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FINAL REPORT

DIGITAL ADAPTIVE CONTROLLERS FOR VTOL VEHICLES

II. Software Documentation

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16. Abstract

The VTOL Approach and Landing Technology (VALT) Program of the National Aeronautics and Space Administration is conducting research in navigation, guidance, control display, and flight management for future VTOL aircraft. As part of the research in advanced control technology, Honeywell designed a digital self-adaptive flight control system for flight test in the VALT research aircraft -- a tandem-rotor, medium-transport helicopter (a modified CH-47).

The control laws accept commands from an automatic on-board guidance system. The primary objective of the control laws is to provide good command-following with a minimum cross-axis response. Three attitudes and vertical velocity are separately commanded. Adaptation of the control laws is based on information from rate and attitude gyros and a vertical velocity measurement. The final design resulted from a comparison of two different adaptive concepts -- one based on explicit parameter estimates from a real-time Maximum-Likelihood Estimation algorithm, the other based on an implicit Model Reference adaptive system. The two designs were compared on the basis of performance and complexity.

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SECTION 1
INTRODUCTION

This volume documents the VALT adaptive software developed for NASA Langley Research Center under Contract NAS1-14921. Two self-adaptive algorithms were evaluated on NASA's VALT (VTOL Approach and Landing Technology) simulation. One is based on an implicit model reference design,[1] the other on an explicit parameter estimation technique.[2] The latter was recommended for flight test in the VALT research helicopter. The remainder of this volume presents the organization of the software, user options, and a nominal set of input data. This volume also contains a flow chart and program listing of each algorithm. For a discussion of the design theory of these algorithms, the reader is referred to Volume I.

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[1] Referred to as the Model Reference (MR) algorithm.

[2] Referred to as the Maximum Likelihood Estimation (MLE) algorithm.

SECTION 2
OVERVIEW OF VALT ADAPTIVE SOFTWARE

The VALT adaptive software consists of separate longitudinal and lateral-directional controllers plus an adaptive gain adjustment algorithm for the longitudinal controller. The two controllers were designed to accept independent commands from a guidance algorithm. The guidance commands are the the three attitudes plus vertical velocity. The primary objective of the control law is to provide good command-following with minimal cross-axis response. The control laws provides differential collective and collective servocommands for the longitudinal axis. Cyclic and differential cyclic commands are provided for lateral-directional control.

The Honeywell-supplied software consists of separate subroutines written in standard FORTRAN for the CDC computer facility at NASA LRC. All data required by the real-time subroutines are stored in labeled arrays. The subroutines are listed in Table 1 and the arrays (common blocks) in Table 2.

The interface between the adaptive control software and NASA's VALT simulation on the CDC CYBER computer is contained in subroutine CONTRL3. A flow chart of this subroutine is shown in Figure 1. The data interface between the NASA simulation and the Honeywell-supplied subroutines is the VARDAT array.

Two different adaptive algorithms were evaluated for the gain adjustment function. The dashed line in Figure 1 shows the call statement to the MR algorithm. The algorithm that was selected adjusts the gain based on explicit parameter estimates from a parallel-channel Maximum-Likelihood Estimator (PCMLE). Consequently, the dashed line path does not exist in the current CONTRL3 subroutine.

TABLE 1. - LIST OF SUBROUTINES

Subroutine	Function
CONTRL3	Real-time interface between VALT adaptive software and simulation on CDC CYBER computer.
HCON1	Pitch-axis control law.
HCON2	Lateral-directional control law.
GAIN1	Gain schedule for pitch axis.
GAIN2	Gain table for pitch axis.
PCMLE FH TSIG FILT SENS ACUM	Real-time subroutines for MLE algorithm.
NRTIC MODEL DISC FHIC DIAK CAL MP INPT	Initialization and filter design software for the MLE algorithm.
RFMOD INTEGRAL	Real-time MR algorithm.
RMIC	Initialization for MR algorithm.

TABLE 2. -COMMON BLOCKS USED BY VALT ADAPTIVE SOFTWARE

Common Block	Function
CI	Stores four integrator values for control laws.
VARDAT	Contains UX and LX arrays. Used for all data transfer and mode logic.
DAT SENSP IPIC MEAS	Data storage used by MLE algorithm.
SUBR	Data storage used by MLE initialization.
SUBRH	Stores frequency and damping constants for highpass filters.
UTEST	Stores test signal parameters.
DEVICE	Stores logical assignment of card reader and line printer.
MRINT MRDAT	Data storage for MR algorithm.

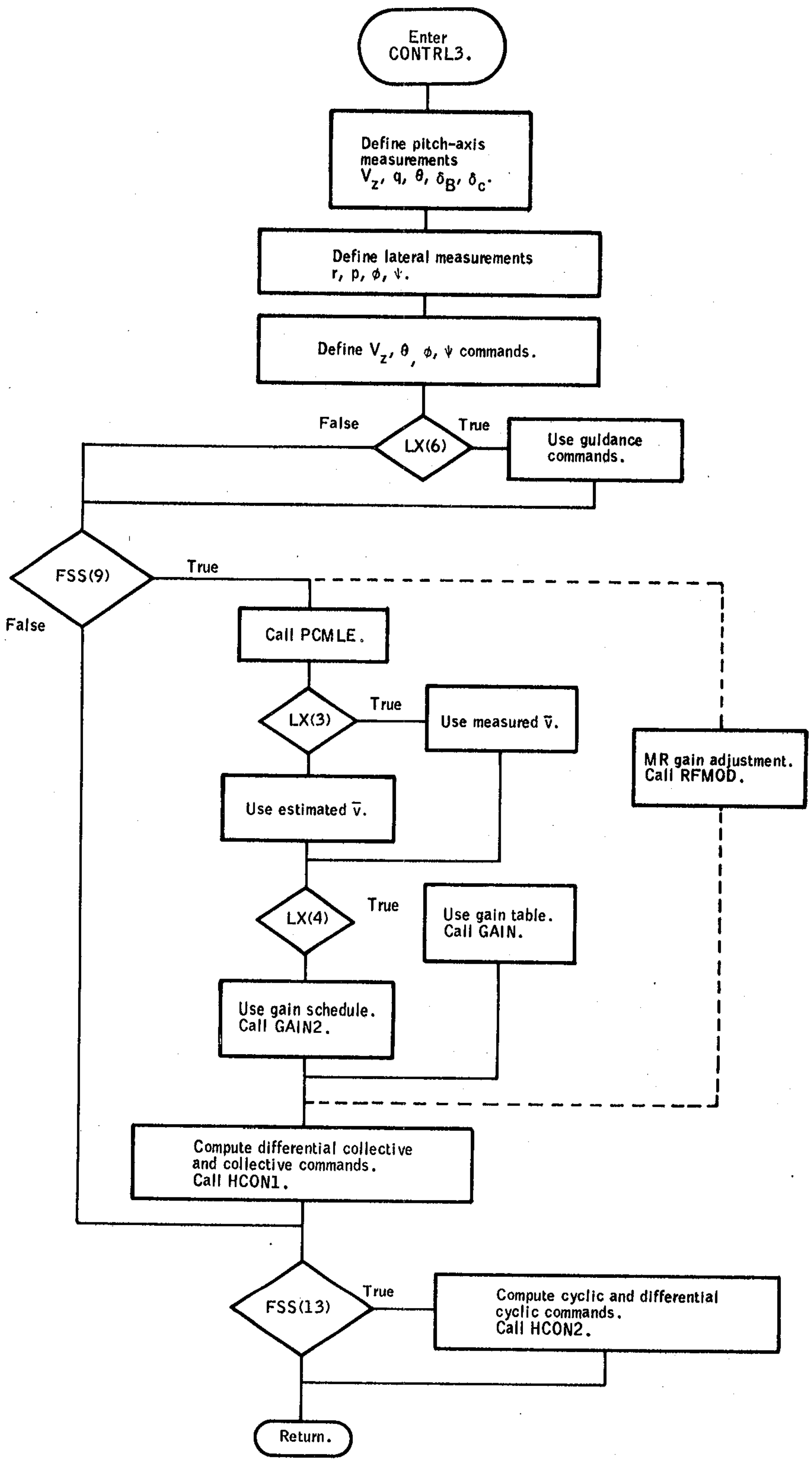


Figure 1. - Flow chart of subroutine CONTRL3.

SECTION 3
THE VALT ADAPTIVE CONTROL LAWS

Description

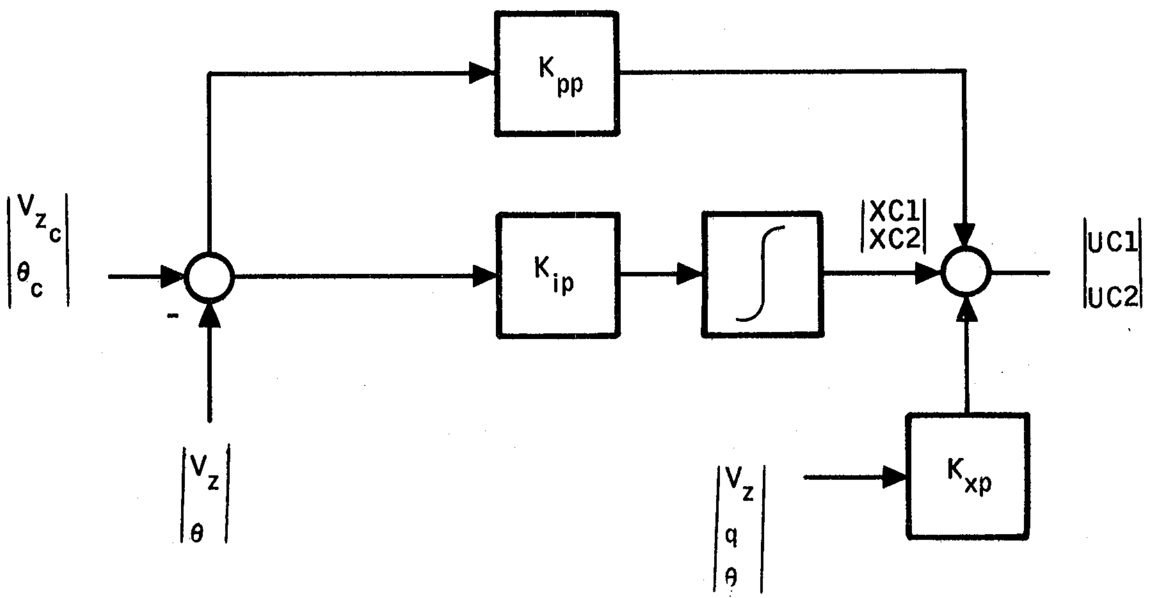
Separate longitudinal and lateral-directional controllers are implemented in subroutines HCON1 and HCON2. Each of the controllers forms servocommands from a combination of guidance commands and measured responses. Program listings are continued in Appendix A.

The longitudinal controller determines the differential collective command (UC1) and the collective command (UC2) from the θ and V_z measurements. Proportional plus integral shaping is applied to each command. The two command integrators are denoted XC1 and XC2 in the CI array.

The functional block diagram of the longitudinal controller is shown in Figure 2, which also shows the various gains stored in the UX array. The computation of these gain elements is discussed later. The variables used in HCON1 are defined in Table 3.

The lateral-directional controller determines the cyclic (UC3) and differential cyclic commands (UC4). The controller assumes guidance commands in the form of ϕ and ψ attitude commands. The controller uses proportional plus integral control for each command and uses measurements of p, r, ϕ, and ψ as feedback. The two command integrators are XC3 and XC4 in the CI array.

The functional block diagram of the lateral controller is shown in Figure 3, and the symbols are defined in Table 4.



Gain matrix elements

$$K_{pp} = \begin{bmatrix} UX(51) & 0.8UX(52) \\ UX(53) & 0.8UX(54) \end{bmatrix}$$

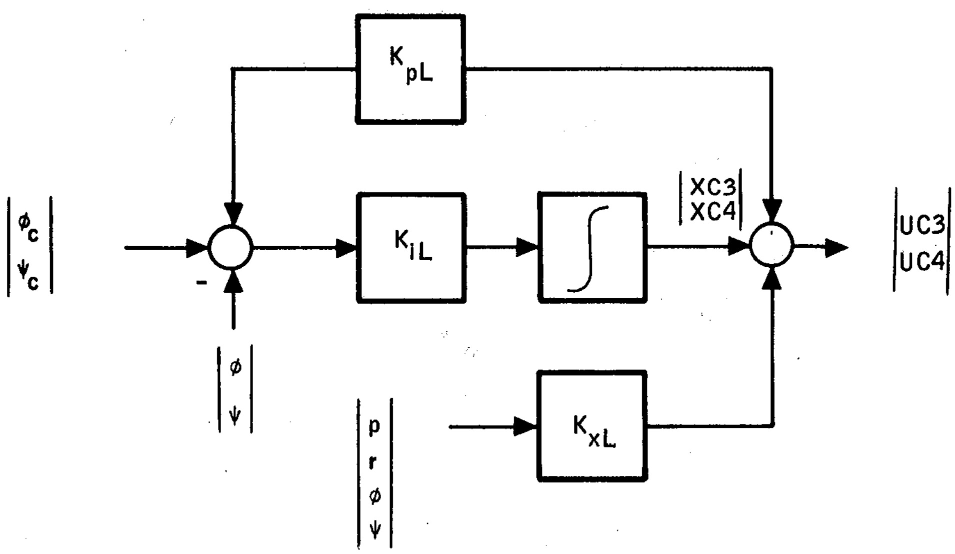
$$K_{ip} = \begin{bmatrix} UX(44) & 0.8UX(45) \\ UX(49) & 0.8UX(50) \end{bmatrix}$$

$$K_{xp} = \begin{bmatrix} UX(41) & UX(42) & UX(43) \\ UX(46) & UX(47) & UX(48) \end{bmatrix}$$

Figure 2. - Functional block diagram for pitch-axis control.

TABLE 3. -HCON1 VARIABLES

Variable	Definition
UX(1)	Total V_z command, ft/s
2	Total θ command, rad
11	V_z, measured vertical velocity, ft/s
12	q, measured pitch rate, rad/s
13	θ, measured pitch attitude, rad
19	Δt, sample rate, sec
41 • • • 50	10 gain values used by pitch-axis controller.
XC1	Integral for differential collective command.
XC2	Integral for collective command.



Subscript c denotes commanded value.

UC3 = Cyclic command (in.)

UC4 = Differential cyclic command (in.)

Gain matrices K_{pL}, K_{iL}, K_{xL} are constant.

Figure 3. - Functional block diagram for lateral-directional control.

TABLE 4.-HCON2 VARIABLES

Variable	Definition
UX(3)	ϕ command, rad
4	ψ command, rad
19	DT, sample time, s
37	p, measured roll rate, rad/s
38	r, measured yaw rate, rad/s
39	ϕ, measured roll attitude, rad
40	ψ, measured yaw attitude, rad

Initialization

The four integrators in the CI array must be initialized using trim values to prevent transients when the controllers are engaged. The appropriate initial values for XC1, XC2, XC3, and XC4 are determined with the following relations from Figures 2 and 3:

$$\begin{bmatrix} V_{z_t} \\ \theta_t \end{bmatrix} \begin{bmatrix} K_{pp} \end{bmatrix} + \begin{bmatrix} XC1 \\ XC2 \end{bmatrix} + \begin{bmatrix} V_{z_t} \\ 0 \\ \theta_t \end{bmatrix} \begin{bmatrix} K_{xp} \end{bmatrix} = \begin{bmatrix} 0 \\ 0 \end{bmatrix}$$

$$\begin{bmatrix} \phi_t \\ \psi_t \end{bmatrix} \begin{bmatrix} K_{pl} \end{bmatrix} + \begin{bmatrix} XC3 \\ XC4 \end{bmatrix} + \begin{bmatrix} 0 \\ \phi_t \\ \psi_t \end{bmatrix} \begin{bmatrix} K_{xl} \end{bmatrix} = \begin{bmatrix} 0 \\ 0 \end{bmatrix}$$

where the subscript "t" denotes a trim value existing prior to engaging the control law and the rates are assumed zero.

The variable UX(19) must be initialized with the appropriate sample time. The remaining program initialization is specific to either the MR or the MLE adaptive algorithm and will be discussed in later sections.

Real-Time Operations

The VALT adaptive system is structured to require a call to subroutine CONTRL3 at each sample time. This subroutine controls all the signals sent to the various subroutines and contains all the logic for exercising the various user options discussed below. A program listing is given in Appendix A. The listing for the gain computation is given in Appendix B.

User Inputs and Options

The interface between the Honeywell adaptive software resides in subroutine CONTRL3. Data are exchanged via the UX array. Various options for using the software have been provided by a set of logical variables (LX) and five panel switches, FSS(9) through FSS(13), located on the CDC console. The various options are defined below:

- Panel Switches:

  9 - Engages the pitch-axis controller and continually updates PCMLE highpass filters.

  10 - Positive command.

  11 - Negative command.

  12 - Engages the PCMLE estimator [requires FSS(9) to be on].

  13 - Engages the lateral controller.

- LX Array:

  1 - T fixes the PCMLE algorithm on the channel determined by starting value of JS.

  - F uses likelihood select logic to determine channel used.

  2 - T sets NOEST logic which skips parameter updates in PCMLE.

  - F nominal operation.

  3 - T replaces measured $\bar{v}$ with $\bar{v}$ estimate from PCMLE for gain schedule.

  4 - T uses table lookup in GAIN subroutine.

  - F uses schedule in GAIN2 subroutine.

  5 - T = PRINT prints out selected PCMLE variables. This can only be used in a batch mode.

- LX:

  6 - T selects commands from automatic guidance.

  7 - Not used.

  8 - Controls printout in NRTIC subroutine.

  9 - T engages the estimation computation set by switch 12.

  10 - T causes pitch controller to use a fixed set of gains from subroutine GAIN2.

  11 - T applies step command via FSS(10) and FSS(11) to V_z input.

  12 - T applies step command via FSS(10) and FSS(11) to θ input.

13 - T applies step command via FSS(10) and FSS(11) to ϕ input.

14 - T applies step command via FSS(10) and FSS(11) to ψ input.

As previously discussed, the logic to select the MR algorithm was deleted following selection of the MLE algorithm for flight evaluation. For completeness, the MR algorithm is documented in a later section of this report.

Outputs From VALT Adaptive Software

The primary outputs from the software are the four servocommands (UC1, UC2, UC3, UC4) previously discussed. For purposes of checkout, eight variables are output on a strip chart for real-time plots. Other selected variables are available in the UX array for monitoring from the CDC console.

The variables plotted are variables from the MLE algorithm and are defined in Section 4 (Table 12).

SECTION 4

THE PARALLEL CHANNEL MAXIMUM LIKELIHOOD ESTIMATION ALGORITHM

Description

This algorithm uses measurements of vertical velocity, pitch rate, and pitch attitude together with the collective and differential collective positions to estimate the dominant parameters of the VALT helicopter. The estimation is based on a maximum-likelihood method using parallel processing of the data by Kalman filters. Each filter is a four-state representation of the longitudinal dynamics.

The explicit parameter estimates are used to algebraically adjust the feedback and feedforward gains of the pitch-axis control law.

The estimation software is organized as shown in Figure 4. It consists of a non-real-time segment (definition and initialization of Kalman filter channels) and the real-time parameter identification. The initialization program permits different designs by providing the following flexibility:

- Variable number and location of Kalman filter channels
- Variable sample rates
- Variable number of identified parameters (up to four)
- Significance tests to monitor data validity

The computations have been divided among a number of subroutines. The subroutines are listed in Table 5 together with their use in either initialization or real time. For fast execution, most of the data exchanged between subroutines is done via labeled common blocks. Seven blocks are used in the estimation software. They are defined in Table 6.

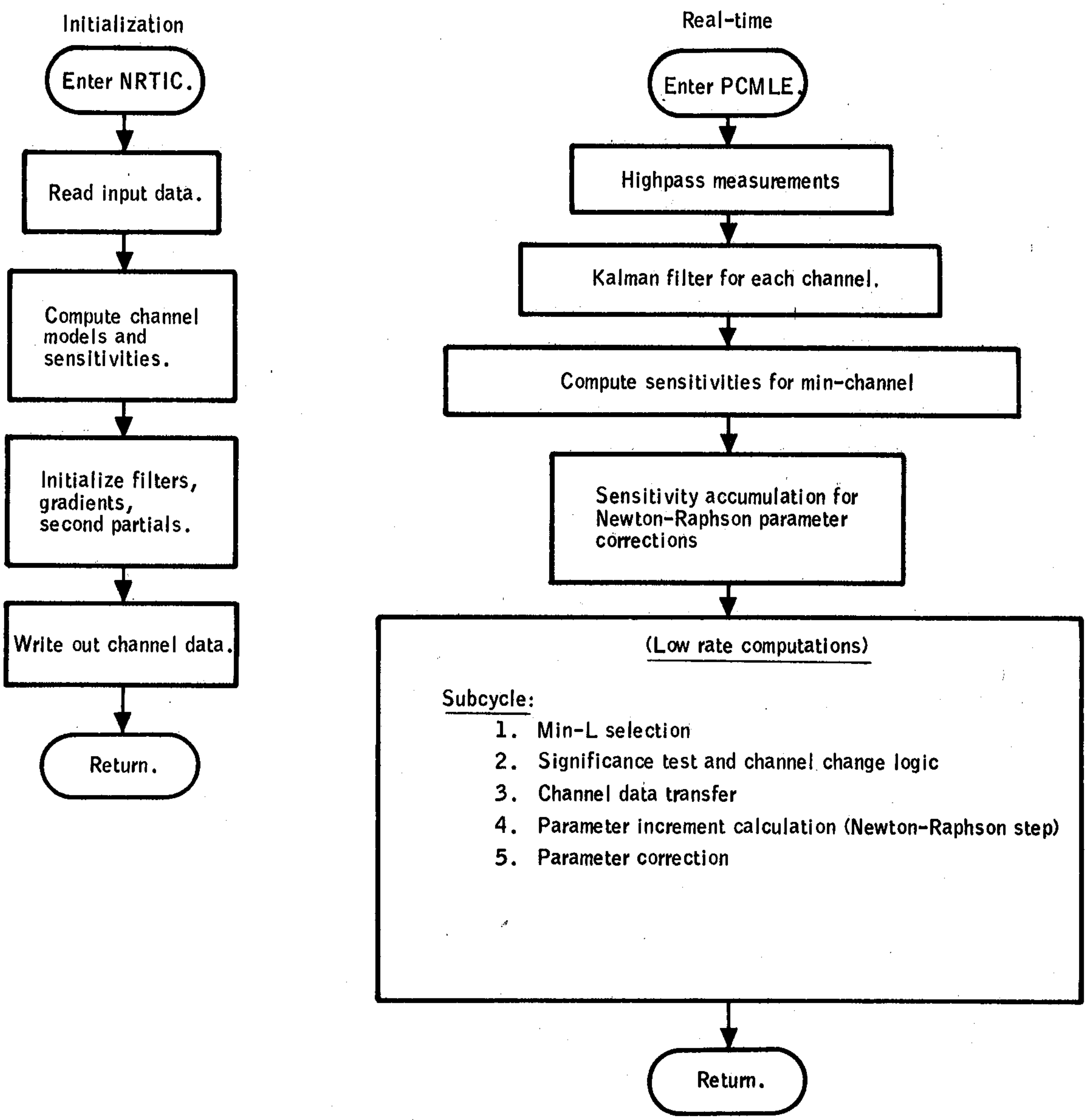


Figure 4. -PCMLE software structure.

TABLE 5. - PCMLE SUBROUTINES

Subroutine	Function
Non-real-time:	
NRTIC	Main executive routine for non-real-time operation. Reads data to define number and location of channels, number of parameters estimated, sample rate, etc. Performs all initialization with calls to other subroutines.
MODEL	Defines the system matrices and sensitivities for a discrete four-state model for each channel.
DISC	Computes disctete model from a continuous-time model.
FHIC	Computes filter coefficients and initializes high-pass filter applied to measurements.
DIAK CAL	Solves for the Kalman filter gains for a discrete system. It uses an iterative procedure.
INPT	Reads card input for starting value of filter gains.
MP	Prints out matrix.
Real-time:	
PCMLE	Main executive routine for parallel-channel MLE real-time computations.
FH	Highpass filter applied to measurements.
TSIG	Produces test signal and two random numbers for simulated sensor noise.
FILT	Performs a fourth-order Kalman filter computation for each pitch channel.
SENS	Performs a sensitivity filter for a given parameter.
ACUM	Accumulates likelihood gradients and approximate second partials for a Newton-Raphson parameter update.

TABLE 6. - LABELED COMMON BLOCKS FOR DATA TRANSFER

Common block	Function
VARDAT	Contains UX and LX arrays. Used to input user data and output selected real-time parameters. Defined in Tables 8 and 9.
DAT	Main arrays for storing channel model parameters. Defined in MODEL and used in NRTIC, PCMLE, SENS, ACUM, and FILT subroutines. The X, F, and D arrays of this common block are defined in Tables 3, 4, and 5.
IPIC	Contains all the parameter initialization defined by NRTIC and transferred to the real-time routine PCMLE.
MEAS	Stored current value of high-passed measurements. Initialized in NRTIC, defined in PCMLE and used in FILT, and SENS subroutines.
SUBR	Transmits model data to DIAK and CAL for solving a Ricatti equation to determine Kalman filter gains. Used in NRTIC, PCMLE, MODEL, DIAK, and CAL subroutines.
SUBRH	Stores highpass filter constants. Used in NRTIC, PCMLE, MODEL, FHIC, and FH subroutines.
SENSP	Stores the sensitivity of each channel model variable with respect to each of the four parameters estimated. See Table 10 for details. Used by NRTIC, PCMLE, MODEL, SENS, and ACUM subroutines.

Definitions of the arrays used in the MLE software are given in Tables 7, 8, 9, and 10.

Initialization

The initialization of PCMLE is performed out of real time with a call to subroutine NRTIC. This subroutine reads a data file containing all the common blocks used by the PCMLE software. This data file is generated by a separate batch program which is discussed later in this section.

TABLE 7. -DEFINITION OF X-ARRAY IN DAT COMMON BLOCK

X (IC, I)

IC = 1, 5 for channel index

I = 1, 19 for variable

Index (I)	Variable	
1	V_{x_k}	
2	V_{z_k}	Current state at time t_k
3	q_k	
4	θ_k	
5	$V_{x_{k+1}}$	
6	$V_{z_{k+1}}$	Predicted state at time t_{k+1}
7	q_{k+1}	
8	θ_{k+1}	
9	ν_{v_z}	
10	ν_q	Current filter residual
11	ν_θ	
12	$\nu^t R^{-1} \nu$	
13	$\nu^t R^{-1} \nu$ + Indet R	
14	sum $\nu^t R^{-1}$	
15	sum $\nu^t R^{-1} \nu$ + Indet R	
16	---	
17	---	
18	---	
19	---	

TABLE 8. -DEFINITION OF F-ARRAY IN DAT COMMON BLOCK

F (IC, I)

IC = 1, 5 filter (channel) index

I = 1, 22 for parameter index

Index (I)	Variable	
1	KF(1, 1)	Kalman filter gains
2	KF(2, 1)	
3	KF(3, 1)	
4	KF(4, 1)	
5	KF(1, 2)	
6	KF(2, 2)	
7	KF(3, 2)	
8	KF(4, 2)	
9	KF(1, 3)	
10	KF(2, 3)	
11	KF(3, 3)	
12	KF(4, 3)	
13	Ln Det R	
14	$R^{-1}(1, 1)$	Inverse of residual co-variance matrix
15	$R^{-1}(1, 2)$	
16	$R^{-1}(1, 3)$	
17	$R^{-1}(2, 1)$	
18	$R^{-1}(2, 2)$	
19	$R^{-1}(2, 3)$	
20	$R^{-1}(3, 1)$	
21	$R^{-1}(3, 2)$	
22	$R^{-1}(3, 3)$	

TABLE 9. -DEFINITION OF D-ARRAY IN DAT COMMON BLOCK

D (IC, I)

IC = 1, 5 for channel index

I = 1, 22 for parameter

For the model:

$$x_{n+1} = Ax_n + Bu_n$$

Index (I)	Variable	
1	A (1, 1)	Non-zero elements of discrete A matrix
2	A (1, 2)	
3	A (1, 3)	
4	A (1, 4)	
5	A (2, 1)	
6	A (2, 2)	
7	A (2, 3)	
8	A (2, 4)	
9	A (3, 1)	
10	A (3, 2)	
11	A (3, 3)	
12	A (3, 4)	
13	A (4, 1)	
14	A (4, 2)	
15	A (4, 3)	
16	A (4, 4)	
17	B(1, 1)	Non-zero elements of discrete B matrix
18	B(1, 2)	
19	B(2, 1)	
20	B(2, 2)	
21	B(3, 1)	
22	B(3, 2)	

TABLE 10. -DEFINITION OF XS AND DS ARRAY IN SENSP COMMON BLOCK

Array	Definition
XS	(IP, I) IP = 1, 4 parameter index I = 1, 19 variable index for sensitivity filter quantities Same list for I as Table 3.
DS	(IC, IP, I) IC = 1, 5 for channel index IP = 1, 4 for parameter index I = 1, 22 for sensitivity quantities In general DS (IC, IP, I) = $\frac{\Delta D\ (IC,\ I)}{\Delta \text{ parameter } IP}$ where I is as given in Table 5.

Real-Time Operation

The real-time computations are executed with a callto subroutine PCMLE. PCMLE is called once per sample time. The sampled values of pitch rate, pitch attitude, down velocity, and collective and differential collective position are highpassed, and residuals and likelihood functions are computed for each Kalman filter (fixed in parameter space). Gradients and second partials are accumulated for a Newton-Raphson parameter update. The remaining real-time operations are spread over five subcycles as shown in Figure 4. During real-time operation, selected variables can be monitored using the UX array.

The real-time data that are input to the algorithm at each sample time are defined in Table 11. The data are transferred from the VALT simulation via the UX array.

TABLE 11. -REAL-TIME INPUT VARIABLE ASSIGNMENT

User variables	Description	Mneumonic expression	Units
UX(11)	Down velocity	ZDOTE	ft/s
12	Pitch rate	QI	rad/s
13	Pitch attitude	THEI	rad
14	Differential collective	DC(1)	in.
15	Collective	DC(2)	in.
16	Forward velocity[a]	XDOTE	ft/s

[a]Not used by controller. Used for evaluation only.

Selected output variables are available for monitoring performance. They are contained in the UX array and are defined in Table 12.

A flow chart of the real-time computations is contained in Appendix C. A complete program listing appears in Appendix D.

