=0        SAME + Y-BUS MATRIX AND AT EACH ITERATION
C                     THE JACOBIAN AND VOLTAGE CORRECTIONS
C     JFAIL=-1        NO CONVERGENCE AFTER MAXIT ITERATIONS
C     JFAIL=0         THE SOLUTION IS FOUND
C     JFAIL=1         ERROR IN NB OR NL
C     JFAIL=2         THE JACCOBIAN IS SINGULAR
C
C     SUBROUTINE REQUIRED
C               DECOM
C               MPRI
C               SOLVB
C
      PARAMETER MB=10,MX=2*(MB-1),MMB=2*MB
C
      COMPLEX YAA(1),ZAB(1),YBB(1),SINJ(1),VB(1),
     1Y(MB,MB),SMM(MB),DV(MB),IB(MB),SA,SB,SI,SL,ETT,NOLL
C
```

```
      DIMENSION LTA(1),LTB(1),INDEX(MB),A(MX,MX),B(MX),X(MX)
C
      DATA NOLL/(0.0,0.0)/,ETT/(1.0,0.0)/,LP/6/,JJAC/1/,EPSJ/1.0E-7/
C
      IF(NB.GT.MB) GO TO 10
      IF(NB) 10,10,30
   10 WRITE(LP,20) NB
   20 FORMAT(5H NB =,I5,9H IN NRLFR)
      JFAIL=1
      GO TO 990
C
   30 IF(NL) 40,40,60
   40 WRITE(LP,50) NL
   50 FORMAT(5H NL =,I5,9H IN NRLFR)
      JFAIL=1
      GO TO 990
C
   60 IF(IPRINT-2) 70,70,200
   70 WRITE(LP,80)
   80 FORMAT(20H0PRINTOUT FROM NRLFR/1X,19(1H*)//
     123H TRANSMISSION-LINE DATA/1X,22(1H-)/
     210H      LINE
     3,10H     A-END
     4,10H     B-END,5X
     5,15H          GAA
     6,15H          BAA
     7,15H          RAB
     8,15H          XAB
     9,15H          GBB
     1,15H          BBB
     2)
      DO 90 I=1,NL
   90 WRITE(LP,100) I,LTA(I),LTB(I),YAA(I),ZAB(I),YBB(I)
  100 FORMAT(3I10,6F15.5)
      WRITE(LP,110)
  110 FORMAT(42H0INITIAL BUS VOLTAGES AND POWER INJECTIONS/
     11X,41(1H-)/
     110H       BUS
     2,15H    REAL(VB(I))
     3,15H    IMAG(VB(I))
     4,15H        PINJ(I)
     5,15H        QINJ(I)
     6)
      DO 160 I=1,NB
      IF(I-IS) 120,140,120
  120 WRITE(LP,130) I,VB(I),SINJ(I)
  130 FORMAT(I10,4F15.5)
      GO TO 160
  140 WRITE(LP,150) I,VB(I)
  150 FORMAT(I10,2F15.5,5X,10H SLACK BUS)
  160 CONTINUE
```

```
C
C     FORM YBUS-MATRIX
C
  200 DO 210 I=1,NB
      DO 210 J=1,NB
  210 Y(I,J)=NOLL
      DO 220 I=1,NL
      SL=ETT/ZAB(I)
      SA=SL+YAA(I)
      SB=SL+YBB(I)
      II=LTA(I)
      JJ=LTB(I)
      Y(II,JJ)=Y(II,JJ)-SL
      Y(JJ,II)=Y(JJ,II)-SL
      Y(II,II)=Y(II,II)+SA
  220 Y(JJ,JJ)=Y(JJ,JJ)+SB
      IF(IPRINT) 230,230,250
  230 WRITE(LP,240)
  240 FORMAT(12H0YBUS-MATRIX/1X,11(1H-)/
     F54H0NOTE:  REAL PART OF Y(I,J) IS LISTED ON PLACE 2*I-1,J/
     F52H        IMAG PART OF Y(I,J) IS LISTED ON PLACE 2*I,J//)
      NNB=2*NB
      CALL MPRI(Y,NNB,NB,MMB,8,0,IE)
C
C     COMPUTE BUS INDEX
C
  250 II=1
      DO 270 I=1,NB
      IF(I-IS) 260,270,260
  260 INDEX(II)=I
      II=II+1
  270 CONTINUE
      IJAC=JJAC-1
      JFAIL=0
      NX=NB-1
      NXX=2*NX
      DV(IS)=NOLL
C
C     START THE ITERATION
C
      DO 570 K=1,MAXIT
C
C     COMPUTE APPARENT POWER MISMATCH
C
      SMMM=0.0
      DO 340 I=1,NB
      SL=NOLL
      DO 310 J=1,NB
  310 SL=SL+Y(I,J)*VB(J)
      IB(I)=SL
      SI=VB(I)*CONJG(SL)
      IF(I-IS) 330,320,330
  320 SINJ(I)=SI
```

```
  330 SMM(I)=SINJ(I)-SI
  340 SMMM=AMAX1(SMMM,CABS(SMM(I)))
      IF(IPRINT-1) 350,350,390
  350 WRITE(LP,360) K,(VB(I),I=1,NB)
  360 FORMAT(//19H ITERATION NUMBER =,I5/1X,18(1H-)/
     110X,12HBUS VOLTAGES/(10X,10F12.5))
      WRITE(LP,370) (SMM(I),I=1,NB)
  370 FORMAT(/10X,23HAPPARENT POWER MISMATCH/(10X,10F12.5))
      WRITE(LP,380) SMMM
  380 FORMAT(/10X,31HMAXIMUM APPARENT POWER MISMATCH/10X,2F12.5)
  390 IF(SMMM-EPS) 600,600,400
C
C     CALCULATE THE ELEMENTS OF THE JACCOBIAN IF IJAC=JJAC
C
  400 IJAC=IJAC+1
      IF(JJAC-IJAC) 410,410,470
  410 DO 440 I=1,NX
      II=INDEX(I)
      DO 430 J=1,NX
      JJ=INDEX(J)
      SL=VB(II)*CONJG(Y(II,JJ))
      A(I,J)=REAL(SL)
      A(I,J+NX)=AIMAG(SL)
      A(I+NX,J)=AIMAG(SL)
      A(I+NX,J+NX)=-REAL(SL)
      IF(I-J) 430,420,430
  420 A(I,I)=A(I,I)+REAL(IB(II))
      A(I,I+NX)=A(I,I+NX)+AIMAG(IB(II))
      A(I+NX,I)=A(I+NX,I)-AIMAG(IB(II))
      A(I+NX,I+NX)=A(I+NX,I+NX)+REAL(IB(II))
  430 CONTINUE
  440 CONTINUE
      IJAC=0
      IF(IPRINT) 450,450,470
  450 WRITE(LP,460)
  460 FORMAT(1H0,9X,13HTHE JACCOBIAN/10X,13(1H-)/)
      CALL MPRI(A,NXX,NXX,MX,8,0,IE)
  470 DO 480 I=1,NX
      II=INDEX(I)
      B(I)=REAL(SMM(II))
  480 B(I+NX)=AIMAG(SMM(II))
C
C     SOLVE THE EQUATION A*DV=SMM
C
  500 CALL DECOM(A,NXX,MX,EPSJ,ISING)
      IF(ISING) 510,530,510
  510 JFAIL=2
      WRITE(LP,520)
  520 FORMAT(26H THE JACCOBIAN IS SINGULAR)
      GO TO 990
C
  530 CALL SOLVB(B,X,NXX,1,MX)
      DO 540 I=1,NX
```

```
      II=INDEX(I)
      DV(II)=CMPLX(X(I),X(I+NX))
  540 VB(II)=VB(II)+DV(II)
      IF(IPRINT) 550,550,570
  550 WRITE(LP,560) (DV(I),I=1,NB)
  560 FORMAT(1H0,9X,19HVOLTAGE CORRECTIONS/(10X,10F12.5))
  570 CONTINUE
      WRITE(LP,580) MAXIT
  580 FORMAT(22H NO CONVERGENCE AFTER,I5,11H ITERATIONS)
      JFAIL=-1
      GO TO 990
C
C     PRINT OUT THE RESULTS
C
  600 IF(IPRINT-2) 610,610,990
  610 WRITE(LP,620)
  620 FORMAT(33H0RESULT OF LOAD-FLOW CALCULATIONS/1X,32(1H-)/
     110H       BUS
     2,15H     REAL(VB(I))
     3,15H     IMAG(VB(I))
     4,15H         PINJ(I)
     5,15H         QINJ(I)
     6,15H         DELP(I)
     7,15H         DELQ(I)
     8)
      DO 630 I=1,NB
  630 WRITE(LP,640) I,VB(I),SINJ(I),SMM(I)
  640 FORMAT(I10,6F15.5)
  990 RETURN
      END
```

```
      SUBROUTINE PRENET
C
C     PRINTS ESTIMATOR NETWORK DATA
C     AUTHOR: TON VAN OVERBEEK 1973-12-12
C
C     SUBROUTINE REQUIRED
C             NONE
C
      PARAMETER ML=13
C
      COMPLEX YAA,ZAB,YBB
C
      COMMON /ENET/ NB,NL,LTA(ML),LTB(ML),YAA(ML),ZAB(ML),YBB(ML)
C
      IF (NL .GT. 0 .AND. NL .LE. ML) GO TO 20
      WRITE (6,10) NL
   10 FORMAT(22H0ERROR IN PRENET  NL =,I5)
      GO TO 99
C
   20 WRITE(6,30) NB,NL
   30 FORMAT(23H0ESTIMATOR NETWORK DATA/1X,22(1H-)//
     F5H NB =,I3,6H  NL =,I3/)
      WRITE (6,40)
   40 FORMAT(11H0 LINE
     F,10HA-END
     F,13HB-END
     F,10HGAA
     F,10HBAA
     F,10HRAB
     F,10HXAB
     F,10HGBB
     F,3HBBB/)
      WRITE (6,50)(I,LTA(I),LTB(I),YAA(I),ZAB(I),YBB(I),I=1,NL)
   50 FORMAT(I5,2I10,5X,6F10.5)
C
   99 RETURN
      END
```

```
      SUBROUTINE PRJAC
C
C     PRINTS THE JACOBIAN AS STORED IN THE COMMON BLOCK /JAC/
C
C     AUTHOR, TON VAN OVERBEEK 1974-01-24
C
C     SUBROUTINE REQUIRED
C              NONE
C
      PARAMETER MB=10,ML=13
      PARAMETER MMB=2*MB,MML=2*ML
C
      COMMON /JAC/ AJAC1(MB,2),AJAC2(ML,4),AJAC3(ML,4),AJAC4(MML,4),
     1             AJAC5(MML,4),AJAC6(MMB,MMB)
     2        /MSI/ MSK1(MB),MSK2(ML),MSK3(ML),MSK4(ML),MSK5(ML),MSK6(MB)
     3        /ENET/ NB,NL,LTA(ML),LTB(ML)
C
      WRITE(6,10)
   10 FORMAT(13H0THE JACOBIAN/1X,12(1H*))
C
C     TYPE 1
C
      WRITE(6,20)
   20 FORMAT(7H0TYPE 1/14H0MSMNR
     F,10HDV/DE
     F,5HDV/DF/)
      DO 50 I=1,NB
      IF (MSK1(I)) 50,50,30
   30 WRITE(6,40) I,(AJAC1(I,J),J=1,2)
   40 FORMAT(I5,5X,2F10.5)
   50 CONTINUE
C
C     TYPE 2
C
      WRITE(6,60)
   60 FORMAT(7H0TYPE 2/24H0MSMNR   LTA   LTB
     F,10HDI/DEA
     F,10HDI/DFA
     F,10HDI/DEB
     F,6HDI/DFB/)
      DO 90 I=1,NL
      IF (MSK2(I)) 90,90,70
   70 WRITE(6,80) I,LTA(I),LTB(I),(AJAC2(I,J),J=1,4)
   80 FORMAT(3I5,5X,4F10.5)
   90 CONTINUE
C
C     TYPE 3
C
      WRITE(6,100)
  100 FORMAT(7H0TYPE 3/24H0MSMNR   LTB   LTA
     F,10HDI/DEB
     F,10HDI/DFB
     F,10HDI/DEA
```

```
     F,6HDI/DFA/)
      DO 120 I=1,NL
      IF (MSK3(I)) 120,120,110
  110 WRITE(6,80) I,LTB(I),LTA(I),(AJAC3(I,J),J=1,4)
  120 CONTINUE
C
C     TYPE 4
C
      WRITE(6,130)
  130 FORMAT(7H0TYPE 4/24H0MSMNR  LTA  LTB
     F,10HDP/DEA
     F,10HDP/DFA
     F,10HDP/DEB
     F,15HDP/DFB
     F,10HDQ/DEA
     F,10HDQ/DFA
     F,10HDQ/DEB
     F,6HDQ/DFB/)
      DO 200 I=1,NL
      I2=2*I
      I1=I2-1
      MS=MSK4(I)
      IF (MS) 200,200,140
  140 WRITE(6,150) I,LTA(I),LTB(I)
  150 FORMAT(3I5)
      IF (MS-2) 160,180,160
  160 WRITE(6,170)(AJAC4(I1,J),J=1,4)
  170 FORMAT(1H+,19X,4F10.5)
      IF (MS-1) 200,200,180
  180 WRITE(6,190)(AJAC4(I2,J),J=1,4)
  190 FORMAT(1H+,64X,4F10.5)
  200 CONTINUE
C
C     TYPE 5
C
      WRITE(6,210)
  210 FORMAT(7H0TYPE 5/24H0MSMNR  LTB  LTA
     F,10HDP/DEB
     F,10HDP/DFB
     F,10HDP/DEA
     F,15HDP/DFA
     F,10HDQ/DEB
     F,10HDQ/DFB
     F,10HDQ/DEA
     F,6HDQ/DFA/)
      DO 250 I=1,NL
      I2=2*I
      I1=I2-1
      MS=MSK5(I)
      IF (MS) 250,250,220
  220 WRITE(6,150) I,LTB(I),LTA(I)
      IF (MS-2) 230,240,230
  230 WRITE(6,170)(AJAC5(I1,J),J=1,4)
```

