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Rotorcraft Linear Simulation Model
Final Report

Volume III. User's Manual

By J. S. REASER

January 1978

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16. ABSTRACT

This report describes a generalized format rotorcraft small perturbation linear model in three volumes (Vol. I Engineering Documentation, Vol. II Computer Implementation, Vol. III User's Manual). Rotor flap, inplane and feathering degrees of freedom, as well as control and augmentation systems are defined in addition to the classical vehicle six degrees of freedom. The primary application is intended to be an analytic tool to assess the handling qualities of a dynamically combined main rotor and body. The modeling method retains the higher frequency response properties which aid in evaluating control and stability augmentation systems.

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FOREWORD

This report describes a generalized rotorcraft small perturbation, linear model and associated computer software which have been refined and documented for NASA, Ames Research Center, Moffett Field, California, under contract NAS2-9374 (November, 1976) as ammended Revision (1) (May, 1977). This work has been performed by the Lockheed-California Company, Burbank, California.

Dr. R.T.N. Chen of the Ames Directorate, U.S. Army Air Mobility Research and Development Laboratory (USAAMRDL) was the technical monitor for this project. P.H. Kretsinger, D.H. Saiki and H.P. Weinberger (all of Lockheed-California Company) performed the software implementation of the linear model and matrix processing routines. A. J. Potthast and Fox Conner (also Lockheed personnel) provided technical assistance and technical editing of the documentation.

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ROTORCRAFT LINEAR SIMULATION MODEL

Volume III. User's Manual

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SUMMARY

This report describes a generalized format rotorcraft small perturbation linear model. Rotor flap, inplane and feathering degrees of freedom, as well as control and augmentation systems are defined in addition to the classical vehicle six degrees of freedom. The model simulates a single main rotor aircraft although it can be readily expanded to simulate compound aircraft with auxiliary thrust and wings. The analysis concept can also be expanded to model multiple lifting rotor configurations.

This report is divided into three volumes. The first volume contains the development of rotorcraft mechanical and aerodynamic equations. The second volume presents the description of a computer program that can be used to process the equations. The third volume contains the computer program operating instructions and defines the input-output data format.

The model development and application assumes that the main rotor control power, i.e., body moment due to blade flapping, has been established analytically or experimentally. These data are used to define the equivalent spring rate of the main rotor to body coupling.

The primary application is intended to be an analytic tool to assess the handling qualities of a dynamically combined main rotor and body. To this end, the rotor degrees of freedom appear explicitly rather than being included in the classical six degrees of freedom through a quasi-steady reduction process. The higher frequency response properties of the rotor are retained, and appear in the handling qualities assessment. Control and stability augmentation systems are therefore evaluated more realistically. The model does not address the area of rotor dynamic stability.

The model has been implemented in IBM 360 and CDC 7600 series computer systems. The IBM 360 implementation includes graphic as well as tabulated output capability.

SYMBOLS

a	rotor blade section lift slope, rad^{-1}
a_{HT}	horizontal tail lift slope, rad^{-1}
a_{VT}	vertical tail lift slope, rad^{-1}
a_W	wing-body lift slope, rad^{-1}
a_o	blade collective flap up angle, rad
a_1	longitudinal flap (up, forward) angle, rad
A	area, ft^2; blade span axis
A_1	longitudinal feather (nose up, forward) angle, rad
AR	aspect ratio
b	wing span, ft
b_1	lateral flap (down, right) angle, rad
B	dissipation function, ft-lb/sec; tip loss factor; body subscript; blade subscript; blade chord (aft) axis
B_1	lateral feather (nose down, right) angle, rad

c	cosine component subscript; blade element chord, ft; wing chord, ft
$\bar{c}$	wing mean chord, ft
C	blade vertical (down) axis
C_D	drag coefficient
$\bar{C}_D$	drag coefficient, input value
C_F	control gyro fixed coordinate damping rate, ft lb/rad/sec
C_L	lift coefficient
C_M	pitching moment coefficient
C_R	control gyro rotating coordinate damping rate, ft lb/rad/sec
C_Y	body-wing side force coefficient
CG	center-of-gravity subscript
$\left(\frac{C_N}{\sigma}\right)_R$	nondimensional rotor thrust, disc axis
$\left(\frac{C_Q}{\sigma}\right)_R$	nondimensional rotor torque, shaft axis
$\left(\frac{C_X}{\sigma}\right)_R$	nondimensional rotor drag, shaft axis
$C_{\delta cc}$	cosine axis cyclic fixed system damping rate, ft lb/rad/sec
$C_{\delta cs}$	cross axis cyclic fixed system damping rate, ft lb/rad/sec

$C_{\delta ss}$	sine axis cyclic fixed system damping rate, ft lb/rad/sec
d_o	collective blade lag angle, rad
d_1	longitudinal blade inplane (lag, forward) angle, rad
D	rotor disc value subscript
e_1	lateral blade inplane (lag, right) angle, rad
E_X	longitudinal rotor inflow gradient
E_Y	lateral rotor inflow gradient
$f_1(X)$	main rotor to wing wake effectiveness function
$f_{\beta 1}$	first flap mode shape (fundamental mode), ft
$f_{\zeta 2}$	second inplane mode shape (fundamental mode), ft
F	fuselage subscript; reference axes; force, lb
g	gravity vector, ft/sec^2
h	height of main rotor hub above fuselage reference axes, ft
h_{TR}	height of tail rotor shaft above fuselage reference axes, ft
h_{VT}	vertical tail center of pressure height above fuselage reference axes, ft
H	main rotor hub reference subscript
HT	horizontal tail subscript

i	induced value subscript
I_A	blade feathering moment of inertia about the feathering hinge, slug ft^2
I_{AB}	blade flap-chord product of inertia about flap and feathering hinges, slug ft^2
I_{AC}	blade inplane-chord product of inertia about inplane and feathering hinges, slug ft^2
I_B	blade flap moment of inertia about flap hinge, slug ft^2
I_C	blade inplane moment of inertia about inplane hinge, slug ft^2
I_{SP}	blade flap-inplane product of inertia about flap and inplane hinges, slug ft^2
I_{XX}	helicopter roll moment of inertia, slug ft^2
I_{XZ}	helicopter roll-yaw product of inertia, slug ft^2
I_{YY}	helicopter pitch moment of inertia, slug ft^2
I_{ZZ}	helicopter yaw moment of inertia, slug ft^2
K	spring rate (general), ft lb/rad
K_F	control gyro fixed coordinate spring rate, ft lb/rad
K_{FB}	flap feedback spring rate, ft lb/rad

K_R	control gyro rotating coordinate spring rate, ft lb/rad; pitch link stiffness, lb/ft
K_{RUD}	rudder pedals to tail rotor collective gear ratio
K_{XCS}	longitudinal cyclic input gear ratio or spring constant
K_{YCS}	lateral cyclic input gear ratio or spring constant
$K_{\delta cc}$	cosine axis control gyro spring rate, ft lb/rad
$K_{\delta cs}$	cross axis control gyro spring rate, ft lb/rad
$K_{\delta ss}$	sine axis control gyro spring rate, ft lb/rad
$K_{\theta o}$	collective handle to collective control element gear ratio
ℓ	length, ft
ℓ_{GCOL}	control gyro to swashplate collective gear ratio
ℓ_{GCYC}	control gyro to swashplate cyclic gear ratio
ℓ_{HT}	length from fuselage reference axes to horizontal tail center of pressure, ft
ℓ_{RC}	swashplate to feathering gear ratio
ℓ_{TR}	length from fuselage reference axes to tail rotor shaft, ft
ℓ_{VT}	length from fuselage reference axes to vertical tail center of pressure, ft
ℓ_1	pitch horn crank arm, ft

ℓ_2	swashplate crank arm, ft
ℓ_3	pitch-flap coupling arm, ft
ℓ_4	pitch-lag coupling arm, ft
L	aircraft rolling moment, ft lb
m	blade element mass, slug/ft
M	aircraft mass, slugs; aircraft pitching moment, ft lb
ML_{IF}	blade flap-radius moment of inertia, slug ft^2
MR	main rotor subscript
M_Y	blade feathering mass moment, slug ft
M_{IF}	blade flap mass moment, slug ft
M_{2L}	blade inplane mass moment, slug ft
M_{β_c}	cosine blade flapping moment, ft lb
M_{β_o}	coning moment, ft lb
M_{β_s}	sine blade flapping moment, ft lb
M_{ζ_c}	cosine blade inplane moment, ft lb
M_{ζ_s}	sine blade inplane moment, ft lb
$\partial M_\zeta/\dot{\zeta}$	blade inplane damping, ft lb/rad/sec

N	number of blades; aircraft yawing moment, ft lb
o	initial value subscript; root value subscript; steady component subscript
p	instantaneous roll rate, rad/sec
P_o	initial roll rate, rad/sec
q	instantaneous pitch rate, rad/sec; generalized coordinate
Q	generalized force
$Q_{E\beta}$	blade root flapping potential energy, ft lb
$Q_{E\theta}$	blade root feathering potential energy, ft lb
$Q_{E\zeta}$	blade root inplane potential energy, ft lb
Q_o	initial pitch rate, rad/sec
Q_R	rotor shaft torque, ft lb
r	instantaneous yaw rate, rad/sec; blade radial distance, ft
R	main rotor blade radius, ft; rotor subscript
R_o	initial yaw rate, rad/sec
s	sine component subscript
S	shaft axes subscript; area, ft^2
S_{HT}	horizontal tail area, ft^2

S_{VT}	vertical tail area, ft^2
S_W	wing area, ft^2
T	kinetic energy, ft lb; rotor thrust, lb
T_{TR}	tail rotor thrust, lb
TR	tail rotor subscript
u	instantaneous longitudinal velocity, ft/sec
U	potential energy function, ft lb
U_o	initial longitudinal velocity, ft/sec
v	instantaneous lateral velocity, ft/sec
V_o	initial lateral velocity, ft/sec
V_T	trajectory velocity, ft/sec
w	instantaneous vertical velocity, ft/sec
W	work function, ft lb; wing subscript
W_o	initial vertical velocity, ft/sec
x	nondimensional blade element radial position
X	instantaneous longitudinal axis
X_{cs}	longitudinal aft stick deflection

X_o	initial longitudinal axis
y	blade element chordwise position to trailing edge, ft
y_{TR}	tail rotor hub lateral offset to right, ft
Y	instantaneous lateral axis
Y_{cs}	lateral right stick deflection
Y_o	initial lateral axis
Z	instantaneous vertical (down) axis
Z_o	initial vertical (down) axis
α	angle of atack, rad
α_s	shaft angle of attack, rad
α_2	pitch-lag coupling
β	blade flapping up deflection, rad
β_{DR}	blade droop from feather axis, rad
β_s	side slip angle, rad
γ	climb angle, rad
δ	control gyro up deflection, rad; infinitesimal increment
δ_c	cosine component control gyro deflection, rad

δ_o collective component control gyro deflection, rad

δ_s sine component control gyro deflection, rad

δ_3 pitch-flap coupling

Δ swashplate up deflection, rad

Δ_c cosine component swashplate deflection, rad

Δ_o collective component swashplate deflection, rad

Δ_s sine component swashplate deflection, rad

ϵ wake angle function, rad

ζ blade inplane lag deflection, rad

ζ_{SW} blade root sweep forward, rad

η load factor

θ pitch euler angle, rad; blade feathering motion, rad; 3/4 radius collective angle, rad

θ_o root collective angle, rad; initial pitch attitude, rad

λ_o nondimensional disc total inflow

λ_i nondimensional induced inflow

λ_D nondimensional disc plane inflow

λ_s nondimensional shaft total inflow

Λ	nondimensional rotor total vector velocity
μ	velocity normalized to rotor tip speed, nondimensional
$\bar{\mu}$	vector nondimensional velocity
μ_P	blade element nondimensional perpendicular velocity
μ_T	blade element nondimensional tangential velocity
μ_X	nondimensional forward velocity, reference axis system
μ_Y	nondimensional right velocity, reference axis system
μ_Z	nondimensional down velocity, reference axis system
ρ	air density, slug/ft^3
σ	main rotor solidity
σ_{TR}	tail rotor solidity
τ_{col}	collective actuator time constant, sec
τ_{cyc}	cyclic actuator time constant, sec
ϕ	roll euler angle, rad
ϕ_o	initial roll attitude, rad
χ	main rotor wake angle, rad
ψ	yaw euler angle, rad

ψ_{FB} blade to control flap feedback lag angle, rad

ψ_G control gyro to swashplate lag angle, rad

ψ_o swashplate to blade lead angle, rad; initial heading, rad

ψ_s control axis lag angle, rad

ω_{col} collective control natural frequency, rad/sec

ω_{cyc} cyclic control natural frequency, rad/sec

Ω main rotor speed, rad/sec

Ω_{TR} tail rotor speed, rad/sec

1. INTRODUCTION

1.1 Contents of Manual

Volume III is a user's manual primarily concerned with the mechanics of operating the program. The user is assumed to be familiar with the contents of Volume I, and have at least an overview knowledge of the computation structure given in Volume II. Input data required to generate the matrix model, and instructions on processing this model with the included analysis tool are described in this volume.

1.2 Depth of Presentation

It is assumed that the user has a limited knowledge of the program and wishes to operate the same, and that he is primarily an engineer and secondarily a programmer. Some experience with FORTRAN formatting codes is desirable.

2. CONFIGURATION REPRESENTED BY THE LINEAR MODEL

2.1 Major Configuration

The linear model package models a single main rotor, pure or winged helicopter. Modeling emphasis is toward rotors having high flapping stiffness and flapping moment feedback. The system is represented by a 20 degree of freedom matrix. A body-oriented reference is used with sets of degrees of freedom allocated to main rotor motion and control distinct from the classical 6 rigid body degrees of freedom. The matrix format is given in Table 2-1.

TABLE 2-1. MATRIX FORMAT

DEPENDENT ROWS		DEPENDENT COLUMNS		INDEPENDENT COLUMNS	
1	Body longitudinal force	1	u	1	X_{cs}
2	Body vertical force	2	w	2	Y_{cs}
3	Body pitch moment	3	θ	3	θo
4	Body lateral force	4	v	4	δ_{RUD}
5	Body roll moment	5	ϕ		
6	Body yaw moment	6	r		
7	Collective flap moment	7	a_o		
8	Longitudinal flap moment	8	a_1		
9	Lateral flap moment	9	b_1		
10	Longitudinal inplane moment	10	d_1		
11	Lateral inplane moment	11	e_1		
12	Collective feather moment	12	θ_o		
13	Longitudinal feather moment	13	A_1		
14	Lateral feather moment	14	B_1		
15	Collective swashplate deflection	15	Δ_o		
16	Long. swashplate deflection	16	Δ_c		
17	Lat. swashplate deflection	17	Δ_s		
18	Coll. control element deflection	18	δ_o		
19	Long. control element mom. or defl.	19	δ_c		
20	Lat. control element mom. or defl.	20	δ_s		

2.2 Control Input System

The pilot input system matrix subset can be used to define static or dynamic augmentation where physical relations or properties may be dynamically interfaced with the pilot controls and swashplate drive. With augmentation the swashplate is driven by the defined control law.

A mechanical gyro element with feedback from the blade flapping response and body roll-pitch motions and input commands from the pilot cyclic stick is given as an example of pilot input processing combined with multiple feedback paths. This particular example has been included in the linear model. The swashplate deflection is slaved to the control gyro motion using a first order lag.

If the inertia and damper values are zero, the modeling gives a direct connection from the pilot to the swashplate servos. If nonzero values are used for inertia, mounting springs and dampers, a gyro controlled rotor configuration results. Depending on the relative size of the inertia and springs, the gyro element can have attitude or rate response properties. These degrees of freedom receive a feedback of rotor hub moment. The amount is specified via input data, and is set to zero when a direct swashplate control is wanted.

2.3 Kinematic Control System

A kinematic control system is obtained from the system of Section 2.2 by input data changes. Data are selected based on the augmentation coupling matrix parameter definitions which may be either dynamic or static (Forces, moments, or displacements). The resulting element response is then used to drive the swashplate.

3. PROGRAM INPUT AND USE

3.1 Model Matrix Generation

The model operation sequence consists of data read in, trim calculations, matrix partial derivatives, and matrix compilation, as shown in Figure 3-1. The trim algorithm balances longitudinal forces with angle of attack, vertical forces with collective, and yaw torque with tail rotor collective. Arrays of inflow, rotor, and non-rotating aerodynamic partial derivatives are then computed. These elements are combined with dynamic terms to compile the system 20 by 20 matrix and forcing functions to be passed to the analysis section of the program.

3.2 Matrix Analysis Procedures Using Control System Analysis Package (CSAP)

The subprogram assembly CSAP as used here normally processes the matrix generated by the linear model routine group. CSAP will minimally return the assembled matrix and characteristic roots. Transfer functions, time histories, and frequency response data may be selected by the user as detailed in Section 3.4.