User Inputs and Options

Five logical variables (LX) are used in the software as switches to control various PCMLE user options. These variables are defined in Table 13. The nominal settings are LX(9) = True, all others false.

The other modes are used for checkout and debugging purposes. LX(1) = T eliminates the channel switching logic so the fit of any of the Kalman filters can be checked against the input data. LX(2) = T skips the parameter estimation steps. LX(5) and LX(8) control line printer output. LX(9) is the logical used to engage the PCMLE algorithm for normal operation.

TABLE 12. -PCMLE OUTPUT VARIABLES

User variable	Description	Mneumonic expression	Units
UX(20)	Channel indicator	0.25JS-.5	
21	V_z estimate (highpassed)	X(JS, 2)/20	20 ft/s
22	q estimate (highpassed)	X(JS, 3)*5.73	10°/s
23	Scaled-likelihood function, filter 1	TJ(1)/400	
24	Scaled-likelihood function, filter 2	TJ(2)/400	
25	Scaled-likelihood function, filter 3	TJ(3)/400	
26	$\tilde{v}$ estimate	ZP1	-
27	$\tilde{v}$ accuracy	SQRT(C1/DET)	-
28	b_{31} estimate	ZP2	
29	b_{32} estimate	ZP3	
30	a_{33} estimate	ZP4	
31	V_x estimate	X(JS, 1)	ft/s
32	θ estimate	X(JS, 4)	rad
33	Residual ratio	S1GSQ	-

TABLE 13. -USER LOGICAL ASSIGNMENTS[a]

User logicals	Function	Mneumonic expression
LX(1)	Disables automatic channel changes.	NOCHC
2	Disables Newton-Raphson parameter step.	NOEST
5	Enables printout from PCMLE (use in batch mode only).	PRINT
8	Disables initialization printout in subroutine model.	
9	Enables PCMLE algorithm.	MLE

[a]Default values: LX(I) = .F.

Generation of PCMLE Data File

The parameters used by the real-time PCMLE software are computed off-line and stored in a data file. This program reads the input data deck and defines the specified number of channels at the specified parameter values. Each channel is a four-state Kalman filter for the longitudinal dynamics. The states are forward and down velocity, pitch rate, and the pitch attitude. The measurements are down velocity, pitch rate, and pitch attitude. The initialization program discretizes the Kalman filter model for the specified sample rate and solves a Ricatti equation for the steady-state filter gains. Parameter sensitivities are computed for each channel using a numerical differencing method by individually perturbing each of four parameters to be estimated.

A flow chart of this program is contained in Appendix E. A complete program listing is contained in Appendix F.

The various input parameters are defined in Table 14. A nominal set of input data and the resulting initialization file is contained in Appendix G.

If a stable Kalman filter is not found for the given set of input data, a STOP 41 or STOP 31 will be encountered. These are defined in Table 15.

TABLE 14. - PCMLE INPUT PARAMETERS

Input	Description
NX	Number of states in Kalman filters
NR	Number of measurements in Kalman filters
NN	Number of noise sources in Kalman filters
NTER	Number of terms used in series to compute discrete model
NRM	Maximum number of measurements
EE	Convergence criteria in DIAK for Ricatti solution
ITER	Maximum number of iterations in DIAK for Ricatti solution
DT0	Nominal sample time (automatically increased if samples skipped)
DT PRINT	Print interval when LX(5) is true (available in batch mode only)
NC	Number of channels
NP0	Number of parameters estimated
JS0	Starting channel location
WUT0	Natural frequency of shaping filter on random test signal:
DUT0	- Damping of shaping filter on random test signal
SIGUT0	- Gain of shaping filter on random test signal
UT10	- Initial state of shaping filter on random test signal
UT20	- Initial state of shaping filter on random test signal
	(Above state initialization is useful for generating deterministic square waves or sine waves with TSIG subroutine.)
UTMAX	Limits size of filtered test signal
TAUP0	Time constant of likelihood accumulation filter
TAUP2	Time constant of lowpass filter on L, ∇L, $\nabla^2 L$ inputs
WHP	Frequency of second-order highpass on measurements
DHP	Damping of second-order highpass on measurements
SIGVZ	RMS noise statistic assumed for down-velocity measurement
SIGQ	RMS noise statistic assumed for pitch-rate measurement
SIGTH	RMS noise statistic assumed for pitch-attitude measurement
SIGXG	RMS statistic assumed for forward wind gusts

TABLE 14. -Concluded

Input	Description
SIGZG	RMS statistic assumed for vertical wind gusts
RTJC0	Threshold parameters controlling channel switch
THRTJC0	
RTJZ0	Threshold parameters controlling Z1MIN selection
THRTJZ0	
RTJS0	Ratio test parameter for significance of likelihood function
ZP1 MAX	Maximum value of parameter 1 estimate
ZP2 MAX	Maximum value of parameter 2 estimate
ZP3 MAX	Maximum value of parameter 3 estimate
ZP4 MAX	Maximum value of parameter 4 estimate
ZP1 MIN	Minimum value of parameter 1 estimate
ZP2 MIN	Minimum value of parameter 2 estimate
ZP3 MIN	Minimum value of parameter 3 estimate
ZP4 MIN	Minimum value of parameter 4 estimate
GSQL0	Elements of $\nabla^2 L_o$ matrix
ZP	Matrix defining location of channels (four parameters per channel times five channels maximum = 20 parameters

TABLE 15. -PCMLE STOP CODES

STOP code		Condition
41	Initialization	Ricatti equation not converging in subroutine CAL during initialization (unstable model).
31		Inverse does not exist in subroutine DIAK for computing filter gains. Check Data Deck.

SECTION 5
THE MODEL REFERENCE ADAPTIVE ALGORITHM

Description

The model reference algorithm adjusts the pitch-axis gains to reduce the error vector between the model response for V_z, q and θ. The resulting gain values are stored in the UX array for use with subroutine HCON1. All the data required by this algorithm are stored in the MRDAT common block.

Initialization

This algorithm is initialized with a call to subroutine RMIC. This call defines the A and B matrices for a three-state continuous-time model and the parameters required by the integration subroutine INTGRAL which are stored in common block MRINT. The INTGRAL subroutine contains three integration routines. The first-order Euler method is used to integrate the thirteenth-order system composed of three model states plus 10 gains. The parameters used in the MRDAT array are defined in Table 16.

The X-array stores the current state. The components are:

X(1) = V_z model

X(2) = q model

X(3) = θ model

X(4) through X(13) } 10 gain values

TABLE 16. -DEFINITION OF MODEL REFERENCE VARIABLES

Variable	Definition
X	Current state
DX	Current derivative
THR1	Threshold on V_z error in gain adjustment
THR2	Threshold on q error in gain adjustment
THR3	Threshold on θ error in gain adjustment
G11 G12 G21 G22	Elements of B^{-1} in gain adjustment
T1	Scaling parameter for the P-matrix
T2 - T11	Set to 1 or 0 depending on which of the gains are to be adjusted
EVZ	V_z error (ft/s)
EQ	q error (rad/s)
ETH	θ error (rad)
FAC FAC1	Error quantities used for monitoring only
P11 P22 P23 P33	Elements of negative definite matrix satisfying Liapunov equation

The DX-array stores the current derivative. The equation for the third-order model is:

$$\frac{d}{dt}\begin{bmatrix} V_z \\ q \\ \theta \end{bmatrix} = [A]\begin{bmatrix} V_z \\ q \\ \theta \end{bmatrix} \quad [B]\begin{bmatrix} U(1) \\ \\ U(2) \end{bmatrix}$$

where

U(1) = V_z command

U(2) = θ command

$$A = \begin{bmatrix} -2 & 0 & 0 \\ 0 & -4 & -7 \\ 0 & 1 & 0 \end{bmatrix} \qquad B = \begin{bmatrix} 2 & 0 \\ 0 & 7 \\ 0 & 0 \end{bmatrix}$$

When the controller is added to this model, the closed-loop model has uncoupled V_z and θ responses with the following transfer functions:

$$\frac{V_z}{V_{z_c}} = \frac{2(s+1)}{(s+2)\ (s+1)}$$

$$\frac{\theta}{\theta_c} = \frac{7(s+0.8)}{(s+0.8)\ (s^2+4s+7)}$$

The gains consist of a feedback matrix, K_x, plus a command input, K_u. Thus, the commands are determined as:

$$\begin{bmatrix} UC1 \\ UC2 \end{bmatrix} = \begin{bmatrix} K_x \end{bmatrix}\begin{bmatrix} V_z \\ q \\ \theta \end{bmatrix} + \begin{bmatrix} K_u \end{bmatrix}\begin{bmatrix} V_c + \int (V_{z_c} - V_z) \\ \theta_c + \int (\theta_c - \theta) \end{bmatrix}$$

These matrices are initialized as:

$$K_x = \begin{bmatrix} 0 & -7.6 & -27 \\ 0.3 & 0 & 0 \end{bmatrix}$$

$$K_u = \begin{bmatrix} 0 & 17.5 \\ -0.23 & 0 \end{bmatrix}$$

Real-Time Operation

The gain adjustment is done with a call to subroutine RFMOD. This routine defines the command inputs, measurements, error vector, and time derivatives for the gains. The actual integration of the model and the gain element is done with subroutine INTGRAL. The integration is performed for the sample-time defined for the controller.

The derivatives of the gain matrices are defined by the following relations:

$$\frac{d}{dt} K_x = -\bar{B}^{-1} P e^T x$$

$$\frac{d}{dt} K_u = -\bar{B}^{-1} P e^T u$$

where

e = error vector of V_z, q, θ errors

x = measured V_z, q, θ states

A flow chart of RFMOD is shown in Figure 5. A program listing of RMIC, RFMOD, and INTGRAL is contained in Appendix H.

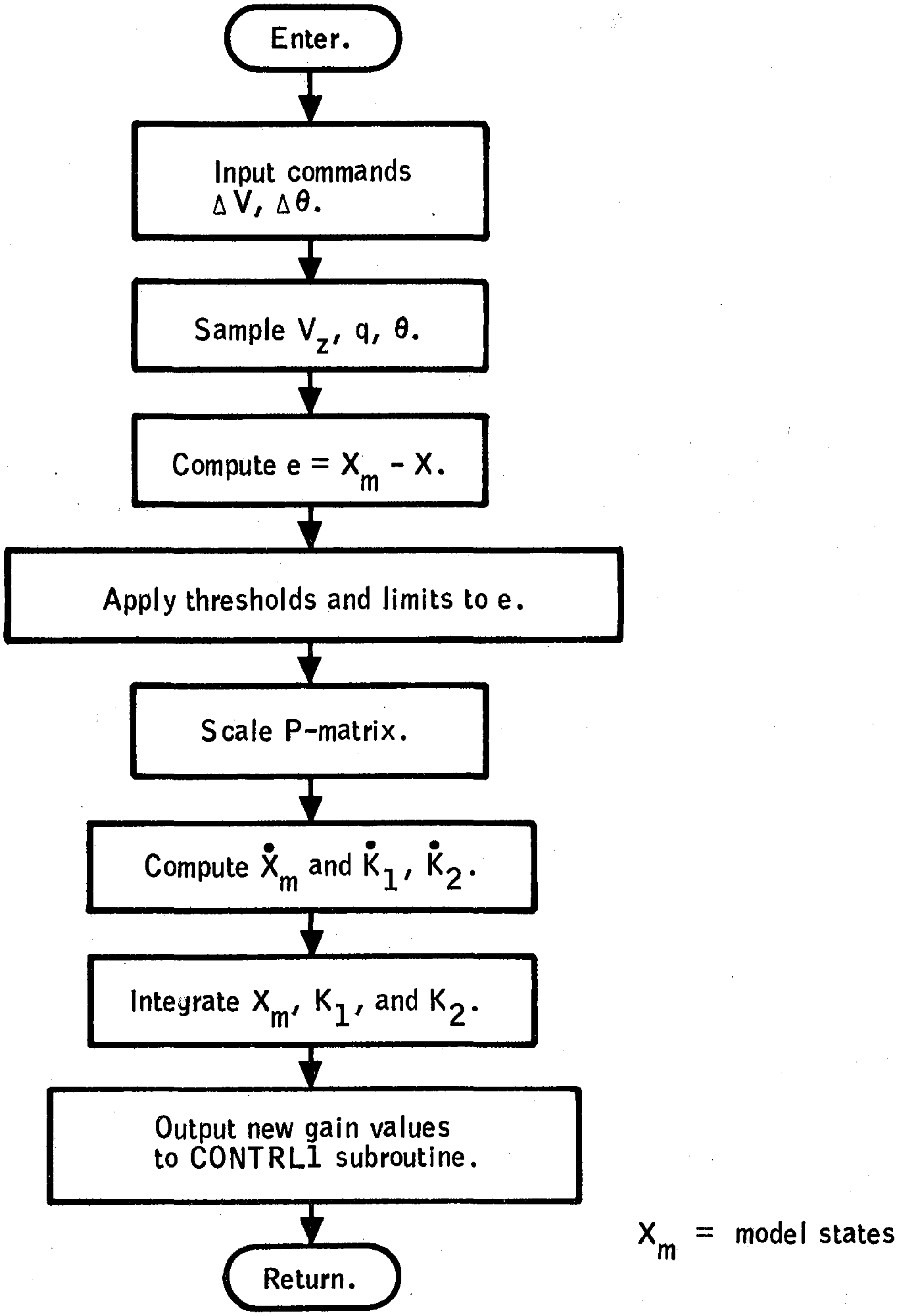


Figure 5. - Flow chart for subroutine REMOD.

APPENDIX A

PROGRAM LISTING OF CONTROLLERS

This appendix consists of the program listings of subroutines CONTRL3 (Fig. 6), HCON1 (Fig. 7), and HON2 (Fig. 8).

```
SUBROUTINE CONTRL3     73/74    OPT=1                    FTN 4.6+452          78/04/06. 08.36.47

      SUBROUTINE CONTRL3                                                       RTVALT    4035
C                                                                              HON09      259
C      THIS SUBROUTINE COMPUTES CONTROLLER COMMANDS. ALL VARIABLES             HON09      260
C      ENDING WITH I ARE INERTIAL MEASUREMENTS. THOSE ENDING WITH              HON09      261
C      G ARE FROM THE GUIDANCE COUPLER.THEN AND PHIN ARE FROM STABDER.         HON09      262
C      UNITS OF DCC ARE IN INCHES. CT IS THE ITERATION PERIOD FUR THE          HON09      263
C      CONTROL MODULE. ALL PAST VALUES ARE INITIALIZED IN ICONTR.              HON09      264
C                                                                              HON09      265
      COMMON/EST/LATE,LONE,ZE,XDOTE,YDOTE,ZDOTE,SSVELWE,SSTHWE,XDTADE,         HON09      266
     A YDTADE,ZDTADE,XE,YE                                                     HON09      267
      COMMON/AR/DAH( 4),DLH( 4),DA1H( 4),DL1H( 4),DA2H( 4),DL2H( 4),           HON09      268
     1   DRLH( 4),DRL1H( 4),DCMIN(4),DCMAX(4),DRLMAX(4),WAH(4),                HON09      269
     2   ZAH(4),WRH(4),ZRH( 4),CON1(6, 4),CON2(6, 4),DTRL,FAR,                 HON09      270
     3   DHH( 4),DH1H( 4),DH2H( 4),VAR2( 4),VAR12( 4),VAR22( 4),               HON09      271
     4   DC(4),DCN(4),GAINH(4)                                                 HON09      272
      COMMON/CONST/NC,G,RE,RE2,PP,SCHULER,ERATE,PP180,PP180I,PP2               HON09      273
      COMMON/CONTROL/DCC(4),DC1C2,W1G,DPL(4),PSIYC,PSIYG                       HON09      274
      COMMON/FREQ/RGT,ALT,RIGT,ADT,GST,GCT,GPT,GRT,CT,PT,HRT,AAT,ENV1,         HON09      275
     1     ENV2,ENV3,ENV4,ENV5,ENV6,ENV7,ENV8,ENV9,XLNT,ANAT,                  HON09      276
     2     FKT,ATCT,PTCT,GNOMT,GSLT,DT,TIMEH                                   HON09      277
      COMMON/GUIDE/UG,VG,WG,XDOTG,YDOTG,ZDOTG,UAG,VAG,WAG,ZBG,PSIHRG           HON09      278
      COMMON/HELCOP/THEH,PHIH,PSIH,DUDOTH,VDOTH,DWDOTH,UH,VH,WH,PDOTH,         HON09      279
     1QDOTH,RDOTH,PH,QH,RH,PSIIHR,ALPHAH,BETAH,FXH,FYH,                        HON09      280
     2FZH,PPH,QQH,RRH,XDTAVH                                                   HON09      281
      COMMON/INERT/THEI,PHII,PSII,UDOTI,VDOTI,WDOTI,PI,QI,RI,PDI,QDI,          HON09      282
     1       RDI,SIGBRII,SIGRRII,SIGFRII,SIGBRI,SIGRRI,SIGSFRI,                HON09      283
     2       SIGBLAI,SIGRLAI,RRII(3),RRI(3),RLAI(3),BRII(3),                   HON09      284
     3       SFRII(3),BRI(3),SFRI(3),BLAI(3)                                   HON09      285
      COMMON/NOM/THEN,PHIN,UN,VN,WN,UAN,VAN,WAN                                HON09      286
      COMMON/SPRNT/DUMOUT(15),IDUM                                             HON09      287
      COMMON/TRAJECT/XDDGSN,XDDAGSN,XDOTGSN,XDTAGSN,ZDDGSN,ZDOTGSN,            HON09      288
     A ZDT1GSN,ZGSN,XDTNGSN,VNGSN,YDTEGSN,VEGSN,LATGSN,                        HON09      289
     B LONGSN,XGSN,YGSN,PGSN,QGSN,RGSN,R1GSN,THEGSN,                           HON09      290
     C PHIGSN,PSIGSN,PSIHRN,TGSN,XDDGSC,XDDAGSC,XDOTGSC,                       HON09      291
     D XDTAGSC,ZDDGSC,ZDOTGSC,ZGSC,ZDTLGSC,LATGSC,LONGSC,                      HON09      292
     E XGSC,YGSC,PGSC,QGSC,RGSC,THEGSC,PHIGSC,PSIGSC,                          HON09      293
     F PSIHRC,TEMGSC,TIMGSC,TIMAGSC,TIMBGSC,TIMCGSC,TGSC,                      HON09      294
     G FIGSC,GAINGSC,PMAX,PHIMAX,ZDTMAX,XDDMAX,YDOTGSC,YDOTGSN                 HON09      295
      COMMON/VARDAT/UX(55),LX(15)                                              HON09      296
      COMMON/VEL/UAD,VAD,WAD,ZBAD,XDOTGS,YDOTGS,ZDOTGS,PSIHR,ZAA,HTER,         HON09      297
     1    ZAAC,ZAAG,ALPHAD,BAD                                                 HON09      298
      COMMON/WIND/NW,HW(4),THW(4),VELW(4),QTHCW,QVELCW,QZCW,THTW,VELTW,        HON09      299
     1     ZTW,SIGVRW,SIGZRW,SSTHW,WVELRW,WZRW,XTHW,THCW,XVELW,SSVELW,         HON09      300
     2       VELCW,ZCW,SIGTHCW,SIGVCW,SIGZCW,SIGW,THC1W,VELC1W,                HON09      301
     3       VELDTW,WTHCW,WTHC1W,WVELCW,WVELC1W,WZCW,WZC1W,ZC1W,               HON09      302
     4       UW,VW,WW                                                          HON09      303
      COMMON/REALTIM/VARCHNG,INTABLS,IVARBUF(5),ITYPE,FSS(16)                  HON09      304
      LOGICAL FSS,LX                                                           HON09      305
      DIMENSION OUT(4),GN(2,10)                                                HON09      306
      DCC(1)=-7.5013*QI-10.*(THEI-THEN)-0.16116*UG                             HON09      307
      DCC(2)=0.99872*DC1C2-0.37068*WG+0.31519*W1G                              HON09      308
      DC1C2=DCC(2)                                                             HON09      309
      W1G=WG                                                                   HON09      310
C                                                                              HON09      311
C     LATERAL CHANNELS                                                         HON09      312
C                                                                              HON09      313
C     ROLL (CYCLIC)                                                            HON09      314
      DCC(3)=7.5*(PGSC-PI)+15.*(PHIGSC+PHIN-PHII)+0.23*VG                      HON09      315
C     YAW (DIFFERENTIAL CYCLIC)                                                HON09      316
```

Figure 6. -Program listing of subroutine CONTRL3.

```
      C                                                                 HON09    317
            PSIY1G=PSIYG                                                HON09    318
            PSIYG=PSIGSC-PSII                                           HON09    319
            IF(PSIYG.GT.PP) PSIYG=PSIYG-PP2                             HON09    320
            IF(PSIYG.LT.-PP)PSIYG=PSIYG+PP2                             HON09    321
            PSIYC=PSIYC+1.4*CT*(PSIY1G+PSIYG)                           HON09    322
            DCC(4)=15.*(RGSC-RI)+17.*PSIYG+PSIYC                        HON09    323
            DPL(1)=DCN(1)                                               HON09    324
            DPL(2)=DCN(2)                                               HON09    325
            DPL(3)=DCN(3)                                               HON09    326
            DPL(4)=DCN(4)                                               HON09    327
      C                                                                 HON09    328
      C****** HONEYWELL ADAPTIVE CONTROL LAWS                           HON09    329
      C         PITCH AXIS SENSOR INPUTS                                HON09    330
      C                                                                 HON09    331
            UX(16)=SQRT(XDOTE*XDOTE+YDOTE*YDOTE)                        HON09    332
            UX(11)=ZDOTE                                                HON09    333
            UX(12)=QI                                                   HON09    334
            UX(13)=THEI                                                 HON09    335
            UX(14)=DC(1)                                                HON09    336
            UX(15)=DC(2)                                                HON09    337
            UX(19)=CT                                                   HON09    338
            VBAR=UX(16)/270.                                            HON09    339
            UX(10)=VBAR                                                 HON09    340
      C                                                                 HON09    341
      C****** LATERAL SENSOR INPUTS                                     HON09    342
      C                                                                 HON09    343
            UX(37)=PI                                                   HON09    344
            UX(38)=RI                                                   HON09    345
            UX(39)=PHII                                                 HON09    346
            UX(40)=PSII                                                 HON09    347
      C                                                                 HON09    348
      C***** COMMAND INPUTS                                             HON09    349
      C                                                                 HON09    350
            CALL TSIG(C1,C2,UTS)                                        HON09    351
            VZC=0.+UX(6)*UTS                                            HON09    352
            THC=THEN+UX(7)*UTS                                          HON09    353
            PHIC=0.                                                     HON09    354
            PSIC=0.                                                     HON09    355
      C                                                                 HON09    356
      C***** COMMAND DOUBLET                                            HON09    357
      C                                                                 HON09    358
            SDB=0.                                                      HON09    359
            IF(FSS(10)) SDB=UX(17)                                      HON09    360
            IF(FSS(11)) SDB=-UX(17)                                     HON09    361
      C                                                                 HON09    362
      C***** LOGIC TO APPLY STEP COMMANDS AS PERTURBATIONS              HON09    363
      C        (CONVERTED TO RAD. FOR ATTITUDE COMMANDS)                HON09    364
      C                                                                 HON09    365
            IF(LX(11)) VZC=SDB                                          HON09    366
            IF(LX(12)) THC=THEN+SDB*0.01745                             HON09    367
            IF(LX(13)) PHIC=SDB*0.01745                                 HON09    368
            IF(LX(14)) PSIC=SDB*0.01745                                 HON09    369
            UX(1)=VZC                                                   HON09    370
            UX(2)=THC                                                   HON09    371
            UX(3)=PHIC                                                  HON09    372
            UX(4)=PSIC                                                  HON09    373
      C                                                                 HON09    374
      C***** LOGIC TO APPLY GUIDANCE                                    HON09    375
      C                                                                 HON09    376
            IF(.NOT.LX(6)) GO TO 400                                    HON09    377
      C                                                                 HON09    378
      C***** COMMANDS VZ,THETA,PHI,PSI GO TO UX 1,2,3,4                 HON09    379
      C                                                                 HON09    380
            UX(1)=ZDOTGSC                                               HON09    381
            UX(2)=THEGSC                                                HON09    382
            UX(3)=PHIGSC                                                HON09    383
            UX(4)=PSIGSC                                                HON09    384
        400 CONTINUE                                                    HON09    385
      C                                                                 HON09    386
            IF(.NOT.FSS(9)) GO TO 500                                   HON09    387
            LX(9)=FSS(12)                                               HON09    388
            CALL PCMLE                                                  HON09    389
      C                                                                 HON09    390
            IF(LX(3)) VBAR=UX(26)                                       HON09    391
            CALL GAIN2(VBAR)                                            HON09    392
            IF(LX(4)) CALL GAIN(VBAR)                                   HON09    393
      C                                                                 HON09    394
      C***** PITCH CONTROLLER                                           HON09    395
      C                                                                 HON09    396
```

Figure 6. -Continued.

```
                  CALL HCON1(DCC(1),DCC(2))                              HON09      397
                  DCC(1)=DCC(1)*(UX(8)+1.)                               HON09      398
                  DCC(2)=DCC(2)*(UX(9)+1.)                               HON09      399
              500 CONTINUE                                               HON09      400
            C****** LATERAL*******                                       HON09      401
                  IF(FSS(13)) CALL HCON2(DCC(3),DCC(4))                  HON09      402
            C                                                            HON09      403
                  RETURN                                                 RTVALT    4036
                  END                                                    RTVALT    4037
```

```
     SYMBOLIC REFERENCE MAP (R=1)

ENTRY POINTS
   1   CONTRL3

VARIABLES       SN  TYPE                RELOCATION
  13   AAT          REAL                   FREQ         3   ADT       REAL                FREQ
  14   ALPHAD       REAL                   VEL         20   ALPHAH    REAL                HELCOP
   1   ALT          REAL                   FREQ        26   ANAT      REAL                FREQ
  30   ATCT         REAL                   FREQ        15   BAD       REAL                VEL
  21   BETAH        REAL                   HELCOP      51   BLAI      REAL      ARRAY     INERT
  43   BRI          REAL        ARRAY      INERT       35   BRII      REAL      ARRAY     INERT
  74   CON1         REAL        ARRAY      AR         124   CON2      REAL      ARRAY     AR
  10   CT           REAL                   FREQ       243   C1        REAL
 244   C2           REAL                                0   DAH       REAL      ARRAY     AR
  10   DA1H         REAL        ARRAY      AR          20   DA2H      REAL      ARRAY     AR
 206   DC           REAL        ARRAY      AR           0   DCC       REAL      ARRAY     CONTROL
  44   DCMAX        REAL        ARRAY      AR          40   DCMIN     REAL      ARRAY     AR
 212   DCN          REAL        ARRAY      AR           4   DC1C2     REAL                CONTROL
 156   DHH          REAL        ARRAY      AR         162   DH1H      REAL      ARRAY     AR
 166   DH2H         REAL        ARRAY      AR           4   DLH       REAL      ARRAY     AR
  14   DL1H         REAL        ARRAY      AR          24   DL2H      REAL      ARRAY     AR
   6   DPL          REAL        ARRAY      CONTROL     30   DRLH      REAL      ARRAY     AR
  50   DRLMAX       REAL        ARRAY      AR          34   DRL1H     REAL      ARRAY     AR
  34   DT           REAL                   FREQ       154   DTRL      REAL                AR
   3   DUDOTH       REAL                   HELCOP       0   DUMOUT    REAL      ARRAY     SPRNT
   5   DWDOTH       REAL                   HELCOP      14   ENV1      REAL                FREQ
  15   ENV2         REAL                   FREQ        16   ENV3      REAL                FREQ
  17   ENV4         REAL                   FREQ        20   ENV5      REAL                FREQ
  21   ENV6         REAL                   FREQ        22   ENV7      REAL                FREQ
  23   ENV8         REAL                   FREQ        24   ENV9      REAL                FREQ
   6   ERATE        REAL                   CONST      155   FAR       REAL                AR
  62   FIGSC        REAL                   TRAJECT     27   FKT       REAL                FREQ
  10   FSS          LOGICAL     ARRAY      REALTIM     22   FXH       REAL                HELCOP
  23   FYH          REAL                   HELCOP      24   FZH       REAL                HELCOP
   1   G            REAL                   CONST       63   GAINGSC   REAL                TRAJECT
 216   GAINH        REAL        ARRAY      AR           5   GCT       REAL                FREQ
 257   GN           REAL        *UNDEF                 32   GNOMT     REAL                FREQ
   6   GPT          REAL                   FREQ         7   GRT       REAL                FREQ
  33   GSLT         REAL                   FREQ         4   GST       REAL                FREQ
  12   HRT          REAL                   FREQ        11   HTER      REAL                VEL
   1   HW           REAL        ARRAY      WIND        17   IDUM      INTEGER             SPRNT
   1   INTABLS      INTEGER                REALTIM      7   ITYPE     INTEGER             REALTIM
   2   IVARBUF      INTEGER     ARRAY      REALTIM      0   LATE      INTEGER             EST
  41   LATGSC       INTEGER                TRAJECT     14   LATGSN    INTEGER             TRAJECT
   1   LONE         INTEGER                EST         42   LONGSC    INTEGER             TRAJECT
  15   LONGSN       INTEGER                TRAJECT     67   LX        LOGICAL   ARRAY     VARDAT
   0   NC           INTEGER                CONST        0   NW        INTEGER             WIND
 253   OUT          REAL        *UNDEF                 11   PDI       REAL                INERT
  11   PDOTH        REAL                   HELCOP      45   PGSC      REAL                TRAJECT
  20   PGSN         REAL                   TRAJECT     14   PH        REAL                HELCOP
 250   PHIC         REAL                               51   PHIGSC    REAL                TRAJECT
  25   PHIGSN       REAL                   TRAJECT      1   PHIH      REAL                HELCOP
   1   PHII         REAL                   INERT       65   PHIMAX    REAL                TRAJECT
   1   PHIN         REAL                   NOM          6   PI        REAL                INERT
  64   PMAX         REAL                   TRAJECT      4   PP        REAL                CONST
  25   PPH          REAL                   HELCOP       7   PP180     REAL                CONST
  10   PP180I       REAL                   CONST       11   PP2       REAL                CONST
 251   PSIC         REAL                               52   PSIGSC    REAL                TRAJECT
  26   PSIGSN       REAL                   TRAJECT      2   PSIH      REAL                HELCOP
   7   PSIHR        REAL                   VEL         53   PSIHRC    REAL                TRAJECT
  12   PSIHRG       REAL                   GUIDE       27   PSIHRN    REAL                TRAJECT
   2   PSII         REAL                   INERT       17   PSIIHR    REAL                HELCOP
  12   PSIYC        REAL                   CONTROL     13   PSIYG     REAL                CONTROL
 241   PSIY1G       REAL                               11   PT        REAL                FREQ
  31   PTCT         REAL                   FREQ        12   QDI       REAL                INERT
```

Figure 6. -Continued.