```
      IF (MS-1) 250,250,240
  240 WRITE(6,190)(AJAC5(I2,J),J=1,4)
  250 CONTINUE
C
C     TYPE 6
C
      WRITE(6,260)
  260 FORMAT(7H0TYPE 6/)
      DO 350 I=1,NB,5
      IA=2*I-1
      IB=MIN(IA+9,2*NB)
      I4=MIN(I+4,NB)
      WRITE(6,270)(J,J,J=I,I4)
  270 FORMAT(11H0D/DE D/DF:,10I10/8H    MSMNR)
      DO 340 J=1,NB
      J2=2*J
      J1=J2-1
      MS=MSK6(J)
      IF (MS) 340,340,280
  280 WRITE(6,290)
  290 FORMAT(1H )
      IF (MS-2) 300,320,300
  300 WRITE(6,310) J,(AJAC6(J1,K),K=IA,IB)
  310 FORMAT(I5,4HACT:,6X,10F10.5)
      IF (MS-1) 340,340,320
  320 WRITE(6,330) J,(AJAC6(J2,K),K=IA,IB)
  330 FORMAT(I5,6HREACT:,4X,10F10.5)
  340 CONTINUE
  350 CONTINUE
C
      RETURN
      END
```

```
      SUBROUTINE PRRES
C
C     PRINTS THE USED MEASUREMENTS, THE CORRESPONDING ESTIMATED VALUES
C     AND THE RESIDUES.
C
C     AUTHOR, TON VAN OVERBEEK 1974-01-22
C
C     SUBROUTINE REQUIRED
C             NONE
C
      PARAMETER MB=10,ML=13
      PARAMETER MMB=2*MB,MML=2*ML
C
      COMPLEX XE,YE2,YE3,YE4,YE5,YE6
C
      COMMON /ENET/ NB,NL
     1       /EST/ XE(MB),YE2(ML),YE3(ML),YE4(ML),YE5(ML),YE6(MB)
     2       /MSM/ YM1(MB),YM2(ML),YM3(ML),YM4(MML),YM5(MML),YM6(MMB)
     3       /MSI/ MSK1(MB),MSK2(ML),MSK3(ML),MSK4(ML),MSK5(ML),MSK6(MB)
     4       /RES/ RES1(MB),RES2(ML),RES3(ML),RES4(MML),RES5(MML),
     5             RES6(MMB)
C
      WRITE(6,10)
   10 FORMAT(13H0THE RESIDUES/1X,12(1H*)/14H0MSMNR
     F,10HMSM
     F,10HEST
     F,3HRES/
     F7H0TYPE 1/)
      DO 40 I=1,NB
      IF (MSK1(I)) 40,40,20
   20 YA=CABS(XE(I))
      WRITE(6,30) I,YM1(I),YA,RES1(I)
   30 FORMAT(I5,5X,3F10.5)
   40 CONTINUE
      WRITE(6,50)
   50 FORMAT(7H0TYPE 2/)
      DO 70 I=1,NL
      IF (MSK2(I)) 70,70,60
   60 YA=CABS(YE2(I))
      WRITE(6,30) I,YM2(I),YA,RES2(I)
   70 CONTINUE
      WRITE(6,80)
   80 FORMAT(7H0TYPE 3/)
      DO 100 I=1,NL
      IF (MSK3(I)) 100,100,90
   90 YA=CABS(YE3(I))
      WRITE(6,30) I,YM3(I),YA,RES3(I)
  100 CONTINUE
      WRITE(6,110)
  110 FORMAT(1H0,23X,33HACTIVE
     F,8HREACTIVE/
     F14H0MSMNR
     F,10HMSM
```

```
     F,10HEST
     F,15HRES
     F,10HMSM
     F,10HEST
     F,3HRES/
     F7HOTYPE 4/)
      DO 180 I=1,NL
      IF (MSK4(I)) 180,180,120
 120  I2=2*I
      I1=I2-1
      YR=REAL(YE4(I))
      YI=AIMAG(YE4(I))
      WRITE(6,130) I
 130  FORMAT(I5)
      IF (MSK4(I)-2) 140,160,140
 140  WRITE(6,150) YM4(I1),YR,RES4(I1)
 150  FORMAT(1H+,9X,3F10.5)
      IF (MSK4(I)-1) 180,180,160
 160  WRITE(6,170) YM4(I2),YI,RES4(I2)
 170  FORMAT(1H+,44X,3F10.5)
 180  CONTINUE
      WRITE(6,185)
 185  FORMAT(7HOTYPE 5/)
      DO 220 I=1,NL
      IF (MSK5(I)) 220,220,190
 190  I2=2*I
      I1=I2-1
      YR=REAL(YE5(I))
      YI=AIMAG(YE5(I))
      WRITE(6,130) I
      IF (MSK5(I)-2) 200,210,200
 200  WRITE(6,150) YM5(I1),YR,RES5(I1)
      IF (MSK5(I)-1) 220,220,210
 210  WRITE(6,170) YM5(I2),YI,RES5(I2)
 220  CONTINUE
      WRITE(6,225)
 225  FORMAT(7HOTYPE 6/)
      DO 260 I=1,NB
      IF (MSK6(I)) 260,260,230
 230  I2=2*I
      I1=I2-1
      YR=REAL(YE6(I))
      YI=AIMAG(YE6(I))
      WRITE(6,130) I
      IF (MSK6(I)-2) 240,250,240
 240  WRITE(6,150) YM6(I1),YR,RES6(I1)
      IF (MSK6(I)-1) 260,260,250
 250  WRITE(6,170) YM6(I2),YI,RES6(I2)
 260  CONTINUE
C
      RETURN
      END
```

```
      SUBROUTINE PRTNET
C
C     PRINTS TRUE NETWORK DATA
C     AUTHOR: TON VAN OVERBEEK 1973-12-12
C
C     SUBROUTINE REQUIRED
C             NONE
C
      PARAMETER ML=13
C
      COMPLEX YAA,ZAB,YBB
C
      COMMON /TNET/ NB,NL,LTA(ML),LTB(ML),YAA(ML),ZAB(ML),YBB(ML)
C
      IF (NL .GT. 0 .AND. NL .LE. ML) GO TO 20
      WRITE (6,10) NL
   10 FORMAT(22H0ERROR IN PRTNET  NL =,I5)
      GO TO 99
C
   20 WRITE(6,30) NB,NL
   30 FORMAT(18H0TRUE NETWORK DATA/1X,17(1H-)//
     F5H NB =,I3,6H  NL =,I3/)
      WRITE (6,40)
   40 FORMAT(11H0 LINE
     F,10HA-END
     F,13HB-END
     F,10HGAA
     F,10HBAA
     F,10HRAB
     F,10HXAB
     F,10HGBB
     F,3HBBB/)
      WRITE (6,50)(I,LTA(I),LTB(I),YAA(I),ZAB(I),YBB(I),I=1,NL)
   50 FORMAT(I5,2I10,5X,6F10.5)
C
   99 RETURN
      END
```

```
      SUBROUTINE PRWF
C
C     PRINTS ALL WEIGHTING FACTORS
C
C     AUTHOR, TON VAN OVERBEEK 1974-01-22
C
C     SUBROUTINE REQUIRED
C             NONE
C
      PARAMETER MB=10,ML=13
      PARAMETER MMB=2*MB,MML=2*ML,MM=3*(MB+MML)
C
      COMMON /ENET/ NB,NL
     1       /METE/ WF1(MB),WF2(ML),WF3(ML),WF4(MML),WF5(MML),WF6(MMB)
C
      WRITE(6,10)(I,WF1(I),WF6(2*I-1),WF6(2*I),I=1,NB)
   10 FORMAT(22H0ALL WEIGHTING FACTORS/1X,21(1H-)/
     F17H0MSMNR
     F,7HWF1
     F,16HWF6ACT   WF6REACT//
     F(I5,5X,3F10.2))
      WRITE(6,20)
   20 FORMAT(/17H0MSMNR
     F,10HWF2
     F,7HWF3
     F,20HWF4ACT   WF4REACT
     F,16HWF5ACT   WF5REACT/)
      DO 30 I=1,NL
      I2=2*I
      I1=I2-1
   30 WRITE(6,40) I,WF2(I),WF3(I),WF4(I1),WF4(I2),WF5(I1),WF5(I2)
   40 FORMAT(I5,5X,6F10.2)
C
      RETURN
      END
```

```
      SUBROUTINE RDENET(IPRINT,IERR)
C
C     READS ESTIMATOR NETWORK DATA IN COMMON BLOCK /ENET/
C
C     AUTHOR, TON VAN OVERBEEK 1974-01-14
C
C     IPRINT=1       NO PRINTOUT
C     IPRINT=0       ESTIMATOR NETWORK DATA IS PRINTED
C     IERR=1         ERROR IN NB OR NL
C     IERR=0         NO ERROR
C
C     SUBROUTINE REQUIRED
C             PRENET
C
      PARAMETER MB=10,ML=13
C
      COMPLEX YAA,ZAB,YBB
C
      COMMON /ENET/ NB,NL,LTA(ML),LTB(ML),YAA(ML),ZAB(ML),YBB(ML)
C
      READ (5,10) NB,NL
   10 FORMAT(2I5)
      IF (NB) 30,30,20
   20 IF (NB-MB) 50,50,30
   30 IERR=1
      WRITE (6,40) NB
   40 FORMAT(15H0NB IN RDENET =,I5)
      RETURN
C
   50 IF (NL) 70,70,60
   60 IF (NL-ML) 90,90,70
   70 IERR=1
      WRITE (6,80) NL
   80 FORMAT(15H0NL IN RDENET =,I5)
      RETURN
C
   90 IERR=0
      READ (5,100)(LTA(I),LTB(I),YAA(I),ZAB(I),YBB(I),I=1,NL)
  100 FORMAT(2I5,6F10.5)
      IF (IPRINT-1) 110,990,990
  110 CALL PRENET
C
  990 RETURN
      END
```

```
      SUBROUTINE RDGEN(IPRINT,IERR)
C
C     READS GENERATOR DATA IN COMMON BLOCK /GEN/
C
C     AUTHOR, TON VAN OVERBEEK 1974-01-15
C
C     IPRINT=1        NO PRINTOUT
C     IPRINT=0        GENERATOR DATA IS PRINTED
C     IERR=1          ERROR IN NG
C     IERR=0          NO ERROR
C
C     SUBROUTINE REQUIRED
C             NONE
C
      PARAMETER MG=14
C
      COMMON /GEN/ NG,NGB(MG),A1(MG),A2(MG),PMIN(MG),PMAX(MG)
C
      READ (5,10) NG
   10 FORMAT(I5)
      IF (NG) 30,30,20
   20 IF (NG-MG) 50,50,30
   30 IERR=1
      WRITE (6,40) NG
   40 FORMAT(14H0NG IN RDGEN =,I5)
      RETURN
C
   50 IERR=0
      READ (5,60)(NGB(I),A1(I),A2(I),PMIN(I),PMAX(I),I=1,NG)
   60 FORMAT(I5,4F10.5)
      IF (IPRINT) 70,70,99
   70 WRITE (6,80)(NGB(I),A1(I),A2(I),PMIN(I),PMAX(I),I=1,NG)
   80 FORMAT(15H0GENERATOR DATA/1X,14(1H-)/
     F14H0   NGB
     F,10HA1
     F,10HA2
     F,10HPMIN
     F,4HPMAX//
     F(I5,5X,4F10.5))
C
   99 RETURN
      END
```

```
      SUBROUTINE RDLD(SDB,SSL,KTMX,U,IPRINT,IERR)
C
C     READS THE SIMULATION TIME, DEMAND CONTROL DATA AND THE
C     START DEMAND.  IT USES THE DEMAND CONTROL DATA TO COMPUTE
C     THE STANDARD SLOPES AND THE DEMAND CONTROL VECTOR.  THESE
C     ARE USED BY THE SUBROUTINE CASDB.
C
C     AUTHOR, TON VAN OVERBEEK 1974-02-08
C
C     SDB(*)              COMPLEX  DEMAND AT BUS *
C                         RDLD READS THE START DEMAND INTO SDB(*)
C     SSL(*)              COMPLEX STANDARD SLOPE FOR BUS *
C                         SSL=(SDMAX(*)-SDMIN(*))/KTSL.
C                         SDMAX(*) IS THE MAXIMUM COMPLEX DEMAND AT BUS *,
C                         SDMIN(*) THE MINIMUM DEMAND.  KTSL IS THE SLOPE
C                         TIME.  KTSL, SDMIN(*) AND SDMAX(*) ARE READ BY RDLD
C     KTMX                SIMULATION TIME
C     U(*)                DEMAND CONTROL VECTOR.  SEE SUBROUTINE CASDB
C     IPRINT=1            NO PRINTOUT
C     IPRINT=0            THE SLOPE TIME, THE MINIMUM, MAXIMUM AND
C                         START DEMANDS, THE STANDARD SLOPES, THE DEMAND
C                         CONTROL DATA AND THE DEMAND CONTROL VECTOR
C                         ARE PRINTED
C     IERR=1              ERROR IN KTMX,NOE OR KTCH
C     IERR=0              NO ERROR
C
C     SUBROUTINE REQUIRED
C     NONE
C
      PARAMETER MB=10,MTMX=360
C
      DIMENSION U(1)
C
      COMPLEX SDB(1),SSL(1),SDMIN(MB),SDMAX(MB)
C
      COMMON /TNET/ NB
C
C     READ SLOPE TIME, MINIMUM AND MAXIMUM DEMANDS AND
C     COMPUTE THE STANDARD SLOPES
C
      READ(5,10) KTSL
   10 FORMAT(I5)
      DO 30 I=1,NB
      READ(5,20) SDMIN(I),SDMAX(I)
   20 FORMAT(4F10.5)
   30 SSL(I)=(SDMAX(I)-SDMIN(I))/KTSL
C
C     READ START DEMAND
C
      READ(5,35)(SDB(I),I=1,NB)
   35 FORMAT(2F10.5)
C
```

