1986

Development of a mathematical model that simulates the longitudinal, and lateral-directional response of the F/A-18 for the study of flight control reconfiguration.

Rojek, Fredric W.

Monterey, California: U.S. Naval Postgraduate School

http://hdl.handle.net/10945/21787

NAVAL POSTGRADUATE SCHOOL
Monterey, California

THESIS

DEVELOPMENT OF A MATHEMATICAL MODEL THAT SIMULATES THE LONGITUDINAL, AND LATERAL-DIRECTIONAL RESPONSE OF THE F/A-18 FOR THE STUDY OF FLIGHT CONTROL RECONFIGURATION

by

Fredric W. Rojek

September 1986

Thesis Advisor: Daniel J. Collins

Approved for public release; distribution unlimited.

REPORT DOCUMENTATION PAGE

REPORT SECURITY CLASSIFICATION JNCLASSIFIED	1b. RESTRICTIVE MARKINGS
SECURITY CLASSIFICATION AUTHORITY DECLASSIFICATION / DOWNGRADING SCHEDULE	3 DISTRIBUTION / AVAILABILITY OF REPORT Approved for public release; distribution unlimited.
PERFORMING ORGANIZATION REPORT NUMBER(S)	5. MONITORING ORGANIZATION REPORT NUMBER(S)

NAME OF PERFORMING ORGANIZATION Iaval Postgraduate School	6b. OFFICE SYMBOL (If applicable) Code 67	7a. NAME OF MONITORING ORGANIZATION Naval Postgraduate School
ADDRESS (City, State, and ZIP Code) Monterey, California 93943-5000		7b. ADDRESS (City, State, and ZIP Code) Monterey, California 93943-5000
NAME OF FUNDING / SPONSORING ORGANIZATION	8b. OFFICE SYMBOL (If applicable)	9. PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER

ADDRESS (City, State, and ZIP Code)

10. SOURCE OF FUNDING NUMBERS

PROGRAM ELEMENT NO	PROJECT NO	TASK NO	WORK UNIT ACCESSION NO.

TITLE (Include Security Classification) DEVELOPMENT OF A MATHEMATICAL MODEL THAT SIMULATES THE
)NGITUDINAL, AND LATERAL-DIRECTIONAL RESPONSE OF THE F/A-18 FOR THE STUDY
F FLIGHT CONTROL RECONFIGURATION

PERSONAL AUTHOR(S)
ROJEK, FREDRIC W.

TYPE OF REPORT aster's Thesis	13b TIME COVERED FROM ______ TO ______	14 DATE OF REPORT (Year, Month, Day) September 1986	15 PAGE COUNT 286

SUPPLEMENTARY NOTATION

COSATI CODES			18. SUBJECT TERMS (Continue on reverse if necessary and identify by block number)
FIELD	GROUP	SUB-GROUP	F/A-18, Simulation, Reconfigurable, Flight, Controls

ABSTRACT (Continue on reverse if necessary and identify by block number)

A linearized mathematical model is developed which simulates the dynamic
esponse of the Navy F/A-18 for the study of flight control reconfiguration.
he aircraft is modeled as a multi-input multi-output, sampled data, closed
ystem, which couples the dynamics of the flight control system to the air-
raft linearized small perturbation equations. The discrete time, state
ariable equations for the system are then formulated. A computer program is
eveloped which will compose the model matricies and compute the response of
he aircraft to stick and rudder inputs.

To study flight control reconfiguration, the model allows individual
ctuation of either a left or right control surface. Aircraft response to
he actuation loss of either the left or right stabilator is simulated in the
rogram. The program is designed to implement the reconfigurable control
ixer, currently under study for the Self-Repairing Digital Flight Control
ystem.

DISTRIBUTION / AVAILABILITY OF ABSTRACT ☒ UNCLASSIFIED/UNLIMITED ☐ SAME AS RPT ☐ DTIC USERS	21. ABSTRACT SECURITY CLASSIFICATION UNCLASSIFIED	
NAME OF RESPONSIBLE INDIVIDUAL aniel J. Collins	22b TELEPHONE (Include Area Code) (408) 646-2826	22c. OFFICE SYMBOL Code 67Co

Block 19. ABSTRACT (cont'd)

The computer simulation was written in VS FORTRAN. A copy of the program and simulation results are included in the appendices.

Approved for public release; distribution unlimited.

Development of a Mathematical Model that Simulates the Longitudinal, and Lateral-Directional Response of the F/A-18 for the Study of Flight Control Reconfiguration

by

Fredric W. Rojek
Lieutenant, United States Navy
B.S.E.E., State University of New York at Buffalo

Submitted in partial fulfillment of the
requirements for the degree of

MASTER OF SCIENCE IN AERONAUTICAL ENGINEERING

from the

NAVAL POSTGRADUATE SCHOOL
September 1986

ABSTRACT

A linearized mathematical model is developed which simulates the dynamic response of the Navy F/A-18 for the study of flight control reconfiguration. The aircraft is modeled as a multi-input multi-output, sampled data, closed system, which couples the dynamics of the flight control system to the aircraft linearized small perturbation equations. The discrete time, state variable equations for the system are then formulated. A computer program is developed which will compose the model matricies and compute the response of the aircraft to stick and rudder inputs.

To study flight control reconfiguration, the model allows individual actuation of either a left or right control surface. Aircraft response to the actuation loss of either the left or right stabilator is simulated in the program. The program is designed to implement the reconfigurable control mixer, currently under study for the Self-Repairing Digital Flight Control System.

The computer simulation was written in VS FORTRAN. A copy of the program and simulation results are included in the appendices.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ACKNOWLEDGEMENTS

I wish to express a sincere thank you to those who went out of their way to assist me in the preparation of this thesis: Mr. Duane Robertus of the Air Force Wright Aeronautical Laboratories; Mr. Mark Franko of the Naval Air Test Center; Mr. Marle D. Hewett; and Mr. Ed Funke of McDonnell Douglas. I also wish to express my appreciation to Professor Dan Collins whose patience and assistance made it possible for me to complete this project. CDR Val Gavito worked many hours to detect and correct several critical errors which enabled the program to operate properly. His efforts are deeply appreciated.

Finally I wish to acknowledge the support of my family. Deborah, Lauren, and Audra, who have seen too little of me for too long.

I. INTRODUCTION

Tactical aircraft face airborne and ground based threats which continue to grow in number and capability. In future combat engagements the lethality of these systems will pose a considerable threat to aircraft survivability. In addition to combat losses, the loss of aircraft in battle damage repair, or awaiting repair, will significantly reduce our tactical forces. Projections on the survivability of NATO forces [Ref. 1] during the initial days of engagement indicate 68% of the tactical aircraft will be out of action after the third day of battle. Of this total, 22% will be lost in combat and 46% lost while in repair or awaiting repair. This is indicated in Fig. 1.1 which comes from Reference 1. It is clear from projections such as this, if our forces are to remain a superior threat to the enemy, continued emphasis must be given to reduce the combat vulnerability, and increase the reliability and maintainability of our tactical aircraft.

To improve the combat effectiveness of future tactical aircraft, the United States Air Force initiated the Self Repairing Flight Control System, Reliability and Maintainability Program. Reference 2 outlines the program plan and goals. An Air Force sponsored study [Ref. 1] showed that significant improvements in aircraft survivability and

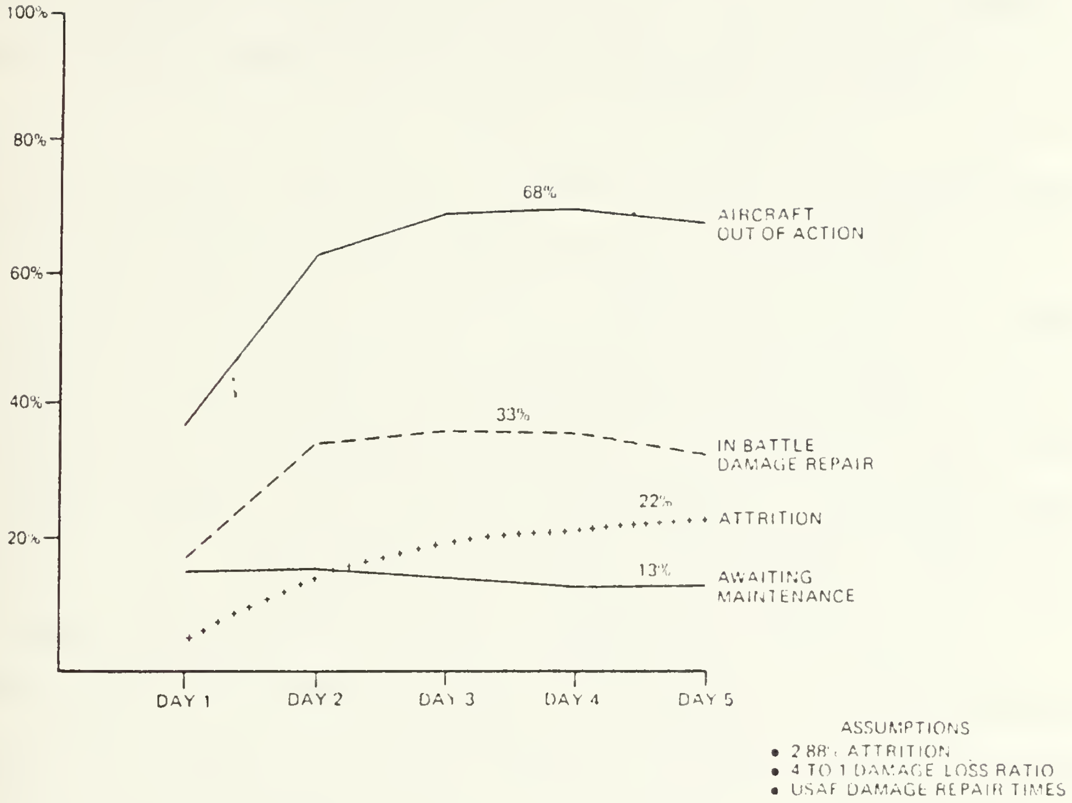


Figure 1.1 Tactical Aircraft Battle Damage Repair Statistics

reliability can be achieved with a self repairing digital flight control system.

One of the principle features of a self repairing system is flight control reconfiguration. A reconfigurable flight control system automatically counters aircraft loss of control due to impairment, or loss, of a control effector. The fundamental idea is to utilize the existing undamaged effectors to preserve the normal flying qualities of the unimpaired aircraft. The approach outlined in Reference 1 is to design a reconfigurable control mixer to be placed between the flight control laws and the control effectors. In the face of aircraft impairment the mixer would reallocate control commands to the unimpaired effectors so that flight critical pitch, yaw, and rolling moments would be preserved to the maximum extent possible. Using the control mixer concept, the existing flight control laws would not be altered.

Although the development of the self repairing system is intended for the advanced tactical aircraft, it is possible that the mixer could be implemented in existing airframes. This could be done with a control reconfiguration module interposed between the aircraft flight control computers and fly-by-wire actuators [Ref. 1].

For this thesis the McDonnell F/A-18 was chosen to study the reconfigurable control law concept utilizing the control mixer as described above. This choice was made based on the following assumptions given in Reference 1 for implementation of the reconfiguration control law process in an existing airframe:

1) "The effector complement provides redundant effector systems and surplus control power for each flight critical control force and moment."

2) "The flight control is a full authority, fly-by-wire digital flight control system."

3) "A control law design exists which has been carried out for the unimpaired airplane, but which is sufficiently robust that only first order impairment-induced stability derivative changes need be accounted for in a drop-in reconfigurable mixer."

Based upon these assumptions it is felt that the F/A-18 is well suited for the reconfigurable control law study.

In this thesis a linearized mathematical model was developed which simulates the dynamic response of the F/A-18 aircraft to stick and rudder inputs. The model includes the control laws for the longitudinal, lateral, and directional axes for the cruise phase of flight. The fly-by-wire actuators and sensor dynamics were modeled and joined to the airframe linearized, small perturbation model. The perturbation model was obtained from the Simulation Control and Technology Group, Flight Systems Branch, Strike Aircraft Test Directorate, at the Naval Air Test Center. A computer program was developed which, with existing software at the Naval Postgraduate School, will simulate F/A-18 longitudinal, lateral, and directional response to stick and rudder inputs.

The model was designed to implement the control mixer gain concept outlined above. Future work at NPS will utilize the simulation program to develop algorithms for determining the control mixer gain matrix. In addition the program will be used to study modern control augmentation systems and aircraft stability and control.

II. MODEL METHODOLOGY

A. INTRODUCTION

This chapter discusses the methods and assumptions used to formulate a mathematical model which simulates the dynamic response of the F/A-18 aircraft. The flight control system is described, including the simplifying assumptions used to develop the control system model. An overview of the complete system, which couples the control system model with the airframe small perturbation model, is then given with a brief description of each functional component.

B. FLIGHT CONTROL SYSTEM DESCRIPTION

A detailed description of the F/A-18 control system and theory of operation can be found in the Flight Control System Design Report by McDonnell Aircraft Company [Ref. 3]. The following discussion briefly describes the basics of the flight control system and the control law mechanization, and is intended to facilitate understanding the model development.

The primary flight control system in the F/A-18 is a fly-by-wire, full authority, control augmentation system. The control law computations are performed by four flight control computers operating in parallel. Each computer receives input from the aircraft motion sensors, air data computer, and pilot stick commands. The computer operates on the input signals according to the control law algorithms and outputs the command signals to fly-by-wire electrohydraulic servoactuators. Figure 2.1, taken from Reference 3, shows a functional block diagram of the flight control system. Exclusive of angle of attack and air data sensors, the system has quadraplex redundancy. The system provides two fail operate performance for augmented motion feedback control. A third failure causes the system to revert to either open loop direct electrical link control, or stabilator mechanical control.

The control augmentation system is gain scheduled with angle of attack and air data to provide optimum flying qualities throughout the flight envelope. Cross axis interconnects (e.g., rolling surface to rudder interconnect) are provided for turn coordination and maneuverability at high angles of attack. The control system also provides feedback to counter inertial coupling at high roll rates.

The F/A-18 has ten primary flight control surfaces: Right and left stabilators, leading edge flaps, trailing edge flaps, ailerons, and rudders. Longitudinal control is provided by collective stabilator, and collective leading and trailing edge flaps. Lateral-directional control is provided by differential stabilator, differential leading and trailing edge flaps, ailerons, and rudders. Collective leading and trailing edge flap deflections are scheduled by the control laws and are a function of angle of attack. The flap positions are designed to provide optimum L/D during

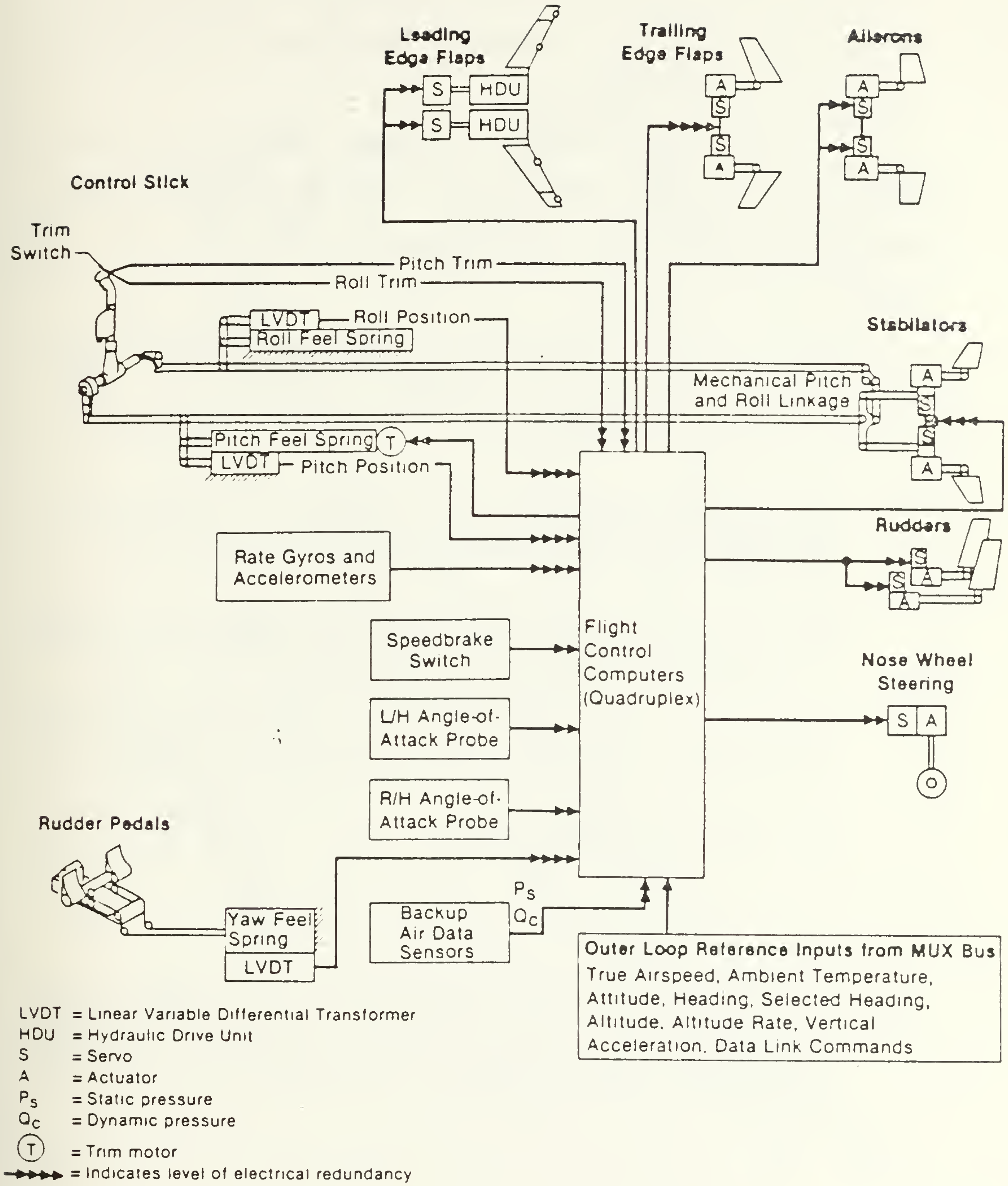


Figure 2.1 Functional Block Diagram of Flight Control System

cruise, and improve flying characteristics in maneuvering and high angle of attack flight. Figure 2.2, copied from Reference 3, shows the control surface positions and direction for positive deflection.

The objective of the thesis did not require a complete model of the F/A-18 control system as given in Reference 3. The following assumptions were made to reduce the model complexity.

1) The aircraft is operating in the up and away flight phase. Under this assumption the control laws are operating in the auto-flaps-up configuration. Control law configurations for the takeoff and landing phases were not modeled.

2) Only inner loop control is modeled. For inner loop control the pilot provides commands to the system. The auto functions (outer loop control) were not modeled.

3) Control is provided by the control augmentation system. The unaugmented modes such as direct electrical link or mechanical backup are not modeled.

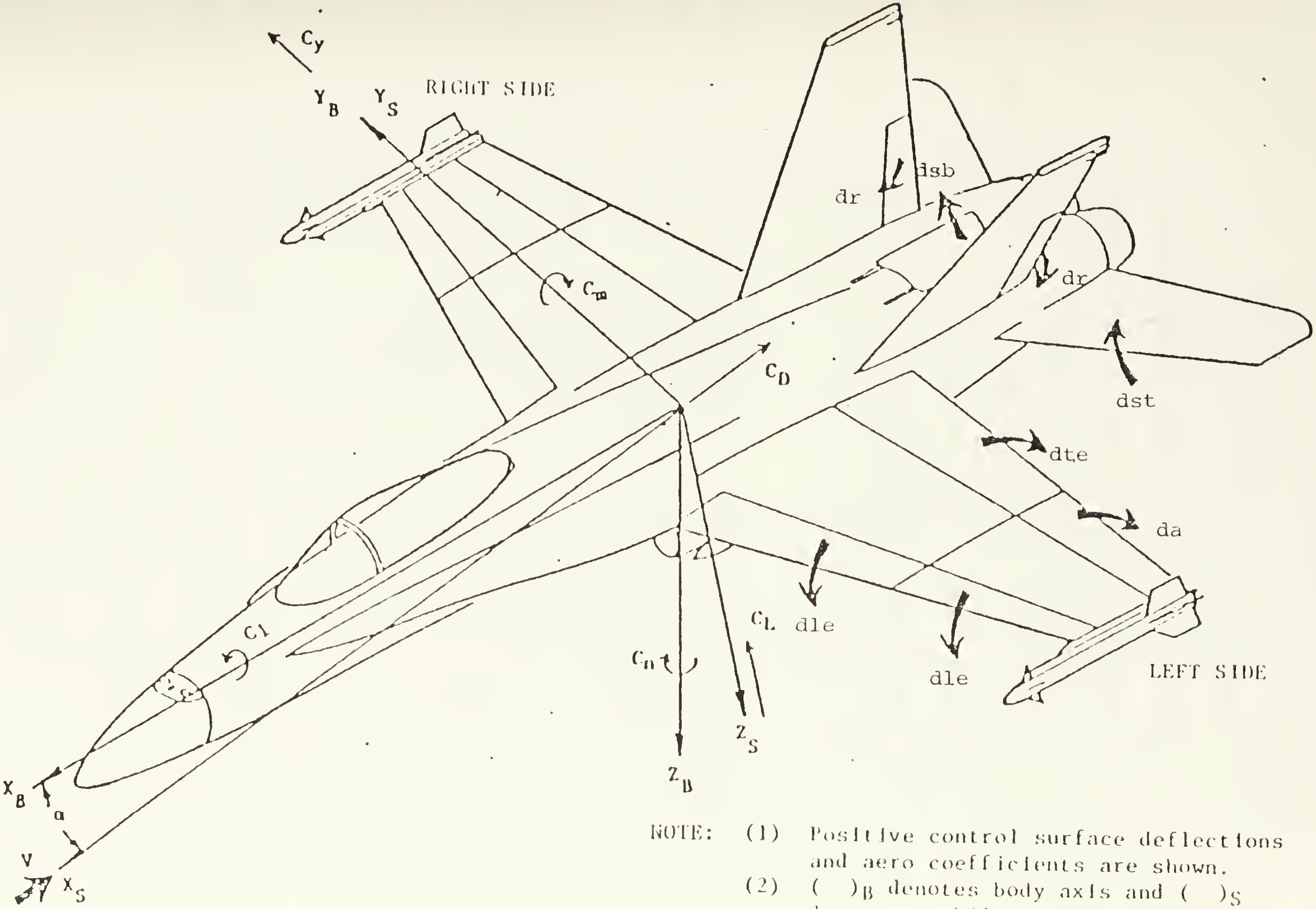
4) The failure logic provided to reconfigure the control laws in the event of a sensor or actuator failure is not modeled.

5) The aircraft is operating with gear up, speedbrakes in, and no external stores.

6) Spin mode control logic is not modeled.

7) The aircraft trim system is not modeled.

8) High angle of attack conditions are not considered in the thesis model, therefore control law configurations for this flight condition are not modeled. For this thesis high angle of attack is defined as flight conditions above 15 degrees.



NOTE: (1) Positive control surface deflections and aero coefficients are shown.
(2) $(\ )_B$ denotes body axis and $(\ )_S$ denotes stability axis.

Figure 2.2 Control Surface Positions and Direction of Positive Deflection

C. F/A-18 DYNAMIC MODEL OVERVIEW

The functional block diagram of the F/A-18 model which couples the flight control system to the basic airframe is shown in Figure 2.3. The diagram represents a multi-input multi-output, sampled data, closed loop control system. Theory on the analysis of sampled data systems, as the one shown in Fig. 2.3, is extensive and covered in a number of texts (see references). The development of the F/A-18 model assumes the reader has a rudimentary understanding of control theory, and in particular the theory of sampled data control systems.

In the nomenclature used to represent the control signals pilot inputs are prefixed by the letter 'P'. Actuating signals, and signals produced by the aircraft sensors are prefixed by the letter 'E'. Control surface deflections are prefixed by the letter 'D'. The nomenclature used to represent the aircraft perturbed motion variables and control surfaces is given in Table 2.1. To denote the motion axis which is being controlled, the signal will be suffixed with either x, y, or z to denote longitudinal, lateral, or directional axis respectfully. Finally a matrix or a vector will be denoted by an upper case letter. A scalar will be denoted by a lower case letter.

The input vector shown in Fig. 2.3,

$$P(t)^t = [px(t)\ py(t)\ pz(t)] \tag{2.1}$$

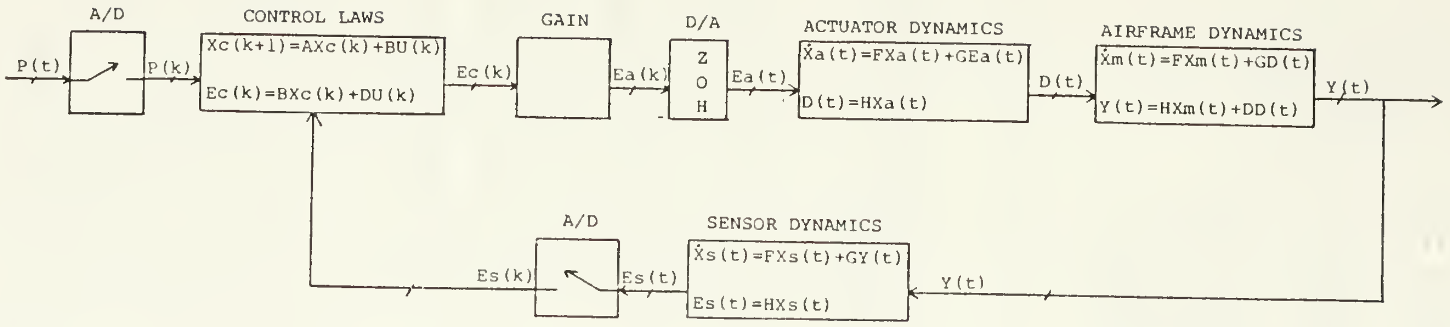


Figure 2.3 Functional Block Diagram of F/A-18 Model

TABLE 2.1

MOTION VARIABLES AND CONTROL SURFACE NOMENCLATURE

q	pitch rate	DEG/SEC
nz	normal acceleration	G
aa	angle of attack	DEG
yr	yaw rate	DEG/SEC
rr	roll rate	DEG/SEC
ny	lateral acceleration	G
str	right stabilator	DEG
stl	left stabilator	"
ter	right trailing edge flap	"
tel	left trailing edge flap	"
ler	right leading edge flap	"
lel	left leading edge flap	"
ar	right aileron	"
al	left aileron	"
rr	right rudder	"
rl	left rudder	"

represents the aircraft longitudinal and lateral stick, and rudder deflection in inches. The output vector,

$$Y(t)^t = [q(t)\ nz(t)\ aa(t)\ yr(t)\ rr(t)\ ny(t)] \quad (2.2)$$

represents the perturbed motion of the aircraft about some steady state operating condition. The motion variable units are degrees, degrees/sec, and G's. Each block in the diagram contains a mathematical model which simulates the dynamics of that particular component. The control law block contains the aircraft flight control law algorithms modeled as linear, time invariant, discrete state equations. One processing channel of the flight control computer described above is represented in the control law model. The input vectors to the control law model are the discrete stick and rudder input signals in inches,

$$P(k)^t = [px(k)\ py(k)\ pz(k)] \tag{2.3}$$

and the discrete motion feedback signals from the sensors,

$$Es(k)^t = [q(k)\ nz(k)\ aa(k)\ yr(k)\ rr(k)\ ny(k)] \tag{2.4}$$

(The units of the motion feedback signals are degrees, degrees/sec, and G's). The input vector to the control law equations is therefore

$$U(k)^t = [Es(k) \mid P(k)] \tag{2.5}$$

The output vector from the control law block,

$$\begin{aligned} Ec(k)^t = [&estr(k)\ estl(k)\ eler(k)\ elel(k)\ eter(k) \\ &etel(k)\ ear(k)\ eal(k)\ err(k)\ erl(k)] \end{aligned} \tag{2.6}$$

represents the discrete command signals to the flight control actuators in degrees. The actuator command signals enter the GAIN block which represents the configuration gain matrix discussed in the introduction. The state space equations shown in the actuator block model the dynamics of the flight control actuators. The input vector to the actuator block,

$$\begin{aligned} Ea(t)^t = [&estr(t)\ estl(t)\ eler(t)\ elel(t)\ eter(t) \\ &etel(t)\ ear(t)\ eal(t)\ err(t)\ erl(t)] \end{aligned} \tag{2.7}$$

represents the continuous time, actuator command signals in degrees. The output vector from the actuator block represents the control surface deflections in degrees,

$$D(t)^t = [dstr(t)\ dstl(t)\ dler(t)\ dlel(t)\ dter(t)\ dtel(t)\ dar(t)\ dal(t)\ drr(t)\ drl(t)] \qquad (2.8)$$

The deflection vector is input to the airframe small perturbation model represented by the state variable equations in the airframe block. The output vector from the small perturbation model, Y(t), enters the sensor dynamics block which contains the state variable model for the aircraft rate gyros, accelerometers, and angle of attack sensors. As discussed above the sensors output the feedback signals which are sent to the control laws. In Chapter III the mathematical models which simulate the dynamics of each component in Fig. 2.3 will be developed in detail.

Analog to digital converters are modeled as impulse samplers. It is assumed that all samplers are operating at the same, constant sampling rate. (The actual system uses multirate sampling. In the thesis model only a single sampling rate is used. The program actually allows any desired sampling rate to be input.) The mathematical operation performed by the impulse samplers is shown in Figure 2.4. Modeling the analog to digital converters as impulse samplers is a valid assumption if the quantization error of the actual system is at an acceptable level. Digital to analog converters are modeled as zero order hold devices. The mathematical operation performed by the zero order hold is shown in

Fig. 2.5. Finally it is assumed that the processing time between the sampler inputs and zero order hold output is very much less than the sampling period (i.e., no processing delay time is assumed). This assumption is used in transforming the continuous time state equations (actuators, airframe, and sensors) into discrete time equations.

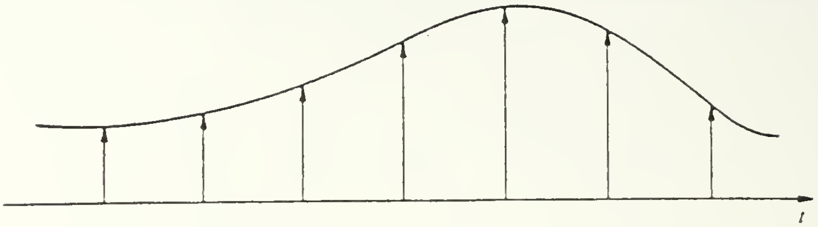


Figure 2.4 Mathematical Operation Performed by Impulse Sampler

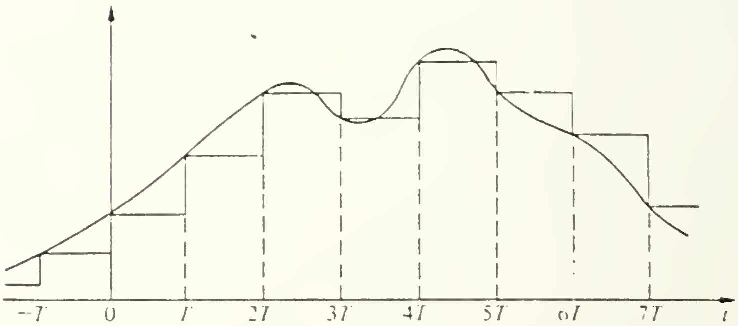


Figure 2.5 Mathematical Operation Performed by Zero Order Hold

III. MODEL DEVELOPMENT

A. CONTROL LAW MODEL DEVELOPMENT

The longitudinal, lateral, and directional control law models were developed from the block diagrams and information provided in Reference 3. In addition to the simplifying assumptions listed in Chapter II, many of the components in this system were eliminated based on the following considerations:

1) The control law model will be coupled to the small perturbation model of the F/A-18. It is assumed that operation of the control system will remain within a linear region. Therefore the non-linear components in the control laws were eliminated. These include position limiters, rate limiters, and dead band regions. Other non-linear functions in the system which were essential to the model (pitch stick gradient for example) were linearized by a taylor series expansion.

2) For the same reasons discussed above, the portions of the system which provide inertial decoupling were not modeled.

3) In the model, the control signals are input as discrete signals. Therefore stick and rudder dynamics are not modeled.

4) Noise, which may be detrimental to control system performance due to aliasing, is not introduced into the model. Therefore the anti-aliasing prefilters were not included in the model.

5) The structural modes were not included in the F/A-18 airframe model. Therefore the structural notch filters were not included in the model.

6) To prevent discontinuities in the signals, the control laws utilize faders in portions of the system. Discontinuities could occur during start up, failures, or transitions. Since none of these conditions are included in the thesis model, faders have not been modeled.

7) The F/A-18 control system uses multi-rate sampling in the input and feedback paths (20, 40 and 80 hz sampling rates are used). To develop a state variable model only a single sampling rate was considered. Therefore the iteration averagers, used to mathematically combine two discrete signals of different sampling periods were not modeled. The simulation program allows any desired sampling rate to be input. For this thesis 80 hz was used as the sampling rate.

Figures 3.1 and 3.2 show the simplified block diagrams of the longitudinal and lateral-directional control laws. The inputs are the discrete stick and rudder commands, and motion feedback signals. The output signals are the commands to be sent to the flight control actuators via the reconfigurable gain matrix. Together Figs. 3.1 and 3.2 make up the control law block shown in Fig. 2.3.

The blocks in the control law model represent two basic transfer functions: Function gains, and digital filters. Table 3.1 lists the notation used to represent the transfer functions. Function gains and digital filters are described below.

TABLE 3.1

CONTROL LAW TRANSFER FUNCTION NOTATION

Prefix	Transfer function
F___	Function gain
P___	Longitudinal digital filter
R___	Lateral digital filter
Y___	Directional digital filter

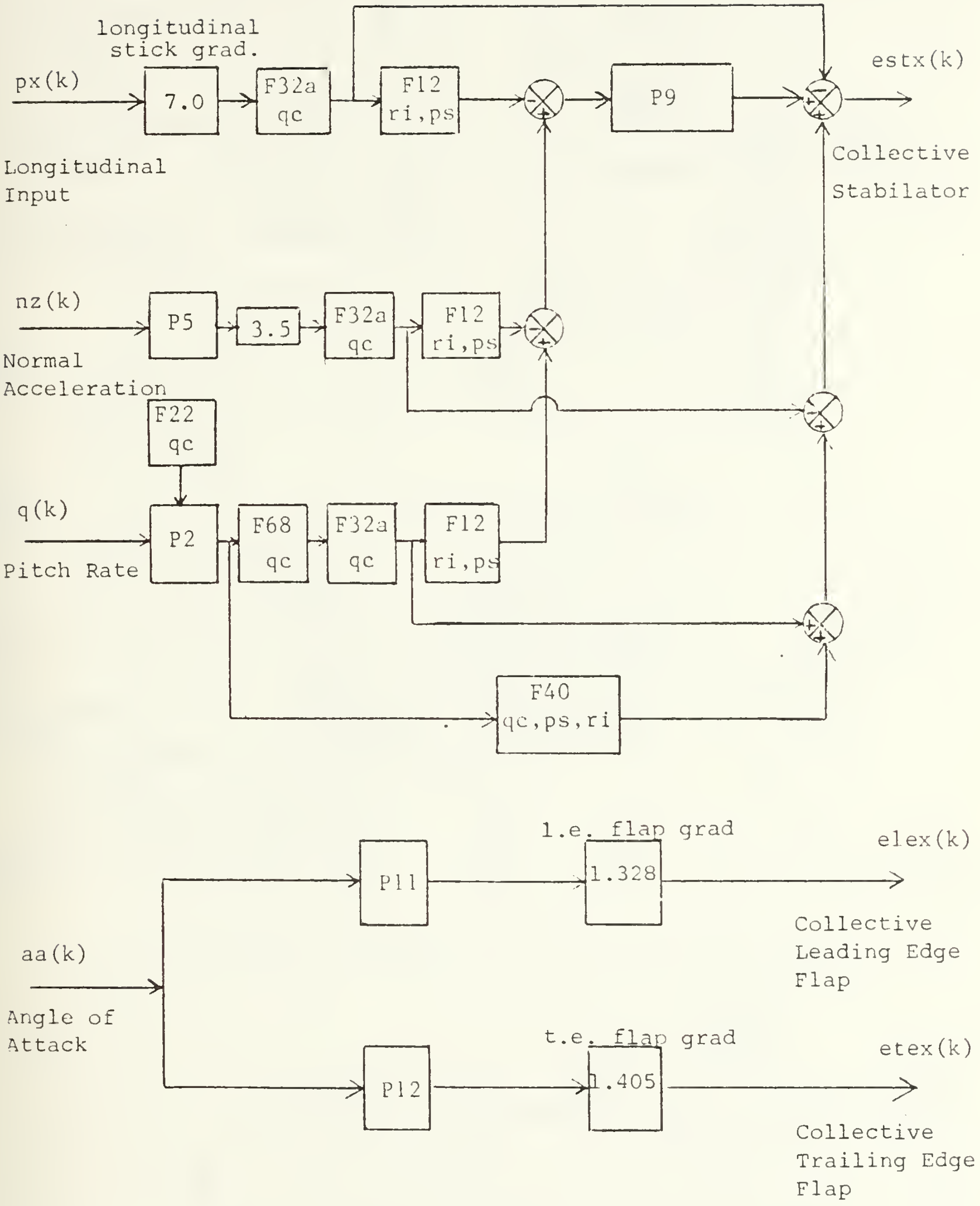


Figure 3.1 Simpified Longitudinal Control Law Diagram

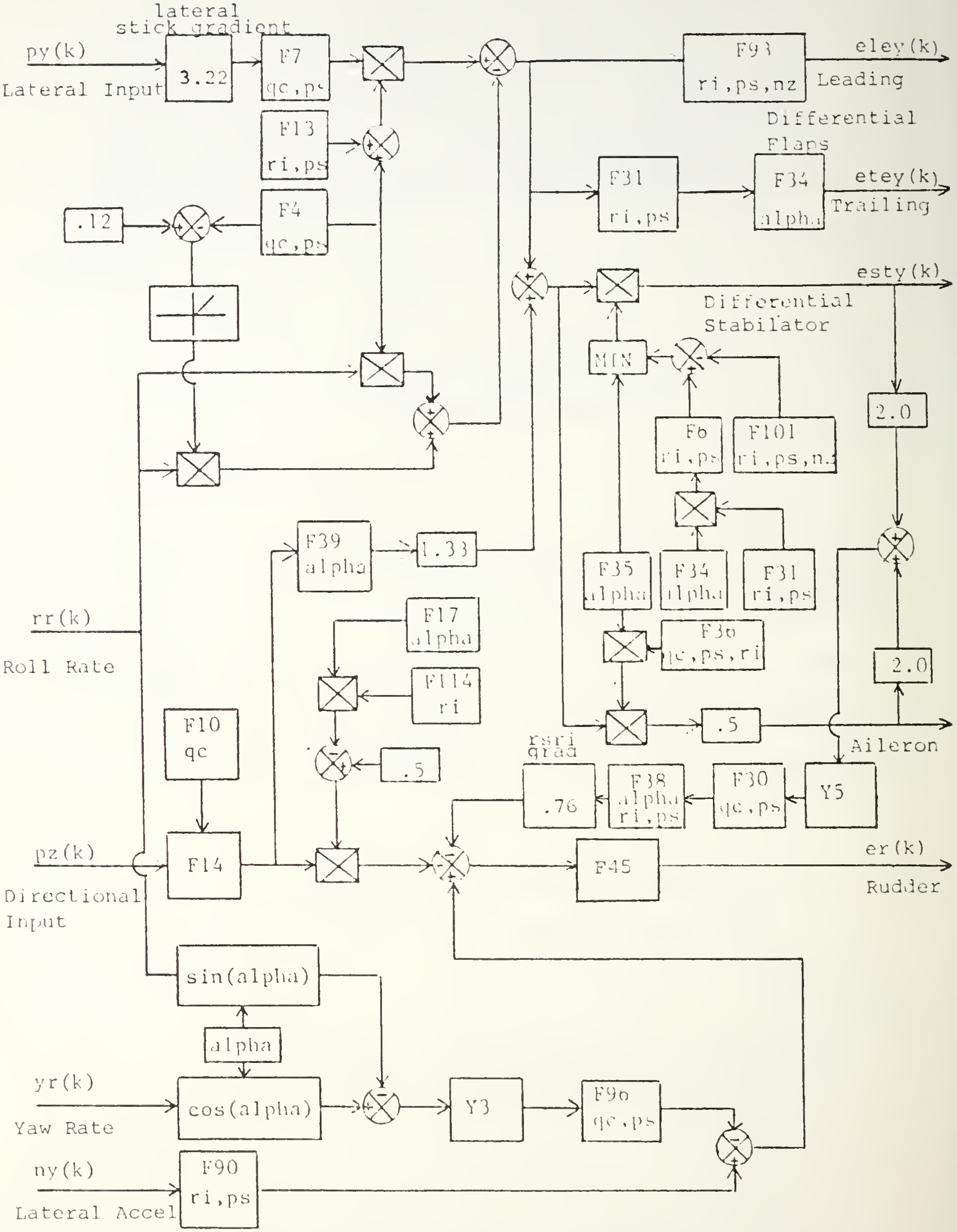


Figure 3.2 Simplified Lateral-Directional Control Law Diagram

1. Functions

The functions in the control law diagrams perform the system gain scheduling described in Sec. II.B. The functions operate on the air data, angle of attack, and normal acceleration to compute the system gains. Table 3.2 lists the notation used to represent the function inputs. The mathematical equations which define the gain schedules are given in Reference 3. Copies of the functions used in the control law model are given in Appendix A. In the simulation program the function gains are computed using steady state conditions for all input values.

TABLE 3.2

FUNCTION INPUT VARIABLES

ps	Indicated static pressure	lbs/ft2
qc	Dynamic pressure	lbs/ft2
ri	Pressure ratio (ps /qc)	ND
nz	Normal acceleration	G
alpha	Angle of attack	DEG

2. Digital Filters

Lead-lag filters are used in the system to shape the output response and provide adequate gain and phase margins. An integrator is used in the forward loop of the longitudinal system to provide zero steady state error between command and feedback. The control system design report [Ref. 3] gives the filter's continuous time transfer function. For the control law model, the digital filter coefficients were computed using the Tustin transform. All filters were modeled as first order systems with two numerator coefficients and a single denominator coefficient. For example

$$H(Z) = \frac{P9N1*Z + P9N2}{Z - P9D} \tag{3.1}$$

is the model for filter P9. Appendix B gives the digital filters used in the model, and the method used to compute the coefficients.

3. State Space Models

Standard control system analysis techniques were used to derive the state space models for longitudinal and lateral-directional control laws shown in Figs. 3.1 and 3.2. The following sections outline the procedures used.

a. Longitudinal System

The block diagram in Fig. 3.1 contains five input/output signal flow paths:

1) Pitch rate to collective stabilator
2) Normal acceleration to collective stabilator
3) Longitudinal stick to collective stabilator
4) Angle of attack to collective leading edge flap
5) Angle of attack to collective trailing edge flap

To obtain the individual path transfer functions the signals are mathematically combined to give the following three Z-transform equations:

$$Estx(Z) = H1(Z)Eq(Z) - H2(Z)Enz(Z) - H3(Z)Epx(Z) \tag{3.2}$$

$$Elex(Z) = H4(Z)Eaa(Z) \tag{3.3}$$

$$Etex(Z) = H5(Z)Eaa(Z) \qquad (3.4)$$

The expressions for each transfer function are given in Appendix C. To obtain a state space expression for longitudinal control laws, the individual Z-transfer functions are first expressed in state variable form. The state variable equations are then combined according to equations 3.2 - 3.4. This procedure is as follows:

1) The transfer function for the pitch rate to collective stabilator path can be expressed as:

$$H1(z) = \frac{b0Z^2 + b1Z + b2}{(Z-P9D)\ (Z-P2D)} \qquad (3.5)$$

The numerator coefficients are functions of the system gains and filter coefficients. The roots in the denominator are the poles from filters P9 and P2. (Appendix C gives the detailed expressions for the numerator coefficients).

2) The state space representation of Eq. 3.5 is obtained using the parallel programming method outlined in Reference 4.

$$\begin{bmatrix} x1(k+1) \\ x2(k+2) \end{bmatrix} = \begin{bmatrix} P9D & 0 \\ 0 & P2D \end{bmatrix} \begin{bmatrix} x1(k) \\ x2(k) \end{bmatrix} + \begin{bmatrix} 1 \\ 1 \end{bmatrix} eq(k) \qquad (3.6)$$

$$estx1(k) = \begin{bmatrix} qst1 & qst2 \end{bmatrix} \begin{bmatrix} x1(k) \\ x2(k) \end{bmatrix} + qst3\ eq(k) \qquad (3.7)$$

Applying the same procedures to the remaining Z-transfer functions in Eq. 3.2 results in similar expressions:

$$\begin{bmatrix} x3(k+1) \\ x4(k+2) \end{bmatrix} = \begin{bmatrix} P9D & 0 \\ 0 & P5D \end{bmatrix} \begin{bmatrix} x3(k) \\ x4(k) \end{bmatrix} + \begin{bmatrix} 1 \\ 1 \end{bmatrix} enz(k) \qquad (3.8)$$

$$estx2(k) = nzst1 \;\; nzst2 \begin{bmatrix} x1(k) \\ x2(k) \end{bmatrix} + nzst3 \; enz(k) \qquad (3.9)$$

for the normal acceleration path, H2(Z); and

$$x5(k+1) = P9D \; x5(k) + 1 \; px(k) \qquad (3.10)$$

$$estx3(k) = pxst1 \; x5(k) + pxst2 \; px(k) \qquad (3.11)$$

for the longitudinal stick path, H3(Z).

Appendix C details the procedures used to compute the coefficients in the output equations. The nomenclature used to represent the coefficients in the output equation combines the notation of the input signal and output control surface, followed by a number indicating the coefficient's numerical order in the equation. For example:

qst1, qst2, qst3

are the first, second, and third coefficients in the pitch rate to stabilator output equation (Eq. 3.7). With this system of nomenclature the respective signal path of the coefficient is easily identified.

3) The state variable equations for H1(Z), H2(Z) and H3(Z) are now combined according to Eq. 3.2.

$$estx(k) = estx1(k) - estx2(k) - estx3(k) \qquad (3.12)$$

Adding Eqs. 3.7, 3.9 and 3.11 gives

$$\mathrm{estx}(k) = \begin{bmatrix} \mathrm{qst1} & \mathrm{qst2} & -\mathrm{nzst1} & -\mathrm{nzst2} & -\mathrm{pxst1} \end{bmatrix} \begin{bmatrix} x1(k) \\ x2(k) \\ x3(k) \\ x4(k) \\ x5(k) \end{bmatrix} +$$

$$\begin{bmatrix} \mathrm{qst3} & -\mathrm{nzst3} \end{bmatrix} \begin{bmatrix} \mathrm{eq}(k) \\ \\ \mathrm{enz}(k) \end{bmatrix} + -\mathrm{pxst1}\ \mathrm{px}(k) \qquad (3.13)$$

for the output equation. Equations 3.6, 3.8, and 3.10 can be combined to give

$$\begin{bmatrix} x1(k+1) \\ x2(k+1) \\ x3(k+1) \\ x4(k+1) \\ x5(k+1) \end{bmatrix} = \begin{bmatrix} \mathrm{P9D} & & & & \\ & \mathrm{P2D} & & & \\ & & \mathrm{P9D} & & \\ & & & \mathrm{P5D} & \\ & & & & \mathrm{P9D} \end{bmatrix} \begin{bmatrix} x1(k) \\ x2(k) \\ x3(k) \\ x4(k) \\ x5(k) \end{bmatrix} + \begin{bmatrix} 1 & 0 \\ 1 & 0 \\ 0 & 1 \\ 0 & 1 \\ 0 & 0 \end{bmatrix} \begin{matrix} \mathrm{eq}(k) \\ \\ \mathrm{enz}(k) \end{matrix} + \begin{bmatrix} o \\ o \\ o \\ o \\ o \end{bmatrix} \mathrm{px}(k) \qquad (3.14)$$

The state space representation of equation 3.2 is given by Eqs. 3.13 and 3.14. These equations output the collective stabilator command given the longitudinal stick and motion feedback inputs. Note that the motion feedback and longitudinal inputs have been separated. This facilitates coupling the control law equations to the aircraft equations to be developed later.

4) Similar state variable equations are derived for the angle of attack to collective flap path transfer functions H4(Z), and H5(Z):

$$x6(k+1) = \mathrm{P11D}\ x6(k) + 1\ \mathrm{eaa}(k) \qquad (3.15)$$

$$\mathrm{elex}(k) = \mathrm{aale1}\ x6(k) + \mathrm{aale2}\ \mathrm{eaa}(k) \qquad (3.16)$$

for the AOA to collective leading edge path H4(Z); and

$$x7(k+1) = P12D\ x7(k) + 1\ eaa(k) \tag{3.17}$$

$$etex(k) = aate1\ x7(k) + aate2\ eaa(k) \tag{3.18}$$

for the AOA to collective trailing edge path H5(Z).

5) The state equations for collective stabilator, and collective leading and trailing edge flaps are now combined to give the following state variable model for the longitudinal control laws:

$$\begin{bmatrix} x1(k+1) \\ x2(k+1) \\ x3(k+1) \\ x4(k+1) \\ x5(k+1) \\ x6(k+1) \\ x7(k+1) \end{bmatrix} = \begin{bmatrix} P9D & & & & & & \\ & P2D & & & & & \\ & & P9D & & & & \\ & & & P5D & & & \\ & & & & P9D & & \\ & & & & & P11D & \\ & & & & & & P12D \end{bmatrix} \begin{bmatrix} x1(k) \\ x2(k) \\ x3(k) \\ x4(k) \\ x5(k) \\ x6(k) \\ x7(k) \end{bmatrix} +$$

$$\begin{bmatrix} 1 & 0 & 0 \\ 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 0 \\ 0 & 0 & 1 \\ 0 & 0 & 1 \end{bmatrix} \begin{matrix} eq(k) \\ enz(k) \\ eaa(k) \end{matrix} + \begin{bmatrix} 0 \\ 0 \\ 0 \\ 0 \\ 1 \\ 0 \\ 0 \end{bmatrix} px(k) \tag{3.19}$$

$$\begin{bmatrix} estx(k) \\ elex(k) \\ etex(k) \end{bmatrix} = \begin{bmatrix} qst1 & qst2 & -nzst1 & -nzst2 & -pxst1 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & aale1 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & aate1 \end{bmatrix} \begin{bmatrix} x1(k) \\ x2(k) \\ x3(k) \\ x4(k) \\ x5(k) \\ x6(k) \\ x7(k) \end{bmatrix} +$$

$$\begin{bmatrix} qst3 & -nzst3 & 0 \\ 0 & 0 & aale2 \\ 0 & 0 & aate2 \end{bmatrix} \begin{bmatrix} eq(k) \\ enz(k) \\ eaa(k) \end{bmatrix} + \begin{bmatrix} -pxst2 \\ 0 \\ 0 \end{bmatrix} px(k) \tag{3.20}$$

Equations 3.19 and 3.20 are the state space representation of the longitudinal control laws shown in the block diagram in Fig. 3.1. The equations represent the longitudinal control law model which computes the collective stabilator command, and collective flap commands, given the longitudinal stick and motion feedback inputs.

b. Lateral-Directional System

The procedures outlined above are applied to the Fig. 3.2 to obtain the state space model for the lateral-directional system. (To complete the discussion of the control law model these procedures will be briefly described.) The individual path transfer functions are first obtained by mathematically combining the signals in Fig. 3.2 to give the following equations:

$$Esty(Z) = -H6(Z)Err(Z) + H7(Z)Py(Z) + H8(Z)Pz(Z) \tag{3.21}$$

$$Eley(Z) = -H9(Z)Err(Z) + H10(Z)Py(z) \tag{3.22}$$

$$Etey(Z) = -H11(Z)Err(Z) + H12(Z)Py(z) \tag{3.23}$$

$$Ea(z) = -H13(Z)Err(Z) + H14(Z)Py(Z) + H15(Z)Pz(Z) \tag{3.24}$$

$$\begin{aligned} Er(Z) = &-H16(Z)Eyr(Z) + H17(Z)Err(Z) + \\ &H18(Z)Eny(Z) + H19(Z)Py(Z) + H20(Z)Pz(Z) \end{aligned} \tag{3.25}$$

These transfer functions represent the following input/output signal paths, numbered respectfully:

6) Roll rate to differential stabilator
7) Lateral stick to differential stabilator
8) Rudder pedal to differential stabilator
9) Roll rate to differential leading edge flap
10) Lateral stick to differential leading edge flap
11) Roll rate to differential trailing edge flap
12) Lateral stick to differential trailing edge flap

13) Roll rate to aileron

14) Lateral stick to aileron

15) Rudder pedal to aileron

16) Yaw rate to rudder

17) Roll rate to rudder

18) Lateral acceleration to rudder

19) Lateral stick to rudder

20) Rudder pedal to rudder

The expression for each transfer function and corresponding state equation are given in Appendix C. Note that the differential stabilator, ailerons, and rudder contain the transfer functions for the cross axis interconnects (e.g., H8(Z) and H15(Z) represent the rudder to rolling surface interconnect, and H19(Z) represents the rolling surface to rudder interconnect.)

The state equations for the lateral and directional control laws are given as:

$$\begin{bmatrix} esty(k) \\ eley(k) \\ etey(k) \\ ea(k) \end{bmatrix} = \begin{bmatrix} 0 & -rrst & 0 \\ 0 & -rrle & 0 \\ 0 & -rrte & 0 \\ 0 & -rra & 0 \end{bmatrix} \begin{bmatrix} eyr(k) \\ err(k) \\ eny(k) \end{bmatrix} + \begin{bmatrix} pyst & pzst \\ pyle & 0 \\ pyte & 0 \\ pya & pza \end{bmatrix} \begin{bmatrix} py(k) \\ pz(k) \end{bmatrix} \qquad (3.26)$$

for the lateral system; and

$$\begin{bmatrix} x8(k+1) \\ x9(k+1) \\ x10(k+1) \\ x11(k+1) \\ x12(k+1) \end{bmatrix} = \begin{bmatrix} Y3D & & & & \\ & Y3D & & & \\ & & Y5D & & \\ & & & Y5D & \\ & & & & Y5D \end{bmatrix} \begin{bmatrix} x8(k) \\ x9(k) \\ x10(k) \\ x11(k) \\ x12(k) \end{bmatrix}$$

$$\begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 0 \\ 0 & 0 & 0 \end{bmatrix} \begin{bmatrix} eyr(k) \\ err(k) \\ eny(k) \end{bmatrix} + \begin{bmatrix} 0 & 0 \\ 0 & 0 \\ 0 & 0 \\ 1 & 0 \\ 0 & 1 \end{bmatrix} \begin{matrix} py(k) \\ \\ pz(k) \end{matrix} \qquad (3.27)$$

$$er(k) = \begin{bmatrix} -yrr1 & rrr1 & rrr2 & pyr1 & pzr1 \end{bmatrix} \begin{bmatrix} x(8) \\ x9(k) \\ x10(k) \\ x11(k) \\ x12(k) \end{bmatrix} +$$

$$\begin{bmatrix} -yrr2 & rrr3 & nyr \end{bmatrix} \begin{bmatrix} eyr(k) \\ err(k) \\ eny(k) \end{bmatrix} + \begin{bmatrix} pyr2 & pzr2 \end{bmatrix} \begin{matrix} py(k) \\ \\ pz(k) \end{matrix} \qquad (3.28)$$

for the directional system. Note that the lateral system is of order zero. No filters were included in the model.

c. Combining the Control Law Models

Equations 3.19 and 3.20, and 3.26 - 3.28 are combined to give the 3-axis control law model.

$$\overset{12x1}{Xc(k+1)} = \overset{12x12}{Ac} \; \overset{12x1}{Xc(k)} + \overset{12x6}{Bfc} \begin{matrix} eq(k) \\ enz(k) \\ eaa(k) \\ eyr(k) \\ err(k) \\ eny(k) \end{matrix} + \overset{12x3}{Bc} \begin{matrix} px(k) \\ py(k) \\ pz(k) \end{matrix} \qquad (3.29)$$

$$\begin{matrix} estx(k) \\ elex(k) \\ etex(k) \\ esty(k) \\ eley(k) \\ etey(k) \\ ea(k) \\ er(k) \end{matrix} = \overset{8x12}{Cc} \; \overset{12x1}{Xc(k)} + \overset{8x6}{Dfc} \begin{matrix} eq(k) \\ enz(k) \\ eaa(k) \\ eyr(k) \\ err(k) \\ eny(k) \end{matrix} + \overset{8x3}{Bc} \begin{matrix} px(k) \\ py(k) \\ pz(k) \end{matrix} \qquad (3.30)$$

Equations 3.29 and 3.30 are written in terms of the matrix coefficients in Appendix D. These equations are represented by the discrete state equations in the control law block in Fig. 2.3.

3. Variable Gain Matrix

As a final step in the control law model development, the variable gain matrix is introduced. The command signals which are output from the control laws (Eqns. 3.29 and 3.30) are distributed to the right and left actuators according to the diagram in Fig. 3.3. For the unimpaired aircraft the individual gains in Fig. 3.3 are set to unity. The following matrix gain equation represents the diagram in Fig. 3.3.

$$\begin{bmatrix} estr(k) \\ estl(k) \\ eler(k) \\ elel(k) \\ eter(k) \\ etel(k) \\ ear(k) \\ eal(k) \\ err(k) \\ erl(k) \end{bmatrix} = \overset{\text{'GAIN'}}{\begin{bmatrix} 1 & 0 & 0 & -1 & 0 & 0 & 0 & 0 \\ 1 & 0 & 0 & 1 & 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & -1 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & -1 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & -1 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 \end{bmatrix}} \begin{bmatrix} estx(k) \\ elex(k) \\ etex(k) \\ esty(k) \\ eley(k) \\ etey(k) \\ ea(k) \\ er(k) \end{bmatrix} \tag{3.31}$$

The matrix gain equation will be recomputed for the impaired aircraft.

B. AIRCRAFT MODEL DEVELOPMENT

A 3-axis control law model has been developed which will operate on the stick and rudder inputs and the motion feedback signals. The model outputs the control signals which are distributed to the aircraft actuators through the variable gain matrix. The next step in building the F/A-18 model

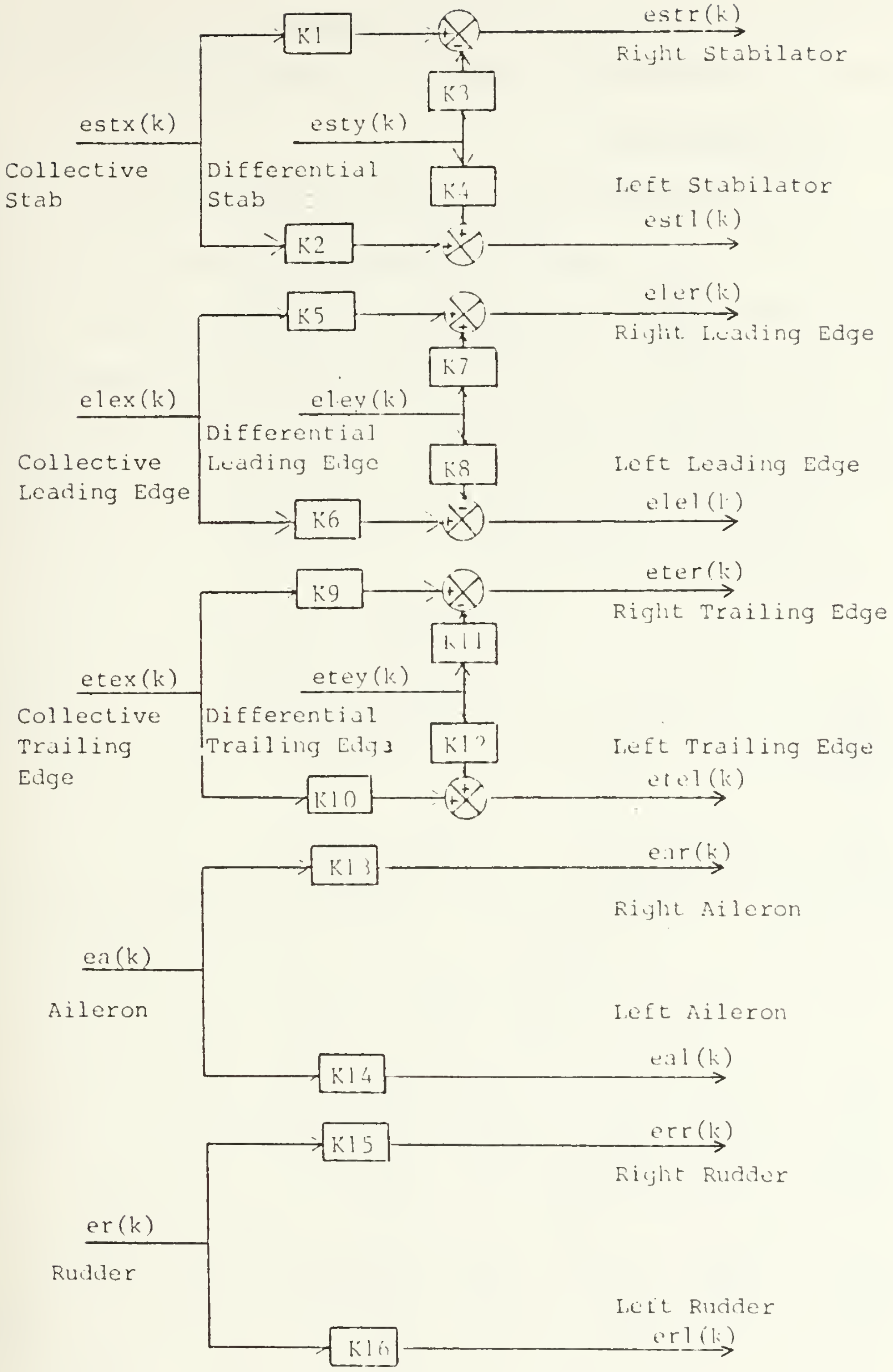


Figure 3.3 Control Law Command Signal Distribution and Gains

is to develop the state variable equations for the airframe, actuators, and sensors.

1. Airframe Model

The airframe model, obtained from the Flight Systems Branch at NATC, is a linearized small perturbation model for both the longitudinal and lateral-directional modes. The dynamic stability and control derivatives were generated from NATC's F/A-18 Simulation Package. The aircraft state for the model is trimmed, unaccelerated 1-g flight. The airframe state equations are given as:

LONGITUDINAL

$$\begin{matrix}\dot{u}(t)\\ \dot{w}(t)\\ \dot{q}(t)\\ \dot{\mathrm{thed}}(t)\end{matrix} = \overset{4\mathrm{x}4}{\mathrm{Fx}} \begin{matrix}u(t)\\ w(t)\\ q(t)\\ \mathrm{thed}(t)\end{matrix} + \overset{4\mathrm{x}3}{\mathrm{Gx}} \begin{matrix}\mathrm{dstx}(t)\\ \mathrm{dlex}(t)\\ \mathrm{dtex}(t)\end{matrix} \tag{3.32}$$

$$\begin{matrix}q(t)\\ \mathrm{nz}(t)\\ \mathrm{aa}(t)\end{matrix} = \overset{3\mathrm{x}4}{\mathrm{Hx}} \begin{matrix}u(t)\\ w(t)\\ q(t)\\ \mathrm{thed}(t)\end{matrix} + \overset{3\mathrm{x}3}{\mathrm{Dx}} \begin{matrix}\mathrm{dstx}(t)\\ \mathrm{dlex}(t)\\ \mathrm{dtex}(t)\end{matrix} \tag{3.33}$$

LATERAL DIRECTIONAL

$$\begin{matrix}v(t)\\ r(t)\\ p(t)\\ \mathrm{phi}(t)\end{matrix} = \overset{4\mathrm{x}4}{\mathrm{Fyz}} \begin{matrix}v(t)\\ r(t)\\ p(t)\\ \mathrm{phi}(t)\end{matrix} + \overset{4\mathrm{x}5}{\mathrm{Gyz}} \begin{matrix}\mathrm{dsty}(t)\\ \mathrm{dley}(t)\\ \mathrm{dtey}(t)\\ \mathrm{da}(t)\\ \mathrm{dr}(t)\end{matrix} \tag{3.34}$$

$$\begin{matrix}r(t)\\ p(t)\\ \mathrm{ny}(t)\\ \mathrm{phi}(t)\end{matrix} = \overset{3\mathrm{x}4}{\mathrm{Hyz}} \begin{matrix}v(t)\\ r(t)\\ p(t)\end{matrix} + \overset{3\mathrm{x}5}{\mathrm{Dyz}} \begin{matrix}\mathrm{dsty}(t)\\ \mathrm{dley}(t)\\ \mathrm{dtey}(t)\\ \mathrm{da}(t)\\ \mathrm{dr}(t)\end{matrix} \tag{3.35}$$

Airframe variable definitions and units are listed in Table 3.3. The definitions of the stability and control derivatives,

TABLE 3.3

AIRFRAME VARIABLE DEFINITIONS

Notation	Variable	Units
u(t)	longitudinal velocity perturbation	ft/s
w(t)	perturbed normal velocity	ft/s
q(t)	perturbed pitch rate	rad/s
v(t)	perturbed lateral velocity	ft/s
yr(t)	aircraft perturbed yaw rate	rad/s
rr(t)	aircraft perturbed roll rate	rad/s
thed(t)	aircraft perturbed pitch angle	rad
phi(t)	aircraft perturbed roll angle	"
dstx(t)	collective stabilator deflection	"
dlex(t)	collective leading edge flap deflection	"
dtex(t)	collective trailing edge flap deflection	"
dsty(t)	differential stabilator deflection	"
dley(t)	differential leading edge deflection	"
dtey(t)	differential trailing edge deflection	"
da(t)	aileron deflection	"
dr(t)	rudder deflection	"
nz(t)	normal acceleration	ft/s2
aa(t)	angle of attack	rad
ny(t)	lateral acceleration	ft/s2

and associated units, which make up the matricies in Eqs. 3.32 through 3.35 are given in Appendix E. Note that the units of the perturbation model are not compatible with the actuators or sensors. (The actuator output units are in degrees, and the sensor input units are in degrees/sec, degrees, and G's.) The input and output variables for the perturbation model were scaled in the simulation program to properly interface the models. Combining equations 3.32 - 3.35 gives

$$\begin{array}{l} \dot{u}(t) \\ \dot{w}(t) \\ \dot{q}(t) \\ \dot{thed}(t) \\ \dot{v}(t) \\ r(t) \\ \dot{p}(t) \\ phi(t) \end{array} = \begin{array}{c|c} 4x4 & 4x4 \\ Fx & 0 \\ \hline 4x4 & 4x4 \\ 0 & Fyz \end{array} \begin{array}{l} u(t) \\ w(t) \\ q(t) \\ thed(t) \\ v(t) \\ yr(t) \\ p(t) \\ phi(t) \end{array} + \begin{array}{c|c} 4x3 & 4x5 \\ Gx & 0 \\ \hline 4x3 & 4x5 \\ 0 & Gyz \end{array} \begin{array}{l} dstx \\ dlex \\ dtex \\ dsty \\ dley \\ dtey \\ da \\ dr \end{array} \tag{3.36}$$

$$\begin{array}{l} q(t) \\ nz(t) \\ aa(t) \\ r(t) \\ p(t) \\ ny(t) \end{array} = \begin{array}{c|c} 3x4 & 3x4 \\ Hx & 0 \\ \hline 3x4 & 3x4 \\ 0 & Hyz \end{array} \begin{array}{l} u(t) \\ w(t) \\ q(t) \\ thed(t) \\ v(t) \\ r(t) \\ rr(t) \\ phi(t) \end{array} + \begin{array}{c|c} 3x3 & 3x5 \\ Dx & 0 \\ \hline 3x3 & 3x5 \\ 0 & Dyz \end{array} \begin{array}{l} dstx \\ dlex \\ dtex \\ dsty \\ dley \\ dtey \\ da \\ dr \end{array} \tag{3.37}$$

To study reconfigurable flight controls the aircraft model should be capable of using the full set of control surfaces available to produce the required forces and moments. To achieve this the control surfaces are split into independent right and left hand complements (i.e., right elevator, left elevator, etc.). The equations are then coupled so that a complement of control surfaces used either collectively, differentially, or as a single side, will produce the appropriate moments. For example the stabilators deflected collectively will produce a pitching moment, deflected differentially will produce primarily a rolling moment, and a single side deflected will produce, to some degree, moments about all three axes.

The F/A-18 airframe modeled in equations 3.36 and 3.37 inherently offers control coupling through the stabilator, leading edge flap, and trailing edge flap surfaces.

Additional longitudinal coupling could be achieved with the ailerons and rudders. At the time this thesis was written control derivatives were not available on the longitudinal effects of the ailerons or rudders. (The rudder is capable of toe-in or flare-out and will effect the longitudinal response of the aircraft. This feature is normally used during takeoff and landing.)

To split the control surface deflections into right and left hand complements, the following equations are used which compute the deflection inputs to Eqs. 3.36 and 3.37. (Also refer to Fig. 2.2 which shows the control surface positions and corresponding positive deflections.)

LONGITUDINAL DEFLECTIONS

dstx = (dstl + dstr)/2

dlex = (dlel + dler)/2

dtex = (dtel + dter)/2

LATERAL-DIRECTIONAL DEFLECTIONS

dsty = dstl - dstr

dley = -dlel + dler

dtey = dtel - dter

da = (drl + drr)/2

dr = (dal + dar)/2

Where r and l correspond to right and left surfaces. These equations are rewritten in the following matrix format:

'LONG' distribution matrix

$$\begin{bmatrix} dstx \\ dlex \\ dtex \end{bmatrix} = \begin{bmatrix} .5 & .5 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & .5 & .5 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & .5 & .5 & 0 & 0 & 0 & 0 \end{bmatrix} \begin{bmatrix} dstr \\ dstl \\ dler \\ dlel \\ dter \\ dtel \\ dar \\ dal \\ drr \\ drl \end{bmatrix} \qquad (3.38)$$

'LATD' distribution matrix

$$\begin{bmatrix} dsty \\ dley \\ dtey \\ da \\ dr \end{bmatrix} = \begin{bmatrix} -1 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & -1 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & -1 & 1 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & -1 & 1 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & .5 & .5 \end{bmatrix} \begin{bmatrix} dstr \\ dstl \\ dler \\ dlel \\ dter \\ dtel \\ dar \\ dal \\ drr \\ drl \end{bmatrix} \qquad (3.39)$$

Note these equations are for the unimpaired aircraft only! Damage to one or more of the control surfaces will change the LONG and LATD matricies directly.

Replacing the input vectors in Eqs. 3.36 and 3.37 with the r.h.s. of equations 3.38 and 3.39 gives the following modified airframe equations:

$$\begin{array}{c} \dot{u}(t) \\ \dot{w}(t) \\ \dot{q}(t) \\ \dot{\text{thed}}(t) \\ \dot{v}(t) \\ \dot{r}(t) \\ \dot{p}(t) \\ \dot{\text{phi}}(t) \end{array} = \overset{Fm}{\begin{array}{c|c} 4x4 & 4x4 \\ Fx & 0 \\ \hline 4x4 & 4x4 \\ 0 & Fyz \end{array}} \begin{array}{c} u(t) \\ w(t) \\ q(t) \\ \text{thed}(t) \\ v(t) \\ yr(t) \\ rr(t) \\ \text{phi}(t) \end{array} + \overset{Gm}{\begin{array}{cc} 4x3 & 3x10 \\ Gx & LONG \\ \hline 4x5 & 5x10 \\ Gyz & LATD \end{array}} \begin{array}{c} dstr \\ dstl \\ dler \\ dlel \\ dter \\ dtel \\ dar \\ dal \\ drr \\ drl \end{array} \qquad (3.40)$$

$$\begin{bmatrix} q(t) \\ nz(t) \\ aa(t) \\ yr(t) \\ rr(t) \\ ny(t) \end{bmatrix} = \overset{Hm}{\left[\begin{array}{c|c} 3x4 & 3x4 \\ Hx & 0 \\ \hline 3x4 & 3x4 \\ 0 & Hyz \end{array}\right]} \begin{bmatrix} u(t) \\ w(t) \\ q(t) \\ thed(t) \\ v(t) \\ yr(t) \\ rr(t) \\ phi(t) \end{bmatrix} + \overset{Dm}{\left[\begin{array}{cc} 3x3 & 3x10 \\ Dx & LONG \\ \hline 3x5 & 5x10 \\ Dyz & LATD \end{array}\right]} \begin{bmatrix} dstr \\ dstl \\ dler \\ dlel \\ dter \\ dtel \\ dar \\ dal \\ drr \\ drl \end{bmatrix} \qquad (3.41)$$

The names of the individual matricies appear above the equations.

2. Actuator Model

Transfer functions for the flight control actuators were given in Reference 3 and are listed in Appendix F. These transfer functions are low order approximations of the more complicated actuator models presented in Reference 3. The models were used in the F/A-18 rigid body stability analysis described in Reference 3, and approximate the frequency characteristics of the higher order models out to 5 hz.

To incorporate the actuators into the modified airframe model, the transfer functions are first put into state variable form. This procedure is outlined in Appendix F. The following equations represent the actuator state variable model:

$$\overset{24x1}{\dot{Xa}(t)} = \overset{24x24}{Fa}\ \overset{24x1}{Xa(t)} + \overset{24x10}{Ga}\ \overset{10x1}{Ea(t)} \qquad (3.42)$$

$$\overset{10x1}{D(t)} = \overset{12x24}{Ha}\ \overset{24x1}{Xa(t)} \qquad (3.43)$$

where,

$$Ea(t)^t = [estr(t)\ estl(t)\ eler(t)\ elel(t)\ eter(t)\ etel(t)\ ear(t)\ eal(t)\ err(t)\ erl(t)]$$

and,

$$D(t)^t = [dstr(t)\ dstl(t)\ dler(t)\ dlel(t)\ dter(t)\ dtel(t)\ dar(t)\ dal(t)\ drr(t)\ drl(t)]$$

The input vector, Ea(t), represents the input signal in degrees from the control laws, via the GAIN matrix. The output vector, D(t), represents the right and left control surface deflections in degrees. Equations 3.40 - 3.43 are combined to give the following equations of the airframe plus actuator model:

$$\begin{array}{c} \overset{8x1}{\dot{X}m(t)} \\ \hline \overset{24x1}{\dot{X}a(t)} \end{array} = \overset{Fp}{\begin{array}{c|cc} \overset{8x8}{Fm} & \overset{8x10}{Gm} & \overset{10x24}{Ha} \\ \hline \overset{24x8}{0} & \multicolumn{2}{c}{\overset{24x24}{Fa}} \end{array}} \ \overset{Xp(t)}{\begin{array}{c} \overset{8x1}{Xm(t)} \\ \hline \overset{24x1}{Xa(t)} \end{array}} + \overset{Gp}{\begin{array}{c} \overset{8x10}{0} \\ \hline \overset{24x10}{Ga} \end{array}} \ \overset{10x1}{Ea(t)} \qquad (3.44)$$

$$\begin{array}{c} q(t) \\ nz(t) \\ aa(t) \\ yr(t) \\ rr(t) \\ ny(t) \end{array} = \overset{Hp}{\begin{array}{c|cc} \overset{6x8}{Hm} & \overset{6x12}{Dm} & \overset{12x24}{Ha} \end{array}} \ \overset{Xp(t)}{\begin{array}{c} \overset{8x1}{Xm(t)} \\ \hline \overset{24x1}{Xa(t)} \end{array}} \qquad (3.45)$$

As before the names of the matricies appear above the equations. The airframe plus actuator model inputs the command signals to the actuators, and outputs aircraft motion. Since the control surface deflections in the perturbation model are in radians, it was necessary to scale the Hm and Dm matricies to interface with the actuator model which outputs deflections in degrees. This is done in the simulation program.

3. Sensor Model

In the final step of the development of the aircraft model, the state variable model for the aircraft sensors is incorporated into the airframe plus actuator model. The sensor transfer functions are given in Appendix G. In state variable form the sensor equations are given as:

$$\overset{11\mathrm{x}1}{\dot{X}s(t)} = \overset{11\mathrm{x}11}{Fs}\;\overset{11\mathrm{x}1}{Xs(t)} + \overset{11\mathrm{x}6}{Gs}\;\begin{matrix} q(t) \\ nz(t) \\ aa(t) \\ r(t) \\ p(t) \\ ny(t) \end{matrix} \qquad (3.46)$$

$$\begin{matrix} eq(t) \\ enz(t) \\ eaa(t) \\ eyr(t) \\ err(t) \\ eny(t) \end{matrix} = \overset{6\mathrm{x}11}{Hs}\;\overset{11\mathrm{x}1}{Xs(t)} \qquad (3.47)$$

The sensor model inputs the aircraft motion variables in degrees/second, degrees, or G's, and outputs the corresponding signals to the control laws in the same units. Combining Eqs. 3.44 - 3.47 gives the following model of airframe plus actuators plus sensors:

$$\begin{array}{c} \\ \overset{32\times1}{\dot{X}p(t)} \\ \hline \overset{11\times1}{\dot{X}s(t)} \end{array} = \overset{Fps}{\begin{array}{cc|c} \multicolumn{2}{c|}{\overset{32\times32}{FP}} & \overset{32\times11}{0} \\ \hline \overset{11\times6}{Gs} & \overset{6\times32}{Hp} & \overset{11\times11}{Fp} \end{array}} \quad \overset{Xps(t)}{\begin{array}{c} \overset{32\times1}{Xp(t)} \\ \hline \overset{11\times1}{Xs(t)} \end{array}} + \overset{Gps}{\begin{array}{c} \overset{32\times10}{Gp} \\ \hline \overset{11\times10}{0} \end{array}} \quad \overset{10\times1}{Ea(t)} \tag{3.48}$$

$$\begin{array}{c} eq(t) \\ enz(t) \\ eaa(t) \\ eyr(t) \\ err(t) \\ eny(t) \end{array} = \overset{Hps}{\begin{array}{c|c} \overset{6\times32}{0} & \overset{6\times11}{Hs} \end{array}} \quad \overset{Xps(t)}{\begin{array}{c} \overset{32\times1}{Xp(t)} \\ \hline \overset{11\times1}{Xs(t)} \end{array}} \tag{3.49}$$

The aircraft model inputs the actuator signals from the control laws via the GAIN matrix and outputs the motion signals from the sensors which are sent to the control law equations.