12	QDOTH	REAL		HELCOP	46	QGSC	REAL		TRAJECT
21	QGSN	REAL		TRAJECT	15	QH	REAL		HELCOP
7	QI	REAL		INERT	26	QQH	REAL		HELCOP
15	QTHCW	REAL		WIND	16	QVELCW	REAL		WIND
17	QZCW	REAL		WIND	13	RDI	REAL		INERT
13	RDOTH	REAL		HELCOP	2	RE	REAL		CONST
3	RE2	REAL		CONST	47	RGSC	REAL		TRAJECT
22	RGSN	REAL		TRAJECT	0	RGT	REAL		FREQ
16	RH	REAL		HELCOP	10	RI	REAL		INERT
2	RIGT	REAL		FREQ	32	RLAI	REAL	ARRAY	INERT
27	RRH	REAL		HELCOP	27	RRI	REAL	ARRAY	INERT
24	RRII	REAL	ARRAY	INERT	23	R1GSN	REAL		TRAJECT
5	SCHULER	REAL		CONST	252	SDB	REAL		
46	SFRI	REAL	ARRAY	INERT	40	SFRII	REAL	ARRAY	INERT
22	SIGBLAI	REAL		INERT	17	SIGBRI	REAL		INERT
14	SIGBRII	REAL		INERT	16	SIGFRII	REAL		INERT
23	SIGRLAI	REAL		INERT	20	SIGRRI	REAL		INERT
15	SIGRRII	REAL		INERT	21	SIGSFRI	REAL		INERT
36	SIGTHCW	REAL		WIND	37	SIGVCW	REAL		WIND
23	SIGVRW	REAL		WIND	41	SIGW	REAL		WIND
40	SIGZCW	REAL		WIND	24	SIGZRW	REAL		WIND
25	SSTHW	REAL		WIND	7	SSTHWE	REAL		EST
33	SSVELW	REAL		WIND	6	SSVELWE	REAL		EST
54	TEMGSC	REAL		TRAJECT	61	TGSC	REAL		TRAJECT
30	TGSN	REAL		TRAJECT	247	THC	REAL		
31	THCW	REAL		WIND	42	THC1W	REAL		WIND
50	THEGSC	REAL		TRAJECT	24	THEGSN	REAL		TRAJECT
0	THEH	REAL		HELCOP	0	THEI	REAL		INERT
0	THEN	REAL		NOM	20	THTW	REAL		WIND
5	THW	REAL	ARRAY	WIND	56	TIMAGSC	REAL		TRAJECT
57	TIMBGSC	REAL		TRAJECT	60	TIMCGSC	REAL		TRAJECT
35	TIMEH	REAL		FREQ	55	TIMGSC	REAL		TRAJECT
0	UAD	REAL		VEL	6	UAG	REAL		GUIDE
5	UAN	REAL		NOM	3	UDOTI	REAL		INERT
0	UG	REAL		GUIDE	6	UH	REAL		HELCOP
2	UN	REAL		NOM	245	UTS	REAL		
54	UW	REAL		WIND	0	UX	REAL	ARRAY	VARDAT
1	VAD	REAL		VEL	7	VAG	REAL		GUIDE
6	VAN	REAL		NOM	0	VARCHNG	REAL		REALTIM
176	VAR12	REAL	ARRAY	AR	172	VAR2	REAL	ARRAY	AR
202	VAR22	REAL	ARRAY	AR	242	VBAR	REAL		
4	VDOTH	REAL		HELCOP	4	VDOTI	REAL		INERT
13	VEGSN	REAL		TRAJECT	34	VELCW	REAL		WIND
43	VELC1W	REAL		WIND	44	VELDTW	REAL		WIND
21	VELTW	REAL		WIND	11	VELW	REAL	ARRAY	WIND
1	VG	REAL		GUIDE	7	VH	REAL		HELCOP
3	VN	REAL		NOM	11	VNGSN	REAL		TRAJECT
55	VW	REAL		WIND	246	VZC	REAL		
2	WAD	REAL		VEL	10	WAG	REAL		GUIDE
54	WAH	REAL	ARRAY	AR	7	WAN	REAL		NOM
5	WDOTI	REAL		INERT	2	WG	REAL		GUIDE
10	WH	REAL		HELCOP	4	WN	REAL		NOM
64	WRH	REAL	ARRAY	AR	45	WTHCW	REAL		WIND
46	WTHC1W	REAL		WIND	47	WVELCW	REAL		WIND
50	WVELC1W	REAL		WIND	26	WVELRW	REAL		WIND
56	WW	REAL		WIND	51	WZCW	REAL		WIND
52	WZC1W	REAL		WIND	27	WZRW	REAL		WIND
5	W1G	REAL		CONTROL	32	XDDAGSC	REAL		TRAJECT
1	XDDAGSN	REAL		TRAJECT	31	XDDGSC	REAL		TRAJECT
0	XDDGSN	REAL		TRAJECT	67	XDDMAX	REAL		TRAJECT
3	XDOTE	REAL		EST	3	XDOTG	REAL		GUIDE
4	XDOTGS	REAL		VEL	33	XDOTGSC	REAL		TRAJECT
2	XDOTGSN	REAL		TRAJECT	10	XDTADE	REAL		EST
34	XDTAGSC	REAL		TRAJECT	3	XDTAGSN	REAL		TRAJECT
30	XDTAVH	REAL		HELCOP	10	XDTNGSN	REAL		TRAJECT
13	XE	REAL		EST	43	XGSC	REAL		TRAJECT
16	XGSN	REAL		TRAJECT	25	XLNT	REAL		FREQ
30	XTHW	REAL		WIND	32	XVELW	REAL		WIND
4	YDOTE	REAL		EST	4	YDOTG	REAL		GUIDE
5	YDOTGS	REAL		VEL	70	YDOTGSC	REAL		TRAJECT
71	YDOTGSN	REAL		TRAJECT	11	YDTADE	REAL		EST
12	YDTEGSN	REAL		TRAJECT	14	YE	REAL		EST
44	YGSC	REAL		TRAJECT	17	YGSN	REAL		TRAJECT
10	ZAA	REAL		VEL	12	ZAAC	REAL		VEL
13	ZAAG	REAL		VEL	60	ZAH	REAL	ARRAY	AR
3	ZBAD	REAL		VEL	11	ZBG	REAL		GUIDE
35	ZCW	REAL		WIND	53	ZC1W	REAL		WIND
35	ZDDGSC	REAL		TRAJECT	4	ZDDGSN	REAL		TRAJECT
5	ZDOTE	REAL		EST	5	ZDOTG	REAL		GUIDE
6	ZDOTGS	REAL		VEL	36	ZDOTGSC	REAL		TRAJECT

Figure 6. -Continued.

```
  5  ZDOTGSN   REAL                TRAJECT      12  ZDTADE   REAL          EST
 40  ZDTLGSC   REAL                TRAJECT      66  ZDTMAX   REAL          TRAJECT
  6  ZDT1GSN   REAL                TRAJECT       2  ZE       REAL          EST
 37  ZGSC      REAL                TRAJECT       7  ZGSN     REAL          TRAJECT
 70  ZRH       REAL       ARRAY    AR           22  ZTW      REAL          WIND

EXTERNALS        TYPE     ARGS
       GAIN                 1                       GAIN2                  1
       HCON1                2                       HCON2                  2
       PCMLE                0                       SQRT     REAL          1 LIBRARY
       TSIG                 3

STATEMENT LABELS
  155  400                          200   500

COMMON BLOCKS    LENGTH
       EST           13
       AR           146
       CONST         10
       CONTROL       12
       FREQ          30
       GUIDE         11
       HELCOP        25
       INERT         44
       NOM            8
       SPRNT         16
       TRAJECT       58
       VARDAT        70
       VEL           14
       WIND          47
       REALTIM       24

STATISTICS
  PROGRAM LENGTH                3038       195
  CM LABELED COMMON LENGTH     10208       528
        73000B CM USED
```

Figure 6. -Concluded.

Appendix A

```
SUBROUTINE HCON1      73/74    OPT=1                          FTN 4.6+452        78/04/06. 08.36.47

             SUBROUTINE HCON1(UC1,UC2)                                              HON09      740
      C                                                                             HON09      741
             COMMON/CI/ XC1,XC2                                                     HON09      742
             COMMON/VARDAT/ UX(55),LX(15)                                           HON09      743
             LOGICAL LX                                                             HON09      744
             VZ=UX(11)                                                              HON09      745
             Q=UX(12)                                                               HON09      746
             TH=UX(13)                                                              HON09      747
             VZC=UX(1)                                                              HON09      748
             THC=UX(2)                                                              HON09      749
             DT=UX(19)                                                              HON09      750
      C      PITCH CONTROL                                                          HON09      751
             UC1=XC1 + UX(51)*VZC + UX(52)*0.8*THC                                  HON09      752
             UC2=XC2 + UX(53)*VZC + UX(54)*0.8*THC                                  HON09      753
             UC1=UC1 + UX(41)*VZ + UX(42)*Q + UX(43)*TH                             HON09      754
             UC2=UC2 + UX(46)*VZ + UX(47)*Q + UX(48)*TH                             HON09      755
             DXC1=UX(44)*(VZC-VZ) + UX(45)*0.8*(THC-TH)                             HON09      756
             DXC2=UX(49)*(VZC-VZ) + UX(50)*0.8*(THC-TH)                             HON09      757
      C                                                                             HON09      758
             XC1= XC1 + DXC1*DT                                                     HON09      759
             XC2= XC2 + DXC2*DT                                                     HON09      760
             RETURN                                                                 HON09      761
             END                                                                    HON09      762


     SYMBOLIC REFERENCE MAP (R=1)

ENTRY POINTS
   3   HCON1

VARIABLES       SN  TYPE          RELOCATION
   62  DT           REAL                              63  DXC1    REAL
   64  DXC2         REAL                              67  LX      LOGICAL    ARRAY    VARDAT
   56  Q            REAL                              57  TH      REAL
   61  THC          REAL                               0  UC1     REAL                F.P.
    0  UC2          REAL            F.P.               0  UX      REAL       ARRAY    VARDAT
   55  VZ           REAL                              60  VZC     REAL
    0  XC1          REAL            CI                 1  XC2     REAL                CI


     SUBROUTINE HCON1      73/74    OPT=1                     FTN 4.6+452        78/04/06. 08.36.47

COMMON BLOCKS    LENGTH
       CI             2
       VARDAT        70

STATISTICS
  PROGRAM LENGTH                 65B       53
  CM LABELED COMMON LENGTH      110B       72
        73000B CM USED
```

Figure 7. -Program listing of subroutine HCON1.

```
SUBROUTINE HCON2        73/74    OPT=1                    FTN 4.6+452        78/04/06. 08.36.47

      SUBROUTINE HCON2(UC3,UC4)
C
      COMMON/CONST/NC,G,RE,RE2,PP,SCHULER,ERATE,PP180,PP180I,PP2
C
      COMMON/CI/XC1,XC2,XC3,XC4
      COMMON/VARDAT/UX(55),LX(15)
      LOGICAL LX
C
      PHIC=UX(3)
      PSIC=UX(4)
      P=UX(37)
      R=UX(38)
      PHI=UX(39)
      PSI=UX(40)
      DT=UX(19)
C
      DUM=PSIC-PSI
      IF(ABS(DUM).LT.PP) GO TO 100
      IF(DUM.GT.PP.AND.PSI.LT.0.) XC3=XC3-7.*PP2
      IF(DUM.GT.PP.AND.PSI.LT.0.) XC4=XC4-50.*PP2
      IF(DUM.GT.PP.AND.PSIC.GT.0.)XC3=XC3-4.5*0.8*PP2
      IF(DUM.GT.PP.AND.PSIC.GT.0.) XC4=XC4-34.38*0.8*PP2
      IF(DUM.LT.-PP.AND.PSI.GT.0.) XC3=XC3+7.*PP2
      IF(DUM.LT.-PP.AND.PSI.GT.0.) XC4=XC4+50.*PP2
      IF(DUM.LT.-PP.AND.PSIC.LT.0.) XC3=XC3+4.5*0.8*PP2
      IF(DUM.LT.-PP.AND.PSIC.LT.0.) XC4=XC4+34.38*0.8*PP2
         IF(DUM.GT.PP) DUM=DUM-PP2
         IF(DUM.LT.-PP) DUM=DUM+PP2
  100 CONTINUE
C
      UC3=XC3+15.94*0.8*PHIC+4.5*0.8*PSIC
      UC4=XC4+3.31*0.8*PHIC+34.38*0.8*PSIC
      UC3=UC3-9.*P-3.*R-23.5*PHI-7.*PSI
      UC4=UC4+2.375*P-24.*R+4.9*PHI-50.*PSI
C
      S1=(PHIC-PHI)*.8
      S2=DUM*.8
      XC3=XC3+(15.94*S1+4.5*S2)*DT
      XC4=XC4+(3.31*S1+34.38*S2)*DT
C
      RETURN
      END

     SYMBOLIC REFERENCE MAP (R=1)

ENTRY POINTS
    3  HCON2

VARIABLES      SN   TYPE              RELOCATION
  203  DT           REAL                              204  DUM       REAL
    6  ERATE        REAL                CONST           1  G         REAL                 CONST
   67  LX           LOGICAL     ARRAY   VARDAT          0  NC        INTEGER              CONST
  177  P            REAL                              201  PHI       REAL
  175  PHIC         REAL                                4  PP        REAL                 CONST
    7  PP180        REAL                CONST          10  PP180I    REAL                 CONST
   11  PP2          REAL                CONST         202  PSI       REAL
  176  PSIC         REAL                              200  R         REAL
    2  RE           REAL                CONST           3  RE2       REAL                 CONST
    5  SCHULER      REAL                CONST         205  S1        REAL
  206  S2           REAL                                0  UC3       REAL                 F.P.
    0  UC4          REAL                 F.P.           0  UX        REAL       ARRAY     VARDAT
    0  XC1          REAL                CI              1  XC2       REAL                 CI
    2  XC3          REAL                CI              3  XC4       REAL                 CI

INLINE FUNCTIONS    TYPE     ARGS
       ABS          REAL        1  INTRIN

STATEMENT LABELS
  111   100

COMMON BLOCKS   LENGTH
       CONST        10
       CI            4
       VARDAT       70

STATISTICS
  PROGRAM LENGTH                  207B       135
  CM LABELED COMMON LENGTH        124B        84
          73000B CM USED
```

Figure 8. -Program listing of subroutine HCON2.

APPENDIX B

PROGRAM LISTING OF EXPLICIT-GAIN COMPUTATION

This appendix consists of the program listings of subroutine GAIN (Fig. 9) and GAIN2 (Fig. 10).

```
SUBROUTINE GAIN        73/74    OPT=1                                FTN 4.6+452          78/04/06. 06.36.47

                  SUBROUTINE GAIN(Z)                                               HON09      668
                  COMMON/GTAB/GN(14,13)                                            HON09      669
                  COMMON/VARDAT/UX(55),LX(15)                                      HON09      670
                  LOGICAL LX                                                       HON09      671
            C                                                                      HON09      672
            C***** TABLE LOOK-UP FOR PITCH AXIS GAIN                               HON09      673
            C       UX(27)=ACCURACY                                                HON09      674
            C                                                                      HON09      675
                   IS=3                                                            HON09      676
                  IF(UX(27).LT.0.6) IS=1                                           HON09      677
                  IF(UX(27).LT.0.3) IS=2                                           HON09      678
                  IF(.NOT.LX(3)) IS=2                                              HON09      679
                  VB=4.*Z+2.5                                                      HON09      680
                  IVB=VB                                                           HON09      681
                  IF(IVB.LT.1) IVB=1                                               HON09      682
                  IF(IVB.GT.6) IVB=6                                               HON09      683
                  I=IVB*6*(IS-1)+1                                                 HON09      684
                  IF(IS.EQ.3) I=1                                                  HON09      685
                  IF(LX(10)) I=1                                                   HON09      686
                  UX(41)=GN(1,I)                                                   HON09      687
                  UX(42)=GN(2,I)                                                   HON09      688
                  UX(43)=GN(3,I)                                                   HON09      689
                  UX(44)=GN(4,I)                                                   HON09      690
                  UX(45)=GN(5,I)                                                   HON09      691
                  UX(51)=GN(6,I)                                                   HON09      692
                  UX(52)=GN(7,I)                                                   HON09      693
                  UX(46)=GN(8,I)                                                   HON09      694
                  UX(47)=GN(9,I)                                                   HON09      695
                  UX(48)=GN(10,I)                                                  HON09      696
                  UX(49)=GN(11,I)                                                  HON09      697
                  UX(50)=GN(12,I)                                                  HON09      698
                  UX(53)=GN(13,I)                                                  HON09      699
                  UX(54)=GN(14,I)                                                  HON09      700
                  RETURN                                                           HON09      701
                  END                                                              HON09      702


SYMBOLIC REFERENCE MAP (R=1)

ENTRY POINTS
    3   GAIN

VARIABLES       SN   TYPE              RELOCATION
   0   GN            REAL          ARRAY     GTAB             74   I        INTEGER
  71   IS            INTEGER                                  73   IVB      INTEGER
  67   LX            LOGICAL       ARRAY     VARDAT            0   UX       REAL          ARRAY     VARDAT
  72   VB            REAL                                      0   Z        REAL                    F.P.

COMMON BLOCKS    LENGTH
      GTAB          182
      VARDAT         70

STATISTICS
  PROGRAM LENGTH                    75B        61
  CM LABELED COMMON LENGTH         374B       252
          73000B CM USED
```

Figure 9. -Program listing of subroutine GAIN1.

```
      SUBROUTINE GAIN2        73/74    OPT=1                             FTN 4.6+452          78/04/06. 08.36.47

                      SUBROUTINE GAIN2(Z1)                                                   HON09      704
                      COMMON/VARDAT/ UX(55),LX(15)                                           HON09      705
                      LOGICAL LX                                                             HON09      706
                      UX(41)=-0.25*Z1                                                        HON09      707
                      IF(Z1.GE.0.5) UX(41)=-0.125                                            HON09      708
                      UX(42)=-7.6+1.5*Z1                                                     HON09      709
                      UX(43)=-27.+6.*Z1                                                      HON09      710
                      UX(44)=0.14*Z1                                                         HON09      711
                      IF(Z1.GE.0.5) UX(44)=0.07                                              HON09      712
                      UX(45)=17.5-5.*Z1                                                      HON09      713
                      UX(46)=0.3-0.12*Z1                                                     HON09      714
                      UX(47)=-1.*Z1                                                          HON09      715
                      IF(Z1.GE.0.5)UX(47)=-.5                                                HON09      716
                      UX(48)=-18.*Z1                                                         HON09      717
                      UX(49)=-0.23+0.08*Z1                                                   HON09      718
                      UX(50)=2.*Z1                                                           HON09      719
                      UX(51)=UX(44)                                                          HON09      720
                      UX(52)=UX(45)                                                          HON09      721
                      UX(53)=UX(49)                                                          HON09      722
                      UX(54)=UX(50)                                                          HON09      723
                      RETURN                                                                 HON09      724
                      END                                                                    HON09      725


      SYMBOLIC REFERENCE MAP (R=1)

  ENTRY POINTS
      3   GAIN2

  VARIABLES       SN  TYPE              RELOCATION
     67  LX           LOGICAL     ARRAY     VARDAT            0  UX          REAL          ARRAY      VARDAT
      0  Z1           REAL                  F.P.

  COMMON BLOCKS    LENGTH
         VARDAT        70

  STATISTICS
    PROGRAM LENGTH                 73B        59
    CM LABELED COMMON LENGTH      106B        70
```

Figure 10. -Program listing of subroutine GAIN2.

APPENDIX C

FLOW CHART FOR REAL-TIME PORTION OF PCMLE PROGRAM

This appendix consists of the flowchart for subroutine PCMLE (Fig. 11).

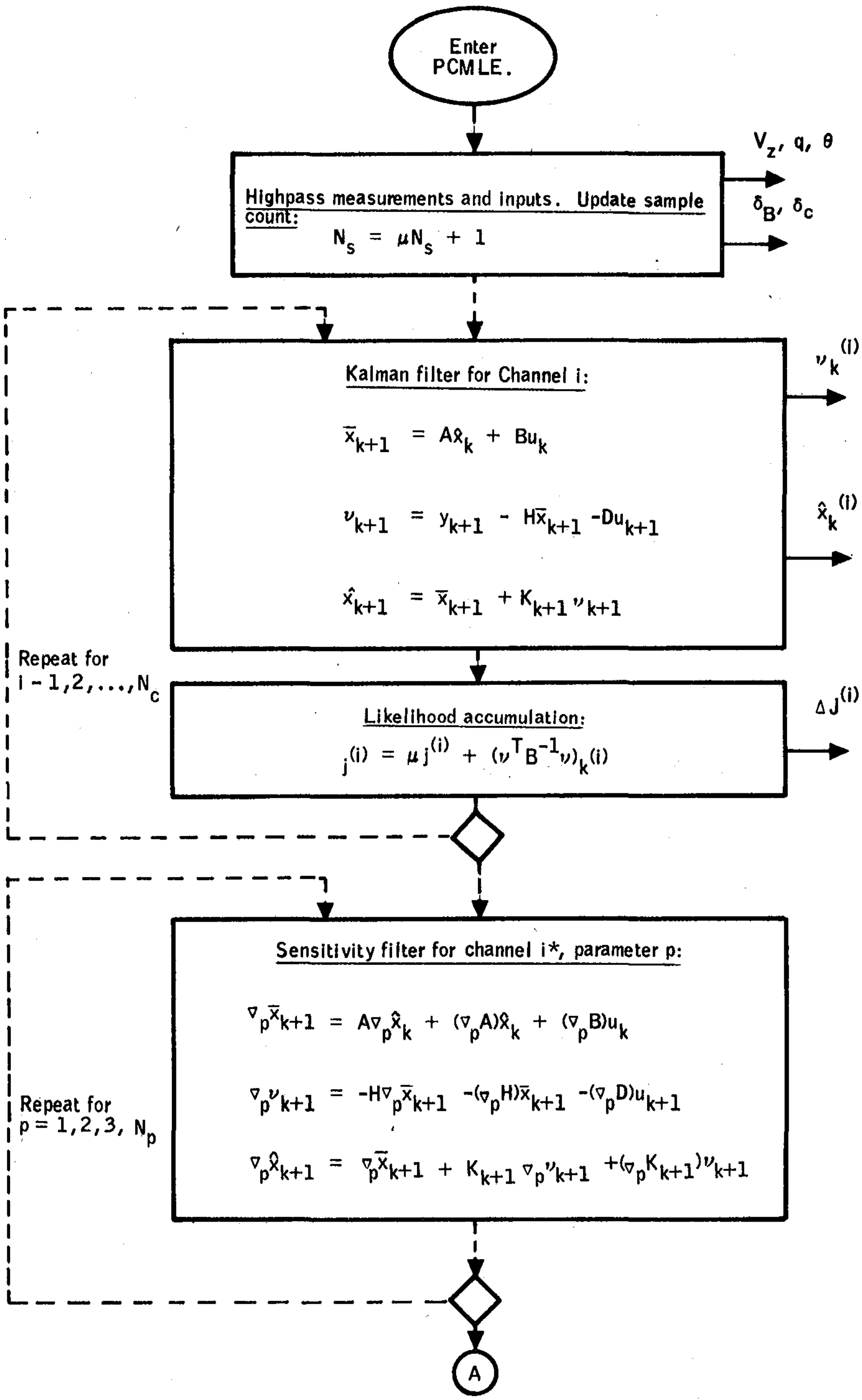


Figure 11. - Flowchart for subroutine PCMLE.

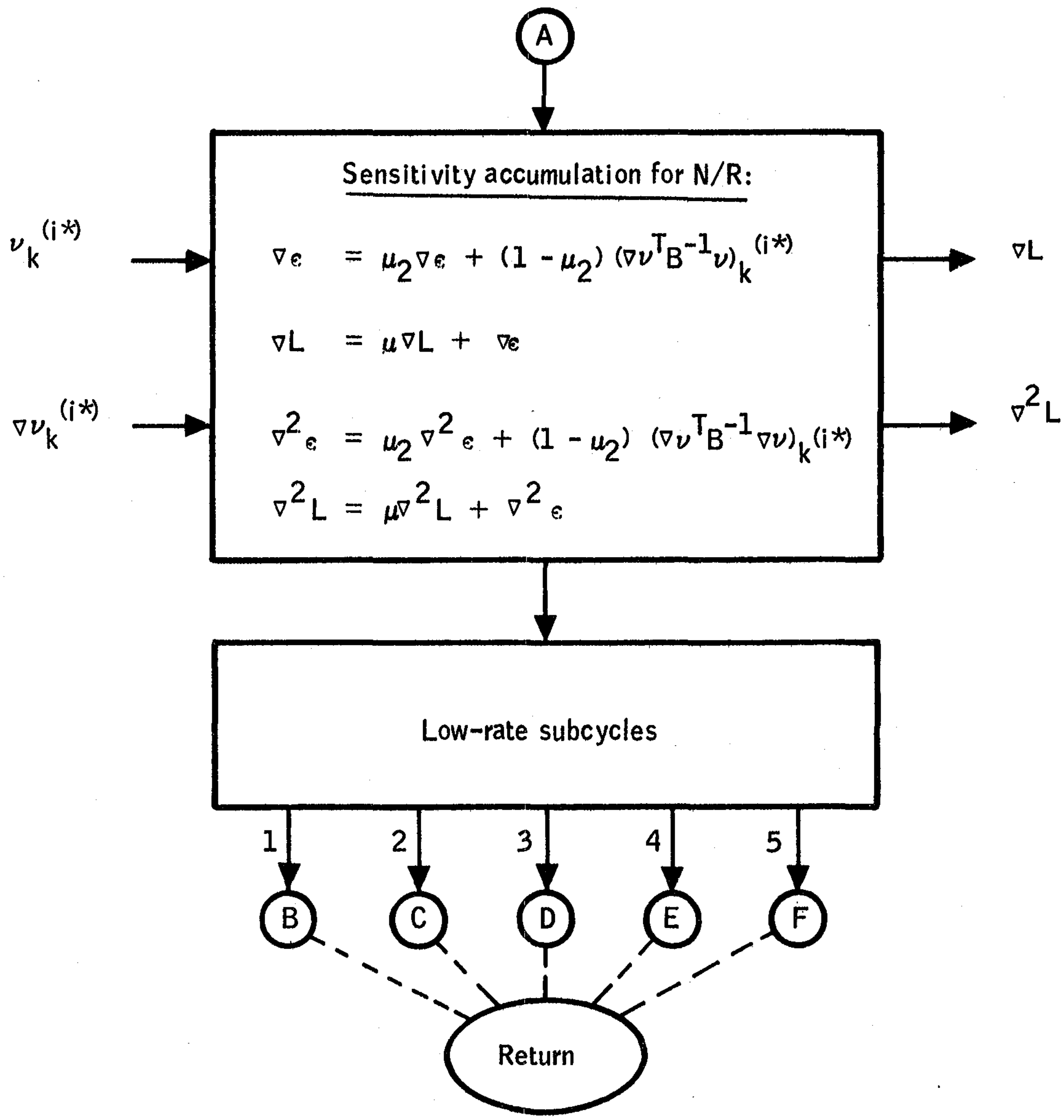


Figure 11. -Continued.

Subcycle 1: Min-L select

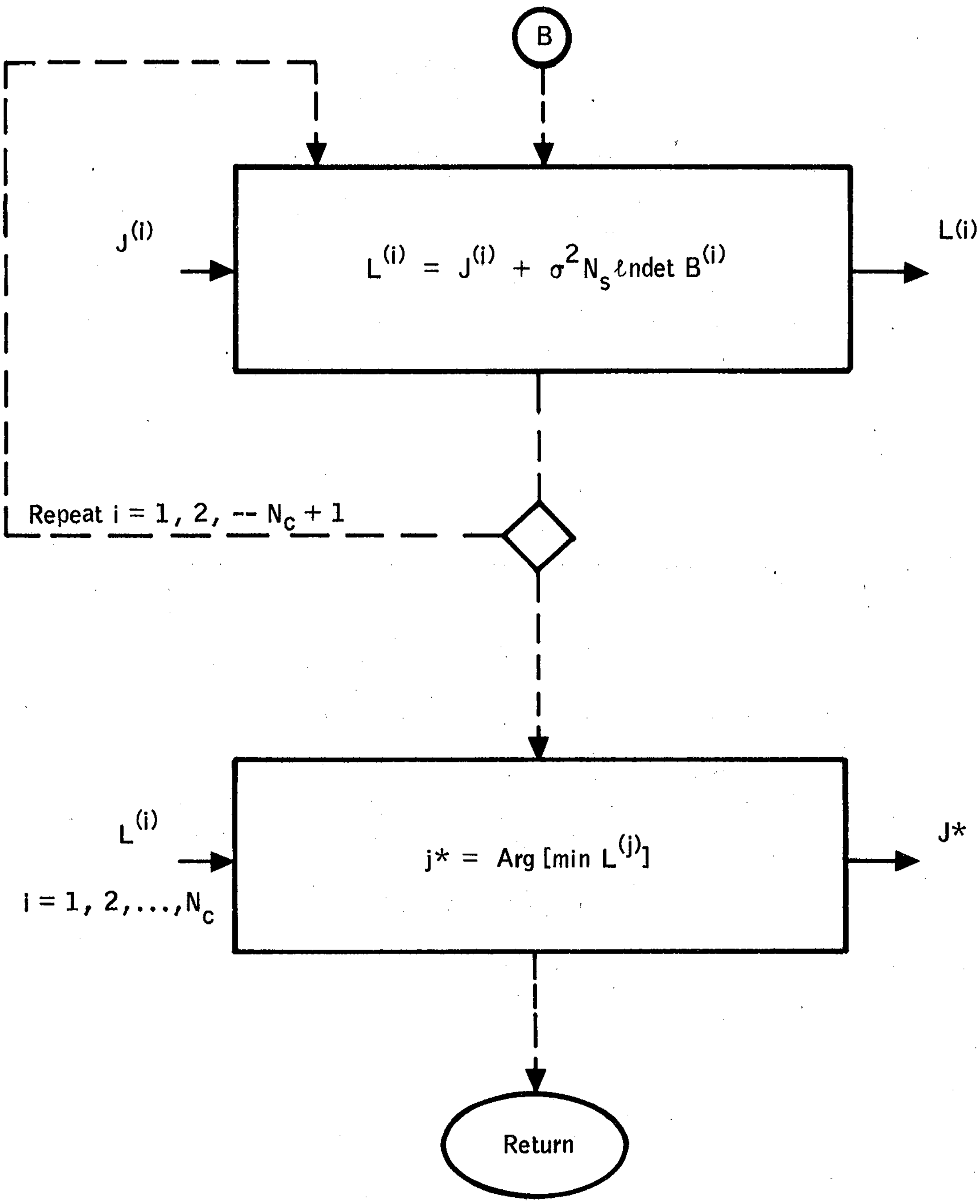


Figure 11. -Continued.