```
C     PRINTOUT
C
      IF (IPRINT) 40,40,70
   40 WRITE(6,50) KTSL
   50 FORMAT(10H0LOAD DATA/1X,9(1H-)/13H0SLOPE TIME =,I5)
      WRITE (6,60)(I,SDMIN(I),SDMAX(I),SSL(I),SDB(I),I=1,NB)
   60 FORMAT(14H0BUSNR
     F,10HPDMIN
     F,15HQDMIN
     F,10HPDMAX
     F,14HQDMAX
     F,10HRE(SSL)
     F,16HIM(SSL)
     F,10HPDEM
     F,4HQDEM//
     F(I5,F15.5,F10.5,F15.5,F10.5,F15.5,F10.5,F15.5,F10.5))
C
C     READ DEMAND CONTROL DATA AND COMPUTE DEMAND CONTROL VECTOR
C
   70 READ(5,10) KTMX
      IF(KTMX) 90,90,80
   80 IF (KTMX-MTMX) 110,110,90
   90 IERR=1
      WRITE(6,100) KTMX
  100 FORMAT(15H0KTMX IN RDLD =,I5)
      RETURN
C
  110 READ(5,10) NOE
      IF (NOE) 130,120,120
  120 IF (NOE-KTMX) 150,150,130
  130 IERR=1
      WRITE(6,140) NOE,KTMX
  140 FORMAT(14H0NOE IN RDLD =,I5,5X,6HKTMX =,I5)
      RETURN
C
  150 DO 160 I=1,MTMX
  160 U(I)=0.0
      IF (IPRINT) 170,170,190
  170 WRITE(6,180) KTMX,NOE
  180 FORMAT(/13H0CONTROL DATA/1X,12(1H-)/
     F7H0KTMX =,I5,5X,5HNOE = I5)
      IF (NOE) 320,320,190
  190 IF (IPRINT) 200,200,220
  200 WRITE(6,210)
  210 FORMAT(15H0TCHANGE
     F,4HUNEW/)
  220 K=1
      UOLD=0.0
      DO 300 I=1,NOE
      READ(5,230) KTCH,UNEW
  230 FORMAT(I5,F10.5)
      IF (KTCH) 250,250,240
  240 IF (KTCH-KTMX) 270,270,250
```

```
  250 IERR=1
      WRITE(6,260) I,KTCH,KTMX
  260 FORMAT(22H0ERROR IN CONTROL DATA/4H0I =,I5,
     F5X,6HKTCH =,I5,5X,6HKTMX =,I5)
      RETURN
C
  270 IF (IPRINT .LT. 1) WRITE(6,280) KTCH,UNEW
  280 FORMAT(I6,F15.5)
      DO 290 J=K,KTCH
  290 U(J)=UOLD
      K=KTCH
      UOLD=UNEW
  300 CONTINUE
      DO 310 I=KTCH,KTMX
  310 U(I)=UNEW
C
C     PRINT THE DEMAND CONTROL VECTOR
C
  320 IF (IPRINT) 330,330,990
  330 WRITE(6,340)(I,I=1,10)
  340 FORMAT(/13H0THE U-VECTOR,10(I10,1X)/1X,12(1H-))
      DO 360 I=1,KTMX,10
      IA=I
      IB=MIN(IA+9,KTMX)
      WRITE(6,350) IA,IB,(U(J),J=IA,IB)
  350 FORMAT(I6,1H-,I5,5X,10F11.5)
  360 CONTINUE
C
  990 IERR=0
      RETURN
      END
```

```
      SUBROUTINE RDMETE(IPRINT)
C
C     READS ESTIMATOR METER DATA TO BE USED FOR THE CALCULATION OF
C     THE WEIGHT FACTORS IN COMMON BLOCK /METE/
C
C     AUTHOR, TON VAN OVERBEEK 1974-01-18
C
C     IPRINT=1          NO PRINTOUT
C     IPRINT=0          ESTIMATOR METER DATA IS PRINTED
C
C     SUBROUTINE REQUIRED
C             NONE
C
      PARAMETER MB=10,ML=13
      PARAMETER MMB=2*MB,MML=2*ML
C
      COMMON /ENET/ NB,NL
     1       /METE/ WF1(MB),WF2(ML),WF3(ML),WF4(MML),WF5(MML),
     2              WF6(MMB),ALFE1(MB),ALFE2(ML),ALFE3(ML),ALFE4(MML),
     3              ALFE5(MML),ALFE6(MMB),FSE1(MB),FSE2(ML),FSE3(ML),
     4              FSE4(MML),FSE5(MML),FSE6(MMB),BETE1(MB),BETE2(ML),
     5              BETE3(ML),BETE4(MML),BETE5(MML),BETE6(MMB)
C
      DO 10 I=1,NB
      I2=2*I
      I1=I2-1
   10 READ(5,20) ALFE1(I),FSE1(I),BETE1(I),
     1           ALFE6(I1),FSE6(I1),BETE6(I1),
     2           ALFE6(I2),FSE6(I2),BETE6(I2)
   20 FORMAT(3F10.5)
      DO 30 I=1,NL
      I2=2*I
      I1=I2-1
   30 READ(5,20) ALFE2(I),FSE2(I),BETE2(I),
     1           ALFE3(I),FSE3(I),BETE3(I),
     2           ALFE4(I1),FSE4(I1),BETE4(I1),
     3           ALFE4(I2),FSE4(I2),BETE4(I2),
     4           ALFE5(I1),FSE5(I1),BETE5(I1),
     5           ALFE5(I2),FSE5(I2),BETE5(I2)
      IF (IPRINT-1) 40,990,990
   40 WRITE(6,50)
   50 FORMAT(21H1ESTIMATOR METER DATA/1X,20(1H*)/
     F14HOMETER
     F,10HALFA
     F,10HFSC
     F,4HBETA/
     F,7HOTYPE 1/)
      WRITE(6,60)(I,ALFE1(I),FSE1(I),BETE1(I),I=1,NB)
   60 FORMAT(I5,5X,3F10.5)
      WRITE(6,70)
   70 FORMAT(7HOTYPE 2/)
      WRITE(6,60)(I,ALFE2(I),FSE2(I),BETE2(I),I=1,NL)
```

```
      WRITE(6,80)
   80 FORMAT(7H0TYPE 3/)
      WRITE(6,60)(I,ALFE3(I),FSE3(I),BETE3(I),I=1,NL)
      WRITE(6,90)
   90 FORMAT(/1H0,22X
     F,34HACTIVE
     F,8HREACTIVE/
     F14H0METER
     F,10HALFA
     F,10HFSC
     F,15HBETA
     F,10HALFA
     F,10HFSC
     F,4HBETA/
     F,7H0TYPE 4/)
      DO 110 I=1,NL
      I2=2*I
      I1=I2-1
      WRITE(6,100) I,ALFE4(I1),FSE4(I1),BETE4(I1),
     1                  ,ALFE4(I2),FSE4(I2),BETE4(I2)
  100 FORMAT(I5,5X,3F10.5,5X,3F10.5)
  110 CONTINUE
      WRITE(6,120)
  120 FORMAT(7H0TYPE 5/)
      DO 130 I=1,NL
      I2=2*I
      I1=I2-1
  130 WRITE(6,100) I,ALFE5(I1),FSE5(I1),BETE5(I1),
     1                  ,ALFE5(I2),FSE5(I2),BETE5(I2)
      WRITE(6,140)
  140 FORMAT(7H0TYPE 6/)
      DO 150 I=1,NB
      I2=2*I
      I1=I2-1
  150 WRITE(6,100) I,ALFE6(I1),FSE6(I1),BETE6(I1),
     1                  ,ALFE6(I2),FSE6(I2),BETE6(I2)
C
  990 RETURN
      END
```

```
      SUBROUTINE RDMETT(IPRINT)
C
C     READS METER DATA TO BE USED FOR THE CALCULATION OF
C     THE MEASUREMENTS IN COMMON BLOCK /METT/
C
C     AUTHOR, TON VAN OVERBEEK 1974-01-18
C
C     IPRINT=1         NO PRINTOUT
C     IPRINT=0         METER DATA IS PRINTED
C
C     SUBROUTINE REQUIRED
C             NONE
C
      PARAMETER MB=10,ML=13
      PARAMETER MMB=2*MB,MML=2*ML
C
      COMMON /TNET/ NB,NL
     1       /METT/ BIAS1(MB),BIAS2(ML),BIAS3(ML),BIAS4(MML),
     2              BIAS5(MML),BIAS6(MMB),WN1(MB),WN2(ML),WN3(ML),
     3              WN4(MML),WN5(MML),WN6(MMB),ALFT1(MB),ALFT2(ML),
     4              ALFT3(ML),ALFT4(MML),ALFT5(MML),ALFT6(MMB),
     5              FST1(MB),FST2(ML),FST3(ML),FST4(MML),
     6              FST5(MML),FST6(MMB),BETT1(MB),BETT2(ML),BETT3(ML),
     7              BETT4(MML),BETT5(MML),BETT6(MMB)
C
      DO 10 I=1,NB
      I2=2*I
      I1=I2-1
   10 READ(5,20) BIAS1(I),ALFT1(I),FST1(I),BETT1(I),
     1           BIAS6(I1),ALFT6(I1),FST6(I1),BETT6(I1),
     2           BIAS6(I2),ALFT6(I2),FST6(I2),BETT6(I2)
   20 FORMAT(4F10.5)
      DO 30 I=1,NL
      I2=2*I
      I1=I2-1
   30 READ(5,20) BIAS2(I),ALFT2(I),FST2(I),BETT2(I),
     1           BIAS3(I),ALFT3(I),FST3(I),BETT3(I),
     2           BIAS4(I1),ALFT4(I1),FST4(I1),BETT4(I1),
     3           BIAS4(I2),ALFT4(I2),FST4(I2),BETT4(I2),
     4           BIAS5(I1),ALFT5(I1),FST5(I1),BETT5(I1),
     5           BIAS5(I2),ALFT5(I2),FST5(I2),BETT5(I2)
      IF (IPRINT-1) 40,990,990
   40 WRITE(6,50)
   50 FORMAT(16H1TRUE METER DATA/1X,15(1H*)/
     F14HOMETER
     F,10HBIAS
     F,10HALFA
     F,10HFSC
     F,4HBETA/
     F,7HOTYPE 1/)
      WRITE(6,60)(I,BIAS1(I),ALFT1(I),FST1(I),BETT1(I),I=1,NB)
   60 FORMAT(I5,5X,4F10.5)
```

```
      WRITE(6,70)
   70 FORMAT(7HOTYPE 2/)
      WRITE(6,60)(I,BIAS2(I),ALFT2(I),FST2(I),BETT2(I),I=1,NL)
      WRITE(6,80)
   80 FORMAT(7HOTYPE 3/)
      WRITE(6,60)(I,BIAS3(I),ALFT3(I),FST3(I),BETT3(I),I=1,NL)
      WRITE(6,90)
   90 FORMAT(/1H0,27X
     F,43HACTIVE
     F,8HREACTIVE/
     F14HOMETER
     F,10HBIAS
     F,10HALFA
     F,10HFSC
     F,15HBETA
     F,10HBIAS
     F,10HALFA
     F,10HFSC
     F,4HBETA/
     F,7HOTYPE 4/)
      DO 110 I=1,NL
      I2=2*I
      I1=I2-1
      WRITE(6,100) I,BIAS4(I1),ALFT4(I1),FST4(I1),BETT4(I1),
     1                 BIAS4(I2),ALFT4(I2),FST4(I2),BETT4(I2)
  100 FORMAT(I5,5X,4F10.5,5X,4F10.5)
  110 CONTINUE
      WRITE(6,120)
  120 FORMAT(7HOTYPE 5/)
      DO 130 I=1,NL
      I2=2*I
      I1=I2-1
  130 WRITE(6,100) I,BIAS5(I1),ALFT5(I1),FST5(I1),BETT5(I1),
     1                 BIAS5(I2),ALFT5(I2),FST5(I2),BETT5(I2)
      WRITE(6,140)
  140 FORMAT(7HOTYPE 6/)
      DO 150 I=1,NB
      I2=2*I
      I1=I2-1
  150 WRITE(6,100) I,BIAS6(I1),ALFT6(I1),FST6(I1),BETT6(I1),
     1                 BIAS6(I2),ALFT6(I2),FST6(I2),BETT6(I2)
C
  990 RETURN
      END
```

```
      SUBROUTINE RDMSM(IPRINT,IERR)
C
C     SUBROUTINE TO READ WHICH MEASUREMENTS ARE TO BE USED AND IN
C     WHICH ORDER THEY ARE TO BE TREATED BY THE ESTIMATORS.  DATA
C     IS READ INTO THE COMMON BLOCK /MSI/.  FROM THE DATA READ INTO
C     NTYP AND NMSM THE MASKVECTORS ARE COMPUTED.  ACTIVE AND REACTIVE
C     MEASUREMENTS ARE TREATED SEPARATELY IN NMSM.  ODD NUMBERS
C     REFER TO ACTIVE, EVEN NUMBERS TO REACTIVE MEASUREMENTS.
C
C     AUTHOR, TON VAN OVERBEEK 1974-01-22
C
C     IPRINT=2         NO PRINTOUT
C     IPRINT=1         THE MASKVECTORS ARE PRINTED
C     IPRINT=0         SAME + NTYP AND NMSM
C     IERR=3           ERROR IN NMSM
C     IERR=2           ERROR IN NTYP
C     IERR=1           ERROR IN NM
C     IERR=0           NO ERROR
C
C     SUBROUTINE REQUIRED
C             NONE
C
      PARAMETER MB=10,ML=13
      PARAMETER MMB=2*MB,MML=2*ML,MM=3*(MB+MML)
C
      COMMON /ENET/ NB,NL
     1       /MSI/ MSK1(MB),MSK2(ML),MSK3(ML),MSK4(ML),MSK5(ML),
     2             MSK6(MB),NM,NTYP(MM),NMSM(MM)
C
C     INITIALIZE MASKVECTORS, NTYP AND NMSM
C
      DO 10 I=1,MB
      MSK1(I)=0.0
   10 MSK6(I)=0.0
      DO 20 I=1,ML
      MSK2(I)=0.0
      MSK3(I)=0.0
      MSK4(I)=0.0
   20 MSK5(I)=0.0
      DO 30 I=1,MM
      NTYP(I)=0.0
   30 NMSM(I)=0.0
      MMX=3*NB+6*NL
C
C     READ AND CHECK NM
C
      READ(5,40) NM
   40 FORMAT(I5)
      IF (NM) 60,60,50
   50 IF (NM-MMX) 80,80,60
   60 IERR=1
      WRITE(6,70) NM
   70 FORMAT(14H0NM IN RDMSM =,I5)
```