C. ASSEMBLING THE OVERALL SYSTEM MODEL

A mathematical model for each component in the control system shown in Fig. 2.3 has now been developed. Before the individual components of the model can be assembled, the discrete state equations for aircraft model (Eqs. 3.48 and 3.49) must be computed. Performing this operation the discrete state equations for the aircraft are given as:

$$\overset{43\times1}{Xps(k+1)} = \overset{43\times43}{Aps}\ \overset{43\times1}{Xps(k)} + \overset{43\times10}{Bps}\ \overset{10\times1}{Ea(k)} \tag{3.50}$$

$$\overset{6\times1}{Es(k)} = \overset{6\times44}{Hps}\ \overset{43\times1}{Xps(k)} \tag{3.51}$$

Where

$$Xps(k)^t = [Xm(k) | Xa(k) | Xs(k)]$$

$$Ea(k)^t = [estr(k)\ estl(k)\ eler(k)\ elel(k)\ eter(k)\ etel(k)\ ear(k)\ eal(k)\ err(k)\ erl(k)]$$

$$Es(k)^t = [eq(K)\ enz(k)\ eaa(h)\ eyr(k)\ err(k)\ eny(k)]$$

The Aps and Bps discrete matricies are computed as follows:

$$Aps = e^{Fps*ts} \qquad (3.52)$$

$$Bps = \int_0^{ts} e^{Fps*s} ds \ X\ Gps \qquad (3.53)$$

Where ts represents the system sampling time.

The GAIN matrix is now introduced to interface the discrete aircraft equations with the control law equations. Replacing the input vector, Ea(k), in the aircraft equation with the r.h.s. of the GAIN equation (Eq. 3.31) gives the following:

$$\overset{43x1}{Xps(k+1)} = \overset{43x43}{Aps}\ \overset{43x1}{Xps(k)} + \overset{43x10}{Bps}\ \overset{10x8}{GAIN}\ \overset{8x1}{Ec(k)} \qquad (3.52)$$

$$\overset{6x1}{Es(k)} = \overset{6x44}{Hps}\ \overset{43x1}{Xps(k)} \qquad (3.53)$$

For convenience the control law equations are repeated below:

$$\overset{12x1}{Xc(k+1)} = \overset{12x12}{Ac}\ \overset{12x1}{Xc(k)} + \overset{12x6}{Bfc}\ \overset{6x1}{Es(k)} + \overset{12x3}{Bc}\ \overset{3x1}{P(k)} \qquad (3.29)$$

$$\overset{8x1}{Ec(k)} = \overset{8x12}{Cc}\ \overset{12x1}{Xc(k)} + \overset{8x6}{Dfc}\ \overset{6x1}{Es(k)} + \overset{8x3}{Dc}\ \overset{3x1}{P(k)} \qquad (3.30)$$

Where:

$Xc(k)^t = [Xx(k) \mid Xz(k)]$

$Es(k)^t = [eq(h)\ enz(k)\ eaa(h)\ eyr(k)\ err(k)\ eny(k)]$

$P(k)^t = [px(k)\ py(k)\ pz(k)]$

$Ec(k)^t = [estx(k)\ elex(k)\ etex(k)\ esty(k)\ eley(k)\ etey(k)\ ea(k)\ er(k)]$

Equations 3.52, 3.53, 3.29, and 3.30 are now combined to give the following matrix equation:

$$
\begin{array}{c}
\overset{43x1}{Xps(k+1)} \\ \hline \overset{12x1}{Xc(k+1)}
\end{array}
=
\begin{array}{c|c}
\overset{43x43}{Aps} + \overset{43x10}{Bps}\ \overset{10x8}{GAIN}\ \overset{8x6}{Dfc}\ \overset{6x43}{Hps} & \overset{43x10}{Bps}\ \overset{10x8}{GAIN}\ \overset{8x12}{Cc} \\ \hline
\overset{12x6}{Bfc}\ \overset{6x43}{Hps} & \overset{12x12}{Ac}
\end{array}
\
\begin{array}{c}
\overset{43x1}{Xps(k)} \\ \hline \overset{12x1}{Xc(k)}
\end{array}
$$

$$
+ \quad
\begin{array}{c}
\overset{43x10}{Bps}\ \overset{10x8}{GAIN}\ \overset{8x3}{Dc} \\ \hline \overset{12x3}{Bc}
\end{array}
\
\begin{array}{c}
px(k) \\ py(k) \\ pz(k)
\end{array}
\tag{3.54}
$$

$$
\begin{array}{c}
\overset{6x1}{Es(k)} \\ \hline \overset{8x1}{Ec(k)}
\end{array}
=
\begin{array}{c|c}
\overset{6x43}{Hps} & \overset{6x12}{0} \\ \hline
\overset{8x6}{Dfc}\ \overset{6x43}{Hps} & \overset{8x12}{Cc}
\end{array}
\
\begin{array}{c}
\overset{43x1}{Xps(k)} \\ \hline \overset{12x1}{Xc(k)}
\end{array}
+
\begin{array}{c}
\overset{6x3}{0} \\ \hline \overset{8x3}{Dc}
\end{array}
\
\begin{array}{c}
px(k) \\ py(k) \\ pz(k)
\end{array}
\tag{3.55}
$$

These equations model the dynamic response of the F/A-18 system shown in Figure 2.3.

D. MODELING EFFECTOR IMPAIRMENT

Effector impairment is divided into four groups termed 'effector impairment classes' (EIC) [Ref. 1]. Figure 3.4, copied from Reference 1, defines the EIC's and indicates

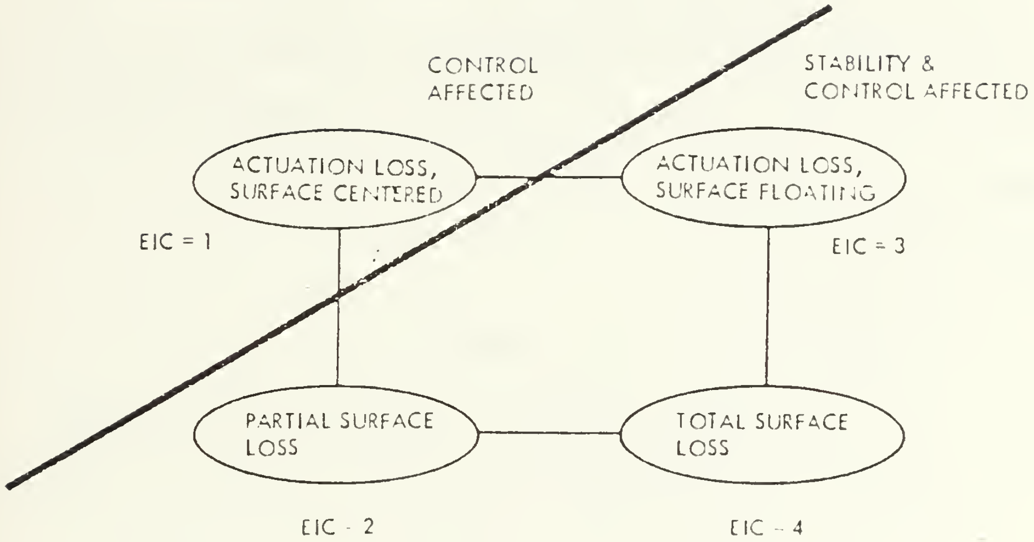


Figure 3.4 Effector Impairment Classes

their affect on aircraft stability and control. As shown in Fig. 3.4, effector impairment class one is unique in that only aircraft control is affected. The remaining impairment classes affect aircraft stability as well as control. A self repairing control system must be capable of detecting and classifying effector damage to compute the proper reconfiguration gains.

For the case of EIC=1, one or more of the aircraft control derivatives will be altered. In the F/A-18 model developed above this is reflected in the LONG and LATD matricies (Eqs. 3.38 and 3.39). For example if the right stabilator is impaired the elements LONG(1,1) and LATD(1,1) would be set to zero:

LONG

$$\begin{matrix} 0 & .5 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & .5 & .5 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & .5 & .5 & 0 & 0 & 0 & 0 \end{matrix}$$

LATD

$$\begin{matrix} 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & -1 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & -1 & 1 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & -1 & 1 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & .5 & .5 \end{matrix}$$

Compare the above matricies with Eqs. 3.38 and 3.39 for the undamaged aircraft. Note that the damaged system will now produce a lateral input for a given longitudinal command and vice versa. For the model developed in this thesis, only class one effector impairments are considered.

E. CONCLUSION

In this chapter the mathematical models for each component in the block diagram of Fig. 2.3 were developed. The individual models were then assembled to form the complete model of the F/A-18 dynamical system. Next the simulation program is developed to compute the model matricies in Eqs. 3.54 and 3.55, and compute the response of the system to stick and rudder inputs.

IV. PROGRAM DEVELOPMENT AND MODEL VALIDATION

A. INTRODUCTION

To validate the F/A-18 system model a computer program was written to compose the model matricies in Eqs. 3.54 and 3.55, and compute the system response to stick and rudder inputs. In addition the program simulates an actuation loss of the right or left stabilator. The program was written in VS Fortran on the IBM 3033 computer at the Naval Postgraduate School. The program is organized to offer flexibility for future development and modification.

B. PROGRAM STRUCTURE

The program may be divided into four major operations:

1) Data input
2) Air data computations
3) Composition of the system matricies
4) System response computation

The operations are performed by a series of subroutines as shown in the flow diagram in Fig. 4.1. In Fig. 4.1 the solid lines indicate control flow, and the dotted lines indicate data flow. The subroutines perform the steps outlined in Chapter II to compose the system matricies and compute the response. A functional description of each subroutine shown in Fig. 4.1 and associated variables is given in Appendix H. Existing subroutines at NPS were used to perform the required matrix manipulations [Ref. 5]. These subroutines are also defined in Appendix H.

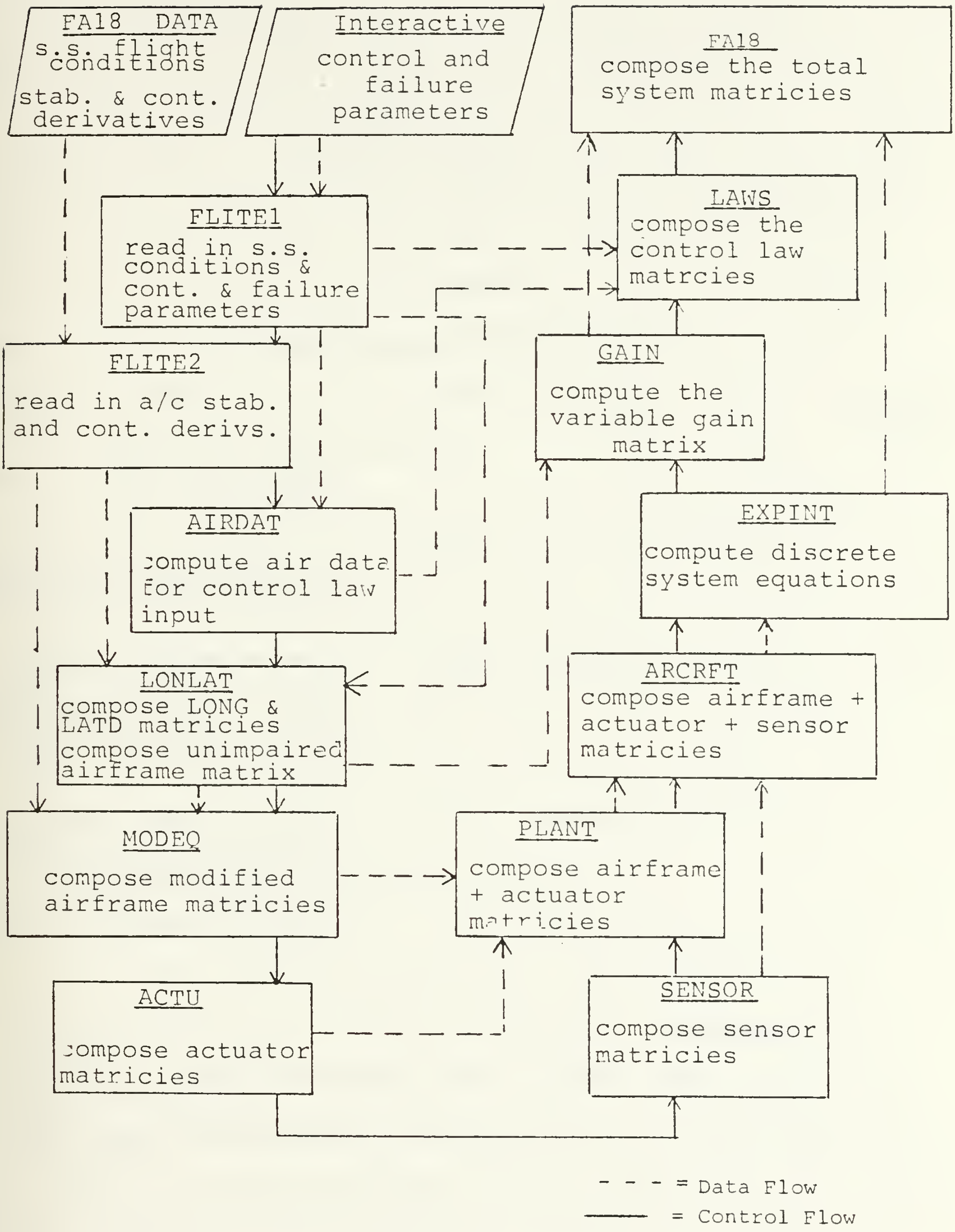


Figure 4.1 Simulation Program Flow Diagram

Execution of the program is controlled by the 'F18' Exec program. The Exec defines the input and output data files as shown in Table 4.1. No user options are provided to define data input/output files. The result of each subroutine computation is written to the FA18 RESULT file, and can be viewed by the user after program execution. A copy of the Exec program is given in Appendix I.

TABLE 4.1

INPUT/OUTPUT FILE DEFINITIONS

Record Number	Device	File Name	Type	Use
01	Disk	FA18	DATA	Contains the FA18 program input data
02	Disk	FA18	RESULT	Contains the result of the operations performed by each subroutine
03	Disk	OPTMATD	DATA	Contains FA18 system matricies (Eqs. 3.54 and 3.55) formated for the control system design package at NPS.
04	Disk	OPTPLOT	DATA	Contains the system response data computed by the FA18 program formated for the interactive plotting program at NPS.

1. Data Input

Subroutines 'FLITE1' and 'FLITE2' perform the data input operations. All data is read from the FA18 data file except the control and failure parameters which are input interactively.

'FLITE1' reads in the aircraft steady state flight conditions and control and failure parameters. As indicated in Fig. 4.1 the flight conditions are read from the FA18 DATA file. The control and failure parameters are read in interactively. This allows the user to conveniently run the program for various control inputs and control surface failures. 'FLITE2' reads in the basic airframe stability and control derivatives from the FA18 DATA file. The stability and control derivatives are arranged in the matrix format shown in Eqs. 3.33 - 3.36, and in Appendix E.

2. Air Data Computations

Prior to composing the system matricies, air data computations are performed by subroutine 'AIRDAT'. The subroutine computes the air data inputs to the control law functions using the standard atmosphere equations [Ref. 6]. The program does not include the logic to compute atmospheric conditions above the gradient (troposphere) region. Therefore the computations are valid only up to 36,000 feet.

3. Composing the System Matricies

As seen in Fig. 4.1 the system matricies are composed by ten subroutine operations. The operations and associated equations in Chapter III are as follows:

1) Compose the LONG and LATD matricies Eqs. 3.38 & 3.39
2) Compose the modified airframe matricies Eqs. 3.40 & 3.41
3) Compose the actuator matricies Eqs. 3.42 & 3.43

4) Compose the sensor matricies Eqs. 3.46 & 3.47

5) Compose the airframe plus actuator matricies Eqs. 3.44 & 3.45

6) Compose the airframe plus actuator sensor matricies Eqs. 3.48 & 3.49

7) Compute the discrete system matricies Eqs. 3.50 & 3.51

8) Compose the GAIN matrix Eqs. 3.31

9) Compose the control law matricies Eqs. 3.29 & 3.30

10) Compose the total system maricies Eqs. 3.54 & 3.55

The basic component matricies are composed by first generating a null matrix of proper dimensions, and then assigning the coefficient values to the proper elements. These matricies include:

1) LONG and LATD
2) Actuator
3) Sensor
4) Control law
5) GAIN

The coefficient values to actuator and sensor models are written into the program as constants; they are not contained on a separate data file. The coefficients in the LONG, LATD, control law, and GAIN matricies are first computed, then assigned to the appropriate matrix element.

The LONG and LATD matricies are composed by subroutine 'LONLAT'. As explained in Section III.C these matricies reflect control surface damage for one of the four control surface impairment classes. In the present program only class one effector impairments are simulated. For EIC=1 the appropriate control surface coefficients in the 'LONG' and 'LATD' matricies are set to zero. 'LONLAT' contains the logic to impair the right or left stabilator. 'LONLAT' also composes the unimpaired airframe control matrix, Gm0. This matrix will be used to compute the impaired gain matrix in subroutine 'VGAIN'.

The control law matricies are composed by subroutine 'LAWS'. The subroutine may be divided into four operations:

1) Compute function gains
2) Compute the filter coefficients
3) Compute the matrix coefficients
4) Assign coefficients to the control law matricies as in Eqs. D.1 & D.2.

The gains are computed according to the function definitions given in Appendix A. The functions use the air data computed in 'AIRDAT', steady state AOA, and normal acceleration to compute the gains. All functions are programmed exactly as shown in Appendix A except for the following non-linear functions:

Function 20	Longitudinal stick gradient
Function 1	Lateral stick gradient
Function 14	Rudder pedal gradient
Function 42	RSRI non-linear gradient

These functions were programmed using the linear terms of a Taylor Series Expansion about the origin. Some of the functions computed in the program are not used in the control law model. They are provided for user information on system performance. These functions are:

Function 24	Trailing edge flap schedule
Function 25	Trailing edge flap schedule qc limit
Function 27	Leading edge flap schedule
Function 29	Leading edge flap schedule ri limit
Function 37	Nz limit on AOA feedback
Function 41	Rolling surface limit schedule
Function 112	Lateral acceleration gain
Function 113	Lateral acceleration gain

The filter coefficients were computed using the procedures outlined in Appendix B to transform the analog filters into digital filters. The control law coefficients were computed using the procedures outlined in Appendix C for transforming the control path transfer functions into state variable form. The function and coefficient values are output to the FA18 RESULT file.

Subroutine 'VGAIN' composes the GAIN matrix based on control effector impairment. For the unimpaired system the GAIN matrix appears as in Eq. 3.31. The subroutine is designed to implement the reconfiguration algorithm described in Reference 1.

Prior to composing the total system matricies the discrete form of the continuous system matricies must be computed. This is done by subroutine 'EXPINT' [Ref. 5]. 'EXPINT' computes the matrix exponential,

$$e^{Fps*ts}$$

and the integral,

$$\int_{0}^{ts} e^{Fps*s} ds$$

The discrete system equations are then computed as:

$$Aps = e^{Fps*ts}$$

and

$$Bps = \int_{o}^{ts} e^{Fps*s} ds \times Gps$$

The Aps and Bps matricies are written to the OPTMATD DATA file. The data file is formatted for the control system design package at NPS.

4. Response Computations

System response is computed for the recursive equation

$$\overset{55x1}{X(k+1)} = \overset{55x55}{AF18} \quad \overset{55x1}{X(k)} + \overset{55x3}{BF18} \ \overset{3x1}{U(k)}$$

The response is computed for 500 data points. The AF18 and BF18 matricies are defined in Eq. 3.54. The state and input vectors are defined as:

$$X(h)^{t} = [\ Xm(k)\ |\ Xa(k)\ |\ Xs(k)\ |\ Xc(k)\ ]$$

$$U(k)^{t} = [\ px \ py \ pz\ ]$$

Response data for all 55 states is written into the OPTPLOT DATA file which is formatted for the interactive plotting routines at NPS. The variables contained in the state vector which are relevant to the user for viewing are:

x1 = u
x2 = w
x3 = q
x4 = thed
x5 = v
x6 = r
x7 = p
x8 = phi
x9 = dstr
x13 = dstl
x17 = dler
x19 = dlel
x21 = dter
x23 = dtel
x25 = dar
x27 = dal
x29 = drr
x31 = drl

The output equation (Eq. 3.55) was not programmed.

C. PROGRAM TESTING AND MODEL VALIDATION

To test the simulation program, four sets of runs were made for the following control inputs:

1) Positive longitudinal stick, no failure
2) Positive longitudinal stick, right stabilator failed
3) Positive lateral stick, no failures
4) Positive rudder pedal, no failures

All deflections were .1 inch step inputs of 3 second duration. All runs were made at .6 mach/10000 feet. The sampling rate was set to 80 hz. (Additional runs were made at 40 hz sampling rates with no noticable difference in the output response.) Aircraft steady state data, including the stability and control derivatives, are given in Appendix J. The FA18 RESULTS file, including the function and control matrix coefficient values, is given in Appendix K.

The model was verified for:

1) Correct direction of motion of control surfaces and corresponding aircraft motion.
2) Expected aircraft response for a right stabilator failure.
3) Proper augmented aircraft motion.

Reference 7 contains response plots for the aircraft for similar flight conditions. These plots were used to verify the model for the proper augmented motion. Some of the plots were reproduced for the thesis and are given in Appendix L. The control inputs used in Reference 7 are slightly different than those used for thesis model. Some comparisons however can still be made. All response plots for the thesis model are given in Appendix M.

The aircraft response to a positive longitudinal input for a no failure condition is shown in Figs. M-1 - M.3. The motion of the right stabilator, and leading and trailing edge flaps compare favorably to the McDonnell model response shown in Fig. L.1. In the thesis model the right stabilator initially travels -2.5 degrees. After a .5 second transient period the stabilator continues to -3.6 degrees in 3 seconds. The corresponding McDonnell response shows an initial travel of -2.2 degrees. After the .5 second transient period the stabilator continues to -1.8 degrees in 3 seconds. The major difference between the two responses is the stabilator rate, the thesis model being slightly greater than the McDonnell model. (Possible explanations for the discrepancies in the model are given below.)

The leading and trailing edge flaps, driven by angle of attacks feedback, deflect approximately 7.5 degrees in 3.4 seconds as shown in Figs. M.1 and M.2. The corresponding McDonnell response show the leading and trailing edge flaps to deflect approximately 4 degrees in 3.5 seconds. (Note the initial conditions of the flaps show Fig. L.1 are not zero as in Figs. M.1 and M.2.) Aircraft pitch rate and pitch angle response for the thesis model are shown in Figs. M.2 and M.3. The thesis model achieved a maximum pitch rate of 8 degrees/second compared to 4 degrees/second for the McDonnell model. Also the McDonnell model achieved a constant pitch rate in 2.5 seconds. The thesis model achieved a 2.5 degree pitch attitude in 5 seconds compared to 15 degrees shown in.Fig. 1.1. The increased travel of the stabilator shown in Fig. M.1 (compare Fig. L.1) may explain the discrepancies in the pitch and flap responses.

Figure M.4 shows the response of the aircraft with the right stabilator failed. Note the decrease in pitch rate and pitch angle magnitudes. Figure M.4 shows a negative roll rate which is to be expected for a right stabilator failure. Reference 7 did not give aircraft response for control surface failures.

Aircraft response to a positive lateral stick input is shown in Figs. M.5 - M.8. The motion of the stabilator, aileron, and trailing edge flap compare favorably to the McDonnell response shown in Fig. L.2. The aileron in the thesis model achieves a steady state deflection of 1.1 degrees in .5 seconds. The McDonnell response shows a steady state deflection of 1.6 degrees in .5 seconds. The thesis model stabilator (Fig. M.5) deflects 0.45 degrees in 0.5

seconds, the corresponding McDonnell response shows a 0.6 degree deflection in 0.5 seconds. The trailing edge flap in Fig. M.6 deflects 0.4 degrees in 0.3 seconds which compares favorably to the response shown in Fig. L.2. (Leading edge differential flaps are not used at the flight conditions tested. Function 93, which sets the gain on the leading edge flap path, is computed as zero.) The rudder response (Fig. M.6) shows an initial negative deflection which is expected for coordinating a right turn. The magnitude of the deflections for the two models is approximately the same, however the thesis response is slightly more oscillatory than the McDonnell response. The aircraft roll rate, yaw rate, and bank angle response are shown in Figs. M.7 and M.8. Again only slight discrepancies exist between the two models.

The aircraft response to a positive rudder pedal input is shown in Figs. M.9 and M.10. The corresponding McDonnell response is shown in Fig. L.3. Comparison of the two models shows the shape of the responses to be approximately the same. However the magnitudes in the thesis model are very much less than the McDonnell model. For example the rudder achieves a maximum deflection of 0.07 degrees as shown in Fig. M.9. Compare this to a 1.5 degree deflection for the McDonnell model shown in Fig. L.3. The response of the differential aileron and stabilator for the thesis model (Figs. M.9 and M.10) is essentially zero. This is expected since the rudder to rolling surface interconnect gain, function 39, is computed as zero for low angle of attack. (See Appendix A, function 39.) It is unknown why the ailerons and stabilators respond as shown in Fig. L.3. Possibly the response shown in Fig. L.3 is based on a different flight control program than that used in the thesis model.

Possible explanations for the discrepancies in the response between the two aircraft models are:

1) Improper derivation of the simplified control law model based on the assumptions and procedures given in Chapters I and II.

2) Programming discrepancies resulting in erroneous computations.

3) Errors in the aircraft linear small perturbation model.

4) Differences between the modeling techniques used in Reference 7 and in this thesis. (The MCAIR model included all aerodynamic and control system nonlinearities, as well as the effects due to digital time delay and quantization.)

5) The McDonnell model response made available to the author may be based on a slightly different flight program than used in the thesis model.

The author investigated each of the items listed above. It is felt the assumptions used in developing the control law model are correct given the available information on the F/A-18 control system. The simplifying assumptions used in developing the model may account for some of the differences. The program code was thoroughly reviewed and revealed no discrepancies. It is assumed however that this item remains a possible source of error. Two possible sources of error exist with respect to the aircraft perturbation model:

1) The coefficients in the NATC small perturbation model are computed with respect to the aircraft body axes (see Appendix E). This may effect the magnitude of the motion variables which are fed back to the control laws.

2) The aircraft model developed in Reference 7 considers the offset position of the accelerometers from the aircraft center of gravity. It has not been determined if this effect is considered in the NATC perturbation model.

Further investigation into these possibilities should be conducted.

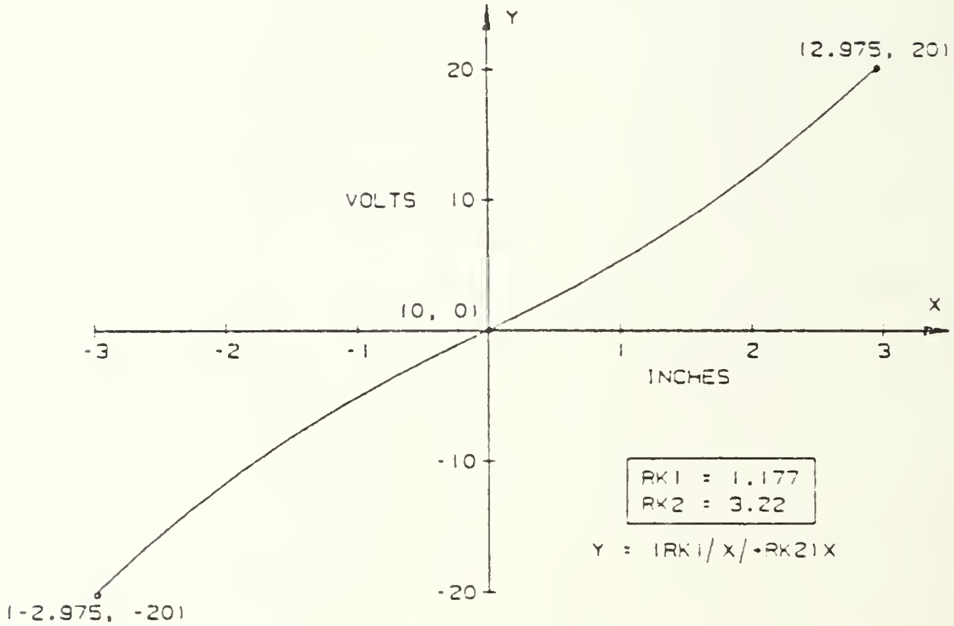
IV. CONCLUSIONS AND RECOMMENDATIONS

A mathematical model was developed which simulates the dynamic response of the F/A-18 aircraft. The model is designed to implement the reconfiguration gain matrix for the study of reconfigurable control systems. A program was written which composes the discrete time state variable matrices of the aircraft, and computes the response to stick and rudder inputs. The program also simulates the actuation loss of the right and left stabilators. Response plots of the thesis model were displayed and compared to the aircraft model developed in Reference 7. Possible sources of error were discussed, and it is recommended that further investigation into each of these areas be conducted.

It is also recommended that the NATC program which computes the stability and control derivatives be acquired by the Aeronautical Engineering Department at the Naval Postgraduate School, to be made an integral part of this program. This would expand the ability of the program to simulate the response of the aircraft for any flight condition, and various degrees of control surface damage.

APPENDIX A

FUNCTION MATHEMATICAL DESCRIPTIONS



FUNCTION 1

LATERAL STICK GRADIENT

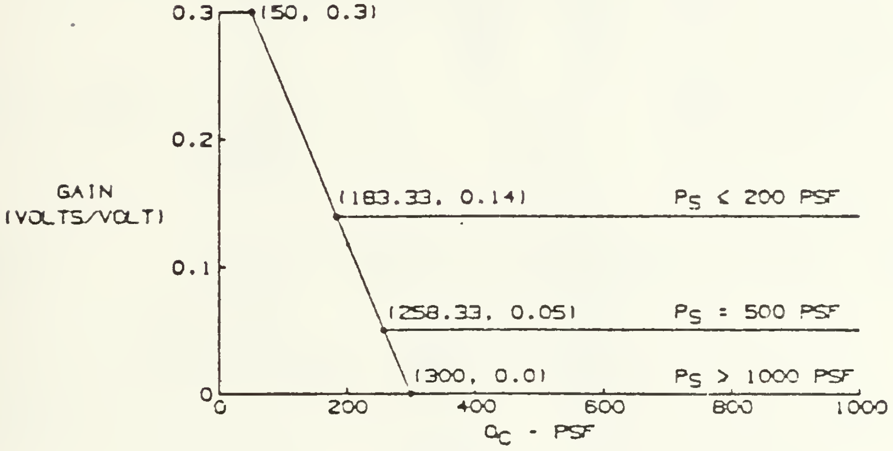
AUTO FLAP UP

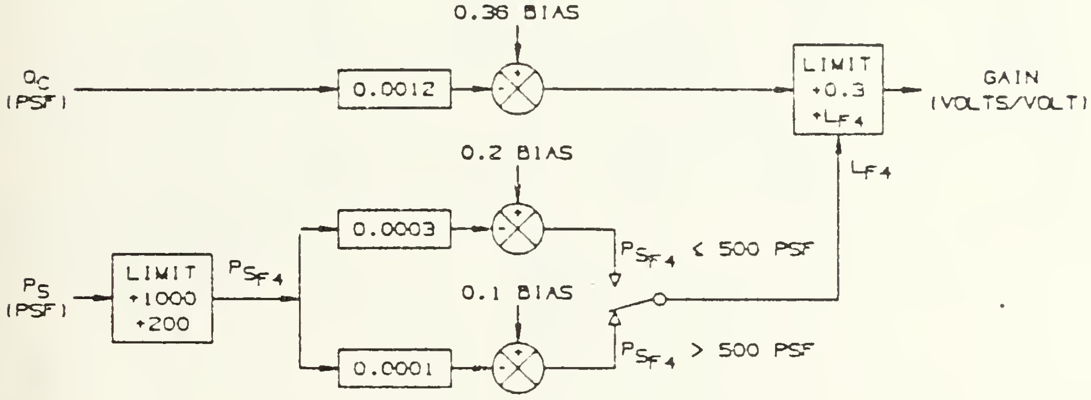
RK1 = 1.177
RK2 = 3.22

$Y = (RK1|X| + RK2)X$

FUNCTION 4

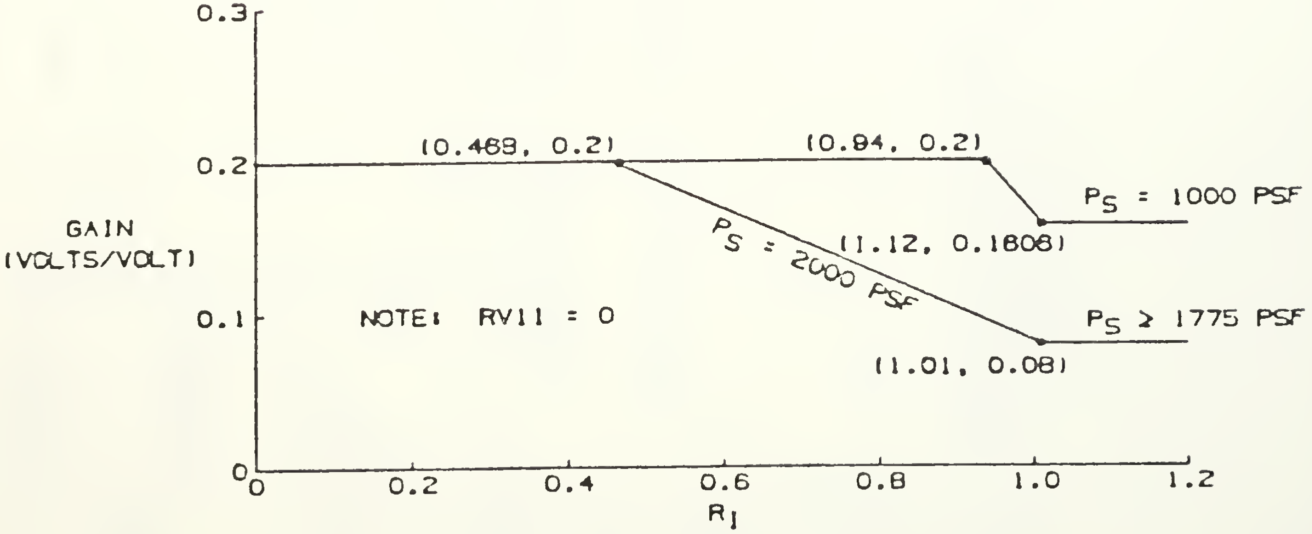
ROLL RATE FEEDBACK GAIN SCHEDULE
AUTO FLAP UP (Q_C, P_S)

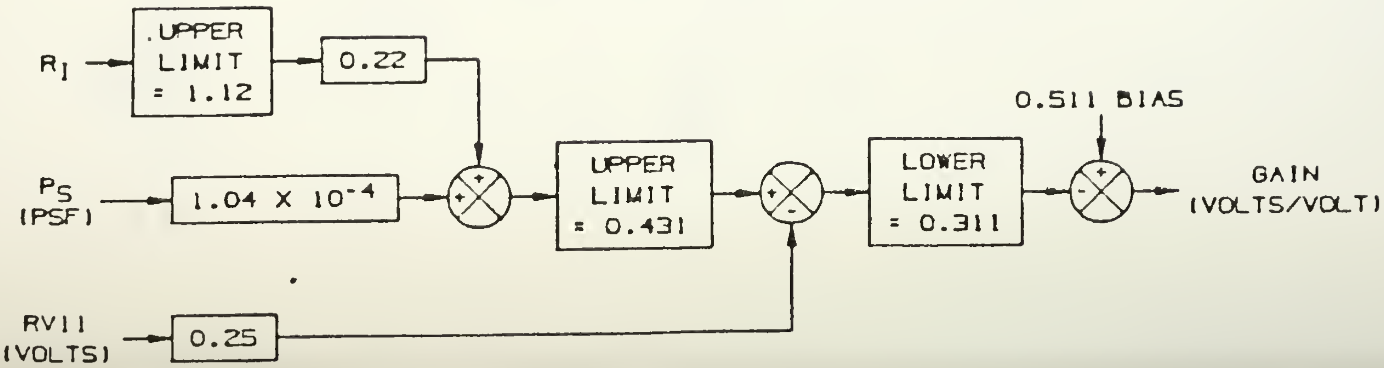




FUNCTION 6

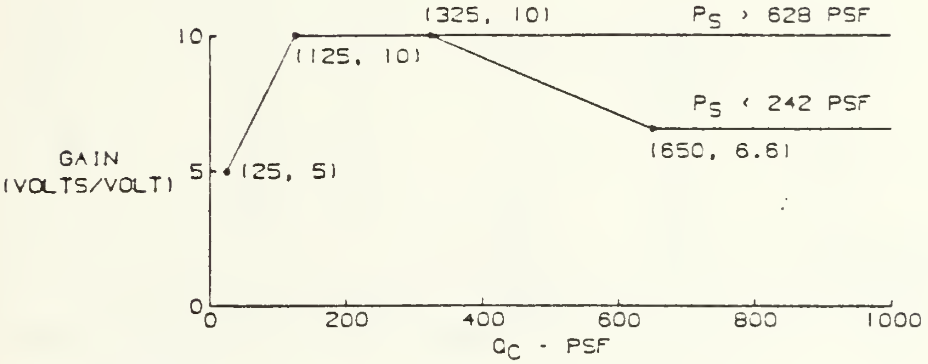
DIFFERENTIAL STABILATOR GAIN SCHEDULE
AUTO FLAP UP (R_I, P_S, RVII)

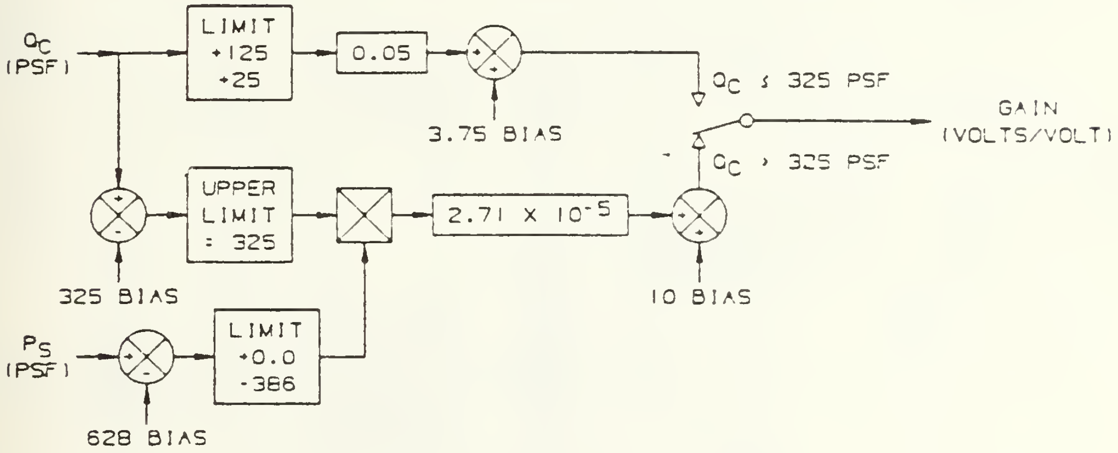




FUNCTION 7

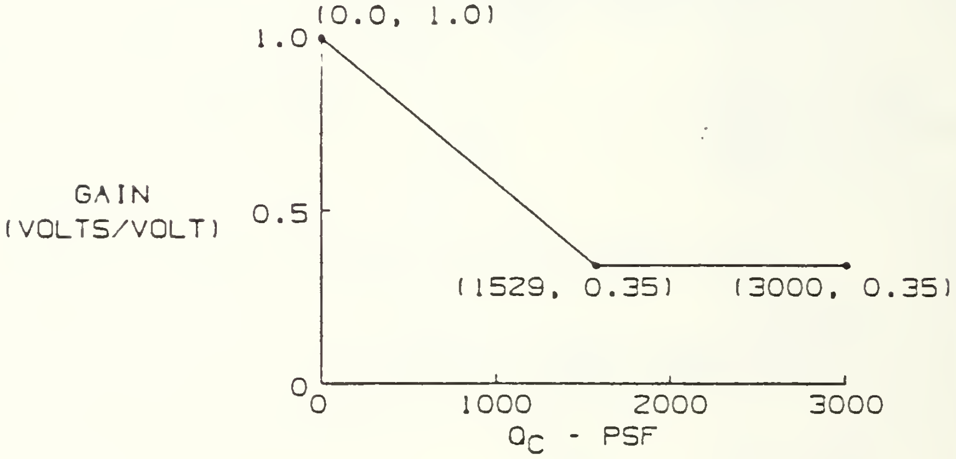
LATERAL COMMAND GAIN SCHEDULE
AUTO FLAP UP (Q_C, P_S)

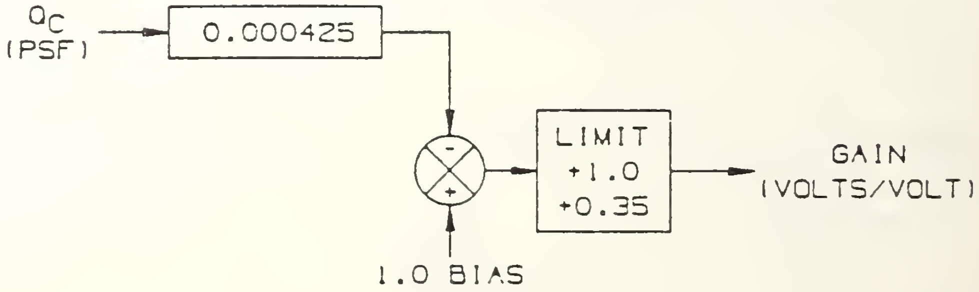




FUNCTION 10

RUDDER COMMAND GAIN AUTO FLAP UP (Q_C)

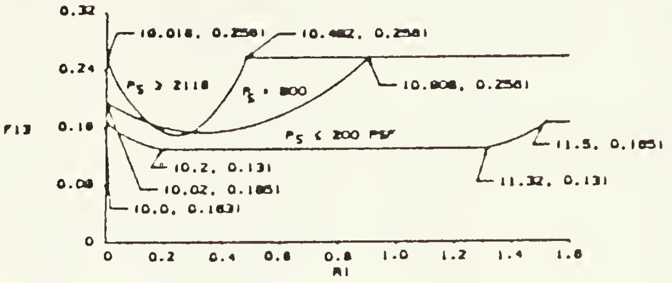




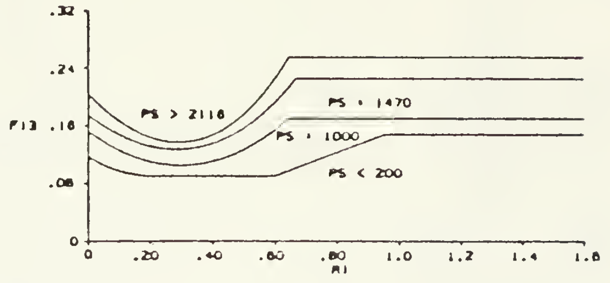
FUNCTION 13

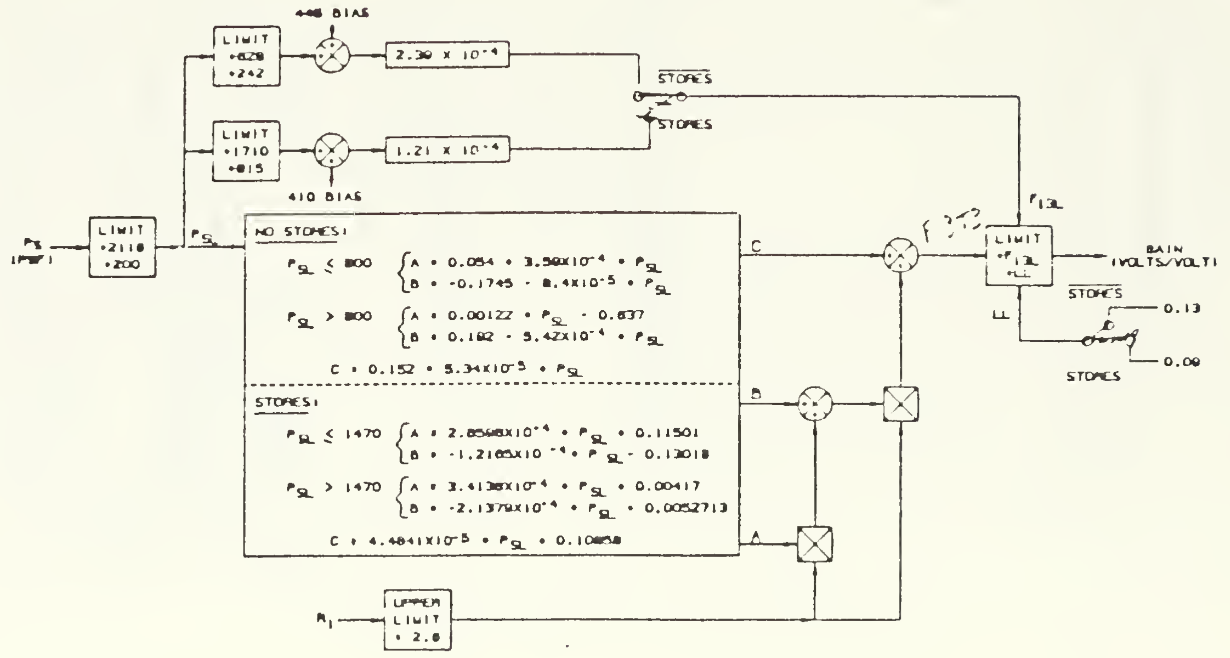
LATERAL COMMAND GAIN SCHEDULE
AUTO FLAP UP (R$_1$, P$_S$, STORES)

FUNCTION 13 VS. RI
LATERAL COMMAND GAIN - NO STORES



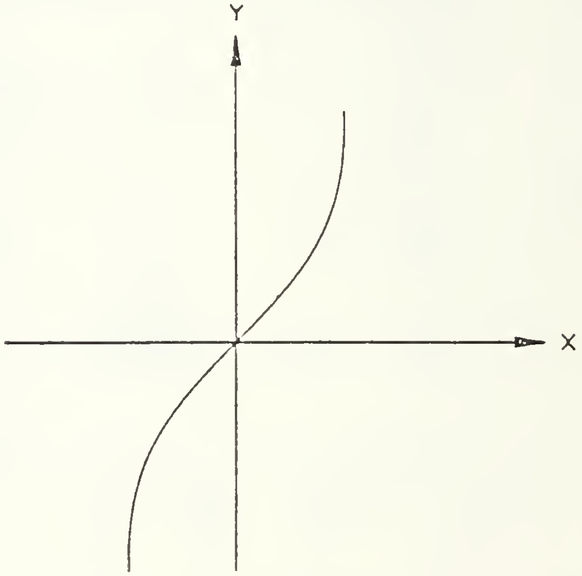
FUNCTION 13 VS. RI
LATERAL COMMAND GAIN - STORES





FUNCTION 14

RUDDER PEDAL GRADIENT

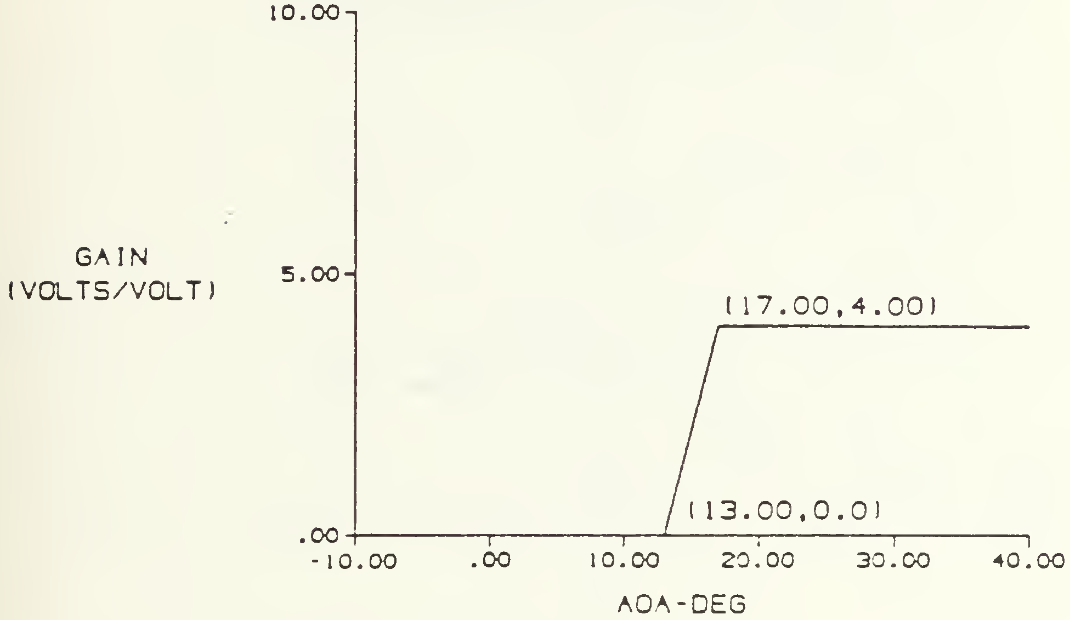


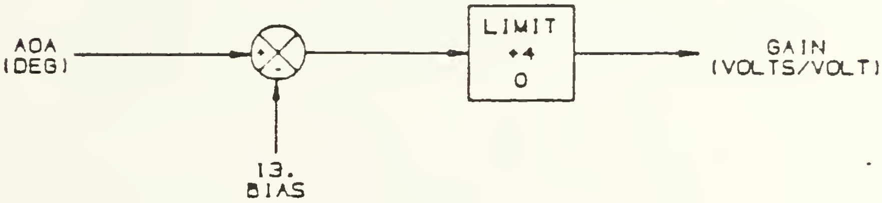
Y = (YK9/X/+YK10)X

MODE	YK9	YK10
YCAS AND $\overline{\text{SPIN}}$ AND AFU	0.00072 X (FUNCTION 10)	0.234 X (FUNCTION 10)
YDEL AND $\overline{\text{SPIN}}$	0.0017	0.138
SPIN	0.00144	0.468
YCAS AND $\overline{\text{SPIN}}$ AND $\overline{\text{AFU}}$	0.00072	0.234

FUNCTION 17

RUDDER PEDAL COMMAND GAIN INCREMENT AUTO FLAP UP (AOA)

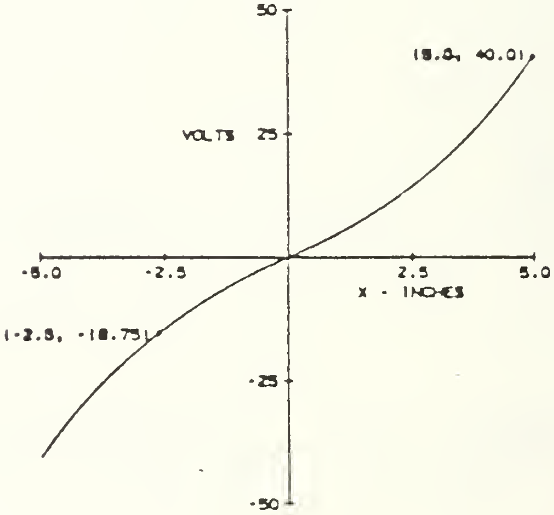




FUNCTION 20

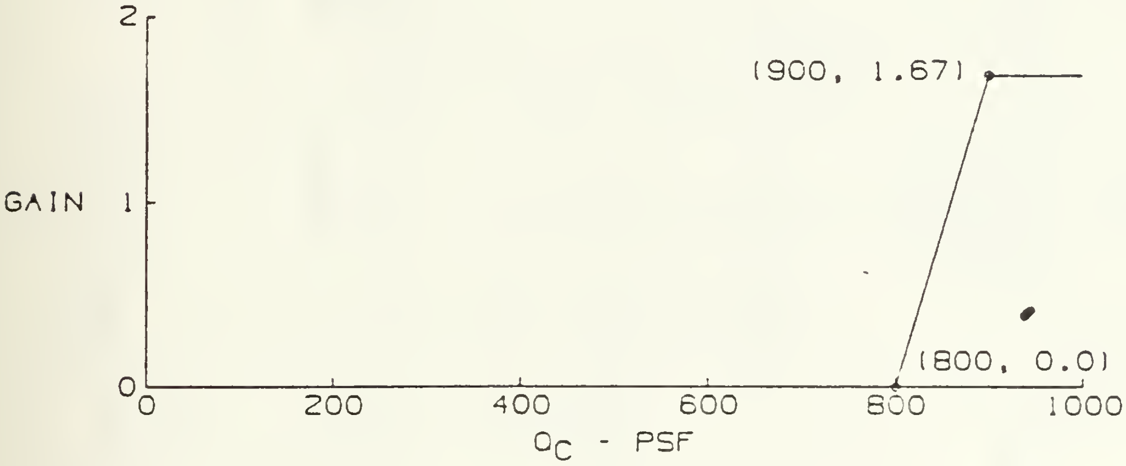
LONGITUDINAL STICK GRADIENT

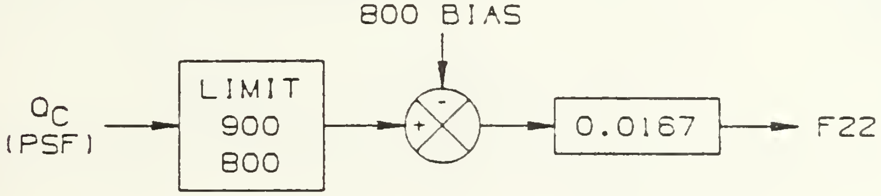
$F20 = X(7.0 + 0.2|X|)$



FUNCTION 22

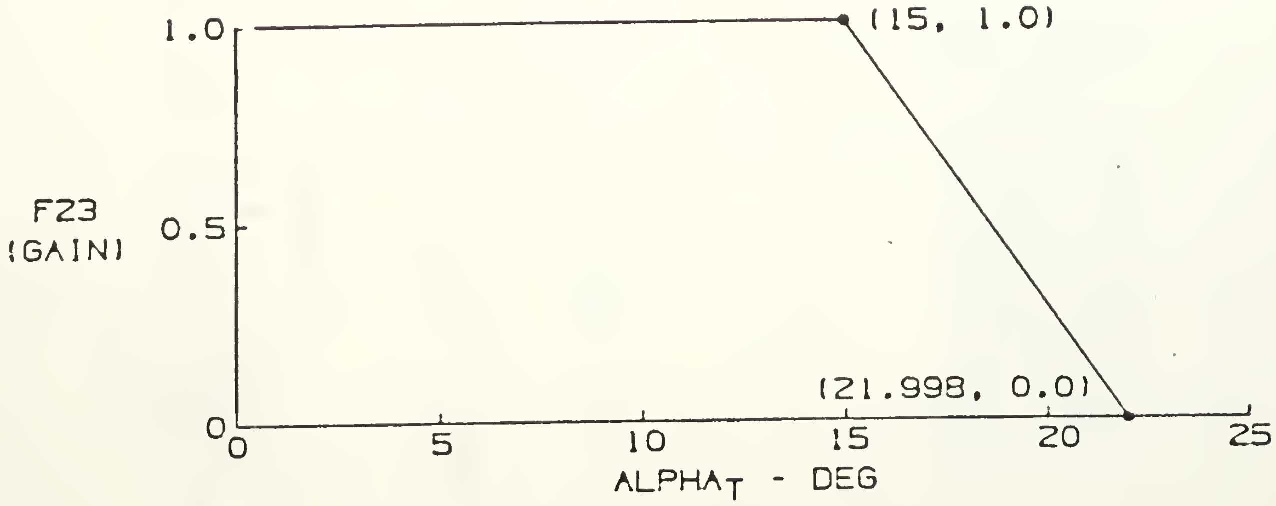
FADER ON THE SUPERSONIC COMPENSATION AUTO FLAP UP (Q_C)

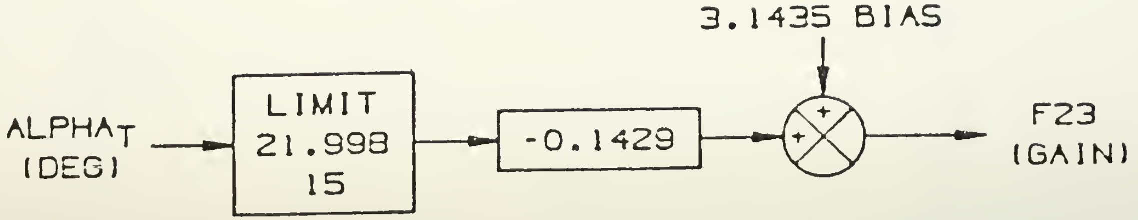




FUNCTION 23

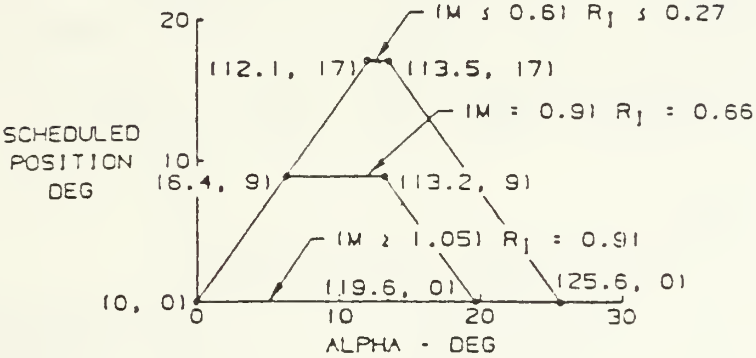
STALL MARGIN GAIN ON PITCH FORWARD LOOP INTEGRATOR (AOA)

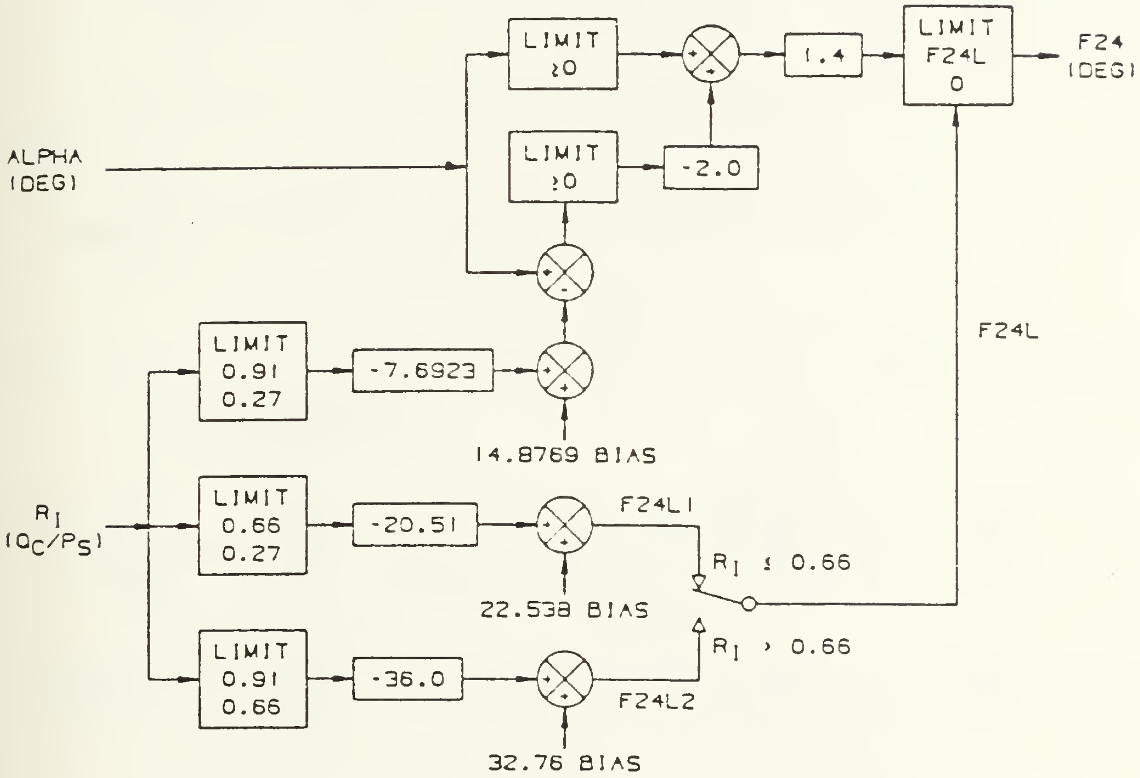




FUNCTION 24

TRAILING EDGE FLAP SCHEDULE
AUTO FLAP UP (AOA, R_I)

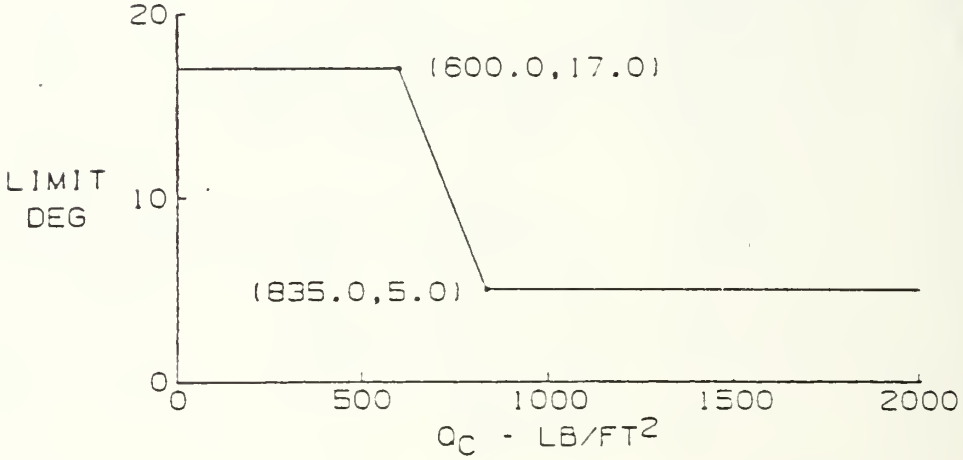


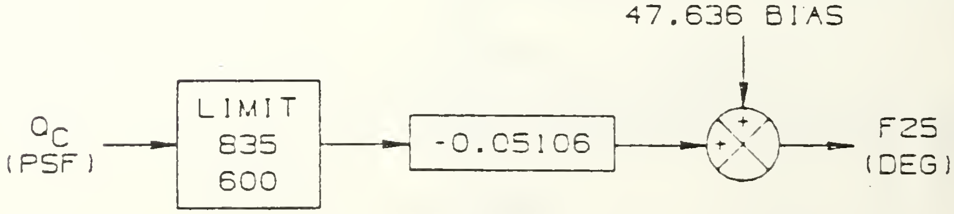


FUNCTION 25

TRAILING EDGE FLAP SCHEDULE

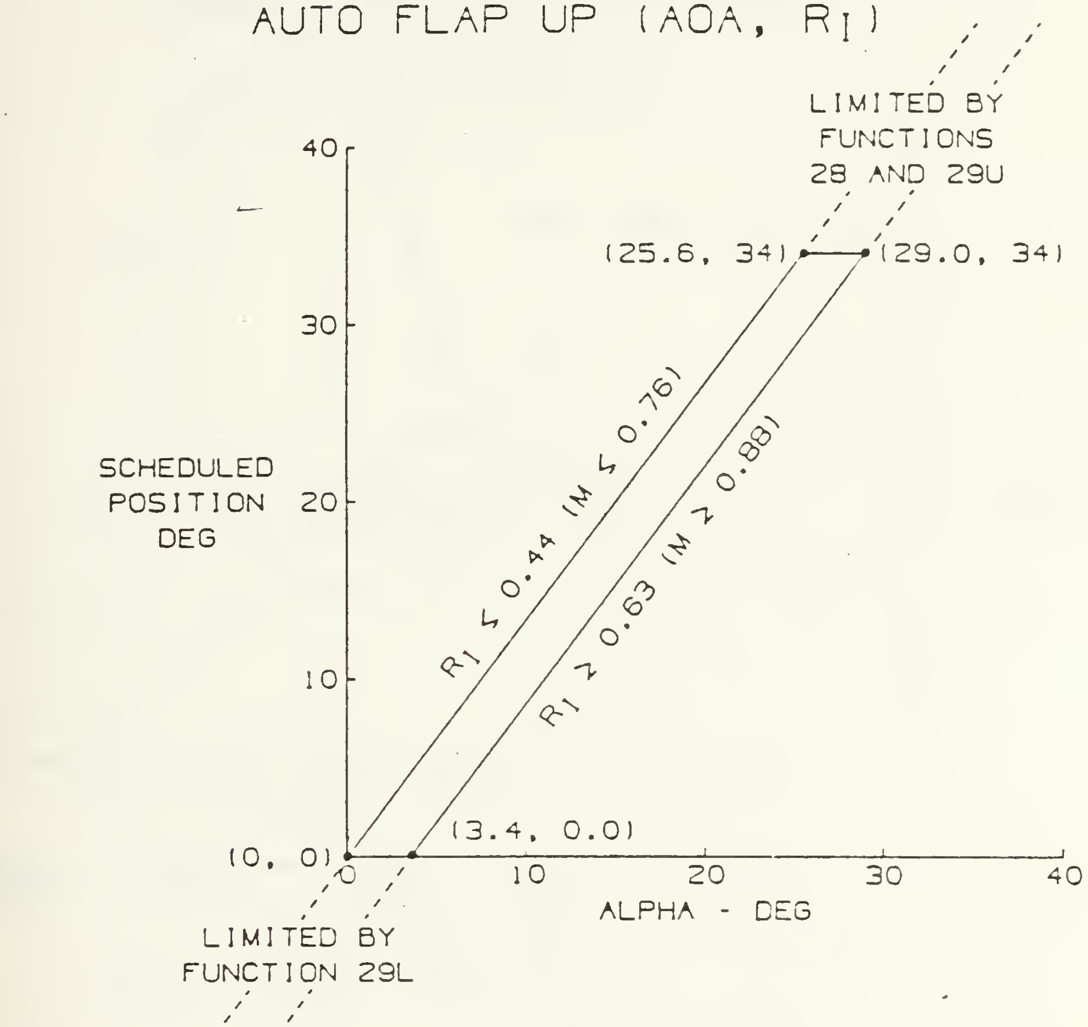
AUTO FLAP UP (Q_C LIMIT)

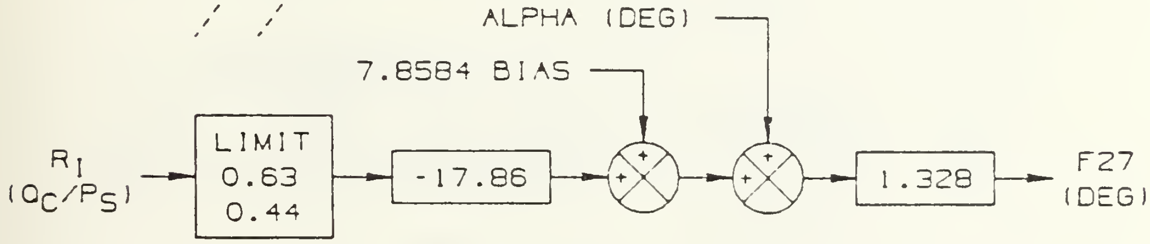




FUNCTION 27

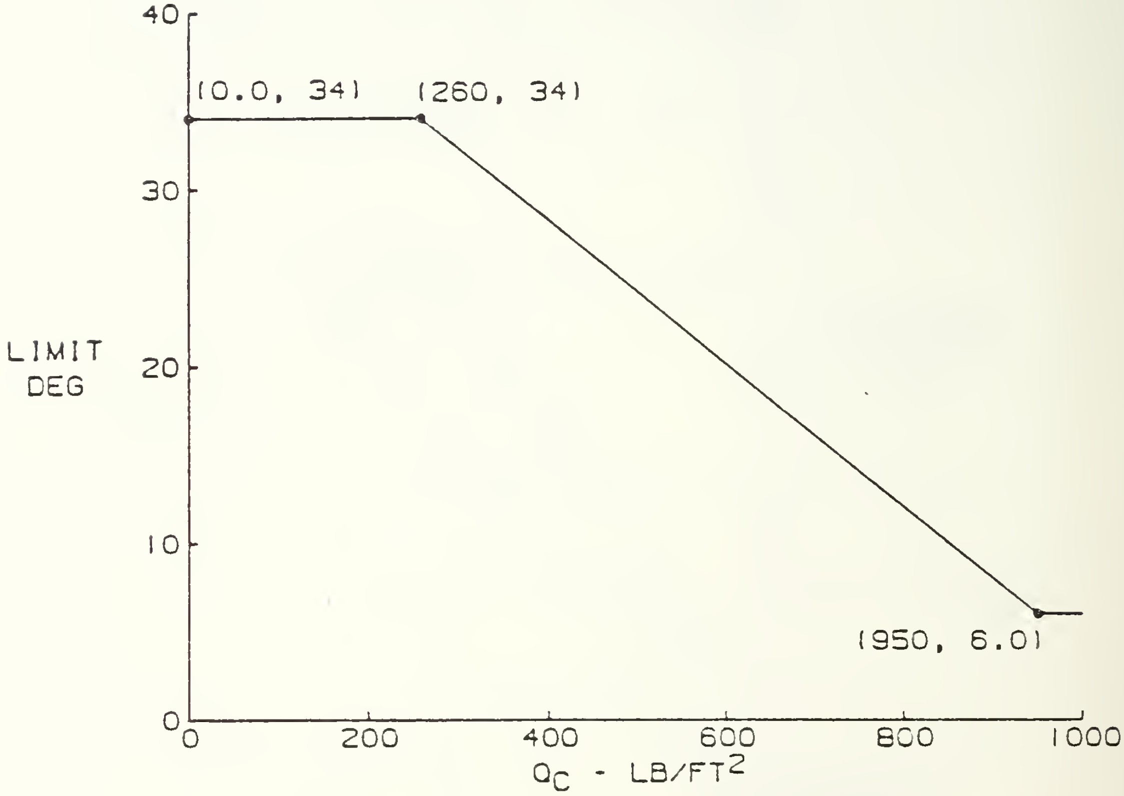
LEADING EDGE FLAP SCHEDULE
AUTO FLAP UP (AOA, R_I)

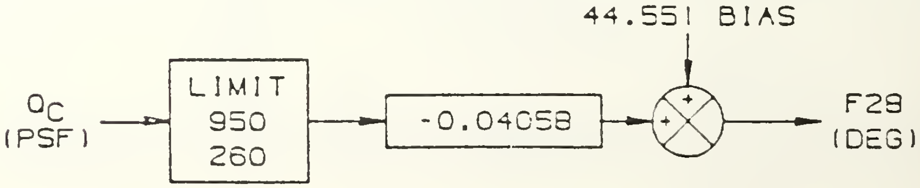




FUNCTION 28

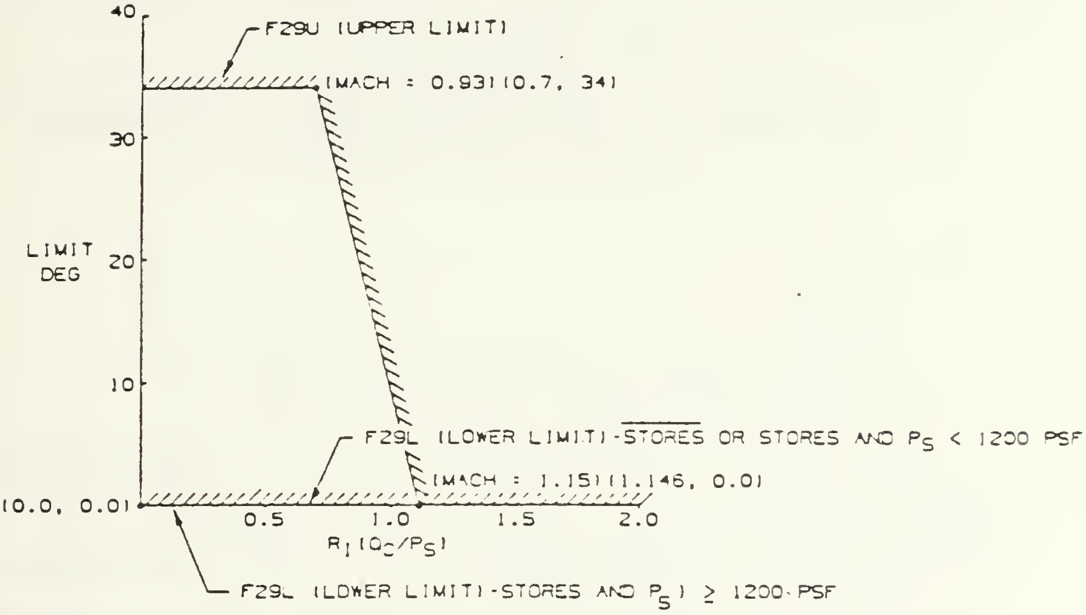
LEADING EDGE FLAP SCHEDULE
AUTO FLAP UP (Q_C LIMIT)

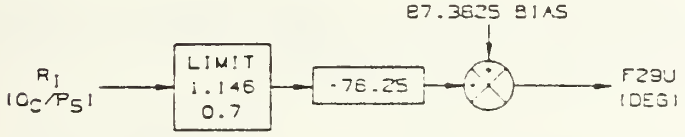


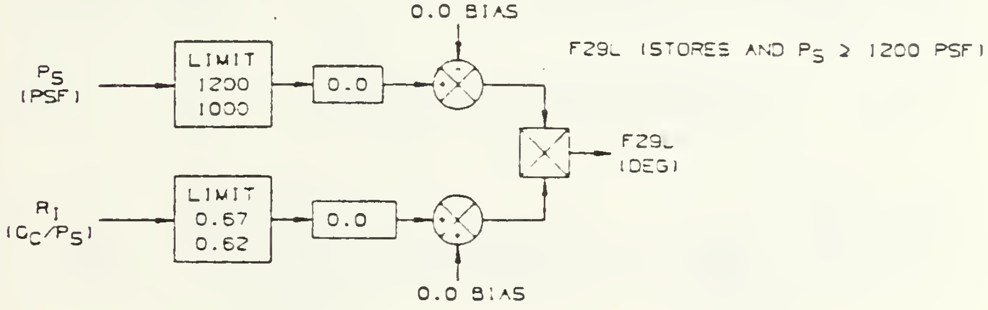


FUNCTION 29

LEADING EDGE FLAP SCHEDULE
AUTO FLAP UP (R_I LIMIT)



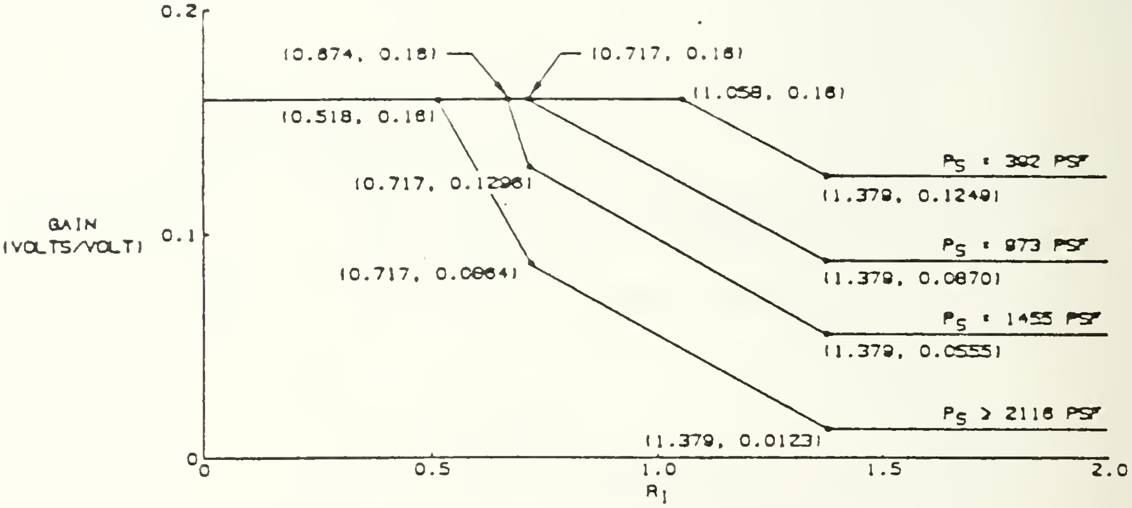


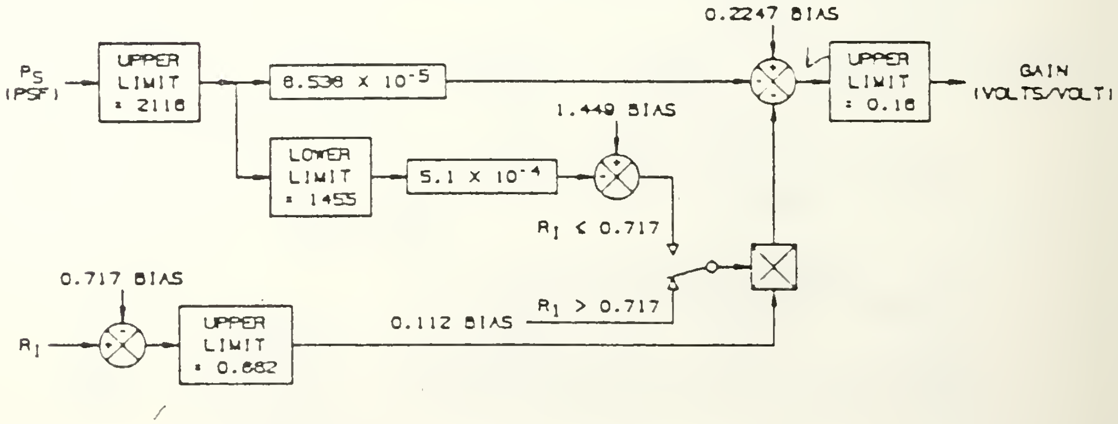


F29L = 0 DEG FOR $\overline{STORES}$ OR STORES AND P_S < 1200 PSF

FUNCTION 31

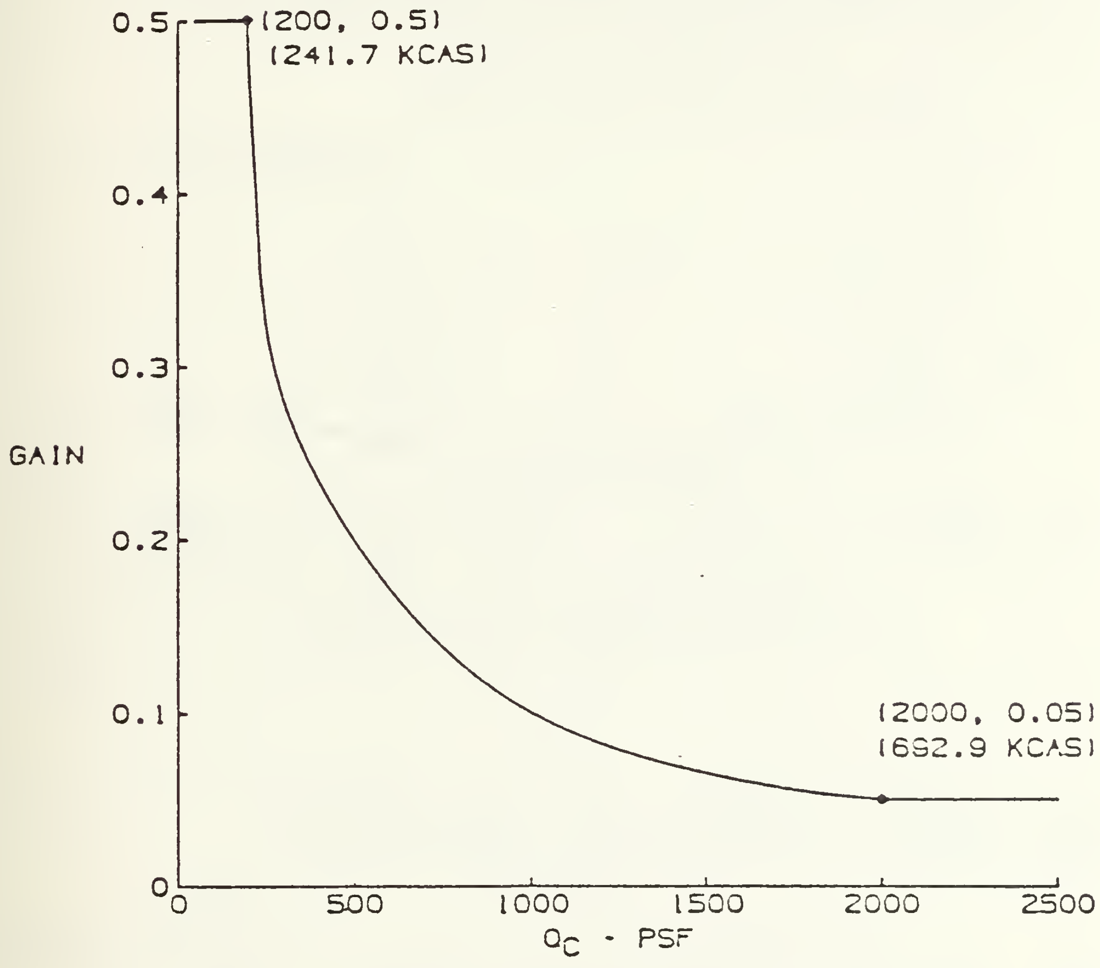
DIFFERENTIAL TRAILING EDGE FLAP GAIN SCHEDULE
AUTO FLAP UP (R_I, P_S)