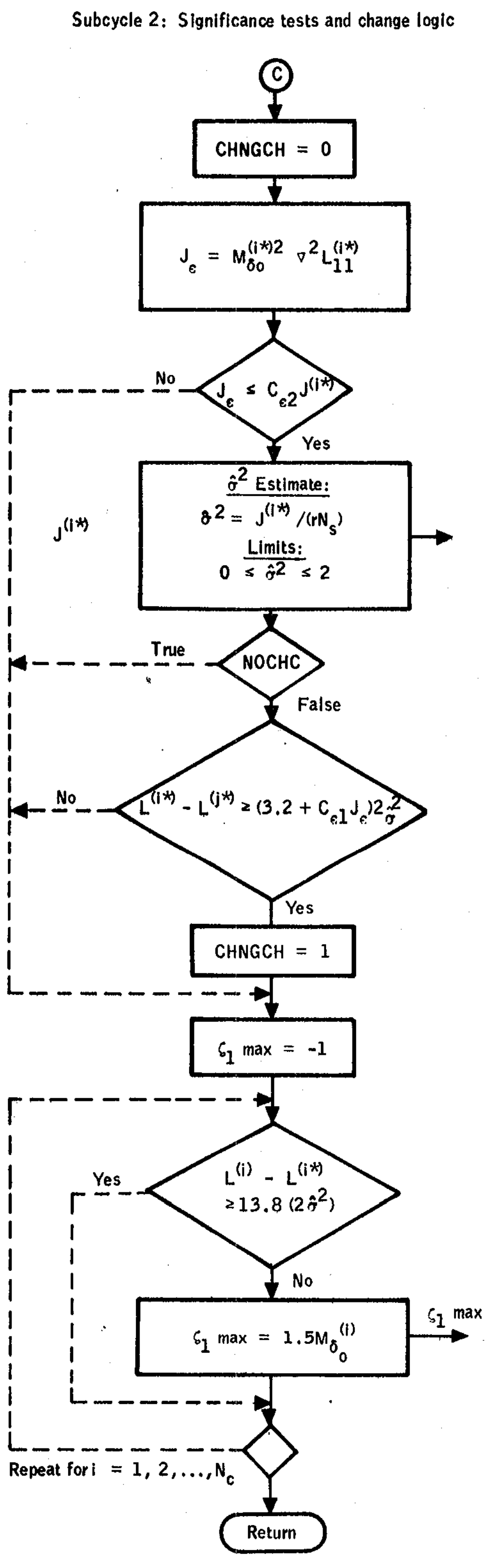


Figure 11. -Continued.

Subcycle 3: Channel data transfer

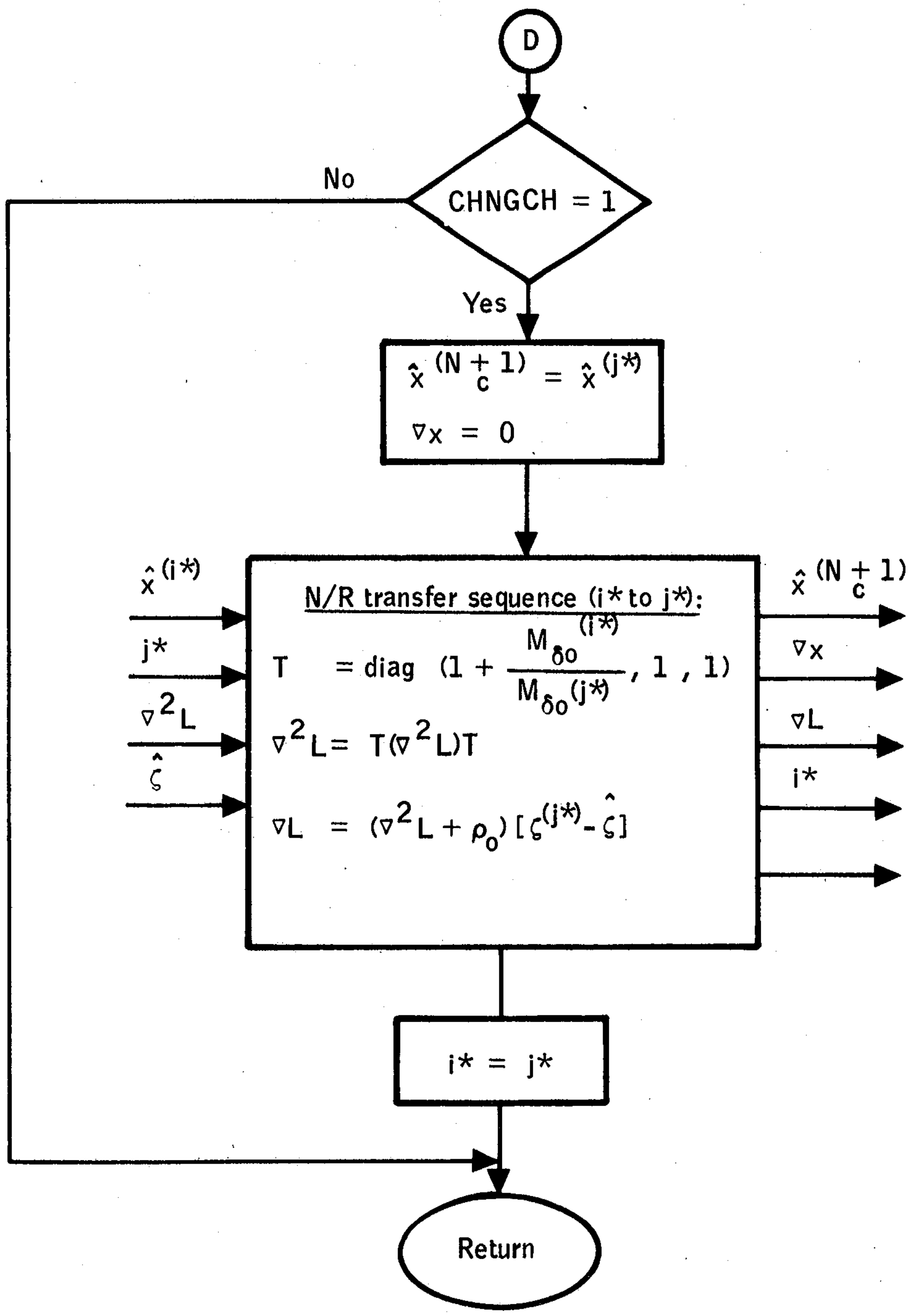
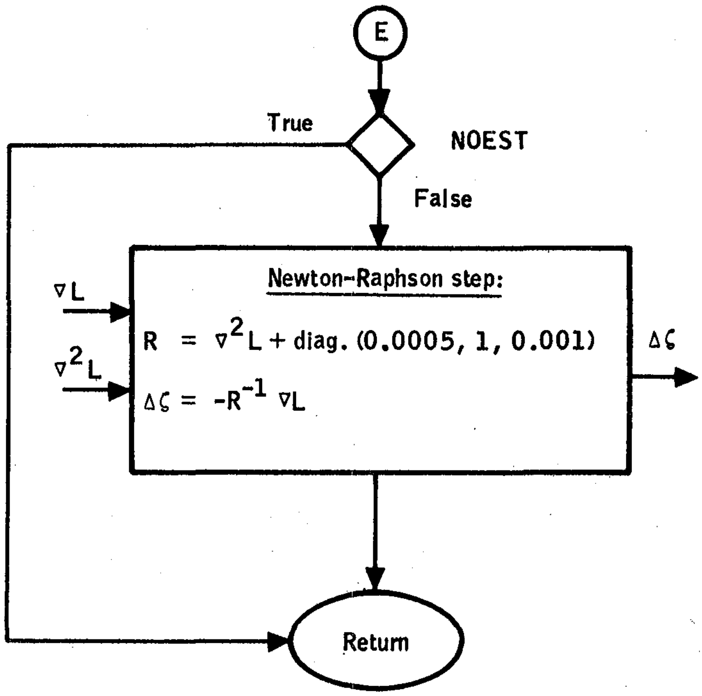


Figure 11. -Continued.

Subcycle 4: Parameter increment



Subcycle 5: Parameter estimates

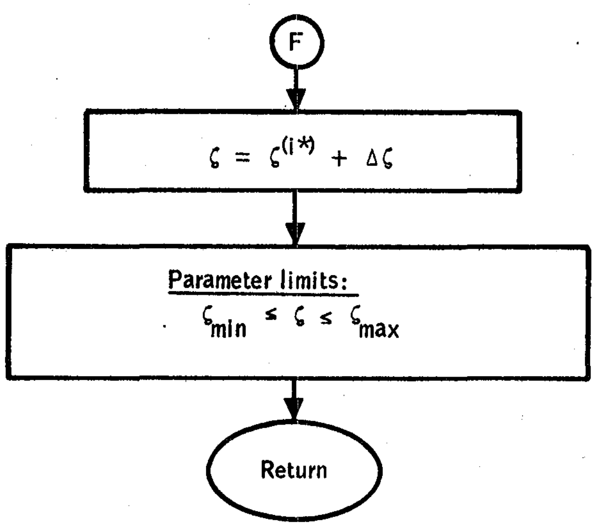


Figure 11. -Concluded.

APPENDIX D
LISTING OF PCMLE REAL-TIME SOFTWARE

This appendix is comprised of the program listings of PCMLE, FILT, SENS, ACUM, FH, and TSIG, as presented in Figures 12 through 17, respectively.

```
SUBROUTINE PCMLE       73/74    OPT=1                                   FTN 4.6+452          78/04/06. 08.36.47

            SUBROUTINE PCMLE                                                          HON09      1213
            COMMON/VARDAT/UX(55),LX(15)                                               HON09      1214
            COMMON/DAT/X(5,19),  F(5,22),D(5,22),E1P,E2P,SIGSQ                        HON09      1215
            COMMON/SENSP/XS(4,19),DS( 5,4,22),GE(4),GL(4),GSQE(10),GSQL(10)           HON09      1216
           1 ,GK(5,4,12)                                                              HON09      1217
            COMMON/IPIC/    NC,NP,JS,CHNGCH,CHSIG,ANS                                 HON09      1218
           1                 ,TPRINT,MODE,SIGUTO,ZP1,ZP2,ZP3,ZP4,TIME,RTJS            HON09      1219
           2                 ,RTJG,THRTJG,RTJC,THRTJC,RTJZ,THRTJZ,DTPRIN              HON09      1220
           3                 ,ZP1MAX,ZP2MAX,ZP3MAX,ZP4MAX                             HON09      1221
           4                 ,ZP1MIN,ZP2MIN,ZP3MIN,ZP4MIN                             HON09      1222
           5                 ,ZP( 5,4),GSQLO(4),Y(3),U(2)                             HON09      1223
           6                 ,XVZ(2),XQ(2),XTH(2),XDB(2),XDC(2),PRTIME                HON09      1224
            COMMON/MEAS/YP(3),UP(2)                                                   HON09      1225
            COMMON/SUBRH/DTHP,DHP,WHP,C1HP,C2HP                                       HON09      1226
            COMMON/UTEST/DTU,SEED,WUT,DUT,SIGUT,UT10,UT20,UTMAX,W2UT,TZWUT,           HON09      1227
           1          UT1,UT2,GAMUTO                                                  HON09      1228
            COMMON/DEVICE/NREAD,MFILE                                                 HON09      1229
            COMMON/REALTIM/VARCHNG,INTABLS,IVARBUF(5),ITYPE,FSS(16)                   HON09      1230
            DIMENSION TL(5),TJ(5),DZP(4),SS(5)                                        HON09      1231
            LOGICAL FSS                                                               HON09      1232
            LOGICAL LX, NOCHC,NOEST,PRINT,MLE                                         HON09      1233
            INTEGER CHNGCH,CHSIG                                                      HON09      1234
      C                                                                               HON09      1235
            EQUIVALENCE (TL(1),X(1,15)),(TJ(1),X(1,14))                               HON09      1236
            EQUIVALENCE (R2,GSQL(2)),(R3,GSQL(3)),(R4,GSQL(4))                        HON09      1237
           1          ,(R6,GSQL(6)),(R7,GSQL(7)),(R9,GSQL(9))                         HON09      1238
      C                                                                               HON09      1239
            TMINCH=2.                                                                 HON09      1240
      C                                                                               HON09      1241
      C                                                                               HON09      1242
      C     REAL TIME MODS                                                            HON09      1243
      C                                                                               HON09      1244
            NOCHC=LX(1)                                                               HON09      1245
            NOEST=LX(2)                                                               HON09      1246
            PRINT=LX(5)                                                               HON09      1247
            MLE=LX(9)                                                                 HON09      1248
      C                                                                               HON09      1249
            SIGUT=SIGUTO                                                              HON09      1250
      C                                                                               HON09      1251
            Y(1)=UX(11)                                                               HON09      1252
            Y(2)=UX(12)                                                               HON09      1253
            Y(3)=UX(13)                                                               HON09      1254
            U(1)=UX(14)                                                               HON09      1255
            U(2)=UX(15)                                                               HON09      1256
      C                                                                               HON09      1257
      C                                                                               HON09      1258
            UX(20)=-.5+.25*JS                                                         HON09      1259
            UX(21)=X(JS,2)/20.                                                        HON09      1260
            UX(22)=X(JS,3)*5.73                                                       HON09      1261
            UX(23)=TJ(1)/400.                                                         HON09      1262
            UX(24)=TJ(2)/400.                                                         HON09      1263
            UX(25)=TJ(3)/400.                                                         HON09      1264
            UX(26)=ZP1                                                                HON09      1265
            UX(28)=ZP2                                                                HON09      1266
            UX(29)=ZP3                                                                HON09      1267
            UX(30)=ZP4                                                                HON09      1268
```

Figure 12. -Program listing of subroutine PCMLE.

```
      UX(31)=X(JS,1)                                                    HON09    1269
      UX(32)=X(JS,4)                                                    HON09    1270
C                                                                       HON09    1271
C                                                                       HON09    1272
C     OUTPUT VARIABLES IN RUNNING MODE (BATCH ONLY)                     HON09    1273
      IF(.NOT.PRINT) GO TO 1100                                         HON09    1274
      PRTIME=PRTIME+DTHP                                                HON09    1275
      IF(PRTIME.LT.TPRINT) GO TO 1100                                   HON09    1276
      WRITE(MFILE,630) PRTIME,JS,SIGSQ                                  HON09    1277
      WRITE(MFILE,631) (TL(I),I=1,NC)                                   HON09    1278
      WRITE(MFILE,632) (TJ(I),I=1,NC)                                   HON09    1279
      WRITE(MFILE,642) (SS(I),I=1,NC)                                   HON09    1280
      WRITE(MFILE,643) Z1MIN                                            HON09    1281
      WRITE(MFILE,636) YP(1),YP(2),YP(3),UP(1),UP(2)                    HON09    1282
      WRITE(MFILE,633)                                                  HON09    1283
      WRITE(MFILE,634)(X(JS,I), I=1,17)                                 HON09    1284
      WRITE(MFILE,637)                                                  HON09    1285
      WRITE(MFILE,634) (XS(1,I),I=1,11)                                 HON09    1286
      WRITE(MFILE,634) (XS(2,I),I=1,11)                                 HON09    1287
      WRITE(MFILE,634) (XS(3,I),I=1,11)                                 HON09    1288
      WRITE(MFILE,634) (XS(4,I),I=1,11)                                 HON09    1289
      WRITE(MFILE,638)                                                  HON09    1290
      WRITE(MFILE,634) (GL(I),I=1,NP)                                   HON09    1291
      WRITE(MFILE,634) (GSQL(I),I=1,10)                                 HON09    1292
      IF(NOEST) GO TO 1090                                              HON09    1293
      IF(TIME.LT.TMINCH) GO TO 1090                                     HON09    1294
      C1 = SQRT(C1/DET)                                                 HON09    1295
      C5 = SQRT(C5/DET)                                                 HON09    1296
      C8 = SQRT(C8/DET)                                                 HON09    1297
      C10= SQRT(C10/DET)                                                HON09    1298
      C2 = C2 /(C1*C5 *DET)                                             HON09    1299
      C3 = C3 /(C1*C8 *DET)                                             HON09    1300
      C4 = C4 /(C1*C10*DET)                                             HON09    1301
      C6 = C6 /(C5*C8 *DET)                                             HON09    1302
      C7 = C7 /(C5*C10*DET)                                             HON09    1303
      C9 = C9 /(C8*C10*DET)                                             HON09    1304
 1092 WRITE(MFILE,640)                                                  HON09    1305
      WRITE(MFILE,634) C1,C2,C3,C4,C5,C6,C7,C8,C9,C10                   HON09    1306
 1090 CONTINUE                                                          HON09    1307
      WRITE(MFILE,639) ZP1,ZP2,ZP3,ZP4                                  HON09    1308
C                                                                       HON09    1309
  606 FORMAT(6E20.5)                                                    HON09    1310
  630 FORMAT(////1X,11HTIME =       ,E12.5, 6H JS = ,I2,                HON09    1311
     1 4X,8HSIGSQ =  ,E12.5,2X,2H**, /)                                 HON09    1312
  631 FORMAT(1X,11HTL =         ,9E12.5)                                HON09    1313
  632 FORMAT(1X,11HTJ =         ,9E12.5)                                HON09    1314
  633 FORMAT(1H0,22HSTATE ESTIMATES  X(JS)    )                         HON09    1315
  634 FORMAT(10E12.5)                                                   HON09    1316
  636 FORMAT(1H0,16HY1,Y2,Y3,U1,U2 =,6E12.5)                            HON09    1317
  637 FORMAT(1X,13HSENSITIVITIES)                                       HON09    1318
  638 FORMAT(1X,5HGRADS )                                               HON09    1319
  639 FORMAT(1H0,11HZP =          ,9E12.5)                              HON09    1320
  640 FORMAT(1X,8HACCURACY)                                             HON09    1321
  642 FORMAT(1X,11HPR =         ,9F12.9)                                HON09    1322
  643 FORMAT(1X,11HZ1MIN =      ,E12.5)                                 HON09    1323
 1099 CONTINUE                                                          HON09    1324
      TPRINT=TPRINT+ DTPRIN                                             HON09    1325
 1100 CONTINUE                                                          HON09    1326
C                                                                       HON09    1327
C     TEST SIGNAL                                                       HON09    1328
      CALL TSIG(ETA1,ETA2,UT)                                           HON09    1329
C                                                                       HON09    1330
C                                                                       HON09    1331
C     HIGH PASS INPUTS                                                  HON09    1332
      CALL FH(Y(1),YP(1),XVZ)                                           HON09    1333
      CALL FH(Y(2),YP(2),XQ)                                            HON09    1334
      CALL FH(Y(3),YP(3),XTH)                                           HON09    1335
      CALL FH(U(1),UP(1),XDB)                                           HON09    1336
      CALL FH(U(2),UP(2),XDC)                                           HON09    1337
C                                                                       HON09    1338
C     PARALLEL CHANNELS                                                 HON09    1339
      IF(.NOT.MLE) RETURN                                               HON09    1340
      TIME=TIME + DTHP                                                  HON09    1341
      ANS=E1P*ANS + 1.                                                  HON09    1342
      GO TO (1210,1209,1208,1207,1206), NC                              HON09    1343
 1206 CALL FILT(5)                                                      HON09    1344
 1207 CALL FILT(4)                                                      HON09    1345
 1208 CALL FILT(3)                                                      HON09    1346
 1209 CALL FILT(2)                                                      HON09    1347
```

Figure 12. -Continued.

```
 1210 CALL FILT(1)
C
C     SENSITIVITIES
      GO TO (1304,1303,1302,1301), NP
 1301 CALL SENS(JS,4)
 1302 CALL SENS(JS,3)
 1303 CALL SENS(JS,2)
 1304 CALL SENS(JS,1)
C
C     LIKELIHOOD ACCUMULATION
      CALL ACUM(JS)
C
  900 CONTINUE
C
C
C     BRANCH TO LOW RATE OPERATIONS ************************************
C
      GO TO (910,920,930,940,950), MODE
C
C     CYCLE 1.  MIN-L CHANNEL SELECTION
C
  910 CONTINUE
      TLMAX = -1.E10
      TLMIN = 1.E10
      TJMIN=1.E10
      DO 911 I=1,NC
      S1=TJ(I) + SIGSQ*ANS*F(I,13)
      TL(I)= S1
      IF(S1.GT.TLMAX) TLMAX=S1
      IF(S1.LT.TLMIN) TLMIN=S1
      IF(TJ(I).GT.TJMIN) GO TO 911
      TJMIN = TJ(I)
      JSTEMP = I
  911 CONTINUE
      MODE = 2
      RETURN
C
C     CYCLE 2.  SIGNIFICANCE TESTS AND CHANGE LOGIC
C
  920 CONTINUE
      CHNGCH=0
      TJE=0.01*GSQL(1)
C
      IF(TJE.GT.RTJS*TJ(JS)) GO TO 925
      SIGSQ= TJ(JS)/(ANS + ANS)
      IF(SIGSQ.GT.2.) SIGSQ=2.
      IF(SIGSQ.LT.1.0E-04) SIGSQ=1.0E-04
C
  925 IF(NOCHC) GO TO 926
      IF(TL(JS) - TL(JSTEMP).GT.(THRTJC+RTJC*TJE)) CHNGCH=1
C
  926 CONTINUE
      DO 927 I=1,NC
      IF(TL(I) - TL(JS).LT.(THRTJZ + RTJZ*TJE)) Z1MIN=ZP(I,1)
      SS(I)= (TL(JS)- TL(I))*0.5
      IF(SS(I).GT.0.) SS(I)=0.
      IF(SS(I).LT.-23.) SS(I)=-23.
 1094 SS(I)=EXP(SS(I))
  927 CONTINUE
      UX(33)=SIGSQ
      MODE= 3
      RETURN
C
C     CHANNEL TRANSFERS
C
  930 CONTINUE
      IF(CHNGCH.EQ.0) GO TO 939
      IF(TIME.GT.THINCH) GO TO 9301
      DO 9303 I=1,10
      GSQL(I)=0.
 9303 GSQE(I)=0.
      DO 9302 I=1,4
      DZP(I)=0.
      GL(I)=0.
 9302 GE(I)=0.
      GO TO 934
 9301 CONTINUE
C
C     CHANNEL TRANSFER SEQUENCE (NR)
```

Figure 12. -Continued.

```
C     SCALE GRAD SQ L                                                  HON09  1427
      S1=1. + ZP(JS,1)/ZP(JSTEMP,1)                                    HON09  1428
      GSQL(1)= GSQL(1)*S1*S1                                           HON09  1429
      GSQL(2)= GSQL(2)*S1                                              HON09  1430
      GSQL(3)= GSQL(3)*S1                                              HON09  1431
      GSQL(4)= GSQL(4)*S1                                              HON09  1432
C                                                                      HON09  1433
      S1=GSQL(1) + GSQLO(1)                                            HON09  1434
      S2=GSQL(5) + GSQLO(2)                                            HON09  1435
      S3=GSQL(8) + GSQLO(3)                                            HON09  1436
      S4=GSQL(10)+ GSQLO(4)                                            HON09  1437
C     NEW GRAD L                                                       HON09  1438
      DZP(1)=-ZP1 + ZP(JSTEMP,1)                                       HON09  1439
      DZP(2)=-ZP2 + ZP(JSTEMP,2)                                       HON09  1440
      DZP(3)=-ZP3 + ZP(JSTEMP,3)                                       HON09  1441
      DZP(4)=-ZP4 + ZP(JSTEMP,4)                                       HON09  1442
      GL(1)=S1      *DZP(1)+GSQL(2)*DZP(2)+GSQL(3)*DZP(3)+GSQL(4)*DZP(4) HON09  1443
      GL(2)=GSQL(2)*DZP(1)+S2      *DZP(2)+GSQL(6)*DZP(3)+GSQL(7)*DZP(4) HON09  1444
      GL(3)=GSQL(3)*DZP(1)+GSQL(6)*DZP(2)+S3      *DZP(3)+GSQL(9)*DZP(4) HON09  1445
      GL(4)=GSQL(4)*DZP(1)+GSQL(7)*DZP(2)+GSQL(9)*DZP(3)+S4      *DZP(4) HON09  1446
  934 JS=JSTEMP                                                        HON09  1447
C                                                                      HON09  1448
  939 CONTINUE                                                         HON09  1449
      MODE= 4                                                          HON09  1450
      RETURN                                                           HON09  1451
C                                                                      HON09  1452
C     CYCLE 4.  PARAMETER INCREMENTS                                   HON09  1453
C                                                                      HON09  1454
  940 CONTINUE                                                         HON09  1455
      IF(NOEST) GO TO 948                                              HON09  1456
C                                                                      HON09  1457
C     NR INCREMENTS                                                    HON09  1458
      R1=GSQL(1) + GSQLO(1)                                            HON09  1459
      R5=GSQL(5) + GSQLO(2)                                            HON09  1460
      R8=GSQL(8) + GSQLO(3)                                            HON09  1461
      R10=GSQL(10)+GSQLO(4)                                            HON09  1462
C     COFACTORS FOR EXPLICIT INVERSE                                   HON09  1463
      R81099=R8*R10-R9*R9                                              HON09  1464
      R61097=R6*R10-R9*R7                                              HON09  1465
      R6978= R6*R9-R7*R8                                               HON09  1466
      R3764=R3*R7-R6*R4                                                HON09  1467
      R2754=R2*R7-R5*R4                                                HON09  1468
      R2653=R2*R6-R5*R3                                                HON09  1469
      R21047=R2*R10 -R4*R7                                             HON09  1470
      R2937=R2*R9 -R3*R7                                               HON09  1471
      R2836=R2*R8-R3*R6                                                HON09  1472
C     INVERSE                                                          HON09  1473
      C1= R5*R81099 - R6*R61097 + R7*R6978                             HON09  1474
      C2=-(R2*R81099 - R3*R61097 + R4*R6978)                           HON09  1475
      C3=R7*R3764 - R9*R2754 + R10*R2653                               HON09  1476
      C4=-(R6*R3764 - R8*R2754 + R9*R2653)                             HON09  1477
      C5=R1*R81099 - R3*(R3*R10 - R4*R9) + R4*(R3*R9 - R4*R8)          HON09  1478
      C6=-(R1*R61097 - R3*R21047 + R4*(R2*R9 - R4*R6))                 HON09  1479
      C7=R1*R6978 - R3*R2937 + R4*R2836                                HON09  1480
      C8=R1*(R5*R10 - R7*R7) -R2*R21047 + R4*R2754                     HON09  1481
      C9=-(R1*(R5*R9 - R6*R7) - R2*R2937 + R4*R2653)                   HON09  1482
      C10=R1*(R5*R8 - R6*R6) - R2*R2836 + R3*R2653                     HON09  1483
      DET= R1*C1 + R2*C2 + R3*C3 + R4*C4                               HON09  1484
      IF(DET.EQ.0.0) STOP 21                                           HON09  1485
C     INCREMENTS                                                       HON09  1486
      DZP(1)= -(C1*GL(1)+C2*GL(2)+C3*GL(3)+C4*GL(4))/DET               HON09  1487
      DZP(2)= -(C2*GL(1)+C5*GL(2)+C6*GL(3)+C7*GL(4))/DET               HON09  1488
      DZP(3)= -(C3*GL(1)+C6*GL(2)+C8*GL(3)+C9*GL(4))/DET               HON09  1489
      DZP(4)= -(C4*GL(1)+C7*GL(2)+C9*GL(3)+C10*GL(4))/DET              HON09  1490
      UX(27)=SQRT(C1/DET)                                              HON09  1491
  948 MODE = 5                                                         HON09  1492
      RETURN                                                           HON09  1493
C                                                                      HON09  1494
C     CYCLE 5.  PARAMETER UPDATES                                      HON09  1495
C                                                                      HON09  1496
  950 CONTINUE                                                         HON09  1497
C     UPDATE ZP                                                        HON09  1498
      ZP1= ZP(JS,1) + DZP(1)                                           HON09  1499
      ZP2= ZP(JS,2) + DZP(2)                                           HON09  1500
      ZP3= ZP(JS,3) + DZP(3)                                           HON09  1501
      ZP4= ZP(JS,4) + DZP(4)                                           HON09  1502
      IF(ZP1.GT.ZP1MAX) ZP1=ZP1MAX                                     HON09  1503
      IF(ZP2.GT.ZP2MAX) ZP2=ZP2MAX                                     HON09  1504
      IF(ZP3.GT.ZP3MAX) ZP3=ZP3MAX                                     HON09  1505
      IF(ZP4.GT.ZP4MAX) ZP4=ZP4MAX                                     HON09  1506
```