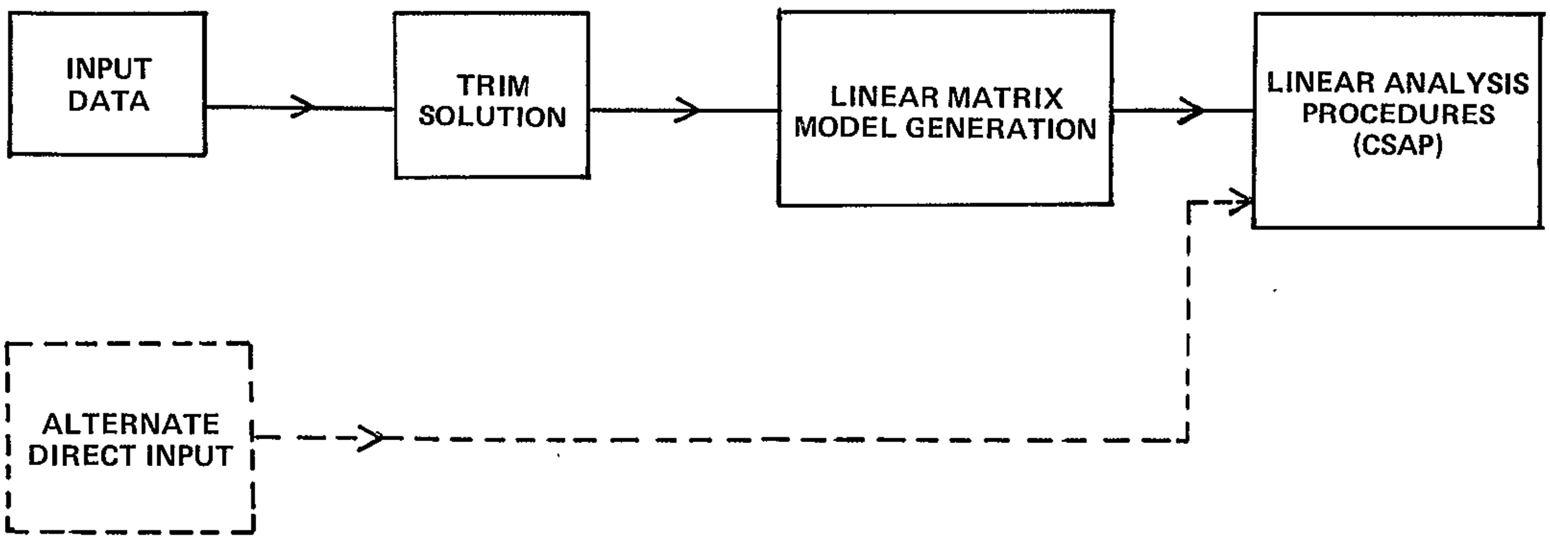

Figure 3-1. Matrix Model Generation

CSAP consists of a QR double iteration eigenvalue routine, the eigenvector, and the transfer function routines. As used by itself, CSAP accepts matrix elements as second order assumed, or as specified order. The latter mode is used in the linear model, and is used in specifying revised matrix elements following a NØMØREEXCEPT. The sequence for the (4I2, 6E 10.0) format is:

K	(00)	dependent variable
	(01)	independent variable
	(02)	end of input changes (or input)
I	matrix row, size alteration (with K = 02)	
J	matrix column	
M	polynomial (term) order	

$$\left.\begin{matrix} A_m \\ \cdot \\ \cdot \\ \cdot \\ A_o \end{matrix}\right\} \text{polynomial coefficients}$$

The second order assumed input uses a (3I2, 3E 10.0) format. The input sequence is:

K	(00)	dependent variable
	(01)	independent variable
	(02)	end of input
I	matrix row, size alteration (with K = 02)	
J	matrix column	

$$\left.\begin{matrix} A_2 \\ A_1 \\ A_o \end{matrix}\right\} \text{polynomial coefficients}$$

Of the matrix analysis options available in the CSAP the frequency and time history options are useful with the linear model. The frequency analysis gives the amplitude and phase of response of a selected dependent-independent variable pair. The response is tablulated from a start frequency f_o in a geometric progression. The increment is the progression common factor.

$$f_{i+1} = (f_i) \quad (\Delta f)$$

F or automatic plotting purposes the number of points, N, can be determined from the specified last point, f_ℓ.

$$f_\ell = (f_o) \quad (\Delta f^{N-1})$$

The time history option converts the selected transfer function into state space. The function thus defined is modeled by a series of numerical integrators with feedback to a common input and feed forward to the desired output. With numerical integrators caution is required to keep to integration interval shorter than the period associated with the highest frequency in the model.

3.3 Data Input Scheme

The data input sequence consists of 23 cards or card images depending on the input device and assembly methods used. The first twenty cards establish a configuration. The next three determine matrix operations, if any, to be performed. These last cards are repeated to specify all the matrix operations, such as transfer functions, wanted. See Figure 3-2. Additional flight conditions or configuration changes can be implemented by repeating the first twenty cards. See Figure 3-3.

As mentioned in Section 3.2 the CSAP capability can be used directly as a linear analysis tool. To do this cards 2 through 19 in the following description are not used. Instead the required matrix elements are entered directly with the one matrix square defined per card. See Figure 3-4. The two input formats are given in Section 3.2. The same procedure is used to add elements or modify existing ones in the linear model mode, and is explained under the Card 23 subheading in Section 3.4.

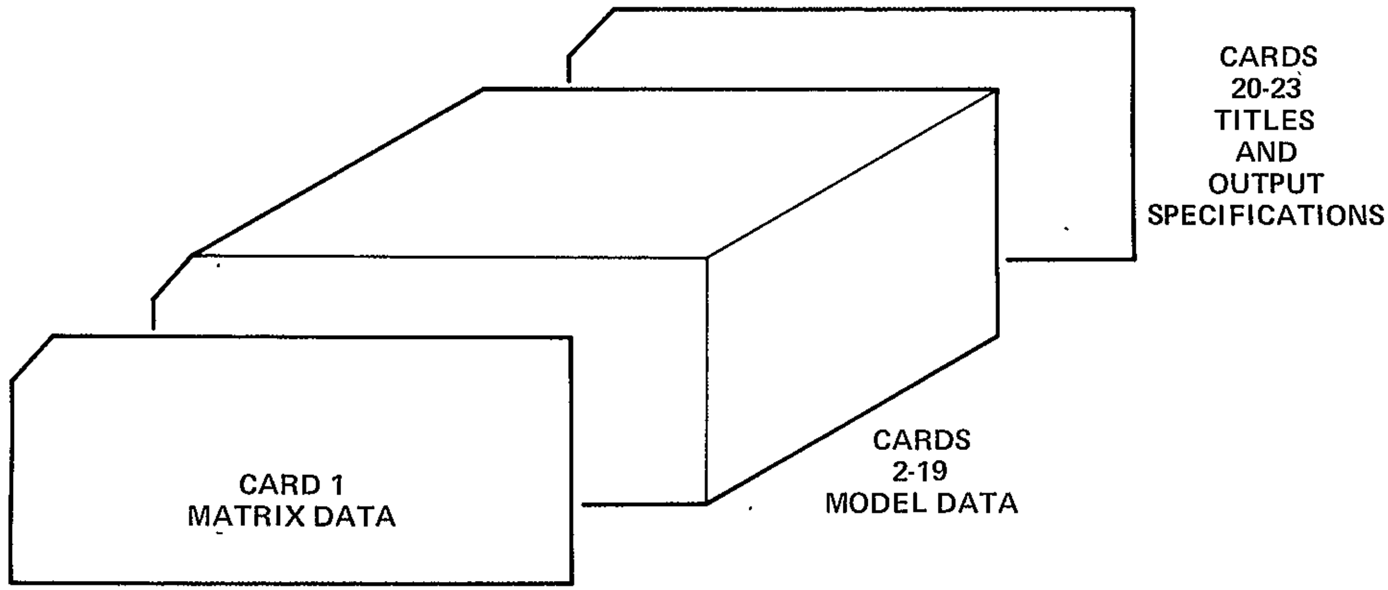

Figure 3-2. Basic card input

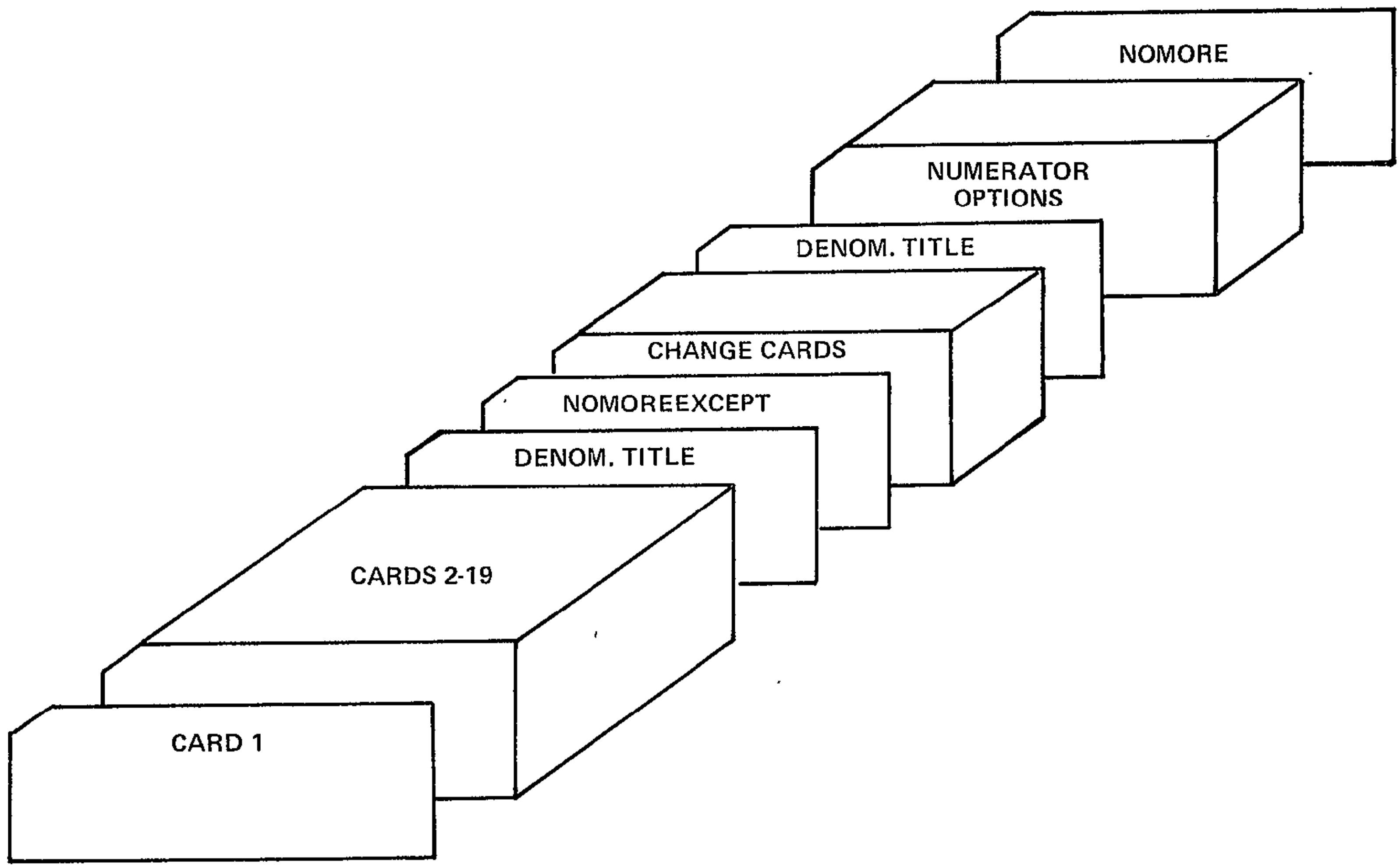

Figure 3-3. Typical input sequence

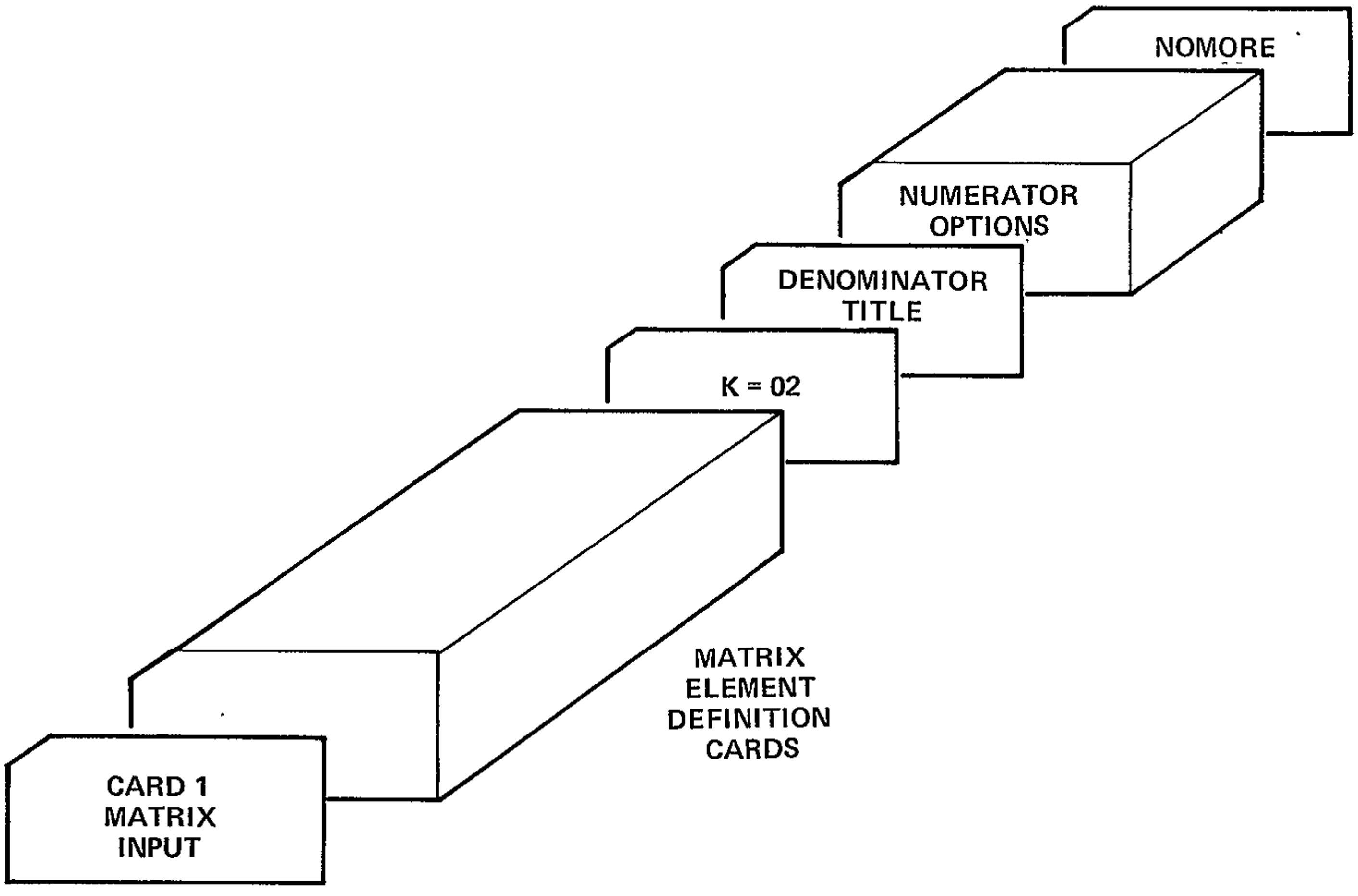

Figure 3-4. Analysis stand alone input.

3.4 Detailed Input Description

MATRIX DATA

Card 1	Format (4I2)
N	Dependent matrix size
INPUT	Value of 2 gives normal operation of program. Values of 1 and 0 override internal matrix generation, and program becomes strictly a matrix analysis tool. Zero defines the second order assumed type of input (See Sec. 3.2).
INV	Number of independent matrix columns. Usual value is 4.
IPUNCH	Value of 1 will cause matrix element coefficients to be punched on unit 7.

CASE IDENTIFIER

Card 2	Format (18A4)
TITLE	Up to 72 alphanumeric characters

(Omit cards 2 through 19 if INPUT $\neq$ 2)

FLIGHT CASE DATA

Card 3	Format (7F10.0)
VKNOT	Airspeed in knots, values 0.0 and 60.0 to 200.0.
RC	Rate of climb in feet/minute.
PHI	Initial roll right attitude in degrees. Symbol ϕ_o.
THETA	Initial pitch attitude in degrees. Symbol θ_o.
THETAC	Root collective blade angle in degrees. Symbol θ_c.
W	Helicopter weight in pounds.
BETAS	Initial sideslip to right, angle in degrees. Symbol β_s.
Card 4	Format (7F10.0)
LØFI	Longitudinal blade flapping in radians for neutral CG from flight test. Symbol a_{1_o}.
LAF	Lateral blade flapping in radians from flight test data. Symbol b_1.

FIX	Rotor to wing wake disturbance coefficient. Symbol f_1 (X). Estimated values of 0.0 at hover and 1.0 at 100 knots up. Depends on wing-rotor geometry. If data is not available use 1.0 except at hover.
ETA	Normal load factor at CG. Symbol η.
EX	Longitudinal rotor inflow gradient. Symbol E_X. Values 0.0 at hover, 1.6 for 100 knots up. See reference 1. Value rapidly reaches 1.6 with increasing speed.
EY	Lateral rotor inflow gradient. Symbol E_Y. Normally 0.0.
LCG	Center of gravity position forward of mast centerline in feet. Symbol ℓ_{cg}.
<u>Card 5</u>	Format (7F10.0)
RØ	Air density in slugs per cubic foot. Symbol ρ. Value .002378 sea level standard.