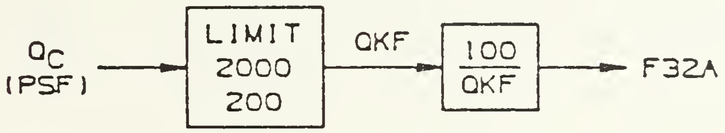




FUNCTION 32A

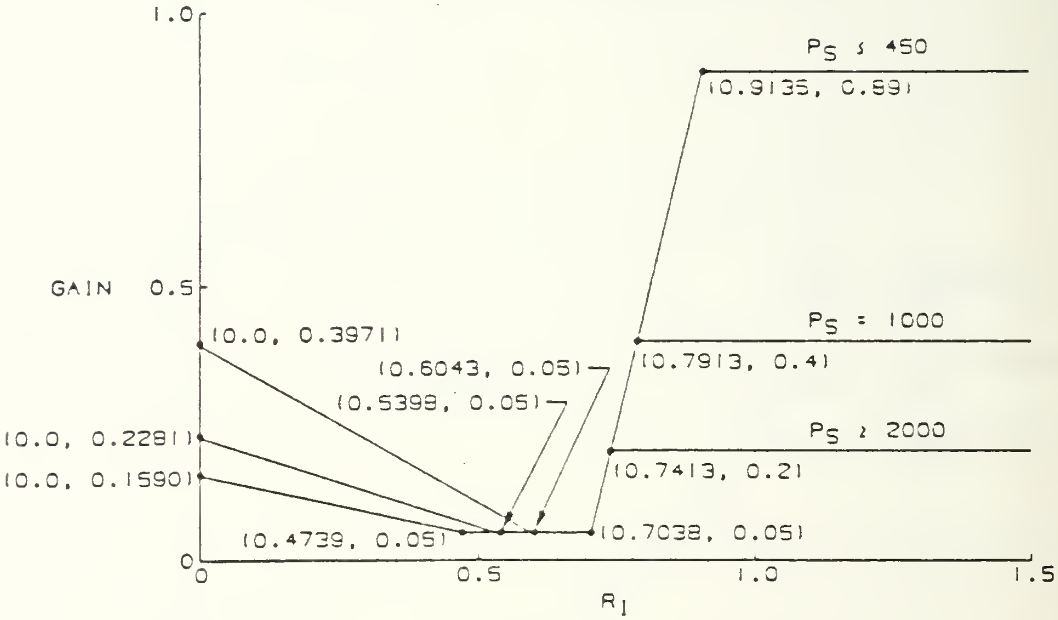
LONGITUDINAL FORWARD LOOP GAIN SCHEDULE
AUTO FLAP UP (Q_C)

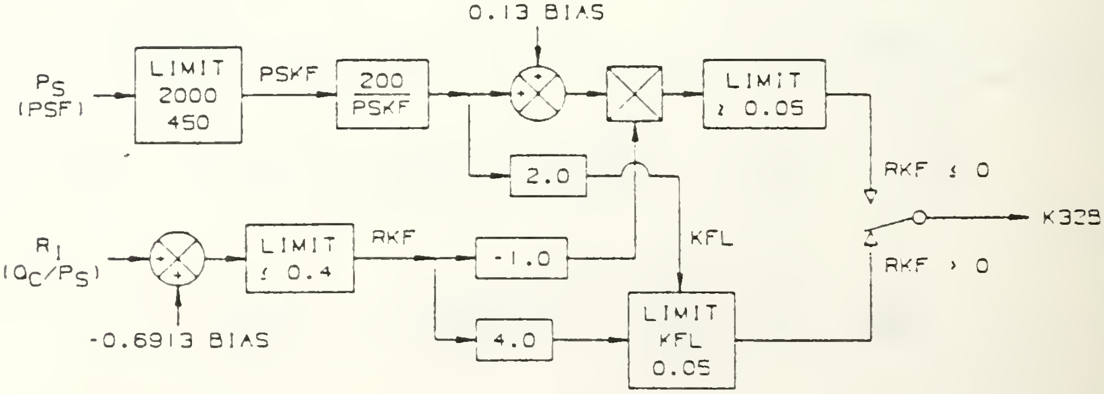




FUNCTION 32B

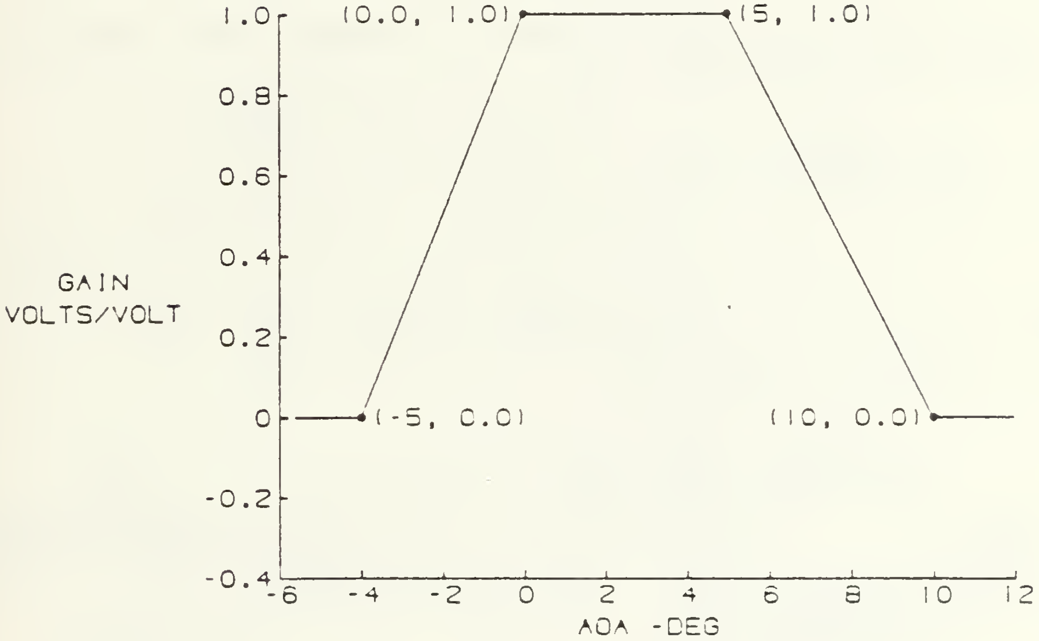
LONGITUDINAL FORWARD LOOP GAIN SCHEDULE AUTO FLAP UP $D_{THETA_{DEL}}$ (R_I, P_S)

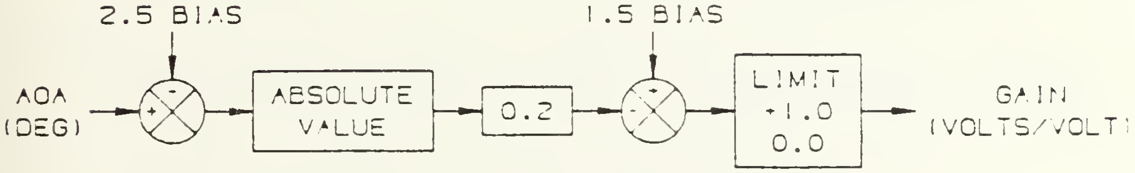




FUNCTION 34

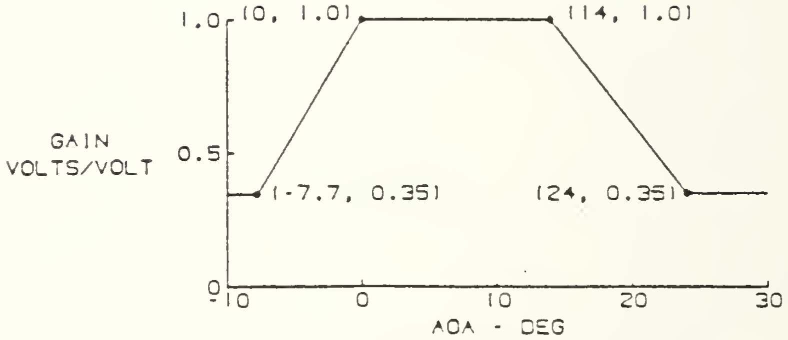
DIFFERENTIAL TRAILING EDGE FLAP
GAIN SCHEDULE
AUTO FLAP UP (AOA)

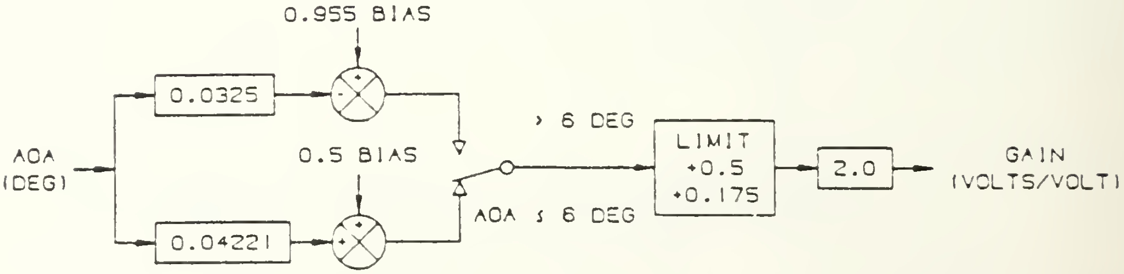




FUNCTION 35

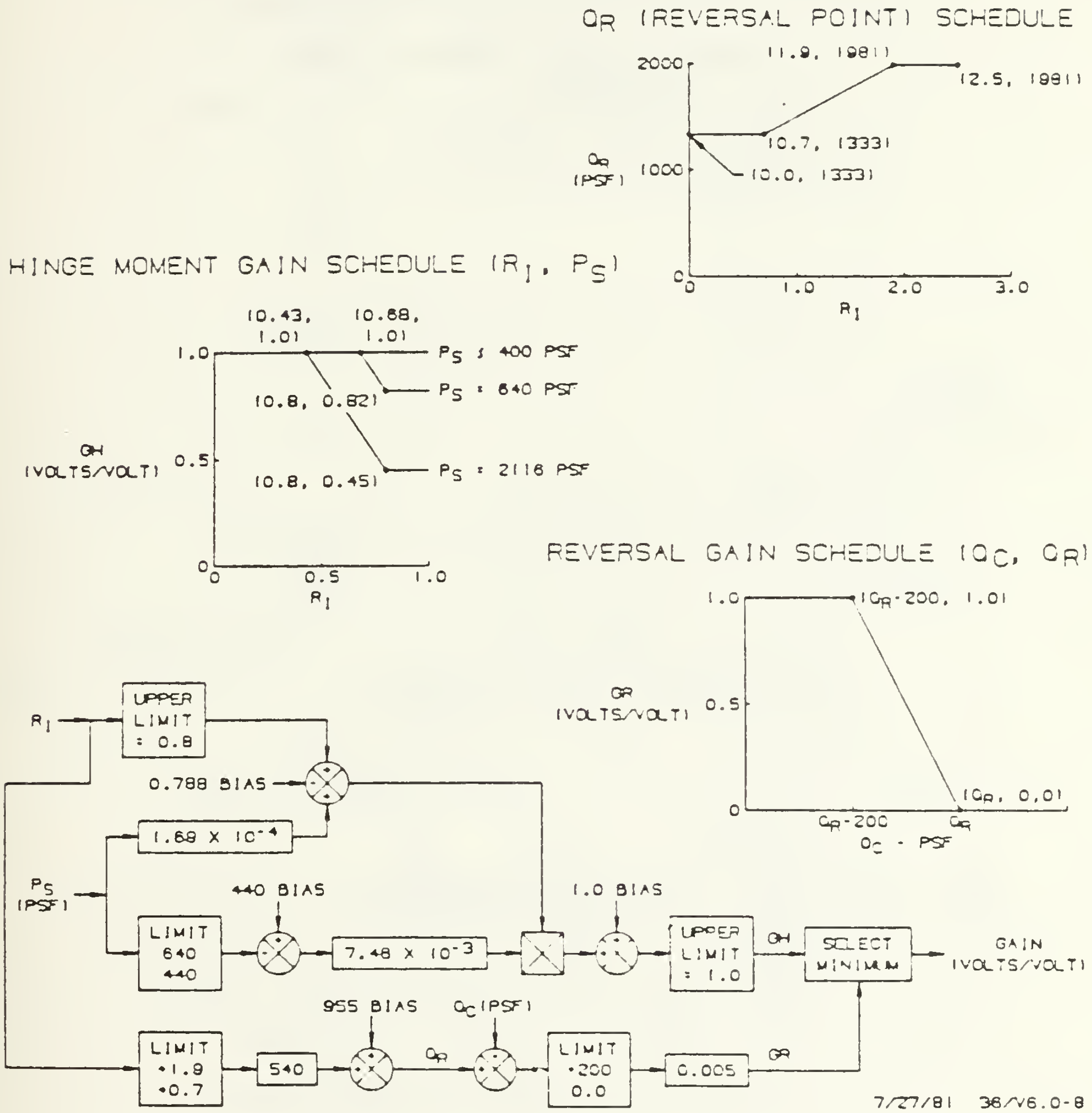
LATERAL FORWARD LOOP GAIN SCHEDULE
AUTO FLAP UP (AOA)





FUNCTION 36

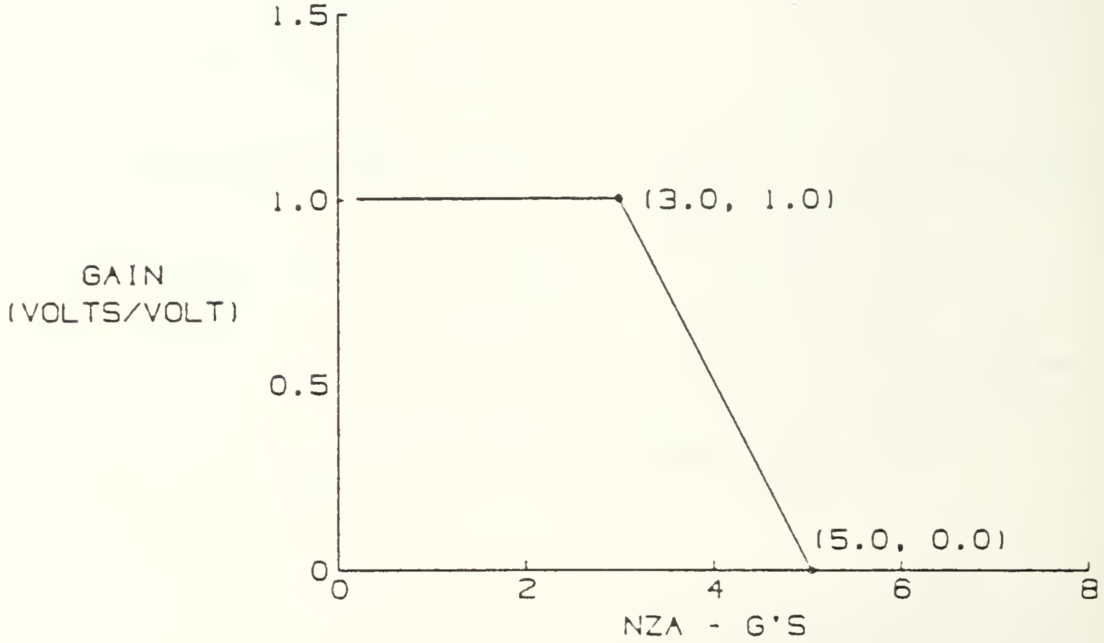
AILERON GAIN SCHEDULE
AUTO FLAP UP (Q_C, P_S, R_I)

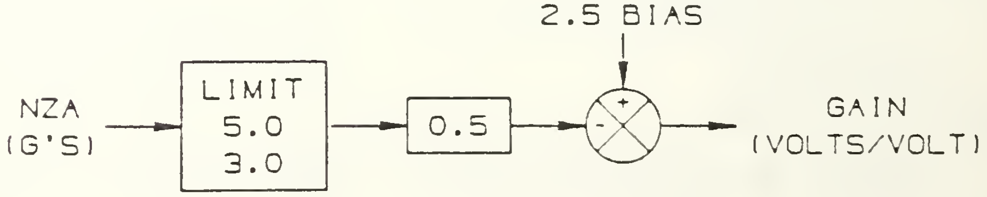


7/27/81 36/V6.0-8

FUNCTION 37

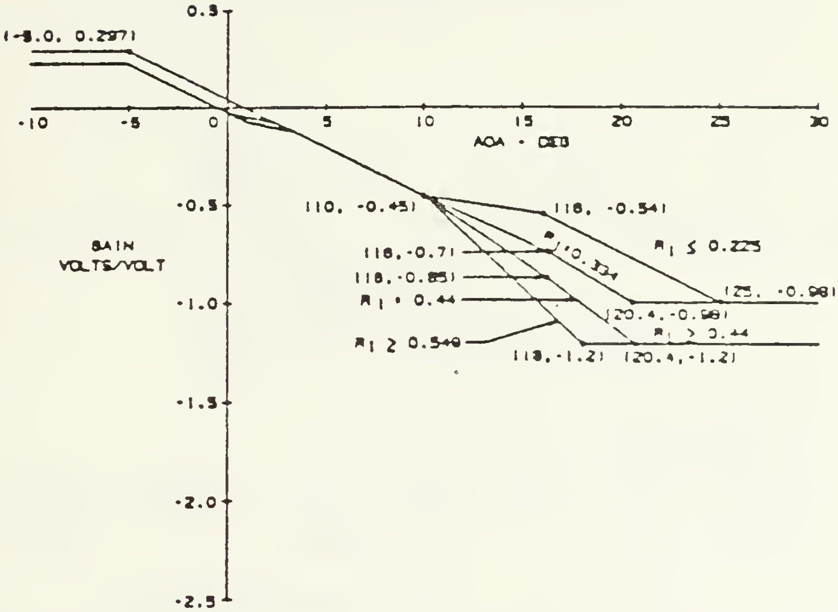
NZ LIMIT ON AOA FEEDBACK
AUTO FLAP UP (NZA)

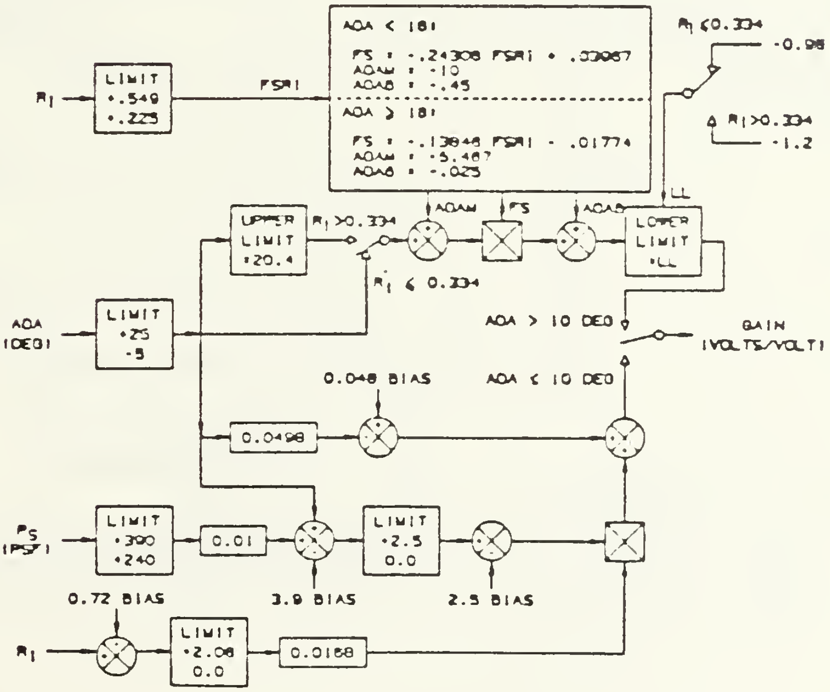




FUNCTION 38

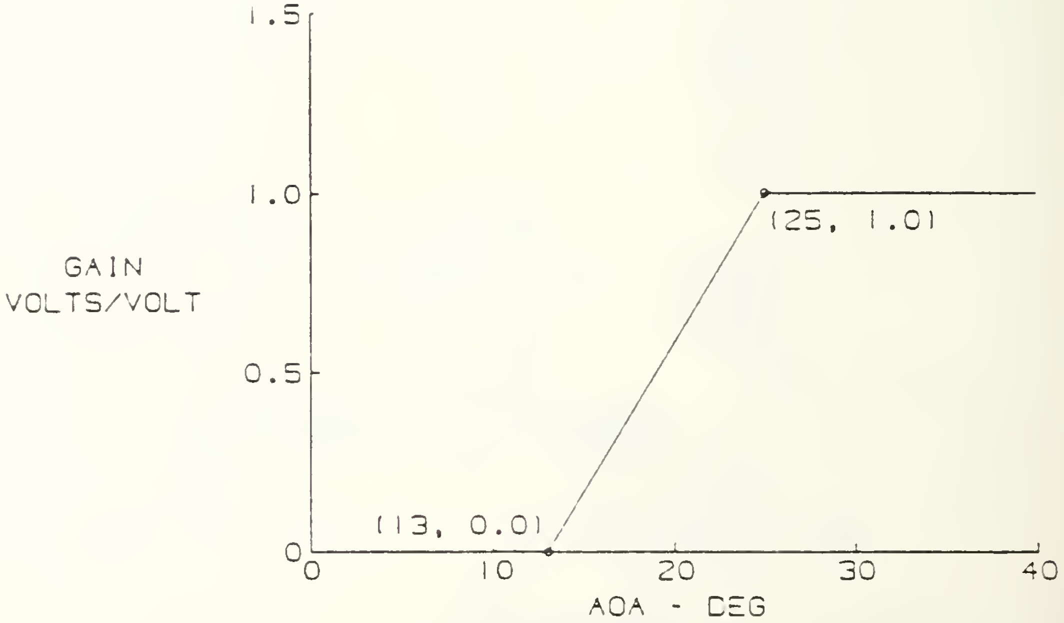
RSRI GAIN SCHEDULE
AUTO FLAP UP (AOA, R_1, P_S)

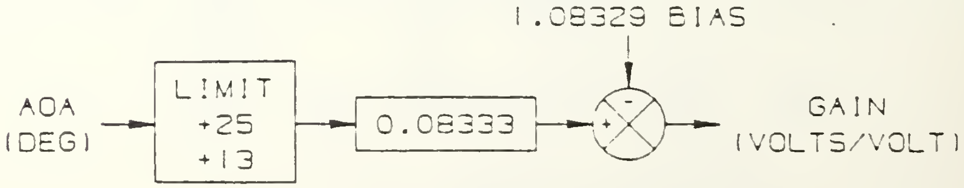




FUNCTION 39

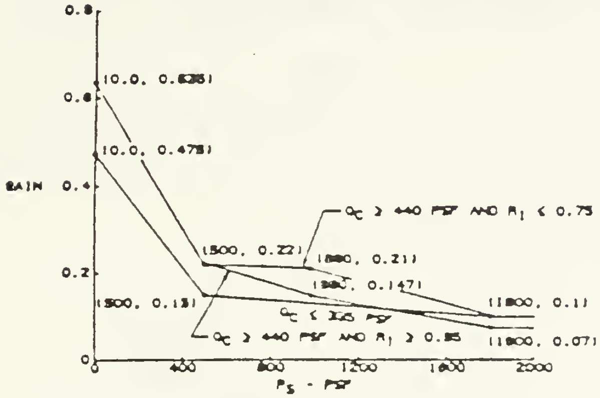
RUDDER PEDAL TO ROLL CAS INTERCONNECT
GAIN SCHEDULE
AUTO FLAP UP (AOA)

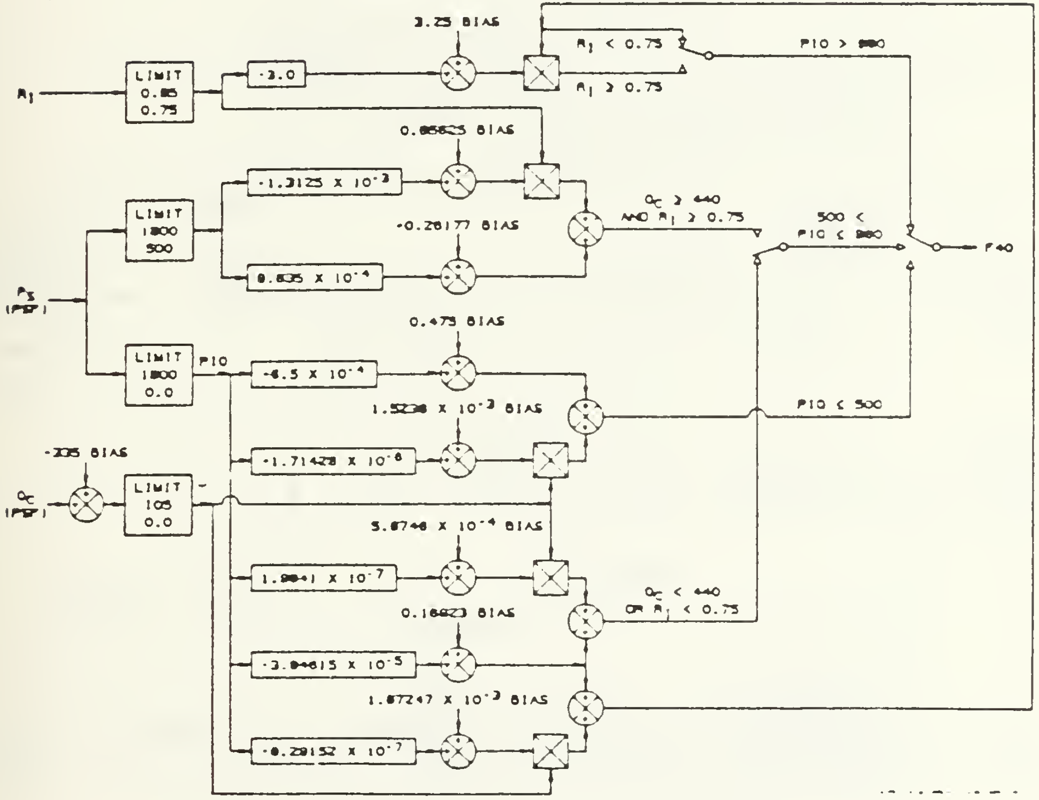




FUNCTION 40

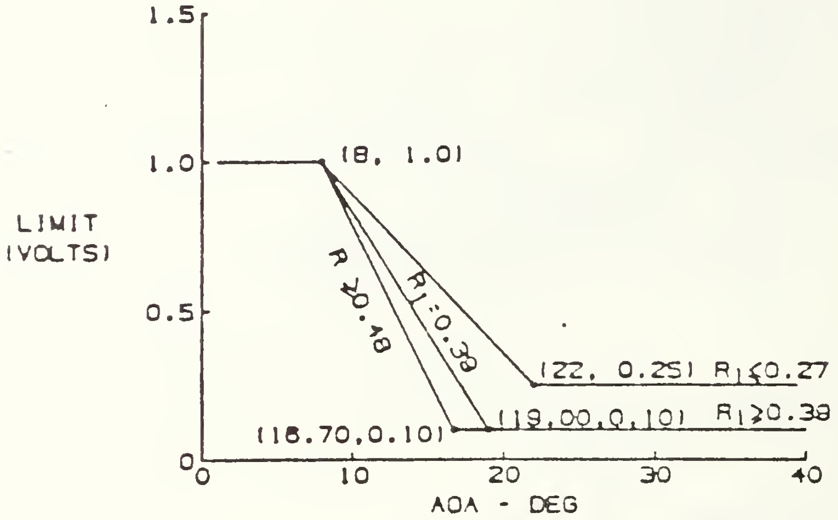
PITCH RATE FEEDBACK GAIN SCHEDULE
AUTO FLAP UP (P_S, Q_C, R_I)

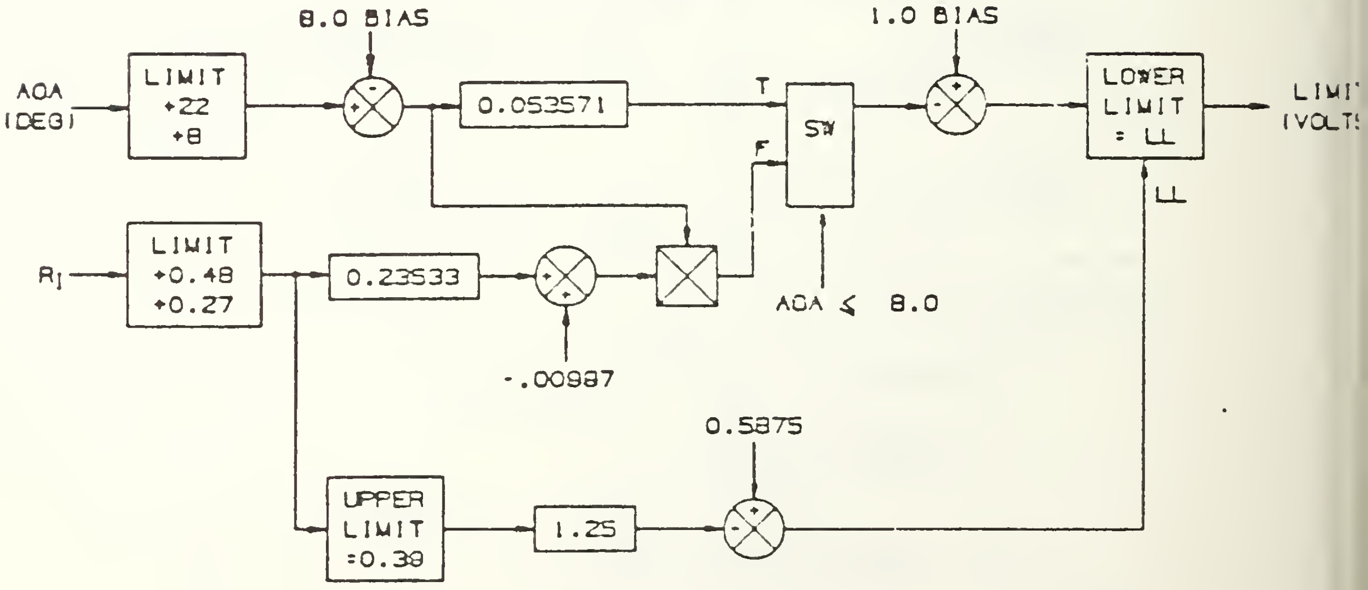




FUNCTION 41

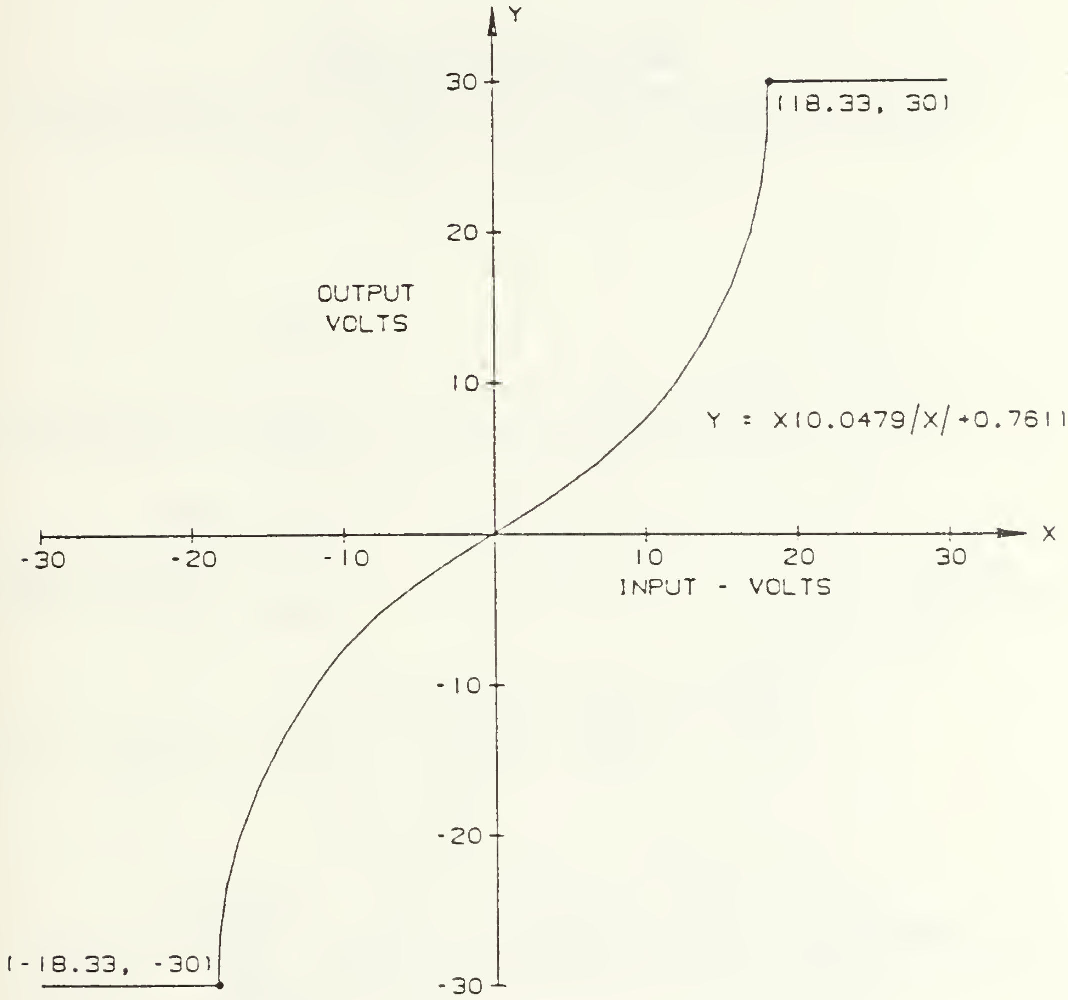
ROLLING SURFACE LIMIT SCHEDULE
AUTO FLAP UP (AOA, R_I)

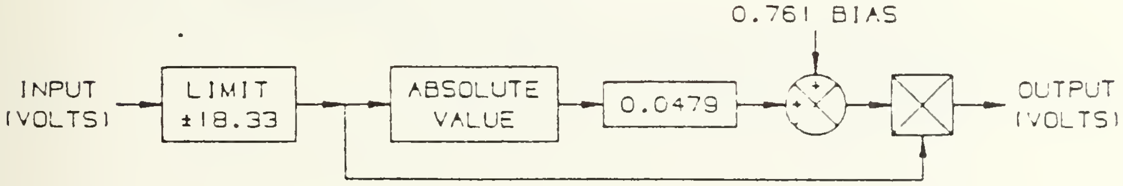




FUNCTION 42

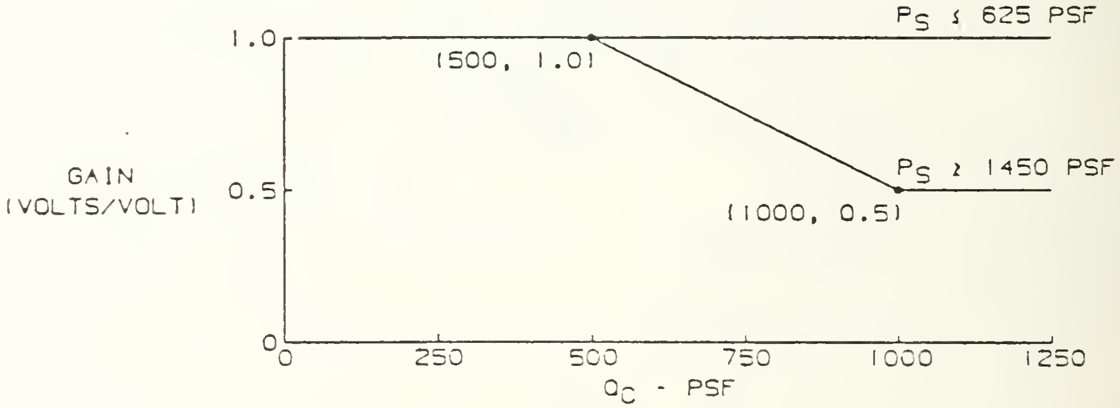
RSRI NONLINEAR GRADIENT

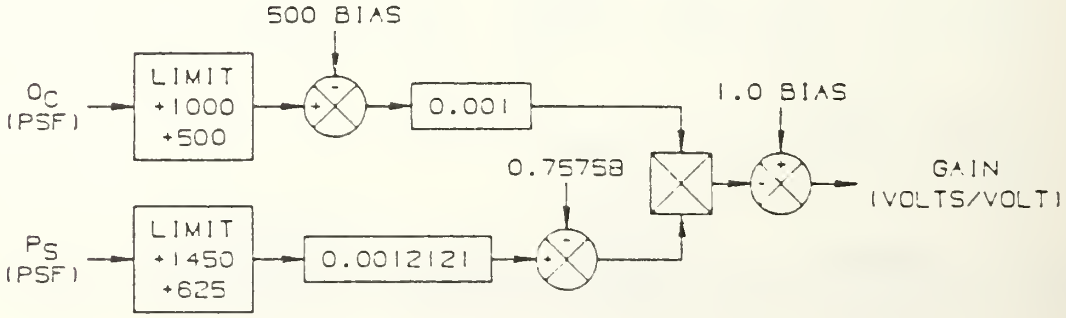




FUNCTION 45

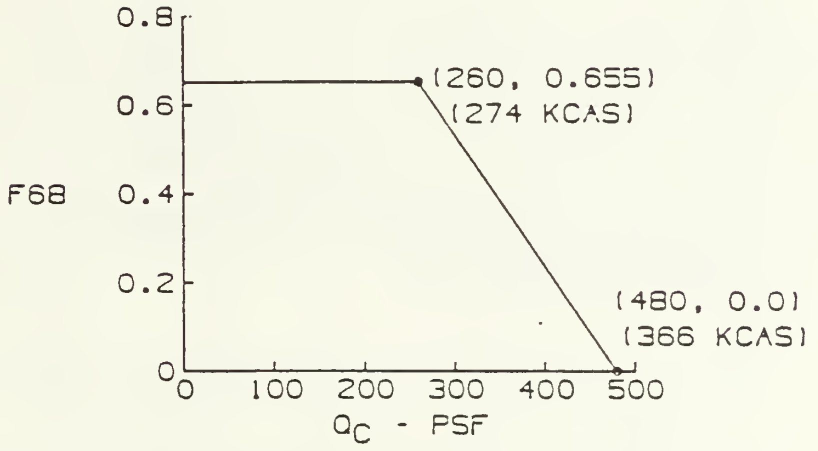
DIRECTIONAL FORWARD LOOP GAIN SCHEDULE
AUTO FLAP UP (Q_C, P_S)

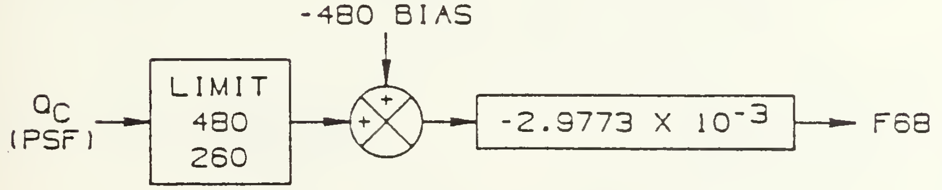




FUNCTION 68

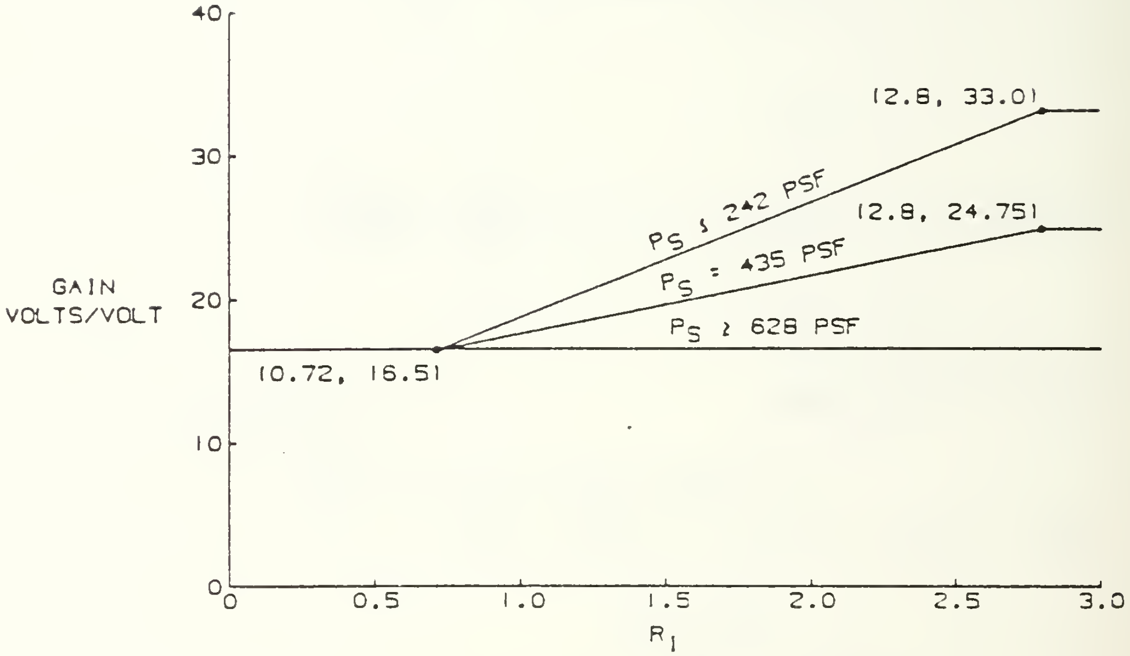
PITCH RATE FEEDBACK GAIN SCHEDULE AUTO FLAP UP (Q_C)

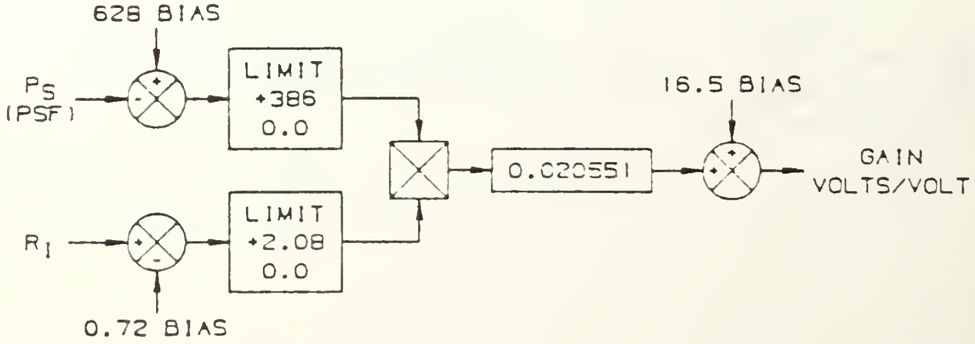




FUNCTION 90

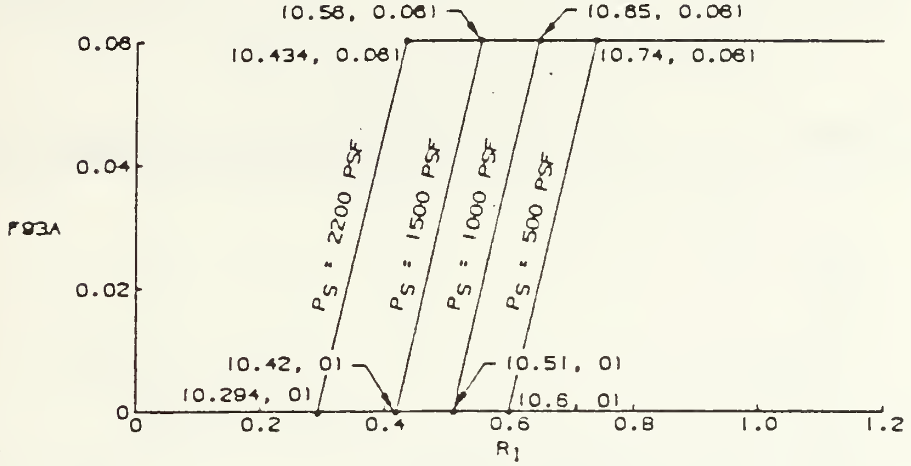
LATERAL ACCELERATION FEEDBACK GAIN SCHEDULE (R_I, P_S)

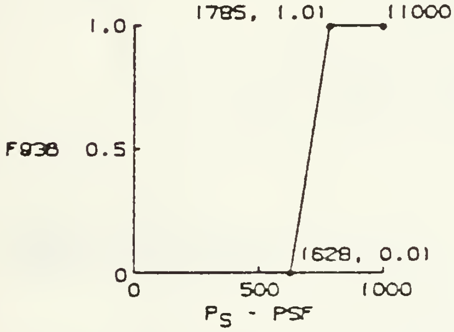


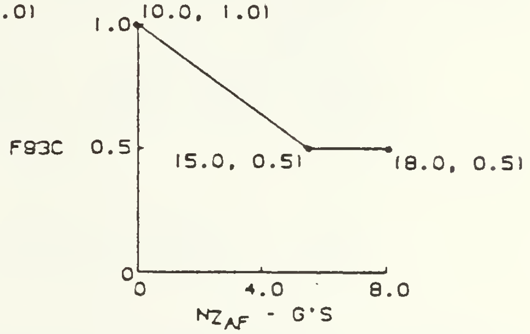


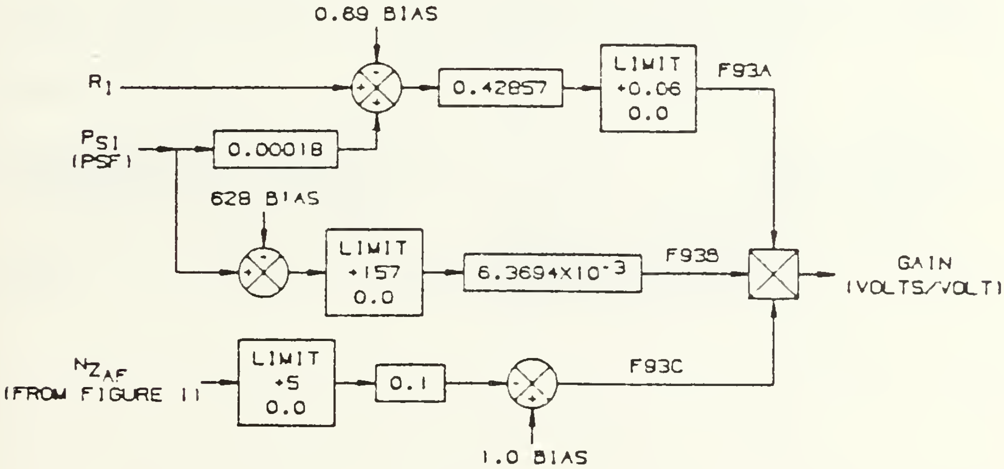
FUNCTION 93

DIFFERENTIAL LEADING EDGE FLAP GAIN SCHEDULE
AUTO FLAP UP (R_I, P_{SI}, N_{ZAF})



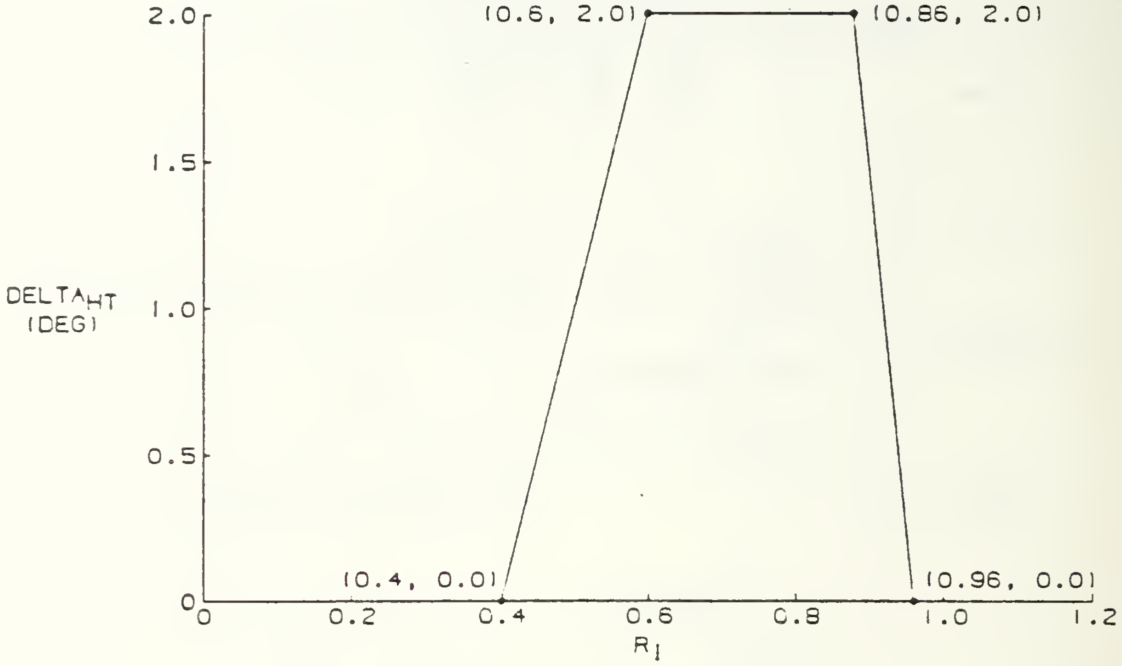


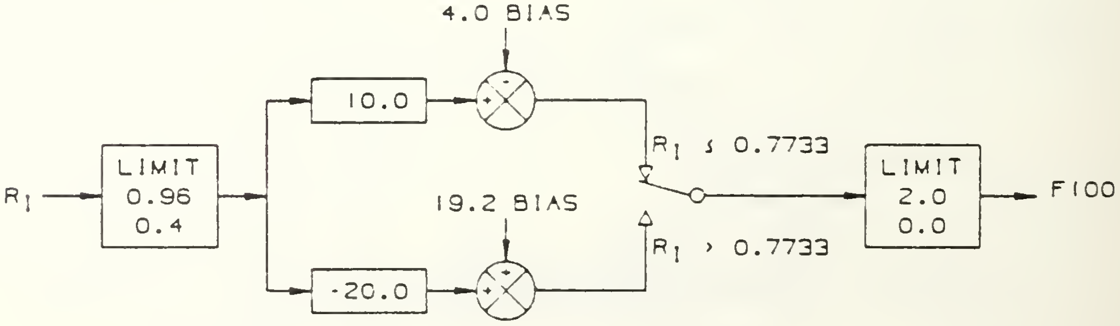




FUNCTION 100

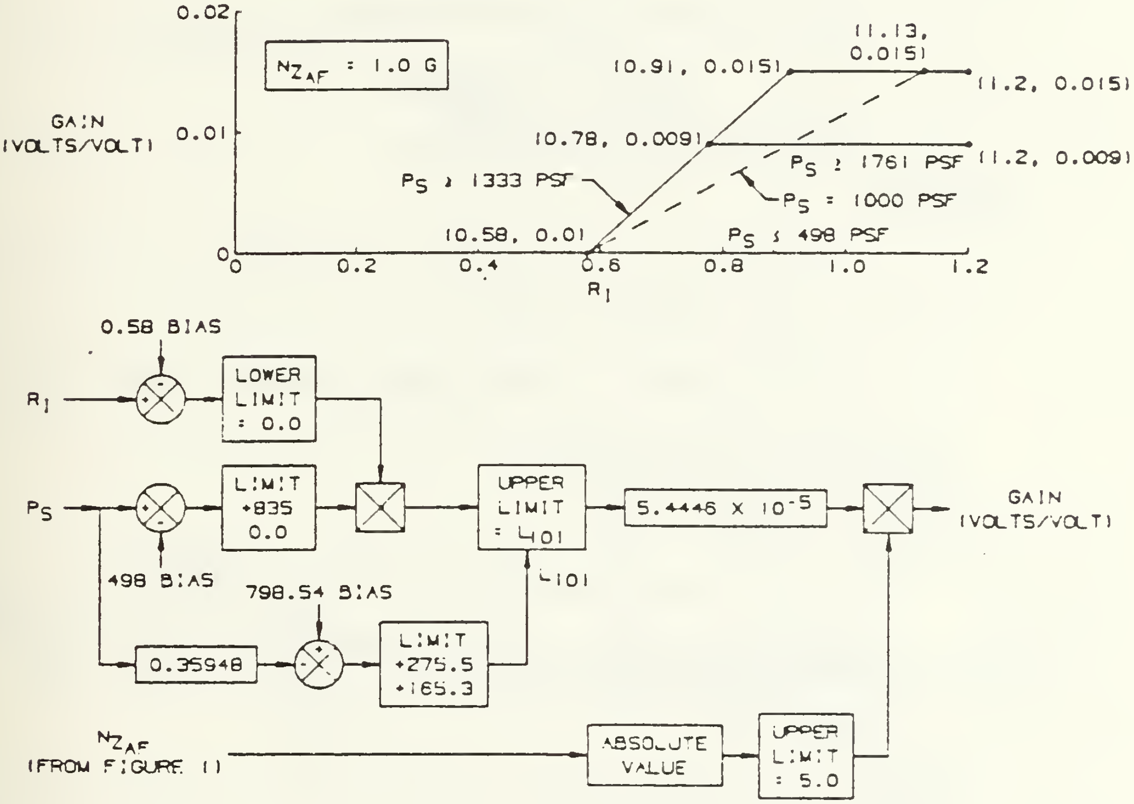
SPEEDBRAKE COMPENSATION INCREMENT AUTO FLAP UP (R_I)





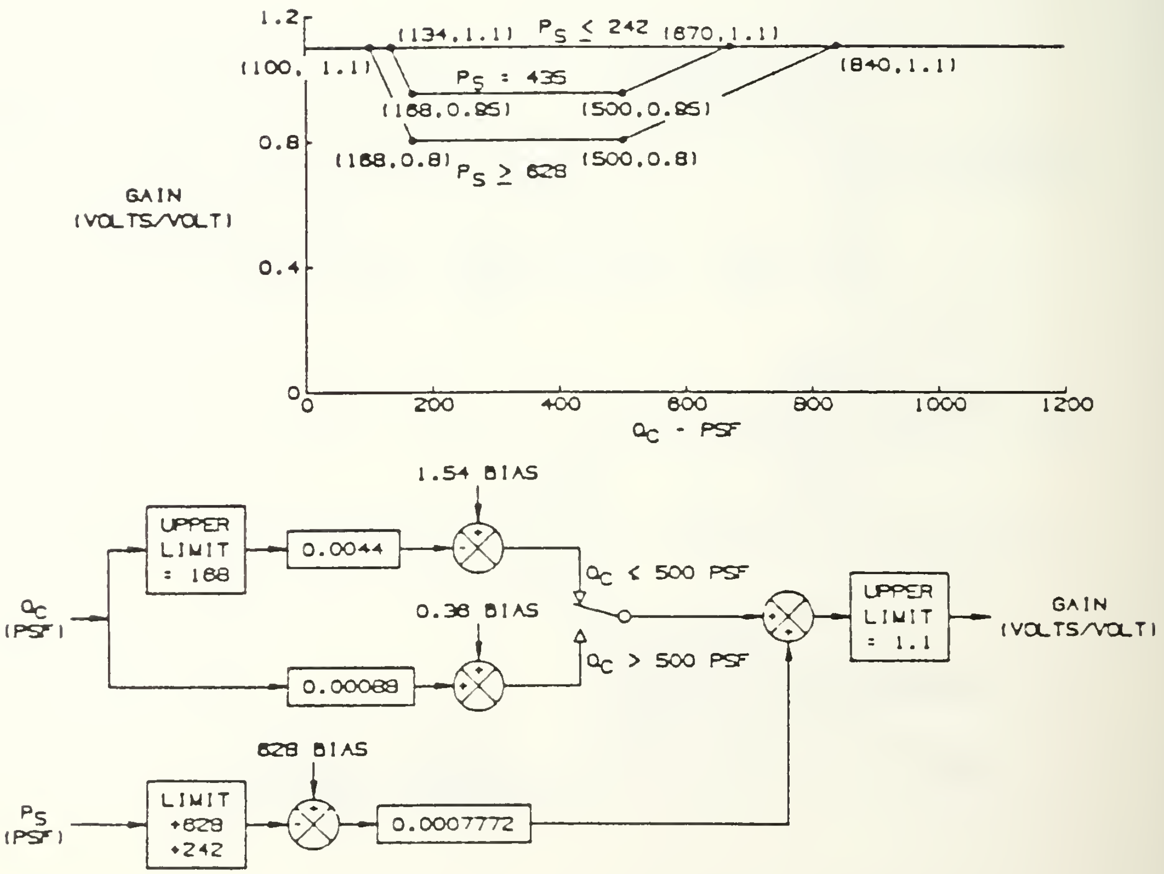
FUNCTION 101

DIFFERENTIAL STABILIZER LOAD ALLEVIATION SCHEDULE
AUTO FLAP UP (R_I, P_S, $N_{Z_{AF}}$)



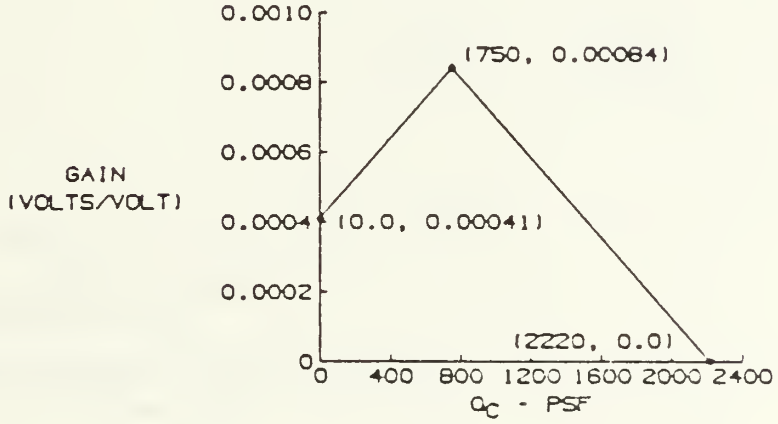
FUNCTION 96

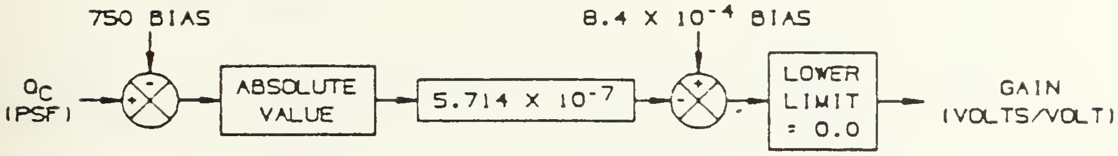
YAW RATE GAIN SCHEDULE
AUTO FLAP UP (Q_C, P_S)



FUNCTION 107

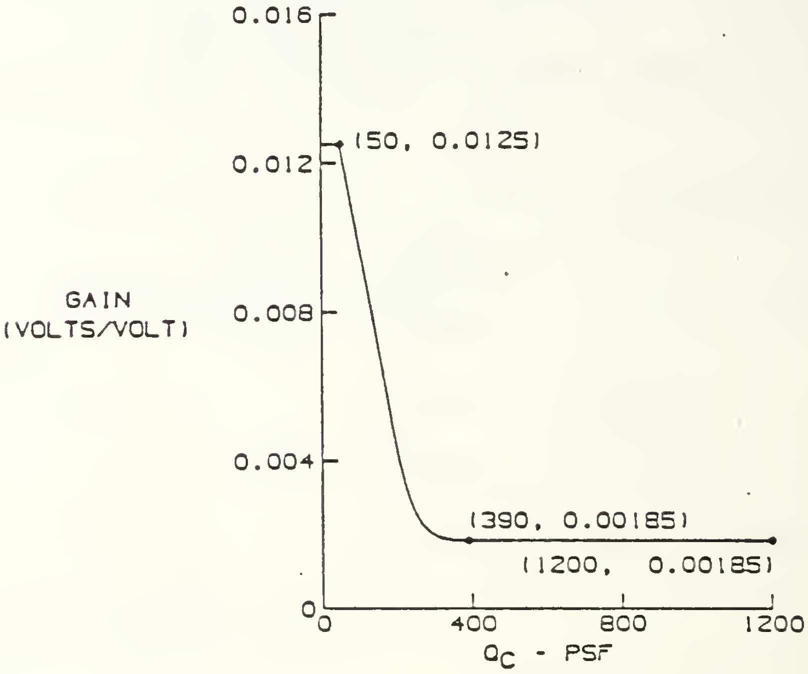
LONGITUDINAL INERTIAL GAIN SCHEDULE
AUTO FLAP UP (Q_C)

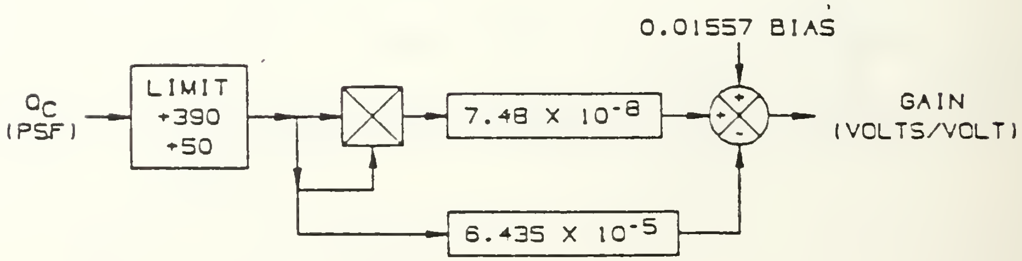




FUNCTION 108

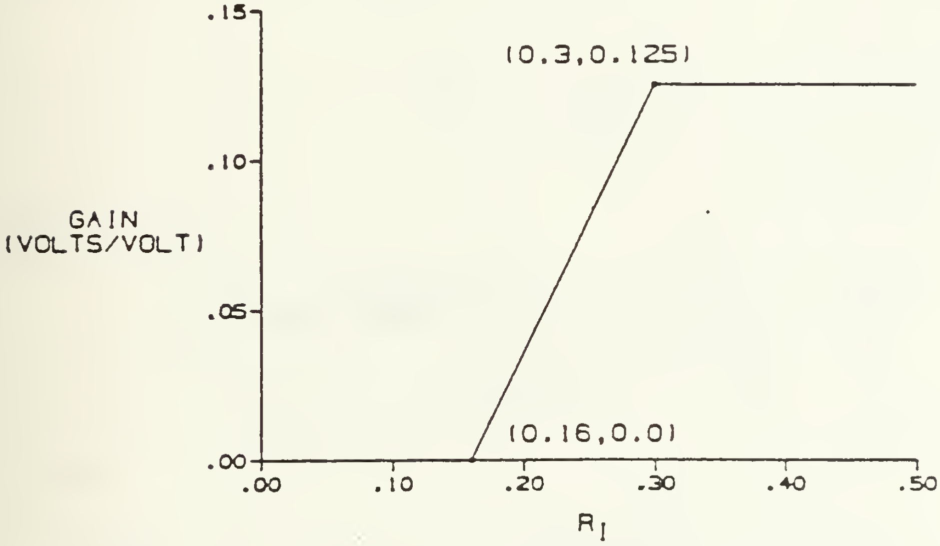
DIRECTIONAL INERTIAL GAIN SCHEDULE
AUTO FLAP UP (Q_C)

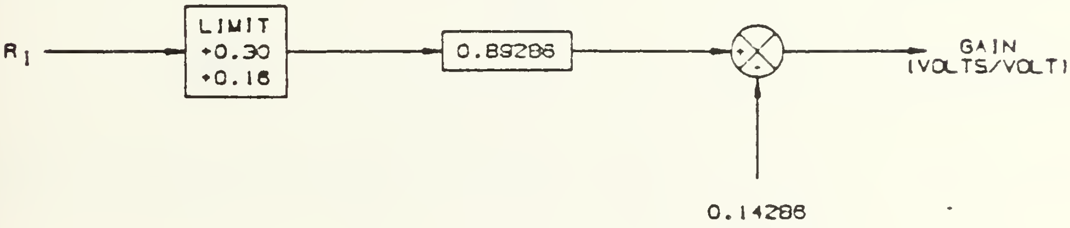




FUNCTION 114

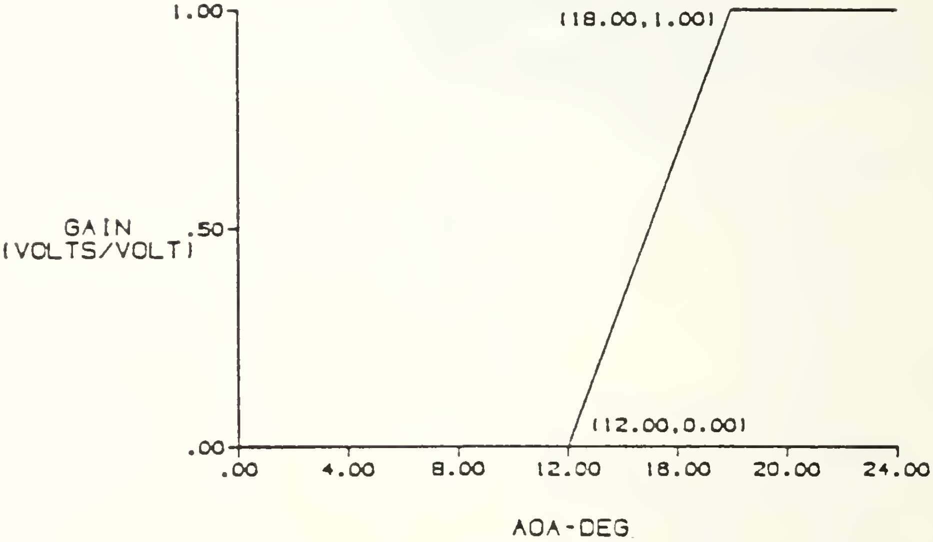
RUDDER PEDAL COMMAND GAIN INCREMENT
AUTO FLAP UP (R_I)

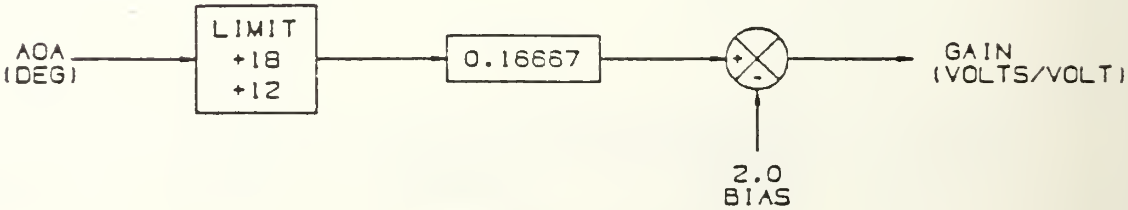




FUNCTION 113

LATERAL ACCELERATION GAIN
AUTO FLAP UP (AOA)





APPENDIX B

DIGITAL FILTER MODELS

A. PITCH RATE LEAD-LAG FILTER P2

$$P2(S) = \frac{.015(1+F22)S + 1}{.015S + 1} \tag{B.1}$$

Using the tustin transform let

$$S = \frac{2\,(Z-1)}{ts(Z+1)}$$

which gives

$$P2(Z) = \frac{\overset{(P2N1)}{\left[\dfrac{2(.015)(1+F22) + ts}{2(.015) + ts}\right]} Z + \overset{(P2N2)}{\left[\dfrac{ts - 2(.015)(1+F22)}{2(.015) + ts}\right]}}{Z - \underset{(P2D)}{\left[\dfrac{2(.015) - ts}{2(.015) + ts}\right]}} \tag{B.2}$$

B. NORMAL ACCELERATION LAG FILTER P5

$$P5(S) = \frac{1}{.04S + 1} \tag{B.3}$$

Using the Tustin transform:

$$P5(Z) = \frac{\overset{(P5N1)}{\dfrac{ts}{.08 + ts}}\, Z + \overset{(P5N2)}{\dfrac{ts}{.08 + ts}}}{Z - \underset{(P5D)}{\left[\dfrac{.08 - ts}{.08 + ts}\right]}} \tag{B.4}$$

C. INTEGRATOR P9

$$P9(S) = \frac{1}{S} \tag{B.5}$$

Reference 3 approximated this filter using the backward difference method. Let

$$S = \frac{Z-1}{tsZ}$$

which gives

$$P9(Z) = \frac{\overset{(P9N1)}{tsZ} + \overset{(P9N2)}{0.0}}{Z - \underset{(P9D)}{1}} \tag{B.6}$$

D. LEADING EDGE AOA LAG FILTER P11

$$P11(S) = \frac{1}{0.39S + 1} \tag{B.8}$$

Using the Tustin transform:

$$P11(Z) = \frac{\overset{(P11N1)}{\left[\frac{ts}{.39(2) + ts}\right]} Z + \overset{(P11N2)}{\frac{ts}{.39(2) + ts}}}{\underset{(P11D)}{Z - \frac{.39(2) - ts}{.39(2) + ts}}} \tag{B.9}$$

E. TRAILING EDGE FLAP AOA LAG FILTER P12

$$P12(S) = \frac{1}{0.79S + 1} \tag{B.10}$$

Using the tustin transform:

$$P12(Z) = \frac{\overset{(P12N1)}{\left[\frac{ts}{.79(2) + ts}\right]} Z + \overset{(P12N2)}{\frac{ts}{.79(2) + ts}}}{\underset{(P12N3)}{Z - \frac{.70(2) - ts}{.79(2) + ts}}} \tag{B.11}$$

F. YAW RATE CANCELLER Y3

$$Y3(S) = \frac{S}{S + 1} \tag{B.12}$$

Using the Tustin transform:

$$Y3(Z) = \frac{\overset{(Y3N1)}{\left[\frac{2}{2 + ts}\right]} Z + \overset{(Y3N2)}{\frac{-2}{2 + ts}}}{Z - \underset{(Y3D)}{\frac{2 - ts}{2 + ts}}} \tag{B.13}$$

G. RSRI LEAD LAG FILTER Y5

$$Y5(S) = \frac{.75S + 1}{.5S + 1} \tag{B.14}$$

Using the Tustin transform:

$$Y5(Z) = \frac{\overset{(Y5N1)}{\left[\frac{2(.75) + ts}{2(.5) + ts}\right]} Z + \overset{(Y5N2)}{\frac{ts - 2(.75)}{2(.5) + ts}}}{Z - \underset{(Y5N3)}{\frac{2(.5) - ts}{2(.5) + ts}}} \tag{B.15}$$

APPENDIX C

SIGNAL PATH TRANSFER FUNCTIONS AND STATE SPACE MODELS

A. PITCH RATE TO COLLECTIVE STABILATOR PATH H1(Z)

From Fig. 3.1 the forward path transfer function is

$$H1(Z) = [P9*P2*F68*F32a*F12 + P2*((F68*F32a)+F40)] \qquad (C.1)$$

Let:

$A = F68*F32A*F12$

$B = (F68*F32a)+F40$

Rewriting Eq. C.1 using the filter Z-transform expressions for P9 and P2 gives

$$H1(Z) = \frac{A*(P9N1*Z + P9N2)*(P2N1*Z + P2N2)}{(Z-P9D)*(Z-P2D)} + \frac{B*(P2N1*Z + P2N2)}{Z-P2D} \qquad (C.2)$$

Expanding Eq. C.2

$$\begin{aligned} H1(Z) = \{ & [A*P9N1*P2N1 + B*P2N1]\, Z^{2} \\ & + [A*(P9N1*P2N2+P9N2*P2N1) + B*(P2N2-P2N1*P9D)]\, Z \\ & + [A*P9N2*P2N2 - B*P2N2*P9D]\} / (Z-P9D)*(Z-P2D) \end{aligned} \qquad (C.3)$$

Equation C.3 can be expressed in terms of the following partial fraction expansion:

$$H1(Z) = \frac{b0*Z^2 + b1*Z + b2}{(Z-P9D)*(Z-P2D)} = qst3 + \frac{qst1}{(Z-P9D)} + \frac{qst2}{(Z-P2D)} \qquad (C.4)$$

Where:

$qst3 = b0$

$qst1 = (b0*P9D^2 + b1*(P9D) + b2) / (P9D-P2D)$

$qst2 = (b0*P2D^2 + b1*(P2D) + b2) / (P2D-P9D)$

Equation C.4 can now be put in the following state variable form:

$$\begin{bmatrix} x1(k+1) \\ x2(k+1) \end{bmatrix} = \begin{bmatrix} P9D & 0 \\ 0 & P2D \end{bmatrix} \begin{matrix} x1(k) \\ x2(k) \end{matrix} + \begin{bmatrix} 1 \\ 1 \end{bmatrix} q(k) \qquad (C.5)$$

$$estx1(k) = \begin{bmatrix} qst1 & qst2 \end{bmatrix} \begin{bmatrix} x1(k) \\ x2(k) \end{bmatrix} + qst3\ q(k) \qquad (C.6)$$

The sytem of nomenclature used for the coefficients in the output equation (Eq. C.6) is described in Sec. III.A.

In the remainder of the appendix only the first and last steps of the state variable development will be given for each transfer function. The equations for each of the coefficients are given in the simulation program listing.