```
      RETURN
C
   80 DO 300 I=1,NM
C
C     READ AND CHECK NTYP AND NMSM
C
      READ(5,90) NTI,NMI
   90 FORMAT(2I5)
      IF (NTI) 110,110,100
  100 IF (NTI-6) 130,130,110
  110 IERR=2
      WRITE(6,120) I,NTI
  120 FORMAT(30H0TYPE ERROR IN RDMSM    MSMNR =,I5,8H  TYPE =,I5)
      RETURN
C
  130 NTYP(I)=NTI
      GO TO (140,150,150,160,160,170),NTI
  140 NMAX=NB
      GO TO 180
  150 NMAX=NL
      GO TO 180
  160 NMAX=2*NL
      GO TO 180
  170 NMAX=2*NB
  180 IF (NMI) 200,200,190
  190 IF (NMI-NMAX) 220,220,200
  200 IERR=3
      WRITE(6,210) I,NTI,NMI
  210 FORMAT(47H0TYPE MEASUREMENT NUMBER OUT OF BOUNDS IN RDMSM/
     F,8H MSMNR =,I5,8H  TYPE =,I5,14H  TYPE MSMNR =,I5)
      RETURN
C
  220 NMSM(I)=NMI
C
C     COMPUTE MASK VECTOR
C
      IERR=0
      GO TO (230,240,250,260,260,260),NTI
  230 MSK1(NMI)=1.0
      GO TO 300
  240 MSK2(NMI)=1.0
      GO TO 300
  250 MSK3(NMI)=1.0
      GO TO 300
  260 MD=MOD(NMI,2)
      J=NMI/2+MD
      NTI=NTI-3
      GO TO (270,280,290),NTI
  270 MSK4(J)=MSK4(J)+2-MD
      GO TO 300
  280 MSK5(J)=MSK5(J)+2-MD
      GO TO 300
  290 MSK6(J)=MSK6(J)+2-MD
  300 CONTINUE
```

```
C
C     PRINTOUT
C
      IF (IPRINT-2) 310,990,990
  310 WRITE(6,320)
  320 FORMAT(20H0PRINTOUT FROM RDMSM/1X,19(1H*)/)
      IF (IPRINT-1) 330,350,350
  330 WRITE(6,340)(I,NTYP(I),NMSM(I),I=1,NM)
  340 FORMAT(12H0MSMNR
     F,10HTYPE
     F,4HNMSM//
     F(I5,2I10))
  350 WRITE(6,360)(I,MSK1(I),MSK6(I),I=1,NB)
  360 FORMAT(/17H0THE MASK VECTORS/1X,16(1H-)/
     F,12H0   MSM
     F,10HMSK1
     F,4HMSK6//
     F(I5,2I10))
      WRITE(6,370)(I,MSK2(I),MSK3(I),MSK4(I),MSK5(I),I=1,NL)
  370 FORMAT(/12H0   MSM
     F,10HMSK2
     F,10HMSK3
     F,10HMSK4
     F,4HMSK5//
     F(I5,4I10))
C
  990 RETURN
      END
```

```
      SUBROUTINE RDTNET(IPRINT,IERR)
C
C     READS TRUE NETWORK DATA IN COMMON BLOCK /TNET/
C
C     AUTHOR, TON VAN OVERBEEK 1974-01-14
C
C     IPRINT=1       NO PRINTOUT
C     IPRINT=0       TRUE NETWORK DATA IS PRINTED
C     IERR=1         ERROR IN NB OR NL
C     IERR=0         NO ERROR
C
C     SUBROUTINE REQUIRED
C             PRTNET
C
      PARAMETER MB=10,ML=13
C
      COMPLEX YAA,ZAB,YBB
C
      COMMON /TNET/ NB,NL,LTA(ML),LTB(ML),YAA(ML),ZAB(ML),YBB(ML)
C
      READ (5,10) NB,NL
   10 FORMAT(2I5)
      IF (NB) 30,30,20
   20 IF (NB-MB) 50,50,30
   30 IERR=1
      WRITE (6,40) NB
   40 FORMAT(15HONB IN RDTNET =,I5)
      RETURN
C
   50 IF (NL) 70,70,60
   60 IF (NL-ML) 90,90,70
   70 IERR=1
      WRITE (6,80) NL
   80 FORMAT(15HONL IN RDTNET =,I5)
      RETURN
C
   90 IERR=0
      READ (5,100)(LTA(I),LTB(I),YAA(I),ZAB(I),YBB(I),I=1,NL)
  100 FORMAT(2I5,6F10.5)
      IF (IPRINT-1) 110,990,990
  110 CALL PRTNET
C
  990 RETURN
      END
```

```
      SUBROUTINE TRUEV(SDB,IPRINT,IERR)
C
C     COMPUTES THE TRUE VALUES OF ALL VARIABLES GIVEN TRUE
C     NETWORK DATA AND A POWER DEMAND.
C
C     AUTHOR, TON VAN OVERBEEK 1974-01-16
C
C     SDB(*)       COMPLEX LOAD AT BUS *
C     IERR=3       ERROR IN NRLFR
C     IERR=2       ERROR IN ELDNL
C     IERR=1       ERROR IN NB,NL OR NG
C     IERR=0       YT HAS BEEN COMPUTED
C     IPRINT=4     NO PRINTOUT
C     IPRINT=3     POWER DEMAND AND YT ARE PRINTED
C     IPRINT=2     SAME + TRUE NETWORK AND GENERATOR DATA
C     IPRINT=1     SAME + OUTPUT FROM THE SUB-
C     IPRINT=0     ROUTINES ELDNL AND NRLFR
C
C     SUBROUTINE REQUIRED
C             ELDNL
C             GXT
C               PRTNET
C             NRLFR
C               DECOM
C               MPRI
C               SOLVB
C
      PARAMETER MB=10,ML=13,MG=14
C
      COMPLEX YAA,ZAB,YBB,XT,YT2,YT3,YT4,YT5,YT6
     1,SDB(1),SDEM,SGEN(MG),SINJ(MB)
C
      DIMENSION PGEN(MG)
C
      COMMON /TNET/ NB,NL,LTA(ML),LTB(ML),YAA(ML),ZAB(ML),YBB(ML)
     1       /GEN/ NG,NGB(MG),A1(MG),A2(MG),PMIN(MG),PMAX(MG)
     2       /TRUE/ XT(MB),YT2(ML),YT3(ML),YT4(ML),YT5(ML),YT6(MB)
C
      IERR=0
      IF (NB .GT. 0 .AND. NB .LE. MB) GO TO 20
      IERR=1
      WRITE (6,10) NB
   10 FORMAT(14H0NB IN TRUEV =,I5)
      RETURN
C
   20 IF (NL .GT. 0 .AND. NL .LE. ML) GO TO 40
      IERR=1
      WRITE (6,30) NL
   30 FORMAT(14H0NL IN TRUEV =,I5)
      RETURN
C
   40 IF (NG .GT. 0 .AND. NG .LE. MG) GO TO 60
      IERR=1
```

```
      WRITE (6,50) NG
   50 FORMAT(14HONG IN TRUEV =,I5)
      RETURN
C
C     PRINT INPUT DATA
C
   60 IF (IPRINT .GE. 4) GO TO 100
      WRITE (6,70) (I,SDB(I),I=1,NB)
   70 FORMAT(20H1PRINTOUT FROM TRUEV/1X,19(1H*)/
     F16H0THE LOAD DEMAND/
     F14H0BUSNR
     F,8HACTIVE
     F,8HREACTIVE//
     F(I5,5X,2F10.5))
      IF (IPRINT .GE. 3) GO TO 100
      WRITE (6,80) NG
   80 FORMAT(/15H0GENERATOR DATA/5H0NG =,I3)
      WRITE (6,90) (I,NGB(I),A1(I),A2(I),PMIN(I),PMAX(I),I=1,NG)
   90 FORMAT(19H0GENNR  NGB
     F,10HA1
     F,10HA2
     F,10HPMIN
     F,4HPMAX//
     F(2I5,5X,4F10.5))
C
C     COMPUTE REAL GENERATED POWERS WITH SUBROUTINE ELDNL
C
  100 SDEM=(0.0,0.0)
      DO 110 I=1,NB
      SINJ(I)=-SDB(I)
  110 SDEM=SDEM+SDB(I)
      CALL ELDNL(A1,A2,PMIN,PGEN,PMAX,REAL(SDEM),0.001,NG,IPRINT,IERR)
      IF (IERR) 120,130,120
  120 IERR=2
      RETURN
C
C     COMPUTE BUSINJECTIONS
C
  130 FACTOR =AIMAG(SDEM)/REAL(SDEM)
      DO 140 I=1,NG
      IB=NGB(I)
      SGEN(I)=CMPLX(PGEN(I),PGEN(I)*FACTOR)
  140 SINJ(IB)=SINJ(IB)+SGEN(I)
C
C     COMPUTE BUSVOLTAGES FROM BUSINJECTIONS
C
      CALL NRLFR(NB,NL,LTA,LTB,YAA,ZAB,YBB,SINJ,XT,0.01,NB,5,
     1IPRINT,JFAIL)
      IF (JFAIL .EQ. 0) GO TO 150
      IERR=3
      RETURN
C
C     COMPUTE OTHER VARIABLES WITH SUBROUTINE GXT
C
  150 CALL GXT(IPRINT-2,I)
      RETURN
      END
```

```
      SUBROUTINE UPDAA(INDEX,ELT,NOE,WI,A)
C
C     SUBROUTINE FOR ESTA
C     UPDATES MATRIX A FOR MEASUREMENT I ACCORDING TO
C     A = A + (JACOBIAN ROW I)**T*WI*(JACOBIAN ROW I)
C
C     AUTHOR, TON VAN OVERBEEK 1974-01-30
C
C     INDEX(*)        PLACE OF ELT(*) IN JACOBIAN ROW I
C     ELT(*)          JACOBIAN ELEMENT
C     NOE             NUMBER OF ELEMENTS IN ELT AND INDEX, MAX=MMB
C     WI              WEIGHTING FACTOR FOR MEASUREMENT I
C     A               MATRIX TO BE UPDATED
C
C     SUBROUTINE REQUIRED
C               NONE
C
      PARAMETER MB=10
      PARAMETER MMB=2*MB
C
      DIMENSION INDEX(1),ELT(1),A(MMB,1)
C
      IF (NOE) 20,99,10
   10 IF (NOE-MMB) 40,40,20
   20 WRITE (6,30) NOE
   30 FORMAT(25H0CALL TO UPDAA WITH NOE =,I5)
      RETURN
C
   40 DO 70 I=1,NOE
      K=INDEX(I)
      A(K,K)=A(K,K)+ELT(I)**2*WI
      IF (I-1) 70,70,50
   50 I1=I-1
      DO 60 J=1,I1
      L=INDEX(J)
      A(K,L)=A(K,L)+ELT(I)*ELT(J)*WI
      A(L,K)=A(K,L)
   60 CONTINUE
   70 CONTINUE
C
   99 RETURN
      END
```

```
      SUBROUTINE UPDAC(IA,IB,DA)
C
C     HELPROUTINE FOR ESTC
C     UPDATES MATRIX A FOR A COMPLEX LINE FLOW MEASUREMENT AT
C     A-END OF THE LINE
C
C     AUTHOR, TON VAN OVERBEEK 1974-03-11
C
C     IA                A-END OF LINE CONNECTED TO BUS IA
C     IB                B-END OF LINE CONNECTED TO BUS IB
C     DA                WEIGHTING FACTOR FOR THE LINEVOLTAGE
C
C     SUBROUTINE REQUIRED
C               NONE
C
      PARAMETER MB=10
C
      COMMON /ENET/ NB
     X       /MAT/ A(MB,MB)
C
      IF (IA) 20,20,10
   10 IF (IA-NB) 40,40,20
   20 WRITE(6,30) IA
   30 FORMAT(14H0IA IN UPDAC =,I5)
      RETURN
C
   40 IF (IB) 60,60,50
   50 IF (IB-NB) 80,80,60
   60 WRITE(6,70) IB
   70 FORMAT(14H0IB IN UPDAC =,I5)
      RETURN
C
   80 A(IA,IA)=A(IA,IA)+DA
      A(IB,IB)=A(IB,IB)+DA
      A(IA,IB)=A(IA,IB)-DA
      A(IB,IA)=A(IA,IB)
C
      RETURN
      END
```

```
      SUBROUTINE UPDBA(INDEX,ELT,NOE,WI,B,RES)
C
C     SUBROUTINE FOR ESTA
C     UPDATES THE B VECTOR FOR MEASUREMENT I ACCORDING TO
C     B = B + (JACOBIAN ROW I)**T*WI*RES
C
C     AUTHOR, TON VAN OVERBEEK 1974-01-30
C
C     INDEX(*)          PLACE OF ELT(*) IN JACOBIAN ROW I
C     ELT(*)            JACOBIAN ELEMENT
C     NOE               NUMBER OF ELEMENTS IN ELT AND INDEX, MAX=MMB
C     WI                WEIGHTING FACTOR FOR MEASUREMENT I
C     B                 VECTOR TO BE UPDATED
C     RES               RESIDU OF MEASUREMENT I
C
C     SUBROUTINE REQUIRED
C              NONE
C
      PARAMETER MB=10
      PARAMETER MMB=2*MB
C
      DIMENSION INDEX(1),ELT(1),B(1)
C
      IF (NOE) 20,99,10
   10 IF (NOE-MMB) 40,40,20
   20 WRITE (6,30) NOE
   30 FORMAT(25H0CALL TO UPDBA WITH NOE =,I5)
      RETURN
C
   40 WIR=WI*RES
      DO 50 I=1,NOE
      K=INDEX(I)
   50 B(K)=B(K)+ELT(I)*WIR
C
   99 RETURN
      END
```