<u>DIMENSIONS</u>

<u>Card 6</u>	Format (7F10.0)
NB	Number of main rotor blades. Symbol N.
H	Height of main rotor hub above c.g. in feet. Symbol h.
R	Main rotor radius in feet. Symbol R.
SIGMA	Main rotor solidity. Symbol σ.
BC	Main rotor blade chord in feet. Symbol c.
HTR	Tail rotor height above c.g. in feet. Symbol h_{TR}.
LTR	Tail rotor distance aft of c.g. in feet. Symbol ℓ_{TR}.
<u>Card 7</u>	Format (7F10.0)
YTR	Tail rotor right offset from c.g. in feet. Symbol y_{TR}.
RTR	Tail rotor radius in feet. Symbol R_{TR}.
STR	Tail rotor solidity. Symbol σ_{TR}.

LHT Horizontal tail center of pressure position aft of c.g. in feet. Symbol ℓ_{HT}.

SHT Area of horizontal tail in square feet. Symbol S_{HT}.

LVT Vertical tail center of pressure position aft of c.g. in feet. Symbol ℓ_{VT}.

HVT Vertical tail center of pressure distance above c.g. in feet. Symbol h_{VT}.

Card 8 Format (7F10.0)

SVT Area of vertical tail in square feet. Symbol S_{VT}.

CBAR Wing mean aerodynamic chord in feet. Symbol $\bar{c}$. Used as reference length in body moment coefficients.

SW Wing area in square feet. Symbol S_W. Note C_{D_O}, Card 19, is based on this reference area.

WS Wing span in feet. Symbol b.

AR Wing aspect ratio. Symbol AR. Use minimum of 1. Zero will cause overflow.

ANGLES

Card 9 Format (7F10.0)

PSIØ Blade pitch input point counter clockwise from feather axis in degrees. Symbol ψ_o.

PSIFB Feedback return angle counter clockwise from feather axis in degrees. Symbol ψ_{FB}.

PSIS Cyclic input axis rotation clockwise from body axis in degrees. Symbol ψ_s.

PSIG Control gyro to swashplate coupling rotation counter clockwise in degrees. Symbol ψ_G.

TWIST Blade twist nose down from root in degrees. Symbol $-\theta_1$.

SWEEP Blade inplane root sweep forward in degrees. Symbol ζ_{SW}.

DROOP Blade droop from feather axis in degrees. Symbol β_{DR}.

LINKAGE RATIOS

Card 10 Format (7F10.0)

LRC Swashplate to blade gear ratio, positive for pitch horn leading blade. Symbol ℓ_{RC}.

DEL3 Ratio of reduction in blade pitch for blade flapping up. Symbol δ_3.

ALPH2 Ratio of reduction in blade pitch for blade lag. Symbol α_2.

LGCØL Collective control element to swashplate collective gear ratio. Symbol ℓ_{GCOL}. Use 1. for non distributed collective linkage ratios.

LGCYC Cyclic control element to swashplate cyclic gear ratio. Symbol ℓ_{GCYC}. Use 1. for non distributed cyclic linkage ratios.

KRUD Rudder pedal to tail rotor collective gear ratio. Symbol K_{RUD}. Rad./unit rudder input.

KTHEØ Collective handle to blade gear ratio. Symbol K_{θ_o}. Rad./unit collective input.

SPRINGS AND DAMPERS

Card 11 Format (7F10.0)

KXCS Longitudinal cyclic control element input. FT lb/unit stick for control gyro configuration. Rad./unit stick for direct, kinematic control. Symbol K_{XCS}.

KYCS Laterial cyclic control element input. Ft lb/unit stick for control gyro configuration. Rad./unit stick for direct, kinematic control. Symbol K_{YCS}.

KC Control gyro spring rate, cosine axis. Symbol K_c. Use 1.0 for kinematic control configuration. Ft lb/rad.

KS Control gyro spring rate, sine axis. Symbol K_s. Use 1.0 for kinematic control configuration. Ft lb/rad.

KFB Feedback linkage spring rate in ft lb/rad. Symbol K_{FB}. Use 0. for kinematic control configuration.

HSLA Lateral hub stiffness in ft lb/rad. Symbol $\partial L_R / \partial b_1$.

HSLØ Longitudinal hub stiffness in ft lb/rad. Symbol $\partial M_R / \partial a_1$.

The coefficients HSLA, HSLØ are best determined from whirl tower data of moment vs blade deflection. Approximations can be made from force or natural frequency considerations. First if an equivalent flapping hinge offset is known, then the coefficients may be calculated as the centrifugal force acting on the hinge offset arm plus aerodynamic shears acting at the hinge. The offset may be obtained from the intercept of the tangent of the outboard section of the flapping mode shape with the horizontal. Secondly the stiffness can be estimated from the blade natural frequency and blade inertia. Only a fraction of this calculated stiffness will be effective at the shaft, typically 25% or less.

Card 12	Format (7F10.0)
KR	Control gyro rotating coordinates spring rate, ft lb/rad. Symbol K_R. Use 0. for kinematic control configuration.
CC	Control gyro damper, cosine axis. Symbol C_c. Use 0. for kinematic control configuration. Ft lb/rad./sec.
CS	Control gyro damper, sine axis. Symbol C_S. Use 0. for kinematic control configuration. Ft lb/rad/sec.
CR	Control gyro rotating coordinates damper. Symbol C_R. Use 0. for kinematic control configuration. Ft lb/rad/sec.
IDC	Inplane damping in ft lb/rad/sec. Symbol $\partial M_\zeta / \partial \dot{\zeta}$.

FREQUENCIES AND PERIODS

Card 13	Format (7F10.0)
ØMEGA	Main rotor rotation speed in radians per second. Symbol Ω.
WB1	First flap mode frequency in radians per second. Symbol ω_{β_1}. (Fundamental mode).
WB2	Second inplane mode frequency in radians per second. Symbol ω_{β_2}. (Fundamental mode).
ØTR	Tail rotor rotation speed in radians per second. Symbol TR.
WCØL	Collective system natural frequency in rad/sec. Symbol ω_c.
WCYC	Cyclic system natural frequency in rad/sec. Symbol ω_{cyc}.

Card 14 Format (7F10.0)

TAUCYC Cyclic actuator servo time constant, sec. Symbol τ_{CYC}.

TAUCØL Collective actuator servo time constant, sec. Symbol τ_{COL}.

INERTIAS AND MOMENTS

Card 15 Format (7F10.0)

IA Blade feathering moment of inertia in slug ft^2. Symbol I_A.

IB Blade flap moment of inertia in slug ft^2. Symbol I_B.

IC Blade inplane moment of inertia in slug ft^2. Symbol I_C.

ISP Cross axis generalized blade inertia $\int_0^R m\, f_{\beta 1}\, f_{\zeta 2}\, dr$ in slug ft^2. Symbol I_{SP}.

M1F Blade generalized flapping mass moment $\int_0^R m\, f_{\beta 1}\, dr$ in slug ft. Symbol M_{IF}.

M2L Blade generalized inplane mass moment $\int_0^R m\, f_{\zeta 2}\, dr$ in slug ft^2. Symbol M_{2L}.

MY Blade Mass Balance $\int_0^R my\, dr$ in slug ft.

Card 16 Format (7F10.0)

ML1F Generalized blade inertia $\int_0^R m\, f_{\beta 1}\, r\, dr$ in slug ft^2. Symbol M_{LIF}.

IAB Blade Product of Inertia $\int_0^R my\, f_{\beta 1}\, dr$ in slug ft^2. Symbol I_{AB}.

IAC	Blade product of inertia $\int_0^R my\, f_{\beta 2}\, dr$ in slug ft^2. Symbol I_{AC}.
IG	Control gyro diametral moment of inertia, slug ft^2. Symbol I_G. Use 0. for kinematic control system.

Card 17 — Format (7F10.0)

IXX	Helicopter roll moment of inertia in slug ft^2. Symbol I_{XX}.
IYY	Helicopter pitch moment of inertia in slug ft^2. Symbol I_{YY}.
IZZ	Helicopter yaw moment of inertia in slug ft^2. Symbol I_{ZZ}.
IXZ	Helicopter longitudinal product of inertia in slug ft^2. Symbol I_{XZ}.

AERODYNAMICS

Card 18 — Format (7F10.0)

AØW	Wing zero lift angle of attack in degrees. Symbol $\alpha_{o}w$.
AØHT	Horizontal tail zero lift angle of attack in degrees. Symbol $\alpha_{o_{HT}}$.
LSB	Blade lift curve slope in rad^{-1}. Symbol a.
AW	Wing lift curve slope in rad^{-1}. Symbol a_W.
AHT	Horizontal tail lift curve slope in rad^{-1}. Symbol a_{HT}.
AVT	Vertical tail lift curve slope in rad^{-1}. Symbol a_{VT}.
DEDA 3	Wing to horizontal tail wake coefficient. Symbol $\frac{\partial \epsilon_3}{\partial \alpha_F}$.

Card 19 — Format (7F10.0)

DCVDB	Body side force due to yaw coefficient in rad^{-1}. Symbol $\partial C_Y/\partial\beta$.
DCMBDA	Body pitch moment due to pitch angle coefficient in rad^{-1}. Symbol $\partial C_{M_B}/\partial\alpha$.
CM	Wing pitching moment coefficient. Symbol C_M.

DCNBDB — Body yaw moment due to yaw angle coefficient in rad^{-1}. Symbol $\partial C_N/\partial\beta$.

MRTHED — Blade aero and friction feather damping in ft lb/rad/sec. Symbol $M_{R\theta}$.

CDØ — Body drag coefficient. Symbol $\overline{C}_D$. Based on wing reference area, Card 8.

TC — Blade tip coefficient. Symbol B. Value 0.97.

(11)

DENOMINATOR TITLE

Card 20 — Format (20A4)

TITLE — Up to 80 alphanumeric characters

NUMERATOR TITLE

Card 21 — Format (20A4)

TITLE — Up to 80 alphanumeric characters. Note: NØMØRE entry gives characteristic roots only, and selects next case.

OPTION CONTROL

Card 22 — Format (3I2, 6E10.0, 3I1)

K — Dependent variable (xx)

L — Independent variable (xx)

M — Option:

(00) Numerator roots only.

(01) Root locus. (OS/360 only)

(02) Frequency response.

(03) Power spectral density. (OS/360 only)

(04) Time history

(05) Nyquist plots. (OS/360 only)

DATA 1	Gain - Option (01)
	Minimum frequency (rad/sec) - Option (02)
	Minimum frequency (rad/sec) - Option (03)
	Finish time (sec) - Option (04)
DATA 2	Maximum frequency (rad/sec) - Option (02)
	Maximum frequency (rad/sec) - Option (03)
	Print interval (sec) - Option (04) Note: 250 maximum points.
DATA 3	Frequency increment - Option (02)
	Frequency increment - Option (03)
	Forcing variable step amplitude - Option (04)
DATA 4	Characteristic length (ft) - Option (03)
	Integration step (sec) - Option (04). Note: Must be comparable to highest model frequency.
DATA 5	Velocity (ft/sec) - Option (03)
	Forcing variable step duration (sec) - Option (04)
DATA 6	Y axis plot scale factor - (OS/360 only) - blank assumes unity factor
IPLOT1	(0) No plots
	(1) All plots and linear X axis (Option 03)
	(2) Phase plot only (Option 02) Log X axis (Option 03) Position plot only (Option 04)
	(3) Rate plot only (Option 04)
	(4) Acceleration plot only (Option 04)
IPLOT 2	(0) No plot error messages.
	(1) Prints plot scaling data and error diagnostics. Use (1).

IPLOT 3 (0) Numerator title on plot.

(1) Denominator title on plot.

<u>NEW CASE CONTROL</u>

<u>Card 23</u>	Format (20A4)
(No Card)	More numerators repeat to card 21.
NØMØRE	New case data. Go to card 1.
NOMOREEXCEPT	Code to revise matrix elements or add new ones (including order expansion - contraction). Format is (4I2, 6E 10.0) for linear model or INPUT = 1 (Card 1) specification. Format is (3I3, 3E 10.0) for INPUT = 0 (second order matrix elements assumed). The change cards follow, using the specification given in Section 3.2.
(NOMORE)	End of run.
(blank)	

3.5 Program Output

The linear model program returns a set of tabulated data, and for OS/360 installations can optionally return CALCOMP plots of selected frequency response and time history functions.

The tabulated output first returns the input with data group titles and coefficient symbols. Next the output of the trim calculations and repeated factors are printed. The array of inflow derivatives is displayed on the following page of output, and is titled GENERAL DERIVATIVES. The row and column guide is given in Table 3-1. The compiled derivative array of main rotor terms follows, and is labeled DERIV ARRAY. The array guide for this printout is given in Table 3-2. The fixed surface aerodynamics are then printed as the FIXED SURFACE ARRAY and supplemental elements. The array key is given in Table 3-3. The supplemental elements can be directly read from the code name. For example PYVTPR is $\partial YVT/\partial r$. The P always means partial.

TABLE 3-1. GENERAL DERIVATIVE PRINT KEY

INDEX	ROW (NUMERATOR)	COLUMN (DENOMINATOR)
1	λi_o	a_o
2	λi_c	$\dot{a}_o$
3	λi_s	a_1
4		$\dot{a}_1$
5		b_1
6		$\dot{b}_1$
7		θ_o
8		A_1
9		B_1
10		u
11		v
12		w
13		p
14		q

The completed matrix is displayed under the title CONTROL SYSTEM ANALYSIS PROGRAM, INPUT DATA. For a given row blank elements or unused high orders of S are not printed. The row and column key is given in Table 2-1.

Depending on the output options selected the remaining information will range from a default set about the characteristic equation to CALCOMP frequency and time history plots.

The characteristic equation in both factored and polynominal form are then printed with the DENOMINATOR title.

TABLE 3-2. DERIV ARRAY PRINT KEY

INDEX	ROW (NUMERATOR)	COLUMN (DENOMINATOR)
1	M_{β_o}	a_o
2	M_{β_c}	$\dot{a}_o$
3	M_{β_s}	a_1
4	M_{ζ_c}	$\dot{a}_1$
5	M_{ζ_s}	b_1
6	X_R	$\dot{b}_1$
7	Y_R	θ_o
8	Z_R	A_1
9	Q_R	B_1
10		u
11		v
12		w
13		p
14		q

The polynomial that is printed is the characteristic equation with the leading coefficient divided out. This coefficient is printed.

Additional information such as time to 1/2 amplitude (sec), damping ratio (no units), and damped and natural frequencies (Hz) are supplied. Eigenvectors are listed for each root with a non-negative imaginary part.

Output similar in form to that printed for the characteristic equation, except for eigenvectors, is given for each numerator requested. Additional information depends on the numerator option selected. For no selection the program print is controlled by specified new case or update information. The

TABLE 3-3. FIXED SURFACE ARRAY PRINT KEY

INDEX	ROW (NUMERATOR)	COLUMN (DENOMINATOR)
1	X_B	u
2	Z_B	v
3	Z_{HT}	w
4	M_B	p
5	M_W	q
6	M_{HT}	
7	Y_{TR}	
8	Y_B	
9	N_B	
10	L_W	
ADDITIONAL DERIVATIVES		
NAME	NUMERATOR	DENOMINATOR
PXTRPU	X TAIL ROTOR	u
PYVTPV	Y VERTICAL TAIL	v
PYVTPR	Y VERTICAL TAIL	r
PYTRPO	Y TAIL ROTOR	θ_{TR}
PZHTWD	Z HORIZONTAL TAIL	$\dot{w}$
Note: M_W is not used.		

frequency response option will provide the gain and phase response of the selected transfer function. The printout includes ω(rad/sec), gain (%), gain (dB), and phase (deg).

The time history option will yield a step response time history for the specified transfer function. Values for position, rate, and acceleration as a function of time are listed. Units are in the foot-pound-second system. A sample output is given in Figure 3-5.

4. OPERATION CONSIDERATIONS

This release of the linear model software is written almost entirely in ANS FORTRAN to enhance portability of the program. However, the word length of the particular machine used is an important factor in obtaining useful results from the program.

The developmental version of the program uses IBM DOUBLE PRECISION REAL (64 bit word size). The release version is written for the CDC 7600 using single word variables (60 bit word size for the CDC). Use of the program on small word size equipment may require reconversion to double word length computation, particularly in the matrix processing subroutines.

4.1 Computer Resources Required

Minimal resources are required to operate the linear model program. Only the normal FORTRAN input, output, and punched output devices are used. The I/O operations are sequential, therefore, the actual device types are not important; the logical I/O unit numbers and function are listed in Table 4-1.

TABLE 4-1. I/O UNITS

Unit#	Function
5	Input
6	Print Output
7	Punched Card Output

Note that all installation-dependent software has been removed (including graphic output) to enhance portability.

On the parent installation's IBM 360/91 (32 bit word size), the linear model program requires 260K bytes to compile using the FORTRAN IV (H) compiler. 188K bytes are required for execution and a typical case will use less than 10 cpu seconds.

It can be expected that these resource requirements will remain relatively constant (i.e., minimal) across machine types. It is estimated that the linear model program will require less than 100K octal words to compile and execute on the CDC 7600 (60 bit word size). Typical run times should be less than 10 cpu seconds.