B. NORMAL ACCELERATION TO COLLECTIVE STABILATOR PATH H2(Z)

$$H2(Z) = [F12*F32a*3.5*P9*P2 + 3.5*F32a*P5] \qquad (C.7)$$

$$\begin{matrix} x3(k+1) \\ x4(k+1) \end{matrix} = \begin{matrix} P9D & 0 \\ 0 & P5D \end{matrix} \begin{matrix} x3(k) \\ x4(k) \end{matrix} + \begin{matrix} 1 \\ 1 \end{matrix} nz(k) \qquad (C.8)$$

$$estx2(k) = nzst1 \ nzst2 \begin{matrix} x3(k) \\ x4(k) \end{matrix} + nzst3 \ q(k) \qquad (C.9)$$

C. PITCH STICK TO COLLECTIVE STABILATOR PATH H3(Z)

$$H3(Z) = [7.0*F32a*F12*P9 + F20*F32a] \qquad (C.10)$$

Note: F20 defines the longitudinal stick gradient. The value 7.0 is a taylor series approximation about the origin of F20. (See F20 in App. A)

$$x5(k+1) = P9D \ x5(k) + 1 \ px(k) \qquad (C.11)$$

$$estx3(k) = pxst1 \ x5(k) + pxst2 \ px(k) \qquad (C.12)$$

D. ANGLE OF ATTACK TO COLLECTIVE LEADING EDGE FLAP H4(Z)

$$H4(Z) = 1.328*P11 \qquad (C.13)$$

Note: The leading edge flap schedule is defined by F27. The value used in Eq. C.13 is the l.e. flap gradient. (See F27 in App. A)

$$x6(k+1) = P11D \ x6(k) + 1 \ aa(k) \qquad (C.14)$$

$$elex(k) = aale1 \ x6(k) + aale2 \ aa(k) \qquad (C.15)$$

E. ANGLE OF ATTACK TO COLLECTIVE TRAILING EDGE FLAP H5(Z)

$$H5(Z) = 1.405*P12 \qquad (C.16)$$

Note: The trailing edge flap schedule is defined by F24. The value used in Eq. C.16 is the t.e. flap gradient. (See F24 in App. A)

$$x7(k+1) = P12D\ x7(k) + 1\ aa(k) \qquad (C.17)$$

$$etex(k) = aate1\ x7(k) + aate2\ aa(k) \qquad (C.18)$$

F. ROLL RATE TO DIFFERENTIAL STABILATOR PATH H6(Z)

$$H6(Z) = rv7*(F4+rk6t) \qquad (C.19)$$

$$esty1(k) = rv7*(F4+rk6t)\ rr(k) \qquad (C.20)$$

where:

$$rv7 = MIN(F6*F35, F6-F101)$$

$$rk6t = LIMIT(\underset{LL}{0}, \underset{UL}{.12-F4}, \underset{X}{.12-F4})$$

G. LATERAL STICK TO DIFFERENTIAL STABILATOR PATH H7(Z)

$$H7(Z) = 3.22*rv7*F7*(F13+F4) \qquad (C.21)$$

Note: The lateral stick gradient is defined by F1. The value 3.22 is a taylor series approximation about the origin of F1. (See F1 in App. A)

$$esty2(k) = 3.22*rv7*F7*(F31+F4)\ py(k) \qquad (C.22)$$

H. RUDDER PEDAL TO DIFFERENTIAL STABILATOR PATH H8(Z)

$$H8(Z) = F14*1.33*rv7*F39 \tag{C.23}$$

$$esty3(k) = F14*1.33*rv7*F39\ pz(k) \tag{C.24}$$

I. ROLL RATE TO DIFFERENTIAL LEADING EDGE FLAP PATH H9(Z)

$$H9(Z) = F93*(F4+rk6T) \tag{C.25}$$

$$eley1(k) = F93*(F4+rk6t)\ rr(k) \tag{C.26}$$

J. LATERAL STICK TO DIFFERENTIAL LEADING EDGE FLAP H10(Z)

$$H10(Z) = 3.22*F93*F7*(F13+F4) \tag{C.27}$$

$$eley2(k) = 3.22*F93*F7*(F31+F4)\ py(k) \tag{C.28}$$

K. ROLL RATE TO DIFFERENTIAL TRAILING EDGE FLAP PATH H11(Z)

$$H11(Z) = F31*F34*(F4+rk6t) \tag{C.29}$$

$$etey1(k) = F31*F34*(F4+rk6t)\ rr(k) \tag{C.30}$$

L. LATERAL STICK TO DIFFERENTIAL LEADING EDGE FLAP H12(Z)

$$H12(Z) = 3.22*F7*F31*F34*(F13+F4) \tag{C.31}$$

$$etey2(k) = 3.22*F7*F31*F34*(F13+F4)\ py(k) \tag{C.32}$$

M. ROLL RATE TO AILERON PATH H13(Z)

$$H13(Z) = F35*F36*.5*(F4+rk6t) \tag{C.33}$$

$$ea1(k) = F35*F36*.5*(F4+rk6t)\ rr(k) \tag{C.34}$$

N. LATERAL STICK TO AILERON PATH H14(Z)

$$H14(Z) = 3.22*F7*F35*F36*.5*(F13+F4) \tag{C.35}$$

$$ea2(k) = 3.22*F7*F35\ py(k) \tag{C.36}$$

O. RUDDER PEDAL TO AILERON PATH H15(Z)

$$H15(Z) = F14*F39*1.33*F35*F36 \tag{C.37}$$

$$ea3(k) = F14*F39*1.33*F35*F36\ pz(k) \tag{C.38}$$

P. YAW RATE TO RUDDER PATH H16(Z)

$$H16(Z) = F45*F96*COS(alpha)*Y3 \tag{C.39}$$

Note: In the simulation program alpha is set to the steady state angle of attack in degrees.

$$x8(k+1) = Y3D\ x8(k) + 1\ yr(k)$$

$$er1(k) = yrr1\ x8(k) + yrr2\ yr(k)$$

Q. ROLL RATE TO RUDDER PATH H17(Z)

$$H17(Z) = F45*F96*Y3*SIN(alpha)$$

$$+\ F45*F38*Y5*F30*0.76*((2*rra)+(2*rrst)) \qquad (C.40)$$

Note: The second term on the r.h.s. of the equation results from the rolling surface to rudder interconnect path. The value, 0.76, represents F42, the RSRI nonlinear gradient. It is a taylor series approximation about the origin of F42.

$$\begin{matrix} x2(k+1) \\ x3(k+1) \end{matrix} = \begin{matrix} Y3D & 0 \\ 0 & Y5D \end{matrix} \begin{matrix} x2(k) \\ x3(k) \end{matrix} + \begin{matrix} 1 \\ 1 \end{matrix} rr(k) \qquad (C.41)$$

$$er2(k) = \begin{matrix} rrr1 & rrr2 \end{matrix} \begin{matrix} x2(k) \\ x3(k) \end{matrix} + rrr3 \ \ rr(k) \qquad (C.42)$$

R. LATERAL ACCELERATION TO RUDDER PATH H18(Z)

$$H18(Z) = F45*F90 \qquad (C.43)$$

$$er3(k) = nyr \ \ ny(k) \qquad (C.44)$$

S. LATERAL STICK TO RUDDER PATH H19(Z)

$$H19(Z) = F45*Y5*F38*F30*0.76*((2*pya)+(2*pyst)) \qquad (C.45)$$

$$x4(k+1) = Y5D\ x4(k) + 1\ py(k) \qquad (C.46)$$

$$er4(k) = pyr1\ x4(k) + pyr2\ py(k) \qquad (C.47)$$

T. RUDDER PEDAL TO RUDDER PATH H20(Z)

$$H20(Z) = F45*Y5*F38*0.76*F30*((2*pza)+(2*pzst) - F45*F14*(.5-(F17*F114)) \qquad (C.48)$$

Note: The first term on the r.h.s. of the equation results from the rudder to rolling surface interconnect path.

$$x5(k+1) = Y5D\ x5(k) + 1\ pz(k)$$

$$er5(k) = pzr1\ x5(k) + pzr2\ pz(k)$$

APPENDIX D

CONTROL LAW MATRICIES

$$\begin{bmatrix} x1(k+1) \\ x2(k+1) \\ x3(k+1) \\ x4(k+1) \\ x5(k+1) \\ x6(k+1) \\ x7(k+1) \\ x8(k+1) \\ x9(k+1) \\ x10(k+1) \\ x11(k+1) \\ x12(k+1) \end{bmatrix} = \overset{[Ac]}{\left[\begin{array}{ccccccc|ccccc} P9D &&&&&&&&&&& \\ & P2D &&&&&&&&&& \\ && P9D &&&&&&& \underset{\sim}{0} && \\ &&& P5D &&&&&&&& \\ &&&& P9D &&&&&&& \\ &&&&& P11D &&&&&& \\ &&&&&& P12D &&&&& \\ \hline &&&&&&& Y3D &&&& \\ &&&&&&&& Y3D &&& \\ && \underset{\sim}{0} &&&&&&& Y5D && \\ &&&&&&&&&& Y5D & \\ &&&&&&&&&&& Y5D \end{array}\right]} \begin{bmatrix} x1(k) \\ x2(k) \\ x3(k) \\ x4(k) \\ x5(k) \\ x6(k) \\ x7(k) \\ x8(k) \\ x9(k) \\ x10(k) \\ x11(k) \\ x12(k) \end{bmatrix}$$

$$+ \overset{[Bfc]}{\left[\begin{array}{ccc|ccc} 1 & 0 & 0 &&& \\ 1 & 0 & 0 &&& \\ 0 & 1 & 0 &&& \\ 0 & 1 & 0 && \underset{\sim}{0} & \\ 0 & 0 & 0 &&& \\ 0 & 0 & 1 &&& \\ 0 & 0 & 1 &&& \\ \hline &&& 1 & 0 & 0 \\ &&& 0 & 1 & 0 \\ & \underset{\sim}{0} && 0 & 1 & 0 \\ &&& 0 & 0 & 0 \\ &&& 0 & 0 & 0 \end{array}\right]} \begin{bmatrix} q(k) \\ nz(k) \\ aa(K) \\ yr(k) \\ rr(k) \\ ny(k) \end{bmatrix} + \overset{[Bc]}{\left[\begin{array}{c|cc} \boxed{0} && \\ 0 && \\ 0 && \\ 0 & \underset{\sim}{0} & \\ 1 && \\ 0 && \\ 0 && \\ \hline & 0 & 0 \\ \underset{\sim}{0} & 0 & 0 \\ & 0 & 0 \\ & 1 & 0 \\ & 0 & 1 \end{array}\right]} \begin{bmatrix} px(k) \\ py(k) \\ pz(k) \end{bmatrix} \qquad (D.1)$$

$$\begin{bmatrix} estx(k) \\ elex(k) \\ etex(k) \\ esty(k) \\ eley(k) \\ etey(k) \\ ea(k) \\ er(k) \end{bmatrix} = \overset{[Cc]}{\left[\begin{array}{ccccccc|ccccc} qst1 & qst2 & -nzst1 & -nzst2 & -pxst1 & 0 & 0 & & & & & \\ 0 & 0 & 0 & 0 & 0 & aale1 & 0 & & & & & \\ 0 & 0 & 0 & 0 & 0 & 0 & aate1 & & & \tilde{0} & & \\ \hline & & & & & & & & & & & \\ & & & \tilde{0} & & & & & & & & \\ & & & & & & & & & & & \\ \cline{8-12} & & & & & & & -yrr1 & rrr1 & rrr2 & pyr1 & pzr1 \end{array}\right]} \begin{bmatrix} x1(k) \\ x2(k) \\ x3(k) \\ x4(k) \\ x5(k) \\ x6(k) \\ x7(k) \\ x8(k) \\ x9(k) \\ x10(k) \\ x11(k) \\ x12(k) \end{bmatrix}$$

$$+ \overset{[Dfc]}{\left[\begin{array}{ccc|ccc} qst3 & -nzst3 & 0 & & & \\ 0 & 0 & aale2 & & \tilde{0} & \\ 0 & 0 & aate2 & & & \\ \hline & & & 0 & -rrst & 0 \\ & & & 0 & -rrle & 0 \\ & \tilde{0} & & 0 & -rrte & 0 \\ & & & 0 & -rrra & 0 \\ & & & -yrr2 & rrr3 & nyr \end{array}\right]} \begin{bmatrix} q(k) \\ nz(k) \\ aa(k) \\ yr(K) \\ rr(k) \\ nv(k) \end{bmatrix} + \overset{[Dc]}{\left[\begin{array}{c|cc} -pxst2 & & \\ 0 & \tilde{0} & \\ 0 & & \\ \hline & pyst & pzst \\ \tilde{0} & pyle & 0 \\ & pyte & 0 \\ & pya & pza \\ & pyr2 & pzr2 \end{array}\right]} \begin{bmatrix} px(k) \\ py(k) \\ pz(k) \end{bmatrix} \qquad (D.2)$$

APPENDIX E

STABILITY AND CONTROL DERIVATIVE DEFINITIONS AND UNITS

The matricies in the small perturbation model (Eqs. 3.32 through 3.36) are defined in this appendix along with the dimensions of the stability and control derivatives. This information was obtained from the flight systems branch at the Naval Air Test Center.

FX MATRIX

$$\begin{array}{ccccc}
 & 1 & 2 & 3 & 4 \\
1 & \mathrm{XU} & \mathrm{XW} & \mathrm{XQ-WB} & \mathrm{-G*CTHT} \\
2 & \dfrac{\mathrm{ZU}}{\mathrm{1-ZWD}} & \dfrac{\mathrm{ZW}}{\mathrm{1-ZWD}} & \dfrac{\mathrm{(ZQ+UB)}}{\mathrm{1-ZWD}} & \dfrac{\mathrm{-G*STHT}}{\mathrm{1-ZWD}} \\
3 & \mathrm{MU}+\dfrac{\mathrm{MWD*ZU}}{\mathrm{1-ZWD}} & \mathrm{MW}+\dfrac{\mathrm{MWD*ZW}}{\mathrm{1-ZWD}} & \mathrm{MQ}+\dfrac{\mathrm{MWD*(ZQ+UB)}}{\mathrm{1-ZWD}} & \dfrac{\mathrm{MWD*(-G)*STHT}}{\mathrm{1-ZWD}} \\
4 & 0 & 0 & 1 & 0
\end{array}$$

GX MATRIX

$$
\begin{array}{c|ccc}
 & 1 & 2 & 3 \\
\hline
1 & 0 & 0 & 0 \\
2 & \frac{ZDS}{1-ZWD} & \frac{ZDLF}{1-ZWD} & \frac{ZDTF}{1-ZWD} \\
3 & MDS+\frac{MWD*ZDS}{1-ZWD} & MDLF+\frac{MWD*ZDLF}{1-ZWD} & MDTF+\frac{MWD*ZDTF}{1-ZWD} \\
4 & 0 & 0 & 0
\end{array}
$$

HX MATRIX

$$
\begin{array}{c|ccc}
 & 1 & 2 & 3 \\
\hline
1 & 0 & 0 & 1 \\
2 & \frac{ZU}{1-ZWD} & \frac{ZW}{1-ZWD} & \frac{ZQ}{1-ZWD} \\
3 & 0 & \frac{1}{UB} & 0
\end{array}
$$

DX MATRIX

$$\begin{array}{cccc}
 & 1 & 2 & 3 \\
1 & 0 & 0 & 0 \\
2 & \frac{\mathrm{ZDS}}{1-\mathrm{ZWD}} & \frac{\mathrm{ZDLF}}{1-\mathrm{ZWD}} & \frac{\mathrm{ZDTF}}{1-\mathrm{ZWD}} \\
3 & 0 & 0 & 0
\end{array}$$

FYZ MATRIX

$$\begin{array}{ccccc}
 & 1 & 2 & 3 & 4 \\
1 & \frac{\mathrm{YV}}{1-\mathrm{YVD}} & \frac{\mathrm{YR-UB}}{1-\mathrm{YVD}} & \frac{\mathrm{YP+WB}}{1-\mathrm{YVD}} & \frac{\mathrm{G*CTHT}}{1-\mathrm{YVD}} \\
2 & \mathrm{NV}+\frac{\mathrm{NVD*YV}}{1-\mathrm{YVD}} & \mathrm{NR}+\frac{\mathrm{NVD*(YR-UB)}}{1-\mathrm{YVD}} & \mathrm{NP}+\frac{\mathrm{NVD*(YP+WP)}}{1-\mathrm{YVD}} & \frac{\mathrm{NVD*G*CTHT}}{1-\mathrm{YVD}} \\
3 & \mathrm{LV}+\frac{\mathrm{LVD*YV}}{1-\mathrm{YVD}} & \mathrm{LR}+\frac{\mathrm{LVD*(YR-UB)}}{1-\mathrm{YVD}} & \mathrm{LP}+\frac{\mathrm{LVD*(YP+WB)}}{1-\mathrm{YVD}} & \frac{\mathrm{LVD*G*CTHT}}{1-\mathrm{YVD}} \\
4 & 0 & \frac{\mathrm{STHT}}{\mathrm{CTHT}} & 1 & 0
\end{array}$$

GYZ MATRIX

$$\begin{array}{ccccc}
1 & 2 & 3 & 4 & 5 \\
\frac{YDHT}{1-YVD} & \frac{YDLF}{1-YVD} & \frac{YDTF}{1-YVD} & \frac{YDA}{1-YVD} & \frac{YDR}{1-YVD} \\
NDHT+\frac{NVD*YDHT}{1-YVD} & NDLF+\frac{NVD*YDLF}{1-YVD} & NDTF+\frac{NVD*YDTF}{1-YVD} & NDA+\frac{NVD*YDA}{1-YVD} & NDR+\frac{NVD*YDR}{1-YVD} \\
LDHT+\frac{LVD*YDHT}{1-YVD} & LDLF+\frac{LVD*YDLF}{1-YVD} & LDTF+\frac{LVD*YDTF}{1-YVD} & LDA+\frac{LVD*YDA}{1-YVD} & LDR+\frac{LVD*YDR}{1-YVD} \\
0 & 0 & 0 & 0 & 0
\end{array}$$

HYZ MATRIX

$$\begin{array}{ccccc}
 & 1 & 2 & 3 & 4 \\
1 & 0 & 1 & 0 & 0 \\
2 & 0 & 0 & 1 & 0 \\
3 & \frac{YV}{1-YVD} & \frac{YR}{1-YVD} & \frac{YP}{1-YVD} & 0
\end{array}$$

DYZ MATRIX

$$\begin{array}{cccccc} & 1 & 2 & 3 & 4 & 5 \\ 1 & 0 & 0 & 0 & 0 & 0 \\ 2 & 0 & 0 & 0 & 0 & 0 \\ 3 & \frac{\mathrm{YDHT}}{1-\mathrm{YVD}} & \frac{\mathrm{YDLF}}{1-\mathrm{YVD}} & \frac{\mathrm{YDTF}}{1-\mathrm{YVD}} & \frac{\mathrm{YDA}}{1-\mathrm{YVD}} & \frac{\mathrm{YDR}}{1-\mathrm{YVD}} \end{array}$$

The following abreviations were used in the above matricies:

UB = BODY AXIS LONGTUDINAL WIND

WB = BODY AXIS VERTICAL WIND

CTHT = COS(THETA)

STHT = SIN(THETA)

DEFINITION OF DIMENSIONAL STABILITY DERIVATIVES

NAME	PARTIAL DERIVATIVE OF:	WITH RESPECT TO:	UNITS
XU	LONGITUDINAL FORCE	FORWARD VELOCITY	FT/SEC2
XW	LONGITUDINAL FORCE	VERTICAL VELOCITY	FT/SEC2
XQ	LONGITUDINAL FORCE	PITCH RATE	RAD/SEC2
XWD	LONGITUDINAL FORCE	VERTICAL ACCELERATION	FT/SEC2
XDSB	LONGITUDINAL FORCE	SPEED BRAKE	RAD/SEC2
XDTH	LONGITUDINAL FORCE	THROTTLE	PCT/SEC2
XDS	LONGITUDINAL FORCE	HORIZONTAL STABILATOR	RAD/SEC2
XDLF	LONGITUDINAL FORCE	LEADING EDGE FLAPS	RAD/SEC2
XDTF	LONGITUDINAL FORCE	TRAILING EDGE FLAPS	RAD/SEC2
ZU	VERTICAL FORCE	FORWARD VELOCITY	FT/SEC2
ZW	VERTICAL FORCE	VERTICAL VELOCITY	FT/SEC2
ZQ	VERTICAL FORCE	PITCH RATE	RAD/SEC2
ZWD	VERTICAL FORCE	VERTICAL ACCELERATION	FT/SEC2
ZDSB	VERTICAL FORCE	SPEED BRAKE	RAD/SEC2
ZDTH	VERTICAL FORCE	THROTTLE	PCT/SEC2
ZDS	VERTICAL FORCE	HORIZONTAL STABILIZER	RAD/SEC2
ZDLF	VERTICAL FORCE	LEADING EDGE FLAPS	RAD/SEC2
ZDTF	VERTICAL FORCE	TRAILING EDGE FLAPS	RAD/SEC2
MU	PITCHING MOMENT	FORWARD VELOCITY	FT/SEC2
MW	PITCHING MOMENT	VERTICAL VELOCITY	FT/SEC2
MQ	PITCHING MOMENT	PITCH RATE	RAD/SEC2
MWD	PITCHING MOMENT	VERTICAL ACCELERATION	FT/SEC2
MDSB	PITCHING MOMENT	SPEED BRAKE	RAD/SEC2
MDTH	PITCHING MOMENT	THROTTLE	PCT/SEC2
MDS	PITCHING MOMENT	HORIZONTAL STABILIZER	RAD/SEC2
MDLF	PITCHING MOMENT	LEADING EDGE FLAPS	RAD/SEC2
MDTF	PITCHING MOMENT	TRAILING EDGE FLAPS	RAD/SEC2
YV	LATERAL FORCE	LATERAL VELOCITY	FT/SEC2
YVD	LATERAL FORCE	LATERAL ACCELERATION	FT/SEC2
YR	LATERAL FORCE	YAW RATE	RAD/SEC2
YP	LATERAL FORCE	ROLL RATE	RAD/SEC2
YDA	LATERAL FORCE	AILERON	RAD/SEC2
YDR	LATERAL FORCE	RUDDER	RAD/SEC2
YDLF	LATERAL FORCE	DIFFERENTIAL LE FLAPS	RAD/SEC2
YDHT	LATERAL FORCE	DIFFERENTIAL HORIZ STABS	RAD/SEC2
YDTF	LATERAL FORCE	DIFFERENTIAL TE FLAPS	RAD/SEC2
LV	ROLLING MOMENT	LATERAL VELOCITY	FT/SEC2
LVD	ROLLING MOMENT	LATERAL ACCELERATION	FT/SEC2
LR	ROLLING MOMENT	YAW RATE	RAD/SEC2
LP	ROLLING MOMENT	ROLL RATE	RAD/SEC2
LDA	ROLLING MOMENT	AILERON	RAD/SEC2
LDR	ROLLING MOMENT	RUDDER	RAD/SEC2
LDLF	ROLLING MOMENT	DIFFERENTIAL LE FLAPS	RAD/SEC2
LDHT	ROLLING MOMENT	DIFFERENTIAL HORIZ STABS	RAD/SEC2
LDTF	ROLLING MOMENT	DIFFERENTIAL TE FLAPS	RAD/SEC2

DEFINITION OF DIMENSIONAL STABILITY DERIVATIVES
(Continued)

NAME	PARTIAL DERIVATIVE OF:	WITH RESPECT TO:	UNITS
NV	YAWING MOMENT	LATERAL VELOCITY	FT/SEC2
NVD	YAWING MOMENT	LATERAL ACCELERATION	FT/SEC2
NR	YAWING MOMENT	YAW RATE	RAD/SEC2
NP	YAWING MOMENT	ROLL RATE	RAD/SEC2
NDA	YAWING MOMENT	AILERON	RAD/SEC2
NDR	YAWING MOMENT	RUDDER	RAD/SEC2
NDLF	YAWING MOMENT	DIFFERENTIAL LE FLAPS	RAD/SEC2
NDHT	YAWING MOMENT	DIFFERENTIAL HORIZ STABS	RAD/SEC2
NDTF	YAWING MOMENT	DIFFERENTIAL TE FLAPS	RAD/SEC2

APPENDIX F

ACTUATOR TRANSFER FUNCTIONS

A. STABILATOR

$$\frac{\mathrm{Dst}(S)}{\mathrm{Est}(S)} = \frac{\left(\frac{S}{82.9}\right)^2 + \frac{2(0.068)}{82.9}S + 1.0}{\left[\left(\frac{S}{36.4}\right)^2 + \frac{2(0.41)}{36.4}S + 1\right]\left[\left(\frac{S}{105.3}\right)^2 + \frac{2(0.59)}{105.3}S + 1\right]}$$

The procedures outlined in Ref. 8 were used to put the transfer functions in state variable form.

1) Arrange the transfer function as

$$\frac{b2\ S^2 + b3\ S + b4}{S^4 + a1\ S^3 + a2\ S^2 + a3\ S + a4}$$

$b2 = 2.1377E+03$ $\qquad$ $a2 = 1.6122E+04$

$b3 = 2.4101E+04$ $\qquad$ $a3 = 4.9559E+05$

$b4 = 1.4691E+07$ $\qquad$ $a4 = 1.4691E+07$

$a1 = 1.5410E+02$

2) Express the transfer function as a differential equation

$$\ddddot{\mathrm{Dst}}(t) + a1\ \dddot{\mathrm{Dst}}(t) + a2\ \ddot{\mathrm{Dst}}(t) + a3\ \dot{\mathrm{Dst}}(t) + a4\ \mathrm{Dst}(t)$$

$$= \ b2\ \ddot{\mathrm{Est}}(t) + b3\ \dot{\mathrm{Est}}(t) + b4\ \mathrm{Est}(t)$$

3) Compute the state equation coefficients

$U0 = b0 = 0$
$U1 = b1 - a1*U0 = 0$
$U2 = b2 - a1*U1 - a2*U0 = 2.1377E+03$
$U3 = b3 - a1*U2 - a2*U1 - a3*U0 = -3.0532E+05$
$U4 = b4 - a1*U3 - a2*B2 - a3*B1 - a4*B0 = 2.7277E+07$

4) Arrange in the following state variable form

$$\begin{array}{c} x1 \\ x2 \\ x3 \\ x4 \end{array} = \overset{Fst}{\begin{array}{cccc} 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \\ -a4 & -a3 & -a2 & -a1 \end{array}} \begin{array}{c} x1 \\ x2 \\ x3 \\ x4 \end{array} + \overset{Gst}{\begin{array}{c} U1 \\ U2 \\ U3 \\ U4 \end{array}} Est(t)$$

$$Dst(t) = \overset{Hst}{\begin{array}{cccc} 1 & 0 & 0 & 0 \end{array}} \begin{array}{c} x1 \\ x2 \\ x3 \\ x4 \end{array}$$

Note input and output for all actuator models is in degrees. The remaining state variable models are developed as above.

B. LEADING EDGE FLAP

$$\frac{Dle(S)}{Ele(S)} = \frac{1.0}{\left(\frac{S}{26.9} + 1.0\right)\left(\frac{S}{82.9} + 1.0\right)}$$

$$\begin{matrix} x1(t) \\ x2(t) \end{matrix} = Fle \begin{matrix} x1(t) \\ x2(t) \end{matrix} + Gle\ Ele(t)$$

$$Dle(t) = Hle \begin{matrix} x1(t) \\ x2(t) \end{matrix}$$

C. TRAILING EDGE FLAP

$$\frac{Dte(S)}{Ete(S)} = \frac{1.0}{\left(\frac{S}{35.0}\right)^{2} + \frac{2(0.71)}{35.0} S + 1.0}$$

$$\begin{matrix} x1(t) \\ x2(t) \end{matrix} = Fte \begin{matrix} x1(t) \\ x2(t) \end{matrix} + Gte\ Ete(t)$$

$$Dte(t) = Hte \begin{matrix} x1(t) \\ x2(t) \end{matrix}$$

D. AILERON

$$\frac{Da(S)}{Ea(S)} = \frac{1.0}{\left(\frac{S}{75.0}\right)^2 + \frac{2(0.59)}{75.0} S + 1.0}$$

$$\begin{matrix} x1(t) \\ x2(t) \end{matrix} = Fa \begin{matrix} x1(t) \\ x2(t) \end{matrix} + Ga\ Ea(t)$$

$$Da(t) = Ha \begin{matrix} x1(t) \\ x2(t) \end{matrix}$$

E. RUDDER

$$\frac{Dr(S)}{Er(S)} = \frac{1.0}{\left(\frac{S}{72.1}\right)^2 + \frac{2(0.69)}{72.1} S + 1.0}$$

$$\begin{matrix} x1(t) \\ x2(t) \end{matrix} = Fr \begin{matrix} x1(t) \\ x2(t) \end{matrix} + Gr\ Er(t)$$

$$Dr(t) = Hr \begin{matrix} x1(t) \\ x2(t) \end{matrix}$$

The actuator state variable model matricies in Eqs. 3.43 & 3.44 are arranged as follows:

FA MATRIX

$$
\begin{array}{cccccccccc}
\mathrm{Fst} & & & & & & & & & \\
 & \mathrm{Fst} & & & & & & & & \\
 & & \mathrm{Fle} & & & & \underset{\sim}{0} & & & \\
 & & & \mathrm{Fle} & & & & & & \\
 & & & & \mathrm{Fte} & & & & & \\
 & & & & & \mathrm{Fte} & & & & \\
 & & \underset{\sim}{0} & & & & \mathrm{Fa} & & & \\
 & & & & & & & \mathrm{Fa} & & \\
 & & & & & & & & \mathrm{Fr} & \\
 & & & & & & & & & \mathrm{Fr}
\end{array}
$$

GA MATRIX

$$
\begin{array}{cccccccccc}
\mathrm{Gst} & & & & & & & & & \\
 & \mathrm{Gst} & & & & & & & & \\
 & & \mathrm{Gle} & & & & \underset{\sim}{0} & & & \\
 & & & \mathrm{Gle} & & & & & & \\
 & & & & \mathrm{Gte} & & & & & \\
 & & & & & \mathrm{Gte} & & & & \\
 & & & & & & \mathrm{Ga} & & & \\
 & & \underset{\sim}{0} & & & & & \mathrm{Ga} & & \\
 & & & & & & & & \mathrm{Gr} & \\
 & & & & & & & & & \mathrm{Gr}
\end{array}
$$

HA MATRIX

$$
\begin{array}{ccccccccccc}
\mathrm{Hst} & & & & & & & & & & \\
 & \mathrm{Hst} & & & & & & & & & \\
 & & \mathrm{Hle} & & & & & & & & \\
 & & & \mathrm{Hte} & & & & \underset{\sim}{0} & & & \\
 & & & & \mathrm{Hte} & & & & & & \\
 & & & & & \mathrm{Hle} & & & & & \\
 & & & & & & \mathrm{Hle} & & & & \\
 & & \underset{\sim}{0} & & & & & \mathrm{Ha} & & & \\
 & & & & & & & & \mathrm{Ha} & & \\
 & & & & & & & & & \mathrm{Hr} & \\
 & & & & & & & & & & \mathrm{Hr}
\end{array}
$$

APPENDIX G

AIRCRAFT SENSOR TRANSFER FUNCTIONS

A. RATE GYRO TRANSFER FUNCTION

$$\frac{Y(S)}{E(S)} = \frac{\dfrac{S}{131.7} + 1.0}{\left[\dfrac{S}{167.8} + 1.0\right]\left[\dfrac{S}{461.7} + 1.0\right]}$$

B. ACCELEROMETER TRANSFER FUNCTION

$$\frac{Y(s)}{E(S)} = \frac{\dfrac{S}{235.8} + 1.0}{\left(\dfrac{S}{395.3}\right)^{2} + \dfrac{2(.96)}{395.3} S + 1.0}$$

C. ANGLE OF ATTACK SENSOR TRANSFER FUNCTION

$$\frac{Y(S)}{E(S)} = \frac{1.0}{\dfrac{S}{14.0} + 1.0}$$

Note: Transfer functions input degrees/second (or degrees) and output degrees/second (or degrees). The state variable model for the transfer functions in Eqs. 3.46 & 3.47 are developed using the procedures outlined in appendix F.

APPENDIX H

SIMULATION PROGRAM SUBROUTINES

Subroutine: FLITE1

Description: Reads in steady state flight conditions, stick and rudder commands, and control surface failure parameters.

Calling sequence: CALL FLITE1(mach,alt,alpha,nz,ncont,nst,nstp,amp,rstf,lstf)

Input arguements: None

Output arguements:

mach	Steady state mach number
alt	Steady state altitude in feet
alpha	Steady state AOA in degrees
nz	Steady state normal acceleration. Normally 1.0.
ts	Sampling time in seconds
ncont	Control number: 1=Longitudinal stick 2=Lateral stick 3=Rudder deflection
nst, nstp	Control start time, and control stop time. Nst and nstp are actually the iteration number: Start time (secs.)=nst*ts Stop time (secs.)=nstp*ts
amp	Control amplitude given as deflection in inches
rstf, lstf	Right and left stabilator failure parameters respectfully: No failure = 0 Failure = 1

Subroutine: FLITE2

Operation: Reads in basic airframe matricies from the 'F/A-18' data file.

Calling arguments: CALL FLITE2(Fx,Gx,Hx,Dx,Fyz,Gyz,Hyz,Dyz,
Nfx,Ngx,Nhx,Ndx,Nfyz,Ngyz,Nhyz,Ndyz)

Input arguments: None

Output arguments:

Fx, Gx, Hx, Dx	Longitudinal state matricies
Fyz, Gyz, Hyz, Dyz	Lateral-directional state matricies
Nfx,Ngx,Nhx,Ndx Nfyz,Ngyz,Nhyz,Ndyz	Two-dimensional vectors giving the number of rows and columns of the respective matricies. Example, Nfx(1) = Number rows in Fx Nfx(2) = Number columns in Fx

Subroutine: LONLAT

Description: Generates the LONG and LATD matricies (Eqs. 3.38 and 3.39) based on the control surface failure parameters.

Computes the unimpaired input matrix, Gm0, to the modified aiframe equations. The Gm0 matrix will be used in the reconfiguration algorithm.

Calling Arguments: CALL LONLAT(rstf,lstf,ifail,Gx,Gyz,LONG, LATD,Gm0,Nlong,Nlatd,Ngm0,Ngx,Ngyz)

Input arguments:

rstf, lstf	Right and left stabilator failure parameters respectfully. (See subroutine FLITE1)
ifail	Failure flag: No failure = 0 Failure = 1
Gx, Gyz	Longitudinal and lateral-directional input matricies.
Ngx, Ngyz	Two dimensional vectors giving the number of rows and columns of the Gx, and, Gyz matricies.

Output arguments:

LONG, LATD	Matricies described in Section III.B. which split the control surface deflections into right and left hand sides. The LONG and LATD matricies reflect control surface failure or damage.
Gm0	The unimpaired input matrix to the modified airframe equations (Eq. 3.40). Gm0 is composed using the unimpaired LONG and LATD matricies. It is subsequently used in the reconfiguration algorithm.
Nlong, Nlatd Ngm0	Two dimensional vectors giving the number of rows and columns in the respective matricies.

Subroutine: AIRDAT

Description: Computes the air data inputs to the control laws based on standard atmosphere conditions.

Calling arguments: CALL AIRDAT(mach,alt,temp,rho,psi,a,ri)

Input arguements:

mach	Steady state mach number
alt	Steady state altitude in feet

Output arguements:

temp	Standard atmosphere temperature in degrees rankine
rho	Standard atmosphere density in lb-sec**2 / ft**4
psi	Standard atmosphere pressure in lb/ft**2
a	Sonic velocity in ft/sec
qc	Dynamic pressure in lb/ft**2
ri	Pressure ratio = qc/psi

Subroutine: MODEQ

Description: Composes the modified airframe matricies (Eqs. 3.40 and 3.41)

Calling Arguments: CALL MODEQ(Fx,Gx,Hx,Dx,Fyz,Gyz,Hyz,Dyz,
LONG,LATD,Fm,Gm,Hm,Dm,Nfx,Ngx,Nhx,Ndx,
Nfyz,Ngyz,Nhyz,Ndyz)

Input arguments:

Fx, Gx, Hx, Dx Fyz, Gyz, Hyz, Dyz	Longidudinal and lateral-directional basic airframe matricies (Eqs. 3.32 - 3.35) Read in from subroutine FLIGHT1
LONG, LATD	LONG and LATD matricies (Eqs. 3.38 and 3.39) Generated in subroutine LONLAT
Nfx, Ngx, Nhx, Ndx Nfyz, Ngyz, Nhyz, Ndyz Nlong, Nlatd,	Two dimensional vectors giving the number of rows and columns in the respective matrix.

Output arguements:

Fm, Gm, Hm, Dm	Modified basic airframe matricies (Eqs. 3.40 and 3.41)
Nfm, Ngm, Nhm, Ndm	Row and column vectors as described as described above

Subroutine: SENSOR

Description: Composes the sensor matricies (Eqs. 3.47 and 3.46)

Calling arguments: CALL SENSOR(Fs,Gs,Hs,Nfs,Ngs,Nhs)

Input arguments: None

Output arguements:

Fs, Gs, Hs	Sensor matricies
Nfs, Ngs, Nhs	Two dimensional row and column vectors

Subroutine: ACTU

Description: Composes the actuator matricies (Eqs. 3.42 and 3.43)

Calling arguements: CALL ACTU(Fa,Ga,Ha,Nfa,Nga,Nha)

Input arguments: None

Output arguments:

Fa, Ga, Ha	Actuator matricies
Nfa, Nga, Nha	Two dimensional Row and column vectors

Subroutine: PLANT

Description: Composes the basic airframe plus actuator matricies (Eqs. 3.44 and 3.45)

Calling arguments: CALL PLANT(Fm,Gm,Hm,Dm,Fa,Ga,Ha,Fp,Gp,Hp,
Nfm,Ngm,Nhm,Ndm,Nfa,Nga,Nha,Nfp,Ngp,Nhp)

Input arguments:

Fm, Gm, Hm, Dm	Modified basic airframe matricies (Eqs. 3.44 and 3.45) Generated in subroutine MODEQ.
Fa, Ga, Ha	Actuator matricies (Eqs. 3.42 and 3.43) Generated in subroutine ACTU.
Nfm, Ngm, Nhm, Ndm Nfa, Nga, Nha	Two dimensional row and column vectors

Output arguements:

Fp, Gp, Hp	Airframe plus actuator matricies
Nfp, Ngp, Nhp	Row and column vectors

Subroutine: LAWS

Description: Computes the function gains (App. A)

Computes the coefficients in the control law matricies

Composes the control law matricies

Calling arguments: CALL LAWS(alpha,nz,psi,qc,ri,ts,Ac,Bfc, Bc,Cc,Dfc,Dc,Nac,Nbfc,Nbc,Ncc,Ndfc,Ndc)

Input arguments:

alpha	Steady state angle of attack in degrees
nz	Steady state normal acceleration = 1.0
psi	standard atmosphere pressure at steady state altitude in lb/ft**2
qc	dynamic pressure in lb/ft**2
ri	pressure ratio
ts	sampling time in seconds

Output arguments:

Ac, Bfc, Bc Cc, Dfc, Dc	Control law matricies (Eqs. 3.29 and 3.30)
Nac, Nbfc, Nbc Ncc, Ndfc, Ndc	Row and column vectors

Subroutine: VGAIN

Description: Computes the variable gain matrix based on control surface impairment. The subroutine is disigned to use reconfiguration algorithm introduced in Ref. 1.

Calling arguments: CALL VGAIN(ifail,ifix,Gm,Gm0,GAIN,Ngm, Ngm0, Ngain)

Input arguments:

ifail	Control surface failure flag set in subroutine LONLAT; No failure = 0 Failure = 1
ifix	Fix parameter. The GAIN matrix will be computed fo the impaired aircraft if ifix = 1 and ifail = 1. Ifix is read interactively by subroutine FLITE1.
Gm	Airframe control matrix. From subroutine MODEO.
Gm0	Unimpaired airframe control matrix. Generated in subroutine LONLAT. Note if none of the control surfaces are damaged or failed, Gm=Gm0.
Ngm, Ngm0	Row and column vectors

Output Arguements:

GAIN	Variable gain matrix described in section III.A.
Ngain	Row and column vector

Subroutine: EXPINT [Ref.5]

Description: Computes both the matrix exponential

$$Aps = e^{Fps*ts}$$

and the integral

$$\int_{0}^{ts} e^{Fps*s} \, ds$$

Reference 5 gives the method used to perform the computations.

Calling arguements: CALL EXPINT(Fps,Nfps,Aps,Naps,Dum1,
Ndum1,ts,iop,Dum2)

Input arguments:

Fps	Airframe plus actuator plus sensor transfer matrix. Generated in ARCRFT
Nfps	Two dimensional row and column vector
ts	Sampling time
iop	Print parameter: 0 = Do not print results Otherwise print Fps, Ts, e^{Fps*ts}
Dum2	Vector of working space for computations

Output arguments:

Aps	Matrix exponential described above
Naps	Two dimensional row and column vector
Dum1	The integral of the matrix exponential. To be used in computing the discrete control matrix Bps.

$$\overset{43x10}{Bps} = \overset{43x43}{Dum1} \times \overset{43x10}{Gps}$$

The following subroutines perform the matrix operations necessary to compose the A/F-18 system matricies.

Subroutine: MULT [Ref.5]

Description: Performs the matrix multiplications.

Calling arguments: CALL MULT(A,NA,B,NB,C,NC)

Input arguments:

A, B	Matricies to be multiplied
Na, Nb	Two dimensional vector giving the number of rows and columns in A, and B.

Output arguments:

C	Product of A and B, C = AB
Nc	Row and column vector

Subroutine ADD and SUBT are called just as MULT.

Subroutine: NULL [Ref. 5]

Description: Generates a null matrix

Calling arguments: CALL NULL(A,NA)

Input arguments:

Na	Two dimensional vevtor giving the number of rows and columns of the null matrix, $Na(1)$ = Number of rows $Na(2)$ = Number of columns

Output arguments:

A	Null matrix having dimension $Na(1) \times Na(2)$

Subroutine: JUXTR [Ref. 5]

Description: Juxtaposes two matricies by row

Calling arguements: CALL JUXTR(A,Na,B,Nb,C,Nc)

Input arguements:

A, B	The two matricies to be juxtaposed by row
Na, Nb	Row and column vectors

Output arguments:

C	The juxtaposition of A and B $C = \frac{A}{B}$
Nc	Row and column vector

Subroutine: JUXTC [Ref.5]

Description: Juxtaposes two matricies by column

Calling arguments: CALL JUXTR(A,Na,B,Nb,C,Nc)

Input arguements:

A, B	The two matricies to be juxtaposed by column
Na, Nb	Row and column vectors

Output arguments:

C	The juxtaposition of A and B $C = A \mid B$
Nc	Row and column vector

Subroutines: ADD and MULT

The calling sequences for these subroutines are exactly as described for those matrix operations above.

Subroutine: OUTPUT

Description: Outputs a matrix with rows and columns numbered.

Calling Arguments: CALL OUTPUT(A,Na(1),Na(2),'A   ')

Input arguments:

A	Matrix to be output
Na(1), Na(2)	Number of rows and number of columns in A respectfully
'A '	Matrix name. Must be placed in quotes and occupy four spaces.

Output arguments:

The A matrix is written to the FA18 RESULTS file

APPENDIX I.

F/A-18 EXEC PROGRAM

```
&TRACE OFF
CLRSCRN
GLOBAL TXTLIB VALTLIB VFORTLIB IMSLDP  NONIMSL  CMSLIB
GLOBAL LOADLIB VFLODLIB
FILEDEF 06 TERMINAL
FILEDEF 01 DISK F/A-18 DATA A1
FILEDEF 02 DISK F/A-18 RESULTS (LRECL 132
FILEDEF 03 DISK OPTMATD DATA A1
FILEDEF 04 DISK OPTPLOT DATA A1
&TYPE LOADING FA18 SIMULATION
LOAD FA18 ORACLS1 (START
&EXIT
```

APPENDIX J

FLIGHT CONDITIONS AND STABILITY AND CONTROL DERIVATIVES

A. FLIGHT CONDITIONS

MACH = 0.6   ALT = 10000.0   VTRUE = 646.42
ALPHA = 2.6184   THRUST = 3531.5   GAMA = 0.0
PCTHLC = 20.496   PCTHRC = 20.496   XIXX = 21227.0
DLHTD = 0.68914   DRHDT = 0.68914   XIXZ = -1827.0
DLAD = 0.0   DRAD = 0.0
DLEFL = 3.0968   DLEFR = 3.0968
DTEFL = 3.2647   DTEFR = 3.2647
DRUDL = 0.0   DRUDR = 0.0
FLARUD = 0.0   DELSB = 0.0
CG = 0.2206   WAIT = 32550
XIYY= 0.1220E+06   XIZZ = 0.13958E+06

B. LONGITUDINAL DERIVATIVES

XU = -0.13257E-01   ZU = -0.73337E-01   MU = -0.12988E-04
XW = 0.71265E-01   ZW = -1.1526   MW = -0.11331E-01
XQ = 0.32650   ZQ = -5.6525   MQ = -0.59346
XWD = 0.39729E-03   ZWD = -0.6917   MWD = -0.34049E-03
XDSB = 0.0   ZDSB = 0.0   MDSB = 0.0
XDTH = 0.14257   ZDTH = 0.0   MDTH = 0.0
XDS = -0.43034E-03   ZDS = -0.19801E-01   MDS = -0.24151E-02
XDLF = -0.412942E-03   ZDLF = 0.64114E-02   MDLF = -0.5230E-03
XDTF = 0.17674E-03   ZDTF = -0.45250E-01   MDTF = 0.32773E-01

C. LATERAL-DIRECTIONAL DERIVATIVES

YV = -0.2437   LV = -0.29125E-01   NV = 0.69481E-02
YVD = 0.0   LVD = 0.0   NVD = 0.0
YR = 0.77567   LR = 0.70076   NR = -0.21705
YP = 0.67478E-02   LP = -3.1241   NP = -0.15254E-01
YDA = 0.86683E-03   LDA = -0.43808E-02   NDA = 0.77305E-04
YDR = 0.52918E-02   LDR = 0.72058E-03   NDR = -0.46503E-03
YDLF = 0.0   LDLF = 0.0   NDLF = 0.0
YDHT = -0.21027E-02   LDHT = 0.39478E-02   NDHT = 0.57361E-04
YDTF = 0.0   LDTF = 0.24948   NDTF = -0.32655E-02

FLIGHT CONDITION PARAMETERS

VARIABLE	DEFINITION	UNITS
XMACH	MACH NUMBER	ND
ALT	ALTITUDE, MSL	FT
VTRUE	TRUE AIRSPEED	FT/SEC
ALFA	ANGLE OF ATTACK	DEG
THRUST	TOTAL ENGINE THRUST	LB
GAMA	FLIGHT PATH ANGLE	RAD
PCTHLC	LEFT THROTTLE POSITION COMMAND (100%=MAX AB)	PERCENT
PCTHRC	RIGHT THROTTLE POSITION COMMAND(100%=MAX AB)	PERCENT
DLHTD	LEFT HORIZONTAL STAB. DEFLECTION (+ TE DOWN)	DEG
DRHTD	RIGHT HORIZONTAL STAB. DEFLECTION (+TE DOWN)	DEG
DLAD	LEFT AILERON DEFLECTION (+TE DOWN)	DEG
DRAD	RIGHT AILERON DEFLECTION (+TE DOWN)	DEG
DLEFL	LEFT LEADING EDGE FLAP DEFL (+LE DOWN)	DEG
DLEFR	RIGHT LEADING EDGE FLAP DEFL. (+LE DOWN)	DEG
DTEFL	LEFT TRAILING EDGE FLAP DEFL. (+TE DOWN)	DEG
DTEFR	RIGHT TRAILING EDGE FLAP DEFL (+TE DOWN)	DEG
DRUDL	LEFT RUDDER DEFLECTION (+ TE LEFT)	DEG
DRUDR	RIGHT RUDDER DEFLECTION (+TE LEFT)	DEG
FLARUD	FLARED RUDDER (PA/TO ONLY)	DEG
DELSB	SPEEDBRAKE DEFLECTION	DEG
CG	LONG. CENTER OF GRAVITY LOCATION IN PCT MAC	PERCENT
WAIT	AIRCRAFT WEIGHT	LB
XIXX	MOMENT OF INERTIA ABOUT X-BODY AXIS	SLUG-FT2
XIYY	MOMENT OF INERTIA ABOUT Y-BODY AXIS	SLUG-FT2
XIZZ	MOMENT OF INERTIA ABOUT Z-BODY AXIS	SLUG-FT2
XIXZ	XZ PLANE PRODUCT OF INERTIA	SLUG-FT2

APPENDIX K

F/A-18 RESULTS FILE

```
AIRCRAFT FLIGHT CONDITIONS AND SAMPLING TIME

MACH = 0.6000E+00 ALT = 0.1000E+05 ALPHA = 0.2618E+01
NZ = 0.1000E+01 TS = 0.1250E-01

CONTROL PARAMETERS, AND FAILURE PARAMETERS

START TIME =  80 STOP TIME = 240
AMPLITUDE = 0.50E+00 CONTROL NUMBER = 1
RIGHT STAB FAILURE = 0 LEFT STAB FAILURE = 0

 FX     MATRIX
           1         2          3         4
 1 -0.133E-01 0.713E-01-0.292E+02-0.322E+02
 2 -0.728E-01-0.114E+01 0.636E+03-0.146E+01
 3  0.118E-04-0.109E-01-0.810E+00 0.497E-03
 4  0.000E+00 0.000E+00 0.100E+01 0.000E+00

 GX     MATRIX
           1         2          3
 1  0.000E+00 0.000E+00 0.000E+00
 2 -0.197E-01 0.637E-02-0.449E-01
 3 -0.241E-02-0.525E-03 0.328E-01
 4  0.000E+00 0.000E+00 0.000E+00

 HX     MATRIX
           1         2          3         4
 1  0.000E+00 0.000E+00 0.100E+01 0.000E+00
 2 -0.728E-01-0.114E+01-0.561E+01 0.000E+00
 3  0.000E+00 0.155E-02 0.000E+00 0.000E+00

 DX     MATRIX
           1         2          3
 1  0.000E+00 0.000E+00 0.000E+00
 2 -0.197E-01 0.637E-02-0.449E-01
 3  0.000E+00 0.000E+00 0.000E+00

 FYZ    MATRIX
```

```
          1          2          3          4
1 -0.244E+00-0.645E+03 0.295E+02 0.322E+02
2  0.695E-02-0.217E+00-0.153E-01 0.000E+00
3 -0.291E-01 0.701E+00-0.312E+01 0.000E+00
4  0.000E+00 0.457E-01 0.100E+01 0.000E+00

GYZ    MATRIX
          1          2          3          4          5
1 -0.210E-02 0.000E+00 0.000E+00 0.867E-03 0.529E-02
2  0.574E-04 0.000E+00-0.327E-02 0.773E-04-0.465E-03
3  0.395E-02 0.000E+00 0.249E+00-0.438E-02 0.721E-03
4  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00

HYZ    MATRIX
          1          2          3          4
1  0.000E+00 0.100E+01 0.000E+00 0.000E+00
2  0.000E+00 0.000E+00 0.100E+00 0.000E+00
3 -0.244E+00 0.776E+00 0.676E-02 0.000E+00

DYZ    MATRIX
          1          2          3          4          5
1  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
2  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
3 -0.210E-02 0.000E+00 0.000E+00 0.867E-03 0.529E-02

AIR DATA CALCULATIONS

T = 0.4831D+03 RHO = 0.1755D-02 PSI = 0.1455D+04
A = 0.1078D+04 QC = 0.3671D+03 RI = 0.2522D+00

GMO    MATRIX
          1          2          3          4          5          6          7
1  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
2 -0.983E-02-0.983E-02 0.318E-02 0.318E-02-0.225E-01-0.225E-01 0.000E+00
3 -0.120E-02-0.120E-02-0.263E-03-0.263E-03 0.164E-01 0.164E-01 0.000E+00
4  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
5  0.210E-02-0.210E-02 0.000E+00 0.000E+00 0.000E+00 0.000E+00-0.867E-03
6 -0.574E-04 0.574E-04 0.000E+00 0.000E+00 0.327E-02-0.327E-02-0.773E-04
7 -0.395E-02 0.395E-02 0.000E+00 0.000E+00-0.249E+00 0.249E+00 0.438E-02
8  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
          8          9         10
1  0.000E+00 0.000E+00 0.000E+00
2  0.000E+00 0.000E+00 0.000E+00
```

```
3  0.000E+00 0.000E+00 0.000E+00
4  0.000E+00 0.000E+00 0.000E+00
5  0.867E-03 0.265E-02 0.265E-02
6  0.773E-04-0.233E-03-0.233E-03
7 -0.438E-02 0.360E-03 0.360E-03
8  0.000E+00 0.000E+00 0.000E+00


LNG    MATRIX
       1         2         3         4         5         6         7
1  0.500E+00 0.500E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
2  0.000E+00 0.000E+00 0.500E+00 0.500E+00 0.000E+00 0.000E+00 0.000E+00
3  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.500E+00 0.500E+00 0.000E+00
       8         9         10
1  0.000E+00 0.000E+00 0.000E+00
2  0.000E+00 0.000E+00 0.000E+00
3  0.000E+00 0.000E+00 0.000E+00


LAT    MATRIX
       1         2         3         4         5         6         7
1 -0.100E+01 0.100E+01 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
2  0.000E+00 0.000E+00 0.100E+01-0.100E+01 0.000E+00 0.000E+00 0.000E+00
3  0.000E+00 0.000E+00 0.000E+00 0.000E+00-0.100E+01 0.100E+01 0.000E+00
4  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00-0.100E+01
5  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
       8         9         10
1  0.000E+00 0.000E+00 0.000E+00
2  0.000E+00 0.000E+00 0.000E+00
3  0.000E+00 0.000E+00 0.000E+00
4  0.100E+01 0.000E+00 0.000E+00
5  0.000E+00 0.500E+00 0.500E+00


FM     MATRIX
       1         2         3         4         5         6         7
1 -0.133E-01 0.713E-01-0.292E+02-0.322E+02 0.000E+00 0.000E+00 0.000E+00
2 -0.728E-01-0.114E+01 0.636E+03-0.146E+01 0.000E+00 0.000E+00 0.000E+00
3  0.118E-04-0.109E-01-0.810E+00 0.497E-03 0.000E+00 0.000E+00 0.000E+00
4  0.000E+00 0.000E+00 0.100E+01 0.000E+00 0.000E+00 0.000E+00 0.000E+00
5  0.000E+00 0.000E+00 0.000E+00 0.000E+00-0.244E+00-0.645E+03 0.295E+02
6  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.695E-02-0.217E+00-0.153E-01
7  0.000E+00 0.000E+00 0.000E+00 0.000E+00-0.291E-01 0.701E+00-0.312E+01
8  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.457E-01 0.100E+01
       8
1  0.000E+00
2  0.000E+00
3  0.000E+00
```

```
4   0.000E+00
5   0.322E+02
6   0.000E+00
7   0.000E+00
8   0.000E+00

GM     MATRIX
        1          2          3          4          5          6          7
1   0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00
2  -0.172E-03-0.172E-03  0.556E-04  0.556E-04-0.392E-03-0.392E-03  0.000E+00
3  -0.210E-04-0.210E-04-0.458E-05-0.458E-05  0.286E-03  0.286E-03  0.000E+00
4   0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00
5   0.367E-04-0.367E-04  0.000E+00  0.000E+00  0.000E+00  0.000E+00-0.151E-04
6  -0.100E-05  0.100E-05  0.000E+00  0.000E+00  0.570E-04-0.570E-04-0.135E-05
7  -0.689E-04  0.689E-04  0.000E+00  0.000E+00-0.435E-02  0.435E-02  0.764E-04
8   0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00
        8          9          10
1   0.000E+00  0.000E+00  0.000E+00
2   0.000E+00  0.000E+00  0.000E+00
3   0.000E+00  0.000E+00  0.000E+00
4   0.000E+00  0.000E+00  0.000E+00
5   0.151E-04  0.462E-04  0.462E-04
6   0.135E-05-0.406E-05-0.406E-05
7  -0.764E-04  0.629E-05  0.629E-05
8   0.000E+00  0.000E+00  0.000E+00

HM     MATRIX
        1          2          3          4          5          6          7
1   0.000E+00  0.000E+00  0.573E+02  0.000E+00  0.000E+00  0.000E+00  0.000E+00
2  -0.226E-02-0.355E-01-0.174E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00
3   0.000E+00  0.887E-01  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00
4   0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.573E+02  0.000E+00
5   0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.573E+01
6   0.000E+00  0.000E+00  0.000E+00  0.000E+00-0.757E-02  0.241E-01  0.210E-03
        8
1   0.000E+00
2   0.000E+00
3   0.000E+00
4   0.000E+00
5   0.000E+00
6   0.000E+00

DM     MATRIX
        1          2          3          4          5          6          7
1   0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00
```

```
 2 -0.533E-05-0.533E-05 0.173E-05 0.173E-05-0.122E-04-0.122E-04 0.000E+00
 3  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 4  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 5  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 6  0.114E-05-0.114E-05 0.000E+00 0.000E+00 0.000E+00 0.000E+00-0.470E-06
        8         9         10
 1  0.000E+00 0.000E+00 0.000E+00
 2  0.000E+00 0.000E+00 0.000E+00
 3  0.000E+00 0.000E+00 0.000E+00
 4  0.000E+00 0.000E+00 0.000E+00
 5  0.000E+00 0.000E+00 0.000E+00
 6  0.470E-06 0.143E-05 0.143E-05


FA     MATRIX
        1         2         3         4         5         6         7
 1  0.000E+00 0.100E+01 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 2  0.000E+00 0.000E+00 0.100E+01 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 3  0.000E+00 0.000E+00 0.000E+00 0.100E+01 0.000E+00 0.000E+00 0.000E+00
 4 -0.147E+08-0.496E+06-0.161E+05-0.154E+03 0.000E+00 0.000E+00 0.000E+00
 5  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.100E+01 0.000E+00
 6  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.100E+01
 7  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 8  0.000E+00 0.000E+00 0.000E+00 0.000E+00-0.147E+08-0.496E+06-0.161E+05
 9  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
10  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
11  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
12  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
13  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
14  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
15  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
16  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
17  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
18  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
19  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
20  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
21  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
22  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
23  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
24  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
        8         9         10        11        12        13        14
 1  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 2  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 3  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 4  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 5  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 6  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 7  0.100E+01 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
```

```
12   0.000E+00 0.000E+00 0.000E+00-0.223E+04-0.109E+03 0.000E+00 0.000
13   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.100
14   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00-0.123E+04-0.497
15   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000
16   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000
17   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000
18   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000
19   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000
20   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000
21   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000
22   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000
23   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000
24   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000
        15        16        17        18        19        20        21
 1   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000
 2   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000
 3   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000
 4   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000
 5   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000
 6   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000
 7   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000
 8   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000
 9   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000
10   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000
11   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000
12   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000
13   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000
14   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000
15   0.000E+00 0.100E+01 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000
16  -0.123E+04-0.497E+02 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000
17   0.000E+00 0.000E+00 0.000E+00 0.100E+01 0.000E+00 0.000E+00 0.000
18   0.000E+00 0.000E+00-0.563E+04-0.885E+02 0.000E+00 0.000E+00 0.000
19   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.100E+01 0.000
20   0.000E+00 0.000E+00 0.000E+00 0.000E+00-0.563E+04-0.885E+02 0.000
21   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000
22   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00-0.520
23   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000
24   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000
        22        23        24
 1   0.000E+00 0.000E+00 0.000E+00
 2   0.000E+00 0.000E+00 0.000E+00
 3   0.000E+00 0.000E+00 0.000E+00
 4   0.000E+00 0.000E+00 0.000E+00
 5   0.000E+00 0.000E+00 0.000E+00
```

```
 6   0.000E+00 0.000E+00 0.000E+00
 7   0.000E+00 0.000E+00 0.000E+00
 8   0.000E+00 0.000E+00 0.000E+00
 9   0.000E+00 0.000E+00 0.000E+00
10   0.000E+00 0.000E+00 0.000E+00
11   0.000E+00 0.000E+00 0.000E+00
12   0.000E+00 0.000E+00 0.000E+00
13   0.000E+00 0.000E+00 0.000E+00
14   0.000E+00 0.000E+00 0.000E+00
15   0.000E+00 0.000E+00 0.000E+00
16   0.000E+00 0.000E+00 0.000E+00
17   0.000E+00 0.000E+00 0.000E+00
18   0.000E+00 0.000E+00 0.000E+00
19   0.000E+00 0.000E+00 0.000E+00
20   0.000E+00 0.000E+00 0.000E+00
21   0.100E+01 0.000E+00 0.000E+00
22  -0.995E+02 0.000E+00 0.000E+00
23   0.000E+00 0.000E+00 0.100E+01
24   0.000E+00-0.520E+04-0.995E+02

GA     MATRIX
         1         2         3         4         5         6         7
 1   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 2   0.214E+04 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 3  -0.305E+06 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 4   0.273E+08 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 5   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 6   0.000E+00 0.214E+04 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 7   0.000E+00-0.305E+06 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 8   0.000E+00 0.273E+08 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 9   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
10   0.000E+00 0.000E+00 0.223E+04 0.000E+00 0.000E+00 0.000E+00 0.000E+00
11   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
12   0.000E+00 0.000E+00 0.000E+00 0.223E+04 0.000E+00 0.000E+00 0.000E+00
13   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
14   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.123E+04 0.000E+00 0.000E+00
15   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
16   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.123E+04 0.000E+00
17   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
18   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.563E+04
19   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
20   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
21   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
22   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
23   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
24   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
         8         9        10
```

```
 1  0.000E+00 0.000E+00 0.000E+00
 2  0.000E+00 0.000E+00 0.000E+00
 3  0.000E+00 0.000E+00 0.000E+00
 4  0.000E+00 0.000E+00 0.000E+00
 5  0.000E+00 0.000E+00 0.000E+00
 6  0.000E+00 0.000E+00 0.000E+00
 7  0.000E+00 0.000E+00 0.000E+00
 8  0.000E+00 0.000E+00 0.000E+00
 9  0.000E+00 0.000E+00 0.000E+00
10  0.000E+00 0.000E+00 0.000E+00
11  0.000E+00 0.000E+00 0.000E+00
12  0.000E+00 0.000E+00 0.000E+00
13  0.000E+00 0.000E+00 0.000E+00
14  0.000E+00 0.000E+00 0.000E+00
15  0.000E+00 0.000E+00 0.000E+00
16  0.000E+00 0.000E+00 0.000E+00
17  0.000E+00 0.000E+00 0.000E+00
18  0.000E+00 0.000E+00 0.000E+00
19  0.000E+00 0.000E+00 0.000E+00
20  0.563E+04 0.000E+00 0.000E+00
21  0.000E+00 0.000E+00 0.000E+00
22  0.000E+00 0.520E+04 0.000E+00
23  0.000E+00 0.000E+00 0.000E+00
24  0.000E+00 0.000E+00 0.520E+04


HA     MATRIX
         1         2         3         4         5         6         7
 1  0.175E-01 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 2  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.175E-01 0.000E+00 0.000E+00
 3  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 4  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 5  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 6  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 7  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 8  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 9  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
10  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
         8         9        10        11        12        13        14
 1  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 2  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 3  0.000E+00 0.175E-01 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 4  0.000E+00 0.000E+00 0.000E+00 0.175E-01 0.000E+00 0.000E+00 0.000E+00
 5  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.175E-01 0.000E+00
 6  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 7  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 8  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 9  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
```

```
10  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
        15        16        17        18        19        20        21
 1  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 2  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 3  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 4  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 5  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 6  0.175E-01 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 7  0.000E+00 0.000E+00 0.175E-01 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 8  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.175E-01 0.000E+00 0.000E+00
 9  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.175E-01
10  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
        22        23        24
 1  0.000E+00 0.000E+00 0.000E+00
 2  0.000E+00 0.000E+00 0.000E+00
 3  0.000E+00 0.000E+00 0.000E+00
 4  0.000E+00 0.000E+00 0.000E+00
 5  0.000E+00 0.000E+00 0.000E+00
 6  0.000E+00 0.000E+00 0.000E+00
 7  0.000E+00 0.000E+00 0.000E+00
 8  0.000E+00 0.000E+00 0.000E+00
 9  0.000E+00 0.000E+00 0.000E+00
10  0.000E+00 0.175E-01 0.000E+00


FS    MATRIX
         1         2         3         4         5         6         7
 1  0.000E+00 0.100E+01 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 2 -0.775E+05-0.629E+03 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 3  0.000E+00 0.000E+00 0.000E+00 0.100E+01 0.000E+00 0.000E+00 0.000E+00
 4  0.000E+00 0.000E+00-0.156E+06-0.759E+03 0.000E+00 0.000E+00 0.000E+00
 5  0.000E+00 0.000E+00 0.000E+00 0.000E+00-0.140E+02 0.000E+00 0.000E+00
 6  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.100E+01
 7  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00-0.775E+05-0.629E+03
 8  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 9  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
10  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
11  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
         8         9        10        11
 1  0.000E+00 0.000E+00 0.000E+00 0.000E+00
 2  0.000E+00 0.000E+00 0.000E+00 0.000E+00
 3  0.000E+00 0.000E+00 0.000E+00 0.000E+00
 4  0.000E+00 0.000E+00 0.000E+00 0.000E+00
 5  0.000E+00 0.000E+00 0.000E+00 0.000E+00
 6  0.000E+00 0.000E+00 0.000E+00 0.000E+00
 7  0.000E+00 0.000E+00 0.000E+00 0.000E+00
 8  0.000E+00 0.100E+01 0.000E+00 0.000E+00
 9 -0.775E+05-0.629E+03 0.000E+00 0.000E+00
```

```
  10 0.000E+00 0.000E+00 0.000E+00 0.100E+01
  11 0.000E+00 0.000E+00-0.156E+06-0.759E+03

 GS    MATRIX
        1         2         3         4         5         6
   1 0.588E+03 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
   2-0.293E+06 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
   3 0.000E+00 0.663E+03 0.000E+00 0.000E+00 0.000E+00 0.000E+00
   4 0.000E+00-0.347E+06 0.000E+00 0.000E+00 0.000E+00 0.000E+00
   5 0.000E+00 0.000E+00 0.140E+02 0.000E+00 0.000E+00 0.000E+00
   6 0.000E+00 0.000E+00 0.000E+00 0.588E+03 0.000E+00 0.000E+00
   7 0.000E+00 0.000E+00 0.000E+00-0.293E+06 0.000E+00 0.000E+00
   8 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.588E+03 0.000E+00
   9 0.000E+00 0.000E+00 0.000E+00 0.000E+00-0.293E+06 0.000E+00
  10 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.663E+03
  11 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00-0.347E+06

 HS    MATRIX
        1         2         3         4         5         6         7
   1 0.100E+01 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
   2 0.000E+00 0.000E+00 0.100E+01 0.000E+00 0.000E+00 0.000E+00 0.000E+00
   3 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.100E+01 0.000E+00 0.000E+00
   4 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.100E+01 0.000E+00
   5 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
   6 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
        8         9        10        11
   1 0.000E+00 0.000E+00 0.000E+00 0.000E+00
   2 0.000E+00 0.000E+00 0.000E+00 0.000E+00
   3 0.000E+00 0.000E+00 0.000E+00 0.000E+00
   4 0.000E+00 0.000E+00 0.000E+00 0.000E+00
   5 0.100E+01 0.000E+00 0.000E+00 0.000E+00
   6 0.000E+00 0.000E+00 0.100E+01 0.000E+00

 GAIN  MATRIX
        1         2         3         4         5         6         7
   1 0.100E+01 0.000E+00 0.000E+00-0.100E+01 0.000E+00 0.000E+00 0.000E+00
   2 0.100E+01 0.000E+00 0.000E+00 0.100E+01 0.000E+00 0.000E+00 0.000E+00
   3 0.000E+00 0.100E+01 0.000E+00 0.000E+00 0.100E+01 0.000E+00 0.000E+00
   4 0.000E+00 0.100E+01 0.000E+00 0.000E+00-0.100E+01 0.000E+00 0.000E+00
   5 0.000E+00 0.000E+00 0.100E+01 0.000E+00 0.000E+00-0.100E+01 0.000E+00
   6 0.000E+00 0.000E+00 0.100E+01 0.000E+00 0.000E+00 0.100E+01 0.000E+00
   7 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00-0.100E+01
   8 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.100E+01
   9 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
  10 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
        8
```

```
 1   0.000E+00
 2   0.000E+00
 3   0.000E+00
 4   0.000E+00
 5   0.000E+00
 6   0.000E+00
 7   0.000E+00
 8   0.000E+00
 9   0.100E+01
10   0.100E+01

                    FUNCTION VALUES

 LONGITUDINAL FUNCTION VALUES

F012 = 0.1606D+01 F020 = 0.7000D+01 F022 = 0.0000D+00

F024 = 0.3666D+01 F025 = 0.1700D+02 F027 = 0.3477D+01

F028 = 0.2965D+02 F29U = 0.3401D+02 F29L = 0.0000D+00

F32A = 0.2724D+00 F32B = 0.1174D+00 F037 = 0.1000D+01

F040 = 0.1235D+00 F068 = 0.3362D+00

 LATERAL FUNCTION VALUES

F001 = 0.3220D+01 F004 = 0.1388D-16 F006 = 0.2000D+00

F007 = 0.1000D+02 F013 = 0.1516D+00 F031 = 0.1600D+00

F034 = 0.1000D+01 F035 = 0.1000D+01 F036 = 0.1000D+01

F039 = -.2220D-15 F041 = 0.1000D+01 F093 = 0.0000D+00

F101 = 0.0000D+00

 DIRECTIONAL FUNCTION VALUES

F010 = 0.8440D+00 F014 = 0.1975D+00 F017 = 0.0000D+00

F030 = 0.6076D+00 F038 = -.8240D-01 F042 = 0.7610D+00

F045 = 0.1000D+01 F090 = 0.1650D+02 F096 = 0.8008D+00
```

```
F112 = 0.0000D+00 F113 = 0.4000D-04 F114 = 0.8234D-01

 FILTER COEFFICIENTS
P2N1  = 0.1000D+01 P2N2  = -.4118D+00 P2D   = 0.4118D+00
P5N1  = 0.1351D+00 P5N2  = 0.1351D+00 P5D   = 0.7297D+00
P9N1  = 0.1250D-01 P9N2  = 0.0000D+00 P9D   = 0.1000D+01
P11N1 = 0.1577D-01 P11N2 = 0.1577D-01 P11D  =0.9685D+00
P12N1 = 0.7849D-02 P12N2 = 0.7849D-02 P12D  = 0.9843D+00
Y3N1  = 0.9938D+00 Y3N2  = -.9938D+00 Y3D   = 0.9876D+00
Y5N1  = 0.1494D+01 Y5N2  = -.1469D+01 Y5D   = 0.9753D+00


              CONTROL SYSTEM COEFFICIENTS

 LONGITUDINAL COEFFICIENTS
QST1  = -.2574D-02 QST2  = 0.7481D-03 QST3  = 0.2144D+00
NZST1 = 0.1914D-01 NZST2 = 0.2108D+00 NZST3 = 0.1314D+00
PXST1 = 0.3828D-01 PXST2 = 0.1945D+01 AALE1 = 0.4124D-01
AALE2 = 0.2095D-01 AATE1 = 0.2188D-01 AATE2 = 0.1103D-01

 LATERAL COEFFICIENTS
RRST = 0.2400D-01 PYST = 0.9764D+00 PZST = -.1166D-16
RRLE = 0.0000D+00 PYLE = 0.0000D+00 RRTE = 0.1920D-01
PYTE = 0.7811D+00 RRA  = 0.6000D-01 PYA  = 0.2441D+01
PZA  = -.2916D-16
```

```
DIRECTIONAL COEFFICIENTS

YRR1 = 0.8564D-02 YRR2 = -.6894D+00 NYR  = 0.1650D+02

RRR1 = -.4940D-02 RRR2 = 0.7804D-04 RRR3 = 0.3881D+00

PYR1 = 0.3175D-02 PYR2 = -.3890D+00 PZR1 = 0.0000D+00

PZR2 = -.9875D-01

AC     MATRIX
          1          2          3          4          5          6          7
 1  0.100E+01  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00
 2  0.000E+00  0.412E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00
 3  0.000E+00  0.000E+00  0.100E+01  0.000E+00  0.000E+00  0.000E+00  0.000E+00
 4  0.000E+00  0.000E+00  0.000E+00  0.730E+00  0.000E+00  0.000E+00  0.000E+00
 5  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.100E+01  0.000E+00  0.000E+00
 6  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.968E+00  0.000E+00
 7  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.984E+00
 8  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00
 9  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00
10  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00
11  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00
12  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00
          8          9         10         11         12
 1  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00
 2  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00
 3  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00
 4  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00
 5  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00
 6  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00
 7  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00
 8  0.988E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00
 9  0.000E+00  0.988E+00  0.000E+00  0.000E+00  0.000E+00
10  0.000E+00  0.000E+00  0.975E+00  0.000E+00  0.000E+00
11  0.000E+00  0.000E+00  0.000E+00  0.975E+00  0.000E+00
12  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.975E+00

BFC    MATRIX
          1          2          3          4          5          6
 1  0.100E+01  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00
 2  0.100E+01  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00
 3  0.000E+00  0.100E+01  0.000E+00  0.000E+00  0.000E+00  0.000E+00
 4  0.000E+00  0.100E+01  0.000E+00  0.000E+00  0.000E+00  0.000E+00
 5  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00
 6  0.000E+00  0.000E+00  0.100E+01  0.000E+00  0.000E+00  0.000E+00
```

```
 7   0.000E+00 0.000E+00 0.100E+01 0.000E+00 0.000E+00 0.000E+00
 8   0.000E+00 0.000E+00 0.000E+00 0.100E+01 0.000E+00 0.000E+00
 9   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.100E+01 0.000E+00
10   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.100E+01 0.000E+00
11   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
12   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00

BC      MATRIX
         1         2         3
 1   0.000E+00 0.000E+00 0.000E+00
 2   0.000E+00 0.000E+00 0.000E+00
 3   0.000E+00 0.000E+00 0.000E+00
 4   0.000E+00 0.000E+00 0.000E+00
 5   0.100E+01 0.000E+00 0.000E+00
 6   0.000E+00 0.000E+00 0.000E+00
 7   0.000E+00 0.000E+00 0.000E+00
 8   0.000E+00 0.000E+00 0.000E+00
 9   0.000E+00 0.000E+00 0.000E+00
10   0.000E+00 0.000E+00 0.000E+00
11   0.000E+00 0.100E+01 0.000E+00
12   0.000E+00 0.000E+00 0.100E+01

CC      MATRIX
         1         2         3         4         5         6         7
 1  -0.257E-02 0.748E-03 0.191E-01 0.211E+00-0.383E-01 0.000E+00 0.000E+00
 2   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.412E-01 0.000E+00
 3   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.219E-01
 4   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 5   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 6   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 7   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 8   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
         8         9        10        11        12
 1   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 2   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 3   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 4   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 5   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 6   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 7   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 8   0.856E-02 0.494E-02-0.780E-04 0.317E-02 0.000E+00

DFC     MATRIX
         1         2         3         4         5         6
 1   0.214E+00 0.131E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
```

```
2   0.000E+00 0.000E+00 0.209E-01 0.000E+00 0.000E+00 0.000E+00
3   0.000E+00 0.000E+00 0.110E-01 0.000E+00 0.000E+00 0.000E+00
4   0.000E+00 0.000E+00 0.000E+00 0.000E+00-0.240E-01 0.000E+00
5   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
6   0.000E+00 0.000E+00 0.000E+00 0.000E+00-0.192E-01 0.000E+00
7   0.000E+00 0.000E+00 0.000E+00 0.000E+00-0.600E-01 0.000E+00
8   0.000E+00 0.000E+00 0.000E+00-0.689E+00-0.388E+00 0.165E+02

DC     MATRIX
          1         2         3
1  -0.195E+01 0.000E+00 0.000E+00
2   0.000E+00 0.000E+00 0.000E+00
3   0.000E+00 0.000E+00 0.000E+00
4   0.000E+00 0.976E+00-0.117E-16
5   0.000E+00 0.000E+00 0.000E+00
6   0.000E+00 0.781E+00 0.000E+00
7   0.000E+00 0.244E+01-0.292E-16
8   0.000E+00-0.389E+00-0.987E-01

AF18   MATRIX
          1         2         3         4         5         6         7
1   0.100E+01 0.909E-03-0.362E+00-0.402E+00 0.000E+00 0.000E+00 0.000E+00
2  -0.903E-03 0.985E+00 0.785E+01-0.179E-01 0.000E+00 0.000E+00 0.000E+00
3   0.209E-06-0.135E-03 0.989E+00 0.738E-05 0.000E+00 0.000E+00 0.000E+00
4   0.118E-08-0.848E-06 0.124E-01 0.100E+01 0.000E+00 0.000E+00 0.000E+00
5   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.997E+00-0.804E+01 0.365E+00
6   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.866E-04 0.997E+00-0.171E-03
7   0.000E+00 0.000E+00 0.000E+00 0.000E+00-0.356E-03 0.100E-01 0.962E+00
8   0.000E+00 0.000E+00 0.000E+00 0.000E+00-0.222E-05 0.631E-03 0.123E-01
9   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
10  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
11  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
12  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
13  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
14  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
15  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
16  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
17  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
18  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
19  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
20  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
21  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
22  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
23  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
24  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
25  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
```

```
26   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
27   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
28   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
29   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
30   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
31   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
32   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
33   0.108E-04-0.723E-02 0.595E+02 0.388E-03 0.000E+00 0.000E+00 0.000E+00
34  -0.580E-02 0.391E+01-0.338E+05-0.209E+00 0.000E+00 0.000E+00 0.000E+00
35  -0.228E-02-0.358E-01-0.440E+00 0.146E-02 0.000E+00 0.000E+00 0.000E+00
36   0.149E+01 0.235E+02 0.277E+03-0.899E+00 0.000E+00 0.000E+00 0.000E+00
37  -0.664E-05 0.141E-01 0.578E-01-0.132E-03 0.000E+00 0.000E+00 0.000E+00
38   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.463E-02 0.599E+02-0.925E-02
39   0.000E+00 0.000E+00 0.000E+00 0.000E+00-0.250E+01-0.340E+05 0.501E+01
40   0.000E+00 0.000E+00 0.000E+00 0.000E+00-0.191E-02 0.528E-01 0.580E+01
41   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.103E+01-0.285E+02-0.330E+04
42   0.000E+00 0.000E+00 0.000E+00 0.000E+00-0.770E-02 0.821E-01-0.241E-02
43   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.505E+01-0.514E+02 0.147E+01
44   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
45   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
46   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
47   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
48   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
49   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
50   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
51   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
52   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
53   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
54   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
55   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
         8         9         10        11        12        13        14
 1   0.000E+00 0.815E-09 0.338E-11 0.993E-14 0.189E-16 0.815E-09 0.338E-11
 2   0.000E+00-0.551E-07-0.305E-09-0.110E-11-0.242E-14-0.551E-07-0.305E-09
 3   0.000E+00-0.455E-08-0.282E-10-0.108E-12-0.245E-15-0.455E-08-0.282E-10
 4   0.000E+00-0.285E-10-0.118E-12-0.347E-15-0.661E-18-0.285E-10-0.118E-12
 5   0.401E+00 0.610E-08 0.416E-10 0.165E-12 0.386E-15-0.610E-08-0.416E-10
 6   0.174E-04-0.216E-09-0.134E-11-0.512E-14-0.117E-16 0.216E-09 0.134E-11
 7  -0.721E-04-0.147E-07-0.916E-10-0.350E-12-0.800E-15 0.147E-07 0.916E-10
 8   0.100E+01-0.927E-10-0.385E-12-0.113E-14-0.216E-17 0.927E-10 0.385E-12
 9   0.000E+00 0.990E+00 0.121E-01 0.664E-04 0.191E-06 0.000E+00 0.000E+00
10   0.000E+00-0.280E+01 0.896E+00 0.906E-02 0.369E-04 0.000E+00 0.000E+00
11   0.000E+00-0.543E+03-0.211E+02 0.300E+00 0.337E-02 0.000E+00 0.000E+00
12   0.000E+00-0.495E+05-0.221E+04-0.755E+02-0.219E+00 0.000E+00 0.000E+00
13   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.990E+00 0.121E-01
14   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00-0.280E+01 0.896E+00
15   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00-0.543E+03-0.211E+02
16   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00-0.495E+05-0.221E+04
17   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
```

```
18  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
19  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
20  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
21  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
22  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
23  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
24  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
25  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
26  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
27  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
28  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
29  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
30  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
31  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
32  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
33  0.000E+00-0.243E-06-0.134E-08-0.466E-11-0.985E-14-0.243E-06-0.134E-08
34  0.000E+00 0.132E-03 0.712E-06 0.244E-08 0.513E-11 0.132E-03 0.712E-06
35  0.000E+00-0.916E-07-0.106E-08-0.539E-11-0.145E-13-0.916E-07-0.106E-08
36  0.000E+00 0.603E-04 0.653E-06 0.322E-08 0.852E-11 0.603E-04 0.653E-06
37  0.000E+00-0.362E-09-0.143E-11-0.408E-14-0.762E-17-0.362E-09-0.143E-11
38  0.828E-03-0.116E-07-0.638E-10-0.222E-12-0.469E-15 0.116E-07 0.638E-10
39 -0.438E+00 0.625E-05 0.338E-07 0.116E-09 0.244E-12-0.625E-05-0.338E-07
40 -0.343E-03-0.788E-07-0.437E-09-0.152E-11-0.321E-14 0.788E-07 0.437E-09
41  0.182E+00 0.426E-04 0.231E-06 0.796E-09 0.167E-11-0.426E-04-0.231E-06
42 -0.287E-02 0.201E-07 0.230E-09 0.116E-11 0.312E-14-0.201E-07-0.230E-09
43  0.177E+01-0.132E-04-0.141E-06-0.694E-09-0.183E-11 0.132E-04 0.141E-06
44  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
45  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
46  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
47  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
48  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
49  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
50  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
51  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
52  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
53  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
54  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
55  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
        15        16        17        18        19        20        21
 1  0.993E-14 0.189E-16 0.183E-09 0.564E-12 0.183E-09 0.564E-12-0.112E-07
 2 -0.110E-11-0.242E-14 0.767E-08 0.370E-10 0.767E-08 0.370E-10 0.160E-06
 3 -0.108E-12-0.245E-15-0.953E-09-0.404E-11-0.953E-09-0.404E-11 0.604E-07
 4 -0.347E-15-0.661E-18-0.609E-11-0.188E-13-0.609E-11-0.188E-13 0.383E-09
 5 -0.165E-12-0.386E-15 0.000E+00 0.000E+00 0.000E+00 0.000E+00-0.221E-06
 6  0.512E-14 0.117E-16 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.122E-07
 7  0.350E-12 0.800E-15 0.000E+00 0.000E+00 0.000E+00 0.000E+00-0.906E-06
 8  0.113E-14 0.216E-17 0.000E+00 0.000E+00 0.000E+00 0.000E+00-0.577E-08
 9  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
```

```
10  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
11  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
12  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
13  0.664E-04 0.191E-06 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
14  0.906E-02 0.369E-04 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
15  0.300E+00 0.337E-02 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
16 -0.755E+02-0.219E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
17  0.000E+00 0.000E+00 0.887E+00 0.645E-02 0.000E+00 0.000E+00 0.000E+00
18  0.000E+00 0.000E+00-0.144E+02 0.184E+00 0.000E+00 0.000E+00 0.000E+00
19  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.887E+00 0.645E-02 0.000E+00
20  0.000E+00 0.000E+00 0.000E+00 0.000E+00-0.144E+02 0.184E+00 0.000E+00
21  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.923E+00
22  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00-0.110E+02
23  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
24  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
25  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
26  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
27  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
28  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
29  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
30  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
31  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
32  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
33 -0.466E-11-0.985E-14-0.514E-07-0.200E-09-0.514E-07-0.200E-09 0.325E-05
34  0.244E-08 0.513E-11 0.278E-04 0.107E-06 0.278E-04 0.107E-06-0.176E-02
35 -0.539E-11-0.145E-13 0.276E-07 0.194E-09 0.276E-07 0.194E-09-0.217E-06
36  0.322E-08 0.852E-11-0.182E-04-0.122E-06-0.182E-04-0.122E-06 0.142E-03
37 -0.408E-14-0.762E-17 0.671E-10 0.222E-12 0.671E-10 0.222E-12 0.596E-09
38  0.222E-12 0.469E-15 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.653E-06
39 -0.116E-09-0.244E-12 0.000E+00 0.000E+00 0.000E+00 0.000E+00-0.353E-03
40  0.152E-11 0.321E-14 0.000E+00 0.000E+00 0.000E+00 0.000E+00-0.488E-05
41 -0.796E-09-0.167E-11 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.264E-02
42 -0.116E-11-0.312E-14 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.154E-08
43  0.694E-09 0.183E-11 0.000E+00 0.000E+00 0.000E+00 0.000E+00-0.917E-06
44  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
45  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
46  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
47  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
48  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
49  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
50  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
51  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
52  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
53  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
54  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
55  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
        22        23        24        25        26        27        28
 1 -0.405E-10-0.112E-07-0.405E-10 0.000E+00 0.000E+00 0.000E+00 0.000E+00
```

```
 2   0.447E-09 0.160E-06 0.447E-09 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 3   0.314E-09 0.604E-07 0.314E-09 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 4   0.138E-11 0.383E-09 0.138E-11 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 5  -0.798E-09 0.221E-06 0.798E-09 0.106E-08-0.584E-12-0.106E-08 0.584E-12
 6   0.631E-10-0.122E-07-0.631E-10-0.263E-09-0.123E-11 0.263E-09 0.123E-11
 7  -0.474E-08 0.906E-06 0.474E-08 0.146E-07 0.686E-10-0.146E-07-0.686E-10
 8  -0.209E-10 0.577E-08 0.209E-10 0.968E-10 0.320E-12-0.968E-10-0.320E-12
 9   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
10   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
11   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
12   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
13   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
14   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
15   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
16   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
17   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
18   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
19   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
20   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
21   0.902E-02 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
22   0.474E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
23   0.000E+00 0.923E+00 0.902E-02 0.000E+00 0.000E+00 0.000E+00 0.000E+00
24   0.000E+00-0.110E+02 0.474E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
25   0.000E+00 0.000E+00 0.000E+00 0.707E+00 0.652E-02 0.000E+00 0.000E+00
26   0.000E+00 0.000E+00 0.000E+00-0.367E+02 0.129E+00 0.000E+00 0.000E+00
27   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.707E+00 0.652E-02
28   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00-0.367E+02 0.129E+00
29   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
30   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
31   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
32   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
33   0.153E-07 0.325E-05 0.153E-07 0.000E+00 0.000E+00 0.000E+00 0.000E+00
34  -0.811E-05-0.176E-02-0.811E-05 0.000E+00 0.000E+00 0.000E+00 0.000E+00
35  -0.193E-08-0.217E-06-0.193E-08 0.000E+00 0.000E+00 0.000E+00 0.000E+00
36   0.120E-05 0.142E-03 0.120E-05 0.000E+00 0.000E+00 0.000E+00 0.000E+00
37   0.115E-11 0.596E-09 0.115E-11 0.000E+00 0.000E+00 0.000E+00 0.000E+00
38   0.306E-08-0.653E-06-0.306E-08-0.144E-07-0.611E-10 0.144E-07 0.611E-10
39  -0.163E-05 0.353E-03 0.163E-05 0.779E-05 0.325E-07-0.779E-05-0.325E-07
40  -0.230E-07 0.488E-05 0.230E-07 0.797E-07 0.341E-09-0.797E-07-0.341E-09
41   0.122E-04-0.264E-02-0.122E-04-0.432E-04-0.182E-06 0.432E-04 0.182E-06
42   0.526E-11-0.154E-08-0.526E-11-0.622E-08-0.541E-10 0.622E-08 0.541E-10
43  -0.308E-08 0.917E-06 0.308E-08 0.420E-05 0.340E-07-0.420E-05-0.340E-07
44   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
45   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
46   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
47   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
48   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
49   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
```

```
 50   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 51   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 52   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 53   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 54   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 55   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
         29        30        31        32        33        34        35
  1   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.689E-11 0.000E+00 0.422E-11
  2   0.000E+00 0.000E+00 0.000E+00 0.000E+00-0.729E-09 0.000E+00-0.447E-09
  3   0.000E+00 0.000E+00 0.000E+00 0.000E+00-0.706E-10 0.000E+00-0.433E-10
  4   0.000E+00 0.000E+00 0.000E+00 0.000E+00-0.241E-12 0.000E+00-0.148E-12
  5   0.127E-07 0.522E-10 0.127E-07 0.522E-10 0.000E+00 0.000E+00 0.000E+00
  6  -0.797E-09-0.357E-11-0.797E-09-0.357E-11 0.000E+00 0.000E+00 0.000E+00
  7   0.121E-08 0.544E-11 0.121E-08 0.544E-11 0.000E+00 0.000E+00 0.000E+00
  8   0.775E-11 0.248E-13 0.775E-11 0.248E-13 0.000E+00 0.000E+00 0.000E+00
  9   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.200E-01 0.000E+00 0.123E-01
 10   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.234E+01 0.000E+00 0.143E+01
 11   0.000E+00 0.000E+00 0.000E+00 0.000E+00-0.425E+03 0.000E+00-0.261E+03
 12   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.558E+05 0.000E+00 0.342E+05
 13   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.200E-01 0.000E+00 0.123E-01
 14   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.234E+01 0.000E+00 0.143E+01
 15   0.000E+00 0.000E+00 0.000E+00 0.000E+00-0.425E+03 0.000E+00-0.261E+03
 16   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.558E+05 0.000E+00 0.342E+05
 17   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 18   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 19   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 20   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 21   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 22   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 23   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 24   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 25   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 26   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 27   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 28   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 29   0.737E+00 0.625E-02 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 30  -0.325E+02 0.116E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 31   0.000E+00 0.000E+00 0.737E+00 0.625E-02 0.000E+00 0.000E+00 0.000E+00
 32   0.000E+00 0.000E+00-0.325E+02 0.116E+00 0.000E+00 0.000E+00 0.000E+00
 33   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.191E+00 0.407E-03-0.192E-08
 34   0.000E+00 0.000E+00 0.000E+00 0.000E+00-0.315E+02-0.652E-01 0.101E-05
 35   0.000E+00 0.000E+00 0.000E+00 0.000E+00-0.333E-08 0.000E+00 0.310E-01
 36   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.201E-05 0.000E+00-0.121E+02
 37   0.000E+00 0.000E+00 0.000E+00 0.000E+00-0.284E-11 0.000E+00-0.174E-11
 38  -0.434E-07-0.178E-09-0.434E-07-0.178E-09 0.000E+00 0.000E+00 0.000E+00
 39   0.235E-04 0.947E-07 0.235E-04 0.947E-07 0.000E+00 0.000E+00 0.000E+00
 40   0.659E-08 0.272E-10 0.659E-08 0.272E-10 0.000E+00 0.000E+00 0.000E+00
 41  -0.357E-05-0.145E-07-0.357E-05-0.145E-07 0.000E+00 0.000E+00 0.000E+00
```

```
42   0.195E-07 0.158E-09 0.195E-07 0.158E-09 0.000E+00 0.000E+00 0.000E+00
43  -0.131E-04-0.994E-07-0.131E-04-0.994E-07 0.000E+00 0.000E+00 0.000E+00
44   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.100E+01 0.000E+00 0.000E+00
45   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.100E+01 0.000E+00 0.000E+00
46   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.100E+01
47   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.100E+01
48   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
49   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
50   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
51   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
52   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
53   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
54   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
55   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
        36        37        38        39        40        41        42
 1   0.000E+00-0.336E-11 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 2   0.000E+00 0.429E-10 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 3   0.000E+00 0.357E-10 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 4   0.000E+00 0.115E-12 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 5   0.000E+00 0.000E+00-0.164E-08 0.000E+00-0.105E-08 0.000E+00 0.392E-07
 6   0.000E+00 0.000E+00 0.120E-09 0.000E+00 0.762E-10 0.000E+00-0.287E-08
 7   0.000E+00 0.000E+00-0.183E-09 0.000E+00-0.897E-09 0.000E+00 0.439E-08
 8   0.000E+00 0.000E+00-0.596E-12 0.000E+00-0.288E-11 0.000E+00 0.143E-10
 9   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.224E-02 0.000E+00 0.000E+00
10   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.262E+00 0.000E+00 0.000E+00
11   0.000E+00 0.000E+00 0.000E+00 0.000E+00-0.476E+02 0.000E+00 0.000E+00
12   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.625E+04 0.000E+00 0.000E+00
13   0.000E+00 0.000E+00 0.000E+00 0.000E+00-0.224E-02 0.000E+00 0.000E+00
14   0.000E+00 0.000E+00 0.000E+00 0.000E+00-0.262E+00 0.000E+00 0.000E+00
15   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.476E+02 0.000E+00 0.000E+00
16   0.000E+00 0.000E+00 0.000E+00 0.000E+00-0.625E+04 0.000E+00 0.000E+00
17   0.000E+00 0.237E-02 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
18   0.000E+00 0.301E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
19   0.000E+00 0.237E-02 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
20   0.000E+00 0.301E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
21   0.000E+00 0.854E-03 0.000E+00 0.000E+00 0.149E-02 0.000E+00 0.000E+00
22   0.000E+00 0.122E+00 0.000E+00 0.000E+00 0.212E+00 0.000E+00 0.000E+00
23   0.000E+00 0.854E-03 0.000E+00 0.000E+00-0.149E-02 0.000E+00 0.000E+00
24   0.000E+00 0.122E+00 0.000E+00 0.000E+00-0.212E+00 0.000E+00 0.000E+00
25   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.176E-01 0.000E+00 0.000E+00
26   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.220E+01 0.000E+00 0.000E+00
27   0.000E+00 0.000E+00 0.000E+00 0.000E+00-0.176E-01 0.000E+00 0.000E+00
28   0.000E+00 0.000E+00 0.000E+00 0.000E+00-0.220E+01 0.000E+00 0.000E+00
29   0.000E+00 0.000E+00-0.181E+00 0.000E+00-0.102E+00 0.000E+00 0.433E+01
30   0.000E+00 0.000E+00-0.224E+02 0.000E+00-0.126E+02 0.000E+00 0.536E+03
31   0.000E+00 0.000E+00-0.181E+00 0.000E+00-0.102E+00 0.000E+00 0.433E+01
32   0.000E+00 0.000E+00-0.224E+02 0.000E+00-0.126E+02 0.000E+00 0.536E+03
33   0.000E+00 0.154E-08 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
```

```
34   0.000E+00-0.808E-06 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
35   0.773E-04-0.197E-09 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
36  -0.277E-01 0.117E-06 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
37   0.000E+00 0.839E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
38   0.000E+00 0.000E+00 0.191E+00 0.407E-03 0.334E-08 0.000E+00-0.126E-06
39   0.000E+00 0.000E+00-0.315E+02-0.652E-01-0.175E-05 0.000E+00 0.661E-04
40   0.000E+00 0.000E+00-0.807E-09 0.000E+00 0.191E+00 0.407E-03 0.193E-07
41   0.000E+00 0.000E+00 0.424E-06 0.000E+00-0.315E+02-0.652E-01-0.101E-04
42   0.000E+00 0.000E+00-0.810E-08 0.000E+00-0.474E-08 0.000E+00 0.310E-01
43   0.000E+00 0.000E+00 0.486E-05 0.000E+00 0.284E-05 0.000E+00-0.121E+02
44   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
45   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
46   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
47   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
48   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
49   0.000E+00 0.100E+01 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
50   0.000E+00 0.100E+01 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
51   0.000E+00 0.000E+00 0.100E+01 0.000E+00 0.000E+00 0.000E+00 0.000E+00
52   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.100E+01 0.000E+00 0.000E+00
53   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.100E+01 0.000E+00 0.000E+00
54   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
55   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
        43        44        45        46        47        48        49
 1   0.000E+00-0.827E-13 0.240E-13 0.615E-12 0.677E-11-0.123E-11 0.346E-12
 2   0.000E+00 0.875E-11-0.254E-11-0.651E-10-0.717E-09 0.130E-09 0.345E-10
 3   0.000E+00 0.848E-12-0.247E-12-0.631E-11-0.695E-10 0.126E-10-0.345E-11
 4   0.000E+00 0.289E-14-0.841E-15-0.215E-13-0.237E-12 0.430E-13-0.115E-13
 5   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 6   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 7   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 8   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 9   0.000E+00-0.240E-03 0.699E-04 0.179E-02 0.197E-01-0.358E-02 0.000E+00
10   0.000E+00-0.281E-01 0.816E-02 0.209E+00 0.230E+01-0.417E+00 0.000E+00
11   0.000E+00 0.510E+01-0.148E+01-0.380E+02-0.418E+03 0.759E+02 0.000E+00
12   0.000E+00-0.671E+03 0.195E+03 0.499E+04 0.549E+05-0.997E+04 0.000E+00
13   0.000E+00-0.240E-03 0.699E-04 0.179E-02 0.197E-01-0.358E-02 0.000E+00
14   0.000E+00-0.281E-01 0.816E-02 0.209E+00 0.230E+01-0.417E+00 0.000E+00
15   0.000E+00 0.510E+01-0.148E+01-0.380E+02-0.418E+03 0.759E+02 0.000E+00
16   0.000E+00-0.671E+03 0.195E+03 0.499E+04 0.549E+05-0.997E+04 0.000E+00
17   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.466E-02
18   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.593E+00
19   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.466E-02
20   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.593E+00
21   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
22   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
23   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
24   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
25   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
```

```
26  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
27  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
28  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
29  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
30  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
31  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
32  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
33  0.000E+00 0.376E-10-0.109E-10-0.280E-09-0.308E-08 0.560E-09-0.152E-09
34  0.000E+00-0.198E-07 0.574E-08 0.147E-06 0.162E-05-0.294E-06 0.796E-07
35  0.000E+00 0.400E-10-0.116E-10-0.298E-09-0.328E-08 0.595E-09 0.250E-09
36  0.000E+00-0.241E-07 0.700E-08 0.179E-06 0.197E-05-0.358E-06-0.150E-06
37  0.000E+00 0.341E-13-0.992E-14-0.254E-12-0.279E-11 0.508E-12 0.144E-12
38  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
39  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
40  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
41  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
42  0.773E-04 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
43 -0.277E-01 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
44  0.000E+00 0.100E+01 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
45  0.000E+00 0.000E+00 0.412E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
46  0.000E+00 0.000E+00 0.000E+00 0.100E+01 0.000E+00 0.000E+00 0.000E+00
47  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.730E+00 0.000E+00 0.000E+00
48  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.100E+01 0.000E+00
49  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.968E+00
50  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
51  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
52  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
53  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
54  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
55  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
       50        51        52        53        54        55
 1 -0.702E-11 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 2  0.503E-10 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 3  0.742E-10 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 4  0.240E-12 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 5  0.000E+00 0.204E-10 0.117E-10-0.186E-12 0.755E-11 0.000E+00
 6  0.000E+00-0.149E-11-0.858E-12 0.136E-13-0.552E-12 0.000E+00
 7  0.000E+00 0.228E-11 0.131E-11-0.208E-13 0.845E-12 0.000E+00
 8  0.000E+00 0.741E-14 0.427E-14-0.675E-16 0.275E-14 0.000E+00
 9  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
10  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
11  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
12  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
13  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
14  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
15  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
16  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
17  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
```

```
18   0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00
19   0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00
20   0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00
21   0.169E-02  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00
22   0.242E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00
23   0.169E-02  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00
24   0.242E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00
25   0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00
26   0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00
27   0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00
28   0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00
29   0.000E+00  0.225E-02  0.130E-02-0.205E-04  0.834E-03  0.000E+00
30   0.000E+00  0.278E+00  0.160E+00-0.253E-02  0.103E+00  0.000E+00
31   0.000E+00  0.225E-02  0.130E-02-0.205E-04  0.834E-03  0.000E+00
32   0.000E+00  0.278E+00  0.160E+00-0.253E-02  0.103E+00  0.000E+00
33   0.321E-08  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00
34  -0.168E-05  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00
35  -0.642E-09  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00
36   0.383E-06  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00
37   0.748E-13  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00
38   0.000E+00-0.654E-10-0.377E-10  0.596E-12-0.243E-10  0.000E+00
39   0.000E+00  0.343E-07  0.198E-07-0.313E-09  0.127E-07  0.000E+00
40   0.000E+00  0.100E-10  0.578E-11-0.914E-13  0.372E-11  0.000E+00
41   0.000E+00-0.526E-08-0.304E-08  0.480E-10-0.195E-08  0.000E+00
42   0.000E+00  0.101E-09  0.580E-10-0.917E-12  0.373E-10  0.000E+00
43   0.000E+00-0.604E-07-0.348E-07  0.550E-09-0.224E-07  0.000E+00
44   0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00
45   0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00
46   0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00
47   0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00
48   0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00
49   0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00
50   0.984E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00
51   0.000E+00  0.988E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00
52   0.000E+00  0.000E+00  0.988E+00  0.000E+00  0.000E+00  0.000E+00
53   0.000E+00  0.000E+00  0.000E+00  0.975E+00  0.000E+00  0.000E+00
54   0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.975E+00  0.000E+00
55   0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.975E+00

BF18   MATRIX
          1          2          3
1  -0.625E-10  0.000E+00  0.000E+00
2   0.662E-08  0.000E+00  0.000E+00
3   0.641E-09  0.000E+00  0.000E+00
4   0.219E-11  0.000E+00  0.000E+00
5   0.000E+00  0.407E-08-0.235E-09
6   0.000E+00-0.291E-09  0.172E-10
```

```
 7   0.000E+00 0.322E-07-0.263E-10
 8   0.000E+00 0.103E-09-0.854E-13
 9  -0.182E+00-0.912E-01 0.109E-17
10  -0.212E+02-0.106E+02 0.127E-15
11   0.386E+04 0.194E+04-0.231E-13
12  -0.507E+06-0.254E+06 0.304E-11
13  -0.182E+00 0.912E-01-0.109E-17
14  -0.212E+02 0.106E+02-0.127E-15
15   0.386E+04-0.194E+04 0.231E-13
16  -0.507E+06 0.254E+06-0.304E-11
17   0.000E+00 0.000E+00 0.000E+00
18   0.000E+00 0.000E+00 0.000E+00
19   0.000E+00 0.000E+00 0.000E+00
20   0.000E+00 0.000E+00 0.000E+00
21   0.000E+00-0.605E-01 0.000E+00
22   0.000E+00-0.863E+01 0.000E+00
23   0.000E+00 0.605E-01 0.000E+00
24   0.000E+00 0.863E+01 0.000E+00
25   0.000E+00-0.716E+00 0.855E-17
26   0.000E+00-0.896E+02 0.107E-14
27   0.000E+00 0.716E+00-0.855E-17
28   0.000E+00 0.896E+02-0.107E-14
29   0.000E+00-0.102E+00-0.259E-01
30   0.000E+00-0.126E+02-0.321E+01
31   0.000E+00-0.102E+00-0.259E-01
32   0.000E+00-0.126E+02-0.321E+01
33   0.284E-07 0.000E+00 0.000E+00
34  -0.149E-04 0.000E+00 0.000E+00
35   0.303E-07 0.000E+00 0.000E+00
36  -0.182E-04 0.000E+00 0.000E+00
37   0.258E-10 0.000E+00 0.000E+00
38   0.000E+00-0.124E-07 0.754E-09
39   0.000E+00 0.650E-05-0.396E-06
40   0.000E+00 0.139E-06-0.116E-09
41   0.000E+00-0.728E-04 0.607E-07
42   0.000E+00 0.261E-08-0.116E-08
43   0.000E+00-0.156E-05 0.696E-06
44   0.000E+00 0.000E+00 0.000E+00
45   0.000E+00 0.000E+00 0.000E+00
46   0.000E+00 0.000E+00 0.000E+00
47   0.000E+00 0.000E+00 0.000E+00
48   0.100E+01 0.000E+00 0.000E+00
49   0.000E+00 0.000E+00 0.000E+00
50   0.000E+00 0.000E+00 0.000E+00
51   0.000E+00 0.000E+00 0.000E+00
52   0.000E+00 0.000E+00 0.000E+00
53   0.000E+00 0.000E+00 0.000E+00
54   0.000E+00 0.100E+01 0.000E+00
```

```
55   0.000E+00 0.000E+00 0.100E+01

 CF18   MATRIX
          1         2         3         4         5         6         7
  1  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
  2  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
  3  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
  4  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
  5  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
  6  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
  7  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
  8  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
  9  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 10  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 11  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 12  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 13  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 14  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
          8         9        10        11        12        13        14
  1  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
  2  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
  3  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
  4  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
  5  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
  6  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
  7  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
  8  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
  9  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 10  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 11  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 12  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 13  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 14  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
         15        16        17        18        19        20        21
  1  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
  2  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
  3  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
  4  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
  5  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
  6  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
  7  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
  8  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
  9  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 10  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 11  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 12  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 13  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
```

```
 14 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
        22        23        24        25        26        27        28
  1 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
  2 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
  3 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
  4 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
  5 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
  6 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
  7 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
  8 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
  9 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 10 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 11 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 12 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 13 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 14 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
        29        30        31        32        33        34        35
  1 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.100E+01 0.000E+00 0.000E+00
  2 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.100E+01
  3 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
  4 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
  5 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
  6 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
  7 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.214E+00 0.000E+00 0.131E+00
  8 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
  9 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 10 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 11 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 12 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 13 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 14 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
        36        37        38        39        40        41        42
  1 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
  2 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
  3 0.000E+00 0.100E+01 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
  4 0.000E+00 0.000E+00 0.100E+01 0.000E+00 0.000E+00 0.000E+00 0.000E+00
  5 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.100E+01 0.000E+00 0.000E+00
  6 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.100E+01
  7 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
  8 0.000E+00 0.209E-01 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
  9 0.000E+00 0.110E-01 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 10 0.000E+00 0.000E+00 0.000E+00 0.000E+00-0.240E-01 0.000E+00 0.000E+00
 11 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 12 0.000E+00 0.000E+00 0.000E+00 0.000E+00-0.192E-01 0.000E+00 0.000E+00
 13 0.000E+00 0.000E+00 0.000E+00 0.000E+00-0.600E-01 0.000E+00 0.000E+00
 14 0.000E+00 0.000E+00-0.689E+00 0.000E+00-0.388E+00 0.000E+00 0.165E+02
        43        44        45        46        47        48        49
  1 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
```

```
 2   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 3   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 4   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 5   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 6   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 7   0.000E+00-0.257E-02 0.748E-03 0.191E-01 0.211E+00-0.383E-01 0.000E+00
 8   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.412E-01
 9   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
10   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
11   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
12   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
13   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
14   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
         50        51        52        53        54        55
 1   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 2   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 3   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 4   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 5   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 6   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 7   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 8   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 9   0.219E-01 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
10   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
11   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
12   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
13   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
14   0.000E+00 0.856E-02 0.494E-02-0.780E-04 0.317E-02 0.000E+00

DF18  MATRIX
         1         2         3
 1   0.000E+00 0.000E+00 0.000E+00
 2   0.000E+00 0.000E+00 0.000E+00
 3   0.000E+00 0.000E+00 0.000E+00
 4   0.000E+00 0.000E+00 0.000E+00
 5   0.000E+00 0.000E+00 0.000E+00
 6   0.000E+00 0.000E+00 0.000E+00
 7  -0.195E+01 0.000E+00 0.000E+00
 8   0.000E+00 0.000E+00 0.000E+00
 9   0.000E+00 0.000E+00 0.000E+00
10   0.000E+00 0.976E+00-0.117E-16
11   0.000E+00 0.000E+00 0.000E+00
12   0.000E+00 0.781E+00 0.000E+00
13   0.000E+00 0.244E+01-0.292E-16
14   0.000E+00-0.389E+00-0.987E-01
```