Figure 12. -Continued.

```
 295          IF(ZP1.LT.ZP1MIN) ZP1=ZP1MIN                                  HON09    1507
              IF(ZP2.LT.ZP2MIN) ZP2=ZP2MIN                                  HON09    1508
              IF(ZP3.LT.ZP3MIN) ZP3=ZP3MIN                                  HON09    1509
              IF(ZP4.LT.ZP4MIN) ZP4=ZP4MIN                                  HON09    1510
        C     OTHER VARIABLES                                               HON09    1511
 300          MODE= 1                                                       HON09    1512
              RETURN                                                        HON09    1513
        C                                                                   HON09    1514
              END                                                           HON09    1515
```

```
    SYMBOLIC REFERENCE MAP (R=1)

ENTRY POINTS
   1  PCMLE

VARIABLES      SN  TYPE             RELOCATION
   5  ANS          REAL                  IPIC          3  CHNGCH   INTEGER           IPIC
   4  CHSIG        INTEGER               IPIC       1362  C1       REAL
   3  C1HP         REAL                  SUBRH      1366  C10      REAL
1367  C2           REAL                                4  C2HP     REAL              SUBRH
1370  C3           REAL                             1371  C4       REAL
1364  C5           REAL                             1372  C6       REAL
1373  C7           REAL                             1365  C8       REAL
1374  C9           REAL                              315  D        REAL     ARRAY    DAT
1363  DET          REAL                                1  DHP      REAL              SUBRH
 114  DS           REAL       ARRAY      SENSP         0  DTHP     REAL              SUBRH
  25  DTPRIN       REAL                  IPIC          0  DTU      REAL              UTEST
   3  DUT          REAL                  UTEST      1426  DZP      REAL     ARRAY
1375  ETA1         REAL                             1376  ETA2     REAL
 473  E1P          REAL                  DAT         474  E2P      REAL              DAT
 137  F            REAL       ARRAY      DAT          10  FSS      LOGICAL  ARRAY    REALTIM
  14  GAMUTO       REAL                  UTEST      1004  GE       REAL     ARRAY    SENSP
1040  GK           REAL       ARRAY      SENSP      1010  GL       REAL     ARRAY    SENSP
1014  GSQE         REAL       ARRAY      SENSP      1026  GSQL     REAL     ARRAY    SENSP
  62  GSQLO        REAL       ARRAY      IPIC       1360  I        INTEGER
   1  INTABLS      INTEGER               REALTIM       7  ITYPE    INTEGER           REALTIM
   2  IVARBUF      INTEGER    ARRAY      REALTIM       2  JS       INTEGER           IPIC
1404  JSTEMP       INTEGER                            67  LX       LOGICAL  ARRAY    VARDAT
   1  MFILE        INTEGER               DEVICE     1356  MLE      LOGICAL
   7  MODE         INTEGER               IPIC          0  NC       INTEGER           IPIC
1353  NOCHC        LOGICAL                          1354  NOEST    LOGICAL
   1  NP           INTEGER               IPIC          0  NREAD    INTEGER           DEVICE
1355  PRINT        LOGICAL                           105  PRTIME   REAL              IPIC
  21  RTJC         REAL                  IPIC         17  RTJG     REAL              IPIC
  16  RTJS         REAL                  IPIC         23  RTJZ     REAL              IPIC
1411  R1           REAL                             1414  R10      REAL
1027  R2           REAL                  SENSP      1423  R21047   REAL
1422  R2653        REAL                             1421  R2754    REAL
1425  R2836        REAL                             1424  R2937    REAL
1030  R3           REAL                  SENSP      1420  R3764    REAL
1031  R4           REAL                  SENSP      1412  R5       REAL
1033  R6           REAL                  SENSP      1416  R61097   REAL
1417  R6978        REAL                             1034  R7       REAL              SENSP
1413  R8           REAL                             1415  R81099   REAL
1036  R9           REAL                  SENSP         1  SEED     REAL              UTEST
 475  SIGSQ        REAL                  DAT           4  SIGUT    REAL              UTEST
  10  SIGUTO       REAL                  IPIC       1432  SS       REAL     ARRAY
1403  S1           REAL                             1406  S2       REAL
1407  S3           REAL                             1410  S4       REAL
  22  THRTJC       REAL                  IPIC         20  THRTJG   REAL              IPIC
  24  THRTJZ       REAL                  IPIC         15  TIME     REAL              IPIC
 101  TJ           REAL       ARRAY      DAT        1405  TJE      REAL
1402  TJMIN        REAL                              106  TL       REAL     ARRAY    DAT
1400  TLMAX        REAL                             1401  TLMIN    REAL
1357  TMINCH       REAL                                6  TPRINT   REAL              IPIC
  11  TZWUT        REAL                  UTEST        71  U        REAL     ARRAY    IPIC
   3  UP           REAL       ARRAY      MEAS       1377  UT       REAL
   7  UTMAX        REAL                  UTEST        12  UT1      REAL              UTEST
   5  UT10         REAL                  UTEST        13  UT2      REAL              UTEST
   6  UT20         REAL                  UTEST         0  UX       REAL     ARRAY    VARDAT
   0  VARCHNG      REAL                  REALTIM       2  WHP      REAL              SUBRH
   2  WUT          REAL                  UTEST        10  W2UT     REAL              UTEST
   0  X            REAL       ARRAY      DAT         101  XDB      REAL     ARRAY    IPIC
 103  XDC          REAL       ARRAY      IPIC         75  XQ       REAL     ARRAY    IPIC
   0  XS           REAL       ARRAY      SENSP        77  XTH      REAL     ARRAY    IPIC
```

Figure 12. -Continued.

```
     73  XVZ        REAL       ARRAY     IPIC          66  Y          REAL       ARRAY     IPIC
      0  YP         REAL       ARRAY     MEAS          36  ZP         REAL       ARRAY     IPIC
     11  ZP1        REAL                 IPIC          26  ZP1MAX     REAL                 IPIC
     32  ZP1MIN     REAL                 IPIC          12  ZP2        REAL                 IPIC
     27  ZP2MAX     REAL                 IPIC          33  ZP2MIN     REAL                 IPIC
     13  ZP3        REAL                 IPIC          30  ZP3MAX     REAL                 IPIC
     34  ZP3MIN     REAL                 IPIC          14  ZP4        REAL                 IPIC
     31  ZP4MAX     REAL                 IPIC          35  ZP4MIN     REAL                 IPIC
   1361  Z1MIN      REAL

 EXTERNALS            TYPE    ARGS
         ACUM                  1                           EXP        REAL       1 LIBRARY
         FH                    3                           FILT                  1
         SENS                  2                           SQRT       REAL       1 LIBRARY
         TSIG                  3

 STATEMENT LABELS
   1246  606     FMT   NO REFS           1250  630     FMT                      1260  631     FMT
   1264  632     FMT                     1270  633     FMT                      1274  634     FMT
   1276  636     FMT                     1302  637     FMT                      1305  638     FMT
   1310  639     FMT                     1314  640     FMT                      1317  642     FMT
   1323  643     FMT                        0  900         INACTIVE              352  910
    377  911                              403  920                               417  925
    427  926                                0  927                               462  930
    562  934                              564  939                               566  940
    763  948                              765  950                               244  1090
      0  1092        INACTIVE               0  1094        INACTIVE                0  1099        INACTIVE
    250  1100                             303  1206                              305  1207
    307  1208                             311  1209                              313  1210
    326  1301                             330  1302                              332  1303
    334  1304                             503  9301                                0  9302
      0  9303

 LOOPS   LABEL     INDEX      FROM-TO     LENGTH     PROPERTIES
    105              * I       72  72       11B                EXT REFS
    124              * I       74  74        7B                EXT REFS
    137              * I       75  75        7B                EXT REFS
    152              * I       76  76        7B                EXT REFS
    165              * I       77  77        7B                EXT REFS
    363  911           I      161 169       15B          OPT
    430  927         * I      188 194       27B                EXT REFS
    470  9303          I      204 206        3B       INSTACK
    476  9302          I      207 210        3B       INSTACK

 COMMON BLOCKS    LENGTH
        VARDAT        70
        DAT          318

COMMON BLOCKS    LENGTH
       SENSP        784
       IPIC          70
       MEAS           5
       SUBRH          5
       UTEST         13
       DEVICE         2
       REALTIM       24

STATISTICS
  PROGRAM LENGTH                  1441B       801
  CM LABELED COMMON LENGTH        2413B      1291
           73000B CM USED
```

Figure 12. -Concluded.

```
SUBROUTINE FILT        73/74    OPT=1                         FTN 4.6+439        78/02/14. 08.28.50

             SUBROUTINE FILT(K)                                                    HON09      589
             COMMON/DAT/X(5,19),   F(5,22),D(5,22),E1P,E2P,SIGSQ                   HON09      590
             COMMON/MEAS/YP(3),UP(2)                                               HON09      591
      C      K=CHANNEL INDEX                                                       HON09      592
      C      SAVE X                                                                HON09      593
             X(K,1)=X(K,5)                                                         HON09      594
             X(K,2)=X(K,6)                                                         HON09      595
             X(K,3)=X(K,7)                                                         HON09      596
             X(K,4)=X(K,8)                                                         HON09      597
      C      RESIDUALS                                                             HON09      598
             X(K,9)= YP(1) - X(K,2)                                                HON09      599
             X(K,10)=YP(2) - X(K,3)                                                HON09      600
             X(K,11)=YP(3) - X(K,4)                                                HON09      601
      C      UPDATE X                                                              HON09      602
             X(K,5)=D(K, 1)*X(K,5) + D(K, 2)*X(K,6) + D(K, 3)*X(K,7) +             HON09      603
            1        D(K, 4)*X(K,8) + D(K,17)*UP(1) + D(K,18)*UP(2) +              HON09      604
            2        F(K,1)*X(K,9) + F(K,5)*X(K,10) + F(K,9)*X(K,11)               HON09      605
             X(K,6)=D(K, 5)*X(K,5) + D(K, 6)*X(K,6) + D(K, 7)*X(K,7) +             HON09      606
            1        D(K, 8)*X(K,8) + D(K,19)*UP(1) + D(K,20)*UP(2) +              HON09      607
            2        F(K,2)*X(K,9) + F(K,6)*X(K,10) + F(K,10)*X(K,11)              HON09      608
             X(K,7)=D(K, 9)*X(K,5) + D(K,10)*X(K,6) + D(K,11)*X(K,7) +             HON09      609
            1        D(K,12)*X(K,8) + D(K,21)*UP(1) + D(K,22)*UP(2) +              HON09      610
            2        F(K,3)*X(K,9) + F(K,7)*X(K,10) + F(K,11)*X(K,11)              HON09      611
             X(K,8)=D(K,13)*X(K,5) + D(K,14)*X(K,6) + D(K,15)*X(K,7) +             HON09      612
            1        D(K,16)*X(K,8) +                                              HON09      613
            2        F(K,4)*X(K,9) + F(K,8)*X(K,10) + F(K,12)*X(K,11)              HON09      614
      C      (NU)(RI)(NU)                                                          HON09      615
             X(K,12)=F(K,14)*X(K,9)*X(K,9) + F(K,18)*X(K,10)*X(K,10) +             HON09      616
            1 F(K,22)*X(K,11)*X(K,11) + (F(K,15)+F(K,17))*X(K,9)*X(K,10) +         HON09      617
            2 (F(K,16)+F(K,20))*X(K,9)*X(K,11) + (F(K,19)+F(K,21))*X(K,10)*        HON09      618
            3 X(K,11)                                                              HON09      619
      C      SUM                                                                   HON09      620
             X(K,14)=E1P*X(K,14) + X(K,12)                                         HON09      621
      C      (NU)(RI)(NU) + LNDETR                                                 HON09      622
             X(K,13)=X(K,12) + SIGSQ*F(K,13)                                       HON09      623
             RETURN                                                                HON09      624
             END                                                                   HON09      625
```

```
     SYMBOLIC REFERENCE MAP (R=1)

ENTRY POINTS
    3  FILT

VARIABLES        SN   TYPE            RELOCATION
   315  D              REAL        ARRAY     DAT              473  E1P        REAL                 DAT
   474  E2P            REAL                  DAT              137  F          REAL        ARRAY    DAT
     0  K              INTEGER                F.P.            475  SIGSQ      REAL                 DAT
     3  UP             REAL        ARRAY     MEAS               0  X          REAL        ARRAY    DAT
     0  YP             REAL        ARRAY     MEAS

COMMON BLOCKS    LENGTH
       DAT          318
       MEAS           5

STATISTICS
  PROGRAM LENGTH                     172B      122
  CM LABELED COMMON LENGTH           503B      323
```

Figure 13. -Program listing of subroutine FILT.

```
SUBROUTINE SENS        73/74    OPT=1                         FTN 4.6+439          78/02/14. 08.28.50

      SUBROUTINE SENS(K,J)                                                 HON09     1679
      COMMON/DAT/X(5,19),  F(5,22),D(5,22),E1P,E2P,SIGSQ                   HON09     1680
      COMMON/MEAS/YP(3),UP(2)                                              HON09     1681
      COMMON/SENSP/XS(4,19),DS( 5,4,22),GE(4),GL(4),GSQE(10),GSQL(10)      HON09     1682
     1 ,GK(5,4,12)                                                         HON09     1683
C     J=PARAMETER INDEX                                                    HON09     1684
C     K=CHANNEL INDEX                                                      HON09     1685
C     SAVE GRAD X                                                          HON09     1686
      XS(J,1)= XS(J,5)                                                     HON09     1687
      XS(J,2)= XS(J,6)                                                     HON09     1688
      XS(J,3)= XS(J,7)                                                     HON09     1689
      XS(J,4)= XS(J,8)                                                     HON09     1690
C     GRAD NU= -H*(GX)                                                     HON09     1691
      XS(J, 9)= -XS(J,2)                                                   HON09     1692
      XS(J,10)= -XS(J,3)                                                   HON09     1693
      XS(J,11)= -XS(J,4)                                                   HON09     1694
C     GRAD X UPDATE                                                        HON09     1695
      XS(J,5)=D(K, 1)*XS(J,5) + D(K, 2)*XS(J,6) + D(K, 3)*XS(J,7) +        HON09     1696
     1        D(K, 4)*XS(J,8) + DS(K,J, 1)*X(K,5) + DS(K,J, 2)*X(K,6) +    HON09     1697
     2        DS(K,J, 3)*X(K,7) + DS(K,J, 4)*X(K,8) + DS(K,J,17)*UP(1)     HON09     1698
     3      + DS(K,J,18)*UP(2) + F(K, 1)*XS(J,9) + F(K, 5)*XS(J,10) +      HON09     1699
     4        F(K, 9)*XS(J,11) + GK(K,J, 1)*X(K,9) + GK(K,J, 5)*X(K,10)    HON09     1700
     5      + GK(K,J, 9)*X(K,11)                                           HON09     1701
      XS(J,6)=D(K, 5)*XS(J,5) + D(K, 6)*XS(J,6) + D(K, 7)*XS(J,7) +        HON09     1702
     1        D(K, 8)*XS(J,8) + DS(K,J, 5)*X(K,5) + DS(K,J, 6)*X(K,6) +    HON09     1703
     2        DS(K,J, 7)*X(K,7) + DS(K,J, 8)*X(K,8) + DS(K,J,19)*UP(1)     HON09     1704
     3      + DS(K,J,20)*UP(2) + F(K, 2)*XS(J,9) + F(K, 6)*XS(J,10) +      HON09     1705
     4        F(K,10)*XS(J,11) + GK(K,J, 2)*X(K,9) + GK(K,J, 6)*X(K,10)    HON09     1706
     5      + GK(K,J,10)*X(K,11)                                           HON09     1707
      XS(J,7)=D(K, 9)*XS(J,5) + D(K,10)*XS(J,6) + D(K,11)*XS(J,7) +        HON09     1708
     1        D(K,12)*XS(J,8) + DS(K,J, 9)*X(K,5) + DS(K,J,10)*X(K,6) +    HON09     1709
     2        DS(K,J,11)*X(K,7) + DS(K,J,12)*X(K,8) + DS(K,J,21)*UP(1)     HON09     1710
     3      + DS(K,J,22)*UP(2) + F(K, 3)*XS(J,9) + F(K, 7)*XS(J,10) +      HON09     1711
     4        F(K,11)*XS(J,11) + GK(K,J, 3)*X(K,9) + GK(K,J, 7)*X(K,10)    HON09     1712
     5      + GK(K,J,11)*X(K,11)                                           HON09     1713
      XS(J,8)=D(K,13)*XS(J,5) + D(K,14)*XS(J,6) + D(K,15)*XS(J,7) +        HON09     1714
     1        D(K,16)*XS(J,8) + DS(K,J,13)*X(K,5) + DS(K,J,14)*X(K,6) +    HON09     1715
     2        DS(K,J,15)*X(K,7) + DS(K,J,16)*X(K,8)                        HON09     1716
     3                         + F(K, 4)*XS(J,9) + F(K, 8)*XS(J,10) +      HON09     1717
     4        F(K,12)*XS(J,11) + GK(K,J, 4)*X(K,9) + GK(K,J, 8)*X(K,10)    HON09     1718
     5      + GK(K,J,12)*X(K,11)                                           HON09     1719
      RETURN                                                               HON09     1720
      END                                                                  HON09     1721
```

```
        SYMBOLIC REFERENCE MAP (R=1)

ENTRY POINTS
    3   SENS

VARIABLES       SN  TYPE              RELOCATION
  315   D           REAL         ARRAY   DAT            114   DS     REAL       ARRAY    SENSP
  473   E1P         REAL                 DAT            474   E2P    REAL                DAT
  137   F           REAL         ARRAY   DAT           1004   GE     REAL       ARRAY    SENSP
 1040   GK          REAL         ARRAY   SENSP         1010   GL     REAL       ARRAY    SENSP
 1014   GSQE        REAL         ARRAY   SENSP         1026   GSQL   REAL       ARRAY    SENSP
    0   J           INTEGER                F.P.           0   K      INTEGER               F.P.
  475   SIGSQ       REAL                 DAT              3   UP     REAL       ARRAY    MEAS
    0   X           REAL         ARRAY   DAT              0   XS     REAL       ARRAY    SENSP
    0   YP          REAL         ARRAY   MEAS

COMMON BLOCKS    LENGTH
      DAT          318
      MEAS           5
      SENSP        784

STATISTICS
  PROGRAM LENGTH                  402B       258
  CM LABELED COMMON LENGTH       2123B      1107
```

Figure 14. -Program listing of subroutine SENS.

```
SUBROUTINE ACUM        73/74   OPT=1                          FTN 4.6+439        78/02/14. 08.28.50

      SUBROUTINE ACUM(K)
      COMMON/DAT/X(5,19),   F(5,22),D(5,22),E1P,E2P,SIGSQ
      COMMON/SENSP/XS(4,19),DS( 5,4,22),GE(4),GL(4),GSQE(10),GSQL(10)
     1 ,GK(5,4,12)
C     K=CHANNEL INDICATOR
      T11=XS(1,9)*F(K,14) + XS(1,10)*F(K,17) + XS(1,11)*F(K,20)
      T12=XS(1,9)*F(K,15) + XS(1,10)*F(K,18) + XS(1,11)*F(K,21)
      T13=XS(1,9)*F(K,16) + XS(1,10)*F(K,19) + XS(1,11)*F(K,22)
      T21=XS(2,9)*F(K,14) + XS(2,10)*F(K,17) + XS(2,11)*F(K,20)
      T22=XS(2,9)*F(K,15) + XS(2,10)*F(K,18) + XS(2,11)*F(K,21)
      T23=XS(2,9)*F(K,16) + XS(2,10)*F(K,19) + XS(2,11)*F(K,22)
      T31=XS(3,9)*F(K,14) + XS(3,10)*F(K,17) + XS(3,11)*F(K,20)
      T32=XS(3,9)*F(K,15) + XS(3,10)*F(K,18) + XS(3,11)*F(K,21)
      T33=XS(3,9)*F(K,16) + XS(3,10)*F(K,19) + XS(3,11)*F(K,22)
      T41=XS(4,9)*F(K,14) + XS(4,10)*F(K,17) + XS(4,11)*F(K,20)
      T42=XS(4,9)*F(K,15) + XS(4,10)*F(K,18) + XS(4,11)*F(K,21)
      T43=XS(4,9)*F(K,16) + XS(4,10)*F(K,19) + XS(4,11)*F(K,22)
C
C     S=(GRAD NU)(RI)(NU)
C
      S1=T11*X(K,9) + T12*X(K,10) + T13*X(K,11)
      S2=T21*X(K,9) + T22*X(K,10) + T23*X(K,11)
      S3=T31*X(K,9) + T32*X(K,10) + T33*X(K,11)
      S4=T41*X(K,9) + T42*X(K,10) + T43*X(K,11)
      GE(1)=E2P*(GE(1) - S1) + S1
      GE(2)=E2P*(GE(2) - S2) + S2
      GE(3)=E2P*(GE(3) - S3) + S3
      GE(4)=E2P*(GE(4) - S4) + S4
C
      GL(1)= E1P*GL(1) + GE(1)
      GL(2)= E1P*GL(2) + GE(2)
      GL(3)= E1P*GL(3) + GE(3)
      GL(4)= E1P*GL(4) + GE(4)
C
C     S = (GRAD NU)(RI)(GRAD NU)
C
      S11=T11*XS(1,9) + T12*XS(1,10) + T13*XS(1,11)
      S12=T11*XS(2,9) + T12*XS(2,10) + T13*XS(2,11)
      S13=T11*XS(3,9) + T12*XS(3,10) + T13*XS(3,11)
      S14=T11*XS(4,9) + T12*XS(4,10) + T13*XS(4,11)
      S22=T21*XS(2,9) + T22*XS(2,10) + T23*XS(2,11)
      S23=T21*XS(3,9) + T22*XS(3,10) + T23*XS(3,11)
      S24=T21*XS(4,9) + T22*XS(4,10) + T23*XS(4,11)
      S33=T31*XS(3,9) + T32*XS(3,10) + T33*XS(3,11)
      S34=T31*XS(4,9) + T32*XS(4,10) + T33*XS(4,11)
      S44=T41*XS(4,9) + T42*XS(4,10) + T43*XS(4,11)
      GSQE(1)=E2P*(GSQE(1) - S11) + S11
      GSQE(2)=E2P*(GSQE(2) - S12) + S12
      GSQE(3)=E2P*(GSQE(3) - S13) + S13
      GSQE(4)=E2P*(GSQE(4) - S14) + S14
      GSQE(5)=E2P*(GSQE(5) - S22) + S22
      GSQE(6)=E2P*(GSQE(6) - S23) + S23
      GSQE(7)=E2P*(GSQE(7) - S24) + S24
      GSQE(8)=E2P*(GSQE(8) - S33) + S33
      GSQE(9)=E2P*(GSQE(9) - S34) + S34
      GSQE(10)=E2P*(GSQE(10) - S44) + S44
C
      GSQL(1) = E1P*GSQL(1) + GSQE(1)
      GSQL(2) = E1P*GSQL(2) + GSQE(2)
      GSQL(3) = E1P*GSQL(3) + GSQE(3)
      GSQL(4) = E1P*GSQL(4) + GSQE(4)
      GSQL(5) = E1P*GSQL(5) + GSQE(5)
      GSQL(6) = E1P*GSQL(6) + GSQE(6)
      GSQL(7) = E1P*GSQL(7) + GSQE(7)
      GSQL(8) = E1P*GSQL(8) + GSQE(8)
      GSQL(9) = E1P*GSQL(9) + GSQE(9)
      GSQL(10)= E1P*GSQL(10)+ GSQE(10)
      RETURN
      END

      SYMBOLIC REFERENCE MAP (R=1)

ENTRY POINTS
    3  ACUM
```

Figure 15. -Program listing of subroutine ACUM.

```
VARIABLES      SN  TYPE            RELOCATION
  315  D           REAL     ARRAY     DAT              114  DS       REAL      ARRAY     SENSP
  473  E1P         REAL               DAT              474  E2P      REAL                DAT
  137  F           REAL     ARRAY     DAT             1004  GE       REAL      ARRAY     SENSP
 1040  GK          REAL     ARRAY     SENSP           1010  GL       REAL      ARRAY     SENSP
 1014  GSQE        REAL     ARRAY     SENSP           1026  GSQL     REAL      ARRAY     SENSP
    0  K           INTEGER              F.P.           475  SIGSQ    REAL                DAT
  344  S1          REAL                                350  S11      REAL
  351  S12         REAL                                352  S13      REAL
  353  S14         REAL                                345  S2       REAL
  354  S22         REAL                                355  S23      REAL
  356  S24         REAL                                346  S3       REAL
  357  S33         REAL                                360  S34      REAL
  347  S4          REAL                                361  S44      REAL
  330  T11         REAL                                331  T12      REAL
  332  T13         REAL                                333  T21      REAL
  334  T22         REAL                                335  T23      REAL
  336  T31         REAL                                337  T32      REAL
  340  T33         REAL                                341  T41      REAL
  342  T42         REAL                                343  T43      REAL
    0  X           REAL     ARRAY     DAT                0  XS       REAL      ARRAY     SENSP

COMMON BLOCKS   LENGTH
       DAT         318
       SENSP       784

STATISTICS
  PROGRAM LENGTH                   362B      242
  CM LABELED COMMON LENGTH        2116B     1102
```

Figure 15. -Concluded.

```
      SUBROUTINE FH          73/74    OPT=1                            FTN 4.6+439          78/02/14. 08.28.50

                   SUBROUTINE FH(U,Y,X)                                               HONO9       567
                   COMMON/SUBRH/ DT ,D,W,C1,C2                                        HONO9       568
                   DIMENSION X(2)                                                     HONO9       569
             C     FILTER                                                             HONO9       570
             C     Y/U= (S*S)/(S*S + 2*D*W*S + W*W)                                   HONO9       571
                 2 Y=U - X(2)*C2 - X(1)*C1                                            HONO9       572
                   X(1)=X(1) + DT*X(2)                                                HONO9       573
                   X(2)=X(2) + DT*Y                                                   HONO9       574
                   RETURN                                                             HONO9       575
                   END                                                                HONO9       576


      SYMBOLIC REFERENCE MAP (R=1)

ENTRY POINTS
    3  FH

VARIABLES      SN  TYPE            RELOCATION
    3  C1          REAL                SUBRH               4  C2       REAL                SUBRH
    1  D           REAL                SUBRH               0  DT       REAL                SUBRH
    0  U           REAL                 F.P.               2  W        REAL                SUBRH
    0  X           REAL      ARRAY      F.P.               0  Y        REAL                 F.P.

STATEMENT LABELS
    0  2              INACTIVE

COMMON BLOCKS   LENGTH
       SUBRH         5

STATISTICS
  PROGRAM LENGTH                    16B       14
  CM LABELED COMMON LENGTH           5B        5
```

Figure 16. -Program listing of subroutine FH.

```
      SUBROUTINE TSIG        74/74    OPT=1                    FTN 4.6+439        77/12/14. 18.57.02

      SUBROUTINE TSIG(ETA1,ETA2,UT)                                              HON09    1720
C     UT/INPUT = S*SIGUT/(S*S + 2*DUT*WUT*S + WUT*WUT)                           HON09    1721
C     INPUT = RANDOM NO WITH 0 MEAN  UNIFORM  -0.5 TO  0.5                       HON09    1722
C     UT1,UT2  STATES IN SECOND ORDER FILTER                                     HON09    1723
      COMMON/UTEST/DT,SEED,WUT,DUT,SIGUT,UT10,UT20,UTMAX,W2UT,TZWUT,             HON09    1724
     1              UT1,UT2,GAMUTO                                               HON09    1725
    2 SEED=AMOD(3125.*SEED,34359738368.)                                         HON09    1726
      S=0.29103830456?E-10*SEED - 0.5                                            HON09    1727
      S=W2UT*UT1 + TZWUT*UT2 + GAMUTO*SIGUT*S                                    HON09    1728
      UT1=UT1 + DT*UT2                                                           HON09    1729
      UT2=UT2 + S                                                                HON09    1730
      UT=UT2                                                                     HON09    1731
      IF(ABS(UT).GE.UTMAX) UT=SIGN(UTMAX,UT)                                     HON09    1732
      SEED=AMOD(3125.*SEED,34359738368.)                                         HON09    1733
      S=0.29103830456?E-10*SEED - 0.5                                            HON09    1734
      ETA1=S                                                                     HON09    1735
      SEED=AMOD(3125.*SEED,34359738368.)                                         HON09    1736
      S=0.29103830456?E-10*SEED - 0.5                                            HON09    1737
      ETA2=S                                                                     HON09    1738
      RETURN                                                                     HON09    1739
      END                                                                        HON09    1740
```

```
     SYMBOLIC REFERENCE MAP (R=1)

ENTRY POINTS
    3  TSIG

VARIABLES       SN   TYPE             RELOCATION
    0  DT            REAL                   UTEST        3  DUT        REAL                  UTEST
    0  ETA1          REAL                   F.P.         0  ETA2       REAL                  F.P.
   14  GAMUTO        REAL                   UTEST       46  S          REAL
    1  SEED          REAL                   UTEST        4  SIGUT      REAL                  UTEST
   11  TZWUT         REAL                   UTEST        0  UT         REAL                  F.P.
    7  UTMAX         REAL                   UTEST       12  UT1        REAL                  UTEST
    5  UT10          REAL                   UTEST       13  UT2        REAL                  UTEST
    6  UT20          REAL                   UTEST        2  WUT        REAL                  UTEST
   10  W2UT          REAL                   UTEST

INLINE FUNCTIONS      TYPE     ARGS
       ABS            REAL       1  INTRIN                  AMOD       REAL          2  INTRIN
       SIGN           REAL       2  INTRIN

STATEMENT LABELS
    0  2              INACTIVE

COMMON BLOCKS     LENGTH
       UTEST           13

STATISTICS
  PROGRAM LENGTH                   47B        39
  CM LABELED COMMON LENGTH         15B        13
```

Figure 17. -Program listing of subroutine TSIG.

APPENDIX E

FLOW CHART FOR INITIALIZATION PORTION OF PCMLE SOFTWARE

This appendix consists of the flowcharts for subroutine NRTIC (Fig. 18) and MODEL (Fig. 19).