5. REFERENCES

1. Castles, W., Jr., and De Leeuw, J. H., the Normal Component of the Induced Velocity in the Vicinity of a Lifting Rotor and Some Examples of its Application, NACA Report 1184, 1954.

FLIGHT CASE DATA

VKNOT LOFI RO	RC LAF	PHI F1X	THETA ETA	THETAC EX	W EY	BETAS LCG
0.0 0.0 2.37800E-03	0.0 0.0	0.0 0.0	0.0 1.00000E 00	1.00000E 01 0.0	5.07000E 03 0.0	0.0 0.0

DIMENSIONS

NB YTR SVT	H RTR CBAR	R STR SW	SIGMA LHT WS	BC SHT AR	HTR LVT	LTR HVT
4.00000E 00 -1.07800E 00 6.40000E 00	5.16000E 00 3.11700E 00 1.00000E 00	1.61000E 01 1.20000E-01 1.48000E 01	7.00000E-02 1.44800E 01 1.00000E 00	8.86000E-01 8.67000E 00 1.00000E 00	5.76000E 00 1.78600E 01	1.92250E 01 3.85000E 00

ANGLES

PSIO	PSIFB	PSIS	PSIG	TWIST	SWEEP	DROOP
4.00000E 01	0.0	-7.00000E 01	0.0	8.00000E 00	0.0	0.0

LINKAGE RATIOS

LRC	DEL3	ALPH2	LGCOL	LGCYC	KRUD	KTHED
1.00000E 00	6.00000E-01	-3.00000E-01	3.73000E-01	2.41400E-01	1.35000E 00	1.00000E 00

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Figure 3-5. Program sample output.

SPRINGS AND DAMPERS

KXCS	KYCS	KC	KS	KFR	HSLA	HSLD
KR	CC	CS	CR	IDC		
1.00000E 00	1.00000E 00	1.00000E 00	1.00000E 00	0.0	1.05000E 05	1.05000E 05
0.0	0.0	0.0	0.0	7.91000E 02		

FREQUENCIES AND PERIODS

OMEGA	WB1	WB2	OTR	WCOL	WCYC
TAUCYC	TAUCOL				
4.44000E 01	4.94559E 01	3.11080E 01	2.32500E 02	1.60000E 02	1.60000E 02
2.50000E-02	2.50000E-02				

INERTIAS AND MOMENTS

IA	IB	IC	ISP	M1F	M2L	MY
ML1F	IAB	IAC	IG			
IXX	IYY	IZZ	IXZ			
1.74000E-01	1.49800E 02	1.41520E 02	1.53680E 02	1.47900E 01	1.41400E 01	0.0
1.73800E 02	0.0	0.0	0.0			
1.41900E 03	3.73400E 03	3.33000E 03	0.0			

AERODYNAMICS

AOW	AOHT	LSB	AW	AHT	AVT	DEDA3
DCVDB	DCMBDA	CM	DCNBDB	MRTHED	CDO	TC
-3.00000E 00	-3.00000E 00	5.73000E 00	2.50000E 00	4.53000E 00	3.61000E 00	6.50000E-01
-4.05000E 00	4.26000E 00	-9.12000E-01	-2.65300E 01	5.00000E 01	7.22000E-01	9.70000E-01

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Figure 3-5. Program sample output (Continued).

TRIM CALCULATIONS

V RS LAMITR	Q LAMD CLW	AA OMRTR B1	LAMI CD ALPHS	ATR TTR	AO A1	TMR MUX	THEO LAMS
0.0	0.0	0.81433E 03	-0.51806E-01	0.30523E 02	0.45159E-01	0.50150E 04	0.16400E 00
0.0	-0.51806E-01	0.72470E 03	0.12565E-01	0.30868E 03	0.0	0.0	-0.51806E-01
0.66499E-01	0.0	0.0	0.0				

PRELIMINARY CALCULATIONS

MUY DEDA2	MUBAR2 DLMTR	MUTRBR CLHT	LAM	LAM1	LAMSQ	LAM2TR	DEDA1
0.0	0.0	0.0	0.51806E-01	0.33695E 00	0.26839E-02	0.60744E 00	0.66305E 00
0.33152E 00	0.30372E 00	0.23719E 00					

GENERAL DERIVATIVES

	A ZERO CAP A ONE	A ZERO DOT CAP B ONE	A ONE U	A ONE DOT V	B ONE W	B ONE DOT P	THETA ZERO Q
LAMDAIO	0.0	4.74946E-03	0.0	0.0	0.0	0.0	-2.10876E-01
	0.0	0.0	-4.71367E-04	-4.71367E-04	-9.27549E-04	0.0	0.0
LAMDAIC	0.0	0.0	0.0	-7.34453E-03	-3.26097E-01	0.0	0.0
	3.26097E-01	0.0	3.18567E-05	-1.56026E-04	0.0	0.0	-7.34453E-03
LAMDAIS	0.0	0.0	3.26097E-01	0.0	0.0	-7.34453E-03	0.0
	0.0	3.26097E-01	-1.56026E-04	-3.18567E-05	0.0	-7.34453E-03	0.0

Figure 3-5. Program sample output (Continued)

DERIV ARRAY - MAIN ROTOR DERIVATIVES

	A ZERO CAP A ONE	A ZERO DOT CAP B ONE	A ONE U	A ONE DOT V	B ONE W	B ONE DOT P	THETA ZERO Q
M BETA O	0.0	-0.28302E 04	0.0	0.0	0.0	0.0	0.12566E 06
	0.0	0.0	-0.11465E 03	-0.11465E 03	0.11465E 03	0.0	0.0
M BETA C	0.0	0.0	0.0	0.26858E 04	0.11925E 06	0.0	0.0
	-0.11925E 06	0.0	-0.97289E 01	0.56737E 02	0.0	0.0	0.26858E 04
M BETA S	0.0	0.0	-0.11925E 06	0.0	0.0	0.26858E 04	0.0
	0.0	-0.11925E 06	0.56737E 02	0.97289E 01	0.0	0.26858E 04	0.0
M ZETA C	0.0	0.0	0.0	-0.79246E 02	-0.35185E 04	0.0	0.0
	-0.12900E 05	0.0	0.28728E-01	0.62487E 01	0.0	0.0	-0.79246E 02
M ZETA X	0.0	0.0	0.35185E 04	0.0	0.0	-0.79246E 02	0.0
	0.0	-0.12900E 05	0.62487E 01	-0.28728E-01	0.0	-0.79246E 02	0.0
X ROTOR	0.0	0.0	-0.26460E 04	0.30703E 02	0.13632E 04	0.25641E 01	0.0
	-0.13632E 04	0.24183E 04	-0.15736E 01	0.50586E 00	0.0	0.25641E 01	0.30703E 02
Y ROTOR	0.0	0.0	0.13632E 04	0.15926E 00	0.26460E 04	-0.19070E 01	0.0
	0.24183E 04	0.13632E 04	-0.50586E 00	-0.15815E 01	0.0	-0.19070E 01	0.15926E 00
Z ROTOR	0.0	0.91635E 03	0.0	0.0	0.0	0.0	-0.40686E 05
	0.0	0.0	0.44007E 02	0.44007E 02	-0.44007E 02	0.0	0.0
Q ROTOR	0.0	-0.32619E 03	0.0	0.0	0.0	0.0	-0.51129E 05
	0.0	0.0	-0.17279E 01	-0.17279E 01	0.17279E 01	0.0	0.0

Figure 3-5. Program sample output (Continued)

FIXED SURFACE ARRAY

	U	V	W	P	Q
X BODY	0.0	0.0	0.0	0.0	0.0
Z BODY	0.0	0.0	0.0	0.0	0.0
Z HOR TL	0.0	0.0	0.0	0.0	0.0
M BODY	0.0	0.0	0.0	0.0	0.0
M WING	0.0	0.0	0.0	0.0	0.0
M HOR TL	0.0	0.0	0.0	0.0	0.0
Y TL RTR	0.0	-0.25840E 01	0.0	0.0	0.0
Y BODY	0.0	0.0	0.0	0.0	0.0
N BODY	0.0	0.0	0.0	0.0	0.0
L WING	0.0	0.0	0.0	0.0	0.0

PXTRPU = -0.14181E-01 PYVTPV = 0.0 PYVTPR = 0.0 PYTRPQ = 0.24219E 04 PZHTWD = -0.43952E 00

Figure 3-5. Program sample output (Continued)

```
                              CONTROL SYSTEM ANALYSIS PROGRAM
                                         INPUT DATA
ROW COL              COL              COL              COL              COL              COL

 1   1  1.00000E 00   3 -2.46354E-01   4  0.0           5 -3.28348E-02   6  0.0           8 -1.94828E-01
        1.00756E-02      3.21725E 01     -3.21005E-03     0.0              1.52871E-02      1.67908E 01

     9 -1.62709E-02  13  0.0          14  0.0
       -8.65037E 00      8.65037E 00     -1.53460E 01

 2   1  0.0           2  0.0           4  0.0           7 -3.75409E-01  12  0.0
        0.0              1.00000E 00      0.0             -5.81482E 00      0.0
       -2.79255E-01      2.79254E-01     -2.79255E-01      0.0              2.58178E 02

 3   1  0.0           2  0.0           3  1.00000E 00   4  0.0           5  0.0           6  0.0
        0.0              1.70441E-03      5.36486E-02      0.0              7.15043E-03      0.0
       -2.19644E-03      0.0              0.0              6.99053E-04      0.0             -8.80538E-02

     8  0.0           9  0.0          13  0.0          14  0.0
        4.24278E-02      3.54332E-03      0.0              0.0
       -3.17765E 01      1.88379E 00     -1.88379E 00      3.34190E 00

 4   1  0.0           3 -1.75744E-02   4  1.00000E 00   5  1.58331E-01   6  0.0           8 -1.01062E-03
        3.21005E-03      0.0              2.64325E-02     -3.21725E 01     -3.15232E-01     -8.65037E 00

     9  1.21011E-02  13  0.0          14  0.0
       -1.67908E 01     -1.53460E 01     -8.65037E 00

 5   1  0.0           3  0.0           4  0.0           5  1.00000E 00   6  0.0           8  0.0
        0.0             -1.00710E-02      0.0              9.70246E-02      0.0             -5.79131E-04
        1.83951E-03      0.0              1.62397E-02      0.0             -2.01648E-01     -4.95707E 00

     9  0.0          13  0.0          14  0.0
        6.93452E-03      0.0              0.0
       -8.36177E 01     -8.79397E 00     -4.95707E 00

 6   1  0.0           2  0.0           4  0.0           5 -8.59274E-02   6  1.00000E 00   7  6.42311E-01
       -5.14311E-04      5.18902E-04     -1.54368E-02      0.0              2.86802E-01      0.0

    12  0.0
       -7.64939E 00

 7   1  0.0           2  0.0           4  0.0           7  1.00000E 00  12  0.0
        0.0             -9.87316E-02      0.0              1.88934E 01      0.0
        7.65383E-01     -7.65382E-01      7.65383E-01      2.44588E 03     -8.33728E 02

 8   1  0.0           3 -1.16021E 00   4  0.0           5  0.0           8 -1.00000E 00   9  0.0
        0.0             -1.79295E 01      0.0             -1.03027E 02     -1.79295E 01     -8.88000E 01
        6.49462E-02      0.0             -3.78750E-01      0.0             -4.74525E 02     -7.96068E 02

    10  0.0          11  0.0          13  0.0
        4.11397E 00      0.0              0.0
        0.0              1.82660E 02      7.90927E 02

 9   1  0.0           3  0.0           4  0.0           5 -1.16021E 00   8  0.0           9 -1.00000E 00
        0.0              1.03027E 02      0.0             -1.79295E 01      8.88000E 01     -1.79295E 01
       -3.78750E-01      0.0             -6.49462E-02      0.0              7.96068E 02     -4.74525E 02
```


Figure 3-5. Program sample output (Continued)

```
       10  0.0             11  0.0             14  0.0
           0.0                 4.11397E 00         0.0
          -1.82660E 02         0.0                 7.90927E 02

10      1  0.0              3  0.0              4  0.0              5 -5.15562E-01    8  0.0              9  0.0
           0.0                 5.59967E-01        -9.99152E-02         0.0                -3.79470E 00         0.0
          -2.02997E-04         0.0                -4.41544E-02         0.0                 0.0                -1.68485E 02

       10 -1.00000E 00     11  0.0             13  0.0
          -5.58932E 00        -8.88000E 01         0.0
           1.00365E 03        -2.48166E 02         4.58324E 01

11      1  0.0              3  5.15562E-01      4  0.0              5  0.0              8  0.0              9  0.0
          -9.99152E-02         0.0                 0.0                 5.59967E-01         0.0                -3.79470E 00
          -4.41544E-02         0.0                 2.02997E-04         0.0                 1.68485E 02         0.0

       10  0.0             11 -1.00000E 00     14  0.0
           8.88000E 01        -5.58932E 00         0.0
           2.48166E 02         1.00365E 03         4.58324E 01

12      7  0.0             12  1.00000E 00     15  0.0
           0.0                 2.87356E 02         0.0
           1.97857E 04         2.75714E 04        -2.56000E 04

13      8  0.0             10  0.0             13 -1.00000E 00     14  0.0             16  0.0             17  0.0
           0.0                 0.0                -2.87356E 02        -8.88000E 01         0.0                 0.0
          -1.97857E 04        -2.91833E 04        -2.56000E 04        -1.27586E 04        -1.96107E 04        -1.64554E 04

14      9  0.0             11  0.0             13  0.0             14 -1.00000E 00     16  0.0             17  0.0
           0.0                 0.0                 8.88000E 01        -2.87356E 02         0.0                 0.0
          -1.97857E 04        -2.91833E 04         1.27586E 04        -2.56000E 04         1.64554E 04        -1.96107E 04

15     15  2.50000E-02     18  0.0
           1.00000E 00        -3.73000E-01

16     16  2.50000E-02     19  0.0
           1.00000E 00        -2.41400E-01

17     17  2.50000E-02     20  0.0
           1.00000E 00        -2.41400E-01

18     18  1.00000E 00

19     19  1.00000E 00

20     20  1.00000E 00
```


Figure 3-5. Program sample output (Continued)

INDEPENDENT VARIABLE DATA

ROW	COL		COL		COL	COL	COL	COL
4	4	-2.07476E 01						
5	4	-1.32718E 01						
6	4	1.88761E 01						
18	3	1.00000E 00						
19	1	-9.39693E-01	2	-3.42020E-01				
20	1	3.42020E-01	2	-9.39693E-01				

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Figure 3-5. Program sample output (Continued)

DENOMINATOR

HINGELESS ROTOR HOVER DEMONSTRATION
LEADING COEFFICIENT = 1.504583E-05

POLY		REAL	IMAG	TIME TO 1/2	DAMPING RATIO	FREQUENCY (D)	FREQUENCY (N)
1.00000E 00	S**27	-1.46843E 02	-1.29569E 02				
1.04848E 03	S**26	-1.46843E 02	1.29569E 02	4.72033E-03	7.49833E-01	2.06216E 01	3.11680E 01
5.26940E 05	S**25	-1.46737E 02	-8.51610E 01				
1.66943E 08	S**24	-1.46737E 02	8.51610E 01	4.72375E-03	8.64894E-01	1.35538E 01	2.70020E 01
3.74471E 10	S**23	-1.46864E 02	-4.07533E 01				
6.37910E 12	S**22	-1.46864E 02	4.07533E 01	4.71966E-03	9.63589E-01	6.48608E 00	2.42573E 01
8.65460E 14	S**21	-6.43775E 00	-9.84971E 01				
9.60954E 16	S**20	-6.43775E 00	9.84971E 01	1.07669E-01	6.52207E-02	1.56763E 01	1.57097E 01
8.83013E 18	S**19	-2.20749E 00	-7.56208E 01				
6.75965E 20	S**18	-2.20749E 00	7.56208E 01	3.13998E-01	2.91791E-02	1.20354E 01	1.20406E 01
4.33075E 22	S**17	-6.32465E 00	-5.44739E 01				
2.29665E 24	S**16	-6.32465E 00	5.44739E 01	1.09595E-01	1.15329E-01	8.66979E 00	8.72803E 00
9.98277E 25	S**15	-4.86333E 00	-1.35494E 01				
3.50935E 27	S**14	-4.86333E 00	1.35494E 01	1.42525E-01	3.37831E-01	2.15645E 00	2.29115E 00
9.60900E 28	S**13	-1.81173E 00	-1.37087E 01				
1.98311E 30	S**12	-1.81173E 00	1.37087E 01	3.82588E-01	1.31020E-01	2.18180E 00	2.20078E 00
3.14337E 31	S**11	-1.86088E 00	-2.81395E 00				
3.87224E 32	S**10	-1.86088E 00	2.81395E 00	3.72483E-01	5.51600E-01	4.47854E-01	5.36926E-01
3.41236E 33	S** 9	1.82806E-02	-3.73053E-01				
2.31273E 34	S** 8	1.82806E-02	3.73053E-01	-3.79171E 01	-4.89440E-02	5.93732E-02	5.94444E-02
7.63214E 34	S** 7	-9.70848E-02	-4.32602E-01				
1.70198E 35	S** 6	-9.70848E-02	4.32602E-01	7.13961E 00	2.18974E-01	6.88506E-02	7.05631E-02
1.03034E 35	S** 5	-2.10267E-01	-3.60263E-02				
6.61850E 34	S** 4	-2.10267E-01	3.60263E-02	3.29651E 00	9.85637E-01	5.73376E-03	3.39527E-02
2.39793E 34	S** 3	-4.00000E 01	0.0	1.73287E-02			
7.10644E 33	S** 2	-4.00000E 01	0.0	1.73287E-02			
1.62200E 33	S** 1	-4.00000E 01	0.0	1.73287E-02			
1.54907E 32	S** 0						