```
      SUBROUTINE UPDBC(CB,IA,IB,NR,XEA,XEB,ZL,YA,CYM,CLV,DA)
C
C     HELPROUTINE FOR ESTC
C     UPDATES THE RIGHT HAND B-VECTOR OF THE EQUATION A*E=B FOR
C     A COMPLEX LINE FLOW MEASUREMENT
C
C     AUTHOR, TON VAN OVERBEEK 1974-03-11
C
C     CB(*)              COMPLEX B-VECTOR
C     IA                 A-END OF LINE CONNECTED TO BUS IA
C     IB                 B-END OF LINE CONNECTED TO BUS IB
C     NR                 NUMBER OF ELEMENTS IN THE REFERENCE VECTOR
C     XEA                COMPLEX BUSVOLTAGE AT A-END OF LINE
C     XEB                COMPLEX BUSVOLTAGE AT B-END OF LINE
C     ZL                 LINE SERIES IMPEDANCE
C     YA                 LINE SHUNT ADMITTANCE AT A-END
C     CYM                COMPLEX LINE FLOW MEASUREMENT AT A-END
C     CLV                COMPUTED COMPLEX LINEVOLTAGE
C     DA                 WEIGHTING FACTOR FOR LINEVOLTAGE AT A-END
C
C     SUBROUTINE REQUIRED
C              NONE
C
      PARAMETER MB=10
C
      COMPLEX CB(1),XEA,XEB,ZL,YA,CYM,CLV
C
      COMMON /ENET/ NB
C
      IF (IA) 20,20,10
   10 IF (IA-NB) 40,40,20
   20 WRITE(6,30) IA
   30 FORMAT(14H0IA IN UPDBC =,I5)
      RETURN
C
   40 IF (IB) 60,60,50
   50 IF (IB-NB) 80,80,60
   60 WRITE(6,70) IB
   70 FORMAT(14H0IB IN UPDBC =,I5)
      RETURN
C
   80 IF (NR) 100,100,90
   90 IF (NR-NB) 120,120,100
  100 WRITE(6,110) NR
  110 FORMAT(14H0NR IN UPDBC =,I5)
      RETURN
C
  120 CLV=ZL*(CONJG(CYM/XEA)-YA*XEA)
      NE=NB-NR
C
      IF (IA-NE) 130,130,140
  130 CB(IA)=CB(IA)+DA*CLV
      GO TO 150
  140 CB(IB)=CB(IB)+DA*XEA
```

```
C
  150 IF (IB-NE) 160,160,170
  160 CB(IB)=CB(IB)-DA*CLV
      GO TO 990
  170 CB(IA)=CB(IA)+DA*XEB
C
  990 RETURN
      END
```

```
      SUBROUTINE UPDEP(IA,IB,RES,WF,G,P,AK,XE)
C
C     HELPROUTINE FOR ESTB.  IT COMPUTES THE TWO NEW ESTIMATED
C     VOLTAGES FOR LINE FLOW AND LINE CURRENT MEASUREMENTS, GIVEN THE
C     RESIDUE, IA, IB, THE FOUR NON ZERO JACOBIAN ELEMENTS AND THE FOUR
C     P ELEMENTS.
C
C     AUTHOR, TON VAN OVERBEEK 1974-03-04
C
C     IA                  A-END OF LINE CONNECTED TO BUS IA
C     IB                  B-END OF LINE CONNECTED TO BUS IB
C     RES                 THE RESIDUE OF THE MEASUREMENT
C     G(1)                JACOBIAN ELEMENT D(MSM)/DEA
C     G(2)                JACOBIAN ELEMENT D(MSM)/DFA
C     G(3)                JACOBIAN ELEMENT D(MSM)/DEB
C     G(4)                JACOBIAN ELEMENT D(MSM)/DFB
C     P(*)                THE FOUR P-ELEMENTS
C     AK(*)               THE COMPUTED FOUR GAIN ELEMENTS
C     XE(*)               THE ESTIMATE
C
C     SUBROUTINE REQUIRED
C              NONE
C
      COMMON /ENET/ NB
C
      COMPLEX XE(1)
C
      DIMENSION G(1),P(1),AK(1)
C
      R=1/WF
      DEN=0.0
      DO 10 I=1,4
      AK(I)=P(I)*G(I)
   10 DEN=DEN+AK(I)*G(I)
      DEN=DEN+R
      DO 30 I=1,4
   30 AK(I)=AK(I)/DEN
      IF (IA .EQ. NB) AK(2)=0.0
      IF (IB .EQ. NB) AK(4)=0.0
      XE(IA)=XE(IA)+CMPLX(AK(1),AK(2))*RES
      XE(IB)=XE(IB)+CMPLX(AK(3),AK(4))*RES
      DO 40 I=1,4
   40 P(I)=P(I)*(1-AK(I)*G(I))
C
      RETURN
      END
```

```
C        MAINPROGRAM FOR METHOD A
C
C        AUTHOR, TON VAN OVERBEEK 1974-02-19
C
C        SUBROUTINE REQUIRED
C                ADMA
C                  ALOSS
C                    PRRES
C                  CAJAC
C                    JACBI
C                      JACLF
C                    JACI
C                    JACLF
C                    JACV
C                    PRENET
C                    PRJAC
C                  CARES
C                    GXE
C                      PRENET
C                    PRRES
C                  ESTA
C                    DESYM
C                    MPRI
C                    PRJAC
C                    PRRES
C                    SOLVS
C                    UPDAA
C                    UPDBA
C                  PRRES
C                  PRWF
C                ALLMSM
C                  NODI
C                CASDB
C                CAWF
C                CAWN
C                EVAL
C                RDENET
C                  PRENET
C                RDGEN
C                RDLD
C                RDMETE
C                RDMETT
C                RDMSM
C                RDTNET
C                  PRTNET
C                TRUEV
C                  ELDNL
C                  GXT
C                    PRTNET
C                  NRLFR
C                  DECOM
C                  MPRI
C                  SOLVB
C
```

```
      PARAMETER MB=10,ML=13,MTMX=360
      PARAMETER MMB=2*MB,MML=2*ML,MM=3*(MB+MML),MTMX1=MTMX+1
C
      INTEGER TIME
C
      DIMENSION U(MTMX),IPR(MTMX),KXB(MTMX),KXE(MTMX),IEXIT(MTMX)
C
      COMPLEX XT,YT2,YT3,YT4,YT5,YT6,YAAT,ZABT,YBBT,SDB(MB),SSL(MB),
     1        XE,YE2,YE3,YE4,YE5,YE6,YAAE,ZABE,YBBE,XL(MB)
C
      COMMON /TRUE/ XT(MB),YT2(ML),YT3(ML),YT4(ML),YT5(ML),YT6(MB)
     X       /EST/ XE(MB),YE2(ML),YE3(ML),YE4(ML),YE5(ML),YE6(MB)
     X       /TNET/ NBT,NLT,LTAT(ML),LTBT(ML),YAAT(ML),ZABT(ML),YBBT(ML)
     X       /ENET/ NBE,NLE,LTAE(ML),LTBE(ML),YAAE(ML),ZABE(ML),YBBE(ML)
     X       /MSM/ YM1(MB),YM2(ML),YM3(ML),YM4(MML),YM5(MML),YM6(MMB)
     X       /METT/ BIAS1(MB),BIAS2(ML),BIAS3(ML),BIAS4(MML),
     X              BIAS5(MML),BIAS6(MMB),WN1(MB),WN2(ML),WN3(ML),
     X              WN4(MML),WN5(MML),WN6(MMB),ALFT1(MB),ALFT2(ML),
     X              ALFT3(ML),ALFT4(MML),ALFT5(MML),ALFT6(MMB),
     X              FST1(MB),FST2(ML),FST3(ML),FST4(MML),
     X              FST5(MML),FST6(MMB),BETT1(MB),BETT2(ML),BETT3(ML),
     X              BETT4(MML),BETT5(MML),BETT6(MMB)
      COMMON /METE/ WF1(MB),WF2(ML),WF3(ML),WF4(MML),WF5(MML),
     X              WF6(MMB),ALFE1(MB),ALFE2(ML),ALFE3(ML),ALFE4(MML),
     X              ALFE5(MML),ALFE6(MMB),FSE1(MB),FSE2(ML),FSE3(ML),
     X              FSE4(MML),FSE5(MML),FSE6(MMB),BETE1(MB),BETE2(ML),
     X              BETE3(ML),BETE4(MML),BETE5(MML),BETE6(MMB)
     X       /RES/ RES1(MB),RES2(ML),RES3(ML),RES4(MML),RES5(MML),
     X             RES6(MMB)
     X       /MAT/ A(MMB,MMB),T(MMB,MMB)
     X       /MSI/ MSK1(MB),MSK2(ML),MSK3(ML),MSK4(ML),MSK5(ML),
     X             MSK6(MB),NM,NTYP(MM),NMSM(MM)
     X       /JAC/ AJAC1(MB,2),AJAC2(ML,4),AJAC3(ML,4),AJAC4(MML,4),
     X             AJAC5(MML,4),AJAC6(MMB,MMB)
      COMMON /EVL/ EE(MTMX1),EEM(MTMX1,2),AEE,EEMT(2),EEMMT(3),
     X             EL(MTMX1),ELM(MTMX1,2),AEL,ELMT(2),ELMMT(3),
     X             EM(MTMX1),AEM,EMMT(2)
C
C     ******************
C     * OUTPUT CONTROL *
C     ******************
C
C     READ AND PRINT OUTPUT CONTROL DATA
C     COMPUTE THE OUTPUT MASK IPR(*)
C
C     ALL DATA READ BY MAINA AND THE RESULTS ARE ALWAYS PRINTED
C     THE OUTPUT DURING THE SIMULATION IS DETERMINED BY THE OUTPUT
C     CONTROL MASK IPR(*) .  IPR(*) CONTAINS THE OUTPUT PARAMETER
C     IPRINT FOR TIMEPOINT * .  IPR(*) IS COMPUTED FROM THE FOLLOWING
C     OUTPUT CONTROL DATA READ BY MAINA :
C     IOUT POS        OUTPUT AT EVERY IOUT-TH TIMEPOINT
C     IOUT NEG        OUTPUT ONLY DURING THE TIMEPERIODS
C                     SPECIFIED BY NXOP, KXB(*) AND KXE(*)
```

```
C      NXOP                NUMBER OF TIMEPERIODS DURING WHICH OUTPUT
C                          IS PRODUCED IRRESPECTIVE OF THE VALUE OF IOUT
C      KXB(*)              START TIMEPOINT FOR PERIOD *
C      KXE(*)              END TIMEPOINT FOR PERIOD *
C
       READ(5,10) IOUT,NXOP
   10 FORMAT(2I5)
       IF (NXOP) 30,20,20
   20 IF (NXOP-MTMX) 50,50,30
   30 WRITE(6,40) NXOP
   40 FORMAT(7H0NXOP =,I5)
       GO TO 990
C
   50 M=IABS(IOUT)
       IF (IOUT .LE. 0) M=MTMX1
       DO 60 I=1,MTMX
       IPR(I)=1
       IF (I/M*M .EQ. I) IPR(I)=0
   60 CONTINUE
       IF (NXOP) 100,100,70
   70 READ(5,10)(KXB(I),KXE(I),I=1,NXOP)
       DO 90 I=1,NXOP
       J1=IABS(KXB(I))
       J2=IABS(KXE(I))
       DO 80 J=J1,J2
   80 IPR(J)=0
   90 CONTINUE
  100 WRITE(6,110) IOUT,NXOP
  110 FORMAT(26H1MAIN PROGRAM FOR METHOD A/1X,25(1H*)//
     F20H0OUTPUT CONTROL DATA/1X,19(1H-)/
     F7H0IOUT =,I5,5X,6HNXOP =,I5)
       IF (NXOP) 140,140,120
  120 WRITE(6,130)(KXB(I),KXE(I),I=1,NXOP)
  130 FORMAT(7H0  TBEG,5X,4HTEND//(I5,I10))
C
C      ******************************
C      * READ AND PRINT FIXED DATA *
C      ******************************
C
C       READ AND PRINT TRUE DATA: NETWORK, GENERATOR, AND LOAD
C       CONTROL DATA
C
       IPRINT=0
  140 CALL RDTNET(IPRINT,IERR)
       IF (IERR) 150,150,990
  150 CALL RDMETT(IPRINT)
       CALL RDGEN(IPRINT,IERR)
       IF (IERR) 160,160,990
  160 CALL RDLD(SDB,SSL,KTMX,U,IPRINT,IERR)
       IF (IERR) 170,170,990
C
C       READ AND PRINT ESTIMATOR DATA: NETWORK AND METER DATA,
C       MEASUREMENT CHOICE AND ORDER
C
```