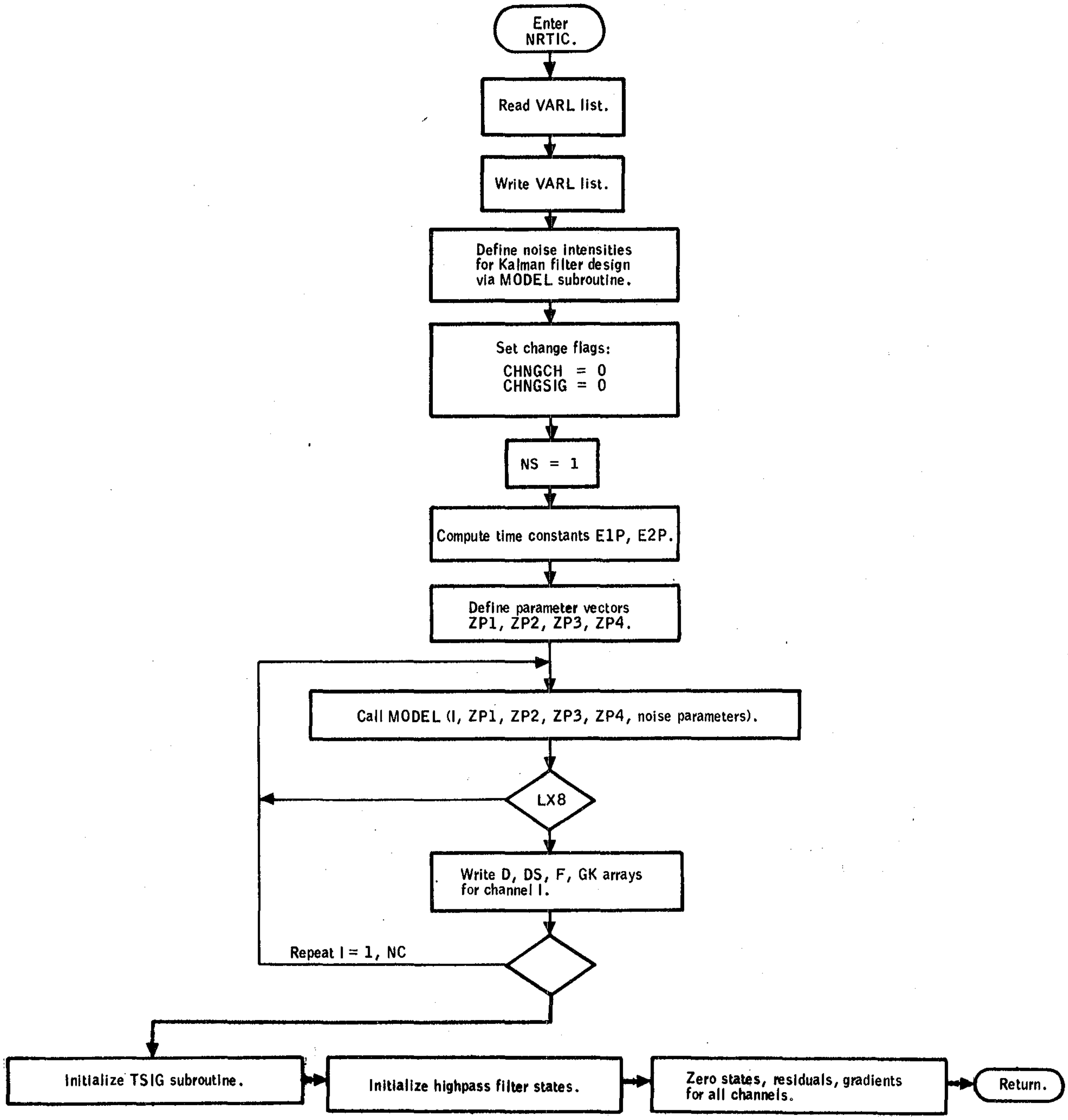


Figure 18. -Flowchart for subroutine NRTIC.

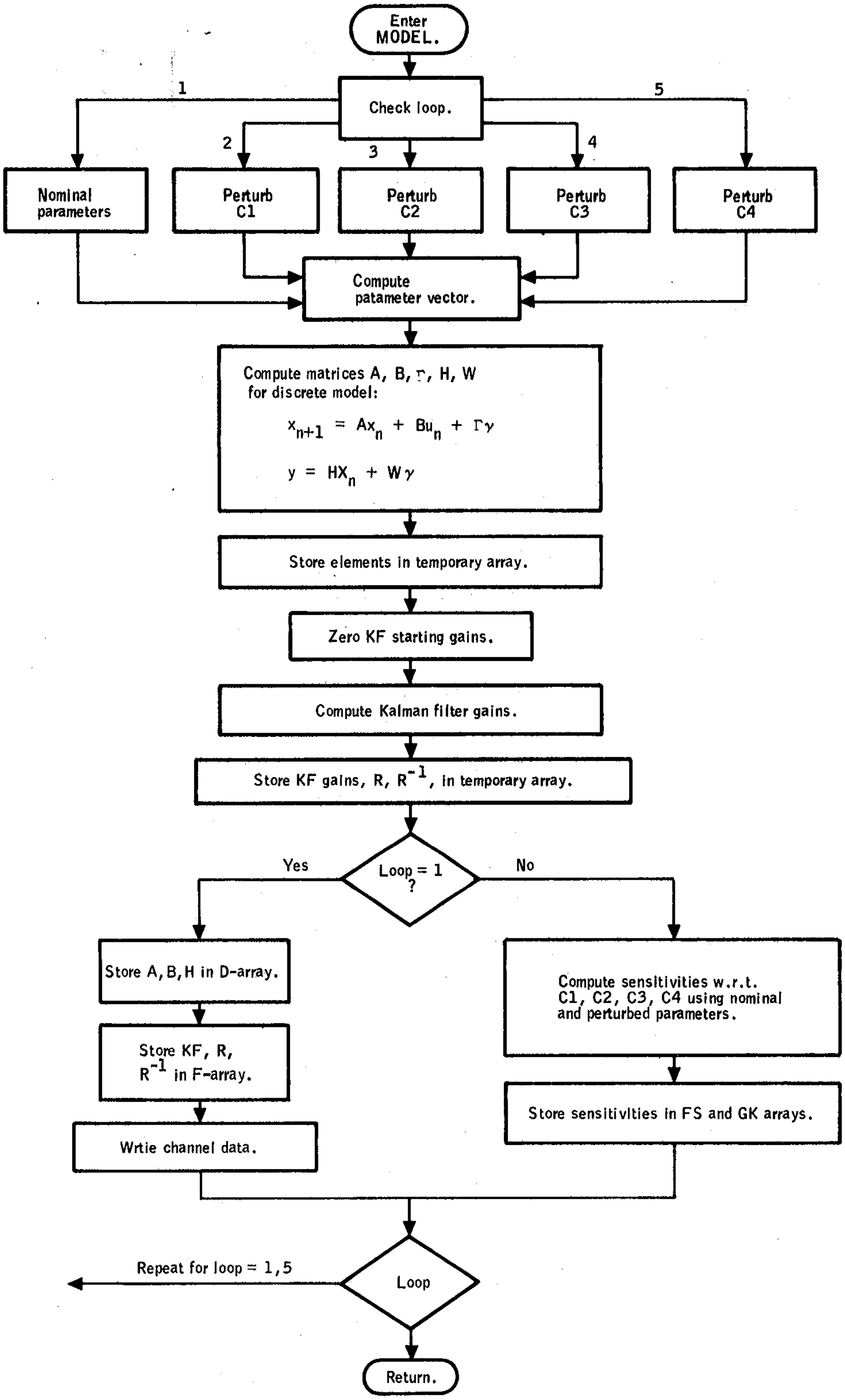


Figure 19. - Flowchart for subroutine MODEL.

APPENDIX F

LISTING OF PCMLE INITIALIZATION SOFTWARE

This appendix contains the program listings of subroutines NRTIC, MODEL, DISC, DIAK, CAL, MP, FHIC, and INPT, as presented in Figures 20 through 27, respectively.

```
SUBROUTINE NRTIC        73/74    OPT=1                              FTN 4.6+452          78/04/06. 06.36.47

              SUBROUTINE NRTIC                                                          HONO9      1163
              COMMON/PRSWTCH/IPSCH                                                      HONO9      1164
              COMMON/CI/XC1,XC2,XC3,XC4                                                 HONO9      1165
              COMMON/OFILE/MF                                                           HONO9      1166
              COMMON/VARDAT/UX(55),LX(15)                                               HONO9      1167
              COMMON/SENSP/XS(4,19),DS( 5,4,22),GE(4),GL(4),GSQE(10),GSQL(10)           HONO9      1168
             1 ,GK(5,4,12)                                                              HONO9      1169
              COMMON/DAT/X(5,19),   F(5,22),D(5,22),E1P,E2P,SIGSQ                       HONO9      1170
              COMMON/IPIC/     NC,NP,JS,CHNGCH,CHSIG,ANS                                HONO9      1171
             1                  ,TPRINT,MODE,SIGUTO,ZP1,ZP2,ZP3,ZP4,TIME,RTJS           HONO9      1172
             2                  ,RTJG,THRTJG,RTJC,THRTJC,RTJZ,THRTJZ,DTPRIN             HONO9      1173
             3                  ,ZP1MAX,ZP2MAX,ZP3MAX,ZP4MAX                            HONO9      1174
             4                  ,ZP1MIN,ZP2MIN,ZP3MIN,ZP4MIN                            HONO9      1175
             5                  ,ZP( 5,4),GSQLO(4),Y(3),U(2)                            HONO9      1176
             6                  ,XVZ(2),XQ(2),XTH(2),XDB(2),XDC(2),PRTIME               HONO9      1177
              COMMON/MEAS/YP(3),UP(2)                                                   HONO9      1178
              COMMON/SUBR/      NX,NR,NN,NRM,EE,ITER,DT,DETR                            HONO9      1179
             1                  ,DUMM(292)                                              HONO9      1180
              COMMON/SUBRH/DTHP,DHP,WHP,C1HP,C2HP                                       HONO9      1181
              COMMON/UTEST/DTU,SEED,WUT,DUT,SIGUT,UT10,UT20,UTMAX,W2UT,TZWUT,           HONO9      1182
             1              UT1,UT2,GAMUTO                                              HONO9      1183
              COMMON/DEVICE/NREAD,MFILE                                                 HONO9      1184
              COMMON/NOM/THEN,PHIN,UN,VN,WN,UAN,VAN,WAN                                 HONO9      1185
              DIMENSION GN(2,10)                                                        HONO9      1186
              INTEGER CHNGCH,CHSIG                                                      HONO9      1187
              LOGICAL LX                                                                HONO9      1188
        C                                                                               HONO9      1189
              CALL RTHOLD1                                                              HONO9      1190
              REWIND 10                                                                 HONO9      1191
              READ(10) XS,DS,GE,GL,GSQE,GSQL,GK                                         HONO9      1192
              READ(10) X,F,D,E1P,E2P,SIGSQ                                              HONO9      1193
              READ(10) NC,NP,JS,CHNGCH,CHSIG,ANS,PRTIME                                 HONO9      1194
             1         ,TPRINT,MODE,SIGUTO,ZP1,ZP2,ZP3,ZP4,TIME,RTJS                    HONO9      1195
             2         ,RTJG,THRTJG,RTJC,THRTJC,RTJZ,THRTJZ,DTPRIN                      HONO9      1196
             3         ,ZP1MAX,ZP2MAX,ZP3MAX,ZP4MAX                                     HONO9      1197
             4         ,ZP1MIN,ZP2MIN,ZP3MIN,ZP4MIN                                     HONO9      1198
             5         ,ZP,GSQLO,Y,U,XVZ,XQ,XTH,XDB,XDC                                 HONO9      1199
              READ(10) DTHP,DHP,WHP,C1HP,C2HP,DTU,SEED,WUT,DUT,SIGUT                    HONO9      1200
             1           ,UT10,UT20,UTMAX,W2UT,TZWUT,UT1,UT2,GAMUTO                     HONO9      1201
              READ(10) NREAD,MFILE                                                      HONO9      1202
              READ(10) UX,LX                                                            HONO9      1203
        C                                                                               HONO9      1204
              XC1=0.                                                                    HONO9      1205
              XC2=0.                                                                    HONO9      1206
              XC3=0.                                                                    HONO9      1207
              XC4=0.                                                                    HONO9      1208
              CALL RTSRT                                                                HONO9      1209
              RETURN                                                                    HONO9      1210
              END                                                                       HONO9      1211


     SYMBOLIC REFERENCE MAP (R=1)

ENTRY POINTS
   1   NRTIC

VARIABLES      SN   TYPE              RELOCATION
    5   ANS          REAL                  IPIC              3   CHNGCH      INTEGER                IPIC
    4   CHSIG        INTEGER               IPIC              3   C1HP        REAL                   SUBRH
    4   C2HP         REAL                  SUBRH           315   D           REAL          ARRAY    DAT
```

Figure 20. -Program listing of subroutine NRTIC.

Appendix F

```
   7  DETR     REAL               SUBR          1  DHP      REAL              SUBRH
 114  DS       REAL     ARRAY     SENSP         6  DT       REAL              SUBR
   0  DTHP     REAL               SUBRH        25  DTPRIN   REAL              IPIC
   0  DTL      REAL               UTEST        10  DUMM     REAL     ARRAY    SUBR
   3  DUT      REAL               UTEST         4  EE       REAL              SUBR
 473  E1P      REAL               DAT         474  E2P      REAL              DAT
 137  F        REAL     ARRAY     DAT          14  GAMUTO   REAL              UTEST
1004  GE       REAL     ARRAY     SENSP      1040  GK       REAL     ARRAY    SENSP
1010  GL       REAL     ARRAY     SENSP       167  GN       REAL    *UNDEF
1014  GSQE     REAL     ARRAY     SENSP      1026  GSQL     REAL     ARRAY    SENSP
  62  GSQLO    REAL     ARRAY     IPIC          0  IPSCH    INTEGER           PRSWTCH
   5  ITER     INTEGER            SUBR          2  JS       INTEGER           IPIC
  67  LX       LOGICAL  ARRAY     VARDAT        0  MF       INTEGER           OFILE
   1  MFILE    INTEGER            DEVICE        7  MODE     INTEGER           IPIC
   0  NC       INTEGER            IPIC          2  NN       INTEGER           SUBR
   1  NP       INTEGER            IPIC          1  NR       INTEGER           SUBR
   0  NREAD    INTEGER            DEVICE        3  NRM      INTEGER           SUBR
   0  NX       INTEGER            SUBR          1  PHIN     REAL              NOM
 105  PRTIME   REAL               IPIC         21  RTJC     REAL              IPIC
  17  RTJG     REAL               IPIC         16  RTJS     REAL              IPIC
  23  RTJZ     REAL               IPIC          1  SEED     REAL              UTEST
 475  SIGSQ    REAL               DAT           4  SIGUT    REAL              UTEST
  10  SIGUTO   REAL               IPIC          0  THEN     REAL              NOM
  22  THRTJC   REAL               IPIC         20  THRTJG   REAL              IPIC
  24  THRTJZ   REAL               IPIC         15  TIME     REAL              IPIC
   6  TPRINT   REAL               IPIC         11  TZWUT    REAL              UTEST
  71  U        REAL     ARRAY     IPIC          5  UAN      REAL              NOM
   2  UN       REAL               NOM           3  UP       REAL     ARRAY    MEAS
   7  UTMAX    REAL               UTEST        12  UT1      REAL              UTEST
   5  UT10     REAL               UTEST        13  UT2      REAL              UTEST
   6  UT20     REAL               UTEST         0  UX       REAL     ARRAY    VARDAT
   6  VAN      REAL               NOM           3  VN       REAL              NOM
   7  WAN      REAL               NOM           2  WHP      REAL              SUBRH
   4  WN       REAL               NOM           2  WUT      REAL              UTEST
  10  W2UT     REAL               UTEST         0  X        REAL     ARRAY    DAT
   0  XC1      REAL               CI            1  XC2      REAL              CI
   2  XC3      REAL               CI            3  XC4      REAL              CI
 101  XDB      REAL     ARRAY     IPIC        103  XDC      REAL     ARRAY    IPIC
  75  XO       REAL     ARRAY     IPIC          0  XS       REAL     ARRAY    SENSP
  77  XTH      REAL     ARRAY     IPIC         73  XVZ      REAL     ARRAY    IPIC
  66  Y        REAL     ARRAY     IPIC          0  YP       REAL     ARRAY    MEAS
  36  ZP       REAL     ARRAY     IPIC         11  ZP1      REAL              IPIC
  26  ZP1MAX   REAL               IPIC         32  ZP1MIN   REAL              IPIC
  12  ZP2      REAL               IPIC         27  ZP2MAX   REAL              IPIC
  33  ZP2MIN   REAL               IPIC         13  ZP3      REAL              IPIC
  30  ZP3MAX   REAL               IPIC         34  ZP3MIN   REAL              IPIC
  14  ZP4      REAL               IPIC         31  ZP4MAX   REAL              IPIC
  35  ZP4MIN   REAL               IPIC

FILE NAMES      MODE
      TAPE10    UNFMT

EXTERNALS         TYPE    ARGS
      RTHOLD1               0                     RTSRT              0

COMMON BLOCKS   LENGTH
      PRSWTCH       1
      CI            4
      OFILE         1
      VARDAT       70
      SENSP       784
      DAT         318
      IPIC         70
      MEAS          5
      SUBR        300
      SUBRH         5
      UTEST        13
      DEVICE        2
      NOM           8

STATISTICS
  PROGRAM LENGTH                     213B      139
  CM LABELED COMMON LENGTH          3055B     1581
      73000B CM USED
```

Figure 20. -Concluded.

```
SUBROUTINE MODEL       73/74    OPT=1                          FTN 4.6+439         78/02/14. 08.28.50

          SUBROUTINE MODEL(ZP1,ZP2,ZP3,ZP4,SIGVZ,SIGQ,SIGTH,                 HON09     835
         1 SIGXG,SIGZG,ICH,NTER)                                             HON09     836
C         ICH IS CHANNEL INDICATOR USED FOR DEFINING STORED DATA             HON09     837
          COMMON/VARDAT/UX(50),LX(50)                                        HON09     838
          COMMON/DAT/X(5,19),  F(5,22),D(5,22),E1P,E2P,SIGSQ                 HON09     839
          COMMON/SENSP/XS(4,19),DS( 5,4,22),GE(4),GL(4),GSQE(10),GSQL(10)    HON09     840
         1 ,GK(5,4,12)                                                       HON09     841
          COMMON/SUBRH/DTHP,DHP,WHP,C1HP,C2HP                                HON09     842
          COMMON /SUBR/                                                      HON09     843
         1         NX,NR,NN,NRM,EE,ITER,DT,DETR                              HON09     844
         2        ,A(4,4),GM(4,6),H(4,4),W(4,6),B(4,2)                       HON09     845
         3        ,AKH(4,4),GMKW(4,6),KF(4,4),P(4,4),P1(4,4),R(4,4)          HON09     846
         4        ,RI(4,4),HP(4,4),Q(4,4),WW(4,4),GMW(4,4),SS(4,4),SC(4)     HON09     847
          COMMON/DEVICE/NREAD,MFILE                                          HON09     848
          DIMENSION DD(22),FD(22),GIC(4,4)                                   HON09     849
C                                                                            HON09     850
          LOGICAL LX                                                         HON09     851
          REAL KF                                                            HON09     852
          DATA L2/6HA      /,L1/6HA - KH/                                    HON09     853
          DATA NPD/22/,NPF/22/                                               HON09     854
          DATA DVBAR/.05/,DC2/.01/,DC3/.01/,DC4/.01/                         HON09     855
C                                                                            HON09     856
          DO 60 I=1,NX                                                       HON09     857
          DO 60 J=1,NR                                                       HON09     858
       60 GIC(I,J)=0.                                                        HON09     859
          CALL INPT(GIC,4,4,NREAD)                                           HON09     860
          CALL MP(NX,NR,GIC,NX,4HKFIC,MFILE)                                 HON09     861
C         LOOP COMPUTES NOMINAL FIRST,THEN SENSITIVITIES                     HON09     862
          DO 999 LOOP=1,5                                                    HON09     863
C                                                                            HON09     864
C         DEFINE PARAMETERS                                                  HON09     865
          VBAR=ZP1                                                           HON09     866
          C2=ZP2                                                             HON09     867
          C3=ZP3                                                             HON09     868
          C4=ZP4                                                             HON09     869
          GO TO (100,200,300,400,500),LOOP                                   HON09     870
      500 DELT=DC4                                                           HON09     871
          IP=4                                                               HON09     872
          C4=C4 + DC4                                                        HON09     873
          GO TO 100                                                          HON09     874
      400 DELT=DC3                                                           HON09     875
          IP=3                                                               HON09     876
          C3=C3 + DC3                                                        HON09     877
          GO TO 100                                                          HON09     878
      300 DELT=DC2                                                           HON09     879
          IP=2                                                               HON09     880
          C2=C2 + DC2                                                        HON09     881
          GO TO 100                                                          HON09     882
      200 DELT=DVBAR                                                         HON09     883
          IP=1                                                               HON09     884
          VBAR=VBAR + DVBAR                                                  HON09     885
      100 CONTINUE                                                           HON09     886
C                                                                            HON09     887
          VBS=VBAR*VBAR                                                      HON09     888
          A(1,1)=-.018-.034*VBS                                              HON09     889
          A(1,2)=.048*VBS                                                    HON09     890
          A(1,3)=2.4                                                         HON09     891
          A(1,4)=-32.2 + 14.*VBS                                             HON09     892
          A(2,1)=.18*(VBAR-.75)/0.75                                         HON09     893
          IF(VBAR.LT.0.0) A(2,1)=0.18*(.75+VBAR)/0.75                        HON09     894
          A(2,2)=-.5                                                         HON09     895
          A(2,3)=0.                                                          HON09     896
          A(2,4)=-180.*VBAR                                                  HON09     897
          A(3,1)=0.                                                          HON09     898
          A(3,2)=.02*VBAR                                                    HON09     899
          A(3,3)=-1.5 + C4                                                   HON09     900
          A(3,4)=4.*VBAR                                                     HON09     901
          IF(VBAR.LT.0.0) A(3,4)=-4.*VBAR                                    HON09     902
          A(4,1)=0.                                                          HON09     903
          A(4,2)=0.                                                          HON09     904
          A(4,3)=1.                                                          HON09     905
          A(4,4)=0.                                                          HON09     906
          B(1,1)=0.12                                                        HON09     907
          B(1,2)=0.                                                          HON09     908
          B(2,1)=.7*VBAR                                                     HON09     909
          B(2,2)=-7.8 - 3.*VBAR                                              HON09     910
          B(3,1)=.35 + .12*VBAR + C3                                         HON09     911
```

Figure 21. -Program listing of subroutine MODEL.

```
      B(3,2)=.24*VBAR + C2
      B(4,1)=0.
      B(4,2)=0.
C
      DO 550 I=1,NR
      DO 550 J=1,NX
  550 H(I,J)=0.
      H(1,2)=1.
      H(2,3)=1.
      H(3,4)=1.
C
      DO 50 I=1,NX
      DO 50 J=1,NN
      W(I,J)=0.
   50 GM(I,J)=0.
C
      GM(1,1)=SQRT(2.)*SIGXG
      GM(2,2)=SQRT(2.)*SIGZG
      GM(3,6)=SQRT(2.)*(.02*SIGXG+.01*SIGZG)/A(3,3)
C
      CALL DISC(NTER)
C
      W(1,3)=SIGVZ
      W(2,4)=SIGQ
      W(3,5)=SIGTH
C
C     DEFINE WORKING DATA ARRAYS
      DD(1)=A(1,1)
      DD(2)=A(1,2)
      DD(3)=A(1,3)
      DD(4)=A(1,4)
      DD(5)=A(2,1)
      DD(6)=A(2,2)
      DD(7)=A(2,3)
      DD(8)=A(2,4)
      DD(9)=A(3,1)
      DD(10)=A(3,2)
      DD(11)=A(3,3)
      DD(12)=A(3,4)
      DD(13)=A(4,1)
      DD(14)=A(4,2)
      DD(15)=A(4,3)
      DD(16)=A(4,4)
      DD(17)=B(1,1)
      DD(18)=B(1,2)
      DD(19)=B(2,1)
      DD(20)=B(2,2)
      DD(21)=B(3,1)
      DD(22)=B(3,2)
C
C     PROVIDE DIAK STARTING GAINS
      DO 150 I=1,NX
      DO 150 J=1,NR
  150 KF(I,J)=GIC(I,J)
C
      CALL DIAK
C
      FD(1)=KF(1,1)
      FD(2)=KF(2,1)
      FD(3)=KF(3,1)
      FD(4)=KF(4,1)
      FD(5)=KF(1,2)
      FD(6)=KF(2,2)
      FD(7)=KF(3,2)
      FD(8)=KF(4,2)
      FD(9)=KF(1,3)
      FD(10)=KF(2,3)
      FD(11)=KF(3,3)
      FD(12)=KF(4,3)
      IF(DETR.GT.0.0) FD(13)=ALOG(DETR)
      FD(14)=RI(1,1)
      FD(15)=RI(1,2)
      FD(16)=RI(1,3)
      FD(17)=RI(2,1)
      FD(18)=RI(2,2)
      FD(19)=RI(2,3)
      FD(20)=RI(3,1)
      FD(21)=RI(3,2)
      FD(22)=RI(3,3)
C
```

Figure 21. -Continued.

```
              IF(LOOP.NE.1) GO TO 900                                     HON09      992
      C                                                                   HON09      993
              DO 115 I=1,NPD                                              HON09      994
          115 D(ICH,I)=DD(I)                                              HON09      995
              DO 120 I=1,NPF                                              HON09      996
          120 F(ICH,I)=FD(I)                                              HON09      997
      C                                                                   HON09      998
              IF(LX(9)) GO TO 999                                         HON09      999
              WRITE(MFILE,1199) ICH                                       HON09     1000
              WRITE(MFILE,1201) SIGVZ,SIGQ,SIGTH,SIGXG,SIGZG              HON09     1001
              DO 1209 I=1,NX                                              HON09     1002
         1209 P(I,I) = SQRT(P(I,I))                                       HON09     1003
              WRITE(MFILE,1202) (P(I,I),I=1,NX)                           HON09     1004
              WRITE(MFILE,1205)                                           HON09     1005
              DO 1208 I=1,NX                                              HON09     1006
         1208 WRITE(MFILE,1203) (A(I,J),J=1,NX)                           HON09     1007
      C       CALL POLES(4,A,4,SS,M,DT,L2)                                HON09     1008
              WRITE(MFILE,1205)                                           HON09     1009
              DO 1207 I=1,NX                                              HON09     1010
         1207 WRITE(MFILE,1204) (AKH(I,J),J=1,NX)                         HON09     1011
      C       CALL POLES(4,AKH,4,SS,M,DT,L1)                              HON09     1012
         1199 FORMAT(1H1,19HFILTER DATA  ICH = ,I2)                       HON09     1013
         1201 FORMAT(1X ,11HSTATS IN    ,9E12.5)                          HON09     1014
         1202 FORMAT(1X ,11HSTATS OUT   ,9E12.5)                          HON09     1015
         1203 FORMAT(1X,11HA          ,4E12.5)                            HON09     1016
         1204 FORMAT(1X,11HAKH        ,4E12.5)                            HON09     1017
         1205 FORMAT(1H0)                                                 HON09     1018
      C                                                                   HON09     1019
              GO TO 999                                                   HON09     1020
      C                                                                   HON09     1021
          900 CONTINUE                                                    HON09     1022
      C       SENSITIVITIES                                               HON09     1023
              DO 910 I=1,NPD                                              HON09     1024
          910 DS(ICH,IP,I)= (DD(I) - D(ICH,I))/DELT                       HON09     1025
      C       GAIN SENSITIVITIES                                          HON09     1026
              DO 920 I=1,12                                               HON09     1027
          920 GK(ICH,IP,I)=(FD(I) - F(ICH,I))/DELT                        HON09     1028
          999 CONTINUE                                                    HON09     1029
      C                                                                   HON09     1030
              RETURN                                                      HON09     1031
              END                                                         HON09     1032
```

```
     SYMBOLIC REFERENCE MAP (R=1)

ENTRY POINTS
    3  MODEL

VARIABLES      SN  TYPE            RELOCATION
   10  A           REAL      ARRAY    SUBR           140  AKH      REAL      ARRAY   SUBR
  130  B           REAL      ARRAY    SUBR             3  C1HP     REAL              SUBRH
  677  C2          REAL                                4  C2HP     REAL              SUBRH
  700  C3          REAL                              701  C4       REAL
  315  D           REAL      ARRAY    DAT            540  DC2      REAL
  541  DC3         REAL                              542  DC4      REAL
  705  DD          REAL      ARRAY                   702  DELT     REAL
    7  DETF        REAL               SUBR             1  DHP      REAL              SUBRH
  114  DS          REAL      ARRAY    SENSP            6  DT       REAL              SUBR
    0  DTHP        REAL               SUBRH          537  DVBAR    REAL
    4  EE          REAL               SUBR           473  E1P      REAL              DAT
  474  E2P         REAL               DAT            137  F        REAL      ARRAY   DAT
  733  FD          REAL      ARRAY                  1004  GE       REAL      ARRAY   SENSP
  761  GIC         REAL      ARRAY                  1040  GK       REAL      ARRAY   SENSP
 1010  GL          REAL      ARRAY    SENSP           30  GM       REAL      ARRAY   SUBR
  160  GMKW        REAL      ARRAY    SUBR           410  GMW      REAL      ARRAY   SUBR
 1014  GSQE        REAL      ARRAY    SENSP         1026  GSQL     REAL      ARRAY   SENSP
   60  H           REAL      ARRAY    SUBR           330  HP       REAL      ARRAY   SUBR
  673  I           INTEGER                             0  ICH      INTEGER            F.P.
  703  IP          INTEGER                             5  ITER     INTEGER           SUBR
  674  J           INTEGER                           210  KF       REAL      ARRAY   SUBR
  675  LOOP        INTEGER                            62  LX       LOGICAL   ARRAY   VARDAT
  534  L1          INTEGER                           533  L2       INTEGER
    1  MFILE       INTEGER            DEVICE           2  NN       INTEGER           SUBR
  535  NPD         INTEGER                           536  NPF      INTEGER
    1  NR          INTEGER            SUBR             0  NREAD    INTEGER           DEVICE
    3  NRM         INTEGER            SUBR             0  NTER     INTEGER            F.P.
```