Figure 3-5. Program sample output (Continued)

EIGENVECTORS

REAL	IMAG	ROW		ROW		ROW		ROW		ROW	
-4.00000E 01	0.0	1	1.07359E-04	2	-4.74317E 00	3	-1.75727E-04	4	-3.17861E-03	5	5.02286E-05
		6	4.00669E-01	7	-2.82314E-01	8	2.16727E-04	9	-3.05469E-09	10	-3.47445E-05
		11	3.38913E-06	12	-1.13221E 00	13	-1.52407E-04	14	-9.56337E-05	15	-1.00000E 00
		16	0.0	17	0.0	18	0.0	19	0.0	20	0.0
-4.00000E 01	0.0	1	1.07359E-04	2	-4.74317E 00	3	-1.75727E-04	4	-3.17861E-03	5	5.02286E-05
		6	4.00669E-01	7	-2.82314E-01	8	2.16727E-04	9	-3.05469E-09	10	-3.47445E-05
		11	3.38913E-06	12	-1.13221E 00	13	-1.52407E-04	14	-9.56337E-05	15	-1.00000E 00
		16	0.0	17	0.0	18	0.0	19	0.0	20	0.0
-4.00000E 01	0.0	1	1.07359E-04	2	-4.74317E 00	3	-1.75727E-04	4	-3.17861E-03	5	5.02286E-05
		6	4.00669E-01	7	-2.82314E-01	8	2.16727E-04	9	-3.05469E-09	10	-3.47445E-05
		11	3.38913E-06	12	-1.13221E 00	13	-1.52407E-04	14	-9.56337E-05	15	-1.00000E 00
		16	0.0	17	0.0	18	0.0	19	0.0	20	0.0

*NOTE – SOME VECTORS MAY BE MISSING (CONVERGENCE PROBLEMS)
AND REPEATED ROOTS WILL YIELD IDENTICAL VECTORS

Figure 3-5. Program sample output (Continued)

NUMERATOR DEP VAR 5 / INDEP VAR 2

ROLL DUE TO LATERAL STICK STEP
LEADING COEFFICIENT = 3.754312E 01

POLY		REAL	IMAG	TIME TO 1/2	DAMPING RATIO	FREQUENCY (D)	FREQUENCY (N)
1.00000E 00	S**22	-1.46728E 02	-8.51647E 01				
7.19850E 02	S**21	-1.46728E 02	8.51647E 01	4.72402E-03	8.64871E-01	1.35544E 01	2.70011E 01
2.48547E 05	S**20	-1.52579E 02	-6.61686E 01				
5.58372E 07	S**19	-1.52579E 02	6.61686E 01	4.54286E-03	9.17444E-01	1.05311E 01	2.64689E 01
9.51513E 09	S**18	9.10767E 00	-1.24693E 02				
1.30187E 12	S**17	9.10767E 00	1.24693E 02	-7.61059E-02	-7.28469E-02	1.98454E 01	1.98983E 01
1.42873E 14	S**16	-2.73589E 00	-7.53433E 01				
1.25911E 16	S**15	-2.73589E 00	7.53433E 01	2.53353E-01	3.62884E-02	1.19913E 01	1.19992E 01
9.19479E 17	S**14	-6.32487E 00	-5.44711E 01				
5.40182E 19	S**13	-6.32487E 00	5.44711E 01	1.09591E-01	1.15339E-01	8.66934E 00	8.72759E 00
2.54711E 21	S**12	-1.75368E 01	-1.75723E 01				
9.55704E 22	S**11	-1.75368E 01	1.75723E 01	3.95252E-02	7.06393E-01	2.79671E 00	3.95116E 00
2.68585E 24	S**10	-3.99986E 01	0.0	1.73293E-02			
5.38338E 25	S** 9	-2.03841E 00	-1.32804E 01				
7.57405E 26	S** 8	-2.03841E 00	1.32804E 01	3.40042E-01	1.51714E-01	2.11363E 00	2.13839E 00
7.32500E 27	S** 7	-1.69910E 00	0.0	4.07949E-01			
5.13227E 28	S** 6	3.17624E-02	-4.08555E-01				
8.88454E 28	S** 5	3.17624E-02	4.08555E-01	-2.18229E 01	-7.75093E-02	6.50236E-02	6.52198E-02
4.13164E 28	S** 4	-1.98767E-01	0.0	3.48724E 00			
1.73158E 28	S** 3	-3.44088E-01	0.0	2.01445E 00			
6.17616E 27	S** 2	-2.44432E-03	0.0	2.83575E 02			
7.53840E 26	S** 1	-4.00000E 01	0.0	1.73287E-02			
1.80597E 24	S** 0						

Figure 3-5. Program sample output (Continued)

STEP RESPONSE DEP VAR 5 / INDEP VAR 2 FOR A STEP SIZE OF 9.999996E-02 INTEG. INT. IS 5.000003E-03

ROLL DUE TO LATERAL STICK STEP

TIME	POSITION	RATE	ACCELERATION
2.000001E-02	2.452147E-06	5.080563E-04	7.709253E-02
4.000002E-02	3.963975E-05	3.885369E-03	2.783747E-01
6.000003E-02	1.890668E-04	1.180184E-02	4.984464E-01
8.000004E-02	5.332797E-04	2.295455E-02	6.020201E-01
1.000000E-01	1.118639E-03	3.593107E-02	7.072755E-01
1.200001E-01	1.988188E-03	5.147505E-02	8.396534E-01
1.400000E-01	3.189996E-03	6.883132E-02	8.785021E-01
1.600001E-01	4.741713E-03	8.632195E-02	8.733425E-01
1.800001E-01	6.643586E-03	1.039048E-01	8.826693E-01
2.000001E-01	8.896459E-03	1.212320E-01	8.372694E-01
2.200001E-01	1.148263E-02	1.370884E-01	7.479498E-01
2.400001E-01	1.436859E-02	1.512536E-01	6.697365E-01
2.600001E-01	1.752171E-02	1.637401E-01	5.728959E-01
2.800002E-01	2.090325E-02	1.740250E-01	4.566354E-01
3.000001E-01	2.446833E-02	1.821688E-01	3.616922E-01
3.200002E-01	2.817823E-02	1.885251E-01	2.720996E-01
3.400002E-01	3.199675E-02	1.930137E-01	1.787843E-01
3.600002E-01	3.588776E-02	1.958737E-01	1.129574E-01
3.800002E-01	3.982454E-02	1.976696E-01	6.736881E-02
4.000002E-01	4.378819E-02	1.985569E-01	2.226743E-02
4.200002E-01	4.776140E-02	1.986809E-01	-5.347561E-03
4.400002E-01	5.173314E-02	1.984862E-01	-1.238843E-02
4.600002E-01	5.569995E-02	1.981879E-01	-1.763439E-02
4.800003E-01	5.965971E-02	1.978027E-01	-1.922921E-02
5.000002E-01	6.361187E-02	1.974774E-01	-1.255404E-02
5.200003E-01	6.755918E-02	1.972864E-01	-7.245645E-03
5.400003E-01	7.150340E-02	1.971659E-01	-4.783049E-03
5.600003E-01	7.544571E-02	1.970888E-01	-3.380732E-03
5.800003E-01	7.938635E-02	1.969805E-01	-8.767612E-03
6.000003E-01	8.332342E-02	1.966984E-01	-1.969228E-02
6.200003E-01	8.725244E-02	1.961871E-01	-3.177948E-02
6.400003E-01	9.116870E-02	1.953879E-01	-4.945356E-02
6.600003E-01	9.506494E-02	1.941644E-01	-7.327163E-02
6.800004E-01	9.893161E-02	1.924618E-01	-9.645921E-02
7.000003E-01	1.027601E-01	1.903126E-01	-1.186064E-01
7.200004E-01	1.065410E-01	1.877040E-01	-1.423808E-01
7.400004E-01	1.102648E-01	1.846274E-01	-1.646252E-01
7.600004E-01	1.139231E-01	1.811498E-01	-1.824124E-01
7.800004E-01	1.175085E-01	1.773559E-01	-1.963969E-01
8.000004E-01	1.210157E-01	1.733190E-01	-2.066810E-01
8.200004E-01	1.244403E-01	1.691160E-01	-2.130123E-01
8.400005E-01	1.277796E-01	1.648241E-01	-2.154194E-01
8.600004E-01	1.310329E-01	1.605289E-01	-2.133629E-01
8.800005E-01	1.342012E-01	1.563122E-01	-2.079383E-01
9.000005E-01	1.372860E-01	1.522180E-01	-2.013394E-01
9.200005E-01	1.402904E-01	1.482673E-01	-1.933685E-01
9.400005E-01	1.432172E-01	1.444952E-01	-1.835479E-01
9.600005E-01	1.460705E-01	1.409229E-01	-1.738092E-01
9.800005E-01	1.488544E-01	1.375293E-01	-1.657584E-01

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Figure 3-5. Program sample output (Continued)

1.000000E 00	1.515720E-01	1.342847E-01	-1.587498E-01
1.020000E 00	1.542253E-01	1.309656E-01	-1.964727E-01
1.040000E 00	1.567955E-01	1.255292E-01	-3.664339E-01
1.060000E 00	1.592165E-01	1.158267E-01	-5.986114E-01
1.080000E 00	1.614023E-01	1.023597E-01	-7.271920E-01
1.100000E 00	1.632981E-01	8.699095E-02	-8.181024E-01
1.120000E 00	1.648650E-01	6.924844E-02	-9.561675E-01
1.140000E 00	1.660519E-01	4.926518E-02	-1.022755E 00
1.160000E 00	1.668320E-01	2.883692E-02	-1.018360E 00
1.180000E 00	1.672043E-01	8.382425E-03	-1.028538E 00
1.200000E 00	1.671665E-01	-1.203718E-02	-1.000583E 00
1.220000E 00	1.667312E-01	-3.121561E-02	-9.131355E-01
1.240000E 00	1.659300E-01	-4.861656E-02	-8.296109E-01
1.260000E 00	1.647972E-01	-6.433731E-02	-7.368383E-01
1.280001E 00	1.633711E-01	-7.787335E-02	-6.152158E-01
1.300000E 00	1.616982E-01	-8.905232E-02	-5.074259E-01
1.320001E 00	1.598222E-01	-9.826040E-02	-4.124885E-01
1.340000E 00	1.577809E-01	-1.054798E-01	-3.095744E-01
1.360001E 00	1.556152E-01	-1.107849E-01	-2.268014E-01
1.380000E 00	1.533574E-01	-1.147401E-01	-1.707910E-01
1.400001E 00	1.510314E-01	-1.176205E-01	-1.173067E-01
1.420000E 00	1.486583E-01	-1.195143E-01	-7.622844E-02
1.440001E 00	1.462533E-01	-1.208369E-01	-5.909675E-02
1.460000E 00	1.438248E-01	-1.219160E-01	-4.644685E-02
1.480000E 00	1.413767E-01	-1.227897E-01	-4.029000E-02
1.500000E 00	1.389122E-01	-1.235978E-01	-4.192786E-02
1.520000E 00	1.364309E-01	-1.244766E-01	-4.535446E-02
1.540000E 00	1.339317E-01	-1.253898E-01	-4.591592E-02
1.560000E 00	1.314142E-01	-1.263171E-01	-4.669381E-02
1.580000E 00	1.288784E-01	-1.272226E-01	-4.257891E-02
1.600000E 00	1.263257E-01	-1.279714E-01	-3.171429E-02
1.620001E 00	1.237603E-01	-1.284832E-01	-1.940670E-02
1.640000E 00	1.211872E-01	-1.287203E-01	-3.096163E-03
1.660001E 00	1.186132E-01	-1.285557E-01	2.041364E-02
1.680000E 00	1.160473E-01	-1.278955E-01	4.525490E-02
1.700001E 00	1.134993E-01	-1.267547E-01	6.880385E-02
1.720000E 00	1.109787E-01	-1.251295E-01	9.400821E-02
1.740001E 00	1.084960E-01	-1.229938E-01	1.190614E-01
1.760000E 00	1.060608E-01	-1.203912E-01	1.403872E-01
1.780001E 00	1.036816E-01	-1.174024E-01	1.579280E-01
1.800000E 00	1.013659E-01	-1.140969E-01	1.718779E-01
1.820001E 00	9.911865E-02	-1.105542E-01	1.817338E-01
1.840000E 00	9.694421E-02	-1.068531E-01	1.876407E-01
1.860001E 00	9.484476E-02	-1.030774E-01	1.890265E-01
1.880000E 00	9.282076E-02	-9.931952E-02	1.861508E-01
1.900001E 00	9.087133E-02	-9.564334E-02	1.811921E-01
1.920001E 00	8.899438E-02	-9.208018E-02	1.747160E-01
1.940001E 00	8.718699E-02	-8.867031E-02	1.658878E-01
1.960001E 00	8.544606E-02	-8.545113E-02	1.560557E-01
1.980000E 00	8.376741E-02	-8.241957E-02	1.472647E-01
2.000001E 00	8.214796E-02	-7.955289E-02	1.394273E-01

STEP DURATION = 0.100E 01

'SCALE'= 0.202E 02

Figure 3-5. Program sample output (Continued)

NUMERATOR DEP VAR 3 / INDEP VAR 1

PITCH RESPONSE TO LONG. STICK
LEADING COEFFICIENT = 1.426716E 01

POLY		REAL	IMAG	TIME TO 1/2	DAMPING RATIO	FREQUENCY (D)	FREQUENCY (N)
1.00000E 00	S**22	-1.54230E 02	-6.54129E 01				
7.16446E 02	S**21	-1.54230E 02	6.54129E 01	4.49423E-03	9.20621E-01	1.04108E 01	2.66630E 01
2.44889E 05	S**20	-1.46732E 02	-8.51721E 01				
5.43141E 07	S**19	-1.46732E 02	8.51721E 01	4.72391E-03	8.64858E-01	1.35556E 01	2.70022E 01
9.16394E 09	S**18	1.26965E 01	-1.22295E 02				
1.24989E 12	S**17	1.26965E 01	1.22295E 02	-5.45935E-02	-1.03264E-01	1.94639E 01	1.95685E 01
1.37367E 14	S**16	-2.76517E 00	-7.53761E 01				
1.21459E 16	S**15	-2.76517E 00	7.53761E 01	2.50670E-01	3.66604E-02	1.19965E 01	1.20045E 01
8.92582E 17	S**14	-6.32651E 00	-5.44766E 01				
5.28694E 19	S**13	-6.32651E 00	5.44766E 01	1.09562E-01	1.15357E-01	8.67022E 00	8.72849E 00
2.51979E 21	S**12	-3.99987E 01	0.0	1.73292E-02			
9.59283E 22	S**11	-1.66079E 01	-1.81269E 01				
2.75471E 24	S**10	-1.66079E 01	1.81269E 01	4.17359E-02	6.75539E-01	2.88498E 00	3.91277E 00
5.72455E 25	S** 9	-1.90952E 00	-1.37289E 01				
8.52095E 26	S** 8	-1.90952E 00	1.37289E 01	3.62996E-01	1.37761E-01	2.18503E 00	2.20606E 00
8.88349E 27	S** 7	-4.18478E 00	0.0	1.65635E-01			
6.77376E 28	S** 6	-4.70321E-02	-4.87055E-01				
1.97786E 29	S** 5	-4.70321E-02	4.87055E-01	1.47377E 01	9.61173E-02	7.75172E-02	7.78777E-02
1.04888E 29	S** 4	1.40607E-02	0.0	-4.92969E 01			
5.90253E 28	S** 3	-2.17439E-01	-4.58973E-02				
1.75681E 28	S** 2	-2.17439E-01	4.58973E-02	3.18778E 00	9.78440E-01	7.30478E-03	3.53691E-02
1.66230E 27	S** 1	-4.00000E 01	0.0	1.73287E-02			
-2.70146E 25	S** 0						

Figure 3-5. Program sample output (Continued)

