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Final Design and Fabrication of an Active Control System for Flutter Suppression on a Supercritical Aeroelastic Research Wing

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SYMBOLS

a	Servoactuator pressure feedback loop washout break frequency, rad/s
C_A	Actuator coefficient, m^3 (in^3)
C_1	Ratio of accumulator precharge pressure to the supply pressure
D	Flutter suppression system filter scheduled break frequency, rad/s
D_{EQ}	Equivalent viscous damping of trapped fluid, N·m/rad/s (in-lb/rad/sec)
g	Acceleration of gravity, m/s^2 (ft/sec^2)
I_{EQ}	Equivalent rotary inertia of trapped fluid, $N\cdot m\cdot s^2$ ($in\text{-}lb\text{-}sec^2$)
I_S	Rotary inertia of control surface relative to hinge line, $N\cdot m\cdot s^2$ ($in\text{-}lb\text{-}sec^2$)
i	Servovalve coil current, mA
j	$\sqrt{-1}$
$j\omega$	Root locus imaginary component, rad/s
K	Flutter suppression system selectable gain
K_A	Servovalve drive amplifier gain, mA/V
K_F	Servoactuator position feedback gain, V/rad (volt/deg)
K_P	Servoactuator load pressure feedback gain, $V/N/m^2$ (volt/psi)
K_V	Servovalve flow gain, m^3/mA (in^3/mA)
$K_{S_{EQ}}$	Equivalent rotary spring constant of the actuator shaft free length in series with one-third of the estimated control surface spring rate, N·m/rad (in-lb/rad)
K_α	Automatic flight control system angle of attack limiter slope, rad/rad (deg/deg)
K_γ	Automatic flight control system glide path angle feedback gain, rad/rad
K_θ	Automatic flight control system pitch angle feedback gain, rad/rad
K_ϕ	Automatic flight control system roll angle feedback gain, rad/rad
K_1	Flutter suppression system vertical acceleration channel fixed gain, rad/g (deg/g)
K_2	Flutter suppression system roll acceleration channel gain, $g/rad/s^2$ ($g/deg/sec^2$)
k	Ratio of specific heats
ℓ	Actuator vane length, mm (in.)
P_I	Impact pressure, N/m^2 (lb/ft^2)
P_L	Actuator load pressure, N/m^2 (lb/in^2)
P_S	Static pressure, N/m^2 (lb/ft^2)
P_S	Hydraulic supply pressure, N/m^2 (lb/in^2)

SYMBOLS (Continued)

Q	Instantaneous servovalve flow, m^3/s (in^3/sec)
Q_L	Servovalve quiescent leakage flow rate, m^3/s (in^3/sec)
Q_M	Maximum fluid flow demand of the servoactuators, m^3/s (in^3/sec)
Q_P	Fluid flow rate supplied by pump, m^3/s (in^3/sec)
Q_O	Servovalve no-load flow rate, m^3/s (in^3/sec)
r_D	Actuator vane radius, mm (in.)
r_S	Actuator shaft radius, mm (in.)
S	Laplace transform operator, rad/s
T	Actuator torque, N·m (in-lb)
V	Fluid volume trapped on one side between servovalve and actuator, m^3 (in^3)
V_A	Volume of fluid in accumulator after volume V_P is discharged, m^3 (in^3)
V_C	Servoactuator command, volt
V_f	Flutter speed, m/s (ft/sec)
V_P	Fluid volume required from the hydraulic accumulator per half cycle of sine wave command, m^3 (in^3)
V_R	Accumulator replenish volume per half cycle of sine wave command, m^3 (in^3)
X_F	Body station, m (in.)
Y_F	Body buttock line, m (in.)
Z_F	Body water line, m (in.)
$\ddot{Z}$	Vertical acceleration, g (positive up)
α	Angle of attack, rad
α_1	Automatic flight control system angle of attack positive limit, rad (deg)
α_2	Automatic flight control system angle of attack negative limit, rad (deg)
β	Hydraulic fluid bulk modulus, N/m^2 (lb/in^2)
γ	Glide path angle, rad
ΔP	Pressure drop across rotary actuator vane, N/m^2 (lb/in^2)
δ	Control surface displacement, rad (deg)
δ_A	Aileron displacement, rad (deg)
ζ	Ratio of actual damping to critical damping
θ	Pitch angle, rad
θ_A	Aileron servoactuator displacement, rad (deg)

SYMBOLS (Concluded)

θ_C	Aileron servoactuator displacement command, rad (deg)
θ_S	Aileron control surface displacement, rad (deg)
$\ddot{\theta}_X$	Roll acceleration, rad/s^2 (deg/sec^2)
σ	Root locus real component, rad/s
ϕ	Roll angle, rad
ω	Frequency, rad/s
ω_n	Undamped natural frequency, rad/s

SUBSCRIPTS:

A_L	Left wing panel aileron
A_R	Right wing panel aileron
CG	Center of gravity
H.S.	Horizontal stabilizer
LW	Left wing panel
RW	Right wing panel

1.0 INTRODUCTION

This study was performed under NASA Contract NAS1-14675 with the objective to accomplish the final design and hardware fabrication for an active control system capable of the required flutter suppression, compatible with and ready for installation in the NASA Aeroelastic Research Wing Number 1 (ARW-1) and Firebee II drone flight test vehicle.

The National Aeronautics and Space Administration (NASA) is pursuing applications of active control technology systems under the Drones for Aeronautical and Structural Testing (DAST) program which utilizes a BQM-34E/F (Firebee II) drone as the test vehicle. The first wing to be designed for this vehicle, ARW-1, was designed by Ryan Aeronautical under NASA Contract NAS1-13451 to exhibit flutter within the aircraft flight envelope. The DAST ARW-1 configuration general arrangement is shown on Figure 1-1 and Figure 1-2 shows the flight envelope. Preliminary design of the flutter suppression system was accomplished by Boeing Wichita Company under Contract NAS1-14028 (Reference 1). Under the present study, the flutter suppression system synthesis analysis was completed and the hardware and electronics required to implement the system on the DAST ARW-1 vehicle were designed, fabricated, tested and delivered to NASA for installation in the drone.

The DAST ARW-1 test vehicle is air launched from a B-52B aircraft, controlled from a ground based cockpit and recovered by air snatching the recovery parachute with a helicopter. The vehicle will be flown as a Remotely Piloted Research Vehicle (RPRV) similar to the illustration shown on Figure 1-3 and described in Reference 2.

This report provides historical documentation and describes the completion of the flutter suppression system synthesis, design of the electronic and mechanical components required to mechanize the system on the drone, and results of the flightworthiness tests conducted prior to delivery of the system components to NASA. Results from the first ARW-1 free flight indicated that the flutter mode was predominantly wing first bending rather than wing torsion as predicted by early analysis. Since a mathematical model generated in-house by NASA predicted predominant wing first bending in the flutter mode, that model was utilized to revise the FSS control law. Section 10 presents the revised control law and predicted results.

The flutter suppression system printed circuit board assemblies are detailed on Boeing drawings 39-27724, 39-27726, 39-27728, 39-27730, 39-27732, 39-27734, 39-27736, 39-27738, 39-27741, 38-27742, 39-27744, 39-27745, 39-27746, 39-27748 and 39-27750. The interface unit wire harness assembly is shown on 32-2569 and the electronic interface unit assembly (electronic box) is on drawing 35-34536-1 with parts list on PL35-34536. Ground test equipment provided under the contract included a flutter suppression system tester, on Boeing drawing EX-3467; a card tester, on EX-3468; a test cart panel on EX-3528; and a test

WING
Gross Area: 2.787 m^2 (30 ft^2)
Airfoil: Supercritical T/C 11% Root, 7% Tip
Aspect Ratio: 6.8
Taper Ratio: 0.36

TAIL-HORIZONTAL
Gross Area: 0.845 m^2 (9.1 ft^2)
Net Exposed Area: 0.511 m^2 (5.5 ft^2)
Airfoil: NACA-65003.5 (Modified) Tip With
NACA-65005 (Modified) Y_F = 0.257 (10.10)
Aspect Ratio: 3.5
Incidence: All-Movable
Taper Ratio: 0.40
Dihedral: 0 rad (0 deg)
Stabilizer Hinge Axis: X_F 9.133 (359.56)

TAIL-VERTICAL
Gross Area: 0.804 m^2 (8.65 ft^2)
Airfoil: NACA 65-003 (Modified)
Aspect Ratio (Geometric): 1.2
Taper Ratio: 0.30
Rudder Hinge Axis: 85% Chord
Rudder Area: 0.057 m^2 (0.61 ft^2)
Net Exposed Area: 0.632 m^2 (6.8 ft^2)

POWER PLANT
Continental (YJ69-T-406 CAE Model 356.34)
Rated Thrust: 8185 N (1840 lb) Sea Level Static

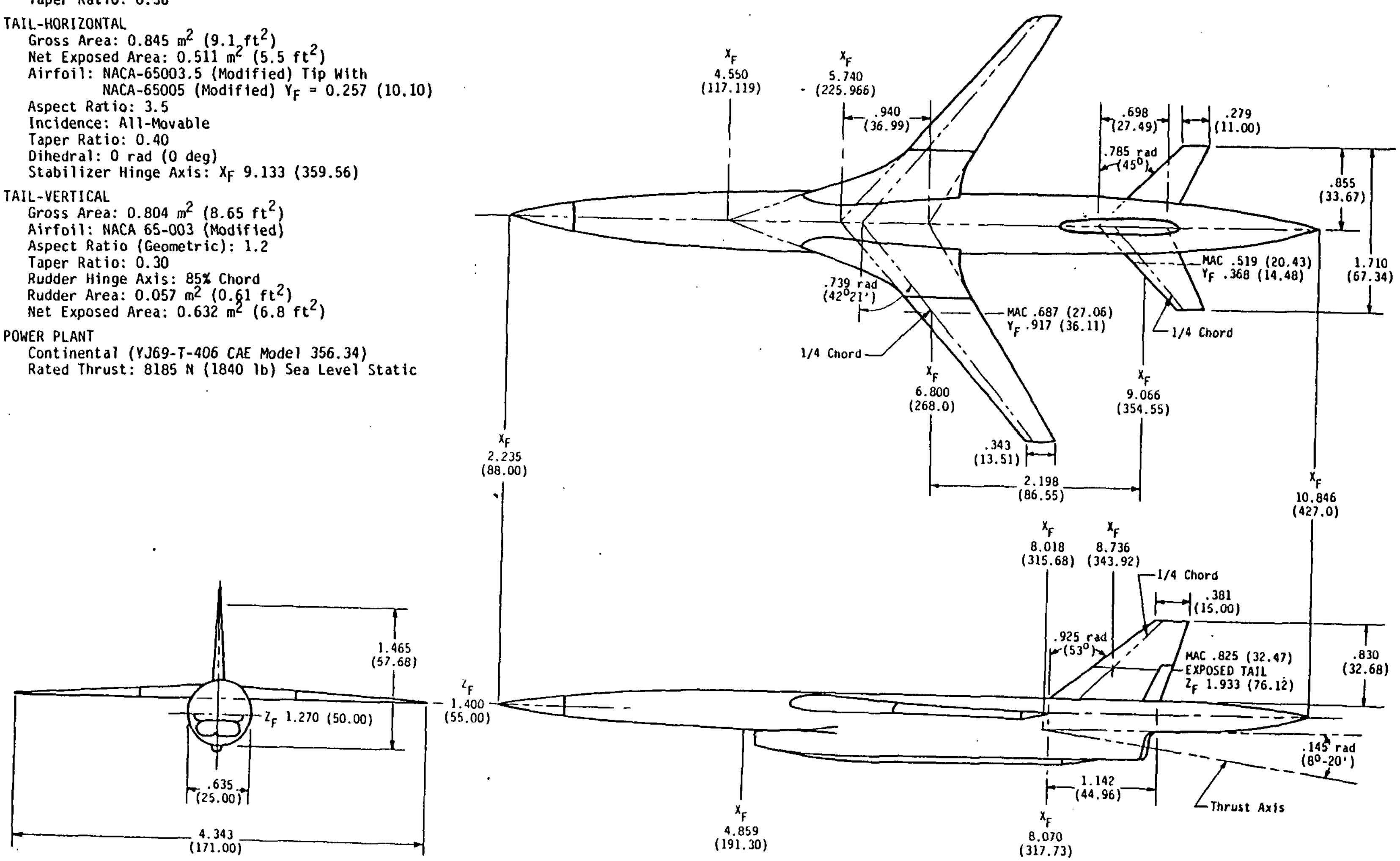


FIGURE 1-1 - DAST ARW-1 GENERAL ARRANGEMENT cable harness assembly on EX-3529. Boeing drawing 35-34547 shows the hydraulic system installation aft of the Body Station 5.931 (233.5) bulkhead, 35-34555 shows the wing control surface and actuator installation and drawing EX-3317 shows the actuator detailed design.

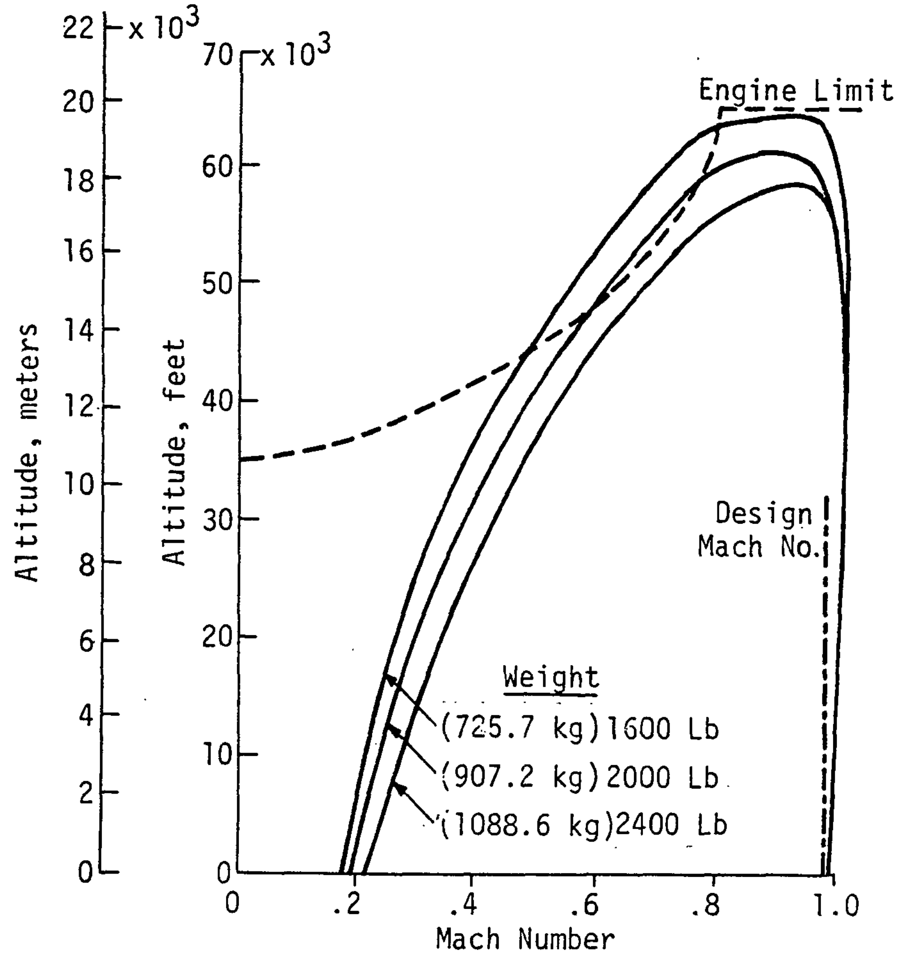


FIGURE 1-2 - DAST ARW-1 FLIGHT ENVELOPE

Flight assurance and electromagnetic capability (EMC) test results are presented in Boeing documents D3-11473-1 (Reference 3) and D3-11404-2 (Reference 4), respectively. The corresponding test procedures are contained in D3-11443-1 (Reference 5) and D3-11404-1 (Reference 6). Maintenance and operation instructions for the flutter suppression system, and the electronics design drawings are contained in D3-11474-1 (Reference 7). In addition to these reports prepared under this contract, copies of the Bceing Wichita Company quality assurance plan, D3-4801, were provided to NASA.

Support was also provided for analysis and wind tunnel tests for a full scale DAST ARW-1 aeroelastically scaled cantilever wing model equipped with the drone flutter suppression system scaled to model frequencies. Results of the anlayses conducted and a description of the support provided are discussed in Boeing document D3-11412-1 (Reference 8).

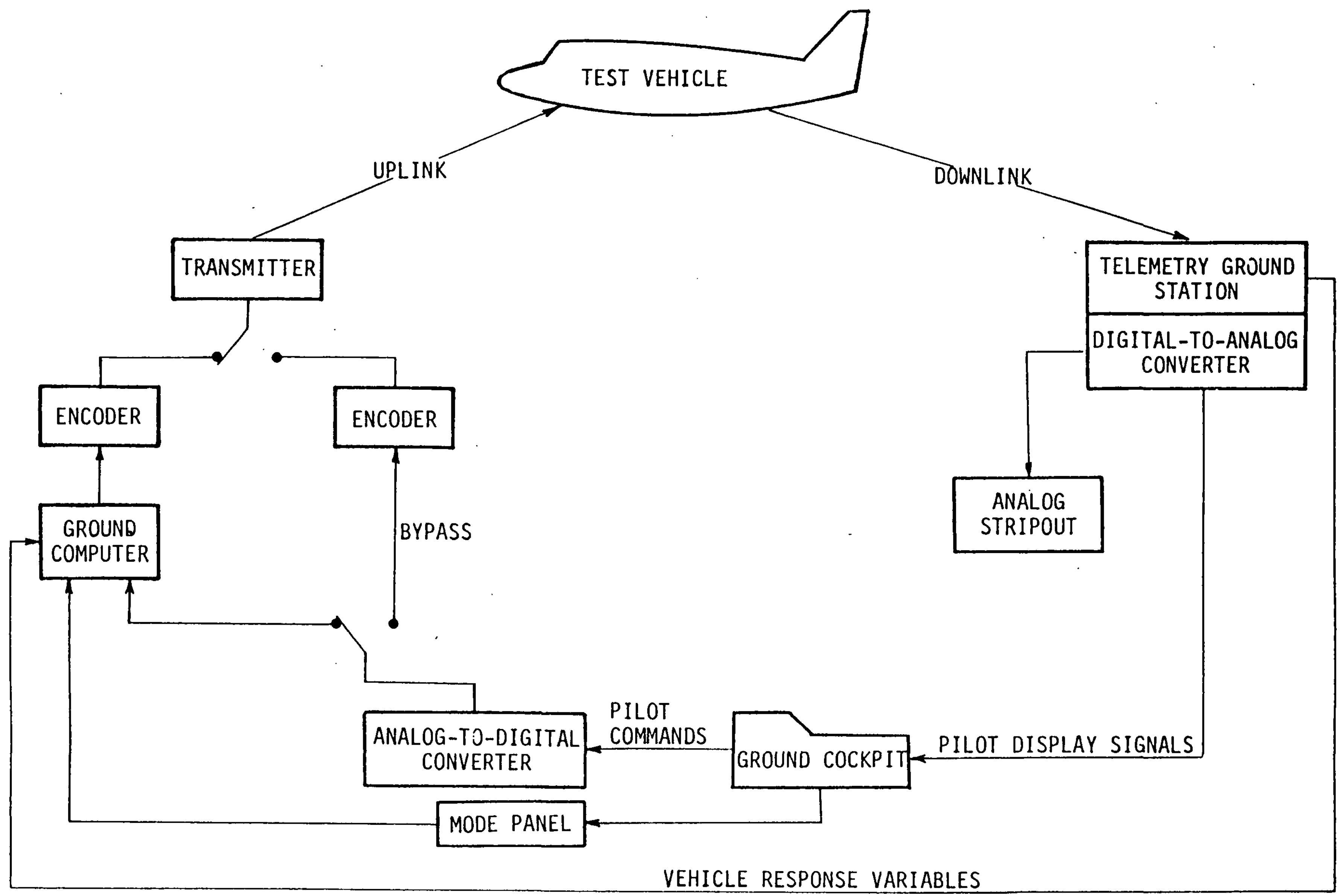


FIGURE 1-3 - FUNCTIONAL BLOCK DIAGRAM OF THE REMOTELY PILOTED RESEARCH VEHICLE

2.0 SUMMARY

This final report summarizes results of Contract NAS1-14675 with the objective to accomplish final design and fabrication of an active flutter suppression system for flight tests on a BQM-34E/F drone with the DAST ARW-1 wing. Results of this program are the flutter suppression system mechanical and electronic components ready for installation in the DAST ARW-1 wing and BQM-34E/F drone fuselage.

The DAST ARW-1 vehicle flutter boundaries with and without the flutter suppression system (FSS) engaged are shown on Figure 2-1. Analysis of the flutter suppression system design indicated that the system would satisfy the goal of providing a 20 percent velocity margin above the system off boundary. The block diagram of the system is shown on Figure 2-2. The system uses vertical

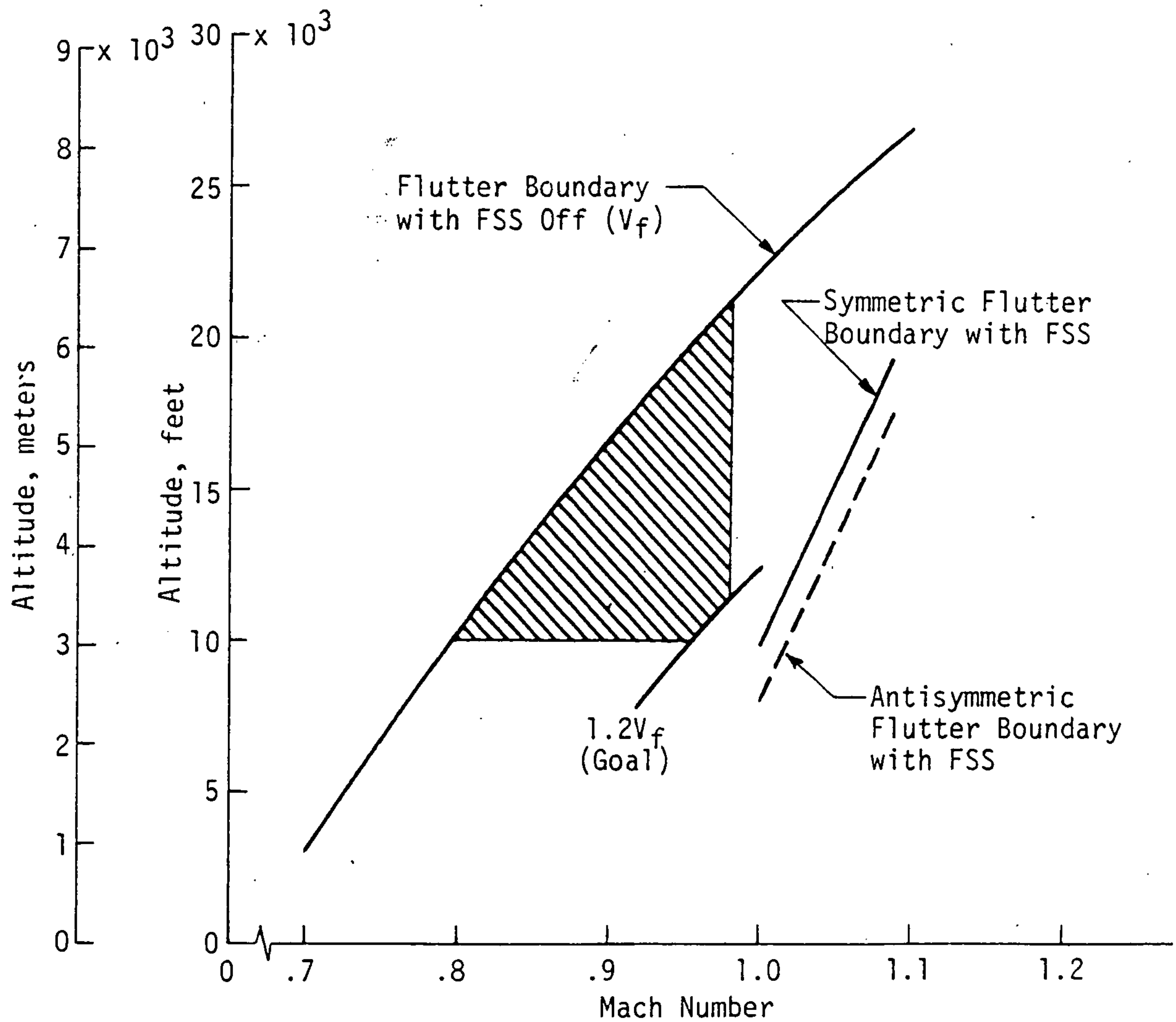
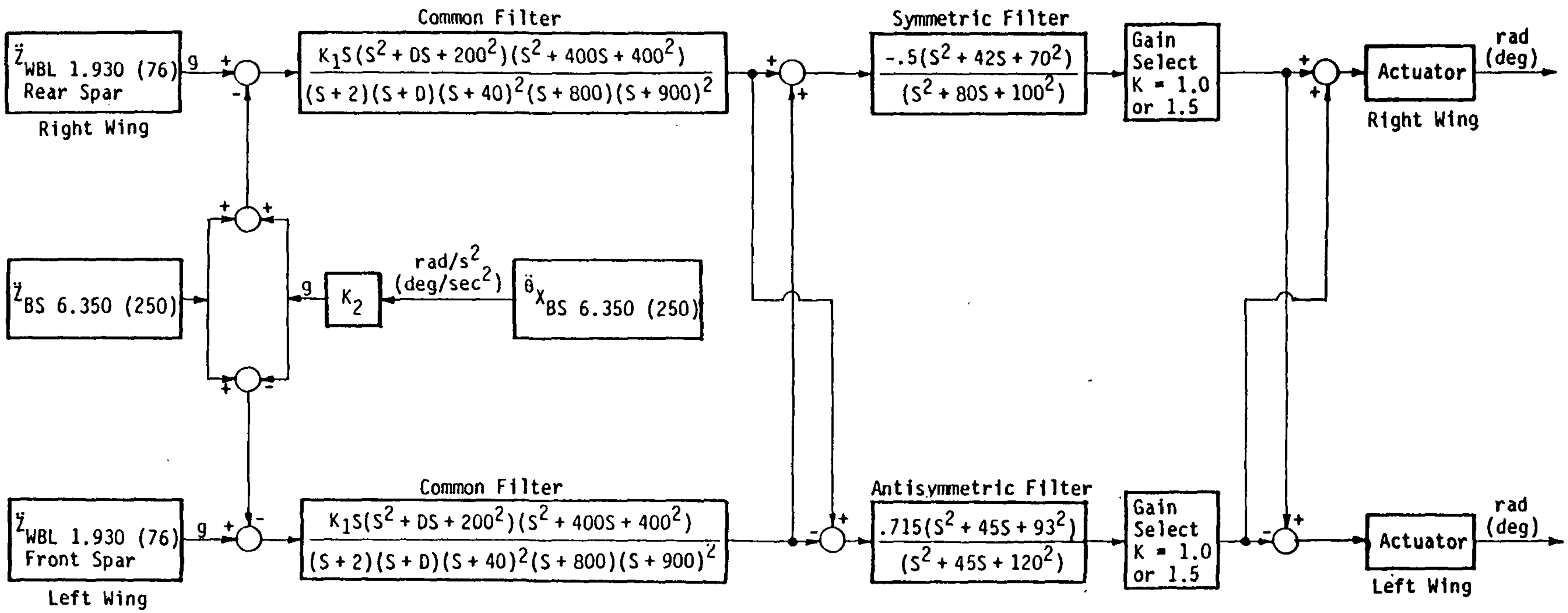


FIGURE 2-1 - DAST ARW-1 FSS FLUTTER BOUNDARY



$K_1 = 1.932 \times 10^4$ rad/g (1.107×10^6 deg/g)

$K_2 = 5.934 \times 10^{-5}$ (.0034)

$D = f(P_S, P_I)$

$\ddot{Z} \sim +$ Up

$\ddot{\theta}_X \sim +$ Right Wing Up

$\delta_A \sim +$ TED

FIGURE 2-2 - DAST ARW-1 FLUTTER SUPPRESSION SYSTEM BLOCK DIAGRAM

acceleration at Wing Buttock Line 1.930 (76), with fuselage vertical and roll accelerations subtracted out, to drive wing outboard aileron control surfaces through appropriate symmetric and antisymmetric shaping filters. The shaping filters have a variable first order break frequency "D" scheduled in the system electronics as functions of static and impact pressures measured onboard the drone.

The flutter suppression system shaping filters are mechanized in analog form. The filters, uplink and downlink telemetry signal conditioning, a function generator for inputing commands to the aileron servoactuators for flutter suppression system testing, servoactuator feedback loops and servovalve drive amplifiers are all located in an electronics box that will be installed in the drone fuselage at Body Station 5.405 (212.8). The box measures 0.123 meter (4.85 inches) wide by 0.116 meter (4.58 inches) high and 0.460 meter (18.1 inches) long and accommodates twenty 0.083 meter (3.25 inches) by 0.115 meter (4.52 inches) circuit cards.

Installation of the flutter suppression system components in the DAST ARW-1 wing and BQM-34E/F fuselage is shown in the sketch on Figure 2-3. A Sundstrand-Pesco Model 165-100 hydraulic power unit, as recommended in the preliminary design study, provides hydraulic power for the outboard aileron servoactuators with a hydraulic accumulator provided by Boeing. Special design subminiature rotary actuators mount at the inboard edges of the control surfaces. Moog Series 30 flow control servovalves mount in the wing center section with about 2.159 meters (85 inches) of .00476 meter (3/16 inch) outside diameter tubing required between the servovalve control ports and the actuators. The two aileron control surfaces were fabricated using upper and lower skins cut from ARW-1 wing trailing edge panels provided by NASA.

The flutter suppression system components were procured or fabricated from engineering drawings and tested for flightworthiness prior to delivery to NASA. Servoactuator functional tests showed modes and mode frequencies not predicted by linear analysis. System performance when installed in the DAST ARW-1 wing equivalent to that predicted by linear analysis could not be attained. Considerable ground testing and the addition of several notch filters was required to stabilize the closed loop FSS system. Further analysis indicates that a servovalve with a wider bandwidth may be required to allow damping of the coupled surface-actuator mode. Hydraulic fluid modes would be insignificant on a full-scale transport because sufficient space would exist to mount the servovalves directly on the actuators. Also, separation between the actuator first order lag and the second order surface-actuator mode frequencies would be greater because corresponding frequencies would be lower than the drone and lower actuator bandpass could be used.

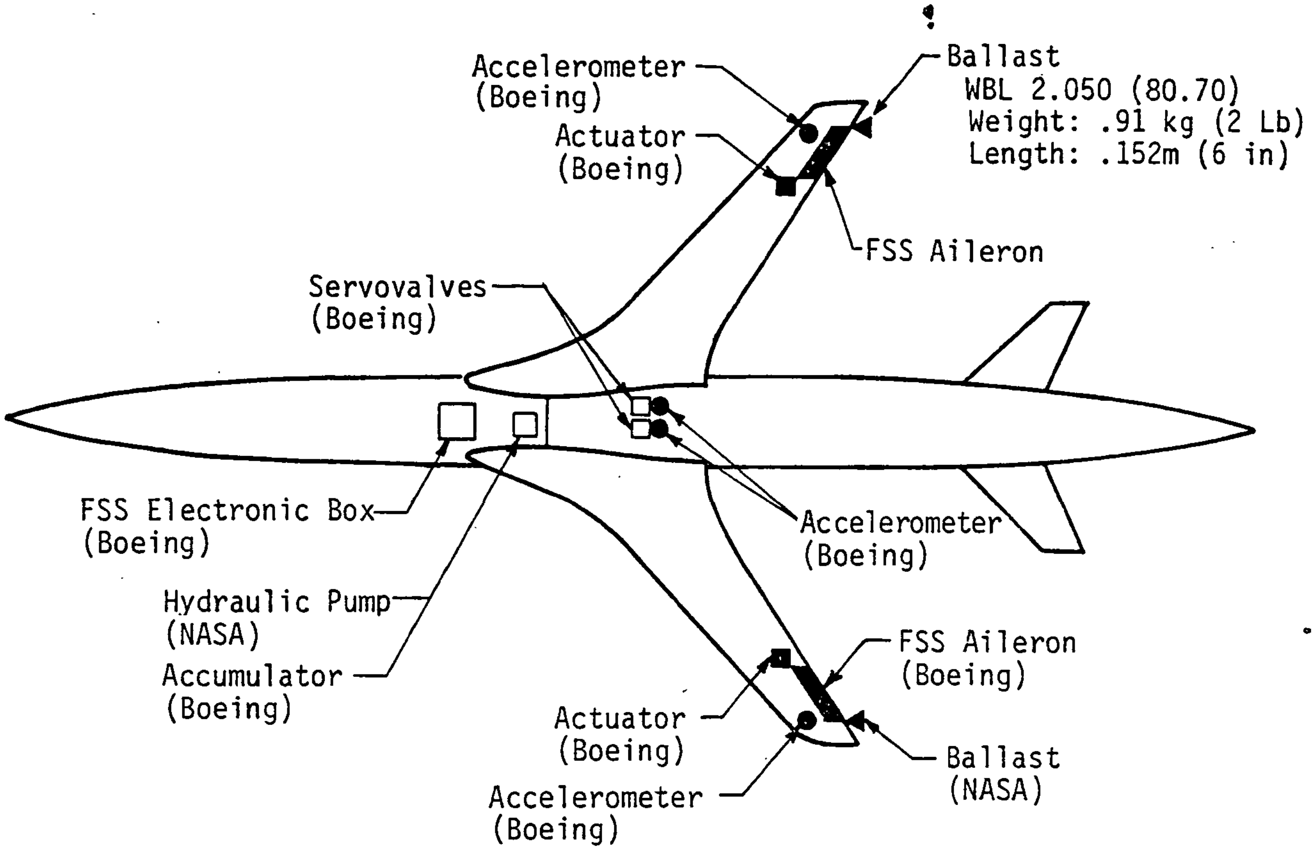


FIGURE 2-3 - DAST ARW-1 EQUIPMENT INSTALLATION

Temperature/altitude and vibration tests were conducted per NASA DFRC Process Specification No. 21-2 and electromagnetic capability (EMC) tests were conducted per appropriate sections of MIL-STD-461A. The environmental tests were successfully passed, except that a relaxed temperature range of 10°C (50°F) to 37.8°C (100°F) was required for the parameter scheduler units. This temperature range for the electronics is realistic based on measured flight data and NASA approval was obtained. Results of the EMC tests showed the flutter suppression system was not susceptible to interference from other electronic components nor was it a source of interference to other electronic components with the revised narrowband radiated emission test requirement as defined in Reference 4.

The flutter suppression system electronic and mechanical components, including required spare components, were provided to NASA for installation in the DAST ARW-1 wing and BQM-34E/F drone fuselage. NASA will install the system components and conduct flight tests with engineer support provided by Boeing.

Results from the first ARW-1 free flight indicated that the flutter mode was predominantly wing first vertical bending rather than wing torsion as predicted by analysis. Predicted frequency of the antisymmetric flutter mode from the mathematical model was also lower than the ground vibration test (GVT) results. The antisymmetric first bending GVT frequency was 14 Hertz compared to 12.5 Hertz from the mathematical model. The symmetric first vertical bending mode frequencies from the math model and GVT were approximately the same. The antisymmetric first bending frequency was increased to 14 Hertz in the math model but the flutter mode was still the torsion mode rather than the first bending mode. NASA's unsteady aerodynamic model (with the GVT frequency for the wing first antisymmetric bending mode included in the structural model) predicted that the flutter mode was predominantly wing vertical bending rather than torsion. Based on the better correlation with flight test results NASA's math model was used to revise the FSS control law. The revised control law provides 20 percent improvement in flutter speed. Section 10 presents the revised control law and predicted results.

3.0 STRUCTURAL ANALYSIS

The structural analysis methods used in defining the generalized equations of motion and the open loop flutter boundary for DAST ARW-1 are described in the following paragraphs, along with the results of the flutter analyses. The block diagram for the analyses is shown on Figure 3-1.

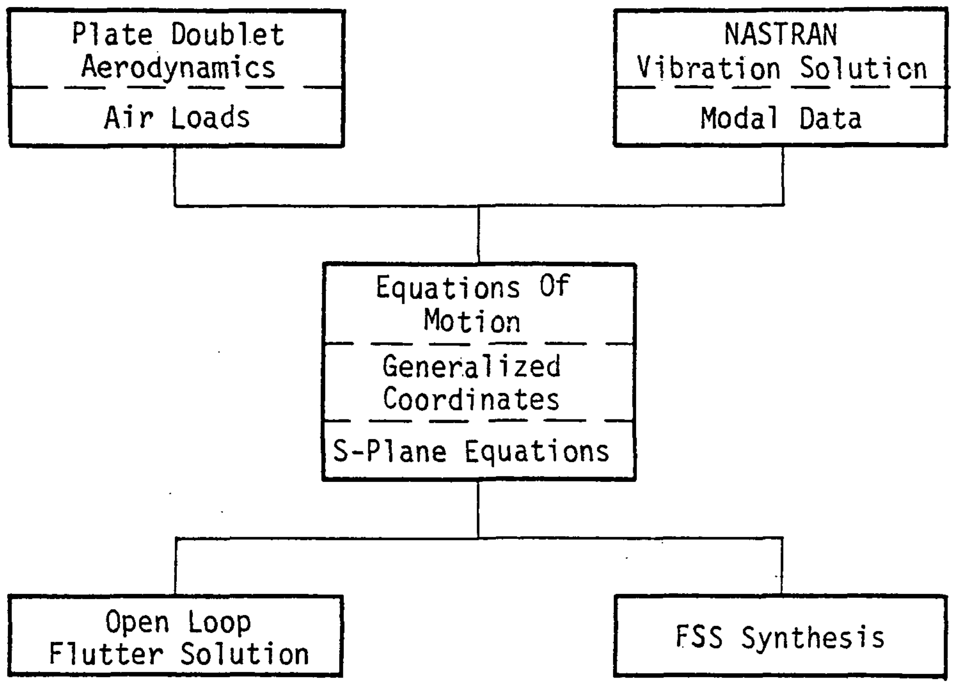


FIGURE 3-1 - FLUTTER ANALYSIS SEQUENCE

3.1 Structural Description

The wing structure consists of two machined steel spars, ribs spaced at 0.305 meters (12 inch) intervals and fiberglass skin. The between spar skin is stiffened by a single stiffener located between the spars, and the trailing edge skin is stiffened by a foam core. The leading and trailing edge skins are attached to the spars and ribs with screws so that they can be removed for access. All of the skins are 181 fiberglass/polyester composite. The ribs are formed aluminum alloy.

The wing is spliced to the center section at WS 0.583 (22.96). The machined spars incorporate integrally machined end fittings which mate with similar fittings on the center section. The two sections are joined by tension bolts at the midpoint of each spar. These bolts are preloaded so that the maximum depth portion of the spar flanges bear against the mating part. The preload is sufficient to prevent separation of the interface under limit loading.

The center section is an integrally machined aluminum alloy component. The region which provides bending and shear continuity for the wing center box consists of rectangular beams arranged in a truss pattern, while the aft portion stiffeners form a rectangular grid. The lower surface incorporates an integrally machined skin which provides a structural cover for the fuselage fuel cell. The center section is attached by tension bolts to five fuselage frames along BL 0.229 (9.0).

The fuselage and empennage are standard BQM-34E/F drone structural components.

3.2 Vibration Model

The vibration model consisted of a NASA supplied NASTRAN model of the wing, wing center section, fuselage and empennage structure. The NASTRAN data for the drone test vehicle with the DAST ARW-1 supercritical wing are presented in Appendix A.

The wing idealization was a detailed model including the leading and trailing edge structure, constructed of elements providing stiffness only for translational degrees of freedom. Wing skins were modeled utilizing shear elements with axial rods added to represent the membrane stiffness. The trailing edge structure and wing tip cap structure were constructed with a full depth core of sandwich or foam material. To idealize vertical stiffness provided by the core, the spar webs were extended past the solid aluminum rib at WBL 2.013 (79.25) to the wing tip at WBL 2.172 (85.5) using 2.54 millimeter (0.1 inch) thick aluminum shear panels. In addition, the trailing edge idealization of each of the ribs was stiffened by adding 1.27 millimeter (0.05 inch) thick aluminum triangular membrane elements. The wing was connected to a model of the wing center section with single point connections at the front and rear spars. The wing center section was modeled with beam and plate elements lying in a horizontal plane.

Elastic axis representations were used in the modeling of the fuselage, fin and horizontal stabilizer. The connections between the wing center section and the fuselage were defined by constraint equations relating translations at the side-of-body BL 0.229 (9.0) to the motions of the elastic axis at the fuselage centerline. The center section was also constrained at the centerline, in roll for the symmetric model and vertical translation for the antisymmetric model, to complete the definition of the wing constraints.

A summary of the frequencies and modes shapes resulting from the symmetric and antisymmetric vibration analyses is shown in Table 3-I. Plots of the mode shapes are shown in Appendix A.

TABLE 3-I

SYMMETRIC AND ANTISYMMETRIC ELASTIC MODE DESCRIPTION

Elastic Mode	Symmetric		Antisymmetric	
	Frequency, Hz	Mode Description	Frequency, Hz	Mode Description
1	9.09	Wing Bending	12.45	Wing Bending
2	16.38	Fuselage Bending	23.31	Wing Bending & Torsion
3	29.88	Wing Bending & Torsion	30.35	Wing Chordwise Bending
4	34.01	Wing Torsion	34.25	Wing Torsion & Fin Bending
5	39.37	Fuselage Bending	36.12	Fin Bending
6	48.75	Wing Bending & Torsion	49.59	Wing Bending & Torsion
7	65.09	Stabilizer Bending	53.22	Wing & Fuselage Bending
8	68.63	Stabilizer Bending & Wing Torsion	54.48	Stabilizer
9	78.80	Wing Torsion	79.14	Wing Torsion, Fin & Stabilizer Bending
10	102.89	Fuselage & Stabilizer Bending	81.40	Wing Torsion, Fin & Stabilizer Bending

3.3 Aerodynamic Forces

Unsteady aerodynamic forces on the wing, horizontal stabilizer and fin (antisymmetric analysis only) were generated using a three-dimensional plate doublet finite element solution. The theory accounts for Mach number and finite span effects, and includes aerodynamic coupling between all drone components. The unknown pressure distribution is determined for each drone mode by considering pressure to be constant over a given aerodynamic panel and solving for the pressure based on a specified reduced frequency and Mach number. The primary surfaces and control surfaces were modeled with a mesh of trapezoidal elements arranged in strips parallel to the free stream. The control surface was modeled with four patches. The aerodynamic panel idealizations are shown in Appendix A.

3.4 Equations of Motion

Initial equations of motion were formed using complex oscillatory aerodynamic coefficients generated for specific values of the reduced frequency parameter, ω/U_o. Final equations of motion were formulated in terms of real matrices through introduction of an "interpolating" or "approximating" function.

The original equations were the standard form:

$$\left(-(j\omega)^2[\text{Mass}] + (j\omega)[\text{Damping}] + [\text{Stiffness}]\right) \{q(j\omega)\}$$
$$+ \rho U_o^2 \left[A_I\left(\frac{j\omega}{U_o}\right)\right]\left([C_\theta]\ \{q(j\omega)\} + \frac{j\omega}{U_o}\ [C_Z]\{q(j\omega)\}\right.$$
$$\left. + \frac{1}{U_o}\ [C_W] \begin{Bmatrix} W_g(j\omega) \\ \hline V_g(j\omega) \end{Bmatrix}\right) = 0$$

where q is the generalized coordinate and A_I is an aerodynamic influence coefficient matrix which can be evaluated for specific values of ω/U_o. The matrices C_θ, C_Z and C_W prescribe the usual linearized boundary conditions.

If one of the elements of the complex matrix A_I is plotted, as ω takes on selected values from 0 to 400 radians/second, the result appears as the X's on Figure 3-2.

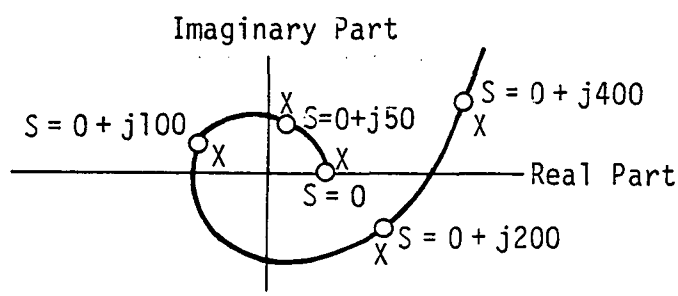


FIGURE 3-2 - TYPICAL COMPLEX COEFFICIENT AS A FUNCTION OF FREQUENCY

The solid line of Figure 3-2 is an approximating function, chosen as a rational polynominal function of the complex variable S. The circles are values of the approximating function at values of S for which the X's are plotted. The approximating function was chosen to permit accurate approximating of the time delays inherent in the unsteady aerodynamics subject to the following restrictions:

- It must have complex conjugate symmetry
- It must have denominator roots in the left half-plane
- It must approximate the value of the complex coefficient when $S = 0 + j\omega$, for those values of ω analyzed.

The approximating function for each element in the aerodynamic influence coefficient matrix was determined after analysis at twelve discrete frequencies. When the approximating functions are substituted in the equations of motion for the complex aerodynamic coefficients, a new set of equations results, whose coefficients are coefficients of the approximating function. After rearrangement, the final form of the equations of motion with variable density ρ and velocity U_o and without gust penetration is:

$$
\begin{aligned}
&(S^2[\text{Mass}] + S[\text{Damping}] + [\text{Stiffness}])\ \{q(S)\} \\
&+ \left(S^2\rho[C_1] + S\rho U_o[C_2] + \rho U_o{}^2\ [C_3] + \rho U_o{}^2 \sum_{i=1}^{4} [D_i]\ \frac{S}{S + U_o B_i}\right) \{q(S)\} \\
&+ \left(\rho U_o[R_o] + \rho U_o \sum_{i=1}^{4} [R_i]\ \frac{S}{S + U_o G_i}\right) \begin{Bmatrix} W_g(S) \\ \hline V_g(S) \end{Bmatrix} = \{0\}.
\end{aligned}
$$

The items in the first line of the above equation are structural coefficients; items in the second line are aerodynamic coefficients; items in the third line are gust velocity coefficients, where:

S	= LaPlace variable
ρ	= Air density
U_o	= True airspeed
[MASS]	= Structural mass
[DAMPING]	= Structural damping
[STIFFNESS]	= Structural stiffness
$[C_1]$, $[C_2]$, $[C_3]$	= Aerodynamic parameters
$[D_1]$, $[D_2]$, $[D_3]$, $[D_4]$	= Aerodynamic parameters
$[B_i]$, $[G_i]$	= Lift growth parameters
$[R_0]$, $[R_1]$, $[R_2]$, $[R_3]$, $[R_4]$	= Vertical and lateral gust coefficients
$q(S)$	= Rigid body, structural and control surface freedoms
$W_g(S)$	= Vertical gust
$V_g(S)$	= Lateral gust

The drone equations of motion for Mach 0.90 are presented in Appendix B. Velocity and air density are explicit functions which are selected by the user.

Because of the continuity of the aerodynamic coefficients as ω varies (no aerodynamic poles or zeroes in the vicinity of the imaginary axis) these equations are considered to be good approximations of the LaPlace transformed equations. They should not be depended upon for values of S too remote from the imaginary axis (greater than 40 radians/second) or above the highest frequency analyzed (greater than 400 radians/second).

3.5 Unsymmetric Equations of Motion

Equations of motion were used which would accept independant left and right side inputs directly, and provide left and right side outputs. Since there were no dissymmetries in the open loop aircraft, an uncoupled stacking of the symmetric and antisymmetric equations was accomplished. The control surface freedoms for the unsymmetric equations were defined by transforming the full airplane control freedoms to the right and left sides of the unsymmetric model. Symmetric, antisymmetric and unsymmetric control freedoms were obtained by the appropriate combinations of right and left side control freedoms.

The form of the resulting equations of motion was unchanged. Although input and output coefficient matrices were fully populated, the equation coefficients were 50% sparse. No computing advantage was taked of the sparseness, however, since the same software for synthesis and input/output was used as in the solely symmetric and solely antisymmetric cases.

The order of the displacement freedoms in the unsymmetric equations of motion was as listed in Table 3-II.

3.6 Open Loop Flutter Analysis Results

Flutter analyses were performed for the drone with the ARW-1 wing with standard planar doublet aerodynamics defined for a Mach number 0.1 higher than the condition being analyzed and with scaled planar doublet aerodynamics as described in Reference 9.

Flutter analyses were performed using the standard planar doublet aerodynamics with fixed ailerons, free floating ailerons and floating ailerons with actuator damping. The ailerons were not mass balanced for any of the analyses. For the fixed aileron configuration, analyses were performed for both the symmetric and antisymmetric model with the resulting flutter boundaries shown on Figure 3-3. Flutter mode frequency and damping curves

TABLE 3-II

DEGREES OF FREEDOM FOR THE UNSYMMETRIC EQUATIONS OF MOTION

NO.	FREEDOM
1	Rigid body, X - displacement, + aft
2	Rigid body, Y - displacement, + right
3	Rigid body, Z - displacement, + up
4	Rigid body, ϕ - roll, + right wing up
5	Rigid body, θ - pitch, + nose up
6	Rigid body, ψ - yaw, + nose left
7 : 16	Symmetric elastic modes 1 thru 10
17 : 26	Antisymmetric elastic modes 1 thru 10
27	Symmetric aileron, + trailing edge down
28	Antisymmetric aileron, + trailing edge down on right side
29	Symmetric stabilizer, + trailing edge down
30	Antisymmetric stabilizer, + trailing edge down on right side
31	Rudder, + trailing edge left
32	Right wing aileron, + trailing edge down
33	Left wing aileron, + trailing edge down

Freedoms 32 and 33 may be used in combination to model symmetric or antisymmetric ailerons.

Symmetric = +0.5(32) + 0.5(33), + trailing edge down, both wings

Antisymmetric = +0.5(32) - 0.5(33), + trailing edge down, right wing
+ trailing edge up, left wing

are shown, for each of the Mach numbers analyzed, on Figures 3-4 through 3-17. The symmetrical model was analyzed with free floating ailerons and with ailerons with actuator damping. A damping value of 0.226 Newton-meter/radian/second (2 in-lb/rad/sec) was used for the actuator. This is 50 percent of the measured damping for an actuator of similar design. The flutter boundaries from these analyses are presented on Figure 3-18. The normal mode flutter boundary for the floating aileron with actuator damping is coincident with the fixed aileron flutter boundary. There is no aileron flutter below an altitude of 15 240 meters (50 000 feet) when actuator damping is included. The free floating aileron has minimal effect on the normal flutter mode flutter boundary with an increase of approximately 152.4 meters (500 feet) in the flutter altitude. The free floating aileron (corresponding to an actuator shaft failure) also flutters in a different mode at low dynamic pressures. This failed-shaft flutter mode would probably limit-cycle at maximum aileron deflection producing non-destructive wing bending deflections.

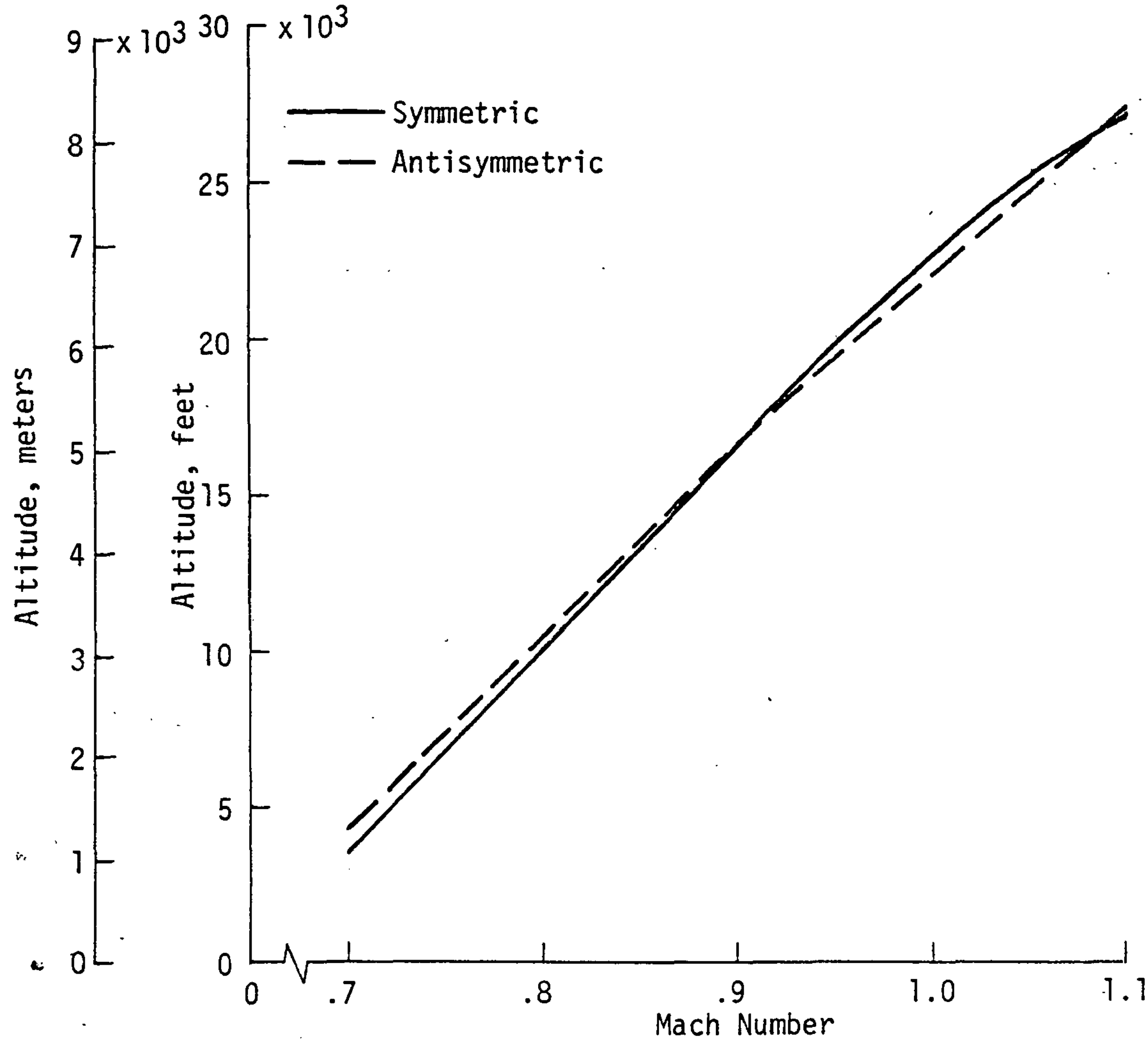


FIGURE 3-3 - SYMMETRIC AND ANTISYMMETRIC OPEN LOOP FLUTTER BOUNDARIES

Flutter analyses were performed to show the effects of variations in the aerodynamic model. Mach effects were analyzed by using Mach number plus 0.1 aerodynamics (i.e., the Mach 0.80 condition was analyzed with Mach 0.90 aerodynamics and the Mach 0.95 condition with Mach 1.05 aerodynamics). The flutter altitude increased less than 152.4 meters (500 feet) when using the higher Mach number aerodynamics. Additional analyses were performed using planar doublet aerodynamics with pressure and normalwash effectivity factors. The effectivity factors are shown on Figure 3-19. The flutter altitude for Mach 0.90 using the effectivity factors shown on Figure 3-19 is approximately 1219.2 meters (4000 feet) higher than the flutter altitude defined with the standard aerodynamics. This is consistent with the results published for ARW-2 in Reference 9.