```
  170 CALL RDENET(IPRINT,IERR)
      IF (IERR) 180,180,990
  180 CALL RDMETE(IPRINT)
      CALL RDMSM(IPRINT,IERR)
      IF (IERR) 190,190,990
C
C     READ AND PRINT PARAMETERS FOR ESTIMATOR A
C
  190 READ(5,200) MAXIT,JS,CRLOSS,CRLIN
  200 FORMAT(2I5,2F10.5)
      WRITE(6,210) MAXIT,JS,CRLOSS,CRLIN
  210 FORMAT(21H0ESTIMATOR PARAMETERS/1X,20(1H-)/
     F8H0MAXIT =,I5,5X,4HJS =,I5,5X,8HCRLOSS =,F10.5,
     F5X,7HCRLIN =,F10.5)
C
C     ******************
C     * INITIALIZATION *
C     ******************
C
C
C      TIMEPOINT 0:  COMPUTE THE TRUE VARIABLES FROM THE START DEMAND
C      (READ BY RDLD INTO SDB), SET THE ESTIMATE EQUAL TO THE TRUE
C      STATE, COMPUTE THE MEASUREMENTS AND INITIALIZE THE ESTIMATOR
C      BY LINEARIZING AROUND THE TRUE STATE
C
      K=0
      WRITE(6,220) K
  220 FORMAT(11H1TIMEPOINT ,I5/1X,15(1H*))
      DO 230 I=1,NBT
  230 XT(I)=(1.0,0.0)
      CALL TRUEV(SDB,IPRINT+3,IERR)
      IF (IERR) 240,240,990
  240 CALL CAWN(IPRINT+1)
      NODD=19
      CALL ALLMSM(NODD,IPRINT+1)
      CALL CAWF(IPRINT+1)
      DO 250 I=1,NBE
  250 XE(I)=XT(I)
      CALL ADMA(1,2,CRLOSS,XL,CRLIN,IXIT,TIME,IPRINT+4)
      IF (IXIT) 990,990,260
  260 CALL EVAL(K,IPRINT)
C
C     **************
C     * SIMULATION *
C     **************
C
      AEE=0.0
      AEL=0.0
      AEM=0.0
      DO 270 I=1,2
      EEMT(I)=0.0
      ELMT(I)=0.0
  270 EMMT(I)=0.0
```

```
      DO 280 I=1,3
      EEMMT(I)=0.0
  280 ELMMT(I)=0.0
C
      DO 310 K=1,KTMX
      IPRINT=IPR(K)
      IF (IPRINT .LE. 0) WRITE(6,220) K
C
C     COMPUTE THE LOAD DEMAND AND ALL TRUE VARIABLES
C
      CALL CASDB(SDB,SSL,U(K),IPRINT)
      CALL TRUEV(SDB,IPRINT+3,IERR)
      IF (IERR) 290,290,990
C
C     COMPUTE THE STANDARD DEVIATIONS FOR THE MEASUREMENT NOISE,
C     ALL POSSIBLE MEASUREMENTS AND THE WEIGHTING FACTORS FOR
C     THE ESTIMATOR
C
  290 CALL CAWN(IPRINT+1)
      CALL ALLMSM(NODD,IPRINT+1)
      CALL CAWF(IPRINT+1)
C
C     COMPUTE THE NEW ESTIMATE AND THE EVALUATION QUANTITIES
C
      CALL ADMA(MAXIT,JS,CRLOSS,XL,CRLIN,IEXIT(K),TIME,IPRINT+4)
      IF (IEXIT(K)) 990,990,300
  300 CALL EVAL(K,IPRINT)
C
  310 CONTINUE
C
C    ****************************
C    * PRINTOUT OF THE RESULTS *
C    ****************************
C
      WRITE(6,320) KTMX
  320 FORMAT(17H1THE RESULTS FOR ,I5,11H TIMEPOINTS/1X,33(1H*)//
     F12H0TIME
     F,10HEST ERR
     F,21HMAX ELT BUS ROI
     F,11HLF ERROR
     F,27HMAX ELT END LINE AOR
     F,15HMSMT IND
     F,5HIEXIT/)
      DO 420 K=1,KTMX
      K1=K+1
      I=INT(EEM(K1,2))
      M=MOD(I,2)
      J=I/2+M
      IF (M) 330,330,340
  330 ROI=1HI
      GO TO 350
  340 ROI=1HR
  350 I=INT(ELM(K1,2))
      IF (I) 360,360,370
```

```
360 AOB=1HB
    GO TO 380
370 AOB=1HA
    I=IABS(I)
    M=MOD(I,2)
    J1=I/2+M
    IF (M) 380,380,390
380 AOR=1HR
    GO TO 400
390 AOR=1HA
400 WRITE(6,410) K,EE(K1),EEM(K1,1),J,ROI,EL(K1),ELM(K1,1),AOB,J1,AOR,
   1              EM(K1)
410 FORMAT(I4,5X,2F10.7,I3,3X,A1,5X,2F10.7,2X,A1,I5,3X,A1,6X,F10.7)
420 CONTINUE
    WRITE(6,430) KTMX
430 FORMAT(14H1TOTALS AFTER ,I5,11H TIMEPOINTS/1X,29(1H*))
    AEE=AEE/KTMX
    WRITE(6,440) AEE
440 FORMAT(17H0ESTIMATION ERROR/1X,16(1H-)//
   F6X,27HAVERAGE ESTIMATION ERROR  =,F10.7)
    KT=INT(EEMT(2))
    WRITE(6,450) ELMT(1),KT
450 FORMAT(6X,27HMAXIMUM ESTIMATION ERROR  =,F10.7,7H AT T =,I4)
    I=INT(EEMMT(2))
    M=MOD(I,2)
    J=I/2+M
    IF (M) 460,460,470
460 ROI=4HIMAG
    GO TO 480
470 ROI=4HREAL
480 KT=INT(EEMMT(3))
    WRITE(6,490) EEMMT(1),KT,ROI,J
490 FORMAT(6X,27HMAX ELEMENT IN ALL ERRORS =,F10.7,7H AT T =,I4,
   F4H IN /8X,A4,20H PART OF BUSVOLTAGE ,I2)
    AEL=AEL/KTMX
    WRITE(6,500) AEL
500 FORMAT(16H0LINE FLOW ERROR/1X,15(1H-)//
   F6X,27HAVERAGE LINE FLOW ERROR   =,F10.7)
    KT=INT(ELMT(2))
    WRITE(6,510) ELMT(1),KT
510 FORMAT(6X,27HMAXIMUM LINE FLOW ERROR   =,F10.7,7H AT T =,I4)
    I=INT(ELMMT(2))
    IF (I) 520,520,530
520 AOB=1HB
    GO TO 540
530 AOB=1HA
540 I=IABS(I)
    M=MOD(I,2)
    J=I/2+M
    IF (M) 550,550,560
550 AOR=6HREACT.
    GO TO 570
```

```
  560 AOR=6HACTIVE
  570 KT=INT(ELMMT(3))
      WRITE(6,580) ELMMT(1),KT,AOR,AOB,J
  580 FORMAT(6X,27HMAX ELEMENT IN ALL ERRORS =,F10.7,7H AT T =,I4,
     F4H IN /8X,A6,9H FLOW AT ,A1,13H-END OF LINE ,I2)
      AEM=AEM/KTMX
      WRITE(6,590) AEM
  590 FORMAT(20H0MEASUREMENT QUALITY/1X,19(1H-)//
     F6X,27HAVERAGE MEASUREMENT INDEX =,F10.7)
      KT=INT(EMMT(2))
      WRITE(6,600) EMMT(1),KT
  600 FORMAT(6X,27HMAXIMUM MEASUREMENT INDEX =,F10.7,7H AT T =,I4)
C
C     ******************************
C     * WRITE PLOTDATA TO PLOTFILE *
C     ******************************
C
      KTMX1=KTMX+1
      WRITE(1) KTMX1,(EE(I),EL(I),EM(I),I=1,MTMX1)
C
  990 STOP
      END
```

```
C      MAINPROGRAM FOR METHOD B
C
C      AUTHOR, TON VAN OVERBEEK 1974-02-19
C
C      SUBROUTINE REQUIRED
C              ADMB
C                ALOSS
C                  PRRES
C                CARES
C                  GXE
C                    PRENET
C                  PRRES
C                ESTB
C                  JACBI
C                    JACLF
C                  JACI
C                  JACLF
C                  JACV
C                  UPDEP
C                PRRES
C                PRWF
C              ALLMSM
C                NODI
C              CASDB
C              CAWF
C              CAWN
C              EVAL
C              RDENET
C                PRENET
C              RDGEN
C              RDLD
C              RDMETE
C              RDMETT
C              RDMSM
C              RDTNET
C                PRTNET
C              TRUEV
C                ELDNL
C                GXT
C                  PRTNET
C                NRLFR
C                DECOM
C                MPRI
C                SOLVB
C
       PARAMETER MB=10,ML=13,MTMX=360
       PARAMETER MMB=2*MB,MML=2*ML,MM=3*(MB+MML),MTMX1=MTMX+1
C
       INTEGER TIME
C
       DIMENSION U(MTMX),IPR(MTMX),KXB(MTMX),KXE(MTMX),Q(MMB),IEXIT(MTMX)
C
       COMPLEX XT,YT2,YT3,YT4,YT5,YT6,YAAT,ZABT,YBBT,SDB(MB),SSL(MB),
      1        XE,YE2,YE3,YE4,YE5,YE6,YAAE,ZABE,YBBE
```

```
C
       COMMON /TRUE/ XT(MB),YT2(ML),YT3(ML),YT4(ML),YT5(ML),YT6(MB)
      X        /EST/ XE(MB),YE2(ML),YE3(ML),YE4(ML),YE5(ML),YE6(MB)
      X        /TNET/ NBT,NLT,LTAT(ML),LTBT(ML),YAAT(ML),ZABT(ML),YBBT(ML)
      X        /ENET/ NBE,NLE,LTAE(ML),LTBE(ML),YAAE(ML),ZABE(ML),YBBE(ML)
      X        /MSM/ YM1(MB),YM2(ML),YM3(ML),YM4(MML),YM5(MML),YM6(MMB)
      X        /METT/ BIAS1(MB),BIAS2(ML),BIAS3(ML),BIAS4(MML),
      X               BIAS5(MML),BIAS6(MMB),WN1(MB),WN2(ML),WN3(ML),
      X               WN4(MML),WN5(MML),WN6(MMB),ALFT1(MB),ALFT2(ML),
      X               ALFT3(ML),ALFT4(MML),ALFT5(MML),ALFT6(MMB),
      X               FST1(MB),FST2(ML),FST3(ML),FST4(MML),
      X               FST5(MML),FST6(MMB),BETT1(MB),BETT2(ML),BETT3(ML),
      X               BETT4(MML),BETT5(MML),BETT6(MMB)
       COMMON /METE/ WF1(MB),WF2(ML),WF3(ML),WF4(MML),WF5(MML),
      X               WF6(MMB),ALFE1(MB),ALFE2(ML),ALFE3(ML),ALFE4(MML),
      X               ALFE5(MML),ALFE6(MMB),FSE1(MB),FSE2(ML),FSE3(ML),
      X               FSE4(MML),FSE5(MML),FSE6(MMB),BETE1(MB),BETE2(ML),
      X               BETE3(ML),BETE4(MML),BETE5(MML),BETE6(MMB)
      X        /RES/ RES1(MB),RES2(ML),RES3(ML),RES4(MML),RES5(MML),
      X               RES6(MMB)
      X        /VAR/ COV(MMB),PNEW(MMB)
      X        /MSI/ MSK1(MB),MSK2(ML),MSK3(ML),MSK4(ML),MSK5(ML),
      X               MSK6(MB),NM,NTYP(MM),NMSM(MM)
       COMMON /EVL/ EE(MTMX1),EEM(MTMX1,2),AEE,EEMT(2),EEMMT(3),
      X               EL(MTMX1),ELM(MTMX1,2),AEL,ELMT(2),ELMMT(3),
      X               EM(MTMX1),AEM,EMMT(2)
C
C      ******************
C      * OUTPUT CONTROL *
C      ******************
C
C      READ AND PRINT OUTPUT CONTROL DATA
C      COMPUTE THE OUTPUT MASK IPR(*)
C
C      ALL DATA READ BY MAINB AND THE RESULTS ARE ALWAYS PRINTED
C      THE OUTPUT DURING THE SIMULATION IS DETERMINED BY THE OUTPUT
C      CONTROL MASK IPR(*) .  IPR(*) CONTAINS THE OUTPUT PARAMETER
C      IPRINT FOR TIMEPOINT * .  IPR(*) IS COMPUTED FROM THE FOLLOWING
C      OUTPUT CONTROL DATA READ BY MAINB :
C      IOUT POS        OUTPUT AT EVERY IOUT-TH TIMEPOINT
C      IOUT NEG        OUTPUT ONLY DURING THE TIMEPERIODS
C                      SPECIFIED BY NXOP, KXB(*) AND KXE(*)
C      NXOP            NUMBER OF TIMEPERIODS DURING WHICH OUTPUT
C                      IS PRODUCED IRRESPECTIVE OF THE VALUE OF IOUT
C      KXB(*)          START TIMEPOINT FOR PERIOD *
C      KXE(*)          END TIMEPOINT FOR PERIOD *
C
       READ(5,10) IOUT,NXOP
    10 FORMAT(2I5)
       IF (NXOP) 30,20,20
    20 IF (NXOP-MTMX) 50,50,30
    30 WRITE(6,40) NXOP
    40 FORMAT(7H0NXOP =,I5)
       GO TO 990
```

```
C
   50 M=IABS(IOUT)
      IF (IOUT .LE. 0) M=MTMX1
      DO 60 I=1,MTMX
      IPR(I)=1
      IF (I/M*M .EQ. I) IPR(I)=0
   60 CONTINUE
      IF (NXOP) 100,100,70
   70 READ(5,10)(KXB(I),KXE(I),I=1,NXOP)
      DO 90 I=1,NXOP
      J1=IABS(KXB(I))
      J2=IABS(KXE(I))
      DO 80 J=J1,J2
   80 IPR(J)=0
   90 CONTINUE
  100 WRITE(6,110) IOUT,NXOP
  110 FORMAT(26H1MAIN PROGRAM FOR METHOD B/1X,25(1H*)//
     F20H0OUTPUT CONTROL DATA/1X,19(1H-)/
     F7H0IOUT =,I5,5X,6HNXOP =,I5)
      IF (NXOP) 140,140,120
  120 WRITE(6,130)(KXB(I),KXE(I),I=1,NXOP)
  130 FORMAT(7H0   TBEG,5X,4HTEND//(I5,I10))
C
C     ******************************
C     * READ AND PRINT FIXED DATA *
C     ******************************
C
C      READ AND PRINT TRUE DATA: NETWORK, GENERATOR, AND LOAD
C      CONTROL DATA
C
      IPRINT=0
  140 CALL RDTNET(IPRINT,IERR)
      IF (IERR) 150,150,990
  150 CALL RDMETT(IPRINT)
      CALL RDGEN(IPRINT,IERR)
      IF (IERR) 160,160,990
  160 CALL RDLD(SDB,SSL,KTMX,U,IPRINT,IERR)
      IF (IERR) 170,170,990
C
C      READ AND PRINT ESTIMATOR DATA: NETWORK AND METER DATA,
C      MEASUREMENT CHOICE AND ORDER
C
  170 CALL RDENET(IPRINT,IERR)
      IF (IERR) 180,180,990
  180 CALL RDMETE(IPRINT)
      CALL RDMSM(IPRINT,IERR)
      IF (IERR) 190,190,990
C
C      READ AND PRINT PARAMETERS FOR ESTIMATOR B
C
  190 READ(5,200) MAXIT,JS,JQ,CRLOSS,PIN
  200 FORMAT(3I5,2F10.5)
      READ(5,205)(Q(2*I-1),Q(2*I),I=1,NBT)
  205 FORMAT(2E10.3)
```