FREQUENCY RESPONSE

DEP VAR 3 / INDEP VAR 1
PITCH RESPONSE TO LONG. STICK

FREQ (RPS)	GAIN	GAIN (DB)	PHASE (DEG)	FREQ (RPS)	GAIN	GAIN (DB)	PHASE (DEG)
1.00000E-01	1.26340E 00	2.03081E 00	9.33712E 01	2.89823E-01	8.21827E 00	1.82956E 01	8.28432E 01
1.03000E-01	1.30600E 00	2.31889E 00	9.30231E 01	2.98518E-01	9.26010E 00	1.93323E 01	8.29965E 01
1.06090E-01	1.35049E 00	2.60983E 00	9.26792E 01	3.07473E-01	1.05809E 01	2.04904E 01	8.34200E 01
1.09273E-01	1.39698E 00	2.90382E 00	9.23394E 01	3.16697E-01	1.23055E 01	2.18020E 01	8.42908E 01
1.12551E-01	1.44562E 00	3.20110E 00	9.20034E 01	3.26198E-01	1.46414E 01	2.33117E 01	8.59306E 01
1.15927E-01	1.49656E 00	3.50188E 00	9.16711E 01	3.35984E-01	1.79466E 01	2.50796E 01	8.89637E 01
1.19405E-01	1.54996E 00	3.80639E 00	9.13422E 01	3.46063E-01	2.28357E 01	2.71723E 01	9.46925E 01
1.22987E-01	1.60600E 00	4.11491E 00	9.10168E 01	3.56445E-01	3.00934E 01	2.95694E 01	1.05945E 02
1.26676E-01	1.66490E 00	4.42774E 00	9.06944E 01	3.67138E-01	3.83570E 01	3.16769E 01	1.27624E 02
1.30477E-01	1.72687E 00	4.74520E 00	9.03748E 01	3.78152E-01	3.81427E 01	3.16282E 01	1.58239E 02
1.34391E-01	1.79219E 00	5.06767E 00	9.00579E 01	3.89497E-01	2.85538E 01	2.91133E 01	-1.76479E 02
1.38423E-01	1.86113E 00	5.39552E 00	8.97434E 01	4.01181E-01	1.99631E 01	2.60045E 01	-1.66648E 02
1.42575E-01	1.93401E 00	5.72918E 00	8.94312E 01	4.13217E-01	1.41745E 01	2.30302E 01	-1.61097E 02
1.46852E-01	2.01121E 00	6.06913E 00	8.91208E 01	4.25613E-01	1.02389E 01	2.02051E 01	-1.58182E 02
1.51258E-01	2.09312E 00	6.41588E 00	8.88122E 01	4.38381E-01	7.44964E 00	1.74427E 01	-1.55721E 02
1.55796E-01	2.18022E 00	6.77001E 00	8.85050E 01	4.51533E-01	5.43959E 00	1.47113E 01	-1.52053E 02
1.60469E-01	2.27305E 00	7.13218E 00	8.81990E 01	4.65078E-01	4.02688E 00	1.20994E 01	-1.45766E 02
1.65283E-01	2.37220E 00	7.50303E 00	8.78940E 01	4.79031E-01	3.11055E 00	9.85675E 00	-1.36170E 02
1.70242E-01	2.47839E 00	7.88339E 00	8.75896E 01	4.93401E-01	2.60021E 00	8.30017E 00	-1.24305E 02
1.75349E-01	2.59242E 00	8.27409E 00	8.72855E 01	5.08203E-01	2.37684E 00	7.52000E 00	-1.12652E 02
1.80609E-01	2.71522E 00	8.67610E 00	8.69816E 01	5.23449E-01	2.31152E 00	7.27795E 00	-1.03907E 02
1.86028E-01	2.84790E 00	9.09049E 00	8.66773E 01	5.39153E-01	2.30923E 00	7.26933E 00	-9.77905E 01
1.91608E-01	2.99174E 00	9.51848E 00	8.63729E 01	5.55327E-01	2.31955E 00	7.30808E 00	-9.38833E 01
1.97356E-01	3.14827E 00	9.96144E 00	8.60679E 01	5.71986E-01	2.32193E 00	7.31698E 00	-9.14789E 01
2.03277E-01	3.31929E 00	1.04209E 01	8.57625E 01	5.89146E-01	2.31052E 00	7.27421E 00	-9.00496E 01
2.09375E-01	3.50698E 00	1.08987E 01	8.54566E 01	6.06820E-01	2.28563E 00	7.18014E 00	-8.92471E 01
2.15656E-01	3.71393E 00	1.13967E 01	8.51508E 01	6.25024E-01	2.24964E 00	7.04228E 00	-8.88495E 01
2.22126E-01	3.94336E 00	1.19173E 01	8.48457E 01	6.43775E-01	2.20528E 00	6.86929E 00	-8.87164E 01
2.28790E-01	4.19918E 00	1.24633E 01	8.45425E 01	6.63088E-01	2.15502E 00	6.66902E 00	-8.87579E 01
2.35653E-01	4.48630E 00	1.30378E 01	8.42431E 01	6.82981E-01	2.10089E 00	6.44806E 00	-8.89159E 01
2.42723E-01	4.81087E 00	1.36445E 01	8.39505E 01	7.03470E-01	2.04448E 00	6.21167E 00	-8.91526E 01
2.50004E-01	5.18076E 00	1.42879E 01	8.36691E 01	7.24574E-01	1.98700E 00	5.96395E 00	-8.94434E 01
2.57504E-01	5.60619E 00	1.49734E 01	8.34059E 01	7.46311E-01	1.92934E 00	5.70815E 00	-8.97712E 01
2.65230E-01	6.10067E 00	1.57075E 01	8.31711E 01	7.68700E-01	1.87213E 00	5.44672E 00	-9.01253E 01
2.73186E-01	6.68237E 00	1.64986E 01	8.29806E 01	7.91760E-01	1.81585E 00	5.18161E 00	-9.04980E 01
2.81382E-01	7.37637E 00	1.73568E 01	8.28585E 01	8.15513E-01	1.76084E 00	4.91439E 00	-9.08846E 01

Figure 3-5. Program sample output (Continued)

FREQUENCY RESPONSE

DEP VAR 3 / INDEP VAR 1
PITCH RESPONSE TO LONG. STICK

FREQ (RPS)	GAIN	GAIN (DB)	PHASE (DEG)
8.39978E-01	1.70729E 00	4.64613E 00	-9.12825E 01
8.65177E-01	1.65535E 00	4.37780E 00	-9.16695E 01
8.91132E-01	1.60512E 00	4.11013E 00	-9.21048E 01
9.17866E-01	1.55663E 00	3.84368E 00	-9.25280E 01
9.45402E-01	1.50988E 00	3.57887E 00	-9.29592E 01
9.73764E-01	1.46488E 00	3.31606E 00	-9.33990E 01
1.00298E 00	1.42160E 00	3.05557E 00	-9.38479E 01
1.03306E 00	1.37999E 00	2.79750E 00	-9.43072E 01
1.06406E 00	1.34000E 00	2.54207E 00	-9.47778E 01
1.09598E 00	1.30159E 00	2.28948E 00	-9.52607E 01
1.12885E 00	1.26470E 00	2.03974E 00	-9.57578E 01
1.16272E 00	1.22928E 00	1.79301E 00	-9.62702E 01
1.19760E 00	1.19527E 00	1.54932E 00	-9.68000E 01
1.23353E 00	1.16260E 00	1.30862E 00	-9.73488E 01
1.27053E 00	1.13123E 00	1.07100E 00	-9.79183E 01
1.30865E 00	1.10109E 00	8.36490E-01	-9.85104E 01
1.34791E 00	1.07215E 00	6.05082E-01	-9.91276E 01
1.38834E 00	1.04433E 00	3.76736E-01	-9.97721E 01
1.42999E 00	1.01758E 00	1.51396E-01	-1.00446E 02
1.47289E 00	9.91866E-01	-7.09369E-02	-1.01153E 02
1.51708E 00	9.67108E-01	-2.90497E-01	-1.01894E 02
1.56259E 00	9.43266E-01	-5.07318E-01	-1.02674E 02
1.60947E 00	9.20288E-01	-7.21521E-01	-1.03495E 02
1.65775E 00	8.98121E-01	-9.33301E-01	-1.04359E 02
1.70748E 00	8.76715E-01	-1.14283E 00	-1.05272E 02
1.75870E 00	8.56010E-01	-1.35043E 00	-1.06236E 02
1.81146E 00	8.35946E-01	-1.55644E 00	-1.07255E 02
1.86581E 00	8.16470E-01	-1.76120E 00	-1.08332E 02
1.92178E 00	7.97517E-01	-1.96520E 00	-1.09473E 02
1.97943E 00	7.79027E-01	-2.16895E 00	-1.10679E 02
2.03882E 00	7.60934E-01	-2.37306E 00	-1.11957E 02
2.09998E 00	7.43166E-01	-2.57828E 00	-1.13308E 02
2.16298E 00	7.25658E-01	-2.78537E 00	-1.14738E 02
2.22787E 00	7.08329E-01	-2.99530E 00	-1.16248E 02
2.29470E 00	6.91108E-01	-3.20908E 00	-1.17843E 02
2.36354E 00	6.73917E-01	-3.42787E 00	-1.19524E 02

FREQ (RPS)	GAIN	GAIN (DB)	PHASE (DFG)
2.43445E 00	6.56678E-01	-3.65295E 00	-1.21292E 02
2.50748E 00	6.39315E-01	-3.88571E 00	-1.23149E 02
2.58270E 00	6.21756E-01	-4.12760E 00	-1.25094E 02
2.66018E 00	6.03945E-01	-4.38005E 00	-1.27125E 02
2.73999E 00	5.85826E-01	-4.64463E 00	-1.29239E 02
2.82218E 00	5.67358E-01	-4.92286E 00	-1.31430E 02
2.90685E 00	5.48515E-01	-5.21624E 00	-1.33693E 02
2.99405E 00	5.29290E-01	-5.52613E 00	-1.36018E 02
3.08387E 00	5.09700E-01	-5.85370E 00	-1.38396E 02
3.17639E 00	4.89781E-01	-6.19996E 00	-1.40816E 02
3.27168E 00	4.69591E-01	-6.56560E 00	-1.43265E 02
3.36983E 00	4.49208E-01	-6.95104E 00	-1.45729E 02
3.47092E 00	4.28728E-01	-7.35636E 00	-1.48196E 02
3.57505E 00	4.08259E-01	-7.78128E 00	-1.50651E 02
3.68230E 00	3.87921E-01	-8.22514E 00	-1.53080E 02
3.79276E 00	3.67824E-01	-8.68718E 00	-1.55473E 02
3.90654E 00	3.48090E-01	-9.16616E 00	-1.57817E 02
4.02374E 00	3.28827E-01	-9.66065E 00	-1.60103E 02
4.14445E 00	3.10129E-01	-1.01692E 01	-1.62324E 02
4.26878E 00	2.92081E-01	-1.06899E 01	-1.64472E 02
4.39684E 00	2.74751E-01	-1.12212E 01	-1.66545E 02
4.52875E 00	2.58185E-01	-1.17614E 01	-1.68539E 02
4.66461E 00	2.42421E-01	-1.23086E 01	-1.70454E 02
4.80454E 00	2.27479E-01	-1.28612E 01	-1.72289E 02
4.94868E 00	2.13362E-01	-1.34176E 01	-1.74048E 02
5.09714E 00	2.00067E-01	-1.39765E 01	-1.75732E 02
5.25005E 00	1.87579E-01	-1.45363E 01	-1.77346E 02
5.40755E 00	1.75879E-01	-1.50957E 01	-1.78894E 02
5.56977E 00	1.64934E-01	-1.56538E 01	1.79618E 02
5.73686E 00	1.54715E-01	-1.62093E 01	1.78186E 02
5.90897E 00	1.45187E-01	-1.67615E 01	1.76802E 02
6.08624E 00	1.36312E-01	-1.73093E 01	1.75460E 02
6.26882E 00	1.28055E-01	-1.78521E 01	1.74153E 02
6.45688E 00	1.20377E-01	-1.83891E 01	1.72875E 02
6.65059E 00	1.13242E-01	-1.89198E 01	1.71617E 02
6.85010E 00	1.06615E-01	-1.94436E 01	1.70373E 02

Figure 3-5. Program sample output (Continued)

FREQUENCY RESPONSE

DEP VAR 3 / INDEP VAR 1
PITCH RESPONSE TO LONG. STICK

FREQ (RPS)	GAIN	GAIN (DB)	PHASE (DEG)	FREQ (RPS)	GAIN	GAIN (DB)	PHASE (DEG)
7.05560E 00	1.00460E-01	-1.99601E 01	1.69133E 02	2.04488E 01	6.21491E-03	-4.41313E 01	7.48572E 01
7.26727E 00	9.47463E-02	-2.04688E 01	1.67891E 02	2.10623E 01	5.49081E-03	-4.52073E 01	7.37867E 01
7.48528E 00	8.94411E-02	-2.09692E 01	1.66637E 02	2.16941E 01	4.85925E-03	-4.62686E 01	7.29106E 01
7.70984E 00	8.45156E-02	-2.14612E 01	1.65361E 02	2.23449E 01	4.30851E-03	-4.73134E 01	7.22066E 01
7.94113E 00	7.99416E-02	-2.19445E 01	1.64055E 02	2.30153E 01	3.82816E-03	-4.83402E 01	7.16524E 01
8.17937E 00	7.56927E-02	-2.24189E 01	1.62707E 02	2.37057E 01	3.40886E-03	-4.93478E 01	7.12269E 01
8.42474E 00	7.17434E-02	-2.28844E 01	1.61307E 02	2.44169E 01	3.04243E-03	-5.03356E 01	7.09098E 01
8.67748E 00	6.80699E-02	-2.33409E 01	1.59841E 02	2.51494E 01	2.72171E-03	-5.13032E 01	7.06814E 01
8.93781E 00	6.46493E-02	-2.37887E 01	1.58298E 02	2.59038E 01	2.44049E-03	-5.22505E 01	7.05238E 01
9.20594E 00	6.14608E-02	-2.42260E 01	1.56662E 02	2.66809E 01	2.19340E-03	-5.31777E 01	7.04195E 01
9.48211E 00	5.84821E-02	-2.46595E 01	1.54918E 02	2.74814E 01	1.97581E-03	-5.40851E 01	7.03530E 01
9.76657E 00	5.56930E-02	-2.50840E 01	1.53050E 02	2.83058E 01	1.78377E-03	-5.49732E 01	7.03100E 01
1.00596E 01	5.30729E-02	-2.55025E 01	1.51040E 02	2.91549E 01	1.61383E-03	-5.58428E 01	7.02768E 01
1.03614E 01	5.06014E-02	-2.59167E 01	1.48867E 02	3.00296E 01	1.46307E-03	-5.66947E 01	7.02412E 01
1.06722E 01	4.82579E-02	-2.63286E 01	1.46513E 02	3.09305E 01	1.32896E-03	-5.75297E 01	7.01929E 01
1.09923E 01	4.60222E-02	-2.67406E 01	1.43955E 02	3.18584E 01	1.20937E-03	-5.83488E 01	7.01219E 01
1.13221E 01	4.38726E-02	-2.71561E 01	1.41170E 02	3.28141E 01	1.10244E-03	-5.91529E 01	7.00194E 01
1.16618E 01	4.17872E-02	-2.75791E 01	1.38133E 02	3.37985E 01	1.00657E-03	-5.99431E 01	6.98799E 01
1.20116E 01	3.97425E-02	-2.80149E 01	1.34814E 02	3.48124E 01	9.20425E-04	-6.07202E 01	6.96954E 01
1.23720E 01	3.77100E-02	-2.84709E 01	1.31181E 02	3.58568E 01	8.42817E-04	-6.14853E 01	6.94612E 01
1.27431E 01	3.56505E-02	-2.89587E 01	1.27199E 02	3.69325E 01	7.72749E-04	-6.22392E 01	6.91723E 01
1.31254E 01	3.35099E-02	-2.94965E 01	1.22853E 02	3.80404E 01	7.09343E-04	-6.29829E 01	6.88254E 01
1.35192E 01	3.12274E-02	-3.01093E 01	1.18194E 02	3.91816E 01	6.51857E-04	-6.37169E 01	6.84172E 01
1.39247E 01	2.87813E-02	-3.08178E 01	1.13389E 02	4.03570E 01	5.99629E-04	-6.44423E 01	6.79449E 01
1.43425E 01	2.62309E-02	-3.16237E 01	1.08675E 02	4.15677E 01	5.52112E-04	-6.51594E 01	6.74064E 01
1.47728E 01	2.36910E-02	-3.25083E 01	1.04223E 02	4.28147E 01	5.08808E-04	-6.58689E 01	6.68001E 01
1.52159E 01	2.12588E-02	-3.34492E 01	1.00086E 02	4.40992E 01	4.69292E-04	-6.65711E 01	6.61243E 01
1.56724E 01	1.89847E-02	-3.44319E 01	9.62557E 01	4.54221E 01	4.33193E-04	-6.72664E 01	6.53779E 01
1.61426E 01	1.68878E-02	-3.54485E 01	9.27178E 01	4.67848E 01	4.00176E-04	-6.79550E 01	6.45592E 01
1.66268E 01	1.49732E-02	-3.64937E 01	8.94714E 01	4.81883E 01	3.69953E-04	-6.86371E 01	6.36673E 01
1.71256E 01	1.32405E-02	-3.75619E 01	8.65212E 01	4.96339E 01	3.42271E-04	-6.93126E 01	6.27009E 01
1.76394E 01	1.16852E-02	-3.86472E 01	8.38708E 01	5.11229E 01	3.16901E-04	-6.99815E 01	6.16590E 01
1.81686E 01	1.02995E-02	-3.97436E 01	8.15187E 01	5.26566E 01	2.93639E-04	-7.06437E 01	6.05407E 01
1.87136E 01	9.07274E-03	-4.08452E 01	7.94566E 01	5.42363E 01	2.72306E-04	-7.12988E 01	5.93475E 01
1.92750E 01	7.99218E-03	-4.19467E 01	7.76711E 01	5.58633E 01	2.52755E-04	-7.19460E 01	5.80821E 01
1.98532E 01	7.04420E-03	-4.30434E 01	7.61447E 01	5.75392E 01	2.34858E-04	-7.25839E 01	5.67459E 01

Figure 3-5. Program sample output (Continued)