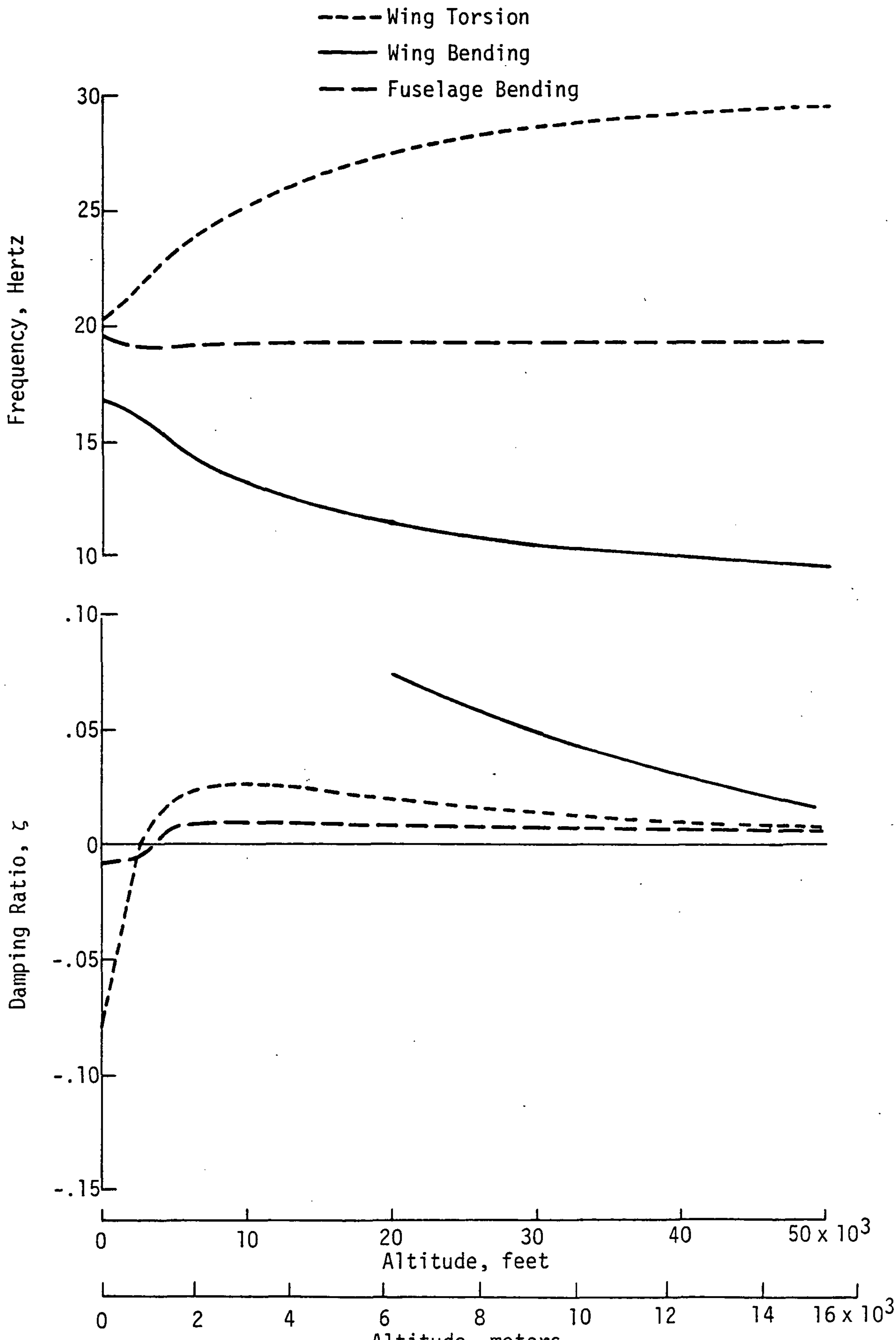


FIGURE 3-4 - FREQUENCY AND DAMPING, SYMMETRIC FLUTTER MODES, MACH 0.70

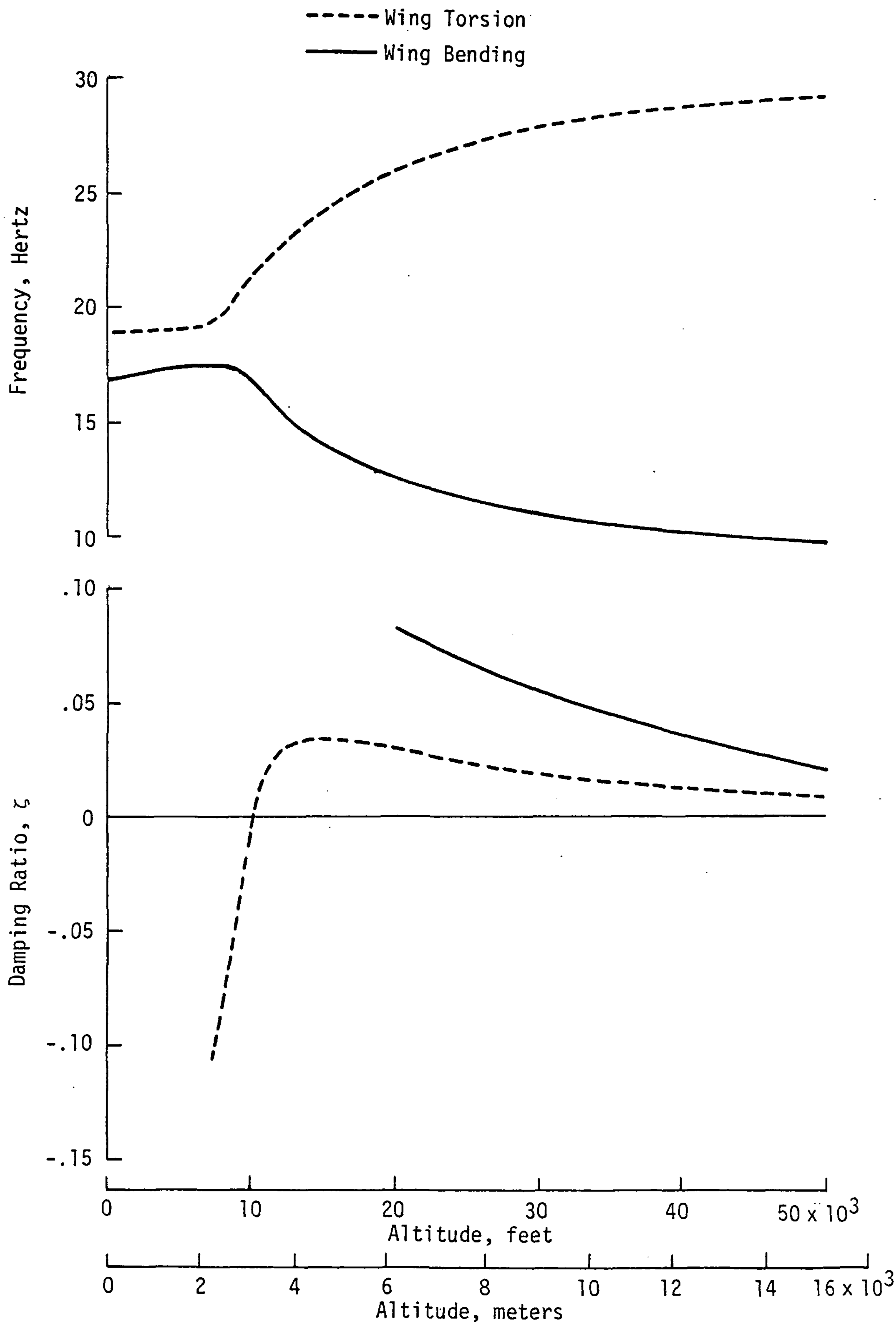


FIGURE 3-5 - FREQUENCY AND DAMPING, SYMMETRIC FLUTTER MODES, MACH 0.80

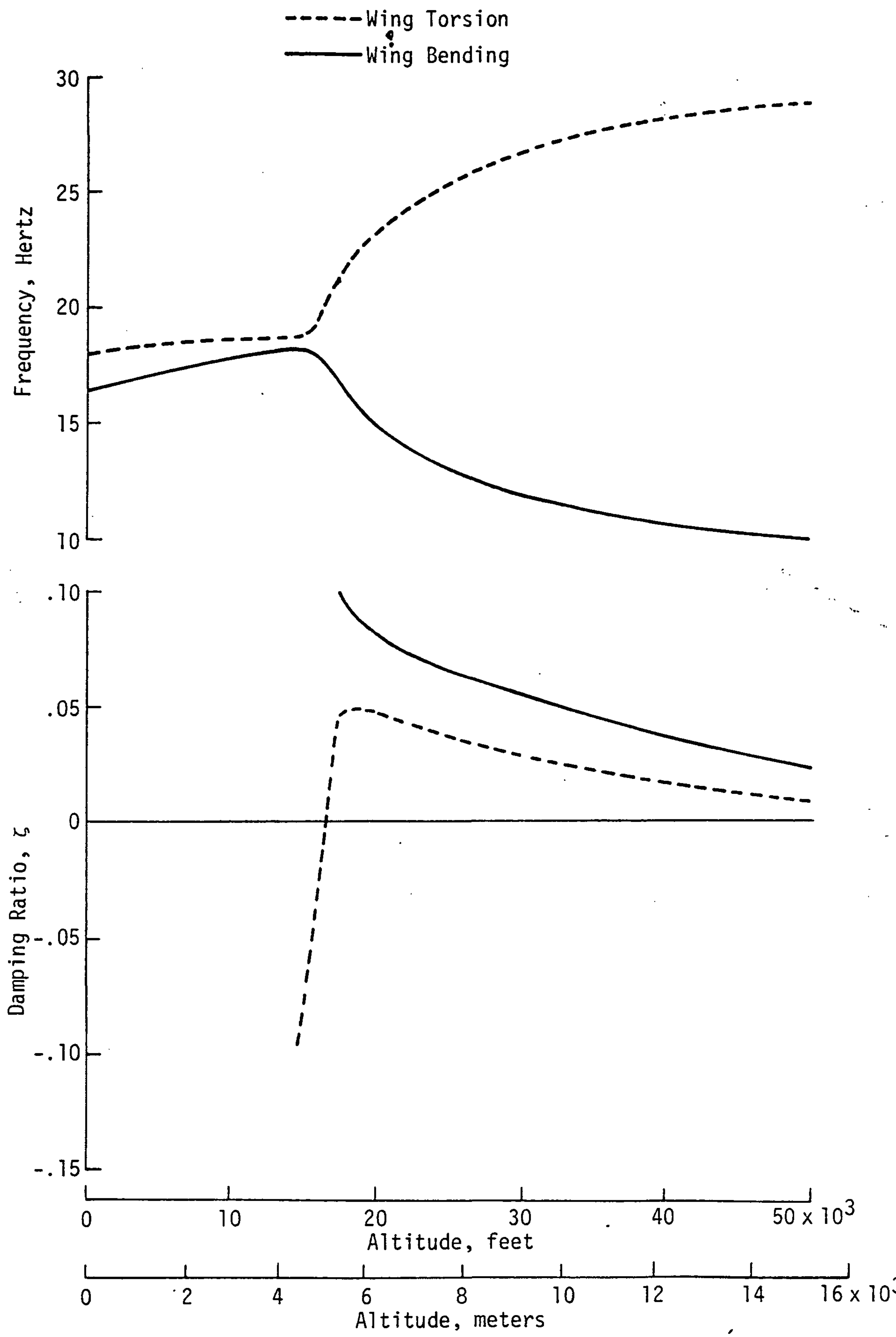


FIGURE 3-6 - FREQUENCY AND DAMPING, SYMMETRIC FLUTTER MODES, MACH 0.90

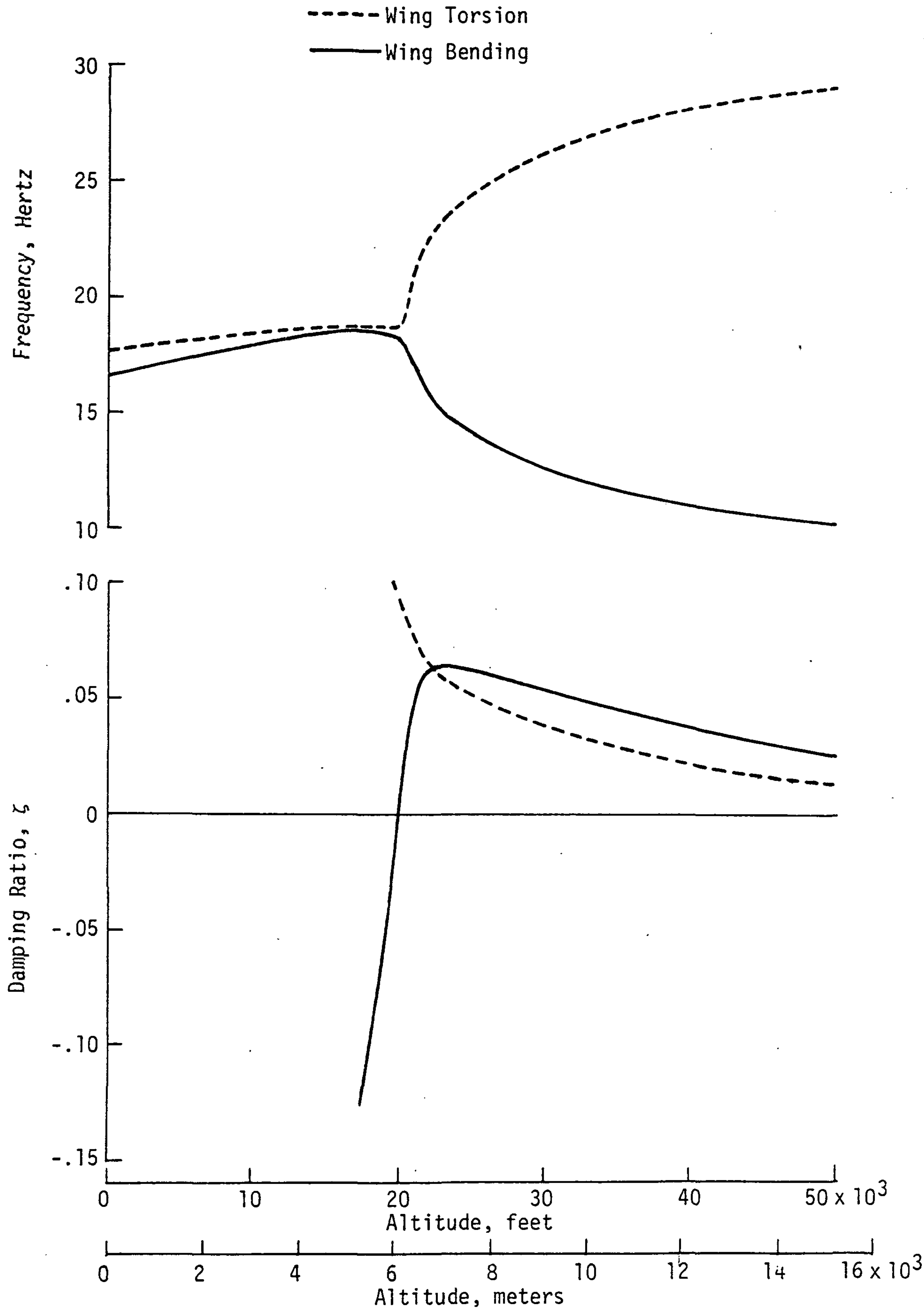


FIGURE 3-7 - FREQUENCY AND DAMPING, SYMMETRIC FLUTTER MODES, MACH 0.95

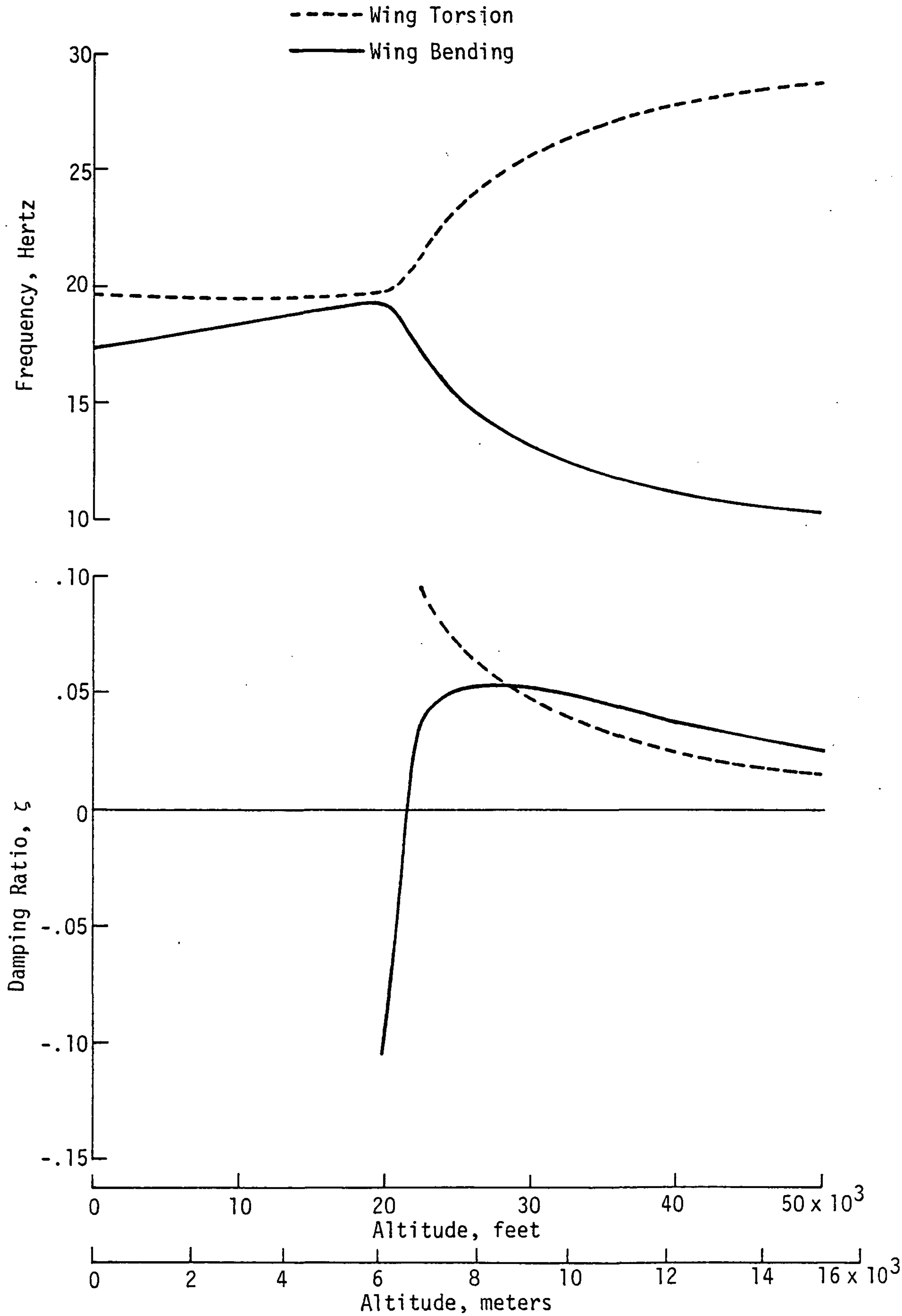


FIGURE 3-8 - FREQUENCY AND DAMPING, SYMMETRIC FLUTTER MODES, MACH 0.98

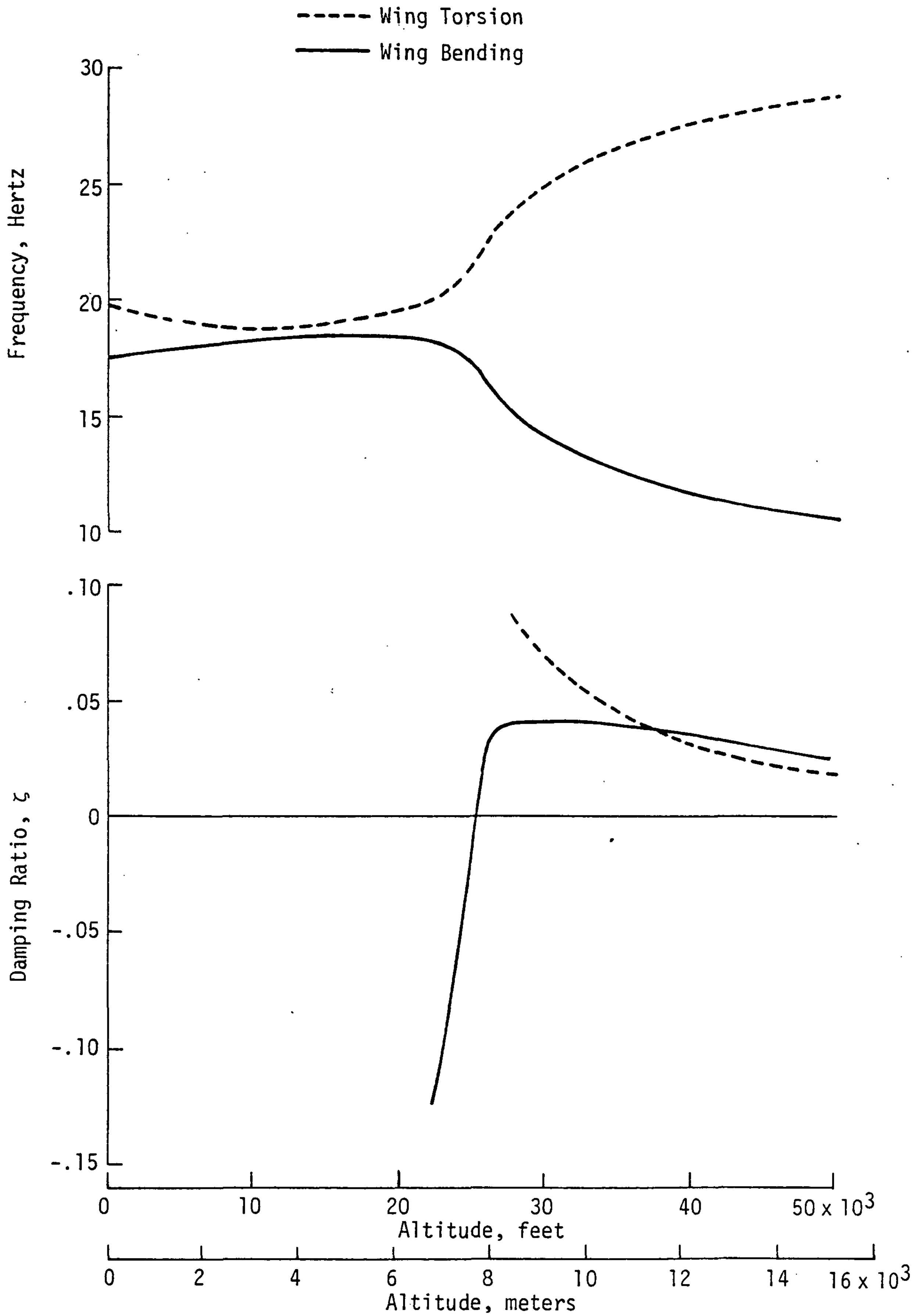


FIGURE 3-9 - FREQUENCY AND DAMPING, SYMMETRIC FLUTTER MODES, MACH 1.05

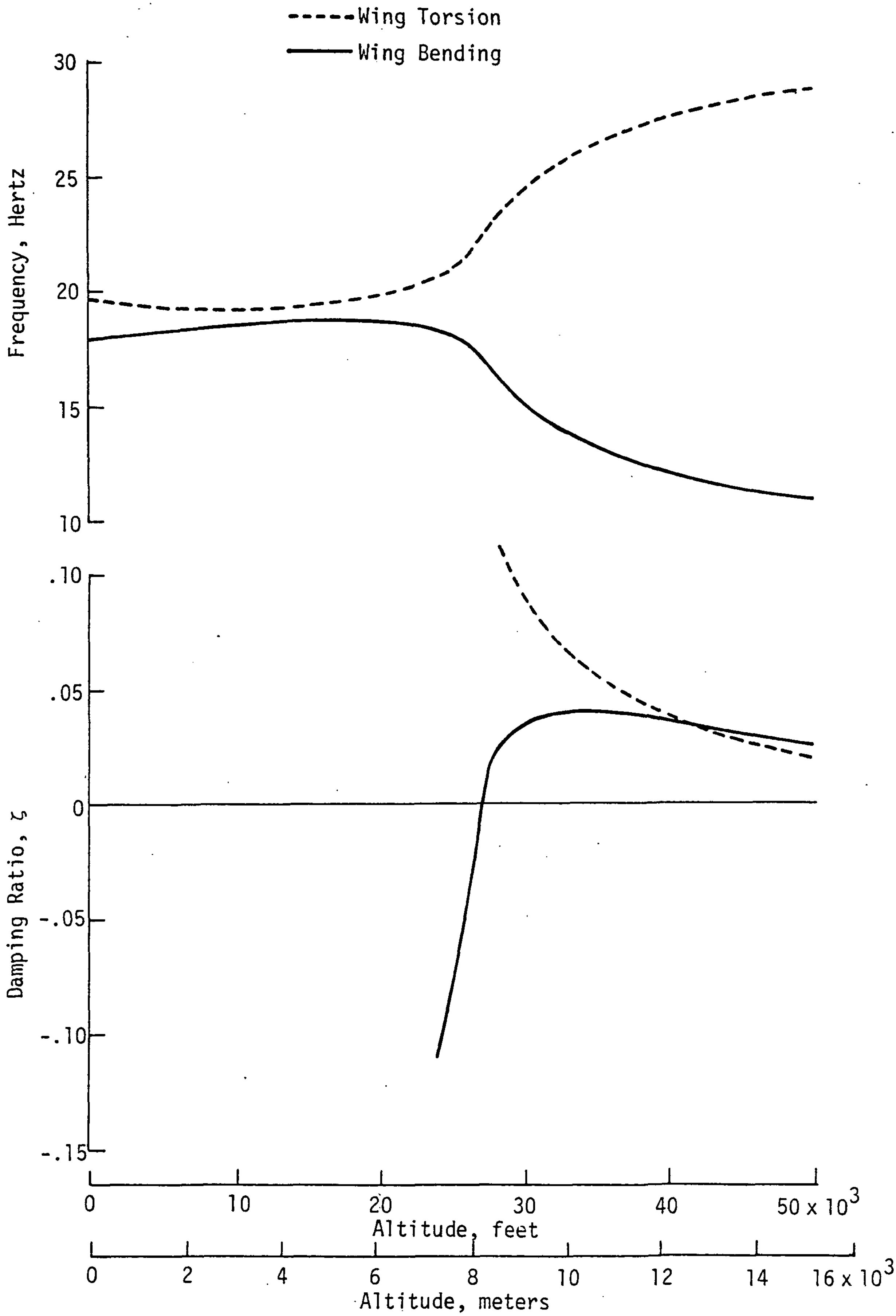


FIGURE 3-10 - FREQUENCY AND DAMPING, SYMMETRIC FLUTTER MODES, MACH 1.10

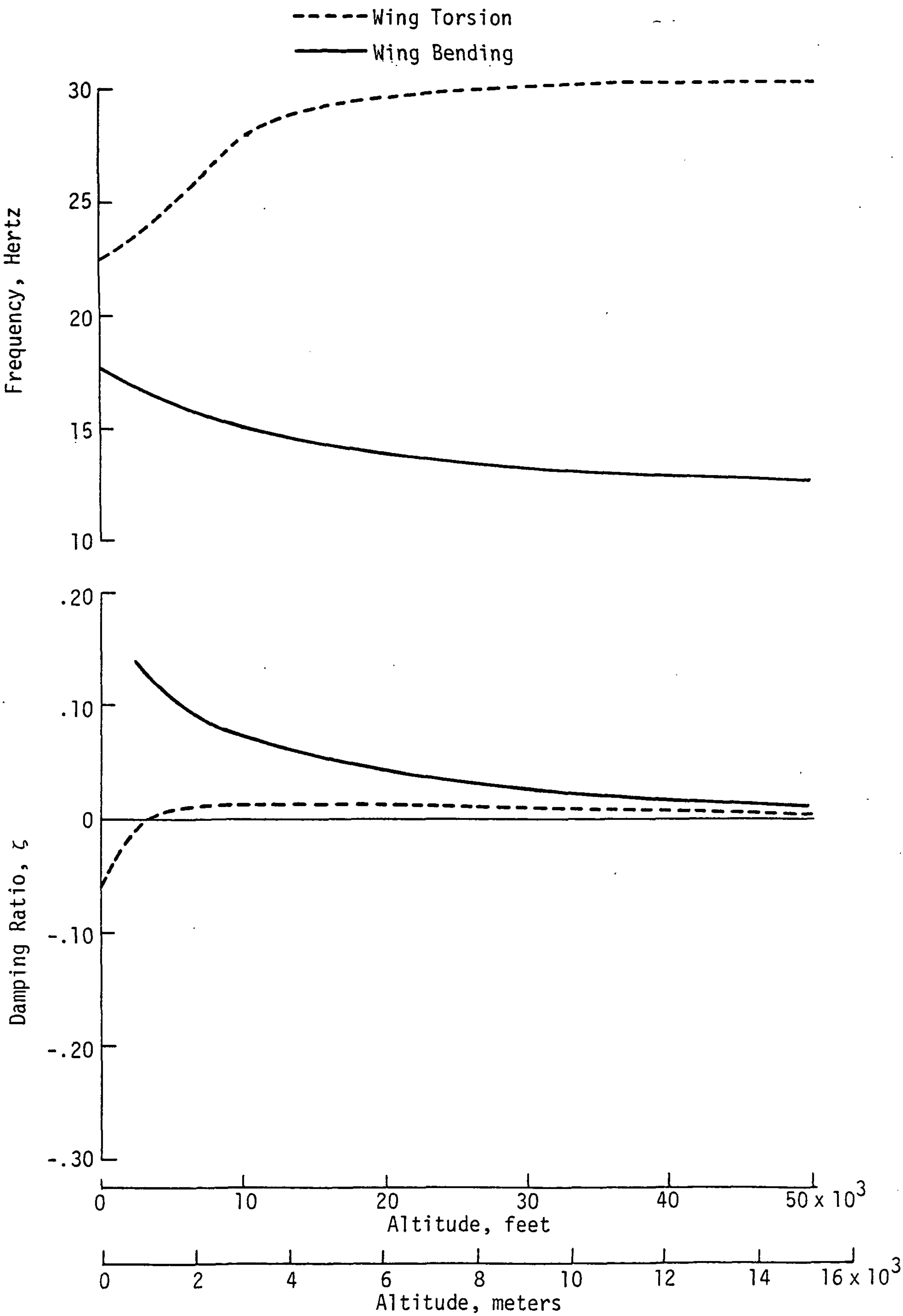


FIGURE 3-11 - FREQUENCY AND DAMPING, ANTISYMMETRIC FLUTTER MODES, MACH 0.70

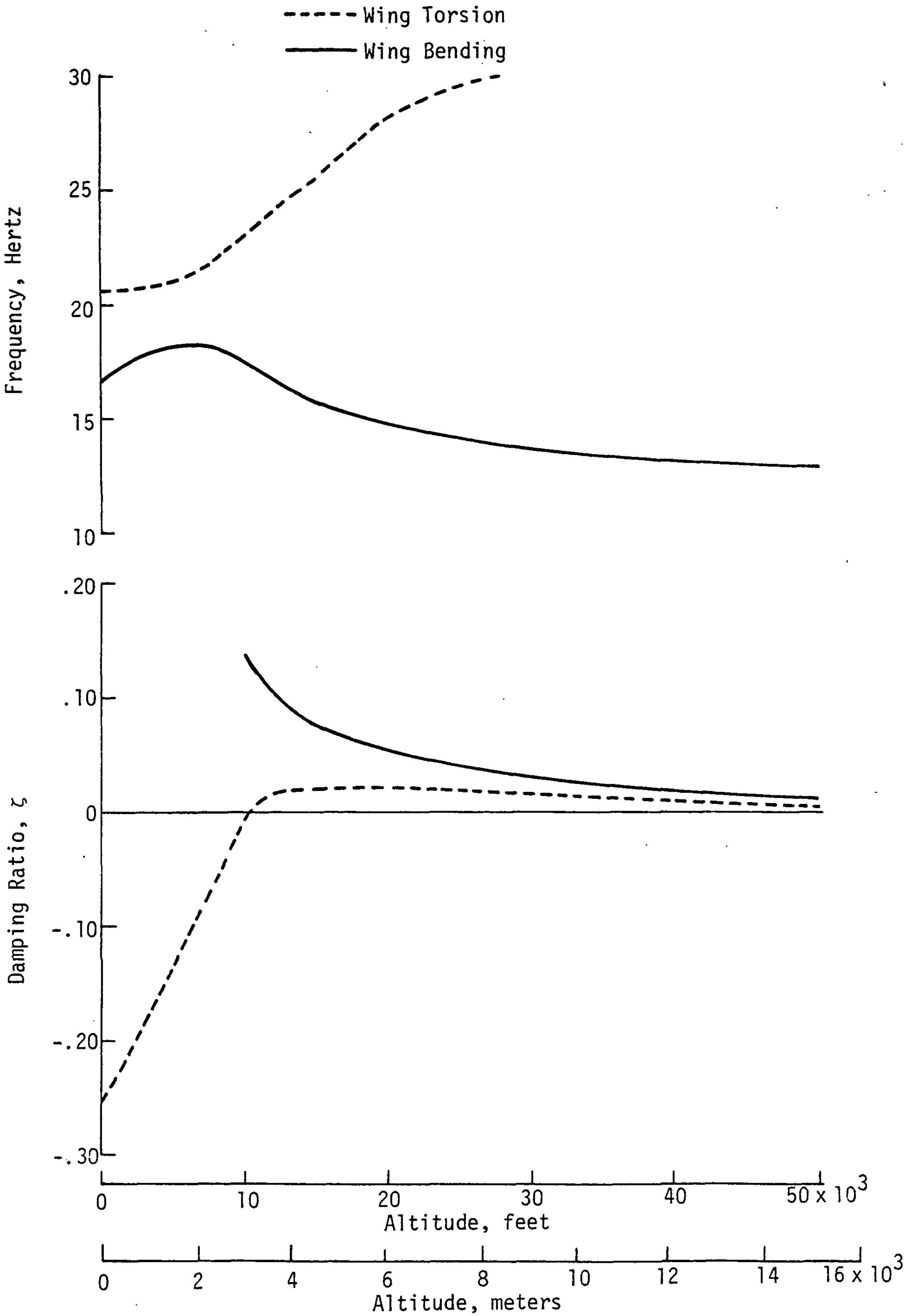


FIGURE 3-12 - FREQUENCY AND DAMPING, ANTISYMMETRIC FLUTTER MODES, MACH 0.80

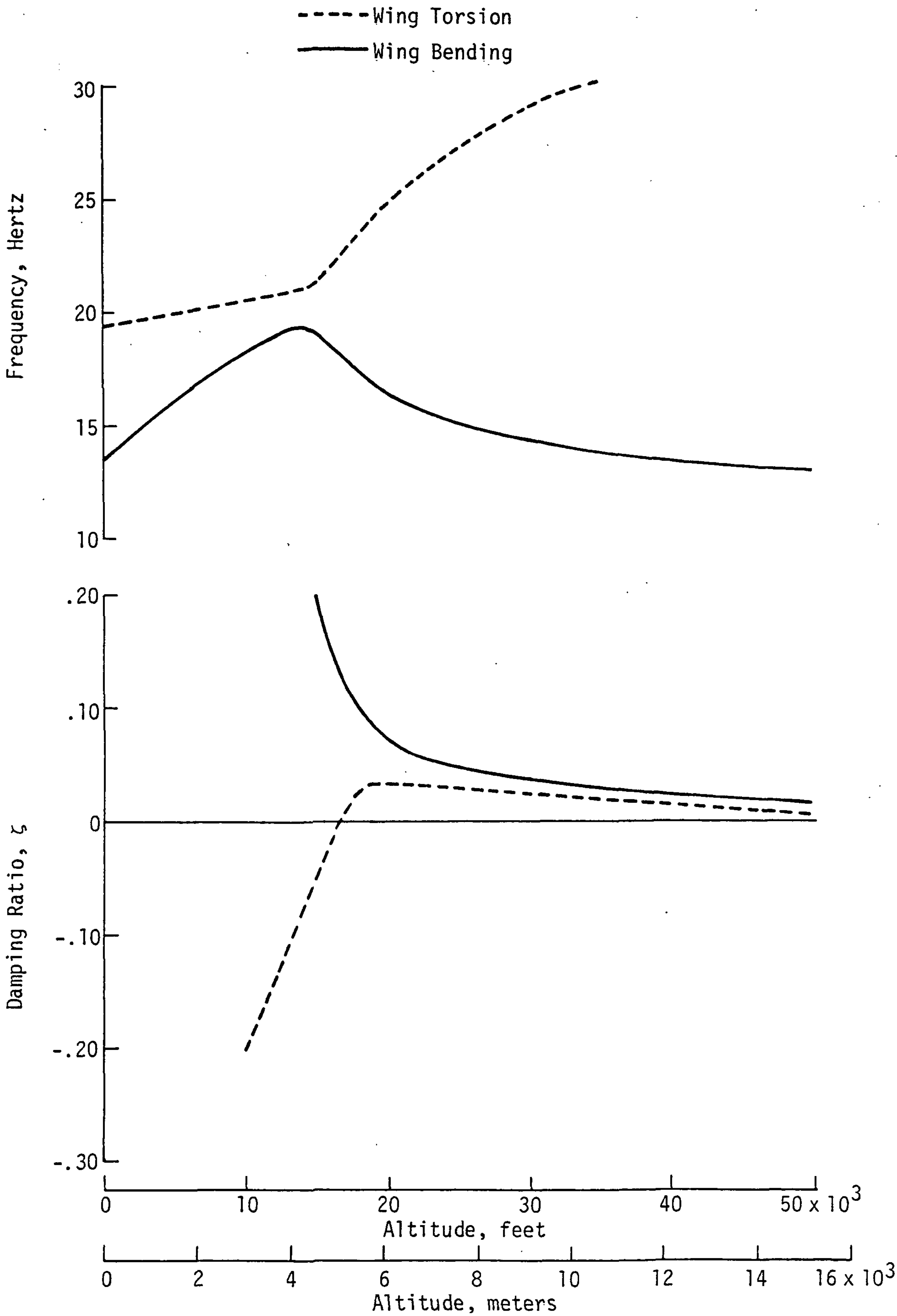


FIGURE 3-13 - FREQUENCY AND DAMPING, ANTISYMMETRIC FLUTTER MODES, MACH 0.90

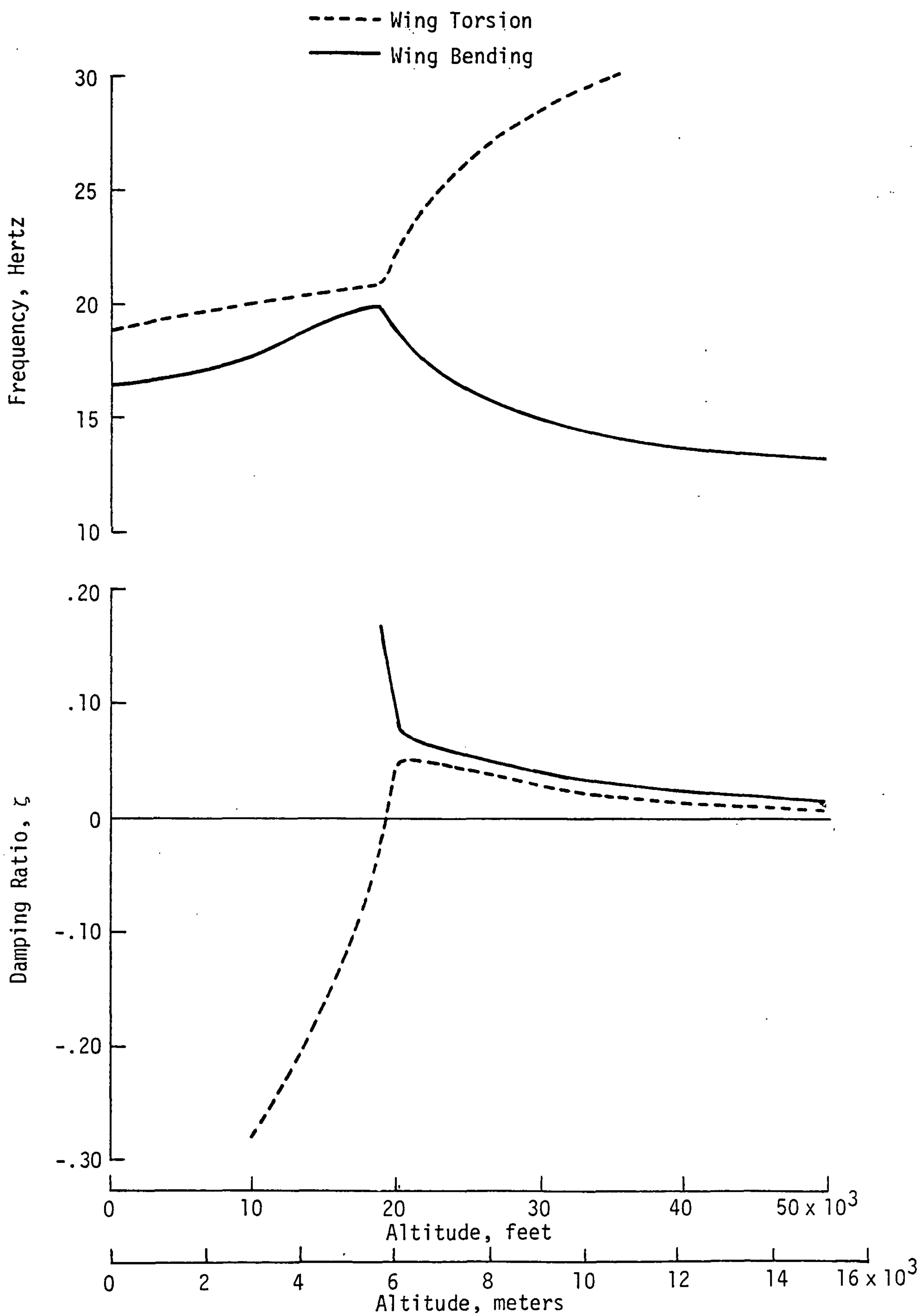


FIGURE 3-14 - FREQUENCY AND DAMPING, ANTISYMMETRIC FLUTTER MODES, MACH 0.95

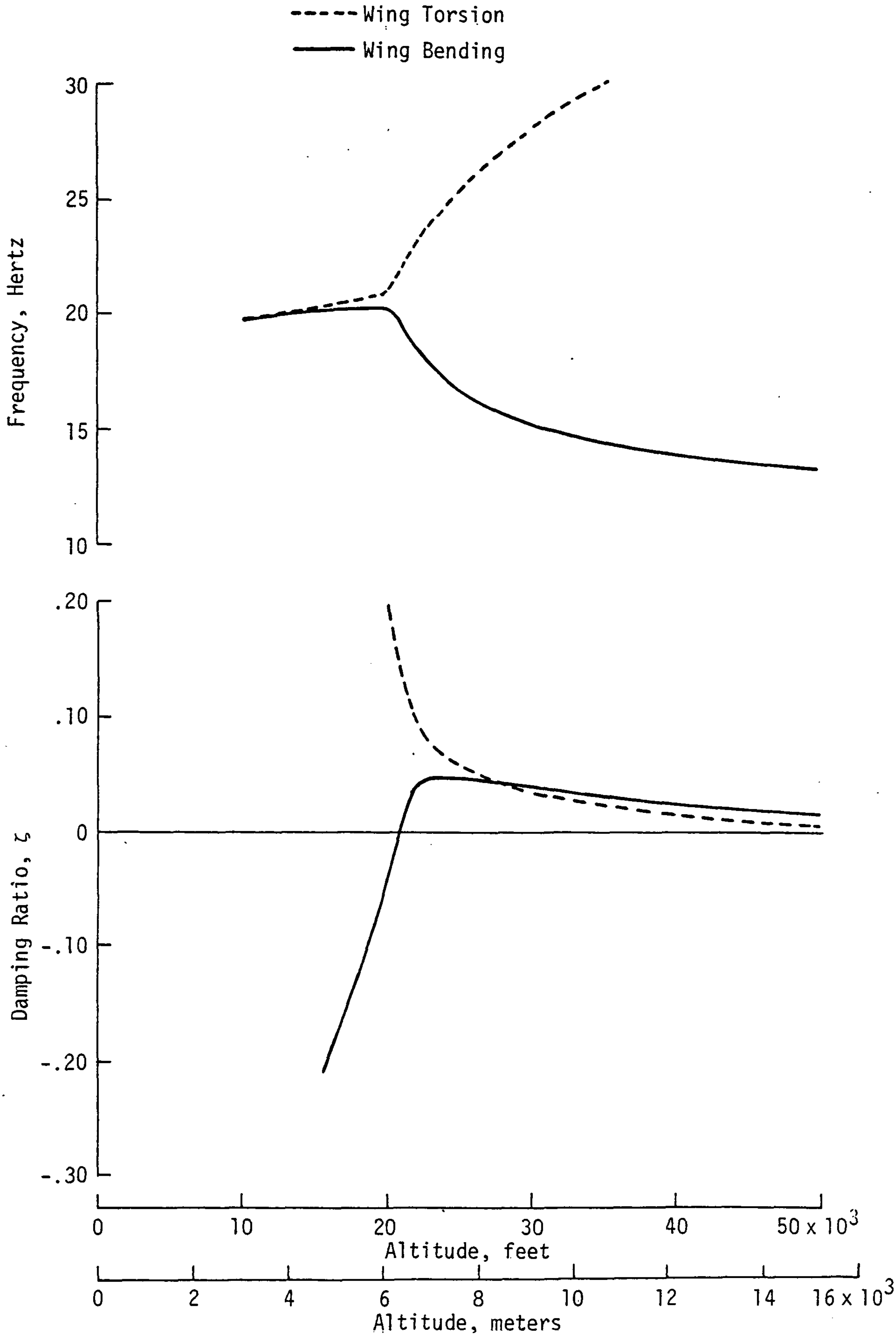


FIGURE 3-15 - FREQUENCY AND DAMPING, ANTISYMMETRIC FLUTTER MODES, MACH 0.98

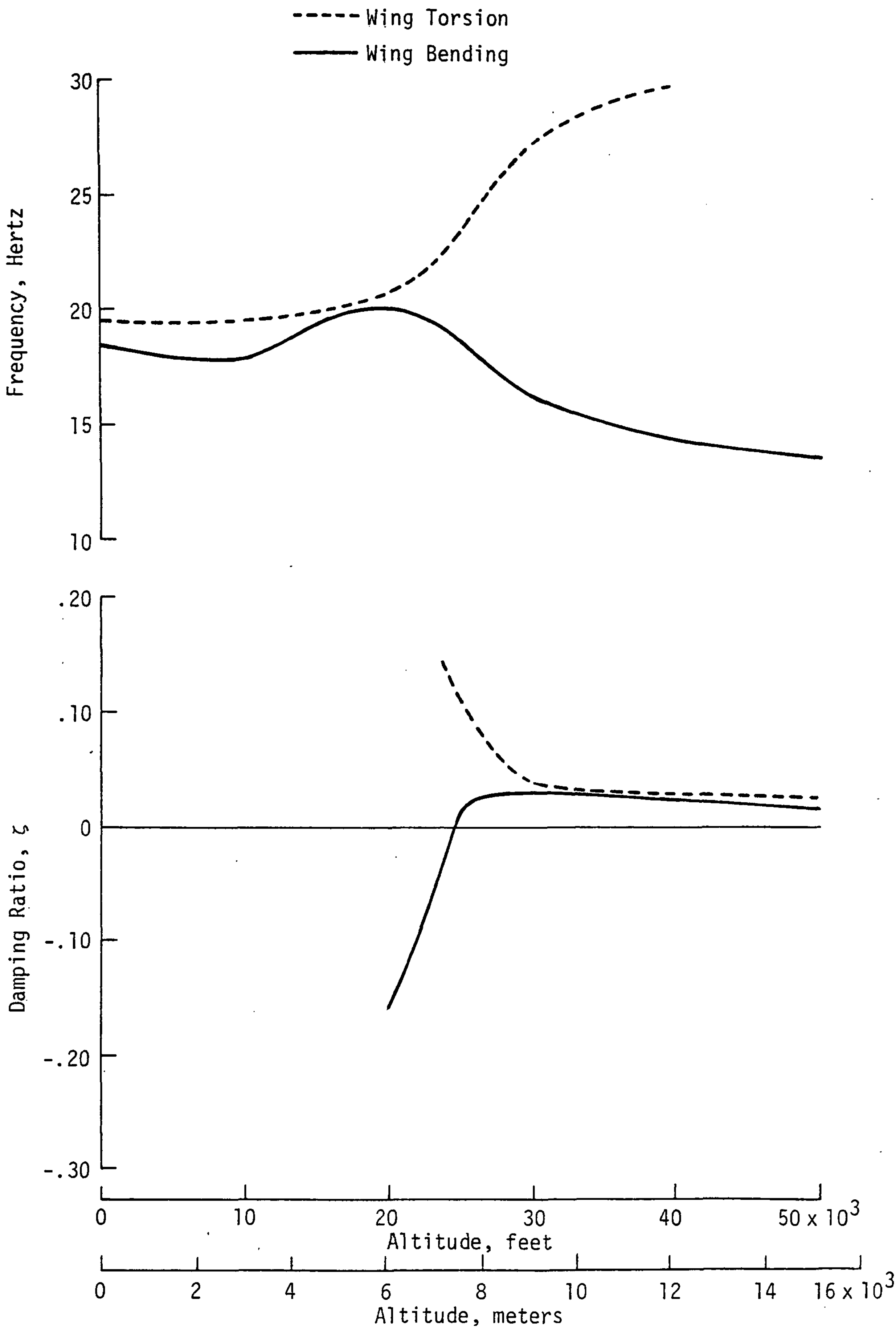


FIGURE 3-16 - FREQUENCY AND DAMPING, ANTISYMMETRIC FLUTTER MODES, MACH 1.05

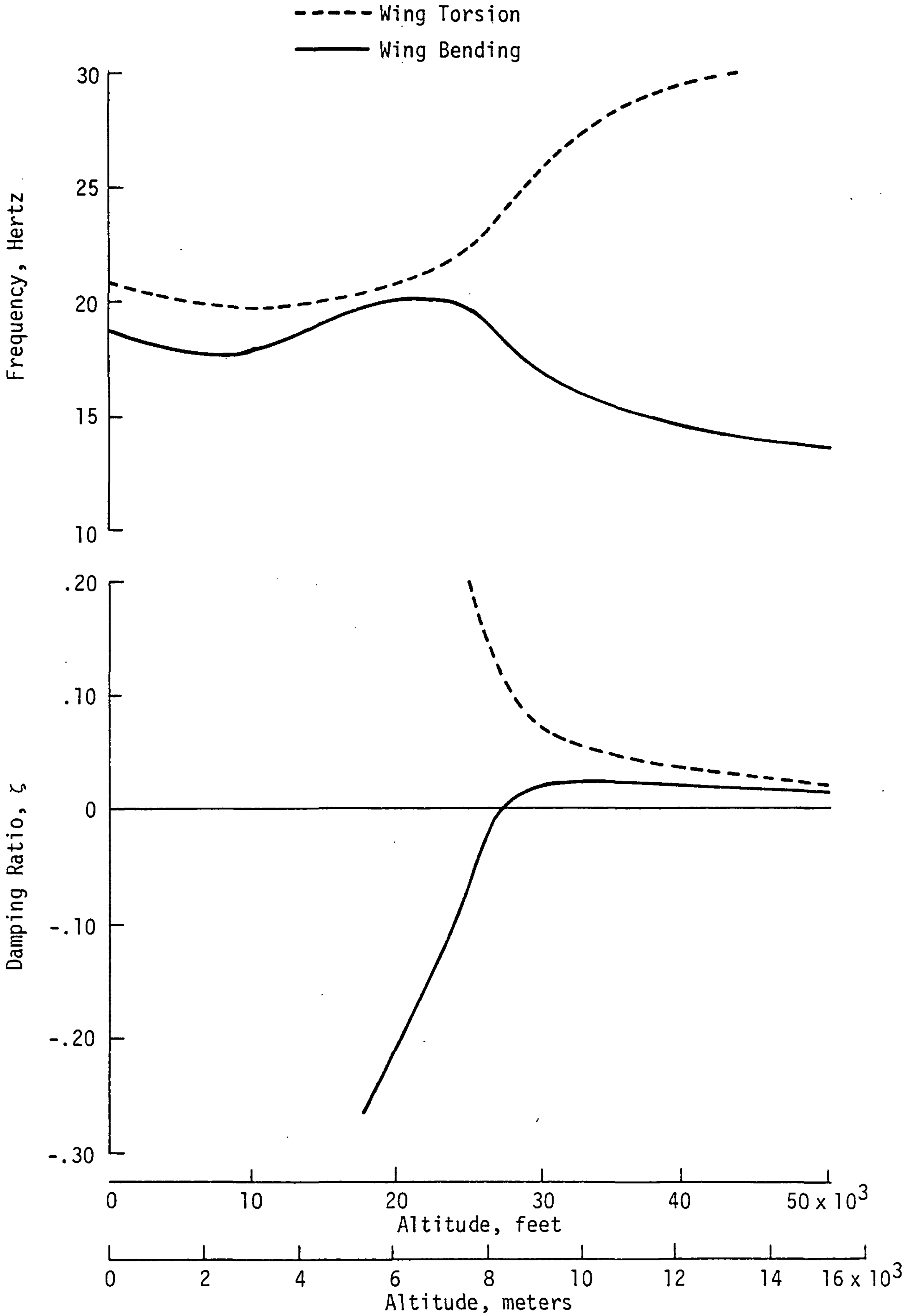


FIGURE 3-17 - FREQUENCY AND DAMPING, ANTISYMMETRIC FLUTTER MODES, MACH 1.10

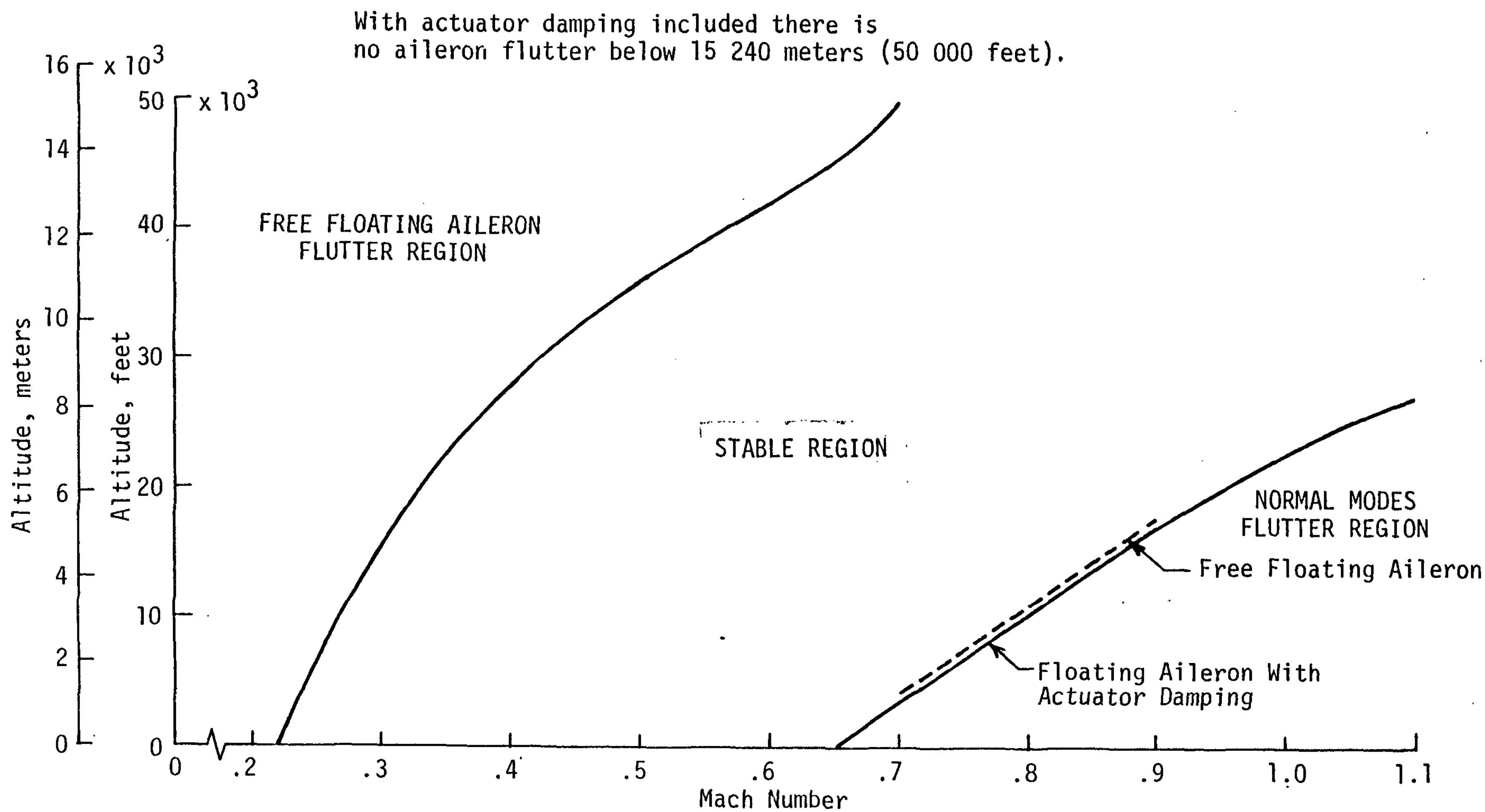


FIGURE 3-18 - FLOATING AILERON FLUTTER BOUNDARIES

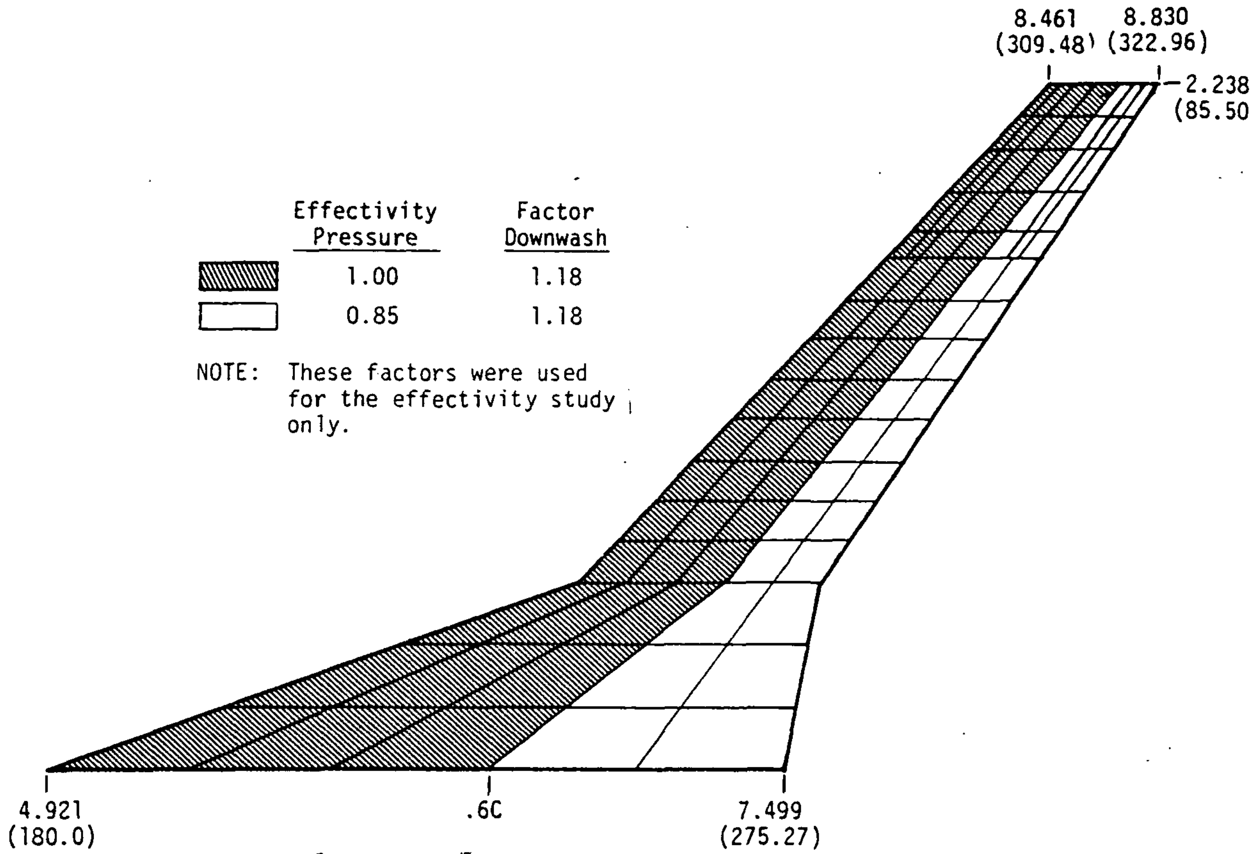


FIGURE 3-19 - PLANAR DOUBLET EFFECTIVITY FACTORS

4.0 FLUTTER SUPPRESSION SYSTEM SYNTHESIS

Analysis was conducted in this study to finalize the synthesis of a flutter suppression system (FSS) for the DAST ARW-1 drone configuration. Analysis was conducted previously in the preliminary design study (Reference 1), which identified a wing ballast configuration that met the design objective of a wing flutter mode 20 percent below the ARW-1 drone limit velocity, Mach 0.98. Preliminary symmetric and antisymmetric flutter suppression systems were synthesized during the preliminary design study for this configuration. A summary of the preliminary design study results is presented in Paragraph 4.1.

Final synthesis was conducted using the mathematical models described in Section 3.0. These equations of motion contain fuselage structural elastic modes in addition to the wing modes modeled during the preliminary analysis. An outboard wing, 0.254 meter (10 inches) span control surface was modeled as a result of the study conducted during the preliminary analysis. After the FSS was finalized, a thorough performance evaluation was conducted as described in Section 5.0.

4.1 Preliminary Design Study Results

This section summarizes results of the preliminary design study analyses documented in Reference 1. In this study, preliminary design of a flutter suppression system for the DAST ARW-1 drone was accomplished.

4.1.1 Configuration - During the course of the preliminary design study four configurations were modeled and analyzed. The final configuration included a 0.907 kilogram (two pound) ballast added to each wing tip at WBL 2.013 (79.25) and an outboard 0.254 meter (10 inch) span control surface between WBL 1.965 (77.35) and WBL 1.711 (67.35). This configuration exhibited symmetric and antisymmetric flutter modes that were similar in nature with flutter onset at more than 20 percent below the limit velocity at 3048 meter (10 000 feet) altitude.

4.1.2 Actuator dynamics and compensation - The servoactuator model used throughout the analysis was

$$\frac{\delta_A(S)}{V_C(S)} = \frac{K}{(S+3608)(S^2+634S+387^2)(S^2+351S+628^2)(S^2+1591S+1492^2)}$$

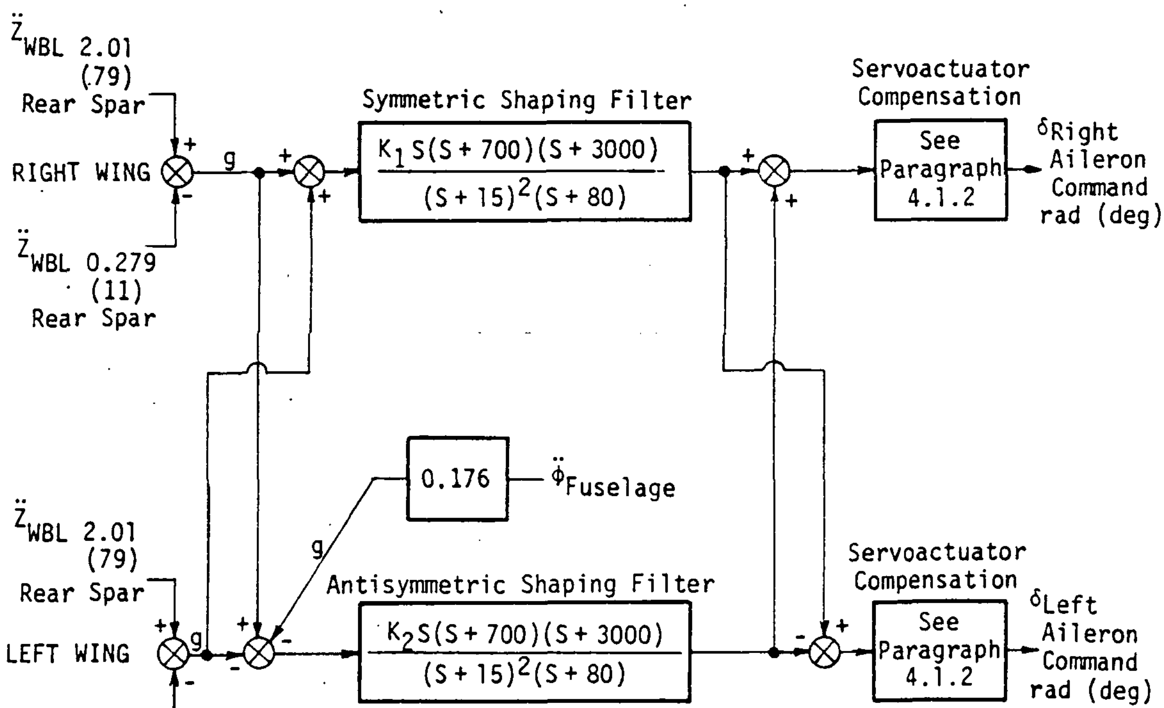
where $K = 8.51 \times 10^{18}$ rad/volt (4.88×10^{20} deg/volt). The steady state gain of the servoactuator was 0.01745 rad/volt (1.0 deg/volt).

The servoactuator transfer function was modified using compensation to nullify the two lower frequency, second order terms. The compensation, which has a steady state gain of 1.0 volt/volt, is given as:

$$\frac{V_o(S)}{V_i(S)} = \frac{7466(S^2 + 634S + 387^2)(S^2 + 351S + 628^2)}{(S^2 + 1800S + 3000^2)(S^2 + 7000S + 7000^2)} \frac{\text{Volt}}{\text{Volt}} .$$

With this compensation the total transfer function of the compensated servoactuator could be simplified to unity due to the large separation in frequency between the remaining terms and the flutter mode.

4.1.3 FSS definition - Initially, each configuration was analyzed using zero root loci to determine combinations of sensors and control surfaces that could control the flutter modes. Initial analysis results indicated that a vertical accelerometer on the wing rear spar combined with an outboard wing control surface provided the best coupling with the flutter mode. Analysis on subsequent configurations indicated that by subtracting inboard wing vertical acceleration from outboard vertical acceleration and using a 0.254 meter (10 inch) control surface, coupling with the short period mode could be minimized and control surface rate requirement reduced. Symmetric and antisymmetric FSS filters were then synthesized using root locus methods in an iterative manner. A block diagram of the final system is shown on Figure 4-1.



Mach Number	K_1
0.8	5.52×10^{-4} rad (.0316 deg)
0.9	5.52×10^{-4} rad (.0316 deg)
1.0	2.62×10^{-4} rad (.0150 deg)

$K_2 = 5.52 \times 10^{-4}$ rad (.0316 deg)

FIGURE 4-1 - PRELIMINARY DESIGN STUDY FLUTTER SUPPRESSION BLOCK DIAGRAM

4.1.4 Results and recommendations - Although the preliminary FSS stabilized the flutter mode at all design conditions, the system had several undesirable characteristics. The actuator compensation had high frequency gain of 7466 volts/volt. The shaping filters did not have high frequency roll-off and had low frequency gain of approximately 0.873 rad/g (50 deg/g). The FSS did not have adequate phase margin at low dynamic pressure conditions. These characteristics required correcting while meeting the design criteria during the final design study analysis.

4.2 System Criteria

Criteria used during the FSS synthesis guided the form of the final system. The criteria included constraints on the system, such as type of sensors or maximum order of the shaping filters, and synthesis criteria which set performance goals such as stability margins and modal damping.

4.2.1 System constraints - Constraint criteria ultimately affect performance of a system but do not specify any particular system performance. All constraints imposed were either directly or indirectly attributable to the preliminary design study results. Constraints that were a direct result of the preliminary design study were intended to minimize duplication of analyses already performed, while the indirect constraints were to improve the preliminary system.

NASA requested that the control surfaces be 0.254 meter (10 inch) span, trailing-edge surfaces, with approximately 20 percent chord, located between WBL 1.711 (67.35) and WBL 1.976 (77.35), as established in the preliminary design study. The sensors should be accelerometers with location and orientation to be determined through analysis. The control laws synthesized during the preliminary analysis should be considered for use in the final system.

Other constraints were imposed to improve the preliminary system. Actuator compensation should be avoided to reduce phase shifts induced when the pole-zero cancellation is imperfect and to eliminate the extremely large high-frequency gain required to produce unity steady-state gain (see Paragraph 4.1). The control laws should have at least 40 dB/decade roll off to reduce coupling with high frequency modes and to reduce high frequency noise. The control laws should have as low gain as possible at low frequencies to reduce coupling with rigid body and filter modes.

4.2.2 Synthesis criteria - Synthesis criteria specify desired performance of the system. The synthesis criteria used in the FSS development are discussed in the next paragraph.

The FSS should produce a minimum increase of 20 percent in flutter velocity for the lowest flutter boundary (symmetric or antisymmetric). At altitudes where a 20 percent increase in flutter velocity ($1.2\ V_f$) exceeds Mach 0.98, the FSS should increase the flutter velocity to Mach 0.98. These requirements and the minimum flight altitude of 3048 meters (10 000 feet) are indicated by the shaded area on Figure 4-2. The FSS should exhibit MIL-F-9490D stability margins at or below V_f as given in Table 4-I. The FSS should not degrade damping of any mode to below a damping ratio of 0.01 (except the flutter mode) and should not significantly reduce damping of any mode with damping ratio below 0.01. The FSS should be capable of operating in 1.83 m/s (6 ft/sec) rms random turbulence with 3.66 m/s (12 ft/sec) peaks. Sensitivity analysis should be conducted to determine the maximum variations allowable in system parameters. The feasibility of a single wing FSS (using one control surface on either wing) should be evaluated using unsymmetric equations of motion. Although beyond the scope of this contract, implementation of such a system would be considered if proven feasible.

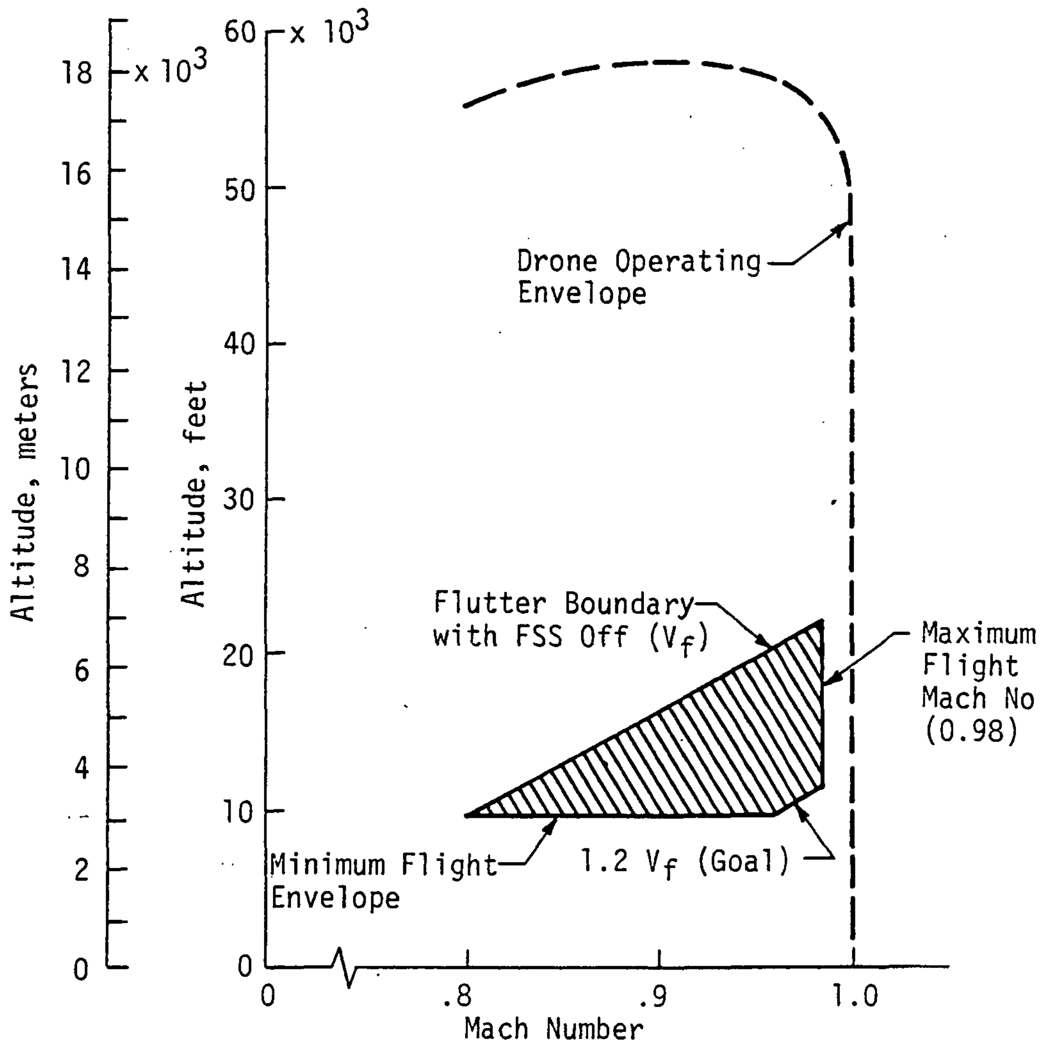


FIGURE 4-2 - DAST ARW-1 FLUTTER IMPROVEMENT AND OPERATING ENVELOPE

TABLE 4-I

MIL-F-9490D STABILITY MARGINS

Mode	Gain	Phase
Frequency $\leq$.06 Hz	±3.0dB	±0.349 rad (20°)
.06 Hz < Frequency < First Structural Mode	±4.5dB	±0.524 rad (30°)
All Structural Modes	±6.0dB	±0.785 rad (40°)

4.3 Final Flutter Suppression System

The form of the preliminary FSS, without the actuator compensation, was used as the starting point in the final system synthesis. The preliminary design study results including sensor type, position and orientation, control law form, and the constraints discussed in Paragraph 4.2.1, were used in the synthesis.

4.3.1 Configuration - The final DAST ARW-1 wing configuration is shown on Figure 4-3. The 0.907 kilogram (two pound) ejectable ballast is located near the wing tip at WBL 2.050 (80.70) and the outboard 0.254 meter (10 inch), 23 percent chord, trailing edge control surface is located between WBL 1.711 (67.35) and WBL 1.965 (77.35). The control surface chord was set at 23 percent chord to keep the actuators within the airfoil. The final FSS accelerometer position is shown on Figure 4-3 to illustrate the physical relationship of the various components.

The mathematical model included all the above components and fuselage and empennage structural elastic modes. These modes account for wing-body and wing-wing coupling which might affect the flutter modes and give better modeling of fuselage mounted sensors.

4.3.2 Servoactuator dynamics - Dynamics of the coupled actuator and control surface modes were included in the synthesis analysis. The transfer functions for the servoactuators were defined through analysis described in Section 6.0. The simplified transfer function of the servoactuator for the no-load condition is

$$\frac{\delta_{AIL}}{\delta_{CMD}}(S) = \frac{6.032 \times 10^{14}}{(S + 405.8)(S^2 + 608.1S + 971.6^2)(S^2 + 781.S + 1276^2)} \frac{\text{rad}}{\text{rad}}.$$

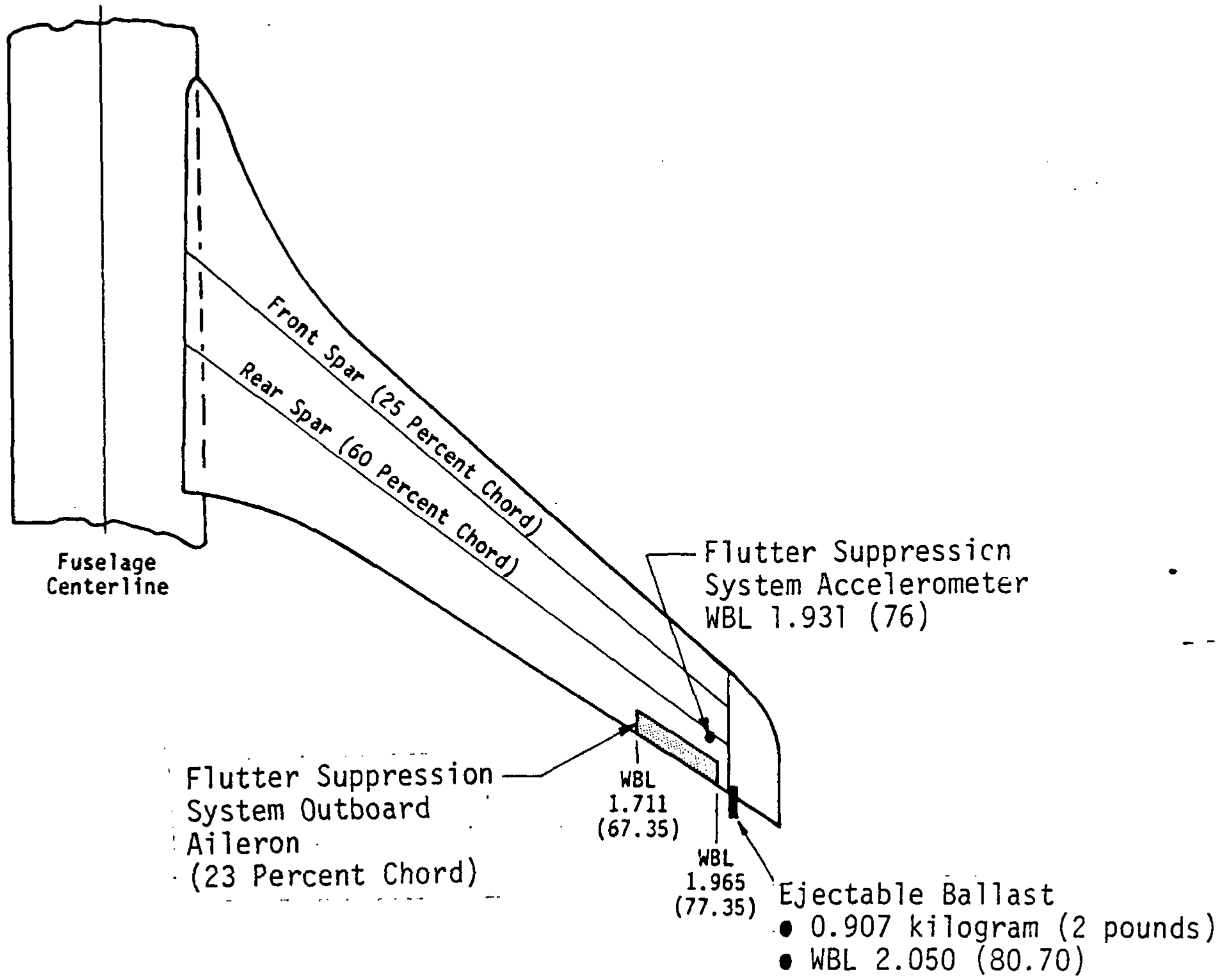


FIGURE 4-3 - FINAL DAST ARW-1 WING CONFIGURATION

Servoactuator dynamics vary with hinge moment, as discussed in Paragraph 6.1.3. The transfer functions for the maximum resisting and maximum aiding hinge moments are

MAXIMUM RESISTING

$$\frac{\delta_{AIL}}{\delta_{CMD}}(S) = \frac{3.2129 \times 10^{14}}{(S+179.9)(S^2+408.9S+970.5^2)(S^2+1236S+1377^2)} \quad \frac{rad}{rad},$$

MAXIMUM AIDING

$$\frac{\delta_{AIL}}{\delta_{CMD}}(S) = \frac{7.833 \times 10^{14}}{(S+499.5)(S^2+1228S+846.7^2)(S^2+120.0S+1479^2)} \quad \frac{rad}{rad}.$$

The no-load transfer function was used during the synthesis study. The effect of maximum reisting and maximum aiding hinge moment variations in actuator dynamics on FSS performance was evaluated and is discussed in Section 5.0.

4.3.3 Sensor selection - Sensor type and control surface size and location were fixed in the system constraints as described in Paragraph 4.2.1 leaving sensor location and orientation to be defined. Zero locus techniques were used to select these two parameters to satisfy two primary goals. Coupling with the flutter mode was to be maximized while minimizing adverse coupling with other structural and rigid body modes.

To establish sensor location(s), the selection process must be an integral part of the overall FSS synthesis, as shown on Figure 4-4. This method was used in an iterative manner to establish sensor position(s) based upon closed-loop system results.

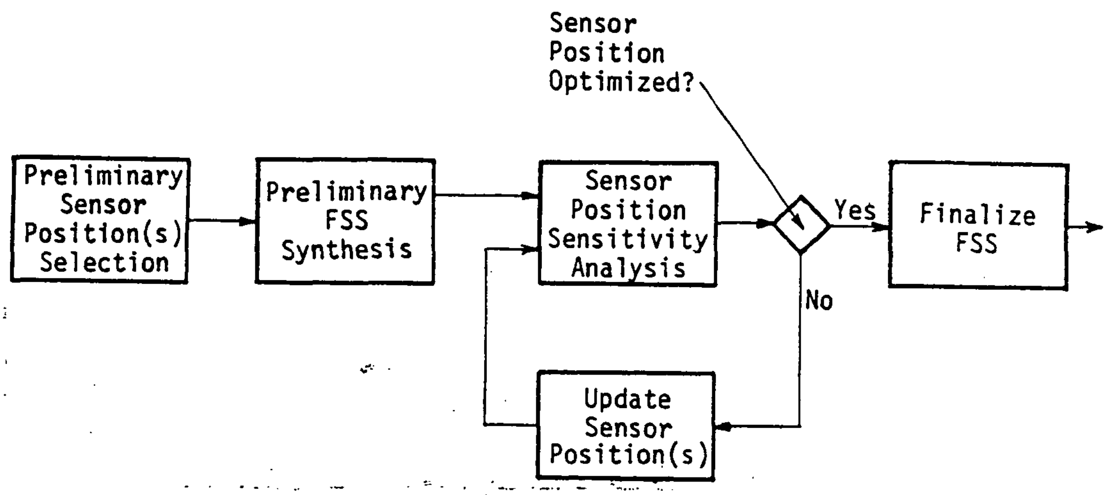


FIGURE 4-4 - SENSOR POSITION SELECTION METHODOLOGY

During the preliminary design analysis described in Reference 1, the sensor combinations analyzed using zero locus techniques included a single vertical accelerometer on front or rear spar, the difference of two vertical accelerometer signals on the front and rear spar and an accelerometer on the front or rear spar minus the rigid body motion sensed on the wing or fuselage.

The differential sensor pair on the front and rear spar, which would sense predominately wing torsion, did not exhibit adequate flutter mode coupling. This indicated that the flutter mode was predominately a bending mode which could best be sensed by the other two sensor options.

Initially, zero loci were produced for a single vertical accelerometer along the front and rear spars. Results for the symmetric and antisymmetric axes indicated that the front spar sensor exhibited adverse coupling, but the rear spar sensor exhibited adequate coupling characteristics except for rigid body modes, as shown by the zero locus on Figure 4-5 for these low frequency modes. Zero loci for mid and high frequency modes are shown on Figures 4-6 and 4-7. Based on these results, the outboard sensor location chosen for the initial FSS synthesis was at WBL 2.007 (79) on the rear spar.

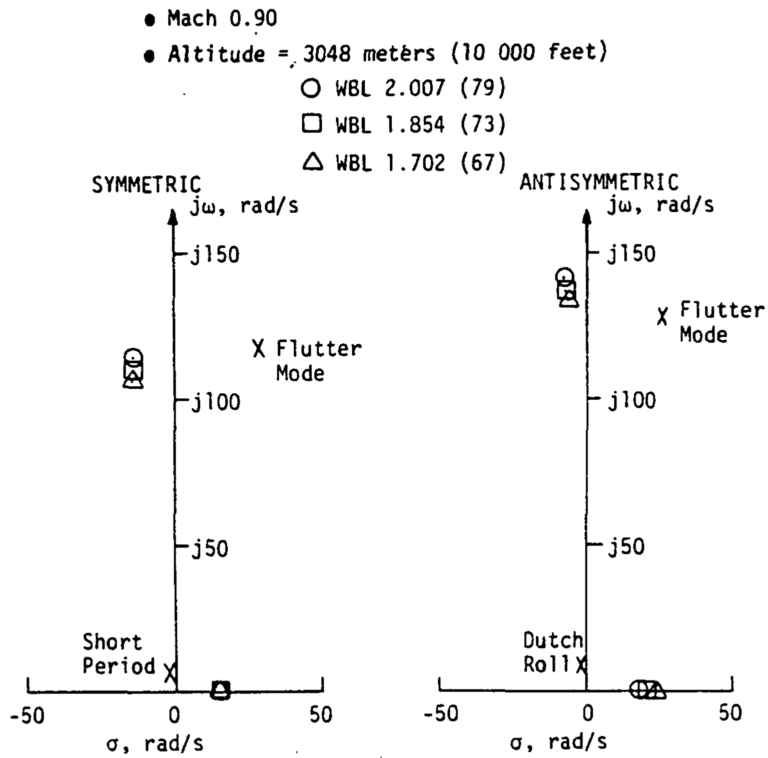


FIGURE 4-5 - ZERO LOCI OF VERTICAL ACCELEROMETER ON THE REAR SPAR - LOW FREQUENCY (FLUTTER AND RIGID BODY MODES)

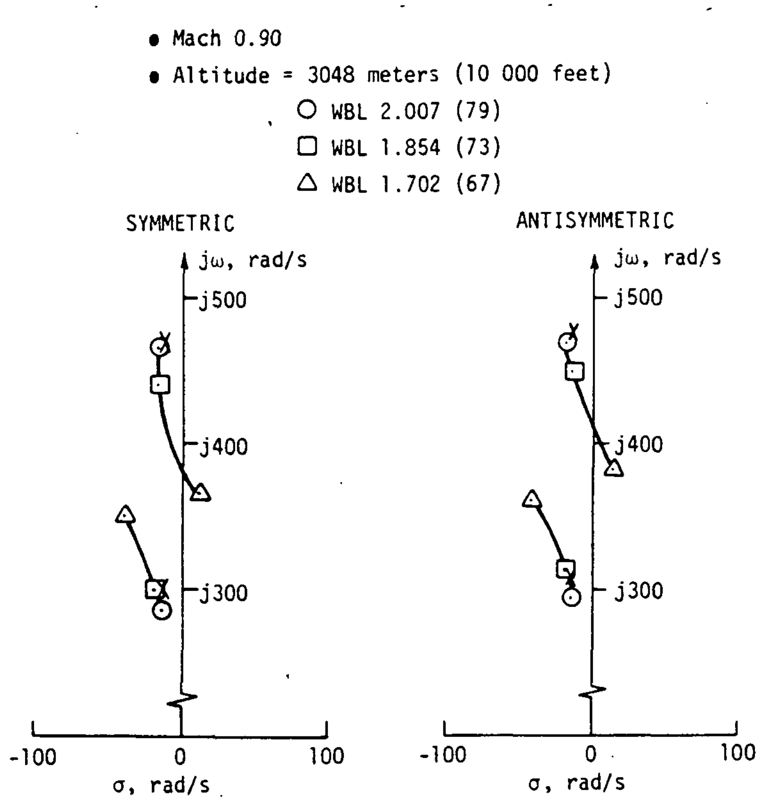


FIGURE 4-6 - ZERO LOCI OF VERTICAL ACCELEROMETER ON THE REAR SPAR - MID-FREQUENCY STRUCTURAL MODES

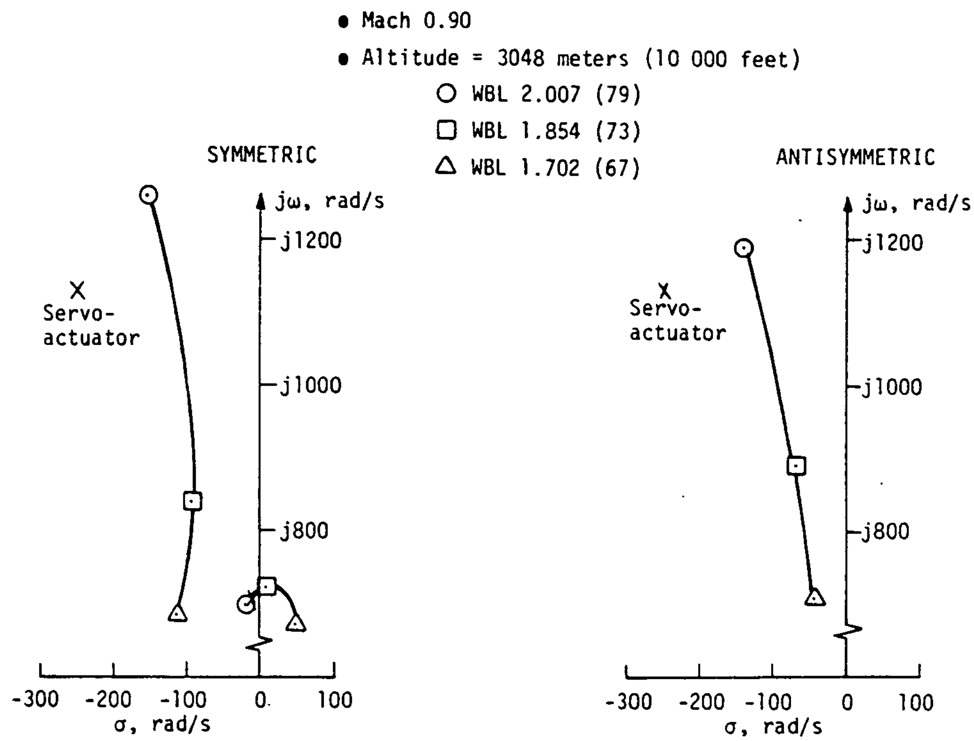


FIGURE 4-7 - ZERO LOCI OF VERTICAL ACCELEROMETER ON THE REAR SPAR - HIGH FREQUENCY STRUCTURAL MODES

To decouple rigid body motion from flutter mode motion, removal of the signals associated with these modes from the outboard accelerometers signals is necessary. Rigid body motions sensed by the outboard wing accelerometer consist of vertical acceleration in the symmetric axis and roll acceleration in the antisymmetric axis. Appropriate sensors were evaluated along the wing and fuselage. In general, sensors on the wing exhibited adverse coupling with other wing modes while the fuselage sensors provided better phasing and less coupling. A preliminary location was chosen for each sensor which was evaluated in the same manner as the outboard wing accelerometers. The vertical and roll accelerometers were located at BS 6.731 (265) on the centerline of the fuselage.

Using these initial sensor locations, symmetric and antisymmetric flutter suppression system filters were synthesized. After evaluation of the systems at various flight conditions for damping performance, sensor location sensitivity analysis was performed. Results of this study at Mach 0.90, 3048 meters (10 000 feet) is shown for the antisymmetric and symmetric systems on Figures 4-8 and 4-9, respectively. Based on phase plots, the sensor locations were adjusted to give equal inboard-outboard sensitivity margins. The final locations are outboard vertical accelerometers at WBL 1.931 (76) on the rear spar, fuselage vertical accelerometer at BS 6.35 (250) on the fuselage centerline and fuselage roll accelerometer at BS 6.35 (250) on the fuselage centerline.

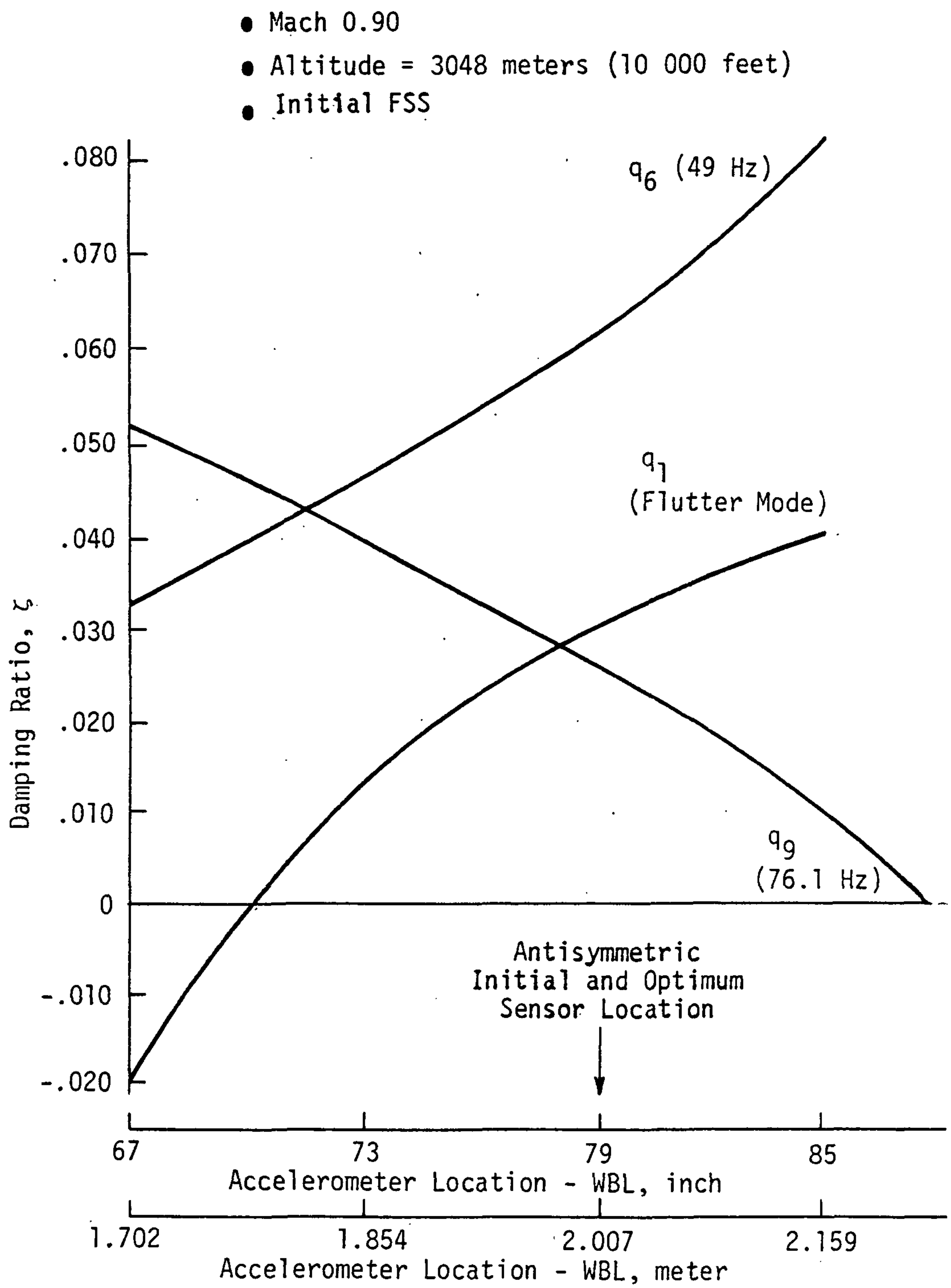


FIGURE 4-8 - VARIATION IN ANTISYMMETRIC WING ACCELEROMETER LOCATION

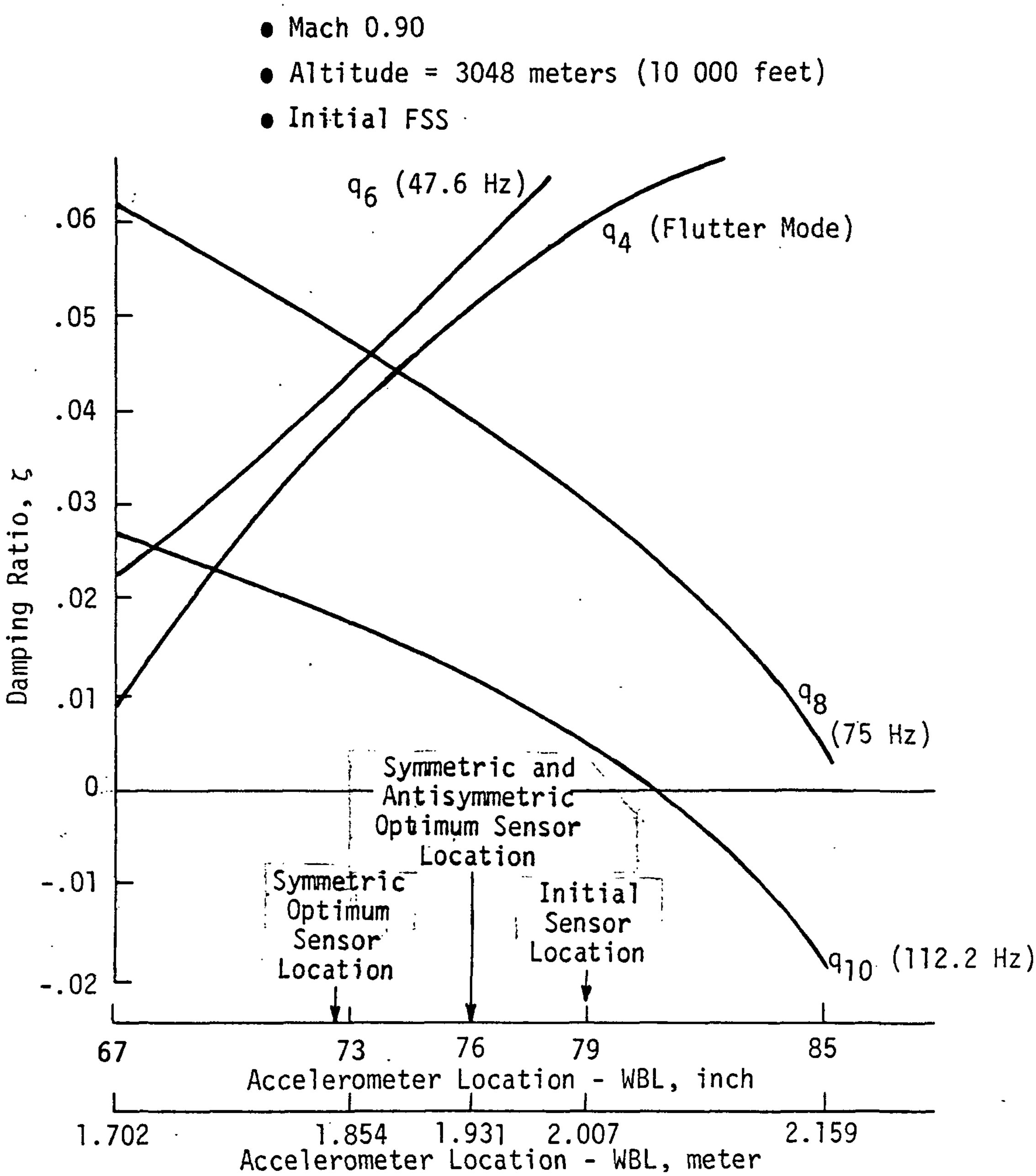


FIGURE 4-9 - VARIATION IN SYMMETRIC WING ACCELEROMETER LOCATION

The resulting sensor equations are:

$$\ddot{Z}_{SYMMETRIC} = \underset{\text{Rear Spar}}{\ddot{Z}_{WBL\ 1.931\,(76)}} - \underset{\text{Fuselage C.L.}}{\ddot{Z}_{BS\ 6.35\,(250)}} \qquad (g's)$$

$$\ddot{Z}_{ANTISYMMETRIC} = \underset{\text{Rear Spar}}{\ddot{Z}_{WBL\ 1.931\,(76)}} - \underset{\text{Fuselage C.G.}}{\ddot{\phi}_{BS\ 6.35\,(250)}} \cdot (0.197) \qquad (g's)$$

where ϕ is roll acceleration in rad/s^2. The relationship of the sensors and control surfaces to drone structure is shown on Figure 4-10.

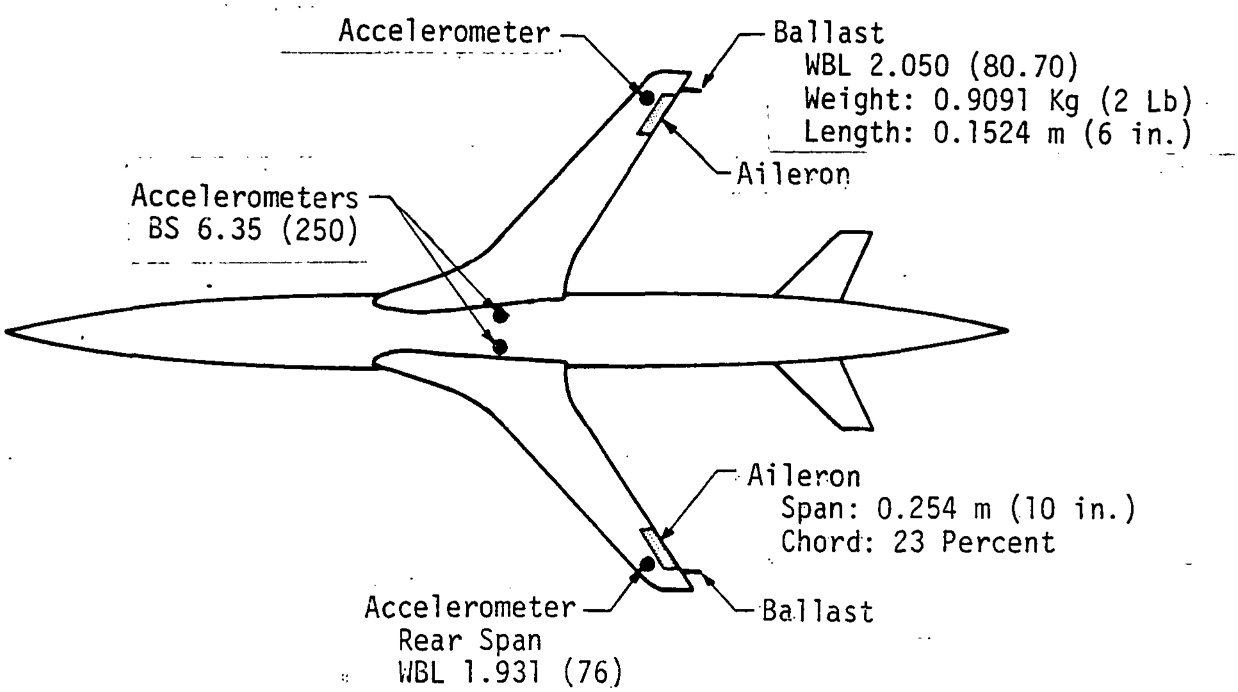


FIGURE 4-10 - SYMMETRIC AND ANTISYMMETRIC CONTROL SURFACE AND SENSOR LOCATION

4.3.4 Symmetric FSS synthesis - The region in the flight envelope in which the FSS is required to stabilize the flutter modes is shown on Figure 4-11 by the shaded area. The intersection of the 1.2 V_f boundary with the minimum altitude of 3048 meters (10 000 feet) and the maximum Mach number, 0.98, occurs at Mach 0.95 and 3658 meters (12 000 feet) altitude, respectively.

Synthesis was conducted simultaneously at the flight conditions given in Table 4-II. When a satisfactory filter had been defined, performance of the system was verified throughout the flutter envelope.

TABLE 4-II

FSS SYNTHESIS FLIGHT CONDITIONS

Condition Number	Mach Number	Altitude, meters (feet)
1	0.80	3048 (10 000)
2	0.90	3048 (10 000)
3	0.95	3048 (10 000)
4	0.98	3658 (12 000)

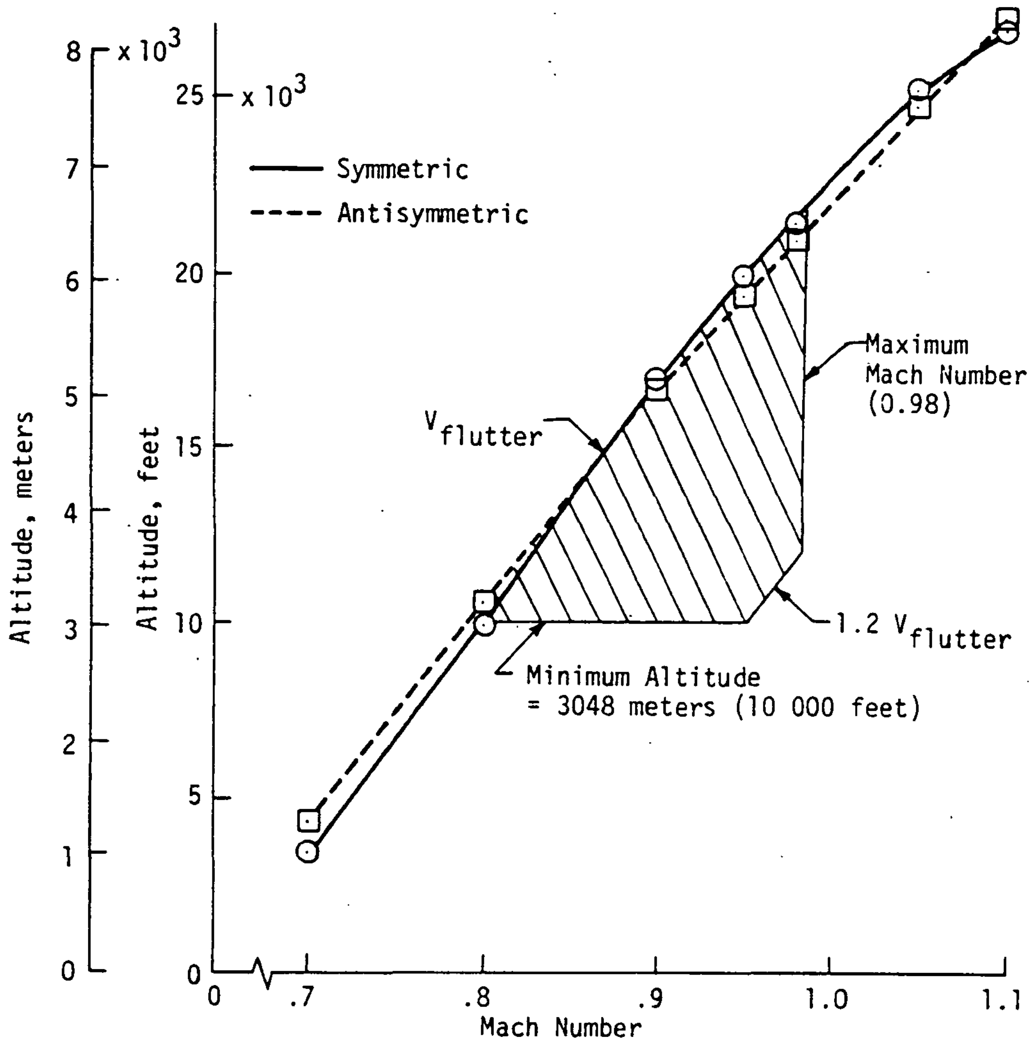


FIGURE 4-11 - DAST ARW-1 FLUTTER BOUNDARY AND FSS OPERATING ENVELOPE

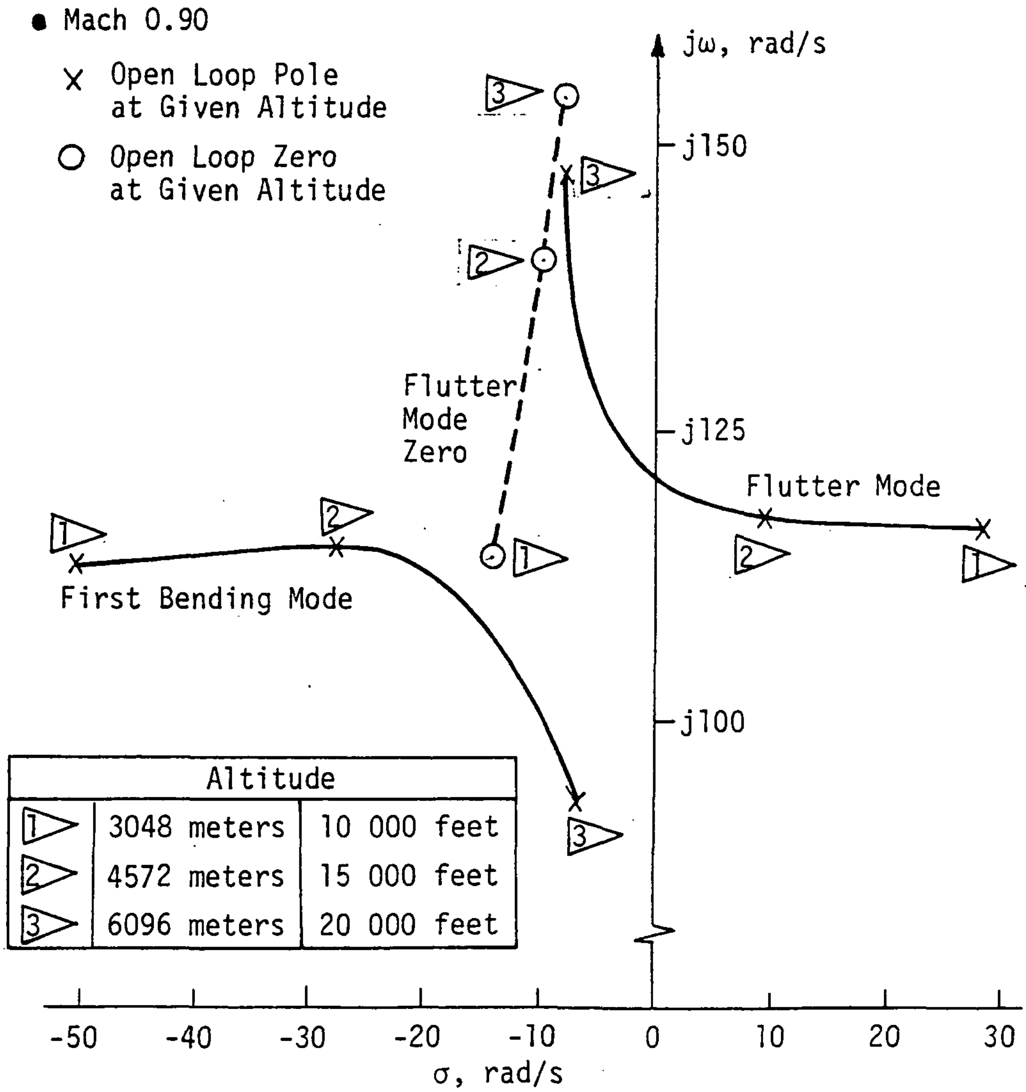
Synthesis was initiated using the form of the preliminary design study filters without the actuator compensation. Iterative root locus techniques were used to refine the form and size of the filter transfer functions. After analysis and refinements due to sensor location update the final symmetric FSS shaping filter is

$$\frac{\delta_{AIL}}{\ddot{Z}_{WBL\ 1.931} - \ddot{Z}_{C.G.}} = \frac{KS(S^2 + 42S + 70^2)(S^2 + 400S + 400^2)}{(S+2)(S+40)^2(S^2 + 80S + 100^2)} \times \frac{(S^2 + DS + 200^2)}{(S+D)(S+800)(S+900)^2} \quad \text{rad/g (deg/g)}$$

where $K = 1.932 \times 10^4$ rad/g (1.107×10^6 deg/g). The $S/(S + 2)$ washout prevents the FSS from commanding a steady state aileron offset. The $K/(S + 40)^2$ lag term provides 40 dB per decade roll-off to reduce coupling with high frequency modes. The

$(S^2 + 42S + 70^2)/(S^2 + 80S + 100^2)$ lead-lag terms negate some of the phase lag induced at the flutter mode frequency by the $K/(S + 40)^2$ term and also increases gain at the flutter frequency. The $(S^2 + DS + 200^2)/(S + D)(S + 800)$ lead-lag term primarily schedule gain and phase at the flutter mode frequency as a function of flight condition. The $(S^2 + 400S + 400^2)/(S + 900)^2$ lead-lag terms compensate for the phase shift and increased gain induced by the servoactuator dynamics.

Scheduling of the parameter "D" as a function of flight condition was necessary primarily because phasing of the flutter mode changes with flight condition. This is illustrated on Figure 4-12 where positions of the open loop poles and sensor zero are shown as functions of altitude at Mach 0.90. In this example the phase relationship between the flutter mode and the zero varies about 1.571 radians (90 degrees), making nearly impossible definition of a constant filter with adequate phase margins.



Altitude		
1	3048 meters	10 000 feet
2	4572 meters	15 000 feet
3	6096 meters	20 000 feet

FIGURE 4-12 - POLE-ZERO VARIATIONS WITH ALTITUDE

Several methods of achieving the desired 1.396 rad (80°) to 1.571 rad (90°) phase change at 20 hertz without varying gain significantly were investigated. The phase and gain induced at the flutter mode frequency (approximately 20 Hz) between the "D" parameter limits of 100 to 800 rad/s are shown on Figure 4-13. The upper limit was imposed because very little additional benefit would be gained by allowing "D" to go above 800 rad/s and the lower unit was selected to avoid the region where gain and phase are changing rapidly which could lead to sensitivity problems.

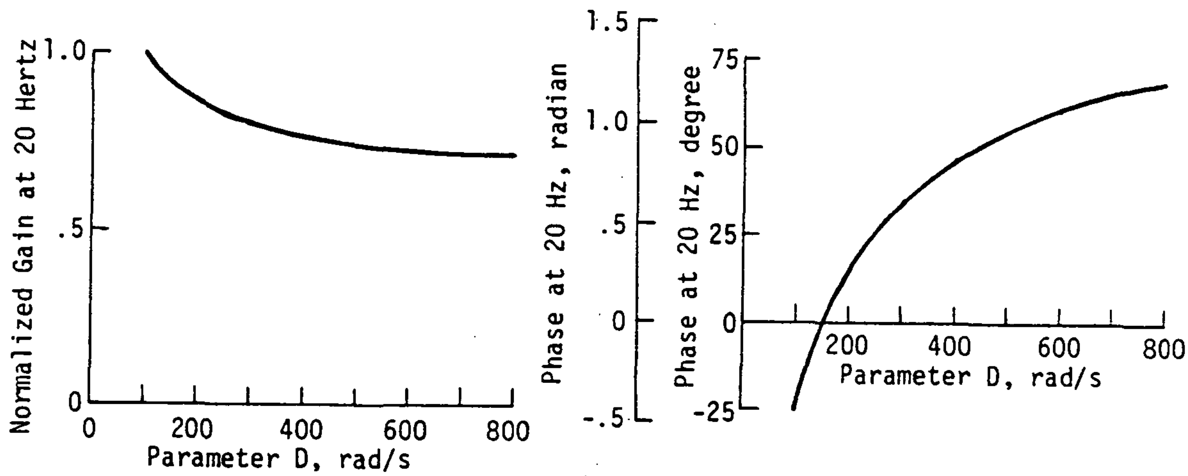


FIGURE 4-13 - PHASE AND GAIN AT 20 HERTZ DUE TO D SCHEDULING

Originally, the "D" parameter was scheduled as a function of altitude and Mach number. However, air density, which was needed instead of altitude, was not available onboard the drone and accuracy of the BQM-34E/F Mach number sensor was unknown. Because static and impact pressures were available onboard the drone in an accurate form, the scheduling was curve fit using these two parameters. The resulting "D" schedule is given by the following equation and is shown for the original and final forms on Figure 4-14:

$$D = \frac{8.492 \times 10^7}{P_I - .3825 P_S + 26650} - 1490,$$

Where P_S and P_I are static and impact pressures, respectively, in Newtons-per-square-meter.

A frequency response of the symmetric FSS shaping filter with scheduled break frequency of 300 rad/s is shown on Figure 4-15. The gain peak at about one hertz is due to the washout and the two 40 radian-per-second lags. Though gain at this point is about ten times the gain at the flutter frequency, there is no mode in this frequency gain to cause excessive control surface activity.

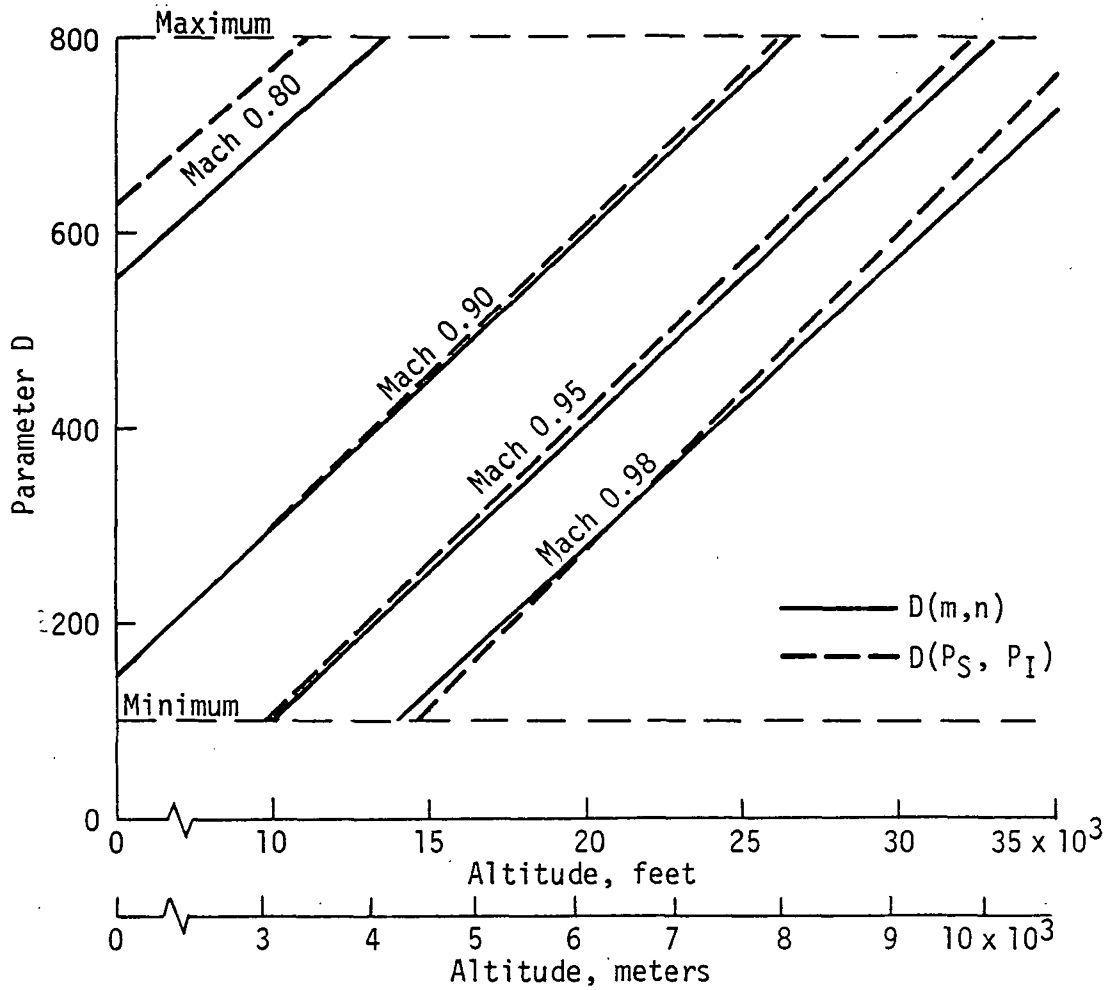


FIGURE 4-14 - COMPARISON OF INITIAL AND FINAL PARAMETER SCHEDULING

A gain root locus of the symmetric system at Mach 0.90, 3048 meter (10 000 feet) altitude is shown on Figure 4-16. The FSS does not couple strongly with any structural mode but the flutter pair, q_1 and q_2.

4.3.5 Antisymmetric FSS synthesis - Initially, the symmetric FSS filter was evaluated to determine if the same filter could control the antisymmetric flutter mode. The symmetric filter exhibited adequate phasing characteristics on all antisymmetric modes but the filter could not achieve the required negative gain margin on the flutter mode without driving another elastic mode unstable. Therefore, the term in the symmetric filter that produced the gain peak at the flutter mode frequency was modified to give increased gain. This resulted in the filter transfer function

$$\frac{\delta_{AIL}}{\ddot{Z}_{ANTISYMMETRIC}} = \frac{KS(S^2 + 45S + 93^2)(S^2 + 400S + 400^2)}{(S+2)(S+40)^2(S^2 + 45S + 180^2)} \times \frac{(S^2 + DS + 200^2)}{(S+D)(S+800)(S+900)^2} \quad \text{rad/g (deg/g)}$$

where $K = 2.5382 \times 10^5$ rad/g (1.4543×10^7 deg/g).

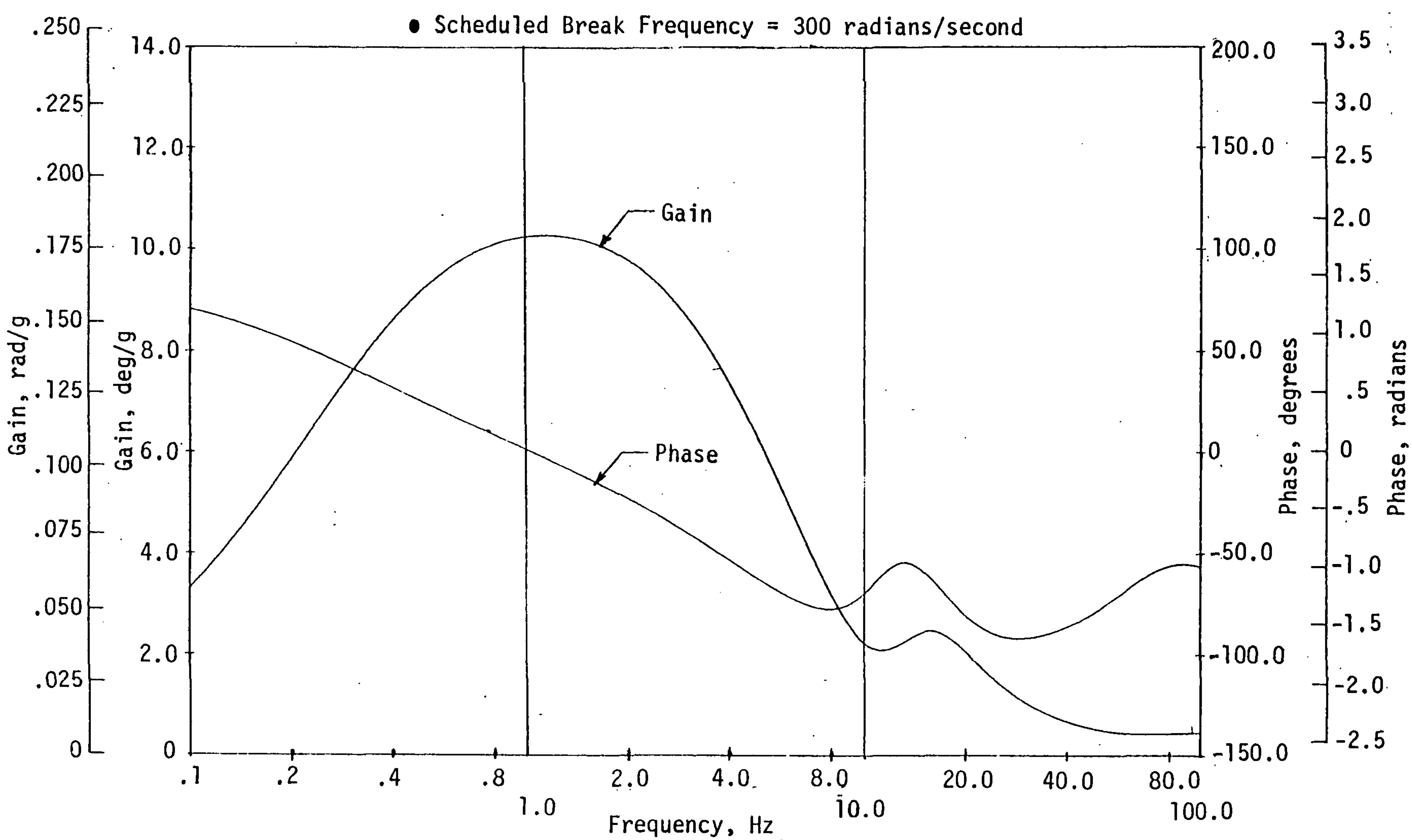


FIGURE 4-15 - FREQUENCY RESPONSE OF SYMMETRIC FSS SHAPING FILTER

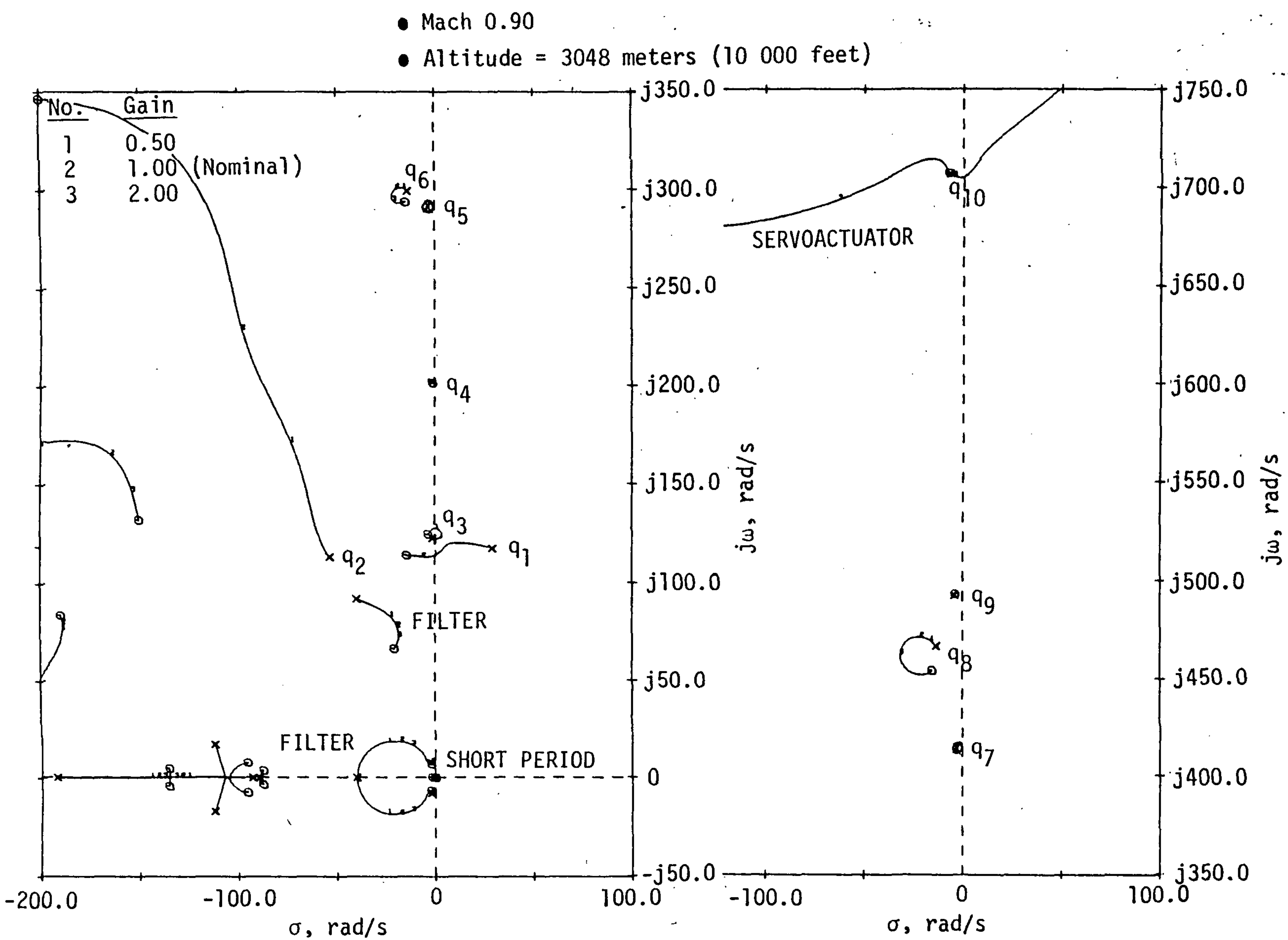


FIGURE 4-16 - GAIN ROOT LOCUS OF SYMMETRIC FSS

This filter, with the exception of the changes discussed above, is identical to the symmetric FSS shaping filter including the "D" parameter scheduling.