APPENDIX L

MCDONNELL DOUGLAS MODEL RESPONSE PLOTS

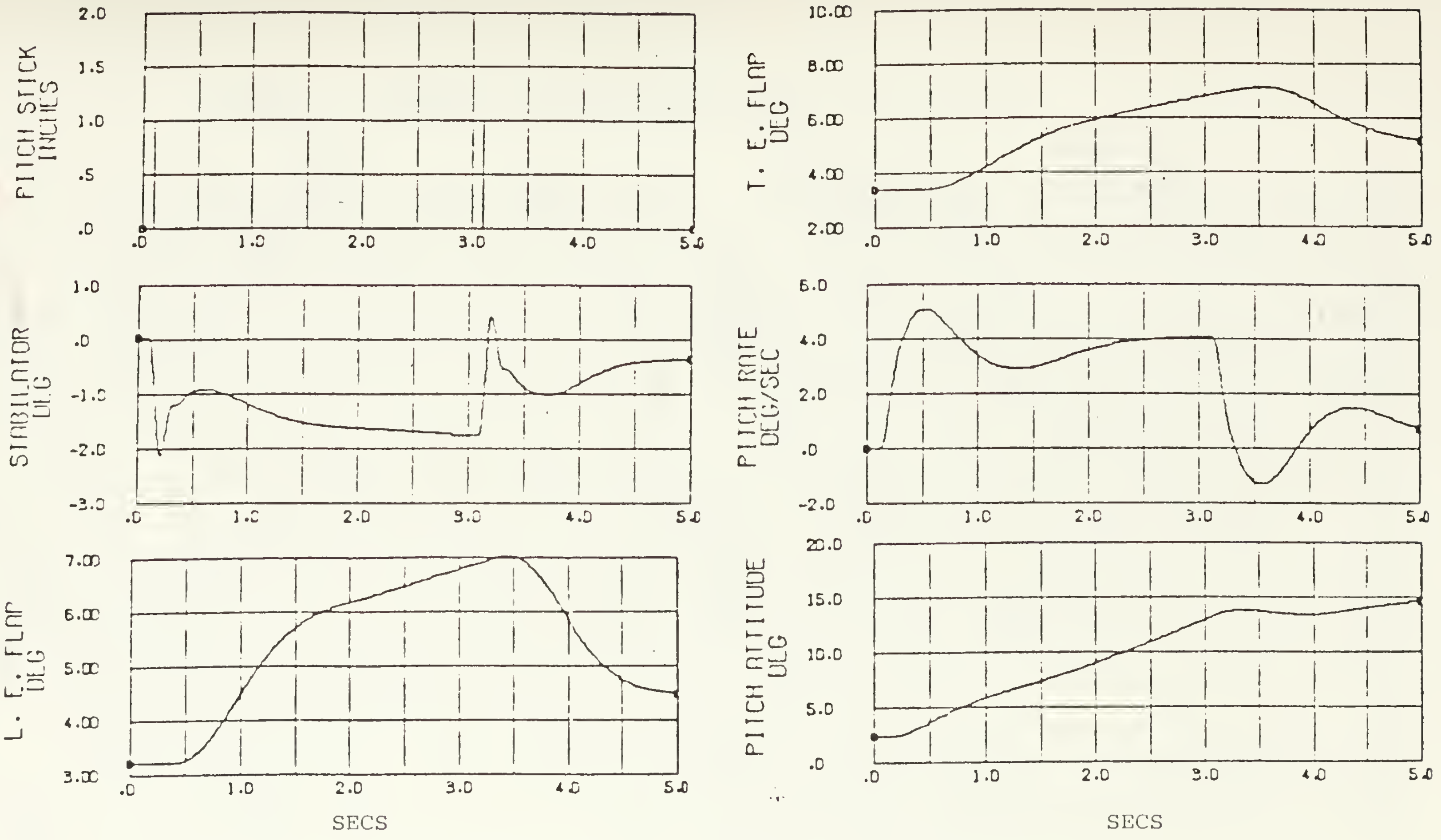


Figure L.1 Longitudinal Stick Response Mach 0.6/10,000 Feet

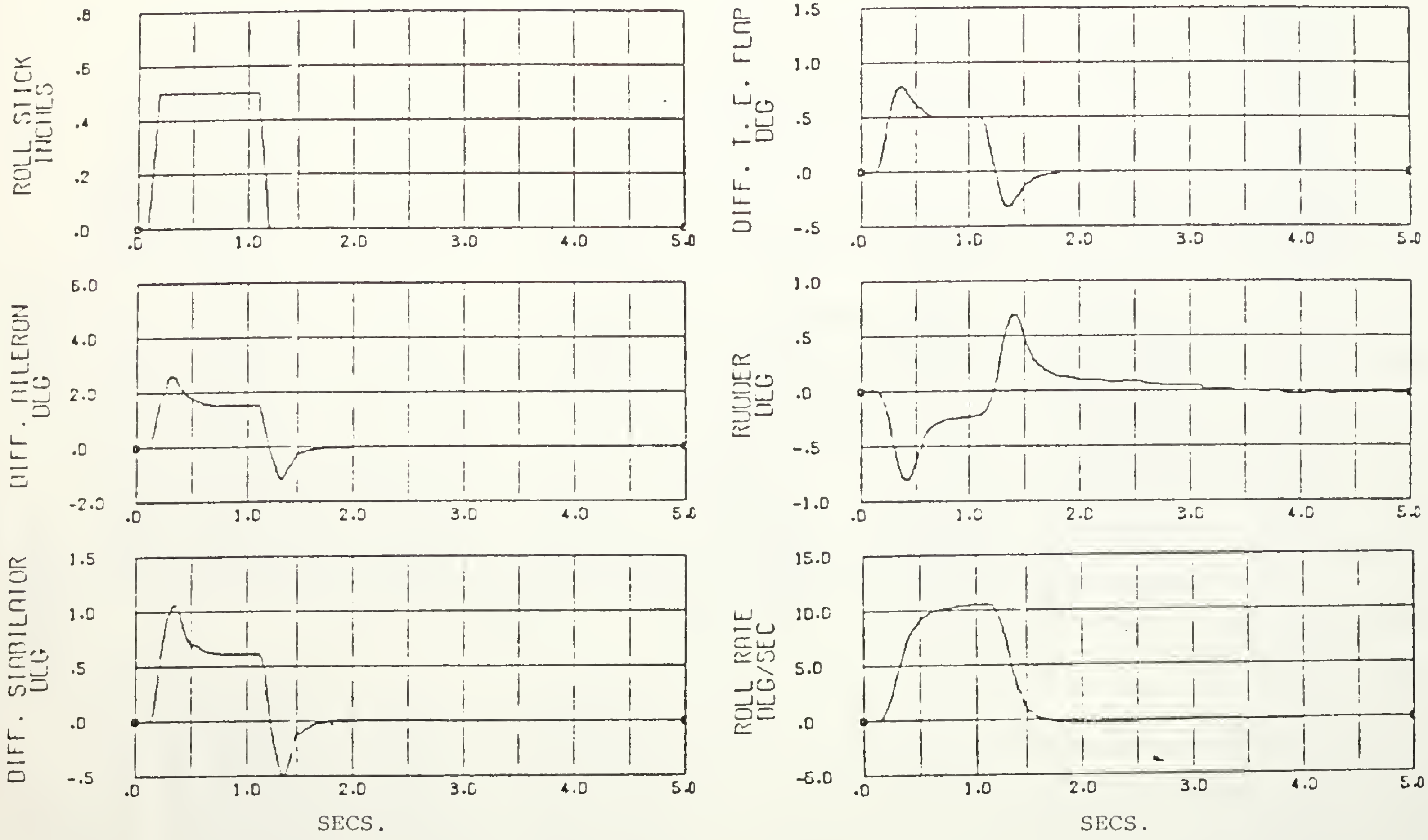


Figure L.2 Lateral Stick Response Mach 0.6/10,000 Feet

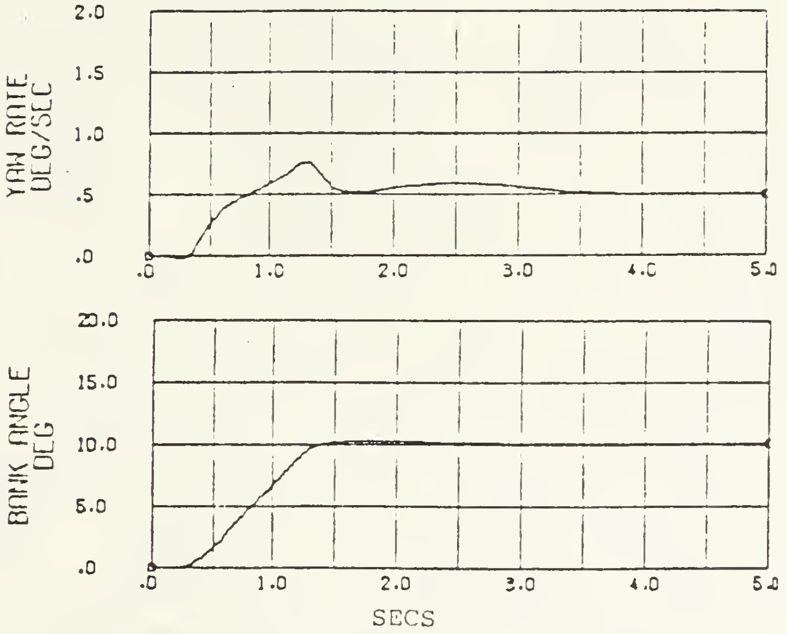


Figure L.2 Continued

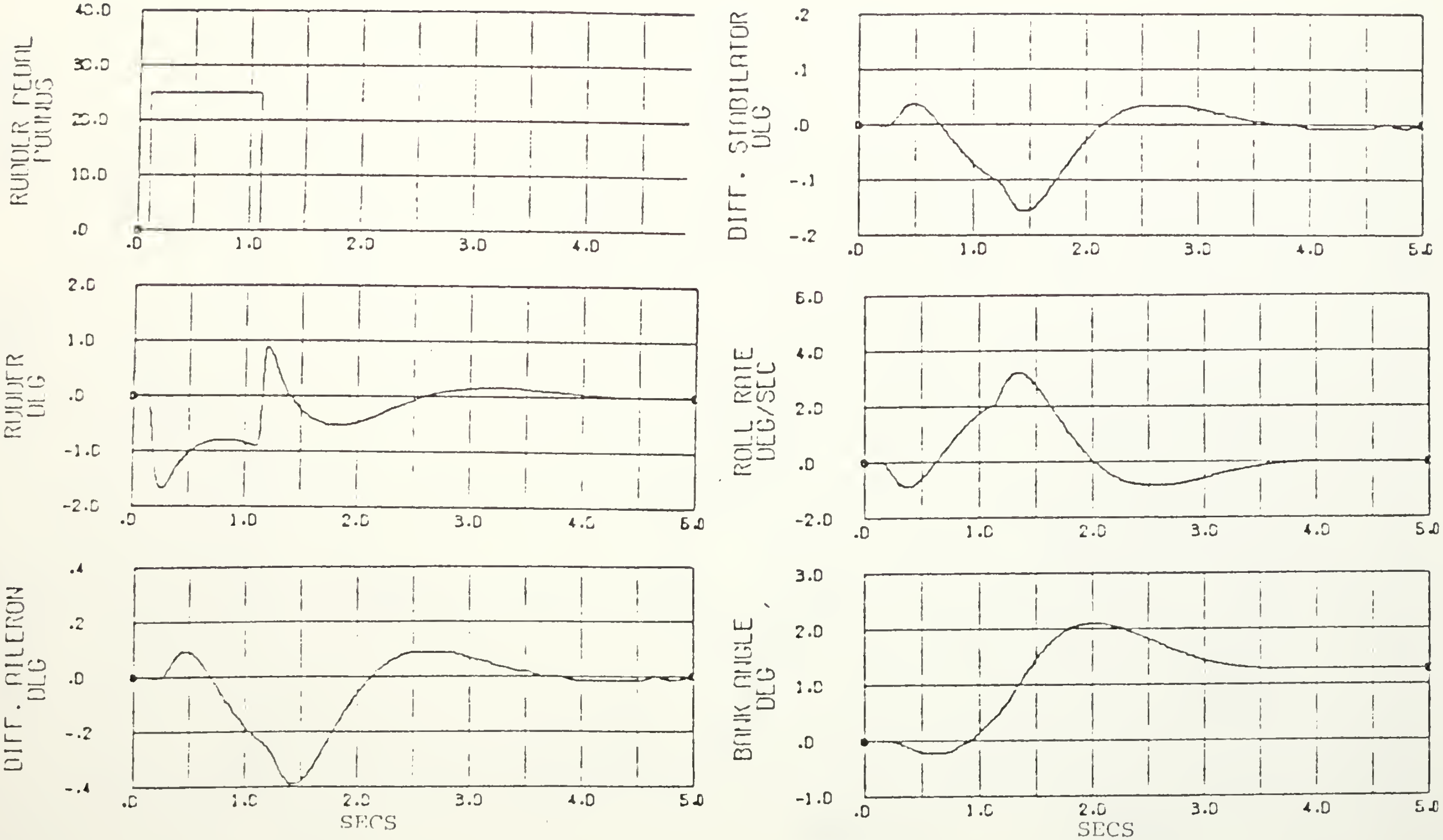


Figure L.3 Rudder Response Mach 0.6/10,000 Feet

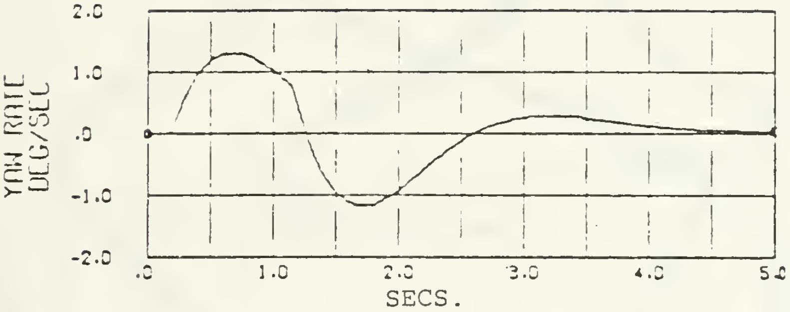


Figure L.3 Continued

APPENDIX M THESIS MODEL RESPONSE PLOTS

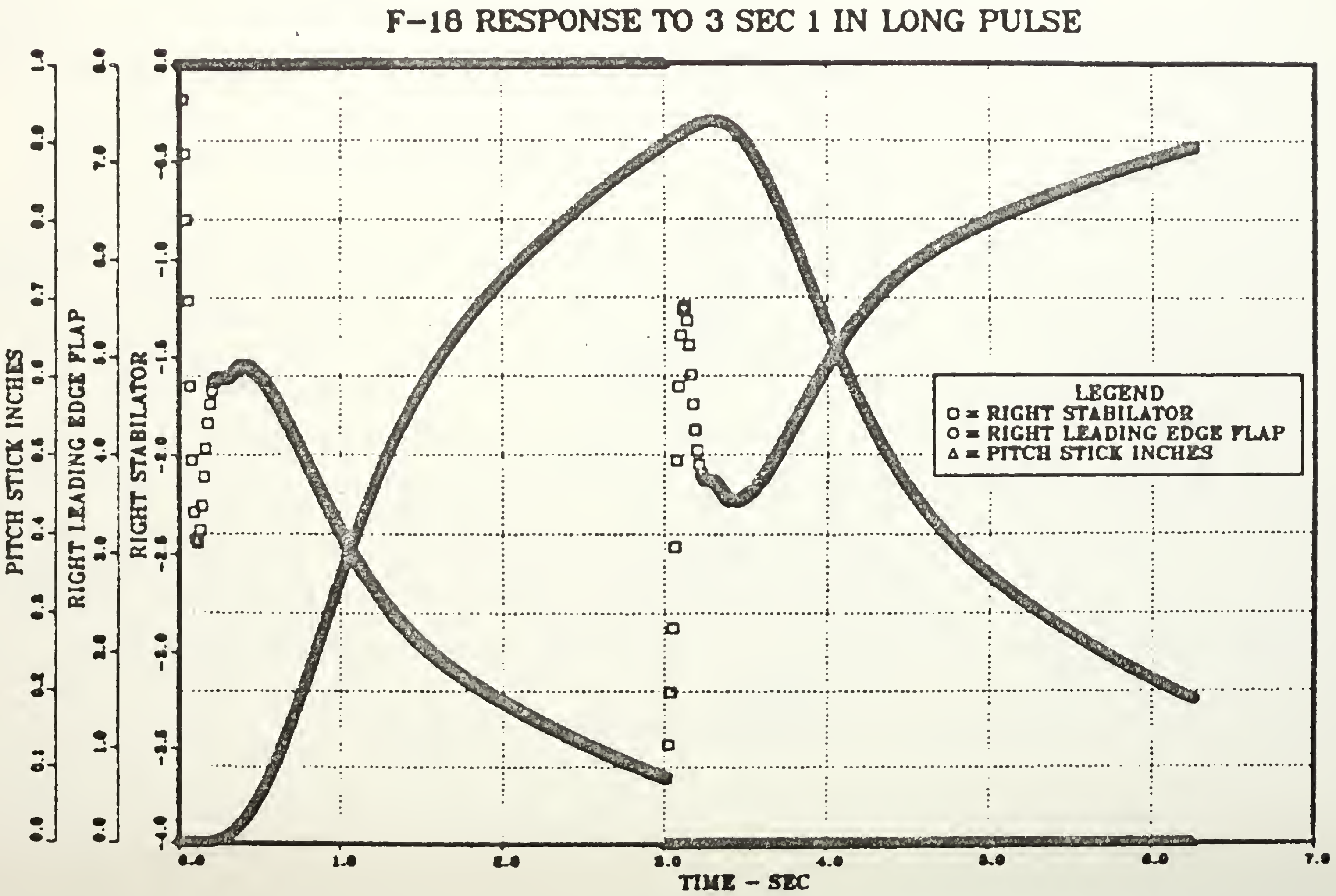


Figure M.1

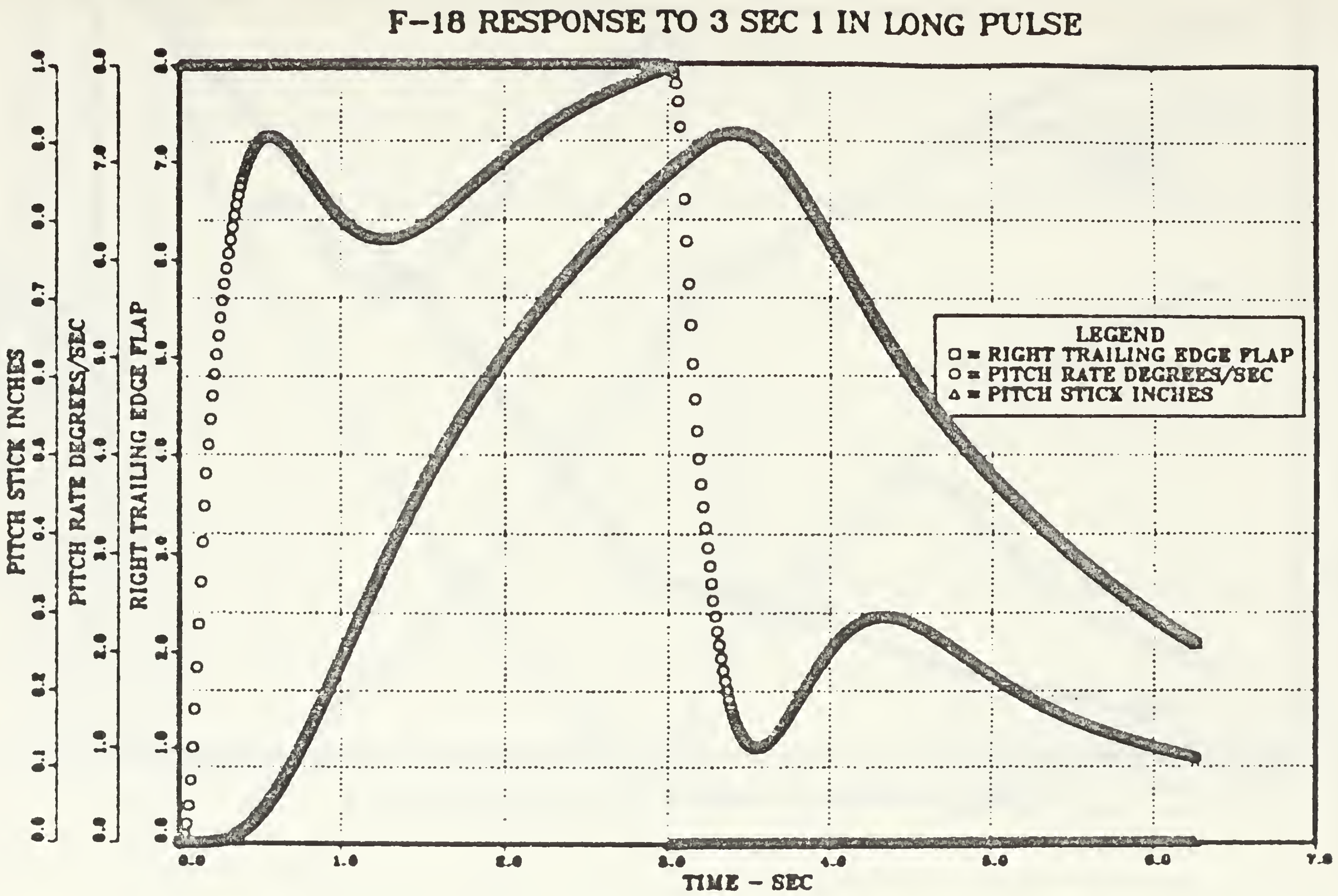

F-18 RESPONSE TO 3 SEC 1 IN LONG PULSE
LEGEND
□ = RIGHT TRAILING EDGE FLAP
○ = PITCH RATE DEGREES/SEC
△ = PITCH STICK INCHES
PITCH STICK INCHES
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
PITCH RATE DEGREES/SEC
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
RIGHT TRAILING EDGE FLAP
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
TIME - SEC
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0

Figure M.2

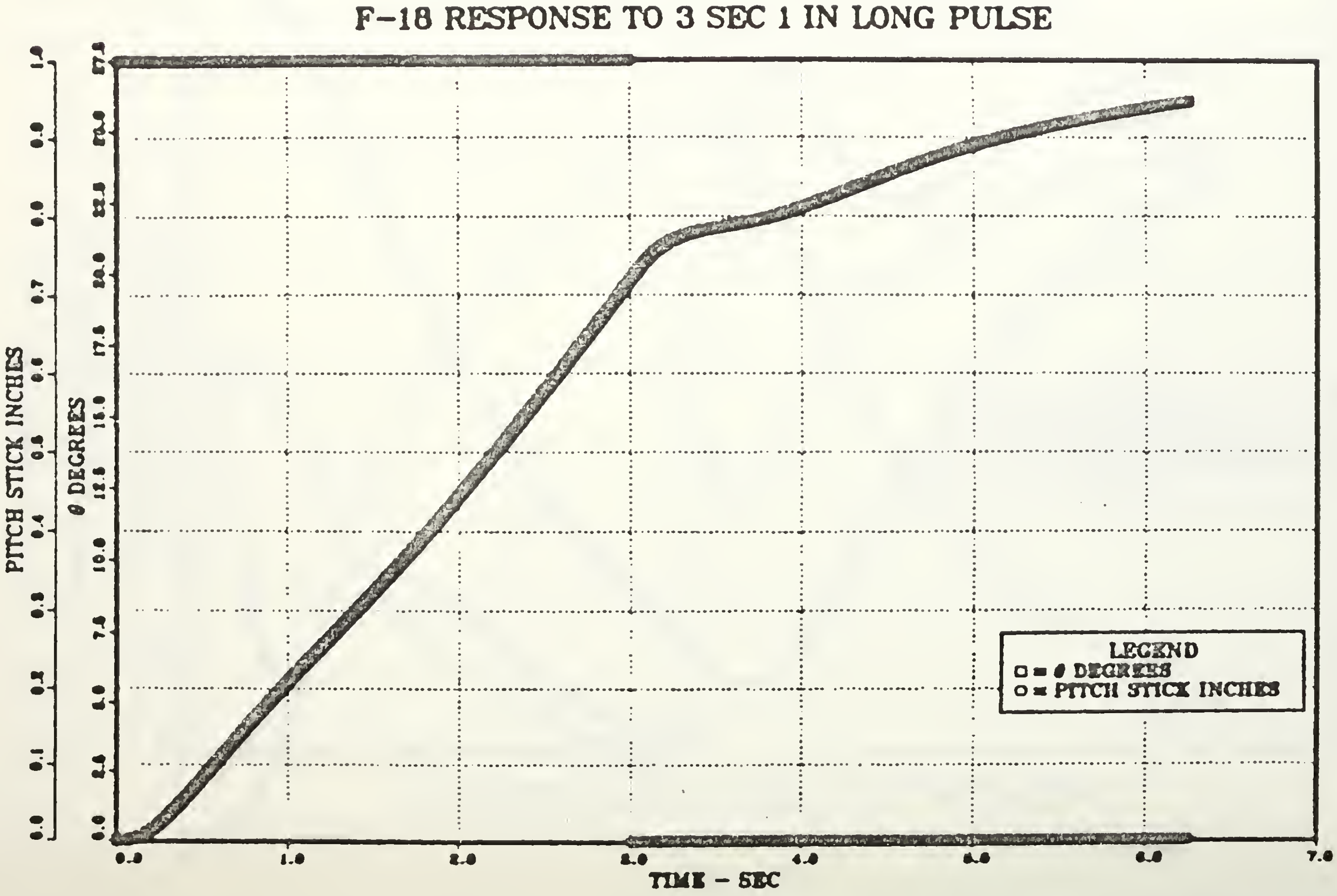
F-18 RESPONSE TO 3 SEC 1 IN LONG PULSE
PITCH STICK INCHES
θ DEGREES
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
0.0
2.5
5.0
7.5
10.0
12.5
15.0
17.5
20.0
22.5
25.0
27.5
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
TIME - SEC
LEGEND
□ = θ DEGREES
○ = PITCH STICK INCHES

Figure M.3

F-18 RESPONSE TO 1.0 IN 3 SEC.
LONGITUDINAL PULSE WITH
RIGHT STABILATOR CENTERED AND LOCKED

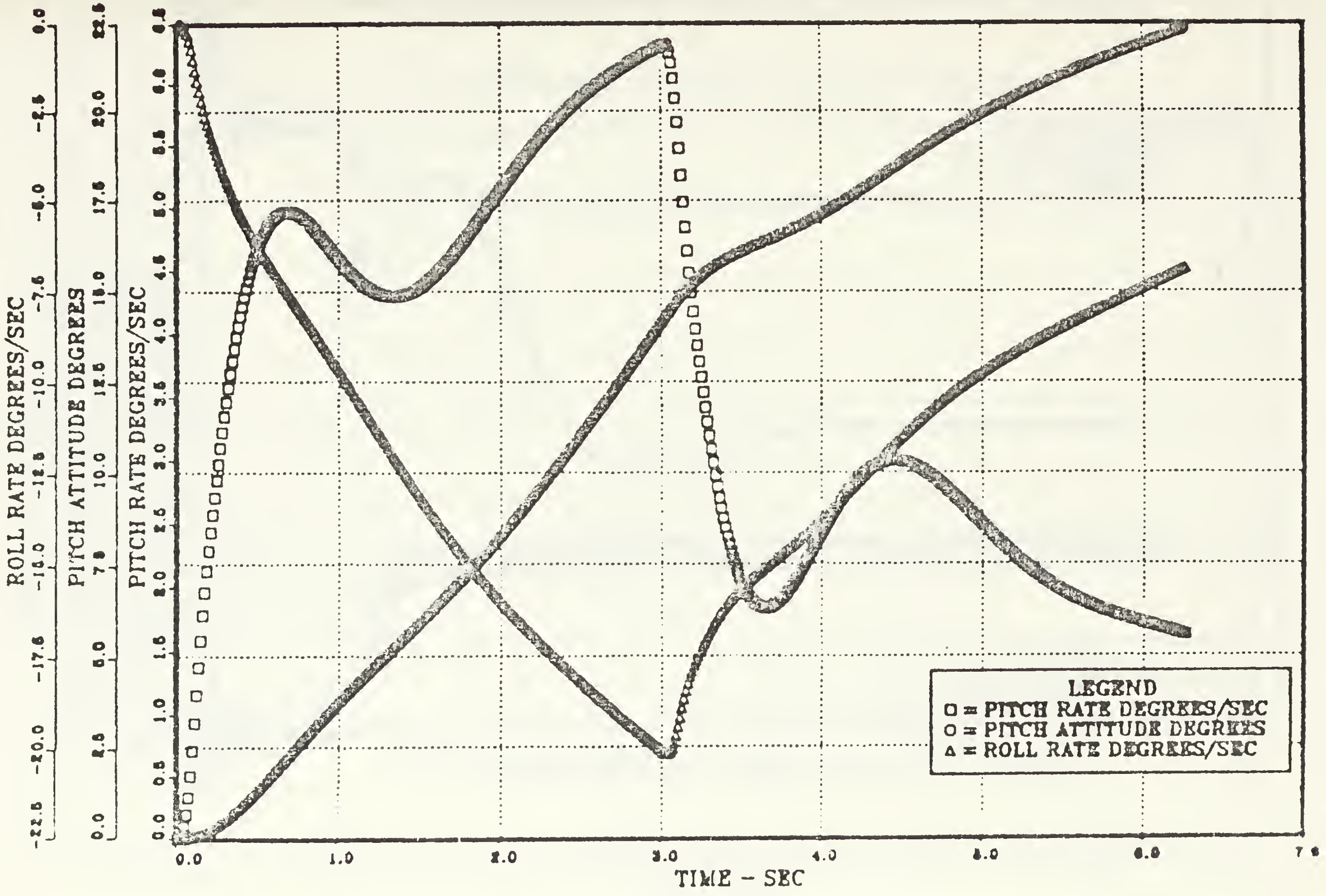


Figure M.4

F–18 RESPONSE TO 1 SEC 0.5 IN LAT PULSE

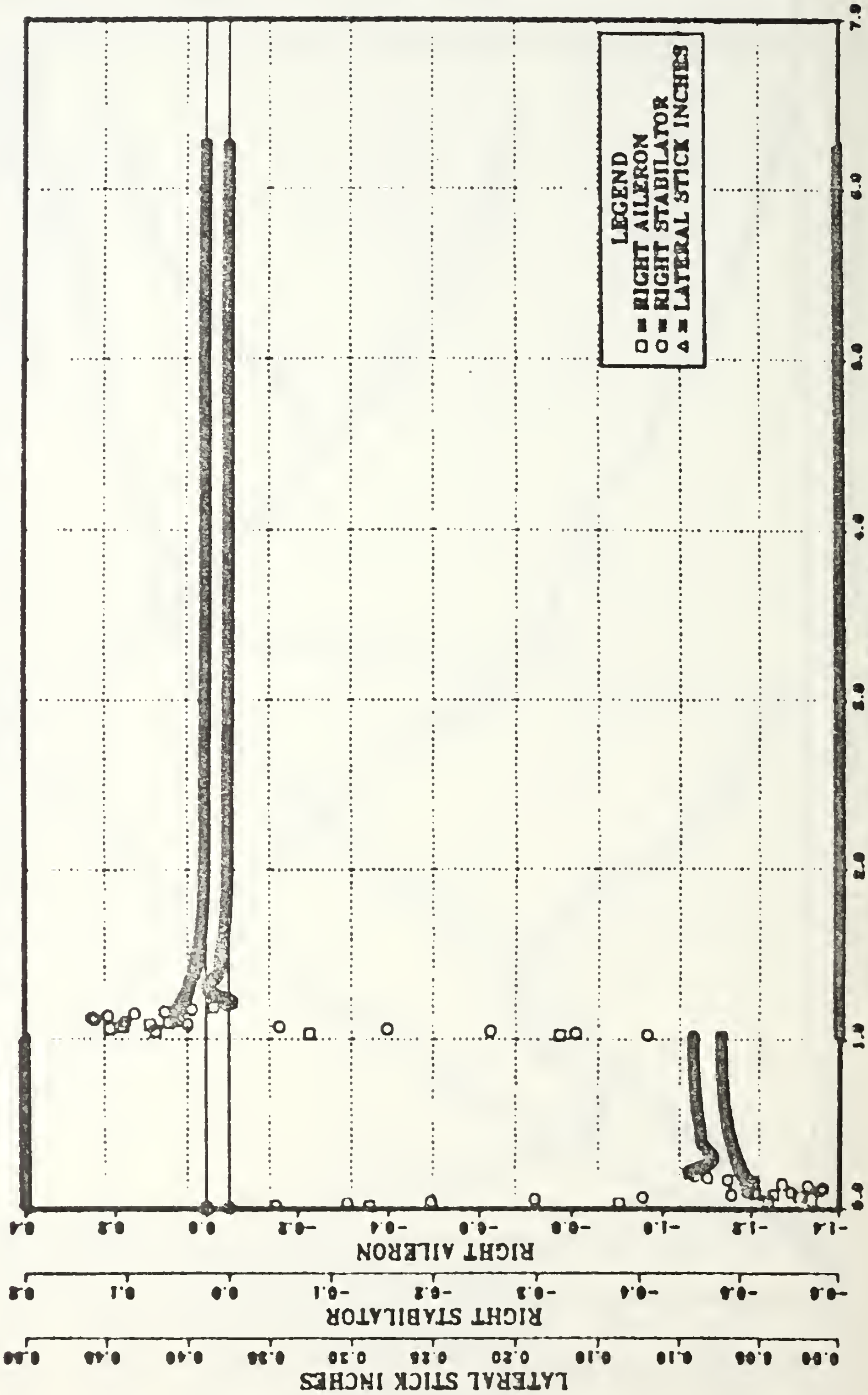


Figure M.5

F-18 RESPONSE TO 1 SEC 0.5 IN LAT PULSE

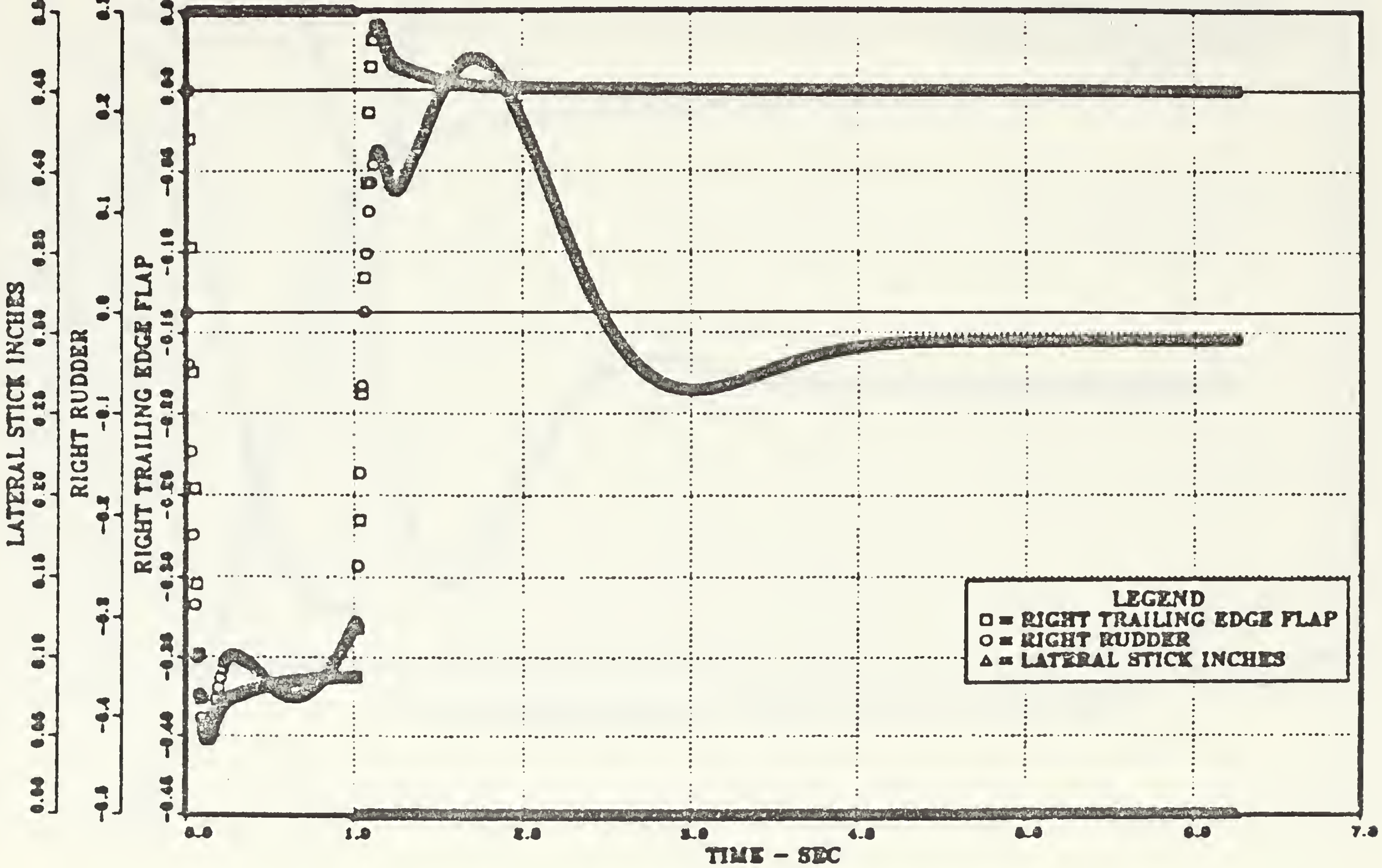


Figure M.6

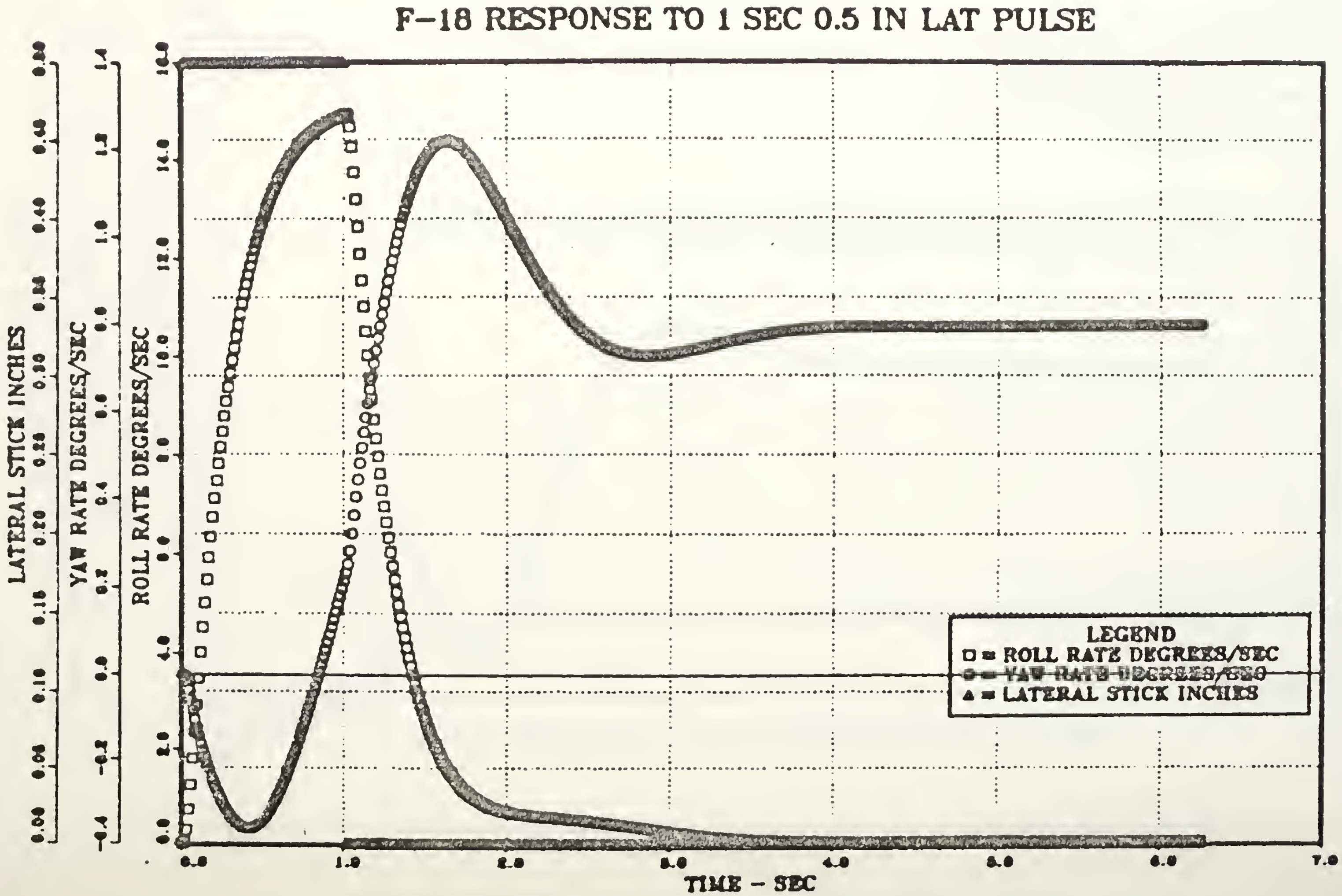

F-18 RESPONSE TO 1 SEC 0.5 IN LAT PULSE
LATERAL STICK INCHES
0.00
0.05
0.10
0.15
0.20
0.25
0.30
0.35
0.40
0.45
0.50
YAW RATE DEGREES/SEC
-0.4
-0.2
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
ROLL RATE DEGREES/SEC
0.0
2.0
4.0
6.0
8.0
10.0
12.0
14.0
16.0
TIME - SEC
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
LEGEND
□ = ROLL RATE DEGREES/SEC
○ = YAW RATE DEGREES/SEC
▲ = LATERAL STICK INCHES