```
      WRITE(6,210) MAXIT,JS,JQ,CRLOSS,PIN
  210 FORMAT(21H0ESTIMATOR PARAMETERS/1X,20(1H-)/
     F8H0MAXIT =,I5,5X,4HJS =,I5,5X,4HJQ =,I5,5X,8HCRLOSS =,F10.5,
     F5X,5HPIN =,F10.5)
      WRITE(6,215)(I,Q(2*I-1),Q(2*I),I=1,NBT)
  215 FORMAT(14H0BUSNR
     F,10HQREAL
     F,5HQIMAG//(I5,5X,2E10.3))
C
C     *****************
C     * INITIALIZATION *
C     *****************
C
C
C      TIMEPOINT 0:  COMPUTE THE TRUE VARIABLES FROM THE START DEMAND
C      (READ BY RDLD INTO SDB), SET THE ESTIMATE EQUAL TO THE TRUE
C      STATE, COMPUTE THE MEASUREMENTS AND INITIALIZE THE ESTIMATOR
C
      K=0
      WRITE(6,220) K
  220 FORMAT(11H1TIMEPOINT ,I5/1X,15(1H*))
      DO 230 I=1,NBT
  230 XT(I)=(1.0,0.0)
      CALL TRUEV(SDB,IPRINT+3,IERR)
      IF (IERR) 240,240,990
  240 CALL CAWN(IPRINT+1)
      NODD=19
      CALL ALLMSM(NODD,IPRINT+1)
      CALL CAWF(IPRINT+1)
      DO 250 I=1,NBE
  250 XE(I)=XT(I)
      CALL ADMB(1,1,CRLOSS,1,PIN,Q,IXIT,TIME,IPRINT+3)
      IF (IXIT) 990,990,260
  260 CALL EVAL(K,IPRINT)
C
C     **************
C     * SIMULATION *
C     **************
C
      AEE=0.0
      AEL=0.0
      AEM=0.0
      DO 270 I=1,2
      EEMT(I)=0.0
      ELMT(I)=0.0
  270 EMMT(I)=0.0
      DO 280 I=1,3
      EEMMT(I)=0.0
  280 ELMMT(I)=0.0
C
      DO 310 K=1,KTMX
      IPRINT=IPR(K)
      IF (IPRINT .LE. 0) WRITE(6,220) K
```

```
C
C     COMPUTE THE LOAD DEMAND AND ALL TRUE VARIABLES
C
      CALL CASDB(SDB,SSL,U(K),IPRINT)
      CALL TRUEV(SDB,IPRINT+3,IERR)
      IF (IERR) 290,290,990
C
C     COMPUTE THE STANDARD DEVIATIONS FOR THE MEASUREMENT NOISE,
C     ALL POSSIBLE MEASUREMENTS AND THE WEIGHTING FACTORS FOR
C     THE ESTIMATOR
C
  290 CALL CAWN(IPRINT+1)
      CALL ALLMSM(NODD,IPRINT+1)
      CALL CAWF(IPRINT+1)
C
C     COMPUTE THE NEW ESTIMATE AND THE EVALUATION QUANTITIES
C
      CALL ADMB(MAXIT,JS,CRLOSS,JQ,PIN,Q,IEXIT(K),TIME,IPRINT+3)
      IF (IEXIT(K)) 990,990,300
  300 CALL EVAL(K,IPRINT)
C
  310 CONTINUE
C
C    ***************************
C    * PRINTOUT OF THE RESULTS *
C    ***************************
C
      WRITE(6,320) KTMX
  320 FORMAT(17H1THE RESULTS FOR ,I5,11H TIMEPOINTS/1X,33(1H*)//
     F12H0TIME
     F,10HEST ERR
     F,21HMAX ELT BUS ROI
     F,11HLF ERROR
     F,27HMAX ELT END LINE AOR
     F,15HMSMT IND
     F,5HIEXIT/)
      DO 420 K=1,KTMX
      K1=K+1
      I=INT(EEM(K1,2))
      M=MOD(I,2)
      J=I/2+M
      IF (M) 330,330,340
  330 ROI=1HI
      GO TO 350
  340 ROI=1HR
  350 I=INT(ELM(K1,2))
      IF (I) 360,360,370
  360 AOB=1HB
      GO TO 380
  370 AOB=1HA
      I=IABS(I)
      M=MOD(I,2)
      J1=I/2+M
      IF (M) 380,380,390
```

```
380 AOR=1HR
    GO TO 400
390 AOR=1HA
400 WRITE(6,410) K,EE(K1),EEM(K1,1),J,ROI,EL(K1),ELM(K1,1),AOB,J1,AOR,
   1             EM(K1),IEXIT(K)
410 FORMAT(I4,5X,2F10.7,I3,3X,A1,5X,2F10.7,2X,A1,I5,3X,A1,6X,F10.7,
   F5X,I5)
420 CONTINUE
    WRITE(6,430) KTMX
430 FORMAT(14H1TOTALS AFTER ,I5,11H TIMEPOINTS/1X,29(1H*))
    AEE=AEE/KTMX
    WRITE(6,440) AEE
440 FORMAT(17H0ESTIMATION ERROR/1X,16(1H-)//
   F6X,27HAVERAGE ESTIMATION ERROR  =,F10.7)
    KT=INT(EEMT(2))
    WRITE(6,450) EEMT(1),KT
450 FORMAT(6X,27HMAXIMUM ESTIMATION ERROR  =,F10.7,7H AT T =,I4)
    I=INT(EEMMT(2))
    M=MOD(I,2)
    J=I/2+M
    IF (M) 460,460,470
460 ROI=4HIMAG
    GO TO 480
470 ROI=4HREAL
480 KT=INT(EEMMT(3))
    WRITE(6,490) EEMMT(1),KT,ROI,J
490 FORMAT(6X,27HMAX ELEMENT IN ALL ERRORS =,F10.7,7H AT T =,I4,
   F4H IN /8X,A4,20H PART OF BUSVOLTAGE ,I2)
    AEL=AEL/KTMX
    WRITE(6,500) AEL
500 FORMAT(16H0LINE FLOW ERROR/1X,15(1H-)//
   F6X,27HAVERAGE LINE FLOW ERROR   =,F10.7)
    KT=INT(ELMT(2))
    WRITE(6,510) ELMT(1),KT
510 FORMAT(6X,27HMAXIMUM LINE FLOW ERROR   =,F10.7,7H AT T =,I4)
    I=INT(ELMMT(2))
    IF (I) 520,520,530
520 AOB=1HB
    GO TO 540
530 AOB=1HA
540 I=IABS(I)
    M=MOD(I,2)
    J=I/2+M
    IF (M) 550,550,560
550 AOR=6HREACT.
    GO TO 570
560 AOR=6HACTIVE
570 KT=INT(ELMMT(3))
    WRITE(6,580) ELMMT(1),KT,AOR,AOB,J
580 FORMAT(6X,27HMAX ELEMENT IN ALL ERRORS =,F10.7,7H AT T =,I4,
   F4H IN /8X,A6,9H FLOW AT ,A1,13H-END OF LINE ,I2)
    AEM=AEM/KTMX
    WRITE(6,590) AEM
```

```
  590 FORMAT(20HOMEASUREMENT QUALITY/1X,19(1H-)//
     F6X,27HAVERAGE MEASUREMENT INDEX =,F10.7)
      KT=INT(EMMT(2))
      WRITE(6,600) EMMT(1),KT
  600 FORMAT(6X,27HMAXIMUM MEASUREMENT INDEX =,F10.7,7H AT T =,I4)
C
C     ******************************
C     * WRITE PLOTDATA TO PLOTFILE *
C     ******************************
C
      KTMX1=KTMX+1
      IUNIT=1
      WRITE(IUNIT) KTMX1,(EE(I),EL(I),EM(I),I=1,MTMX1)
C
  990 STOP
      END
```

```
C     MAINPROGRAM FOR METHOD C
C
C     AUTHOR, TON VAN OVERBEEK 1974-03-15
C
C     SUBROUTINE REQUIRED
C             ADMC
C               ALOSS
C                 PRRES
C               CAD
C               CARES
C                 GXE
C                   PRENET
C                 PRRES
C               ESTC
C                 DESYM
C                 MPRI
C                 SOLVS
C                 UPDAC
C                 UPDBC
C               PRRES
C             ALLMSM
C               NODI
C             CASDB
C             CAWF
C             CAWN
C             EVAL
C             RDENET
C               PRENET
C             RDGEN
C             RDLD
C             RDMETE
C             RDMETT
C             RDMSM
C             RDTNET:
C               PRTNET
C             TRUEV
C               ELDNL
C               GXT
C                 PRTNET
C               NRLFR
C               DECOM
C               MPRI
C               SOLVB
C
      PARAMETER MB=10,ML=13,MTMX=360
      PARAMETER MMB=2*MB,MML=2*ML,MM=3*(MB+MML),MTMX1=MTMX+1
C
      INTEGER TIME
C
      DIMENSION U(MTMX),IPR(MTMX),KXB(MTMX),KXE(MTMX),IEXIT(MTMX)
C
      COMPLEX XT,YT2,YT3,YT4,YT5,YT6,YAAT,ZABT,YBBT,SDB(MB),SSL(MB),
     1        XE,YE2,YE3,YE4,YE5,YE6,YAAE,ZABE,YBBE
```

```
C
      COMMON /TRUE/ XT(MB),YT2(ML),YT3(ML),YT4(ML),YT5(ML),YT6(MB)
     X       /EST/ XE(MB),YE2(ML),YE3(ML),YE4(ML),YE5(ML),YE6(MB)
     X       /TNET/ NBT,NLT,LTAT(ML),LTBT(ML),YAAT(ML),ZABT(ML),YBBT(ML)
     X       /ENET/ NBE,NLE,LTAE(ML),LTBE(ML),YAAE(ML),ZABE(ML),YBBE(ML)
     X       /MSM/ YM1(MB),YM2(ML),YM3(ML),YM4(MML),YM5(MML),YM6(MMB)
     X       /METT/ BIAS1(MB),BIAS2(ML),BIAS3(ML),BIAS4(MML),
     X              BIAS5(MML),BIAS6(MMB),WN1(MB),WN2(ML),WN3(ML),
     X              WN4(MML),WN5(MML),WN6(MMB),ALFT1(MB),ALFT2(ML),
     X              ALFT3(ML),ALFT4(MML),ALFT5(MML),ALFT6(MMB),
     X              FST1(MB),FST2(ML),FST3(ML),FST4(MML),
     X              FST5(MML),FST6(MMB),BETT1(MB),BETT2(ML),BETT3(ML),
     X              BETT4(MML),BETT5(MML),BETT6(MMB)
      COMMON /METE/ WF1(MB),WF2(ML),WF3(ML),WF4(MML),WF5(MML),
     X              WF6(MMB),ALFE1(MB),ALFE2(ML),ALFE3(ML),ALFE4(MML),
     X              ALFE5(MML),ALFE6(MMB),FSE1(MB),FSE2(ML),FSE3(ML),
     X              FSE4(MML),FSE5(MML),FSE6(MMB),BETE1(MB),BETE2(ML),
     X              BETE3(ML),BETE4(MML),BETE5(MML),BETE6(MMB)
     X       /RES/ RES1(MB),RES2(ML),RES3(ML),RES4(MML),RES5(MML),
     X             RES6(MMB)
     X       /MAT/ A(MB,MB),T(MB,MB)
     X       /MSI/ MSK1(MB),MSK2(ML),MSK3(ML),MSK4(ML),MSK5(ML),
     X             MSK6(MB),NM,NTYP(MM),NMSM(MM)
      COMMON /EVL/ EE(MTMX1),EEM(MTMX1,2),AEE,EEMT(2),EEMMT(3),
     X             EL(MTMX1),ELM(MTMX1,2),AEL,ELMT(2),ELMMT(3),
     X             EM(MTMX1),AEM,EMMT(2)
C
C     ******************
C     * OUTPUT CONTROL *
C     ******************
C
C     READ AND PRINT OUTPUT CONTROL DATA
C     COMPUTE THE OUTPUT MASK IPR(*)
C
C     ALL DATA READ BY MAINC AND THE RESULTS ARE ALWAYS PRINTED
C     THE OUTPUT DURING THE SIMULATION IS DETERMINED BY THE OUTPUT
C     CONTROL MASK IPR(*) .  IPR(*) CONTAINS THE OUTPUT PARAMETER
C     IPRINT FOR TIMEPOINT * .  IPR(*) IS COMPUTED FROM THE FOLLOWING
C     OUTPUT CONTROL DATA READ BY MAINC :
C     IOUT POS        OUTPUT AT EVERY IOUT-TH TIMEPOINT
C     IOUT NEG        OUTPUT ONLY DURING THE TIMEPERIODS
C                     SPECIFIED BY NXOP, KXB(*) AND KXE(*)
C     NXOP            NUMBER OF TIMEPERIODS DURING WHICH OUTPUT
C                     IS PRODUCED IRRESPECTIVE OF THE VALUE OF IOUT
C     KXB(*)          START TIMEPOINT FOR PERIOD *
C     KXE(*)          END TIMEPOINT FOR PERIOD *
C
      READ(5,10) IOUT,NXOP
   10 FORMAT(2I5)
      IF (NXOP) 30,20,20
   20 IF (NXOP-MTMX) 50,50,30
   30 WRITE(6,40) NXOP
   40 FORMAT(7H0NXOP =,I5)
      GO TO 990
```