A frequency response of the antisymmetric FSS filter with a scheduled break frequency of 300 rad/s is shown on Figure 4-17. Again, the filter exhibits gain peaks at around one and 20 hertz.

A gain root locus of the antisymmetric FSS at Mach 0.90, 3048 meters (10 000 feet) is shown on Figure 4-18. The only modes that couple strongly with the FSS are the flutter pair, q_1 and q_2.

4.3.6 Delivered FSS configuration - A block diagram of the delivered FSS is shown on Figure 4-19. The initial summation of sensors provides right and left wing panel vertical acceleration minus the rigid body accelerations due to vertical and roll accelerations. These signals are fed into the the common filters and then summed to form inputs to the symmetric and antisymmetric filters. The symmetric and antisymmetric filter outputs are summed and differenced to form the left and right aileron commands.

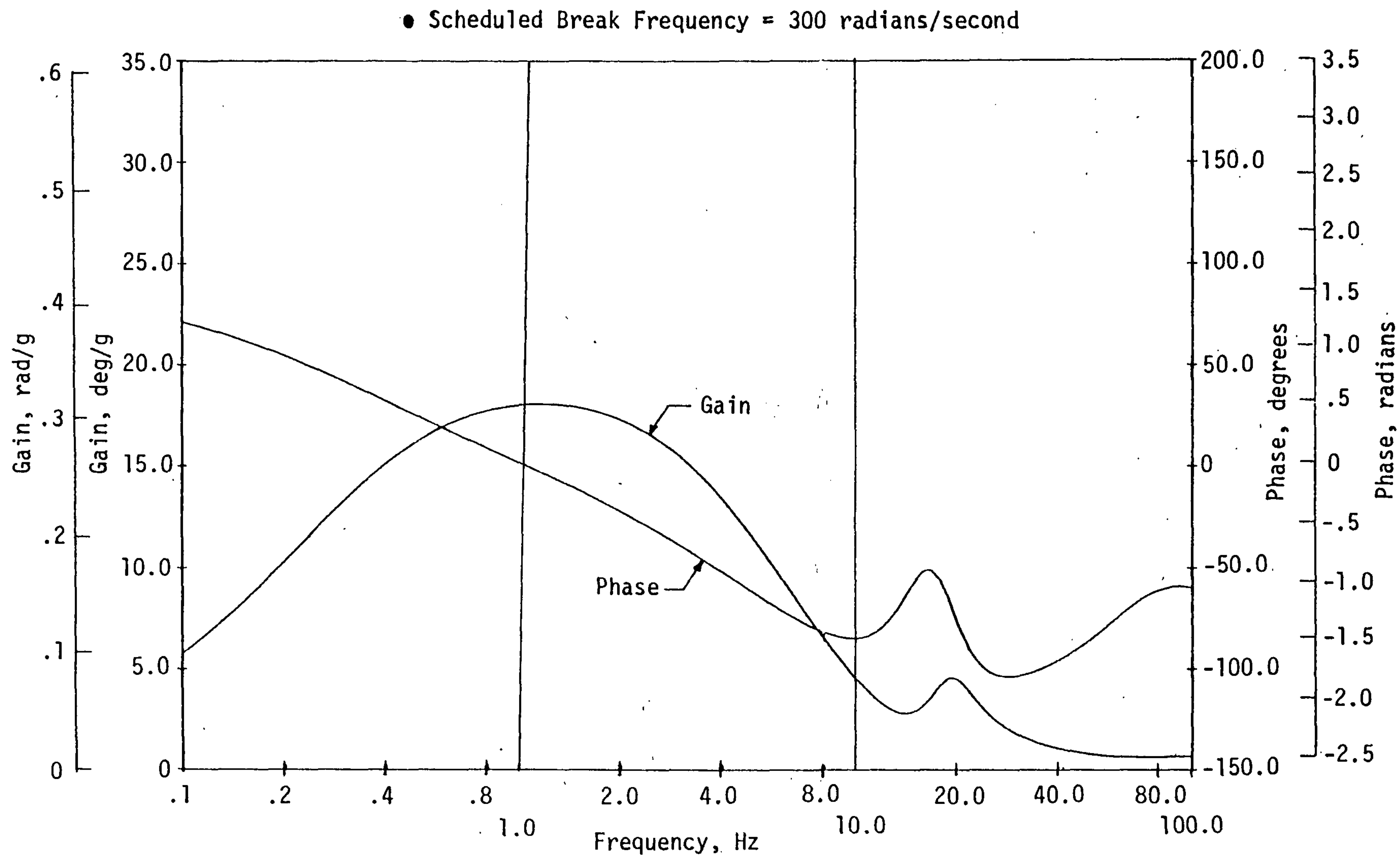


FIGURE 4-17 - FREQUENCY RESPONSE OF ANTISYMMETRIC FSS SHAPING FILTER

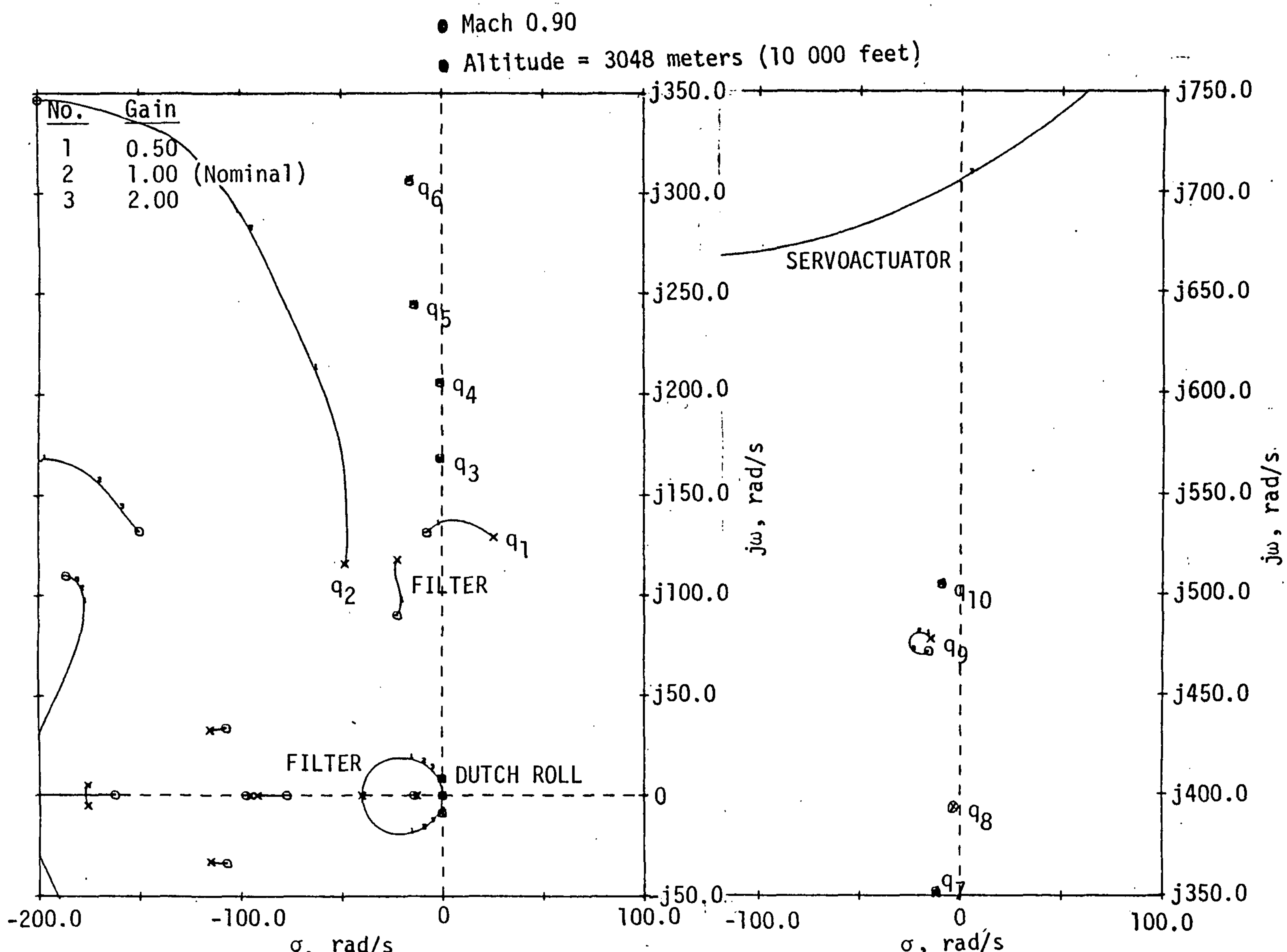
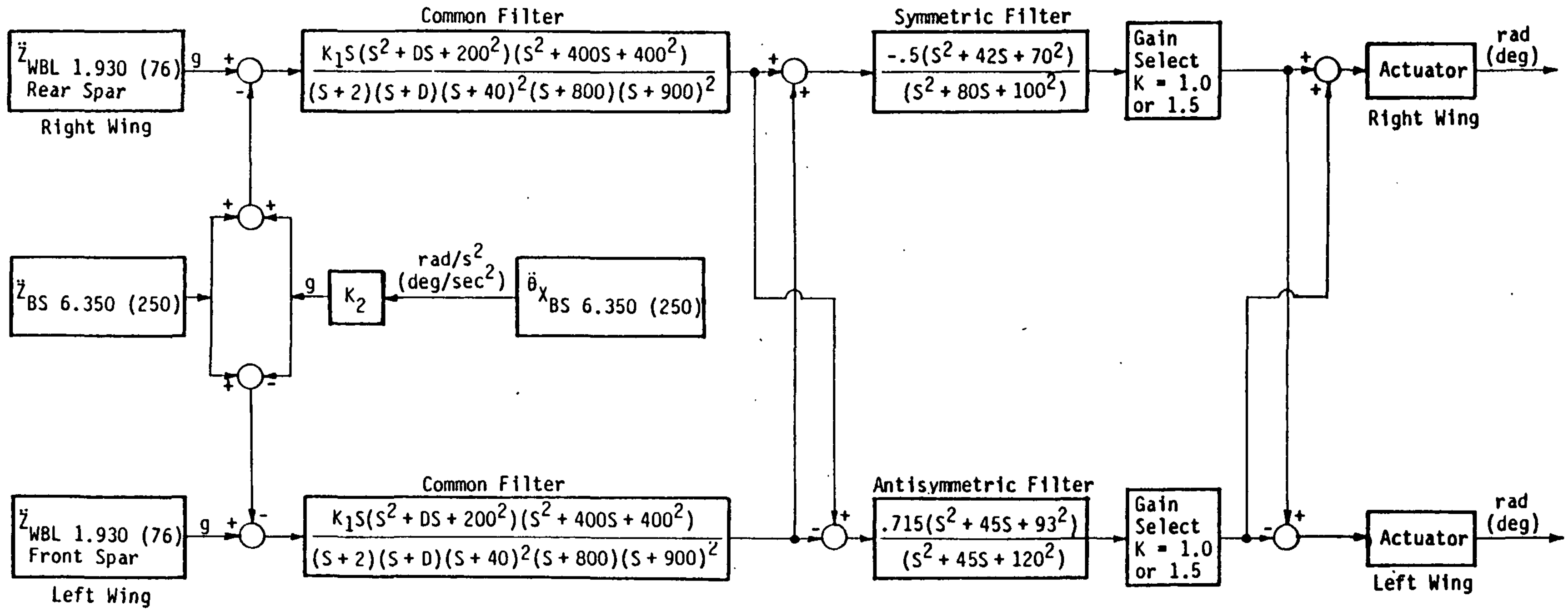


FIGURE 4-18 - GAIN ROOT LOCUS OF ANTISYMMETRIC FSS



$K_1 = 1.932 \times 10^4$ rad/g $(1.107 \times 10^6$ deg/g)
$K_2 = 5.934 \times 10^{-5}$ (.0034)
$D = f(P_S, P_I)$
$\ddot{Z} \sim +$ Up
$\ddot{\theta}_X \sim +$ Right Wing Up
$\delta_A \sim +$ TED

FIGURE 4-19 - DAST ARW-1 FLUTTER SUPPRESSION SYSTEM BLOCK DIAGRAM

5.0 FLUTTER SUPPRESSION SYSTEM PERFORMANCE

Analysis was conducted to evaluate performance and sensitivity of the flutter suppression system and compatibility of the system with the drone Automatic Flight Control System (AFCS). Performance evaluation consisted of analysis to establish the ability of the FSS to stabilize the flutter mode and not degrade stability of the other structural modes throughout the flutter envelope to a damping ratio of less than 0.01, except when the unaugmented modal damping ratio is below 0.01, as discussed in Paragraph 4.2. The flutter suppression system definition used for the performance evaluation described in Section 5.0 is presented in Paragraph 4.3.6.

Analysis was also conducted to define sensitivity of the FSS to various expected system variations. Included in the variation analyses were changes in actuator dynamics, control surface displacement saturation, sensor location sensitivity and parameter scheduling variations.

Effects of the FSS on rigid body modes and effects of the AFCS on the flutter modes were examined to determine if the two systems were compatible. The performance of a single wing FSS was evaluated to determine feasibility. An extension of this study was the analysis of the effects of failure of either a wing accelerometer or a servoactuator.

5.1 Stability

Analysis was conducted to determine stability characteristics of the DAST ARW-1 vehicle with the FSS over the entire flutter envelope. This included determination of damping and frequency of the flutter mode and other structural elastic modes with the FSS operating and evaluation of stability margins of the system.

5.1.1 Damping and frequency evaluation - Closed loop damping and frequency were determined for each of the rigid body and structural elastic modes with the FSS engaged. The resulting flutter boundaries with the systems operating are shown on Figure 5-1. Both systems exceed design goals. The higher antisymmetric flutter boundary is due to the higher loop gain.

Damping ratios and frequencies with the FSS on and off are presented for the symmetric and antisymmetric systems at Mach 0.90 and 3048 meters (10 000 feet) altitude in Tables 5-I and 5-II, respectively. This data shows that the FSS does not reduce mode damping ratio to below 0.01 or degrade damping of modes with damping ratios below 0.01.

Flutter mode damping ratio versus Mach number at constant altitude of 3048 meters (10 000 feet) is shown for the symmetric and antisymmetric systems on Figures 5-2 and 5-3, respectively.

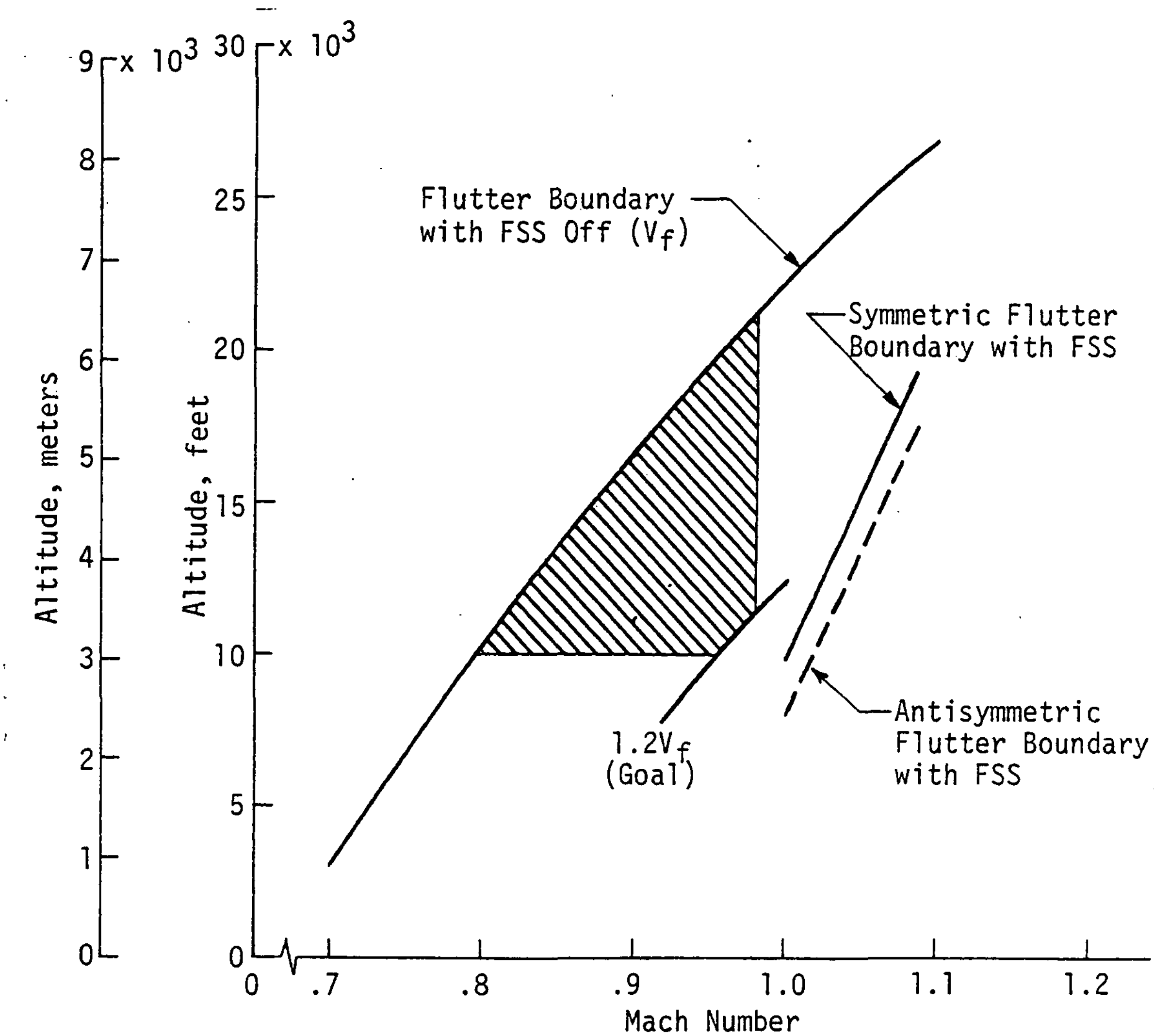


FIGURE 5-1 - DAST ARW-1 SYMMETRIC AND ANTISYMMETRIC FSS FLUTTER BOUNDARY

TABLE 5-I

SYMMETRIC OPEN AND CLOSED LOOP MODAL DAMPING AND FREQUENCIES

- Mach 0.90
- Altitude = 3048 meters (10 000 feet)

Mode	FSS Off		FSS On	
	Damping Ratio, ζ	Frequency, Hertz	Damping Ratio, ζ	Frequency, Hertz
Short Period	.242	1.283	.238	1.29
Flutter (q_1)	-.241	19.28	.0592	18.03
q_2	.427	19.93	.397	40.04
q_3	.011	19.52	.0226	20.23
q_4	.0069	32.17	.0083	32.09
q_5	.006	46.00	.006	46.00
q_6	.0472	47.68	.066	47.95
q_7	.005	65.89	.005	65.89
q_8	.0287	74.34	.0458	75.12
q_9	.0087	78.44	.0075	78.37
q_{10}	.010	112.6	.0096	112.5
Filter	1.0	6.37	.688	4.12
Filter	.40	15.92	.239	12.69
Filter	1.0	127.3	.613	218.6
Servoactuator	.313	154.6	.277	113.2
Servovalve	.309	203.1	.211	187.8

TABLE 5-II

ANTISYMMETRIC OPEN AND CLOSED LOOP MODAL DAMPING AND FREQUENCIES

- Mach 0.90
- Altitude = 3048 meters (10 000 feet)

Mode	FSS Off		FSS On	
	Damping Ratio, ζ	Frequency, Hertz	Damping Ratio, ζ	Frequency, Hertz
Dutch Roll	.0458	1.378	.0470	1.375
Flutter (q_1)	-.195	20.95	.0414	21.20
q_2	.387	19.98	.332	48.02
q_3	.0067	26.78	.0072	26.79
q_4	.0062	32.80	.0067	32.72
q_5	.0575	39.00	.0579	38.89
q_6	.0512	48.96	.0585	48.92
q_7	.0336	55.83	.0288	55.92
q_8	.0056	62.75	.0057	62.75
q_9	.0309	76.07	.0456	76.53
q_{10}	.0191	80.45	.0195	80.42
Filter	1.0	6.37	.515	3.06
Filter	.1875	19.10	.219	15.26
Filter	1.0	127.3	.607	233.3
Servoactuator	.313	154.6	.197	108.7
Servovalve	.309	203.1	.182	186.2

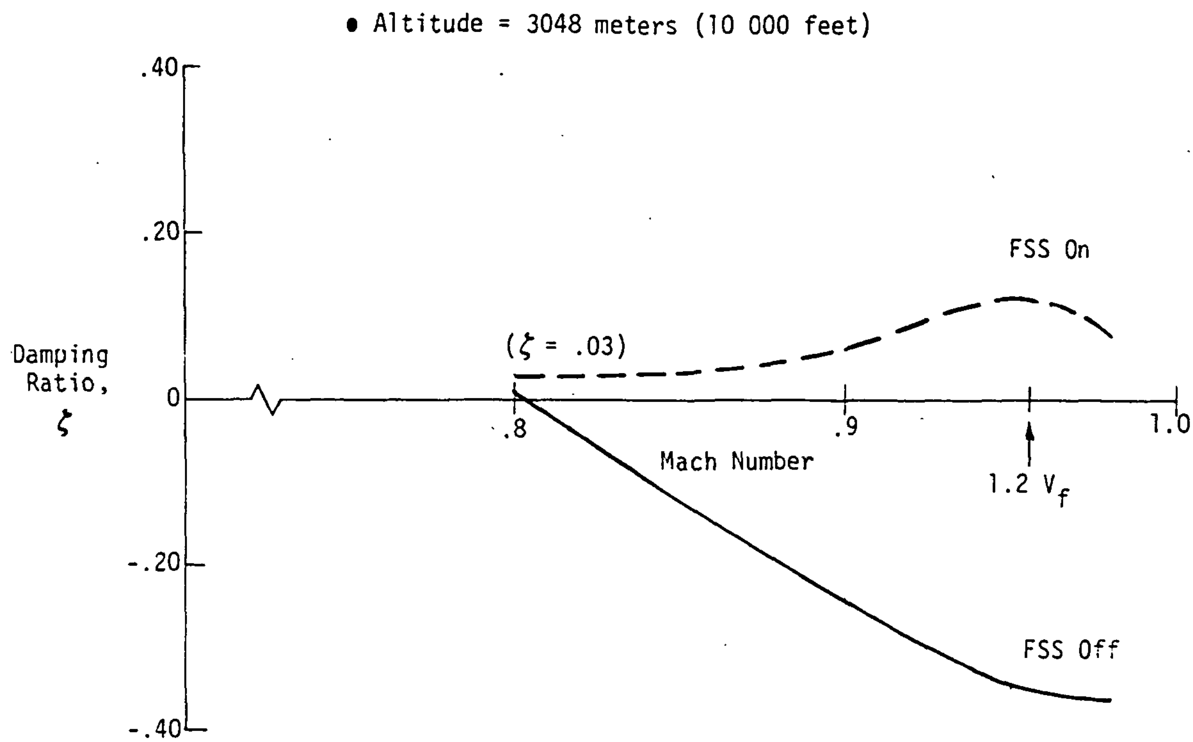


FIGURE 5-2 - DAST ARW-1 SYMMETRIC FLUTTER MODE DAMPING RATIO

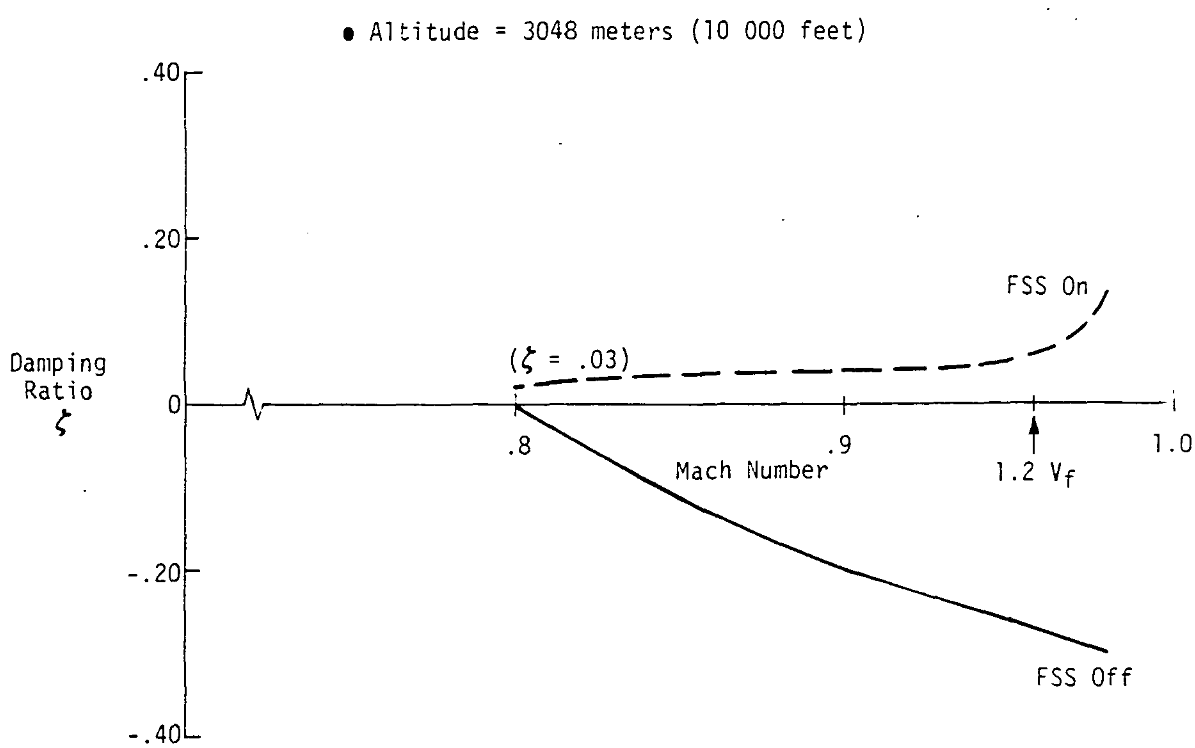


FIGURE 5-3 - DAST ARW-1 ANTISYMMETRIC FLUTTER MODE DAMPING RATIO

These plots illustrate the violence of the flutter modes and the capability of the FSS to stabilize the modes to beyond 1.2 V_f. Flutter mode damping ratio and frequency versus airspeed at Mach 0.90 is shown for both systems on Figures 5-4 and 5-5. The FSS degrades flutter mode damping slightly at subcritical airspeeds, but increases damping significantly above the open loop flutter speed. Flutter mode frequency is not significantly affected.

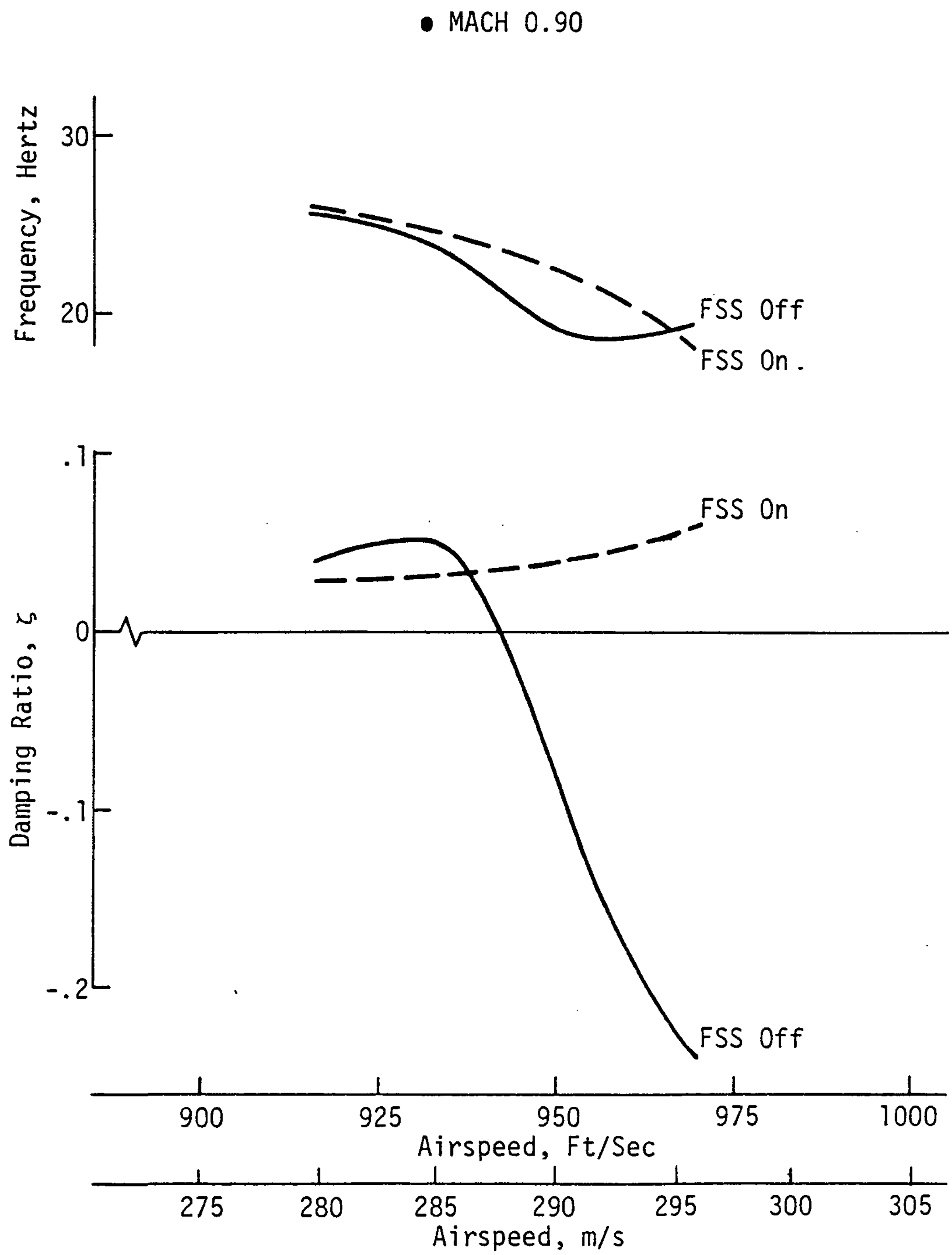


FIGURE 5-4 - DAST ARW-1 SYMMETRIC FLUTTER MODE DAMPING RATIO AND FREQUENCY

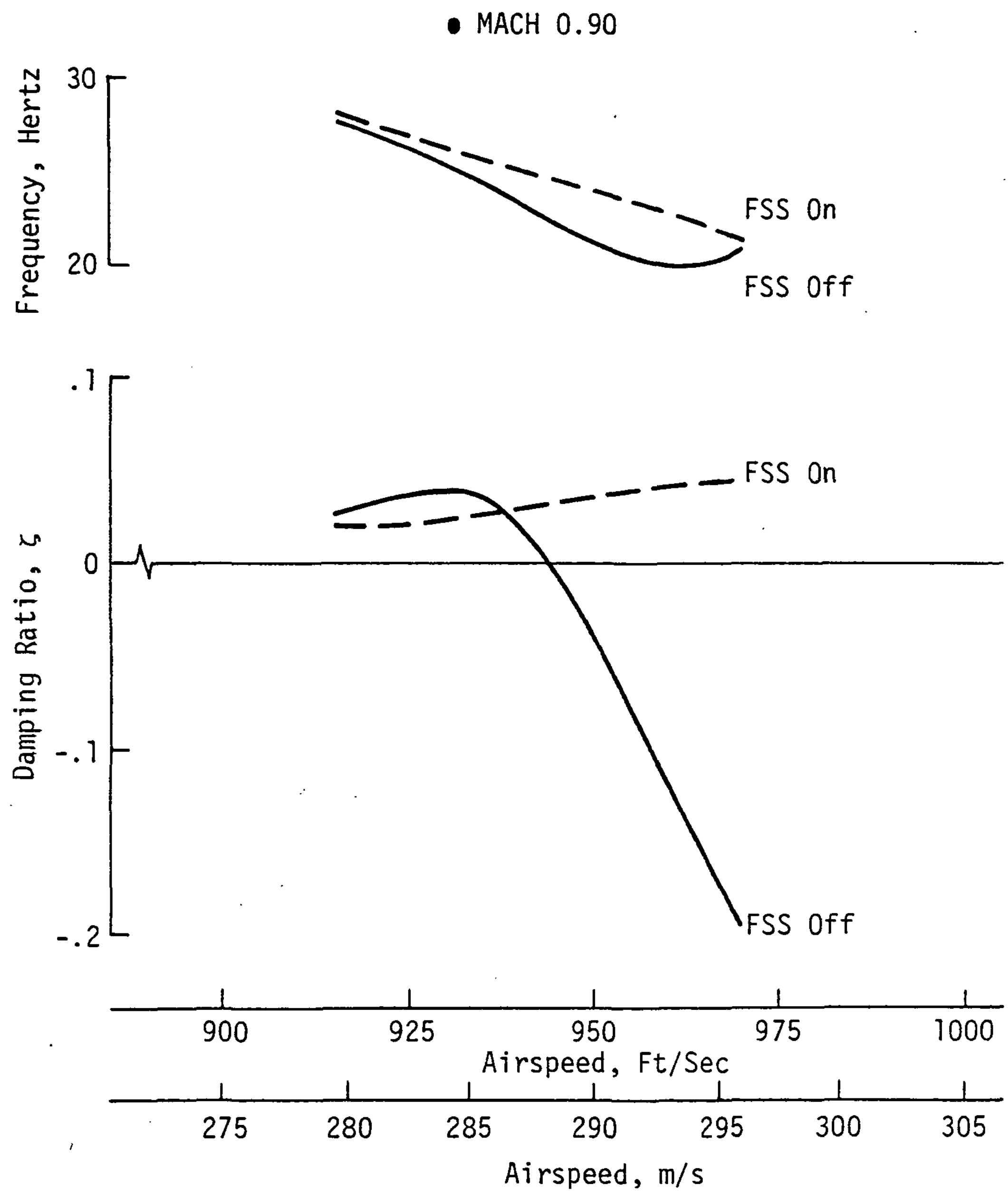


FIGURE 5-5 - DAST ARW-1 ANTISYMMETRIC FLUTTER MODE DAMPING RATIO AND FREQUENCY

5.1.2 <u>FSS stability margins</u> - Analysis was conducted to demonstrate that the FSS met the stability margin requirements presented in Paragraph 4.2. Figures 5-6 and 5-7 show that the FSS has greater than ±6.0 dB gain margins and ±0.78 rad (45°) phase margin at Mach 0.8. All other flight conditions at V_f exhibit full stability margins and at velocities greater than V_f the FSS has at least 6 dB negative gain margin on the flutter modes.

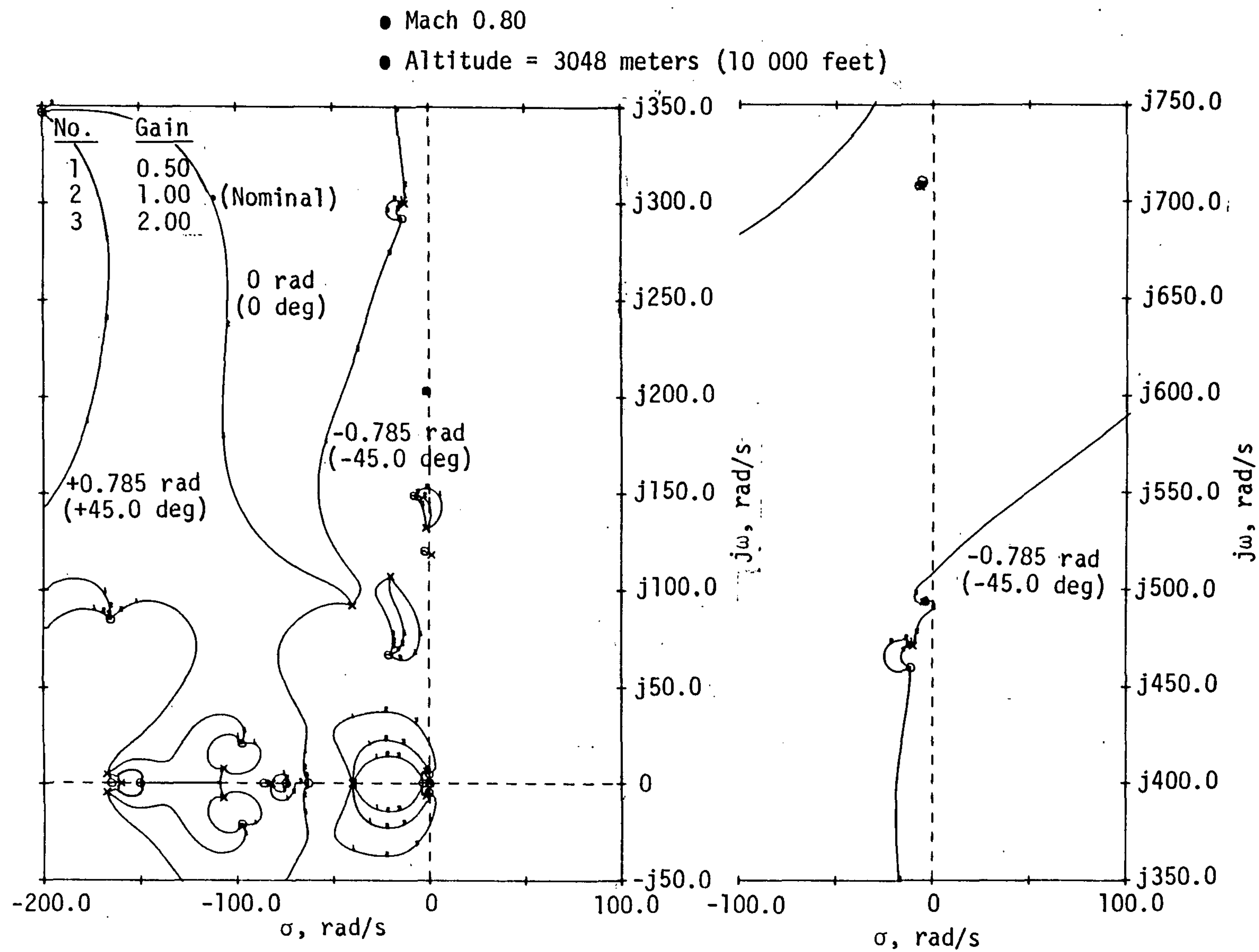


FIGURE 5-6 - PHASE-GAIN ROOT LOCUS OF SYMMETRIC FSS AT V_f

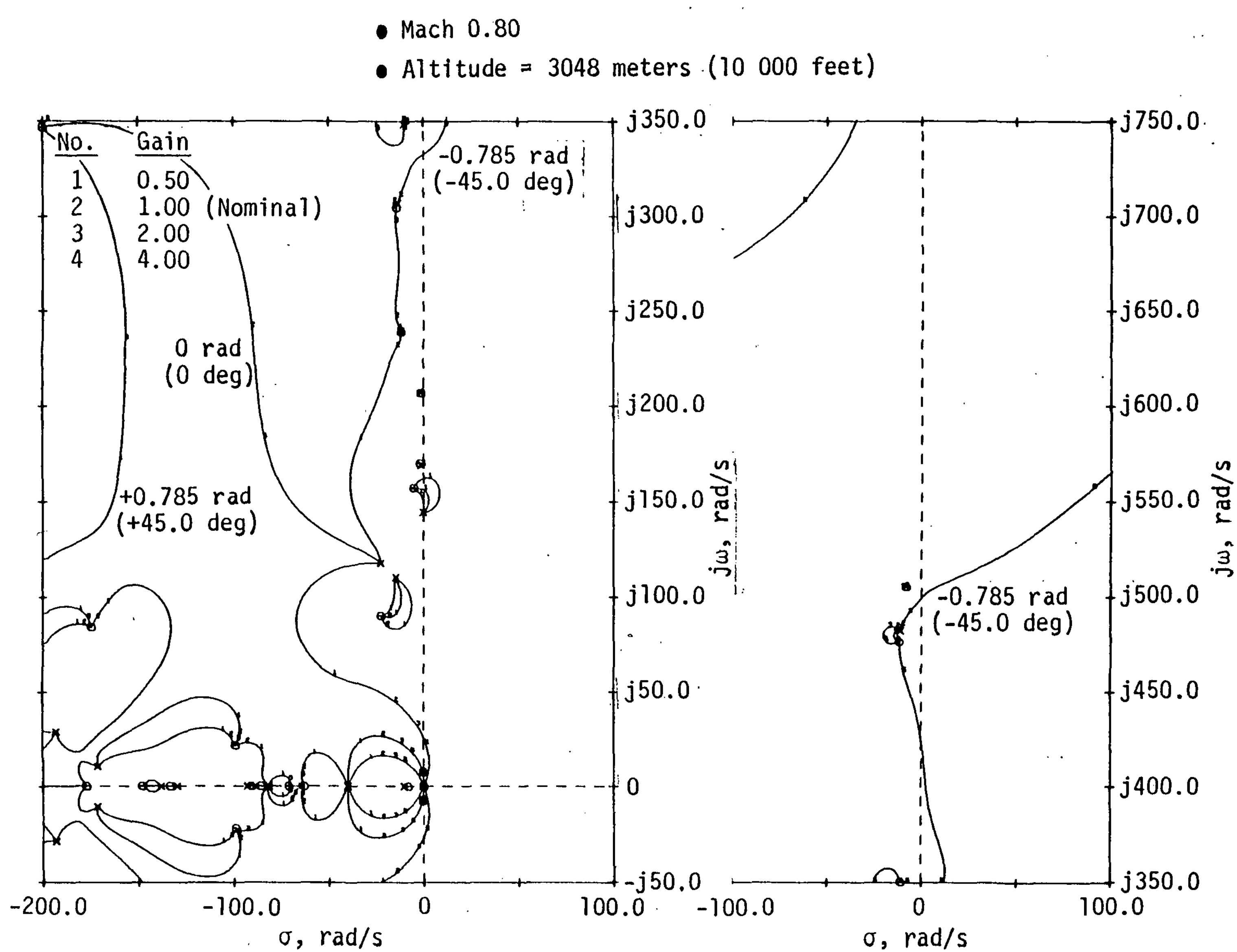


FIGURE 5-7 - PHASE-GAIN ROOT LOCUS OF ANTISYMMETRIC FSS AT V_f

5.2 Control Surface Requirements

Analysis was conducted to determine maximum control surface activity in random turbulence to size the servoactuator system components.

5.2.1 <u>Power spectral density analysis</u> - Von Karman spectrum with characteristic gust scale length of 762 meters (2500 feet) was used to represent the random atmospheric turbulence characteristics. Aileron RMS displacement and rate per unit gust at Mach 0.98 and 3658 meters (12 000 feet) altitude for the symmetric and antisymmetric flutter suppression systems are shown on Figures 5-8 and 5-9, respectively.

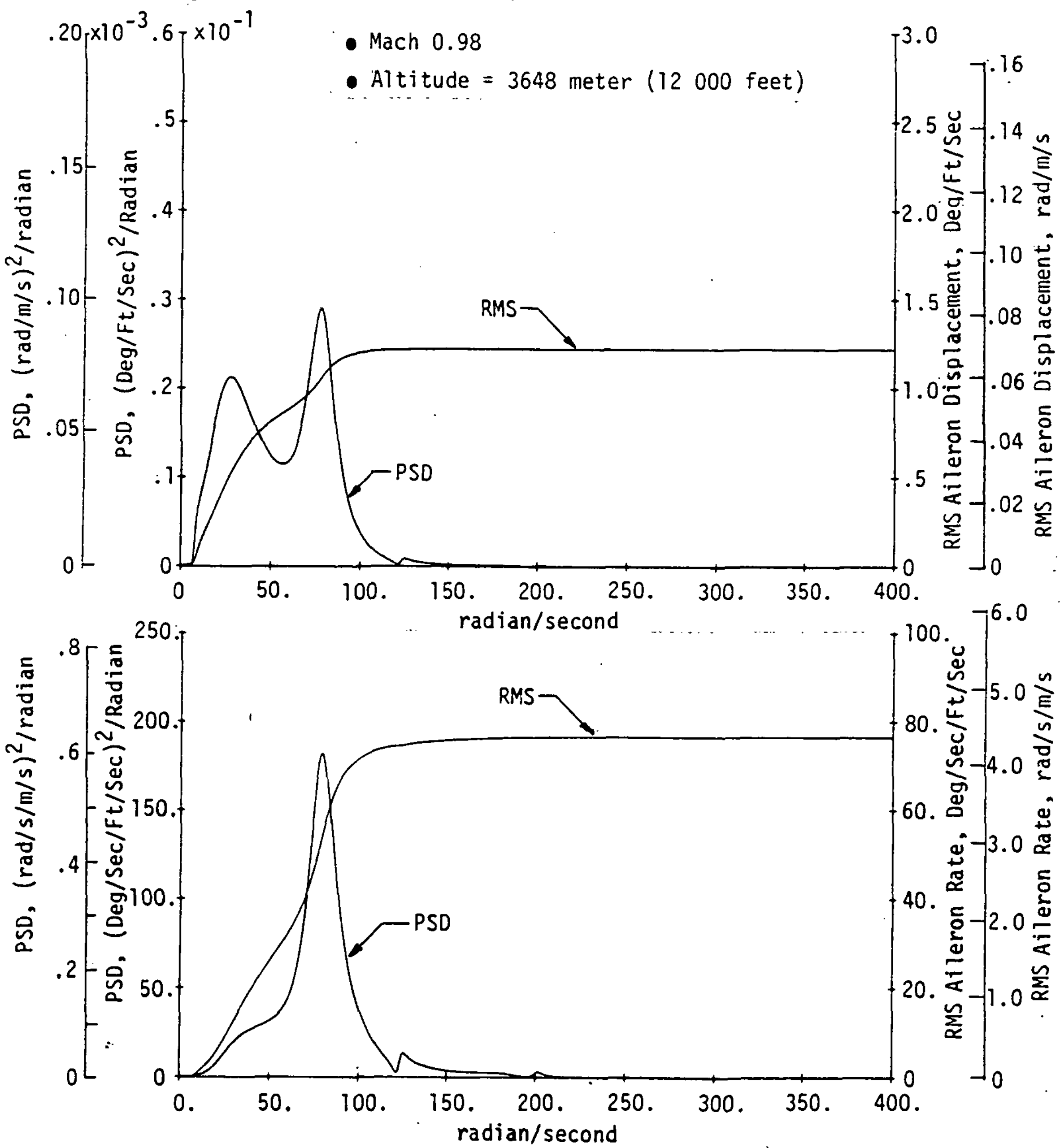


FIGURE 5-8 - SYMMETRIC FSS AILERON DISPLACEMENT AND RATE IN RANDOM TURBULENCE

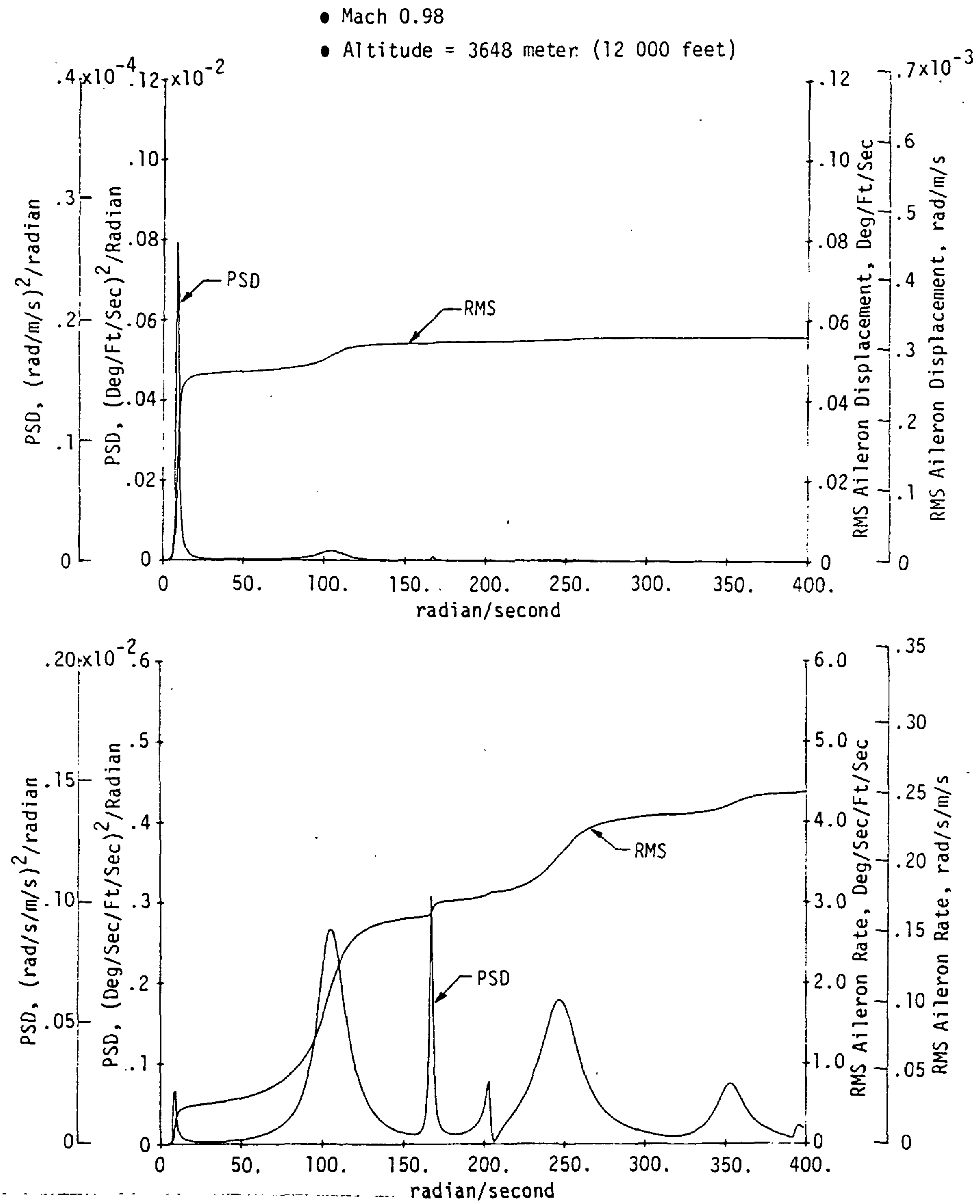


FIGURE 5-9 - ANTISYMMETRIC FSS AILERON DISPLACEMENT AND RATE IN RANDOM TURBULENCE

5.2.2 Maximum aileron requirements - Maximum aileron requirements were defined by multiplying the per-unit RMS surface rate and displacement values by the peak turbulence level. The peak turbulence level for the ARW-1 design is 3.66 m/s (12 ft/sec) which is a 2σ peak at 1.83 m/s (6 ft/sec) gust level. Results for the symmetric and antisymmetric systems at the lowest possible altitude are given for Mach numbers between 0.80 and 0.98 on Figure 5-10. Effects of surface displacement saturation will be discussed in Paragraph 5.3.

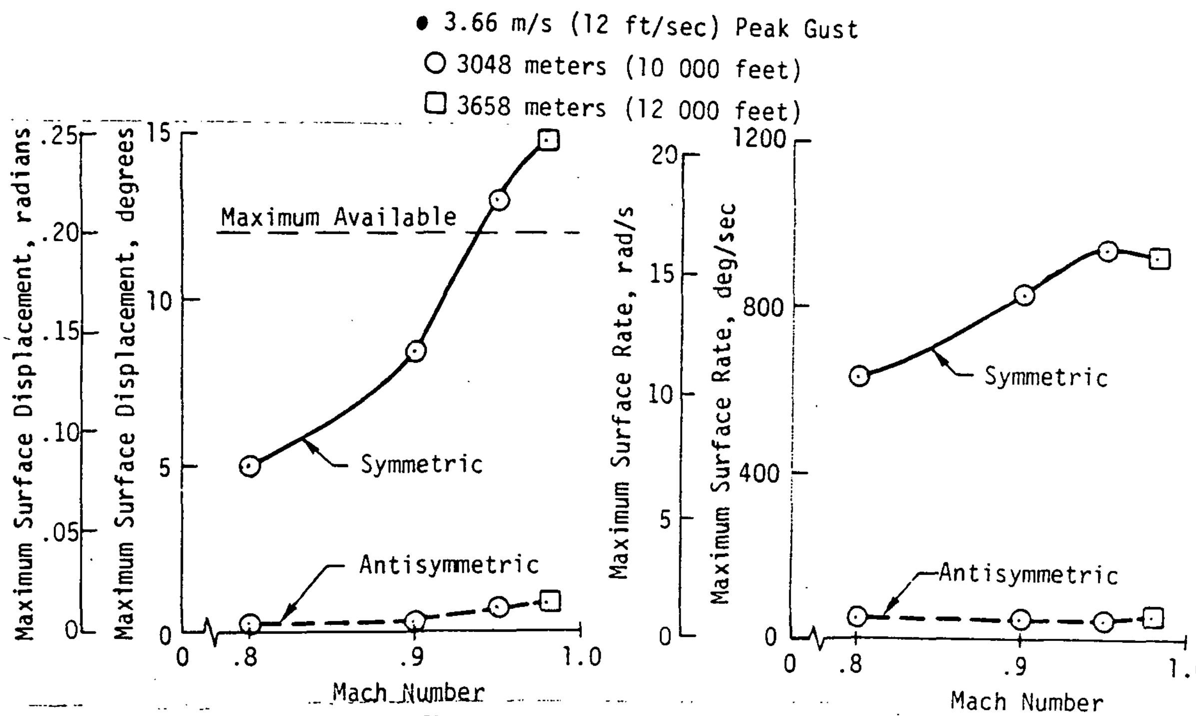


FIGURE 5-10 - MAXIMUM AILERON DISPLACEMENT AND RATE IN RANDOM TURBULENCE

5.3 FSS Sensitivity

Analysis was conducted to determine sensitivity of the FSS to variations of system parameters.

5.3.1 Sensor location sensitivity - The sensitivity study not only determines sensor location sensitivity, but also gives some indication as to sensitivity of the control system to accuracy of the drone mathematical model.

Because locations of the fuselage sensors were adjusted to give approximately equal (inboard-outboard) margins on the outboard sensors, only outboard sensor sensitivity was evaluated. Results of the symmetric and antisymmetric systems at Mach 0.90, 3048 meters (10 000 feet), are presented on Figures 5-11 and 5-12, respectively. The flutter mode is not significantly affected by variations in sensor location while those modes which are sensitive have margins that are nearly equal. The symmetric FSS exhibits +0.127m (5 in) margin outboard and -0.2032m (8 in) margin inboard while the antisymmetric FSS is balanced at ±0.1524m (6 in).

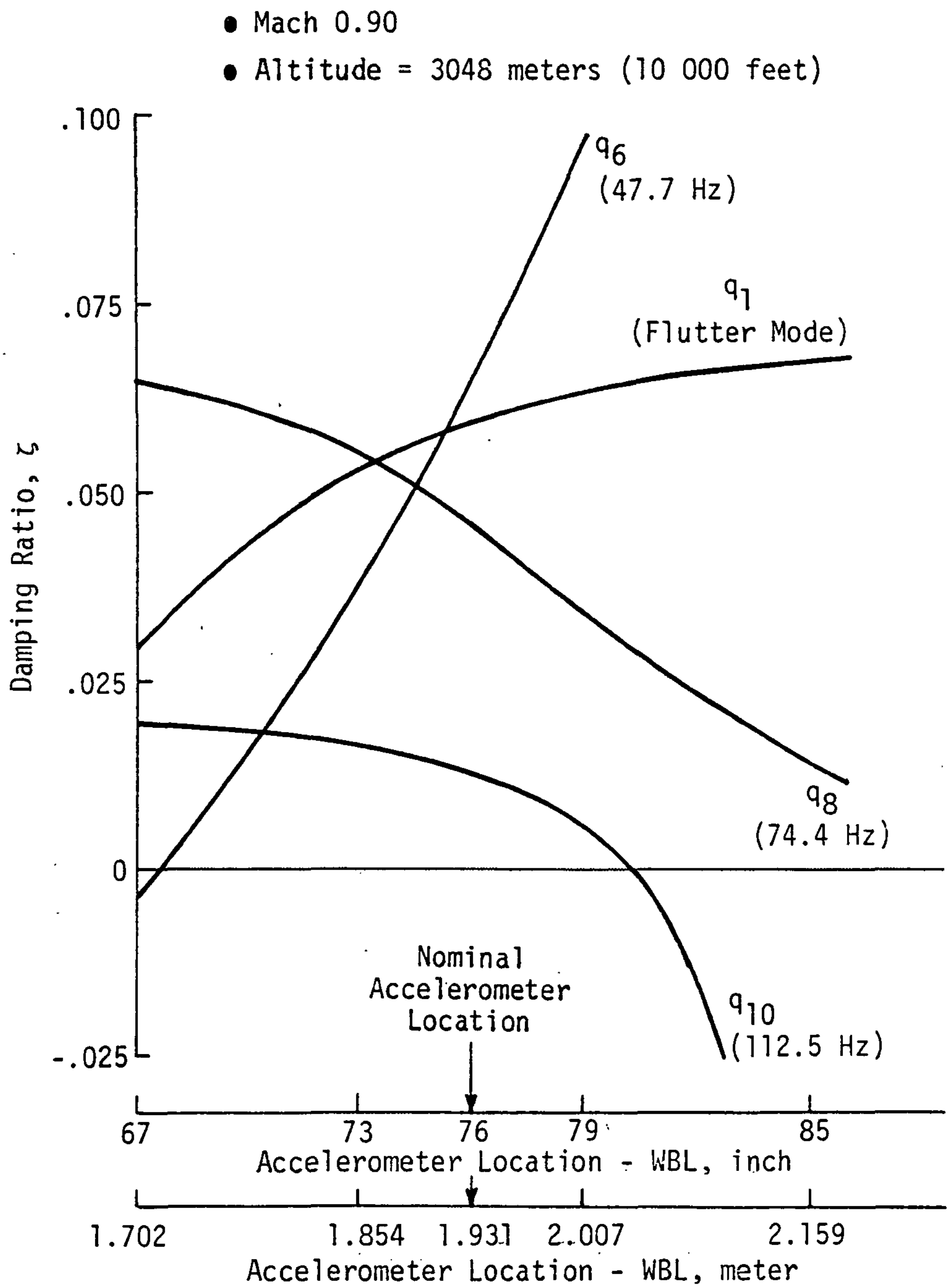


FIGURE 5-11 - VARIATION IN SYMMETRIC WING ACCELEROMETER LOCATION

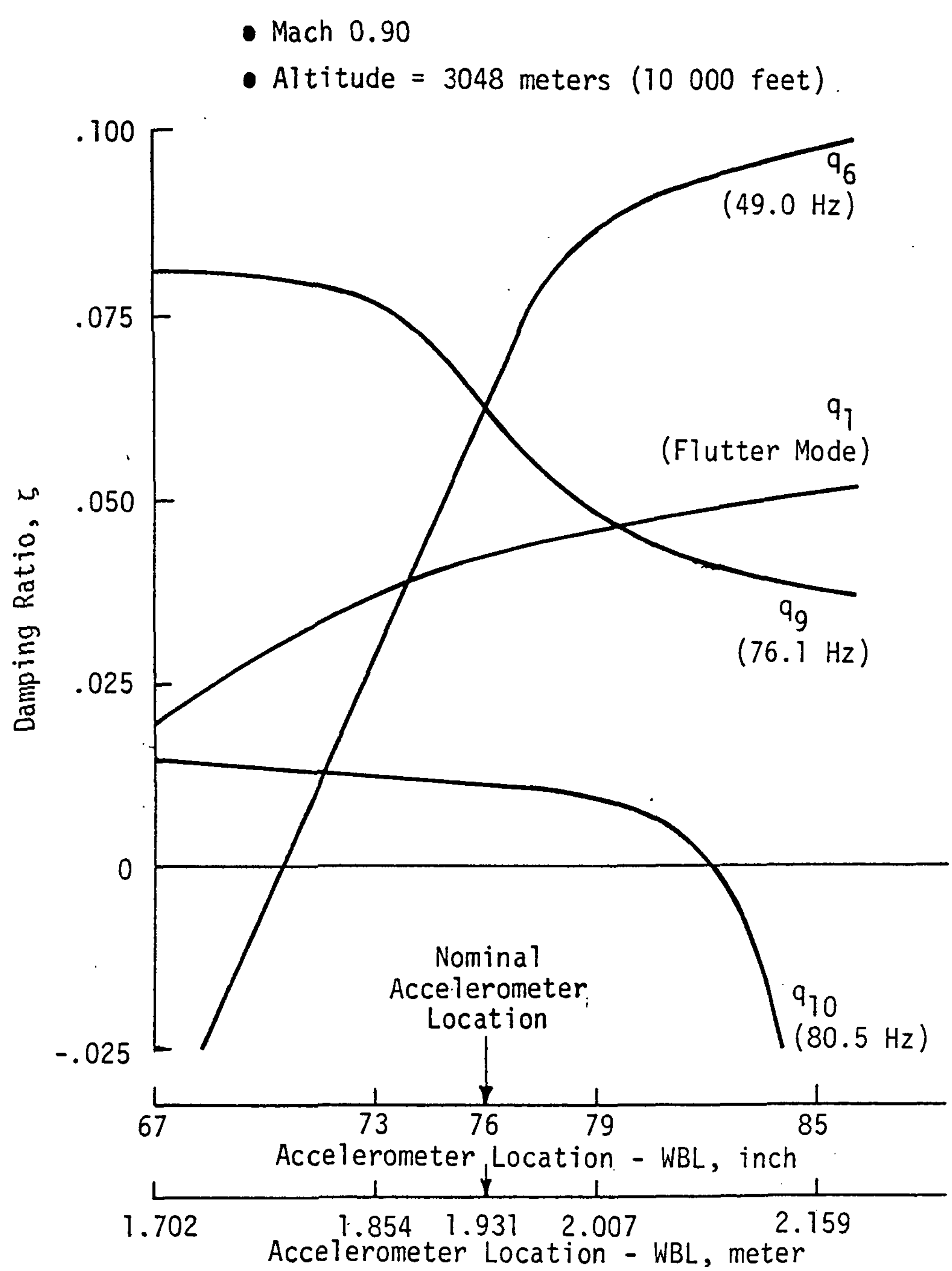


FIGURE 5-12 - VARIATION IN ANTISYMMETRIC WING ACCELEROMETER LOCATION

5.3.2 Sensitivity to servoactuator dynamics - As discussed in Paragraph 4.3.2, actuator dynamics change with changing control surface hinge moment. The FSS was synthesized using the no-load actuator dynamics, then the effect of maximum resisting and maximum aiding hinge moment variations on stability was evaluated.

Capability of the FSS to stabilize the flutter mode at 3048 meters, (10 000 feet) for the symmetric and antisymmetric flutter suppression system is shown on Figures 5-13 and 5-14, respectively. The system-on flutter boundary for the symmetric FSS has been lowered from about Mach 1.0 to Mach 0.96 for the actuator response with the maximum resisting hinge moment, which is equal to 1.2 V_f, while the antisymmetric FSS is not significantly affected.

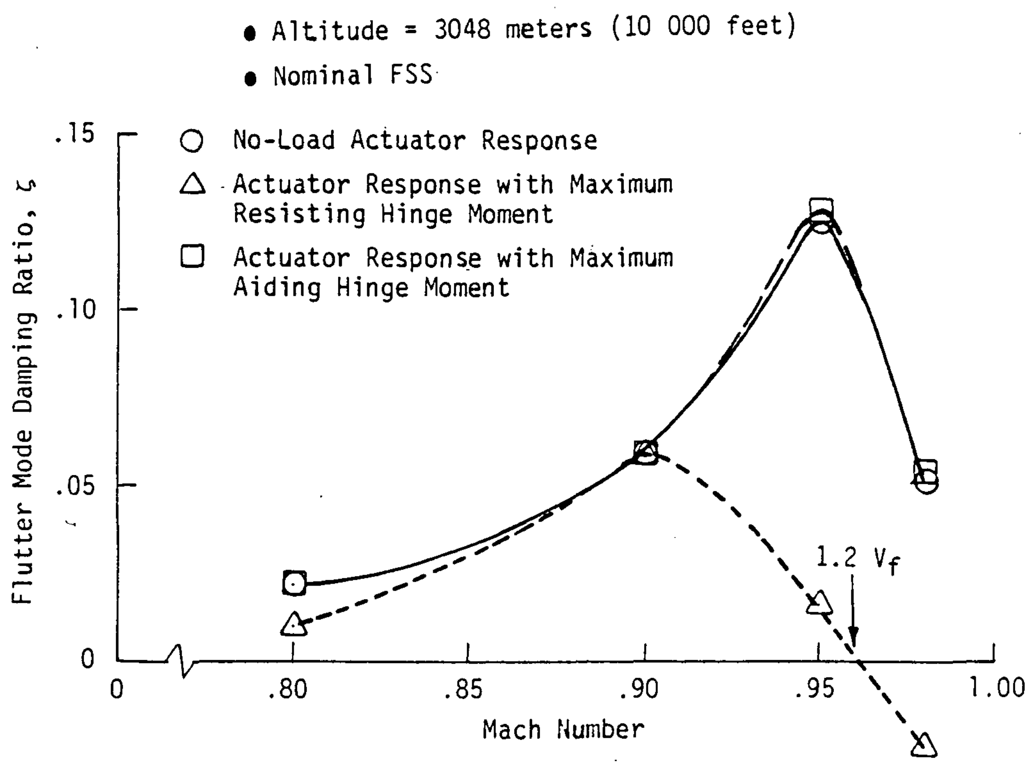


FIGURE 5-13 - SYMMETRIC FLUTTER MODE DAMPING WITH ACTUATOR VARIATIONS

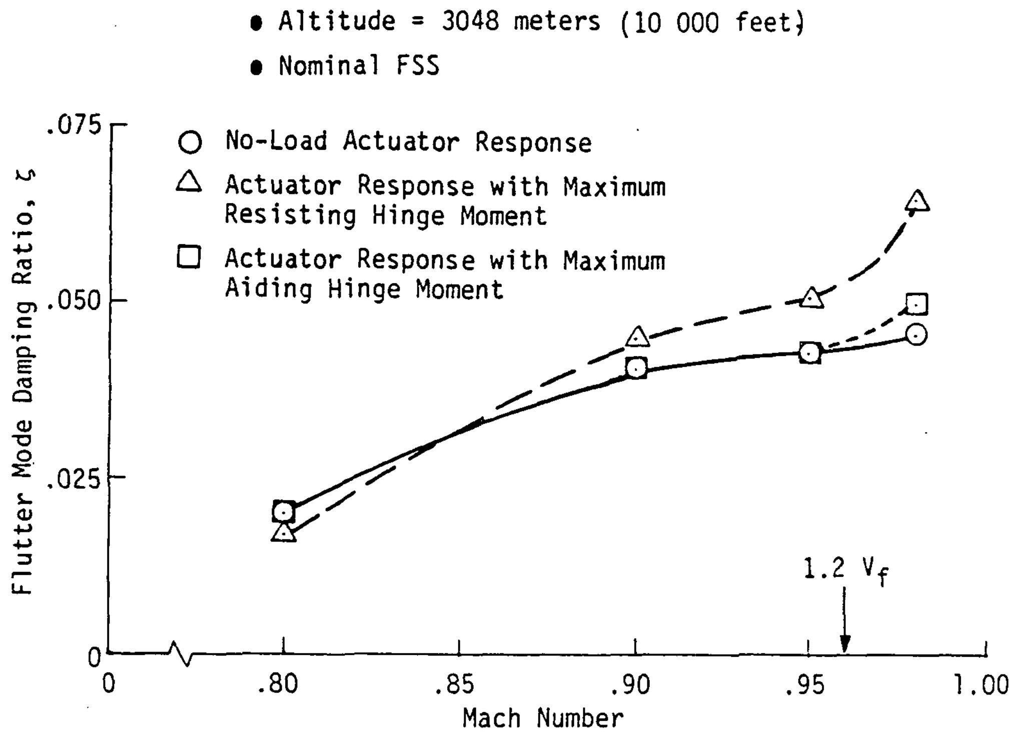


FIGURE 5-14 - ANTISYMMETRIC FLUTTER MODE DAMPING WITH ACTUATOR VARIATIONS

5.3.3 Parameter scheduling sensitivity - Because the filter time constant scheduling is complex, effects of scheduling variations are not readily apparent. The static and impact pressure sensors were determined to be accurate within ±0.2 percent and variations in these parameters were not evaluated. The effect of temperature variations on the "D" parameter was used to evaluate parameter scheduling sensitivity. Results of air temperature variations of ±17.2°C (31°F) on the "D" parameter for the symmetric and antisymmetric systems are shown on Figures 5-15 and 5-16, respectively. These plots show that the FSS performance is not appreciably degraded.

5.3.4 FSS gain sensitivity - The FSS has at least -6 dB gain margin on the flutter mode. The following data is presented to show the flutter mode damping ratio at -6 dB gain margin. FSS performance with gain reduced by 2.0 (-6 dB) is shown on Figures 5-17 and 5-18 for the 3048 meter (10 000 feet) condition. The FSS exhibits more than -6 dB gain margin at many of the flight conditions, especially the antisymmetric system.

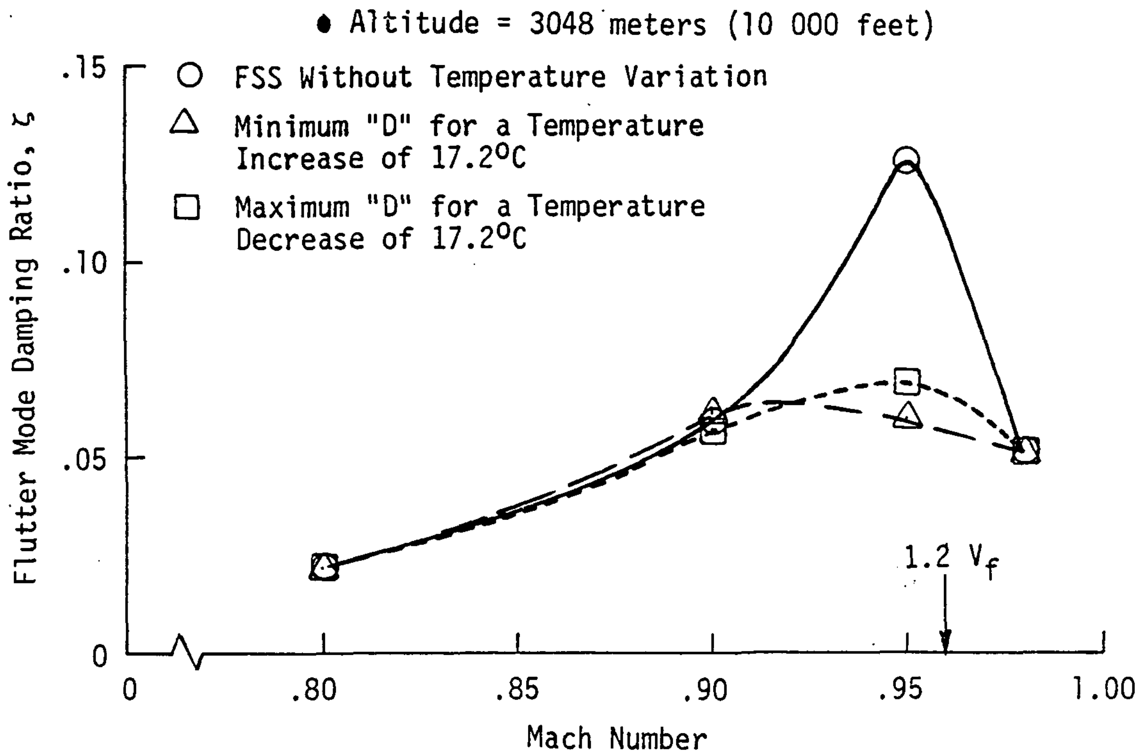


FIGURE 5-15 - SYMMETRIC FLUTTER MODE DAMPING WITH PARAMETER (D) VARIATIONS

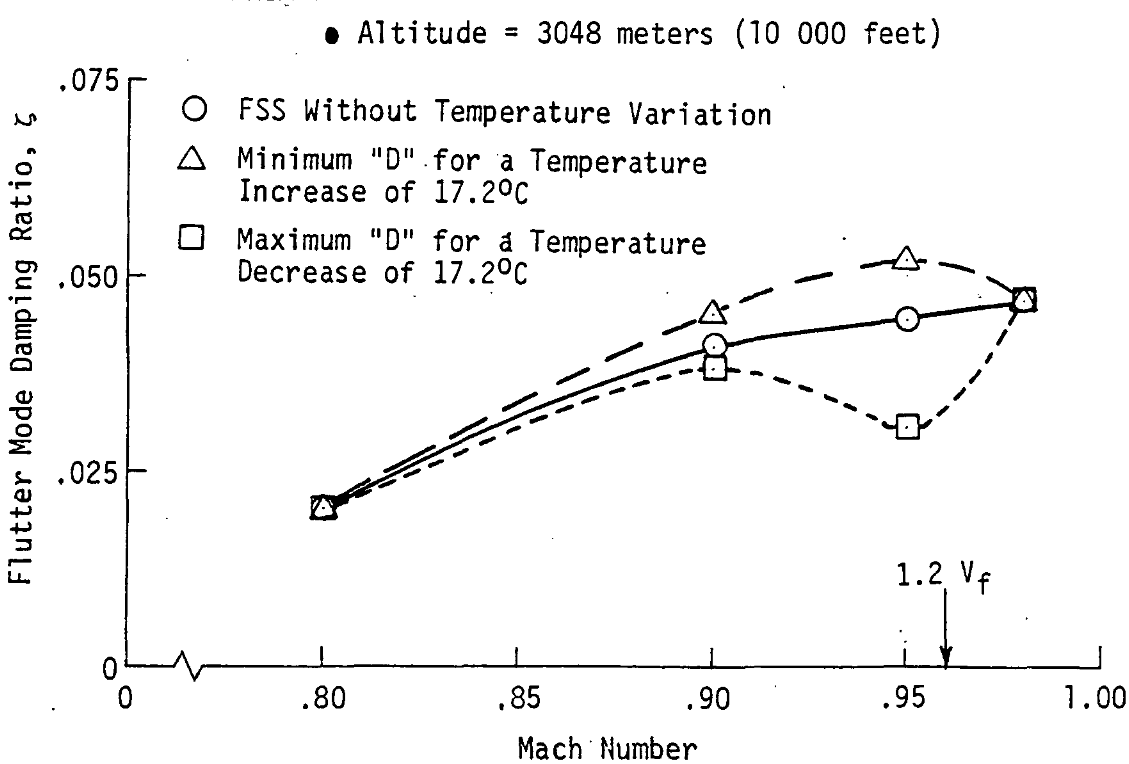


FIGURE 5-16 - ANTISYMMETRIC FLUTTER MODE DAMPING WITH PARAMETER (D) VARIATIONS

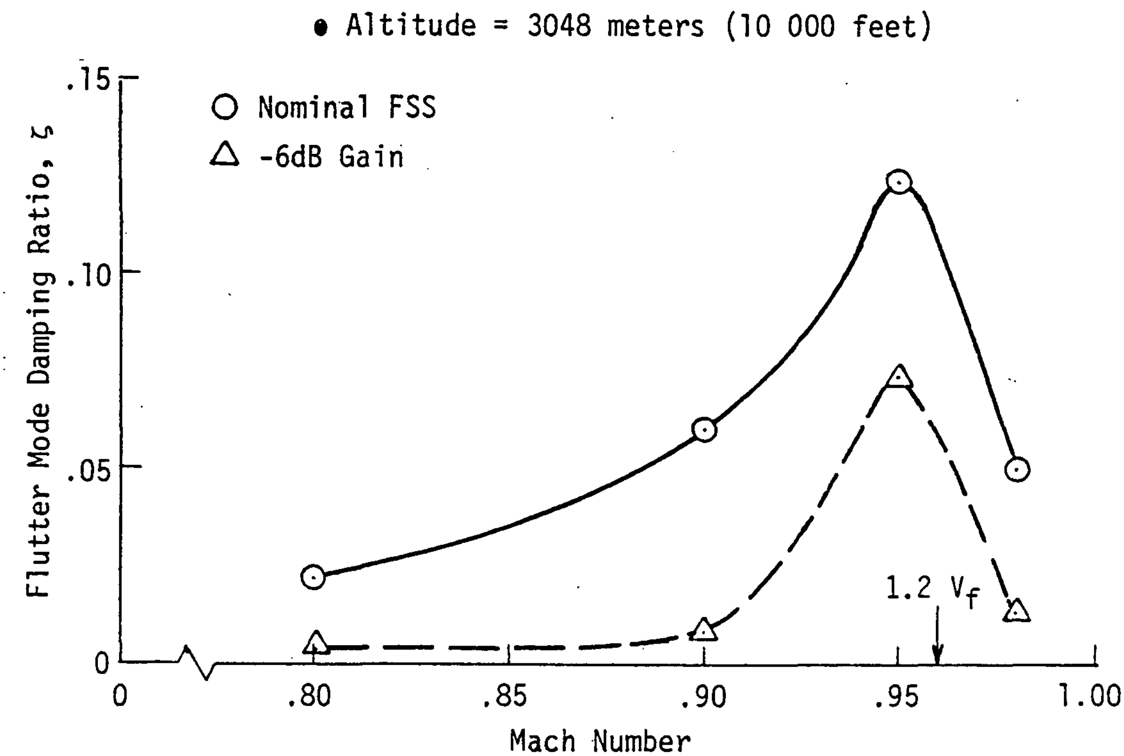


FIGURE 5-17 - SYMMETRIC FLUTTER MODE DAMPING WITH GAIN VARIATIONS

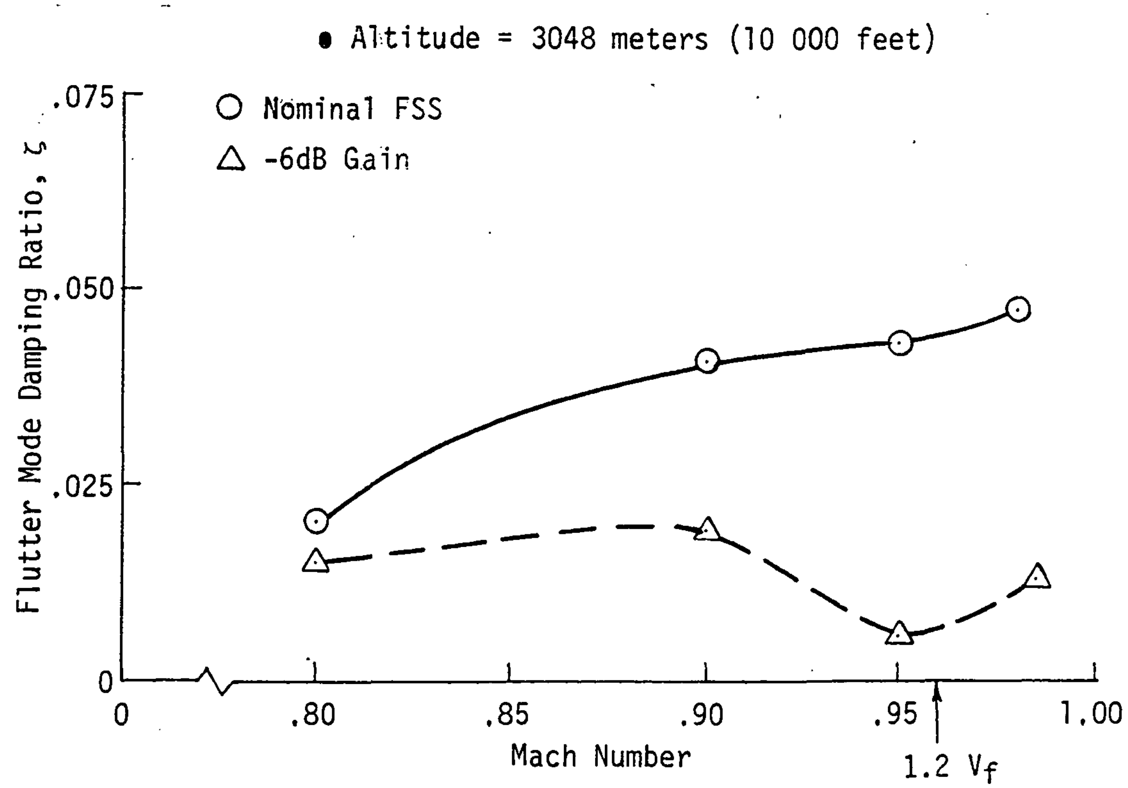


FIGURE 5-18 - ANTISYMMETRIC FLUTTER MODE DAMPING WITH GAIN VARIATIONS

5.3.5 Combined worst case variations - Effects of aileron displacement saturation and the combined effects of saturation with variations in actuator dynamics and temperature on "D" parameter scheduling were analyzed.

As described in Paragraph 6.1, control surface displacement saturation can occur during operation of the symmetric system at Mach numbers above 0.94 in 3.66 m/s (12 ft/sec) peak turbulence. This effect was approximated by reducing the FSS gain by the ratio of maximum available surface to maximum commanded surface. This is a valid approximation because displacement saturation appears as a gain reduction with no change in phase. The effects on the symmetric FSS performance are shown on Figure 5-19, and effects on the antisymmetric system performance are shown on Figure 5-20.

Also included on Figures 5-19 and 5-20 are the results of combining aileron displacement saturation with the actuator dynamics for maximum resisting hinge moment and with temperature effects on "D" parameter scheduling. The antisymmetric FSS continued to extend the flutter boundary to 1.2 V_f with combined worst case variations while the symmetric FSS is degraded to 1.16 V_f. However, the likelihood of all of these variations occurring simultaneously is remote.

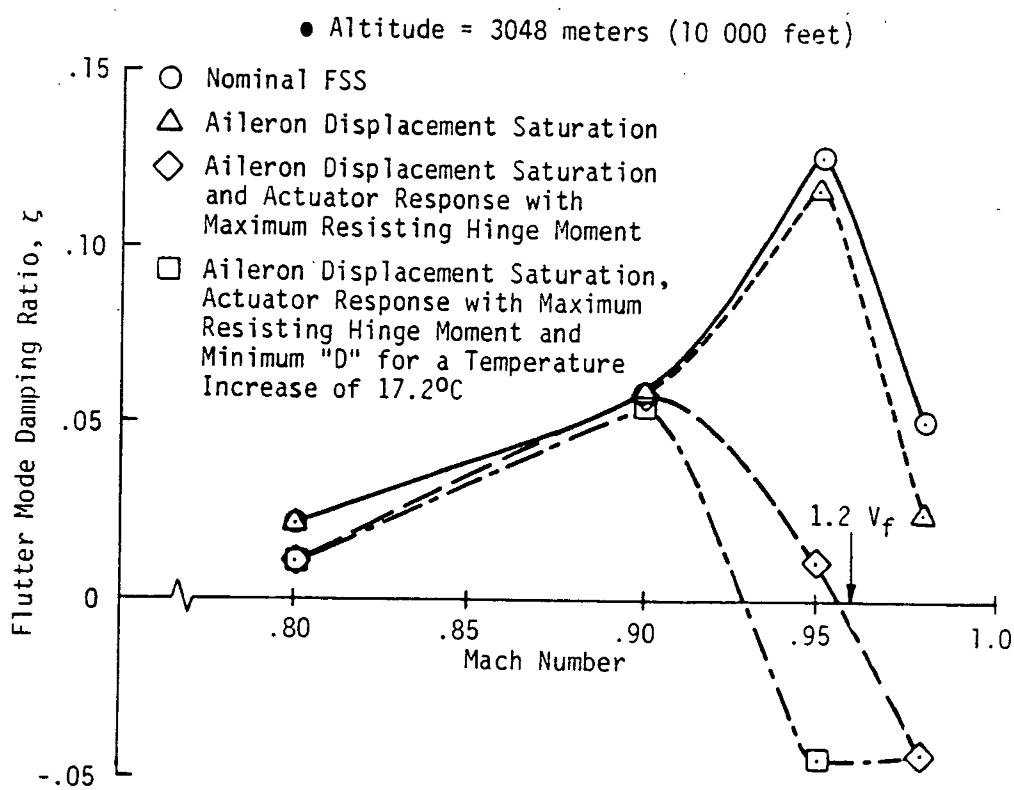


FIGURE 5-19 - SYMMETRIC FLUTTER MODE DAMPING FOR COMBINED WORST CASE VARIATIONS

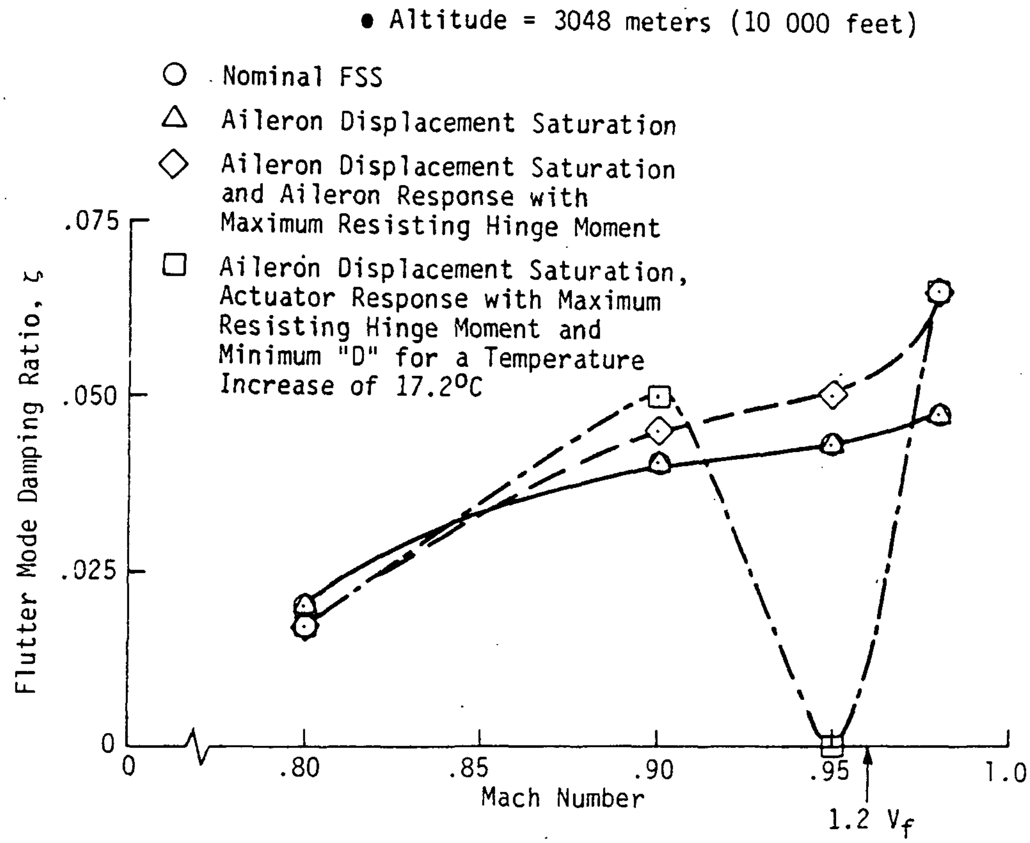


FIGURE 5-20 - ANTISYMMETRIC FLUTTER MODE DAMPING FOR COMBINED WORST CASE VARIATIONS

5.4 FSS and AFCS Compatibility

Flutter suppression system and automatic flight control system compatibility was verified by determining the effects of the FSS on rigid body modes and the effects of the AFCS on the flutter modes.

A block diagram of the AFCS furnished by NASA to evaluate compatibility of the flutter suppression system and the automatic flight control system is shown on Figure 5-21.

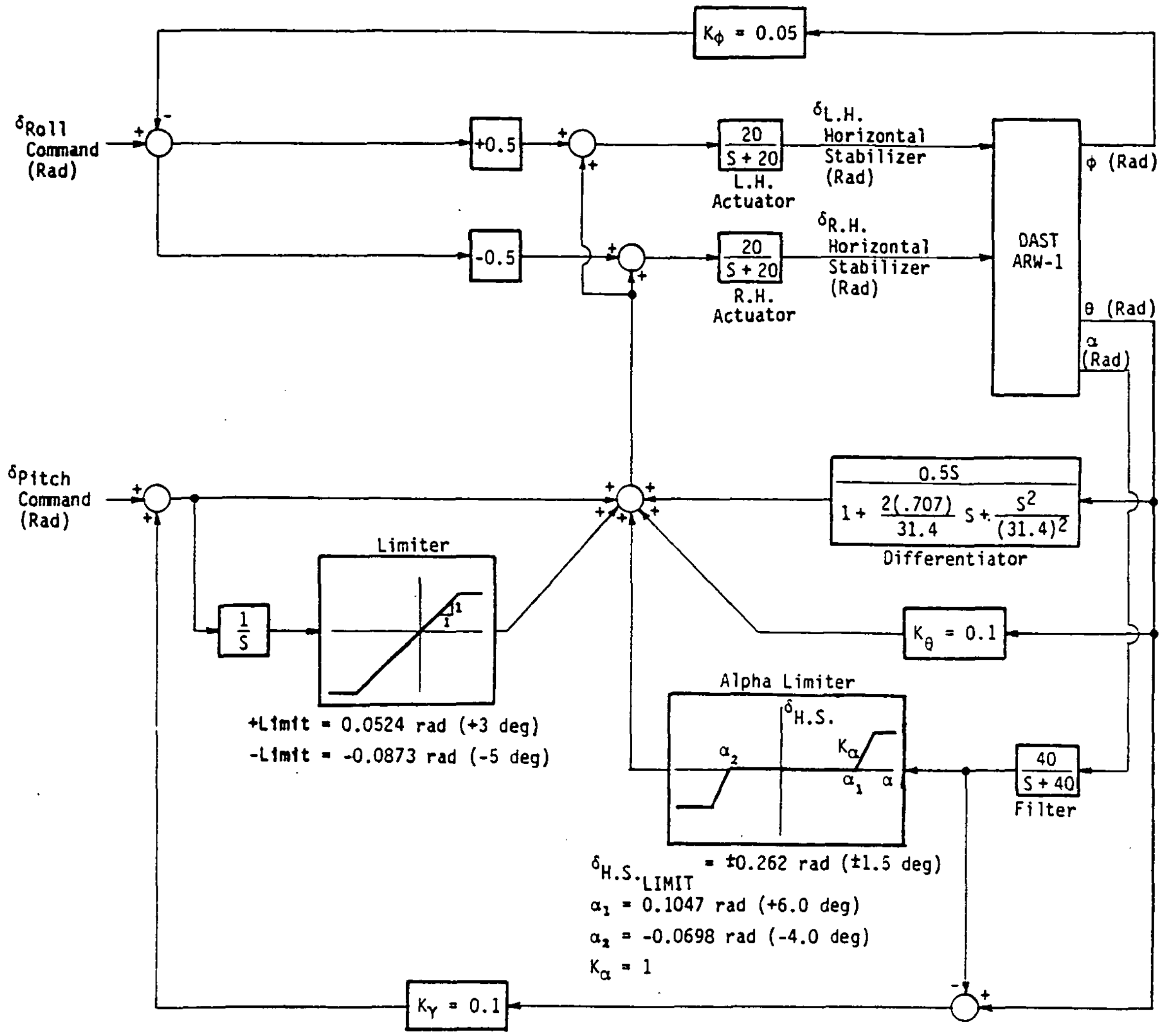


FIGURE 5-21 - DAST ARW-1 AFCS BLOCK DIAGRAM

5.4.1 FSS compatibility with the FSS - Closed loop transfer functions were obtained and the effects of the FSS on the short period and dutch roll damping and frequency are shown in Figures 5-22 and 5-23, respectively for the 3048 meter (10 000 feet) altitude conditions. The FSS affects damping of these modes only at high Mach numbers, decreasing short period mode damping and increasing dutch roll mode damping slightly.

5.4.2 AFCS compatibility with the FSS - With the FSS and the lateral and longitudinal AFCS feedback loops closed compatibility of the AFCS with the FSS was evaluated. The effects on the flutter modes are shown on Figures 5-24 and 5-25 at Mach 0.9. The AFCS increases the symmetric flutter mode damping slightly and has no affect on the antisymmetric flutter mode.