Figure 21. -Continued.

```
     0  NX         INTEGER              SUBR          230  P          REAL        ARRAY    SUBR
   250  P1         REAL       ARRAY     SUBR          350  Q          REAL        ARRAY    SUBR
   270  R          REAL       ARRAY     SUBR          310  RI         REAL        ARRAY    SUBR
   450  SC         REAL       ARRAY     SUBR            0  SIGO       REAL                  F.P.
   475  SIGSQ      REAL                 DAT             0  SIGTH      REAL                  F.P.
     0  SIGVZ      REAL                  F.P.           0  SIGXG      REAL                  F.P.
     0  SIGZG      REAL                  F.P.         430  SS         REAL        ARRAY    SUBR
     0  UX         REAL       ARRAY     VARDAT        676  VBAR       REAL
   704  VBS        REAL                               100  W          REAL        ARRAY    SUBR
     2  WHP        REAL                 SUBRH         370  WW         REAL        ARRAY    SUBR
     0  X          REAL       ARRAY     DAT             0  XS         REAL        ARRAY    SENSP
     0  ZP1        REAL                  F.P.           0  ZP2        REAL                  F.P.
     0  ZP3        REAL                  F.P.           0  ZP4        REAL                  F.P.


EXTERNALS          TYPE    ARGS
       ALOG        REAL      1 LIBRARY                  DIAK                  0
       DISC                  1                          INPT                  4
       MP                    6                          SQRT        REAL      1 LIBRARY

STATEMENT LABELS
     0  50                               0  60                                   77  100
     0  115                              0  120                                   0  150
    73  200                             66  300                                  61  400
    54  500                              0  550                                 457  900
     0  910                              0  920                                 512  999
   607  1199    FMT                    613  1201    FMT                         617  1202    FMT
   623  1203    FMT                    627  1204    FMT                         633  1205    FMT
     0  1207                             0  1208                                  0  1209

LOOPS  LABEL    INDEX     FROM-TO    LENGTH    PROPERTIES
   16  50     * I          23 25       13B               NOT INNER
   23  60       J          24 25        2B      INSTACK
   35  999    * LOOP       29 195     460B               EXT REFS  NOT INNER
  150  550    * I          82 84       13B               NOT INNER
  155  550      J          83 84        2B      INSTACK
  166  50     * I          89 92       13B               NOT INNER
  172  50       J          90 92        3B      INSTACK
  265  150    * I         129 131      13B               NOT INNER
  271  150      J         130 131       3B      INSTACK
  350  115      I         160 161       3B      INSTACK
  360  120      I         162 163       3B      INSTACK
  371  1209   * I         168 169       7B               EXT REFS
  403         * I         170 170      10B               EXT REFS
  417  1208   * I         172 173      17B               EXT REFS  NOT INNER
  422         * J         173 173      10B               EXT REFS
  440  1207   * I         176 177      17B               EXT REFS  NOT INNER
  443         * J         177 177      10B               EXT REFS
  467  910      I         190 191       5B      INSTACK
  504  920      I         193 194       5B      INSTACK

COMMON BLOCKS   LENGTH
       VARDAT     100
       DAT        316
       SENSP      784
       SUBRH        5
       SUBR       300
       DEVICE       2

STATISTICS
  PROGRAM LENGTH                 1036B      542
  CM LABELED COMMON LENGTH       2745B     1509
```

Figure 21. -Concluded.

```
SUBROUTINE DISC        73/74    OPT=1                   FTN 4.6+439        78/02/14. 08.28.50

          SUBROUTINE DISC(NTER)
          COMMON /SUBR/
         1       NX,NR,NN,NRM,EE,ITER,DT,DETR
         2      ,A(4,4),GM(4,6),H(4,4),W(4,6),B(4,2)
         3      ,AKH(4,4),GMKW(4,6),KF(4,4),P(4,4),P1(4,4),R(4,4)
         4      ,RI(4,4),HP(4,4),Q(4,4),WW(4,4),GMW(4,4),SS(4,4),SC(4)
          REAL KF
          DATA NU/2/
C         P, P1, R, RI USED AS WORKING ARRAYS
C         A,B AND GM ARE REPLACED WITH DISCRETE VERSION
C
C         P1=I + (A*DT) + ((A*DT)**2)/2 + . .
C
C         P=DT + ((A*DT)**2)/2 + . .
C         B=P*B
C         GM=P*GM/SQRT(DT)
C
          DO 1 I=1,NX
          DO 1 J=1,NX
          P(I,J)=0.
          R(I,J)=0.
          P1(I,J)=0.
          R(I,I)=1.
        1 P1(I,I)=1.
          DO 100 II=1,NTER
          DO 10 I=1,NX
          DO 10 J=1,NX
       10 RI(I,J)=P(I,J)*DT/FLOAT(II)
          DO 11 I=1,NX
          DO 11 J=1,NX
       11 P(I,J)=P(I,J) + RI(I,J)
          DO 12 I=1,NX
          DO 12 J=1,NX
          R(I,J)=0.
          DO 12 K=1,NX
       12 R(I,J)=R(I,J) + A(I,K)*RI(K,J)
          DO 13 I=1,NX
          DO 13 J=1,NX
       13 P1(I,J)=P1(I,J) + R(I,J)
      100 CONTINUE
C
          DO 15 I=1,NX
          DO 15 J=1,NX
       15 A(I,J)=P1(I,J)
          S1=1./SQRT(DT)
          DO 16 I=1,NX
          DO 16 J=1,NN
          GMKW(I,J)=0.
          DO 16 K=1,NX
       16 GMKW(I,J)=GMKW(I,J) + P(I,K)*GM(K,J)
          DO 18 I=1,NX
          DO 18 J=1,NN
       18 GM(I,J)=GMKW(I,J)*S1
          DO 17 I=1,NX
          DO 17 J=1,NU
          P1(I,J)=0.
          DO 17 K=1,NX
       17 P1(I,J)=P1(I,J) + P(I,K)*B(K,J)
          DO 19 I=1,NX
          DO 19 J=1,NU
       19 B(I,J)=P1(I,J)
          RETURN
          END
```

SYMBOLIC REFERENCE MAP (R=1)

ENTRY POINTS
3 DISC

VARIABLES

SN		TYPE		RELOCATION	SN		TYPE		RELOCATION
10	A	REAL	ARRAY	SUBR	140	AKH	REAL	ARRAY	SUBR
130	B	REAL	ARRAY	SUBR	7	DETR	REAL		SUBR
6	DT	REAL		SUBR	4	EE	REAL		SUBR
30	GM	REAL	ARRAY	SUBR	160	GMKW	REAL	ARRAY	SUBR
410	GMW	REAL	ARRAY	SUBR	60	H	REAL	ARRAY	SUBR

Figure 22. -Program listing of subroutine DISC.

```
 330  HP         REAL       ARRAY     SUBR            264  I          INTEGER
 266  II         INTEGER                                5  ITER       INTEGER                SUBR
 265  J          INTEGER                              267  K          INTEGER
 210  KF         REAL       ARRAY     SUBR              2  NN         INTEGER                SUBR
   1  NR         INTEGER              SUBR              3  NPM        INTEGER                SUBR
   0  NTER       INTEGER               F.P.           262  NU         INTEGER
   0  NX         INTEGER              SUBR            230  P          REAL       ARRAY       SUBR
 250  P1         REAL       ARRAY     SUBR            350  Q          REAL       ARRAY       SUBR
 270  R          REAL       ARRAY     SUBR            310  RI         REAL       ARRAY       SUBR
 450  SC         REAL       ARRAY     SUBR            430  SS         REAL       ARRAY       SUBR
 270  S1         REAL                                 100  W          REAL       ARRAY       SUBR
 370  WW         REAL       ARRAY     SUBR

EXTERNALS          TYPE    ARGS
      SQRT       REAL        1 LIBRARY

INLINE FUNCTIONS   TYPE    ARGS
      FLOAT      REAL        1  INTRIN

STATEMENT LABELS
    0  1                                    0  10                                   0  11
    0  12                                   0  13                                   0  15
    0  16                                   0  17                                   0  18
    0  19                                   0  100

LOOPS  LABEL    INDEX     FROM-TO    LENGTH    PROPERTIES
   16  1      * I         18 24       16B                 NOT INNER
   23  1        J         19 24        5B       INSTACK
   35  100    * II        25 40      101B                 NOT INNER
   36  10     * I         26 28       16B                 NOT INNER
   45  10       J         27 28        4B       INSTACK
   55  11     * I         29 31       14B                 NOT INNER
   62  11       J         30 31        3B       INSTACK
   72  12     * I         32 36       25B                 NOT INNER
   73  12     * J         33 36       21B                 NOT INNER
  105  12       K         35 36        4B       INSTACK
  120  13     * I         37 39       14B                 NOT INNER
  125  13       J         38 39        3B       INSTACK
  137  15     * I         42 44       13B                 NOT INNER
  143  15       J         43 44        3B       INSTACK
  156  16     * I         46 50       25B                 NOT INNER
  157  16     * J         47 50       21B                 NOT INNER
  171  16       K         49 50        4B       INSTACK
  204  18     * I         51 53       13B                 NOT INNER
  210  18       J         52 53        4B       INSTACK
  220  17     * I         54 58       25B                 NOT INNER
  221  17     * J         55 58       21B                 NOT INNER
  233  17       K         57 58        4B       INSTACK
  246  19     * I         59 61       13B                 NOT INNER
  252  19       J         60 61        3B       INSTACK

COMMON BLOCKS   LENGTH
      SUBR         300

STATISTICS
  PROGRAM LENGTH                 273B      187
  CM LABELED COMMON LENGTH       454B      300
```

Figure 22. -Concluded.

```
      SUBROUTINE DIAK
      COMMON / SUBR /
     1           NX,NR,NN,NRM,EE,ITER,DT,DETR
     2          ,A(4,4),GM(4,6),H(4,4),W(4,6),B(4,2)
     3          ,AKH(4,4),GMKW(4,6),KF(4,4),P(4,4),P1(4,4),R(4,4)
     4          ,RI(4,4),HP(4,4),Q(4,4),WW(4,4),GMW(4,4),SS(4,4),SC(4)
      REAL KF
C
      DO 101 I=1,NX
      DO 101 J=1,NX
  101 P(I,J)=0.
C GMW*, WW*
      DO 1 I=1,NR
      DO 2 J=1,NX
      S=0.
      DO 3 K=1,NN
    3 S = S + GM(J,K)*W(I,K)
    2 GMW(J,I) = S
      DO 1 J=I,NR
      S=0.
      DO 4 K=1,NN
    4 S = S + W(I,K)*W(J,K)
      WW(I,J) = S
    1 WW(J,I) = S
      IT = 0
C
  800 CONTINUE
      E1 = 0.
      IT = IT + 1
C
C  AKH = A - KH, GMKW = GM - KW, P1 = GMKW GMKW*
      DO 10 I=1,NX
      DO 12 J=1,NX
      S = A(I,J)
      DO 14 K=1,NR
   14 S = S - KF(I,K)*H(K,J)
   12 AKH(I,J) = S
      DO 16 J=1,NN
      S = GM(I,J)
      DO 18 K=1,NR
   18 S = S - KF(I,K)*W(K,J)
   16 GMKW(I,J) = S
      DO 10 J=1,I
      S=0.
      DO 20 K=1,NN
   20 S = S + GMKW(I,K)*GMKW(J,K)
      P1(I,J) = S
   10 P1(J,I) = S
C
C  P = AKH P AKH* + GMKW GMKW*
      CALL CAL
C
C  KF = (APH* + GMW*)(HPH* + WW*)-1
      DO 36 I=1,NR
      DO 32 J=1,NX
      S=0.
      DO 34 K=1,NX
   34 S = S + H(I,K)*P1(K,J)
   32 HP(I,J) = S
      DO 36 J=1,I
      S = WW(I,J)
      DO 38 K=1,NX
   38 S = S + HP(I,K)*H(J,K)
      RI(I,J) = S
   36 RI(J,I) = S
C
      IF(NR .GT. 1) GO TO 333
      DETR = RI(1,1)
      RI(1,1) = 1./RI(1,1)
      GO TO 334
  333 CONTINUE
      DO 39 I=1,NR
      DO 39 J=1,NR
   39 R(I,J)=RI(I,J)
C     CALL TOINVR(I,J,NR,NR,RI,NRM,SC,DETR)
C     EXPLICIT 3X3 INVERSE
      DETR=R(1,1)*(R(2,2)*R(3,3)-R(3,2)*R(2,3))
```

Figure 23. -Program listing of subroutine DIAK.

```
     1 - R(2,1)*(R(1,2)*R(3,3)-R(3,2)*R(1,3))
     2 + R(3,1)*(R(1,2)*R(2,3)-R(2,2)*R(1,3))
      IF(DETR.EQ.0.0) STOP 31
      RI(1,1)=(R(2,2)*R(3,3)-R(3,2)*R(2,3))/DETR
      RI(1,2)=(R(3,2)*R(1,3)-R(1,2)*R(3,3))/DETR
      RI(1,3)=(R(1,2)*R(2,3)-R(2,2)*R(1,3))/DETR
      RI(2,1)=(R(3,1)*R(2,3)-R(2,1)*R(3,3))/DETR
      RI(2,2)=(R(1,1)*R(3,3)-R(1,3)*R(3,1))/DETR
      RI(2,3)=(R(2,1)*R(1,3)-R(1,1)*R(2,3))/DETR
      RI(3,1)=(R(2,1)*R(3,2)-R(3,1)*R(2,2))/DETR
      RI(3,2)=(R(3,1)*R(1,2)-R(1,1)*R(3,2))/DETR
      RI(3,3)=(R(1,1)*R(2,2)-R(2,1)*R(1,2))/DETR
C
  334 CONTINUE
C
      DO 46 I=1,NX
      DO 30 J=I,NX
      S = P(I,J)
      IF(S .EQ. 0) GO TO 31
      S = ABS((P1(I,J)-S)/S)
      IF(E1 .LT. S) E1 = S
   31 P(I,J) = P1(I,J)
   30 P(J,I) = P(I,J)
      DO 42 J=1,NR
      S = GMW(I,J)
      DO 44 K=1,NX
   44 S = S + A(I,K)*HP(J,K)
   42 SC(J) = S
      DO 46 J=1,NR
      S=0.
      DO 48 K=1,NR
   48 S = S + SC(K)*RI(K,J)
   46 KF(I,J) = S
C
      IF(IT .LE. 1) GO TO 800
      IF(E1 .LT. EE) GO TO 220
      IF(IT .GT. ITER) GO TO 220
      GO TO 800
  220 CONTINUE
C
      RETURN
      END
```

```
        SYMBOLIC REFERENCE MAP (R=1)

ENTRY POINTS
    1  DIAK

VARIABLES      SN  TYPE            RELOCATION
    10  A          REAL        ARRAY   SUBR         140  AKH     REAL       ARRAY   SUBR
   130  B          REAL        ARRAY   SUBR           7  DETR    REAL               SUBR
     6  DT         REAL                SUBR           4  EE      REAL               SUBR
   453  E1         REAL                              30  GM      REAL       ARRAY   SUBR
   160  GMKW       REAL        ARRAY   SUBR         410  GMW     REAL       ARRAY   SUBR
    60  H          REAL        ARRAY   SUBR         330  HP      REAL       ARRAY   SUBR
   446  I          INTEGER                          452  IT      INTEGER
     5  ITER       INTEGER             SUBR         447  J       INTEGER
   451  K          INTEGER                          210  KF      REAL       ARRAY   SUBR
     2  NN         INTEGER             SUBR           1  NR      INTEGER            SUBR
     3  NRM        INTEGER             SUBR           0  NX      INTEGER            SUBR
   230  P          REAL        ARRAY   SUBR         250  P1      REAL       ARRAY   SUBR
   350  Q          REAL        ARRAY   SUBR         270  R       REAL       ARRAY   SUBR
   310  RI         REAL        ARRAY   SUBR         450  S       REAL
   450  SC         REAL        ARRAY   SUBR         430  SS      REAL       ARRAY   SUBR
   100  W          REAL        ARRAY   SUBR         370  WW      REAL       ARRAY   SUBR

EXTERNALS          TYPE    ARGS
       CAL                  0

INLINE FUNCTIONS   TYPE    ARGS
       ABS         REAL     1  INTRIN
```

Figure 23. -Continued.

```
STATEMENT LABELS
     0  1                                                   0  2                                  0  3
     0  4                                                   0  10                                 0  12
     0  14                                                  0  16                                 0  18
     0  20                                                  0  30                               361  31
     0  32                                                  0  34                                 0  36
     0  38                                                  0  39                                 0  42
     0  44                                                  0  46                                 0  48
     0  101                                               442  220                              260  333
   343  334                                                72  800

LOOPS  LABEL    INDEX      FROM-TO     LENGTH    PROPERTIES
    3  101      * I           9 11       13B                  NOT INNER
   10  101        J          10 11        2B      INSTACK
   17  1        * I          13 24       52B                  NOT INNER
   20  2        * J          14 18       22B                  NOT INNER
   30  3          K          15 17        4B      INSTACK
   43  1        * J          19 24       23B                  NOT INNER
   53  4          K          21 22        4B      INSTACK
   75  10       * I          32 48      100B                  NOT INNER
   76  12       * J          33 37       24B                  NOT INNER
  110  14         K          35 36        4B      INSTACK
  123  16       * J          38 42       24B                  NOT INNER
  135  18         K          40 41        4B      INSTACK
  150  10       * J          43 48       23B                  NOT INNER
  160  20         K          45 46        4B      INSTACK
  200  36       * I          54 65       53B                  NOT INNER
  201  32       * J          55 59       22B                  NOT INNER
  211  34         K          57 58        4B      INSTACK
  224  36       * J          60 65       25B                  NOT INNER
  236  38         K          62 63        4B      INSTACK
  261  39       * I          72 74       13B                  NOT INNER
  265  39         J          73 74        3B      INSTACK
  344  46       * I          93 110      70B                  NOT INNER
  354  30         J          94 100      10B        OPT
  366  42       * J         101 105      23B                  NOT INNER
  400  44         K         103 104       4B      INSTACK
  412  46       * J         106 110      20B                  NOT INNER
  420  48         K         108 109       4B      INSTACK

COMMON BLOCKS   LENGTH
      SUBR         300

STATISTICS
  PROGRAM LENGTH                      456B      302
  CM LABELED COMMON LENGTH            454B      300
```

Figure 23. -Concluded.

```
SUBROUTINE CAL        73/74    OPT=1                      FTN 4.6+439       78/02/14. 08.28.50

      SUBROUTINE CAL
      COMMON / SUBR /
     1       NX,NR,NN,NRM,EE,ITER,DT,DETR
     2      ,A(4,4),GM(4,6),H(4,4),W(4,6),B(4,2)
     3      ,AKH(4,4),GMKW(4,6),KF(4,4),P(4,4),P1(4,4),R(4,4)
     4      ,RI(4,4),HP(4,4),Q(4,4),WW(4,4),GMW(4,4),SS(4,4),SC(4)
      REAL KF
C
C  Q = AKF
      DO 10 I=1,NX
      DO 10 J=1,NX
   10 Q(I,J) = AKH(I,J)
      IT = 0
C
  800 CONTINUE
      E1 = 0.
      IT = IT +1
C
C  P1 = Q P1 Q* + P1
      DO 20 I=1,NX
      DO 20 J=1,NX
      S=0.
      DO 24 K=1,NX
   24 S = S + Q(I,K)*P1(K,J)
   20 SS(I,J) = S
      DO 26 I=1,NX
      DO 26 J=I,NX
      S=0.
      DO 28 K=1,NX
   28 S = S + SS(I,K)*Q(J,K)
      S3 = P1(I,J)
      IF(S3 .EQ. 0) GO TO 30
      S3 = ABS(S/S3)
      IF(E1 .LT. S3) E1 = S3
   30 P1(I,J) = P1(I,J) + S
   26 P1(J,I) = P1(I,J)
C
C  Q =QQ
      S3 = 0.
      DO 40 I=1,NX
      DO 40 J=1,NX
      S=0.
      DO 42 K=1,NX
   42 S = S + Q(I,K)*Q(K,J)
   40 SS(I,J) = S
      DO 45 I=1,NX
      DO 44 J=1,NX
   44 Q(I,J) = SS(I,J)
   45 S3 = S3 + SS(I,I)
C
      IF(IT .LE. 1) GO TO 800
      IF(S3 .GT. NX) GO TO 230
      IF(E1 .LT. EE) GO TO 220
      IF(IT .GT. ITER) GO TO 220
      GO TO 800
C
  220 CONTINUE
      RETURN
  230 CONTINUE
      STOP 41
      END
```

```
     SYMBOLIC REFERENCE MAP (R=1)

ENTRY POINTS
    1   CAL

VARIABLES      SN   TYPE            RELOCATION
   10  A             REAL       ARRAY     SUBR          140  AKH       REAL        ARRAY      SUBR
  130  B             REAL       ARRAY     SUBR            7  DETR      REAL                   SUBR
    6  DT            REAL                 SUBR            4  EE        REAL                   SUBR
  173  E1            REAL                                30  GM        REAL        ARRAY      SUBR
  160  GMKW          REAL       ARRAY     SUBR          410  GMW       REAL        ARRAY      SUBR
   60  H             REAL       ARRAY     SUBR          330  HP        REAL        ARRAY      SUBR
  170  I             INTEGER                            172  IT        INTEGER
```

Figure 24. -Program listing of subroutine CAL.

```
    5  ITER      INTEGER              SUBR        171  J     INTEGER
  175  K         INTEGER                          210  KF    REAL       ARRAY    SUBR
    2  NN        INTEGER              SUBR          1  NR    INTEGER             SUBR
    3  NRM       INTEGER              SUBR          0  NX    INTEGER             SUBR
  230  P         REAL       ARRAY     SUBR        250  P1    REAL       ARRAY    SUBR
  350  Q         REAL       ARRAY     SUBR        270  R     REAL       ARRAY    SUBR
  310  RI        REAL       ARRAY     SUBR        174  S     REAL
  450  SC        REAL       ARRAY     SUBR        430  SS    REAL       ARRAY    SUBR
  176  S3        REAL                             100  W     REAL       ARRAY    SUBR
  370  WW        REAL       ARRAY     SUBR

INLINE FUNCTIONS   TYPE   ARGS
       ABS         REAL     1  INTRIN

STATEMENT LABELS
    0  10                            0  20                             0  24
    0  26                            0  28                            76  30
    0  40                            0  42                             0  44
    0  45                          166  220                          167  230
   17  800

LOOPS  LABEL    INDEX      FROM-TO    LENGTH    PROPERTIES
    3  10      * I          10 12       13B                NOT INNER
    7  10        J          11 12        3B      INSTACK
   22  20      * I          20 25       25B                NOT INNER
   23  20      * J          21 25       22B                NOT INNER
   33  24        K          23 24        4B      INSTACK
   50  26      * I          26 36       40B                NOT INNER
   52  26      * J          27 36       33B                NOT INNER
   62  28        K          29 30        4B      INSTACK
  112  40      * I          40 45       25B                NOT INNER
  113  40      * J          41 45       22B                NOT INNER
  123  42        K          43 44        4B      INSTACK
  140  45      * I          46 49       16B                NOT INNER
  144  44        J          47 48        3B      INSTACK

COMMON BLOCKS   LENGTH
       SUBR        300

STATISTICS
  PROGRAM LENGTH                    201B      129
 CM LABELED COMMON LENGTH           454B      300
```

Figure 24. -Concluded.

```
SUBROUTINE MP          73/74    OPT=1                            FTN 4.6+439          78/02/14. 08.28.50

                  SUBROUTINE MP(N1,N2,A,NM,LABEL,NO)                                  HON09     1034
                  DIMENSION A(NM,1)                                                   HON09     1035
                  IF(N1.EQ.1) GO TO 20                                                HON09     1036
                  IF(N2.EQ.1) GO TO 30                                                HON09     1037
                  WRITE(NO,600) LABEL                                                 HON09     1038
              600 FORMAT(1H0,7HMATRIX   ,A4)                                          HON09     1039
                  DO 100 I=1,N1                                                       HON09     1040
              100 WRITE(NO,601) (A(I,J),J=1,N2)                                       HON09     1041
              601 FORMAT(1X,10E11.4)                                                  HON09     1042
                  RETURN                                                              HON09     1043
               20 WRITE(NO,610) LABEL                                                 HON09     1044
              610 FORMAT(1H0,12HROW VECTOR   ,A4)                                     HON09     1045
                  WRITE(NO,601)(A(1,I),I=1,N2)                                        HON09     1046
                  RETURN                                                              HON09     1047
               30 WRITE(NO,620) LABEL                                                 HON09     1048
              620 FORMAT(1H0,12HCOL VECTOR   ,A4)                                     HON09     1049
                  WRITE(NO,601)(A(I,1),I=1,N1)                                        HON09     1050
                  RETURN                                                              HON09     1051
                  END                                                                 HON09     1052

SYMBOLIC REFERENCE MAP (R=1)
```

Figure 25. -Program listing of subroutine MP.

```
ENTRY POINTS
    3   MP

VARIABLES       SN  TYPE            RELOCATION
    0   A           REAL        ARRAY     F.P.          150   I         INTEGER
  151   J           INTEGER                               0   LABEL     INTEGER              F.P.
    0   NM          INTEGER               F.P.            0   NO        INTEGER              F.P.
    0   N1          INTEGER               F.P.            0   N2        INTEGER              F.P.

STATEMENT LABELS
   45   20                                      64   30                             0   100
  102   600     FMT                            113   601      FMT                 122   610      FMT
  140   620     FMT

LOOPS   LABEL     INDEX       FROM-TO     LENGTH      PROPERTIES
   25   100       * I          7  8        20B                   EXT REFS   NOT INNER
   30             * J          8  8        11B                   EXT REFS
   52             * I         13 13        10B                   EXT REFS

STATISTICS
  PROGRAM LENGTH                     170B      120
```

Figure 25. -Concluded.

```
      SUBROUTINE FHIC        73/74    OPT=1                          FTN 4.6+439         78/02/14. 08.28.50

                            SUBROUTINE FHIC(U,Y,X)                                        HON09       578
                            COMMON/SUBRH/ DT ,D,W,C1,C2                                   HON09       579
                            DIMENSION X(2)                                                HON09       580
                          1 C2=2.*D*W                                                     HON09       581
                            C1=W*W                                                        HON09       582
                            X(1)=U/C1                                                     HON09       583
                            X(2)=0.                                                       HON09       584
                            Y=0.                                                          HON09       585
                            RETURN                                                        HON09       586
                            END                                                           HON09       587
```

```
      SYMBOLIC REFERENCE MAP (R=1)

ENTRY POINTS
    3   FHIC

VARIABLES       SN  TYPE            RELOCATION
    3   C1          REAL                  SUBRH           4   C2        REAL                 SUBRH
    1   D           REAL                  SUBRH           0   DT        REAL                 SUBRH
    0   U           REAL                  F.P.            2   W         REAL                 SUBRH
    0   X           REAL        ARRAY     F.P.            0   Y         REAL                 F.P.

STATEMENT LABELS
    0   1             INACTIVE

COMMON BLOCKS    LENGTH
       SUBRH           5

STATISTICS
  PROGRAM LENGTH                     15B       13
  CM LABELED COMMON LENGTH            5B        5
```

Figure 26. -Program listing of subroutine FHIC.

```
   SUBROUTINE INPT        73/74    OPT=1                              FTN 4.6+439         78/02/14. 08.28.50

                       SUBROUTINE INPT(A,II,JJ,N)                                          HON09      735
                       DIMENSION A(II,JJ),ID(5),JD(5),YD(5)                                HON09      736
                     2 FORMAT(5(2I2,E12.5))                                                HON09      737
                     1 READ(N,2)(ID(L),JD(L),YD(L),L=1,5)                                  HON09      738
                       IF(ID(1))3,10,3                                                     HON09      739
                     3 DO 5 L=1,5                                                          HON09      740
                       IF(ID(L))4,1,4                                                      HON09      741
                     4 I=ID(L)                                                             HON09      742
                       J=JD(L)                                                             HON09      743
                     5 A(I,J)=YD(L)                                                        HON09      744
                       GO TO 1                                                             HON09      745
                    10 CONTINUE                                                            HON09      746
                       RETURN                                                              HON09      747
                       END                                                                 HON09      748


   SYMBOLIC REFERENCE MAP (R=1)

ENTRY POINTS
    3  INPT

VARIABLES       SN  TYPE            RELOCATION
    0  A            REAL        ARRAY      F.P.          70  I          INTEGER
   72  ID           INTEGER     ARRAY                     0  II         INTEGER                   F.P.
   71  J            INTEGER                              77  JD         INTEGER     ARRAY
    0  JJ           INTEGER                F.P.          67  L          INTEGER
    0  N            INTEGER                F.P.         104  YD         REAL        ARRAY

STATEMENT LABELS
   17  1                                        53  2         FMT                             0  3          INACTIVE
    0  4            INACTIVE                     0  5                                        50  10

LOOPS  LABEL     INDEX      FROM-TO     LENGTH      PROPERTIES
   22             * L         4  4        12B                   EXT REFS
   37  5          * L         6  10       10B          OPT       EXITS

STATISTICS
  PROGRAM LENGTH                  121B      81
```

Figure 27. -Program listing of subroutine INPT.

APPENDIX G

SAMPLE RUN OF PCMLE INITIALIZATION SOFTWARE

This appendix consists of a sample run of PCMLE initialization software, as presented in Figure 28.

```
   1=    T     2=    F     3=    F     4=    F     5=    F     6=    F     7=    F     8=    F     9=    F    10=    F
4 3 6 420 3 4 311
    .0313      .5000     6.0000     1.2500     4.0000     0.0000     0.0000    10.0000
   5.0000      .6000     2.0000      .7000
   4.0000      .0026      .0175     1.0000     1.0000
    .0100     3.2200      .1000     3.2200      .1000    13.8000      .2500
   5.0000     5.0000     5.0000     5.0000
  -1.0000    -1.0000    -1.0000    -1.0000
    .0010      .1000      .0030      .0100
   1.0000      .5000     0.0000     0.0000     0.0000
   -.0700      .0532      .0190     0.0000     0.0000
   -.0500      .0087     -.0208     0.0000     0.0000
   -.0450     -.2368      .2707     0.0000     0.0000
SAMPLE TIME=     .31250E-01


MATRIX KFIC
  .1200E-01    .4600E+02 -.1470E+00
  .3000E-01    .8500E+02 -.1470E+01
 0.            .4600E+00 0.
 0.            .6800E-01  .7000E-02


FILTER DATA   ICH =   1
STATS IN       .40000E+01   .26080E-02   .17500E-01   .10000E+01   .10000E+01
STATS OUT      .39599E+01   .87400E+00   .52811E-02   .11438E-02


A              .99838E+00   .15082E-02   .64419E-01  -.56828E+00
A              .18589E-02   .98448E+00  -.86007E-01  -.55854E+01
A              .57349E-06   .60577E-03   .95474E+00   .12039E+00
A              .60057E-08   .95634E-05   .30527E-01   .10019E+01


AKH            .99838E+00  -.22130E-01  -.89325E+01  -.12767E+01
AKH            .18589E-02   .93998E+00  -.14170E+02  -.51650E+01
AKH            .57349E-06   .57348E-03   .17594E+00   .11967E+00
AKH            .60057E-08   .16701E-04  -.15542E-01   .99769E+00


CHANNEL MODELS      1
        D ARRAY           GRAD D(VBAR)        GRAD D(C2)        GRAD D(C3)        GRAD D(C4)
         .99838E+00         -.21654E-02        0.                0.                 .10623E-09
         .15082E-02          .30709E-02        0.                0.                 .22323E-06
         .64419E-01          .13622E-01        0.                0.                 .10444E-02
        -.56828E+00          .88825E+00        0.                0.                 .44503E-04
         .18589E-02          .74332E-02        0.                0.                -.52473E-10
         .98448E+00         -.27754E-04        0.                0.                -.13938E-06
        -.86007E-01         -.85836E-01        0.                0.                -.88999E-03
        -.55854E+01         -.55897E+01        0.                0.                -.27807E-04
         .57349E-06          .29819E-05        0.                0.                 .59353E-08
         .60577E-03          .60618E-03        0.                0.                 .94146E-05
         .95474E+00          .18562E-02        0.                0.                 .29821E-01
```

Figure 28. -Sample run of PCMLE initialization software.