```
C
   50 M=IABS(IOUT)
      IF (IOUT .LE. 0) M=MTMX1
      DO 60 I=1,MTMX
      IPR(I)=1
      IF (I/M*M .EQ. I) IPR(I)=0
   60 CONTINUE
      IF (NXOP) 100,100,70
   70 READ(5,10)(KXB(I),KXE(I),I=1,NXOP)
      DO 90 I=1,NXOP
      J1=IABS(KXB(I))
      J2=IABS(KXE(I))
      DO 80 J=J1,J2
   80 IPR(J)=0
   90 CONTINUE
  100 WRITE(6,110) IOUT,NXOP
  110 FORMAT(26H1MAIN PROGRAM FOR METHOD C/1X,25(1H*)//
     F20H0OUTPUT CONTROL DATA/1X,19(1H-)/
     F7H0IOUT =,I5,5X,6HNXOP =,I5)
      IF (NXOP) 140,140,120
  120 WRITE(6,130)(KXB(I),KXE(I),I=1,NXOP)
  130 FORMAT(7H0   TBEG,5X,4HTEND//(I5,I10))
C
C     *****************************
C     * READ AND PRINT FIXED DATA *
C     *****************************
C
C      READ AND PRINT TRUE DATA: NETWORK, GENERATOR, AND LOAD
C      CONTROL DATA
C
      IPRINT=0
  140 CALL RDTNET(IPRINT,IERR)
      IF (IERR) 150,150,990
  150 CALL RDMETT(IPRINT)
      CALL RDGEN(IPRINT,IERR)
      IF (IERR) 160,160,990
  160 CALL RDLD(SDB,SSL,KTMX,U,IPRINT,IERR)
      IF (IERR) 170,170,990
C
C      READ AND PRINT ESTIMATOR DATA: NETWORK AND METER DATA,
C      MEASUREMENT CHOICE AND ORDER
C
  170 CALL RDENET(IPRINT,IERR)
      IF (IERR) 180,180,990
  180 CALL RDMETE(IPRINT)
      CALL RDMSM(IPRINT,IERR)
      IF (IERR) 190,190,990
C
C      READ AND PRINT PARAMETERS FOR ESTIMATOR C
C
  190 READ(5,200) NEWA,MAXIT,CRLOSS,EPS
  200 FORMAT(2I5,2F10.5)
      WRITE(6,210) NEWA,MAXIT,CRLOSS,EPS
  210 FORMAT(21H0ESTIMATOR PARAMETERS/1X,20(1H-)/
```

```
      F7HONEWA =,I5,5X,7HMAXIT =,I5,5X,8HCRLOSS =,F10.5,
      F5HEPS =,F10.5)
C
C     *****************
C     * INITIALIZATION *
C     *****************
C
C
C      TIMEPOINT 0:  COMPUTE THE TRUE VARIABLES FROM THE START DEMAND
C      (READ BY RDLD INTO SDB), SET THE ESTIMATE EQUAL TO THE TRUE
C      STATE, COMPUTE THE MEASUREMENTS AND INITIALIZE THE ESTIMATOR
C
       K=0
       WRITE(6,220) K
   220 FORMAT(11H1TIMEPOINT ,I5/1X,15(1H*))
       DO 230 I=1,NBT
   230 XT(I)=(1.0,0.0)
       CALL TRUEV(SDB,IPRINT+3,IERR)
       IF (IERR) 240,240,990
   240 CALL CAWN(IPRINT+1)
       NODD=19
       CALL ALLMSM(NODD,IPRINT+1)
       CALL CAWF(IPRINT+1)
       DO 250 I=1,NBE
   250 XE(I)=XT(I)
       CALL ADMC(1,1.0,MAXIT,EPS,IXIT,TIME,IPRINT+3)
       IF (IXIT) 990,260,260
   260 CALL EVAL(K,IPRINT)
C
C     **************
C     * SIMULATION *
C     **************
C
       AEE=0.0
       AEL=0.0
       AEM=0.0
       DO 270 I=1,2
       EEMT(I)=0.0
       ELMT(I)=0.0
   270 EMMT(I)=0.0
       DO 280 I=1,3
       EEMMT(I)=0.0
   280 ELMMT(I)=0.0
C
       DO 310 K=1,KTMX
       IPRINT=IPR(K)
       IF (IPRINT .LE. 0) WRITE(6,220) K
C
C      COMPUTE THE LOAD DEMAND AND ALL TRUE VARIABLES
C
       CALL CASDB(SDB,SSL,U(K),IPRINT)
       CALL TRUEV(SDB,IPRINT+3,IERR)
       IF (IERR) 290,290,990
C
```

```
C       COMPUTE THE STANDARD DEVIATIONS FOR THE MEASUREMENT NOISE,
C       ALL POSSIBLE MEASUREMENTS AND THE WEIGHTING FACTORS FOR
C       THE ESTIMATOR
C
    290 CALL CAWN(IPRINT+1)
        CALL ALLMSM(NODD,IPRINT+1)
        CALL CAWF(IPRINT+1)
C
C       COMPUTE THE NEW ESTIMATE AND THE EVALUATION QUANTITIES
C
        CALL ADMC(NEWA,CRLOSS,MAXIT,EPS,IEXIT(K),TIME,IPRINT+3)
        IF (IEXIT(K)) 990,300,300
    300 CALL EVAL(K,IPRINT)
C
    310 CONTINUE
C
C      ***************************
C      * PRINTOUT OF THE RESULTS *
C      ***************************
C
        WRITE(6,320) KTMX
    320 FORMAT(17H1THE RESULTS FOR ,I5,11H TIMEPOINTS/1X,33(1H*)//
       F12H0TIME
       F,10HEST ERR
       F,21HMAX ELT BUS ROI
       F,11HLF ERROR
       F,27HMAX ELT END LINE AOR
       F,15HMSMT IND
       F,5HIEXIT/)
        DO 420 K=1,KTMX
        K1=K+1
        I=INT(EEM(K1,2))
        M=MOD(I,2)
        J=I/2+M
        IF (M) 330,330,340
    330 ROI=1HI
        GO TO 350
    340 ROI=1HR
    350 I=INT(ELM(K1,2))
        IF (I) 360,360,370
    360 AOB=1HB
        GO TO 380
    370 AOB=1HA
        I=IABS(I)
        M=MOD(I,2)
        J1=I/2+M
        IF (M) 380,380,390
    380 AOR=1HR
        GO TO 400
    390 AOR=1HA
    400 WRITE(6,410) K,EE(K1),EEM(K1,1),J,ROI,EL(K1),ELM(K1,1),AOB,J1,AOR,
       1             EM(K1),IEXIT(K)
    410 FORMAT(I4,5X,2F10.7,I3,3X,A1,5X,2F10.7,2X,A1,I5,3X,A1,6X,F10.7,
       F5X,I5)
    420 CONTINUE
```

```
      WRITE(6,430) KTMX
  430 FORMAT(14H1TOTALS AFTER ,I5,11H TIMEPOINTS/1X,29(1H*))
      AEE=AEE/KTMX
      WRITE(6,440) AEE
  440 FORMAT(17H0ESTIMATION ERROR/1X,16(1H-)//
     F6X,27HAVERAGE ESTIMATION ERROR  =,F10.7)
      KT=INT(EEMT(2))
      WRITE(6,450) EEMT(1),KT
  450 FORMAT(6X,27HMAXIMUM ESTIMATION ERROR  =,F10.7,7H AT T =,I4)
      I=INT(EEMMT(2))
      M=MOD(I,2)
      J=I/2+M
      IF (M) 460,460,470
  460 ROI=4HIMAG
      GO TO 480
  470 ROI=4HREAL
  480 KT=INT(EEMMT(3))
      WRITE(6,490) EEMMT(1),KT,ROI,J
  490 FORMAT(6X,27HMAX ELEMENT IN ALL ERRORS =,F10.7,7H AT T =,I4,
     F4H IN /8X,A4,20H PART OF BUSVOLTAGE ,I2)
      AEL=AEL/KTMX
      WRITE(6,500) AEL
  500 FORMAT(16H0LINE FLOW ERROR/1X,15(1H-)//
     F6X,27HAVERAGE LINE FLOW ERROR   =,F10.7)
      KT=INT(ELMT(2))
      WRITE(6,510) ELMT(1),KT
  510 FORMAT(6X,27HMAXIMUM LINE FLOW ERROR   =,F10.7,7H AT T =,I4)
      I=INT(ELMMT(2))
      IF (I) 520,520,530
  520 AOB=1HB
      GO TO 540
  530 AOB=1HA
  540 I=IABS(I)
      M=MOD(I,2)
      J=I/2+M
      IF (M) 550,550,560
  550 AOR=6HREACT.
      GO TO 570
  560 AOR=6HACTIVE
  570 KT=INT(ELMMT(3))
      WRITE(6,580) ELMMT(1),KT,AOR,AOB,J
  580 FORMAT(6X,27HMAX ELEMENT IN ALL ERRORS =,F10.7,7H AT T =,I4,
     F4H IN /8X,A6,9H FLOW AT ,A1,13H-END OF LINE ,I2)
      AEM=AEM/KTMX
      WRITE(6,590) AEM
  590 FORMAT(20H0MEASUREMENT QUALITY/1X,19(1H-)//
     F6X,27HAVERAGE MEASUREMENT INDEX =,F10.7)
      KT=INT(EMMT(2))
      WRITE(6,600) EMMT(1),KT
  600 FORMAT(6X,27HMAXIMUM MEASUREMENT INDEX =,F10.7,7H AT T =,I4)
C
```

```
C     *****************************
C     * WRITE PLOTDATA TO PLOTFILE *
C     *****************************
C
      KTMX1=KTMX+1
      IUNIT=1
      WRITE(IUNIT) KTMX1,(EE(I),EL(I),EM(I),I=1,MTMX1)
C
  990 STOP
      END
```

```
C       PLOTPROGRAM
C
        PARAMETER MTMX=360
        PARAMETER MTMX1=MTMX+1
C
        DIMENSION EE(MTMX1),EL(MTMX1),EM(MTMX1),XTEXT(4),YTEXT(3),Y(121)
C
        COMMON /RITFIG/ HTEX,HTEY,HNUX,HNUY,NWX,NWY,FMTX(3),FMTY(3),MX,MY
C
        DATA HTEX/0.24/,HTEY/0.24/,HNUX/0.24/,HNUY/0.24/,NWX/4/,NWY/-7/,
       X      FMTX(1)/6H(F4.0)/,FMTX(2)/6H      /,FMTX(3)/6H      /,
       X      FMTY(1)/6H(F7.5)/,FMTY(2)/6H      /,FMTY(3)/6H      /,
       X      MX/1/,MY/1/
        DATA X0/0./,DX/-1./,YMIN/0./,DY/1/,SY/4./,IX/-1/,IY/1/,NX/6/,
       X      IAXIS/1/,ITEXT/1/,IPLOT/0/,LINTYP/0/,XTEXT(1)/6H     T/,
       X      XTEXT(2)/6HIME (S/,XTEXT(3)/6HAMPLES/,XTEXT(4)/6H)     /
C
        READ(5,10) NPL
     10 FORMAT(I5)
C
        DO 60 K=1,NPL
        CALL PLOTS(0,0,0)
        CALL PLOT(3.,0.,-3)
C
        IUNIT=K+10
        READ(IUNIT) KTMX1,(EE(I),EL(I),EM(I),I=1,MTMX1)
        Y0=0.0
C
        DO 50 I=1,KTMX1,120
        IF (I .EQ. KTMX1) GO TO 50
        XMIN=FLOAT(I-1)
        NP=MIN0(121,KTMX1-I+1)
        SX=FLOAT((NP-1)/NX)
C
        YTEXT(1)=6HESTIMA
        YTEXT(2)=6HTION E
        YTEXT(3)=6HRROR
        YMAX=1.0
        DO 20 J=1,NP
     20 Y(J)=EE(I+J-1)
        CALL RITA(Y,NP,X0,Y0,XMIN,DX,YMIN,YMAX,DY,SX,SY,IX,IY,NX
       1,IAXIS,ITEXT,IPLOT,LINTYP,INTEQ,XTEXT,YTEXT)
C
        Y0=5.5
C
        YTEXT(1)=6HLINE F
        YTEXT(2)=6HLOW ER
        YTEXT(3)=6HROR
        YMAX=2.0
        DO 30 J=1,NP
     30 Y(J)=EL(I+J-1)
        CALL RITA(Y,NP,X0,Y0,XMIN,DX,YMIN,YMAX,DY,SX,SY,IX,IY,NX
       1,IAXIS,ITEXT,IPLOT,LINTYP,INTEQ,XTEXT,YTEXT)
C
```

```
      YTEXT(1)=6HMEASUR
      YTEXT(2)=6HEMENT
      YTEXT(3)=6HINDEX
      YMAX=2.0
      DO 40 J=1,NP
   40 Y(J)=EM(I+J-1)
      CALL RITA(Y,NP,X0,Y0,XMIN,DX,YMIN,YMAX,DY,SX,SY,IX,IY,NX
     1,IAXIS,ITEXT,IPLOT,LINTYP,INTEQ,XTEXT,YTEXT)
C
      Y0=7.0
   50 CONTINUE
C
      CALL PLOT(0.,0.,999)
C
   60 CONTINUE
C
      END
```

6. References.

1. Van Overbeek, A.J.M.; State Estimation in Power Networks I, a Literature Survey; Report 7331(C), Lund Institute of Technology, Division of Automatic Control, Lund, November 1973.
2. Van Overbeek, A.J.M.; State Estimation in Power Networks II, Comparison of Methods; Report 7403(C), Lund Institute of Technology, Division of Automatic Control, Lund, to appear.