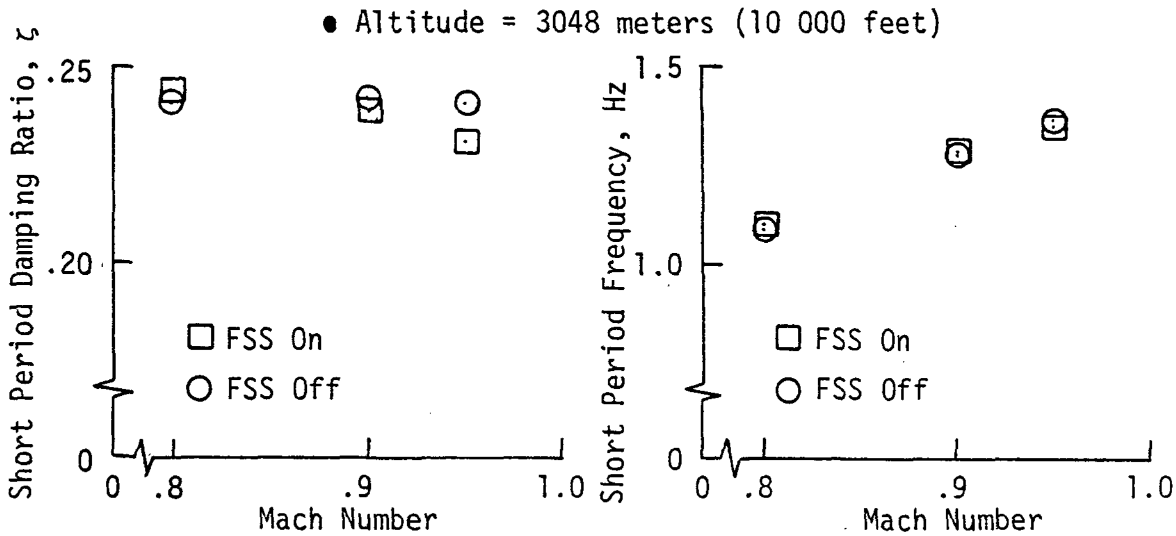


FIGURE 5-22 - FSS COMPATIBILITY WITH SHORT PERIOD

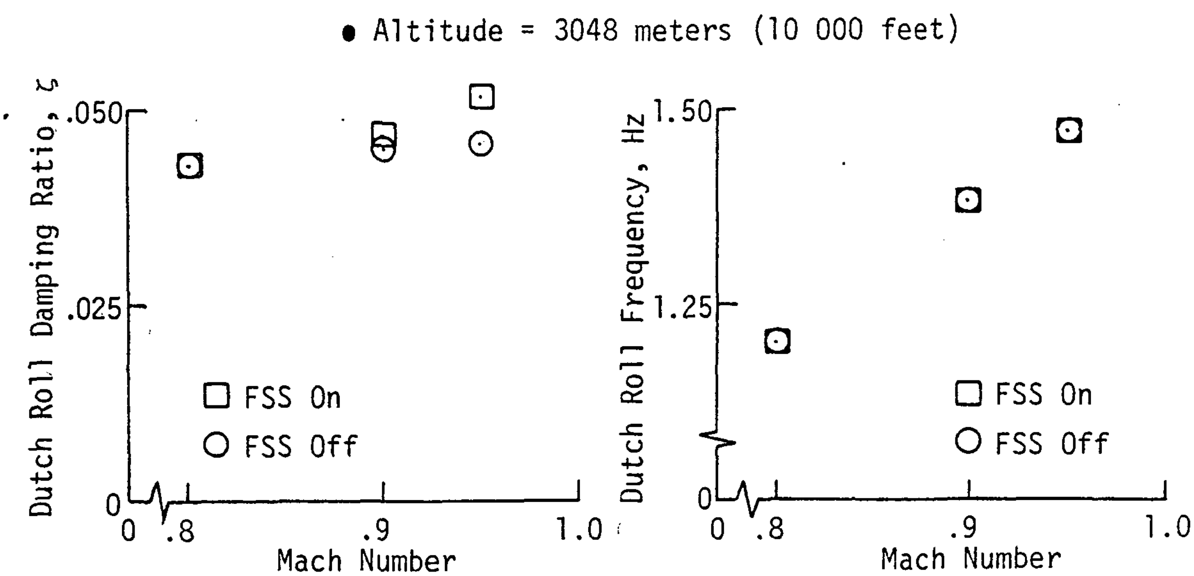


FIGURE 5-23 - FSS COMPATIBILITY WITH DUTCH ROLL

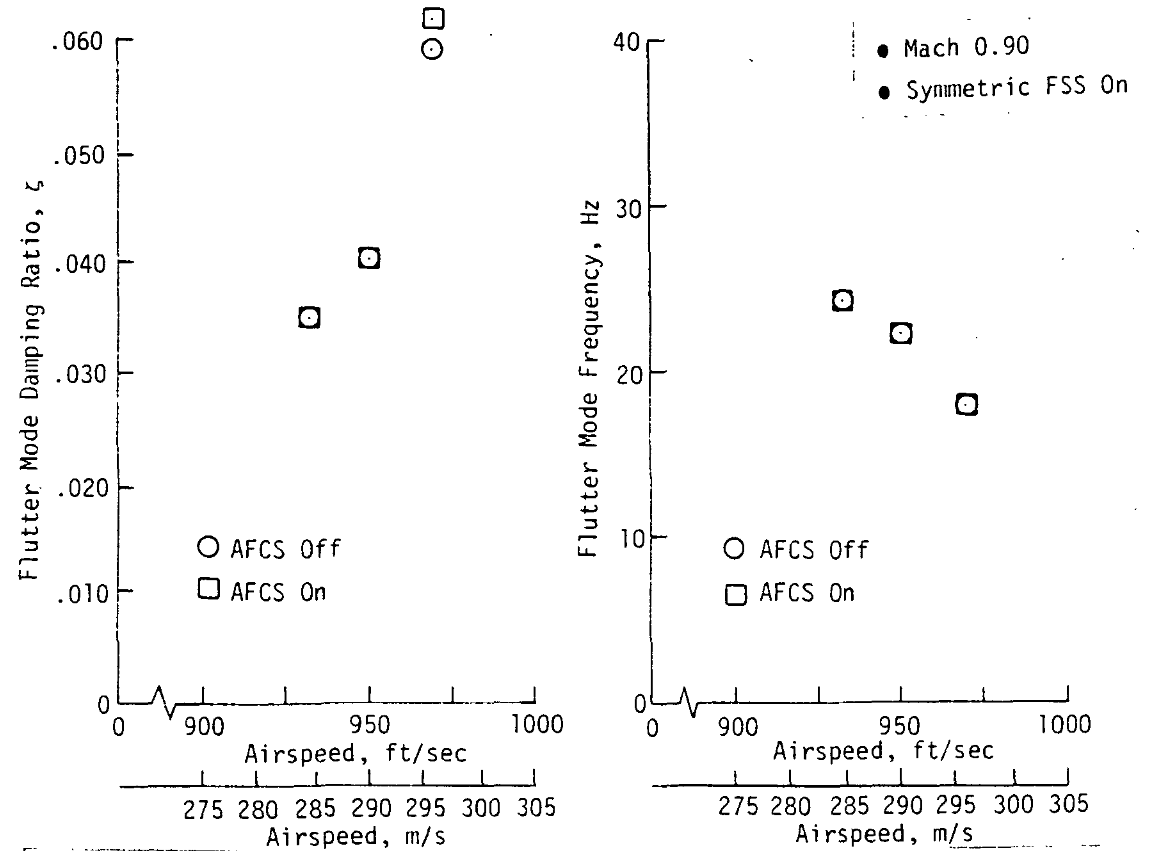


FIGURE 5-24 - LONGITUDINAL AFCS EFFECTS ON SYMMETRIC FLUTTER MODE

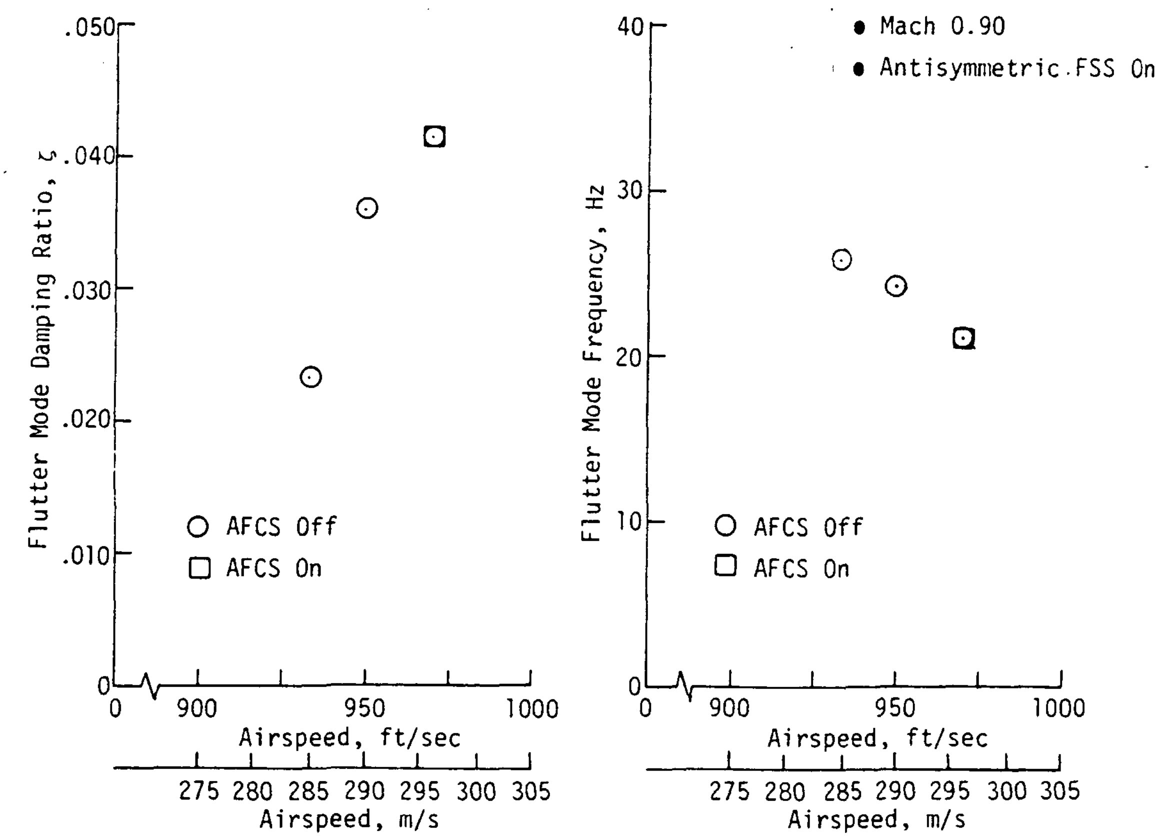


FIGURE 5-25 - LATERAL AFCS EFFECTS ON ANTISYMMETRIC FLUTTER MODE

5.5 Unsymmetric FSS Analysis

Analysis was conducted using the unsymmetric equations of motion described in Section 3.5. These equations allow the left and right wing control surfaces to move independently and left and right wing sensors to sense motion independently. A single wing FSS was evaluated on the unsymmetric equations to determine if a system using control surface and sensors on only one wing panel could stabilize the flutter mode on both wing panels. Capability of the FSS to stabilize the flutter modes after sustaining the loss of a single wing accelerometer or control surface was also evaluated.

5.5.1 Single wing FSS - A single wing FSS was defined by simplifying the full drone FSS defined in Paragraph 4.3.6 down to only the loop from the right wing sensor to the right wing aileron. A block diagram of this system is shown on Figure 5-26. The fuselage sensors remain to cancel the rigid body motion and the "D" parameter scheduling was unchanged.

A pole-zero altitude root locus was obtained to determine if this system was feasible. As shown on Figure 5-27, the flutter modes coalesce with the bending modes as altitude decreases with one of the flutter mode zeroes behaving as before. However, accompanying the flutter and bending modes are two zeroes which will make two of these modes uncontrollable. This is confirmed by the root locus at Mach 0.90, 3048 meters (10 000 feet) on Figure 5-28.

Apparently the wings are decoupled, preventing a single wing FSS from controlling flutter on the opposite wing.

5.5.2 Unsymmetric failure analysis - Two unsymmetric failure modes were analyzed using the unsymmetric equations of motion. Block diagrams of the FSS with a failed wing sensor and a failed actuator are shown on Figure 5-29. These systems could represent an unsymmetric FSS compromising between a single wing and a dual wing system.

With the right sensor to right aileron loop closed as previously shown on the root locus of Figure 5-28, effects of closing the remaining left wing loops shown on Figure 5-29 are depicted on Figures 5-30 and 5-31. A failed sensor or actuator on one wing will cause that wing flutter mode to be unstable at the Mach 0.90,3048 meters (10 000 feet) altitude condition.

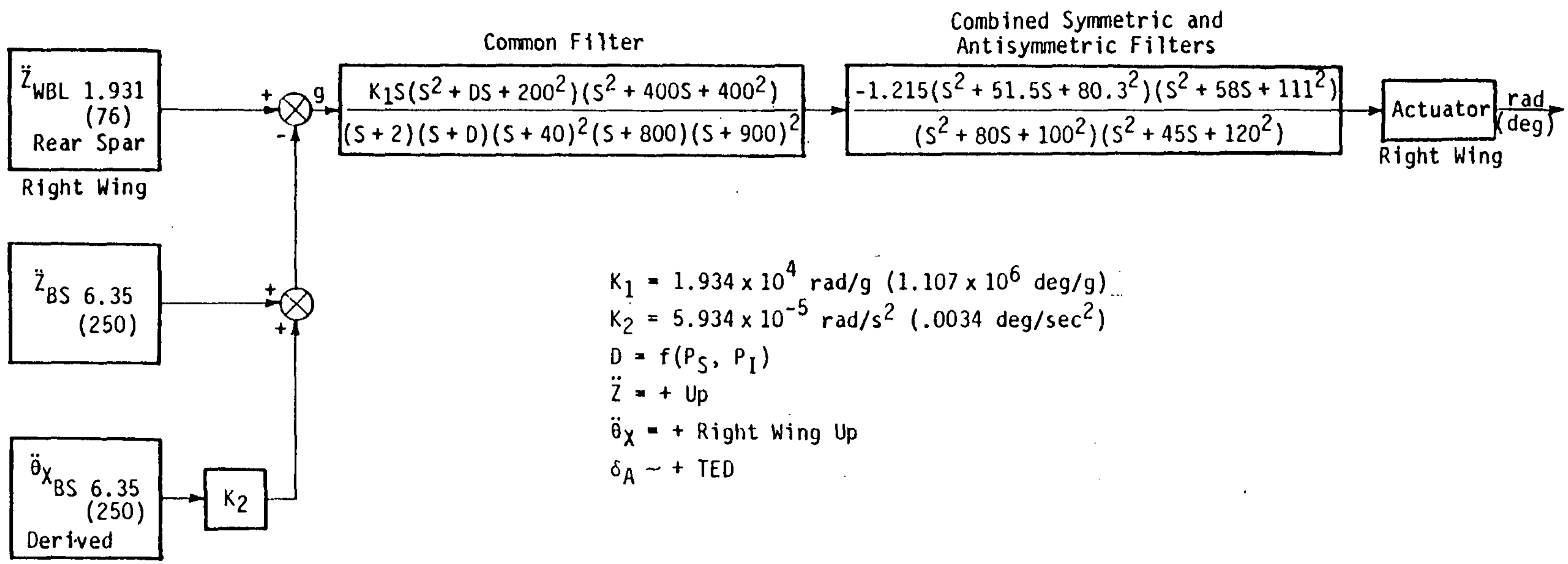


FIGURE 5-26 - DAST ARW-1 UNSYMMETRIC FLUTTER SUPPRESSION SYSTEM

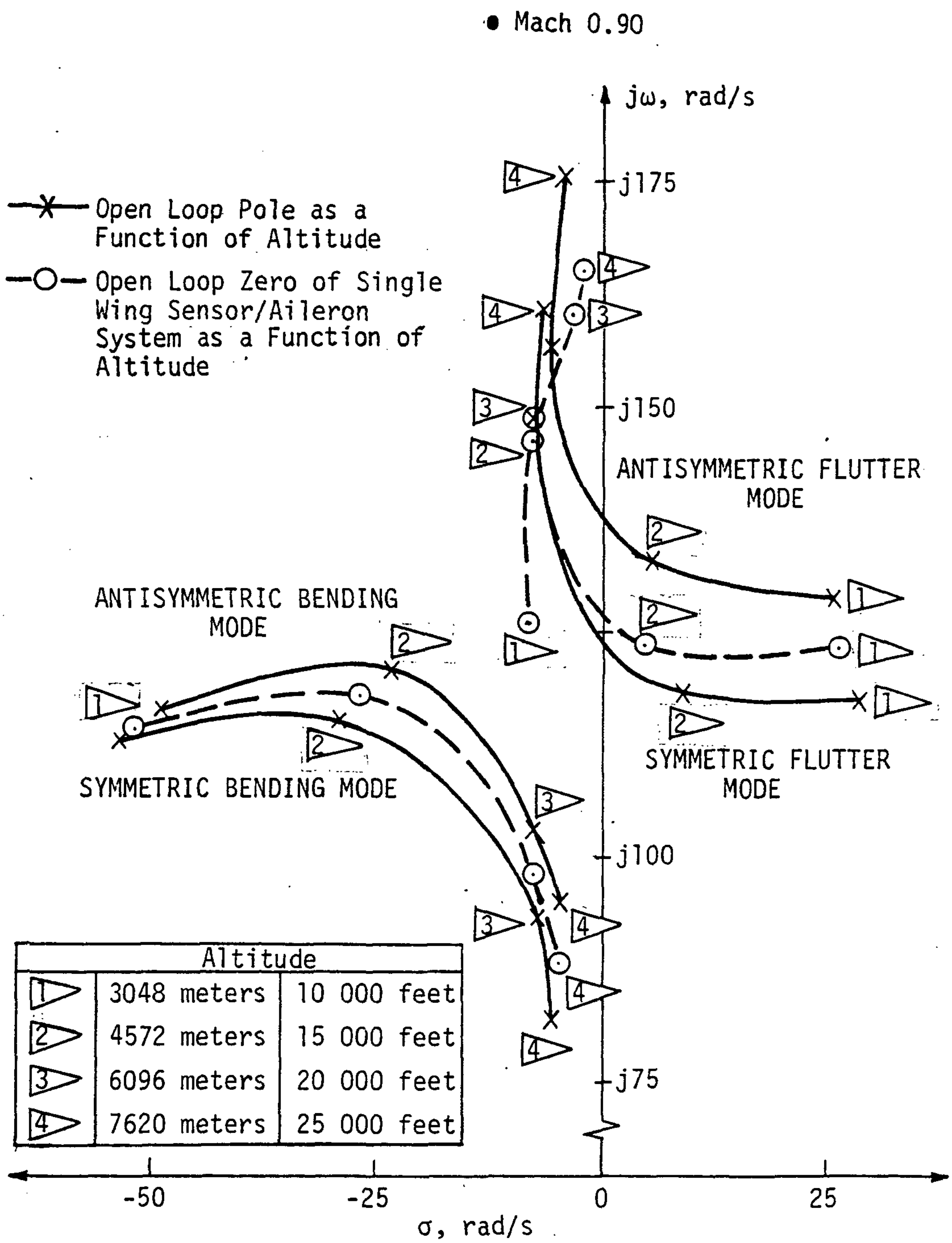


FIGURE 5-27 - DAST ARW-1 UNSYMMETRIC POLE-ZERO LOCATIONS VERSUS ALTITUDE

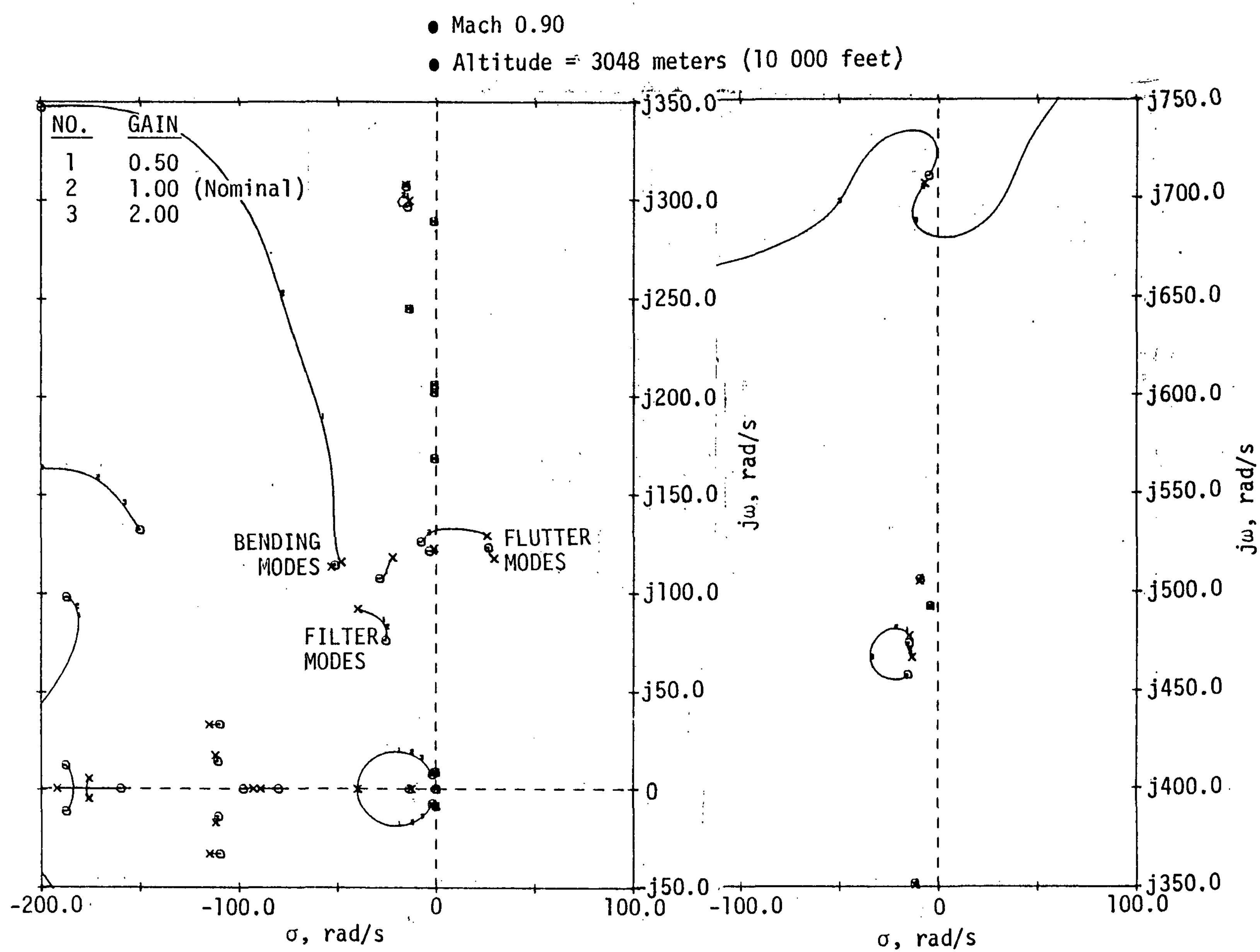
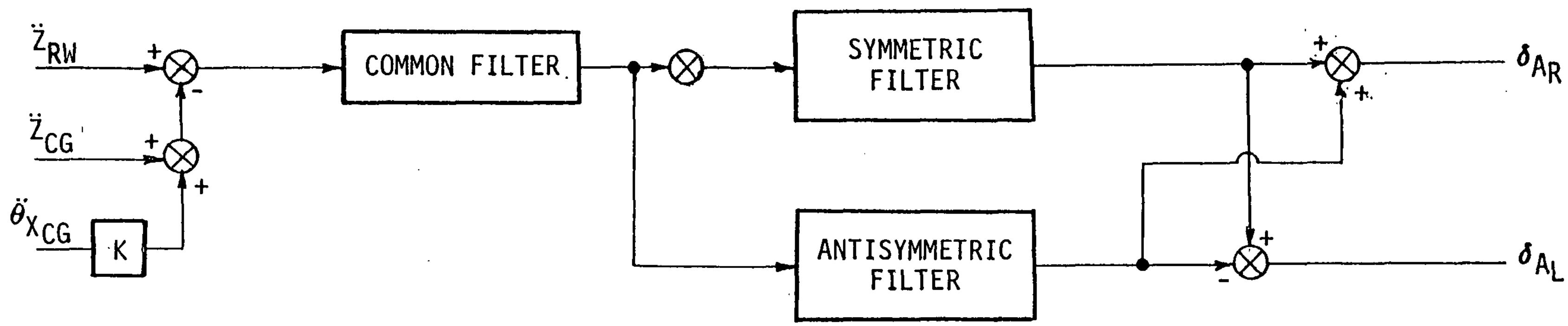
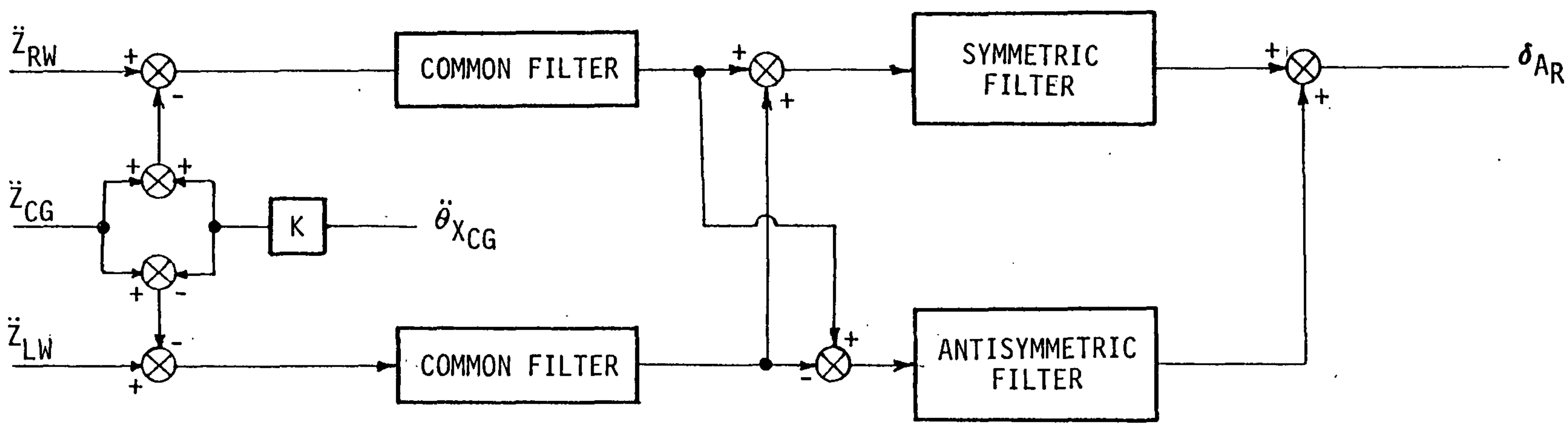


FIGURE 5-28 - DAST ARW-1 UNSYMMETRIC FSS GAIN ROOT LOCUS



FAILED LEFT WING SENSOR



FAILED LEFT WING ACTUATOR

FIGURE 5-29 - BLOCK DIAGRAMS OF THE FSS WITH SENSOR AND ACTUATOR FAILED

- Mach 0.90
- Altitude = 3048 meters (10 000 feet)
- Right Sensor to Right Aileron Loop Closed

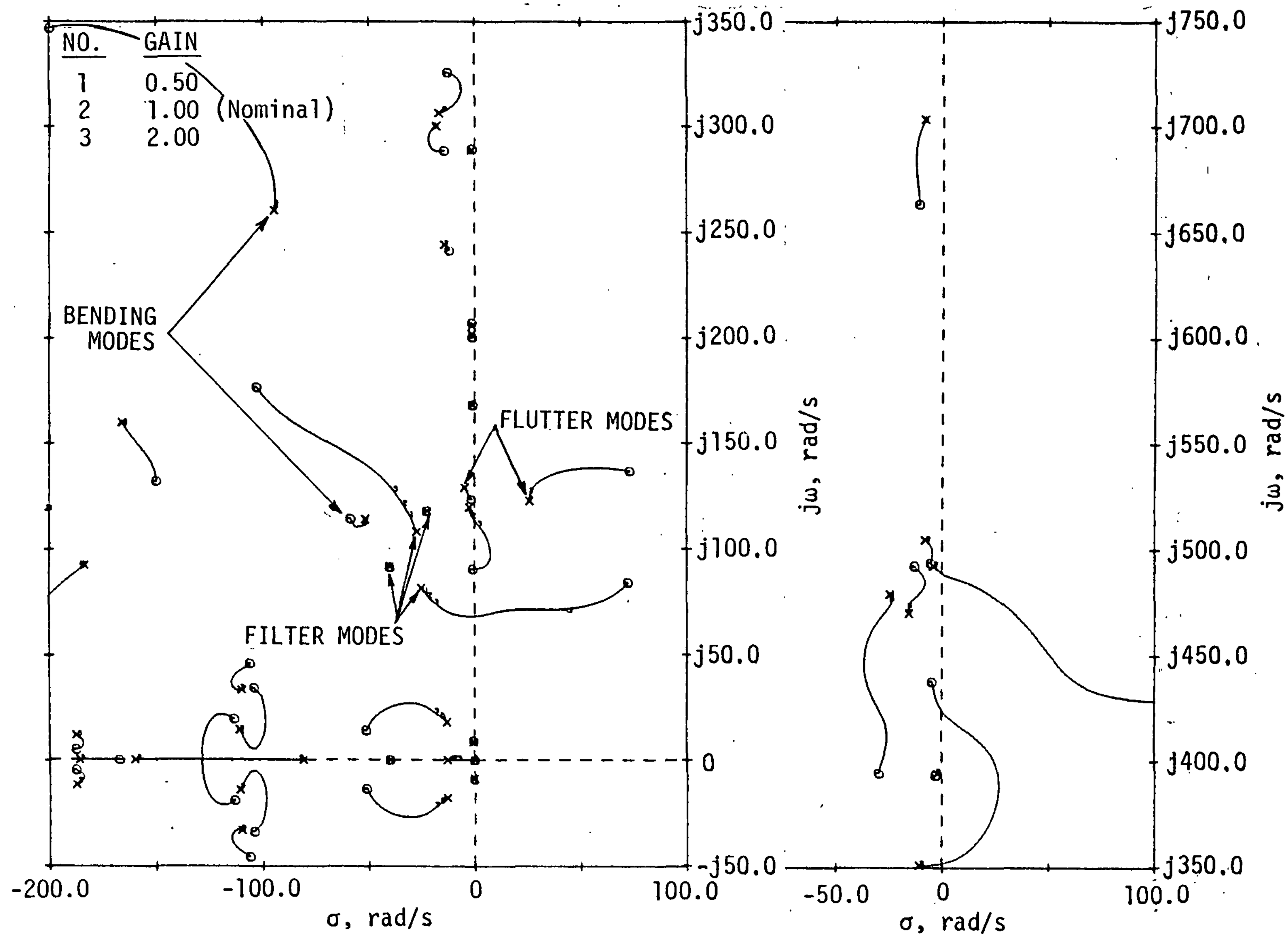


FIGURE 5-30 - GAIN ROOT LOCUS OF FSS WITH LEFT SENSOR FAILED

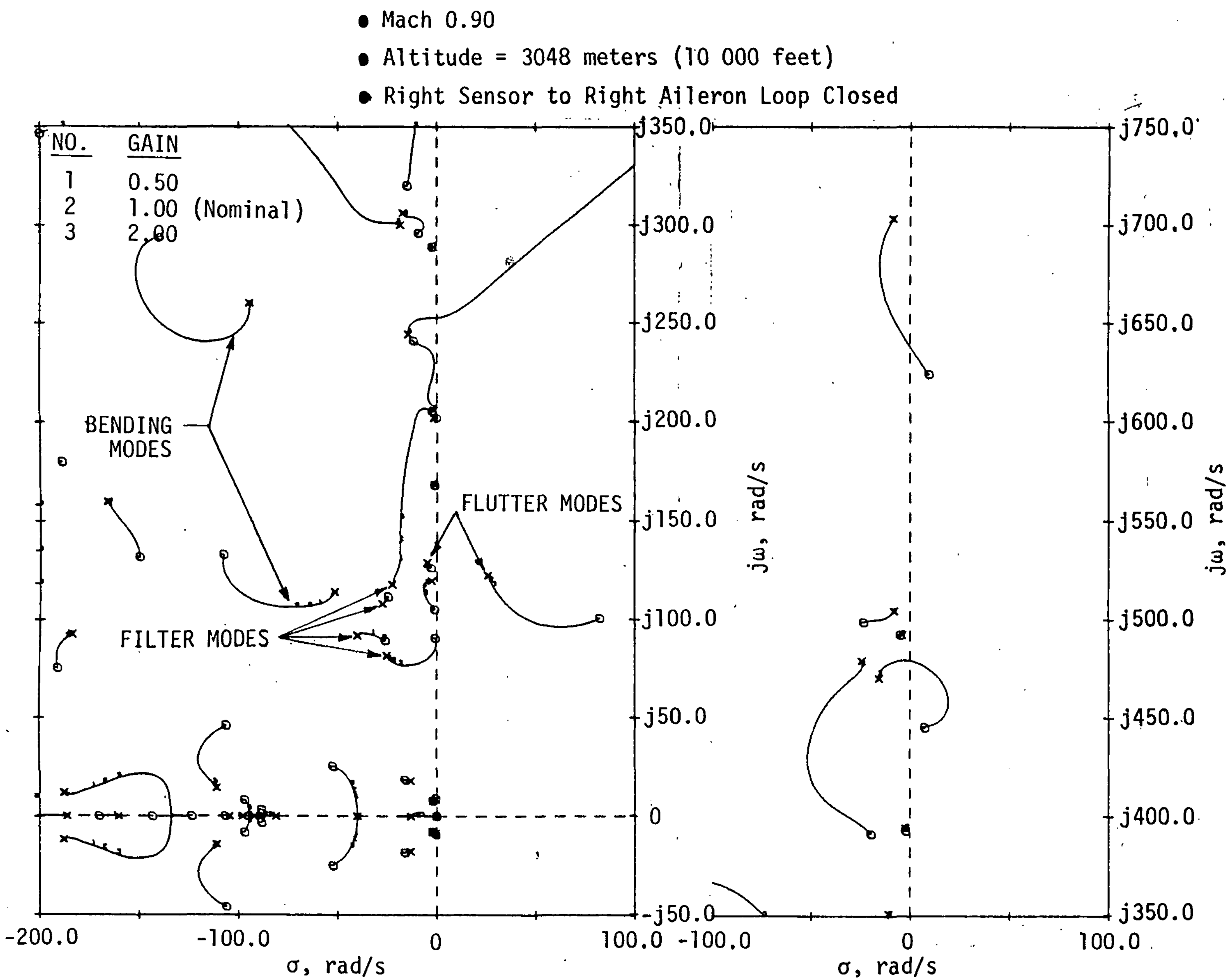


FIGURE 5-31 - GAIN ROOT LOCUS OF FSS WITH LEFT AILERON FAILED

6.0 FLUTTER SUPPRESSION SYSTEM MECHANIZATION

A functional block diagram of the DAST ARW-1 configuration flight control system is shown on Figure 6-1. The new equipment added to the drone for the flutter suppression system flight tests includes the system motion sensors and electronic shaping filters and the outboard aileron servoactuation system. NASA will install the hydraulic power supply unit, accumulator, filter and lines aft to the BS 5.931 (233.5) bulkhead. All other components were either designed and fabricated or procured by Boeing for installation in the drone test vehicle, including the hydraulic accumulator.

Mechanization of the wing outboard ailerons required for the flutter suppression system is discussed in Paragraph 6.1. The ailerons utilize special design, subminiature rotary actuators and Moog Series 30 flow control servovalves. Servoactuator position and load pressure feedback loops and the servovalve drive amplifiers are mechanized in the flutter suppression system electronics.

Design of the flutter suppression electronics and three special ground support test units is discussed in Paragraph 6.2. The flutter suppression system electronics consists of twenty electronic circuit cards in a box that mounts in the drone fuselage, the system feedback sensors and interconnecting wiring. Interface requirements and ground support equipment requirements are also discussed in Paragraph 6.2.

6.1 Servoactuator and Hydraulic System

The wing outboard aileron required for the flutter suppression system is mechanized using a special design subminiature rotary actuator located at the inboard edge of the surface controlled by a flow control servovalve mounted in the wing center section. The servoactuators use actuator shaft position and differential load pressure feedback. Hydraulic power for the outboard aileron servoactuator is provided by a hydraulic power unit mounted in the drone fuselage as shown on Figure 6-2. A hydraulic accumulator is used with the hydraulic power unit to help meet peak flow requirements of the flutter suppression system.

The following paragraphs discuss the control surface requirements, actuator sizing and servoactuator stability and hydraulic system analyses.

6.1.1 <u>Control surface requirements</u> - Displacement and rate requirements for the outboard aileron were determined during the flutter suppression system synthesis and performance evaluation and are discussed in Paragraph 5.2. The peak displacement and rate requirements occur at the Mach 0.98, 3658 meters (12 000 feet)

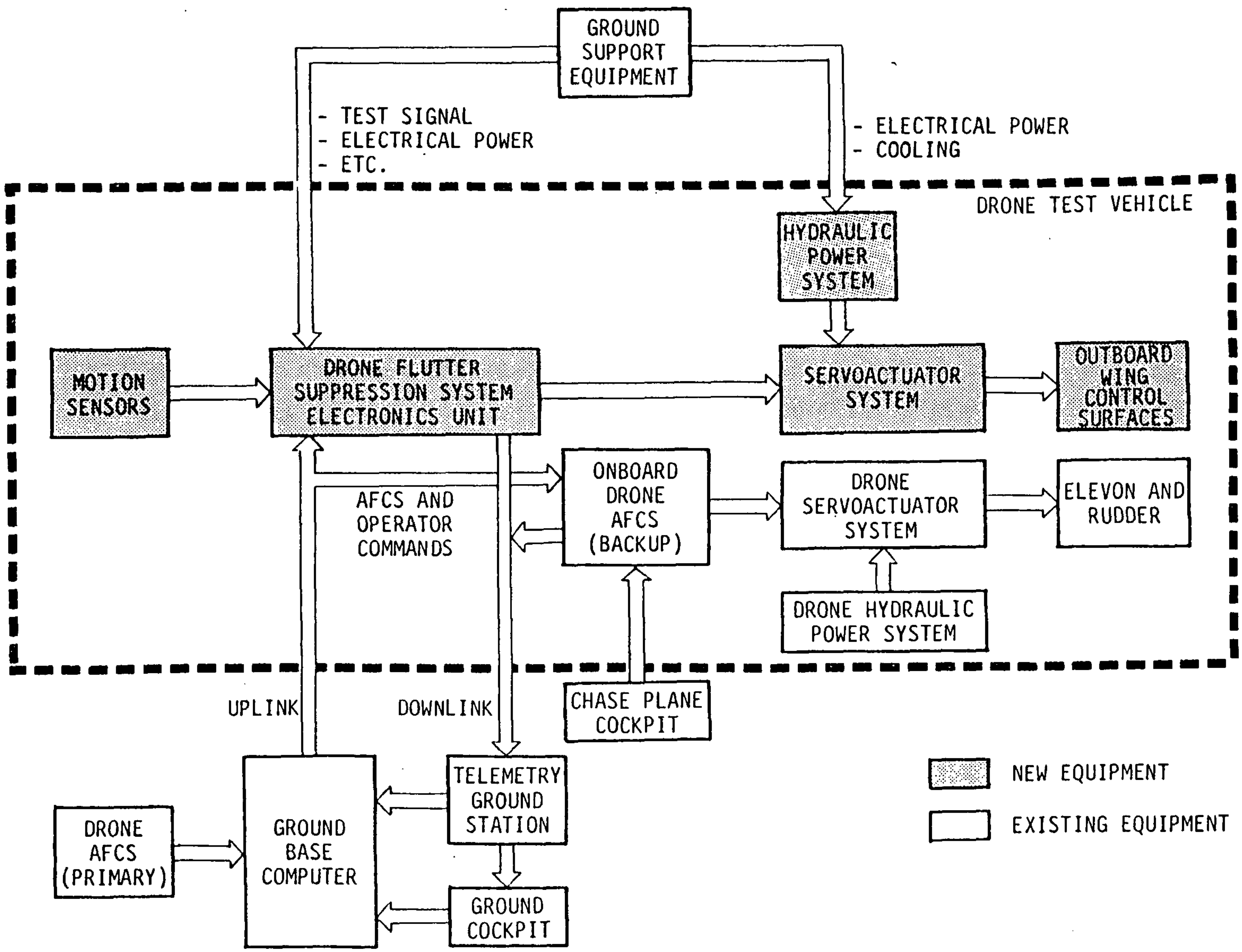


FIGURE 6-1 - FUNCTIONAL BLOCK DIAGRAM OF DRONE FLIGHT CONTROL SYSTEM

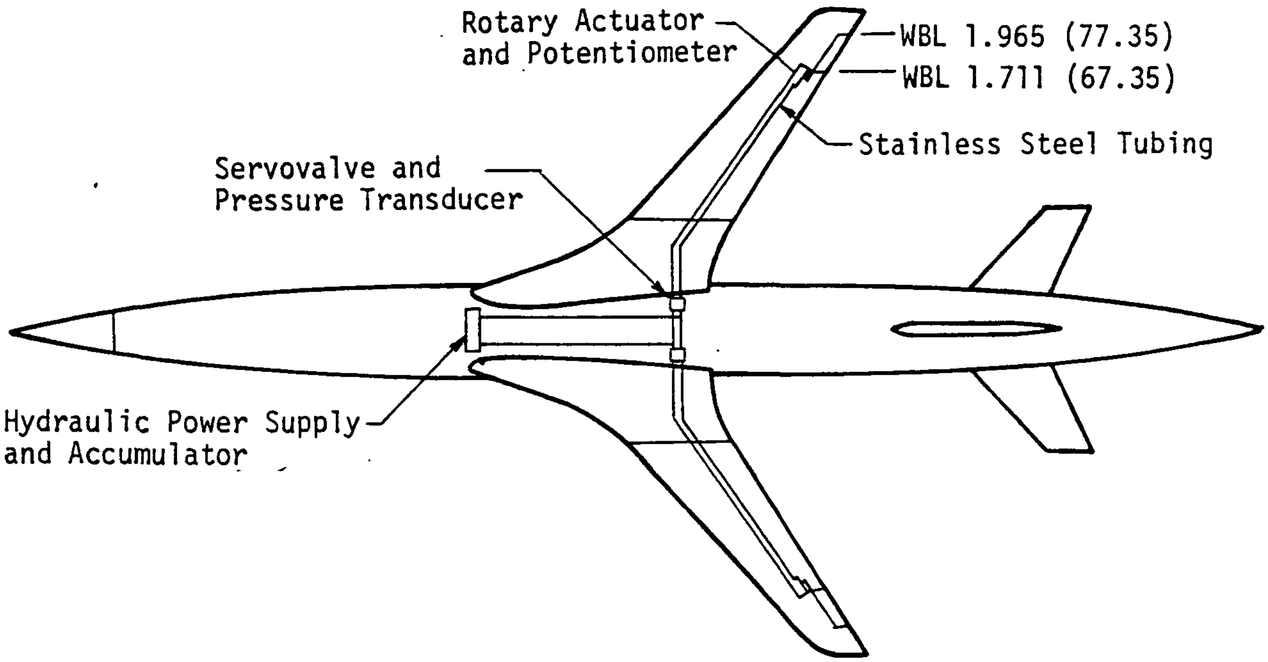


FIGURE 6-2 - OUTBOARD AILERON SERVOACTUATOR AND HYDRAULIC SYSTEM

altitude condition. The maximum displacement required is ±0.07 rad/m/s (1.223 deg/ft/sec) RMS gust, which is the square root of the sum of the symmetric system requirement squared and antisymmetric system requirement squared. Similarily, the maximum control surface angular rate required is 4.387 rad/s/m/s (76.62 deg/sec/ft/sec) RMS gust.

The design peak gust velocity is 3.658 m/s (12 ft/sec), which corresponds to twice the 1.829 m/s (6 ft/sec) RMS design gust. The control surface requirements for this gust velocity are ±0.256 radians (14.65 degrees) displacement and 16.05 rad/s (919.5 deg/sec) angular rate.

6.1.2 Actuator sizing - The outboard aileron actuator was sized to meet maximum estimated hinge moment with 75 percent of the 10.34×10^6 N/m^2 (1500 psi) supply pressure across the actuator vane. Preliminary design layouts showed that actuator displacements above ±0.21 radian (12 degrees) were not possible if the actuator were not permitted to violate the wing airfoil.

The maximum estimated hinge moment to be overcome by the outboard aileron actuator is about 23.73 N·m (210 in-lb), based on hinge moment coefficient taken from Reference 10 for 0.21 radian (12 degrees) full trailing edge down with 0.033 radian (1.9 degrees) angle of attack estimated for a 2.5g maneuver at Mach

0.98, 3658 meters (12 000 feet) at 1043 kilograms (2300 pounds) gross weight. The estimated hinge moment at this condition with the control surface at the faired position is 18 N·m (160 in-lb).

Torque developed in a single vane rotary actuator is given by the equation from Reference 11:

$$T = 1/2\,\ell\,(r_D^2 - r_S^2)\Delta P$$

where ℓ is the vane length, r_D is the vane radius, r_S is the actuator shaft radius and ΔP is the pressure drop across the vane. With the pressure differential given by $\Delta P = P_L$, the torque may be expressed in terms of the actuator coefficient,

$$C_A = 1/2\ell(r_D^2 - r_S^2), \text{ as } T = C_A P_L \cdot$$

The vane radius was chosen as 15.2 millimeters (0.60 inch) as the maximum that would permit ±0.21 radian (12 degrees) rotation with the actuator fitting within the wing skin at the inboard edge of the control surface. The actuator shaft diameter was estimated for the linear stability analysis assuming a factor of safety of 2.5 on ultimate shearing stress for the 15-5PH stainless steel shaft and that the shaft was loaded in pure torsion. The minimum diameter calculated was 7.404 millimeters (0.2915 inch), so 7.9378 millimeters (0.3125 inch) (5/16 inch) diameter shaft was used. This gives vane length of 28.4 millimeters (1.12 inches) and actuator coefficient C_A of $3.059 \times 10^{-6} m^3$ ($0.1867\ in^3$).

6.1.3 Servoactuator stability analysis - Root locus analysis was conducted on the outboard aileron servoactuators to determine feedback compensation required and to estimate the dynamic performance that could be attained with the hardware in the DAST ARW-1 wing. The servoactuator mathematical model used in the analysis was developed for the NASA delta wing model as reported in References 12 and 13. Figure 6-3 shows the servoactuator block diagram in parametric form with position and load pressure feedback.

The servovalve transfer function was taken from Moog Technical Bulletin 103 (Reference 14) for a Moog Series 30 flow control servovalve with damping ratio 0.5 and undamped natural frequency of 240 Hz. The transfer function of actuator shaft position, θ_A, to flow out of the servovalve, Q, was derived from test data in Reference 12 and accounts for hydraulic fluid trapped between the servovalve and actuator as a second order mode with equivalent rotary inertia I_{EQ} and equivalent damping D_{EQ}. The shaft torsional spring rate $K_{S_{EQ}}$, is the spring rate of the shaft in series with one-third of the estimated spring rate of the control surface. The transfer function of load pressure, P_L, to actuator shaft position was derived in Reference 13 and also accounts for the trapped hydraulic fluid between the servovalve and actuator. A washout filter is included in the pressure feedback path to eliminate static offsets due to the aerodynamic hinge moment.

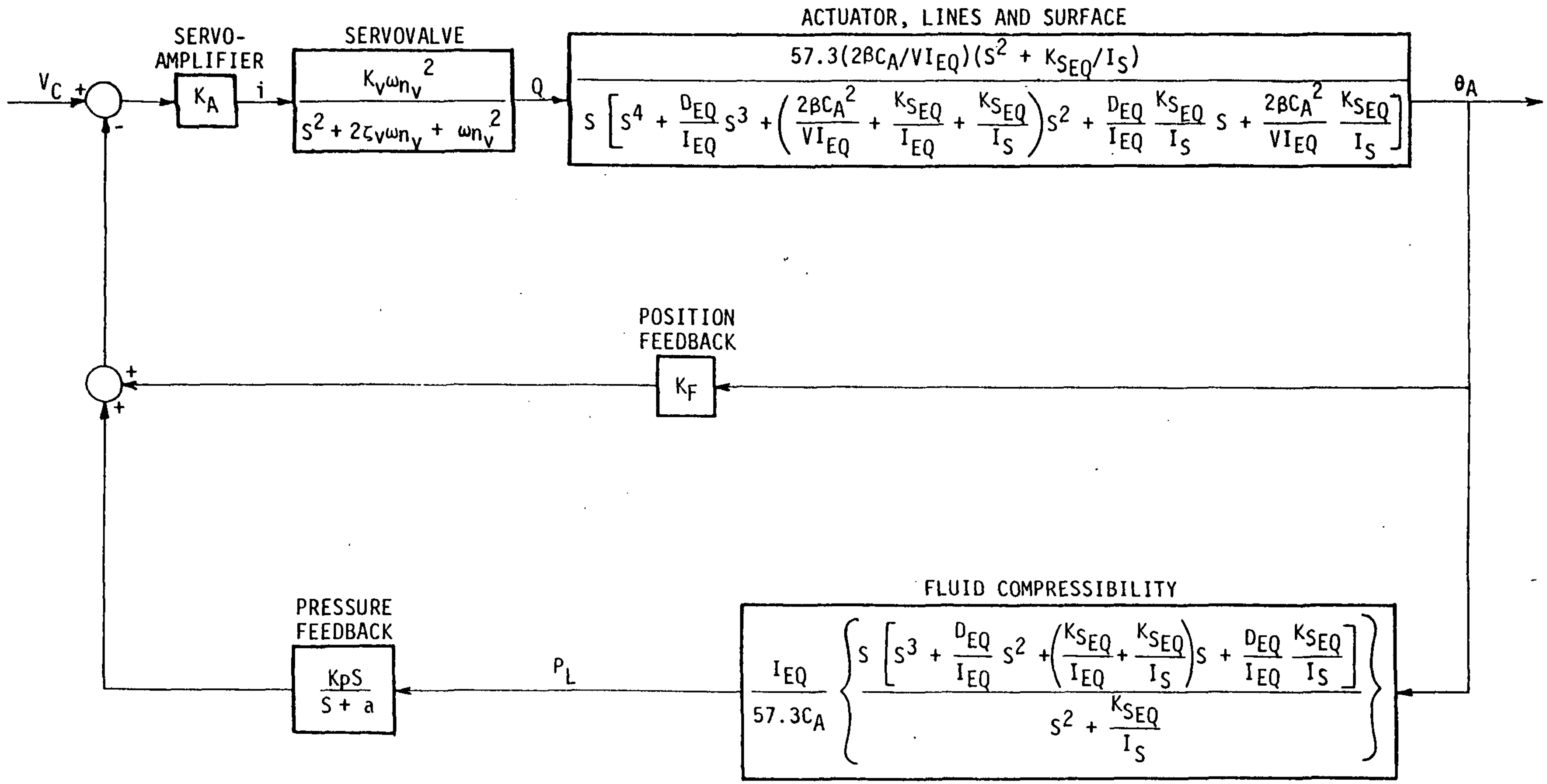


FIGURE 6-3 - SERVOACTUATOR BLOCK DIAGRAM

Tubing between the servovalves and actuators was sized to keep fluid velocity at maximum flow rate below 4.572 m/s (15 ft/sec) to keep laminar flow in the lines. The fluid trapped in one line between the servovalve and actuator was estimated at $2.622 \times 10^{-5} m^3$ ($1.60\ in^3$) based on 2.21 meters (87 inches) of 4.763 millimeters (3/16 inch) outside diameter tubing with 0.457 millimeter (0.018 inch) wall thickness plus a small amount in the servovalve manifold block and the actuator.

The parameter values used in the servoactuator analysis are presented in Table 6-I. The equivalent viscous damping of the trapped hydraulic fluid was taken as the same value estimated for the NASA delta wing model actuator, which is smaller than the DAST ARW-1 outboard aileron actuator. The equivalent rotary inertia was estimated by increasing the value estimated for the delta wing model actuator by the ratio of the trapped fluid volumes. The fluid bulk modulus was estimated for fluid temperature of about 93.3°C (200°F) at $10.34 \times 10^6\ N/m^2$ ($1500\ lb/in^2$) pressure.

TABLE 6-I

SERVOACTUATOR PARAMETER UNITS

Parameter	Description	Units	Value
D_{EQ}	Equivalent Damping of Trapped Fluid	N·m/rad/s (in-lb/rad/sec)	.45 (4.0)
I_{EQ}	Equivalent Inertia of Trapped Fluid	$N \cdot m\text{-}s^2$ ($in\text{-}lb\text{-}sec^2$)	2.757×10^{-4} (0.00244)
β	Fluid BUlk Modulus	N/m^2 (lb/in^2)	1.17×10^9 (1.70×10^5)
C_A	Actuator Coefficient	m^3 (in^3)	$.306 \times 10^{-5}$ (0.1867)
V	Trapped Fluid Volume	m^3 (in^3)	2.622×10^{-5} (1.60)
I_S	Surface Inertia	$N \cdot m\text{-}s^2$ ($in\text{-}lb\text{-}sec^2$)	4.519×10^{-4} (0.004)
$K_{S_{EQ}}$	Equivalent Spring Rate of Shaft and Surface	N·m/rad (in-lb/rad)	9.844×10^2 (8.713×10^3)

With only the position feedback loop closed, the characteristic denominator (denominator of the transfer function of actuator shaft position to voltage command, $\theta_A/V_C(S)$) is

$$S(S^4 + 1644S^3 + 8.785 \times 10^6 S^2 + 3.581 \times 10^9 S + 6.612 \times 10^{12})$$
$$\times (S^2 + 1508S + 2.274 \times 10^6) + (K_F K_A K_V)(2.119 \times 10^{15})(S^2 + 2.178 \times 10^6).$$

The root locus with increasing gain $K_F K_A K_V$ is shown on Figure 6-4. The plot shows that as position gain is increased, the open loop actuator pole moves out the negative real axis, the surface-actuator mode destabilizes and lowers some in frequency, the servovalve mode decreases in damping and the fluid mode moves very little. At position feedback gain of 1.002 m^3/s/rad (1.067 in^3/sec/deg), the real pole is at -448 rad/sec and the surface-actuator mode is at 127 Hz with only 0.033 damping ratio. This indicates pressure feedback is required to give desired damping ratio of about 0.30. This position feedback gain corresponds to position loop gain of 327.4 rad/sec.

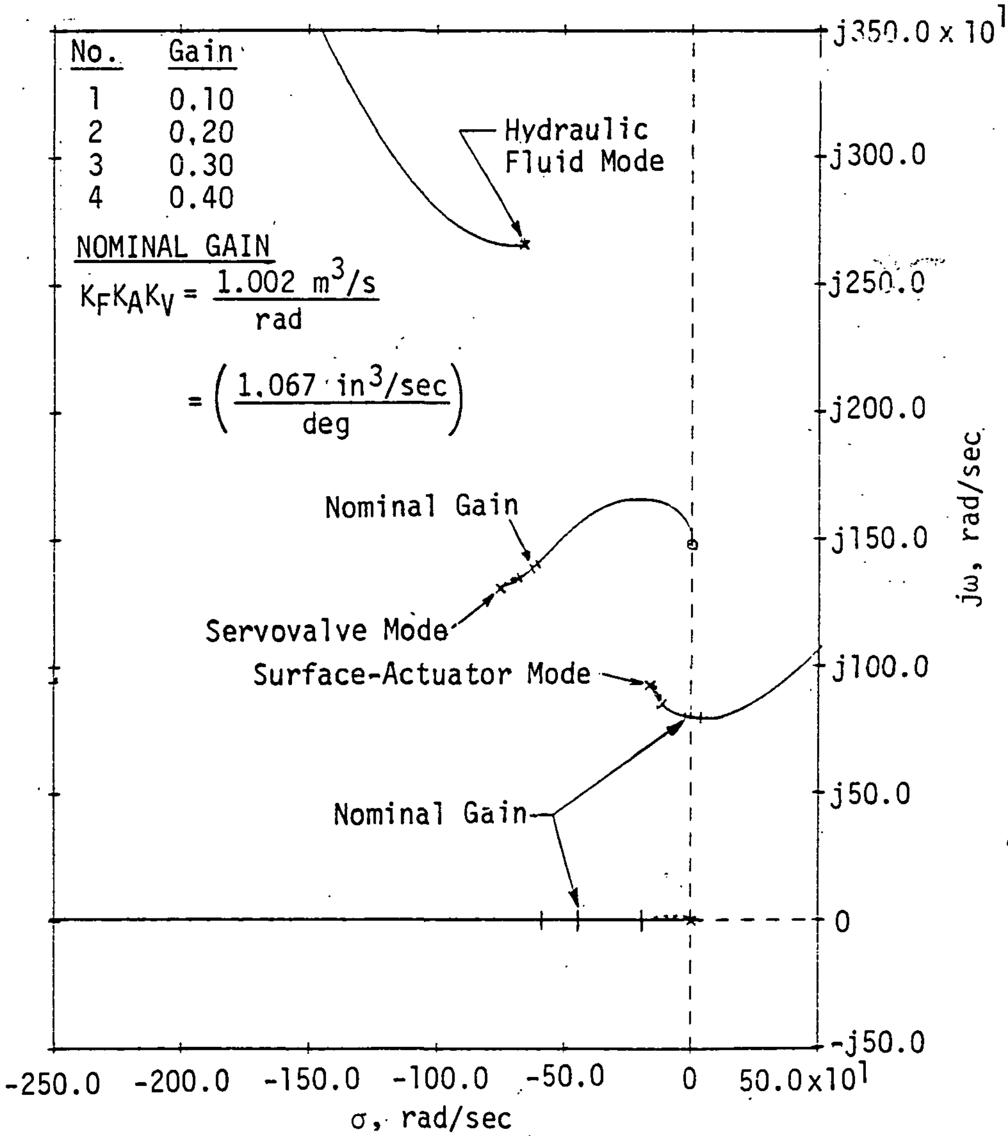


FIGURE 6-4.- SERVOACTUATOR POSITION LOOP ROOT LOCUS

The characteristic denominator with position feedback gain set at 1.002 $m^3/s/rad$ (1.067 $in^3/sec/deg$) and with the pressure feedback loop closed through a washout $S/(S + 10)$ is

$$(S + 448.4)(S^2 + 53.24S + 6.389 \times 10^5)(S^2 + 1278S + 2.291 \times 10^6)$$
$$\times\ (S^2 + 1372S + 7.503 \times 10^6)(S + 10) + (K_P K_A K_V)(4.833 \times 10^{11})$$
$$\times\ (S^5 + 1644S^4 + 5.749 \times 10^6 S^3 + 3.581 \times 10^9 S^2).$$

Figure 6-5 shows the root locus with increasing pressure feedback gain $K_P K_A K_V$. The plot shows that the surface-actuator mode damping increases and then decreases with frequency increasing. The servovalve mode decreases in frequency. A lead-lag filter, $(S + 900)/(S + 1200)$ was added to the pressure feedback loop

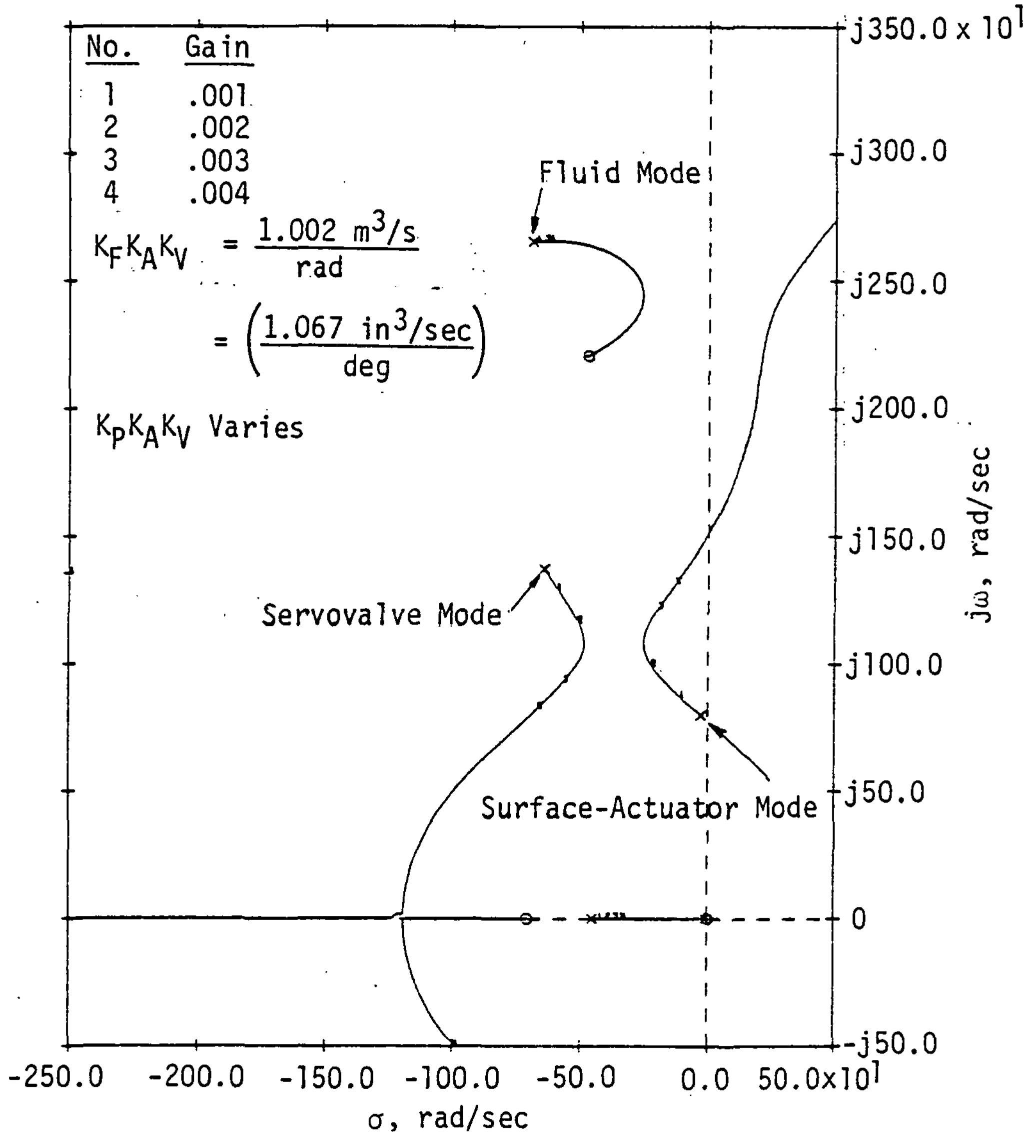


FIGURE 6-5 - SERVOACTUATOR PRESSURE LOOP ROOT LOCUS WITH WASHOUT to improve damping of the surface-actuator mode. The root locus with this filter is shown on Figure 6-6. This compensation has the desired effect of rotating the surface-actuator mode locus counter-clockwise, so that damping increases at about constant frequency as pressure feedback gain increases. At gain $K_P K_A K_V = 5.942 \times 10^{-12}$ $m^3/s/N/m^2$ (0.0025 $in^3/sec/psi$), the real pole is at -405.8 rad/sec, the surface-actuator mode is at 154.5 Hz with 0.31 damping ratio, and the servovalve mode is at 203.1 Hz with 0.31 damping ratio.

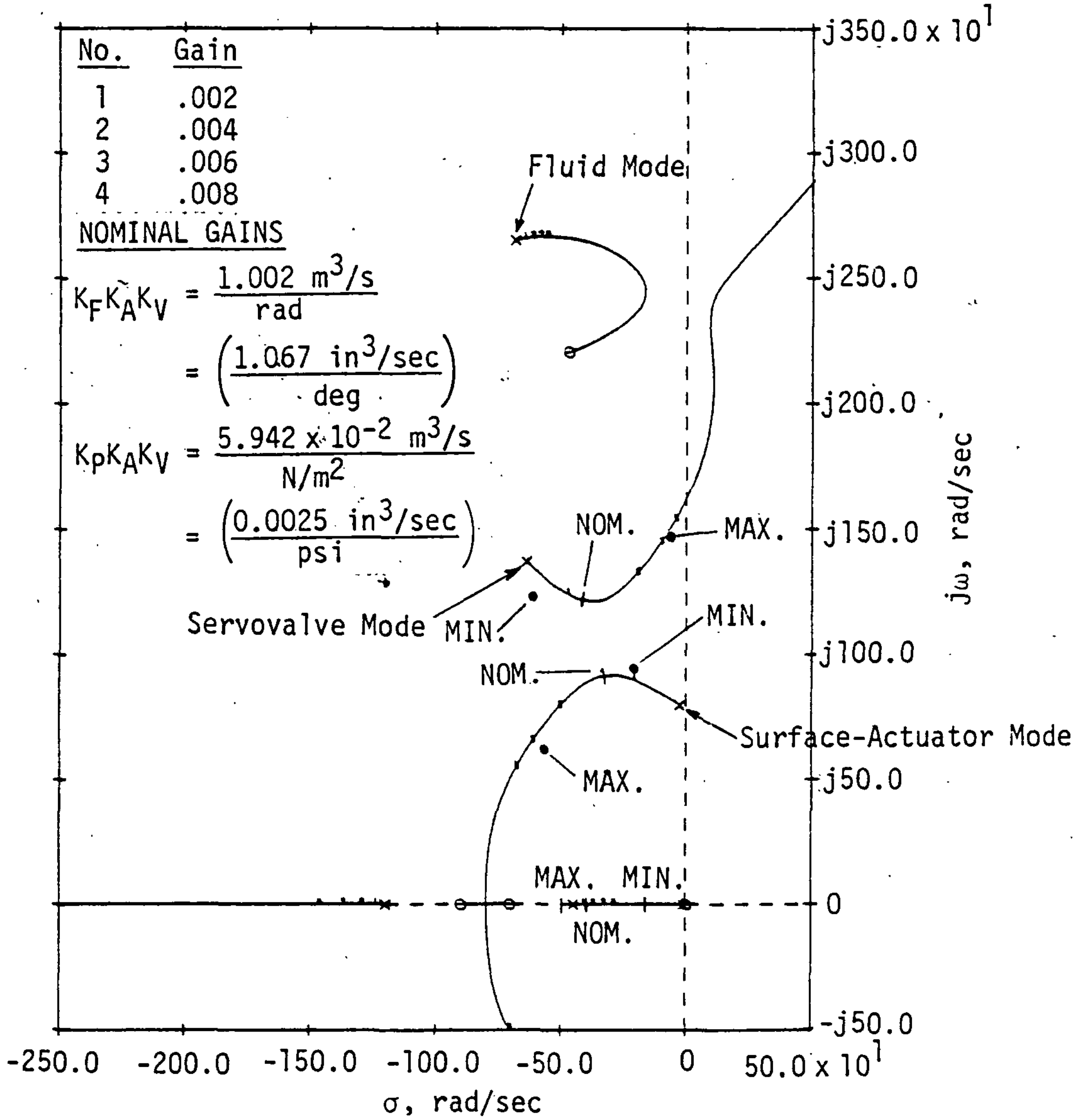


FIGURE 6-6 - SERVOACTUATOR PRESSURE LOOP ROOT LOCUS WITH WASHOUT AND LEAD/LAG

Characteristics of the ARW-1 airfoil do not permit the no-load actuator to be attainable around the zero displacement position because of significant static hinge moments. At the maximum design condition, Mach 0.98 at 3658 meters (12 000 feet), the actuator is under load throughout the ±0.21 radian (12 degree) displacement capability, with the hinge moment acting to drive the surface trailing edge up. This causes the servoactuator-dynamic characterisitics to vary with control surface position and direction of travel.

Flow out of the servovalve obeys the usual square root relationship $Q/Q_0 = \sqrt{1-(P_L/P_S)}$, where Q_0 is the flow out of the servovalve with load pressure at zero. The servovalve flow gain is defined by $K_V = Q/i$, the flow out of the servovalve divided by the coil current. Then, the servovalve flow gain varies with load pressure according to the equation

$$K_V/K_{V_{No\text{-}Load}} = \sqrt{1-(P_L/P_S)}.$$

Figure 6-7 shows the variation of the position and pressure loop gains as a function of position and direction of travel for the Mach 0.98, 3658 meters (12 000 foot) altitude condition. The minimum loop gain occurs at the 0.21 radian (12 degrees) trailing edge down deflection with the surface being driven down. The maximum loop gain occurs instantaneously when the surface is being driven up from 0.21 radian (12 degrees) trailing edge down.

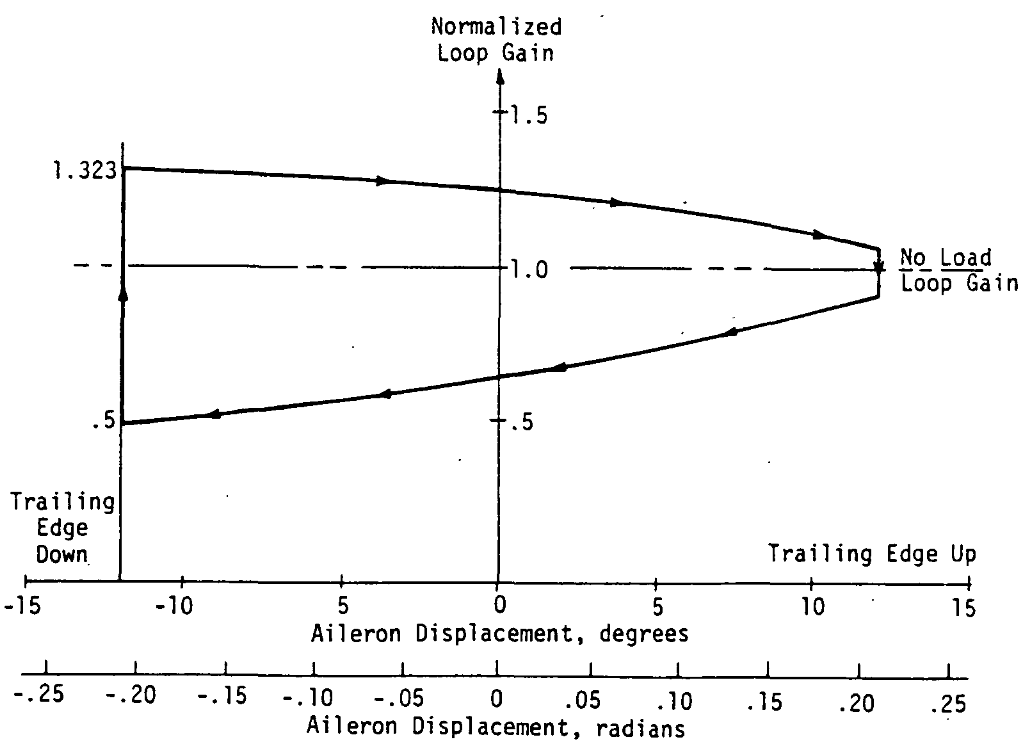


FIGURE 6-7 - LOOP GAIN VARIATIONS DURING SYSTEM OPERATION AT MAXIMUM HINGE MOMENT OPERATION

Servoactuator transfer functions were determined at the minimum and maximum loop gains for evaluation with the flutter suppression system. Table 6-II shows the transfer functions developed, including the no-load transfer function. The root locations are marked on the pressure loop root locus shown on Figure 6-6.

TABLE 6-II

CLOSED LOOP SERVOACTUATOR TRANSFER FUNCTIONS

- No-Load (Nominal Feedback Loop Gains)

$$\frac{\theta_S(S)}{\theta_C} = \frac{4.925 \times 10^{21}(S+10)(S+1200)}{(S+10.066)(S+405.8)(S+1257)(S^2+608.1S+9.440 \times 10^5)} \times \frac{1}{(S^2+787.1S+1.628 \times 10^6)(S^2+1294S+7.489 \times 10^6)}$$

- Maximum Resisting Hinge Moment (Minimum Feedback Loop Gains)

$$\frac{\theta_S(S)}{\theta_C} = \frac{2.462 \times 10^{21}(S+10)(S+1200)}{(S+10.07)(S+179.9)(S+1223)(S^2+408.9S+9.418 \times 10^5)} \times \frac{1}{(S^2+1236S+1.895 \times 10^6)(S^2+1304S+7.471 \times 10^6)}$$

- Maximum Aiding Hinge Moment (Maximum Feedback Loop Gains)

$$\frac{\theta_S(S)}{\theta_C} = \frac{6.519 \times 10^{21}(S+10)(S+1200)}{(S+10.159)(S+499.5)(S+1328)(S^2+1228S+7.169 \times 10^5)} \times \frac{1}{(S^2+120.0S+2.188 \times 10^6)(S^2+1177S+7.401 \times 10^6)}$$

6.1.4 Hydraulic system analysis - Hydraulic fluid flow required to sustain a given actuator rate is the product of the actuator coefficient times the angular rate in rad/sec. The maximum angular rate required for the flutter suppression system is 16.05 rad/s (919.5 deg/sec), as discussed in Paragraph 6.1.1. This gives maximum flow rate of 4.910×10^{-5} m^3/s (2.996 in^3/sec) per actuator, or 9.819×10^{-5} m^3/s (5.992 in^3/sec) for both actuators.

The Sundstrand-Pesco Model 165-100 hydraulic power supply unit selected in the preliminary design study, discussed in Reference 1, produces 5.931×10^{-5} m^3/s (3.619 in^3/sec or 0.94 gal/min) maximum flow at 10.34×10^6 N/m^2 (1500 psi). This unit requires about 43 amperes current at 28 VDC, which exceeds the current allocated during the preliminary design study. Reassessment of electrical power requirements indicated that sufficient electrical power for this hydraulic power supply was available from the drone's 28 VDC electrical power system.

The maximum quiescent leakage through a Moog Series 30 servovalve is about 0.403×10^{-5} m^3/s (0.246 in^3/sec) at 10.34×10^6 N/m^2 (1500 psi) pressure. According to Reference 11, an optimum design of a hydraulic pump system is to have the pump capable of delivering the average flow required plus the servovalve quiescent leakage, and an accumulator sized to supply peak demands. If the flow rate required by the actuators is assumed to be sinusoidal, $Q_M \sin 2\pi ft$, the average flow is given by $2Q_M/\pi$. Then, for the maximum flow determined for the flutter suppression system, the average flow is 6.252×10^{-5} m^3/s (3.815 in^3/sec). Thus, the pump will supply about 95 percent of the average flow, if servovalve quiescent leakage flow is ignored, for sinusoidal flow demand.

The hydraulic accumulator will supply flow to meet the requirement above what the pump will provide less the servovalve quiescent leakage. The volume of fluid required from the accumulator per half cycle of the assumed sine wave demand is given by

$$V_P = \frac{Q_M}{\pi f} \mathrm{Cos}\left(\mathrm{Sin}^{-1} \frac{Q_P - Q_L}{Q_M}\right) + \frac{Q_P - Q_L}{2\pi f}\left(2 \ \mathrm{Sin}^{-1} \frac{Q_P - Q_L}{Q_M} - \pi\right)$$

where Q_P is the flow provided by the pump and Q_L is the total servovalve quiescent leakage. Assuming maximum servovalve quiescent leakage, this volume is 0.0800×10^{-5} m^3 (0.0488 in^3), at the 12.5 Hz symmetric flutter mode frequency at the Mach 0.98, 3658 meters (12 000 foot) altitude condition.

The accumulator size required to supply this flow is small. For example, with the accumulator charged to two-thirds of the supply pressure, the accumulator size required to keep pressure from falling below 90 percent of the supply pressure is only 1.082×10^{-5} m^3 (0.66 in^3), assuming isothermal expansion of the gas in the accumulator, and 1.540×10^{-5} m^3 (0.94 in^3), assuming reversible adiabatic expansion of the gas. These volumes were calculated using the equation,

$$(C_1 V_A + V_P)^k P_2 = (C_1 V_A)^k P_S$$

where the accumulator precharge pressure is C_1 times the supply pressure P_S, V_A is the accumulator volume after volume V_P is discharged and $k = 1$ for isothermal expansion of the gas and $k = 1.4$ for reversible adiabatic expansion.

The accumulator size was selected on the basis of the smallest size available. Breadboard tests conducted with the Sundstrand-Pesco Model 165-100 hydraulic supply unit with an MS 28797-1 40.97×10^{-5} m^3 (25 in^3) accumulator precharged to 6.895×10^6 N/m^2 (1000 psi) showed that the accumulator was too large for the reservoir capacity of the pump. A 16.39×10^{-5} m^3 (10 in^3) Parker-Hannifin commercial type accumulator, Model A2A0010A1K, was procured for installation in the drone. Further discussion of the servoactuation system breadboard tests is presented in Paragraph 9-1.

The length of time the accumulator will sustain the maximum flow rate, 9.819×10^{-5} m^3/s (5.992 in^3/sec), with the maximum servovalve quiescent leakage and the pump operating at maximum flow is of interest. Assuming the flow demand to be sinusoidal, the accumulator must provide 0.0800×10^{-5} m^3 (0.0488 in^3)/ half cycle, as determined above. The pump will replenish part of this volume, given by the equation

$$V_R = \frac{1}{\pi f} \left\{ (Q_P - Q_L) \sin^{-1}\left(\frac{Q_P - Q_L}{Q_M}\right) + Q_M \left[\cos\left(\sin^{-1} \frac{Q_P - Q_L}{Q_M}\right) - 1 \right] \right\}$$

on a half cycle basis. The replenish volume is 0.0349×10^{-5} m^3 (0.0213 in^3) / half cycle. Based on 6.227×10^{-5} m^3 (3.80 in^3) oil volume for isothermal charging of the accumulator to 6.895×10^6 N/m^2 (1000 psi), the accumulator will sustain this flow for 69.1 cycles or 5.53 seconds. Assuming reversible, adiabatic charging of the accumulator, the oil volume is 4.654×10^{-5} m^3 (2.84 in^3) and the demand is sustained for 51.6 cycles or 4.13 seconds. The assumed sinusoidal flow demand with maximum servovalve quiescent leakage should be more severe than will be encountered during the DAST ARW-1 flutter suppression system flight tests.

Another item of interest is the length of time the accumulator will meet the flow requirement of the flutter suppression system at Mach 0.98, 3658 meters (12 000 foot) altitude condition assuming 0.305 m/s (one ft/sec) gust with the hydraulic power unit off. The flow requirement for this gust is 0.818×10^{-5} m^3/s (0.499 in^3/sec), for both actuators, plus the servovalve quiescent leakage. If the flow requirement is assumed sinusoidal as before, the time average is 0.521×10^{-5} m^3/s (0.318 in^3/sec) plus the constant leakage flow of 0.806×10^{-5} m^3/s (0.492 in^3/sec). Then, with isothermal charging of the accumulator to 6.895×10^6 N/m^2 (1000 psi), the accumulator will sustain operation of the flutter suppression system for 4.69 seconds. Assuming reversible, adiabatic charging of the accumulator, the accumulator will deplete in 3.51 seconds.

The A2A0010A1K accumulator, precharged to 6.895×10^6 N/m^2 (1000 psi), will be used with the Sundstrand-Pesco Model 165-100 hydraulic power supply unit onboard the drone. This system will provide hydraulic power for the wing outboard ailerons only and will provide required performance in meeting peak flow demands above what the pump can deliver. The accumulator will also isolate the aileron servoactuators from pump transients and ripple.

6.2 *Electrical/Electronic Design and Modification*

This section details design requirements and the methods used to comply with these requirements for the DAST ARW-1 FSS electrical and electronic components.

The FSS electronics includes motion feedback sensors, uplink and downlink telemetry signal conditioning, mechanization of the flutter suppression filters and a function generator for inputting commands to the aileron servoactuators for flutter suppression system testing, servoactuator feedback loops and servovalve drive amplifiers. Figure 6-8 shows the "as-delivered" functional block diagram of the FSS, however modifications were made prior to first flight. Excitation voltages required by the FSS accelerometer and servoactuator position and pressure feedback transducers were furnished by DC to DC converters. Table 6-III defines symbols used on Figure 6-8.

6.2.1 Design philosophy - The basic design philosophy was to provide as much flexibility as possible to ease maintenance and to provide required performance within the constraints of reasonable cost, minimum physical size and the expected drone flight environment.

The number of circuit cards and components were kept to a minimum. The components are military grade mounted on two sided epoxy glass etched circuit cards with plated through holes. Card edge connectors are not used.

Filter networks were isolated to allow critical break frequencies to be selected at test (S.A.T.). A built in test generator with mode and signal amplitude selectable and triggered by telemetry was provided. Parameter changes are implemented by S.A.T. component provisions for infrequent changes, variable gain controls for rapid changes between flights and inflight logic-controlled gain changes and parameter time constant scheduling.

The sensors and output signals are analog and are compatible with the existing telemetry system.

6.2.2 FSS electronics box design - The box is required to house the FSS electronics and mate with an existing BQM-34E/F mounting tray. All connectors are required to be mounted on the front of the box for accessibility. Space is available beneath the mounting tray for mounting of the FSS electronics power supplies.

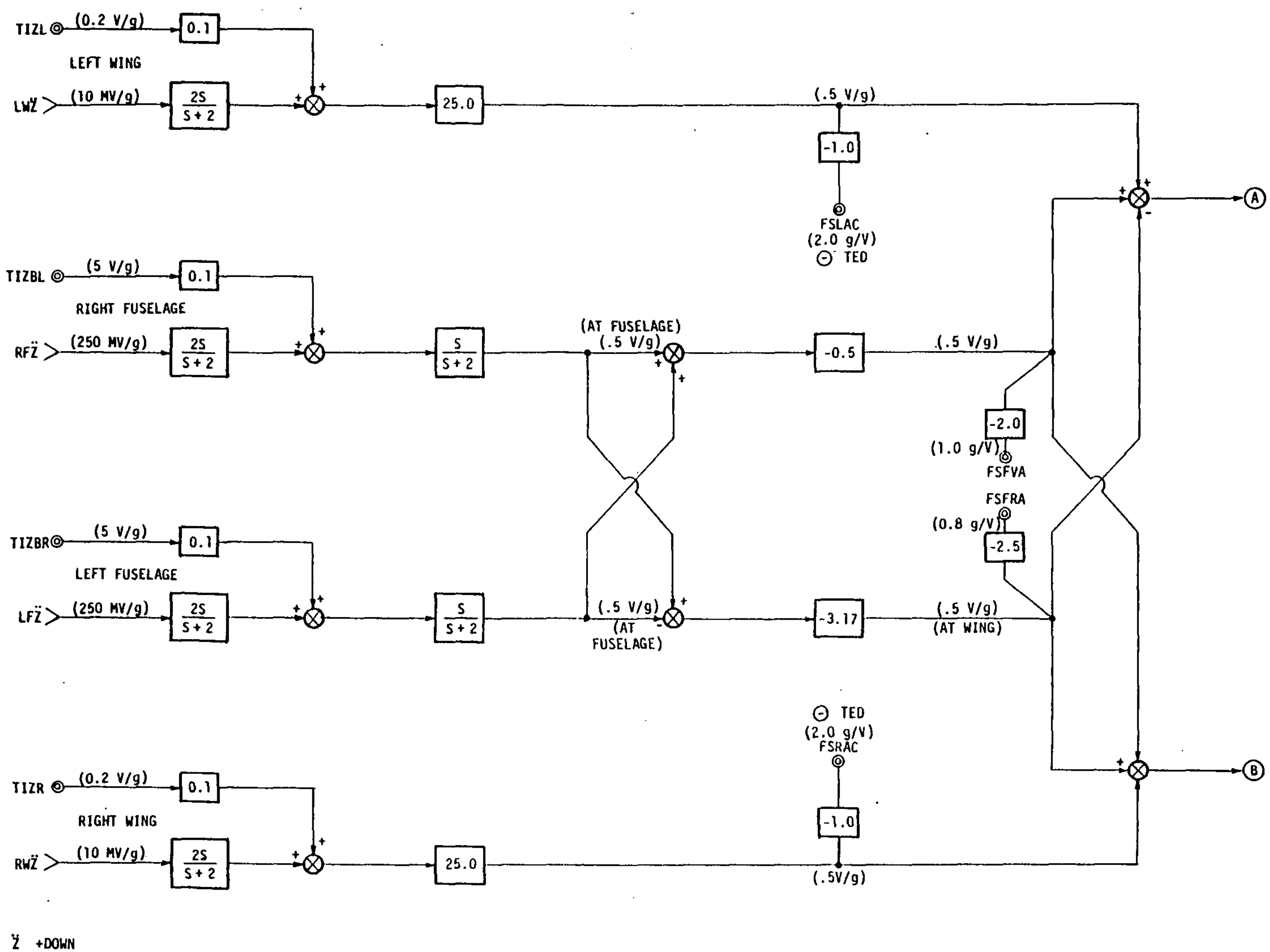


FIGURE 6-8 - DAST ARW-1 FLUTTER SUPPRESSION SYSTEM BLOCK DIAGRAM

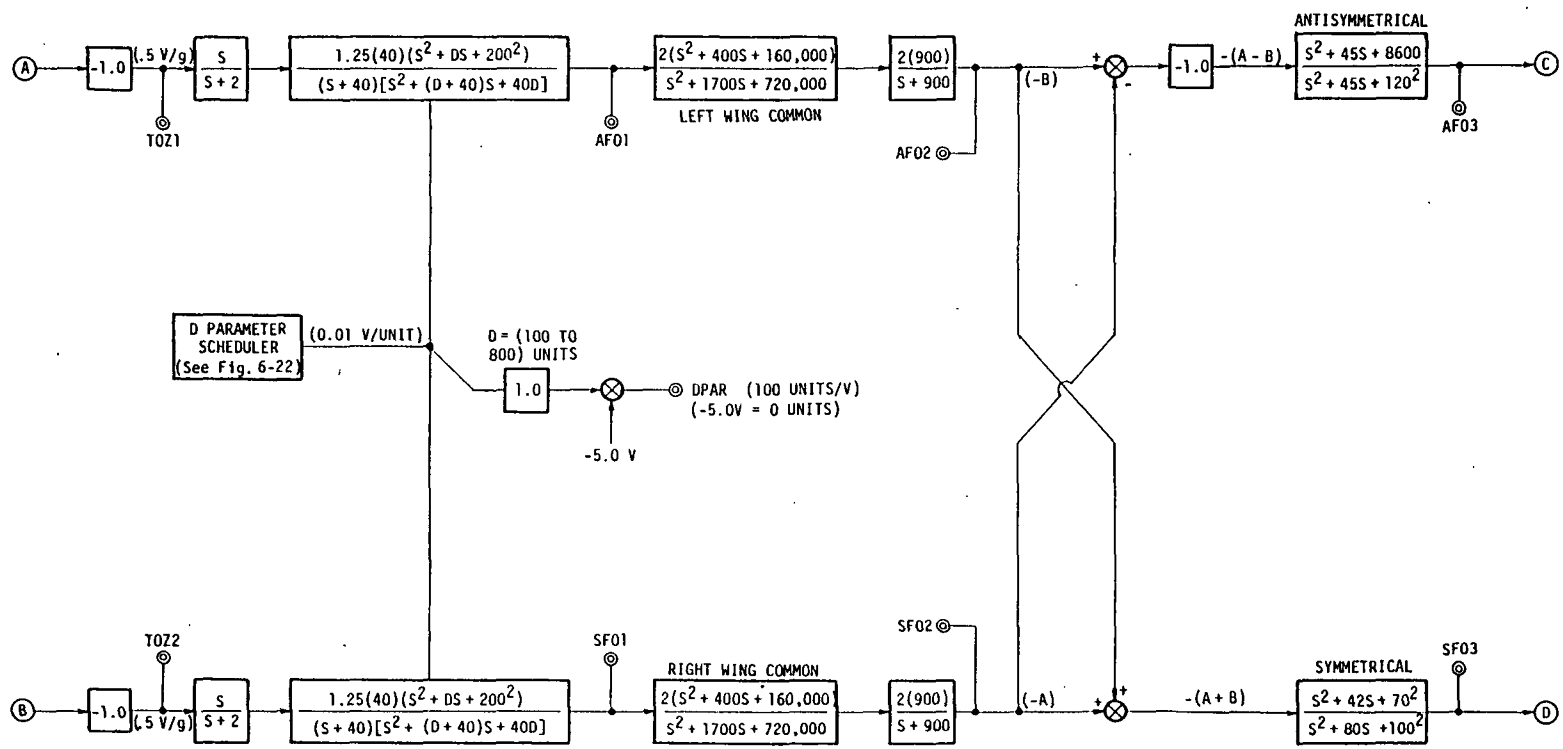


FIGURE 6-8 - DAST ARW-1 FLUTTER SUPPRESSION SYSTEM BLOCK DIAGRAM (CONTINUED)

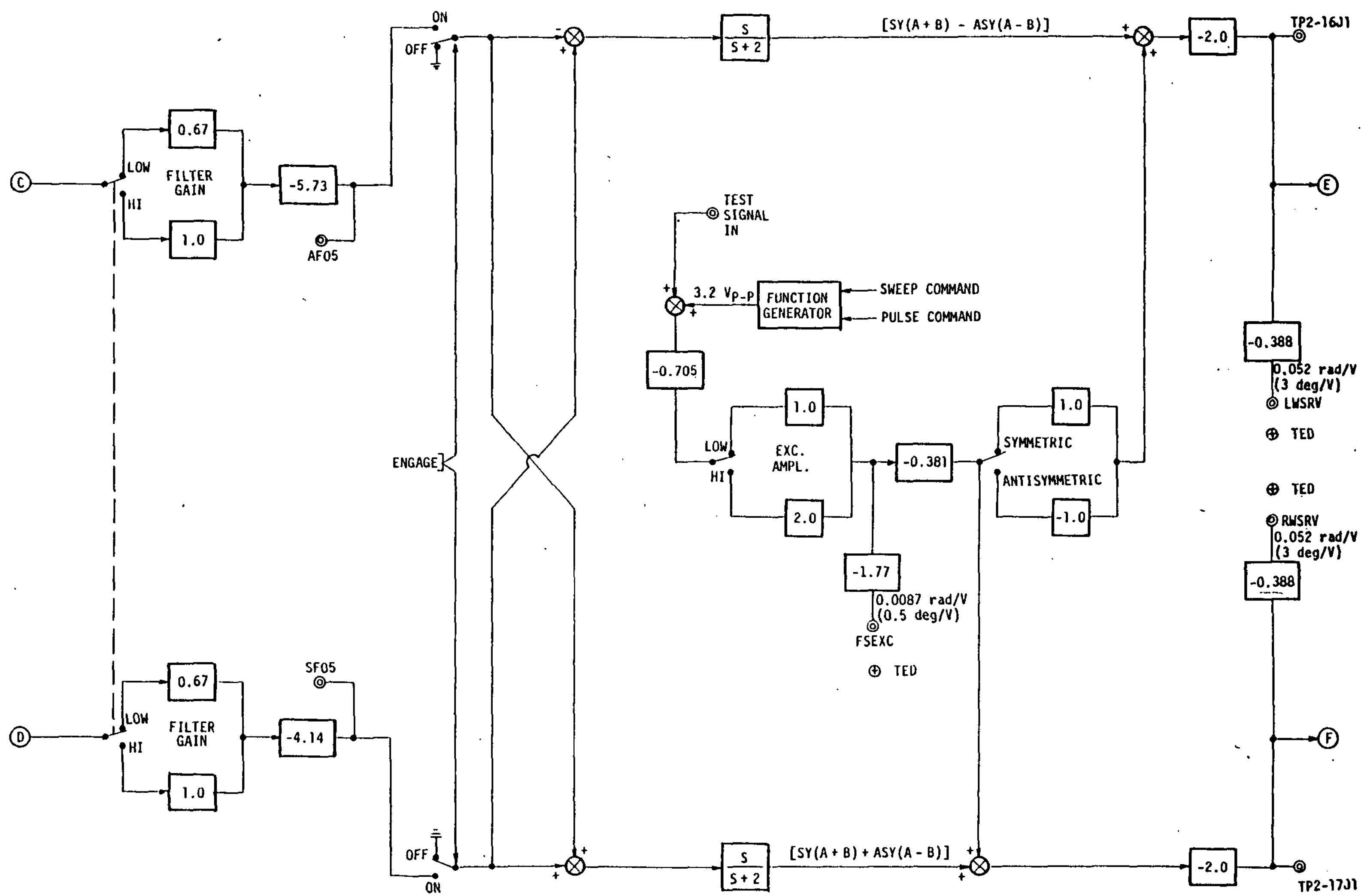


FIGURE 6-8 - DAST ARW-1 FLUTTER SUPPRESSION SYSTEM BLOCK DIAGRAM (CONTINUED)

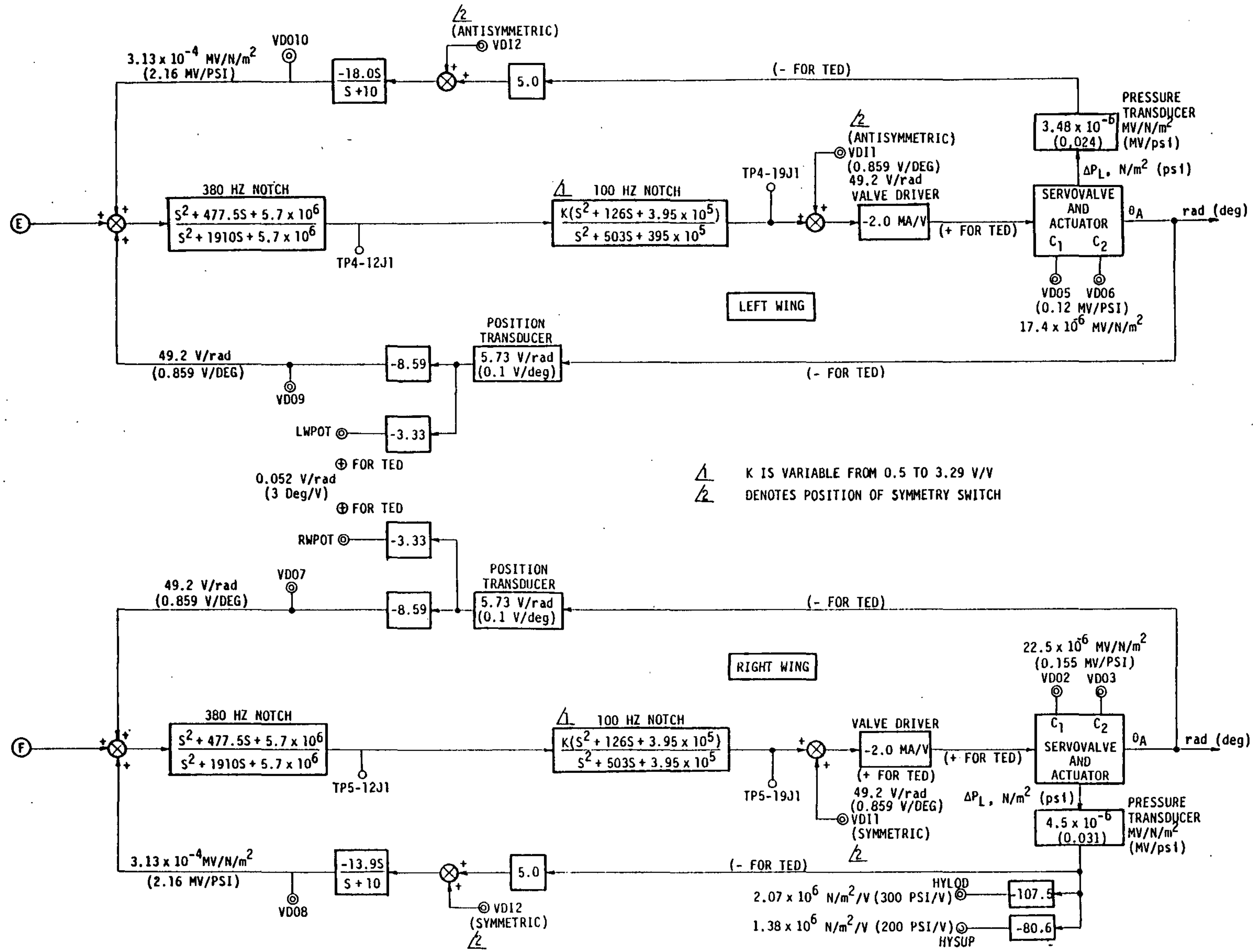


FIGURE 6-8 - DAST ARW-1 FLUTTER SUPPRESSION SYSTEM BLOCK DIAGRAM (CONCLUDED)

TABLE 6-III

SYMBOLS USED ON FSS BLOCK DIAGRAM (FIGURE 6-8)

SYMBOL	FUNCTION
AF01	Left Wing Gain Scheduled Filter Ouput
AF02	Left Wing Common Filter Output
AF03	Left Wing Antisymmetrical Filter Output
AF05	Left Wing Final Filter Output
DPAR	Downlink Parameter "D" Output
DSI1	Static Pressure Test Input
DSI2	Dynamic Pressure Test Input
DS01	Static Pressure Test Output
DS02	Dynamic Pressure Test Output
DS03	Parameter "D" Output
FG01	Function Generator Ramp Control Output
FG02	Function Generator Sine Output
FG03	Function Generator Sweep Function
FSEXC	Downlink Function Generator Output
FSFRA	Downlink Angular Acceleration
FSFVA	Downlink Vertical Acceleration
FSLAC	Downlink Left Wing Acceleration
FSRAC	Downlink Right Wing Acceleration
HYLOD	Downlink Hydraulic Differential Pressure
HYSUP	Downlink Hydraulic Pressure
LWPOT	Downlink Left Wing Surface Position
LWSRV	Downlink Left Wing Servo Command
RWPOT	Downlink Right Wing Surface Position
RWSRV	Downlink Right Wing Servo Command
SF01	Right Wing Gain Scheduled Filter Output
SF02	Right Wing Common Filter Output
SF03	Right Wing Symmetrical Filter Output
SF04	Right Wing Final Filter Output
TEST SIGNAL IN	Test Input Valve Drivers (Left and right simultaneously, ANTI inverts left surface)
TIZBL	Test Input to Left Fuselage Signal Conditioning

TABLE 6-III (Concluded)

SYMBOLS USED ON FSS BLOCK DIAGRAM (FIGURE 6-8)

SYMBOL	FUNCTION
TIZBR	Test Input to Right Fuselage Signal Conditioning
TIZL	Test Input to Left Wing Signal Conditioning
TIZR	Test Input to Right Wing Signal Conditioning
TOZ1	Left Wing Vertical Acceleration
TOZ2	Right Wing Vertical Acceleration
VDI1	Input to Valve Drivers (SYM RW) (One at a time) (ANTI LW)
VDI2	Input to Pressure Feedback Circuit (SYM RW) (ANTI LW)
VDO2	Right Wing C1 Port Pressure Transducer
VDO3	Right Wing C2 Port Pressure Transducer
VDO4	Not Used
VDO5	Left Wing C1 Port Pressure Transducer
VDO6	Left Wing C2 Port Pressure Transducer
VDO7	Right Wing Position Feedback
VDO8	Right Wing Pressure Feedback
VDO9	Left Wing Position Feedback
VDO10	Left Wing Pressure Feedback

The dimensions of this space are 0.152 x 0.254 x 0.038 meters (6 x 10 x 1.5 inches) high.