Figure M.7

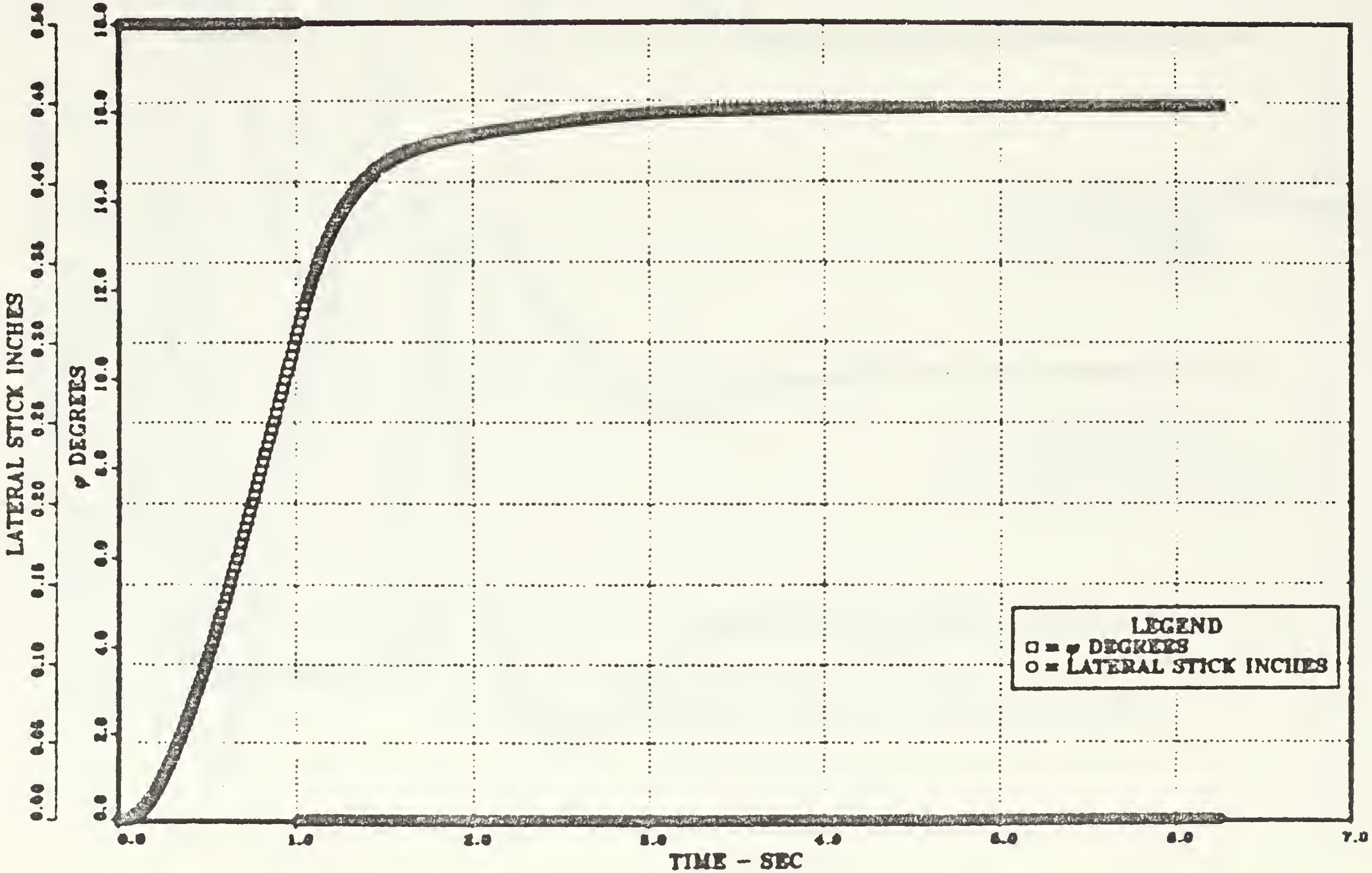

F-18 RESPONSE TO 1 SEC 0.5 IN LAT PULSE

Figure M.8

F-18 RESPONSE TO 1 SEC 0.5 IN DIR PULSE

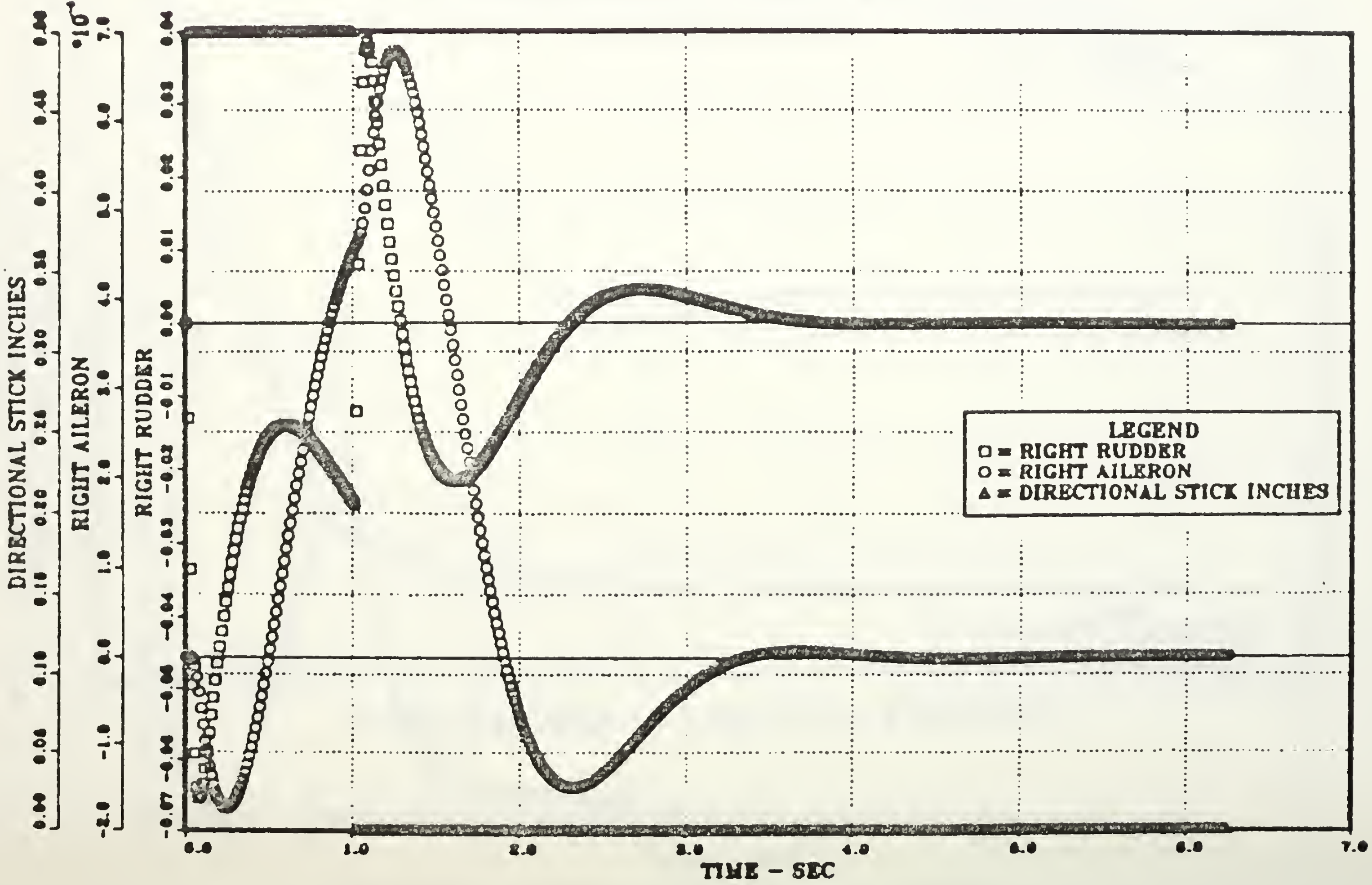


Figure M.9

F-18 RESPONSE TO 1 SEC 0.5 IN DIR PULSE

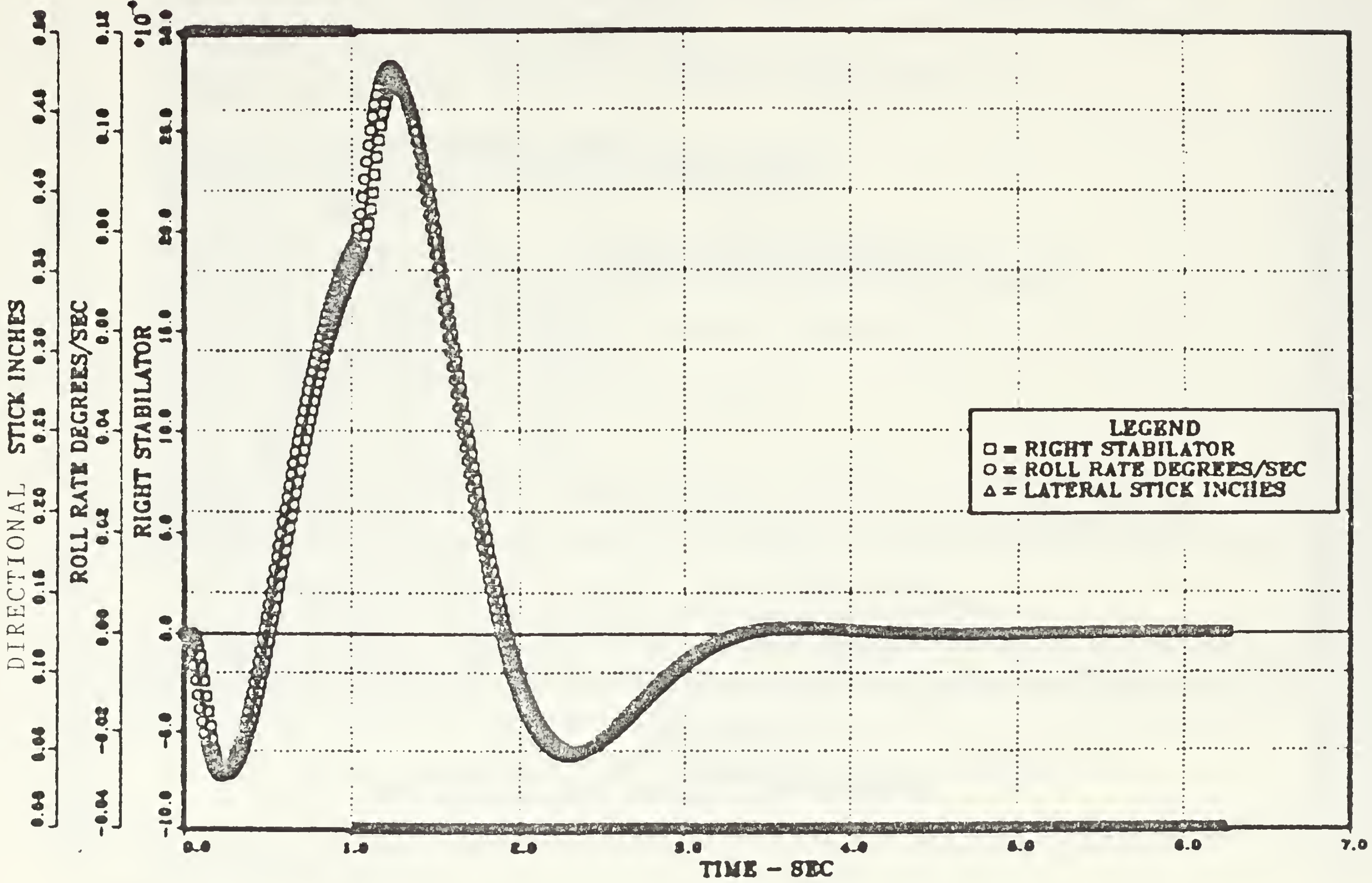


Figure M.10

APPENDIX N COMPUTER PROGRAM

```
C***********************************************************************FAG00010
C                                                                       FAG00020
C                 F/A-18 DYNAMIC SIMULATION PROGRAM                     FAG00030
C                    VERSION 1.01    FEBRUARY 1986                      FAG00040
C                        LT F.W. ROJEK,USN                              FAG00050
C                        CDR V.F. GAVITO,USN                            FAG00060
C                                                                       FAG00070
C***********************************************************************FAG00080
      IMPLICIT REAL*8(A-H,O-Z)                                          FAG00090
      REAL*8  LIMIT,MIN,MACH,NZ,NZST1,NZST2,NZST3,NYR                   FAG00100
      INTEGER RSTF                                                      FAG00110
C                                                                       FAG00120
C     AIRFRAME MATRICIES                                                FAG00130
C                                                                       FAG00140
      DIMENSION FX(4,4),GX(4,3),HX(3,4),DX(3,3),FYZ(4,4),GYZ(4,5),      FAG00150
     *HYZ(3,4),DYZ(3,5)                                                 FAG00160
      DIMENSION NFX(2),NGX(2),NHX(2),NDX(2),NFYZ(2),NGYZ(2),NHYZ(2),    FAG00170
     *NDYZ(2)                                                           FAG00180
C                                                                       FAG00190
C     LONG AND LATD MATRICIES                                           FAG00200
C                                                                       FAG00210
      REAL*8 LONG(3,10),LATD(5,10)                                      FAG00220
      DIMENSION NLONG(2),NLATD(2)                                       FAG00230
C                                                                       FAG00240
C     MODIFIED AIRFRAME MATRICIES                                       FAG00250
C                                                                       FAG00260
      DIMENSION FM(8,8),GM(8,10),HM(6,8),DM(6,10),GMO(8,10)             FAG00270
      DIMENSION NFM(2),NGM(2),NHM(2),NDM(2),NGMO(2)                     FAG00280
C                                                                       FAG00290
C     ACTUATOR MATRICIES                                                FAG00300
C                                                                       FAG00310
      DIMENSION FA(24,24),GA(24,10),HA(10,24)                           FAG00320
      DIMENSION NFA(2),NGA(2),NHA(2)                                    FAG00330
C                                                                       FAG00340
C     SENSOR MATRICIES                                                  FAG00350
C                                                                       FAG00360
      DIMENSION FS(11,11),GS(11,6),HS(6,11)                             FAG00370
      DIMENSION NFS(2),NGS(2),NHS(2)                                    FAG00380
C                                                                       FAG00390
C     AIRFRAME PLUS ACTUATOR MATRICIES                                  FAG00400
C                                                                       FAG00410
      DIMENSION FP(32,32),GP(32,10),HP(6,32)                            FAG00420
      DIMENSION NFP(2),NGP(2),NHP(2)                                    FAG00430
C                                                                       FAG00440
C     AIRFRAME PLUS ACTUATOR PLUS SENSOR MATRICIES                      FAG00450
C                                                                       FAG00460
      DIMENSION FPS(43,43),GPS(43,10),HPS(6,43),APS(43,43),BPS(43,10)   FAG00470
      DIMENSION NFPS(2),NGPS(2),NHPS(2),NAPS(2),NBPS(2)                 FAG00480
```

```
C                                                                       FAG00490
C     CONTROL SYSTEM MATRICIES                                          FAG00500
C                                                                       FAG00510
      DIMENSION AC(12,12),BFC(12,6),BC(12,3),CC(8,12),DFC(8,6),         FAG00520
     *DC(8,3),GAIN(10,8)                                                FAG00530
      DIMENSION NAC(2),NBFC(2),NBC(2),NCC(2),NDFC(2),NDC(2),NGAIN(2)    FAG00540
C                                                                       FAG00550
C     TOTAL SYSTEM DISCRETE MATRICIES                                   FAG00560
C                                                                       FAG00570
      REAL*8 AF18(55,55),BF18(55,3),CF18(18,55),DF18(18,3)              FAG00580
      DIMENSION NAF18(2),NBF18(2),NCF18(2),NDF18(2)                     FAG00590
C                                                                       FAG00600
C     TIME RESPONSE MATRICIES                                           FAG00610
C                                                                       FAG00620
      REAL*8 U(3),X(55),DUM4(4000),DUM5(4000)                           FAG00630
      DIMENSION NU(2),NX(2),NDUM4(2),NDUM5(2)                           FAG00640
C                                                                       FAG00650
C     WORKING MATRICIES                                                 FAG00660
C                                                                       FAG00670
      DIMENSION DUM1(4000),DUM2(4000),DUM3(4000),TMAT1(4000),           FAG00680
     *TMAT2(4000),TMAT3(4000)                                           FAG00690
      DIMENSION NDUM1(2),NDUM2(2),NDUM3(2),NTMAT1(2),                   FAG00700
     *NTMAT2(2),NTMAT3(2)                                               FAG00710
C                                                                       FAG00720
      COMMON/LINES/NLP,LIN,TITLE(15),TIL(4)                             FAG00730
      CALL ERRSET(208,256,-1,1)                                         FAG00740
      CALL ERRSET(215,256,-1,1)                                         FAG00750
      CALL ERRSET(187,256,-1,1)                                         FAG00760
      CALL ERRSET(207,256,-1,1,1,209)                                   FAG00770
      IOL=1                                                             FAG00780
      CALL RDTITL (IOL)                                                 FAG00790
C********************************************************************** FAG00800
C                                                                       FAG00810
C             READ IN STEADY STATE FLIGHT CONDITIONS,                   FAG00820
C            CONTROL PARAMETERS, AND FAILURE PARAMETERS                 FAG00830
C                                                                       FAG00840
C***********************************************************************FAG00850
      CALL FLITE1(MACH,ALT,ALPHA,NZ,TS,NST,NSTP,AMP,NCONT,RSTF,         FAG00860
     *LSTF,IFIX)                                                        FAG00870
C********************************************************************** FAG00880
C                                                                       FAG00890
C          READ IN F/A-18 BASIC AIRFRAME EQUATIONS OF MOTION            FAG00900
C             'FX' 'GX' 'HX' 'DX' 'FYZ' 'GYZ' 'HYZ' 'DYZ'               FAG00910
C                                                                       FAG00920
C********************************************************************** FAG00930
6     CALL FLITE2(FX,GX,HX,DX,FYZ,GYZ,HYZ,DYZ,NFX,NGX,NHX,NDX,NFYZ,     FAG00940
     *NGYZ,NHYZ,NDYZ)                                                   FAG00950
C********************************************************************** FAG00960
```

```
C                                                                       FAG00970
C                    COMPUTE AIR DATA                                   FAG00980
C                                                                       FAG00990
C********************************************************************** FAG01000
      CALL AIRDAT(MACH,ALT,TEMP,RHO,PSI,A,QC,RI)                        FAG01010
      WRITE(6,10)                                                       FAG01020
  10  FORMAT(//1X,'COMPOSING F/A-18 SYSTEM MATRICIES')                  FAG01030
C***********************************************************************FAG01040
C                                                                       FAG01050
C              COMPOSE THE 'LONG' AND 'LATD' MATRICIES                  FAG01060
C       COMPOSE THE UNIMPAIRED AIRFRAME CONTROL INPUT MATRIX            FAG01070
C                            'GMO'                                      FAG01080
C                                                                       FAG01090
C***********************************************************************FAG01100
      CALL LONLAT(RSTF,LSTF,IFAIL,LONG,LATD,GX,GYZ,GMO,NLONG,           FAG01110
     *NLATD,NGX,NGYZ,NGMO)                                              FAG01120
C***********************************************************************FAG01130
C                                                                       FAG01140
C              COMPOSE THE MODIFIED AIRFRAME MATRICIES                  FAG01150
C                    'FM' 'GM' 'HM' 'DM'                                FAG01160
C                                                                       FAG01170
C***********************************************************************FAG01180
      CALL MODEQ(FX,GX,HX,DX,FYZ,GYZ,HYZ,DYZ,LONG,LATD,FM,GM,HM,        FAG01190
     *DM,NFX,NGX,NHX,NDX,NFYZ,NGYZ,NHYZ,NDYZ,NLONG,NLATD,NFM,NGM,NHM,   FAG01200
     *NDM)                                                              FAG01210
C***********************************************************************FAG01220
C                                                                       FAG01230
C                 COMPOSE THE ACTUATOR MATRICIES                        FAG01240
C                        'FA' 'GA' 'HA'                                 FAG01250
C                                                                       FAG01260
C***********************************************************************FAG01270
      CALL ACTU(FA,GA,HA,NFA,NGA,NHA)                                   FAG01280
C***********************************************************************FAG01290
C                                                                       FAG01300
C                 COMPOSE THE SENSOR MATRICIES                          FAG01310
C                        'FS' 'GS' 'HS'                                 FAG01320
C                                                                       FAG01330
C***********************************************************************FAG01340
      CALL SENSOR(FS,GS,HS,NFS,NGS,NHS)                                 FAG01350
C***********************************************************************FAG01360
C                                                                       FAG01370
C           COMPOSE THE AIRFRAME PLUS ACTUATOR MATRICIES                FAG01380
C                        'FP' 'GP' 'HP'                                 FAG01390
C                                                                       FAG01400
C***********************************************************************FAG01410
      CALL PLANT(FM,GM,HM,DM,FA,GA,HA,FP,GP,HP,NFM,NGM,NHM,NDM,         FAG01420
     *NFA,NGA,NHA,NFP,NGP,NHP)                                          FAG01430
C***********************************************************************FAG01440
```

```
C                                                                       FAG01450
C       GENERATE THE AIRFRAME PLUS ACTUATOR PLUS SENSOR MATRICIES      FAG01460
C                       'FPS' 'GPS' 'HPS'                               FAG01470
C                                                                       FAG01480
C***********************************************************************FAG01490
      CALL ARCRFT(FP,GP,HP,FS,GS,HS,FPS,GPS,HPS,NFP,NGP,NHP,NFS,        FAG01500
     *NGS,NHS,NFPS,NGPS,NHPS)                                           FAG01510
C********************************************************************** FAG01520
C                                                                       FAG01530
C              DISCRITIZE THE 'FPS', AND 'GPS' MATRICIES                FAG01540
C                ASSIGN TO 'APS', AND 'BPS' MATRICIES                   FAG01550
C                                                                       FAG01560
C********************************************************************** FAG01570
      CALL EXPINT(FPS,NFPS,APS,NAPS,DUM1,NDUM1,TS,0,DUM2)               FAG01580
      CALL MULT(DUM1,NDUM1,GPS,NGPS,BPS,NBPS)                           FAG01590
      CALL OUTPUT(APS,NAPS(1),NAPS(2),'APS ')                           FAG01600
      CALL OUTPUT(BPS,NBPS(1),NBPS(2),'BPS ')                           FAG01610
C********************************************************************** FAG01620
C                                                                       FAG01630
C                  COMPOSE THE 'GAIN' MATRIX                            FAG01640
C                                                                       FAG01650
C********************************************************************** FAG01660
      CALL VGAIN(IFAIL,IFIX,GM,GMO,GAIN,NGM,NGMO,NGAIN)                 FAG01670
C     GOTO 9000                                                         FAG01680
C***********************************************************************FAG01690
C                                                                       FAG01700
C                 GENERATE CONTROL LAW MATRICIES                        FAG01710
C                'AC' 'BFC' 'BC' 'CC' 'CFC' 'DC'                        FAG01720
C                                                                       FAG01730
C********************************************************************** FAG01740
9001  CALL LAWS(ALPHA,NZ,PSI,QC,RI,TS,AC,BFC,BC,CC,DFC,DC,NAC,          FAG01750
     *NBFC,NBC,NCC,NDFC,NDC)                                            FAG01760
C********************************************************************** FAG01770
C                                                                       FAG01780
C            COMPOSE THE TOTAL SYSTEM MATRICIES                         FAG01790
C              'AF18', 'BF18', 'CF18', 'DF18'                           FAG01800
C                                                                       FAG01810
C********************************************************************** FAG01820
C--------------------------- AF18 MATRIX ------------------------------ FAG01830
      CALL MULT(BPS,NBPS,GAIN,NGAIN,DUM1,NDUM1)                         FAG01840
      CALL MULT(DUM1,NDUM1,DFC,NDFC,DUM2,NDUM2)                         FAG01850
      CALL MULT(DUM2,NDUM2,HPS,NHPS,DUM3,NDUM3)                         FAG01860
      CALL ADD(APS,NAPS,DUM3,NDUM3,TMAT1,NTMAT1)                        FAG01870
C     CALL OUTPUT(TMAT1,NTMAT1(1),NTMAT1(2),'MAT1')                     FAG01880
C                                                                       FAG01890
      CALL MULT(BPS,NBPS,GAIN,NGAIN,DUM1,NDUM1)                         FAG01900
      CALL MULT(DUM1,NDUM1,CC,NCC,TMAT2,NTMAT2)                         FAG01910
C     CALL OUTPUT(TMAT2,NTMAT2(1),NTMAT2(2),'MAT2')                     FAG01920
```

```
C                                                                       FAG01930
      CALL MULT(BFC,NBFC,HPS,NHPS,TMAT3,NTMAT3)                         FAG01940
C     CALL OUTPUT(TMAT3,NTMAT3(1),NTMAT3(2),'MAT3')                     FAG01950
C                                                                       FAG01960
      CALL JUXTC(TMAT1,NTMAT1,TMAT2,NTMAT2,DUM1,NDUM1)                  FAG01970
      CALL JUXTC(TMAT3,NTMAT3,AC,NAC,DUM2,NDUM2)                        FAG01980
      CALL JUXTR(DUM1,NDUM1,DUM2,NDUM2,AF18,NAF18)                      FAG01990
      CALL OUTPUT(AF18,NAF18(1),NAF18(2),'AF18')                        FAG02000
C---------------------- BF18 MATRIX -----------------------------------  FAG02010
      CALL MULT(BPS,NBPS,GAIN,NGAIN,DUM1,NDUM1)                         FAG02020
      CALL MULT(DUM1,NDUM1,DC,NDC,DUM2,NDUM2)                           FAG02030
      CALL JUXTR(DUM2,NDUM2,BC,NBC,BF18,NBF18)                          FAG02040
      CALL OUTPUT(BF18,NBF18(1),NBF18(2),'BF18')                        FAG02050
C----------------------- CF18 MATRIX ----------------------------------- FAG02060
      NDUM1(1)=6                                                        FAG02070
      NDUM1(2)=12                                                       FAG02080
      CALL NULL(DUM1,NDUM1)                                             FAG02090
      CALL JUXTC(HPS,NHPS,DUM1,NDUM1,DUM2,NDUM2)                        FAG02100
      CALL MULT(DFC,NDFC,HPS,NHPS,DUM1,NDUM1)                           FAG02110
      CALL JUXTC(DUM1,NDUM1,CC,NCC,DUM3,NDUM3)                          FAG02120
      CALL JUXTR(DUM2,NDUM2,DUM3,NDUM3,CF18,NCF18)                      FAG02130
      CALL OUTPUT(CF18,NCF18(1),NCF18(2),'CF18')                        FAG02140
C-------------------------- DF18 MATRIX -------------------------------- FAG02150
      NDUM1(1)=6                                                        FAG02160
      NDUM1(2)=3                                                        FAG02170
      CALL NULL(DUM1,NDUM1)                                             FAG02180
      CALL JUXTR(DUM1,NDUM1,DC,NDC,DF18,NDF18)                          FAG02190
      CALL OUTPUT(DF18,NDF18(1),NDF18(2),'DF18')                        FAG02200
C*********************************************************************** FAG02210
C                                                                       FAG02220
C  COMPUTE RESPONSE FOR 500 DATA POINTS AND CREATE OPTPLOT DATA FILE    FAG02230
C                                                                       FAG02240
C*********************************************************************** FAG02250
111   WRITE(6,190)                                                      FAG02260
  190 FORMAT(//1X,'SYSTEM MATRICIES CREATED, COMPUTING TIME RESPONSE')  FAG02270
C-- WRITE OPTPLOT PARAMETERS AND NULL FEEDBACK MATRIX INTO DATA FILE -- FAG02280
      NDUM4(1)=55                                                       FAG02290
      NDUM4(2)=3                                                        FAG02300
      CALL NULL(DUM4,NDUM4)                                             FAG02310
      WRITE(4,100) 55,3,501,1,1                                         FAG02320
      WRITE(4,110) (DUM4(I),I=1,165)                                    FAG02330
  100 FORMAT(5I5)                                                       FAG02340
  110 FORMAT(5E14.7)                                                    FAG02350
C-------- INITIALIZE THE STATE AND INPUT VARIABLS ---------------------- FAG02360
      NX(1)=55                                                          FAG02370
      NX(2)=1                                                           FAG02380
      NU(1)=3                                                           FAG02390
      NU(2)=1                                                           FAG02400
```

```
      CALL NULL(X,NX)                                                   FAG02410
      CALL NULL(U,NU)                                                   FAG02420
C***********************************************************************FAG02430
C                       COMPUTE RESPONSE                                FAG02440
C***********************************************************************FAG02450
      DO 120 I=0,500                                                    FAG02460
      TIME=I*TS                                                         FAG02470
      IF(I.NE.10.OR.I.NE.20.OR.I.NE.30.OR.I.NE.50.OR.I.NE.90)GOTO 400   FAG02480
      WRITE(6,401)I                                                     FAG02490
401   FORMAT(//1X,'PRESENTLY AT RESPONSE CALCULATION NO. ',I4)          FAG02500
C-------------- CHECK CONTROL PARAMETERS AND SET CONTROL INPUT ---------FAG02510
400   IF (I.GE.NST.AND.I.LE.NSTP) THEN                                  FAG02520
         U(NCONT)=AMP                                                   FAG02530
      ELSE                                                              FAG02540
         U(NCONT)=0.0                                                   FAG02550
      END IF                                                            FAG02560
      WRITE(4,130) TIME,(U(J),J=1,3),(X(J),J=1,55)                      FAG02570
C............RESET SCALE FACTORS FOR X3,X4,X6,X7,X8.....................FAG02580
C............TO RADIANS FOR PROPER CALCULATIONS.........................FAG02590
      DO 800 K = 1,10                                                   FAG02600
      IF(K.LT.3.OR.K.GT.8)GOTO 800                                      FAG02610
      IF(K.EQ.5)GOTO 800                                                FAG02620
      X(K)=X(K)/5.7296D+01                                              FAG02630
800   CONTINUE                                                          FAG02640
C----------------- MULTIPLY AF18 BY X(N) -------------------------------FAG02650
        DO 200 M=1,55                                                   FAG02660
        DUM4(M)=0.0                                                     FAG02670
          DO 210 N=1,55                                                 FAG02680
  210     DUM4(M)=DUM4(M)+AF18(M,N)*X(N)                                FAG02690
  200   CONTINUE                                                        FAG02700
C----------------- MULTIPLY BF18 BY U(N) -------------------------------FAG02710
        DO 220 M=1,55                                                   FAG02720
        DUM5(M)=0.0                                                     FAG02730
          DO 230 N=1,3                                                  FAG02740
  230     DUM5(M)=DUM5(M)+BF18(M,N)*U(N)                                FAG02750
  220   CONTINUE                                                        FAG02760
C------------- ADD AF18 X(N) AND BF18 U(N) ---------------------------- FAG02770
        DO 240 M = 1,55                                                 FAG02780
        X(M)=DUM4(M)+DUM5(M)                                            FAG02790
C..............SCALE X3,X4,X6,X7,X8 TO DEGREES FOR PLOTTING PURPOSES....FAG02800
C                                                                       FAG02810
        IF (M.LT.3.OR.M.GT.8) GOTO 240                                  FAG02820
        IF (M.EQ.5) GOTO 240                                            FAG02830
 222    X(M) = X(M)*5.7296D+01                                          FAG02840
  240 CONTINUE                                                          FAG02850
  120 CONTINUE                                                          FAG02860
  130 FORMAT(5E14.7)                                                    FAG02870
C********************************************************************** FAG02880
```

```
C                                                                       FAG02890
C                 CREATE OPTMATD DATA FILE                              FAG02900
C                                                                       FAG02910
C********************************************************************** FAG02920
      CALL WRMATD(AF18,BF18,CF18,DF18,TS)                               FAG02930
      WRITE(6,999)                                                      FAG02940
  999 FORMAT(//1X,'PROGRAM COMPLETE--OPMATD AND OPTPLOT DATA FILE CREATEFAG02950
     *D')                                                               FAG02960
      WRITE(6,1000)                                                     FAG02970
 1000 FORMAT(//1X,'TO PLOT RESPONSE GO TO CONTROLS EXEC, SELECT ORACLS, FAG02980
     *THEN SELECT OPTPLOT.',                                            FAG02990
     */1X,'YOU MUST BE AT A 618 TERMINAL')                              FAG03000
9000  STOP                                                              FAG03010
      END                                                               FAG03020
C********************************************************************** FAG03030
C                           SUBROUTINES                                 FAG03040
C********************************************************************** FAG03050
C***********************************************************************FAG03060
C                   SUBROUTINE FLITE1                                   FAG03070
C         READS IN: 1) AIRCRAFT FLIGHT CONDITIONS FROM FA18 DATA FILE   FAG03080
C                   2) CONTROL PARAMETERS INTERACTIVELY                 FAG03090
C                   3) FAILURE PARAMETERS INTERACTIVELY                 FAG03100
C  INPUT FROM MAIN: NONE                                                FAG03110
C   OUTPUT TO MAIN: 1) MACH  MACH NUMBER                                FAG03120
C                   2) ALT  ALTITUDE IN FEET                            FAG03130
C                   3) ALPHA  ANGLE OF ATTACK IN DEGREES                FAG03140
C                   4) NZ  NORMAL ACCELERATION                          FAG03150
C                   5) TS  SAMPLING TIME IN SECONDS                     FAG03160
C                   6) NCONT  CONTROL NUMBER  1=LONG STICK              FAG03170
C                                             2=LAT STICK               FAG03180
C                                             3=RUDDER                  FAG03190
C                   7) NST  CONTROL START TIME ITERATION NUMBER         FAG03200
C                   8) NSTP  CONTROLROL STOP TIME  "        "           FAG03210
C                   9) AMP  CONTROL AMPLITUDE IN INCHES                 FAG03220
C                  10) RSTF,LSTF  STAB FAILURE PARAMETERS               FAG03230
C                      SIMULATES RIGHT OR LEFT ACTUATION LOSS WHEN      FAG03240
C                      STE TO 1         RSTF=RIGHT STAB FAIL            FAG03250
C                                       LSTF=LEFT STABILATOR FAILURE    FAG03260
C                  11) IFIX  GAIN MATRIX FLAG                           FAG03270
C                           IFIX=0  DO NOT COMPUTE IMPAIRED GAIN MATRIX FAG03280
C                           IFIX=1  COMPUTE IMPAIRED GAIN MATRIX        FAG03290
C                                                                       FAG03300
C***********************************************************************FAG03310
      SUBROUTINE FLITE1(MACH,ALT,ALPHA,NZ,TS,NST,NSTP,AMP,NCONT,RSTF,   FAG03320
     *LSTF,IFIX)                                                        FAG03330
      IMPLICIT REAL*8(A-H,O-Z)                                          FAG03340
      REAL*8 MACH,NZ                                                    FAG03350
      INTEGER RSTF                                                      FAG03360
```

```
      READ(1,*) MACH,ALT,ALPHA,NZ,TS
      WRITE(6,10)
   10 FORMAT(///1X,'INPUT CONTROL PARAMETERS')
      WRITE(6,14)
   14 FORMAT(//1X,'CONTROL NUMBER 1 2 OR 3 ? ')
      READ(5,*) NCONT
      WRITE(6,11)
   11 FORMAT(1X,'START TIME =')
      READ(5,*) NST
      WRITE(6,12)
   12 FORMAT(1X,'STOP TIME =')
      READ(5,*) NSTP
      WRITE(6,13)
   13 FORMAT(1X,'AMPLITUDE =')
      READ(5,*) AMP
      WRITE(6,20)
   20 FORMAT(///1X,'INPUT DAMAGE PARAMETERS'//1X,'NO FAILURE=0  FAILURE=
     *1'//1X,'FAILURE IS INTERPRETED TO MEAN EIC CLASS 1 OR CONTROL SFC
     *S CENTERED AND LOCKED')
      WRITE(6,21)
   21 FORMAT(1X,'RSTF =')
      READ(5,*) RSTF
      WRITE(6,22)
   22 FORMAT(1X,'LSTF =')
      READ(5,*) LSTF
      WRITE(6,23)
   23 FORMAT(///1X,'COMPUTE NEW GAIN MATRIX ? ',//1X,'NO = 0  YES = 1')
C    *//1X,'NOTE VERSION 1.0 OF THE PROGRAM DOES NOT COMPUTE A NEW GAIN
C    *MATRIX')
      READ(5,*) IFIX
C
      WRITE(2,30)
      WRITE(2,31) MACH,ALT,ALPHA,NZ,TS
      WRITE(2,32)
      WRITE(2,33) NST,NSTP,AMP,NCONT
      WRITE(2,34) RSTF,LSTF
   30 FORMAT(//1X,'AIRCRAFT FLIGHT CONDITIONS AND SAMPLING TIME')
   31 FORMAT(//1X,'MACH = ',E10.4,1X,'ALT = ',E10.4,1X,'ALPHA = ',E10.4,
     */1X,'NZ = ',E10.4,1X,'TS = ',E10.4)
   32 FORMAT(//1X,'CONTROL PARAMETERS, AND FAILURE PARAMETERS')
   33 FORMAT(//1X,'START TIME = ',I3,1X,'STOP TIME = ',I3,
     */1X,'AMPLITUDE = ',E8.2,1X,'CONTROL NUMBER = ',I1)
   34 FORMAT(1X,'RIGHT STAB FAILURE = ',I1,1X,'LEFT STAB FAILURE = ',I1
     *)
      RETURN
      END
C***********************************************************************
C
```

```
C                          SUBROUTINE FLITE2                            FAG03850
C             READS IN  F/A-18 BASIC AIRFRAME EQUATIONS                 FAG03860
C                    OF MOTION FROM FA18 DATA FILE                      FAG03870
C        INPUT FROM MAIN: NONE                                          FAG03880
C        OUTPUT TO MAIN: 1) FX,GX,HX,DX  LONGITUDINAL MATRICIES         FAG03890
C                        2) FYZ,GYZ,HYZ,DYZ  LAT-DIRECTIONAL MATRICIES  FAG03900
C                        3) NFX,NGX,NHX,NDX   ROW AND COLUMN VECTORS    FAG03910
C                           NFYZ,NGYZ,NHYZ,NDYZ                         FAG03920
C                                                                       FAG03930
C***********************************************************************FAG03940
      SUBROUTINE FLITE2(FX,GX,HX,DX,FYZ,GYZ,HYZ,DYZ,NFX,NGX,NHX,NDX,    FAG03950
     *NFYZ,NGYZ,NHYZ,NDYZ)                                              FAG03960
      IMPLICIT REAL*8(A-H,O-Z)                                          FAG03970
      DIMENSION FX(4,4),GX(4,3),HX(3,4),DX(3,3),FYZ(4,4),GYZ(4,5),      FAG03980
     *HYZ(3,4),DYZ(3,5)                                                 FAG03990
      DIMENSION NFX(2),NGX(2),NHX(2),NDX(2),NFYZ(2),NGYZ(2),NHYZ(2),    FAG04000
     *NDYZ(2)                                                           FAG04010
      READ(1,*) ((FX(I,J),J=1,4),I=1,4)                                 FAG04020
      READ(1,*) ((GX(I,J),J=1,3),I=1,4)                                 FAG04030
      READ(1,*) ((HX(I,J),J=1,4),I=1,3)                                 FAG04040
      READ(1,*) ((DX(I,J),J=1,3),I=1,3)                                 FAG04050
      READ(1,*) ((FYZ(I,J),J=1,4),I=1,4)                                FAG04060
      READ(1,*) ((GYZ(I,J),J=1,5),I=1,4)                                FAG04070
      READ(1,*) ((HYZ(I,J),J=1,4),I=1,3)                                FAG04080
      READ(1,*) ((DYZ(I,J),J=1,5),I=1,3)                                FAG04090
C------------- WRITE AIRFRAME MATRICIES TO RESULT FILE -----------------FAG04100
      NFX(1)=4                                                          FAG04110
      NFX(2)=4                                                          FAG04120
      NGX(1)=4                                                          FAG04130
      NGX(2)=3                                                          FAG04140
      NHX(1)=3                                                          FAG04150
      NHX(2)=4                                                          FAG04160
      NDX(1)=3                                                          FAG04170
      NDX(2)=3                                                          FAG04180
      NFYZ(1)=4                                                         FAG04190
      NFYZ(2)=4                                                         FAG04200
      NGYZ(1)=4                                                         FAG04210
      NGYZ(2)=5                                                         FAG04220
      NHYZ(1)=3                                                         FAG04230
      NHYZ(2)=4                                                         FAG04240
      NDYZ(1)=3                                                         FAG04250
      NDYZ(2)=5                                                         FAG04260
      CALL OUTPUT(FX,NFX(1),NFX(2),'FX  ')                              FAG04270
      CALL OUTPUT(GX,NGX(1),NGX(2),'GX  ')                              FAG04280
      CALL OUTPUT(HX,NHX(1),NHX(2),'HX  ')                              FAG04290
      CALL OUTPUT(DX,NDX(1),NDX(2),'DX  ')                              FAG04300
      CALL OUTPUT(FYZ,NFYZ(1),NFYZ(2),'FYZ  ')                          FAG04310
      CALL OUTPUT(GYZ,NGYZ(1),NGYZ(2),'GYZ  ')                          FAG04320
```

```
      CALL OUTPUT(HYZ,NHYZ(1),NHYZ(2),'HYZ   ')                         FAG04330
      CALL OUTPUT(DYZ,NDYZ(1),NDYZ(2),'DYZ   ')                         FAG04340
      RETURN                                                            FAG04350
      END                                                               FAG04360
C***********************************************************************FAG04370
C                                                                       FAG04380
C                        SUBROUTINE AIRDAT                              FAG04390
C      COMPUTES AIR DATA BASED UPON STD ATMOSPHERE CONDITIONS           FAG04400
C          INPUT FROM MAIN: 1) MACH   MACH NUMBER                       FAG04410
C                           2) ALT  ALTITUDE IN FEET                    FAG04420
C           OUTPUT TO MAIN: 1) TEMP  TEMPERATURE IN DEGREES R           FAG04430
C                           2) PSI  PRESSURE IN PSF                     FAG04440
C                           3) RHO  DENSITY  IN SLUGS/FT**3             FAG04450
C                           4) Q  DYNAMIC PRESSURE IN PSF               FAG04460
C                           5) A  SPEED OF SOUND  IN FT/S               FAG04470
C                           6) RI  PRESSURE RATIO                       FAG04480
C                                                                       FAG04490
C***********************************************************************FAG04500
      SUBROUTINE AIRDAT(MACH,ALT,TEMP,RHO,PSI,A,QC,RI)                  FAG04510
      IMPLICIT REAL*8(A-H,O-Z)                                          FAG04520
      REAL*8 MACH                                                       FAG04530
      PO=2.1162D+03                                                     FAG04540
      TO=5.1869D+02                                                     FAG04550
      RHOO=2.3769D-03                                                   FAG04560
      GO=3.22D+01                                                       FAG04570
      ALAPSE=-3.56D-03                                                  FAG04580
      R=1.718D+03                                                       FAG04590
      GAMA=1.4D+00                                                      FAG04600
      T=TO+ALAPSE*ALT                                                   FAG04610
      TEMP=T/TO                                                         FAG04620
      PWR=GO/(ALAPSE*R)                                                 FAG04630
      RHO=RHOO*TEMP**(-(PWR+1.0D+00))                                   FAG04640
      PSI=PO*TEMP**(-PWR)                                               FAG04650
      A=DSQRT(GAMA*R*T)                                                 FAG04660
      QC=5.0D-01*RHO*(MACH*A)**2.0D+00                                  FAG04670
      RI=QC/PSI                                                         FAG04680
      WRITE(2,10)                                                       FAG04690
      WRITE(2,20) T,RHO,PSI,A,QC,RI                                     FAG04700
  10  FORMAT(//1X,'AIR DATA CALCULATIONS')                              FAG04710
  20  FORMAT(/1X,'T = ',D10.4,1X,'RHO = ',D10.4,1X,'PSI = ',D10.4,      FAG04720
     */1X,'A = ',D10.4,1X,'QC = ',D10.4,1X,'RI = ',D10.4)               FAG04730
      RETURN                                                            FAG04740
      END                                                               FAG04750
C********************************************************************** FAG04760
C                                                                       FAG04770
C       SUBROUTINE LONLAT GENERATES THE LONG AND LATD MATRICIES         FAG04780
C             DEPENDING UPON CONTROL SURFACE FAILURES                   FAG04790
C     INPUT FROM MAIN: 1) RSTF,LSTF  STABILATOR FAILURE PARAMETERS      FAG04800
```

```
C                      2) GX, GYZ  BASIC AIRFRAME CONTROL MATRICIES     FAG04810
C                      3) NGX,NGYZ  ROW AND COL. VECTORS                FAG04820
C      OUTPUT TO MAIN: 1) LONG, LATD  THE LONG AND LATD MATRICIES       FAG04830
C                      2) GMO  UNIMPAIRED MODIFIED AIRFRAME INPUT MATRIXFAG04840
C                      3) IFAIL  CONTROL SURFACE FAILURE FLAG           FAG04850
C                                    IFAIL=0  NO FAILURE                FAG04860
C                                    IFAIL=1  FAILURE                   FAG04870
C                      4) NLONG,NLATD,NGMO  ROW AND COL VECTORS         FAG04880
C                                                                       FAG04890
C********************************************************************** FAG04900
      SUBROUTINE LONLAT(RSTF,LSTF,IFAIL,LONG,LATD,GX,GYZ,GMO,NLONG,     FAG04910
     *NLATD,NGX,NGYZ,NGMO)                                              FAG04920
      IMPLICIT REAL*8(A-H,O-Z)                                          FAG04930
      INTEGER RSTF                                                      FAG04940
      DIMENSION GX(4,3),GYZ(4,5),GMO(8,10)                              FAG04950
      DIMENSION NGX(2),NGYZ(2),NGMO(2)                                  FAG04960
C                                                                       FAG04970
      REAL*8 LONG(3,10),LATD(5,10)                                      FAG04980
      DIMENSION NLONG(2),NLATD(2)                                       FAG04990
C                                                                       FAG05000
      DIMENSION DUM1(50),DUM2(50)                                       FAG05010
      DIMENSION NDUM1(2),NDUM2(2)                                       FAG05020
C-------- COMPOSE THE UNIMPAIRED LONG AND LATD MATRICIES -------------- FAG05030
C     COMPOSE THE UNIMPAIRED AIRFRAME CONTROL INPUT MATRIX GMO          FAG05040
      NLONG(1)=3                                                        FAG05050
      NLONG(2)=10                                                       FAG05060
      NLATD(1)=5                                                        FAG05070
      NLATD(2)=10                                                       FAG05080
      CALL NULL(LONG,NLONG)                                             FAG05090
      CALL NULL(LATD,NLATD)                                             FAG05100
      LONG(1,1)=5.0D-01                                                 FAG05110
      LONG(1,2)=5.0D-01                                                 FAG05120
      LONG(2,3)=5.0D-01                                                 FAG05130
      LONG(2,4)=5.0D-01                                                 FAG05140
      LONG(3,5)=5.0D-01                                                 FAG05150
      LONG(3,6)=5.0D-01                                                 FAG05160
      LATD(1,1)=-1.0D+00                                                FAG05170
      LATD(1,2)=1.0D+00                                                 FAG05180
      LATD(2,3)=1.0D+00                                                 FAG05190
      LATD(2,4)=-1.0+00                                                 FAG05200
      LATD(3,5)=-1.0D+00                                                FAG05210
      LATD(3,6)=1.0D+00                                                 FAG05220
      LATD(4,7)=-1.0D+00                                                FAG05230
      LATD(4,8)=1.0D+00                                                 FAG05240
      LATD(5,9)=5.0D-01                                                 FAG05250
      LATD(5,10)=5.0D-01                                                FAG05260
      CALL MULT(GX,NGX,LONG,NLONG,DUM1,NDUM1)                           FAG05270
      CALL MULT(GYZ,NGYZ,LATD,NLATD,DUM2,NDUM2)                         FAG05280
```

```
      CALL JUXTR(DUM1,NDUM1,DUM2,NDUM2,GMO,NGMO)                        FAG05290
C------------ SET THE IFAIL FLAG TO FAILURE CONDITION ----------------  FAG05300
      IFAIL=1                                                           FAG05310
C--------- CHECK CONTROL SURFACE FAILURE PARAMETERS -------------------  FAG05320
C          MODIFY LONG AND LATD MATRICIES ACCORDINGLY                   FAG05330
      IF (RSTF.EQ.1) THEN                                               FAG05340
         LONG(1,1) = 0.0D+00                                            FAG05350
         LATD(1,1) = 0.0D+00                                            FAG05360
      ELSE IF (LSTF.EQ.1) THEN                                          FAG05370
         LONG(1,2) = 0.0D+00                                            FAG05380
         LATD(1,2) = 0.0D+00                                            FAG05390
      ELSE                                                              FAG05400
         IFAIL=0                                                        FAG05410
      END IF                                                            FAG05420
C                                                                       FAG05430
      CALL OUTPUT(GMO,NGMO(1),NGMO(2),'GMO ')                           FAG05440
      CALL OUTPUT(LONG,NLONG(1),NLONG(2),'LNG ')                        FAG05450
      CALL OUTPUT(LATD,NLATD(1),NLATD(2),'LAT ')                        FAG05460
      RETURN                                                            FAG05470
      END                                                               FAG05480
C*********************************************************************** FAG05490
C                                                                       FAG05500
C                    SUBROUTINE MODEQ                                   FAG05510
C               GENERATES THE MODIFIED AIRFRAME MATRICIES               FAG05520
C       INPUT FROM MAIN:  1) FX,GX,HX,DX  BASIC AIRFRAME MATRICIES      FAG05530
C                            FYZ,GYZ,HYZ,DYZ                            FAG05540
C                         2) LONG,LATD  LONG AND LATD MATRICIES         FAG05550
C                         3) NFX,NGX,NHX,NDX  ROW AND COL VECTORS       FAG05560
C                            NFYZ,NGYZ,NHYZ,NDYZ                        FAG05570
C                            NLONG, NLATD                               FAG05580
C        OUTPUT TO MAIN:  1) FM,GM,HM,DM  MODEFIED AIRFRAME MATRICIES   FAG05590
C                         2) NFM,NGM,NHM,NDM  ROW AND COL VECTORS       FAG05600
C                                                                       FAG05610
C*********************************************************************** FAG05620
      SUBROUTINE MODEQ(FX,GX,HX,DX,FYZ,GYZ,HYZ,DYZ,LONG,LATD,FM,GM,HM,  FAG05630
     *DM,NFX,NGX,NHX,NDX,NFYZ,NGYZ,NHYZ,NDYZ,NLONG,NLATD,NFM,NGM,NHM,   FAG05640
     *NDM)                                                              FAG05650
      IMPLICIT REAL*8(A-H,O-Z)                                          FAG05660
C                                                                       FAG05670
      DIMENSION FX(4,4),GX(4,3),HX(3,4),DX(3,3),FYZ(4,4),GYZ(4,5),      FAG05680
     *HYZ(3,4),DYZ(3,5),FM(8,8),GM(8,10),HM(6,8),DM(6,10)               FAG05690
      DIMENSION NFX(2),NGX(2),NHX(2),NDX(2),NFYZ(2),NGYZ(2),NHYZ(2),    FAG05700
     *NDYZ(2),NFM(2),NGM(2),NHM(2),NDM(2)                               FAG05710
C                                                                       FAG05720
      REAL*8 LONG(3,10),LATD(5,10)                                      FAG05730
      DIMENSION NLONG(2),NLATD(2)                                       FAG05740
C                                                                       FAG05750
      DIMENSION DUM1(100),DUM2(100),DUM3(100)                           FAG05760
```

```
      DIMENSION NDUM1(2),NDUM2(2),NDUM3(2)                               FAG05770
C------------------------- FM MATRIX -----------------------------------  FAG05780
      NDUM1(1)=4                                                         FAG05790
      NDUM1(2)=4                                                         FAG05800
      CALL NULL(DUM1,NDUM1)                                              FAG05810
      CALL JUXTC(FX,NFX,DUM1,NDUM1,DUM2,NDUM2)                           FAG05820
      CALL JUXTC(DUM1,NDUM1,FYZ,NFYZ,DUM3,NDUM3)                         FAG05830
      CALL JUXTR(DUM2,NDUM2,DUM3,NDUM3,FM,NFM)                           FAG05840
C--------------------------- GM MATRIX ---------------------------------  FAG05850
      CALL MULT(GX,NGX,LONG,NLONG,DUM1,NDUM1)                            FAG05860
      CALL MULT(GYZ,NGYZ,LATD,NLATD,DUM2,NDUM2)                          FAG05870
      CALL JUXTR(DUM1,NDUM1,DUM2,NDUM2,GM,NGM)                           FAG05880
C---------------------------- HM MATRIX --------------------------------  FAG05890
      NDUM1(1)=3                                                         FAG05900
      NDUM1(2)=4                                                         FAG05910
      CALL NULL(DUM1,NDUM1)                                              FAG05920
      CALL JUXTC(HX,NHX,DUM1,NDUM1,DUM2,NDUM2)                           FAG05930
      CALL JUXTC(DUM1,NDUM1,HYZ,NHYZ,DUM3,NDUM3)                         FAG05940
      CALL JUXTR(DUM2,NDUM2,DUM3,NDUM3,HM,NHM)                           FAG05950
C--------------------------- DM MATRIX ---------------------------------  FAG05960
      CALL MULT(DX,NDX,LONG,NLONG,DUM1,NDUM1)                            FAG05970
      CALL MULT(DYZ,NDYZ,LATD,NLATD,DUM2,NDUM2)                          FAG05980
      CALL JUXTR(DUM1,NDUM1,DUM2,NDUM2,DM,NDM)                           FAG05990
C----- SCALE THE GM AND DM MATRICIES TO INPUT DEG RATHER THAN RAD ----  FAG06000
C                                                                        FAG06010
C     R = 1.745D-02                                                      FAG06020
C     DO 10 I = 1,6                                                      FAG06030
C     DO 20 J = 1,10                                                     FAG06040
C     DM(I,J) = DM(I,J) * R                                              FAG06050
C0    CONTINUE                                                           FAG06060
C0    CONTINUE                                                           FAG06070
C     DO 30 I = 1,8                                                      FAG06080
C     DO 40 J = 1,10                                                     FAG06090
C     GM(I,J) = GM(I,J) * R                                              FAG06100
C0    CONTINUE                                                           FAG06110
C0    CONTINUE                                                           FAG06120
      NDUM1(1)=10                                                        FAG06130
      NDUM1(2)=10                                                        FAG06140
      CALL UNITY(DUM1,NDUM1)                                             FAG06150
      CALL SCALE(DUM1,NDUM1,DUM2,NDUM2,1.745D-02)                        FAG06160
      CALL MULT(GM,NGM,DUM2,NDUM2,DUM1,NDUM1)                            FAG06170
      CALL EQUATE(DUM1,NDUM1,GM,NGM)                                     FAG06180
      CALL MULT(DM,NDM,DUM2,NDUM2,DUM1,NDUM1)                            FAG06190
      CALL EQUATE(DUM1,NDUM1,DM,NDM)                                     FAG06200
C------- SCALE OUTPUT VECTOR TO OUTPUT DEG/SEC, DEG, AND G -----------   FAG06210
C     HM(1,3)=HM(1,3)*5.7296D+01                                         FAG06220
C     HM(3,2)=HM(3,2)*5.7296D+01                                         FAG06230
C     HM(4,6)=HM(4,6)*5.7296D+01                                         FAG06240
```

```
C     HM(5,7)=HM(5,7)*5.7296D+01                                        FAG06250
C     HM(2,1)=HM(2,1)/3.22D+01                                          FAG06260
C     HM(2,2)=HM(2,2)/3.22D+01                                          FAG06270
C     HM(2,3)=HM(2,3)/3.22D+01                                          FAG06280
C     HM(6,5)=HM(6,5)/3.22D+01                                          FAG06290
C     HM(6,6)=HM(6,6)/3.22D+01                                          FAG06300
C     HM(6,7)=HM(6,7)/3.22D+01                                          FAG06310
C     DM(2,1)=DM(2,1)/3.22D+01                                          FAG06320
C     DM(2,2)=DM(2,2)/3.22D+01                                          FAG06330
C     DM(2,3)=DM(2,3)/3.22D+01                                          FAG06340
C     DM(2,4)=DM(2,4)/3.22D+01                                          FAG06350
C     DM(2,5)=DM(2,5)/3.22D+01                                          FAG06360
C     DM(2,6)=DM(2,6)/3.22D+01                                          FAG06370
C     DM(6,1)=DM(6,1)/3.22D+01                                          FAG06380
C     DM(6,2)=DM(6,2)/3.22D+01                                          FAG06390
C     DM(6,7)=DM(6,7)/3.22D+01                                          FAG06400
C     DM(6,8)=DM(6,8)/3.22D+01                                          FAG06410
C     DM(6,9)=DM(6,9)/3.22D+01                                          FAG06420
C     DM(6,10)=DM(6,10)/3.22D+01                                        FAG06430
      CALL OUTPUT(FM,NFM(1),NFM(2),'FM  ')                              FAG06440
      CALL OUTPUT(GM,NGM(1),NGM(2),'GM  ')                              FAG06450
      CALL OUTPUT(HM,NHM(1),NHM(2),'HM  ')                              FAG06460
      CALL OUTPUT(DM,NDM(1),NDM(2),'DM  ')                              FAG06470
      RETURN                                                            FAG06480
      END                                                               FAG06490
C*********************************************************************** FAG06500
C                                                                       FAG06510
C                       SUBROUTINE ACTU                                 FAG06520
C                GENERATES THE ACTUATOR MATRICIES                       FAG06530
C          INPUT FROM MAIN: NONE                                        FAG06540
C           OUTPUT TO MAIN: 1) FA,GA,HA  ACTUATOR DYNAMICS MATRICIES    FAG06550
C                           2) NFA,NGA,NHA  ROW AND COLUMN MATRICIES    FAG06560
C                                                                       FAG06570
C*********************************************************************** FAG06580
      SUBROUTINE ACTU(FA,GA,HA,NFA,NGA,NHA)                             FAG06590
      IMPLICIT REAL*8(A-H,O-Z)                                          FAG06600
      DIMENSION FA(24,24),GA(24,10),HA(10,24)                           FAG06610
      DIMENSION NFA(2),NGA(2),NHA(2)                                    FAG06620
      NFA(1)=24                                                         FAG06630
      NFA(2)=24                                                         FAG06640
      NGA(1)=24                                                         FAG06650
      NGA(2)=10                                                         FAG06660
      NHA(1)=10                                                         FAG06670
      NHA(2)=24                                                         FAG06680
      CALL NULL(FA,NFA)                                                 FAG06690
      CALL NULL(GA,NGA)                                                 FAG06700
      CALL NULL(HA,NHA)                                                 FAG06710
C-------------------SET STABILATOR COEFFICIENTS --------------------    FAG06720
```

```
C  SCALE THE COEFFICIENTS SO THAT THE ACTUATOR MODEL INPUTS DEGREES     FAG06730
C  AND OUTPUTS RADIANS.  SEE APPENDIX ON ACTUATOR MODEL DEVELOPMENT.    FAG06740
      STF1=1.541D+02                                                    FAG06750
      STF2=1.6122D+04                                                   FAG06760
      STF3=4.9559D+05                                                   FAG06770
      STF4=1.4691D+07                                                   FAG06780
      STG1=2.1377D+03                                                   FAG06790
      STG2=-3.0532D+05                                                  FAG06800
      STG3=2.7277D+07                                                   FAG06810
C----------------------SET LEADING EDGE COEFFICIENTS ----------------   FAG06820
      LEF1=1.098D+02                                                    FAG06830
      LEF2=2.230D+03                                                    FAG06840
      LEG=2.230D+03                                                     FAG06850
C----------------------SET TRAILING EDGE COEFFICIENTS ---------------   FAG06860
      TEF1=4.97D+01                                                     FAG06870
      TEF2=1.225D+03                                                    FAG06880
      TEG=1.225D+03                                                     FAG06890
C----------------------SET AILERON COEFFICIENTS ---------------------   FAG06900
      AF1=8.85D+01                                                      FAG06910
      AF2=5.625D+03                                                     FAG06920
      AG=5.625D+03                                                      FAG06930
C----------------------SET RUDDER COEFFICIENTS -------------------------FAG06940
      RF1=9.9498D+01                                                    FAG06950
      RF2=5.1984D+03                                                    FAG06960
      RG=5.1984D+03                                                     FAG06970
C------------ ASSIGN COEFFICIENT VALUES TO ACTUATOR MATRICIES-----------FAG06980
C--------------------- RIGHT AND LEFT STABILATOR -----------------------FAG06990
      FA(1,2)=1.0D+00                                                   FAG07000
      FA(2,3)=1.0D+00                                                   FAG07010
      FA(3,4)=1.0D+00                                                   FAG07020
      FA(4,1)=-STF4                                                     FAG07030
      FA(4,2)=-STF3                                                     FAG07040
      FA(4,3)=-STF2                                                     FAG07050
      FA(4,4)=-STF1                                                     FAG07060
      FA(5,6)=1.0D+00                                                   FAG07070
      FA(6,7)=1.0D+00                                                   FAG07080
      FA(7,8)=1.0D+00                                                   FAG07090
      FA(8,5)=-STF4                                                     FAG07100
      FA(8,6)=-STF3                                                     FAG07110
      FA(8,7)=-STF2                                                     FAG07120
      FA(8,8)=-STF1                                                     FAG07130
      GA(2,1)=STG1                                                      FAG07140
      GA(3,1)=STG2                                                      FAG07150
      GA(4,1)=STG3                                                      FAG07160
      GA(6,2)=STG1                                                      FAG07170
      GA(7,2)=STG2                                                      FAG07180
      GA(8,2)=STG3                                                      FAG07190
C     HA(1,1)=1.0D+00*1.745D-02                                         FAG07200
```

```
      HA(1,1)=1.0D+00                                                   FAG07210
C     HA( 2,5)=1.0D+00*1.745D-02                                        FAG07220
      HA( 2,5)=1.0D+00                                                  FAG07230
C--------------------- RIGHT AND LEFT LEADING EDGE FLAPS -------------- FAG07240
      FA( 9,10)=1.0D+00                                                 FAG07250
      FA( 10,9)=-LEF2                                                   FAG07260
      FA( 10,10)=-LEF1                                                  FAG07270
      FA( 11,12)=1.0D+00                                                FAG07280
      FA( 12,11)=-LEF2                                                  FAG07290
      FA( 12,12)=-LEF1                                                  FAG07300
      GA( 10,3)=LEG                                                     FAG07310
      GA( 12,4)=LEG                                                     FAG07320
C     HA( 3,9)=1.0D+00*1.745D-02                                        FAG07330
      HA( 3,9)=1.0D+00                                                  FAG07340
C     HA( 4,11)=1.0D+00*1.745D-02                                       FAG07350
      HA( 4,11)=1.0D+00                                                 FAG07360
C--------------------- RIGHT AND LEFT TRAILING EDGE FLAPS ------------- FAG07370
      FA( 13,14)=1.0D+00                                                FAG07380
      FA( 14,13)=-TEF2                                                  FAG07390
      FA( 14,14)=-TEF1                                                  FAG07400
      FA( 15,16)=1.0D+00                                                FAG07410
      FA( 16,15)=-TEF2                                                  FAG07420
      FA( 16,16)=-TEF1                                                  FAG07430
      GA( 14,5)=TEG                                                     FAG07440
      GA( 16,6)=TEG                                                     FAG07450
C     HA( 5,13)=1.0D+00*1.745D-02                                       FAG07460
      HA( 5,13)=1.0D+00                                                 FAG07470
C     HA( 6,15)=1.0D+00*1.745D-02                                       FAG07480
      HA( 6,15)=1.0D+00                                                 FAG07490
C---------------------- RIGHT AND LEFT AILERONS ------------------------FAG07500
      FA( 17,18)=1.0D+00                                                FAG07510
      FA( 18,17)=-AF2                                                   FAG07520
      FA( 18,18)=-AF1                                                   FAG07530
      FA( 19,20)=1.0D+00                                                FAG07540
      FA( 20,19)=-AF2                                                   FAG07550
      FA( 20,20)=-AF1                                                   FAG07560
      GA( 18,7)=AG                                                      FAG07570
      GA( 20,8)=AG                                                      FAG07580
C     HA( 7,17)=1.0D+00*1.745D-02                                       FAG07590
      HA( 7,17)=1.0D+00                                                 FAG07600
C     HA( 8,19)=1.0D+00*1.745D-02                                       FAG07610
      HA( 8,19)=1.0D+00                                                 FAG07620
C----------------------- RIGHT AND LEFT RUDDERS ------------------------FAG07630
      FA( 21,22)=1.0D+00                                                FAG07640
      FA( 22,21)=-RF2                                                   FAG07650
      FA( 22,22)=-RF1                                                   FAG07660
      FA( 23,24)=1.0D+00                                                FAG07670
      FA( 24,23)=-RF2                                                   FAG07680
```

```
      FA(24,24)=-RF1                                                    FAG07690
      GA(22,9)=RG                                                       FAG07700
      GA(24,10)=RG                                                      FAG07710
C     HA(9,21)=1.0D+00*1.745D-02                                        FAG07720
      HA(9,21)=1.0D+00                                                  FAG07730
C     HA(10,23)=1.0D+00*1.745D-02                                       FAG07740
      HA(10,23)=1.0D+00                                                 FAG07750
      CALL OUTPUT(FA,NFA(1),NFA(2),'FA  ')                              FAG07760
      CALL OUTPUT(GA,NGA(1),NGA(2),'GA  ')                              FAG07770
      CALL OUTPUT(HA,NHA(1),NHA(2),'HA  ')                              FAG07780
      RETURN                                                            FAG07790
      END                                                               FAG07800
C***********************************************************************FAG07810
C C                       SUBROUTINE SENSOR                             FAG07820
C                 GENERATES THE SENSOR MATRICIES                        FAG07830
C         INPUT FROM MAIN:  NONE                                        FAG07840
C          OUTPUT TO MAIN:  1) FS,GS,HS   SENSOR DYNAMICS MATRICIES     FAG07850
C                           2) NFS,NGS,NHS  ROW AND COLUMN VECTORS      FAG07860
C                                                                       FAG07870
C***********************************************************************FAG07880
      SUBROUTINE SENSOR(FS,GS,HS,NFS,NGS,NHS)                           FAG07890
      IMPLICIT REAL*8(A-H,O-Z)                                          FAG07900
      DIMENSION FS(11,11),GS(11,6),HS(6,11)                             FAG07910
      DIMENSION NFS(2),NGS(2),NHS(2)                                    FAG07920
      NFS(1)=11                                                         FAG07930
      NFS(2)=11                                                         FAG07940
      NGS(1)=11                                                         FAG07950
      NGS(2)=6                                                          FAG07960
      NHS(1)=6                                                          FAG07970
      NHS(2)=11                                                         FAG07980
      CALL NULL(FS,NFS)                                                 FAG07990
      CALL NULL(GS,NGS)                                                 FAG08000
      CALL NULL(HS,NHS)                                                 FAG08010
C-------------------- SET GYRO COEFFICIENTS ----------------------------FAG08020
      GYF1=6.2949D+02                                                   FAG08030
      GYF2=7.7471D+04                                                   FAG08040
      GYG1=5.8824D+02                                                   FAG08050
      GYG2=-2.9282D+05                                                  FAG08060
C-------------------- SET AOA SENSOR COEFFICIENTS ----------------------FAG08070
      AOAF=-1.4D+01                                                     FAG08080
      AOAG=1.4D+01                                                      FAG08090
C-------------------- SET ACCELEROMETER COEFFICIENTS -------------------FAG08100
      ACELF1=7.5898D+02                                                 FAG08110
      ACELF2=1.5626D+05                                                 FAG08120
      ACELG1=6.6269D+02                                                 FAG08130
      ACELG2=-3.4671D+05                                                FAG08140
C------------------ ASSIGN COEFFICIENTS TO MATRICIES -------------------FAG08150
C------------------------- PITCH RATE GYRO -----------------------------FAG08160
```

```
      FS(1,2)=1.0D+00                                                   FAG08170
      FS(2,1)=-GYF2                                                     FAG08180
      FS(2,2)=-GYF1                                                     FAG08190
      GS(1,1)=GYG1*5.7296D+01                                           FAG08200
      GS(2,1)=GYG2*5.7296D+01                                           FAG08210
      HS(1,1)=1.0D+00                                                   FAG08220
C-------------------- NORMAL ACCELEROMETER SENSOR ----------------------FAG08230
      FS(3,4)=1.0D+00                                                   FAG08240
      FS(4,3)=-ACELF2                                                   FAG08250
      FS(4,4)=-ACELF1                                                   FAG08260
      GS(3,2)=ACELG1/32.2                                               FAG08270
      GS(4,2)=ACELG2/32.2                                               FAG08280
      HS(2,3)=1.0D+00                                                   FAG08290
C---------------------- ANGLE OF ATTACK SENSOR ------------------------ FAG08300
      FS(5,5)=AOAF                                                      FAG08310
      GS(5,3)=AOAG*5.7296D+01                                           FAG08320
      HS(3,5)=1.0D+00                                                   FAG08330
C-------------------------- YAW RATE GYRO ------------------------------FAG08340
      FS(6,7)=1.0D+00                                                   FAG08350
      FS(7,6)=-GYF2                                                     FAG08360
      FS(7,7)=-GYF1                                                     FAG08370
      GS(6,4)=GYG1*5.7296D+01                                           FAG08380
      GS(7,4)=GYG2*5.7296D+01                                           FAG08390
      HS(4,6)=1.0D+00                                                   FAG08400
C-------------------------- ROLL RATE GYRO -----------------------------FAG08410
      FS(8,9)=1.0D+00                                                   FAG08420
      FS(9,8)=-GYF2                                                     FAG08430
      FS(9,9)=-GYF1                                                     FAG08440
      GS(8,5)=GYG1*5.7296D+01                                           FAG08450
      GS(9,5)=GYG2*5.7296D+01                                           FAG08460
      HS(5,8)=1.0D+00                                                   FAG08470
C----------------------- LATERAL ACCELEROMETER ------------------------ FAG08480
      FS(10,11)=1.0D+00                                                 FAG08490
      FS(11,10)=-ACELF2                                                 FAG08500
      FS(11,11)=-ACELF1                                                 FAG08510
      GS(10,6)=ACELG1/32.2                                              FAG08520
      GS(11,6)=ACELG2/32.2                                              FAG08530
      HS(6,10)=1.0D+00                                                  FAG08540
      CALL OUTPUT(FS,NFS(1),NFS(2),'FS  ')                              FAG08550
      CALL OUTPUT(GS,NGS(1),NGS(2),'GS  ')                              FAG08560
      CALL OUTPUT(HS,NHS(1),NHS(2),'HS  ')                              FAG08570
      RETURN                                                            FAG08580
      END                                                               FAG08590
C********************************************************************** FAG08600
C                                                                       FAG08610
C                      SUBROUTINE PLANT                                 FAG08620
C         COMPOSES THE MODIFIED AIRFRAME PLUS ACTUATOR MATRICIES        FAG08630
C INPUT FROM MAIN: 1) FM,GM,HM  MODIFIED AIRFRAME MATRICIES             FAG08640
```

```
C                  2) FA,GA,HA  ACTUATOR MATRICIES                      FAG08650
C                  3) NFA,NGA,NHA  ROW AND COLUMN VECTORS               FAG08660
C  OUTPUT TO MAIN: 1) FP,GP,HP  AIRFRAME PLUS ACTUATOR MATRICIES        FAG08670
C                  2) NFP,NGP,NHP  ROW AND COLUMN VECTORS               FAG08680
C********************************************************************** FAG08690
      SUBROUTINE PLANT(FM,GM,HM,DM,FA,GA,HA,FP,GP,HP,NFM,NGM,NHM,NDM,   FAG08700
     *NFA,NGA,NHA,NFP,NGP,NHP)                                          FAG08710
      IMPLICIT REAL*8(A-H,O-Z)                                          FAG08720
C                                                                       FAG08730
      DIMENSION FM(8,8),GM(8,10),HM(6,8),DM(6,10)                       FAG08740
      DIMENSION NFM(2),NGM(2),NHM(2),NDM(2)                             FAG08750
C                                                                       FAG08760
      DIMENSION FA(24,24),GA(24,10),HA(10,24)                           FAG08770
      DIMENSION NFA(2),NGA(2),NHA(2)                                    FAG08780
C                                                                       FAG08790
      DIMENSION FP(32,32),GP(32,10),HP(6,32)                            FAG08800
      DIMENSION NFP(2),NGP(2),NHP(2)                                    FAG08810
C                                                                       FAG08820
      DIMENSION DUM1(1050),DUM2(1050),DUM3(1050)                        FAG08830
      DIMENSION NDUM1(2),NDUM2(2),NDUM3(2)                              FAG08840
C----------------------------- FP MATRIX ------------------------------ FAG08850
      CALL MULT(GM,NGM,HA,NHA,DUM1,NDUM1)                               FAG08860
      NDUM2(1)=24                                                       FAG08870
      NDUM2(2)=8                                                        FAG08880
      CALL NULL(DUM2,NDUM2)                                             FAG08890
      CALL JUXTC(FM,NFM,DUM1,NDUM1,DUM3,NDUM3)                          FAG08900
      CALL JUXTC(DUM2,NDUM2,FA,NFA,DUM1,NDUM1)                          FAG08910
      CALL JUXTR(DUM3,NDUM3,DUM1,NDUM1,FP,NFP)                          FAG08920
C----------------------------- GP MATRIX ------------------------------ FAG08930
      NDUM1(1)=8                                                        FAG08940
      NDUM1(2)=10                                                       FAG08950
      CALL NULL(DUM1,NDUM1)                                             FAG08960
      CALL JUXTR(DUM1,NDUM1,GA,NGA,GP,NGP)                              FAG08970
C------------------------------ HP MATRIX ----------------------------- FAG08980
      CALL MULT(DM,NDM,HA,NHA,DUM1,NDUM1)                               FAG08990
      CALL JUXTC(HM,NHM,DUM1,NDUM1,HP,NHP)                              FAG09000
      CALL OUTPUT(FP,NFP(1),NFP(2),'FP  ')                              FAG09010
      CALL OUTPUT(GP,NGP(1),NGP(2),'GP  ')                              FAG09020
      CALL OUTPUT(HP,NHP(1),NHP(2),'HP  ')                              FAG09030
      RETURN                                                            FAG09040
      END                                                               FAG09050
C***********************************************************************FAG09060
C                                                                       FAG09070
C                         SUBROUTINE ARCRFT                             FAG09080
C    COMPOSES THE MODIFIED AIRFRAME PLUS ACTUATOR PLUS SENSOR MATRICIES FAG09090
C  INPUT FROM MAIN: 1) FP,GP,HP AIRFRAME PLUS ACTUATOR MATRICIES        FAG09100
C                   2) FS,GS,HS SENSOR MATRICIES                        FAG09110
C                   3) NFP,NGP,NHP  ROW AND COLUMN VECTORS              FAG09120
```

```
C                      NFS,NGS,NHS                                      FAG09130
C   OUTPUT TO MAIN:  1) FPS,GPS,HPS   AIRFRAME PLUS ACTUATOR PLUS SENSOR  FAG09140
C                                     MATRICIES                          FAG09150
C                    2) NFPS,NGPS,NHPS ROW AND COLUMN VECTORS            FAG09160
C                                                                        FAG09170
C***********************************************************************FAG09180
      SUBROUTINE ARCRFT(FP,GP,HP,FS,GS,HS,FPS,GPS,HPS,NFP,NGP,NHP,NFS,  FAG09190
     *NGS,NHS,NFPS,NGPS,NHPS)                                           FAG09200
      IMPLICIT REAL*8(A-H,O-Z)                                          FAG09210
C                                                                        FAG09220
      DIMENSION FP(32,32),GP(32,10),HP(6,32)                            FAG09230
      DIMENSION NFP(2),NGP(2),NHP(2)                                    FAG09240
C                                                                        FAG09250
      DIMENSION FS(11,11),GS(11,6),HS(6,11)                             FAG09260
      DIMENSION NFS(2),NGS(2),NHS(2)                                    FAG09270
C                                                                        FAG09280
      DIMENSION FPS(43,43),GPS(43,10),HPS(6,43)                         FAG09290
      DIMENSIONN FPS(2),NGPS(2),NHPS(2)                                 FAG09300
C                                                                        FAG09310
      DIMENSION DUM1(1900),DUM2(1900),DUM3(1900)                        FAG09320
      DIMENSION NDUM1(2),NDUM2(2),NDUM3(2)                              FAG09330
C------------------- FPS MATRIX --------------------------------------- FAG09340
      NDUM1(1)=32                                                       FAG09350
      NDUM1(2)=11                                                       FAG09360
      CALL NULL(DUM1,NDUM1)                                             FAG09370
      CALL JUXTC(FP,NFP,DUM1,NDUM1,DUM2,NDUM2)                          FAG09380
      CALL MULT(GS,NGS,HP,NHP,DUM3,NDUM3)                               FAG09390
      CALL JUXTC(DUM3,NDUM3,FS,NFS,DUM1,NDUM1)                          FAG09400
      CALL JUXTR(DUM2,NDUM2,DUM1,NDUM1,FPS,NFPS)                        FAG09410
C------------------ GPS MATRIX ---------------------------------------- FAG09420
      NDUM1(1)=11                                                       FAG09430
      NDUM1(2)=10                                                       FAG09440
      CALL NULL(DUM1,NDUM1)                                             FAG09450
      CALL JUXTR(GP,NGP,DUM1,NDUM1,GPS,NGPS)                            FAG09460
C------------------- HPS MATRIX ----------------------------------------FAG09470
      NDUM1(1)=6                                                        FAG09480
      NDUM1(2)=32                                                       FAG09490
      CALL NULL(DUM1,NDUM1)                                             FAG09500
      CALL JUXTC(DUM1,NDUM1,HS,NHS,HPS,NHPS)                            FAG09510
      RETURN                                                            FAG09520
      END                                                               FAG09530
C***********************************************************************FAG09540
C                                                                        FAG09550
C                   SUBROUTINE LAWS                                     FAG09560
C             COMPOSES THE CONTROL LAW MATRICIES                        FAG09570
C    INPUT FROM MAIN:  1) ALPHA    STEADY STATE ANGLE OF ATTACK         FAG09580
C                      2) NZ  STEADY STATE NORMAL ACCELERATION          FAG09590
C                      3) PSI,QC,RI  AIR DATA (SEE SUBROUTINE AIRDAT)   FAG09600
```

```
C                     4) TS  SAMPLING TIME IN SECONDS                   FAG09610
C           COMPUTES: 1) FUNCTION VALUES                                FAG09620
C                     2) FILTER COEFFICIENTS                            FAG09630
C                     3) CONTROL LAW MATRIX COEFFICIENTS                FAG09640
C     OUTPUT TO MAIN: 1) AC,BFC,BC  CONTROL LAW MATRICIES               FAG09650
C                        CC,DFC,DC                                      FAG09660
C                     2) NAC,NBFC,NBC  ROW AND COL VECTORS              FAG09670
C                        NCC,NBFC,NBC                                   FAG09680
C                                                                       FAG09690
C***********************************************************************FAG09700
      SUBROUTINE LAWS(ALPHA,NZ,PSI,QC,RI,TS,AC,BFC,BC,CC,DFC,DC,NAC,    FAG09710
     *NBFC,NBC,NCC,NDFC,NDC)                                            FAG09720
      IMPLICIT REAL*8(A-H,O-Z)                                          FAG09730
      REAL*8  LIMIT,MIN,MACH,NZ,NZST1,NZST2,NZST3,NYR                   FAG09740
      DIMENSION AC(12,12),BFC(12,6),BC(12,3),CC(8,12),DFC(8,6),         FAG09750
     *DC(8,3)                                                           FAG09760
      DIMENSION NAC(2),NBFC(2),NBC(2),NCC(2),NDFC(2),NDC(2)             FAG09770
C********************************************************************** FAG09780
C                   LONGITUDINAL FUNCTIONS                              FAG09790
C********************************************************************** FAG09800
C--------------------------- FUNCTION 12 ------------------------------ FAG09810
      F12T1=9.625D+00*(RI**2.0D+00)-(2.5D-02*RI)+1.0D+00                FAG09820
      F12T2=PSI*7.969D-04+8.4D-01                                       FAG09830
      F12MAX=LIMIT(1.0D+00,8.0D+00,F12T2)                               FAG09840
      F12T3=LIMIT(1.0D+00,F12MAX,F12T1)                                 FAG09850
      F12T5=LIMIT(5.0D-01,1.35D+00,RI)                                  FAG09860
      F12T6=F12T5*((9.52D-03*PSI)+4.04D+00)+((3.96D-03*(-PSI))-1.18D+00)FAG09870
      F12T4=LIMIT(1.0D+00,8.0D+00,F12T6)                                FAG09880
      IF (RI.GT.5.0D-01) THEN                                           FAG09890
         F12=F12T4                                                      FAG09900
         ELSE                                                           FAG09910
         F12=F12T3                                                      FAG09920
      END IF                                                            FAG09930
C---------------------------- FUNCTION 20 ----------------------------- FAG09940
      F20=7.0D+00                                                       FAG09950
C---------------------------- FUNCTION 22 ----------------------------- FAG09960
      F22=0.0167D+00*(LIMIT(0.800D+03,0.900D+03,QC)-0.800D+03)          FAG09970
C---------------------------- FUNCTION 24 ----------------------------- FAG09980
      F24L1=2.2538D+01-2.051D+01*LIMIT(2.7D-01,6.6D-01,RI)              FAG09990
      F24L2=3.276D+01-3.6D+01*LIMIT(6.6D-01,9.1D-01,RI)                 FAG10000
      IF (RI.GT.6.6D-01) THEN                                           FAG10010
         F24L=F24L2                                                     FAG10020
         ELSE                                                           FAG10030
         F24L=F24L1                                                     FAG10040
      END IF                                                            FAG10050
      F24T5=1.48769D+01-7.6923D+00*LIMIT(2.7D-01,9.1D-01,RI)            FAG10060
      F24T2=ALPHA-F24T5                                                 FAG10070
      F24T3=-2.0D+00*LIMIT(0.0D+00,3.0D+01,F24T2)                       FAG10080
```

```
      F24T1=LIMIT(0.0D+00,3.0D+01,ALPHA)                                FAG10090
      F24T4=1.4D+00*(F24T1+F24T3)                                       FAG10100
      F24=LIMIT(0.0D+00,F24L,F24T4)                                     FAG10110
C---------------------------- FUNCTION 25 ----------------------------- FAG10120
      F25=4.7636D+01-5.106D-02*LIMIT(6.0D+02,8.35D+02,QC)               FAG10130
C---------------------------- FUNCTION 27 ----------------------------- FAG10140
      F27=1.328D+00*(ALPHA+7.8584D+00-1.786D+01*LIMIT(4.4D-01,6.3D-01   FAG10150
     *,RI))                                                             FAG10160
C---------------------------- FUNCTION 28 ------------------------------FAG10170
      F28=4.4551D+01-4.058D-02*LIMIT(2.6D+02,9.5D+02,QC)                FAG10180
C---------------------------- FUNCTION 29U -----------------------------FAG10190
      F29U=8.73825D+01-7.625D+01*LIMIT(7.0D-01,1.146D+00,RI)            FAG10200
C---------------------------- FUNCTION 29L -----------------------------FAG10210
      F29L=0.0D+00                                                      FAG10220
C---------------------------- FUNCTION 32A -----------------------------FAG10230
      F32AT1=LIMIT(2.00D+02,2.00D+03,QC)                                FAG10240
      F32A=1.0D+02/F32AT1                                               FAG10250
C---------------------------- FUNCTION 32B ---------------------------- FAG10260
      PSKF=LIMIT(4.5D+02,2.0D+03,PSI)                                   FAG10270
      F32BT1=RI-6.913D-01                                               FAG10280
      RKF=LIMIT(-1.0D+00,4.0D-01,F32BT1)                                FAG10290
      F32BT2=-RKF*(1.3D-01+2.0D+02/PSKF)                                FAG10300
      FKFL=2.0D+00*(2.0D+02/PSKF)                                       FAG10310
      F32BT3=RKF*4.0D+00                                                FAG10320
      IF(RKF.LE.0.0D+00) THEN                                           FAG10330
         F32B=LIMIT(5.0D-02,1.0D+00,F32BT2)                             FAG10340
         ELSE                                                           FAG10350
         F32B=LIMIT(5.0D-02,FKFL,F32BT3)                                FAG10360
      END IF                                                            FAG10370
C---------------------------- FUNCTION 37 ----------------------------- FAG10380
      F37=0.25D+01-0.5D+00*LIMIT(0.3D+01,0.5D+01,NZ)                    FAG10390
C---------------------------- FUNCTION 40 ----------------------------- FAG10400
      F40T1=3.25D+00-3.0D+00*LIMIT(7.5D-01,8.5D-01,RI)                  FAG10410
      F40T2=6.5625D-01-1.3125D-03*LIMIT(5.0D+02,8.0D+02,PSI)            FAG10420
      F40T3=-2.6177D-01+9.635D-04*LIMIT(5.0D+02,1.8D+03,PSI)            FAG10430
      PIQ=LIMIT(0.0D+00,1.8D+03,PSI)                                    FAG10440
      F40T4=QC-3.35D+02                                                 FAG10450
      F40T5=LIMIT(0.0D+00,1.05D+02,F40T4)                               FAG10460
      TEMP1=F40T5*(1.67247D-03-9.29152D-07*PIQ)                         FAG10470
      TEMP2=1.6923D-01-3.84615D-05*PIQ                                  FAG10480
      F40T6=TEMP1+TEMP2                                                 FAG10490
      TEMP1=F40T5*(5.6746D-04+1.9841D-07*PIQ)                           FAG10500
      F40T7=TEMP1+TEMP2                                                 FAG10510
      TEMP1=4.75D-01-PIQ*6.5D-04                                        FAG10520
      TEMP2=F40T5*(1.5238D-03-1.71428D-06*PIQ)                          FAG10530
      F40T8=TEMP1+TEMP2                                                 FAG10540
      F40T9=F40T3+F40T2*LIMIT(7.5D-01,8.5D-01,RI)                       FAG10550
      IF (PIQ.LE.5.0D+02) THEN                                          FAG10560
```

```
         F40=F40T8                                                      FAG10570
      ELSE IF (PIQ.GT.9.8D+02.AND.RI.GE.7.5D-01) THEN                   FAG10580
         F40=F40T1*F40T6                                                FAG10590
      ELSE IF (PIQ.GT.9.8D+02.AND.RI.LT.7.5D-01) THEN                   FAG10600
         F40=F40T6                                                      FAG10610
      ELSE IF (QC.GE.4.4D+02.AND.RI.GE.7.5D-01) THEN                    FAG10620
         F40=F40T9                                                      FAG10630
         ELSE                                                           FAG10640
         F40=F40T7                                                      FAG10650
      END IF                                                            FAG10660
C---------------------------- FUNCTION 68 ------------------------------FAG10670
      F68=-2.9773D-03*(LIMIT(0.260D+03,0.480D+03,QC)-0.480D+03)         FAG10680
C***********************************************************************FAG10690
C                       LATERAL FUNCTIONS                               FAG10700
C***********************************************************************FAG10710
C---------------------------- FUNCTION 1 -------------------------------FAG10720
      F1=3.22D+00                                                       FAG10730
C---------------------------- FUNCTION 4 -------------------------------FAG10740
      F4T1=3.6D-01-1.2D-03*QC                                           FAG10750
      PSF4=LIMIT(2.0D+02,1.0D+03,PSI)                                   FAG10760
      F4T3=2.0D-01-PSF4*3.0D-04                                         FAG10770
      F4T4=1.0D-01-PSF4*1.0D-04                                         FAG10780
      IF (PSF4.LE.5.0D+02) THEN                                         FAG10790
         FLF4=F4T3                                                      FAG10800
         ELSE                                                           FAG10810
         FLF4=F4T4                                                      FAG10820
      END IF                                                            FAG10830
      F4=LIMIT(FLF4,3.0D-01,F4T1)                                       FAG10840
C---------------------------- FUNCTION 7 -------------------------------FAG10850
      F7T1=3.75D+00+5.0D-02*LIMIT(1.25D+02,2.5D+01,QC)                  FAG10860
      F7T2=QC-3.25D+02                                                  FAG10870
      F7T3=PSI-6.28D+02                                                 FAG10880
      F7T4=1.00D+01+LIMIT(-3.25D+02,3.25D+02,F7T2)                      FAG10890
     **LIMIT(-3.86D+02,0.0D+00,F7T3)*2.71D-05                           FAG10900
      IF (QC.LE.3.25D+02) THEN                                          FAG10910
         F7=F7T1                                                        FAG10920
         ELSE                                                           FAG10930
         F7=F7T4                                                        FAG10940
      END IF                                                            FAG10950
C---------------------------- FUNCTION 13 ------------------------------FAG10960
      PSL=LIMIT(2.0D+02,2.116D+03,PSI)                                  FAG10970
      F13L=(4.45D+02+LIMIT(2.42D+02,6.28D+02,PSL))*2.39D-04             FAG10980
      FLL=1.3D-01                                                       FAG10990
      IF (PSL.LE.8.0D+02) THEN                                          FAG11000
         A=5.4D-02+3.59D-04*PSL                                         FAG11010
         B=-1.745D-01-8.4D-05*PSL                                       FAG11020
         ELSE                                                           FAG11030
         A=1.22D-03*PSL-6.37D-01                                        FAG11040
```

```
         B=1.92D-01-5.42D-04*PSL                                        FAG11050
      END IF                                                            FAG11060
      C=1.52D-01+5.34D-05*PSL                                           FAG11070
      D=LIMIT(0.0D+00,2.8D+00,RI)                                       FAG11080
      F13T1=C+(D*(B+(A*D)))                                             FAG11090
      F13=LIMIT(FLL,F13L,F13T1)                                         FAG11100
C-------------------------- FUNCTION 31 ------------------------------- FAG11110
      F31T1=6.538D-05*LIMIT(0.0D+00,2.116D+03,PSI)                      FAG11120
      F31T2=1.449D+00-LIMIT(1.455D+03,2.116D+03,PSI)*5.1D-04            FAG11130
      IF(RI.LE.7.17D-01) THEN                                           FAG11140
         F31T3=F31T2                                                    FAG11150
         ELSE                                                           FAG11160
         F31T3=1.12D-01                                                 FAG11170
      END IF                                                            FAG11180
      F31T4=RI-7.17D-01                                                 FAG11190
      F31T5=LIMIT(-7.17D-01,6.62D-01,F31T4)*F31T3                       FAG11200
      F31T6=2.247D-01-F31T1-F31T5                                       FAG11210
      F31=LIMIT(0.0D+00,1.6D-01,F31T6)                                  FAG11220
C-------------------------- FUNCTION 34 ------------------------------- FAG11230
      F34T1=1.5D+00-2.0D-01*DABS(ALPHA-2.5D+00)                         FAG11240
      F34=LIMIT(0.0D+00,1.0D+00,F34T1)                                  FAG11250
C--------------------------- FUNCTION 6 ------------------------------- FAG11260
      RV11=F34*F31                                                      FAG11270
      F6T1=PSI*1.04D-04+2.2D-01*LIMIT(0.0D+00,1.12D+00,RI)              FAG11280
      F6T2=LIMIT(0.0D+00,4.31D-01,F6T1)-RV11*2.5D-01                    FAG11290
      F6=5.11D-01-LIMIT(3.11D-01,1.0D+04,F6T2)                          FAG11300
C-------------------------- FUNCTION 35 ------------------------------- FAG11310
      F35T1=9.55D-01-ALPHA*3.25D-02                                     FAG11320
      F35T2=5.0D-01+ALPHA*4.221D-02                                     FAG11330
      IF(ALPHA.LE.6.0D+00) THEN                                         FAG11340
         F35T3=F35T2                                                    FAG11350
         ELSE                                                           FAG11360
         F35T3=F35T1                                                    FAG11370
      END IF                                                            FAG11380
      F35=2.0*LIMIT(1.75D-01,5.0D-01,F35T3)                             FAG11390
C-------------------------- FUNCTION 36 ------------------------------- FAG11400
      F36T1=LIMIT(0.0D+00,8.0D-01,RI)+PSI*1.69D-04-7.88D-01             FAG11410
      F36T2=7.46D-03*(4.4D+02-LIMIT(4.4D+02,6.4D+02,PSI))               FAG11420
      QR=9.5D+02+LIMIT(7.0D-01,1.9D+00,RI)*5.4D+02                      FAG11430
      F36T3=QR-QC                                                       FAG11440
      GR=LIMIT(0.0D+00,2.0D+02,F36T3)*5.0D-03                           FAG11450
      F36T4=1.0D+00+F36T1*F36T2                                         FAG11460
      GH=LIMIT(0.0D+00,1.0D+00,F36T4)                                   FAG11470
      F36=MIN(GH,GR)                                                    FAG11480
C-------------------------- FUNCTION 39 --------------------------------FAG11490
      F39=LIMIT(1.3D+01,2.5D+01,ALPHA)*8.333D-02-1.08329D+00            FAG11500
C-------------------------- FUNCTION 41 --------------------------------FAG11510
      F41T1=LIMIT(8.0D+00,2.2D+01,ALPHA)-8.0D+00                        FAG11520
```

```
      F41TRU=F41T1*5.3571D-02                                           FAG11530
      F41FLS=F41T1*(2.3533D-01*LIMIT(2.7D-01,4.8D-01,RI)-9.97D-03)      FAG11540
      IF (ALPHA.LE.8.0D+00) THEN                                        FAG11550
         F41T2=1.0D+00-F41TRU                                           FAG11560
         ELSE                                                           FAG11570
         F41T2=1.0D+00-F41FLS                                           FAG11580
      END IF                                                            FAG11590
      F41LL=5.8745D-01-1.25D+00*LIMIT(2.7D-01,3.9D-01,RI)               FAG11600
      F41=LIMIT(F41LL,1.0D+00,F41T2)                                    FAG11610
C---------------------------- FUNCTION 93 ----------------------------- FAG11620
      F93T1=4.2857D-01*(RI-6.9D-01+PSI*1.8D-04)                         FAG11630
      F93A=LIMIT(0.0D+00,6.0D-02,F93T1)                                 FAG11640
      F93T2=PSI-6.28D+02                                                FAG11650
      F93B=LIMIT(0.0D+00,1.57D+02,F93T2)*6.3694D-03                     FAG11660
      F93C=1.0D+00-1.0D-01*LIMIT(0.0D+00,5.0D+00,NZ)                    FAG11670
      F93=F93A*F93B*F93C                                                FAG11680
C---------------------------- FUNCTION 101 -----------------------------FAG11690
      F101T1=RI-5.8D-01                                                 FAG11700
      F101T2=LIMIT(0.0D+00,5.0D+00,F101T1)                              FAG11710
      F101T3=PSI-4.98D+02                                               FAG11720
      F101T4=F101T2*LIMIT(0.0D+00,8.35D+02,F101T3)                      FAG11730
      F101T5=7.9854D+02-PSI*3.5948D-01                                  FAG11740
      FL101=LIMIT(1.653D+02,2.755D+02,F101T5)                           FAG11750
      F101T6=5.4446D-05*LIMIT(0.0D+00,FL101,F101T4)                     FAG11760
      F101T7=DABS(NZ)                                                   FAG11770
      F101T8=LIMIT(0.0D+00,5.0D+00,F101T7)                              FAG11780
      F101=F101T8*F101T6                                                FAG11790
C***********************************************************************FAG11800
C                       DIRECTIONAL FUNCTIONS                           FAG11810
C***********************************************************************FAG11820
C---------------------------- FUNCTION 10 ------------------------------FAG11830
      F10T1=1.0D+00-QC*4.25D-04                                         FAG11840
      F10=LIMIT(3.5D-01,1.0D+00,F10T1)                                  FAG11850
C---------------------------- FUNCTION 14 ----------------------------- FAG11860
      F14=2.34D-01*F10                                                  FAG11870
C---------------------------- FUNCTION 17 ----------------------------- FAG11880
      F17T1=ALPHA-1.3D+01                                               FAG11890
      F17=LIMIT(0.0D+00,4.0D+00,F17T1)                                  FAG11900
C____________________________ FUNCTION 30 _____________________________ FAG11910
      F30L=1.7035D+00-3.3203D-03*LIMIT(2.42D+02,4.98D+02,PSI)           FAG11920
      F30T1=1.0803D+00-1.2878D-03*LIMIT(1.4D+02,8.0D+02,QC)             FAG11930
      F30=LIMIT(F30L,9.0D-01,F30T1)                                     FAG11940
C---------------------------- FUNCTION 38 ----------------------------- FAG11950
      FSRI=LIMIT(2.25D-01,5.94D-01,RI)                                  FAG11960
      IF(ALPHA.GE.1.6D+01) THEN                                         FAG11970
         FS1=-1.3846D-01*FSRI-1.774D-02                                 FAG11980
         AOAM=-5.467D+00                                                FAG11990
         AOAB=-2.5D-02                                                  FAG12000
```

```
         ELSE                                                            FAG12010
         FS1=-2.4306D-01*FSRI+3.967D-02                                  FAG12020
         AOAM=-1.0D+01                                                   FAG12030
         AOAB=-4.5D-01                                                   FAG12040
      END IF                                                             FAG12050
      IF (RI.LE.3.34D-01) THEN                                           FAG12060
          FLL=-9.8D-01                                                   FAG12070
          ELSE                                                           FAG12080
          FLL=-1.2D+00                                                   FAG12090
      END IF                                                             FAG12100
      F38T1=LIMIT(-5.0D+00,2.5D+01,ALPHA)                                FAG12110
      F38T2=LIMIT(-5.0D+00,2.04D+01,ALPHA)                               FAG12120
      IF (RI.LE.3.34D-01) THEN                                           FAG12130
         F38T3=F38T1                                                     FAG12140
         ELSE                                                            FAG12150
         F38T3=F38T2                                                     FAG12160
      END IF                                                             FAG12170
      F38T4=(FS1*(F38T3+AOAM))+AOAB                                      FAG12180
      F38T5=LIMIT(FLL,1.0D+01,F38T4)                                     FAG12190
      F38T6=4.8D-02-F38T1*4.98D-02                                       FAG12200
      F38T7=F38T1-3.9D+00+1.0D-02*LIMIT(2.4D+02,3.09D+02,PSI)            FAG12210
      F38T8=LIMIT(0.0D+00,2.5D+00,F38T7)-2.5D+00                         FAG12220
      F38T9=RI-7.2D-01                                                   FAG12230
      F38T10=1.68D-02*LIMIT(0.0D+00,2.08D+00,F38T9)                      FAG12240
      F38T11=F38T6+F38T8*F38T10                                          FAG12250
      IF (ALPHA.LE.1.0D+01) THEN                                         FAG12260
         F38=F38T11                                                      FAG12270
         ELSE                                                            FAG12280
         F38=F38T5                                                       FAG12290
      END IF                                                             FAG12300
C---------------------------- FUNCTION 42 ------------------------------ FAG12310
      F42=7.61D-01                                                       FAG12320
C---------------------------- FUNCTION 45 ------------------------------ FAG12330
      F45T1=(LIMIT(5.0D+02,1.0D+03,QC)-5.0D+02)*1.0D-03                  FAG12340
      F45T2=1.2121D-03*LIMIT(6.25D+02,1.45D+03,PSI)-7.5758D-01           FAG12350
      F45=1.0D+00-F45T1*F45T2                                            FAG12360
C---------------------------- FUNCTION 90 ------------------------------ FAG12370
      F90T1=6.28D+02-PSI                                                 FAG12380
      F90T2=RI-7.2D-01                                                   FAG12390
      F90=1.65D+01+2.0551D-02*(LIMIT(0.0D+00,3.86D+02,F90T1)             FAG12400
     **LIMIT(0.0D+00,2.08D+00,F90T2))                                    FAG12410
C---------------------------- FUNCTION 96 ------------------------------ FAG12420
      F96T1=1.54D+00-4.4D-03*LIMIT(0.0D+00,1.68D+02,QC)                  FAG12430
      F96T2=3.6D-01+QC*8.8D-04                                           FAG12440
      IF (QC.LE.5.0D+02) THEN                                            FAG12450
         F96T3=F96T1                                                     FAG12460
         ELSE                                                            FAG12470
         F96T3=F96T2                                                     FAG12480
```

```
      END IF                                                            FAG12490
      F96T4=(6.28D+02-LIMIT(2.42D+02,6.28D+02,PSI))*7.772D-04           FAG12500
      F96T5=F96T3+F96T4                                                 FAG12510
      F96=LIMIT(0.0D+00,1.1D+00,F96T5)                                  FAG12520
C---------------------------- FUNCTION 112 ---------------------------- FAG12530
      IF (RI.GE.2.8D-01.AND.RI.LE.7.6D-01) THEN                         FAG12540
         F112=4.0D+00                                                   FAG12550
         ELSE                                                           FAG12560
         F112=0.0D+00                                                   FAG12570
      END IF                                                            FAG12580
C---------------------------- FUNCTION 113 ---------------------------- FAG12590
      F113=1.6667D-01*LIMIT(1.2D+01,1.8D+01,ALPHA)-2.0D+00              FAG12600
C---------------------------- FUNCTION 114 ---------------------------- FAG12610
      F114=8.9286D-01*LIMIT(1.6D-01,3.0D-01,RI)-1.4286D-01              FAG12620
C***********************************************************************FAG12630
C                  COMPUTE FILTER COEFFICIENTS                          FAG12640
C***********************************************************************FAG12650
C--------------------- FILTER P2 -------------------------------------- FAG12660
      P2N1=(2.0D+00*1.5D-02*(1.0D+00+F22)+TS)/(2.0D+00*1.5D-02+TS)      FAG12670
      P2N2=(TS-2.0D+00*1.5D-02*(1.0D+00+F22))/(2.0D+00*1.5D-02+TS)      FAG12680
      P2D=(2.0D+00*1.5D-02-TS)/(2.0D+00*1.5D-02+TS)                     FAG12690
C---------------------------- FILTER P5 ------------------------------- FAG12700
      P5N1=TS/(8.0D-02+TS)                                              FAG12710
      P5N2=P5N1                                                         FAG12720
      P5D=(8.0D-02-TS)/(8.0D-02+TS)                                     FAG12730
C---------------------------- FILTER P9 ------------------------------- FAG12740
      P9N1=TS                                                           FAG12750
      P9N2=0.0D+00                                                      FAG12760
      P9D=1.0D+00                                                       FAG12770
C---------------------------- FILTER P11 ------------------------------ FAG12780
      P11N1=TS/(3.9D-01*2.0D+00+TS)                                     FAG12790
      P11N2=P11N1                                                       FAG12800
      P11D=(3.9D-01*2.0D+00-TS)/(3.9D-01*2.0D+00+TS)                    FAG12810
C---------------------------- FILTER P12 ------------------------------ FAG12820
      P12N1=TS/(7.9D-01*2.0D+00+TS)                                     FAG12830
      P12N2=P12N1                                                       FAG12840
      P12D=(7.9D-01*2.0D+00-TS)/(7.9D-01*2.0D+00+TS)                    FAG12850
C---------------------------- FILTER Y3 ------------------------------- FAG12860
      Y3N1=2.0D+00/(2.0D+00+TS)                                         FAG12870
      Y3N2=-1.0D+00*Y3N1                                                FAG12880
      Y3D=(2.0D+00-TS)/(2.0D+00+TS)                                     FAG12890
C---------------------------- FILTER Y5 ------------------------------- FAG12900
      Y5N1=(7.5D-01*2.0D+00+TS)/(5.0D-01*2.0D+00+TS)                    FAG12910
      Y5N2=(TS-7.5D-01*2.0)/(5.0D-01*2.0+TS)                            FAG12920
      Y5D=(5.0D-01*2.0D+00-TS)/(5.0D-01*2.0D+00+TS)                     FAG12930
C********************************************************************** FAG12940
C              COMPUTE LONGITUDNAL CONTROL SYSTEM COEFFICIENTS          FAG12950
C********************************************************************** FAG12960
```

```
C-------- PITCH RATE TO COLLECTIVE STABILATOR COEFFICIENTS ------------ FAG12970
      T1=F68*F32A*F12                                                   FAG12980
      T2=F68*F32A+F40                                                   FAG12990
      B0=T1*P9N1*P2N2+T2*P2N1                                           FAG13000
      B1=T1*(P9N1*P2N2+P9N2*P2N1)+T2*(P2N2-P2N1*P9D)                    FAG13010
      B2=T1*P9N2*P2N2-T2*P2N2*P9D                                       FAG13020
      QST3 = B0                                                         FAG13030
      QST1=(B0*P9D**2.0+B1*P9D+B2)/(P9D-P2D)                            FAG13040
      QST2=(B0*P2D**2.0+B1*P2D+B2)/(P2D-P9D)                            FAG13050
C-------- NORMAL ACCELERATION TO COLLECTIVE STABILATOR COEFFICIENTS --- FAG13060
      T1=3.5D+00*F12*F32A                                               FAG13070
      T2=3.5D+00*F32A                                                   FAG13080
      B0=T1*P5N1*P9N1+T2*P5N1                                           FAG13090
      B1=T1*(P9N1*P5N2+P9N2*P5N1)+T2*(P5N2-P5N1*P9D)                    FAG13100
      B2=T1*P9N2*P5N2-T2*P5N2*P9D                                       FAG13110
      NZST3=-B0                                                         FAG13120
      NZST1=-(B0*P9D**2.0+B1*P9D+B2)/(P9D-P5D)                          FAG13130
      NZST2=-(B0*P5D**2.0+B1*P5D+B2)/(P5D-P9D)                          FAG13140
C     NZST3 = 0.0D+00                                                   FAG13150
C     NZST1 = 0.0D+00                                                   FAG13160
C     NZST2 = 0.0D+00                                                   FAG13170
C--------- PITCH STICK TO COLLECTIVE STABILATOR COEFFICIENTS ---------- FAG13180
      T1=F20*F32A*F12                                                   FAG13190
      T2=F20*F32A                                                       FAG13200
      B0=T1*P9N1+T2                                                     FAG13210
      B1=T1*P9N2-T2*P9D                                                 FAG13220
      PXST2=B0                                                          FAG13230
      PXST1=B0*P9D+B1                                                   FAG13240
C----------- ANGLE OF ATTACK TO LEADING EDGE FLAP COEFFICIENTS -------- FAG13250
      B0=1.3281D+00*P11N1                                               FAG13260
      B1=1.3281D+00*P11N2                                               FAG13270
      AALE2=B0                                                          FAG13280
      AALE1=B0*P11D+B1                                                  FAG13290
C----------- ANGLE OF ATTACK TO TRAILING EDGE FLAP COEFFICIENTS ------- FAG13300
      B0=1.405D+00*P12N1                                                FAG13310
      B1=1.405D+00*P12N2                                                FAG13320
      AATE2=B0                                                          FAG13330
      AATE1=B0*P12D+B1                                                  FAG13340
C***********************************************************************FAG13350
C             COMPUTE LATERAL CONTROL SYSTEM COEFFICIENTS               FAG13360
C***********************************************************************FAG13370
      RK6T=LIMIT(0.0D+00,5.0D-01,1.2D-01-F4)                            FAG13380
      RV7=MIN(F6*F35,F6-F101)                                           FAG13390
C-------------- ROLL RATE TO DIFFERENTIAL STABILATOR COEFFICIENT ------  FAG13400
      RRST=RV7*(F4+RK6T)                                                FAG13410
C     RRST = 0.0D+00                                                    FAG13420
C-------------- LATERAL STICK TO DIFFERENTIAL STABILATOR  COEFFICIENT    FAG13430
      PYST=RV7*F1*F7*(F13+F4)                                           FAG13440
```

```
C------------- RUDDER TO DIFFERENTIAL STABILATOR COEFFICIENT ---------- FAG13450
      PZST=RV7*F14*F39*1.33D+00                                         FAG13460
C------------- ROLL RATE TO DIFFERENTIAL LEADING EDGE COEFFICIENT ----- FAG13470
      RRLE=F93*(F4+RK6T)                                                FAG13480
C     RRLE = 0.0D+00                                                    FAG13490
C------------- LATERAL STICK TO DIFFERENTIAL LEADING EDGE COEFFICIENT   FAG13500
      PYLE=F93*F1*F7*(F13+F4)                                           FAG13510
C------------- ROLL RATE TO DIFFERENTIAL TRAILING EDGE COEFFICIENT ---- FAG13520
      RRTE=F31*F34*(F4+RK6T)                                            FAG13530
C     RRTE = 0.0D+00                                                    FAG13540
C------------- LATERAL STICK TO DIFFERENTIAL TRAILING EDGE COEFFICIENT  FAG13550
      PYTE=F31*F34*F1*F7*(F13+F4)                                       FAG13560
C------------- ROLL RATE TO AILERON COEFFICIENT ----------------------- FAG13570
      RRA=F35*F36*5.0D-01*(F4+RK6T)                                     FAG13580
C     RRA = 0.0D+00                                                     FAG13590
C------------- LATERAL STICK TO AILERON COEFFICIENT ------------------- FAG13600
      PYA=F35*F36*5.0D-01*F1*F7*(F13+F4)                                FAG13610
C------------- RUDDER TO AILERON COEFFICIENT -------------------------- FAG13620
      PZA=F35*F36*5.0D-01*F14*F39*1.33D+00                              FAG13630
C***********************************************************************FAG13640
C               COMPUTE DIRECTIONAL SYSTEM COEFFICIENTS                 FAG13650
C***********************************************************************FAG13660
C---------------- YAW RATE TO RUDDER COEFFICIENTS --------------------- FAG13670
      T1=F45*F96*DCOS(ALPHA)                                            FAG13680
      B0=T1*Y3N1                                                        FAG13690
      B1=T1*Y3N2                                                        FAG13700
      YRR2=B0                                                           FAG13710
C     YRR2 = 0.0D+00                                                    FAG13720
      YRR1=B0*Y3D+B1                                                    FAG13730
C     YRR1 = 0.0D+00                                                    FAG13740
C---------------- LATERAL ACCELERATION TO RUDDER COEFFICIENT----------  FAG13750
      NYR=F45*F90                                                       FAG13760
C     NYR = 0.0D+00                                                     FAG13770
C---------------- ROLL RATE TO RUDDER COEFFICIENTS--------------------  FAG13780
      T1=F45*F96*DSIN(ALPHA)                                            FAG13790
      T2=F45*F38*F30*F42*(2.0D+00*RRA+2.0D+00*RRST)                     FAG13800
      B0=T1*Y3N1+T2*Y5N1                                                FAG13810
      B1=T1*(Y3N2-Y3N1*Y5D)+T2*(Y5N2-Y5N1*Y3D)                          FAG13820
      B2=-1.0D+00*(T1*Y3N2*Y5D+T2*Y5N2*Y3D)                             FAG13830
      RRR3=B0                                                           FAG13840
      RRR1=(B0*Y3D**2.0+B1*Y3D+B2)/(Y3D-Y5D)                            FAG13850
      RRR2=(B0*Y5D**2.0+B1*Y5D+B2)/(Y5D-Y3D)                            FAG13860
C     RRR3 = 0.0D+00                                                    FAG13870
C     RRR1 = 0.0D+00                                                    FAG13880
C     RRR2 = 0.0D+00                                                    FAG13890
C---------------- LATERAL STICK TO RUDDER COEFFICIENTS----------------  FAG13900
      T1=F45*F38*F30*F42*(2.0D+00*PYA+2.0D+00*PYST)                     FAG13910
      B0=T1*Y5N1                                                        FAG13920
```

```
      B1=T1*Y5N2                                                        FAG13930
      PYR2=B0                                                           FAG13940
      PYR1=B0*Y5D+B1                                                    FAG13950
C---------------- RUDDER TO RUDDER COEFFICIENTS------------------------ FAG13960
      T1=F45*F38*F30*F42*(2.0D+00*PZA+2.0D+00*PZST)                     FAG13970
      T2=F45*F14*(5.0D-01-(F17*F114))                                   FAG13980
      B0=T1*Y5N1-T2                                                     FAG13990
      B1=T1*Y5N2+T2*Y5D                                                 FAG14000
      PZR2=B0                                                           FAG14010
      PZR1=B0*Y5D+B1                                                    FAG14020
C***********************************************************************FAG14030
C               OUTPUT FUNCTION VALUES AND COEFFICIENTS                 FAG14040
C***********************************************************************FAG14050
      WRITE(2,10)                                                       FAG14060
      WRITE(2,20) F12,F20,F22,F24,F25,F27,F28,F29U,F29L,F32A,F32B,F37,  FAG14070
     *F40,F68                                                           FAG14080
      WRITE(2,30) F1,F4,F6,F7,F13,F31,F34,F35,F36,F39,F41,F93,F101      FAG14090
      WRITE(2,40) F10,F14,F17,F30,F38,F42,F45,F90,F96,F112,F113,F114    FAG14100
      WRITE(2,50) P2N1,P2N2,P2D,P5N1,P5N2,P5D,P9N1,P9N2,P9D,P11N1,      FAG14110
     *P11N2,P11D,P12N1,P12N2,P12D,Y3N1,Y3N2,Y3D,Y5N1,Y5N2,Y5D           FAG14120
      WRITE(2,60)                                                       FAG14130
      WRITE(2,70) QST1,QST2,QST3,NZST1,NZST2,NZST3,PXST1,PXST2,AALE1,   FAG14140
     *AALE2,AATE1,AATE2                                                 FAG14150
      WRITE(2,80) RRST,PYST,PZST,RRLE,PYLE,RRTE,PYTE,RRA,PYA,PZA        FAG14160
      WRITE(2,90) YRR1,YRR2,NYR,RRR1,RRR2,RRR3,PYR1,PYR2,PZR1,PZR2      FAG14170
  10  FORMAT(//32X,'FUNCTION VALUES')                                   FAG14180
  20  FORMAT(//2X,'LONGITUDINAL FUNCTION VALUES',                       FAG14190
     *//1X,'F012 = ',D10.4,1X,'F020 = ',D10.4,1X,'F022 = ',D10.4,       FAG14200
     *//1X,'F024 = ',D10.4,1X,'F025 = ',D10.4,1X,'F027 = ',D10.4,       FAG14210
     *//1X,'F028 = ',D10.4,1X,'F29U = ',D10.4,1X,'F29L = ',D10.4,       FAG14220
     *//1X,'F32A = ',D10.4,1X,'F32B = ',D10.4,1X,'F037 = ',D10.4,       FAG14230
     *//1X,'F040 = ',D10.4,1X,'F068 = ',D10.4)                          FAG14240
  30  FORMAT(//2X,'LATERAL FUNCTION VALUES',                            FAG14250
     *//1X,'F001 = ',D10.4,1X,'F004 = ',D10.4,1X,'F006 = ',D10.4,       FAG14260
     *//1X,'F007 = ',D10.4,1X,'F013 = ',D10.4,1X,'F031 = ',D10.4,       FAG14270
     *//1X,'F034 = ',D10.4,1X,'F035 = ',D10.4,1X,'F036 = ',D10.4,       FAG14280
     *//1X,'F039 = ',D10.4,1X,'F041 = ',D10.4,1X,'F093 = ',D10.4,       FAG14290
     *//1X,'F101 = ',D10.4)                                             FAG14300
  40  FORMAT(//2X,'DIRECTIONAL FUNCTION VALUES',                        FAG14310
     *//1X,'F010 = ',D10.4,1X,'F014 = ',D10.4,1X,'F017 = ',D10.4,       FAG14320
     *//1X,'F030 = ',D10.4,1X,'F038 = ',D10.4,1X,'F042 = ',D10.4,       FAG14330
     *//1X,'F045 = ',D10.4,1X,'F090 = ',D10.4,1X,'F096 = ',D10.4,       FAG14340
     *//1X,'F112 = ',D10.4,1X,'F113 = ',D10.4,1X,'F114 = ',D10.4)       FAG14350
  50  FORMAT(//2X,'FILTER COEFFICIENTS',                                FAG14360
     *//1X,'P2N1  = ',D10.4,1X,'P2N2  = ',D10.4,1X,'P2D   = ',D10.4,    FAG14370
     *//1X,'P5N1  = ',D10.4,1X,'P5N2  = ',D10.4,1X,'P5D   = ',D10.4,    FAG14380
     *//1X,'P9N1  = ',D10.4,1X,'P9N2  = ',D10.4,1X,'P9D   = ',D10.4,    FAG14390
     *//1X,'P11N1 = ',D10.4,1X,'P11N2 = ',D10.4,1X,'P11D  =',D10.4,     FAG14400
```

```
     *//1X,'P12N1 = ',D10.4,1X,'P12N2 = ',D10.4,1X,'P12D  = ',D10.4,    FAG14410
     *//1X,'Y3N1  = ',D10.4,1X,'Y3N2  = ',D10.4,1X,'Y3D   = ',D10.4,    FAG14420
     *//1X,'Y5N1  = ',D10.4,1X,'Y5N2  = ',D10.4,1X,'Y5D   = ',D10.4)    FAG14430
   60 FORMAT(//// 30X,'CONTROL SYSTEM COEFFICIENTS')                    FAG14440
   70 FORMAT(//2X,'LONGITUDINAL COEFFICIENTS',                          FAG14450
     *//1X,'QST1  = ',D10.4,1X,'QST2  = ',D10.4,1X,'QST3  = ',D10.4,    FAG14460
     *//1X,'NZST1 = ',D10.4,1X,'NZST2 = ',D10.4,1X,'NZST3 = ',D10.4,    FAG14470
     *//1X,'PXST1 = ',D10.4,1X,'PXST2 = ',D10.4,1X,'AALE1 = ',D10.4,    FAG14480
     *//1X,'AALE2 = ',D10.4,1X,'AATE1 = ',D10.4,1X,'AATE2 = ',D10.4)    FAG14490
   80 FORMAT(//2X,'LATERAL COEFFICIENTS',                               FAG14500
     *//1X,'RRST = ',D10.4,1X,'PYST = ',D10.4,1X,'PZST = ',D10.4,       FAG14510
     *//1X,'RRLE = ',D10.4,1X,'PYLE = ',D10.4,1X,'RRTE = ',D10.4,       FAG14520
     *//1X,'PYTE = ',D10.4,1X,'RRA  = ',D10.4,1X,'PYA  = ',D10.4,       FAG14530
     *//1X,'PZA  = ',D10.4)                                             FAG14540
   90 FORMAT(//2X,'DIRECTIONAL COEFFICIENTS',                           FAG14550
     *//1X,'YRR1 = ',D10.4,1X,'YRR2 = ',D10.4,1X,'NYR  = ',D10.4,       FAG14560
     *//1X,'RRR1 = ',D10.4,1X,'RRR2 = ',D10.4,1X,'RRR3 = ',D10.4,       FAG14570
     *//1X,'PYR1 = ',D10.4,1X,'PYR2 = ',D10.4,1X,'PZR1 = ',D10.4,       FAG14580
     *//1X,'PZR2 = ',D10.4)                                             FAG14590
C***********************************************************************FAG14600
C                 GENERATE CONTROL LAW MATRICIES                        FAG14610
C***********************************************************************FAG14620
      NAC(1)=12                                                         FAG14630
      NAC(2)=12                                                         FAG14640
      NBFC(1)=12                                                        FAG14650
      NBFC(2)=6                                                         FAG14660
      NBC(1)=12                                                         FAG14670
      NBC(2)=3                                                          FAG14680
      NCC(1)=8                                                          FAG14690
      NCC(2)=12                                                         FAG14700
      NDFC(1)=8                                                         FAG14710
      NDFC(2)=6                                                         FAG14720
      NDC(1)=8                                                          FAG14730
      NDC(2)=3                                                          FAG14740
      CALL NULL(AC,NAC)                                                 FAG14750
      CALL NULL(BFC,NBFC)                                               FAG14760
      CALL NULL(BC,NBC)                                                 FAG14770
      CALL NULL(CC,NCC)                                                 FAG14780
      CALL NULL(DFC,NDFC)                                               FAG14790
      CALL NULL(DC,NDC)                                                 FAG14800
C---------------------- AC MATRIX ------------------------------------- FAG14810
      AC(1,1)=P9D                                                       FAG14820
      AC(2,2)=P2D                                                       FAG14830
      AC(3,3)=P9D                                                       FAG14840
      AC(4,4)=P5D                                                       FAG14850
      AC(5,5)=P9D                                                       FAG14860
      AC(6,6)=P11D                                                      FAG14870
      AC(7,7)=P12D                                                      FAG14880
```

```
      AC( 8,8)=Y3D                                                      FAG14890
      AC( 9,9)=Y3D                                                      FAG14900
      AC( 10,10)=Y5D                                                    FAG14910
      AC( 11,11)=Y5D                                                    FAG14920
      AC( 12,12)=Y5D                                                    FAG14930
C-------------------------- AFC MATRIX --------------------------------- FAG14940
      BFC( 1,1)=1.0D+00                                                 FAG14950
      BFC( 2,1)=1.0D+00                                                 FAG14960
      BFC( 3,2)=1.0D+00                                                 FAG14970
      BFC( 4,2)=1.0D+00                                                 FAG14980
      BFC( 6,3)=1.0D+00                                                 FAG14990
      BFC( 7,3)=1.0D+00                                                 FAG15000
      BFC( 8,4)=1.0D+00                                                 FAG15010
      BFC( 9,5)=1.0D+00                                                 FAG15020
      BFC( 10,5)=1.0D+00                                                FAG15030
C-------------------------- BC MATRIX ---------------------------------- FAG15040
      BC( 5,1)=1.0D+00                                                  FAG15050
      BC( 11,2)=1.0D+00                                                 FAG15060
      BC( 12,3)=1.0D+00                                                 FAG15070
C-------------------------- CC MATRIX ---------------------------------- FAG15080
      CC( 1,1)=QST1                                                     FAG15090
      CC( 1,2)=QST2                                                     FAG15100
      CC( 1,3)=NZST1                                                    FAG15110
      CC( 1,4)=NZST2                                                    FAG15120
      CC( 1,5)=-PXST1                                                   FAG15130
      CC( 2,6)=AALE1                                                    FAG15140
      CC( 3,7)=AATE1                                                    FAG15150
      CC( 8,8)=-YRR1                                                    FAG15160
      CC( 8,9)=RRR1                                                     FAG15170
      CC( 8,10)=RRR2                                                    FAG15180
      CC( 8,11)=PYR1                                                    FAG15190
      CC( 8,12)=PZR1                                                    FAG15200
C-------------------------- CFC MATRIX --------------------------------- FAG15210
      DFC( 1,1)=QST3                                                    FAG15220
      DFC( 1,2)=NZST3                                                   FAG15230
      DFC( 2,3)=AALE2                                                   FAG15240
      DFC( 3,3)=AATE2                                                   FAG15250
      DFC( 4,5)=-RRST                                                   FAG15260
      DFC( 5,5)=-RRLE                                                   FAG15270
      DFC( 6,5)=-RRTE                                                   FAG15280
      DFC( 7,5)=-RRA                                                    FAG15290
      DFC( 8,4)=-YRR2                                                   FAG15300
      DFC( 8,5)=RRR3                                                    FAG15310
      DFC( 8,6)=NYR                                                     FAG15320
C-------------------------- DC MATRIX ---------------------------------- FAG15330
      DC( 1,1)=-PXST2                                                   FAG15340
      DC( 4,2)=PYST                                                     FAG15350
      DC( 4,3)=PZST                                                     FAG15360
```

```
      DC(5,2)=PYLE                                                      FAG15370
      DC(6,2)=PYTE                                                      FAG15380
      DC(7,2)=PYA                                                       FAG15390
      DC(7,3)=PZA                                                       FAG15400
      DC(8,2)=PYR2                                                      FAG15410
      DC(8,3)=PZR2                                                      FAG15420
      CALL OUTPUT(AC,NAC(1),NAC(2),'AC  ')                              FAG15430
      CALL OUTPUT(BFC,NBFC(1),NBFC(2),'BFC ')                           FAG15440
      CALL OUTPUT(BC,NBC(1),NBC(2),'BC  ')                              FAG15450
      CALL OUTPUT(CC,NCC(1),NCC(2),'CC  ')                              FAG15460
      CALL OUTPUT(DFC,NDFC(1),NDFC(2),'DFC ')                           FAG15470
      CALL OUTPUT(DC,NDC(1),NDC(2),'DC  ')                              FAG15480
      RETURN                                                            FAG15490
      END                                                               FAG15500
C***********************************************************************FAG15510
C                                                                       FAG15520
C                        SUBROUTINE VGAIN                               FAG15530
C                 COMPOSES THE VARIABLE GAIN MATRIX                     FAG15540
C      INPUT FROM MAIN: 1) IFAIL  FAILURE FLAG SET TO 1 FOR FAILURE     FAG15550
C                       2) IFIX  GAIN MATRIX FLAG SET TO 1 TO COMPUTE   FAG15560
C                                IMPAIRED GAIN MATRIX                   FAG15570
C                       2) GM  IMPAIRED AIRFRAME CONTROL INPUT MATRIX   FAG15580
C                       3) GMO  UNIMPAIRED AIRFRAME CONTROL INPUT MATRIXFAG15590
C                       4) NGM,NGMO  ROW AND COLUMN VECTORS             FAG15600
C       OUTPUT TO MAIN: 1) GAIN  GAIN MATRIX                            FAG15610
C                       2) NGAIN  ROW AND COLUMN VECTOR                 FAG15620
C                                                                       FAG15630
C***********************************************************************FAG15640
      SUBROUTINE VGAIN(IFAIL,IFIX,GM,GMO,GAIN,NGM,NGMO,NGAIN)           FAG15650
      IMPLICIT REAL*8(A-H,O-Z)                                          FAG15660
      DIMENSION GM(8,10),GMO(8,10),GAIN(10,8),GAINO(10,8),              FAG15670
     *GMINV(10,10),GAINI(10,8),GMT(10,8)                                FAG15680
      DIMENSION NGM(2),NGMO(2),NGAIN(2),NGAINO(2),NGMINV(2),NGAINI(2),  FAG15690
     *NGMT(2)                                                           FAG15700
C                                                                       FAG15710
      DIMENSION DUM1(100),DUM2(100),DUM3(100),DUM4(100),DUM5(100)       FAG15720
      DIMENSION DUM6(100)                                               FAG15730
      DIMENSION NDUM1(2),NDUM2(2),NDUM3(2),NDUM4(2),NDUM5(2),NDUM6(2)   FAG15740
      DIMENSION AUTH(10,10),NAUTH(2),WA(30)                             FAG15750
C------------ GENERATE THE UNIMPAIRED GAIN MATRIX 'GAINO' --------------FAG15760
      RTD = 1.745D-02                                                   FAG15770
      NGAINO(1)=10                                                      FAG15780
      NGAINO(2)=8                                                       FAG15790
      NAUTH(1) = 10                                                     FAG15800
      NAUTH(2) = 10                                                     FAG15810
      NGMINV(1) = 10                                                    FAG15820
      NGMINV(2) = 10                                                    FAG15830
      CALL NULL(GAINO,NGAINO)                                           FAG15840
```

```
      CALL NULL(AUTH,NAUTH)                                             FAG15850
      GAINO(1,1)=1.0D+00                                                FAG15860
      GAINO(2,1)=1.0D+00                                                FAG15870
      GAINO(3,2)=1.0D+00                                                FAG15880
      GAINO(4,2)=1.0D+00                                                FAG15890
      GAINO(5,3)=1.0D+00                                                FAG15900
      GAINO(6,3)=1.0D+00                                                FAG15910
      GAINO(1,4)=-1.0D+00                                               FAG15920
      GAINO(2,4)=1.0D+00                                                FAG15930
      GAINO(3,5)=1.0D+00                                                FAG15940
      GAINO(4,5)=-1.0D+00                                               FAG15950
      GAINO(5,6)=-1.0D+00                                               FAG15960
      GAINO(6,6)=1.0D+00                                                FAG15970
      GAINO(7,7)=-1.0D+00                                               FAG15980
      GAINO(8,7)=1.0D+00                                                FAG15990
      GAINO(9,8)=1.0D+00                                                FAG16000
      GAINO(10,8)=1.0D+00                                               FAG16010
      AUTH(1,1) = 10.5D+00*RTD                                          FAG16020
      AUTH(2,2) = AUTH(1,1)                                             FAG16030
      AUTH(3,3) = 3.D+00*RTD                                            FAG16040
      AUTH(4,4) = AUTH(3,3)                                             FAG16050
      AUTH(5,5) = 30.D+00 *RTD                                          FAG16060
      AUTH(6,6) = AUTH(5,5)                                             FAG16070
      AUTH(7,7) = 25.D+00*RTD                                           FAG16080
      AUTH(8,8) = AUTH(7,7)                                             FAG16090
      AUTH(9,9) = 30.D+00 *RTD                                          FAG16100
      AUTH(10,10) = AUTH(9,9)                                           FAG16110
C     SCALE GMO TO SIMILAR UNITS AS GM                                  FAG16120
      DO 10 I = 1,8                                                     FAG16130
      DO 20 J = 1,10                                                    FAG16140
      GMO(I,J) = GMO(I,J)*RTD                                           FAG16150
20    CONTINUE                                                          FAG16160
10    CONTINUE                                                          FAG16170
C CHECK FAILURE AND FIX FLAGS, COMPUTE IMPAIRED GAIN MATRIX IF POSITIVE FAG16180
      IF (IFAIL.EQ.1.AND.IFIX.EQ.1) THEN                                FAG16190
C               COMPUTE GENERALIZED INVERSE OF GM                       FAG16200
C        CALL TRANP(GM,NGM,GMT,NGMT)                                    FAG16210
C        CALL MULT(GM,NGM,GMT,NGMT,DUM1,NDUM1)                          FAG16220
C        CALL MINV(64,DUM1,8,D,DUM2,DUM3)                               FAG16230