FREQUENCY RESPONSE

DEP VAR 3 / INDEP VAR 1
PITCH RESPONSE TO LONG. STICK

FREQ (RPS)	GAIN	GAIN (DB)	PHASE (DEG)	FREQ (RPS)	GAIN	GAIN (DB)	PHASE (DEG)
5.92653E 01	2.18502E-04	-7.32109E 01	5.53409E 01	1.71765E 02	2.82140E-06	-1.10991E 02	3.22141E 01
6.10433E 01	2.03586E-04	-7.38250E 01	5.38728E 01	1.76918E 02	2.57989E-06	-1.11768E 02	2.82768E 01
6.28745E 01	1.90029E-04	-7.44236E 01	5.23546E 01	1.82226E 02	2.34926E-06	-1.12581E 02	2.45462E 01
6.47608E 01	1.77786E-04	-7.50020E 01	5.08157E 01	1.87692E 02	2.13112E-06	-1.13428E 02	2.09866E 01
6.67036E 01	1.66878E-04	-7.55520E 01	4.93168E 01	1.93323E 02	1.92647E-06	-1.14305E 02	1.75718E 01
6.87046E 01	1.57519E-04	-7.60534E 01	4.79889E 01	1.99123E 02	1.73585E-06	-1.15210E 02	1.42827E 01
7.07657E 01	1.50581E-04	-7.64446E 01	4.71012E 01	2.05096E 02	1.55938E-06	-1.16141E 02	1.11046E 01
7.28887E 01	1.49839E-04	-7.64875E 01	4.68404E 01	2.11249E 02	1.39692E-06	-1.17097E 02	8.02651E 00
7.50753E 01	1.64792E-04	-7.56613E 01	4.22517E 01	2.17587E 02	1.24810E-06	-1.18075E 02	5.04084E 00
7.73275E 01	1.56549E-04	-7.61070E 01	2.84997E 01	2.24114E 02	1.11239E-06	-1.19075E 02	2.14144E 00
7.96473E 01	1.38111E-04	-7.71954E 01	2.26992E 01	2.30838E 02	9.89150E-07	-1.20095E 02	-6.75989E-01
8.20367E 01	1.29232E-04	-7.77726E 01	1.84950E 01	2.37763E 02	8.77657E-07	-1.21133E 02	-3.41478E 00
8.44978E 01	1.25181E-04	-7.80492E 01	1.33143E 01	2.44895E 02	7.77154E-07	-1.22190E 02	-6.07706E 00
8.70327E 01	1.24322E-04	-7.81090E 01	6.48009E 00	2.52242E 02	6.86849E-07	-1.23263E 02	-8.66503E 00
8.96436E 01	1.26307E-04	-7.79714E 01	-2.82168E 00	2.59809E 02	6.05951E-07	-1.24351E 02	-1.11805E 01
9.23329E 01	1.30607E-04	-7.76807E 01	-1.60380E 01	2.67604E 02	5.33688E-07	-1.25454E 02	-1.36244E 01
9.51029E 01	1.33803E-04	-7.74707E 01	-3.54410E 01	2.75631E 02	4.69311E-07	-1.26571E 02	-1.59977E 01
9.79559E 01	1.25091E-04	-7.80555E 01	-6.24241E 01	2.83900E 02	4.12100E-07	-1.27700E 02	-1.83016E 01
1.00895E 02	9.67330E-05	-8.02885E 01	-9.23277E 01	2.92417E 02	3.61375E-07	-1.28841E 02	-2.05371E 01
1.03921E 02	6.42535E-05	-8.38421E 01	-1.17591E 02	3.01189E 02	3.16496E-07	-1.29993E 02	-2.27054E 01
1.07039E 02	4.07402E-05	-8.77995E 01	-1.37260E 02	3.10225E 02	2.76866E-07	-1.31155E 02	-2.48076E 01
1.10250E 02	2.59782E-05	-9.17078E 01	-1.54016E 02	3.19531E 02	2.41937E-07	-1.32326E 02	-2.68448E 01
1.13558E 02	1.69490E-05	-9.54171E 01	-1.70315E 02	3.29117E 02	2.11203E-07	-1.33506E 02	-2.88185E 01
1.16964E 02	1.14752E-05	-9.88048E 01	1.72174E 02	3.38990E 02	1.84203E-07	-1.34694E 02	-3.07301E 01
1.20473E 02	8.25392E-06	-1.01667E 02	1.52800E 02	3.49160E 02	1.60519E-07	-1.35889E 02	-3.25810E 01
1.24087E 02	6.46904E-06	-1.03783E 02	1.32473E 02	3.59634E 02	1.39768E-07	-1.37092E 02	-3.43727E 01
1.27810E 02	5.54260E-06	-1.05126E 02	1.13332E 02	3.70423E 02	1.21613E-07	-1.38300E 02	-3.61066E 01
1.31644E 02	5.06021E-06	-1.05917E 02	9.70421E 01	3.81536E 02	1.05745E-07	-1.39515E 02	-3.77845E 01
1.35593E 02	4.76758E-06	-1.06434E 02	8.38885E 01	3.92981E 02	9.18907E-08	-1.40734E 02	-3.94078E 01
1.39661E 02	4.53665E-06	-1.06865E 02	7.33428E 01	4.04771E 02	7.98065E-08	-1.41959E 02	-4.09783E 01
1.43851E 02	4.31376E-06	-1.07303E 02	6.47375E 01	4.16914E 02	6.92764E-08	-1.43188E 02	-4.24971E 01
1.48167E 02	4.08124E-06	-1.07784E 02	5.75278E 01	4.29421E 02	6.01064E-08	-1.44421E 02	-4.39666E 01
1.52611E 02	3.83667E-06	-1.08321E 02	5.13219E 01	4.42303E 02	5.21271E-08	-1.45659E 02	-4.53680E 01
1.57190E 02	3.58356E-06	-1.08914E 02	4.58486E 01	4.55572E 02	4.51692E-06	-1.46699E 02	-4.67632E 01
1.61905E 02	3.32688E-06	-1.09559E 02	4.09204E 01	4.69239E 02	3.91598E-08	-1.48143E 02	-4.80931E 01
1.66762E 02	3.07147E-06	-1.10253E 02	3.64064E 01	4.83316E 02	3.39233E-08	-1.49390E 02	-4.93797E 01

Figure 3-5. Program sample output (Continued)

NUMERATOR DEP VAR 6 / INDEP VAR 4

YAW RESPONSE TO RUDDER INPUT
LEADING COEFFICIENT = 2.840064E-04

POLY		REAL	IMAG	TIME TO 1/2	DAMPING RATIO	FREQUENCY (D)	FREQUENCY (N)
1.00000E 00	S**26	-1.46843E 02	-1.29570E 02				
1.04811E 03	S**25	-1.46843E 02	1.29570E 02	4.72032E-03	7.49832E-01	2.06217E 01	3.11680E 01
5.26550E 05	S**24	-1.46734E 02	-8.51386E 01				
1.66746E 08	S**23	-1.46734E 02	8.51386E 01	4.72382E-03	8.64948E-01	1.35502E 01	2.69999E 01
3.73846E 10	S**22	-1.46864E 02	-4.07540E 01				
6.36506E 12	S**21	-1.46864E 02	4.07540E 01	4.71965E-03	9.63568E-01	6.48621E 00	2.42574E 01
8.63069E 14	S**20	-6.43820E 00	-9.84969E 01				
9.57709E 16	S**19	-6.43820E 00	9.84969E 01	1.07662E-01	6.52253E-02	1.56763E 01	1.57097E 01
8.79412E 18	S**18	-2.20672E 00	-7.56200E 01				
6.72660E 20	S**17	-2.20672E 00	7.56200E 01	3.14108E-01	2.91693E-02	1.20353E 01	1.20404E 01
4.30549E 22	S**16	-6.32596E 00	-5.44693E 01				
2.28051E 24	S**15	-6.32596E 00	5.44693E 01	1.09572E-01	1.15362E-01	8.66907E 00	8.72733E 00
9.89749E 25	S**14	-4.85457E 00	-1.35425E 01				
3.47248E 27	S**13	-4.85457E 00	1.35425E 01	1.42782E-01	3.37444E-01	2.15535E 00	2.28965E 00
9.48040E 28	S**12	-1.80903E 00	-1.37094E 01				
1.94829E 30	S**11	-1.80903E 00	1.37094E 01	3.83159E-01	1.30822E-01	2.18191E 00	2.20082E 00
3.07258E 31	S**10	-1.84481E 00	-2.82852E 00				
3.76214E 32	S** 9	-1.84481E 00	2.82852E 00	3.75728E-01	5.46294E-01	4.50173E-01	5.37460E-01
3.27960E 33	S** 8	1.45567E-02	-3.74410E-01				
2.19901E 34	S** 7	1.45567E-02	3.74410E-01	-4.76169E 01	-3.88498E-02	5.95892E-02	5.96342E-02
6.88682E 34	S** 6	-2.62838E-02	-4.08480E-01				
1.47613E 35	S** 5	-2.62838E-02	4.08480E-01	2.63717E 01	6.42125E-02	6.50116E-02	6.51460E-02
5.42924E 34	S** 4	-2.43645E-01	0.0	2.84490E 00			
4.40853E 34	S** 3	-4.00000E 01	0.0	1.73287E-02			
1.12034E 34	S** 2	-4.00000E 01	0.0	1.73287E-02			
3.35329E 33	S** 1	-4.00000E 01	0.0	1.73287E-02			
7.11667E 32	S** 0						

Figure 3-5. Program sample output (Continued)

FREQUENCY RESPONSE

DEP VAR 6 / INDEP VAR 4
YAW RESPONSE TO RUDDER INPUT

FREQ (RPS)	GAIN	GAIN (DB)	PHASE (DEG)	FREQ (RPS)	GAIN	GAIN (DB)	PHASE (DEG)
1.00000E-01	7.64444E 01	3.76669E 01	-3.12198E 01	2.89823E-01	3.80909E 01	3.16164E 01	-7.15631E 01
1.03000E-01	7.59021E 01	3.76051E 01	-3.20571E 01	2.98518E-01	3.61842E 01	3.11704E 01	-7.28609E 01
1.06090E-01	7.53353E 01	3.75400E 01	-3.29116E 01	3.07473E-01	3.41555E 01	3.06692E 01	-7.40806E 01
1.09273E-01	7.47438E 01	3.74715E 01	-3.37836E 01	3.16697E-01	3.19777E 01	3.00969E 01	-7.51562E 01
1.12551E-01	7.41268E 01	3.73995E 01	-3.46728E 01	3.26198E-01	2.96112E 01	2.94291E 01	-7.59747E 01
1.15927E-01	7.34837E 01	3.73238E 01	-3.55793E 01	3.35984E-01	2.69922E 01	2.86248E 01	-7.63433E 01
1.19405E-01	7.28140E 01	3.72443E 01	-3.65030E 01	3.46063E-01	2.39987E 01	2.76038E 01	-7.59564E 01
1.22987E-01	7.21174E 01	3.71608E 01	-3.74436E 01	3.56445E-01	2.03788E 01	2.61836E 01	-7.45806E 01
1.26676E-01	7.13931E 01	3.70731E 01	-3.84014E 01	3.67138E-01	1.59494E 01	2.40549E 01	-7.39378E 01
1.30477E-01	7.06407E 01	3.69811E 01	-3.93760E 01	3.78152E-01	1.25533E 01	2.19752E 01	-7.83817E 01
1.34391E-01	6.98599E 01	3.68846E 01	-4.03672E 01	3.89497E-01	1.11718E 01	2.09624E 01	-7.64456E 01
1.38423E-01	6.90505E 01	3.67833E 01	-4.13750E 01	4.01181E-01	1.01758E 01	2.01513E 01	-6.32980E 01
1.42575E-01	6.82119E 01	3.66772E 01	-4.23991E 01	4.13217E-01	1.03620E 01	2.03089E 01	-4.43490E 01
1.46852E-01	6.73441E 01	3.65660E 01	-4.34395E 01	4.25613E-01	1.23030E 01	2.18002E 01	-2.87416E 01
1.51258E-01	6.64466E 01	3.64494E 01	-4.44959E 01	4.38381E-01	1.54078E 01	2.37548E 01	-2.08765E 01
1.55796E-01	6.55192E 01	3.63274E 01	-4.55681E 01	4.51533E-01	1.88524E 01	2.55073E 01	-1.66776E 01
1.60469E-01	6.45622E 01	3.61996E 01	-4.66560E 01	4.65078E-01	2.20791E 01	2.68796E 01	-2.01984E 01
1.65283E-01	6.35747E 01	3.60657E 01	-4.77594E 01	4.79031E-01	2.47885E 01	2.78850E 01	-2.31840E 01
1.70242E-01	6.25573E 01	3.59256E 01	-4.88782E 01	4.93401E-01	2.68697E 01	2.85853E 01	-2.68785E 01
1.75349E-01	6.15093E 01	3.57788E 01	-5.00124E 01	5.08203E-01	2.83349E 01	2.90464E 01	-3.07501E 01
1.80609E-01	6.04306E 01	3.56251E 01	-5.11618E 01	5.23449E-01	2.92627E 01	2.93263E 01	-3.45181E 01
1.86028E-01	5.93212E 01	3.54642E 01	-5.23265E 01	5.39153E-01	2.97547E 01	2.94711E 01	-3.80491E 01
1.91608E-01	5.81806E 01	3.52956E 01	-5.35063E 01	5.55327E-01	2.99096E 01	2.95162E 01	-4.12927E 01
1.97356E-01	5.70084E 01	3.51188E 01	-5.47016E 01	5.71986E-01	2.98125E 01	2.94879E 01	-4.42429E 01
2.03277E-01	5.58039E 01	3.49333E 01	-5.59124E 01	5.89146E-01	2.95310E 01	2.94055E 01	-4.69156E 01
2.09375E-01	5.45667E 01	3.47385E 01	-5.71388E 01	6.06820E-01	2.91174E 01	2.92830E 01	-4.93361E 01
2.15656E-01	5.32952E 01	3.45337E 01	-5.83811E 01	6.25024E-01	2.86109E 01	2.91306E 01	-5.15316E 01
2.22126E-01	5.19885E 01	3.43181E 01	-5.96395E 01	6.43775E-01	2.80405E 01	2.89557E 01	-5.35290E 01
2.28790E-01	5.06445E 01	3.40906E 01	-6.09142E 01	6.63088E-01	2.74274E 01	2.87637E 01	-5.53525E 01
2.35653E-01	4.92612E 01	3.38501E 01	-6.22052E 01	6.82981E-01	2.67874E 01	2.85586E 01	-5.70238E 01
2.42723E-01	4.78351E 01	3.35949E 01	-6.35123E 01	7.03470E-01	2.61319E 01	2.83434E 01	-5.85615E 01
2.50004E-01	4.63629E 01	3.33234E 01	-6.48349E 01	7.24574E-01	2.54695E 01	2.81204E 01	-5.99818E 01
2.57504E-01	4.48397E 01	3.30332E 01	-6.61715E 01	7.46311E-01	2.48061E 01	2.78912E 01	-6.12985E 01
2.65230E-01	4.32597E 01	3.27216E 01	-6.75194E 01	7.68700E-01	2.41465E 01	2.76571E 01	-6.25235E 01
2.73186E-01	4.16149E 01	3.23850E 01	-6.88738E 01	7.91760E-01	2.34939E 01	2.74191E 01	-6.36667E 01
2.81382E-01	3.98960E 01	3.20186E 01	-7.02263E 01	8.15513E-01	2.28505E 01	2.71779E 01	-6.47371E 01

Figure 3-5. Program sample output (Continued)