The electronics box is a Boeing designed and fabricated aluminum box, Drawing number 35-34536-1, that mates with an existing mounting tray in the drone fuselage at Fuselage Station 5.405 (212.8). Electronic components used are military qualified or commercial grade meeting military environmental specifications. The electronics box is 0.459 meter (18.1 inches) long, 0.123 meter (4.85 inches) wide and 0.116 meter (4.58 inches) high with extending mounting flanges making an overall length of 0.572 meter (22.5 inches) and an overall width of 0.137 meter (5.4 inches). The box weight is 6.237 kilograms (13.75 pounds).

The circuit cards are 0.0826 meter (3.25 inches) high and 0.1148 meter (4.52 inches) wide. The box includes provisions for 20 circuit cards and all interface connectors are mounted on the front. Figures showing the box design size are presented in Paragraph 8.2. All power is supplied by externally mounted DC to DC converters. EMI filters are included on all power and power returns and all cable connectors include EMI backshells to insure electromagnetic compatibility. The EMC Test Report, Reference 4, verifies FSS electronics compliance with RFI MIL-STD-461A.

6.2.3 Flutter suppression systems sensors - The DAST ARW-1 flutter suppression system requires accelerometers as the aircraft motion sensors for feedback signals. Potentiometers were selected as the FSS aileron position feedback sensors and pressure transducers are required for pressure feedback actuator stabilization. The following paragraphs outline performance and installation requirements of these sensors as well as the design philosophy and approach.

6.2.3.1 Sensor performance requirements: The FSS will require four motion sensors with type, orientation and location as follows:

Sensor	Type	Location	Orientation	B.S.	WBL	WL
1	Accelerometer	Fuselage (Left)	Vertical (±0.0175 rad) (±1 deg)	6.731 ±0.127 (265 ±5)	0.305 ±0.0127 (12 ±0.5)	As Available
2	Accelerometer	Fuselage (Right)	Vertical (±0.0175 rad) (±1 deg)	6.731 ±0.127 (265 ±5)	0.305 ±0.0127 (12 ±0.5)	As Available
3	Accelerometer	Left Wing	Vertical (±0.0175 rad) (±1 deg)	Rear Spar	2.007 ±0.0254 (79 ±1)	Center of Rear Spar
4	Accelerometer	Right Wing	Vertical (±0.0175 rad) (±1 deg)	Rear Spar	2.007 ±0.0254 (79 ±1)	Center of Rear Spar

The vertical accelerometers in the wings (sensors 3 and 4) should have their sensitive axis vertical when the wing is in 1g flight at Mach 0.80, 14 265 meters (46 800 feet) (Design Cruise Condition). This orientation should be transformed into a jig shape for installation.

The accelerometers shall have the following characteristics:

Sensors	Amplitude Range	Frequency Range	Accuracy (% of Applied Accel.)
1, 2	±5g	0.5 - 200 Hz	4
3, 4	±10g	0.5 - 1000 Hz	3

The sensors were required to be flightworthy. All sensors were required to meet these requirements while operating in the BQM-34E/F drone environment defined by Reference 15.

Performance requirements of the wing and fuselage accelerometers varied in application; however, cost, spares requirements and delivery schedules could be minimized by procuring only one type. Angular acceleration is obtained from the fuselage accelerometers. During the airworthiness testing, it was determined that the selected fuselage crystal type accelerometers could not be used because of their excessive thermal drift and were replaced by servo type accelerometers. Table 6-IV contains the accelerometers performance requirements.

TABLE 6-IV

COMPOSITE ACCELEROMETER PERFORMANCE REQUIREMENTS

Parameter	Requirement	
	Wing	Fuselage
Range	±10g	±5g
Natural Frequency	1000 Hz	200 Hz
Size	7.6mm x 12.7mm (0.3 x 0.5 inch)	31.75mm x 44.45mm (1.25 x 1.75 inch)
Damping Ratio	0.6 minimum	
Resolution	0.02g minimum	
Hysteresis	0.001g maximum	
Threshold	0.001g maximum	
Cross-Axis Sensitivity	0.05g/g maximum	
Temperature Range	-40°C to 93.3°C (-40°F to 200°F)	

The potentiometer performance requirements are presented in Table 6-V. The potentiometers are mounted on the rotary servo-actuator shafts at both left and right ailerons as shown on Boeing drawing EX-3317. Size and resolution were the primary requirements.

TABLE 6-V

POTENTIOMETER PERFORMANCE REQUIREMENTS

Case Diameter	12.7mm (0.5 inch)
Type Resistive Element	Conductive Plastic
Usable Angle of Rotation	±0.26 radian (±15 degrees) Minimum
Output Gradient	±1.0 Volt for ±0.21 rad. (±12 deg) Rotations, Minimum
Center Tap Required	No

The pressure transducer performance requirements are presented in Table 6-VI. Four transducers are required, two for each servoactuator to measure C1 and C2 port pressures.

TABLE 6-VI

PRESSURE TRANSDUCER PERFORMANCE REQUIREMENTS

Pressure Range	0 to 10.34×10^6 N/m^2 (0 to 1500 psi)
Rated Excitation	10 VDC
Input Impedance	350 OHM Nominal
Sensitivity	40 MV $\pm$5% (Open Circuit at Rated Excitation)
Frequency Response	> 1000 Hz

6.2.3.2 Sensor selection: The initial design approach to accelerometer selection was to use Piezotronics quartz accelerometers similar to those previously used by NASA Langley for model testing. The model 303A03 accelerometer was selected based on manufacturer's specifications and the space limitations of the ARW-1 wing. The manufacturer specifications are listed in Table 6-VII and a sketch of the accelerometer is shown on Figure 6-9. During testing, it was determined that these accelerometers have a random thermal drift which made their use for measuring fuselage acceleration questionable. Measurement of the fuselage acceleration required a much higher gain than measurement of the wing accelerations. This higher gain accentuated the thermal drift and caused surface motion greater than could be tolerated. It was decided, however, that these accelerometers were adequate for measuring the wing accelerations because of the lower gain requirement. Testing showed covers were required for the wing accelerometers.

TABLE 6-VII

PCB 303A03 ACCELEROMETER PERFORMANCE SPECIFICATION

Sensitivity, Nominal	10mV/g
Resolution	.02g
Resonant Frequency, MTD.	70 KHz
Frequency Range, $\pm$5%	1 to 10 000 Hz
Overload Recovery	10 uSec
Discharge Time Constant	1 Sec
Amplitude Linearity	1% FS
Range for $\pm$5V	$\pm$500g
Output Impedance	100 Ohms
Output Bias	11 Volts
Transverse Sensitivity	5%

TABLE 6-VII (CONCLUDED)

PCB 303A03 ACCELEROMETER PERFORMANCE SPECIFICATION

Strain Sensitivity	.05 g/μ m/m (in/in)
Temperature Sensitivity	.03%/°C (/°F)
Temperature Range	-40°C to 93.3°C (-40°F to 200°F)
Vibration Maximum	±1000g
Shock, Maximum	2000g
Structure	Iso-Compression, Upright
Size, Hex x Height	7.144 x 10.668 mm (9/32 x .42 inch)
Connections	Solder Pins
Case Material	Aluminum/Titanium
Power Supply Voltage	+18 to +24 Volts
Power Supply Current	2 to 20mA thru current regulating diode

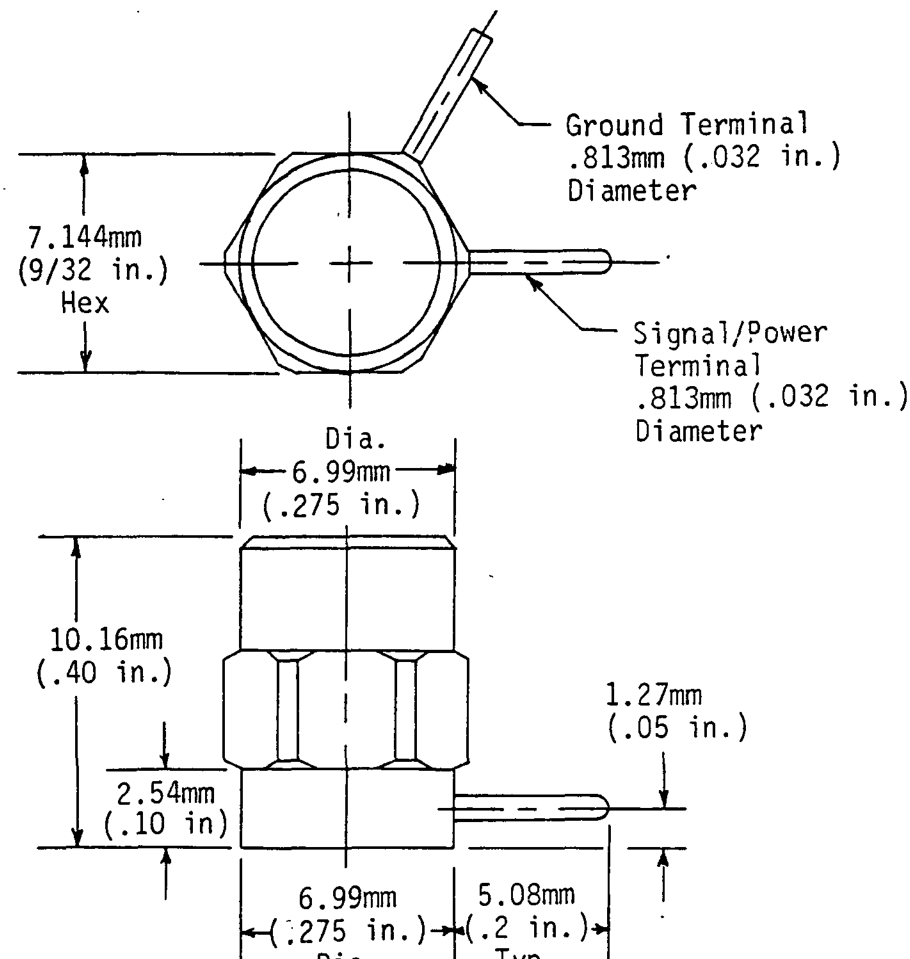


FIGURE 6-9 - SKETCH OF PCB PIEZOTRONICS MODEL 303A03 MINIATURE ACCELEROMETER

More space was available for mounting transducers in the fuselage, allowing the use of servo type accelerometers. Manufacturer's specifications, availability and NASA's recommendations led to the selection of the Sundstrand Model QA1100-AA01-12 accelerometer. The manufacturer's specifications are listed in Table 6-VIII, and Figure 6-10 shows a sketch of the accelerometer and a wiring diagram. Figure 6-11 shows an exploded view of the accelerometer.

TABLE 6-VIII

SUNDSTRAND QA1100-AA01-12 ACCELEROMETER PERFORMANCE SPECIFICATION

Range, Maximum Full Scale	±g
Scale Factor/Sensitivity	250mV/g±10%
Frequency Response (±5%)	300 Hz
Natural Frequency	Greater Than 800 Hz
Damping Ratio	0.3 to 0.7
Noise	
0-10 Hz	<10 nanoamps RMS
0-50 Hz	<100 nanoamps RMS
500-10 K Hz	<1 microamp RMS
Excitation/Power Supply Voltage	±13VDC to ±28VDC
Excitation/Power Supply Quiescent Current	15 ma per supply
Scale Factor/Sensitivity Shift with Supply Voltage	.002%/V
Bias/Zero Shift with Supply Voltage	10 micro-g/V
Resolution (DC)	0.000 001 g
Threshold (DC)	0.000 001 g
Linearity (DC)	
QA-1000,1100,1200	20 μ g/g^2
Hysteresis	0.001% of Full Scale
Repeatability	0.003% of Full Scale
Bias/Zero Unbalance	±3 milli-g Typical ±10 milli-g Max.
Scale Factor Temperature Coefficient/Thermal Sensitivity Shift	180 ppm/^{o}C (maximum)
Axis Alignment/Transverse Sensitivity	0.002 g/g
Vibration Rectification Coefficient (Discrete Point)	75 μ g/g^2 RMS Uncompensated

TABLE 6-VIII (CONCLUDED)

SUNDSTRAND QA1100-AA01-12 ACCELEROMETER PERFORMANCE SPECIFICATION

Constant g Random Spectrum 50 to 2 K Hz	40 $\mu g/g^2$ RMS
Grounding	Electronics are isolated from case 50 megohms of 50 VDC. Shield is common to case.
Case Material	Stainless Steel
Temperature:	
Operating Range	-55°C to 115°C
Specified Performance Range	-18°C to 100°C
Storage Range	-65°C to 125°C
Static Overload	100g
Shock	
Environmental	250g, 11 milliseconds, Half Sine, All Axes
Heavy Duty	1000g, 0.5 milliseconds, Half Sine, All Axes
Vibration	50 g Pk. Sine All Axes (20 Hz to 2 K Hz)
Humidity	Epoxy Sealed (Weld Seal on QA 1100 if Required)

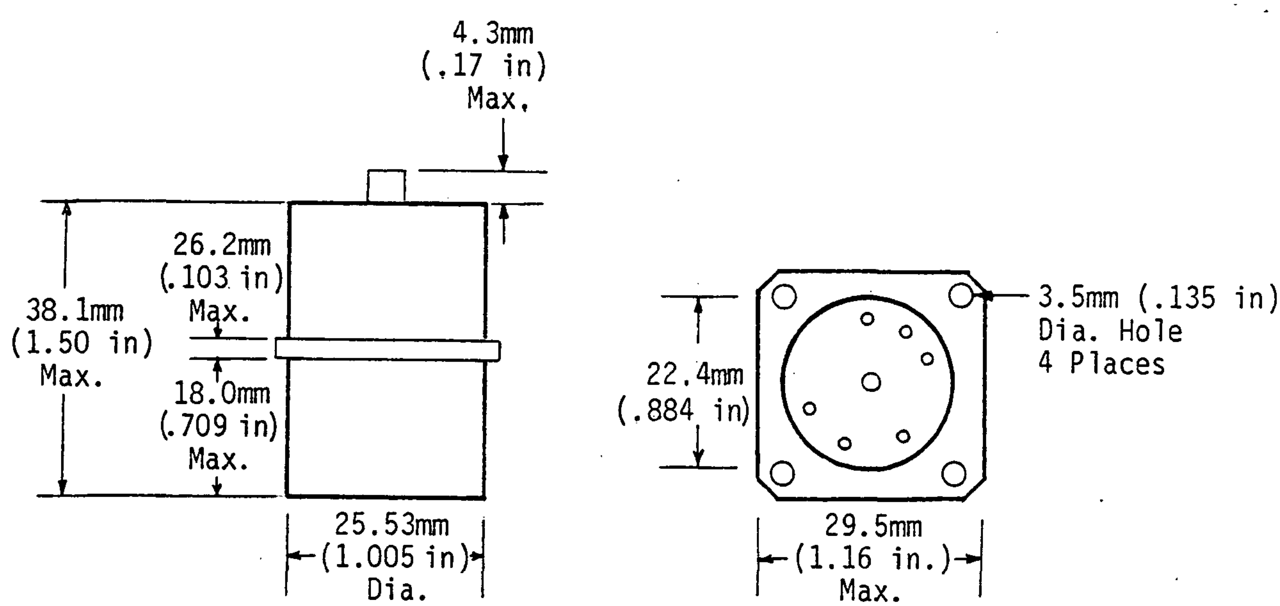


FIGURE 6-10 - SUNDSTRAND MODEL QA1100-AA01-12 ACCELEROMETER

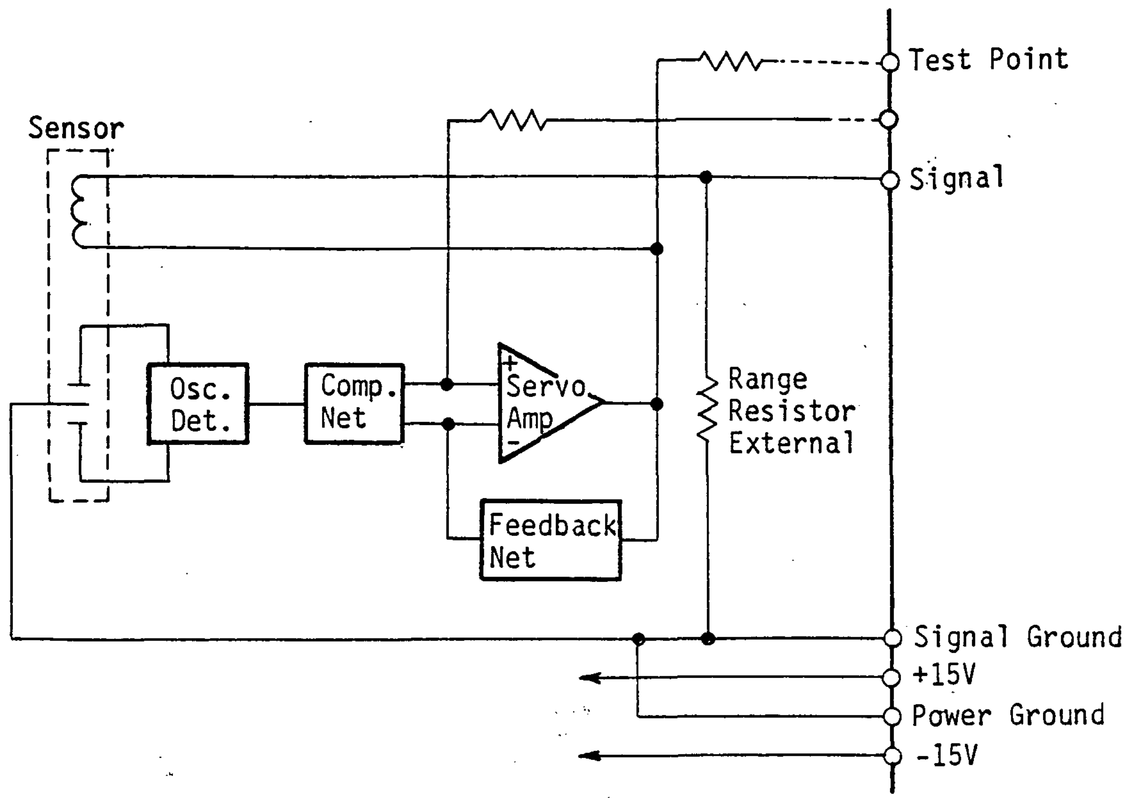


FIGURE 6-10 (CONCLUDED) - SUNDSTRAND MODEL QA1100-AA01-12 ACCELEROMETER

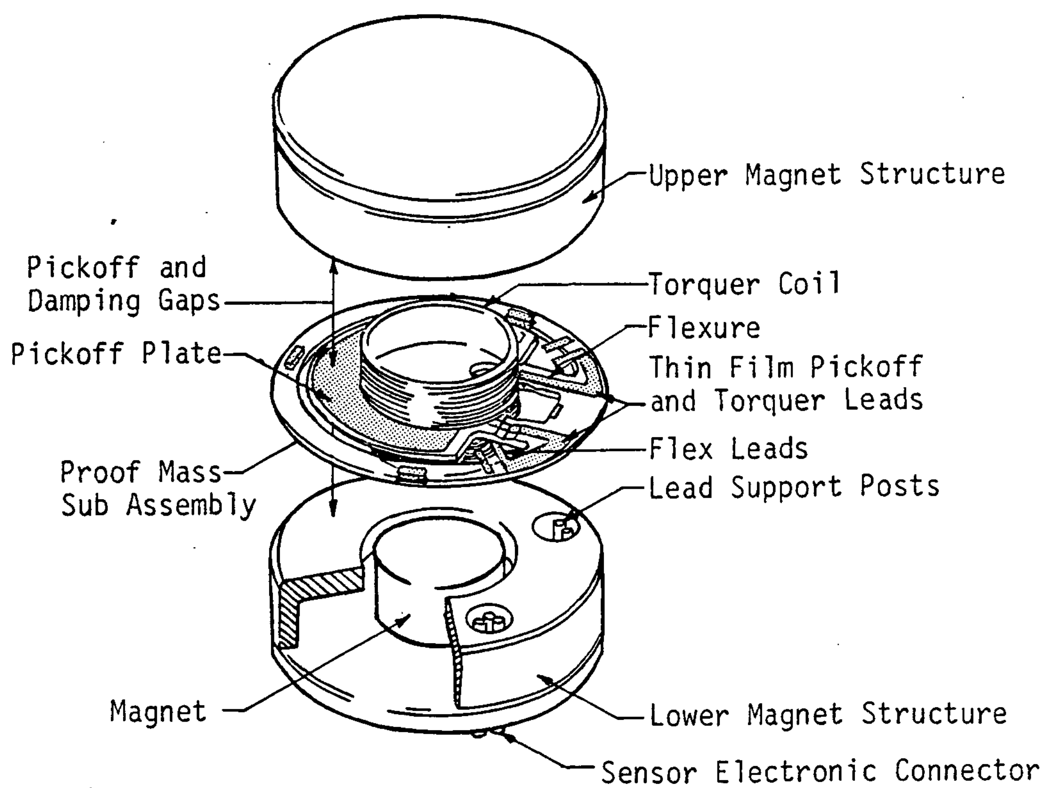


FIGURE 6-11 - EXPLODED VIEW OF SUNDSTRAND MODEL QA1100-AA01-2 ACCELEROMETER

A possible replacement for the wing accelerometers was considered and the Entran EGAL-50 was selected for evaluation. The evaluation tests were satisfactory and this accelerometer was recommended for future applications provided satisfactory inflight evaluation can be accomplished. Figure 6-12 gives a comparison between the thermal drifts of the PCB and the Entran accelerometers. The Entran shows virtually no thermal drift.

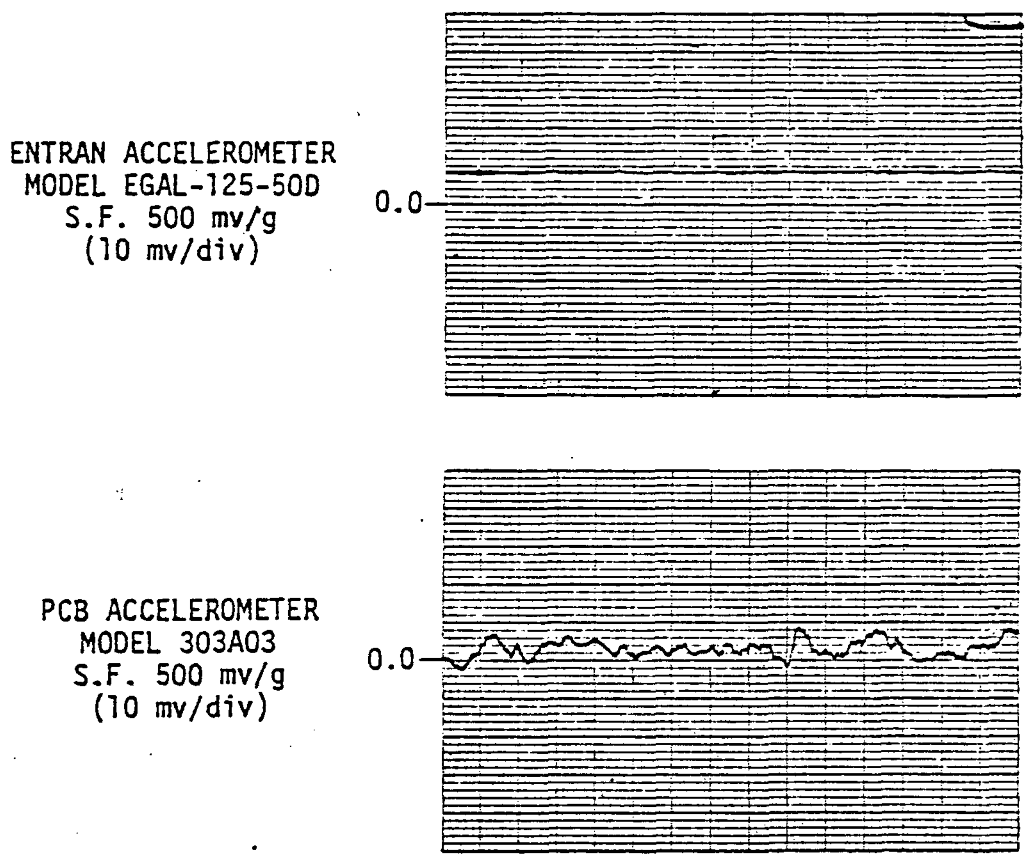


FIGURE 6-12 - ENTRAN AND PCB ACCELEROMETER THERMAL DRIFT COMPARISON

The potentiometers selected were the New England Instrument Company Model 55 FL1-134. These potentiometers are single turn 5.236 rad. (300°) precision conductive plastic type presenting nearly infinite travel resolution. The 12.7 mm (1/2 inch) diameter was selected to be compatible with the space available. The manufacturer specifications are listed in Table 6-IX.

TABLE 6-IX

NEI 55FL1-134 POTENTIOMETER PERFORMANCE SPECIFICATIONS

ELECTRICAL SPECIFICATIONS	
Typical Absolute Linearity	±0.35%
Theoretical Electrical Angle	5.236 rad. (300^o)
Resistance	5000 Ohms
Resistance Tolerance	±10%
Output Smoothness	±0.2% Maximum
Dielectric Withstanding Voltage	750V rms
Insulation Resistance	1000 megohms Minimum
MECHANICAL SPECIFICATIONS	
Starting Torque, Single Cup	1.41×10^{-3} N·m (0.2 oz.-in.) Maximum
Mechanical Angle	6.28 rad (360^o) Continuous rotation
Weight, Single Cup	7.1 gram (0.25 oz.) Maximum
Shaft Runout	.0508mm/mm (.002 in/in) of Shaft Length
Pilot Runout	.0254mm (.001 in.) T.I.R. Maximum
Lateral Runout	.0254mm (.001 in.) T.I.R. Maximum
Shaft Radial Play	.0254mm (.001 in.) T.I.R. Maximum
Shaft End Play	.1270mm (.005 in.) T.I.R. Maximum

The pressure transducers selected were the Bell & Howell Type 4-326-0001. These transducers are a four arm active strain gage Wheatstone design with rugged construction offering highly reliable service. The manufacturer's specifications are listed in Table 6-X. Figure 6-13 shows the outline dimensions for the Type 4-326-001 pressure transducer.

TABLE 6-X

BELL & HOWELL TYPE 4-325-0001 PRESSURE TRANSDUCER PERFORMANCE SPECIFICATION

Pressure Range	0 to 1.034×10^7 N/m^2 (0 to 1500 psi)
Pressure Limits	2.5 x rated pressure for $.6895 \times 10^6$ N/m^2 (100 psi) to 2 x for 3.448×10^7 N/m^2 for 3 min. at room temperature with maximum zero set at 0.5% FR
Rated Excitation	10V DC
Maximum Excitation	12V DC or AC rms without damage

TABLE 6-X (CONCLUDED)

BELL & HOWELL TYPE 4-325-0001 PRESSURE TRANSDUCER PERFORMANCE SPECIFICATION

Input Impedance	350 ohms nominal, 330 ohms minimum at 25°C (77°F)
Sensitivity	40 mV +20% -10% open circuit at rated excitation and 25°C (77°F)
Residual Unbalance	Within +5% FR at zero pressure, rated excitation and 25°C (77°F)
Combined Linearity & Hysteresis (Best straight line thru calibration points)	Within ±0.5% FR
Natural Frequency	50 000 Hz for 3.448×10^7 N/m^2 (5000 psi) units decreasing logarithmically with range of 10 000 Hz for $.172 \times 10^6$ N/m^2 (25 psi) units and below
Output Impedance	350 ohms +10% at 25°C (77°F)
Resolution	Infinite
Temperature Range, Conpensated	-53.9°C to +121°C (-65°F to +250°F)
Temperature Range, Operable	-196°C to +148.9°C (-320°F to +300°F)
Thermal Zero Shift	Within 0.010% FR/°C(°F) over compensated temperature range
Thermal Sensitivity Shift	Within 0.010% FR/°C(°F) over compensated temperature range
Static Acceleration (100 g)	0.005% FR/g for 3.448×10^7 N/m^2 (5000 psi) units increasing logarthmically with range of 0.05% FR/g for 6.895×10^4 N/m^2 (10 psi) units
Linear Vibration (35g peak, 5 to 2000 Hz, 12.7mm (.5 in.) D.A. Maximum)	0.02% FR/g maximum for 6.895×10^6 N/m^2 (1000 psi) units and above, increasing logarithmically with range to 0.08% FR/g for 6.895×10^4 N/m^2 (10 psi) units
Humidity	Meets MIL-F-5272C Proc 1
Shock	1000 g half-sine-wave pulse for 1 msec without damage
Insulation Resistance	500 megohms minimum at 45VDC over compensated temperature range
Weight (Excluding Mating Connector)	114 grams (4 ounces) maximum
Pressure Media	Compatible with 17-4PH and silver plated 321 SS O ring
Mating Connector	Furnished, B&H P/N 84479-0004

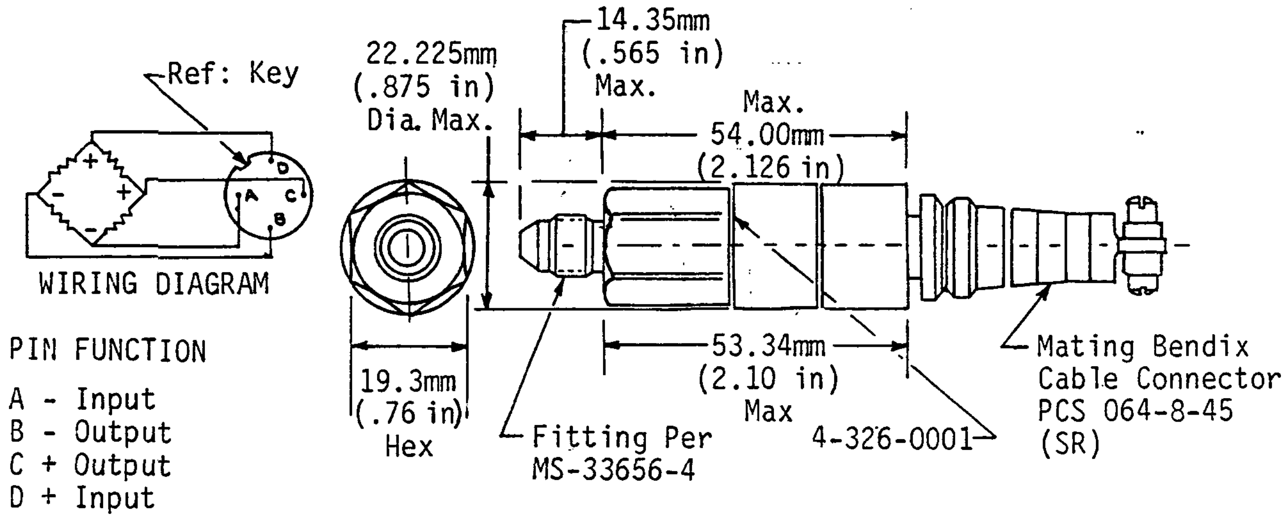


FIGURE 6-13 - BELL & HOWELL TYPE 4-326-0001 PRESSURE TRANSDUCER OUTLINE DIMENSIONS

6.2.4 Circuit design - The electronics provides signal conditioning for the analog signals from the sensors, accepts uplink discrete telemetry commands and provides downlink analog and discrete signals to be compatible with the existing telemetry system. The primary function of the electronics is signal shaping and the filter network required flexibility to allow critical break points to be selected by resistor changes at designated places in the circuitry. A built-in test generator is required to provide FSS test signals to assist in determining proper FSS operation during flight. Parameter changes were to be implemented by designated resistor changes for infrequent changes, variable gain controls for rapid changes between flights and in-flight logic-controlled gain changes and parameter gain scheduling.

The FSS electronics was designed with all circuitry on cards. When the cards are removed from the box, no electronics are left in the box except for EMI filters and wire harness. Circuits for each of the circuit cards are included in Reference 7, Maintenance and Operating Instructions.

6.2.4.1 Signal conditioning: The uplink commands and downlink signals to be received and transmitted by telemetry are conditioned in the electronics to be compatible with the drone primary telemetry system.

The uplink commands are required to be compatible with the existing telemetry system. The telemetry commands are discrete 0 to 5 VDC Schottky TTL Totem-Pole outputs. The commands are as follows:

- FSS Engage-Disengage
- Square Doublet Excitation
- Sweep Excitation
- Symmetric or Antisymmetric Excitation
- Excitation Amplitude (High/Low)
- FSS Gain Select (High/Nominal)

Static and impact pressure signals are onboard analogs and are required for parameter scheduling. Access to these signals is through the uplink interface cable.

The uplink commands consist of six discrete signals and are defined by Table 6-XI. Figure 6-14 presents a typical uplink signal conditioning circuit. The circuit shown by this figure includes one of the downlink discrete signals and a relay driver. The circuitry will accept 0 to 5 VDC Schottky TTL totem-pole telemetry outputs. The pull up resistors are provided in the FSS box as shown by Figure 6-14 to improve noise immunity. Modifications to some of these uplink commands were made prior to first flight.

UPLINK TELEMETRY COMMANDS

Command	Parameter Identification	Range	Signal Level
FSS Box Engage	FSSON	On/Off	On: 5 VDC Off: 0 VDC
Excitation Pulse Command	PULCOM	On/Off	On: 5 VDC Off: 0 VDC
Excitation Sweep Command	SWECOM	On/Off	On: 5 VDC Off: 0 VDC
Excitation Symmetry Command	SYMCOM	Symmetric Antisymmetric	Sym: 0 VDC Anti: 5 VDC
Excitation Amplitude Command	AMPCOM	High/Low	Hi: 5 VDC Low: 0 VDC
FSS Gain	FSGAIN	High/Low	Hi: 5 VDC Low: 0 VDC

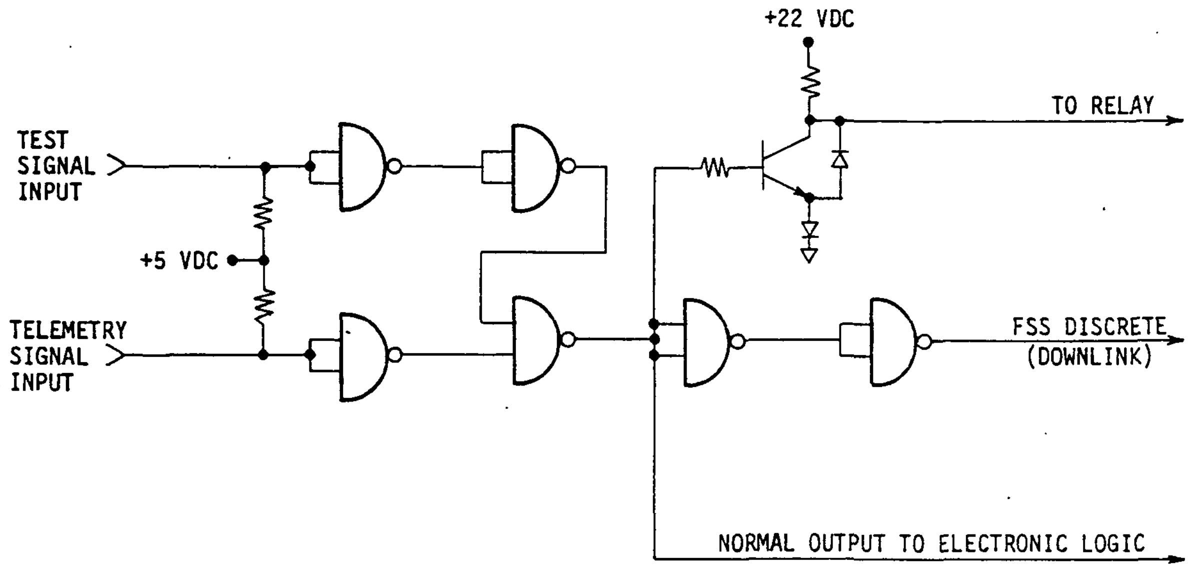


FIGURE 6-14 - TYPICAL UPLINK SIGNAL CONDITIONING AND LOGIC CIRCUIT

The downlink signal requirement is to be compatible with an existing telemetry system. The telemetry system accepts ±5 VDC analog signals and 0 to 5 VDC discrete signals. The downlink signals are as follows:

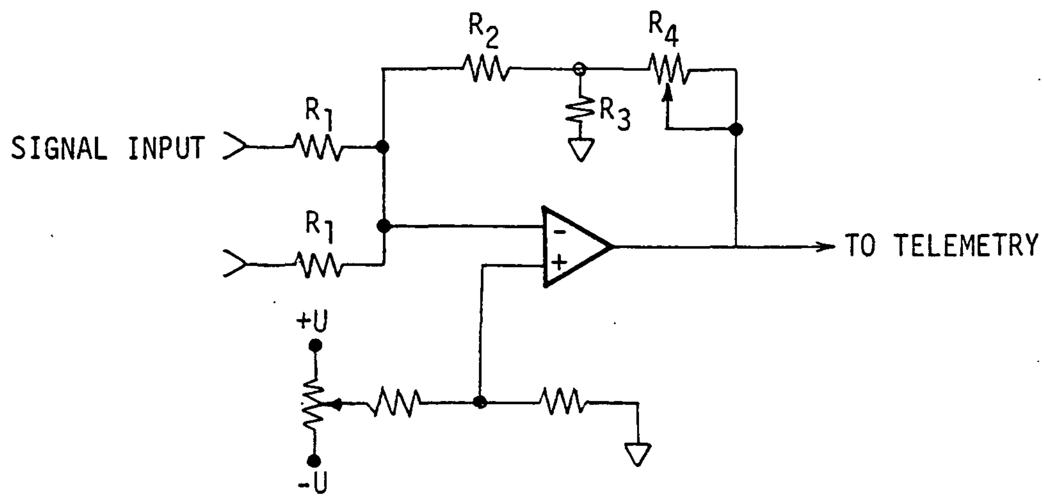
- Discrete FSS Engage and FSS Gain Select (uplink signal verification)
- Left Wing Surface/Actuator Position
- Right Wing Surface/Actuator Position
- Left Wing FSS Vertical Acceleration
- Right Wing FSS Vertical Acceleration
- Fuselage FSS Roll Acceleration
- Fuselage FSS Vertical Acceleration
- Left Wing Servoactuator Command
- Right Wing Servoactuator Command
- FSS Excitation
- Hydraulic Supply Pressure
- Hydraulic Differential Load Pressure
- Parameter "D" Time Constant

The downlink signals consist of twelve analog and two discrete signals. These signals are defined by Table 6-XII. Figure 6-15 presents a typical downlink signal conditioning circuit. Additional inverting and non-inverting circuits are provided on the downlink circuit cards for use as required. Provisions are provided to allow adjustment of offset and gain for the downlink signals. Multiple inputs are included for versatility. Sign convention and signal location are shown by the block diagram of Figure 6-8. The signals are scaled to ±5 VDC as shown by Table 6-XII and the discrete outputs are 0 to 5 VDC TTL compatible.

TABLE 6-XII

DOWNLINK TELEMETRY SIGNALS

Measurement	Parameter Identification	Range	Signal Level	Scale Factor
Left Wing Aileron Position	LWPOT	±.262 rad (±15 deg)	±5 VDC	19.079 V/rad (0.333 V/deg)
Right Wing Aileron Position	RWPOT	±.262 rad (±15 deg)	±5 VDC	19.079 V/rad (0.333 V/deg)
FSS Left Wing Accelerometer	FSSLAC	±10g	±5 VDC	0.5 V/g
FSS Right Wing Accelerometer	FSSRAC	±10g	±5 VDC	0.5 V/g
FSS Vertical Acceleration	FSFUVAC	±5g	±5 VDC	1.0 V/g
FSS Roll Acceleration	FSFURAC	±4g	±5 VDC	1.25 V/g
Left Wing Servo Command	LWSERV	±.262 rad (±15 deg)	±5 VDC	19.079 V/rad (0.333 V/deg)
Right Wing Servo Command	RWSERV	±.262 rad (±15 deg)	±5 VDC	19.079 V/rad (0.333 V/deg)
Excitation Output Signal	FSSEXC	±.035 rad (±2. deg)	±5 VDC	114.59 V/rad (2.0 V/deg)
Parameter D Time Constant	DPAR	0-1000 units	0: -5 VDC 1000: +5 VDC	0.1 V/unit
Hydraulic Supply Pressure	HYDSUP	0- 1.38×10^{7} Pa (0-2000 psi)	0: -5 VDC 2000: +5 VDC	7.25×10^{-7} V/Pa (0.005 V/psi)
Hydraulic Load Differential Pressure	HYDLOD	$\pm1.034\times10^{7}$ Pa (±1500 psi)	±5 VDC	4.79×10^{-7} V/Pa (0.0033 V/psi)
FSS Box Engage	FSSON	On/Off	On: 5 VDC Off: 0 VDC	N/A
FSS Gain	FSGAIN	High/Low	High: 5 VDC Low: 0 VDC	N/A



$$\text{GAIN} = \frac{R_2R_3 + R_2R_4 + R_3R_4}{R_1R_3}$$

FIGURE 6-15 - TYPICAL DOWNLINK SIGNAL CONDITIONING CIRCUIT

A single card was used for signal conditioning outputs of the two wing accelerometers, PCB 303A03, and the two fuselage accelerometers, Sundstrand QA1100-AA01-12. The card provides the constant current source required for the PCB accelerometers and the circuitry to provide the necessary vertical and roll motion signals required by the FSS. A two radian washout was provided in each of the wing circuits to block the DC offset of the PCB accelerometers electronics. A double two radian washout was included in the fuselage accelerometer circuits in order to match the approximate two radian washout built into the PCB accelerometer electronics.

Vertical and roll accelerations were derived from the right ($RF\ddot{Z}$) and the left ($LF\ddot{Z}$) fuselage accelerations and the equations:

$$\ddot{Z} = (RF\ddot{Z} + LF\ddot{Z})/2 \text{ for vertical acceleration and}$$

$$\ddot{\theta}_X = (RF\ddot{Z} - LF\ddot{Z})\left(\frac{76.8125}{12.125}\right)/2 \text{ for roll acceleration.}$$

6.2.4.2 Signal shaping: The requirements are summarized below. A functional block diagram of the ARW-1 flutter suppression system is presented on Figure 4-19. The tolerances on gain and phase as a function of frequency are presented on Figure 6-16.

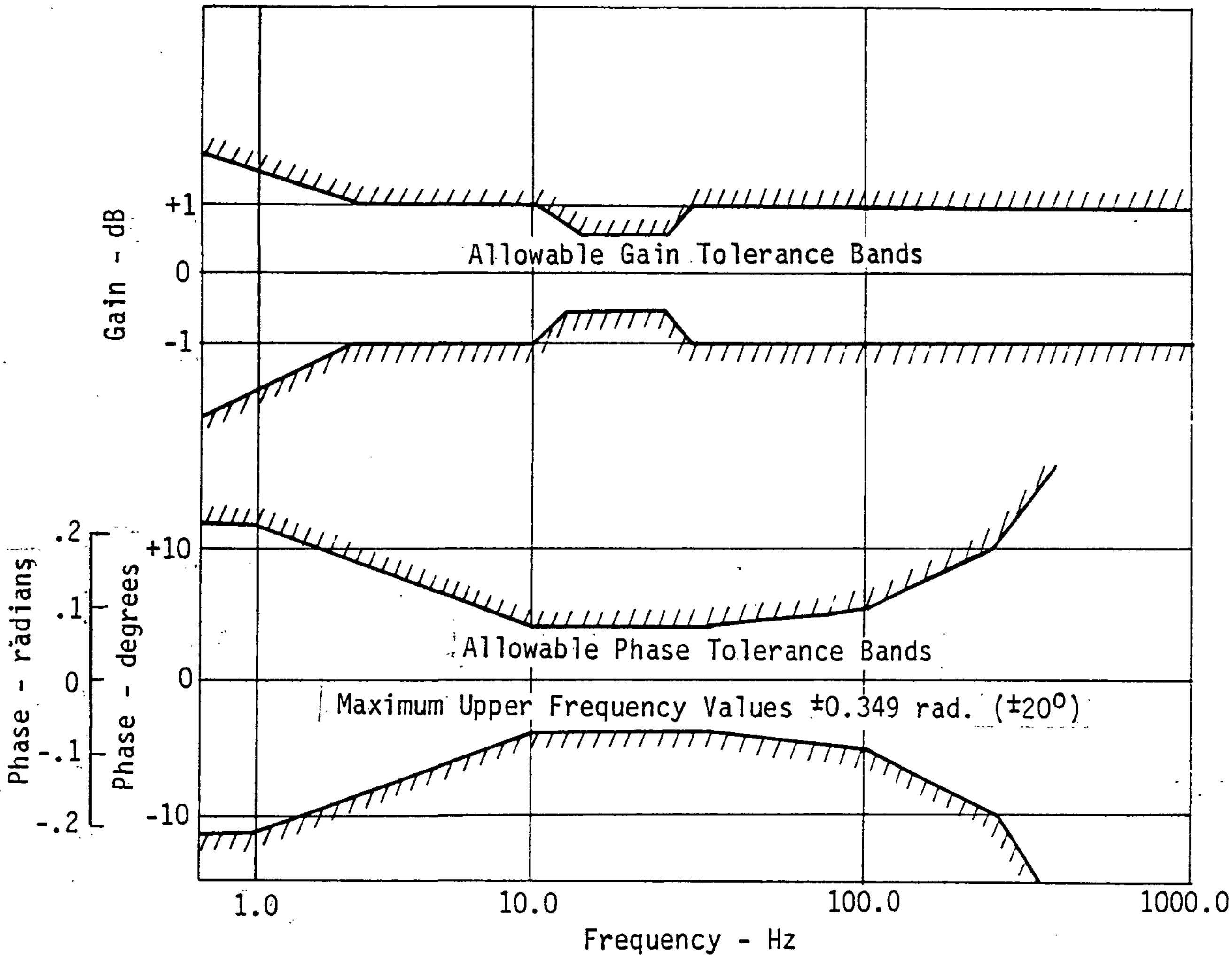


FIGURE 6-16 - ALLOWABLE TOLERANCE BANDS FOR FLUTTER MODE CONTROL SYSTEM FILTERS

Provisions for two discrete inflight gain changes are required. The gains required are nominal and 1.5 times nominal.

The symmetric FSS sensor-to-surface steady state phasing are as follows:

- Right and left wing vertical acceleration in the up direction shall cause both ailerons to deflect trailing edge up.
- Fuselage vertical acceleration BS 0.731 (265) in the up direction shall cause both ailerons to deflect trailing edge down.

The antisymmetric FSS sensor-to-surface steady state phasing is as follows:

- Right wing vertical acceleration in the up direction shall cause the right aileron to deflect trailing edge up and the left aileron trailing edge down.

- Left wing vertical acceleration in the up direction shall cause the right aileron to deflect trailing edge down and the left aileron trailing edge up.

- Angular acceleration about the X axis that moves the right wing up (BS 0.731 (265)) shall cause the right wing aileron to deflect trailing edge down and left wing aileron trailing edge up.

The flutter suppression system consists of wing and fuselage vertical accelerometers driving the ailerons through appropriate symmetric and antisymmetric shaping filters. The gain was distributed throughout the FSS to prevent signal saturation. Figure 6-17 presents gain distribution for the FSS.

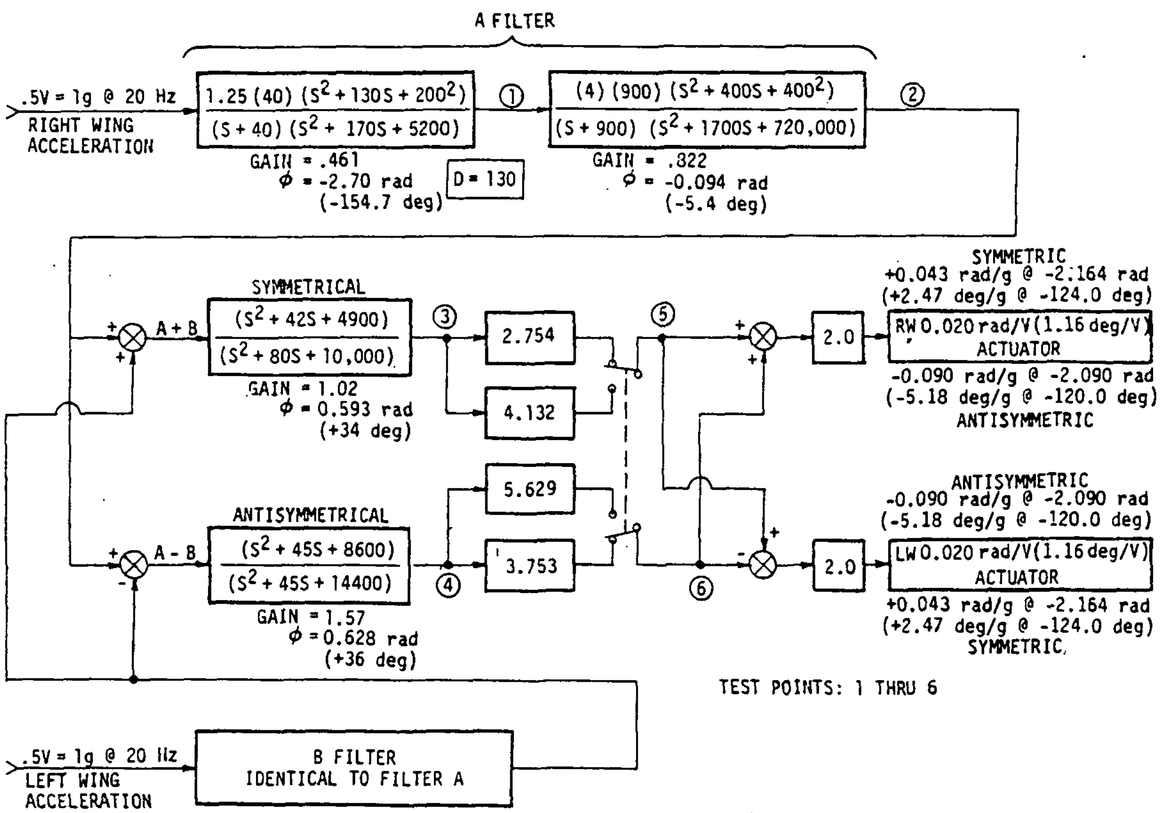
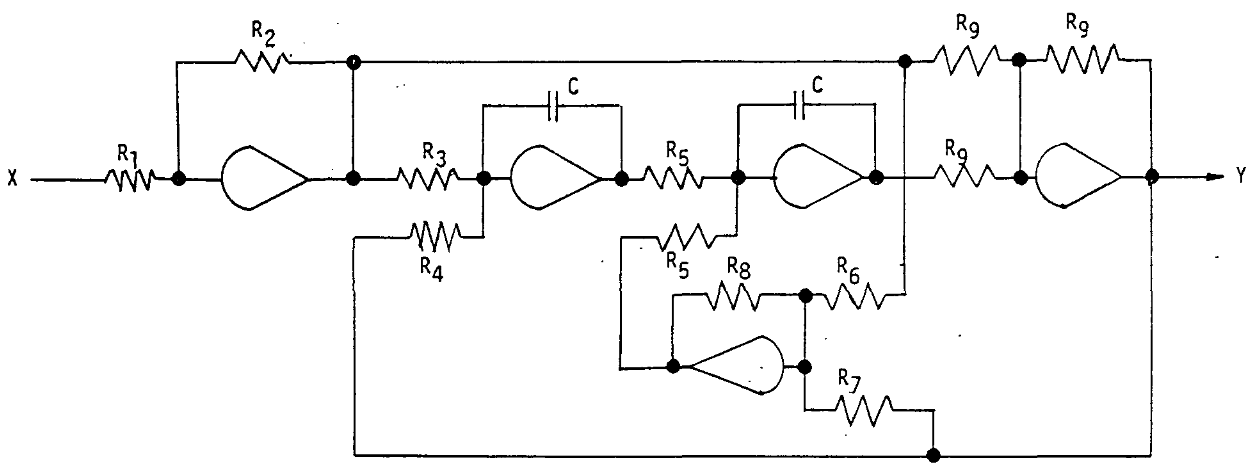


FIGURE 6-17 - FILTER GAIN DISTRIBUTION

The primary function of the FSS electronics is signal shaping. Each shaping filter input and output is brought out to the circuit card connector to facilitate adding a filter if required, anywhere in the electronic circuitry. The filters are mechanized by a second order over a second order with the general transfer function:

$$\frac{E_o}{E_i}(S) = \frac{K(S^2 + 2\zeta_1\omega_{n_1}S + \omega_{n_1}{}^2)}{(S^2 + 2\zeta_2\omega_{n_2}S + \omega_{n_2}{}^2)} \text{ volt/volt.}$$

The second order blocks are implemented in state variable form with voltage out of operational amplifiers being proportional to first or second derivatives of the output, or proportional to the output itself. The state variable design approach facilitates relatively easy gain and break point changes throughout the filters. Figure 6-18 presents a typical filter circuit as implemented in the electronics. The resistor values are calculated as shown on the figure.



$$Y/X = \frac{K(S^2 + 2\delta_1\omega_1 S + \omega_{N_1}{}^2)}{(S^2 + 2\delta_2\omega_2 S + \omega_{N_2}{}^2)}$$

WHERE:

$2\delta_1\omega_1 = R_8/R_6$

$2\delta_2\omega_2 = R_8/R_7$

$\omega_{N_1}^2 = 1/R_3C$

$\omega_{N_2}^2 = 1/R_4C$

$K = \omega_{N_2}{}^2/\omega_{N_1}{}^2$

FIGURE 6-18 - TYPICAL SECOND ORDER FILTER CIRCUIT

Two of the filter blocks, one each for the left and right wing, were selected for "D" parameter scheduling. Parameter scheduling as a function of Mach number, as presented by Figure 4-14, is required for proper FSS operation. The "D" parameter input to the parameter scheduling filter is shown on Figure 6-19. The "D" parameter signal is generated as described by Paragraph 6.2.4.3. Figure 6-20 related phase shift to the "D" parameter. The theory of the above described functions is to change the time constant of the filter as a function of Mach number.

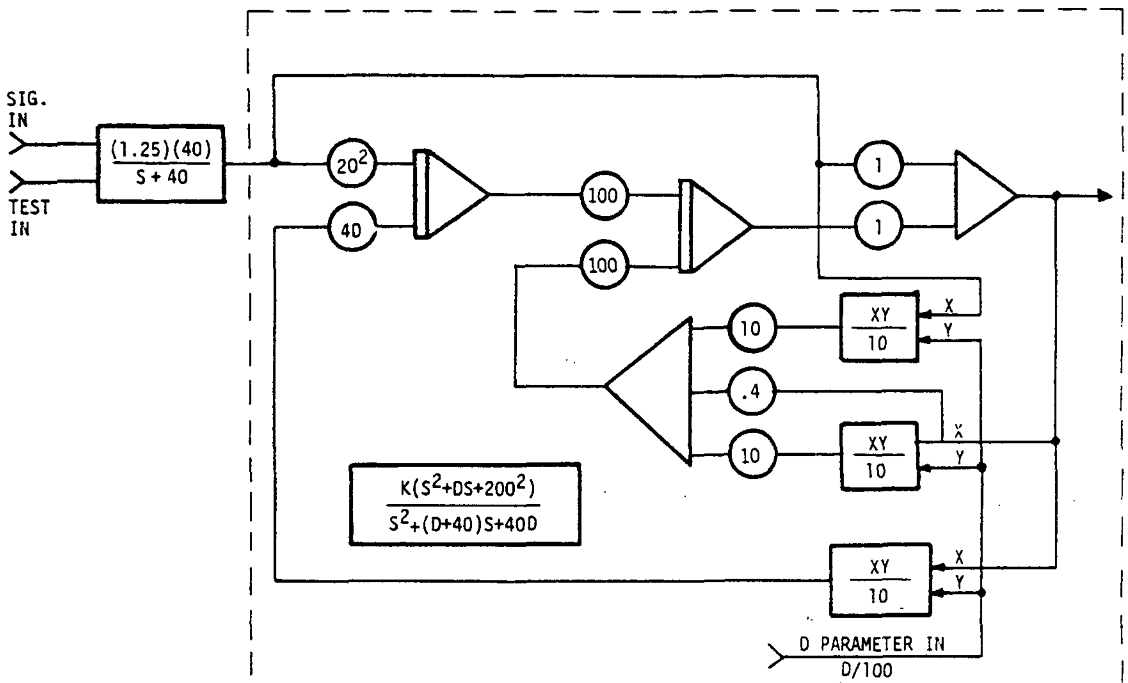


FIGURE 6-19 - D PARAMETER SCHEDULING

The symmetric and antisymmetric filters were mechanized using the same basic circuit described above and shown on Figure 6-18. The same circuit boards were used for all filters. The transfer functions are given on Figures 6-8 and 6-17.

The filter interface card provides final gains and summations for the FSS filter. The final gains are adjustable and are shown by the symmetric gains between test points 3 and 5 and the antisymmetric gains between tests points 4 and 6 on Figure 6-17. The inflight gain select and the FSS engage capabilities are mechanized on this circuit card and receive these commands from the uplink logic. The mechanization of the inflight symmetric and the antisymmetric excitation select functions are initiated on this card and completed on the power interface card.

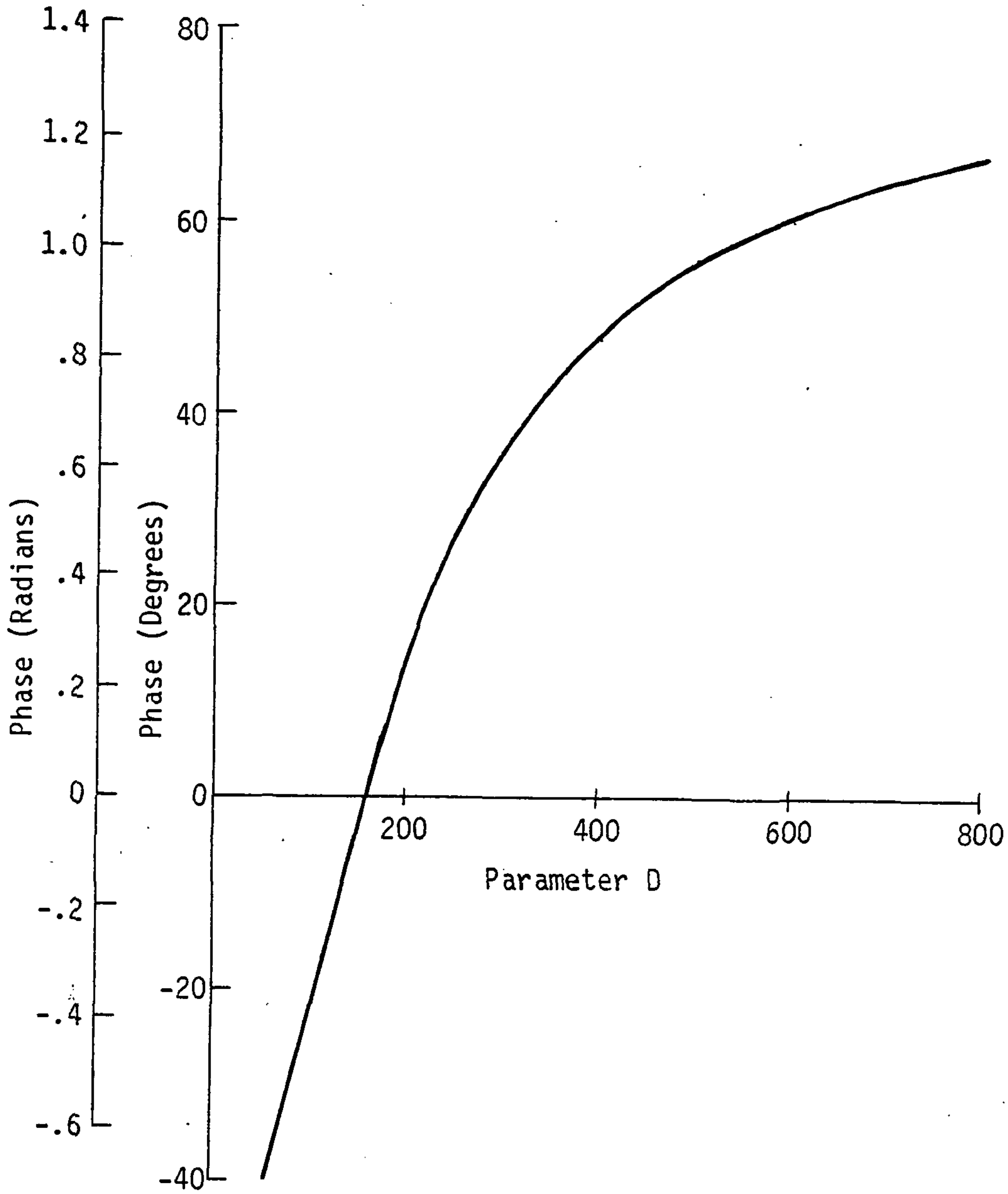


FIGURE 6-20 - PHASE OF $(S^2 + DS + 200^2)/(S + D)$ AT THE FLUTTER BOUNDARY

6.2.4.3 Parameter scheduling: Analyses stipulated that parameter scheduling as a function of Mach number was required. Static and impact pressure signals required for parameter scheduling were obtained from onboard circuitry. These scaled voltage signals will be provided and the parameter scheduler converts these to parameter "D" units. The scaled signals to be received are as follows:

Static Pressure:	0 N/m^2 (0 psf):	-5 VDC
	105 336 N/m^2 (2200 psf):	+5 VDC
Impact Pressure:	0 N/m^2 (0 psf):	-5 VDC
	71 820 N/m^2 (1500 psf):	+5 VDC

The mechanization for determining the parameter "D" was derived from the approximate equation and the functional block diagram shown on Figure 6-21. The "D" parameter sensor characteristics as a function of static and impact pressures are presented on Figure 6-22 and 6-23, respectively.

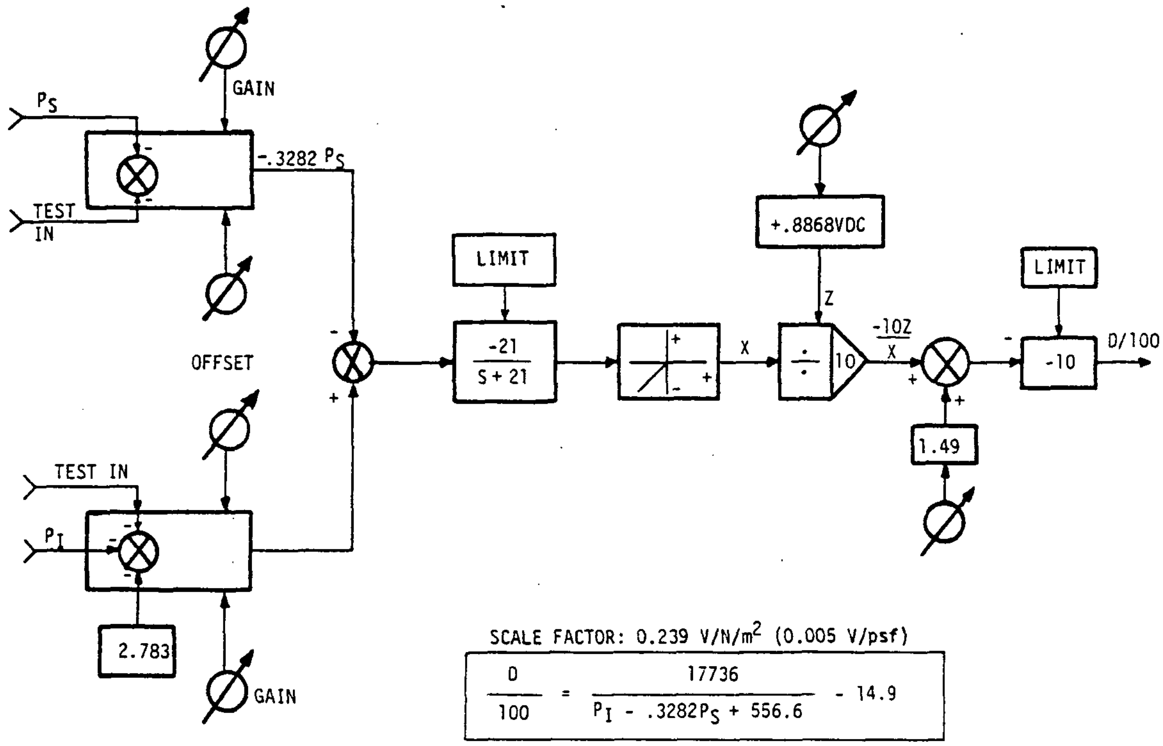


FIGURE 6-21 - D PARAMETER SCHEDULER

The parameter scheduler was discovered to be temperature dependent. The problem was isolated to the AD534SD multipliers. Insufficient space was available on the circuit cards to add temperature stabilized ovens to alleviate this problem. However, testing provided data showing that the FSS filters remained within the required tolerances when the electronics box was subjected to a limited ambient temperature range of 10°C (50°F) to 37.8°C (100°F). Actual flight data verified that the ambient temperature at the proposed FSS box location would be within this temperature range. The electronics box was qualified for flight in this restricted ambient temperature range.

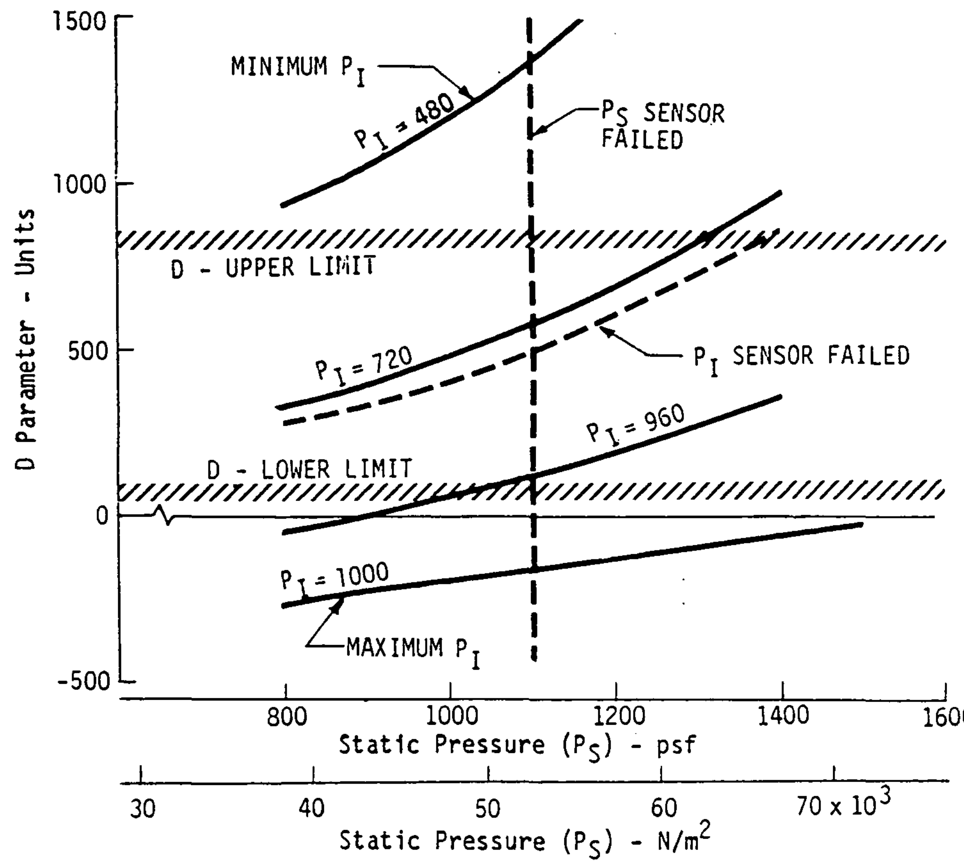


FIGURE 6-22 - D PARAMETER SCHEDULER CHARACTERISTICS, FUNCTION OF STATIC PRESSURE

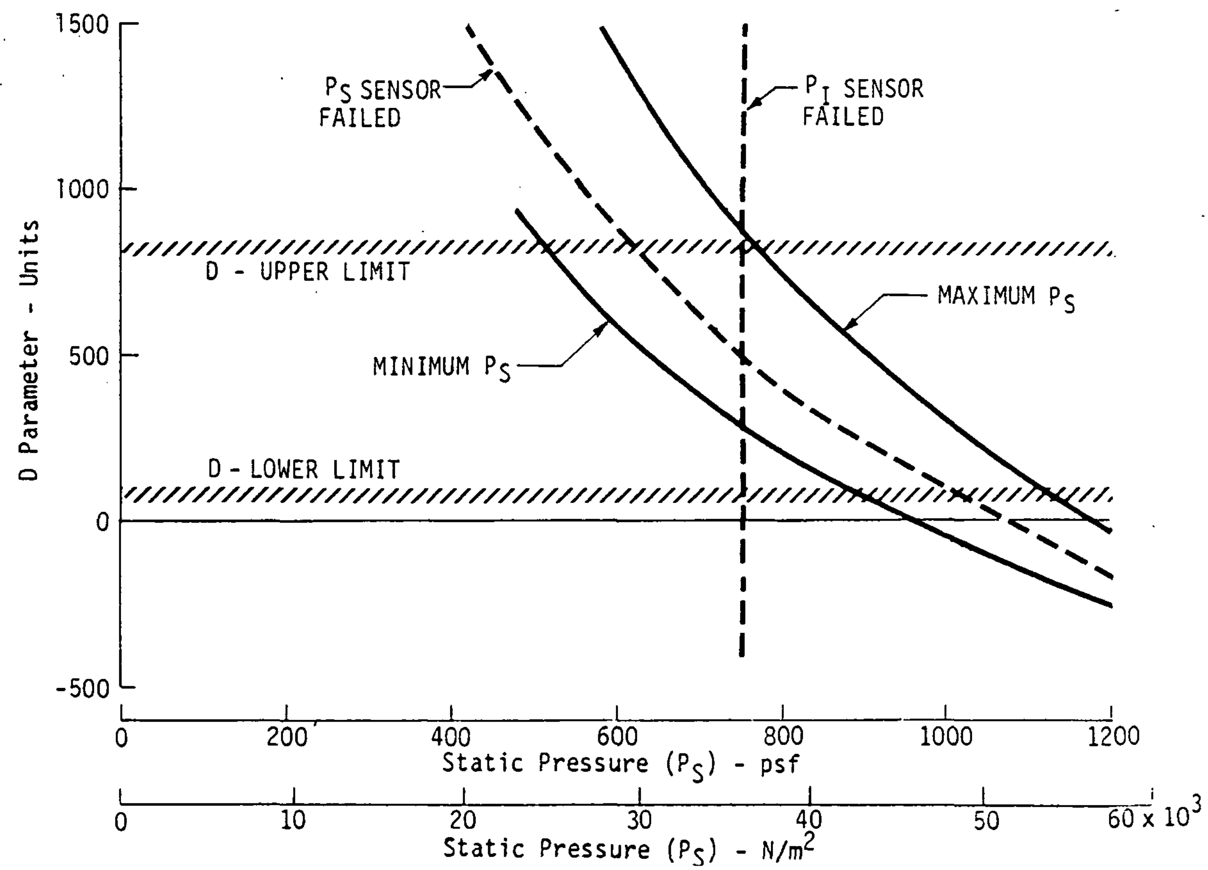


FIGURE 6-23 - D PARAMETER SCHEDULER CHARACTERISTICS, FUNCTION OF IMPACT PRESSURE

6.2.4.4 Function generator: The requirements are summarized below. An aileron square wave doublet and sine wave sweep excitation is required in the onboard FSS electronics box. The design requirements are as follows:

- Sinusoidal Sweep
  - Frequency range: 10 to 40 Hertz
  - Duration: 10 seconds
  - Type of sweep: antilog
  - Amplitudes: 1.745 and 3.490 x 10^{-2} radian (1 and 2 degrees) aileron
- Square Wave Doublet
  - Frequency: 25 Hertz
  - Duration: 1 cycle
  - Amplitudes: 1.745 and 3.490 x 10^{-2} radian (1 and 2 degrees) aileron

Provisions are required to allow the sweep and doublet amplitudes to be changed during ground testing. One uplink command is used to select a "high" or "low" gain for both sweep and doublet.

The excitiation generator is required to have capability to select symmetric or antisymmetric inputs to the control surfaces. Automatic reset capability is required when the excitation is disengaged.

The function generator was included in the FSS electronics to provide inputs to the aileron for testing the flutter suppression system. The generator was programmed to produce two basic commands as outputs. One command is a sine wave with the frequency swept from 10 to 40 Hertz in 10 seconds, and the other command is a one cycle, 25 Hertz square wave doublet.

These signals can produce either symmetric or antisymmetric commands, and the command amplitudes can be logically switched inflight to two different levels, one two times the other. At present, these amplitudes are 1.745 x 10^{-2} radian (one degree) and 3.490 x 10^{-2} radian (two degrees) of aileron displacement. These amplitudes can be adjusted between flights to values from 8.727 x 10^{-3} radian (0.5 degree) to 8.727 x 10^{-2} radian (5.0 degrees) surface command based upon the low amplitude command. The functional block diagram of Figure 6-24 describes the theory of operation of the function generator.

The VCO is free running at the start frequency initially set. The output of the multiplier is approximately zero and the analog switch output is zero. The sweep enable will enable the sweep logic

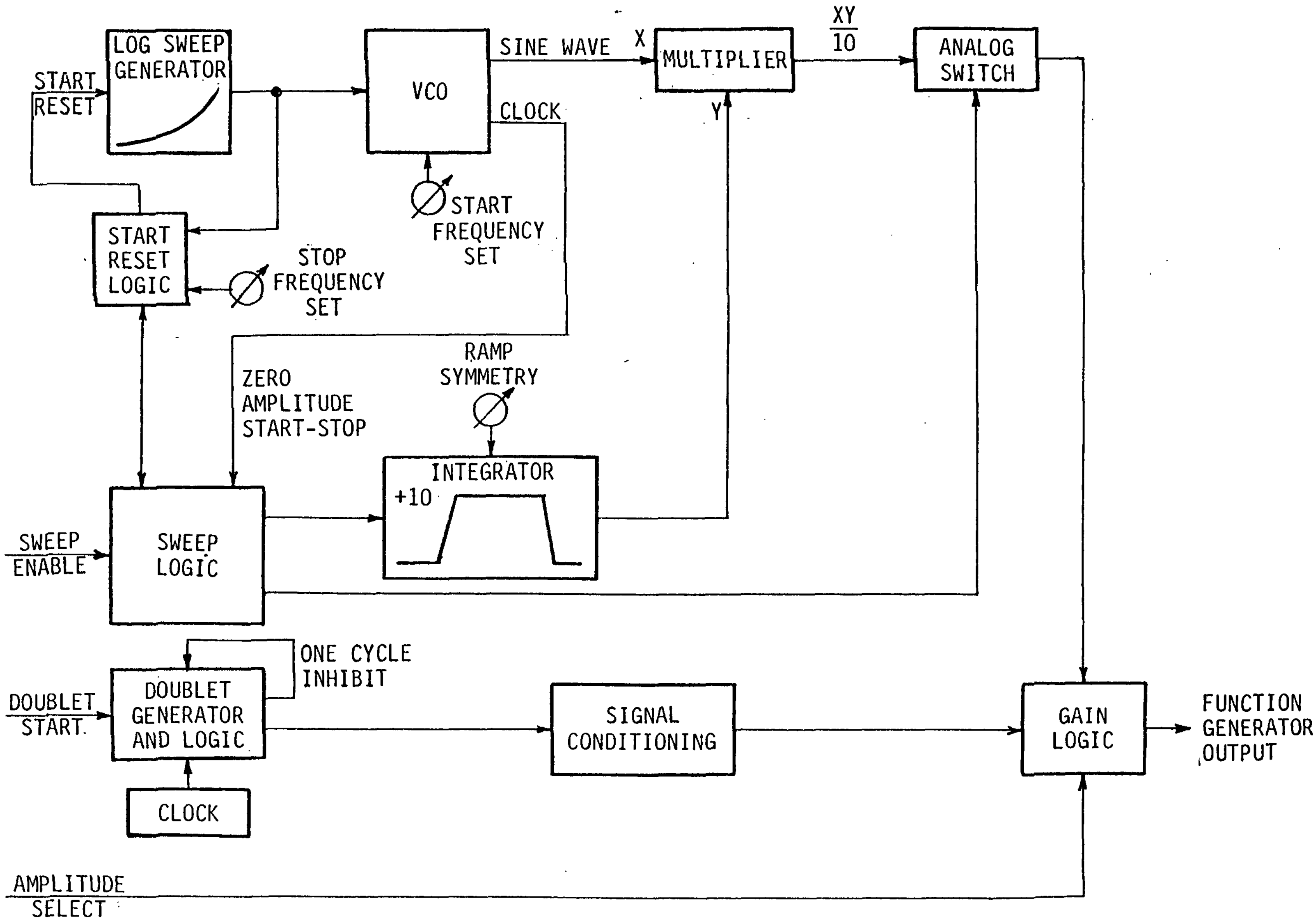


FIGURE 6-24 - FUNCTION GENERATOR BLOCK DIAGRAM which will in turn enable the start logic when the VCO sine wave goes through zero in the positive direction as determined by the clock signal. The start logic will enable the log sweep generator. At the same time, the analog switch is opened and the integrator begins to ramp up and limits at 10 VDC in 0.5 seconds. The sweep function causes the VCO frequency to increase until the stop frequency is reached. At that time the reset logic is enabled and sweep logic is inhibited causing the integrator to ramp down, and the sweep is reset to zero and the analog switch is closed. The frequency is swept according to:

$$f = \frac{af_0}{a-t} = \dot{\Delta}$$

$$a = \frac{f_1 T}{f_1 - f_0}$$

$$\delta = \delta_0 \sin\Delta$$

where:

f_0 = start frequency

f_1 = end frequency

f = output frequency

T = sweep time

δ = control surface angle

δ_0 = maximum control surface angle

Δ = phase angle

The sweep enable signal must be present to allow a complete sweep. Only one sweep can occur for each time the sweep enable signal is applied. The sweep will immediately stop after the amplitude ramps down when the sweep enable signal is removed.

A square wave doublet is generated when the doublet start signal is applied. The period of the doublet is determined by the clock. Only one doublet can occur for each time the doublet start signal is applied. The doublet cannot be terminated before completion once it has been initiated.

An amplitude select signal will cause the amplitude of either the sine wave or the doublet to be increased by a factor of two. Both the sine wave and doublet can be initiated at the same time. A logical "one" (+5 VDC) enables all function generator commands. The sine wave sweep start and stop frequencies may be varied ±5.0 Hertz. The sweep duration is variable from five to twenty seconds. The soft start and stop provided by the integration ramp time of 0.5 seconds up and down may be adjusted nonsymmetrically ±0.2 seconds; that is, 0.7 seconds up and 0.3 seconds down to 0.3 seconds up and 0.7 seconds down. The square doublet is not variable and can be changed only by circuit modification.

The function generator when used with the FSS engage command can provide open loop (engage off) or closed loop (engage on) modes of operation. The function generator also provides a method to input commands to the FSS during flight testing.

6.2.4.5 Servoactuator electronics: The requirements are summarized below. The theoretical position and pressure loop gains required to give desired servoactuator performance were 327.4 rad/sec and 0.0466 rad/sec, respectively. The actual gains were to be set experimentally to match the desired closed loop no-load servoactuator transfer function given in Table 6-II in Paragraph 6.1.3.

The servovalve selected had two 1500 ohm coils to be wired in parallel presenting a resistive load of 750 ohms and a typical inductance of 4.1 henry at 50 Hertz. The rated servovalve current was 8.0 ma, giving a flow gain of 1.024 m^3/s/ma (0.625 in^3/sec/ma) at the FSS operating pressure of 10.34 x 10^6 N/m^2 (1500 psi). The servoamplifier gain requirement is 2.0 ± 0.2 ma/volt and could not exhibit voltage or current saturation with 8 ma at 20 Hertz into the servovalve coil impedance of 4.1 henry and 750 ohms.

The servoamplifier is required to accept inputs from the position and pressure feedback loops, from the flutter suppression system, from the excitation generator contained in the flutter suppression system electronics and from an external excitation generator for ground tests. The servoamplifier and interface electronics are required to include provisions to compensate for unwanted null offsets in the system and provide capability to drive the surface to zero angular position. Provisions also are required to provide in the servoamplifier or other system electronics capability to permit continuous variations of position and pressure feedback gains.

The position potentiometer and pressure transducer requirements are defined in Paragraph 6.2.3.

Two wing control surfaces are required by the DAST ARW-1 FSS system. The surfaces are powered by hydraulic servoactuators. Each of the servoactuators utilize position and load pressure feedback, as shown on the servovalve driver electronics block diagram of Figure 6-25. The position feedback signal comes from a potentiometer mounted to measure actuator shaft angular position. The load pressure signal is formed from the outputs of strain gage bridge pressure transducers plumbed into the servovalve control ports between the servovalve and actuator. The position signal is fed back through gain only and the pressure signal is fed through a washout. The input filter commands are fed through washouts in order to eliminate gains and offsets that may result in the filters.

A 100 Hertz and a 380 Hertz notch filter was added as shown on Figure 6-25 to reduce the effects of hydraulic fluid modes on the servoactuator stability. The 380 Hertz notch is mechanized on the slot 12 card and the 100 Hertz notch is mechanized on the slot 19 card. These filters use the same unpopulated circuit card and are derived in the same manner as the second order filters discussed in Paragraph 6.2.4.2.

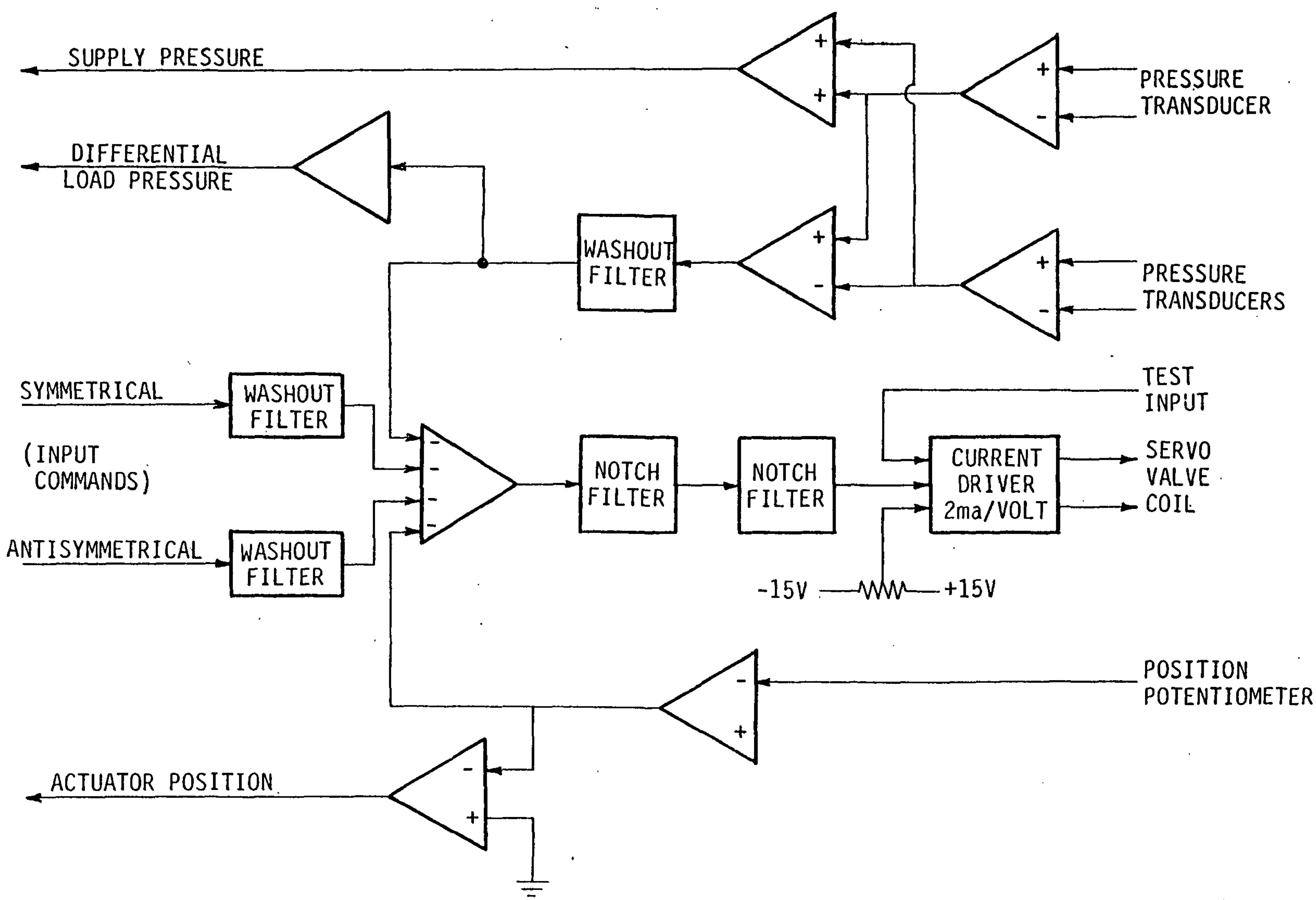


FIGURE 6-25 - SERVOVALVE DRIVER ELECTRONICS BLOCK DIAGRAM

6.2.5 FSS modifications - During system testing and test analysis, several modifications were made. Initially, the fuselage accelerometers were selected to be the same type as the wing. Testing revealed that the PCB accelerometers exhibit a random thermal DC drift which was not blocked by washout filters. The high gain associated with the roll acceleration circuit required replacement of these crystal accelerometers. They were replaced with the servo type described in Paragraph 6.2.3.2. To match the response of the servo type with the crystal type accelerometers, an additional washout filter was added to each fuselage accelerometer circuit. This was done on the accelerometer signal conditioning circuit card.