C        CALL MULT(GMT,NGMT,DUM1,NDUM1,GMINV,NGMINV)                    FAG16240
C        CALL OUTPUT(GMINV,NGMINV(1),NGMINV(2),'GMIN')                  FAG16250
C              COMPUTE IMPAIRED GAIN MATRIX GAINI                       FAG16260
C        CALL MULT(GMINV,NGMINV,GMO,NGMO,DUM1,NDUM1)                    FAG16270
C        CALL MULT(DUM1,NDUM1,GAINO,NGAINO,GAINI,NGAINI)                FAG16280
         CALL MULT(GM,NGM,AUTH,NAUTH,DUM1,NDUM1)                        FAG16290
         CALL TRANP(DUM1,NDUM1,DUM2,NDUM2)                              FAG16300
         CALL MULT(DUM2,NDUM2,DUM1,NDUM1,DUM3,NDUM3)                    FAG16310
         CALL LINV2F(DUM3,NDUM3(1),NDUM3(1),GMINV,1,WA,IER)             FAG16320
```

```
         CALL MULT(GMINV,NGMINV,DUM2,NDUM2,DUM6,NDUM6)                  FAG16330
         CALL MULT(AUTH,NAUTH,DUM6,NDUM6,DUM4,NDUM4)                    FAG16340
         CALL MULT(DUM4,NDUM4,GMO,NGMO,DUM5,NDUM5)                      FAG16350
         CALL MULT(DUM5,NDUM5,GAINO,NGAINO,GAINI,NGAINI)                FAG16360
         CALL EQUATE(GAINI,NGAINI,GAIN,NGAIN)                           FAG16370
      WRITE(6,85)                                                       FAG16380
85    FORMAT(//1X,'CALCULATED IMPAIRED MATRIX VIA G.E.  LOGIC FOLLOWS') FAG16390
      WRITE(6,90) ((GAINI(I,J),J=1,8),I=1,10)                           FAG16400
90    FORMAT(1X,10(E8.1,1X))                                            FAG16410
      ELSE                                                              FAG16420
         CALL EQUATE(GAINO,NGAINO,GAIN,NGAIN)                           FAG16430
      END IF                                                            FAG16440
C                                                                       FAG16450
      CALL OUTPUT(GAIN,NGAIN(1),NGAIN(2),'GAIN')                        FAG16460
      RETURN                                                            FAG16470
      END                                                               FAG16480
C***********************************************************************FAG16490
C                                                                       FAG16500
C                            FUNCTION LIMIT                             FAG16510
C                                                                       FAG16520
C***********************************************************************FAG16530
      FUNCTION LIMIT(X,Y,Z)                                             FAG16540
      REAL*8 X,Y,Z,LIMIT                                                FAG16550
      IF (Z.GE.Y) THEN                                                  FAG16560
         LIMIT=Y                                                        FAG16570
      ELSE IF (Z.LE.X) THEN                                             FAG16580
         LIMIT=X                                                        FAG16590
         ELSE                                                           FAG16600
         LIMIT=Z                                                        FAG16610
      END IF                                                            FAG16620
      RETURN                                                            FAG16630
      END                                                               FAG16640
C********************************************************************** FAG16650
C                                                                       FAG16660
C                         FUNCTION MIN                                  FAG16670
C                                                                       FAG16680
C***********************************************************************FAG16690
      FUNCTION MIN(X,Y)                                                 FAG16700
      REAL*8 MIN,X,Y                                                    FAG16710
      IF (X.LT.Y) THEN                                                  FAG16720
         MIN=X                                                          FAG16730
         ELSE                                                           FAG16740
         MIN=Y                                                          FAG16750
      END IF                                                            FAG16760
      RETURN                                                            FAG16770
      END                                                               FAG16780
C********************************************************************** FAG16790
C                                                                       FAG16800
```

```
C                       SUBROUTINE OUTPUT                               FAG16810
C                                                                       FAG16820
C***********************************************************************FAG16830
      SUBROUTINE OUTPUT(A,NROW,NCOL,NAME)                               FAG16840
      IMPLICIT REAL*8(A-H,O-Z)                                          FAG16850
      DIMENSION  A(NROW,NCOL)                                           FAG16860
      CHARACTER*4 NAME                                                  FAG16870
      WRITE(2,555) NAME                                                 FAG16880
                                                                        FAG16890
      IF (NCOL.EQ.3) THEN                                               FAG16900
         CALL COLM(1,3)                                                 FAG16910
         DO 53 I=1,NROW                                                 FAG16920
 53      WRITE(2,3) I,(A(I,J),J=1,3)                                    FAG16930
                                                                        FAG16940
      ELSE IF (NCOL.EQ.4) THEN                                          FAG16950
         CALL COLM(1,4)                                                 FAG16960
         DO 54 I=1,NROW                                                 FAG16970
 54      WRITE(2,4) I,(A(I,J),J=1,4)                                    FAG16980
                                                                        FAG16990
      ELSE IF (NCOL.EQ.5) THEN                                          FAG17000
         CALL COLM(1,5)                                                 FAG17010
         DO 55 I=1,NROW                                                 FAG17020
 55      WRITE(2,5) I,(A(I,J),J=1,5)                                    FAG17030
                                                                        FAG17040
      ELSE IF (NCOL.EQ.6) THEN                                          FAG17050
         CALL COLM(1,6)                                                 FAG17060
         DO 56 I=1,NROW                                                 FAG17070
 56      WRITE(2,6) I,(A(I,J),J=1,6)                                    FAG17080
                                                                        FAG17090
      ELSE IF (NCOL.EQ.7) THEN                                          FAG17100
         CALL COLM(1,7)                                                 FAG17110
         DO 57 I=1,NROW                                                 FAG17120
 57      WRITE(2,7) I,(A(I,J),J=1,7)                                    FAG17130
                                                                        FAG17140
      ELSE IF (NCOL.EQ.8) THEN                                          FAG17150
         CALL COLM(1,7)                                                 FAG17160
         DO 58 I=1,NROW                                                 FAG17170
 58      WRITE(2,7) I,(A(I,J),J=1,7)                                    FAG17180
         CALL COLM(8,8)                                                 FAG17190
         DO 30 I=1,NROW                                                 FAG17200
 30      WRITE(2,1) I,(A(I,J),J=8,8)                                    FAG17210
                                                                        FAG17220
      ELSE IF (NCOL.EQ.10) THEN                                         FAG17230
         CALL COLM(1,7)                                                 FAG17240
         DO 60 I=1,NROW                                                 FAG17250
 60      WRITE(2,7) I,(A(I,J),J=1,7)                                    FAG17260
         CALL COLM(8,10)                                                FAG17270
         DO 41 I=1,NROW                                                 FAG17280
```

```
41       WRITE(2,4) I,(A(I,J),J=8,10)                                    FAG17290
                                                                         FAG17300
      ELSE IF (NCOL.EQ.11) THEN                                          FAG17310
         CALL COLM(1,7)                                                  FAG17320
         DO 61 I=1,NROW                                                  FAG17330
61       WRITE(2,7) I,(A(I,J),J=1,7)                                     FAG17340
         CALL COLM(8,11)                                                 FAG17350
         DO 42 I=1,NROW                                                  FAG17360
42       WRITE(2,4) I,(A(I,J),J=8,11)                                    FAG17370
                                                                         FAG17380
      ELSE IF (NCOL.EQ.12) THEN                                          FAG17390
         CALL COLM(1,7)                                                  FAG17400
         DO 62 I=1,NROW                                                  FAG17410
62       WRITE(2,7) I,(A(I,J),J=1,7)                                     FAG17420
         CALL COLM(8,12)                                                 FAG17430
         DO 43 I=1,NROW                                                  FAG17440
43       WRITE(2,5) I,(A(I,J),J=8,12)                                    FAG17450
                                                                         FAG17460
      ELSE IF (NCOL.EQ.14) THEN                                          FAG17470
         CALL COLM(1,7)                                                  FAG17480
         DO 64 I=1,NROW                                                  FAG17490
64       WRITE(2,7) I,(A(I,J),J=1,7)                                     FAG17500
         CALL COLM(8,14)                                                 FAG17510
         DO 65 I=1,NROW                                                  FAG17520
65       WRITE(2,7) I,(A(I,J),J=8,14)                                    FAG17530
                                                                         FAG17540
      ELSE IF (NCOL.EQ.18) THEN                                          FAG17550
         CALL COLM(1,7)                                                  FAG17560
         DO 68 I=1,NROW                                                  FAG17570
68       WRITE(2,7) I,(A(I,J),J=1,7)                                     FAG17580
         CALL COLM(8,14)                                                 FAG17590
         DO 69 I=1,NROW                                                  FAG17600
69       WRITE(2,7) I,(A(I,J),J=8,14)                                    FAG17610
         CALL COLM(15,18)                                                FAG17620
         DO 31 I=1,NROW                                                  FAG17630
31       WRITE(2,4) I,(A(I,J),J=15,18)                                   FAG17640
                                                                         FAG17650
      ELSE IF (NCOL.EQ.24) THEN                                          FAG17660
         CALL COLM(1,7)                                                  FAG17670
         DO 74 I=1,NROW                                                  FAG17680
74       WRITE(2,7) I,(A(I,J),J=1,7)                                     FAG17690
         CALL COLM(8,14)                                                 FAG17700
         DO 75 I=1,NROW                                                  FAG17710
75       WRITE(2,7) I,(A(I,J),J=8,14)                                    FAG17720
         CALL COLM(15,21)                                                FAG17730
         DO 44 I=1,NROW                                                  FAG17740
44       WRITE(2,7) I,(A(I,J),J=15,21)                                   FAG17750
         CALL COLM(22,24)                                                FAG17760
```

```
         DO 32 I=1,NROW                                            FAG17770
 32      WRITE(2,3) I,(A(I,J),J=22,24)                             FAG17780
                                                                   FAG17790
      ELSE IF (NCOL.EQ.32) THEN                                    FAG17800
         CALL COLM(1,7)                                            FAG17810
         DO 82 I=1,NROW                                            FAG17820
 82      WRITE(2,7) I,(A(I,J),J=1,7)                               FAG17830
         CALL COLM(8,14)                                           FAG17840
         DO 83 I=1,NROW                                            FAG17850
 83      WRITE(2,7) I,(A(I,J),J=8,14)                              FAG17860
         CALL COLM(15,21)                                          FAG17870
         DO 84 I=1,NROW                                            FAG17880
 84      WRITE(2,7) I,(A(I,J),J=15,21)                             FAG17890
         CALL COLM(22,29)                                          FAG17900
         DO 85 I=1,NROW                                            FAG17910
 85      WRITE(2,7) I,(A(I,J),J=22,29)                             FAG17920
         CALL COLM(30,32)                                          FAG17930
         DO 33 I=1,NROW                                            FAG17940
 33      WRITE(2,3) I,(A(I,J),J=30,32)                             FAG17950
                                                                   FAG17960
      ELSE IF (NCOL.EQ.43) THEN                                    FAG17970
         CALL COLM(1,7)                                            FAG17980
         DO 94 I=1,NROW                                            FAG17990
 94      WRITE(2,7) I,(A(I,J),J=1,7)                               FAG18000
         CALL COLM(8,14)                                           FAG18010
         DO 95 I=1,NROW                                            FAG18020
 95      WRITE(2,7) I,(A(I,J),J=8,14)                              FAG18030
         CALL COLM(15,21)                                          FAG18040
         DO 96 I=1,NROW                                            FAG18050
 96      WRITE(2,7) I,(A(I,J),J=15,21)                             FAG18060
         CALL COLM(22,28)                                          FAG18070
         DO 97 I=1,NROW                                            FAG18080
 97      WRITE(2,7) I,(A(I,J),J=22,28)                             FAG18090
         CALL COLM(29,35)                                          FAG18100
         DO 98 I=1,NROW                                            FAG18110
 98      WRITE(2,7) I,(A(I,J),J=29,35)                             FAG18120
         CALL COLM(36,42)                                          FAG18130
         DO 45 I=1,NROW                                            FAG18140
 45      WRITE(2,7) I,(A(I,J),J=36,42)                             FAG18150
         CALL COLM(43,43)                                          FAG18160
         DO 34 I=1,NROW                                            FAG18170
 34      WRITE(2,1) I,(A(I,J),J=43,43)                             FAG18180
                                                                   FAG18190
      ELSE IF (NCOL.EQ.55) THEN                                    FAG18200
         CALL COLM(1,7)                                            FAG18210
         DO 99 I=1,NROW                                            FAG18220
 99      WRITE(2,7) I,(A(I,J),J=1,7)                               FAG18230
         CALL COLM(8,14)                                           FAG18240
```

```
         DO 100 I=1,NROW                                                FAG18250
  100    WRITE(2,7) I,(A(I,J),J=8,14)                                   FAG18260
         CALL COLM(15,21)                                               FAG18270
         DO 101 I=1,NROW                                                FAG18280
  101    WRITE(2,7) I,(A(I,J),J=15,21)                                  FAG18290
         CALL COLM(22,28)                                               FAG18300
         DO 102 I=1,NROW                                                FAG18310
  102    WRITE(2,7) I,(A(I,J),J=22,28)                                  FAG18320
         CALL COLM(29,35)                                               FAG18330
         DO 103 I=1,NROW                                                FAG18340
  103    WRITE(2,7) I,(A(I,J),J=29,35)                                  FAG18350
         CALL COLM(36,42)                                               FAG18360
         DO 46 I=1,NROW                                                 FAG18370
  46     WRITE(2,7) I,(A(I,J),J=36,42)                                  FAG18380
         CALL COLM(43,49)                                               FAG18390
         DO 47 I=1,NROW                                                 FAG18400
  47     WRITE(2,7) I,(A(I,J),J=43,49)                                  FAG18410
         CALL COLM(50,55)                                               FAG18420
         DO 35 I=1,NROW                                                 FAG18430
  35     WRITE(2,6) I,(A(I,J),J=50,55)                                  FAG18440
                                                                        FAG18450
      ELSE                                                              FAG18460
         WRITE(2,999)                                                   FAG18470
      END IF                                                            FAG18480
                                                                        FAG18490
   1  FORMAT(1X,I2,1X,1(E10.3))                                         FAG18500
   2  FORMAT(1X,I2,1X,2(E10.3))                                         FAG18510
   3  FORMAT(1X,I2,1X,3(E10.3))                                         FAG18520
   4  FORMAT(1X,I2,1X,4(E10.3))                                         FAG18530
   5  FORMAT(1X,I2,1X,5(E10.3))                                         FAG18540
   6  FORMAT(1X,I2,1X,6(E10.3))                                         FAG18550
   7  FORMAT(1X,I2,1X,7(E10.3))                                         FAG18560
   8  FORMAT(1X,I2,1X,8(E10.3))                                         FAG18570
   9  FORMAT(1X,I2,1X,9(E10.3))                                         FAG18580
  10  FORMAT(1X,I2,1X,10(E10.3))                                        FAG18590
  11  FORMAT(1X,I2,1X,11(E10.3))                                        FAG18600
  12  FORMAT(1X,I2,1X,12(E10.3))                                        FAG18610
 999  FORMAT(5X,'ERROR IN OUTPUT SUBROUTINE')                           FAG18620
 555  FORMAT(//2X,A4,2X,'MATRIX')                                       FAG18630
      RETURN                                                            FAG18640
      END                                                               FAG18650
C********************************************************************** FAG18660
C                                                                       FAG18670
C                         SUBROUTINE COLM                               FAG18680
C              WRITES THE COLUMN NUMBERS FOR THE MATRIX                 FAG18690
C                                                                       FAG18700
C***********************************************************************FAG18710
                                                                        FAG18720
```

```
      SUBROUTINE COLM(NST,NSTP)                                         FAG18730
      INTEGER N(60)                                                     FAG18740
      DO 1 I=NST,NSTP                                                   FAG18750
    1 N( I)=I                                                           FAG18760
      WRITE(2,10) (N( I),I=NST,NSTP)                                    FAG18770
   10 FORMAT(8X,I2,8X,I2,8X,I2,8X,I2,8X,I2,8X,I2,8X,I2,8X,I2,8X,I2,     FAG18780
     *8X,I2,8X,I2,8X,I2)                                                FAG18790
      RETURN                                                            FAG18800
      END                                                               FAG18810
C********************** SUBROUTINE WRMATD ****************************** FAG18820
C                                                                       FAG18830
C         WRMATD WRITES THE 'AF18', 'BF18', 'CF18', AND 'DF18'          FAG18840
C     MATRICIES TO THE OPMATD DATA FILE. EXTRA NULL MATRICIES ARE ALSO  FAG18850
C     CREATED AND STORED TO CONFORM TO THE OPMATD DATA FILE STRUCTURE.  FAG18860
C     THESES MATRICIES ARE THE 'GAMD', 'FD', 'FK', 'QD', 'RD', 'V1',    FAG18870
C     'V2', AND 'SD'.                                                   FAG18880
C                                                                       FAG18890
C********************************************************************** FAG18900
      SUBROUTINE WRMATD(AD,BD,HD,GD,DELT)                               FAG18910
      IMPLICIT REAL*8(A-H,O-Z)                                          FAG18920
C                                                                       FAG18930
C     F18 SYSTEM MATRICIES                                              FAG18940
C                                                                       FAG18950
      DIMENSION AD(55,55),BD(55,3),HD(14,55),GD(14,3)                   FAG18960
C                                                                       FAG18970
C     EXTRA MATRICIES REQUIRED IN OPMATD DATA FILE                      FAG18980
C                                                                       FAG18990
      DIMENSION FD(55,3),FK(55,14),QD(14,14),RD(3,3),V2(14,14),SD(55,14)FAG19000
C                                                                       FAG19010
      DIMENSION NFD(2),NFK(2),NQD(2),NRD(2),NV2(2),NSD(2)               FAG19020
C------------ CREATE NULL MATRICIES TO BE STORED ON OPMATD -----------  FAG19030
      NFD( 1)=3                                                         FAG19040
      NFD( 2)=55                                                        FAG19050
      NFK( 1)=55                                                        FAG19060
      NFK( 2)=14                                                        FAG19070
      NQD( 1)=14                                                        FAG19080
      NQD( 2)=14                                                        FAG19090
      NRD( 1)=3                                                         FAG19100
      NRD( 2)=3                                                         FAG19110
      NV2( 1)=14                                                        FAG19120
      NV2( 2)=14                                                        FAG19130
      NSD( 1)=55                                                        FAG19140
      NSD( 2)=14                                                        FAG19150
C                                                                       FAG19160
      CALL NULL(FD,NFD)                                                 FAG19170
      CALL NULL(FK,NFK)                                                 FAG19180
      CALL NULL(QD,NQD)                                                 FAG19190
      CALL NULL(RD,NRD)                                                 FAG19200
```

```
      CALL NULL(V2,NV2)                                                 FAG19210
      CALL NULL(SD,NSD)                                                 FAG19220
C------------ WRITE MATRICIES TO OPMATD DATA FILE-----------------      FAG19230
      I = 0                                                             FAG19240
      IANS = 1                                                          FAG19250
      IDOPTD = 1                                                        FAG19260
      WRITE(3,150) I,IANS,IDOPTD                                        FAG19270
      WRITE(3,120) 55,3,14,0,1,DELT                                     FAG19280
      WRITE(3,131)                                                      FAG19290
      WRITE(3,130) ((AD(I,J),J=1,55),I=1,55)                            FAG19300
      WRITE(3,132)                                                      FAG19310
      WRITE(3,130) ((BD(I,J),J=1,3),I=1,55)                             FAG19320
      WRITE(3,133)                                                      FAG19330
      WRITE(3,130) ((HD(I,J),J=1,55),I=1,14)                            FAG19340
      WRITE(3,135)                                                      FAG19350
      WRITE(3,130) ((FD(I,J),J=1,55),I=1,3)                             FAG19360
      WRITE(3,136)                                                      FAG19370
      WRITE(3,130) ((FK(I,J),J=1,14),I=1,55)                            FAG19380
      WRITE(3,137)                                                      FAG19390
      WRITE(3,130) ((GD(I,J),J=1,3),I=1,14)                             FAG19400
      WRITE(3,138)                                                      FAG19410
      WRITE(3,130) ((QD(I,J),J=1,14),I=1,14)                            FAG19420
      WRITE(3,139)                                                      FAG19430
      WRITE(3,130) ((RD(I,J),J=1,3),I=1,3)                              FAG19440
      WRITE(3,141)                                                      FAG19450
      WRITE(3,130) ((V2(I,J),J=1,14),I=1,14)                            FAG19460
      WRITE(3,142)                                                      FAG19470
      WRITE(3,130) ((SD(I,J),J=1,3),I=1,55)                             FAG19480
C-----------------------------------------------------------------------FAG19490
120   FORMAT(5I5,5X,F10.5)                                              FAG19500
130   FORMAT(4D20.13)                                                   FAG19510
131   FORMAT(1X,2HAD)                                                   FAG19520
132   FORMAT(1X,2HBD)                                                   FAG19530
133   FORMAT(1X,2HHD)                                                   FAG19540
134   FORMAT(1X,4HGAMD)                                                 FAG19550
135   FORMAT(1X,2HFD)                                                   FAG19560
136   FORMAT(1X,2HFK)                                                   FAG19570
137   FORMAT(1X,2HGD)                                                   FAG19580
138   FORMAT(1X,2HQD)                                                   FAG19590
139   FORMAT(1X,2HRD)                                                   FAG19600
140   FORMAT(1X,2HV1)                                                   FAG19610
141   FORMAT(1X,2HV2)                                                   FAG19620
142   FORMAT(1X,2HSD)                                                   FAG19630
150   FORMAT(I1,3X,I1,3X,I1)                                            FAG19640
      RETURN                                                            FAG19650
      END                                                               FAG19660
```

```
 0.60000E+00   0.10000E+05   0.26184E+01   0.10000E+01   0.12500E-01
 0.00000E+00   0.00000E+00   0.00000E+00  -0.32174E+02
 0.00000E+00  -0.11400E+01   0.64192E+03   0.00000E+00
 0.00000E+00  -0.12670E-01  -0.94700E+00   0.00000E+00
 0.00000E+00   0.00000E+00   0.10000E+01   0.00000E+00
 0.00000E+00   0.00000E+00   0.00000E+00
-0.12953E+03   0.19430E+02  -0.14896E+03
-0.15600E+02  -0.16090E+01   0.14990E+01
 0.00000E+00   0.00000E+00   0.00000E+00
 0.00000E+00   0.00000E+00   0.10000E+01   0.00000E+00
 0.00000E+01  -0.11400E+01  -0.57490E+01   0.00000E+00
 0.00000E+00   0.15440E-02   0.00000E+00   0.00000E+00
 0.00000E+00   0.00000E+00   0.00000E+00
-0.12954E+03   0.19430E+02  -0.14896E+03
 0.00000E+00   0.00000E+00   0.00000E+00
-0.24500E+00  -0.64689E+03   0.28497E-01   0.32189E+02
 0.84920E-02  -0.24600E+00   0.11254E+00   0.00000E+00
-0.25553E-01   0.73000E+00  -0.28300E+01   0.00000E+00
 0.00000E+00   0.00000E+00   0.10000E+01   0.00000E+00
-0.69300E+01   0.00000E+00   0.00000E+00  -0.29145E+01   0.34909E+02
-0.39630E+00   0.00000E+00  -0.83500E+00  -0.89600E+00  -0.32600E+01
 0.11860E+02   0.00000E+00   0.13068E+02   0.13140E+02   0.44000E+01
 0.00000E+00   0.00000E+00   0.00000E+00   0.00000E+00   0.00000E+00
 0.00000E+00   0.10000E+01   0.00000E+00   0.00000E+00
 0.00000E+00   0.00000E+00   0.10000E+00   0.00000E+00
-0.24500E+00   0.77720E+00   0.28497E-01   0.15000E-01
 0.00000E+00   0.00000E+00   0.00000E+00   0.00000E+00   0.00000E+00
 0.00000E+00   0.00000E+00   0.00000E+00   0.00000E+00   0.00000E+00
-0.69300E+01   0.00000E+00   0.00000E+00  -0.29145E+01   0.349094+02
```

```
AIRCRAFT FLIGHT CONDITIONS AND SAMPLING TIME


MACH = 0.6000E+00 ALT = 0.1000E+05 ALPHA = 0.2618E+01
NZ = 0.1000E+01 TS = 0.1250E-01


CONTROL PARAMETERS, AND FAILURE PARAMETERS


START TIME =    0 STOP TIME = 240
AMPLITUDE = 0.10E+01 CONTROL NUMBER = 1
RIGHT STAB FAILURE = 0 LEFT STAB FAILURE = 0


 FX    MATRIX
           1          2          3          4
 1  0.000E+00 0.000E+00 0.000E+00-0.322E+02
 2  0.000E+00-0.114E+01 0.642E+03 0.000E+00
 3  0.000E+00-0.127E-01-0.947E+00 0.000E+00
 4  0.000E+00 0.000E+00 0.100E+01 0.000E+00


 GX    MATRIX
           1          2          3
 1  0.000E+00 0.000E+00 0.000E+00
 2 -0.130E+03 0.194E+02-0.149E+03
 3 -0.156E+02-0.161E+01 0.150E+01
 4  0.000E+00 0.000E+00 0.000E+00


 HX    MATRIX
           1          2          3          4
 1  0.000E+00 0.000E+00 0.100E+01 0.000E+00
 2  0.000E+00-0.114E+01-0.575E+01 0.000E+00
 3  0.000E+00 0.154E-02 0.000E+00 0.000E+00


 DX    MATRIX
           1          2          3
 1  0.000E+00 0.000E+00 0.000E+00
 2 -0.130E+03 0.194E+02-0.149E+03
 3  0.000E+00 0.000E+00 0.000E+00


 FYZ   MATRIX
```

```
       1         2         3         4
1 -0.245E+00-0.647E+03 0.285E-01 0.322E+02
2  0.849E-02-0.246E+00 0.113E+00 0.000E+00
3 -0.256E-01 0.730E+00-0.283E+01 0.000E+00
4  0.000E+00 0.000E+00 0.100E+01 0.000E+00

GYZ    MATRIX
       1         2         3         4         5
1 -0.693E+01 0.000E+00 0.000E+00-0.291E+01 0.349E+02
2 -0.396E+00 0.000E+00-0.835E+00-0.896E+00-0.326E+01
3  0.119E+02 0.000E+00 0.131E+02 0.131E+02 0.440E+01
4  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00

HYZ    MATRIX
       1         2         3         4
1  0.000E+00 0.100E+01 0.000E+00 0.000E+00
2  0.000E+00 0.000E+00 0.100E+00 0.000E+00
3 -0.245E+00 0.777E+00 0.285E-01 0.150E-01

DYZ    MATRIX
       1         2         3         4         5
1  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
2  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
3 -0.693E+01 0.000E+00 0.000E+00-0.291E+01 0.349E+02

AIR DATA CALCULATIONS

T = 0.4831D+03 RHO = 0.1755D-02 PSI = 0.1455D+04
A = 0.1078D+04 QC = 0.3671D+03 RI = 0.2522D+00

GMO    MATRIX
       1         2         3         4         5         6         7
1  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
2 -0.648E+02-0.648E+02 0.971E+01 0.971E+01-0.745E+02-0.745E+02 0.000E+00
3 -0.780E+01-0.780E+01-0.804E+00-0.804E+00 0.750E+00 0.750E+00 0.000E+00
4  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
5  0.693E+01-0.693E+01 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.291E+01
6  0.396E+00-0.396E+00 0.000E+00 0.000E+00 0.835E+00-0.835E+00 0.896E+00
7 -0.119E+02 0.119E+02 0.000E+00 0.000E+00-0.131E+02 0.131E+02-0.131E+02
8  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
       8         9        10
1  0.000E+00 0.000E+00 0.000E+00
2  0.000E+00 0.000E+00 0.000E+00
```

```
3  0.000E+00 0.000E+00 0.000E+00
4  0.000E+00 0.000E+00 0.000E+00
5 -0.291E+01 0.175E+02 0.175E+02
6 -0.896E+00-0.163E+01-0.163E+01
7  0.131E+02 0.220E+01 0.220E+01
8  0.000E+00 0.000E+00 0.000E+00

LNG   MATRIX
       1         2         3         4         5         6         7
1  0.500E+00 0.500E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
2  0.000E+00 0.000E+00 0.500E+00 0.500E+00 0.000E+00 0.000E+00 0.000E+00
3  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.500E+00 0.500E+00 0.000E+00
       8         9        10
1  0.000E+00 0.000E+00 0.000E+00
2  0.000E+00 0.000E+00 0.000E+00
3  0.000E+00 0.000E+00 0.000E+00

LAT   MATRIX
       1         2         3         4         5         6         7
1 -0.100E+01 0.100E+01 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
2  0.000E+00 0.000E+00 0.100E+01-0.100E+01 0.000E+00 0.000E+00 0.000E+00
3  0.000E+00 0.000E+00 0.000E+00 0.000E+00-0.100E+01 0.100E+01 0.000E+00
4  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00-0.100E+01
5  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
       8         9        10
1  0.000E+00 0.000E+00 0.000E+00
2  0.000E+00 0.000E+00 0.000E+00
3  0.000E+00 0.000E+00 0.000E+00
4  0.100E+01 0.000E+00 0.000E+00
5  0.000E+00 0.500E+00 0.500E+00

FM    MATRIX
       1         2         3         4         5         6         7
1  0.000E+00 0.000E+00 0.000E+00-0.322E+02 0.000E+00 0.000E+00 0.000E+00
2  0.000E+00-0.114E+01 0.642E+03 0.000E+00 0.000E+00 0.000E+00 0.000E+00
3  0.000E+00-0.127E-01-0.947E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
4  0.000E+00 0.000E+00 0.100E+01 0.000E+00 0.000E+00 0.000E+00 0.000E+00
5  0.000E+00 0.000E+00 0.000E+00 0.000E+00-0.245E+00-0.647E+03 0.285E-01
6  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.849E-02-0.246E+00 0.113E+00
7  0.000E+00 0.000E+00 0.000E+00 0.000E+00-0.256E-01 0.730E+00-0.283E+01
8  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.100E+01
       8
1  0.000E+00
2  0.000E+00
3  0.000E+00
```

```
4   0.000E+00
5   0.322E+02
6   0.000E+00
7   0.000E+00
8   0.000E+00

GM     MATRIX
        1          2          3          4          5          6          7
1   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
2  -0.113E+01-0.113E+01 0.170E+00 0.170E+00-0.130E+01-0.130E+01 0.000E+00
3  -0.136E+00-0.136E+00-0.140E-01-0.140E-01 0.131E-01 0.131E-01 0.000E+00
4   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
5   0.121E+00-0.121E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.509E-01
6   0.692E-02-0.692E-02 0.000E+00 0.000E+00 0.146E-01-0.146E-01 0.156E-01
7  -0.207E+00 0.207E+00 0.000E+00 0.000E+00-0.228E+00 0.228E+00-0.229E+00
8   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
        8          9         10
1   0.000E+00 0.000E+00 0.000E+00
2   0.000E+00 0.000E+00 0.000E+00
3   0.000E+00 0.000E+00 0.000E+00
4   0.000E+00 0.000E+00 0.000E+00
5  -0.509E-01 0.305E+00 0.305E+00
6  -0.156E-01-0.284E-01-0.284E-01
7   0.229E+00 0.384E-01 0.384E-01
8   0.000E+00 0.000E+00 0.000E+00

HM     MATRIX
        1          2          3          4          5          6          7
1   0.000E+00 0.000E+00 0.100E+01 0.000E+00 0.000E+00 0.000E+00 0.000E+00
2   0.000E+00-0.114E+01-0.575E+01 0.000E+00 0.000E+00 0.000E+00 0.000E+00
3   0.000E+00 0.154E-02 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
4   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.100E+01 0.000E+00
5   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.100E+00
6   0.000E+00 0.000E+00 0.000E+00 0.000E+00-0.245E+00 0.777E+00 0.285E-01
        8
1   0.000E+00
2   0.000E+00
3   0.000E+00
4   0.000E+00
5   0.000E+00
6   0.150E-01

DM     MATRIX
        1          2          3          4          5          6          7
1   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
```

```
 2 -0.113E+01-0.113E+01 0.170E+00 0.170E+00-0.130E+01-0.130E+01 0.000E+00
 3  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 4  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 5  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 6  0.121E+00-0.121E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.509E-01
        8         9        10
 1  0.000E+00 0.000E+00 0.000E+00
 2  0.000E+00 0.000E+00 0.000E+00
 3  0.000E+00 0.000E+00 0.000E+00
 4  0.000E+00 0.000E+00 0.000E+00
 5  0.000E+00 0.000E+00 0.000E+00
 6 -0.509E-01 0.305E+00 0.305E+00


FA    MATRIX
        1         2         3         4         5         6         7
 1  0.000E+00 0.100E+01 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 2  0.000E+00 0.000E+00 0.100E+01 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 3  0.000E+00 0.000E+00 0.000E+00 0.100E+01 0.000E+00 0.000E+00 0.000E+00
 4 -0.147E+08-0.496E+06-0.161E+05-0.154E+03 0.000E+00 0.000E+00 0.000E+00
 5  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.100E+01 0.000E+00
 6  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.100E+01
 7  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 8  0.000E+00 0.000E+00 0.000E+00 0.000E+00-0.147E+08-0.496E+06-0.161E+05
 9  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
10  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
11  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
12  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
13  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
14  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
15  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
16  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
17  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
18  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
19  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
20  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
21  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
22  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
23  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
24  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
        8         9        10        11        12        13        14
 1  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 2  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 3  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 4  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 5  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 6  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 7  0.100E+01 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
```

```
 8 -0.154E+03  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00
 9  0.000E+00  0.000E+00  0.100E+01  0.000E+00  0.000E+00  0.000E+00  0.000E+00
10  0.000E+00 -0.223E+04 -0.109E+03  0.000E+00  0.000E+00  0.000E+00  0.000E+00
11  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.100E+01  0.000E+00  0.000E+00
12  0.000E+00  0.000E+00  0.000E+00 -0.223E+04 -0.109E+03  0.000E+00  0.000E+00
13  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.100E+01
14  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00 -0.123E+04 -0.497E+02
15  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00
16  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00
17  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00
18  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00
19  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00
20  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00
21  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00
22  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00
23  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00
24  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00
         15         16         17         18         19         20         21
 1  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00
 2  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00
 3  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00
 4  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00
 5  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00
 6  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00
 7  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00
 8  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00
 9  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00
10  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00
11  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00
12  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00
13  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00
14  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00
15  0.000E+00  0.100E+01  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00
16 -0.123E+04 -0.497E+02  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00
17  0.000E+00  0.000E+00  0.000E+00  0.100E+01  0.000E+00  0.000E+00  0.000E+00
18  0.000E+00  0.000E+00 -0.563E+04 -0.885E+02  0.000E+00  0.000E+00  0.000E+00
19  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.100E+01  0.000E+00
20  0.000E+00  0.000E+00  0.000E+00  0.000E+00 -0.563E+04 -0.885E+02  0.000E+00
21  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00
22  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00 -0.520E+04
23  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00
24  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00
         22         23         24
 1  0.000E+00  0.000E+00  0.000E+00
 2  0.000E+00  0.000E+00  0.000E+00
 3  0.000E+00  0.000E+00  0.000E+00
 4  0.000E+00  0.000E+00  0.000E+00
 5  0.000E+00  0.000E+00  0.000E+00
```

```
 6   0.000E+00 0.000E+00 0.000E+00
 7   0.000E+00 0.000E+00 0.000E+00
 8   0.000E+00 0.000E+00 0.000E+00
 9   0.000E+00 0.000E+00 0.000E+00
10   0.000E+00 0.000E+00 0.000E+00
11   0.000E+00 0.000E+00 0.000E+00
12   0.000E+00 0.000E+00 0.000E+00
13   0.000E+00 0.000E+00 0.000E+00
14   0.000E+00 0.000E+00 0.000E+00
15   0.000E+00 0.000E+00 0.000E+00
16   0.000E+00 0.000E+00 0.000E+00
17   0.000E+00 0.000E+00 0.000E+00
18   0.000E+00 0.000E+00 0.000E+00
19   0.000E+00 0.000E+00 0.000E+00
20   0.000E+00 0.000E+00 0.000E+00
21   0.100E+01 0.000E+00 0.000E+00
22  -0.995E+02 0.000E+00 0.000E+00
23   0.000E+00 0.000E+00 0.100E+01
24   0.000E+00-0.520E+04-0.995E+02

 GA     MATRIX
           1         2         3         4         5         6         7
 1   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 2   0.214E+04 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 3  -0.305E+06 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 4   0.273E+08 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 5   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 6   0.000E+00 0.214E+04 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 7   0.000E+00-0.305E+06 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 8   0.000E+00 0.273E+08 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 9   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
10   0.000E+00 0.000E+00 0.223E+04 0.000E+00 0.000E+00 0.000E+00 0.000E+00
11   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
12   0.000E+00 0.000E+00 0.000E+00 0.223E+04 0.000E+00 0.000E+00 0.000E+00
13   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
14   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.123E+04 0.000E+00 0.000E+00
15   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
16   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.123E+04 0.000E+00
17   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
18   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.563E+04
19   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
20   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
21   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
22   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
23   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
24   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
           8         9        10
```

```
  1  0.000E+00 0.000E+00 0.000E+00
  2  0.000E+00 0.000E+00 0.000E+00
  3  0.000E+00 0.000E+00 0.000E+00
  4  0.000E+00 0.000E+00 0.000E+00
  5  0.000E+00 0.000E+00 0.000E+00
  6  0.000E+00 0.000E+00 0.000E+00
  7  0.000E+00 0.000E+00 0.000E+00
  8  0.000E+00 0.000E+00 0.000E+00
  9  0.000E+00 0.000E+00 0.000E+00
 10  0.000E+00 0.000E+00 0.000E+00
 11  0.000E+00 0.000E+00 0.000E+00
 12  0.000E+00 0.000E+00 0.000E+00
 13  0.000E+00 0.000E+00 0.000E+00
 14  0.000E+00 0.000E+00 0.000E+00
 15  0.000E+00 0.000E+00 0.000E+00
 16  0.000E+00 0.000E+00 0.000E+00
 17  0.000E+00 0.000E+00 0.000E+00
 18  0.000E+00 0.000E+00 0.000E+00
 19  0.000E+00 0.000E+00 0.000E+00
 20  0.563E+04 0.000E+00 0.000E+00
 21  0.000E+00 0.000E+00 0.000E+00
 22  0.000E+00 0.520E+04 0.000E+00
 23  0.000E+00 0.000E+00 0.000E+00
 24  0.000E+00 0.000E+00 0.520E+04

  HA    MATRIX
            1         2         3         4         5         6         7
  1  0.100E+01 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
  2  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.100E+01 0.000E+00 0.000E+00
  3  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
  4  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
  5  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
  6  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
  7  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
  8  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
  9  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 10  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
            8         9        10        11        12        13        14
  1  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
  2  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
  3  0.000E+00 0.100E+01 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
  4  0.000E+00 0.000E+00 0.000E+00 0.100E+01 0.000E+00 0.000E+00 0.000E+00
  5  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.100E+01 0.000E+00
  6  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
  7  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
  8  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
  9  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
```

```
 10  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
        15        16        17        18        19        20        21
  1  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
  2  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
  3  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
  4  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
  5  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
  6  0.100E+01 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
  7  0.000E+00 0.000E+00 0.100E+01 0.000E+00 0.000E+00 0.000E+00 0.000E+00
  8  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.100E+01 0.000E+00 0.000E+00
  9  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.100E+01
 10  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
        22        23        24
  1  0.000E+00 0.000E+00 0.000E+00
  2  0.000E+00 0.000E+00 0.000E+00
  3  0.000E+00 0.000E+00 0.000E+00
  4  0.000E+00 0.000E+00 0.000E+00
  5  0.000E+00 0.000E+00 0.000E+00
  6  0.000E+00 0.000E+00 0.000E+00
  7  0.000E+00 0.000E+00 0.000E+00
  8  0.000E+00 0.000E+00 0.000E+00
  9  0.000E+00 0.000E+00 0.000E+00
 10  0.000E+00 0.100E+01 0.000E+00

  FS    MATRIX
         1         2         3         4         5         6         7
  1  0.000E+00 0.100E+01 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
  2 -0.775E+05-0.629E+03 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
  3  0.000E+00 0.000E+00 0.000E+00 0.100E+01 0.000E+00 0.000E+00 0.000E+00
  4  0.000E+00 0.000E+00-0.156E+06-0.759E+03 0.000E+00 0.000E+00 0.000E+00
  5  0.000E+00 0.000E+00 0.000E+00 0.000E+00-0.140E+02 0.000E+00 0.000E+00
  6  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.100E+01
  7  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00-0.775E+05-0.629E+03
  8  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
  9  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 10  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 11  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
         8         9        10        11
  1  0.000E+00 0.000E+00 0.000E+00 0.000E+00
  2  0.000E+00 0.000E+00 0.000E+00 0.000E+00
  3  0.000E+00 0.000E+00 0.000E+00 0.000E+00
  4  0.000E+00 0.000E+00 0.000E+00 0.000E+00
  5  0.000E+00 0.000E+00 0.000E+00 0.000E+00
  6  0.000E+00 0.000E+00 0.000E+00 0.000E+00
  7  0.000E+00 0.000E+00 0.000E+00 0.000E+00
  8  0.000E+00 0.100E+01 0.000E+00 0.000E+00
  9 -0.775E+05-0.629E+03 0.000E+00 0.000E+00
```

```
10   0.000E+00 0.000E+00 0.000E+00 0.100E+01
11   0.000E+00 0.000E+00-0.156E+06-0.759E+03

 GS     MATRIX
           1         2         3         4         5         6
 1   0.337E+05 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 2  -0.168E+08 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 3   0.000E+00 0.206E+02 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 4   0.000E+00-0.108E+05 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 5   0.000E+00 0.000E+00 0.802E+03 0.000E+00 0.000E+00 0.000E+00
 6   0.000E+00 0.000E+00 0.000E+00 0.337E+05 0.000E+00 0.000E+00
 7   0.000E+00 0.000E+00 0.000E+00-0.168E+08 0.000E+00 0.000E+00
 8   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.337E+05 0.000E+00
 9   0.000E+00 0.000E+00 0.000E+00 0.000E+00-0.168E+08 0.000E+00
10   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.206E+02
11   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00-0.108E+05

 HS     MATRIX
           1         2         3         4         5         6         7
 1   0.100E+01 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 2   0.000E+00 0.000E+00 0.100E+01 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 3   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.100E+01 0.000E+00 0.000E+00
 4   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.100E+01 0.000E+00
 5   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 6   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
           8         9        10        11
 1   0.000E+00 0.000E+00 0.000E+00 0.000E+00
 2   0.000E+00 0.000E+00 0.000E+00 0.000E+00
 3   0.000E+00 0.000E+00 0.000E+00 0.000E+00
 4   0.000E+00 0.000E+00 0.000E+00 0.000E+00
 5   0.100E+01 0.000E+00 0.000E+00 0.000E+00
 6   0.000E+00 0.000E+00 0.100E+01 0.000E+00

 FP     MATRIX
           1         2         3         4         5         6         7
 1   0.000E+00 0.000E+00 0.000E+00-0.322E+02 0.000E+00 0.000E+00 0.000E+00
 2   0.000E+00-0.114E+01 0.642E+03 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 3   0.000E+00-0.127E-01-0.947E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 4   0.000E+00 0.000E+00 0.100E+01 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 5   0.000E+00 0.000E+00 0.000E+00 0.000E+00-0.245E+00-0.647E+03 0.285E-01
 6   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.849E-02-0.246E+00 0.113E+00
 7   0.000E+00 0.000E+00 0.000E+00 0.000E+00-0.256E-01 0.730E+00-0.283E+01
 8   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.100E+01
 9   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
10   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
```

```
11   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
12   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
13   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
14   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
15   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
16   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
17   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
18   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
19   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
20   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
21   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
22   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
23   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
24   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
25   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
26   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
27   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
28   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
29   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
30   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
31   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
32   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
         8         9        10        11        12        13        14
 1   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 2   0.000E+00-0.113E+01 0.000E+00 0.000E+00 0.000E+00-0.113E+01 0.000E+00
 3   0.000E+00-0.136E+00 0.000E+00 0.000E+00 0.000E+00-0.136E+00 0.000E+00
 4   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 5   0.322E+02 0.121E+00 0.000E+00 0.000E+00 0.000E+00-0.121E+00 0.000E+00
 6   0.000E+00 0.692E-02 0.000E+00 0.000E+00 0.000E+00-0.692E-02 0.000E+00
 7   0.000E+00-0.207E+00 0.000E+00 0.000E+00 0.000E+00 0.207E+00 0.000E+00
 8   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 9   0.000E+00 0.000E+00 0.100E+01 0.000E+00 0.000E+00 0.000E+00 0.000E+00
10   0.000E+00 0.000E+00 0.000E+00 0.100E+01 0.000E+00 0.000E+00 0.000E+00
11   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.100E+01 0.000E+00 0.000E+00
12   0.000E+00-0.147E+08-0.496E+06-0.161E+05-0.154E+03 0.000E+00 0.000E+00
13   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.100E+01
14   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
15   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
16   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00-0.147E+08-0.496E+06
17   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
18   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
19   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
20   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
21   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
22   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
23   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
24   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
25   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
```

```
 26  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 27  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 28  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 29  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 30  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 31  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 32  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
         15        16        17        18        19        20        21
  1  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
  2  0.000E+00 0.000E+00 0.170E+00 0.000E+00 0.170E+00 0.000E+00-0.130E+01
  3  0.000E+00 0.000E+00-0.140E-01 0.000E+00-0.140E-01 0.000E+00 0.131E-01
  4  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
  5  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
  6  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.146E-01
  7  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00-0.228E+00
  8  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
  9  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 10  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 11  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 12  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 13  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 14  0.100E+01 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 15  0.000E+00 0.100E+01 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 16 -0.161E+05-0.154E+03 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 17  0.000E+00 0.000E+00 0.000E+00 0.100E+01 0.000E+00 0.000E+00 0.000E+00
 18  0.000E+00 0.000E+00-0.223E+04-0.109E+03 0.000E+00 0.000E+00 0.000E+00
 19  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.100E+01 0.000E+00
 20  0.000E+00 0.000E+00 0.000E+00 0.000E+00-0.223E+04-0.109E+03 0.000E+00
 21  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 22  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00-0.123E+04
 23  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 24  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 25  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 26  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 27  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 28  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 29  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 30  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 31  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 32  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
         22        23        24        25        26        27        28        29
  1  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
0.000E+00
  2  0.000E+00-0.130E+01 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
0.000E+00
  3  0.000E+00 0.131E-01 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
0.000E+00
  4  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
```

```
 0.000E+00
  5  0.000E+00 0.000E+00 0.000E+00 0.509E-01 0.000E+00-0.509E-01 0.000E+00
 0.305E+00
  6  0.000E+00-0.146E-01 0.000E+00 0.156E-01 0.000E+00-0.156E-01 0.000E+00
-0.284E-01
  7  0.000E+00 0.228E+00 0.000E+00-0.229E+00 0.000E+00 0.229E+00 0.000E+00
 0.384E-01
  8  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 0.000E+00
  9  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 0.000E+00
 10  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 0.000E+00
 11  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 0.000E+00
 12  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 0.000E+00
 13  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 0.000E+00
 14  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 0.000E+00
 15  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 0.000E+00
 16  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 0.000E+00
 17  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 0.000E+00
 18  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 0.000E+00
 19  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 0.000E+00
 20  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 0.000E+00
 21  0.100E+01 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 0.000E+00
 22 -0.497E+02 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 0.000E+00
 23  0.000E+00 0.000E+00 0.100E+01 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 0.000E+00
 24  0.000E+00-0.123E+04-0.497E+02 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 0.000E+00
 25  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.100E+01 0.000E+00 0.000E+00
 0.000E+00
 26  0.000E+00 0.000E+00 0.000E+00-0.563E+04-0.885E+02 0.000E+00 0.000E+00
 0.000E+00
 27  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.100E+01
 0.000E+00
 28  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00-0.563E+04-0.885E+02
```

```
 0.000E+00
 29   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 0.000E+00
 30   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
-0.520E+04
 31   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 0.000E+00
 32   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 0.000E+00
          30        31        32
  1   0.000E+00 0.000E+00 0.000E+00
  2   0.000E+00 0.000E+00 0.000E+00
  3   0.000E+00 0.000E+00 0.000E+00
  4   0.000E+00 0.000E+00 0.000E+00
  5   0.000E+00 0.305E+00 0.000E+00
  6   0.000E+00-0.284E-01 0.000E+00
  7   0.000E+00 0.384E-01 0.000E+00
  8   0.000E+00 0.000E+00 0.000E+00
  9   0.000E+00 0.000E+00 0.000E+00
 10   0.000E+00 0.000E+00 0.000E+00
 11   0.000E+00 0.000E+00 0.000E+00
 12   0.000E+00 0.000E+00 0.000E+00
 13   0.000E+00 0.000E+00 0.000E+00
 14   0.000E+00 0.000E+00 0.000E+00
 15   0.000E+00 0.000E+00 0.000E+00
 16   0.000E+00 0.000E+00 0.000E+00
 17   0.000E+00 0.000E+00 0.000E+00
 18   0.000E+00 0.000E+00 0.000E+00
 19   0.000E+00 0.000E+00 0.000E+00
 20   0.000E+00 0.000E+00 0.000E+00
 21   0.000E+00 0.000E+00 0.000E+00
 22   0.000E+00 0.000E+00 0.000E+00
 23   0.000E+00 0.000E+00 0.000E+00
 24   0.000E+00 0.000E+00 0.000E+00
 25   0.000E+00 0.000E+00 0.000E+00
 26   0.000E+00 0.000E+00 0.000E+00
 27   0.000E+00 0.000E+00 0.000E+00
 28   0.000E+00 0.000E+00 0.000E+00
 29   0.100E+01 0.000E+00 0.000E+00
 30  -0.995E+02 0.000E+00 0.000E+00
 31   0.000E+00 0.000E+00 0.100E+01
 32   0.000E+00-0.520E+04-0.995E+02

  GP    MATRIX
           1         2         3         4         5         6         7
  1   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
  2   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
```

```
 3  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 4  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 5  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 6  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 7  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 8  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 9  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
10  0.214E+04 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
11 -0.305E+06 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
12  0.273E+08 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
13  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
14  0.000E+00 0.214E+04 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
15  0.000E+00-0.305E+06 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
16  0.000E+00 0.273E+08 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
17  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
18  0.000E+00 0.000E+00 0.223E+04 0.000E+00 0.000E+00 0.000E+00 0.000E+00
19  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
20  0.000E+00 0.000E+00 0.000E+00 0.223E+04 0.000E+00 0.000E+00 0.000E+00
21  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
22  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.123E+04 0.000E+00 0.000E+00
23  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
24  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.123E+04 0.000E+00
25  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
26  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.563E+04
27  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
28  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
29  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
30  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
31  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
32  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
        8         9         10
 1  0.000E+00 0.000E+00 0.000E+00
 2  0.000E+00 0.000E+00 0.000E+00
 3  0.000E+00 0.000E+00 0.000E+00
 4  0.000E+00 0.000E+00 0.000E+00
 5  0.000E+00 0.000E+00 0.000E+00
 6  0.000E+00 0.000E+00 0.000E+00
 7  0.000E+00 0.000E+00 0.000E+00
 8  0.000E+00 0.000E+00 0.000E+00
 9  0.000E+00 0.000E+00 0.000E+00
10  0.000E+00 0.000E+00 0.000E+00
11  0.000E+00 0.000E+00 0.000E+00
12  0.000E+00 0.000E+00 0.000E+00
13  0.000E+00 0.000E+00 0.000E+00
14  0.000E+00 0.000E+00 0.000E+00
15  0.000E+00 0.000E+00 0.000E+00
16  0.000E+00 0.000E+00 0.000E+00
17  0.000E+00 0.000E+00 0.000E+00
```

```
18   0.000E+00 0.000E+00 0.000E+00
19   0.000E+00 0.000E+00 0.000E+00
20   0.000E+00 0.000E+00 0.000E+00
21   0.000E+00 0.000E+00 0.000E+00
22   0.000E+00 0.000E+00 0.000E+00
23   0.000E+00 0.000E+00 0.000E+00
24   0.000E+00 0.000E+00 0.000E+00
25   0.000E+00 0.000E+00 0.000E+00
26   0.000E+00 0.000E+00 0.000E+00
27   0.000E+00 0.000E+00 0.000E+00
28   0.563E+04 0.000E+00 0.000E+00
29   0.000E+00 0.000E+00 0.000E+00
30   0.000E+00 0.520E+04 0.000E+00
31   0.000E+00 0.000E+00 0.000E+00
32   0.000E+00 0.000E+00 0.520E+04

 HP     MATRIX
           1          2          3          4          5          6          7
 1   0.000E+00 0.000E+00 0.100E+01 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 2   0.000E+00-0.114E+01-0.575E+01 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 3   0.000E+00 0.154E-02 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 4   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.100E+01 0.000E+00
 5   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.100E+00
 6   0.000E+00 0.000E+00 0.000E+00 0.000E+00-0.245E+00 0.777E+00 0.285E-01
           8          9         10         11         12         13         14
 1   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 2   0.000E+00-0.113E+01 0.000E+00 0.000E+00 0.000E+00-0.113E+01 0.000E+00
 3   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 4   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 5   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 6   0.150E-01 0.121E+00 0.000E+00 0.000E+00 0.000E+00-0.121E+00 0.000E+00
          15         16         17         18         19         20         21
 1   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 2   0.000E+00 0.000E+00 0.170E+00 0.000E+00 0.170E+00 0.000E+00-0.130E+01
 3   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 4   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 5   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 6   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
          22         23         24         25         26         27         28          29
 1   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
0.000E+00
 2   0.000E+00-0.130E+01 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
0.000E+00
 3   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
0.000E+00
 4   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
0.000E+00
```

```
 5  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
0.000E+00
 6  0.000E+00 0.000E+00 0.000E+00 0.509E-01 0.000E+00-0.509E-01 0.000E+00
0.305E+00
        30        31        32
 1  0.000E+00 0.000E+00 0.000E+00
 2  0.000E+00 0.000E+00 0.000E+00
 3  0.000E+00 0.000E+00 0.000E+00
 4  0.000E+00 0.000E+00 0.000E+00
 5  0.000E+00 0.000E+00 0.000E+00
 6  0.000E+00 0.305E+00 0.000E+00


 APS   MATRIX
        1         2         3         4         5         6         7
 1  0.100E+01 0.132E-06-0.250E-02-0.402E+00 0.000E+00 0.000E+00 0.000E+00
 2  0.000E+00 0.985E+00 0.792E+01 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 3  0.000E+00-0.156E-03 0.988E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 4  0.000E+00-0.981E-06 0.124E-01 0.100E+01 0.000E+00 0.000E+00 0.000E+00
 5  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.997E+00-0.806E+01-0.278E-02
 6  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.106E-03 0.997E+00 0.138E-02
 7  0.000E+00 0.000E+00 0.000E+00 0.000E+00-0.313E-03 0.102E-01 0.965E+00
 8  0.000E+00 0.000E+00 0.000E+00 0.000E+00-0.197E-05 0.616E-04 0.123E-01
 9  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
10  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
11  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
12  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
13  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
14  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
15  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
16  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
17  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
18  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
19  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
20  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
21  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
22  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
23  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
24  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
25  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
26  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
27  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
28  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
29  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
30  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
31  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
32  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
33  0.000E+00-0.837E-02 0.594E+02 0.000E+00 0.000E+00 0.000E+00 0.000E+00
```

```
34   0.000E+00 0.452E+01-0.337E+05 0.000E+00 0.000E+00 0.000E+00 0.000E+00
35   0.000E+00-0.356E-01-0.446E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
36   0.000E+00 0.234E+02 0.281E+03 0.000E+00 0.000E+00 0.000E+00 0.000E+00
37   0.000E+00 0.141E-01 0.581E-01 0.000E+00 0.000E+00 0.000E+00 0.000E+00
38   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.565E-02 0.599E+02 0.739E-01
39   0.000E+00 0.000E+00 0.000E+00 0.000E+00-0.305E+01-0.340E+05-0.400E+02
40   0.000E+00 0.000E+00 0.000E+00 0.000E+00-0.168E-02 0.540E-01 0.582E+01
41   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.906E+00-0.291E+02-0.331E+04
42   0.000E+00 0.000E+00 0.000E+00 0.000E+00-0.774E-02 0.826E-01 0.929E-03
43   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.507E+01-0.518E+02-0.607E+00
         8          9          10         11         12         13         14
 1   0.000E+00 0.142E-05 0.443E-08 0.106E-10 0.173E-13 0.142E-05 0.443E-08
 2   0.000E+00-0.208E-01-0.115E-03-0.414E-06-0.913E-09-0.208E-01-0.115E-03
 3   0.000E+00-0.169E-02-0.105E-04-0.399E-07-0.911E-10-0.169E-02-0.105E-04
 4   0.000E+00-0.106E-04-0.439E-07-0.129E-09-0.245E-12-0.106E-04-0.439E-07
 5   0.402E+00 0.116E-02 0.788E-05 0.313E-07 0.730E-10-0.116E-02-0.788E-05
 6   0.213E-04 0.844E-04 0.526E-06 0.201E-08 0.460E-11-0.844E-04-0.526E-06
 7  -0.634E-04-0.254E-02-0.158E-04-0.604E-07-0.138E-09 0.254E-02 0.158E-04
 8   0.100E+01-0.160E-04-0.663E-07-0.195E-09-0.372E-12 0.160E-04 0.663E-07
 9   0.000E+00 0.990E+00 0.121E-01 0.664E-04 0.191E-06 0.000E+00 0.000E+00
10   0.000E+00-0.280E+01 0.896E+00 0.906E-02 0.369E-04 0.000E+00 0.000E+00
11   0.000E+00-0.543E+03-0.211E+02 0.300E+00 0.337E-02 0.000E+00 0.000E+00
12   0.000E+00-0.495E+05-0.221E+04-0.755E+02-0.219E+00 0.000E+00 0.000E+00
13   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.990E+00 0.121E-01
14   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00-0.280E+01 0.896E+00
15   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00-0.543E+03-0.211E+02
16   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00-0.495E+05-0.221E+04
17   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
18   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
19   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
20   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
21   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
22   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
23   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
24   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
25   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
26   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
27   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
28   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
29   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
30   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
31   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
32   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
33   0.000E+00-0.903E-01-0.498E-03-0.173E-05-0.366E-08-0.903E-01-0.498E-03
34   0.000E+00 0.488E+02 0.264E+00 0.906E-03 0.190E-05 0.488E+02 0.264E+00
35   0.000E+00-0.346E-01-0.401E-03-0.204E-05-0.548E-08-0.346E-01-0.401E-03
36   0.000E+00 0.227E+02 0.247E+00 0.122E-02 0.322E-05 0.227E+02 0.247E+00
37   0.000E+00-0.136E-03-0.537E-06-0.153E-08-0.286E-11-0.136E-03-0.537E-06
```

```
38  0.101E-02 0.453E-02 0.251E-04 0.872E-07 0.185E-09-0.453E-02-0.251E-04
39 -0.535E+00-0.245E+01-0.133E-01-0.457E-04-0.961E-07 0.245E+01 0.133E-01
40 -0.301E-03-0.136E-01-0.753E-04-0.262E-06-0.554E-09 0.136E-01 0.753E-04
41  0.160E+00 0.735E+01 0.399E-01 0.137E-03 0.288E-06-0.735E+01-0.399E-01
42 -0.242E-02 0.380E-02 0.434E-04 0.219E-06 0.589E-09-0.380E-02-0.434E-04
43  0.146E+01-0.249E+01-0.267E-01-0.131E-03-0.346E-06 0.249E+01 0.267E-01
        15        16        17        18        19        20        21
 1  0.106E-10 0.173E-13 0.145E-06 0.354E-09 0.145E-06 0.354E-09-0.136E-06
 2 -0.414E-06-0.913E-09 0.133E-02 0.644E-05 0.133E-02 0.644E-05-0.150E-01
 3 -0.399E-07-0.911E-10-0.167E-03-0.709E-06-0.167E-03-0.709E-06 0.159E-03
 4 -0.129E-09-0.245E-12-0.107E-05-0.330E-08-0.107E-05-0.330E-08 0.101E-05
 5 -0.313E-07-0.730E-10 0.000E+00 0.000E+00 0.000E+00 0.000E+00-0.722E-03
 6 -0.201E-08-0.460E-11 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.175E-03
 7  0.604E-07 0.138E-09 0.000E+00 0.000E+00 0.000E+00 0.000E+00-0.272E-02
 8  0.195E-09 0.372E-12 0.000E+00 0.000E+00 0.000E+00 0.000E+00-0.174E-04
 9  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
10  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
11  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
12  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
13  0.664E-04 0.191E-06 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
14  0.906E-02 0.369E-04 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
15  0.300E+00 0.337E-02 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
16 -0.755E+02-0.219E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
17  0.000E+00 0.000E+00 0.887E+00 0.645E-02 0.000E+00 0.000E+00 0.000E+00
18  0.000E+00 0.000E+00-0.144E+02 0.184E+00 0.000E+00 0.000E+00 0.000E+00
19  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.887E+00 0.645E-02 0.000E+00
20  0.000E+00 0.000E+00 0.000E+00 0.000E+00-0.144E+02 0.184E+00 0.000E+00
21  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.923E+00
22  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00-0.110E+02
23  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
24  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
25  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
26  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
27  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
28  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
29  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
30  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
31  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
32  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
33 -0.173E-05-0.366E-08-0.901E-02-0.352E-04-0.901E-02-0.352E-04 0.856E-02
34  0.906E-03 0.190E-05 0.488E+01 0.187E-01 0.488E+01 0.187E-01-0.463E+01
35 -0.204E-05-0.548E-08 0.482E-02 0.340E-04 0.482E-02 0.340E-04-0.380E-01
36  0.122E-02 0.322E-05-0.319E+01-0.213E-01-0.319E+01-0.213E-01 0.251E+02
37 -0.153E-08-0.286E-11 0.117E-04 0.386E-07 0.117E-04 0.386E-07-0.113E-03
38 -0.872E-07-0.185E-09 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.941E-02
39  0.457E-04 0.961E-07 0.000E+00 0.000E+00 0.000E+00 0.000E+00-0.509E+01
40  0.262E-06 0.554E-09 0.000E+00 0.000E+00 0.000E+00 0.000E+00-0.147E-01
41 -0.137E-03-0.288E-06 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.793E+01
```

```
 42 -0.219E-06-0.589E-09 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.645E-05
 43  0.131E-03 0.346E-06 0.000E+00 0.000E+00 0.000E+00 0.000E+00-0.387E-02
        22        23        24        25        26        27        28
  1 -0.378E-09-0.136E-06-0.378E-09 0.000E+00 0.000E+00 0.000E+00 0.000E+00
  2 -0.794E-04-0.150E-01-0.794E-04 0.000E+00 0.000E+00 0.000E+00 0.000E+00
  3  0.828E-06 0.159E-03 0.828E-06 0.000E+00 0.000E+00 0.000E+00 0.000E+00
  4  0.364E-08 0.101E-05 0.364E-08 0.000E+00 0.000E+00 0.000E+00 0.000E+00
  5 -0.261E-05 0.722E-03 0.261E-05-0.175E-03 0.207E-06 0.175E-03-0.207E-06
  6  0.913E-06-0.175E-03-0.913E-06 0.172E-03 0.808E-06-0.172E-03-0.808E-06
  7 -0.142E-04 0.272E-02 0.142E-04-0.251E-02-0.118E-04 0.251E-02 0.118E-04
  8 -0.628E-07 0.174E-04 0.628E-07-0.167E-04-0.550E-07 0.167E-04 0.550E-07
  9  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 10  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 11  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 12  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 13  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 14  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 15  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 16  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 17  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 18  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 19  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 20  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 21  0.902E-02 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 22  0.474E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 23  0.000E+00 0.923E+00 0.902E-02 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 24  0.000E+00-0.110E+02 0.474E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 25  0.000E+00 0.000E+00 0.000E+00 0.707E+00 0.652E-02 0.000E+00 0.000E+00
 26  0.000E+00 0.000E+00 0.000E+00-0.367E+02 0.129E+00 0.000E+00 0.000E+00
 27  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.707E+00 0.652E-02
 28  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00-0.367E+02 0.129E+00
 29  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 30  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 31  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 32  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 33  0.402E-04 0.856E-02 0.402E-04 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 34 -0.213E-01-0.463E+01-0.213E-01 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 35 -0.353E-03-0.380E-01-0.353E-03 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 36  0.219E+00 0.251E+02 0.219E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 37 -0.418E-06-0.113E-03-0.418E-06 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 38  0.444E-04-0.941E-02-0.444E-04 0.941E-02 0.402E-04-0.941E-02-0.402E-04
 39 -0.236E-01 0.509E+01 0.236E-01-0.510E+01-0.214E-01 0.510E+01 0.214E-01
 40 -0.692E-04 0.147E-01 0.692E-04-0.137E-01-0.587E-04 0.137E-01 0.587E-04
 41  0.367E-01-0.793E+01-0.367E-01 0.744E+01 0.312E-01-0.744E+01-0.312E-01
 42  0.240E-07-0.645E-05-0.240E-07 0.120E-02 0.104E-04-0.120E-02-0.104E-04
 43 -0.141E-04 0.387E-02 0.141E-04-0.810E+00-0.656E-02 0.810E+00 0.656E-02
        29        30        31        32        33        34        35
  1  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
```

```
  2  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
  3  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
  4  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
  5  0.479E-02 0.197E-04 0.479E-02 0.197E-04 0.000E+00 0.000E+00 0.000E+00
  6 -0.320E-03-0.143E-05-0.320E-03-0.143E-05 0.000E+00 0.000E+00 0.000E+00
  7  0.423E-03 0.191E-05 0.423E-03 0.191E-05 0.000E+00 0.000E+00 0.000E+00
  8  0.280E-05 0.896E-08 0.280E-05 0.896E-08 0.000E+00 0.000E+00 0.000E+00
  9  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 10  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 11  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 12  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 13  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 14  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 15  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 16  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 17  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 18  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 19  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 20  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 21  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 22  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 23  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 24  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 25  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 26  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 27  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 28  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 29  0.737E+00 0.625E-02 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 30 -0.325E+02 0.116E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 31  0.000E+00 0.000E+00 0.737E+00 0.625E-02 0.000E+00 0.000E+00 0.000E+00
 32  0.000E+00 0.000E+00-0.325E+02 0.116E+00 0.000E+00 0.000E+00 0.000E+00
 33  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.191E+00 0.407E-03 0.000E+00
 34  0.000E+00 0.000E+00 0.000E+00 0.000E+00-0.315E+02-0.652E-01 0.000E+00
 35  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.310E-01
 36  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00-0.121E+02
 37  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 38 -0.174E-01-0.714E-04-0.174E-01-0.714E-04 0.000E+00 0.000E+00 0.000E+00
 39  0.944E+01 0.380E-01 0.944E+01 0.380E-01 0.000E+00 0.000E+00 0.000E+00
 40  0.231E-02 0.951E-05 0.231E-02 0.951E-05 0.000E+00 0.000E+00 0.000E+00
 41 -0.125E+01-0.506E-02-0.125E+01-0.506E-02 0.000E+00 0.000E+00 0.000E+00
 42  0.739E-02 0.598E-04 0.739E-02 0.598E-04 0.000E+00 0.000E+00 0.000E+00
 43 -0.497E+01-0.376E-01-0.497E+01-0.376E-01 0.000E+00 0.000E+00 0.000E+00
        36        37        38        39        40        41        42
  1  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
  2  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
  3  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
  4  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
  5  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
```

```
  6  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
  7  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
  8  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
  9  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 10  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 11  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 12  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 13  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 14  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 15  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 16  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 17  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 18  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 19  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 20  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 21  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 22  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 23  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 24  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 25  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 26  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 27  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 28  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 29  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 30  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 31  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 32  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 33  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 34  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 35  0.773E-04 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 36 -0.277E-01 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 37  0.000E+00 0.839E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 38  0.000E+00 0.000E+00 0.191E+00 0.407E-03 0.000E+00 0.000E+00 0.000E+00
 39  0.000E+00 0.000E+00-0.315E+02-0.652E-01 0.000E+00 0.000E+00 0.000E+00
 40  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.191E+00 0.407E-03 0.000E+00
 41  0.000E+00 0.000E+00 0.000E+00 0.000E+00-0.315E+02-0.652E-01 0.000E+00
 42  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.310E-01
 43  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00-0.121E+02
         43
  1  0.000E+00
  2  0.000E+00
  3  0.000E+00
  4  0.000E+00
  5  0.000E+00
  6  0.000E+00
  7  0.000E+00
  8  0.000E+00
  9  0.000E+00
```

```
10   0.000E+00
11   0.000E+00
12   0.000E+00
13   0.000E+00
14   0.000E+00
15   0.000E+00
16   0.000E+00
17   0.000E+00
18   0.000E+00
19   0.000E+00
20   0.000E+00
21   0.000E+00
22   0.000E+00
23   0.000E+00
24   0.000E+00
25   0.000E+00
26   0.000E+00
27   0.000E+00
28   0.000E+00
29   0.000E+00
30   0.000E+00
31   0.000E+00
32   0.000E+00
33   0.000E+00
34   0.000E+00
35   0.000E+00
36   0.000E+00
37   0.000E+00
38   0.000E+00
39   0.000E+00
40   0.000E+00
41   0.000E+00
42   0.773E-04
43  -0.277E-01

 BPS    MATRIX
           1          2          3          4          5          6          7
 1   0.178E-07  0.178E-07  0.206E-08  0.206E-08-0.118E-08-0.118E-08  0.000E+00
 2  -0.641E-03-0.641E-03  0.730E-04  0.730E-04-0.432E-03-0.432E-03  0.000E+00
 3  -0.611E-04-0.611E-04-0.735E-05-0.735E-05  0.446E-05  0.446E-05  0.000E+00
 4  -0.208E-06-0.208E-06-0.245E-07-0.245E-07  0.144E-07  0.144E-07  0.000E+00
 5   0.476E-04-0.476E-04  0.000E+00  0.000E+00-0.103E-04  0.103E-04  0.235E-04
 6   0.308E-05-0.308E-05  0.000E+00  0.000E+00  0.493E-05-0.493E-05  0.212E-04
 7  -0.924E-04  0.924E-04  0.000E+00  0.000E+00-0.770E-04  0.770E-04-0.310E-03
 8  -0.316E-06  0.316E-06  0.000E+00  0.000E+00-0.249E-06  0.249E-06-0.103E-05
 9   0.934E-01  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00
10   0.109E+02  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00
```

```
11 -0.198E+04 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
12  0.261E+06 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
13  0.000E+00 0.934E-01 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
14  0.000E+00 0.109E+02 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
15  0.000E+00-0.198E+04 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
16  0.000E+00 0.261E+06 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
17  0.000E+00 0.000E+00 0.113E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
18  0.000E+00 0.000E+00 0.144E+02 0.000E+00 0.000E+00 0.000E+00 0.000E+00
19  0.000E+00 0.000E+00 0.000E+00 0.113E+00 0.000E+00 0.000E+00 0.000E+00
20  0.000E+00 0.000E+00 0.000E+00 0.144E+02 0.000E+00 0.000E+00 0.000E+00
21  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.774E-01 0.000E+00 0.000E+00
22  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.110E+02 0.000E+00 0.000E+00
23  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.774E-01 0.000E+00
24  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.110E+02 0.000E+00
25  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.293E+00
26  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.367E+02
27  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
28  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
29  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
30  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
31  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
32  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
33 -0.271E-02-0.271E-02-0.323E-03-0.323E-03 0.193E-03 0.193E-03 0.000E+00
34  0.142E+01 0.142E+01 0.169E+00 0.169E+00-0.101E+00-0.101E+00 0.000E+00
35 -0.294E-02-0.294E-02 0.530E-03 0.530E-03-0.273E-02-0.273E-02 0.000E+00
36  0.177E+01 0.177E+01-0.318E+00-0.318E+00 0.163E+01 0.163E+01 0.000E+00
37 -0.249E-05-0.249E-05 0.304E-06 0.304E-06-0.167E-05-0.167E-05 0.000E+00
38  0.137E-03-0.137E-03 0.000E+00 0.000E+00 0.213E-03-0.213E-03 0.930E-03
39 -0.718E-01 0.718E-01 0.000E+00 0.000E+00-0.112E+00 0.112E+00-0.488E+00
40 -0.410E-03 0.410E-03 0.000E+00 0.000E+00-0.333E-03 0.333E-03-0.136E-02
41  0.215E+00-0.215E+00 0.000E+00 0.000E+00 0.175E+00-0.175E+00 0.713E+00
42  0.317E-03-0.317E-03 0.000E+00 0.000E+00 0.973E-07-0.973E-07 0.414E-03
43 -0.190E+00 0.190E+00 0.000E+00 0.000E+00-0.563E-04 0.563E-04-0.248E+00
       8         9        10
 1  0.000E+00 0.000E+00 0.000E+00
 2  0.000E+00 0.000E+00 0.000E+00
 3  0.000E+00 0.000E+00 0.000E+00
 4  0.000E+00 0.000E+00 0.000E+00
 5 -0.235E-04 0.449E-03 0.449E-03
 6 -0.212E-04-0.349E-04-0.349E-04
 7  0.310E-03 0.466E-04 0.466E-04
 8  0.103E-05 0.156E-06 0.156E-06
 9  0.000E+00 0.000E+00 0.000E+00
10  0.000E+00 0.000E+00 0.000E+00
11  0.000E+00 0.000E+00 0.000E+00
12  0.000E+00 0.000E+00 0.000E+00
13  0.000E+00 0.000E+00 0.000E+00
14  0.000E+00 0.000E+00 0.000E+00
```

```
15  0.000E+00 0.000E+00 0.000E+00
16  0.000E+00 0.000E+00 0.000E+00
17  0.000E+00 0.000E+00 0.000E+00
18  0.000E+00 0.000E+00 0.000E+00
19  0.000E+00 0.000E+00 0.000E+00
20  0.000E+00 0.000E+00 0.000E+00
21  0.000E+00 0.000E+00 0.000E+00
22  0.000E+00 0.000E+00 0.000E+00
23  0.000E+00 0.000E+00 0.000E+00
24  0.000E+00 0.000E+00 0.000E+00
25  0.000E+00 0.000E+00 0.000E+00
26  0.000E+00 0.000E+00 0.000E+00
27  0.293E+00 0.000E+00 0.000E+00
28  0.367E+02 0.000E+00 0.000E+00
29  0.000E+00 0.263E+00 0.000E+00
30  0.000E+00 0.325E+02 0.000E+00
31  0.000E+00 0.000E+00 0.263E+00
32  0.000E+00 0.000E+00 0.325E+02
33  0.000E+00 0.000E+00 0.000E+00
34  0.000E+00 0.000E+00 0.000E+00
35  0.000E+00 0.000E+00 0.000E+00
36  0.000E+00 0.000E+00 0.000E+00
37  0.000E+00 0.000E+00 0.000E+00
38 -0.930E-03-0.153E-02-0.153E-02
39  0.488E+00 0.805E+00 0.805E+00
40  0.136E-02 0.205E-03 0.205E-03
41 -0.713E+00-0.108E+00-0.108E+00
42 -0.414E-03 0.222E-02 0.222E-02
43  0.248E+00-0.133E+01-0.133E+01

 GAIN  MATRIX
       1         2         3         4         5         6         7
 1  0.100E+01 0.000E+00 0.000E+00-0.100E+01 0.000E+00 0.000E+00 0.000E+00
 2  0.100E+01 0.000E+00 0.000E+00 0.100E+01 0.000E+00 0.000E+00 0.000E+00
 3  0.000E+00 0.100E+01 0.000E+00 0.000E+00 0.100E+01 0.000E+00 0.000E+00
 4  0.000E+00 0.100E+01 0.000E+00 0.000E+00-0.100E+01 0.000E+00 0.000E+00
 5  0.000E+00 0.000E+00 0.100E+01 0.000E+00 0.000E+00-0.100E+01 0.000E+00
 6  0.000E+00 0.000E+00 0.100E+01 0.000E+00 0.000E+00 0.100E+01 0.000E+00
 7  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00-0.100E+01
 8  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.100E+01
 9  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
10  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
       8
 1  0.000E+00
 2  0.000E+00
 3  0.000E+00
 4  0.000E+00
```

```
  5  0.000E+00
  6  0.000E+00
  7  0.000E+00
  8  0.000E+00
  9  0.100E+01
 10  0.100E+01

                          FUNCTION VALUES

 LONGITUDINAL FUNCTION VALUES
F012 = 0.1606D+01 F020 = 0.7000D+01 F022 = 0.0000D+00
F024 = 0.3666D+01 F025 = 0.1700D+02 F027 = 0.3477D+01
F028 = 0.2965D+02 F29U = 0.3401D+02 F29L = 0.0000D+00
F32A = 0.2724D+00 F32B = 0.1174D+00 F037 = 0.1000D+01
F040 = 0.1235D+00 F068 = 0.3362D+00

 LATERAL FUNCTION VALUES
F001 = 0.3220D+01 F004 = 0.1388D-16 F006 = 0.2000D+00
F007 = 0.1000D+02 F013 = 0.1516D+00 F031 = 0.1600D+00
F034 = 0.1000D+01 F035 = 0.1000D+01 F036 = 0.1000D+01
F039 = -.2220D-15 F041 = 0.1000D+01 F093 = 0.0000D+00
F101 = 0.0000D+00

 DIRECTIONAL FUNCTION VALUES
F010 = 0.8440D+00 F014 = 0.1975D+00 F017 = 0.0000D+00
F030 = 0.6076D+00 F038 = -.8240D-01 F042 = 0.7610D+00
F045 = 0.1000D+01 F090 = 0.1650D+02 F096 = 0.8008D+00
F112 = 0.0000D+00 F113 = 0.4000D-04 F114 = 0.8234D-01
```

```
 FILTER COEFFICIENTS
P2N1  = 0.1000D+01 P2N2  = -.4118D+00 P2D   = 0.4118D+00
P5N1  = 0.1351D+00 P5N2  = 0.1351D+00 P5D   = 0.7297D+00
P9N1  = 0.1250D-01 P9N2  = 0.0000D+00 P9D   = 0.1000D+01
P11N1 = 0.1577D-01 P11N2 = 0.1577D-01 P11D  =0.9685D+00
P12N1 = 0.7849D-02 P12N2 = 0.7849D-02 P12D  = 0.9843D+00
Y3N1  = 0.9938D+00 Y3N2  = -.9938D+00 Y3D   = 0.9876D+00
Y5N1  = 0.1494D+01 Y5N2  = -.1469D+01 Y5D   = 0.9753D+00


                              CONTROL SYSTEM COEFFICIENTS

 LONGITUDINAL COEFFICIENTS
QST1  = -.2574D-02 QST2  = 0.7481D-03 QST3  = 0.2144D+00
NZST1 = -.1914D-01 NZST2 = -.2108D+00 NZST3 = -.1314D+00
PXST1 = 0.3828D-01 PXST2 = 0.1945D+01 AALE1 = 0.4124D-01
AALE2 = 0.2095D-01 AATE1 = 0.2188D-01 AATE2 = 0.1103D-01

 LATERAL COEFFICIENTS
RRST = 0.2400D-01 PYST = 0.9764D+00 PZST = -.1166D-16
RRLE = 0.0000D+00 PYLE = 0.0000D+00 RRTE = 0.1920D-01
PYTE = 0.7811D+00 RRA  = 0.6000D-01 PYA  = 0.2441D+01
PZA  = -.2916D-16

 DIRECTIONAL COEFFICIENTS
YRR1 = 0.8564D-02 YRR2 = -.6894D+00 NYR  = 0.1650D+02
```

```
RRR1 = -.4940D-02 RRR2 = 0.7804D-04 RRR3 = 0.3881D+00

PYR1 = 0.3175D-02 PYR2 = -.3890D+00 PZR1 = 0.0000D+00

PZR2 = -.9875D-01

 AC    MATRIX
          1          2          3          4          5          6          7
 1  0.100E+01 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 2  0.000E+00 0.412E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 3  0.000E+00 0.000E+00 0.100E+01 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 4  0.000E+00 0.000E+00 0.000E+00 0.730E+00 0.000E+00 0.000E+00 0.000E+00
 5  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.100E+01 0.000E+00 0.000E+00
 6  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.968E+00 0.000E+00
 7  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.984E+00
 8  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 9  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
10  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
11  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
12  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
          8          9         10         11         12
 1  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 2  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 3  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 4  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 5  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 6  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 7  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 8  0.988E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 9  0.000E+00 0.988E+00 0.000E+00 0.000E+00 0.000E+00
10  0.000E+00 0.000E+00 0.975E+00 0.000E+00 0.000E+00
11  0.000E+00 0.000E+00 0.000E+00 0.975E+00 0.000E+00
12  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.975E+00

 BFC   MATRIX
          1          2          3          4          5          6
 1  0.100E+01 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 2  0.100E+01 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 3  0.000E+00 0.100E+01 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 4  0.000E+00 0.100E+01 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 5  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 6  0.000E+00 0.000E+00 0.100E+01 0.000E+00 0.000E+00 0.000E+00
 7  0.000E+00 0.000E+00 0.100E+01 0.000E+00 0.000E+00 0.000E+00
 8  0.000E+00 0.000E+00 0.000E+00 0.100E+01 0.000E+00 0.000E+00
 9  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.100E+01 0.000E+00
10  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.100E+01 0.000E+00
```

```
11   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
12   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00

 BC     MATRIX
           1         2         3
 1   0.000E+00 0.000E+00 0.000E+00
 2   0.000E+00 0.000E+00 0.000E+00
 3   0.000E+00 0.000E+00 0.000E+00
 4   0.000E+00 0.000E+00 0.000E+00
 5   0.100E+01 0.000E+00 0.000E+00
 6   0.000E+00 0.000E+00 0.000E+00
 7   0.000E+00 0.000E+00 0.000E+00
 8   0.000E+00 0.000E+00 0.000E+00
 9   0.000E+00 0.000E+00 0.000E+00
10   0.000E+00 0.000E+00 0.000E+00
11   0.000E+00 0.100E+01 0.000E+00
12   0.000E+00 0.000E+00 0.100E+01

 CC     MATRIX
           1         2         3         4         5         6         7
 1  -0.257E-02 0.748E-03-0.191E-01-0.211E+00-0.383E-01 0.000E+00 0.000E+00
 2   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.412E-01 0.000E+00
 3   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.219E-01
 4   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 5   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 6   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 7   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 8   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
           8         9        10        11        12
 1   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 2   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 3   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 4   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 5   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 6   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 7   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 8  -0.856E-02-0.494E-02 0.780E-04 0.317E-02 0.000E+00

 DFC    MATRIX
           1         2         3         4         5         6
 1   0.214E+00-0.131E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 2   0.000E+00 0.000E+00 0.209E-01 0.000E+00 0.000E+00 0.000E+00
 3   0.000E+00 0.000E+00 0.110E-01 0.000E+00 0.000E+00 0.000E+00
 4   0.000E+00 0.000E+00 0.000E+00 0.000E+00-0.240E-01 0.000E+00
 5   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
```

```
 6   0.000E+00 0.000E+00 0.000E+00 0.000E+00-0.192E-01 0.000E+00
 7   0.000E+00 0.000E+00 0.000E+00 0.000E+00-0.600E-01 0.000E+00
 8   0.000E+00 0.000E+00 0.000E+00 0.689E+00 0.388E+00 0.165E+02

DC     MATRIX
          1         2         3
 1 -0.195E+01 0.000E+00 0.000E+00
 2   0.000E+00 0.000E+00 0.000E+00
 3   0.000E+00 0.000E+00 0.000E+00
 4   0.000E+00 0.976E+00-0.117E-16
 5   0.000E+00 0.000E+00 0.000E+00
 6   0.000E+00 0.781E+00 0.000E+00
 7   0.000E+00 0.244E+01-0.292E-16
 8   0.000E+00-0.389E+00-0.987E-01

AF18   MATRIX
          1         2         3         4         5         6         7
 1   0.100E+01 0.132E-06-0.250E-02-0.402E+00 0.000E+00 0.000E+00 0.000E+00
 2   0.000E+00 0.985E+00 0.792E+01 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 3   0.000E+00-0.156E-03 0.988E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 4   0.000E+00-0.981E-06 0.124E-01 0.100E+01 0.000E+00 0.000E+00 0.000E+00
 5   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.997E+00-0.806E+01-0.278E-02
 6   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.106E-03 0.997E+00 0.138E-02
 7   0.000E+00 0.000E+00 0.000E+00 0.000E+00-0.313E-03 0.102E-01 0.965E+00
 8   0.000E+00 0.000E+00 0.000E+00 0.000E+00-0.197E-05 0.616E-04 0.123E-01
 9   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
10   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
11   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
12   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
13   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
14   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
15   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
16   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
17   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
18   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
19   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
20   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
21   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
22   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
23   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
24   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
25   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
26   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
27   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
28   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
29   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
```

```
30  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
31  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
32  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
33  0.000E+00-0.837E-02 0.594E+02 0.000E+00 0.000E+00 0.000E+00 0.000E+00
34  0.000E+00 0.452E+01-0.337E+05 0.000E+00 0.000E+00 0.000E+00 0.000E+00
35  0.000E+00-0.356E-01-0.446E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
36  0.000E+00 0.234E+02 0.281E+03 0.000E+00 0.000E+00 0.000E+00 0.000E+00
37  0.000E+00 0.141E-01 0.581E-01 0.000E+00 0.000E+00 0.000E+00 0.000E+00
38  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.565E-02 0.599E+02 0.739E-01
39  0.000E+00 0.000E+00 0.000E+00 0.000E+00-0.305E+01-0.340E+05-0.400E+02
40  0.000E+00 0.000E+00 0.000E+00 0.000E+00-0.168E-02 0.540E-01 0.582E+01
41  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.906E+00-0.291E+02-0.331E+04
42  0.000E+00 0.000E+00 0.000E+00 0.000E+00-0.774E-02 0.826E-01 0.929E-03
43  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.507E+01-0.518E+02-0.607E+00
44  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
45  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
46  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
47  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
48  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
49  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
50  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
51  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
52  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
53  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
54  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
55  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
        8         9        10        11        12        13        14
 1  0.000E+00 0.142E-05 0.443E-08 0.106E-10 0.173E-13 0.142E-05 0.443E-08
 2  0.000E+00-0.208E-01-0.115E-03-0.414E-06-0.913E-09-0.208E-01-0.115E-03
 3  0.000E+00-0.169E-02-0.105E-04-0.399E-07-0.911E-10-0.169E-02-0.105E-04
 4  0.000E+00-0.106E-04-0.439E-07-0.129E-09-0.245E-12-0.106E-04-0.439E-07
 5  0.402E+00 0.116E-02 0.788E-05 0.313E-07 0.730E-10-0.116E-02-0.788E-05
 6  0.213E-04 0.844E-04 0.526E-06 0.201E-08 0.460E-11-0.844E-04-0.526E-06
 7 -0.634E-04-0.254E-02-0.158E-04-0.604E-07-0.138E-09 0.254E-02 0.158E-04
 8  0.100E+01-0.160E-04-0.663E-07-0.195E-09-0.372E-12 0.160E-04 0.663E-07
 9  0.000E+00 0.990E+00 0.121E-01 0.664E-04 0.191E-06 0.000E+00 0.000E+00
10  0.000E+00-0.280E+01 0.896E+00 0.906E-02 0.369E-04 0.000E+00 0.000E+00
11  0.000E+00-0.543E+03-0.211E+02 0.300E+00 0.337E-02 0.000E+00 0.000E+00
12  0.000E+00-0.495E+05-0.221E+04-0.755E+02-0.219E+00 0.000E+00 0.000E+00
13  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.990E+00 0.121E-01
14  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00-0.280E+01 0.896E+00
15  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00-0.543E+03-0.211E+02
16  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00-0.495E+05-0.221E+04
17  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
18  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
19  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
20  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
21  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
```

```
22  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
23  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
24  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
25  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
26  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
27  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
28  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
29  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
30  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
31  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
32  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
33  0.000E+00-0.903E-01-0.498E-03-0.173E-05-0.366E-08-0.903E-01-0.498E-03
34  0.000E+00 0.488E+02 0.264E+00 0.906E-03 0.190E-05 0.488E+02 0.264E+00
35  0.000E+00-0.346E-01-0.401E-03-0.204E-05-0.548E-08-0.346E-01-0.401E-03
36  0.000E+00 0.227E+02 0.247E+00 0.122E-02 0.322E-05 0.227E+02 0.247E+00
37  0.000E+00-0.136E-03-0.537E-06-0.153E-08-0.286E-11-0.136E-03-0.537E-06
38  0.101E-02 0.453E-02 0.251E-04 0.872E-07 0.185E-09-0.453E-02-0.251E-04
39 -0.535E+00-0.245E+01-0.133E-01-0.457E-04-0.961E-07 0.245E+01 0.133E-01
40 -0.301E-03-0.136E-01-0.753E-04-0.262E-06-0.554E-09 0.136E-01 0.753E-04
41  0.160E+00 0.735E+01 0.399E-01 0.137E-03 0.288E-06-0.735E+01-0.399E-01
42 -0.242E-02 0.380E-02 0.434E-04 0.219E-06 0.589E-09-0.380E-02-0.434E-04
43  0.146E+01-0.249E+01-0.267E-01-0.131E-03-0.346E-06 0.249E+01 0.267E-01
44  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
45  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
46  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
47  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
48  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
49  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
50  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
51  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
52  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
53  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
54  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
55  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
         15        16        17        18        19        20        21
 1  0.106E-10 0.173E-13 0.145E-06 0.354E-09 0.145E-06 0.354E-09-0.136E-06
 2 -0.414E-06-0.913E-09 0.133E-02 0.644E-05 0.133E-02 0.644E-05-0.150E-01
 3 -0.399E-07-0.911E-10-0.167E-03-0.709E-06-0.167E-03-0.709E-06 0.159E-03
 4 -0.129E-09-0.245E-12-0.107E-05-0.330E-08-0.107E-05-0.330E-08 0.101E-05
 5 -0.313E-07-0.730E-10 0.000E+00 0.000E+00 0.000E+00 0.000E+00-0.722E-03
 6 -0.201E-08-0.460E-11 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.175E-03
 7  0.604E-07 0.138E-09 0.000E+00 0.000E+00 0.000E+00 0.000E+00-0.272E-02
 8  0.195E-09 0.372E-12 0.000E+00 0.000E+00 0.000E+00 0.000E+00-0.174E-04
 9  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
10  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
11  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
12  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
13  0.664E-04 0.191E-06 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
```

```
14  0.906E-02 0.369E-04 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
15  0.300E+00 0.337E-02 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
16 -0.755E+02-0.219E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
17  0.000E+00 0.000E+00 0.887E+00 0.645E-02 0.000E+00 0.000E+00 0.000E+00
18  0.000E+00 0.000E+00-0.144E+02 0.184E+00 0.000E+00 0.000E+00 0.000E+00
19  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.887E+00 0.645E-02 0.000E+00
20  0.000E+00 0.000E+00 0.000E+00 0.000E+00-0.144E+02 0.184E+00 0.000E+00
21  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.923E+00
22  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00-0.110E+02
23  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
24  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
25  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
26  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
27  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
28  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
29  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
30  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
31  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
32  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
33 -0.173E-05-0.366E-08-0.901E-02-0.352E-04-0.901E-02-0.352E-04 0.856E-02
34  0.906E-03 0.190E-05 0.488E+01 0.187E-01 0.488E+01 0.187E-01-0.463E+01
35 -0.204E-05-0.548E-08 0.482E-02 0.340E-04 0.482E-02 0.340E-04-0.380E-01
36  0.122E-02 0.322E-05-0.319E+01-0.213E-01-0.319E+01-0.213E-01 0.251E+02
37 -0.153E-08-0.286E-11 0.117E-04 0.386E-07 0.117E-04 0.386E-07-0.113E-03
38 -0.872E-07-0.185E-09 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.941E-02
39  0.457E-04 0.961E-07 0.000E+00 0.000E+00 0.000E+00 0.000E+00-0.509E+01
40  0.262E-06 0.554E-09 0.000E+00 0.000E+00 0.000E+00 0.000E+00-0.147E-01
41 -0.137E-03-0.288E-06 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.793E+01
42 -0.219E-06-0.589E-09 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.645E-05
43  0.131E-03 0.346E-06 0.000E+00 0.000E+00 0.000E+00 0.000E+00-0.387E-02
44  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
45  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
46  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
47  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
48  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
49  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
50  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
51  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
52  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
53  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
54  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
55  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
       22        23        24        25        26        27        28
 1 -0.378E-09-0.136E-06-0.378E-09 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 2 -0.794E-04-0.150E-01-0.794E-04 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 3  0.828E-06 0.159E-03 0.828E-06 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 4  0.364E-08 0.101E-05 0.364E-08 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 5 -0.261E-05 0.722E-03 0.261E-05-0.175E-03 0.207E-06 0.175E-03-0.207E-06
```

```
  6  0.913E-06-0.175E-03-0.913E-06 0.172E-03 0.808E-06-0.172E-03-0.808E-06
  7 -0.142E-04 0.272E-02 0.142E-04-0.251E-02-0.118E-04 0.251E-02 0.118E-04
  8 -0.628E-07 0.174E-04 0.628E-07-0.167E-04-0.550E-07 0.167E-04 0.550E-07
  9  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 10  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 11  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 12  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 13  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 14  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 15  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 16  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 17  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 18  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 19  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 20  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 21  0.902E-02 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 22  0.474E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 23  0.000E+00 0.923E+00 0.902E-02 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 24  0.000E+00-0.110E+02 0.474E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 25  0.000E+00 0.000E+00 0.000E+00 0.707E+00 0.652E-02 0.000E+00 0.000E+00
 26  0.000E+00 0.000E+00 0.000E+00-0.367E+02 0.129E+00 0.000E+00 0.000E+00
 27  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.707E+00 0.652E-02
 28  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00-0.367E+02 0.129E+00
 29  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 30  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 31  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 32  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 33  0.402E-04 0.856E-02 0.402E-04 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 34 -0.213E-01-0.463E+01-0.213E-01 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 35 -0.353E-03-0.380E-01-0.353E-03 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 36  0.219E+00 0.251E+02 0.219E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 37 -0.418E-06-0.113E-03-0.418E-06 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 38  0.444E-04-0.941E-02-0.444E-04 0.941E-02 0.402E-04-0.941E-02-0.402E-04
 39 -0.236E-01 0.509E+01 0.236E-01-0.510E+01-0.214E-01 0.510E+01 0.214E-01
 40 -0.692E-04 0.147E-01 0.692E-04-0.137E-01-0.587E-04 0.137E-01 0.587E-04
 41  0.367E-01-0.793E+01-0.367E-01 0.744E+01 0.312E-01-0.744E+01-0.312E-01
 42  0.240E-07-0.645E-05-0.240E-07 0.120E-02 0.104E-04-0.120E-02-0.104E-04
 43 -0.141E-04 0.387E-02 0.141E-04-0.810E+00-0.656E-02 0.810E+00 0.656E-02
 44  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 45  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 46  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 47  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 48  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 49  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 50  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 51  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 52  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 53  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
```

```
54   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
55   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
        29        30        31        32        33.       34        35
 1   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.762E-08 0.000E+00-0.467E-08
 2   0.000E+00 0.000E+00 0.000E+00 0.000E+00-0.275E-03 0.000E+00 0.168E-03
 3   0.000E+00 0.000E+00 0.000E+00 0.000E+00-0.262E-04 0.000E+00 0.161E-04
 4   0.000E+00 0.000E+00 0.000E+00 0.000E+00-0.894E-07 0.000E+00 0.548E-07
 5   0.479E-02 0.197E-04 0.479E-02 0.197E-04 0.000E+00 0.000E+00 0.000E+00
 6  -0.320E-03-0.143E-05-0.320E-03-0.143E-05 0.000E+00 0.000E+00 0.000E+00
 7   0.423E-03 0.191E-05 0.423E-03 0.191E-05 0.000E+00 0.000E+00 0.000E+00
 8   0.280E-05 0.896E-08 0.280E-05 0.896E-08 0.000E+00 0.000E+00 0.000E+00
 9   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.200E-01 0.000E+00-0.123E-01
10   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.234E+01 0.000E+00-0.143E+01
11   0.000E+00 0.000E+00 0.000E+00 0.000E+00-0.425E+03 0.000E+00 0.261E+03
12   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.558E+05 0.000E+00-0.342E+05
13   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.200E-01 0.000E+00-0.123E-01
14   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.234E+01 0.000E+00-0.143E+01
15   0.000E+00 0.000E+00 0.000E+00 0.000E+00-0.425E+03 0.000E+00 0.261E+03
16   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.558E+05 0.000E+00-0.342E+05
17   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
18   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
19   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
20   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
21   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
22   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
23   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
24   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
25   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
26   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
27   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
28   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
29   0.737E+00 0.625E-02 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
30  -0.325E+02 0.116E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
31   0.000E+00 0.000E+00 0.737E+00 0.625E-02 0.000E+00 0.000E+00 0.000E+00
32   0.000E+00 0.000E+00-0.325E+02 0.116E+00 0.000E+00 0.000E+00 0.000E+00
33   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.190E+00 0.407E-03 0.713E-03
34   0.000E+00 0.000E+00 0.000E+00 0.000E+00-0.309E+02-0.652E-01-0.374E+00
35   0.000E+00 0.000E+00 0.000E+00 0.000E+00-0.126E-02 0.000E+00 0.317E-01
36   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.757E+00 0.000E+00-0.125E+02
37   0.000E+00 0.000E+00 0.000E+00 0.000E+00-0.107E-05 0.000E+00 0.655E-06
38  -0.174E-01-0.714E-04-0.174E-01-0.714E-04 0.000E+00 0.000E+00 0.000E+00
39   0.944E+01 0.380E-01 0.944E+01 0.380E-01 0.000E+00 0.000E+00 0.000E+00
40   0.231E-02 0.951E-05 0.231E-02 0.951E-05 0.000E+00 0.000E+00 0.000E+00
41  -0.125E+01-0.506E-02-0.125E+01-0.506E-02 0.000E+00 0.000E+00 0.000E+00
42   0.739E-02 0.598E-04 0.739E-02 0.598E-04 0.000E+00 0.000E+00 0.000E+00
43  -0.497E+01-0.376E-01-0.497E+01-0.376E-01 0.000E+00 0.000E+00 0.000E+00
44   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.100E+01 0.000E+00 0.000E+00
45   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.100E+01 0.000E+00 0.000E+00
```

```
46  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.100E+01
47  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.100E+01
48  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
49  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
50  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
51  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
52  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
53  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
54  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
55  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
       36        37        38        39        40        41        42
 1  0.000E+00 0.601E-10 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 2  0.000E+00-0.647E-05 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 3  0.000E+00-0.210E-06 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 4  0.000E+00-0.709E-09 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 5  0.000E+00 0.000E+00 0.619E-03 0.000E+00 0.353E-03 0.000E+00 0.148E-01
 6  0.000E+00 0.000E+00-0.481E-04 0.000E+00-0.242E-04 0.000E+00-0.115E-02
 7  0.000E+00 0.000E+00 0.642E-04 0.000E+00-0.839E-05 0.000E+00 0.154E-02
 8  0.000E+00 0.000E+00 0.215E-06 0.000E+00-0.275E-07 0.000E+00 0.515E-05
 9  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.224E-02 0.000E+00 0.000E+00
10  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.262E+00 0.000E+00 0.000E+00
11  0.000E+00 0.000E+00 0.000E+00 0.000E+00-0.476E+02 0.000E+00 0.000E+00
12  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.625E+04 0.000E+00 0.000E+00
13  0.000E+00 0.000E+00 0.000E+00 0.000E+00-0.224E-02 0.000E+00 0.000E+00
14  0.000E+00 0.000E+00 0.000E+00 0.000E+00-0.262E+00 0.000E+00 0.000E+00
15  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.476E+02 0.000E+00 0.000E+00
16  0.000E+00 0.000E+00 0.000E+00 0.000E+00-0.625E+04 0.000E+00 0.000E+00
17  0.000E+00 0.237E-02 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
18  0.000E+00 0.301E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
19  0.000E+00 0.237E-02 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
20  0.000E+00 0.301E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
21  0.000E+00 0.854E-03 0.000E+00 0.000E+00 0.149E-02 0.000E+00 0.000E+00
22  0.000E+00 0.122E+00 0.000E+00 0.000E+00 0.212E+00 0.000E+00 0.000E+00
23  0.000E+00 0.854E-03 0.000E+00 0.000E+00-0.149E-02 0.000E+00 0.000E+00
24  0.000E+00 0.122E+00 0.000E+00 0.000E+00-0.212E+00 0.000E+00 0.000E+00
25  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.176E-01 0.000E+00 0.000E+00
26  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.220E+01 0.000E+00 0.000E+00
27  0.000E+00 0.000E+00 0.000E+00 0.000E+00-0.176E-01 0.000E+00 0.000E+00
28  0.000E+00 0.000E+00 0.000E+00 0.000E+00-0.220E+01 0.000E+00 0.000E+00
29  0.000E+00 0.000E+00 0.181E+00 0.000E+00 0.102E+00 0.000E+00 0.433E+01
30  0.000E+00 0.000E+00 0.224E+02 0.000E+00 0.126E+02 0.000E+00 0.536E+03
31  0.000E+00 0.000E+00 0.181E+00 0.000E+00 0.102E+00 0.000E+00 0.433E+01
32  0.000E+00 0.000E+00 0.224E+02 0.000E+00 0.126E+02 0.000E+00 0.536E+03
33  0.000E+00-0.926E-05 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
34  0.000E+00 0.486E-02 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
35  0.773E-04-0.379E-04 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
36 -0.277E-01 0.226E-01 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
37  0.000E+00 0.839E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
```

```
38   0.000E+00 0.000E+00 0.189E+00 0.407E-03-0.106E-02 0.000E+00-0.506E-01
39   0.000E+00 0.000E+00-0.304E+02-0.652E-01 0.558E+00 0.000E+00 0.266E+02
40   0.000E+00 0.000E+00 0.283E-03 0.000E+00 0.191E+00 0.407E-03 0.677E-02
41   0.000E+00 0.000E+00-0.148E+00 0.000E+00-0.315E+02-0.652E-01-0.355E+01
42   0.000E+00 0.000E+00 0.306E-02 0.000E+00 0.179E-02 0.000E+00 0.104E+00
43   0.000E+00 0.000E+00-0.184E+01 0.000E+00-0.107E+01 0.000E+00-0.561E+02
44   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
45   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
46   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
47   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
48   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
49   0.000E+00 0.100E+01 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
50   0.000E+00 0.100E+01 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
51   0.000E+00 0.000E+00 0.100E+01 0.000E+00 0.000E+00 0.000E+00 0.000E+00
52   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.100E+01 0.000E+00 0.000E+00
53   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.100E+01 0.000E+00 0.000E+00
54   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
55   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
        43        44        45        46        47        48        49
 1   0.000E+00-0.915E-10 0.266E-10-0.680E-09-0.749E-08-0.136E-08 0.170E-09
 2   0.000E+00 0.330E-05-0.959E-06 0.245E-04 0.270E-03 0.491E-04 0.602E-05
 3   0.000E+00 0.315E-06-0.915E-07 0.234E-05 0.258E-04 0.468E-05-0.606E-06
 4   0.000E+00 0.107E-08-0.312E-09 0.798E-08 0.879E-07 0.160E-07-0.202E-08
 5   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 6   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 7   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 8   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 9   0.000E+00-0.240E-03 0.699E-04-0.179E-02-0.197E-01-0.358E-02 0.000E+00
10   0.000E+00-0.281E-01 0.816E-02-0.209E+00-0.230E+01-0.417E+00 0.000E+00
11   0.000E+00 0.510E+01-0.148E+01 0.380E+02 0.418E+03 0.759E+02 0.000E+00
12   0.000E+00-0.671E+03 0.195E+03-0.499E+04-0.549E+05-0.997E+04 0.000E+00
13   0.000E+00-0.240E-03 0.699E-04-0.179E-02-0.197E-01-0.358E-02 0.000E+00
14   0.000E+00-0.281E-01 0.816E-02-0.209E+00-0.230E+01-0.417E+00 0.000E+00
15   0.000E+00 0.510E+01-0.148E+01 0.380E+02 0.418E+03 0.759E+02 0.000E+00
16   0.000E+00-0.671E+03 0.195E+03-0.499E+04-0.549E+05-0.997E+04 0.000E+00
17   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.466E-02
18   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.593E+00
19   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.466E-02
20   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.593E+00
21   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
22   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
23   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
24   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
25   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
26   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
27   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
28   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
29   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
```

```
30   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
31   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
32   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
33   0.000E+00 0.140E-04-0.406E-05 0.104E-03 0.114E-02 0.208E-03-0.266E-04
34   0.000E+00-0.733E-02 0.213E-02-0.545E-01-0.600E+00-0.109E+00 0.140E-01
35   0.000E+00 0.151E-04-0.439E-05 0.112E-03 0.124E-02 0.225E-03 0.437E-04
36   0.000E+00-0.909E-02 0.264E-02-0.676E-01-0.745E+00-0.135E+00-0.262E-01
37   0.000E+00 0.128E-07-0.373E-08 0.954E-07 0.105E-05 0.191E-06 0.251E-07
38   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
39   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
40   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
41   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
42   0.773E-04 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
43  -0.277E-01 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
44   0.000E+00 0.100E+01 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
45   0.000E+00 0.000E+00 0.412E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
46   0.000E+00 0.000E+00 0.000E+00 0.100E+01 0.000E+00 0.000E+00 0.000E+00
47   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.730E+00 0.000E+00 0.000E+00
48   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.100E+01 0.000E+00
49   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.968E+00
50   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
51   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
52   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
53   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
54   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
55   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
        50         51         52         53         54         55
 1  -0.517E-10 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 2  -0.189E-04 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 3   0.195E-06 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 4   0.630E-09 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 5   0.000E+00-0.769E-05-0.444E-05 0.701E-07 0.285E-05 0.000E+00
 6   0.000E+00 0.597E-06 0.345E-06-0.544E-08-0.221E-06 0.000E+00
 7   0.000E+00-0.798E-06-0.460E-06 0.727E-08 0.296E-06 0.000E+00
 8   0.000E+00-0.267E-08-0.154E-08 0.244E-10 0.991E-09 0.000E+00
 9   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
10   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
11   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
12   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
13   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
14   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
15   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
16   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
17   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
18   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
19   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
20   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
21   0.169E-02 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
```

```
22   0.242E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
23   0.169E-02 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
24   0.242E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
25   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
26   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
27   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
28   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
29   0.000E+00-0.225E-02-0.130E-02 0.205E-04 0.834E-03 0.000E+00
30   0.000E+00-0.278E+00-0.160E+00 0.253E-02 0.103E+00 0.000E+00
31   0.000E+00-0.225E-02-0.130E-02 0.205E-04 0.834E-03 0.000E+00
32   0.000E+00-0.278E+00-0.160E+00 0.253E-02 0.103E+00 0.000E+00
33   0.844E-05 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
34  -0.442E-02 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
35  -0.119E-03 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
36   0.713E-01 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
37  -0.733E-07 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
38   0.000E+00 0.263E-04 0.151E-04-0.239E-06-0.974E-05 0.000E+00
39   0.000E+00-0.138E-01-0.795E-02 0.126E-03 0.511E-02 0.000E+00
40   0.000E+00-0.351E-05-0.203E-05 0.320E-07 0.130E-05 0.000E+00
41   0.000E+00 0.184E-02 0.106E-02-0.168E-04-0.683E-03 0.000E+00
42   0.000E+00-0.380E-04-0.219E-04 0.347E-06 0.141E-04 0.000E+00
43   0.000E+00 0.228E-01 0.132E-01-0.208E-03-0.846E-02 0.000E+00
44   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
45   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
46   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
47   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
48   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
49   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
50   0.984E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
51   0.000E+00 0.988E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
52   0.000E+00 0.000E+00 0.988E+00 0.000E+00 0.000E+00 0.000E+00
53   0.000E+00 0.000E+00 0.000E+00 0.975E+00 0.000E+00 0.000E+00
54   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.975E+00 0.000E+00
55   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.975E+00

 BF18  MATRIX
           1         2         3
 1 -0.691E-07 0.000E+00 0.000E+00
 2  0.249E-02 0.000E+00 0.000E+00
 3  0.238E-03 0.000E+00 0.000E+00
 4  0.811E-06 0.000E+00 0.000E+00
 5  0.000E+00-0.541E-03-0.887E-04
 6  0.000E+00-0.900E-04 0.689E-05
 7  0.000E+00 0.178E-02-0.920E-05
 8  0.000E+00 0.592E-05-0.308E-07
 9 -0.182E+00-0.912E-01 0.109E-17
10 -0.212E+02-0.106E+02 0.127E-15
```

```
11  0.386E+04 0.194E+04-0.231E-13
12 -0.507E+06-0.254E+06 0.304E-11
13 -0.182E+00 0.912E-01-0.109E-17
14 -0.212E+02 0.106E+02-0.127E-15
15  0.386E+04-0.194E+04 0.231E-13
16 -0.507E+06 0.254E+06-0.304E-11
17  0.000E+00 0.000E+00 0.000E+00
18  0.000E+00 0.000E+00 0.000E+00
19  0.000E+00 0.000E+00 0.000E+00
20  0.000E+00 0.000E+00 0.000E+00
21  0.000E+00-0.605E-01 0.000E+00
22  0.000E+00-0.863E+01 0.000E+00
23  0.000E+00 0.605E-01 0.000E+00
24  0.000E+00 0.863E+01 0.000E+00
25  0.000E+00-0.716E+00 0.855E-17
26  0.000E+00-0.896E+02 0.107E-14
27  0.000E+00 0.716E+00-0.855E-17
28  0.000E+00 0.896E+02-0.107E-14
29  0.000E+00-0.102E+00-0.259E-01
30  0.000E+00-0.126E+02-0.321E+01
31  0.000E+00-0.102E+00-0.259E-01
32  0.000E+00-0.126E+02-0.321E+01
33  0.105E-01 0.000E+00 0.000E+00
34 -0.554E+01 0.000E+00 0.000E+00
35  0.114E-01 0.000E+00 0.000E+00
36 -0.687E+01 0.000E+00 0.000E+00
37  0.969E-05 0.000E+00 0.000E+00
38  0.000E+00-0.395E-02 0.303E-03
39  0.000E+00 0.207E+01-0.159E+00
40  0.000E+00 0.780E-02-0.405E-04
41  0.000E+00-0.409E+01 0.212E-01
42  0.000E+00-0.437E-02-0.439E-03
43  0.000E+00 0.262E+01 0.263E+00
44  0.000E+00 0.000E+00 0.000E+00
45  0.000E+00 0.000E+00 0.000E+00
46  0.000E+00 0.000E+00 0.000E+00
47  0.000E+00 0.000E+00 0.000E+00
48  0.100E+01 0.000E+00 0.000E+00
49  0.000E+00 0.000E+00 0.000E+00
50  0.000E+00 0.000E+00 0.000E+00
51  0.000E+00 0.000E+00 0.000E+00
52  0.000E+00 0.000E+00 0.000E+00
53  0.000E+00 0.000E+00 0.000E+00
54  0.000E+00 0.100E+01 0.000E+00
55  0.000E+00 0.000E+00 0.100E+01
```