FREQUENCY RESPONSE

DEP VAR 6 / INDEP VAR 4
YAW RESPONSE TO RUDDER INPUT

FREQ (RPS)	GAIN	GAIN (DB)	PHASE (DEG)	FREQ (RPS)	GAIN	GAIN (DB)	PHASE (DEG)
8.39978E-01	2.22183E 01	2.69342E 01	-6.57420E 01	2.43445E 00	7.69658E 00	1.77260E 01	-8.29057E 01
8.65177E-01	2.15983E 01	2.66884E 01	-6.66879E 01	2.50748E 00	7.46961E 00	1.74659E 01	-8.31226E 01
8.91132E-01	2.09916E 01	2.64409E 01	-6.75805E 01	2.58270E 00	7.24935E 00	1.72060E 01	-8.33273E 01
9.17866E-01	2.03986E 01	2.61920E 01	-6.84245E 01	2.66018E 00	7.03558E 00	1.69460E 01	-8.35226E 01
9.45402E-01	1.98196E 01	2.59419E 01	-6.92244E 01	2.73999E 00	6.82817E 00	1.66861E 01	-8.37090E 01
9.73764E-01	1.92549E 01	2.56908E 01	-6.99837E 01	2.82218E 00	6.62701E 00	1.64263E 01	-8.38866E 01
1.00298E 00	1.87045E 01	2.54389E 01	-7.07059E 01	2.90685E 00	6.43189E 00	1.61667E 01	-8.40556E 01
1.03306E 00	1.81682E 01	2.51862E 01	-7.13938E 01	2.99405E 00	6.24268E 00	1.59074E 01	-8.42166E 01
1.06406E 00	1.76461E 01	2.49330E 01	-7.20501E 01	3.08387E 00	6.05930E 00	1.56484E 01	-8.43698E 01
1.09598E 00	1.71380E 01	2.46792E 01	-7.26769E 01	3.17639E 00	5.88153E 00	1.53898E 01	-8.45157E 01
1.12885E 00	1.66435E 01	2.44249E 01	-7.32764E 01	3.27168E 00	5.70928E 00	1.51316E 01	-8.46549E 01
1.16272E 00	1.61627E 01	2.41702E 01	-7.38503E 01	3.36983E 00	5.54235E 00	1.48739E 01	-8.47879E 01
1.19760E 00	1.56949E 01	2.39152E 01	-7.44004E 01	3.47092E 00	5.38055E 00	1.46165E 01	-8.49155E 01
1.23353E 00	1.52402E 01	2.36598E 01	-7.49283E 01	3.57505E 00	5.22380E 00	1.43597E 01	-8.50383E 01
1.27053E 00	1.47981E 01	2.34041E 01	-7.54350E 01	3.68230E 00	5.07189E 00	1.41034E 01	-8.51569E 01
1.30865E 00	1.43684E 01	2.31482E 01	-7.59221E 01	3.79276E 00	4.92465E 00	1.38475E 01	-8.52719E 01
1.34791E 00	1.39508E 01	2.28920E 01	-7.63905E 01	3.90654E 00	4.78191E 00	1.35920E 01	-8.53839E 01
1.38834E 00	1.35450E 01	2.26355E 01	-7.68411E 01	4.02374E 00	4.64351E 00	1.33369E 01	-8.54936E 01
1.42999E 00	1.31506E 01	2.23789E 01	-7.72752E 01	4.14445E 00	4.50926E 00	1.30821E 01	-8.56006E 01
1.47289E 00	1.27673E 01	2.21220E 01	-7.76934E 01	4.26878E 00	4.37903E 00	1.28276E 01	-8.57063E 01
1.51708E 00	1.23950E 01	2.18649E 01	-7.80965E 01	4.39684E 00	4.25265E 00	1.25732E 01	-8.58101E 01
1.56259E 00	1.20332E 01	2.16076E 01	-7.84851E 01	4.52875E 00	4.12997E 00	1.23189E 01	-8.59126E 01
1.60947E 00	1.16817E 01	2.13501E 01	-7.88601E 01	4.66461E 00	4.01092E 00	1.20649E 01	-8.60136E 01
1.65775E 00	1.13403E 01	2.10925E 01	-7.92219E 01	4.80454E 00	3.89531E 00	1.18108E 01	-8.61133E 01
1.70748E 00	1.10086E 01	2.08347E 01	-7.95711E 01	4.94868E 00	3.78303E 00	1.15566E 01	-8.62115E 01
1.75870E 00	1.06863E 01	2.05766E 01	-7.99081E 01	5.09714E 00	3.67395E 00	1.13027E 01	-8.63085E 01
1.81146E 00	1.03733E 01	2.03183E 01	-8.02335E 01	5.25005E 00	3.56802E 00	1.10485E 01	-8.64043E 01
1.86581E 00	1.00692E 01	2.00599E 01	-8.05475E 01	5.40755E 00	3.46512E 00	1.07944E 01	-8.64985E 01
1.92178E 00	9.77378E 00	1.98012E 01	-8.08506E 01	5.56977E 00	3.36516E 00	1.05401E 01	-8.65910E 01
1.97943E 00	9.48689E 00	1.95425E 01	-8.11429E 01	5.73686E 00	3.26803E 00	1.02857E 01	-8.66820E 01
2.03882E 00	9.20812E 00	1.92834E 01	-8.14249E 01	5.90897E 00	3.17369E 00	1.00313E 01	-8.67715E 01
2.09998E 00	8.93739E 00	1.90242E 01	-8.16967E 01	6.08624E 00	3.08201E 00	9.77668E 00	-8.68593E 01
2.16298E 00	8.67445E 00	1.87648E 01	-8.19585E 01	6.26882E 00	2.99293E 00	9.52192E 00	-8.69451E 01
2.22787E 00	8.41909E 00	1.85053E 01	-8.22106E 01	6.45688E 00	2.90639E 00	9.26707E 00	-8.70293E 01
2.29470E 00	8.17111E 00	1.62456E 01	-8.24530E 01	6.65059E 00	2.82231E 00	9.01209E 00	-8.71116E 01
2.36354E 00	7.93037E 00	1.79859E 01	-8.26853E 01	6.85010E 00	2.74064E 00	8.75703E 00	-8.71921E 01

Figure 3-5. Program sample output (Continued)

FREQUENCY RESPONSE

DEP VAR 6 / INDEP VAR 4
YAW RESPONSE TO RUDDER INPUT

FREQ (RPS)	GAIN	GAIN (DB)	PHASE (DEG)	FREQ (RPS)	GAIN	GAIN (DB)	PHASE (DEG)
7.05560E 00	2.66128E 00	8.50180E 00	-8.72707E 01	2.04488E 01	9.22120E-01	-7.04250E-01	-8.89230E 01
7.26727E 00	2.58418E 00	8.24645E 00	-8.73474E 01	2.10623E 01	8.95347E-01	-9.60173E-01	-8.89566E 01
7.48528E 00	2.50926E 00	7.99093E 00	-8.74221E 01	2.16941E 01	8.69334E-01	-1.21627E 00	-8.89895E 01
7.70984E 00	2.43650E 00	7.73532E 00	-8.74948E 01	2.23449E 01	8.44067E-01	-1.47246E 00	-8.90212E 01
7.94113E 00	2.36583E 00	7.47968E 00	-8.75660E 01	2.30153E 01	8.19529E-01	-1.72871E 00	-8.90517E 01
8.17937E 00	2.29717E 00	7.22386E 00	-8.76348E 01	2.37057E 01	7.95696E-01	-1.98506E 00	-8.90812E 01
8.42474E 00	2.23047E 00	6.96795E 00	-8.77021E 01	2.44169E 01	7.72550E-01	-2.24147E 00	-8.91094E 01
8.67748E 00	2.16567E 00	6.71186E 00	-8.77672E 01	2.51494E 01	7.50073E-01	-2.49793E 00	-8.91367E 01
8.93781E 00	2.10274E 00	6.45570E 00	-8.78305E 01	2.59038E 01	7.28246E-01	-2.75444E 00	-8.91631E 01
9.20594E 00	2.04161E 00	6.19947E 00	-8.78918E 01	2.66809E 01	7.07054E-01	-3.01095E 00	-8.91885E 01
9.48211E 00	1.98224E 00	5.94314E 00	-8.79513E 01	2.74814E 01	6.86474E-01	-3.26752E 00	-8.92131E 01
9.76657E 00	1.92458E 00	5.68672E 00	-8.80088E 01	2.83058E 01	6.66497E-01	-3.52404E 00	-8.92369E 01
1.00596E 01	1.86857E 00	5.43019E 00	-8.80643E 01	2.91549E 01	6.47089E-01	-3.78072E 00	-8.92596E 01
1.03614E 01	1.81417E 00	5.17358E 00	-8.81178E 01	3.00296E 01	6.28247E-01	-4.03738E 00	-8.92815E 01
1.06722E 01	1.76131E 00	4.91672E 00	-8.81696E 01	3.09305E 01	6.09954E-01	-4.29406E 00	-8.93029E 01
1.09923E 01	1.71000E 00	4.65990E 00	-8.82193E 01	3.18584E 01	5.92193E-01	-4.55073E 00	-8.93232E 01
1.13221E 01	1.66014E 00	4.40291E 00	-8.82667E 01	3.28141E 01	5.74948E-01	-4.80742E 00	-8.93430E 01
1.16618E 01	1.61172E 00	4.14578E 00	-8.83119E 01	3.37985E 01	5.58205E-01	-5.06413E 00	-8.93622E 01
1.20116E 01	1.56467E 00	3.88846E 00	-8.83545E 01	3.48124E 01	5.41952E-01	-5.32078E 00	-8.93805E 01
1.23720E 01	1.51895E 00	3.63085E 00	-8.83932E 01	3.58568E 01	5.26167E-01	-5.57753E 00	-8.93980E 01
1.27431E 01	1.47455E 00	3.37316E 00	-8.84276E 01	3.69325E 01	5.10840E-01	-5.83429E 00	-8.94151E 01
1.31254E 01	1.43145E 00	3.11552E 00	-8.84551E 01	3.80404E 01	4.95961E-01	-6.09104E 00	-8.94314E 01
1.35192E 01	1.38971E 00	2.85847E 00	-8.84753E 01	3.91816E 01	4.81512E-01	-6.34786E 00	-8.94474E 01
1.39247E 01	1.34937E 00	2.60263E 00	-8.84904E 01	4.03570E 01	4.67485E-01	-6.60465E 00	-8.94623E 01
1.43425E 01	1.31042E 00	2.34824E 00	-8.85062E 01	4.15677E 01	4.53866E-01	-6.86144E 00	-8.94765E 01
1.47728E 01	1.27275E 00	2.09483E 00	-8.85267E 01	4.28147E 01	4.40645E-01	-7.11822E 00	-8.94897E 01
1.52159E 01	1.23621E 00	1.84185E 00	-8.85542E 01	4.40992E 01	4.27812E-01	-7.37494E 00	-8.95021E 01
1.56724E 01	1.20071E 00	1.58879E 00	-8.85864E 01	4.54221E 01	4.15352E-01	-7.63167E 00	-8.95137E 01
1.61426E 01	1.16619E 00	1.33537E 00	-8.86223E 01	4.67848E 01	4.03253E-01	-7.88845E 00	-8.95240E 01
1.66268E 01	1.13260E 00	1.08153E 00	-8.86602E 01	4.81883E 01	3.91512E-01	-8.14509E 00	-8.95330E 01
1.71256E 01	1.09993E 00	8.27284E-01	-8.86991E 01	4.96339E 01	3.80127E-01	-8.40143E 00	-8.95410E 01
1.76394E 01	1.06816E 00	5.72703E-01	-8.87379E 01	5.11229E 01	3.69086E-01	-8.65744E 00	-8.95480E 01
1.81686E 01	1.03726E 00	3.17777E-01	-8.87766E 01	5.26566E 01	3.58386E-01	-8.91296E 00	-8.95560E 01
1.87136E 01	1.00723E 00	6.26125E-02	-8.88147E 01	5.42363E 01	3.46013E-01	-9.16809E 00	-8.95673E 01
1.92750E 01	9.78046E-01	-1.92815E-01	-8.88517E 01	5.58633E 01	3.37934E-01	-9.42334E 00	-8.95835E 01
1.98532E 01	9.49679E-01	-4.48464E-01	-8.88879E 01	5.75392E 01	3.28121E-01	-9.67931E 00	-8.96026E 01

Figure 3-5. Program sample output (Continued)

FREQUENCY RESPONSE

DEP VAR 6 / INDEP VAR 4
YAW RESPONSE TO RUDDER INPUT

FREQ (RPS)	GAIN	GAIN (DB)	PHASE (DEG)	FREQ (RPS)	GAIN	GAIN (DB)	PHASE (DEG)
5.92653E 01	3.18574E-01	-9.93580E 00	-8.96219E 01	1.71765E 02	1.09897E-01	-1.91803E 01	-8.98734E 01
6.10433E 01	3.09287E-01	-1.01928E 01	-8.96389E 01	1.76918E 02	1.06696E-01	-1.94370E 01	-8.98771E 01
6.28745E 01	3.00266E-01	-1.04499E 01	-8.96541E 01	1.82226E 02	1.03589E-01	-1.96938E 01	-8.98808E 01
6.47608E 01	2.91505E-01	-1.07071E 01	-8.96672E 01	1.87692E 02	1.00572E-01	-1.99505E 01	-8.98843E 01
6.67036E 01	2.82998E-01	-1.09643E 01	-8.96791E 01	1.93323E 02	9.76421E-02	-2.02072E 01	-8.98877E 01
6.87046E 01	2.74737E-01	-1.12216E 01	-8.96901E 01	1.99123E 02	9.47979E-02	-2.04640E 01	-8.98910E 01
7.07657E 01	2.66712E-01	-1.14791E 01	-8.96999E 01	2.05096E 02	9.20373E-02	-2.07207E 01	-8.98943E 01
7.28887E 01	2.58905E-01	-1.17372E 01	-8.97060E 01	2.11249E 02	8.93569E-02	-2.09774E 01	-8.98975E 01
7.50753E 01	2.51337E-01	-1.19949E 01	-8.96971E 01	2.17587E 02	8.67543E-02	-2.12342E 01	-8.99007E 01
7.73275E 01	2.44110E-01	-1.22483E 01	-8.96985E 01	2.24114E 02	8.42270E-02	-2.14910E 01	-8.99037E 01
7.96473E 01	2.37023E-01	-1.25042E 01	-8.97168E 01	2.30838E 02	8.17735E-02	-2.17477E 01	-8.99062E 01
8.20367E 01	2.30117E-01	-1.27610E 01	-8.97294E 01	2.37763E 02	7.93920E-02	-2.20045E 01	-8.99083E 01
8.44978E 01	2.23410E-01	-1.30180E 01	-8.97394E 01	2.44895E 02	7.70796E-02	-2.22612E 01	-8.99112E 01
8.70327E 01	2.16899E-01	-1.32748E 01	-8.97475E 01	2.52242E 02	7.48350E-02	-2.25179E 01	-8.99141E 01
8.96436E 01	2.10580E-01	-1.35316E 01	-8.97553E 01	2.59809E 02	7.26553E-02	-2.27746E 01	-8.99166E 01
9.23329E 01	2.04446E-01	-1.37884E 01	-8.97623E 01	2.67604E 02	7.05389E-02	-2.30314E 01	-8.99192E 01
9.51029E 01	1.98494E-01	-1.40450E 01	-8.97691E 01	2.75631E 02	6.84845E-02	-2.32881E 01	-8.99216E 01
9.79559E 01	1.92716E-01	-1.43016E 01	-8.97769E 01	2.83900E 02	6.64900E-02	-2.35449E 01	-8.99240E 01
1.00895E 02	1.87104E-01	-1.45584E 01	-8.97853E 01	2.92417E 02	6.45531E-02	-2.38017E 01	-8.99263E 01
1.03921E 02	1.81650E-01	-1.48153E 01	-8.97927E 01	3.01189E 02	6.26730E-02	-2.40584E 01	-8.99285E 01
1.07039E 02	1.76354E-01	-1.50723E 01	-8.97990E 01	3.10225E 02	6.08475E-02	-2.43151E 01	-8.99306E 01
1.10250E 02	1.71217E-01	-1.53291E 01	-8.98049E 01	3.19531E 02	5.90755E-02	-2.45719E 01	-8.99327E 01
1.13558E 02	1.66228E-01	-1.55859E 01	-8.98105E 01	3.29117E 02	5.73547E-02	-2.48286E 01	-8.99347E 01
1.16964E 02	1.61386E-01	-1.58427E 01	-8.98159E 01	3.38990E 02	5.56841E-02	-2.50654E 01	-8.99365E 01
1.20473E 02	1.56685E-01	-1.60995E 01	-8.98210E 01	3.49160E 02	5.40624E-02	-2.53421E 01	-8.99382E 01
1.24087E 02	1.52120E-01	-1.63562E 01	-8.98262E 01	3.59634E 02	5.24877E-02	-2.55988E 01	-8.99403E 01
1.27810E 02	1.47690E-01	-1.66130E 01	-8.98311E 01	3.70423E 02	5.09590E-02	-2.58556E 01	-8.99419E 01
1.31644E 02	1.43387E-01	-1.68698E 01	-8.98358E 01	3.81536E 02	4.94747E-02	-2.61123E 01	-8.99435E 01
1.35593E 02	1.39211E-01	-1.71265E 01	-8.98405E 01	3.92981E 02	4.80337E-02	-2.63691E 01	-8.99455E 01
1.39661E 02	1.35157E-01	-1.73832E 01	-8.98449E 01	4.04771E 02	4.66348E-02	-2.66258E 01	-8.99472E 01
1.43851E 02	1.31220E-01	-1.76400E 01	-8.98494E 01	4.16914E 02	4.52762E-02	-2.68826E 01	-8.99489E 01
1.48167E 02	1.27399E-01	-1.78967E 01	-8.98538E 01	4.29421E 02	4.39576E-02	-2.71393E 01	-8.99504E 01
1.52611E 02	1.23688E-01	-1.81535E 01	-8.98579E 01	4.42303E 02	4.26771E-02	-2.73961E 01	-8.99517E 01
1.57190E 02	1.20086E-01	-1.84102E 01	-8.98618E 01	4.55572E 02	4.14342E-02	-2.76528E 01	-8.99531E 01
1.61905E 02	1.16588E-01	-1.86669E 01	-8.98657E 01	4.69239E 02	4.02275E-02	-2.79095E 01	-8.99547E 01
1.66762E 02	1.13193E-01	-1.89236E 01	-8.98697E 01	4.83316E 02	3.90557E-02	-2.81663E 01	-8.99561E 01

Figure 3-5. Program sample output (Concluded)

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16. ABSTRACT

This report describes a generalized format rotorcraft small perturbation linear model in three volumes (Vol. I Engineering Documentation, Vol. II Computer Implementation, Vol. III User's Manual). Rotor flap, inplane and feathering degrees of freedom, as well as control and augmentation systems are defined in addition to the classical vehicle six degrees of freedom. The primary application is intended to be an analytic tool to assess the handling qualities of a dynamically combined main rotor and body. The modeling method retains the higher frequency response properties which aid in evaluating control and stability augmentation systems.

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