The testing and analyses done at Boeing as well as the testing done at NASA Langley indicated that two notch filters were required. These were implemented on cards in slots 12 and 19 of the FSS electronics box. Also during testing, some offsets at the outputs of the accelerometer signal conditioning made it necessary to add washouts in front of the shaping filters. These washouts were added to a modified downlink card and installed in slot 18.

6.2.6 FSS power - The power required for the FSS is obtained from Crestronics, Inc., DC to DC converters utilizing the 28 VDC power onboard the drone. The power levels required and converter part numbers are:

VOLTAGE	CURRENT	PART NUMBER
±15 VDC	650 mA	PS 333-24-30-BCT
±5 VDC	450 mA	PS 333-24-10-BCT
±22 VDC	35 mA	PS 333-24-26-FW

The external DC to DC converters were selected to furnish the excitation power to the FSS electronics to eliminate as much wasted power within the electronics box as possible. The manufacturer's specifications are as listed in Table 6-XIII.

The converters are rated for one ampere continuous and the currents listed above are the actual requirements. The three converters are mounted side by side onto a 0.162 x 0.254 x 0.00635 meter (6.0 x 10.0 x 1.4 inch) thick aluminum extrusion with 25.4 millimeter (1.0 inch) high flanges for cooling. Dow Corning PC 340 white silicone grease was used for mounting to reduce the temperature coefficient. The assembled unit is to be mounted beneath the FSS electronics box. A 6.7 microfarad 35 VDC capacitor was installed at the 28 VDC input and one at each power output.

TABLE 6-XIII

CRESTRONICS MODEL PS 333 DC TO DC CONVERTERS
PERFORMANCE SPECIFICATIONS

Model Number: PS 333

Case Units: 38.1 x 76.2 mm (1.5 x 3.0 in.) Extruded Aluminum

$I_{IN\ MAX} = 2.00$

Case Depth = 96.52 mm (3.80 in.)

Mounting Dimension = 63.50 x 30.48 mm (2.50 x 1.20 in.)

Rectifier Systems

FW - Full Wave

BCT - Bridge Center Tap

Regulated Units

Input

Voltage -- $E_{IN\ MAX}$ -- Customer may specify any input voltage between 11 and 28 volts DC. $E_{IN\ MIN}$ is the lowest input voltage applied. This should include the lowest excursion of ripple.

Input Voltage Differential -- ΔE_{IN} -- The normal ΔE_{IN} is 4 volts DC. For ΔE_{IN} greater than 4 volts derate the input current to

$$I\ \text{Derate} = \frac{6\ I_{IN\ MAX}}{\Delta E_{IN} + 2}$$

Input Current -- $I_{IN\ MAX}$ -- 2.0
$I_{IN\ MAX}$ shall be derated for ΔE_{IN} greater than 4 volts.
$I_{IN\ MAX}$ shall be derated for 70°C operation (Derate input $I_{IN\ MAX}$ 1%/°C)

Output

Voltage -- E_O -- The output voltage is screwdriver adjustable from -20% to +5% of nominal

Power -- P_O -- The output power is expressed as $(0.7\ E_{IN\ MAX}\ I_{IN}) - I_O$

Regulation

Line = 0.01%/Δinput volt

Temperature = (0.02%/°C) - 2mv/°C

Load = 100% to 10%
For 30 VDC and over: 3%
For 29 VDC and under: $\% = (0.02E_O) + 0.3/E_O \times 10^{-2}$

Efficiency -- Efficiency is expressed as $\dfrac{(0.7\ E_{IN\ MIN}\ I_{IN}) - I_O}{E_{IN\ MIN}\ I_{IN} \times 10^{-2}}$

6.2.7 FSS electrical wiring - All drone wiring was done by NASA with Boeing furnishing the wing wire. Figure 6-26 shows the DAST ARW-1 FSS wiring. All wire furnished for the wing bundle was either two, three of four wire shielded 22 AWG M27500 MIL Specification wire, except the servovalve wire which was unshielded.

Four primary cable harnesses are required for interfacing the FSS electronics with the drone. The electronic interface is shown on Figure 6-27. One cable interfaces to the DC to DC converter power unit, one cable will interface with the drone AFCS box and the uplink transmitter, one interfaces with the downlink transmitter and one connects the FSS electronics box to the wing cable harness through the pressure bulkhead. Provisions are also included for a ground test cable to permit day-to-day preflight checkout of the FSS.

Tables 6-XIV through 6-XVIII list the connector pin assignments. The power cable power wire size is 18 AWG and includes one each for each voltage level. The power returns are wire size 16 AWG and includes one each for the +22 VDC and ±15 VDC and two for the ±5 VDC. This power cable attaches to the terminal strip provided on the converter power unit. The 28 VDC main ships power also attaches to the designated terminals on this terminal strip.

TABLE 6-XIV.

POWER CABLE CONNECTOR PIN ASSIGNMENT

Chassis: PT02 SE-14-12P (I1)
Cable: PT06 SE-14-12S (P1)

PIN No.	Signal Designator	Box Location	Function
A	22 PWR	FL1-1	22 VDC Power
B			
C	+5 PWR	FL2-1	+5 VDC Power
D	-5 PWR	FL3-1	-5 VDC Power
E			
F	+15 PWR	FL4-1	+15 VDC Power
G	-15 PWR	FL5-1	-15 VDC Power
H			
J	22 RET	FL7-1	22 VDC Return
K	5 RET1	FL6-1	5 VDC Return
L	5 RET2	FL7-1	5 VDC Return
M	15 RET	FL6-1	15 VDC Return

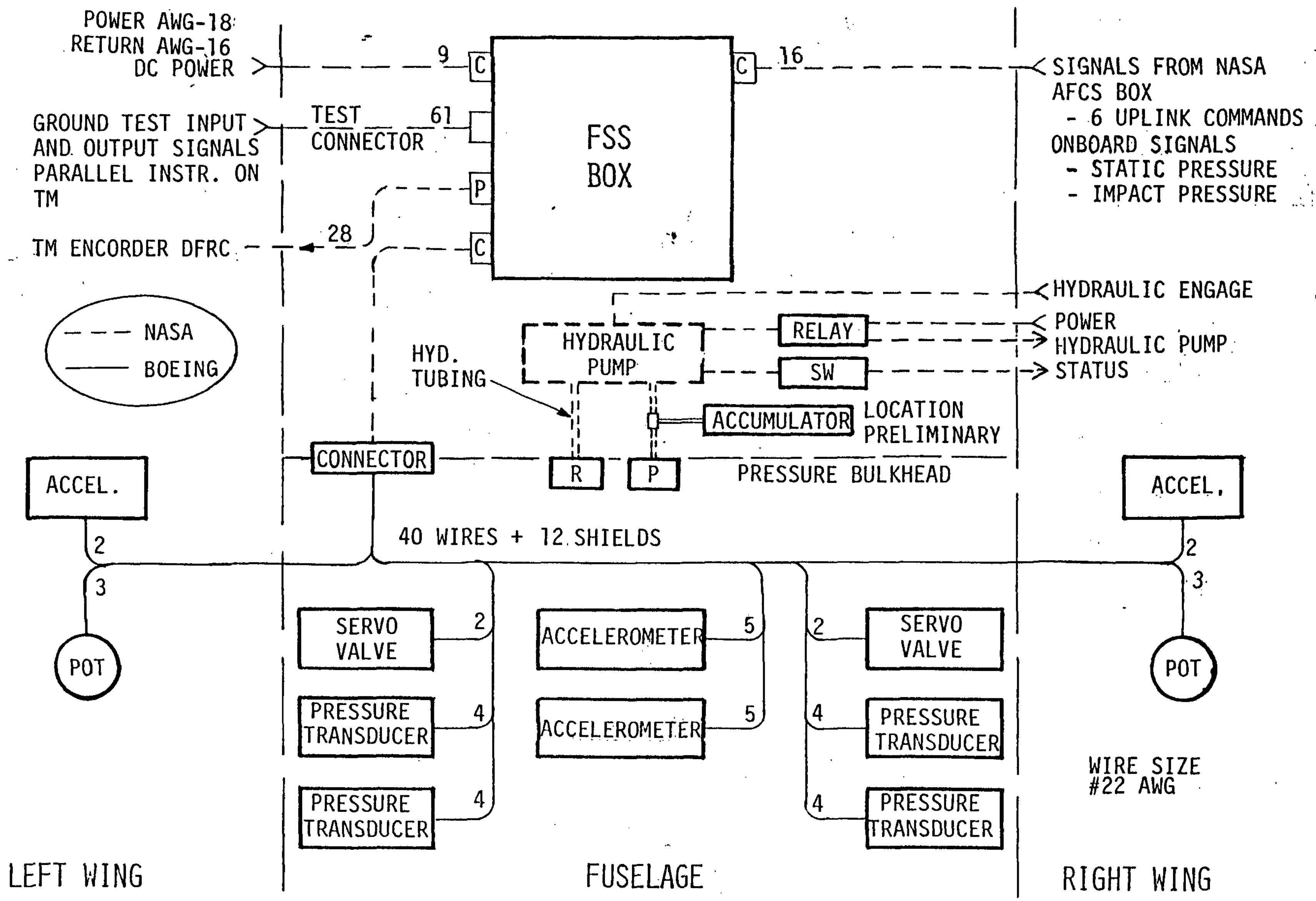


FIGURE 6-26 - DAST ARW-1 FSS WIRING

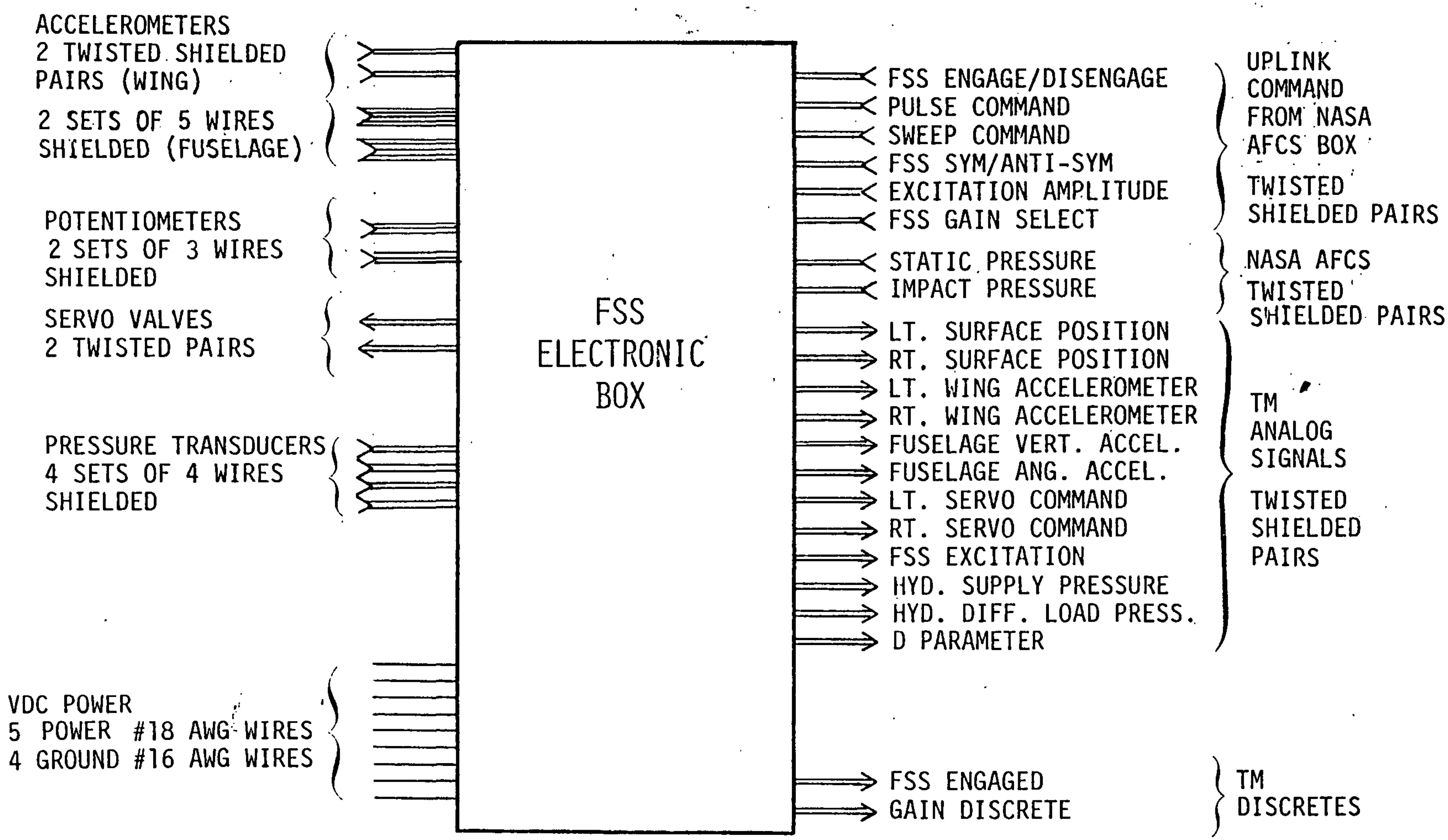


FIGURE 6-27 - DAST ARW-1 ELECTRONIC UNIT INTERFACES

TABLE 6-XV

UPLINK CABLE CONNECTOR PIN ASSIGNMENT

Chassis: PT02SE-16-26P (J2)
Cable: PT06SE-16-26S (P2)
EMI: G3860-K18B

Pin No.	Signal Designator	Box Location	Function
A B	UFSSON	5J1-27 TB1-D1	FSS Box On/Off Input Command (On: 5 VDC) (Off: 0 VDC)
C D	PULCOM	5J1-17 TB1-D1	Excitation Input Pulse Command (On: 5 VDC) (Off: 0 VDC)
E F	SWECOM	5J1-14 TB1-D3	Excitation Input Sweep Command (On: 5 VDC) (Off: 0 VDC)
G H	SYMCOM	5J1-9 TB1-D3	Excitation Input Symmetry Command (Sym: 0 VDC) (Anti: 5 VDC)
J K	AMPCOM	5J1-4 TB1-D5	Excitation Input Amplitude Command (High: 5 VDC) (Low: 0 VDC)
L M	UFSGAN	5J1-22 TB1-D5	FSS Gain Command (High: 5 VDC) (Low: 0 VDC)
N P	STATIC	5J1-55 TB1-D9	Static Pressure Input (0 N/m^2(0 psf): -5 VDC) (.105 x 10^6 N/m^2 (2200 psf): +5 VDC)
R S	IMPACT	5J1-57 TB1-D9	Impact Pressure Input (0 N/m^2(0 psf): -5 VDC) (.072 N/m^2(1500 psf): +5 VDC)

TABLE 6-XVI

FSS WING BUNDLE AFT BULKHEAD CONNECTOR PS3(J3)
CONNECTOR MS27484-T16B-55P
EMI SHELL G3584-168-2.00B

Pin No.	Power	Power Designator	Box Location	Function
1	-15 VDC	LWP03	TB1-C1	Left Wing Surface Potentiometer TED, Pin 3
2	+15 VDC	LWP01	TB1-B1	Left Wing Surface Potentiometer TEUP, Pin 3
3		LWP02	3J1-35	Left Wing Surface Potentiometer wiper, Pin 2
4		LWA01	1J1-26	Left Wing Accelerometer plus Terminal, Red
5		LWA02	1J1-28	Left Wing Accelerometer Ground Terminal Black
6		LBA01	1J1-20	Left Fuselage Accelerometer plus Terminal, Pin 1
7		LBA05	1J1-19	Left Fuselage Accelerometer Ground Terminal, Pin 5
8		LSRVBD	16J1-22	Left Servovalve, Pins B and D
9		LSRVAC	16J1-18	Left Servovalve, Pins A and C
10	+15 VDC	LBA04	TB1-B4	Left Fuselage Accelerometer, Pin 4
11		LBA02	TB1-D8	Left Fuselage Accelerometer PWR Ground Pin 2
12	-15 VDC	LBA03	TB1-C7	Left Fuselage Accelerometer, Pin 3
13				
14				
15				
16				
17	+5 VDC	LPT1D	20J1-17	Left Actuator Pressure Transducer C1 Port Pin D
18		LPT1B	16J1-8	Left Actuator Pressure Transducer C1 Port Pin B
19		LPT1C	16J1-11	Left Actuator Pressure Transducer C1 Port Pin C
20	-5 VDC	LPT1A	20J1-24	Left Actuator Pressure Transducer C1 Port Pin A
21	+5 VDC	LPT2D	20J1-48	Left Actuator Pressure Transducer C2 Port Pin D

TABLE 6-XVI (CONTINUED)

FSS WING BUNDLE AFT BULKHEAD CONNECTOR PS3(J3)
CONNECTOR MS27484-T16B-55P
EMI SHELL G3584-168-2.00B

Pin No.	Power	Power Designator	Box Location	Function
22		LPT2B	16J1-3	Left Actuator Pressure Transducer C2 Port Pin B
23		LPT2C	16J1-2	Left Actuator Pressure Transducer C2 Port Pin C
24	-5 VDC	LPT2A	20J1-55	Left Actuator Pressure Transducer C2 Port Pin A
25				
26				
27				
28				
29				
30				
31				
32	+5 VDC	RPT1D	20J1-46	Right Actuator Pressure Transducer C1 Port Pin D
33		RPT1B	17J1-8	Right Actuator Pressure Transducer C1 Port Pin B-
34		RPT1C	17J1-11	Right Actuator Pressure Transducer C1 Port Pin C+
35	-5 VDC	RPT1A	20J1-53	Right Actuator Pressure Transducer C1 Port Pin A
36	+5 VDC	RPT2D	20J1-49	Right Actuator Pressure Transducer C2 Port Pin D
37		RPT2B	17J1-3	Right Actuator Pressure Transducer C2 Port Pin B-
38		RPT2C	17J1-2	Right Actuator Pressure Transducer C2 Port Pin C+
39	-5 VDC	RPT2A	20J1-52	Right Actuator Pressure Transducer C2 Port Pin A
40				
41				
42				
43				

TABLE 6-XVI (CONCLUDED)

FSS WING BUNDLE AFT BULKHEAD CONNECTOR PA3(J3)
CONNECTOR MS27484-T16B-55P
EMI SHELL G3584-168-2.00B

Pin No.	Power	Power Designator	Box Location	Function
44	+15 VDC	RBA04	TB1-B5	Right Fuselage Accelerometer, Pin 4
45		RBA02	TB1-D8	Right Fuselage Accelerometer PWR Ground, Pin 2
46	-15 VDC	RBA03	TB1-C8	Right Fuselage Accelerometer, Pin 3
47		RWA01	TJ1-3	Right Wing Accelerometer plus Terminal, Red
48		RWA02	TJ1-32	Right Wing Accelerometer Ground Terminal, Black
49		RBA01	TJ1-11	Right Fuselage Accelerometer plus Terminal, Pin 1
50		RBA05	TJ1-9	Right Fuselage Accelerometer Ground Terminal, Pin 5
51		RSRVBD	17J1-22	Right Servovalve Pins B and D
52		RSRVAC	17J1-18	Right Servovalve Pins A and C
53	-15 VDC	RWP01	TB1-C1	Right Wing Surface Potentiometer TED, Pin 1
54	+15 VDC	RWP02	TB1-B1	Right Wing Surface Potentiometer TEUP, Pin 1
55		RWP03	3J1-36	Right Wing Surface Potentiometer Wiper, Pin 2

TABLE 6-XVII

DOWNLINK CABLE CONNECTOR PIN ASSIGNMENT

CHASSIS: PT02SE-18-32S (J4)
CABLE: PT06SE-18-32D (P4)
EMI: G3860-K18B

Pin No.	Power Designator	Box Location	Function
A T	FSSLAC	2J1-2 2J1-1	Left Wing Accelerometer
B U	FSSRAC	2J1-4 2J1-15	Right Wing Accelerometer
1 C V	FSFUVAC	2J1-25 2J1-30	Fuselage Vertical Acceleration
D W	FSFURAC	2J1-27 2J1-44	Fuselage Angular Acceleration
E X	LWPOT	3J1-2 3J1-1	Left Wing Potentiometer Position
F Y	RWPOT	3J1-4 3J1-15	Right Wing Potentiometer Position
2 G Z	LWSERV	3J1-25 3J1-30	Left Wing Servo Command
H J	RWSERV	3J1-27 3J1-44	Right Wing Servo Command
K a	FSSEXC	4J1-29 4J1-1	Excitation Output Signal
L b	DPAR	4J1-4 4J1-15	Parameter D Time Constant
3 M N	HYDSUP	4J1-25 4J1-30	Hydraulic Supply Pressure
P c	HYDLOD	4J1-27 4J1-44	Hydraulic Load Differential Pressure
4 R d	DFSSON	5J1-26 5J1-31	FSS Engage On/Off Command - Discrete
S e	DFSGAN	5J1-25 5J1-44	FSS Gain Command - Discrete

1 Reference or Common, Box Signal Reference TB1-D4

2 Reference or Common, Box Signal Reference TB1-C11

3 Reference or Common, Box Signal Reference TB1-C9

4 Reference of Common, Box Signal Reference TB1-B9

TABLE 6-XVIII

TEST CABLE CONNECTOR PIN ASSIGNMENT

CHASSIS: PT02SE-24-61S (JS)
CABLE: PT06SE-24-61P (PS)
EMI: G3584-249-2.00B (Straight) FSS BOX
G3860-K24B (E1) TESTER

Pin No.	Signal Designator	Box Location	Function
VALVE DRIVER CARD I/O			
A	VDI1	20J1-13	Input Command Test Input (One at a Time)
B	VDI2	20J1-7	Pressure Feedback Test Input
C	VDO2	17J1-43	Right Wing Pressure Transducer Surface Up Cmd
D	VDO3	17J1-34	Right Wing Pressure Transducer Surface Down Cmd
E	VDO5	16J1-43	Left Wing Pressure Transducer Surface Up Cmd
F	VDO6	16J1-34	Left Wing Pressure Transducer Surface Down Cmd
G	VDO8	17J1-23	Right Wing Pressure Feedback
H	VDO10	16J1-23	Left Wing Pressure Feedback
J	VDO7	17J1-25	Right Wing Surface Position Feedback
K	VDO9	16J1-25	Left Wing Surface Position Feedback
FILTER AND FILTER INTERFACE CARDS I/O			
L	SFI2	13J1-5	Symmetrical Test Input
M	AFI2	14J1-4	Antisymmetrical Test Input
N	SFO1	11J1-9	Right Wing "D" Scheduled Filter Output
P	AFO1	10J1-9	Left Wing "D" Scheduled Filter Output
R	SFO2	13J1-2	Right Wing Common Filter Output
S	AFO2	13J1-7	Left Wing Common Filter Output
T	SFO3	13J1-18	Symmetrical Filter Output
U	AFO3	14J1-18	Antisymmetrical Filter Output
V	SFO5	15J1-52	Symmetrical Filter Final Gain Check Point
W	AFO5	15J1-51	Antisymmetrical Filter Final Gain Check Point
ACCELEROMETER SIGNAL CONDITIONING CARD			
x	TIZL	1J1-29	Input to Left Wing Accelerometer Circuit
a	TIZR	1J1-4	Input to Right Wing Accelerometer Circuit
b	TIZBL	1J1-23	Input to Left Fuselage Accelerometer Circuit
c	TIZBR	1J1-14	Input to Right Fuselage Accelerometer Circuit
d	TOZ1	1J1-10	Left Wing FSS Acceleration
e	TOZ2	1J1-13	Right Wing FSS Acceleration

TABLE 6-XVIII (CONTINUED)

TEST CABLE CONNECTOR PIN ASSIGNMENT

CHASSIS: PT02SE-24-61S (JS)
CABLE: PT06SE-24-61P (PS)
EMI: G3584-249-2.00B (Straight) FSS BOX
G3860-K24B (E1) TESTER

Pin No.	Signal Designator	Box Location	Function
POWER AND GROUND			
HH	PVDC	TB1-B2	Plus 15 Volt DC Supply
NN	NVDC	TB1-C2	Negative 15 Volt DC Supply
JJ	GND1	TB1-D8	Reference Pin
KK	GND2	TB1-D9	Reference Pin
PP	GND3	TB1-D9	Reference Pin
FF	FVDC	TB1-A4	Plus 5 Volt DC Supply
GG	AVDC	20J1-32	Plus 24 Volt DC Supply
LL	TVDC	TB1-A9	Negative 5 Volt DC Supply
FUNCTION GENERATOR			
f	FGI1	9J1-24	External Test Input (Test)
g	TCI5	5J1-13	Sweep Enable (SWECOM)
h	TCI4	5J1-16	Square Wave Trigger (PULCOM)
i	TCI6	5J1-5	Excitation Amplitude (AMPCOM)
j	FGO1	8J1-23	Soft Start/Stop Command
k	FGO2	7J1-27	Low Frequency Monitor
m	FGO3	7J1-24	Antilog Command Monitor
UPLINK COMMAND CARD			
q	TCI1	5J1-28	FSS Engage (UFSSON)
r	TCI2	5J1-23	FSS Gain Select (UFGAIN)
s	TCI3	5J1-10	FSS Symmetry (SYMCOM)
DOWNLINK SIGNALS			
t	LWPOT	3J1-32	Left Wing Surface Position
u	REPOT	3J1-34	Right Wing Surface Position
v	FSLAC	2J1-32	Left Wing Vertical Acceleration (FSSLAC)
w	FSRAC	2J1-34	Right Wing Vertical Acceleration (FSSRAC)
x	FSFVA	2J1-54	Normal Acceleration (FSFUVAC)
y	FSFRA	2J1-56	Angular Acceleration (FSFURAC)
z	LWSRV	3J1-54	Left Servo Valve Driver Command (VD01) (LWSERV)

TABLE 6-XVIII (CONCLUDED)

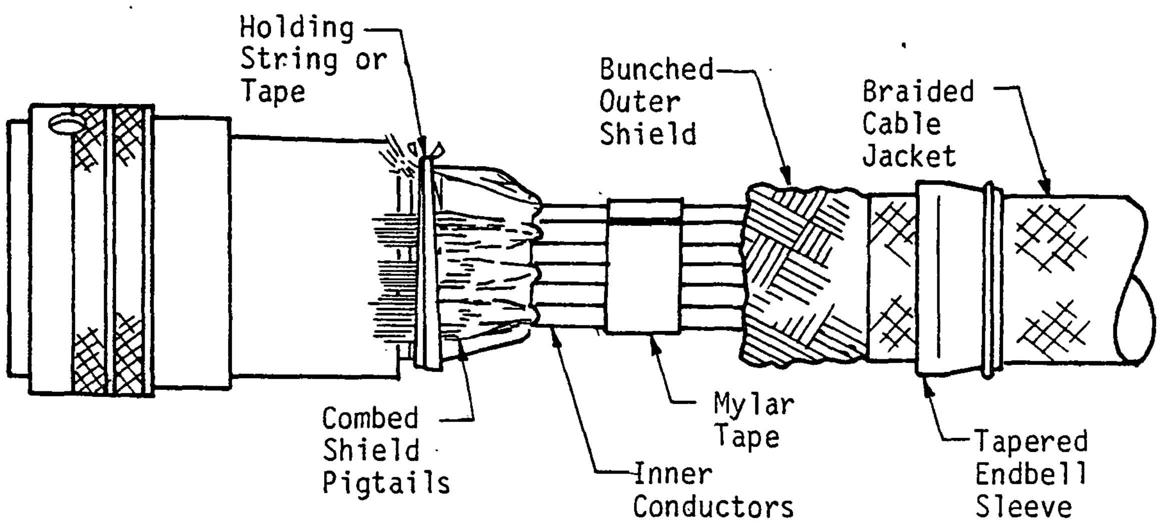
TEST CABLE CONNECTOR PIN ASSIGNMENT

CHASSIS: PT02SE-24-61S (JS)
CABLE: PT06SE-24-61P (PS)
EMI: G3584-249-2.00B (Straight) FSS BOX
G3860-K24B (E1) TESTER

Pin No.	Signal Designator	Box Location	Function
DOWNLINK SIGNALS (CONCLUDED)			
AA	RWSRV	3J1-56	Right Servo Valve Driver Command (VD04) (RWSERV)
BB	FSEXC	4J1-58	FSS Excitation (FSSEXC)
CC	HYLOD	4J1-56	FSS Differential Load Pressure (HYDLOD)
DD	HYSUP	4J1-54	Hydraulic Supply Pressure (HYDSUP)
EE	DPAR	4J1-34	"D" Parameter
"D" PARAMETER SCHEDULER			
MM	DSI1	6J1-28	Static Pressure Test Input
Y	DSI2	6J1-16	Impact Pressure Test Input
Z	DSO1	6J1-27	Scaled Static Pressure Output
n	DSO2	6J1-20	Scaled Impact Pressure Output
r	DSO3	6J1-6	Multiplier Test Point

Left and right wing cable harnesses connect the electronics with the FSS sensors and servoactuator components. This cable, the uplink and downlink test cable all have wire size 22 AWG. The left and right wing cable harness breaks at the Fuselage Station 5.931 (233.5) pressure bulkhead. Shielding of all cables is summarized by Figure 6-28.

6.2.8 Ground support equipment - Three test units are provided for ground, bench and circuit card testing. These test units are described in detail in Reference 7.



- Power Bundle - Unshielded
- Wing Bundle
  Aft of Bulkhead
  - Inner Shields Open at Sensors
  - Inner and Outer Shields Terminated at Bulkhead as above

  Forward of Bulkhead
  - Inner Shields Open at Bulkhead
  - Inner and Outer Shields Terminated at FSS Box and Outer Shield at Bulkhead as above
- Test Cable - Outer Shields only Terminated Both Ends as above
- Uplink Bundle
  - Inner Shields open at Signal Source
  - Inner and Outer Shields Terminated at FSS Box as above
- Downlink Bundle
  - Inner Shields Open at TM Transmitter
  - Inner and Outer Shields Terminated at FSS Box as above

FIGURE 6-28 - SHIELDING

6.2.8.1 Test cart panel: The system test panel is designed to be installed in the existing NASA test cart and to be used for conducting quick look functional tests during preflight. Figure 6-29 shows a front view of this panel. The panel includes all uplink commands and access to all downlink signals. Test points are available to allow external inputs to the servovalve driver and has control surface position indication.

6.2.8.2 FSS tester: The ground and maintenance electronics tester is to be used for making more detail ground tests than can be accomplished with the test cart panel. Figure 6-30 shows a front view of this tester.

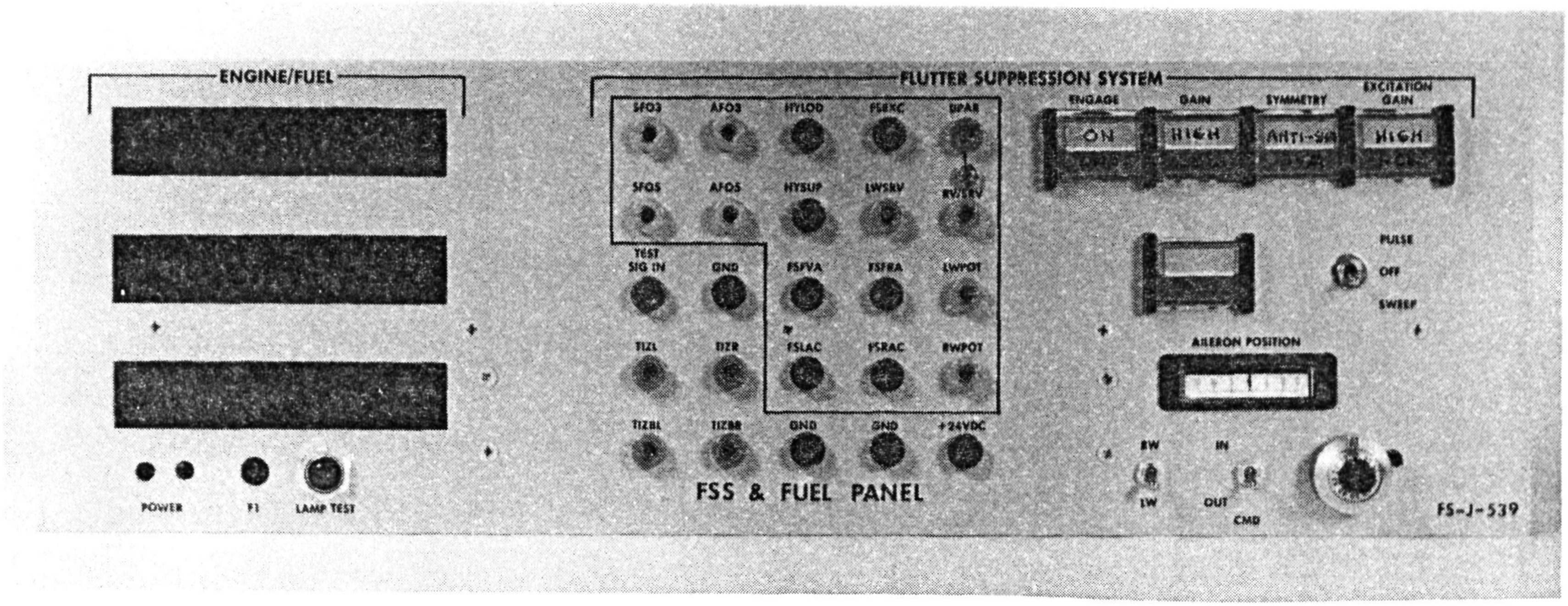


FIGURE 6-29 - TEST CART PANEL

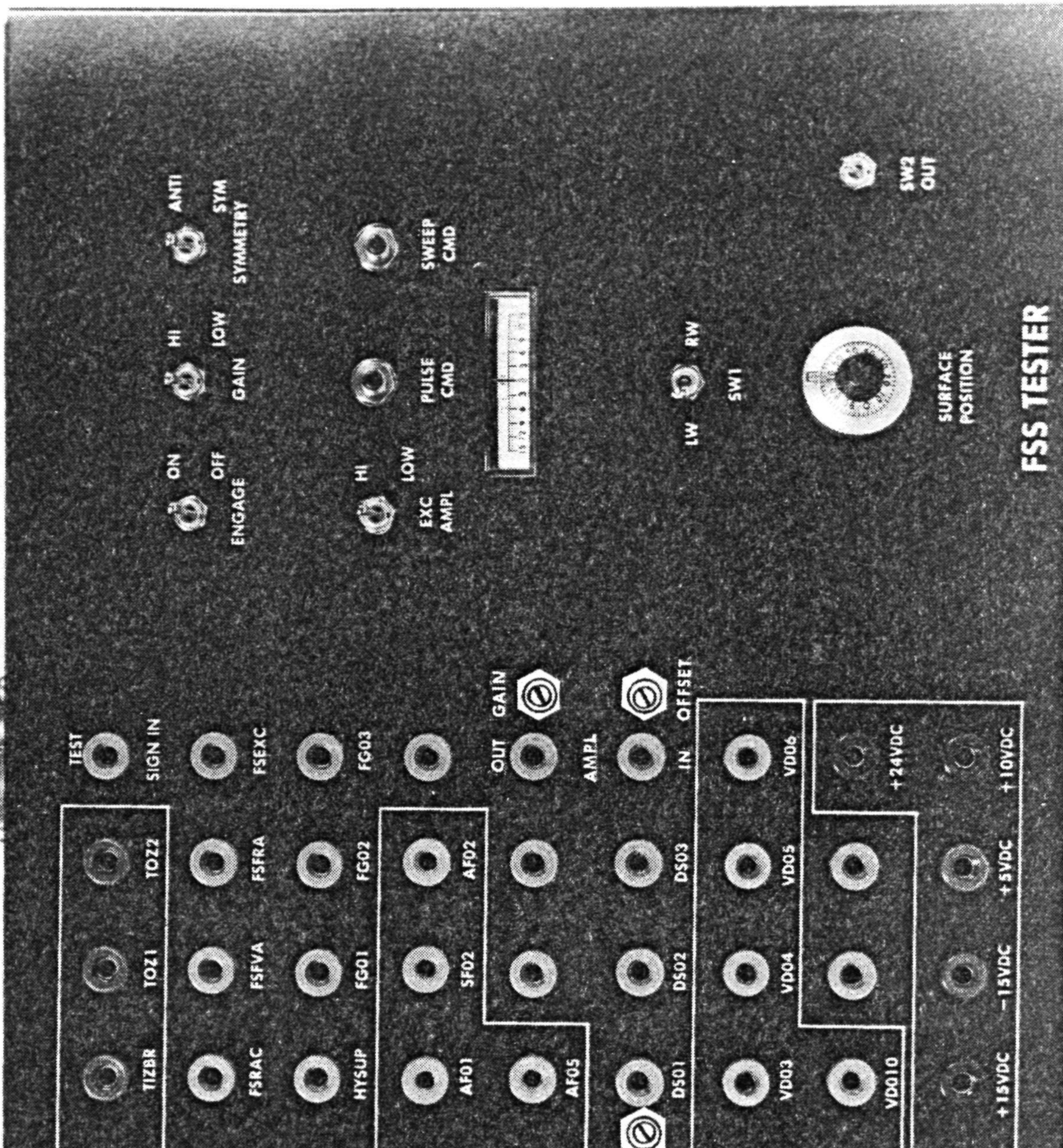


FIGURE 6-30 - FSS TESTER

When a malfunction in the FSS electronics is identified using the system test cart panel, the system ground and maintenance electronics tester will be used to isolate the problem down to the card level. This tester can be used with the electronics installed in the drone as well as for bench tests, because it uses a connector identical to the system test cart panel connector. The ground and maintenance electronics tester was also used during initial checkout and later to check out the electronics at NASA Langley. The system ground and maintenance electronics tester includes all uplink commands, provisions for externally monitoring of downlink signals, filter and function generator inputs and wing control surface positions. Also provisions for external inputs to the system shaping filters and servovalve drivers are included for open and closed loop preflight testing.

6.2.8.3 Electronics card tester: The electronics card tester will be used to isolate faults to individual components on the circuit cards. This tester was required during electronics checkout and will be required on-site during the integration of the FSS into the drone vehicle and during the flight tests. The electronics card tester will include all necessary test points and input capability to test all card types. External power must be provided. Figure 6-31 shows the front view of this tester.

6.2.8.4 Additional ground support equipment: In addition to the three testers described above, other ground support equipment will be required. This miscellaneous equipment is tabulated:

- 28 VDC ground power
- Hydraulic System Service Cart
- Strip Chart Recorder
- Transfer Function Analyzer
- Function Generator
- Variable ± 10 VDC Input
- Digital Voltmeter
- Oscilloscope

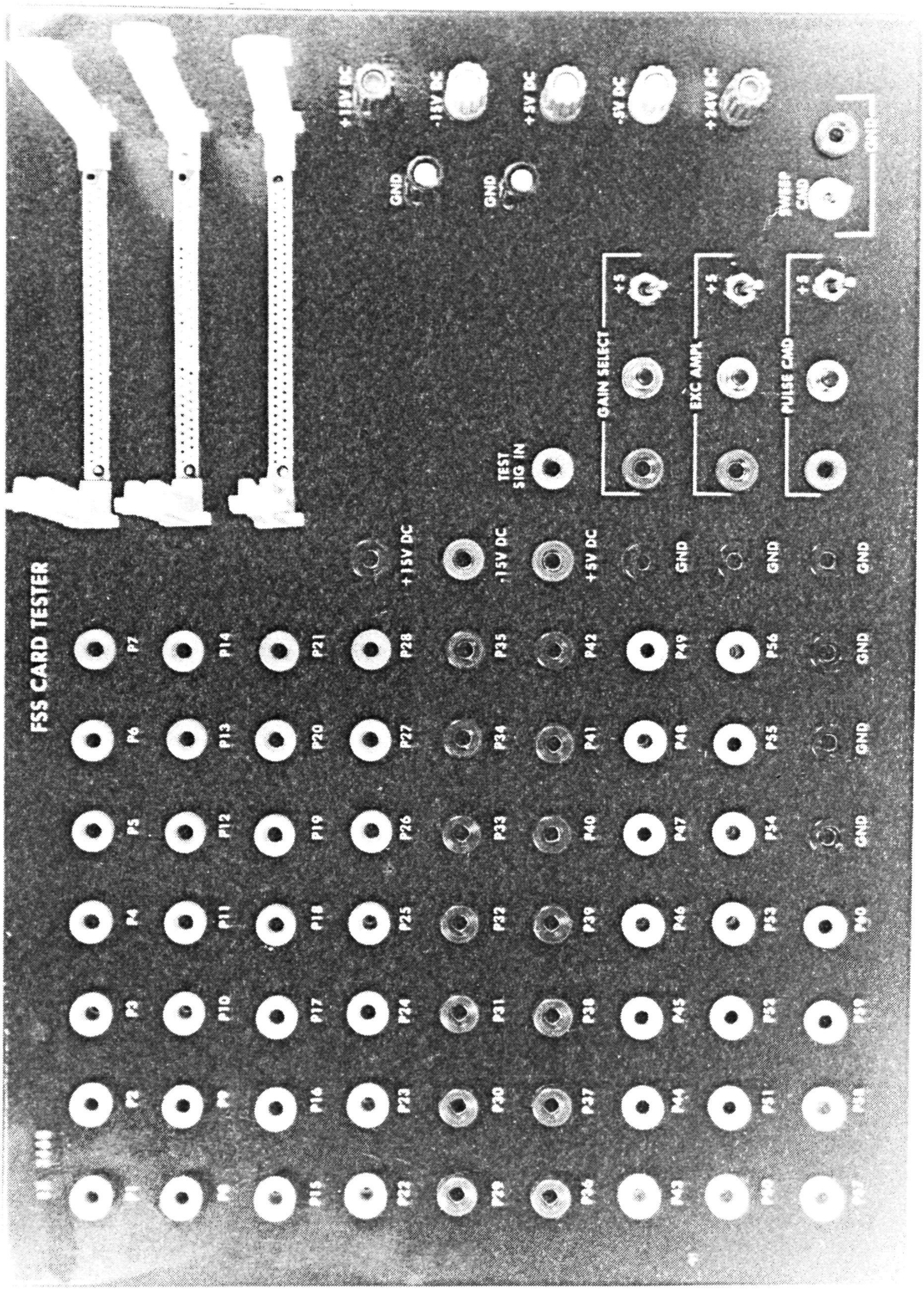


FIGURE 6-31 - ELECTRONIC CARD TESTER

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7.0 MECHANICAL COMPONENT DESIGN

Design of mechanical components of the flutter suppression system was accomplished following guidelines provided by NASA. The mechanical components include the subminiature rotary actuators, control surfaces, servovalves and manifold blocks and tubing between the servovalves and actuators and between the servovalves and the BS 5.931 (233.5) pressure bulkhead. Installation of the hydraulic power supply unit, hydraulic accumulator, filter and lines aft to the pressure bulkhead was designed by NASA.

Design guidelines provided by NASA are discussed in Paragraph 7.1 and design of the mechanical components is discussed in Paragraph 7.2.

7.1 Design Guidelines

The flutter suppression system final design should use the 0.254 meter (10 inch) span outboard wing control surface on each panel determined in the preliminary design study (Reference 1) as required to control the flutter mode. The control surfaces should be about 20 percent local wing chord and located between WBL 1.711 (67.35) and WBL 1.965 (77.35). The control surfaces should be driven by rotary actuators as specified in the preliminary design study. The actuators should provide the control surface deflection, dynamic torque, surface angular rate and frequency response compatible with the flutter suppression system final design requirements. The control surface actuators should be located within the airfoil cross section aft of the wing rear spar.

Consideration should be given to the use of wing closure fairings with a close tolerance fit or low friction seals at the ends and along with spanwise joint between the wing and the control surface to minimize pressure bleed through. The design should minimize requirements for actuator torque and resulting electrical power requirements for the hydraulic pump.

The flutter suppression system should be designed so that components located in the wings can be installed and serviced without access to the space between the front and rear spars. The design should attempt to minimize weight and structural stiffness additions to the wing panels outboard of the wing center section.

The hydraulic power supply unit, accumulator, filter and pressure and return lines aft to the BS 5.931 (233.5) pressure bulkhead shall be installed by NASA. The interface with the pressure and return lines from the servovalves shall be at bulkhead connectors at the pressure bulkhead.

7.2 Component Design

A detailed design drawing was prepared for the subminiature rotary actuators. The hydraulic system and control surface installation drawings include details required to fabricate the component parts. The following paragraphs discuss the component detail and installation design.

7.2.1 Actuator design - The outboard aileron actuator was sized to produce the maximum expected hinge moment with 75 percent of the 10.34×10^6 N/m^2 (1500 psi) supply pressure across the actuator vane, as discussed in Paragraph 6.1.2. The actuator dimensions established in the sizing study are a vane radius of 15.24 millimeters (0.60 inch), vane length of 28.5 millimeters (1.12 inch) and minimum shaft diameter of 7.40 millimeters (0.2915 inch) based on a factor of safety of 2.5 on the ultimate shearing stress for 15-5PH CRES steel.

The actuator detail design is shown on Boeing drawing EX-3317. The actuator body and end caps are 2024-T351 aluminum plate. The actuator body includes a mounting tab, as shown on the sketch of the actuator shown on Figure 7-1. The actuator shaft and vane are made from 15-5PH CRES steel which are welded on assembly and heat treated to 10.34×10^7-11.72×10^7 N/m^2 (150-170 KSI). The vane surface is coated with adiprene to provide vane sealing. A straight segment Buna-N O-ring is used behind the actuator shaft to seal from one side of the vane to the other. The actuator ports are on one side, which is the inboard side when the actuators are installed. The left and right hand actuators are identical until installation.

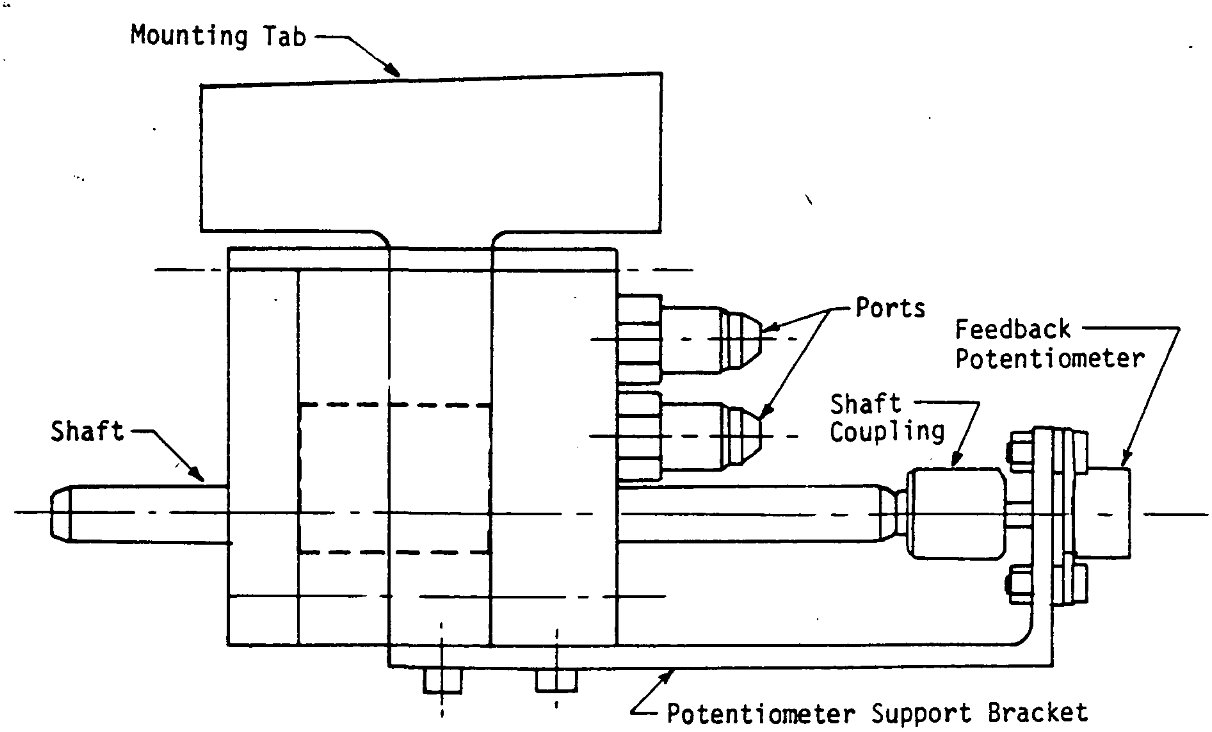


FIGURE 7-1 - DAST ARW-1 AILERON ACTUATOR (PLAN VIEW)

Gasket seal between the actuator body parts and between the actuator body and end caps is provided by 1.02 millimeter (0.040 inch) diameter adiprene O-rings molded to fit a gland milled around the vane cavity. Provisions were included in the actuator design to mount the actuator shaft position feedback potentiometer on the inboard end of the the actuator shaft. The shaft attaches to the control surface through precision keys and keyways in the shaft and surface spar.

7.2.2 Control surface design and installation - The 23 percent chord outboard aileron control surfaces were designed to use 7075-T7351 aluminum hinges (spars) with the control surface upper and lower skins made of 15 plies of BMS 8-169, Type 120, preimpregnated glass fabric, as shown on Figure 7-2. As an option, the surface upper and lower skins could be cut from the ARW-1 wing trailing edge panels provided by NASA. The skins are bonded to the surface hinge with BMS 525, Grade 1, aluminum filled epoxy with #4-40 screws as backup. The control surface details and installation, and actuator installation, are shown on Boeing drawing 35-34555.

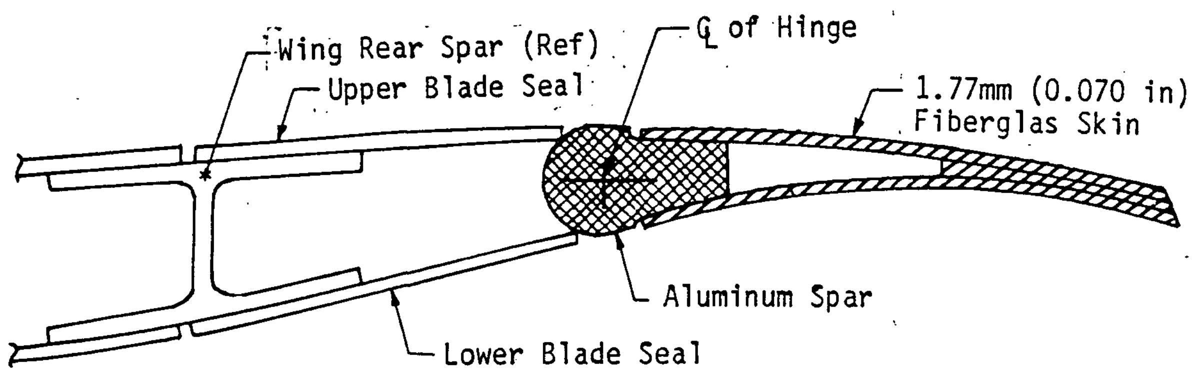


FIGURE 7-2 - DAST ARW-1 AILERON SECTION VIEW

Blade seals are used to seal along the control surface hinge as shown on Figure 7-2. The upper and lower blade seals attach to the wing rear spar to aerodynamically seal the control surface hinge gap. The gap between the edges of the control surface and the wing skin was held to a maximum of 1.27 millimeter (0.050 inch).

The control surfaces are supported by the actuators at the inboard edges, as shown on the surface plan view on Figure 7-3. Bearing support blocks attached to the wing tip rib provide support at the outboard edges of the surfaces.

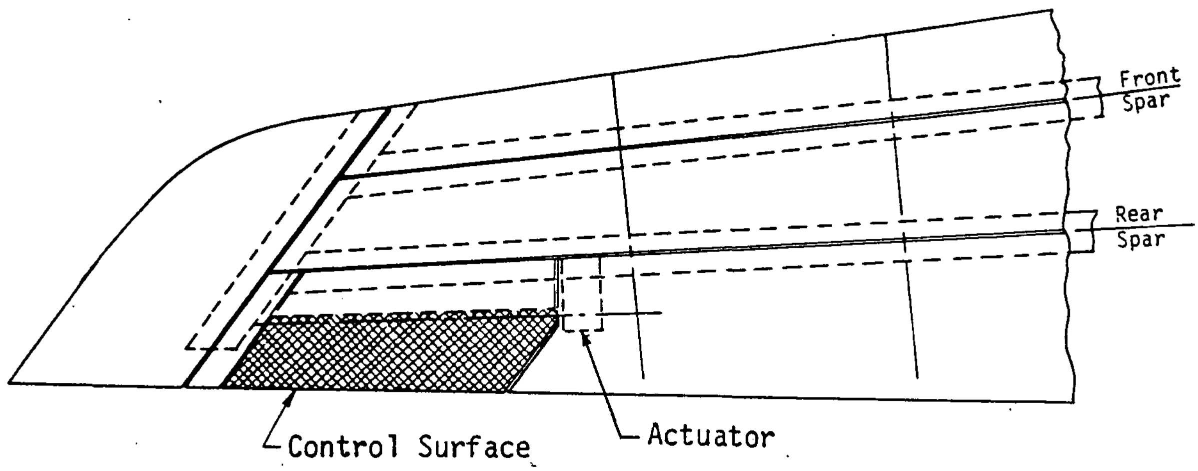


FIGURE 7-3 - DAST ARW-1 AILERON PLAN VIEW

7.2.3 Actuator installation - Installation of the subminiature rotary actuators is shown on Boeing drawing 35-34555. The actuator was designed to fit within the upper and lower skins of the wing trailing edge panels as shown on Figure 7-4. Compound tapered filters (shims) are used between the upper and lower flanges of the wing rear spar and the actuator mounting tab. Screws through the spar flanges hold the actuators in place.

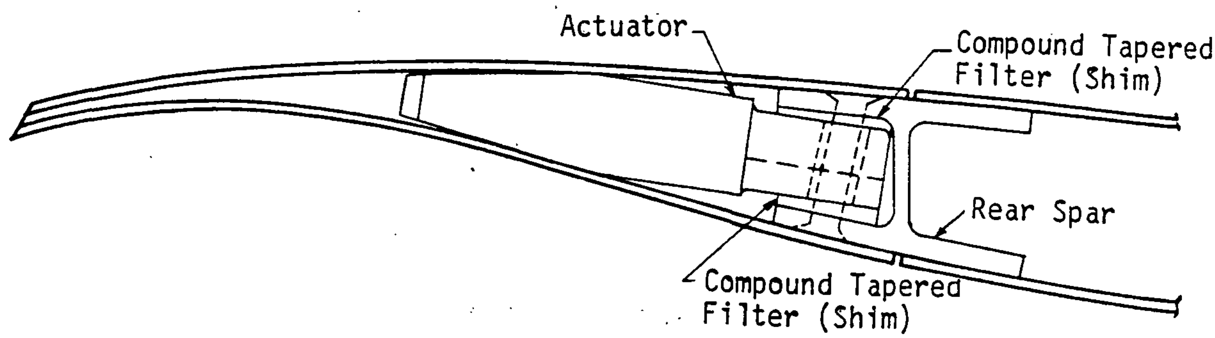


FIGURE 7-4 - DAST ARW-1 ACTUATOR INSTALLATION

The use of tapered shims makes accurate positioning of the actuators difficult. However, the shims are necessary because the spars were already fabricated when the actuators were designed and the shims permit variations in the spar geometry while giving satisfactory installation of the actuator. On the DAST ARW-2 wing design, parallel surface mounting pads were designed on the spars to simplify actuator installation.

7.2.4 Hydraulic component installation - Installation of the outboard aileron servoactuator components other than the actuator is shown on Boeing drawing 35-34547. The servovalves mount in the wing center section and the actuators mount out in the wing at the inboard edges of the aileron as shown on Figure 7-5. Stainless steel tubing, 4.763 millimeters (3/16 inch) outside diameter, is used between the servovalves and actuators. This tubing diameter was chosen to keep the fluid velocity at maximum flow below 4.572 m/s (15 ft/sec) to insure laminar flow and to minimize the fluid volume trapped between the servovalves and actuators. Stainless steel 7.938 millimeters (5/16 inch) outside diameter tubing is used between the hydraulic power supply unit and the servovalves, to keep laminar flow under maximum flow condition.

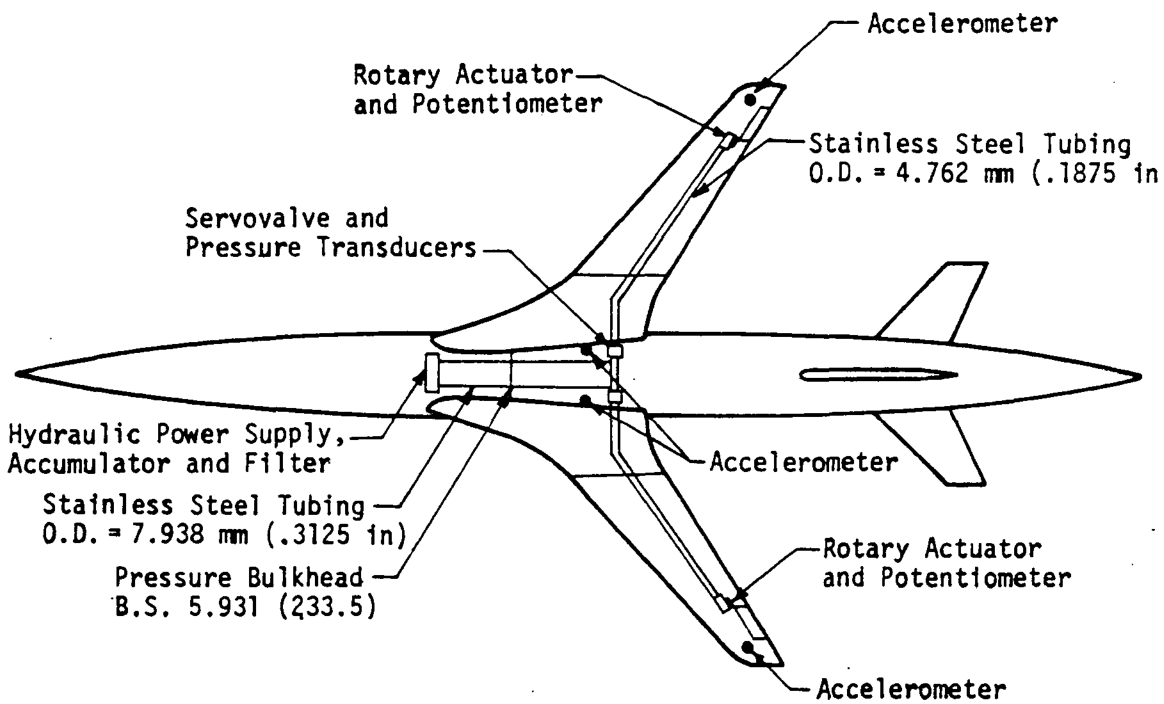


FIGURE 7-5 - DAST ARW-1 FSS EQUIPMENT INSTALLATION

Manifold blocks were designed for use with the Moog Series 30 servovalves. The manifold block detailed design is shown on 35-34547. Bell and Howell CEC Type 4-326-0001 pressure transducers are plumbed into the servovalve control ports to provide voltage signals for forming pressure feedback for the servo-actuators in the flutter suppression system electronics. Tee fittings are used in the manifold block with the pressure transducers plumbed into the back side and the lines going out the wing to the actuators connected to the other side.

7.2.5 Accelerometer installation - Installation of the Sundstrand QA1100-AA01-12 accelerometers is shown on 35-34547. These accelerometers mount in the wing center section, at BS 6.401 (252) and right and left WBL 0.3080 (12.125). These accelerometers are used in the FSS electronics to form voltage signals proportional to fuselage vertical and roll acceleration required by the flutter suppression system.

Installation of the PCB Piezotronics Model 303A03 accelerometers is shown on 35-34555. The accelerometers mount on the upper rear flange of the rear spar at WBL 1.946 (76.60) about 8.636 millimeters (0.34 inches) aft of the spar centerline. The accelerometer is mounted with its sensitive axis positive downward to give phasing required by the FSS electronics.

8.0 COMPONENT FABRICATION

All components required for installation of the flutter suppression system in the drone test vehicle except for the hydraulic power supply and filter, were either fabricated or procured and shipped to NASA. The mechanical components were fabricated per the engineering drawings by Boeing engineering staff laboratory personnel. The flutter suppression system electronics were fabricated by Boeing electronics manufacturing following drawings prepared by electronic design personnel.

Components purchased for installation in the drone were selected to operate within an aircraft environment and in general, are of the quality normally utilized in military equipment. Some components were obtained inplant from Boeing stocks to minimize expenditures for components that had to be procured.

The following paragraphs discuss fabrication and assembly of the mechanical and electronic components required for the DAST ARW-1 flutter suppression system installation.

8.1 Mechanical Components

Four subminiature, single vane rotary actuators were fabricated per Boeing drawing EX-3317 for use on the ARW-1 drone flutter suppression system. The aluminum and stainless steel material required were obtained from Boeing stock. The actuator shaft and vane were machined from 15-5PH CRES steel bar and plate, respectively. They were then welded together, heat treated and inspected in the weld shop. Close tolerance molds were made for molding the adiprene to the vane. The adiprene was molded slightly oversize and milled down on assembly to give the desired compression of the adiprene for vane sealing. The O-ring gasket seals for sealing between the actuator body parts, and the actuator body and end caps, were molded from the same adiprene compound used for the vane seal.

The outboard aileron control surfaces were fabricated using upper and lower skins cut from the ARW-1 wing trailing edge panels provided by NASA bonded to the 7075-T7351 aluminum hinges. The precision keyways were milled in the hinges and then clocked relative to the actuator with the vane centered to give ±0.21 radians (12 degrees) shaft rotation. The control surface upper and lower skins were then bonded to the hinges with BMS 525 aluminum filled epoxy with the surfaces clamped into position assuming the trailing edge panels would just slip onto the wing stub ribs on installation.

The upper and lower blade seals are designed to be cut from Boeing 10-60754-61 blade seal material upon installation in the drone ARW-1 wing. This material measures 2.286 millimeters (0.090 inch) thick by 52.32 millimeters (2.06 inches) wide. Thickness and shape will be trimmed as required on installation with aerodynamic smoother used to fill any gaps over the rear spar flange. A 1.575 meter (62 inch) length of the blade seal material was provided to NASA.

The stainless steel tubing and the tube fittings required to make up the lines from the BS 5.931 (233.5) bulkhead to the servovalves, and from the servovalves out the wing to the actuators, were provided to NASA. The lines will be made up on installation to assure correct length and bends. Phenolic fairlead assemblies, made per 35-34547, were provided to support the tubing in the wing at each stub rib location.

The clips, brackets, etc., shown on the engineering drawings were fabricated and shipped to NASA for the flutter suppression system installation. Fasteners required for the installation, except rivets, were procured and provided to NASA. Miscellaneous parts, such as dummy control surface inertias, were fabricated as required for the actuation system integration and flight worthiness testing discussed in Section 9.0.

8.2 Electronic Components

The electronics box is a Boeing designed and fabricated aluminum box 0.460 meters (18.1 inches) long, 0.123 meters (4.85 inches) wide and 0.116 meters (4.58 inches) high with extending mounting flanges making an overall length of 0.572 meters (22.5 inches) and an overall width of 0.137 meters (5.4 inches). The box weighs 6.237 kilograms (13.75 pounds). The box internal wiring is type ARW-22. Figures 8-1 through 8-4 present photographs of the fabricated electronic box. The box includes provisions for 20 circuit cards. Figure 8-5 shows 18 cards installed. Two more cards have been added to the box, as described by Paragraph 6.2.4.5. Assembly is shown by these figures. Figure 8-6 shows a typical card assembly and Figure 8-7 shows all cards initially installed.

8.3 Spares

Spare components provided to NASA as backup to the DAST ARW-1 flutter suppression system components are shown in Table 8-I. The spare components listed were specified by NASA, except for the pressure transducers. Need for the pressure transducers to provide pressure feedback for servoactuator stability was established during the final design study.

In addition to the components listed in Table 8-I, spares of miscellaneous small parts, such as the actuator gasket seal O-rings, (EX-3317-14), were provided. The excess of all items subject to vendor minimum quantity orders were also provided to NASA.

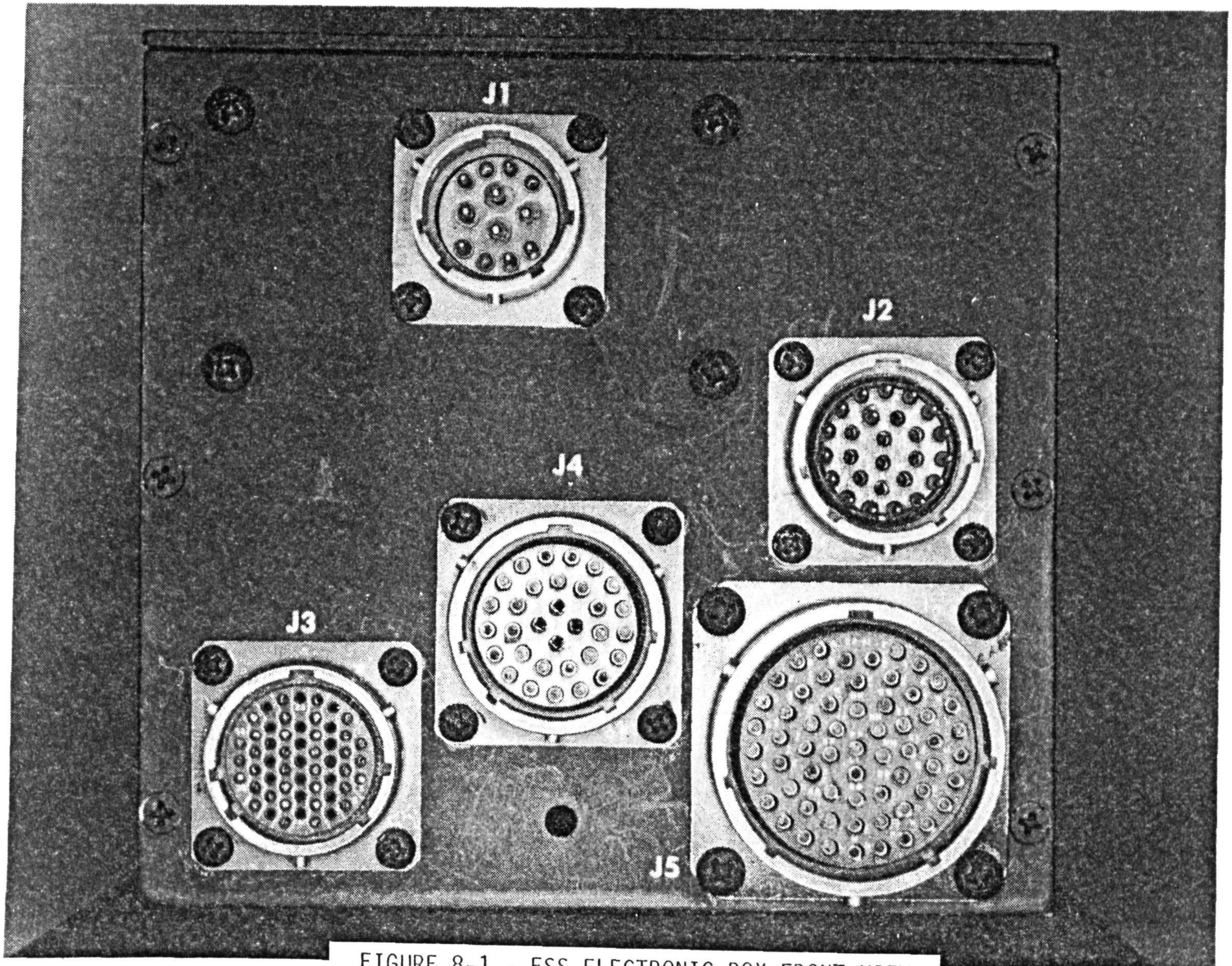


FIGURE 8-1 - FSS ELECTRONIC BOX FRONT VIEW

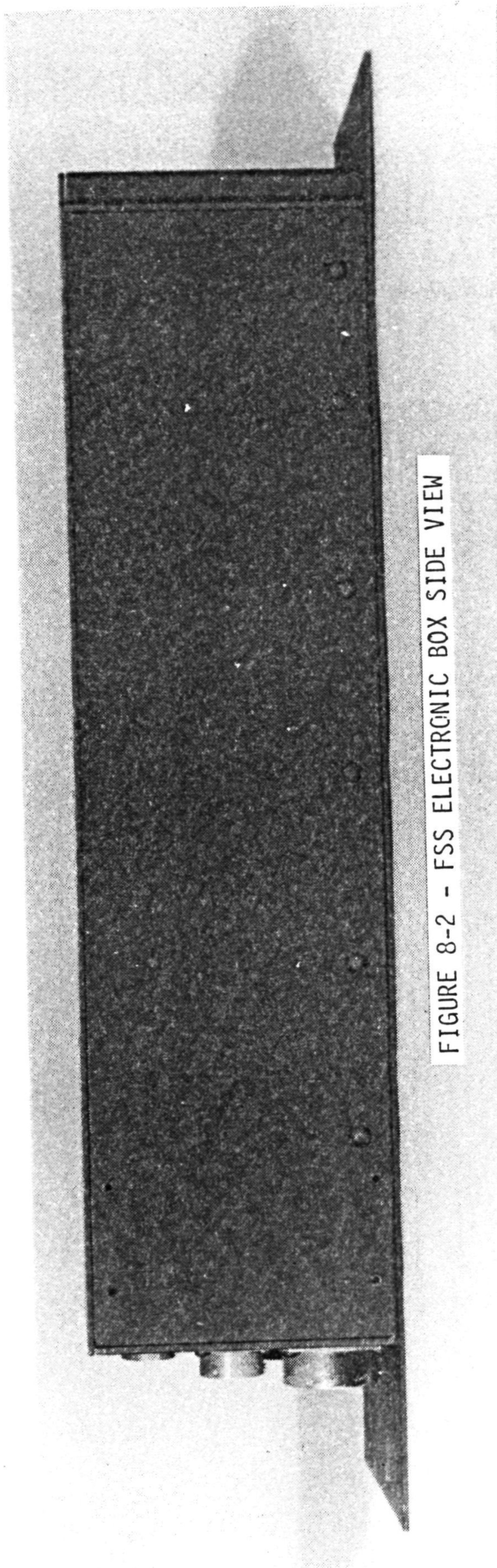


FIGURE 8-2 - FSS ELECTRONIC BOX SIDE VIEW

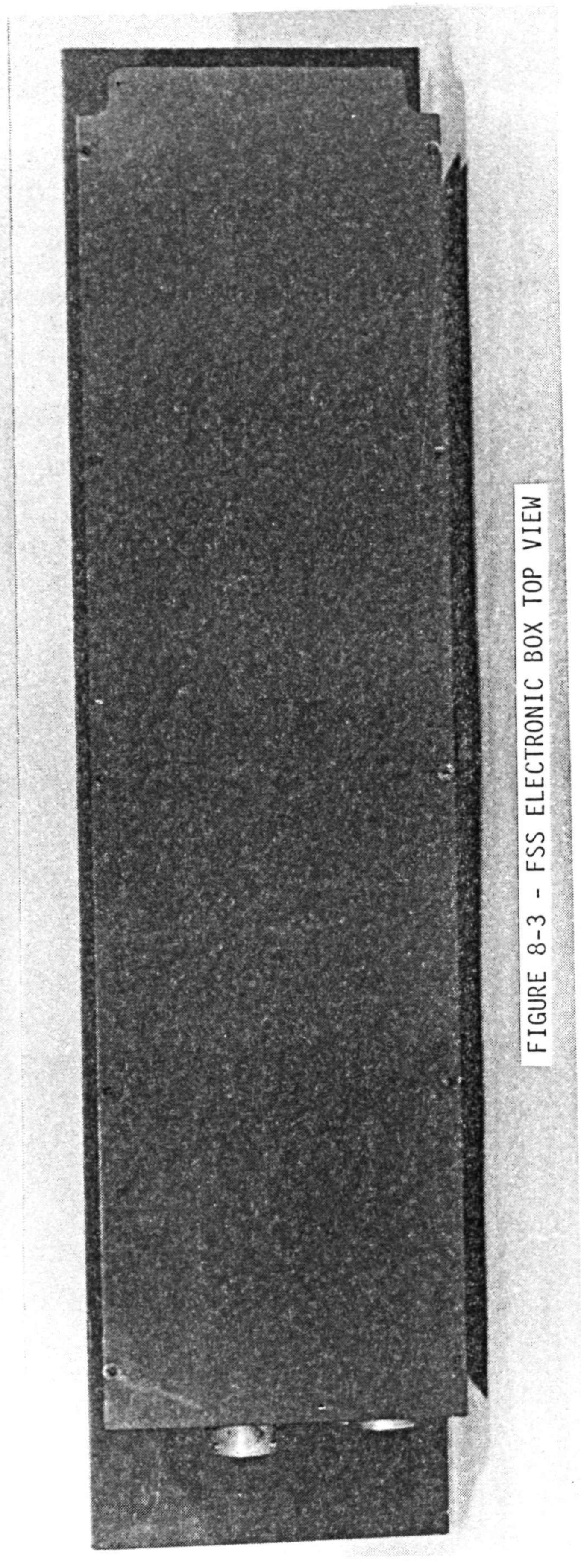


FIGURE 8-3 - FSS ELECTRONIC BOX TOP VIEW

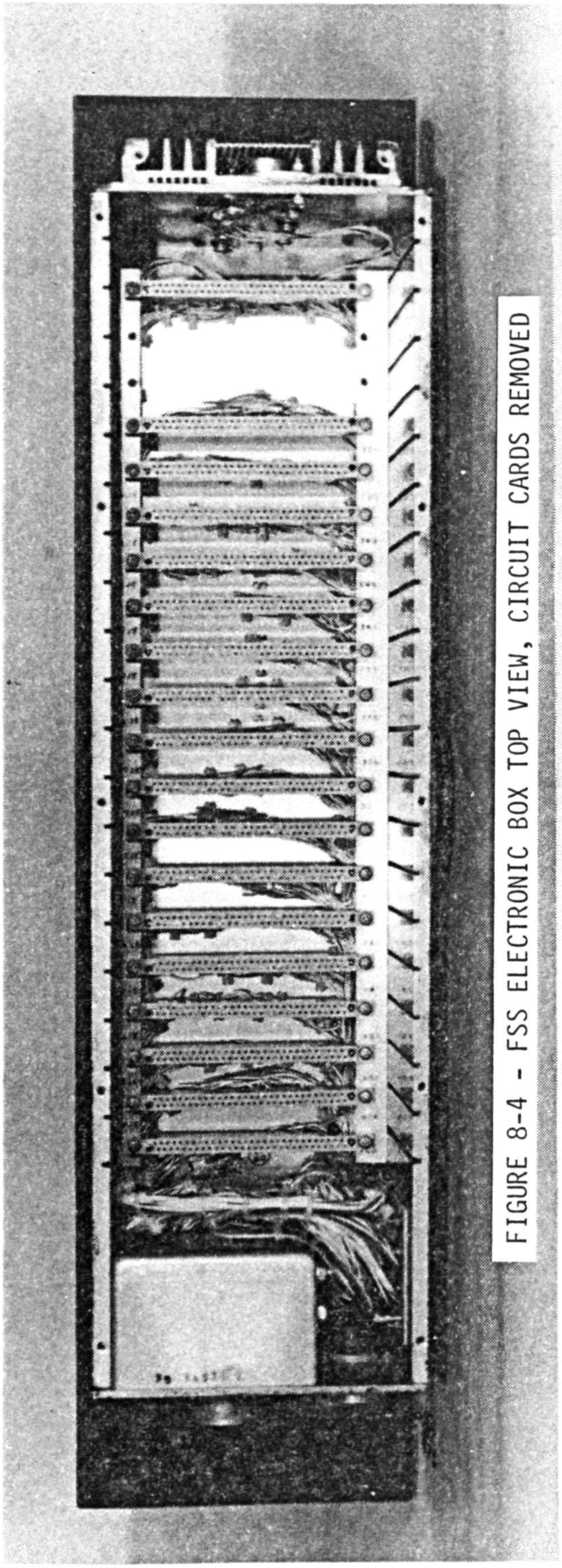


FIGURE 8-4 - FSS ELECTRONIC BOX TOP VIEW, CIRCUIT CARDS REMOVED

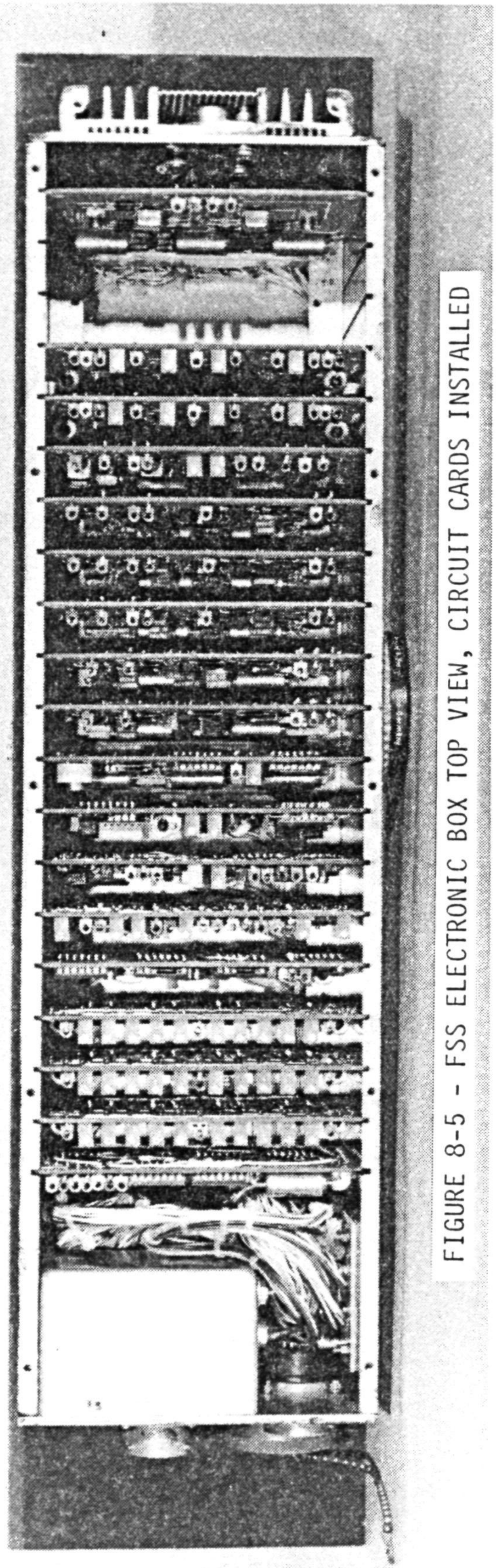


FIGURE 8-5 - FSS ELECTRONIC BOX TOP VIEW, CIRCUIT CARDS INSTALLED

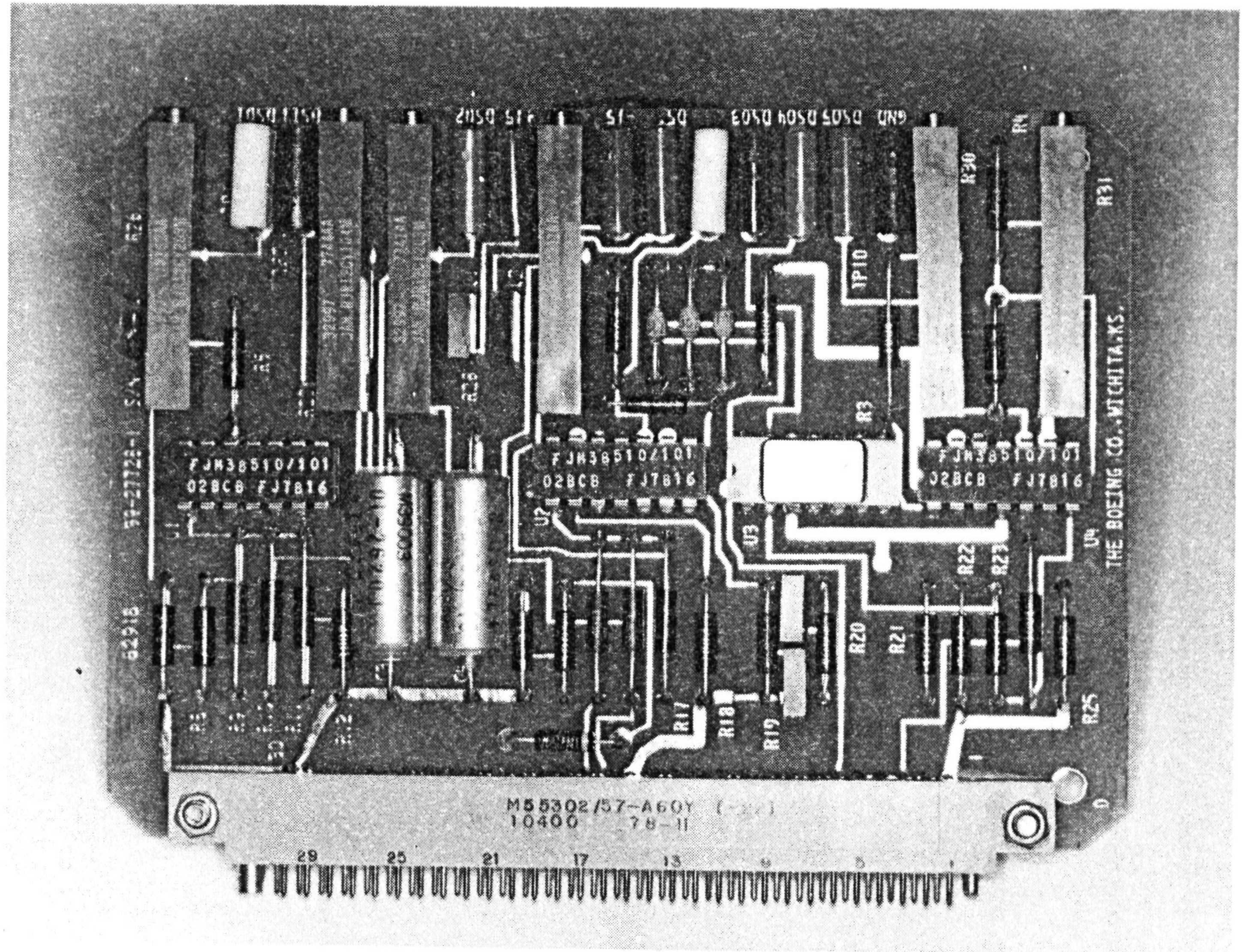


FIGURE 8-6 - FSS TYPICAL CIRCUIT CARD

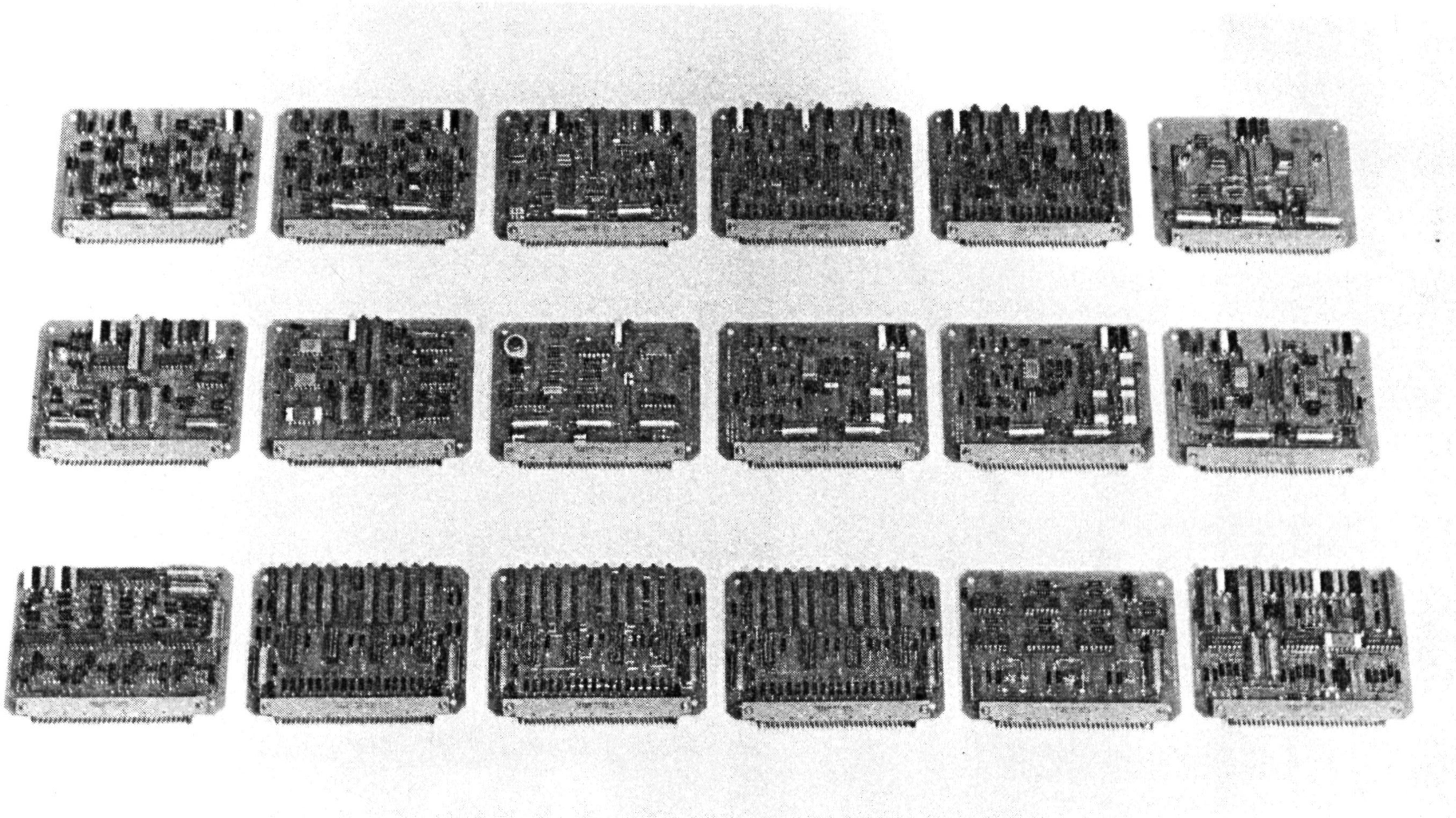


FIGURE 8-7 - FSS ELECTRONIC CIRCUIT CARDS

TABLE 8-I

DAST ARW-1 FLUTTER SUPPRESSION SYSTEM SPARE COMPONENTS

Component	Manufacturer	Part Number	Spares
Rotary Actuator - Potiometer Assembly	Boeing	EX-3317-1	2
Servovalve	Moog	305.01500I15004 CARBUN	2
Accelerometer	PCB Piezotronics, Inc.	Model 303A03	3
Pressure Transducers	Bell and Howell CEC/Instruments Div.	Model 4-326-0001	2
Electronic Cards	Boeing	Various	1 of each card type

9.0 FLIGHTWORTHINESS TESTING

The flutter suppression system electronics and outboard aileron servoactuators were tested to demonstrate flightworthiness prior to delivery of the components to NASA. The tests conducted included component functional tests; integration tests of the electronics, sensors and servoactuators to provide initial performance data; vibration tests; temperature/altitude tests and electromagnetic compatibility tests.

Component functional tests are discussed in Paragraph 9.1. Flight assurance tests, including initial performance, integration, vibration, temperature/altitude, electromagnetic capability and final performance tests, are summarized in Paragraph 9.2.

The temperature/altitude and vibration tests were conducted per NASA-DFRC Process Specification No. 21-2 (Reference 15). Electromagnetic capability tests were conducted per required portions of MIL-STD-461A as discussed in Paragraph 9.2.5.

9.1 Component Functional Tests

Functional tests of the flutter suppression system electronics and outboard aileron actuation system components were conducted to assure satisfactory performance. The servoactuator functional test results showed two hydraulic fluid modes present in the system and that changes to the servoactuator compensation and/or the FSS electronics would be required to give satisfactory performance. All populated cards in the electronics, including the spare cards, were tested for proper operation, the filters were tuned and required gains established.

9.1.1 Servoactuator sytem - Functional tests were conducted on the DAST ARW-1 outboard aileron servoactuator before the integration of the servoactuator with the flutter suppression system electronics. The functional test was conducted to determine the dynamic performance that could be attained with the hardware as a verification of the linear stability analyses discussed in Paragraph 6.1.3. Results of the testing accomplished showed that two hydraulic fluid modes existed which significantly affected servoactuator dynamic performance, and that additional feedback compensation was required to give satisfactory performance. The fluid modes are caused by the 2.210 meter (87 inch) separation between the servovalve and actuator, which would not be necessary on a full scale aircraft because sufficient space would exist to install the servovalve on the control surface actuator.

The following paragraphs discuss the functional test setup and the test results.

9.1.1.1 Test setup: One complete servoactuator was setup for the functional tests using a steel bar dummy load of 4.519×10^{-4} N·m-s^2 (0.004 in-lb-sec^2) rotary inertia, as used in the linear analysis of Paragraph 6.1.3, and an EAI TR-48 analog computer to close feedback loops. A 747 operational amplifier with current feedback was used as the servovalve drive amplifier. Fabrication of the DAST ARW-1 outboard aileron control surfaces and flutter suppression system electronics was not finished when the servoactuator functional tests began.

Geometry of the hydraulic lines between the servovalve and actuator was setup similar to the installation required in the ARW-1 wing, except the bend required at the side of the body caused by the wing sweep was not incorporated. Figure 9-1 shows a sketch of the breadboard setup. The length of the lines was set at 2.210 meters (87 inches), which was about 50.8 millimeters (two inches) longer than scaled from the installation drawing, 35-34547. The pressure transducers were plumbed into the servovalve control ports with line length between the transducers and tee fittings in the manifold block about the same as was estimated for the installation in the drone wing center section.

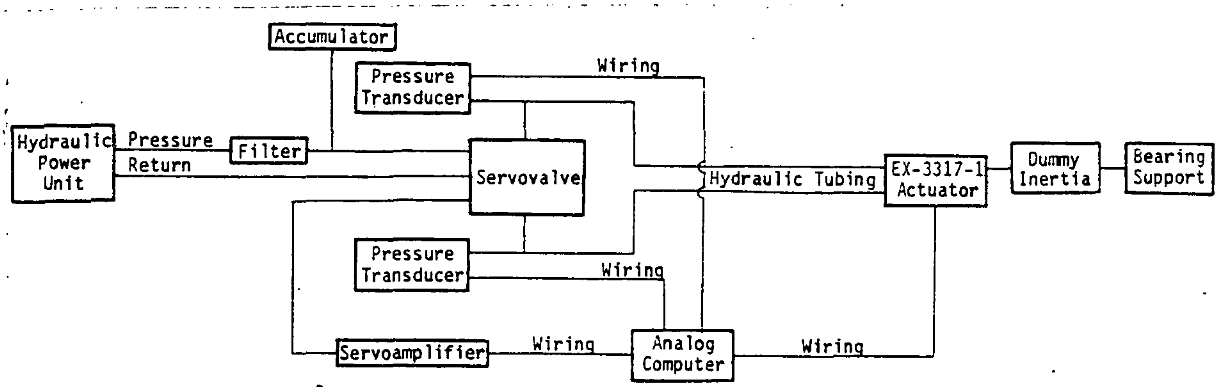


FIGURE 9-1 - DAST ARW-1 SERVOACTUATOR COMPONENT FUNCTIONAL TEST SETUP

Hydraulic power was provided by a laboratory hydraulic power unit with about 3.155×10^{-4} m^3/s (5 gal/min) flow capability at 10.34×10^6 N/m^2 (1500 psi). A 5 micron nominal, 15 micron absolute filter and an MS 28797-1 40.97×10^{-5} m^3 (25 in^3) accumulator were plumbed into the pressure line between the pump and servovalve pressure ports. Pressure could be adjusted manually up to the desired 10.34×10^6 N/m^2 (1500 psi) supply pressure.