CF18 MATRIX

```
          1          2          3          4          5          6          7
 1  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00
 2  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00
 3  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00
 4  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00
 5  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00
 6  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00
 7  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00
 8  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00
 9  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00
10  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00
11  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00
12  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00
13  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00
14  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00
          8          9         10         11         12         13         14
 1  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00
 2  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00
 3  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00
 4  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00
 5  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00
 6  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00
 7  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00
 8  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00
 9  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00
10  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00
11  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00
12  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00
13  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00
14  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00
         15         16         17         18         19         20         21
 1  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00
 2  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00
 3  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00
 4  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00
 5  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00
 6  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00
 7  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00
 8  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00
 9  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00
10  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00
11  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00
12  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00
13  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00
14  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00
         22         23         24         25         26         27         28
 1  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00
 2  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00
```

```
 3  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 4  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 5  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 6  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 7  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 8  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 9  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
10  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
11  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
12  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
13  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
14  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
       29        30        31        32        33        34        35
 1  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.100E+01 0.000E+00 0.000E+00
 2  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.100E+01
 3  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 4  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 5  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 6  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 7  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.214E+00 0.000E+00-0.131E+00
 8  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 9  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
10  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
11  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
12  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
13  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
14  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
       36        37        38        39        40        41        42
 1  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 2  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 3  0.000E+00 0.100E+01 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 4  0.000E+00 0.000E+00 0.100E+01 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 5  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.100E+01 0.000E+00 0.000E+00
 6  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.100E+01
 7  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 8  0.000E+00 0.209E-01 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 9  0.000E+00 0.110E-01 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
10  0.000E+00 0.000E+00 0.000E+00 0.000E+00-0.240E-01 0.000E+00 0.000E+00
11  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
12  0.000E+00 0.000E+00 0.000E+00 0.000E+00-0.192E-01 0.000E+00 0.000E+00
13  0.000E+00 0.000E+00 0.000E+00 0.000E+00-0.600E-01 0.000E+00 0.000E+00
14  0.000E+00 0.000E+00 0.689E+00 0.000E+00 0.388E+00 0.000E+00 0.165E+02
       43        44        45        46        47        48        49
 1  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 2  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 3  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 4  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 5  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
```

```
  6  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
  7  0.000E+00-0.257E-02 0.748E-03-0.191E-01-0.211E+00-0.383E-01 0.000E+00
  8  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.412E-01
  9  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 10  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 11  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 12  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 13  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 14  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
        50        51        52        53        54        55
  1  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
  2  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
  3  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
  4  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
  5  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
  6  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
  7  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
  8  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
  9  0.219E-01 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 10  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 11  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 12  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 13  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 14  0.000E+00-0.856E-02-0.494E-02 0.780E-04 0.317E-02 0.000E+00

 DF18  MATRIX
         1         2         3
  1  0.000E+00 0.000E+00 0.000E+00
  2  0.000E+00 0.000E+00 0.000E+00
  3  0.000E+00 0.000E+00 0.000E+00
  4  0.000E+00 0.000E+00 0.000E+00
  5  0.000E+00 0.000E+00 0.000E+00
  6  0.000E+00 0.000E+00 0.000E+00
  7 -0.195E+01 0.000E+00 0.000E+00
  8  0.000E+00 0.000E+00 0.000E+00
  9  0.000E+00 0.000E+00 0.000E+00
 10  0.000E+00 0.976E+00-0.117E-16
 11  0.000E+00 0.000E+00 0.000E+00
 12  0.000E+00 0.781E+00 0.000E+00
 13  0.000E+00 0.244E+01-0.292E-16
 14  0.000E+00-0.389E+00-0.987E-01
```

LIST OF REFERENCES

1. General Electric Company, Interim Report, AFFDL-TR, Self-Repairing Digital Flight Control System Study, by P. Briggs, May 1983.
2. Chandler, P. R., Self-Repairing Flight Control System Reliability and Maintainability Program-Executive Overview, Proc. 1984 NAECON, pp. 586-590, May 21-25, 1984.
3. McDonnell Aircraft Company, MDC A7813, F/A-18A Flight Control System Design Report, Vol. I, by D. Groll, December 1982.
4. Cadzow, J., Discrete-Time Systems, pp. 364-366, Prentice-Hall, Inc., 1973.
5. NASA Langlay Research Center, L-11769, Oracls - A System for Linear-Quadratic-Gaussian Control Law Design, by E. Armstrong, April 1978.
6. Shevell, R., Fundamentals of Flight, pp. 63-70, Prentice-Hall, Inc., 1983.
7. McDonnell Aircraft Company, MDC A7813, F/A-18A Flight Control System Design Report, Vol. II, by R. Moomaw, June 1984.
8. Ogata, K., Modern Control Engineering, pp. 675-678, Prentice-Hall, Inc., 1970.

INITIAL DISTRIBUTION LIST

		No. of Copies
1.	Defense Technical Information Center Cameron Station Alexandria, Virginia 22304-6145	2
2.	Library, Code 0142 Naval Postgraduate School Monterey, California 93943-5002	2
3.	Department Chairman, Code 67 Department of Aeronautics Naval Postgraduate School Monterey, California 93943-5000	1
4.	Professor D. J. Collins, Code 67Co Department of Aeronautics Naval Postgraduate School Monterey, California 93943-5000	1
5.	Dr. Marle D. Hewett Sparta Inc. 23293 South Pointe Dr. Suite 250 Laguna Hills, California 92653	1
6.	Mr. Mark Franko Naval Air Test Center Code SA60H Patuxent River, Maryland 20670	1
7.	LT D. C. Rigterink Fleet Air Reconnaissance Squadron Three FPO San Francisco, California 96601	1
8.	LT Fred W. Rojek 2103 Agecroft Road Virginia Beach, Virginia 23454	3
9.	John J. Morrow Code 338 Naval Weapons Center China Lake, California 93555-6001	1

10. Dale B. Atkinson 1
Air 5164
Naval Air Systems Command
Washington, D.C. 20361

11. Tor W. Jensen 1
Code 6013
Naval Air Development Center
Warminister, PA 18974