GRAD K(VBR)	GRAD K(C2)	GRAD K(C3)	GRAD K(C4)
.28919E-01	0.	0.	.30195E-02
-.20544E-02	0.	0.	.40119E-02
.29707E-04	0.	0.	-.25065E-05
-.43420E-05	0.	0.	.13207E-05
.21971E+02	0.	0.	-.83095E+01
.12838E+02	0.	0.	-.13942E+02
.25734E-01	0.	0.	.18329E+00
.96002E-03	0.	0.	.86257E-03
.21040E+01	0.	0.	.24581E+00
-.26237E+00	0.	0.	.74300E-01
.41086E-04	0.	0.	-.14309E-04
-.50711E-03	0.	0.	.18197E-03

MATRIX KFIC

-.2000E-01	-.6770E+02	-.4000E+00
.3500E-01	.8360E+02	-.1190E+01
0.	.3000E+00	0.
0.	.8000E-01	.7000E-02

FILTER DATA	ICH = 2				
STATS IN	.40000E+01	.26080E-02	.17500E-01	.10000E+01	.10000E+01
STATS OUT	.47797E+01	.89407E+00	.47435E-02	.11839E-02	

A	.99917E+00	.38194E-03	.59227E-01	-.89502E+00
A	-.18597E-02	.98449E+00	-.43003E-01	-.27907E+01
A	-.28621E-06	.30188E-03	.94811E+00	.60425E-01
A	-.29987E-08	.47714E-05	.30427E-01	.10010E+01

AKH	.99917E+00	.36462E-01	.86723E+01	.68505E+00
AKH	-.18597E-02	.93773E+00	-.92992E+01	-.26069E+01
AKH	-.28621E-06	.28394E-03	.21595E+00	.59747E-01
AKH	-.29987E-08	.78117E-05	-.14755E-01	.99643E+00

CHANNEL MODELS 2

D ARRAY	GRAD D(VBAR)	GRAD D(C2)	GRAD D(C3)	GRAD D(C4)
.99917E+00	-.11144E-02	0.	0.	-.51870E-10
.38194E-03	.15827E-02	0.	0.	.10723E-06
.59227E-01	.70199E-02	0.	0.	.98836E-03
-.89502E+00	.46035E+00	0.	0.	.21454E-04
-.18597E-02	.74395E-02	0.	0.	.13122E-10
.98449E+00	-.18585E-04	0.	0.	-.34837E-07
-.43003E-01	-.85664E-01	0.	0.	-.44456E-03
-.27907E+01	-.55887E+01	0.	0.	-.69694E-05
-.28621E-06	.68691E-06	0.	0.	-.29588E-08
.30188E-03	.60398E-03	0.	0.	.46870E-05
.94811E+00	.18659E-02	0.	0.	.29623E-01
.60425E-01	.11995E+00	0.	0.	.93790E-03
-.29987E-08	.71971E-08	0.	0.	-.23259E-10
.47714E-05	.95446E-05	0.	0.	.49324E-07
.30427E-01	.19659E-04	0.	0.	.47117E-03
.10010E+01	.19000E-02	0.	0.	.98687E-05
.41721E-02	.16357E-03	0.	.10068E-02	.45078E-05
.11917E-03	.40414E-05	.10068E-02	0.	.18566E-05
.10660E-01	.21284E-01	0.	-.45055E-03	-.14633E-05
-.28844E+00	-.93294E-01	-.45055E-03	0.	-.60322E-06
.12741E-01	.36666E-02	0.	.30427E-01	.19730E-03
.52256E-02	.72016E-02	.30427E-01	0.	.81148E-04

F ARRAY

-.36081E-01
.46759E-01
.17942E-04
-.30403E-05

Figure 28. -Continued.

-.86131E+01
.92562E+01
.73216E+00
.45182E-01
-.15801E+01
-.18383E+00
.67764E-03
.45285E-02
-.15703E+02
.59536E-01
-.59256E+00
.11056E-01
-.59256E+00
.34135E+05
-.71031E+02
.11056E-01
-.71031E+02
.32506E+04

.12039E+00	.11866E+00	0.	0.	.18750E-02
.60057E-08	.31227E-07	0.	0.	.46627E-10
.95634E-05	.95666E-05	0.	0.	.98962E-07
.30527E-01	.19583E-04	0.	0.	.47320E-03
.10019E+01	.18864E-02	0.	0.	.19730E-04
.42091E-02	.23582E-03	0.	.10612E-02	.47077E-05
-.73711E-04	-.31555E-03	.10612E-02	0.	.18858E-05
.21330E-01	.21228E-01	0.	-.90055E-03	-.29369E-05
-.33503E+00	-.93399E-01	-.90055E-03	0.	-.11790E-05
.12828E-01	.36854E-02	0.	.30527E-01	.19881E-03
.50864E-02	.71967E-02	.30527E-01	0.	.79376E-04

F ARRAY
.23638E-01
.44496E-01
.32284E-04
-.71381E-05
.89969E+01
.14084E+02
.77880E+00
.46070E-01
.70844E+00
-.42041E+00
.71363E-03
.42178E-02
-.15537E+02
.59681E-01
-.90503E+00
.25283E-01
-.90503E+00
.28840E+05
-.69719E+02
.25283E-01
-.69719E+02
.32516E+04

GRAD K(VBR)	GRAD K(C2)	GRAD K(C3)	GRAD K(C4)
.10498E+00	0.	0.	-.17602E-02
-.10742E-01	0.	0.	.14262E-02
.30290E-04	0.	0.	-.26322E-05
-.11735E-04	0.	0.	.62656E-06
.66867E+01	0.	0.	.77239E+01
.15404E+02	0.	0.	-.84387E+01
.19018E-01	0.	0.	.18726E+00
.29000E-02	0.	0.	.10183E-02
.30052E+00	0.	0.	-.15239E+00
-.66898E+00	0.	0.	.37392E-01
.22958E-03	0.	0.	-.64499E-04
-.66070E-03	0.	0.	.73678E-04

Figure 28. -Continued.

```
MATRIX KFIC
  0.          0.          0.
  0.          0.          0.
  0.          0.          0.
  0.          .3000E-01   .1000E+00


FILTER DATA   ICH =   3
STATS IN      .40000E+01  .26080E-02  .17500E-01  .10000E+01  .10000E+01
STATS OUT     .33367E+01  .93778E+00  .64211E-02  .12007E-02

A             .99944E+00  0.          .58037E-01 -.10060E+01
A            -.55797E-02  .98450E+00 -.17806E-03  .28149E-02
A             0.          0.          .96231E+00  0.
A             0.          0.          .30657E-01  .10000E+01

AKH           .99944E+00  .54521E-01 -.17043E-01 -.51563E+00
AKH          -.55797E-02  .93290E+00  .98787E-03 -.35488E-01
AKH           0.          .34183E-09  .13628E+00 -.37691E-03
AKH           0.         -.69170E-06 -.13294E-01  .99535E+00


CHANNEL MODELS     3
        D ARRAY        GRAD D(VBAR)     GRAD D(C2)      GRAD D(C3)      GRAD D(C4)
         .99944E+00    -.53327E-04     0.              0.              0.
        0.              .94184E-04     0.              0.              0.
         .58037E-01     .37844E-03     0.              0.               .98154E-03
        -.10060E+01     .25862E-01     0.              0.              0.
        -.55797E-02     .74398E-02     0.              0.              0.
         .98450E+00    -.11306E-05     0.              0.              0.
        -.17806E-03    -.86089E-01     0.              0.             -.19209E-05
         .28149E-02    -.55853E+01     0.              0.              0.
        0.             -.16111E-05     0.              0.              0.
        0.              .60837E-03     0.              0.              0.
         .96231E+00     .19029E-02     0.              0.               .30077E-01
        0.              .12255E+00     0.              0.              0.
        0.             -.16859E-07     0.              0.              0.
        0.              .95917E-05     0.              0.              0.
         .30657E-01     .19952E-04     0.              0.               .47600E-03
         .10000E+01     .19275E-02     0.              0.              0.
         .40764E-02     .12059E-03     0.               .99460F-03      .35272E-05
         .18897E-04     .22784E-03      .99460E-03     0.               .20358E-06
        -.11129E-04     .21417E-01     0.             -.19397E-05     -.50808E-08
        -.24186E+00    -.93050E-01    -.19397E-05     0.              -.29328E-09
         .10092E-01     .36859E-02     0.               .30657E-01      .15670E-03
         .58249E-03     .72821E-02      .30657E-01     0.               .90441E-05

        F ARRAY
        -.54521E-01
         .51597E-01
        -.34183E-09
         .69170E-06
         .75080E-01
        -.11659E-02
         .82604E+00
         .43951E-01
        -.49033E+00
         .38303E-01
         .37691E-03
         .46487E-02
        -.15204E+02
         .59244E-01
         .52226E-04
        -.22586E-02
         .52226E-04
         .20820E+05
        -.57584E+02
        -.22586E-02
        -.57584E+02
         .32502E+04
```

Figure 28. -Continued.

GRAD K(VBR)	GRAD K(C2)	GRAD K(C3)	GRAD K(C4)
.84841E-02	0.	0.	-.17092E-07
-.69648E-02	0.	0.	.13519E-08
.36441E-04	0.	0.	.10749E-09
-.37235E-05	0.	0.	.13869E-09
-.12869E+02	0.	0.	.10643E-01
.11445E+02	0.	0.	.26081E-03
.45135E-02	0.	0.	.19843E+00
.43564E-02	0.	0.	.35176E-02
-.24507E+01	0.	0.	-.11378E-03
-.24181E+00	0.	0.	.75688E-05
.67689E-03	0.	0.	-.39295E-04
.52702E-04	0.	0.	.15764E-05

Figure 28. -Concluded.

APPENDIX H

PROGRAM LISTING OF MODEL REFERENCE ALGORITHM

This appendix consists of the program listings of subroutines RFMOD (Fig. 29), INTGRAL (Fig. 30), and RMIC (Fig. 31).

```
SUBROUTINE RFMOD       73/74    OPT=1                        FTN 4.6+439          78/02/15. 07.44.44

                  SUBROUTINE RFMOD                                                 HON09     1564
                  COMMON/MRDAT/A( 3, 3),B( 3,2),DX(39),X(13),U(2)                  HON09     1565
                 1,  T1,T2,T3,T4,T5,T6,T7,T8,T9,T10,T11,THR1,THR2,THR3             HON09     1566
                 2,  G11,G12,G21,G22                                               HON09     1567
                  COMMON/VARDAT/ UX(50),LX(50)                                     HON09     1568
                  COMMON/IPIC/DUM(59),XVZ(2),XQ(2),XTH(2),XDB(2),XDC(2)            HON09     1569
                  LOGICAL LX                                                       HON09     1570
            C                                                                      HON09     1571
                  VZ=UX(11)                                                        HON09     1572
                  Q=UX(12)                                                         HON09     1573
                  TH=UX(13)                                                        HON09     1574
                  U(1)=UX(1)                                                       HON09     1575
                  U(2)=UX(2)                                                       HON09     1576
                  DT=UX(19)                                                        HON09     1577
                  CALL FH(Q,Q,XQ)                                                  HON09     1578
                  CALL FH(VZ,VZ,XVZ)                                               HON09     1579
                  CALL FH(TH,TH,XTH)                                               HON09     1580
                  CALL FH(U(1),U(1),XDB)                                           HON09     1581
                  CALL FH(U(2),U(2),XDC)                                           HON09     1582
            C                                                                      HON09     1583
                  EVZ=X(1)-VZ                                                      HON09     1584
                  EQ=X(2)-Q                                                        HON09     1585
                  ETH=X(3)-TH                                                      HON09     1586
                  UX(24)=EVZ/10.                                                   HON09     1587
                  UX(25)=EQ*5.73                                                   HON09     1588
                  UX(26)=ETH*5.73                                                  HON09     1589
                  IF(EQ.GT.1.) EQ=1.                                               HON09     1590
                  IF(EQ.LT.-1.) EQ=-1.                                             HON09     1591
                  IF(ETH.GT.1.) ETH=1.                                             HON09     1592
                  IF(ETH.LT.-1.) ETH=-1.                                           HON09     1593
                  IF(EVZ.GT.10.) EVZ=10.                                           HON09     1594
                  IF(EVZ.LT.-10.) EVZ=-10.                                         HON09     1595
                  IF(ABS(EVZ).LT.THR1) EVZ=0.                                      HON09     1596
                  IF(ABS(EQ).LT.THR2) EQ=0.                                        HON09     1597
                  IF(ABS(ETH).LT.THR3) ETH=0.                                      HON09     1598
                  T1=UX(34)/(1. + U(1)*U(1)+U(2)*U(2))                             HON09     1599
                  T5=UX(35)                                                        HON09     1600
                  T6=UX(36)                                                        HON09     1601
                  T7=UX(37)                                                        HON09     1602
                  T11=UX(38)                                                       HON09     1603
                  P11=T1*0.25                                                      HON09     1604
                  P22=T1*0.1944                                                    HON09     1605
                  P23=T1*0.08333                                                   HON09     1606
                  P33=T1*1.4167                                                    HON09     1607
                  FAC=1.+P11*EVZ*EVZ+P22*EQ*EQ+2.*P23*EQ*ETH+P33*ETH*ETH           HON09     1608
                  FAC1=SQRT(FAC)                                                   HON09     1609
                  S1=P22*EQ*VZ + P23*ETH*VZ                                        HON09     1610
                  S2=P22*EQ*Q + P23*ETH*Q                                          HON09     1611
                  S3=P22*EQ*TH + P23*ETH*TH                                        HON09     1612
                  S4=P22*EQ*U(1) + P23*ETH*U(1)                                    HON09     1613
                  S5=P22*EQ*U(2) + P23*ETH*U(2)                                    HON09     1614
            C                                                                      HON09     1615
                  DX(4)=(G11*P11*EVZ*VZ + G12*S1)*T2                               HON09     1616
                  DX(5)=(G11*P11*EVZ*Q + G12*S2)*T3                                HON09     1617
                  DX(6)=(G11*P11*EVZ*TH + G12*S3)*T4                               HON09     1618
                  DX(7)=(G11*P11*EVZ*U(1) + G12*S4)*T5                             HON09     1619
                  DX(8)=(G11*P11*EVZ*U(2) + G12*S5)*T6                             HON09     1620
                  DX(9)=(G21*P11*EVZ*VZ + G22*S1)*T7                               HON09     1621
                  DX(10)=(G21*P11*EVZ*Q + G22*S2)*T8                               HON09     1622
```

Figure 29. -Program listing of subroutine RFMOD.

```
         DX(11)=(G21*P11*EVZ*TH + G22*S3)*T9                        HON09     1623
         DX(12)=(G21*P11*EVZ*U(1) + G22*S4)*T10                     HON09     1624
         DX(13)=(G21*P11*EVZ*U(2) + G22*S5)*T11                     HON09     1625
   C                                                                HON09     1626
         DO 100 I=1,3                                               HON09     1627
         S=0.                                                       HON09     1628
         DO 101 J=1,3                                               HON09     1629
     101 S=S + A(I,J)*X(J)                                          HON09     1630
         DO 102 J=1,2                                               HON09     1631
     102 S=S + B(I,J)*U(J)                                          HON09     1632
     100 DX(I)=S                                                    HON09     1633
         CALL INTGRAL(DX,X,DT,TIME,13,1)                            HON09     1634
   C     OUTPUT GAINS                                               HON09     1635
         DO 200 I=1,10                                              HON09     1636
     200 UX(40+I)=X(3+I)                                            HON09     1637
         UX(20)=U(1)/10.                                            HON09     1638
         UX(21)=U(2)*5.73                                           HON09     1639
         UX(22)=X(1)/10.                                            HON09     1640
         UX(23)=X(3)*5.73                                           HON09     1641
         UX(27)=X(13)                                               HON09     1642
         UX(28)=DX(7)                                               HON09     1643
         UX(29)=DX(8)                                               HON09     1644
         UX(30)=DX(12)                                              HON09     1645
         UX(31)=DX(13)                                              HON09     1646
         UX(32)=FAC                                                 HON09     1647
         RETURN                                                     HON09     1648
         END                                                        HON09     1649
```

```
      SYMBOLIC REFERENCE MAP (R=1)

ENTRY POINTS
    1   RFMOD

VARIABLES     SN  TYPE              RELOCATION
    0   A         REAL       ARRAY     MRDAT          11  B        REAL      ARRAY    MRDAT
  355   DT        REAL                                 0  DUM      REAL      ARRAY    IPIC
   17   DX        REAL       ARRAY     MRDAT         357  EQ       REAL
  360   ETH       REAL                               356  EVZ      REAL
  365   FAC       REAL                               366  FAC1     REAL
  123   G11       REAL                 MRDAT         124  G12      REAL               MRDAT
  125   G21       REAL                 MRDAT         126  G22      REAL               MRDAT
  374   I         INTEGER                            376  J        INTEGER
   62   LX        LOGICAL    ARRAY     VARDAT        361  P11      REAL
  362   P22       REAL                               363  P23      REAL
  364   P33       REAL                               353  Q        REAL
  375   S         REAL                               367  S1       REAL
  370   S2        REAL                               371  S3       REAL
  372   S4        REAL                               373  S5       REAL
  354   TH        REAL                               120  THR1     REAL               MRDAT
  121   THR2      REAL                 MRDAT         122  THR3     REAL               MRDAT
  377   TIME      REAL                               105  T1       REAL               MRDAT
  116   T10       REAL                 MRDAT         117  T11      REAL               MRDAT
  106   T2        REAL                 MRDAT         107  T3       REAL               MRDAT
  110   T4        REAL                 MRDAT         111  T5       REAL               MRDAT
  112   T6        REAL                 MRDAT         113  T7       REAL               MRDAT
  114   T8        REAL                 MRDAT         115  T9       REAL               MRDAT
  103   U         REAL       ARRAY     MRDAT           0  UX       REAL      ARRAY    VARDAT
  352   VZ        REAL                                66  X        REAL      ARRAY    MRDAT
  101   XDB       REAL       ARRAY     IPIC          103  XDC      REAL      ARRAY    IPIC
   75   XQ        REAL       ARRAY     IPIC           77  XTH      REAL      ARRAY    IPIC
   73   XVZ       REAL       ARRAY     IPIC

EXTERNALS            TYPE    ARGS
        FH                   3                          INTGRAL              6
        SQRT         REAL    1 LIBRARY

INLINE FUNCTIONS     TYPE    ARGS
        ABS          REAL    1  INTRIN

STATEMENT LABELS
    0  100                                 0  101                               0  102
    0  200
```

Figure 29. -Continued.

```
LOOPS  LABEL     INDEX      FROM-TO     LENGTH     PROPERTIES
  216  100     * I            64 70       27B               NOT INNER
  224  101       J            66 67        4B        INSTACK
  235  102       J            68 69        4B        INSTACK
  252  200       I            73 74        3B        INSTACK

COMMON BLOCKS    LENGTH
       MRDAT        87
       VARDAT      100
       IPIC         69

STATISTICS
  PROGRAM LENGTH                4008       256
  CM LABELED COMMON LENGTH      4008       256
```

Figure 29. -Concluded.

```
 SUBROUTINE INTGRAL     73/74    OPT=1                         FTN 4.6+439          78/02/15. 07.44.44

                 SUBROUTINE INTGRAL(DX,X,DT,TIME,NX,MINTG)                        HON09     750
                 COMMON/MRINT/XO(50),MINTGP,NX2,B0,B1,C0,C1,C2,TIMEO              HON09     751
           C                                                                      HON09     752
           C     THIS SUBROUTINE INTEGRATES DX TO GET X.                          HON09     753
           C                                                                      HON09     754
                 DIMENSION DX(1), X(1)                                            HON09     755
           C                                                                      HON09     756
           C     INITIALIZATION                                                   HON09     757
           C                                                                      HON09     758
                 IF(MINTG .GT. 0) GO TO 10                                        HON09     759
                 NX2 = 2*NX                                                       HON09     760
                 B0 = 3.0*DT/2.0                                                  HON09     761
                 B1 =     -DT/2.0                                                 HON09     762
                 C0 = 23.0*DT/12.0                                                HON09     763
                 C1 =-16.0*DT/12.0                                                HON09     764
                 C2 =  5.0*DT/12.0                                                HON09     765
                 MINTGP = 1                                                       HON09     766
                 TIMEO = TIME                                                     HON09     767
                 DO 5 I = 1, NX                                                   HON09     768
               5 XO(I) = X(I)                                                     HON09     769
                 RETURN                                                           HON09     770
           C                                                                      HON09     771
           C     STARTUP PROCEDURE                                                HON09     772
           C                                                                      HON09     773
              10 IF(MINTGP - MINTG) 20, 60, 90                                    HON09     774
              20 GO TO (30, 40), MINTGP                                           HON09     775
              30 DO 35 I = 1, NX                                                  HON09     776
                 TEMP = DT*DX(I)                                                  HON09     777
                 X(I) = X(I) - TEMP                                               HON09     778
              35 DX(NX+I) = DX(I)                                                 HON09     779
                 GO TO 50                                                         HON09     780
              40 DO 45 I = 1, NX                                                  HON09     781
                 TEMP = B0*DX(I) + B1*DX(NX+I)                                    HON09     782
                 X(I) = X(I) - TEMP                                               HON09     783
                 DX(NX2+I) = DX(NX+I)                                             HON09     784
              45 DX(NX+I) = DX(I)                                                 HON09     785
              50 MINTGP = MINTGP + 1                                              HON09     786
                 TIME = TIME - DT                                                 HON09     787
                 RETURN                                                           HON09     788
           C                                                                      HON09     789
              60 GO TO (87, 70, 80), MINTG                                        HON09     790
              70 DO 75 I = 1, NX                                                  HON09     791
                 X(I) = XO(I)                                                     HON09     792
                 TEMP = DX(I)                                                     HON09     793
                 DX(I) = DX(NX+I)                                                 HON09     794
```

Figure 30. -Program listing of subroutine INTGRAL.

```
             75 DX(NX+I) = TEMP                                                   HON09      795
                GO TO 87                                                          HON09      796
             80 DO 85 I = 1, NX                                                   HON09      797
                X(I) = X0(I)                                                      HON09      798
 50             TEMP = DX(I)                                                      HON09      799
                DX(I) = DX(NX2+I)                                                 HON09      800
             85 DX(NX2+I) = TEMP                                                  HON09      801
             87 MINTGP = MINTGP + 1                                               HON09      802
                TIME = TIME0                                                      HON09      803
 55          90 GO TO (100, 200, 300), MINTG                                      HON09      804
          C                                                                       HON09      805
          C     EULER INTEGRATION (FIRST ORDER)                                   HON09      806
          C                                                                       HON09      807
            100 DO 150 I = 1, NX                                                  HON09      808
 60             TEMP = DT*DX(I)                                                   HON09      809
            150 X(I) = X(I) + TEMP                                                HON09      810
                GO TO 1000                                                        HON09      811
          C                                                                       HON09      812
          C     HARRY BEAN INTEGRATION (SECOND ORDER)                             HON09      813
 65       C                                                                       HON09      814
            200 DO 250 I = 1, NX                                                  HON09      815
                TEMP = B0*DX(I) + B1*DX(NX+I)                                     HON09      816
                X(I) = X(I) + TEMP                                                HON09      817
            250 DX(NX+I) = DX(I)                                                  HON09      818
 70             GO TO 1000                                                        HON09      819
          C                                                                       HON09      820
          C     GUNTER STEIN INTEGRATION (THIRD ORDER)                            HON09      821
          C                                                                       HON09      822
            300 DO 350 I = 1, NX                                                  HON09      823
 75             TEMP = C0*DX(I) + C1*DX(NX+I) + C2*DX(NX2+I)                      HON09      824
                X(I) = X(I) + TEMP                                                HON09      825
                DX(NX2+I) = DX(NX+I)                                              HON09      826
            350 DX(NX+I) = DX(I)                                                  HON09      827
          C                                                                       HON09      828
 80       C     INCREMENT TIME                                                    HON09      829
          C                                                                       HON09      830
           1000 TIME = TIME + DT                                                  HON09      831
                RETURN                                                            HON09      832
                END                                                               HON09      833
```

```
CARD NR. SEVERITY  DETAILS    DIAGNOSIS OF PROBLEM

    26     I                  AN IF STATEMENT MAY BE MORE EFFICIENT THAN A 2 OR 3 BRANCH COMPUTED GO TO STATEMENT.
    41     I                  AN IF STATEMENT MAY BE MORE EFFICIENT THAN A 2 OR 3 BRANCH COMPUTED GO TO STATEMENT.
    55     I                  AN IF STATEMENT MAY BE MORE EFFICIENT THAN A 2 OR 3 BRANCH COMPUTED GO TO STATEMENT.
```

```
         SYMBOLIC REFERENCE MAP (R=1)

 ENTRY POINTS
     3  INTGRAL

 VARIABLES      SN  TYPE              RELOCATION
    64  B0          REAL                   MRINT        65  B1      REAL                 MRINT
    66  C0          REAL                   MRINT        67  C1      REAL                 MRINT
    70  C2          REAL                   MRINT         0  DT      REAL                  F.P.
     0  DX          REAL          ARRAY     F.P.       245  I       INTEGER
     0  MINTG       INTEGER                 F.P.        62  MINTGP  INTEGER              MRINT
     0  NX          INTEGER                 F.P.        63  NX2     INTEGER              MRINT
   246  TEMP        REAL                                 0  TIME    REAL                  F.P.
    71  TIME0       REAL                   MRINT         0  X       REAL       ARRAY      F.P.
     0  X0          REAL          ARRAY    MRINT

 STATEMENT LABELS
     0  5                             34  10                            0  20          INACTIVE
    45  30                             0  35                           61  40
     0  45                           101  50                          106  60
   116  70                             0  75                          132  80
     0  85                           146  87                          151  90
   161  100                            0  150                         174  200
     0  250                          211  300                           0  350
   232  1000
```

Figure 30. -Continued.

```
LOOPS  LABEL    INDEX     FROM-TO    LENGTH    PROPERTIES
   30  5        I           19 20        2B     INSTACK
   54  35       I           27 30        4B     INSTACK
   71  45       I           32 36        7B     INSTACK
  124  75       I           42 46        4B     INSTACK
  141  85       I           48 52        4B     INSTACK
  167  150      I           59 61        4B     INSTACK
  202  250      I           66 69        6B     INSTACK
  221  350      I           74 78       10B        OPT

COMMON BLOCKS   LENGTH
       MRINT        58

STATISTICS
  PROGRAM LENGTH               247B      167
  CM LABELED COMMON LENGTH      72B       58
```

Figure 30. -Concluded.

```
   SUBROUTINE RMIC       73/74    OPT=1                         FTN 4.6+439          78/02/15. 07.44.44

                     SUBROUTINE RMIC                                                 HON09      1651
             C                                                                       HON09      1652
                     COMMON/VARDAT/ UX(50),LX(50)                                    HON09      1653
                     COMMON/MRDAT/A( 3, 3),B( 3,2),DX(39),X(13),U(2)                 HON09      1654
                    1,  T1,T2,T3,T4,T5,T6,T7,T8,T9,T10,T11,THR1,THR2,THR3            HON09      1655
                    2,  G11,G12,G21,G22                                              HON09      1656
                     LOGICAL LX                                                      HON09      1657
             C                                                                       HON09      1658
             C                                                                       HON09      1659
                     DO 20 I=1,3                                                     HON09      1660
                     DO 10 J=1,3                                                     HON09      1661
                  10 A(I,J)=0.                                                       HON09      1662
                     DO 15 J=1,2                                                     HON09      1663
                  15 B(I,J)=0.                                                       HON09      1664
                  20 CONTINUE                                                        HON09      1665
                     A(1,1)=-2.                                                      HON09      1666
                     A(2,2)=-4.                                                      HON09      1667
                     A(2,3)=-7.                                                      HON09      1668
                     A(3,2)= 1.                                                      HON09      1669
                     B(1,1)=2.                                                       HON09      1670
                     B(2,2)=7.                                                       HON09      1671
                     DO 30 I=1,39                                                    HON09      1672
                  30 DX(I)=0.                                                        HON09      1673
                     DT=UX(19)                                                       HON09      1674
                     CALL INTGRAL(DX,X,DT,0.,13,0)                                   HON09      1675
                     RETURN                                                          HON09      1676
                     END                                                             HON09      1677
```

```
   SYMBOLIC REFERENCE MAP (R=1)

ENTRY POINTS
    1  RMIC

VARIABLES      SN  TYPE          RELOCATION
    0  A           REAL       ARRAY    MRDAT          11  B      REAL      ARRAY    MRDAT
   72  DT          REAL                               17  DX     REAL      ARRAY    MRDAT
  123  G11         REAL                MRDAT         124  G12    REAL               MRDAT
  125  G21         REAL                MRDAT         126  G22    REAL               MRDAT
   70  I           INTEGER                            71  J      INTEGER
   62  LX          LOGICAL    ARRAY    VARDAT        120  THR1   REAL               MRDAT
  121  THR2        REAL                MRDAT         122  THR3   REAL               MRDAT
  105  T1          REAL                MRDAT         116  T10    REAL               MRDAT
  117  T11         REAL                MRDAT         106  T2     REAL               MRDAT
  107  T3          REAL                MRDAT         110  T4     REAL               MRDAT
```

Figure 31. -Program listing of subroutine RMIC.

```
   111  T5        REAL                MRDAT          112  T6        REAL                MRDAT
   113  T7        REAL                MRDAT          114  T8        REAL                MRDAT
   115  T9        REAL      ARRAY     MRDAT          103  U         REAL      ARRAY     MRDAT
     0  UX        REAL      ARRAY     VARDAT          66  X         REAL      ARRAY     MRDAT

EXTERNALS         TYPE    ARGS
       INTGRAL               6

STATEMENT LABELS
     0  10                                 0  15                                   0  20
     0  30

LOOPS  LABEL     INDEX     FROM-TO    LENGTH    PROPERTIES
    3  20      * I          10 15       23B               NOT INNER
   10  10        J          11 12        2B      INSTACK
   20  15        J          13 14        2B      INSTACK
   41  30        I          22 23        2B      INSTACK

COMMON BLOCKS    LENGTH
       VARDAT      100
       MRDAT        87

STATISTICS
  PROGRAM LENGTH                  73B      59
  CM LABELED COMMON LENGTH       273B     187
```

Figure 31. -Concluded.