9.1.1.2 Test results: With position feedback loop closed on the analog computer at low gain, the supply pressure was increased slowly up to 10.34×10^6 N/m^2 (1500 psi). Then, the position feedback gain was increased to about 22.9 volt/rad (0.4 volt/deg) when a mode became unstable at about 110 Hz. The position feedback gain desired was 48.9 volt/rad (0.854 volt/deg), which corresponds to 327.4 rad/sec position loop gain. The pressure feedback loop was then closed through a washout at 10 rad/sec and the lead-lag (S + 900)/(S + 1200) predicted in the linear analysis to be necessary to give required performance.

The addition of pressure feedback permitted position gain to be increased, as pressure feedback gain was increased, but not up to the desired position loop gain. A higher frequency mode, at about 380 Hz, was destabilized. This mode apparently was also a fluid mode, which was predicted at about 435 Hz in the linear analysis. A second order notch filter at 380 Hz,

$$[S^2 + 2(0.1)(2\pi)(380)S + (2\pi)^2(380)^2]/[S^2 + 2(0.4)(2\pi)(380)S + (2\pi)^2(380)^2],$$

was added in the servoactuator feedforward path between the summing point and the valve drive amplifier. With this notch filter in the feedforward path, the high frequency fluid mode presented no problem throughout the remainder of the testing. Similar compensation was required on the DAST ARW-1 wing wind tunnel test model where a high frequency wing structural mode (240 Hz) was destabilized due to adverse coupling with a 280 Hz mode, which could also have been a fluid mode caused by the separation between the servovalve and actuator (see Reference 8, Paragraph 6.1).

The dominant servoactuator response predicted in the linear analysis with the lead-lag filter in the pressure feedback path shows a first order break at 64.6 Hz, the second order surface-actuator mode at 154.6 Hz with 0.31 damping ratio, and the servovalve mode at 203.1 Hz with 0.31 damping ratio. The feedback gains for this performance are 48.93 volt/rad (0.854 volt/deg) and 0.290×10^{-6} volt/N/m^2 (0.002 volt/psi) for position and pressure feedback gains, respectively. The frequency response of the theoretical servoactuator transfer function is shown on Figure 9-2. Also shown on Figure 9-2 is the frequency response obtained for 1.745×10^{-2} rad (one degree) input command, with position feedback gain 49.22 volt/rad (0.859 volt/deg), pressure feedback gain 0.215×10^{-6} volt/N/m^2 (0.00148 volt/psi) and the notch filter in the feedforward path.

The frequency response plotted from test data shows the first order break at about 38 Hz, the surface actuator mode at about 75 Hz with 0.1 damping ratio and a second order at about 110 Hz with 0.03 damping ratio. The servovalve mode was estimated from transient response data to be around 200 Hz with 0.2 damping ratio. This data was obtained with the lead-lag removed from the pressure feedback loop because it was ineffective. The mode at 110 Hz is apparently another fluid mode, one that was not predicted in the linear analysis. This mode has the effect of lowering frequencies of the first order break and the surface-actuator mode open loop and for a given position feedback loop gain. The dummy surface inertia used in the

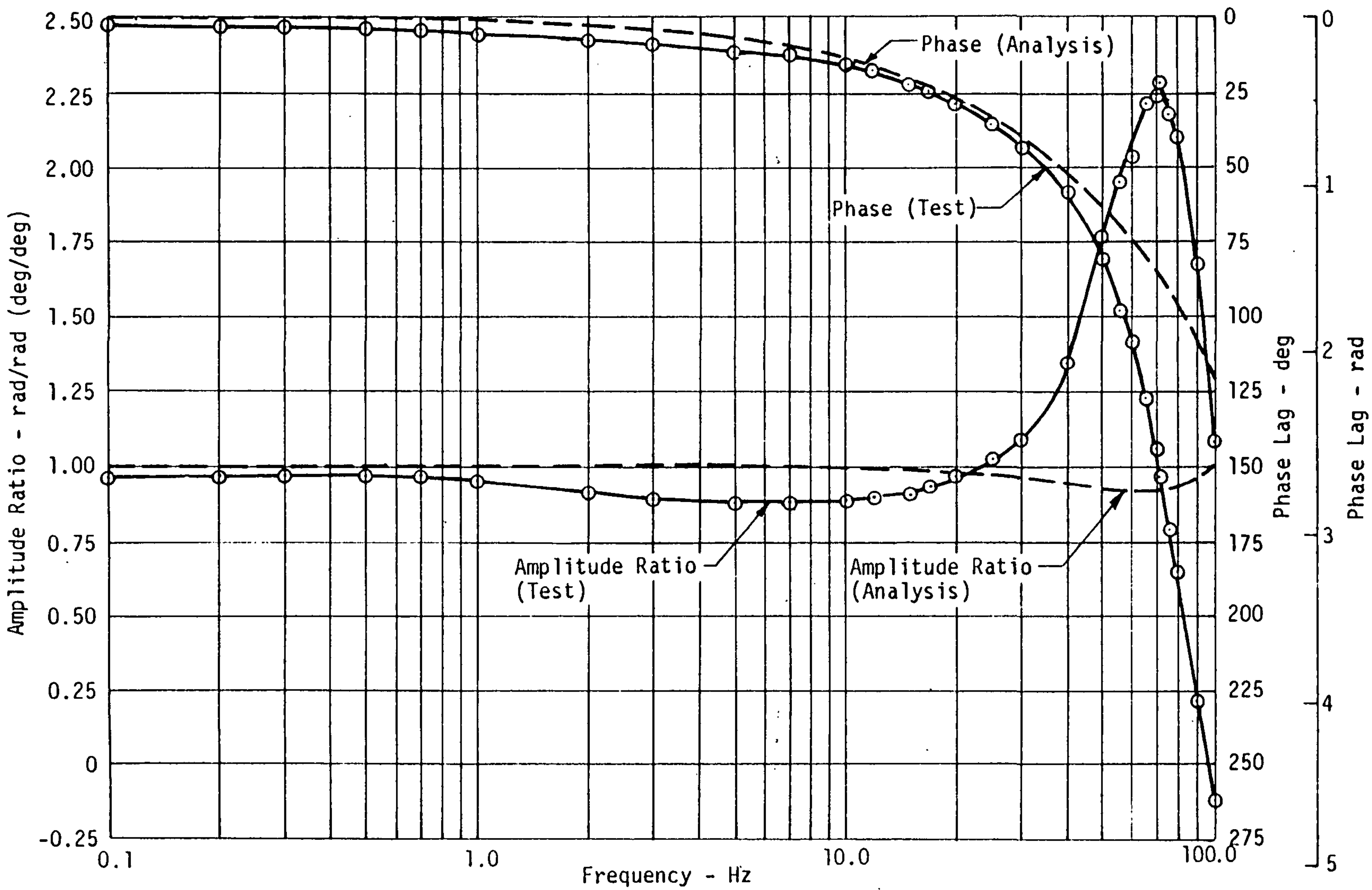


FIGURE 9-2 - SERVOACTUATOR FREQUENCY RESPONSE (ANALYSIS AND TEST) breadboard for the functional tests was made to give 4.519×10^{-4} $N{\cdot}m{\cdot}s^2$ (0.004 in-lb-sec^2) inertia, which was the value used in the linear analysis. The dummy inertia was fabricated from 44.5 millimeters (1.75 inch) diameter steel bar, which should lead to a higher equivalent torsional spring rate for the actuator shaft and surface that estimated in the analysis. (See Paragraph 6.1.3 for the analytical formulation).

Increasing position feedback gain destabilizes the 110 Hz fluid mode and the surface-actuator mode, which appears to be around 95 Hz at zero gain. Pressure feedback appears to lower the frequency of the 110 Hz fluid mode and the surface-actuator mode, and, until the notch filter was added, destabilized the 380 Hz fluid mode while adding damping to the surface-actuator mode. Pressure feedback also has the effect of lowering frequency of the first order break and destabilizing the servovalve.

A second notch filter was added in the servoactuator feedforward path, at 100 Hz with 0.1 numerator damping ratio and 0.4 denominator damping ratio. This compensation permitted higher pressure feedback gain, but significantly lowered frequencies of the first order break and the surface-actuator mode. Figure 9-3 shows a plot of the frequency response obtained during the functional test, with 49.2 volt/rad (0.859 volt/deg) position feedback gain and 0.315×10^{-6} volt/N/m^2 (0.00217 volt/psi) pressure feedback gain. The frequency response shows the first order break at about 33 Hz and the surface-actuator mode at about 49 Hz with 0.14 damping ratio. The 110 Hz fluid mode is not apparent in this frequency response ran to 100 Hz.

The servoactuator functional test results show that performance equivalent to the predicted performance cannot be attained. Further analysis was required prior to the flight test to determine the additional servoactuator compensation and changes to the flutter suppression systems filters were made. This was accomplished using measured servoactuator frequency response with the servoactuation system installed in the DAST ARW-1 wing.

9.1.2 Electronic components - All electronic components used were military qualified or commercial grade meeting military environmental specifications. Initially all populated cards were tested for proper operation. The filters were tuned and required gains established. The box wiring was verified and all dimensions checked. The cards were installed function by function to verify operation. A complete operational check was then performed on the electronic box.

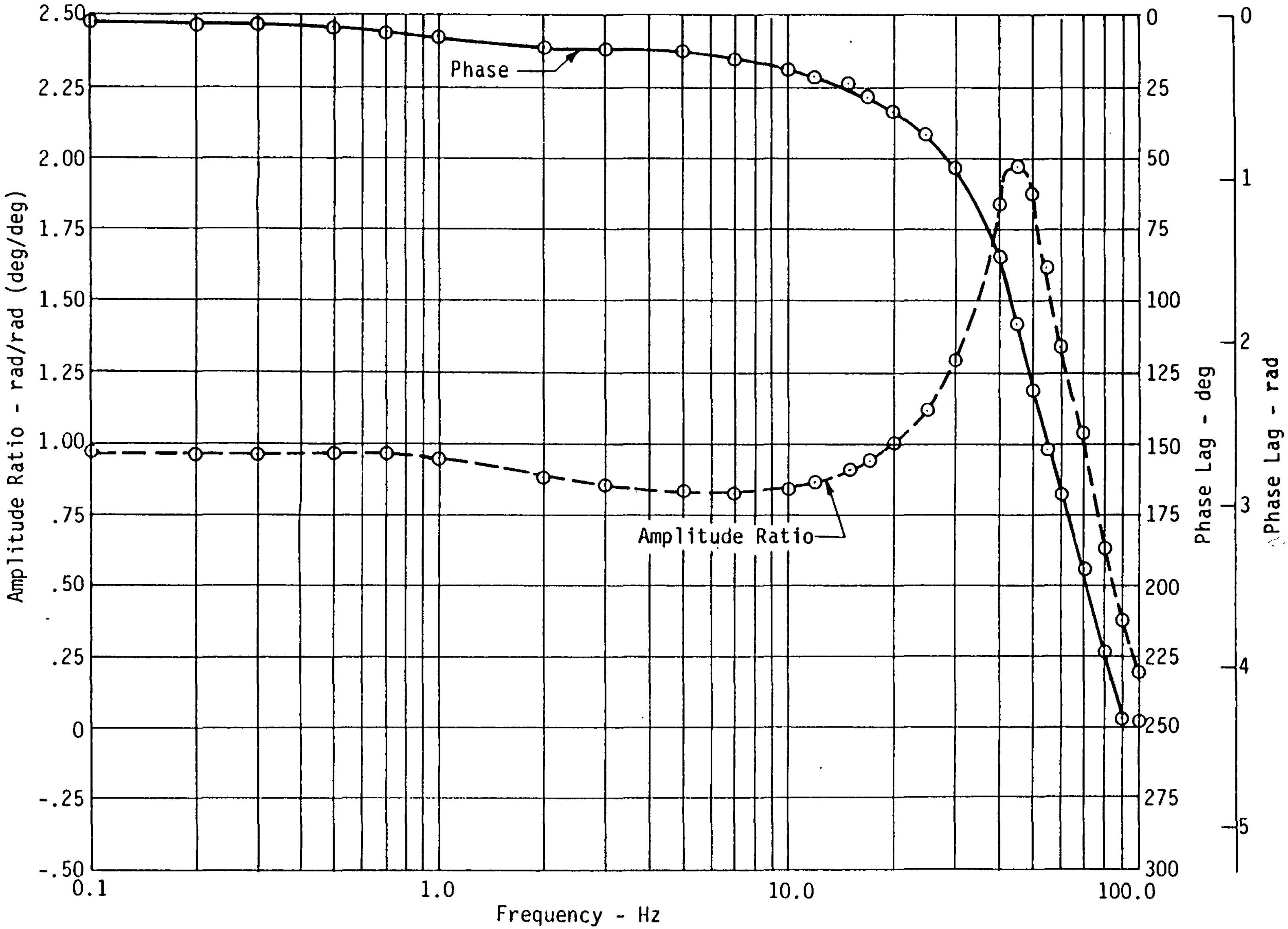


FIGURE 9-3 - FREQUENCY RESPONSE OF SERVOACTUATOR WITH TWO NOTCH FILTERS

9.2 Flight Assurance Test Results

The electronics unit was inspected for workmanship and then verification was made that the unit's envelope would meet the required interface to the BQM-34E/F drone aircraft. The testing consisted of initial performance, integration, EMC, vibration, temperature/altitude, and final performance. The results of these tests are summarized in the following paragraphs. All tests were observed and verified by Boeing Quality Control inspection.

9.2.1 Initial performance - The electronics box was tested during the initial performance. The integration testing provided the initial performance of the remaining components including the servoactuators, the pressure transducers, the servovalve, the hydraulic pump, the hydraulic accumulator, the position transducers and the accelerometers.

9.2.1.1 Power supply performance: The input power was varied from 24.0 VDC to 32.0 VDC while providing the total load current required by the FSS electronics. The operating current for each power supply level were measured. The results are recorded on Data Sheet 4.1.2-1 (D3-11473-1). The power supplies satisfactorily passed all tests.

9.2.1.2 Function generator: The procedure of Table 4.1.2-2 (D3-11443-1) was used to determine proper function generator operation. The results are recorded on Data Sheet 4.1.2-2 (D3-11473-1). The function generation successfully passed all requirements.

9.2.1.3 Parameter scheduler: The procedures of Table 4.1.2-3 (D3-11443-1) were used to determine proper parameter scheduler operation. The results are recorded on Data Sheet 4.1.2-3 (D3-11473-1). The parameter scheduler successfully passed all requirements for the initial performance.

9.2.1.4 Uplink command functions: The procedures of Table 4.1.2-4 (D3-11443-1) were used to check the uplink logic functions. All functions successfully passed the requirements. The results are recorded on Data Sheet 4.1.2-4 (D3-11473-1)

9.2.1.5 Downlink signals: The procedures of Table 4.1.2-5 (D3-11443-1) were used to check the downlink offsets and scale factors. All signals were within the required tolerances. The results are recorded on Data Sheet 4.1.2-5 (D3-11473-1).

9.2.1.6 Filter responses: The procedures of Table 4.1.2-6 (D3-11443-1) were used to verify that the filter gain and phase responses met the requirements determined by analysis. The gains and phases were within the required tolerances and are recorded by Data Sheet 4.1.2-6 (D3-11473-1).

9.2.2 Integration tests - The complete flutter suppression system was integrated (dummy inertia loads were used to simulate the actual surfaces) and the procedures of Paragraph 4.2 (D3-11443-1) were used to set up the test and verify proper system operation. This test also provided the initial performance for all components except the electronics box. This test was witnessed by personnel from NASA Langley.

The left and right hand outboard aileron servoactuators were incorporated into the breadboard setup for the performance tests with the Sundstrand-Pesco Model 165-100 hydraulic power supply providing hydraulic power. An MS 28797-1 hydraulic accumulator, precharged to 6.895×10^6 N/m^2 (1000 psi), was plumbed into the pressure line between the pump and servovalves. The breadboard setup was nearly identical to the servoactuator configuration planned for the drone flight test vehicle.

With the accumulator precharged to 6.895×10^6 N/m^2 (1000 psi), approximately 1.360×10^{-4} m^3 (8.3 in^3) of hydraulic fluid must be transferred from the pump reservoir to the accumulator as pump pressure increases to the required 10.34×10^6 N/m^2 (1500 psi). When the pump started up during the performance test, fluid was transferred to the accumulator, leaving only about 0.328×10^{-4} m^3 (2 in^3) in the pump reservoir. This was insufficient for the pump to sustain the oscillatory commands imposed on the two servoactuators. Instead of the pump pressure compensator cycling normally, the compensator remained engaged even when the commands were removed.

The accumulator was subsequently precharged to 8.27×10^6 N/m^2 (1200 psi), which requires only about 0.819×10^{-4} m^3 (5.0 in^3) of fluid from the reservoir as 10.34×10^6 N/m^2 (1500 psi) was reached. The pump performed satisfactorily for the input commands placed on the servoactuators.

Results of the testing showed that the MS 28797-1 accumulator is too large for the pump reservoir capacity. A Parker-Hannifin Model A2A0010A1K hydraulic accumulator will be used in the drone instead of the MS28797-1 accumulator. This accumulator will require only about 0.541×10^{-4} m^3 (3.3 in^3) of fluid from the pump reservoir as pressure comes up to 10.34×10^{-6} N/m^2 (1500 psi), with 6.89×10^6 N/m^2 (1000 psi) precharged pressure. Functional test of the hydraulic power unit with this accumulator will be conducted at NASA Langley.

The results of this test are recorded on Data Sheets 4.2.2.1 through 4.2.2.5, Data Sheets 4.2.3.2-1 and 4.2.3.2-2, and Data Sheets 4.2.3.3 and 4.2.3.5. These data sheets are found in Appendix A of D3-11473-1. Figures 9-4 through 9-11 show the test setup.

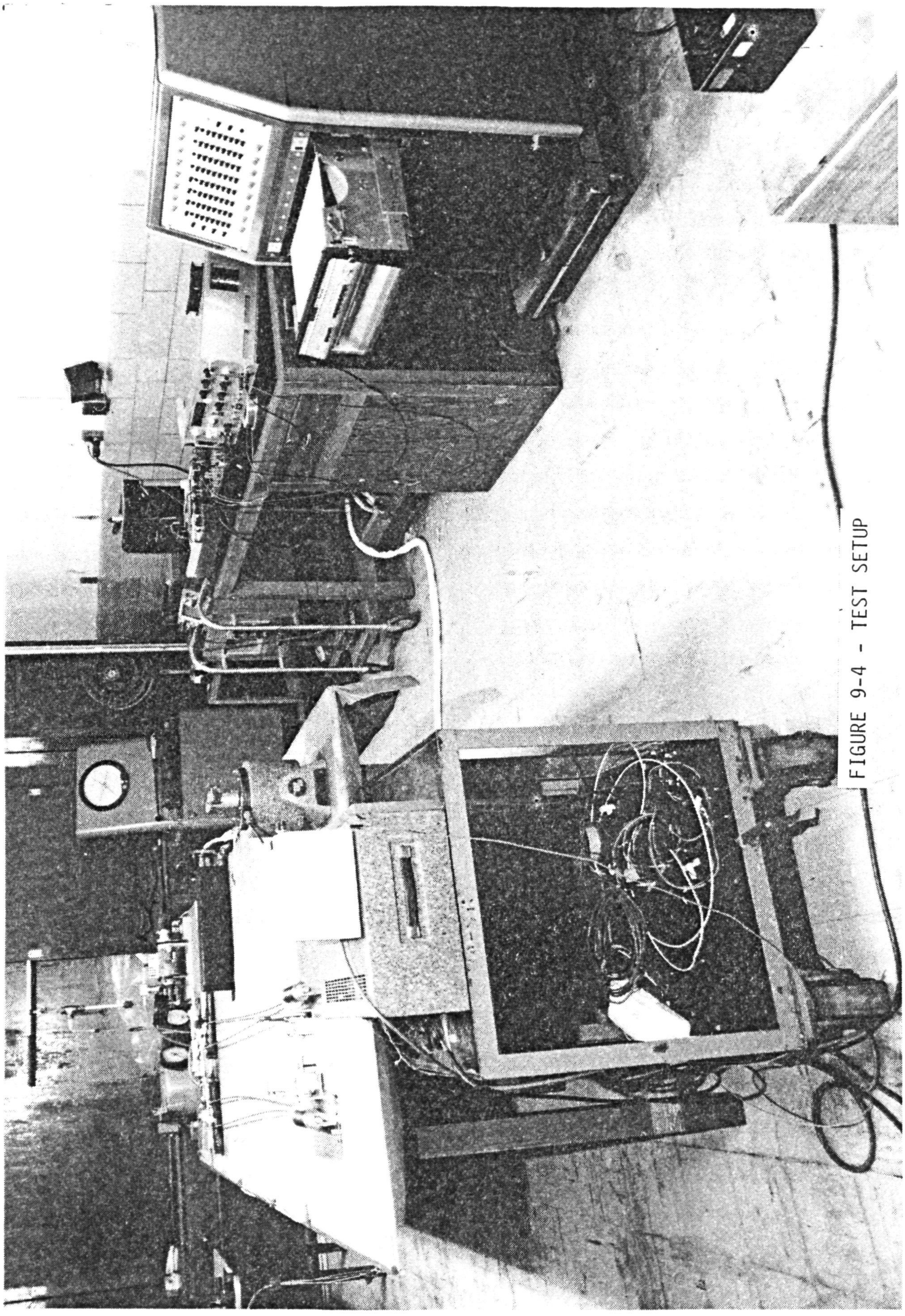


FIGURE 9-4 - TEST SETUP

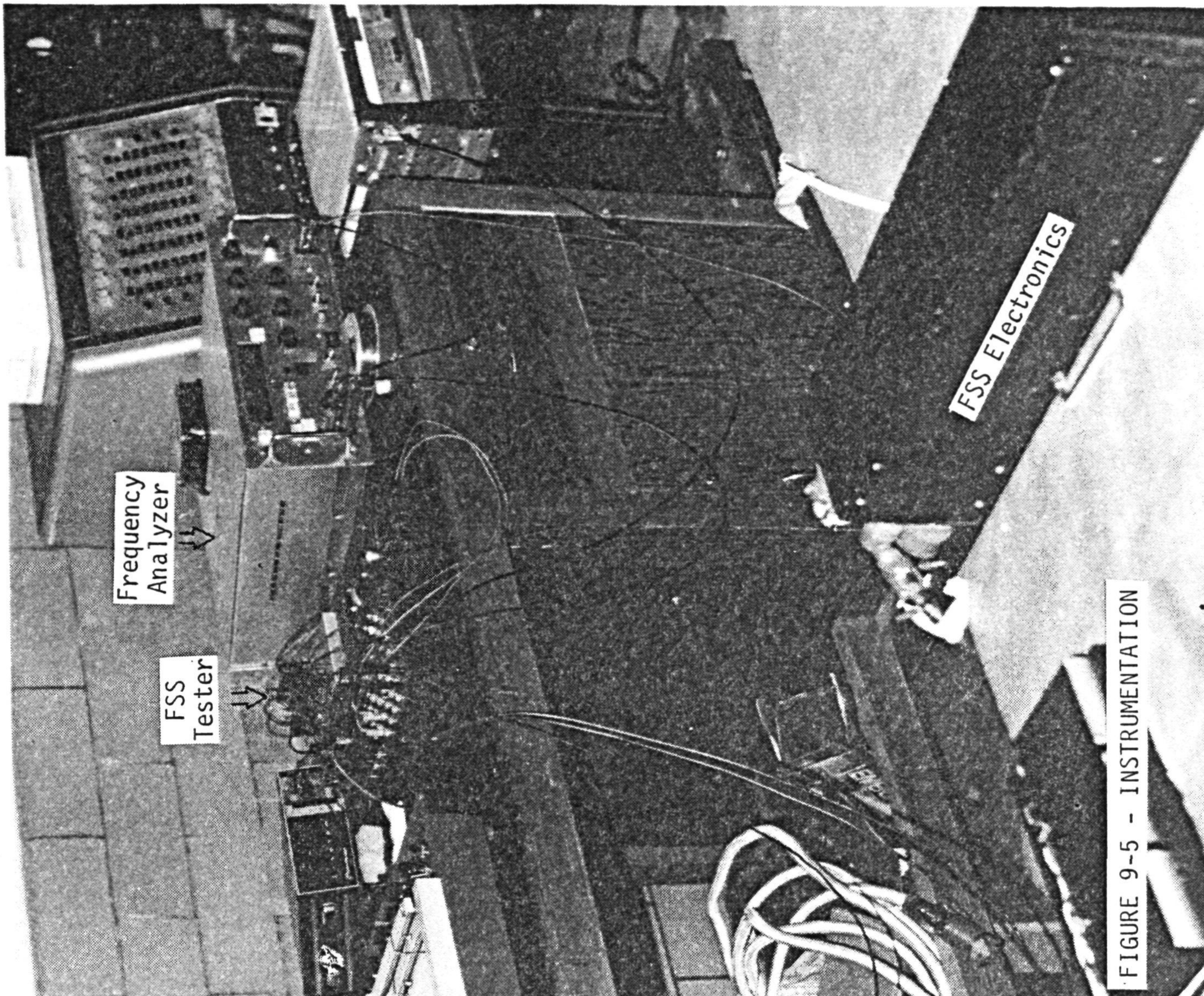


FIGURE 9-5 - INSTRUMENTATION

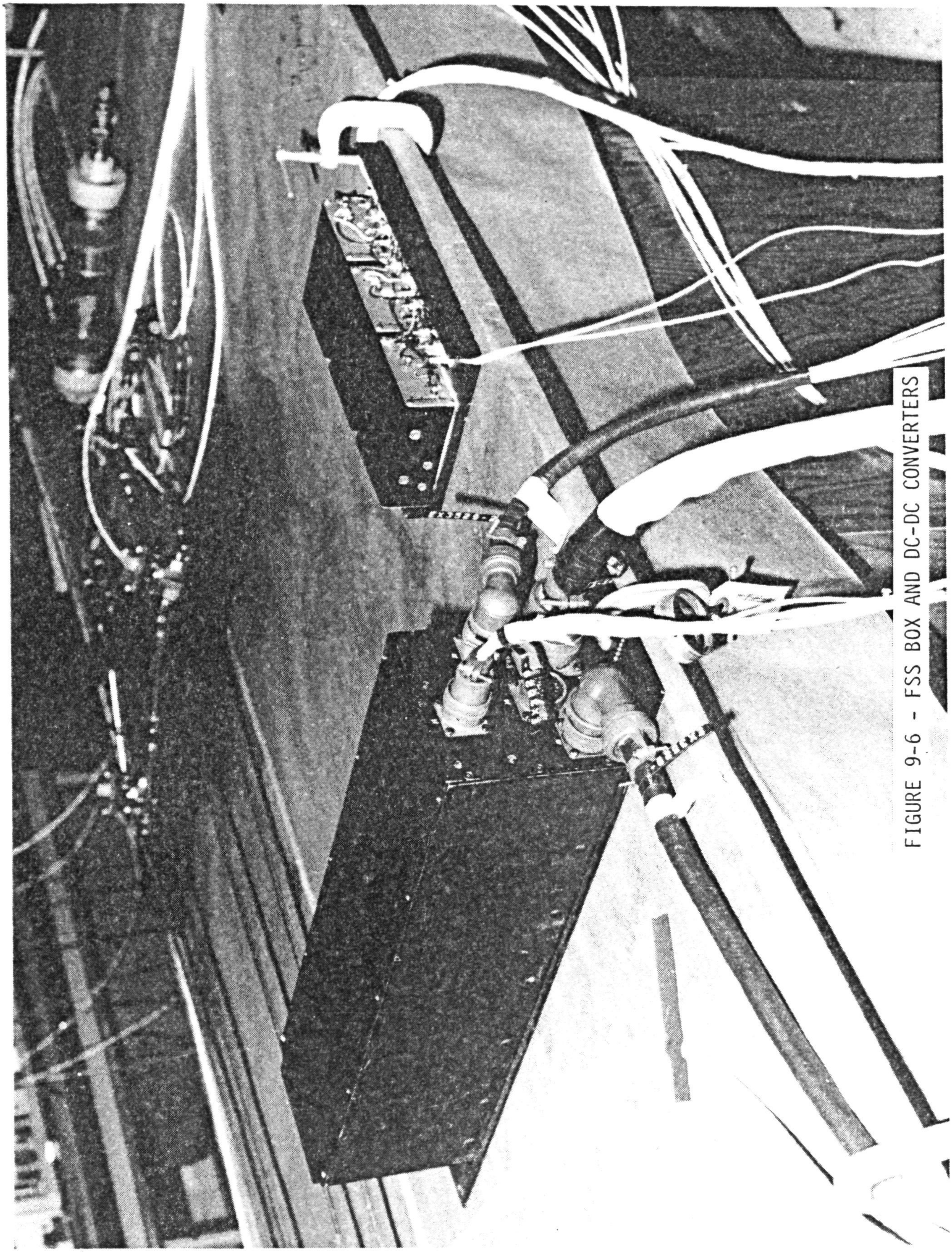


FIGURE 9-6 - FSS BOX AND DC-DC CONVERTERS

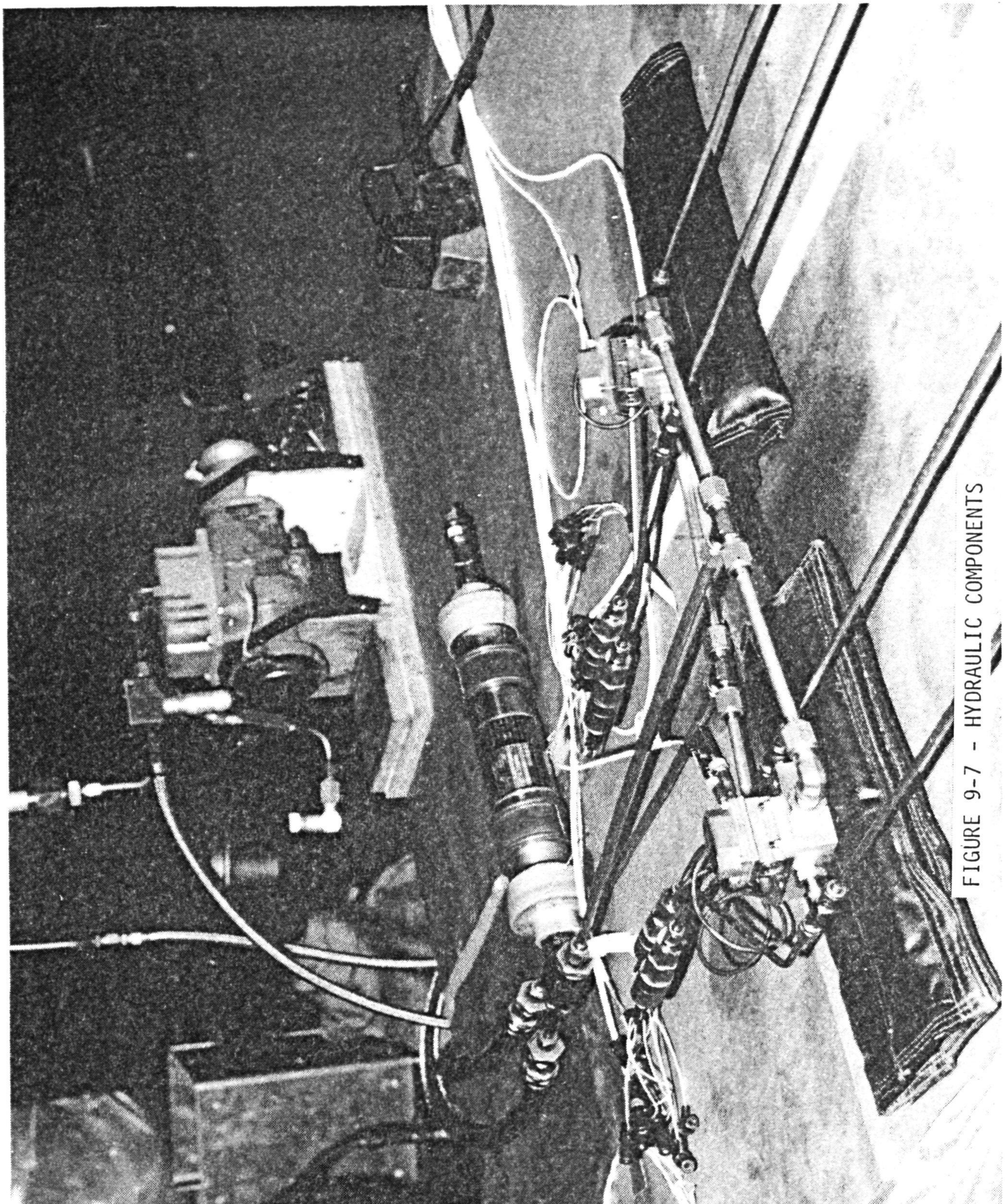


FIGURE 9-7 - HYDRAULIC COMPONENTS

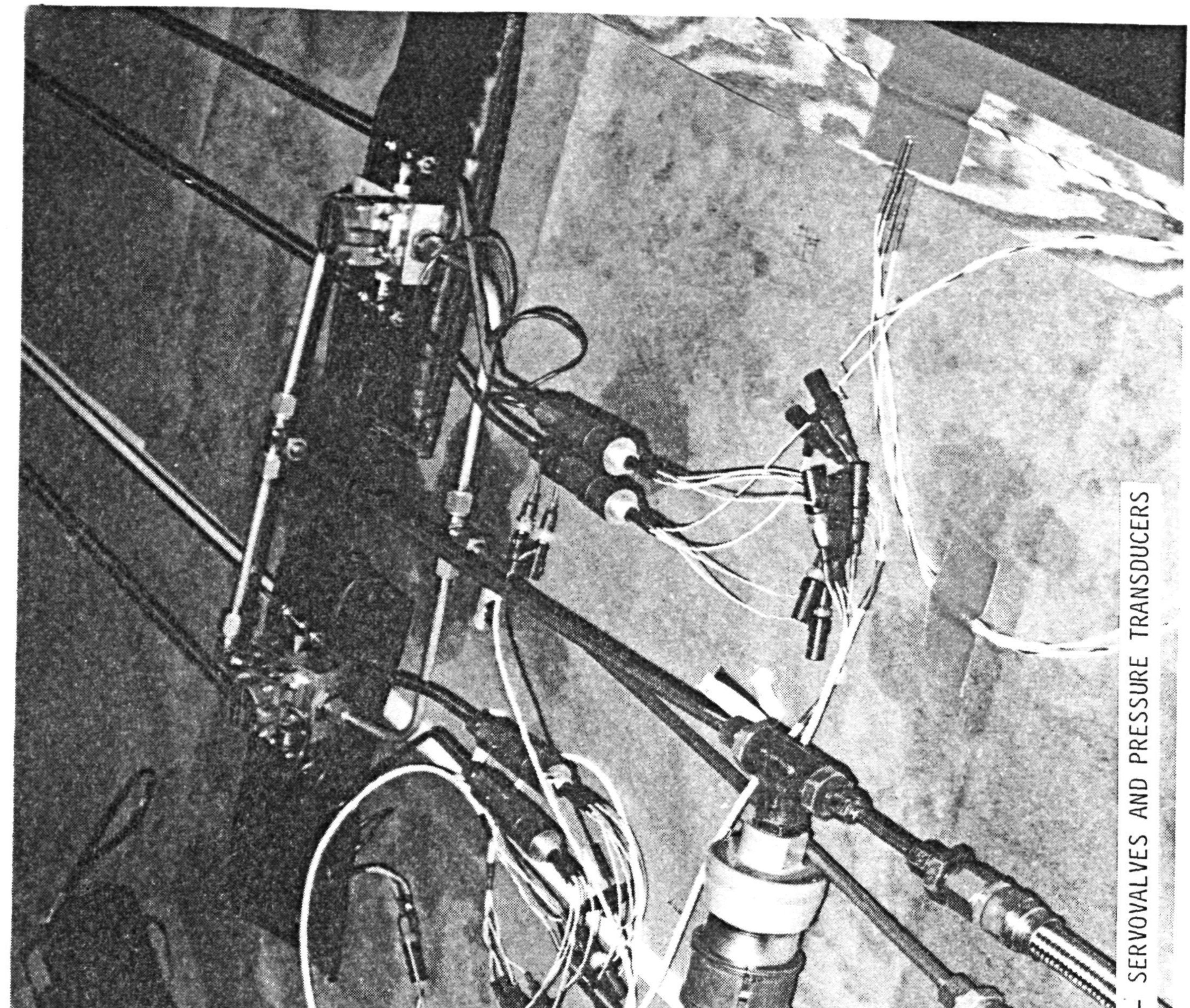


FIGURE 9-8 - SERVOVALVES AND PRESSURE TRANSDUCERS

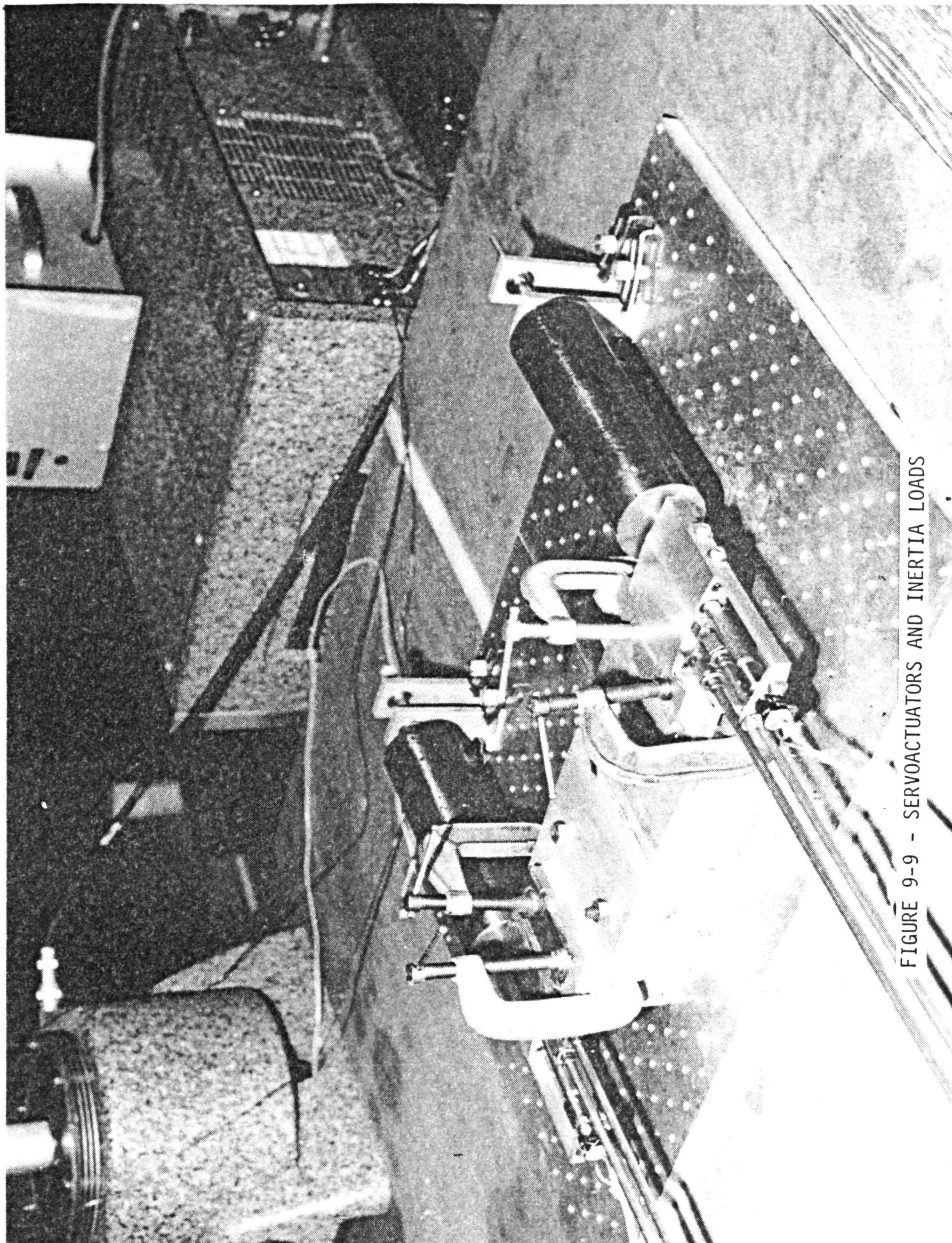


FIGURE 9-9 - SERVOACTUATORS AND INERTIA LOADS

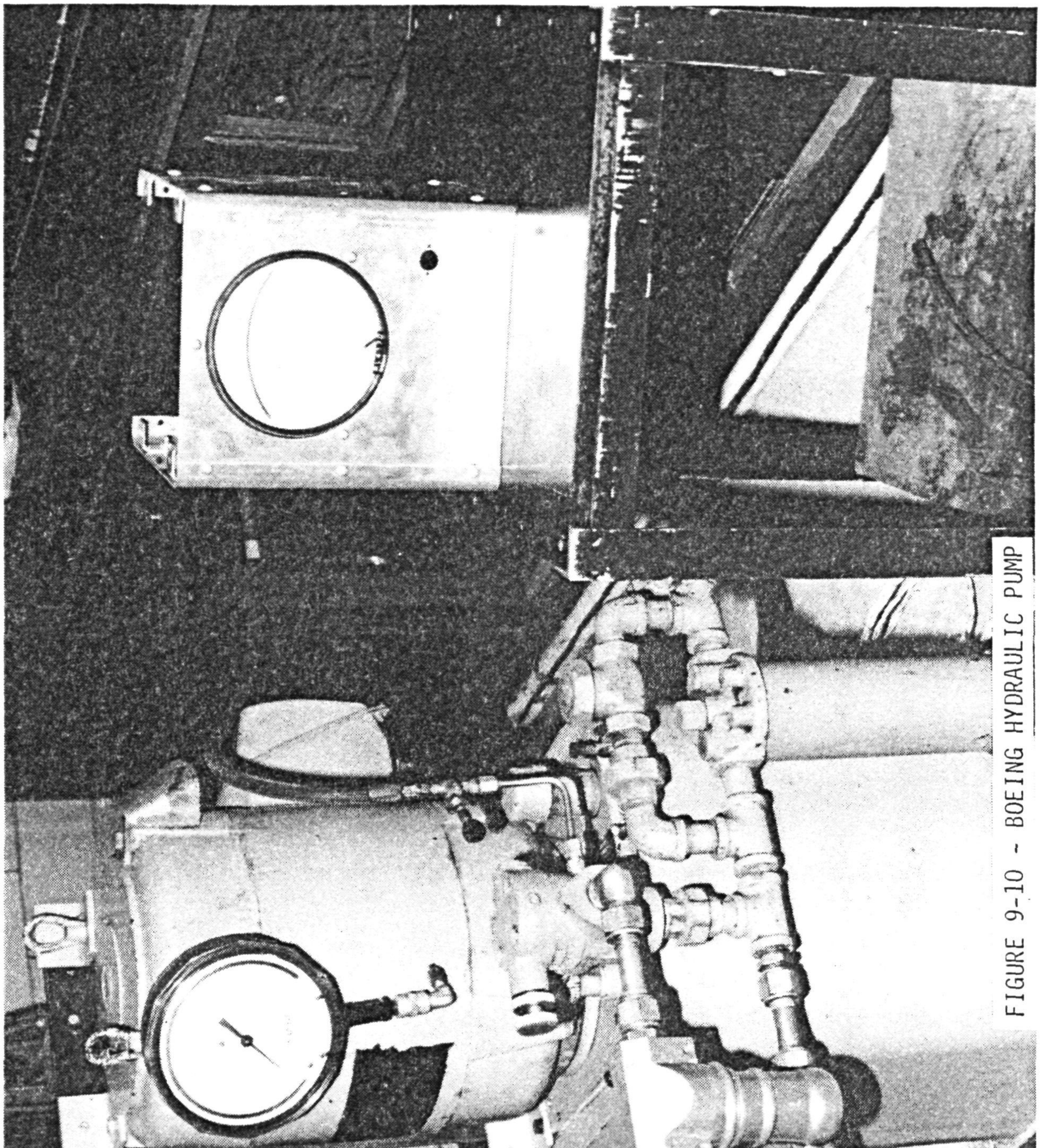


FIGURE 9-10 - BOEING HYDRAULIC PUMP

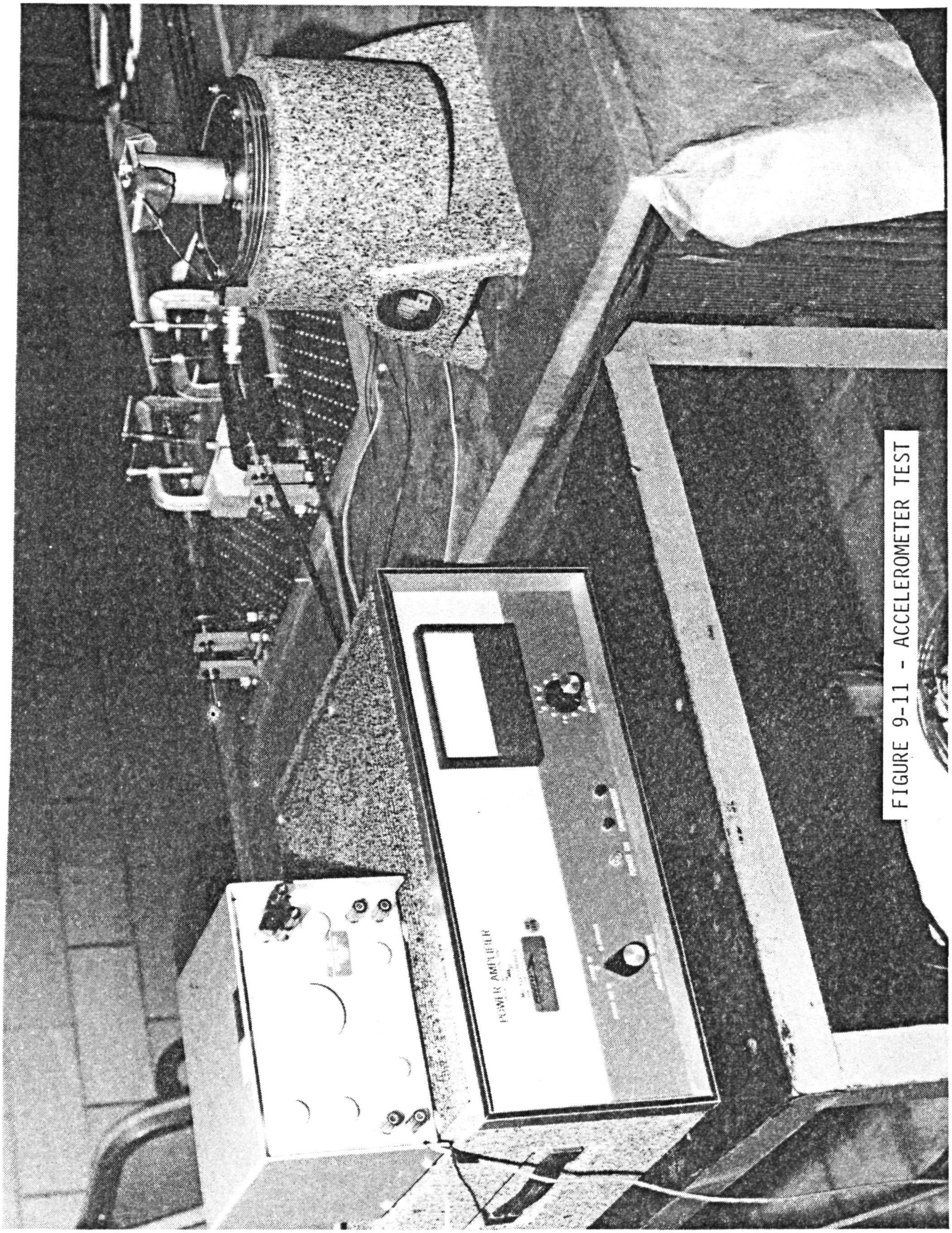


FIGURE 9-11 - ACCELEROMETER TEST

9.2.3 <u>Vibration</u> - This test was performed per the requirements and procedures of Document D3-11443-1. The figures showing the test requirement and test input equivalent of this requirement are found in Appendix C.

Three axis sinusoidal excitation was applied to the electronics box at laboratory ambient temperature. The electronic box was powered and operating during all testing. The inputs to the servovalve drive amplifiers were monitored by a two channel oscilloscope to enable detection of any signal distortion. These signal outputs were measured with a frequency analyzer throughout the test to insure that no change in gain or phase shift occurred. Figure 9-12 shows the instrumentation and test setup. Figure 9-13 shows a typical test setup.

Some distortion (approximately 2 percent) was noted at the peak of the 450 Hz resonance during the second sweep of the vertical axis test and the resonances of 184 Hz and 222 Hz during the longitudinal axis test. During inspection after completion of these tests, several of the larger power supply filter capacitors negative leads were found broken. Only those capacitors mounted horizontally were broken loose. The distortion observed during the above tests was determined to be caused from the intermittent touching of these broken leads. The damaged capacitors were replaced and epoxy was applied to secure these and all of the larger capacitors on all of the printed circuit cards. Some of the horizontal capacitors did not break. These were supported by other capacitors in close vicinity to them.

The results of the performance tests were recorded on Data Sheets 4.3.3 and 4.3.3-1 found in Appendix A of Document D3-11473-1. No phase shift or gain changes were noted during these tests. The securing of the capacitors as described above is sufficient to prevent any problems during the scheduled flight tests.

9.2.4 <u>Temperature/altitude</u> - This test was performed per the requirements and procedures of Document D3-11443-1. Figure C-8 presents the test plan that was followed during testing.

9.2.4.1 Test setup: Figure 9-14 shows the instrumentation setup used during the temperature/altitude testing. Figure 9-15 shows the hydraulic supply and the temperature plotter. Only the right wing servo system was connected and tested. The servovalve, pressure transducers and accumulator are vendor qualified and were not subjected to environmental testing. Figure 9-16 shows these components installed outside of the chamber. Figures 9-17 and 9-18 show the FSS electronics, the servoactuator, position transducers and wing accelerometer installed inside of chamber.

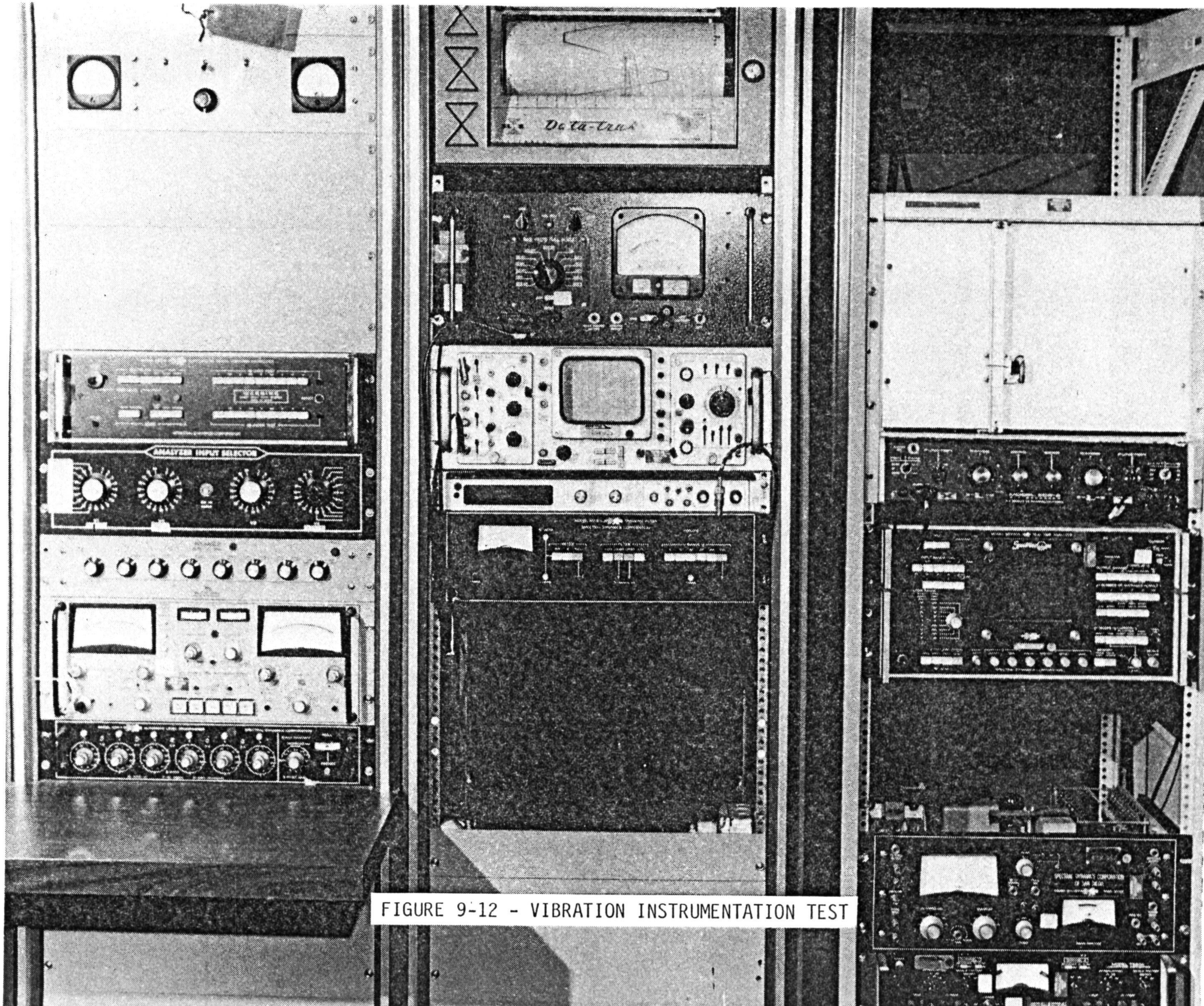


FIGURE 9-12 - VIBRATION INSTRUMENTATION TEST

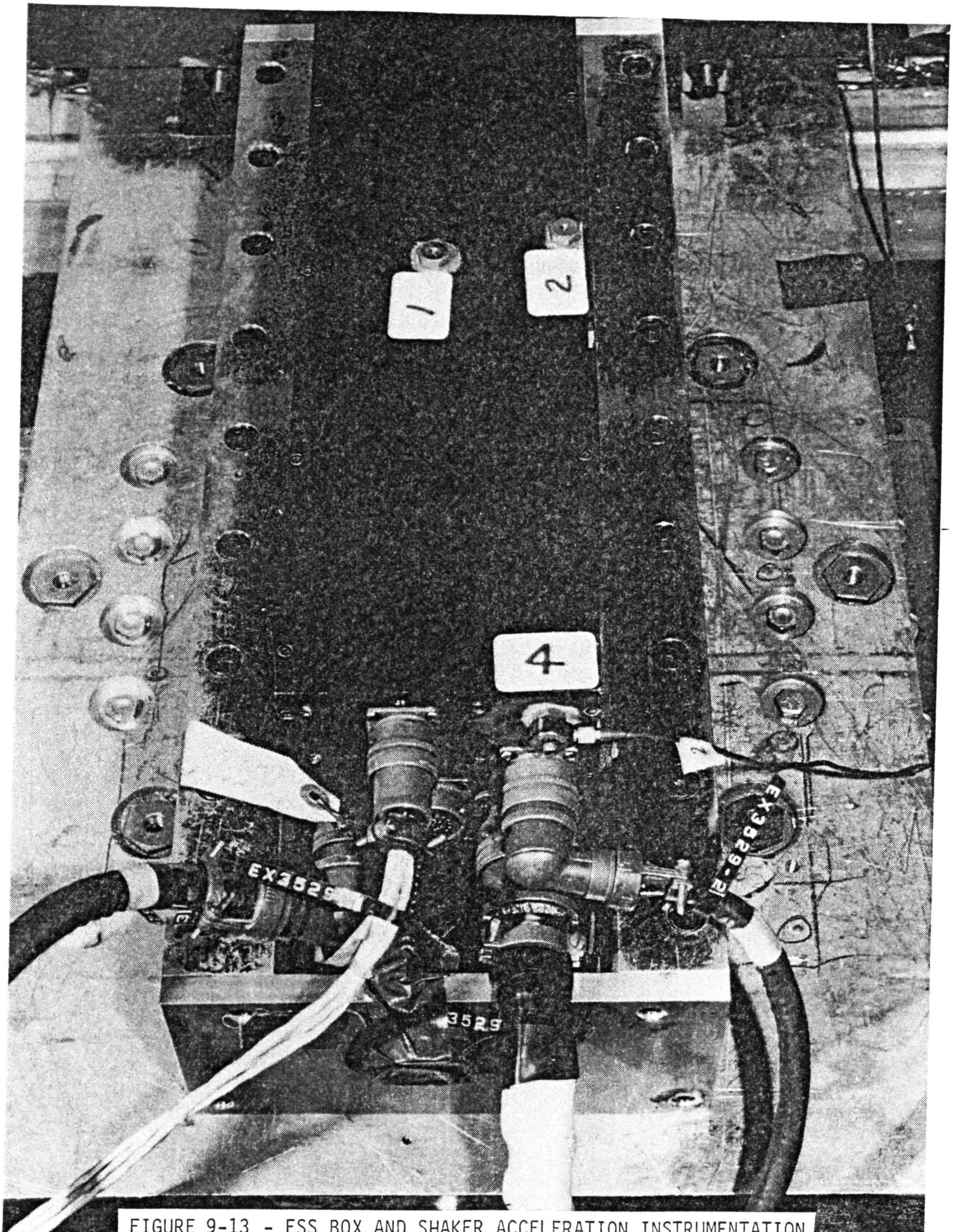


FIGURE 9-13 - FSS BOX AND SHAKER ACCELERATION INSTRUMENTATION

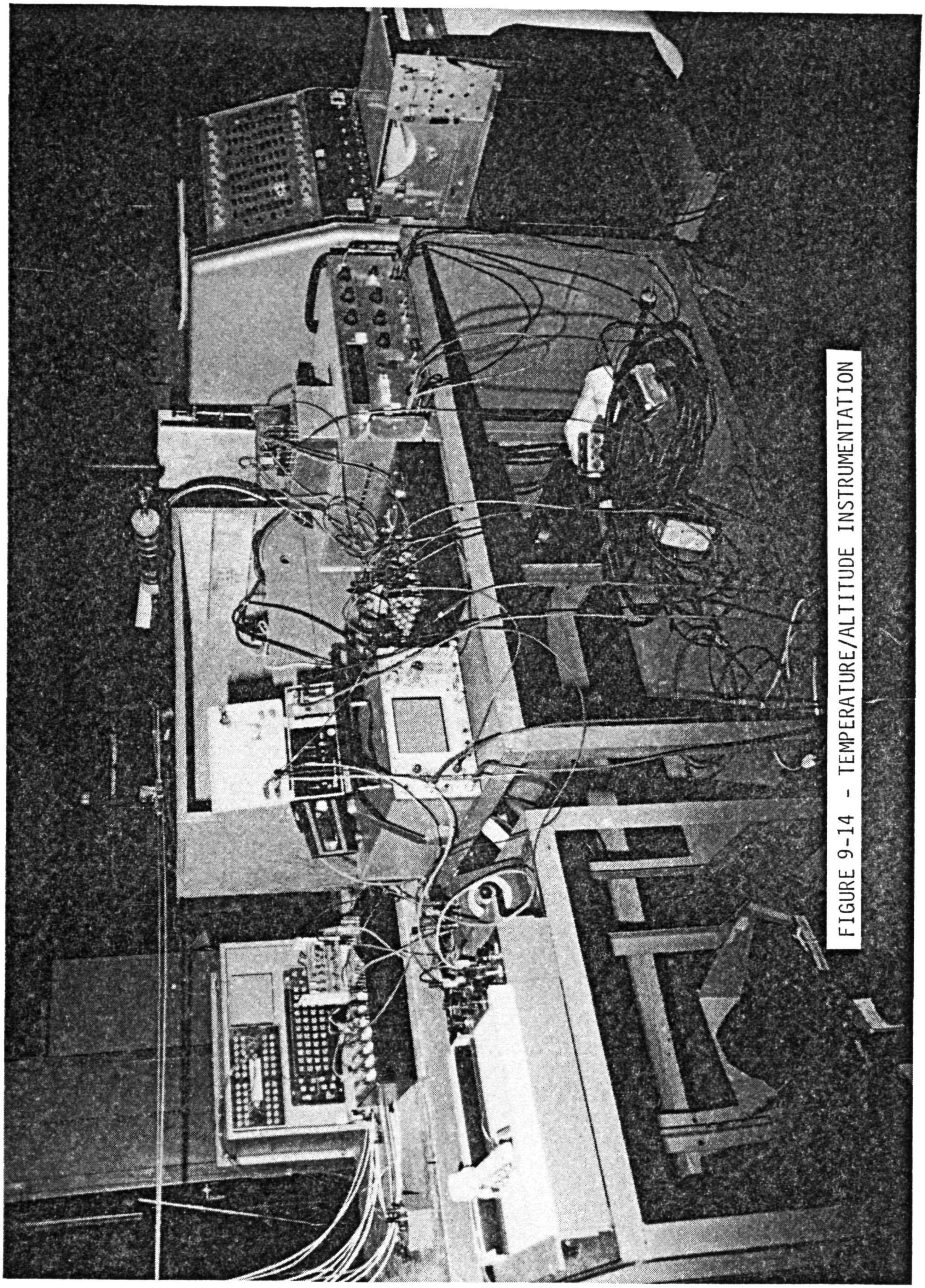


FIGURE 9-14 - TEMPERATURE/ALTITUDE INSTRUMENTATION

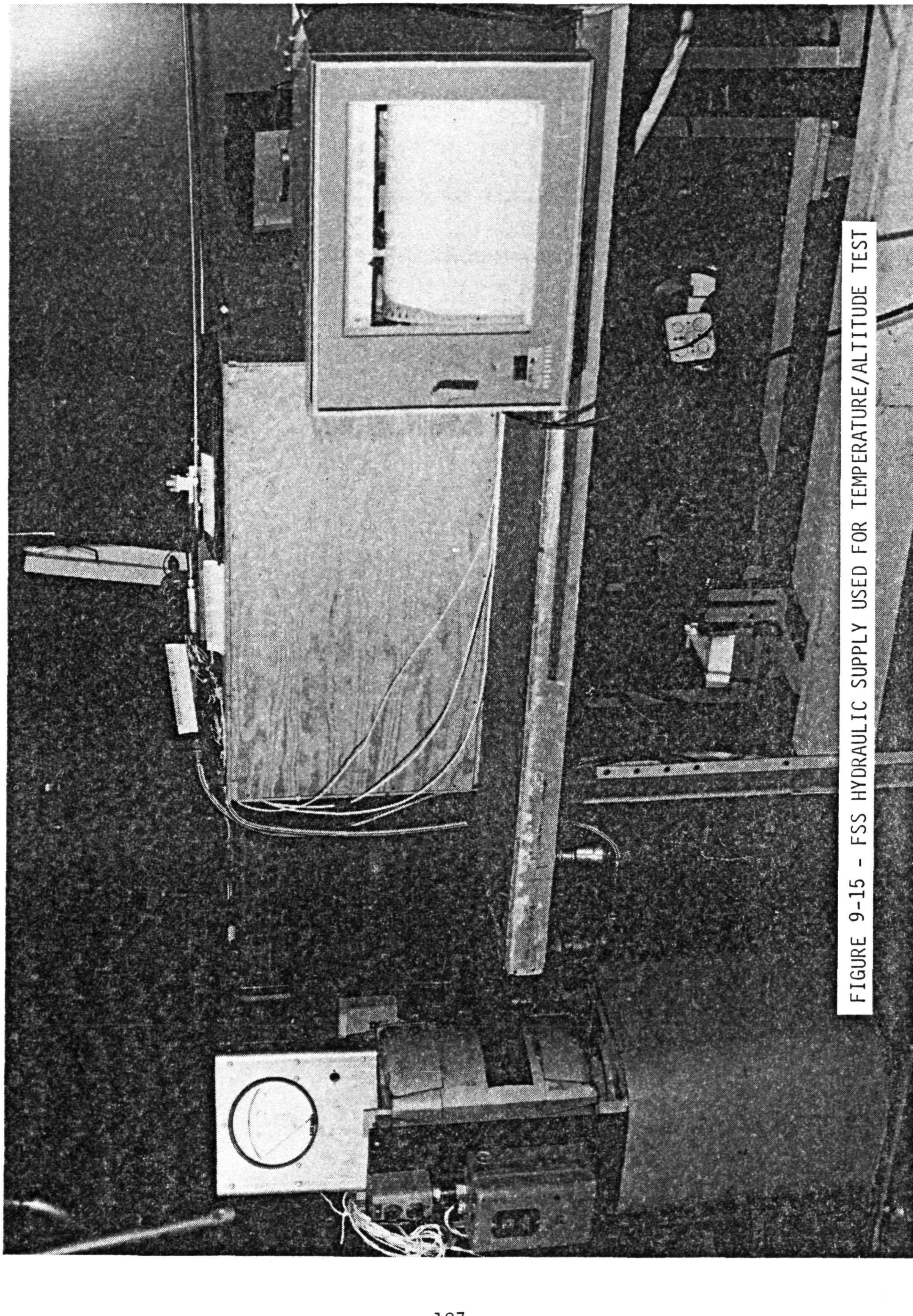


FIGURE 9-15 - FSS HYDRAULIC SUPPLY USED FOR TEMPERATURE/ALTITUDE TEST

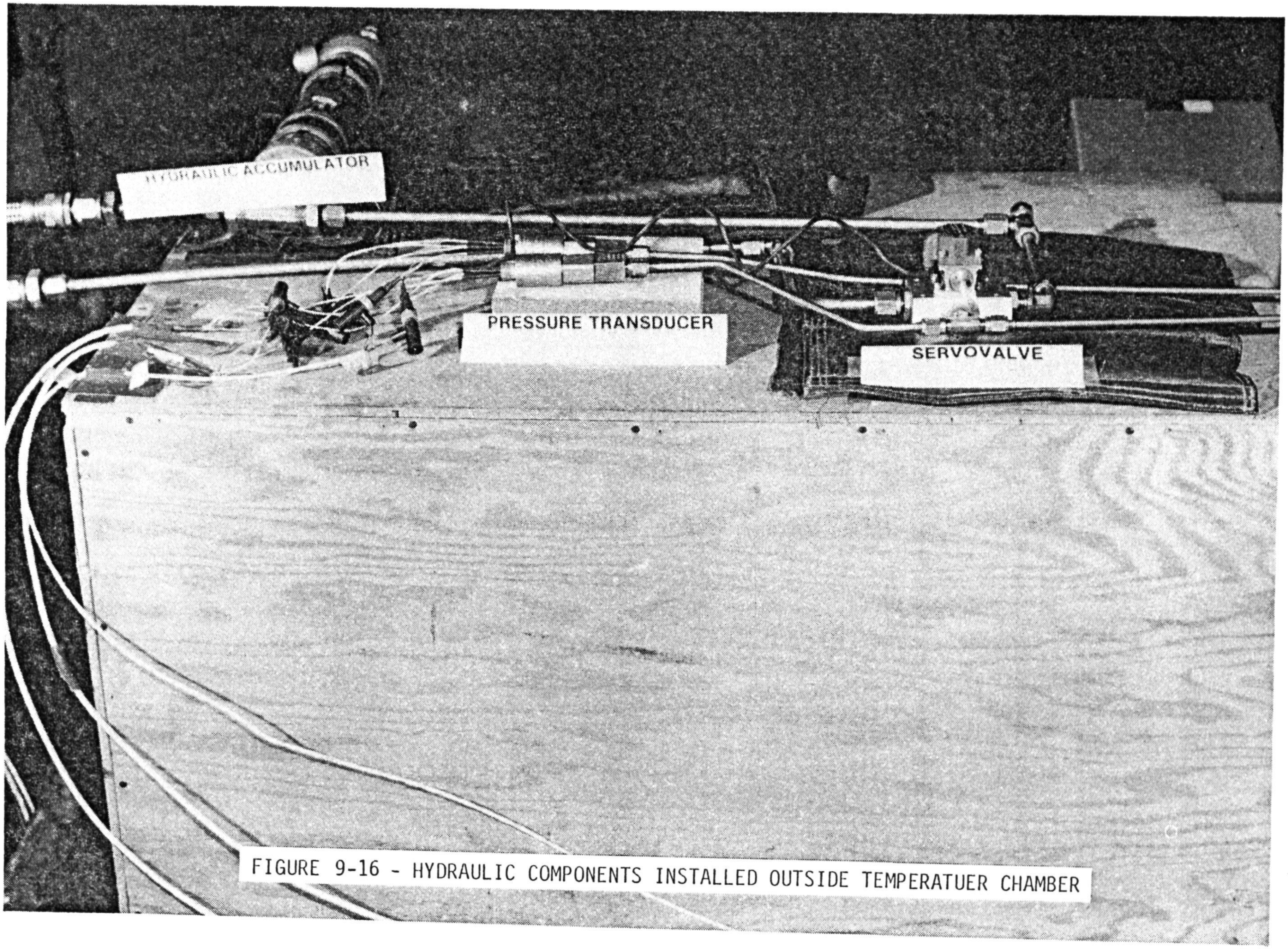


FIGURE 9-16 - HYDRAULIC COMPONENTS INSTALLED OUTSIDE TEMPERATUER CHAMBER

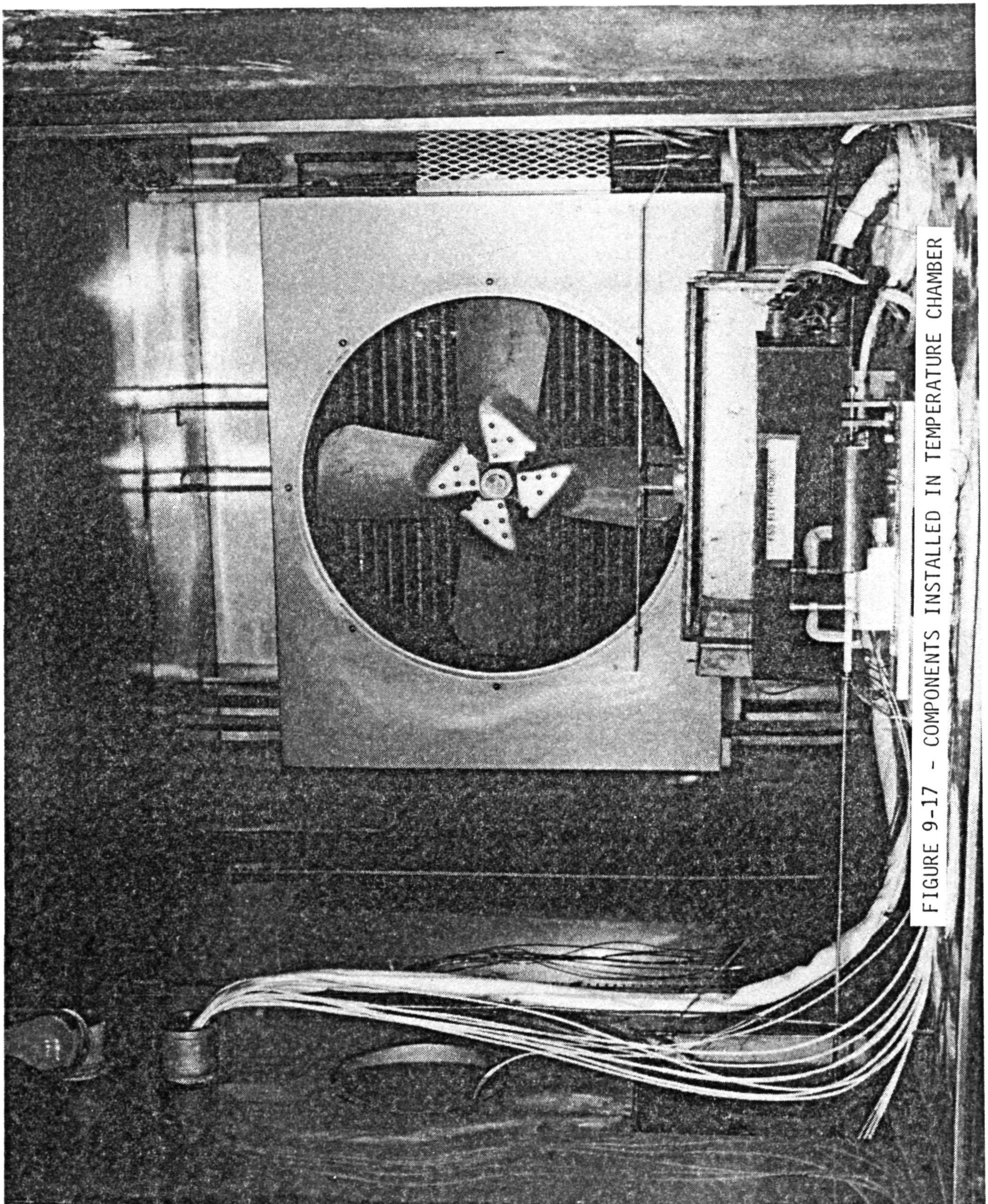


FIGURE 9-17 - COMPONENTS INSTALLED IN TEMPERATURE CHAMBER

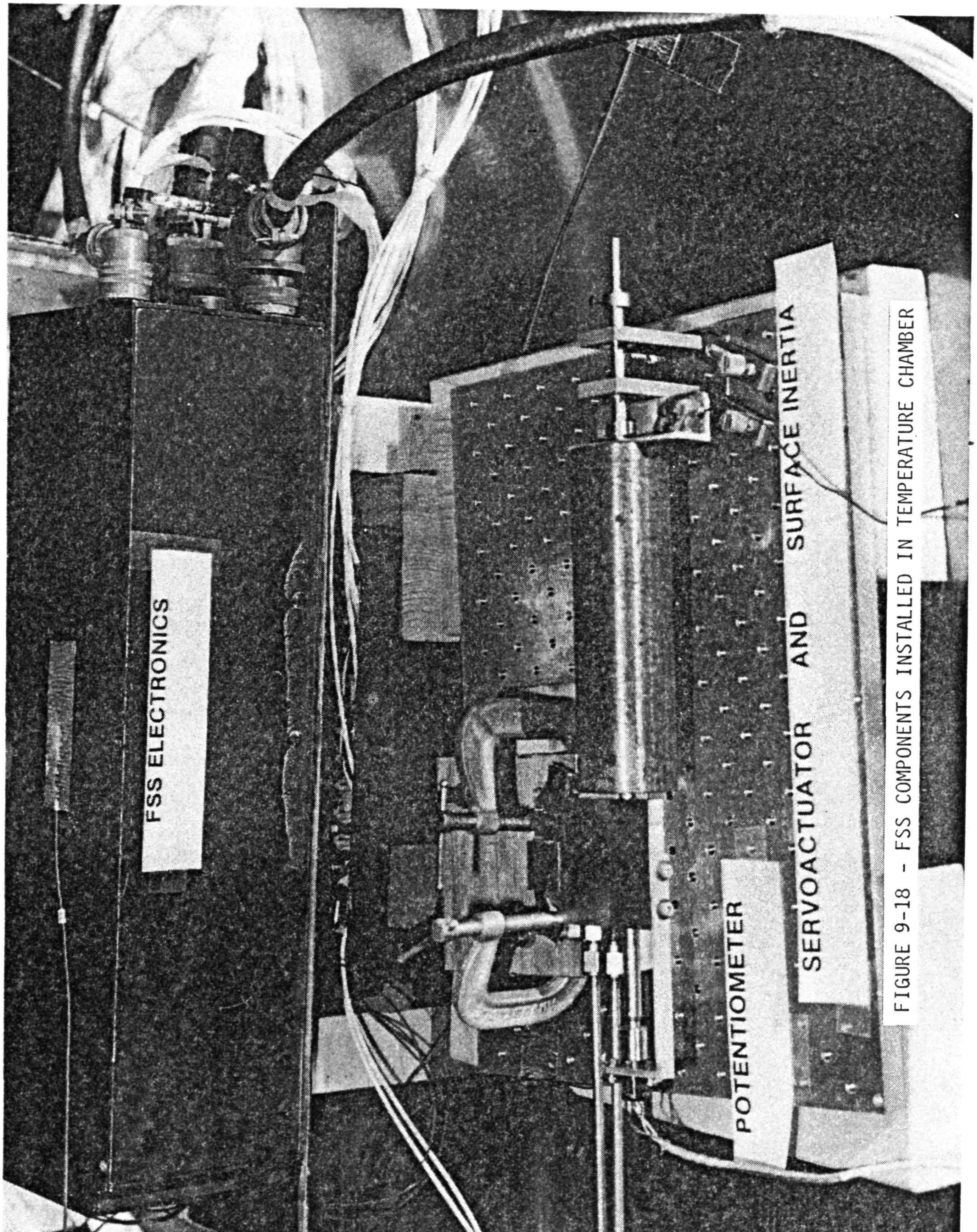


FIGURE 9-18 - FSS COMPONENTS INSTALLED IN TEMPERATURE CHAMBER

Prior to formal temperature testing, the PCB accelerometer exhibited a large amount of random thermal drift caused by air currents. The accelerometer will be covered with an insulating material when installed in the drone wing to minimize the drift. A possible substitute accelerometer is discussed in Paragraph 6.2.

The accelerometer used for this test was mounted on a bracket attached to the surface inertia. The accelerometer signal conditioning was obtained from the spare card mounted in the card tester. Excitation was provided by activating the sweep generator and the results were recorded on a strip chart recorder. This procedure was accomplished for each condition of the test. At each condition the accelerometer turn-on time and turn-on voltage were recorded also. The accelerometer operated satisfactorily for every test condition. The results are recorded by Step 1.0 of Data Sheets 4.4.3.5, 4.4.3.6, 4.4.3.9 and 4.4.3.11 found in Appendix A of Document D3-11473-1.

9.2.4.2 Pretest performance: The FSS system was operated in standard ambient conditions and performance data was recorded after temperature stabilization had occurred. The system met all requirements and the data are recorded on Data Sheets 4.4.3-1 through 4.4.3-5, 4.4.3-6 and 4.4.3-7. These data sheets are found in Appendix A of Document D3-11473-1.

9.2.4.3 Startup and operation at -53.9°C (-65°F): After completion of the cold soak at -53.9°C (-65°F), the system was turned on. The actuator was immediately controllable. The aileron actuator experienced a minor external leak through the gasket seal O-rings when command was first input to the servoactuator. The actuator was inadvertently driven hard over to one side and hydraulic fluid leaked through the gasket seal O-rings between the actuator body parts and between the actuator body and end caps on the other side. In the hardover condition, pressure on one side of the vane goes to zero while pressure on the other side approaches the 10.34×10^6 N/m^2 (1500 psi) supply pressure.

Leakage was not encountered at higher temperatures, -40°C (-40°F) up to 71.1°C (160°F), even during dynamic testing of the servoactuator. Because the leaking occurred in a malfunction condition, the external leakage of fluid was minor and leakage did not occur at higher temperatures, the adiprene O-rings are satisfactory for providing the actuator gasket seal.

The performance results are recorded on Data Sheets 4.4.3.3-1 through 4.4.3.3-3 found in Appendix A of Document D3-11473-1.

9.2.4.4 Performance tests at -40^{o}C (-40^{o}F): The chamber temperature was increased to -40^{o}C (-40^{o}F) and altitude adjusted to 12 192 meters (40 000 feet). The accelerometer, the function generator and the power supply unit performed satisfactorily through the test.

The lower limit of the parameter scheduler is clamped by a zener doide. The breakdown voltage of the particular zener used varied considerably causing the lower limit to be too high. This diode was replaced and a temperature retest over a limited temperature range was conducted. The lower limit operated satisfactorily for the retest. The retest is covered by Paragraph 4.4.8 of D3-11473-1.

The position transducer and the servoactuator passed satisfactorily the -40°C (-40°F) tests. The frequency responses of the actuator were well within tolerances. The downlink signals were well within the tolerances; however, the hydraulic supply pressure (HYSUP) was not scaled correctly. The scale factor should be 13.79 x 10^6 N/m^2 (2000 psi)/5.0 VDC. The method by which HYSUP is derived within the electronic unit caused hydraulic pressure values in excess of the total supply pressure. Pressure on both sides of the actuator are measured and summed by HYSUP and depending upon the particular servovalve and amount of use, the signal may vary indicating pressure above or even below the total supply pressure. This signal, however, is only for indication that the hydraulic supply is functioning and accuracy is not important. Rescaling of all scale factors will be checked prior to flight test.

The antisymmetric filter failed to be within tolerance at this temperature. The output of the divider in the parameter scheduler as well as the outputs of the multipliers in the filter vary with temperature. The parameter scheduler has a temperature compensation circuit that was not correctly set for this test. The retest of Paragraph 4.4.8 of D3-11473-1 describes the procedure used to adjust this compensation to compensate the filter drift as well as possible. A relaxed operating ambient temperature range of 10°C (50°F) to 37.8°C (100°F) was approved for the temperature retest. The parameter scheduler and filters operated satisfactorily during the retest and are considered satisfactory for the planned flight tests. Should ambient temperatures less than 10°C (50°F) be anticipated, a heating pad thermostatically operated should be attached to the bottom of the FSS box. This pad should be capable of dissipating at least 75 watts. The thermostat should also be attached to the box and insulated so as to indicate box temperature.

Servoactuator hysteresis was measured during each condition of the temperature/altitude test. Hysteresis, as shown by Data Sheet 4.4.3.7 of D3-11473-1, recorded during the pretest, was 2.62 milliradians (0.15 degrees) total surface travel, well within the requirements 3.49 milliradians (0.2 degrees) total surface travel.

9.2.4.5 Operation at standard conditions: The chamber temperature was returned to laboratory ambient levels and the performance tests were repeated. An inspection revealed that no physical damage had occurred. The complete FSS sytem was within tolerances and had returned close to the pretest values. All functions operated satisfactorily.

9.2.4.6 Performance at 71.1°C (160°F): The chamber temperature was increased to 71.1°C (160°F). After a 16 hour temperature soak, a performance test was conducted at laboratory ambient altitude. The altitude was then adjusted to 9144 meters (30 000 feet) and the performance tests were repeated. Altitude changes had negligible effect upon the performance of the FSS system.

All components performed satisfactorily except again the lower limit of the parameter scheduler was too high. The replacement of the clamping diode provided satisfactory operation as described by the retest of paragraph 4.4.8 of Document D3-11473-1. The filter responses when operated in the limited ambient temperature range of 10°C (50°F) to 37.8°C (100°F) are satisfactory and meet the gain and phase requirements.

The altitude was adjusted to 18 288 meters (60 000 feet) and the procedure of Table 4.4.3.10 of Document D3-11473-1 was performed. This was an electronic operational verification only. The FSS sytem electronics operated satisfactorily.

9.2.4.7 Operation at standard conditions: The chamber was returned to laboratory ambient conditions and the performance tests were repeated. All functions returned to values close to those of the pretest. Inspection of all components indicated that no physical damage had occurred. Operation was satisfactory.

9.2.5 Electromagnetic compatibility - The EMC tests were satisfactorily completed as discussed in the EMC Qualification Tests Results of Document D3-11404-2. A copy of the Pass/Fail Summary is shown in Table 9-I. The FSS electronic unit met the requirements of MIL-STD-461A except for CE03/04 and RE02 NB. A 1 μf_d capacitor was installed from the +28V DC power supply input to the chassis ground and the FSS subsequently passed all CE03/04 tests. The FSS passed the RE02 NB test through an additional relaxation of the specification.

9.2.6 Final performance - This test demonstrated that the FSS system after being subjected to the required flight assurance testing meets the requirements to provide the flutter suppression and is ready for installation in the ARW-1 wing and BQM-34E/F test aircraft. The results are recorded on Data Sheets 4.6-1 through 4.6-5 found in Appendix A of Document D3-11473-1.

TABLE 9-I

PASS-FAIL SUMMARY OF EMC TEST RESULTS

Test	MIL-STD-461A Test Requirements	Revised Requirements
CE03 BB	Passed*	N/A
CE03 NB	Passed*	N/A
CE04 BB	Passed	Passed
CE04 NB	Passed*	N/A
CS01	Passed	N/A
CS02	Passed	N/A
CS06	Passed	N/A
RE02 BB	Passed	N/A
RE02 NB	Failed	Passed
RS03	Passed	N/A

*FSS Electronic Unit passed after 1 μf capacitor was installed.

10.0 REVISED FSS CONTROL LAW

This section presents a revised FSS control law and predicted flutter results for the ARW-1 vehicle using a revised unsteady aerodynamic mathematical model based on inflight and ground vibration test (GVT) results.

Results from the first ARW-1 free flight indicated that the flutter mode was predominantly wing first vertical bending rather than wing torsion as predicted by analysis. The predicted frequency of the antisymmetric wing first bending mode from the mathematical model was also lower than the ground vibration test results. The antisymmetric first bending mode GVT frequency was 14 Hertz compared to 12.5 Hertz from the mathematical model. The symmetric first bending mode frequencies from the math model and GVT were approximately the same. The antisymmetric first bending frequency was increased to 14 Hertz in the math model but the flutter mode was still the torsion mode rather than the first bending mode. NASA's unsteady aerodynamic model (with the GVT frequency for the wing first antisymmetric bending mode included in the structural model) predicted that the flutter mode was predominantly wing vertical bending rather than torsion. Based on the better correlation with flight test results, NASA's math model was used to revise the FSS control law.

Figure 10-1 presents the symmetric and antisymmetric flutter boundaries for the ARW-1 vehicle using NASA's equations of motion with the GVT antisymmetric bending mode frequency included. The flutter Mach number at 3048 meters (10 000 feet) altitude is 0.761 as shown. The Mach number corresponding to a 20 percent increase in flutter speed is 0.913.

A block diagram of the revised FSS control law with notch filters is presented on Figure 10-2. The notch filters shown here are required to compensate the higher frequency structural modes, other notch filters were required in the servoactuator. The antisymmetric gain and filter frequency is scheduled as a function of dynamic pressure (q). Figure 10-3 shows the relationship between the scheduled parameter and dynamic pressure.

Tables 10-I and 10-II show flutter mode damping ratios and frequencies associated with Mach number and altitude for symmetric and antisymmetric with FSS "on" and "off." The minimum symmetric flutter mode damping ratio with FSS is 0.037 for Mach 0.95 at an altitude of 3048 meters (10 000 feet). The minimum damping ratio for the antisymmetric mode is 0.017 and occurs for Mach 0.80 at an altitude of 3048 meters (10,000 feet).

Plots of the flutter mode damping ratio and frequency corresponding to the data in Tables 10-I and 10-II are presented on Figures 10-4 through 10-9. The damping ratio plots on Figures 10-4 and 10-7 with FSS for symmetric and antisymmetric depict a minimum near Mach 0.8 at 3048 meters (10 000 feet) altitude. This minimum results from the flutter mode pole and zero for the selected sensor and surface being very close to the imaginary axis on the S-plane. These plots show that the revised control law provides at least 20 percent increase in the flutter speed.

Table 10-III presents the FSS symmetric and antisymmetric phase and gain margins for the revised control law. The FSS gain and phase margins exceed the criteria of ± 6 dB and ± 0.524 rad (± 30 degrees) at V_f and stable at nominal gain at 1.2 V_f using a linear interpolation between V_f and 1.2 V_f.

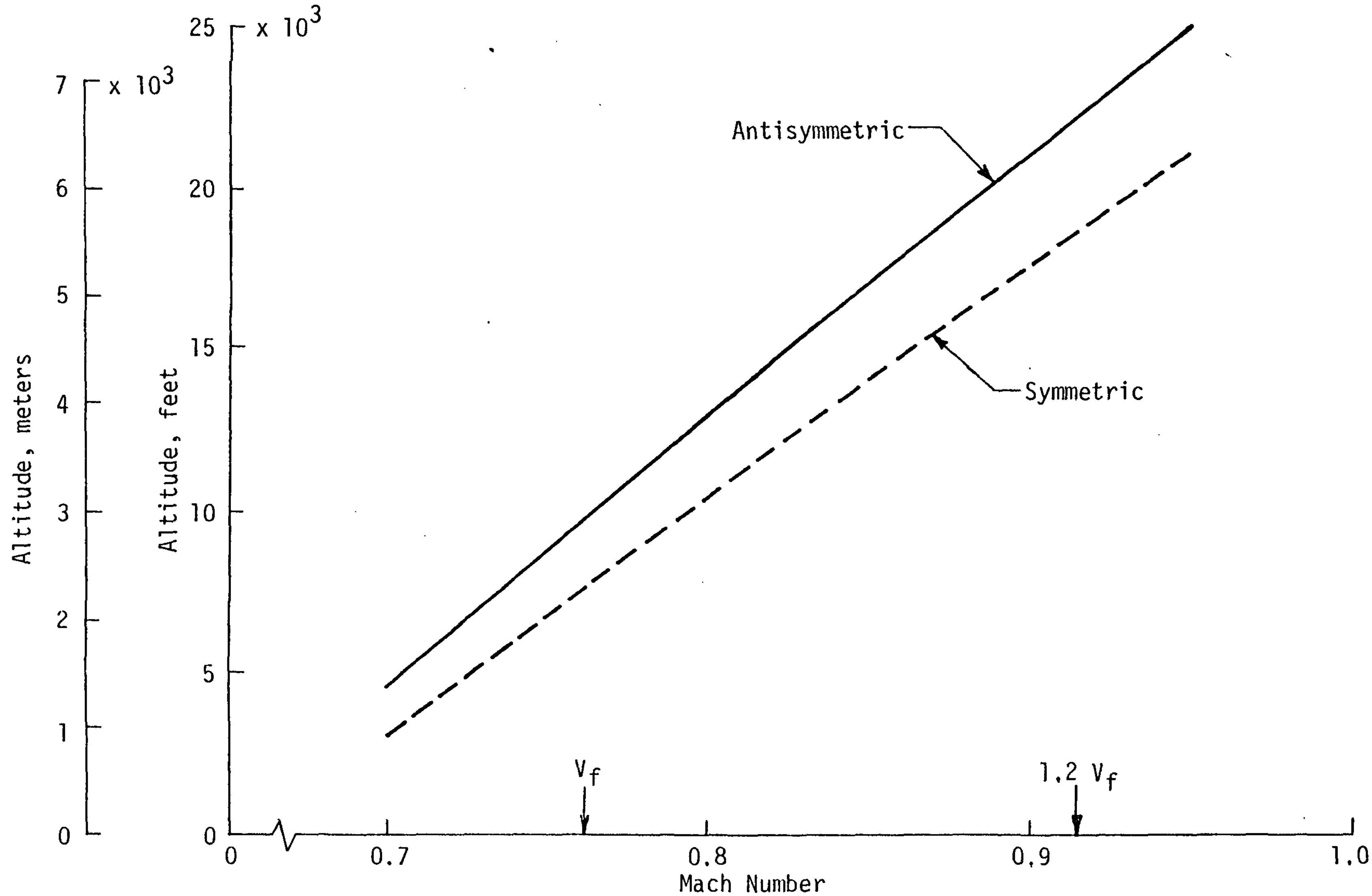
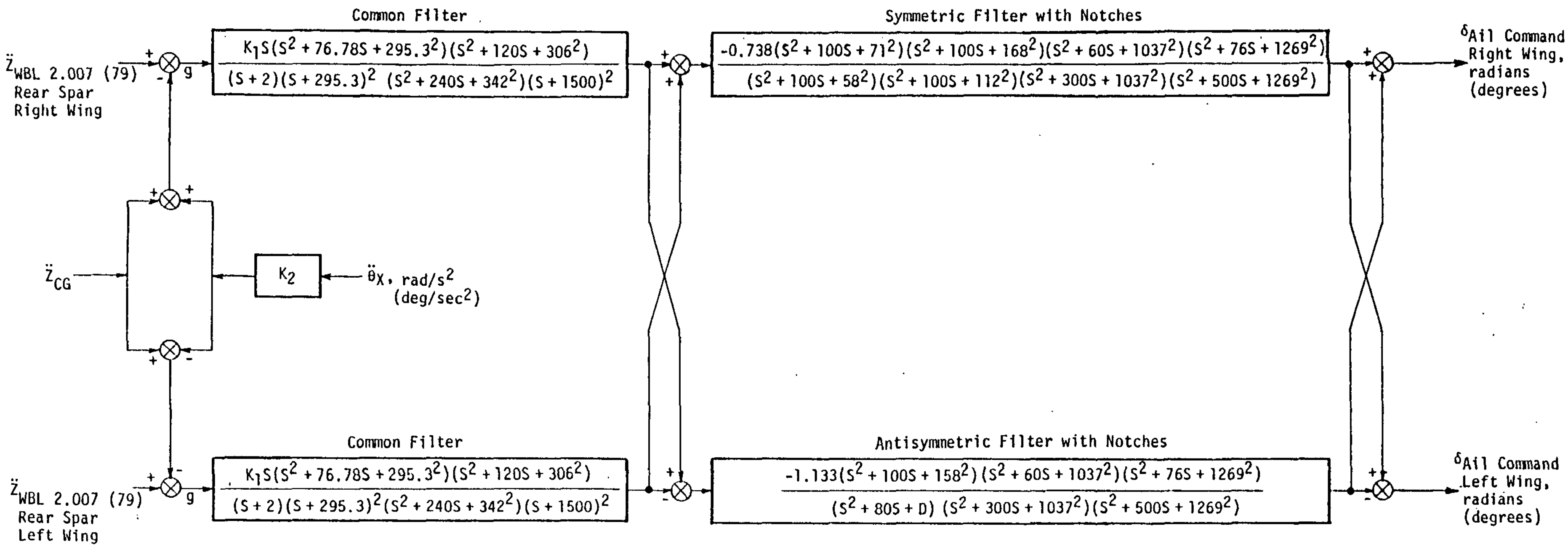


FIGURE 10-1 - DAST ARW-1 FLUTTER BOUNDARIES USING NASA'S UNSTEADY AERODYNAMIC MODEL



$D = -35q + 49\ 000$

D limited to 14 000 to 24 000

q, psf

$K_1 = 3.93 \times 10^4$ rad/g (2.25×10^6 deg/g)

$K_2 = 6.28 \times 10^{-5}$ (0.0036)

FIGURE 10-2 - DAST ARW-1 FLUTTER SUPPRESSION SYSTEM USING NASA EQUATIONS

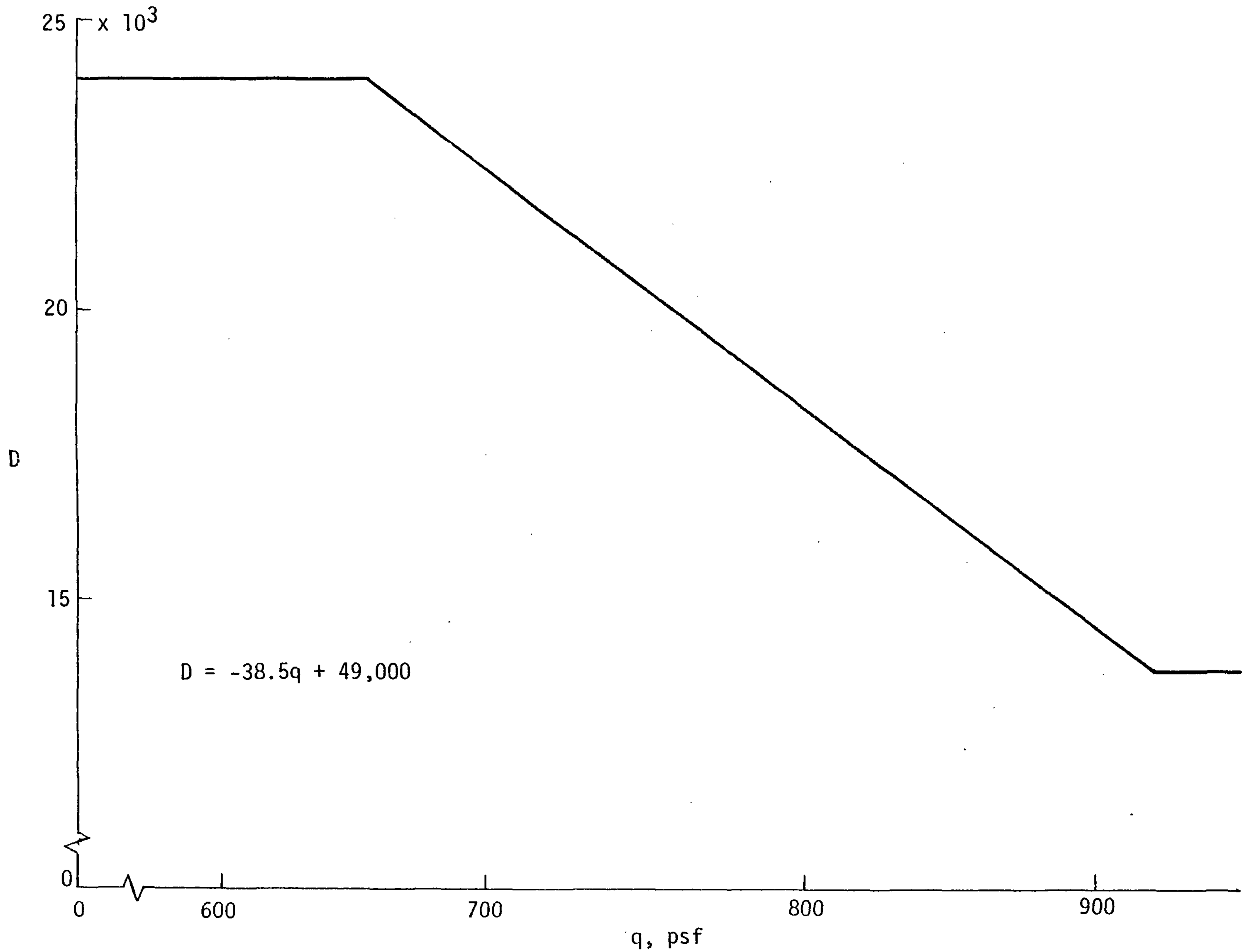


FIGURE 10-3 - ANTISYMMETRIC FILTER SCHEDULING

TABLE 10-I

SYMMETRIC FLUTTER MODE DAMPING RATIO AND FREQUENCY

Mach No.	Altitude	FSS On		FSS Off	
		Damping Ratio	Frequency	Damping Ratio	Frequency
0.70	3048 m (10 000 ft)	0.634	10.6 Hz	0.074	14.0 Hz
	5182 m (17 000 ft)	0.627	10.3 Hz	0.062	12.6 Hz
	7620 m (25 000 ft)	0.459	8.0 Hz	0.048	11.6 Hz
0.80	3048 m (10 000 ft)	0.039	23.1 Hz	0.051	17.3 Hz
	5182 m (17 000 ft)	0.634	10.5 Hz	0.054	14.1 Hz
	7620 m (25 000 ft)	0.476	7.3 Hz	0.048	12.5 Hz
0.90	3048 m (10 000 ft)	0.099	19.6 Hz	-0.180	19.0 Hz
	5182 m (17 000 ft)	0.061	22.1 Hz	0.030	17.9 Hz
	7620 m (25 000 ft)	0.629	10.3 Hz	0.039	14.4 Hz
0.95	3048 m (10 000 ft)	0.037	13.5 Hz	-0.245	19.3 Hz
	5182 m (17 000 ft)	0.088	20.8 Hz	-0.075	17.9 Hz
	7620 m (25 000 ft)	0.628	10.3 Hz	0.026	14.4 Hz

TABLE 10-II

ANTISYMMETRIC FLUTTER MODE DAMPING RATIO AND FREQUENCY

Mach No.	Altitude	FSS On		FSS Off	
		Damping Ratio	Frequency	Damping Ratio	Frequency
0.70	3048 m (10 000 ft)	0.267	11.8 Hz	0.039	17.2 Hz
	5182 m (17 000 ft)	0.242	12.3 Hz	0.034	16.1 Hz
	7620 m (25 000 ft)	0.197	12.8 Hz	0.026	15.4 Hz
0.80	3048 m (10 000 ft)	0.017	23.7 Hz	-0.063	19.8 Hz
	5182 m (17 000 ft)	0.268	11.8 Hz	0.028	17.4 Hz
	7620 m (25 000 ft)	0.233	12.3 Hz	0.028	16.0 Hz
0.90	3048 m (10 000 ft)	0.055	20.6 Hz	-0.194	20.0 Hz
	5182 m (17 000 ft)	0.048	22.8 Hz	-0.067	19.4 Hz
	7620 m (25 000 ft)	0.273	12.0 Hz	0.018	17.1 Hz
0.95	3048 m (10 000 ft)	0.127	18.0 Hz	-0.240	20.1 Hz
	5182 m (17 000 ft)	0.070	21.1 Hz	-0.127	19.7 Hz
	7620 m (25 000 ft)	0.286	12.0 Hz	-0.001	17.9 Hz

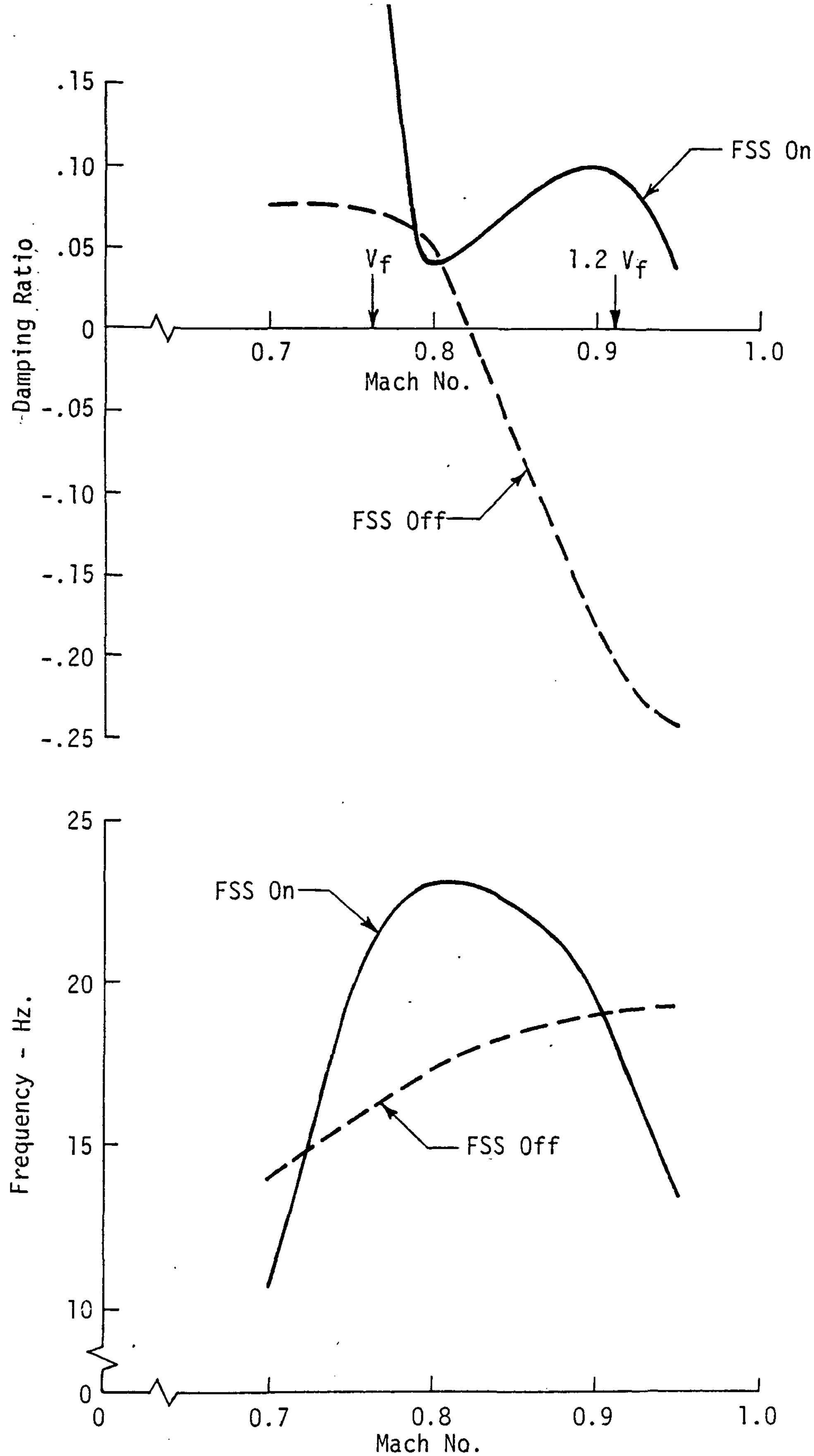


FIGURE 10-4 - SYMMETRIC FLUTTER MODE DAMPING RATIO AND FREQUENCY, ALTITUDE = 3048 m (10 000 ft)

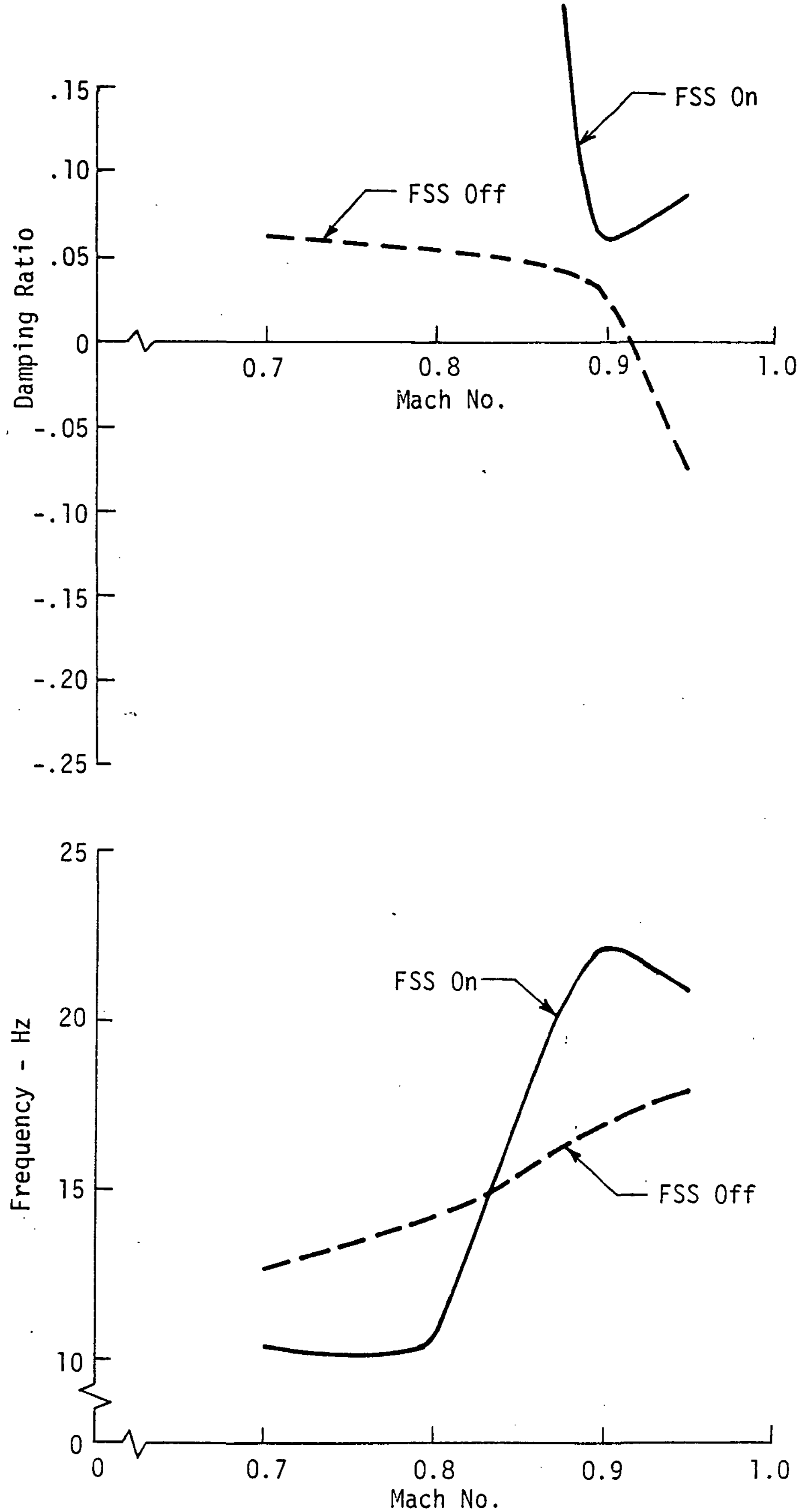


FIGURE 10-5 - SYMMETRIC FLUTTER MODE DAMPING RATIO AND FREQUENCY, ALTITUDE = 5182 m (17 000 ft)

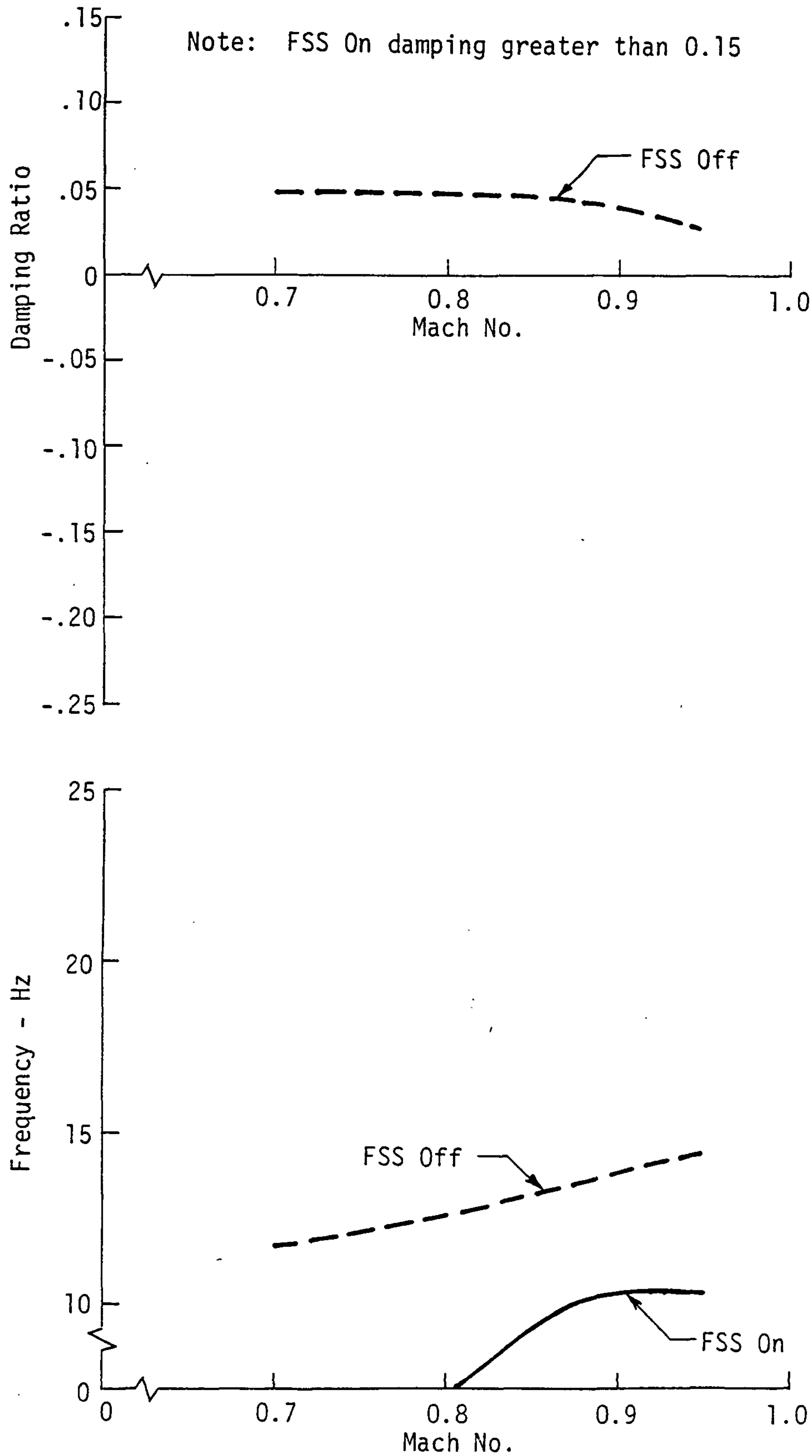


FIGURE 10-6 - SYMMETRIC FLUTTER MODE DAMPING RATIO AND FREQUENCY, ALTITUDE = 7620 m (25 000 ft)

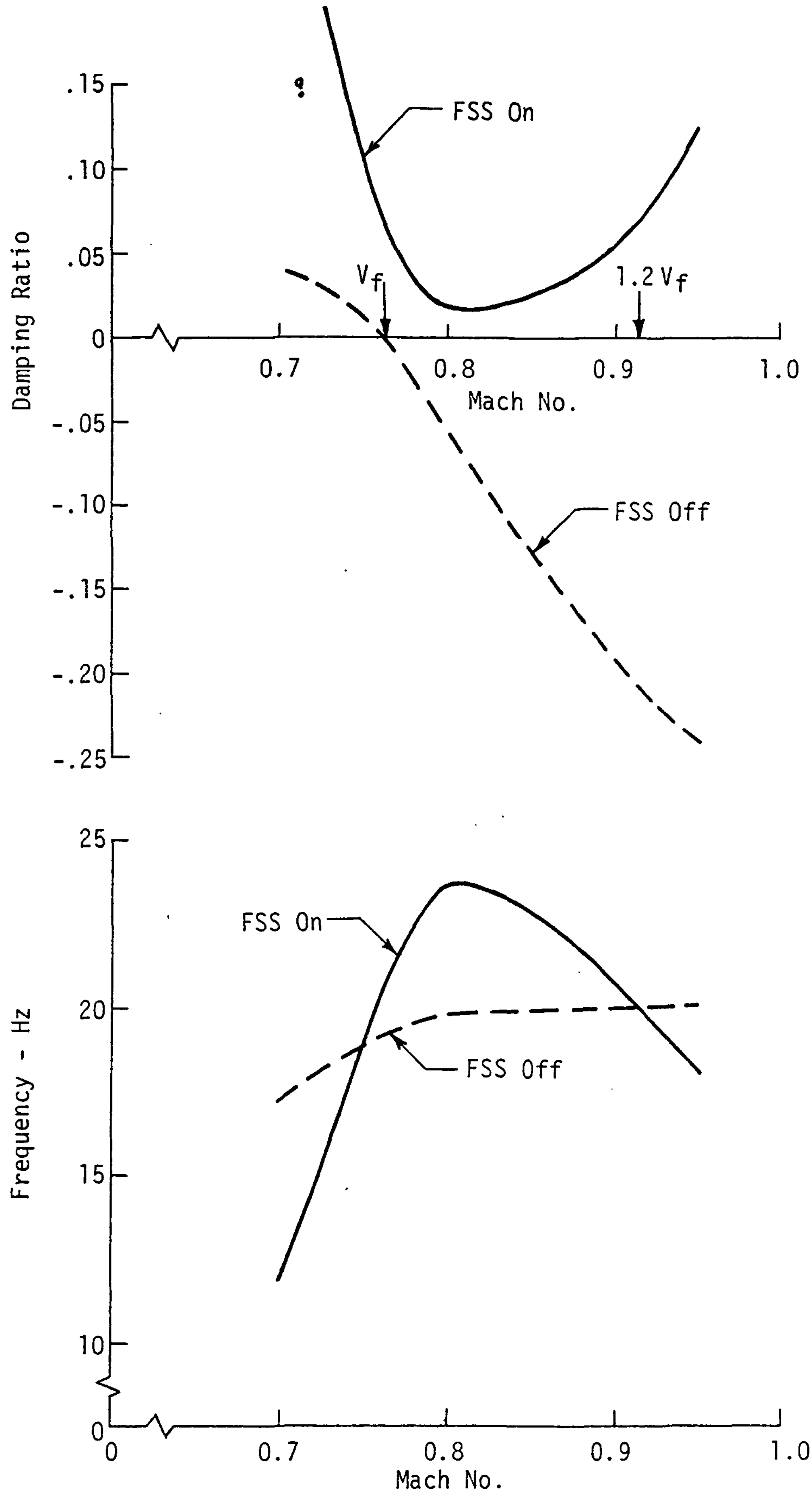


FIGURE 10-7 - ANTISYMMETRIC FLUTTER MODE DAMPING RATIO AND FREQUENCY, ALTITUDE = 3048 m (10 000 ft)

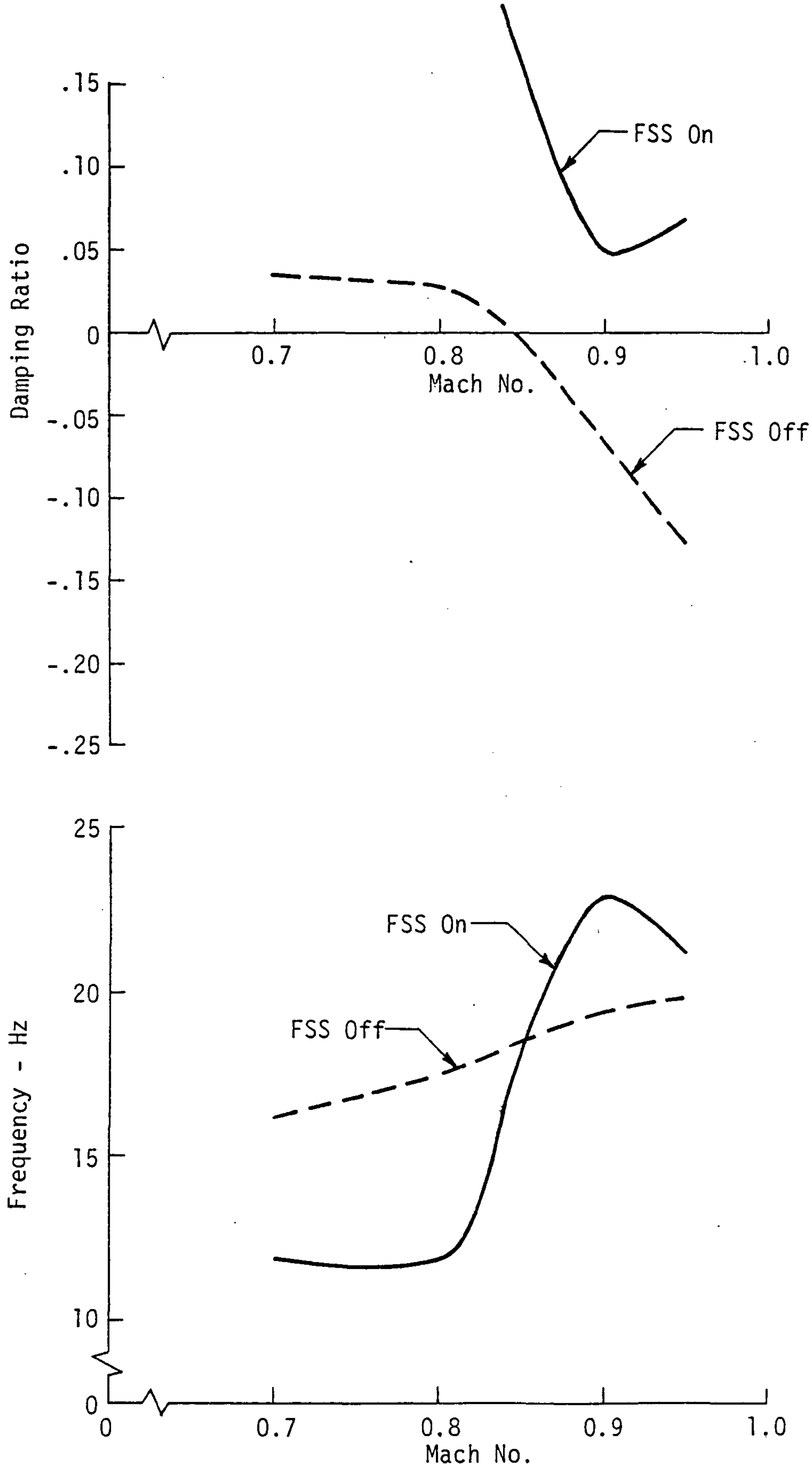


FIGURE 10-8 - ANTISYMMETRIC FLUTTER MODE DAMPING RATIO AND FREQUENCY, ALTITUDE = 5182 m (17 000 ft)

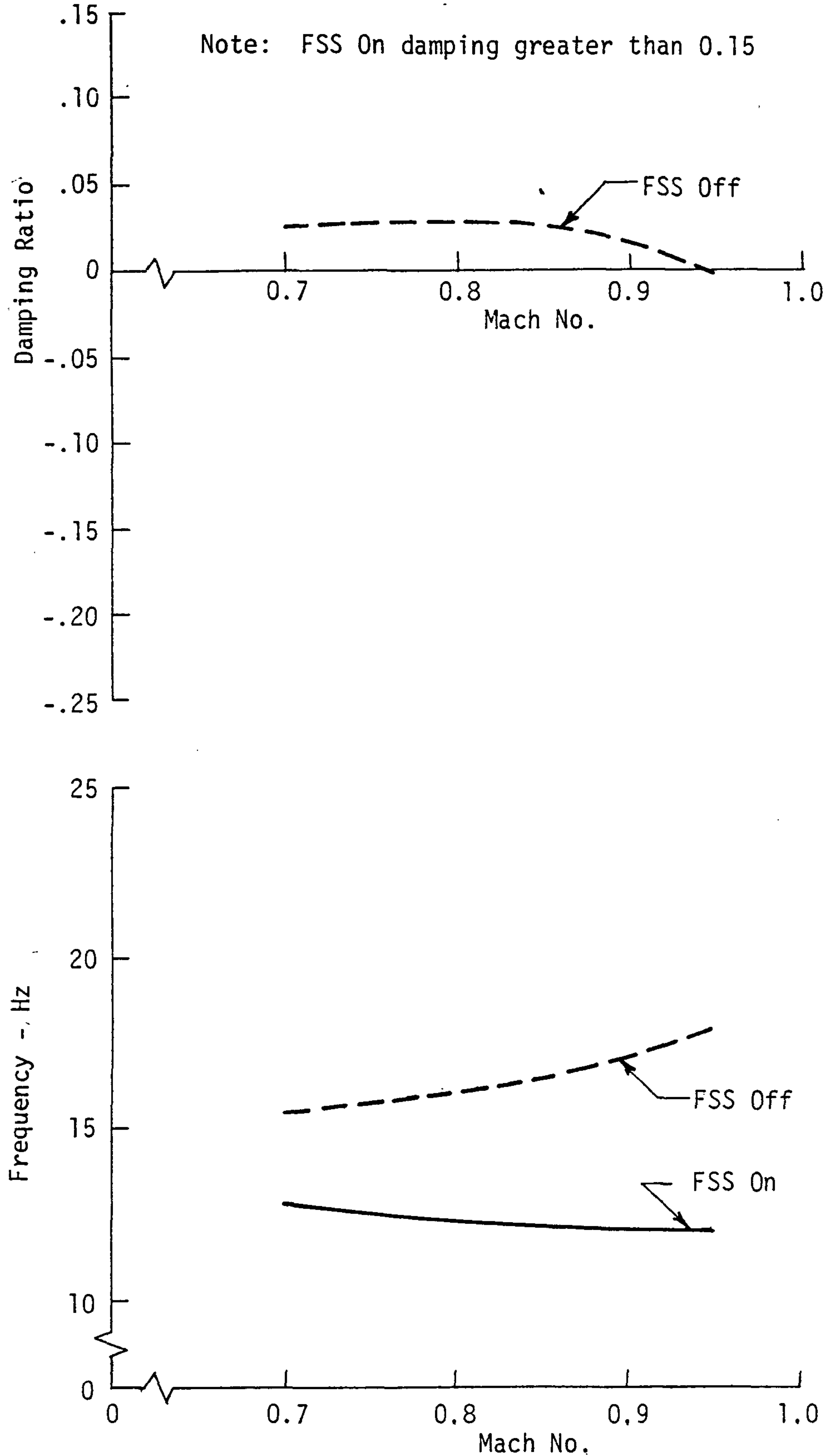


FIGURE 10-9 - ANTISYMMETRIC FLUTTER MODE DAMPING RATIO AND FREQUENCY, ALTITUDE = 7620 m (25 000 ft)

TABLE 10-III

FSS PHASE AND GAIN MARGIN

Mach No.	Altitude	Symmetric		Antisymmetric	
		Gain Margin	Phase Margin	Gain Margin	Phase Margin
0.70	3048 m (10 000 ft)	>±6 dB	>±0.524 rad (>±30 deg)	>±6 dB	>±0.524 rad (>±30 deg)
	5182 m (17 000 ft)	>±6 dB	>±0.524 rad (>±30 deg)	>±6 dB	>±0.524 rad (>±30 deg)
	7620 m (25 000 ft)	>±6 dB	>±0.524 rad (>±30 deg)	>±6 dB	>±0.524 rad (>±30 deg)
0.80	3048 m (10 000 ft)	>±6 dB	>±0.524 rad (>±30 deg)	>±6 dB	>±0.524 rad (>±30 deg)
	5182 m (17 000 ft)	-∞, +11.3 dB	-0.436, +0.524 rad (-25, +30 deg)	>±6 dB	>±0.524 rad (>±30 deg)
	7620 m (25 000 ft)	>±6 dB	>±0.524 rad (>±30 deg)	>±6 dB	>±0.524 rad (>±30 deg)
0.90	3048 m (10 000 ft)	-6.0, +5.7 dB	>±0.524 rad (>±30 deg)	-4.7, +4.2 dB	>±0.524 rad (>±30 deg)
	5182 m (17 000 ft)	-∞, +8.0 dB	>±0.524 rad (>±30 deg)	-20.0, +5.7 dB	>±0.524 rad (>±30 deg)
	7620 m (25 000 ft)	-∞, +6.8 dB	>±0.524 rad (>±30 deg)	-∞, +11.1 dB	>±0.524 rad (>±30 deg)
0.95	3048 m (10 000 ft)	-6.0, +4.0 dB	-0.524, +0.262 rad (-30, +15 deg)	-6.0, +3.5 dB	-0.436, >±0.524 rad (-25, >±30 deg)
	5182 m (17 000 ft)	-6.3, +12.4 dB	>±0.524 rad (>±30 deg)	-8.3, +2.7 dB	>±0.524 rad (>±30 deg)
	7620 m (25 000 ft)	-∞, +8.2 dB	>±0.524 rad (>±30 deg)	-∞, +4.4 dB	>±0.524 rad (>±30 deg)

11.0 CONCLUSIONS AND RECOMMENDATIONS

11.1 Conclusions

Major conclusions resulting from this study are listed below:

1. A flutter suppression system was designed to provide more than 20 percent increase in flutter velocity by working symmetric and antisymmetric flutter modes simultaneously.

2. The flutter suppression system components were purchased or designed and fabricated, and environmentally tested to demonstrate flightworthiness.

3. A single wing flutter suppression system is not capable of controlling flutter on both wing panels, apparently due to lack of coupling from one wing panel to the other through the wing center section.

4. The flutter suppression system filters built up in state variable form on cards with plated through holes and no edge connectors simplified checkout of the electronics and improves reliability of the electronics.

5. Math modeling differences were shown to cause a major impact on design of an effective flutter suppression system, even though the flight condition for predicted stability was nearly identical.

11.2 Recommendations

The recommendations listed below were offered to ensure successful completion of the DAST ARW-1 drone flight test program.

1. The flutter suppression system components should be installed in the ARW-1 wind and BQM-34E/F drone for flight test evaluation of the system.

2. Modifications to the outboard aileron servoactuator compensation and/or the flutter suppression system shaping filters made necessary by the reduced servo-actuator performance capability should be identified and incorporated prior to the flight tests.

12.0 REFERENCES

1. Visor, O.E. and Sevart, F.D., "Preliminary Design Study of Flutter Suppression Control System for the BQM-34E/F Drone Aircraft with a Supercritical Wing," Boeing Document D3-11057-1, July 1, 1976.

2. Edwards, J.W. and Deets, D.A., "Development of a Remote Digital Augmentation System and Application to a Remotely Piloted Research Vehicle," NASA TN D-7941, 1975.

3. McGehee, C.R. and Sevart, F.D., "Flight Assurance Test Report for the Flutter Suppression System for BQM-34E/F Drone with ARW-1 Wing," Boeing Document D3-11473-1, March 9, 1979.

4. Lallement, L.D., "EMC Qualification Test Results for the Flutter Suppression System Electronic Unit for BQM-34E/F Drone with ARW-1 Wing," Boeing Document D3-11404-2, January 3, 1979.

5. McGehee, C.R., "Flight Assurance Test Procedures for the ARW-1 Flutter Suppression System (Firebee II Drone)," Boeing Document D3-11443-1, November 27, 1978.

6. Jensen, J.W. and Walls, J.J., "EMC Qualification Test Procedures for the Flutter Suppression System (Firebee II Drone)," Boeing Document D3-11404-1, June 6, 1978.

7. McGehee, C.R. and Sevart, F.D., "Maintenance and Operating Instructions for the Flutter Suppression System for BQM-34E/F Drone with ARW-1 Wing," Boeing Document D3-11474-1, March 13, 1979.

8. Hull, D.L., Matthew, J.R. and Sevart, F.D., "DAST ARW-1 Wind Tunnel Model Analyses and Test Support - Final Report," Boeing Document D3-11412-1, July 25, 1978.

9. Annon, "Integrated Design of a High Aspect Ratio Research Wing with an Active Control System for Flight Tests on a BQM-34E/F Drone Vehicle," Boeing Document D3-11535-1, Volume I, June 25, 1979.

10. Re, R.J., "Stability and Control Characteristics, Including Aileron Hinge Moments of a Model of a Supercritical Wing Research Airplane," NASA TM X-2020, 1974.

11. Morse, A.C., "Electrohydraulic Servomechanisms," McGraw-Hill Book Company, 1963, pp. 71-76.

12. Sevart, F.D., Wattman, W.J. and Patel. S.M., "Analysis and Testing of Stability Augmentation Systems - Final Report," Boeing Document D3-8884 (Also Available as NASA-CR-132349), June 13, 1972.

13. Sevart, F.D. and Patel, S.M., "Analysis and Testing of Aeroelastic Model Stability Augmentation Systems - Final Report," Boeing Document D3-9245 (Also Available as NASA-CR-132345), October 15, 1973.

14. Thayer, W.J., "Transfer Functions for Moog Servovalves," Moog Technical Bulletin 103, December 1958, Revised January 1965.

15. Annon, "Flight Assurance Testing (Environmental) - Electrical, Electronic and Electromechanical Equipment," NASA Dryden Flight Research Center Process Specification No. 21-2, February 11, 1974.

APPENDIX A

MATHEMATICAL MODELS FOR DAST WITH ARW-1

The aerodynamic paneling and structural mathematical model used in the drone equations of motion are presented in this appendix. The aerodynamic panel idealizations for the wing, stabilizer and fin are shown on Figures A-1 and A-2. The NASTRAN bulk data for the structural model (symmetric analysis) are presented in Table A-I. The mode shapes and frequencies for the symmetric and antisymmetric structural models are presented on Figures A-3 through A-22.

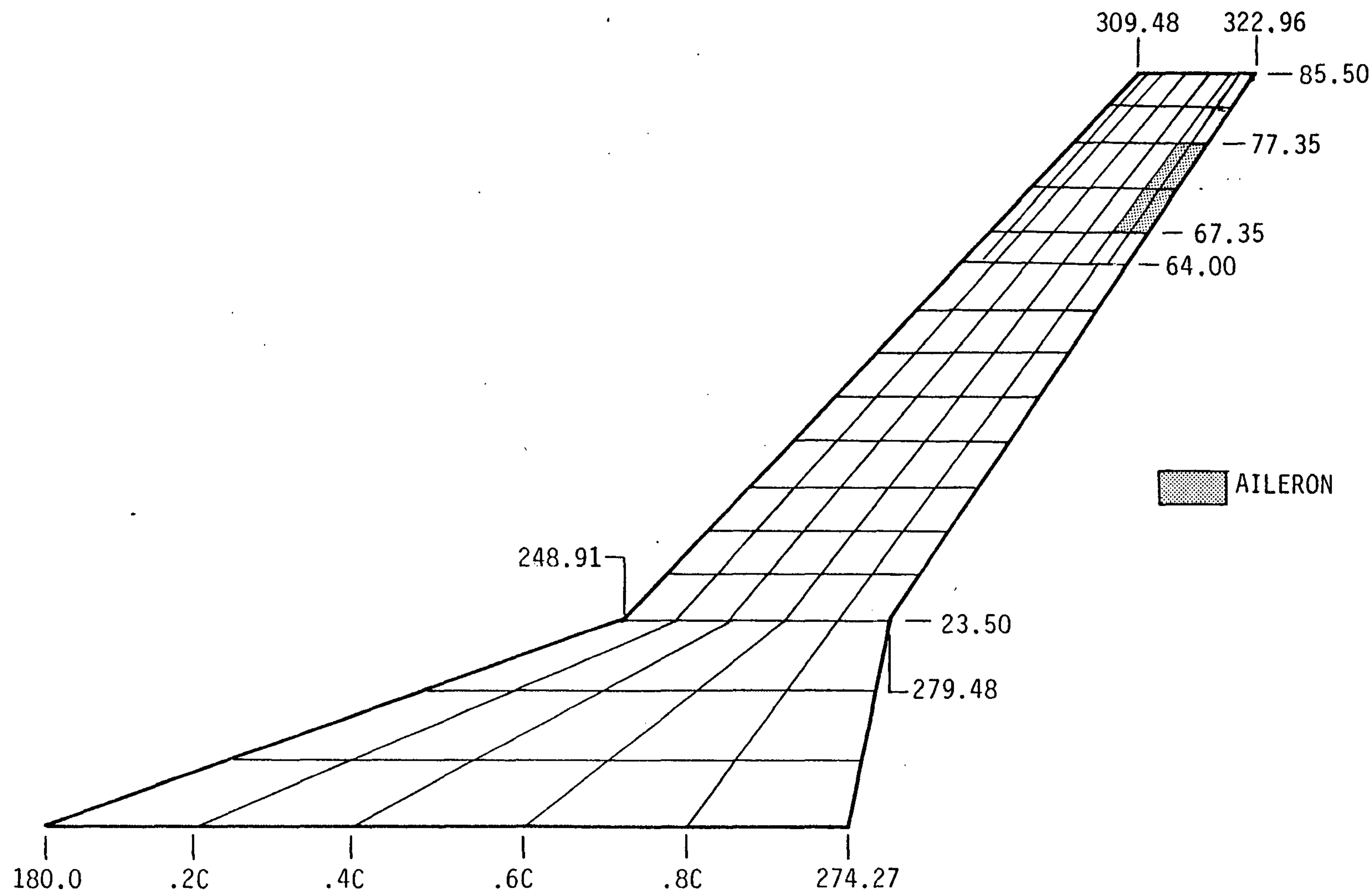


FIGURE A-1 - WING AERODYNAMIC PANEL IDEALIZATION

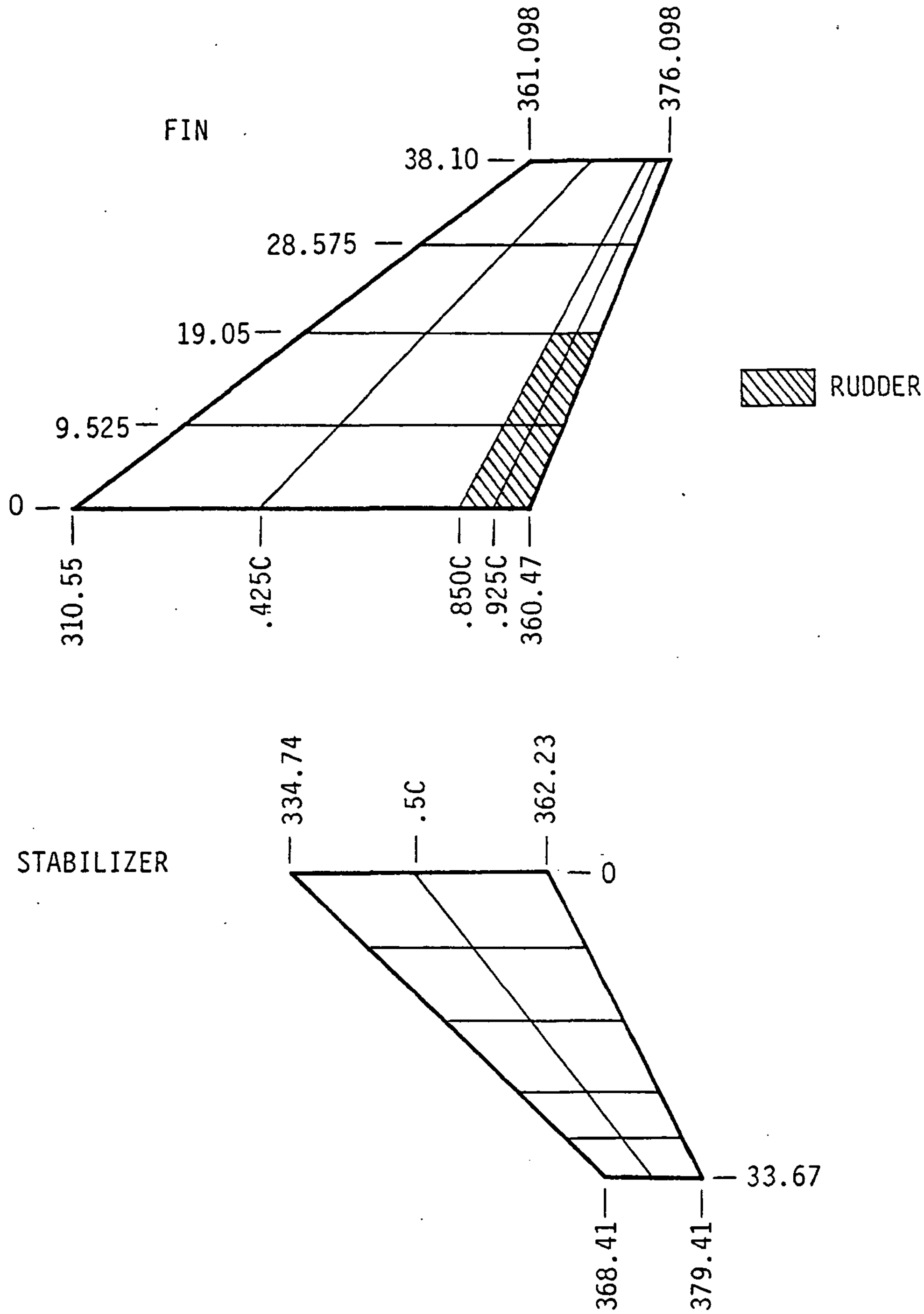


FIGURE A-2 - FIN AND STABILIZER AERODYNAMIC PANEL IDEALIZATION

TABLE A-I

NASTRAN BULK DATA

ASET1	13	201	203	205	207				
ASET1	23	307	308						
ASET1	123	1	6	9	13	25	29	30	+C100059
+C10005930		41	46	49	53	61	66	69	+C100060
+C10006073		81	86	89	93	101	106	109	+C100061
+C100061113		121	126	129	133	141	146	149	+C100062
+C100062165		166	169	170					
ASET1	123	401	403	405	407				
ASET1	135	1001	1003	1005	1007	1009			
ASET1	135	2110	2140	2170	2200	2230	2260	2290	
ASET1	135	2320	2337	2370	2400				
CBAR	306	601	302	305	301	0	0	2	
CBAR	307	601	301	302	305	0	0	2	
CBAR	308	601	302	303	305	0	0	2	
CBAR	309	601	304	305	302	0	0	2	
CBAR	310	601	305	306	302	0	0	2	
CBAR	601	601	602	603	607			2	+CBAR601
+CBAR601456									
CBAR	602	601	604	603	607			2	+CBAR602
+CBAR602456									
CBAR	603	601	606	607	603			2	+CBAR1
+CBAR1	456								
CBAR	604	601	608	607	603			2	+CBAR2
+CBAR2	456								
CBAR	605	601	603	607	602			2	
CBAR	1701	1751	2240	2250	2500			2	
CBAR	1703	1753	2250	2260	2500			2	
CBAR	1705	1755	2260	2270	2500			2	
CBAR	1708	1758	2270	2280	2500			2	
CBAR	1801	1851	2330	2337	2500			2	
CBAR	1802	1852	2337	2340	2500			2	
CBAR	1803	1853	2337	1001	2500			2	
CBAR	4000	1	165	174	145			2	+B1
+B1	456	4							
CBAR	4001	1	166	174	146			2	+B2
+B2	456	4							
CBAR	4002	1	169	176	149			2	+B3
+B3	456	4							
CBAR	4003	1	170	176	150			2	+B4
+B4	456	4							
CBAR	4005	2	174	176	242			2	
CBAR	4006	3	174	202	242			2	
CBAR	4007	4	174	201	242			2	
CBAR	4008	3	200	201	242			2	
CBAR	4009	3	201	202	242			2	
CBAR	4010	3	203	204	242			2	
CBAR	4011	3	204	205	242			2	
CBAR	4012	3	205	206	242			2	
CBAR	4013	3	206	207	242			2	
CBAR	4014	3	207	208	242			2	
CBAR	4015	3	201	242	243			2	
CBAR	4016	3	202	242	243			2	
CBAR	4017	3	202	243	242			2	
CBAR	4018	5	223	225	242			2	
CBAR	4019	5	225	226	242			2	
CBAR	4020	5	226	227	242			2	
CBAR	4021	3	242	243	201			2	
CBAR	4022	5	243	245	201			2	
CBAR	4023	5	245	246	201			2	
CBAR	4024	5	246	247	201			2	
CBAR	4025	3	203	223	242			2	
CBAR	4026	5	205	225	242			2	
CBAR	4027	5	206	226	242			2	
CBAR	4028	5	207	227	242			2	
CBAR	4029	3	223	243	242			2	
CBAR	4030	5	225	245	242			2	
CBAR	4031	5	226	246	242			2	
CBAR	4032	5	227	247	242			2	

TABLE A-I

NASTRAN BULK DATA (CONTINUED)

CBAR	8001	8051	2360	401	2500			2	
CBAR	8002	8052	401	402	410			2	
CBAR	8003	8053	402	403	410			2	
CBAR	8004	8054	403	404	410			2	
CBAR	8005	8055	404	405	410			2	
CBAR	8006	8056	405	406	410			2	
CBAR	8007	8057	406	407	410			2	
CBAR	8008	8058	407	408	410			2	
CBAR	15001	15101	1001	1002	1011			2	
CBAR	15002	15102	1002	1003	1011			2	
CBAR	15003	15103	1003	1004	1011			2	
CBAR	15004	15104	1004	1005	1011			2	
CBAR	15005	15105	1005	1006	1011			2	
CBAR	15006	15106	1006	1007	1011			2	
CBAR	15007	15107	1007	1008	1011			2	
CBAR	15008	15108	1008	1009	1011			2	
CBAR	15009	15109	1009	1010	1011			2	
CBAR	17001	17101	2100	2110	2500			2	
CBAR	17002	17102	2110	2120	2500			2	
CBAR	17003	17103	2120	2130	2500			2	
CBAR	17004	17104	2130	2140	2500			2	
CBAR	17005	17105	2140	2150	2500			2	
CBAR	17006	17106	2150	2160	2500			2	
CBAR	17007	17107	2160	2170	2500			2	
CBAR	17008	17108	2170	2180	2500			2	
CBAR	17009	17109	2180	2190	2500			2	
CBAR	17010	17110	2190	2200	2500			2	
CBAR	17011	17111	2200	2210	2500			2	
CBAR	17012	17112	2210	2220	2500			2	
CBAR	17013	17113	2220	2230	2500			2	
CBAR	17014	17114	2230	2240	2500			2	
CBAR	17019	17119	2280	2290	2500			2	
CBAR	17020	17120	2290	2300	2500			2	
CBAR	17021	17121	2300	2310	2500			2	
CBAR	17022	17122	2310	2320	2500			2	
CBAR	17023	17123	2320	2330	2500			2	
CBAR	17024	17124	2330	2340	2500			2	
CBAR	17025	17125	2340	2350	2500			2	
CBAR	17026	17126	2350	2360	2500			2	
CBAR	17027	17127	2360	2370	2500			2	
CBAR	17028	17128	2370	2380	2500			2	
CBAR	17029	17129	2380	2390	2500			2	
CBAR	17030	17130	2390	2400	2500			2	
CBAR	17031	17131	2400	2410	2500			2	
CONM2	700	29	0	2.	9.038	1.45	.19		+C3
+C3	.2579	.0	6.125	.0	.0	6.125			
CONM2	701	29	0	.196	6.9	1.45	.06		
CONM2	702	29	0	.051	5.9	1.45	-.01		
CONM2	703	29	0	.256	4.55	1.45	-.12		
CONM2	704	29	0	.155	3.45	1.45	-.18		
CONM2	705	29	0	.06	2.55	1.45	-.25		
CONM2	706	29	0	.12	.55	1.45	-.38		
CONM2	707	29	0	.065	1.45	1.45	-.32		
CONM2	708	29	0	.068	3.7	1.45	-.17		
CONM2	709	29	0	.009	5.8	1.45	-.02		
CONM2	710	45	0	.0121	-4.	-2.			
CONM2	711	65	0	.0242	1.5	3.9			
CONM2	712	65	0	.0273	-1.3	.8			
CONM2	713	65	0	.0318	-4.	-2.			
CONM2	714	85	0	.0505	1.5	3.9			
CONM2	715	85	0	.0568	-1.2	.8			
CONM2	716	85	0	.0565	-3.9	-2.1			
CONM2	717	105	0	.0795	1.8	4.2			
CONM2	718	105	0	.1318	-.9	1.3			
CONM2	719	105	0	.1171	-3.7	-1.8			
CONM2	720	125	0	.1944	1.4	3.5			
CONM2	721	125	0	.1590	-1.5	.5			
CONM2	722	125	0	.1590	-3.7	-1.8			

TABLE A-I

NASTRAN BULK DATA (CONTINUED)

CONM2	723	145	0	.2201	1.8	4.1			
CONM2	724	145	0	.3231	1.2	.6			
CONM2	725	165	0	.3231	3.3	5.6			
CONM2	726	165	0	.3231	.0	2.1			
CONM2	727	165	0	.3231	-3.3	-1.6			
CONM2	728	201	0	.3231	.6	2.4			
CONM2	729	201	0	.3231	-2.9	-1.1			
CONM2	730	201	0	.4523	-6.8	-5.6			
CONM2	731	145	0	.399	.7	3.			
CONM2	732	145		.392	3.1	5.5			
CONM2	733	125		.282	-.4	1.6			
CONM2	734	125		.392	2.9	5.6			
CONM2	735	105		.28	.4	2.7			
CONM2	736	105		.273	3.1	5.6			
CONM2	737	85		.152	-2.8	-.8			
CONM2	738	85		.146	2.9	5.4			
CONM2	739	65		.13	-2.8	-1.0			
CONM2	740	65		.13	3.1	5.4			
CONM2	741	45		.121	-2.4	-.6			
CONM2	750	49	0	.125	2.1	.13	-.6		
CONM2	751	50	0	.125	2.1	.13	.6		
CONM2	4001	1001	11	1.	0.0	-4.3	0.0		CON4001
+ON4001	26.9								
CONM2	4002	1002	11	2.	0.0	-2.2	0.0		CON4002
+ON4002	31.2								
CONM2	4003	1003	11	2.	0.0	-.7	0.0		CON4003
+ON4003	34.75								
CONM2	4004	1004	11	2.	0.0	2.1	0.0		CON4004
+ON4004	88.8								
CONM2	4005	1005	11	1.8	0.0	4.1944	0.0		CON4005
+ON4005	116.7								
CONM2	4006	1006	11	1.25	0.0	4.92	0.0		CON4006
+ON4006	71.65								
CONM2	4007	1007	11	.85	0.0	3.5882	0.0		CON4007
+ON4007	33.								
CONM2	4008	1008	11	.55	0.0	1.9091	0.0		CON4008
+ON4008	13.								
CONM2	4009	1009	11	.35	0.0	1.1429	0.0		CON4009
+ON4009	6.25								
CONM2	4010	1010	11	.15	0.0	3.6667	0.0		CON4010
+ON4010	3.2								
CONM2	4011	401	10	1.92	0.0	.6823	0.0		CON4011
+ON4011	11.406		2.56						
CONM2	4012	402	10	1.588	0.0	2.519	0.0		CON4012
+ON4012	19.544		2.12						
CONM2	4013	403	10	1.335	0.0	1.978	0.0		CON4013
+ON4013	15.368		1.78						
CONM2	4014	404	10	1.080	0.0	1.417	0.0		CON4014
+ON4014	11.482		1.44						
CONM2	4015	405	10	.868	0.0	.887	0.0		CON4015
+ON4015	8.627		1.16						
CONM2	4016	406	10	.702	0.0	.1567	0.0		CON4016
+ON4016	6.623		.94						
CONM2	4017	407	10	.553	0.0	-.5425	0.0		CON4017
+ON4017	4.987		.74						
CONM2	4018	408	10	.245	0.0	-1.306	0.0		CON4018
+ON4018	1.662		.33						
CONM2	1002110	2110		10.	-8.				XX100211
+X100211	270.69		218.29			218.29			
CONM2	1002120	2120		21.437					XX100212
+X100212	270.69		218.29			218.29			
CONM2	1002130	2130		8.324					XX100213
+X100213	270.69		218.29			218.29			
CONM2	1002140	2140		20.377					XX100214
+X100214	270.69		218.29			218.29			
CONM2	1002150	2150		10.4895					XX100215
+X100215	270.69		218.29			218.29			
CONM2	1002160	2160		28.7835					XX100216

TABLE A-I

NASTRAN BULK DATA (CONTINUED)

```
+X100216870.48          14.1039                 14.1039
CONM2   1002170 2170            20.3205                                         XX100217
+X100217812.475         195.28                  195.28
CONM2   1002180 2180            18.8115                                         XX100218
+X100218833.38          706.6229                706.6229
CONM2   1002190 2190            21.03                                           XX100219
+X1002191144.12         603.0197                603.0197
CONM2   1002200 2200            33.7356                                         XX100220
+X1002201272.09         624.7932                624.7932
CONM2   1002210 2210            14.7108                                         XX100221
+X1002211772.495        561.1227                561.1227
CONM2   1002220 2220            24.8607                                         XX100222
+X1002222455.45         925.5311                925.5311
CONM2   1002230 2230            31.3672                                         XX100223
+X1002233026.57         863.409                 863.409
CONM2   1002240 2240            31.0975 -2.3                                    XX100224
+X1002243186.54         216.9025                216.9025
CONM2   1002280 2280            19.651                                          XX100228
+X1002282059.27         38.516                  38.516
CONM2   1002290 2290            9.247                                           XX100229
+X1002291103.55         353.6873                353.6873
CONM2   1002300 2300            214.702                                         XX100230
+X1002301 2421.68       201.5102                201.5102
CONM2   1002310 2310            12.0355                                         XX100231
+X100231752.59          1078.872                1078.872
CONM2   1002320 2320            58.7145                                         XX100232
+X1002321320.41         8.0712                  8.0712
CONM2   1002330 2330            17.3275                                         XX100233
+X1002331367.655        62.53                   62.53
CONM2   1002340 2340            12.4815                                         XX100234
+X1002341713.695        333.2733                333.2733
CONM2   1002350 2350            8.792                                           XX100235
+X1002352549.05         612.721                 612.721
CONM2   1002360 2360            18.784                                          XX100236
+X1002363936.16         210.2174                210.2174
CONM2   1002370 2370            19.382                                          XX100237
+X100237592.85          584.8278                584.8278
CONM2   1002380 2380            31.620                                          XX100238
+X100238911.09          323.1961                323.1961
CONM2   1002390 2390            12.3800                                         XX100239
+X100239232.925         143.6738                143.6738
CONM2   1002400 2400            11.2700                                         XX100240
+X100240205.49          248.5268                248.5268
CONM2   1002410 2410            4.8600                                          XX100241
+X10024163.585          17.106                  17.106
CONM2   1012250 2250    0       96.092  -2.6    .0      .0                      XX101225
+X10122510925.38        1917.336                1917.336
CONM2   1012260 2260    0       50.844  1.1     .0      .0                      XX101226
+X10122661817.06        1249.555                1249.555
CONM2   1012270 2270    0       17.05   5.95    .0      .0                      XX101227
+X1012275049.44         292.8614                292.8614
CONROD  125     602     606     3       .186
CONROD  126     604     608     3       .186
CONROD  127     606     51      3       .186
CONROD  128     608     52      3       .186
CONROD  129     31      602     3       .186
CONROD  130     32      604     3       .186
CONROD  131     606     49      3       .1
CONROD  132     608     50      3       .1
CONROD  133     602     601     2       .005
CONROD  134     604     601     2       .005
CONROD  135     606     609     2       .005
CONROD  136     608     609     2       .005
CONROD  137     29      602     3       .1
CONROD  138     30      604     3       .1
CONROD  141     33      601     3       .182
CONROD  142     609     53      3       .182
CONROD  2000    1       21      3       .060
```

TABLE A-I

NASTRAN BULK DATA (CONTINUED)

CONROD	2001	3	23	3	.098
CONROD	2002	5	25	3	.067
CONROD	2003	7	27	3	.134
CONROD	2004	9	29	3	.188
CONROD	2005	11	31	3	.159
CONROD	2006	13	33	3	.155
CONROD	2007	12	32	3	.159
CONROD	2008	10	30	3	.188
CONROD	2009	8	28	3	.134
CONROD	2010	6	26	3	.067
CONROD	2011	4	24	3	.098
CONROD	2012	2	22	3	.060
CONROD	2013	21	41	3	.052
CONROD	2014	23	43	3	.104
CONROD	2015	25	45	3	.122
CONROD	2016	27	47	3	.157
CONROD	2017	29	49	3	.207
CONROD	2021	30	50	3	.207
CONROD	2022	28	48	3	.157
CONROD	2023	26	46	3	.122
CONROD	2024	24	44	3	.104
CONROD	2025	22	42	3	.052
CONROD	2026	41	61	3	.051
CONROD	2027	43	63	3	.114
CONROD	2028	45	65	3	.160
CONROD	2029	47	67	3	.180
CONROD	2030	49	69	3	.232
CONROD	2031	51	71	3	.214
CONROD	2032	53	73	3	.208
CONROD	2033	52	72	3	.214
CONROD	2034	50	70	3	.232
CONROD	2035	48	68	3	.180
CONROD	2036	46	66	3	.160
CONROD	2037	44	64	3	.114
CONROD	2038	42	62	3	.051
CONROD	2039	61	81	3	.058
CONROD	2040	63	83	3	.129
CONROD	2041	65	85	3	.180
CONROD	2042	67	87	3	.203
CONROD	2043	69	89	3	.262
CONROD	2044	71	91	3	.242
CONROD	2045	73	93	3	.235
CONROD	2046	72	92	3	.242
CONROD	2047	70	90	3	.262
CONROD	2048	68	88	3	.203
CONROD	2049	66	86	3	.180
CONROD	2050	64	84	3	.129
CONROD	2051	62	82	3	.058
CONROD	2052	81	101	3	.064
CONROD	2053	83	103	3	.143
CONROD	2054	85	105	3	.201
CONROD	2055	87	107	3	.226
CONROD	2056	89	109	3	.292
CONROD	2057	91	111	3	.269
CONROD	2058	93	113	3	.262
CONROD	2059	92	112	3	.269
CONROD	2060	90	110	3	.292
CONROD	2061	88	108	3	.226
CONROD	2062	86	106	3	.201
CONROD	2063	84	104	3	.143
CONROD	2064	82	102	3	.064
CONROD	2065	101	121	3	.071
CONROD	2066	103	123	3	.149
CONROD	2067	105	125	3	.230
CONROD	2068	107	127	3	.250
CONROD	2069	109	129	3	.322
CONROD	2070	111	131	3	.297
CONROD	2071	113	133	3	.289

TABLE A-I

NASTRAN BULK DATA (CONTINUED)

CONROD	2072	112	132	3	.297
CONROD	2073	110	130	3	.322
CONROD	2074	108	128	3	.250
CONROD	2075	106	126	3	.230
CONROD	2076	104	124	3	.149
CONROD	2077	102	122	3	.071
CONROD	2078	121	141	3	.077
CONROD	2079	123	143	3	.164
CONROD	2080	125	145	3	.251
CONROD	2081	127	147	3	.273
CONROD	2082	129	149	3	.140
CONROD	2083	130	150	3	.140
CONROD	2084	128	148	3	.273
CONROD	2085	126	146	3	.251
CONROD	2086	124	144	3	.164
CONROD	2087	122	142	3	.077
CONROD	2088	145	165	3	.145
CONROD	2089	147	167	3	.295
CONROD	2090	149	169	3	.152
CONROD	2091	150	170	3	.152
CONROD	2092	148	168	3	.295
CONROD	2093	146	166	3	.145
CONROD	2102	47	67	2	.040
CONROD	2103	67	87	2	.0448
CONROD	2104	87	107	2	.0483
CONROD	2105	107	127	2	.0513
CONROD	2106	127	147	2	.0535
CONROD	2112	48	68	2	.040
CONROD	2113	68	88	2	.0448
CONROD	2114	88	108	2	.0483
CONROD	2115	108	128	2	.0513
CONROD	2116	128	148	2	.0535
CONROD	2117	148	168	2	.0553
CONROD	2120	1	3	1	.0197
CONROD	2121	3	5	1	.0312
CONROD	2122	5	7	1	.0332
CONROD	2123	7	9	1	.0309
CONROD	2124	9	11	1	.0191
CONROD	2125	11	13	1	.0004
CONROD	2126	12	13	1	.0004
CONROD	2127	10	12	1	.0191
CONROD	2128	8	10	1	.0309
CONROD	2129	6	8	1	.0332
CONROD	2130	4	6	1	.0312
CONROD	2131	2	4	1	.0197
CONROD	2140	21	23	2	.200
CONROD	2141	23	25	2	.266
CONROD	2142	25	27	2	.291
CONROD	2143	27	29	2	.273
CONROD	2144	29	31	2	.172
CONROD	2145	31	33	2	.046
CONROD	2146	32	33	2	.046
CONROD	2147	30	32	2	.172
CONROD	2148	28	30	2	.273
CONROD	2149	26	28	2	.291
CONROD	2150	24	26	2	.266
CONROD	2151	22	24	2	.200
CONROD	2160	41	43	2	.0221
CONROD	2161	43	45	2	.0306
CONROD	2162	45	47	2	.0295
CONROD	2163	47	49	2	.0291
CONROD	2164	49	51	2	.0240
CONROD	2165	51	53	2	.005
CONROD	2166	52	53	2	.005
CONROD	2167	50	52	2	.0240
CONROD	2168	48	50	2	.0291
CONROD	2169	46	48	2	.0295
CONROD	2170	44	46	2	.0306

TABLE A-I

NASTRAN BULK DATA (CONTINUED)

CONROD	2171	42	44	2	.0221
CONROD	2180	61	63	2	.0253
CONROD	2181	63	65	2	.0339
CONROD	2182	65	67	2	.0329
CONROD	2183	67	69	2	.0324
CONROD	2184	69	71	2	.0269
CONROD	2185	71	73	2	.0074
CONROD	2186	72	73	2	.0074
CONROD	2187	70	72	2	.0269
CONROD	2188	68	70	2	.0324
CONROD	2189	66	68	2	.0329
CONROD	2190	64	66	2	.0339
CONROD	2191	62	64	2	.0253
CONROD	2200	81	83	2	.0284
CONROD	2201	83	85	2	.0374
CONROD	2202	85	87	2	.0364
CONROD	2203	87	89	2	.0355
CONROD	2204	89	91	2	.0296
CONROD	2205	91	93	2	.0095
CONROD	2206	92	93	2	.0095
CONROD	2207	90	92	2	.0296
CONROD	2208	88	90	2	.0355
CONROD	2209	86	88	2	.0364
CONROD	2210	84	86	2	.0374
CONROD	2211	82	84	2	.0284
CONROD	2220	101	103	2	.0313
CONROD	2221	103	105	2	.0408
CONROD	2222	105	107	2	.0397
CONROD	2223	107	109	2	.0385
CONROD	2224	109	111	2	.0320
CONROD	2225	111	113	2	.0115
CONROD	2226	112	113	2	.0115
CONROD	2227	110	112	2	.0320
CONROD	2228	108	110	2	.0385
CONROD	2229	106	108	2	.0397
CONROD	2230	104	106	2	.0408
CONROD	2231	102	104	2	.0313
CONROD	2240	121	123	2	.0338
CONROD	2241	123	125	2	.0439
CONROD	2242	125	127	2	.0428
CONROD	2243	127	129	2	.0413
CONROD	2244	129	131	2	.0342
CONROD	2245	131	133	2	.0132
CONROD	2246	132	133	2	.0132
CONROD	2247	130	132	2	.0342
CONROD	2248	128	130	2	.0413
CONROD	2249	126	128	2	.0428
CONROD	2250	124	126	2	.0439
CONROD	2251	122	124	2	.0338
CONROD	2260	141	143	2	.0361
CONROD	2261	143	145	2	.0468
CONROD	2262	145	147	2	.0458
CONROD	2263	147	149	2	.0439
CONROD	2264	148	150	2	.0439
CONROD	2265	146	148	2	.0458
CONROD	2266	144	146	2	.0468
CONROD	2267	142	144	2	.0361
CONROD	2282	165	167	2	.0747
CONROD	2283	167	169	2	.0711
CONROD	2284	168	170	2	.0711
CONROD	2285	166	168	2	.0747
CONROD	2301	25	45	5	.116
CONROD	2302	45	65	5	.139
CONROD	2303	65	85	5	.163
CONROD	2304	85	105	5	.187
CONROD	2305	105	125	5	.214
CONROD	2306	125	145	5	.243
CONROD	2307	145	165	5	.277

TABLE A-I

NASTRAN BULK DATA (CONTINUED)

CONROD	2311	26	46	5	.116				
CONROD	2312	46	66	5	.139				
CONROD	2313	66	86	5	.163				
CONROD	2314	86	106	5	.187				
CONROD	2315	106	126	5	.214				
CONROD	2316	126	146	5	.243				
CONROD	2317	146	166	5	.277				
CONROD	2321	29	49	5	.137				
CONROD	2322	49	69	5	.155				
CONROD	2323	69	89	5	.172				
CONROD	2324	89	109	5	.190				
CONROD	2325	109	129	5	.207				
CONROD	2326	129	149	5	.228				
CONROD	2327	149	169	5	.250				
CONROD	2331	30	50	5	.137				
CONROD	2332	50	70	5	.155				
CONROD	2333	70	90	5	.172				
CONROD	2334	90	110	5	.190				
CONROD	2335	110	130	5	.207				
CONROD	2336	130	150	5	.228				
CONROD	2337	150	170	5	.250				
CORD2R	1	0	54.5840	33.6420	.0	54.5840	33.6420	-10.0000	+C100001
+C100001	94.0740	85.5000	.0						
CORD2R	10		133.57	9.9	1.948	147.186	.0	1.948	CORD10
+ORD10	147.421	34.234	1.948						
CORD2R	11	0	111.04	0.0	8.198	141.976	0.0	40.878	+CORD11
+CORD11	130.	0.0	0.0						
CORD2R	12		-225.99	0.0	1.948	-225.99	0.0	10.	CORD12
+ORD12	0.0	0.0	10.						
CQUAD2	301	301	307	308	304	301			
CQUAD2	302	301	307	308	306	303			
CQUAD2	305	301	303	306	304	301			
CQUAD2	5500	2	243	223	225	245			
CQUAD2	5501	2	223	203	205	225			
CQUAD2	5502	2	245	225	226	246			
CQUAD2	5503	2	225	205	206	226			
CQUAD2	5504	2	246	226	227	247			
CQUAD2	5505	2	226	206	207	227			
CROD	3000	3	1	2	3001	3	3	4	
CROD	3002	3	5	6	3003	3	7	8	
CROD	3004	3	9	10	3005	3	11	12	
CROD	3006	1	21	22	3007	1	23	24	
CROD	3008	1	25	26	3009	1	27	28	
CROD	3010	1	29	30	3011	1	31	32	
CROD	3012	1	41	42	3013	1	43	44	
CROD	3014	1	45	46	3015	1	47	48	
CROD	3016	1	49	50	3017	1	51	52	
CROD	3018	1	61	62	3019	1	63	64	
CROD	3020	1	65	66	3021	1	67	68	
CROD	3022	1	69	70	3023	1	71	72	
CROD	3024	1	81	82	3025	1	83	84	
CROD	3026	1	85	86	3027	1	87	88	
CROD	3028	1	89	90	3029	1	91	92	
CROD	3030	1	101	102	3031	1	103	104	
CROD	3032	1	105	106	3033	1	107	108	
CROD	3034	1	109	110	3035	1	111	112	
CROD	3036	1	121	122	3037	1	123	124	
CROD	3038	1	125	126	3039	1	127	128	
CROD	3040	1	129	130	3041	1	131	132	
CROD	3042	1	141	142	3043	1	143	144	
CROD	3044	1	145	146	3045	1	147	148	
CROD	3046	1	149	150	3047	1	167	168	
CROD	3052	2	45	46	3053	2	65	66	
CROD	3054	2	85	86	3055	2	105	106	
CROD	3056	2	125	126	3057	2	145	146	
CROD	3062	2	49	50	3063	2	69	70	
CROD	3064	2	89	90	3065	2	109	110	
CROD	3066	2	129	130	3067	2	149	150	

TABLE A-I

NASTRAN BULK DATA (CONTINUED)

CROD	7003	3	5	6	7004	3	9	10
CROD	7005	1	25	26	7006	1	29	30
CSHEAR	1000	1	21	1	3	23		
CSHEAR	1001	1	23	3	5	25		
CSHEAR	1002	1	25	5	7	27		
CSHEAR	1003	1	27	7	9	29		
CSHEAR	1004	1	29	9	11	31		
CSHEAR	1005	1	31	11	13	33		
CSHEAR	1006	1	33	13	12	32		
CSHEAR	1007	1	32	12	10	30		
CSHEAR	1008	1	30	10	8	28		
CSHEAR	1009	1	28	8	6	26		
CSHEAR	1010	1	26	6	4	24		
CSHEAR	1011	1	24	4	2	22		
CSHEAR	1012	1	22	2	1	21		
CSHEAR	1020	1	41	21	23	43		
CSHEAR	1021	1	43	23	25	45		
CSHEAR	1022	1	45	25	27	47		
CSHEAR	1023	1	47	27	29	49		
CSHEAR	1028	1	50	30	28	48		
CSHEAR	1029	1	48	28	26	46		
CSHEAR	1030	1	46	26	24	44		
CSHEAR	1031	1	44	24	22	42		
CSHEAR	1032	1	42	22	21	41		
CSHEAR	1040	1	61	41	43	63		
CSHEAR	1041	1	63	43	45	65		
CSHEAR	1042	1	65	45	47	67		
CSHEAR	1043	1	67	47	49	69		
CSHEAR	1044	1	69	49	51	71		
CSHEAR	1045	1	71	51	53	73		
CSHEAR	1046	1	73	53	52	72		
CSHEAR	1047	1	72	52	50	70		
CSHEAR	1048	1	70	50	48	68		
CSHEAR	1049	1	68	48	46	66		
CSHEAR	1050	1	66	46	44	64		
CSHEAR	1051	1	64	44	42	62		
CSHEAR	1052	1	62	42	41	61		
CSHEAR	1060	1	81	61	63	83		
CSHEAR	1061	1	83	63	65	85		
CSHEAR	1062	1	85	65	67	87		
CSHEAR	1063	1	87	67	69	89		
CSHEAR	1064	1	89	69	71	91		
CSHEAR	1065	1	91	71	73	93		
CSHEAR	1066	1	93	73	72	92		
CSHEAR	1067	1	92	72	70	90		
CSHEAR	1068	1	90	70	68	88		
CSHEAR	1069	1	88	68	66	86		
CSHEAR	1070	1	86	66	64	84		
CSHEAR	1071	1	84	64	62	82		
CSHEAR	1072	1	82	62	61	81		
CSHEAR	1080	1	101	81	83	103		
CSHEAR	1081	1	103	83	85	105		
CSHEAR	1082	1	105	85	87	107		
CSHEAR	1083	1	107	87	89	109		
CSHEAR	1084	1	109	89	91	111		
CSHEAR	1085	1	111	91	93	113		
CSHEAR	1086	1	113	93	92	112		
CSHEAR	1087	1	112	92	90	110		
CSHEAR	1088	1	110	90	88	108		
CSHEAR	1089	1	108	88	86	106		
CSHEAR	1090	1	106	86	84	104		
CSHEAR	1091	1	104	84	82	102		
CSHEAR	1092	1	102	82	81	101		
CSHEAR	1100	1	121	101	103	123		
CSHEAR	1101	1	123	103	105	125		
CSHEAR	1102	1	125	105	107	127		
CSHEAR	1103	1	127	107	109	129		
CSHEAR	1104	1	129	109	111	131		

TABLE A-I

NASTRAN BULK DATA (CONTINUED)

CSHEAR	1105	1	131	111	113	133
CSHEAR	1106	1	133	113	112	132
CSHEAR	1107	1	132	112	110	130
CSHEAR	1108	1	130	110	108	128
CSHEAR	1109	1	128	108	106	126
CSHEAR	1110	1	126	106	104	124
CSHEAR	1111	1	124	104	102	122
CSHEAR	1112	1	122	102	101	121
CSHEAR	1120	1	141	121	123	143
CSHEAR	1121	1	143	123	125	145
CSHEAR	1122	1	145	125	127	147
CSHEAR	1123	1	147	127	129	149
CSHEAR	1128	1	150	130	128	148
CSHEAR	1129	1	148	128	126	146
CSHEAR	1130	1	146	126	124	144
CSHEAR	1131	1	144	124	122	142
CSHEAR	1132	1	142	122	121	141
CSHEAR	1142	1	165	145	147	167
CSHEAR	1143	1	167	147	149	169
CSHEAR	1148	1	170	150	148	168
CSHEAR	1149	1	168	148	146	166
CSHEAR	1200	1	1	3	4	2
CSHEAR	1201	1	3	5	6	4
CSHEAR	1202	1	5	7	8	6
CSHEAR	1203	1	7	9	10	8
CSHEAR	1204	1	9	11	12	10
CSHEAR	1205	11	21	23	24	22
CSHEAR	1206	11	23	25	26	24
CSHEAR	1207	11	25	27	28	26
CSHEAR	1208	11	27	29	30	28
CSHEAR	1209	11	29	31	32	30
CSHEAR	1210	2	41	43	44	42
CSHEAR	1211	2	43	45	46	44
CSHEAR	1212	2	45	47	48	46
CSHEAR	1213	2	47	49	50	48
CSHEAR	1214	2	49	51	52	50
CSHEAR	1215	2	61	63	64	62
CSHEAR	1216	2	63	65	66	64
CSHEAR	1217	2	65	67	68	66
CSHEAR	1218	2	67	69	70	68
CSHEAR	1219	2	69	71	72	70
CSHEAR	1220	2	81	83	84	82
CSHEAR	1221	2	83	85	86	84
CSHEAR	1222	2	85	87	88	86
CSHEAR	1223	2	87	89	90	88
CSHEAR	1224	2	89	91	92	90
CSHEAR	1225	2	101	103	104	102
CSHEAR	1226	2	103	105	106	104
CSHEAR	1227	2	105	107	108	106
CSHEAR	1228	2	107	109	110	108
CSHEAR	1229	2	109	111	112	110
CSHEAR	1230	2	121	123	124	122
CSHEAR	1231	2	123	125	126	124
CSHEAR	1232	2	125	127	128	126
CSHEAR	1233	2	127	129	130	128
CSHEAR	1234	2	129	131	132	130
CSHEAR	1235	2	141	143	144	142
CSHEAR	1236	2	143	145	146	144
CSHEAR	1237	2	145	147	148	146
CSHEAR	1238	2	147	149	150	148
CSHEAR	1239	3	165	167	168	166
CSHEAR	1240	3	167	169	170	168
CSHEAR	1301	4	45	25	26	46
CSHEAR	1302	4	65	45	46	66
CSHEAR	1303	4	85	65	66	86
CSHEAR	1304	4	105	85	86	106
CSHEAR	1305	4	125	105	106	126
CSHEAR	1306	4	145	125	126	146

TABLE A-I

NASTRAN BULK DATA (CONTINUED)

CSHEAR	1307	4	165	145	146	166			
CSHEAR	1311	4	49	29	30	50			
CSHEAR	1312	4	69	49	50	70			
CSHEAR	1313	4	89	69	70	90			
CSHEAR	1314	4	109	89	90	110			
CSHEAR	1315	4	129	109	110	130			
CSHEAR	1316	4	149	129	130	150			
CSHEAR	1317	4	169	149	150	170			
CSHEAR	1320	1	29	49	606	602			
CSHEAR	1321	1	30	50	608	604			
CSHEAR	1332	1	29	30	604	602			
CSHEAR	1333	1	606	608	50	49			
CSHEAR	7001	7001	5	6	26	25			
CSHEAR	7002	7001	9	10	30	29			
CTRIA2	303	303	301	303	307				
CTRIA2	304	303	304	306	308				
CTRIA2	5000	1	202	176	203				
CTRIA2	5001	2	201	202	242				
CTRIA2	5002	2	202	243	242				
CTRIA2	5003	2	202	203	243				
CTRMEM	101	101	602	31	29				
CTRMEM	102	101	604	32	30				
CTRMEM	103	101	31	602	601				
CTRMEM	104	101	32	604	601				
CTRMEM	105	101	33	31	601				
CTRMEM	106	101	33	32	601				
CTRMEM	107	101	49	51	606				
CTRMEM	108	101	50	52	608				
CTRMEM	109	101	51	609	606				
CTRMEM	110	101	52	609	608				
CTRMEM	111	101	51	53	609				
CTRMEM	112	101	52	53	609				
CTRMEM	7007	7008	11	12	13				
CTRMEM	7008	7008	31	32	33				
CTRMEM	7009	7008	51	52	53				
CTRMEM	7010	7008	71	72	73				
CTRMEM	7011	7008	91	92	93				
CTRMEM	7012	7008	111	112	113				
CTRMEM	7013	7008	131	132	133				
CTRMEM	7014	7008	602	604	601				
CTRMEM	7015	7008	606	608	609				
EIGR	1	GIV				13		1.-6	+GIV1
+GIV1	MAX								
GRDSET							456		
GRID	1		83.636	85.5	1.407				
GRID	2		83.636	85.5	.910				
GRID	3		84.852	85.5	1.663				
GRID	4		84.852	85.5	.863				
GRID	5	0	86.8790	85.5000	1.9310	0	6		
GRID	6		86.879	85.5	.979				
GRID	7		89.243	85.5	2.175				
GRID	8		89.243	85.5	1.241				
GRID	9	0	91.6080	85.5000	2.3940	0	6		
GRID	10		91.608	85.5	1.598				
GRID	11		94.986	85.5	2.595				
GRID	12		94.986	85.5	2.287				
GRID	13		96.674	85.5	2.424				
GRID	21		77.55	79.25	1.36				
GRID	22		77.55	79.25	.786				
GRID	23		78.92	79.25	1.631				
GRID	24		78.92	79.25	.744				
GRID	25	0	81.2000	79.2500	1.9300	0	6		
GRID	26		81.20	79.25	.872				
GRID	27		83.87	79.25	2.211				
GRID	28		83.87	79.25	1.14				
GRID	29	0	86.53	79.25	2.456	0	0		
GRID	30		86.53	79.25	1.528				
GRID	31		90.34	79.25	2.655				

TABLE A-I

NASTRAN BULK DATA (CONTINUED)

GRID	32		90.34	79.25	2.321		
GRID	33		92.248	79.25	2.4395		
GRID	41		70.829	72.349	1.347		
GRID	42		70.829	72.349	.663		
GRID	43		71.657	71.598	1.632		
GRID	44		71.657	71.598	.617		
GRID	45	0	73.0810	70.3040	1.9740	0	6
GRID	46		73.081	70.304	.725		
GRID	47		74.819	68.726	2.303		
GRID	48		74.819	68.726	.975		
GRID	49	0	76.6430	67.0700	2.5820	0	6
GRID	50		76.643	67.070	1.387		
GRID	51		79.415	64.553	2.763		
GRID	52		79.415	64.553	2.358		
GRID	53		80.879	63.223	2.453		
GRID	61		62.45	63.747	1.368		
GRID	62		62.45	63.747	.572		
GRID	63		63.393	62.892	1.695		
GRID	64		63.393	62.892	.499		
GRID	65	0	65.0140	61.4200	2.0760	0	6
GRID	66		65.014	61.420	.587		
GRID	67		66.992	59.624	2.419		
GRID	68		66.992	59.624	.834		
GRID	69	0	69.0670	57.7400	2.6840	0	6
GRID	70		69.067	57.740	1.272		
GRID	71		72.221	54.876	2.807		
GRID	72		72.221	54.876	2.348		
GRID	73		73.887	53.363	2.441		
GRID	81		54.074	55.145	1.442		
GRID	82		54.074	55.145	.528		
GRID	83		55.130	54.186	1.816		
GRID	84		55.130	54.186	.408		
GRID	85	0	56.9470	52.5360	2.2320	0	6
GRID	86		56.947	52.536	.456		
GRID	87		59.165	50.522	2.564		
GRID	88		59.165	50.522	.696		
GRID	89	0	61.4920	48.4100	2.7900	0	6
GRID	90		61.492	48.410	1.153		
GRID	91		65.027	45.199	2.837		
GRID	92		65.027	45.199	2.321		
GRID	93		66.896	43.503	2.423		
GRID	101		45.697	46.543	1.551		
GRID	102		45.697	46.543	.509		
GRID	103		46.867	45.481	1.972		
GRID	104		46.867	45.481	.332		
GRID	105	0	48.8800	43.6520	2.4100	0	6
GRID	106		48.880	43.652	.329		
GRID	107		51.338	41.421	2.717		
GRID	108		51.338	41.421	.558		
GRID	109	0	53.9160	39.0800	2.8960	0	6
GRID	110		53.916	39.080	1.034		
GRID	111		57.834	35.522	2.868		
GRID	112		57.834	35.522	2.294		
GRID	113		59.904	33.642	2.404		
GRID	121		37.319	37.941	1.723		
GRID	122		37.319	37.941	.427		
GRID	123		38.603	36.775	2.128		
GRID	124		38.603	36.775	.256		
GRID	125	0	40.8140	34.7680	2.5870	0	6
GRID	126		40.814	34.768	.201		
GRID	127		43.511	32.319	2.871		
GRID	128		43.511	32.319	.420		
GRID	129	0	46.3400	29.7500	3.0020	0	6
GRID	130		46.340	29.750	.915		
GRID	131		50.640	25.845	2.898		
GRID	132		50.640	25.845	2.266		
GRID	133		52.913	23.782	2.385		
GRID	141		28.942	29.339	1.779		

TABLE A-I

NASTRAN BULK DATA (CONTINUED)

GRID	142		28.942	29.339	.472		
GRID	143		30.340	28.069	2.285		
GRID	144		30.340	28.069	.180		
GRID	145	0	32.7470	25.8840	2.7560	0	6
GRID	146		32.747	25.884	.073		
GRID	147		35.683	23.217	3.024		
GRID	148		35.683	23.217	.283		
GRID	149	0	38.7650	20.4200	3.1090	0	6
GRID	150		38.765	20.420	.796		
GRID	165	0	24.6800	17.0000	2.9430	0	6
GRID	166		24.680	17.0	-.055		
GRID	167		27.856	14.116	3.177		
GRID	168		27.856	14.116	.145		
GRID	169	0	31.1890	11.0900	3.2150	0	6
GRID	170		31.189	11.090	.677		
GRID	174		24.680	17.0	1.948		0
GRID	176		31.189	11.09	1.948		0
GRID	200		16.3	9.0	1.948		0
GRID	201		17.42	9.0	1.948		0
GRID	202		24.63	9.0	1.948		0
GRID	203		31.18	9.0	1.948		0
GRID	204		32.88	9.0	1.948		0
GRID	205		36.33	9.0	1.948		0
GRID	206		41.15	9.0	1.948		0
GRID	207		45.39	9.0	1.948		0
GRID	208		48.05	9.0	1.948		0
GRID	223		31.18	4.35	1.948		0
GRID	225		36.33	4.35	1.948		0
GRID	226		41.15	4.35	1.948		0
GRID	227		45.39	4.35	1.948		0
GRID	242		18.78	.0	1.948		0
GRID	243		31.18	.0	1.948		0
GRID	245		36.33	.0	1.948		0
GRID	246		41.15	.0	1.948		0
GRID	247		45.39	.0	1.948		0
GRID	301	0	79.794	67.35	2.685	1	0
GRID	302	0	79.794	67.35	2.347	1	0
GRID	303	0	79.794	67.35	2.009	1	0
GRID	304	0	87.477	77.35	2.599	1	0
GRID	305	0	87.477	77.35	2.423	1	0
GRID	306	0	87.477	77.35	2.246	1	0
GRID	307		83.807	67.35	2.450	1	0
GRID	308		90.9	77.35	2.441	1	0
GRID	401	10	0.0	0.0	0.0		0
GRID	402	10	4.	0.0	0.0		0
GRID	403	10	8.	0.0	0.0		0
GRID	404	10	12.	0.0	0.0		0
GRID	405	10	16.	0.0	0.0		0
GRID	406	10	20.	0.0	0.0		0
GRID	407	10	24.	0.0	0.0		0
GRID	408	10	28.	0.0	0.0		0
GRID	410	10	28.	10.	0.0		0
GRID	601		90.9	77.35	2.441	1	
GRID	602	0	87.477	77.35	2.599	1	
GRID	603	0	87.477	77.35	2.423	1	0
GRID	604	0	87.477	77.35	2.246	1	
GRID	606	0	79.794	67.35	2.685	1	
GRID	607	0	79.794	67.35	2.347	1	0
GRID	608	0	79.794	67.35	2.009	1	
GRID	609		83.807	67.35	2.450	1	
GRID	1001	11	0.0	0.0	0.0	0	0
GRID	1002	11	0.0	0.0	5.	0	0
GRID	1003	11	0.0	0.0	10.	0	0
GRID	1004	11	0.0	0.0	15.	0	0
GRID	1005	11	0.0	0.0	20.	0	0
GRID	1006	11	0.0	0.0	25.	0	0
GRID	1007	11	0.0	0.0	30.	0	0
GRID	1008	11	0.0	0.0	35.	0	0

TABLE A-I

NASTRAN BULK DATA (CONTINUED)

GRID	1009	11	0.0	0.0	40.	0	0		
GRID	1010	11	0.0	0.0	45.	0	0		
GRID	1011	11	0.0	10.	0.0	0	0		
GRID	2100	12	100.	0.0	0.0		0		
GRID	2110	12	110.	0.0	0.0		0		
GRID	2120	12	120.	0.0	0.0		0		
GRID	2130	12	130.	0.0	0.0		0		
GRID	2140	12	140.	0.0	0.0		0		
GRID	2150	12	150.	0.0	0.0		0		
GRID	2160	12	160.	0.0	0.0		0		
GRID	2170	12	170.	0.0	0.0		0		
GRID	2180	12	180.	0.0	0.0		0		
GRID	2190	12	190.	0.0	0.0		0		
GRID	2200	12	200.	0.0	0.0		0		
GRID	2210	12	210.	0.0	0.0		0		
GRID	2220	12	220.	0.0	0.0		0		
GRID	2230	12	230.	0.0	0.0		0		
GRID	2240	12	242.29	0.0	0.0	0	0		
GRID	2250	12	250.62	0.0	0.0	0	0		
GRID	2260	12	258.87	0.0	0.0	0	0		
GRID	2270	12	267.14	0.0	0.0	0	0		
GRID	2280	12	274.04	0.0	0.0	0	0		
GRID	2290	12	290.	0.0	0.0		0		
GRID	2300	12	300.	0.0	0.0		0		
GRID	2310	12	310.	0.0	0.0		0		
GRID	2320	12	320.	0.0	0.0		0		
GRID	2330	12	330.	0.0	0.0		0		
GRID	2337	12	337.03	0.0	0.0		0		
GRID	2340	12	340.	0.0	0.0		0		
GRID	2350	12	350.	0.0	0.0		0		
GRID	2360	12	360.	0.0	0.0		0		
GRID	2370	12	370.	0.0	0.0		0		
GRID	2380	12	380.	0.0	0.0		0		
GRID	2390	12	390.	0.0	0.0		0		
GRID	2400	12	400.	0.0	0.0		0		
GRID	2410	12	410.	0.0	0.0		0		
GRID	2500	12	400.	0.0	50.		0		
GRID	5000	0	-225.99				123456		
MAT1	1	2.50+6	.840+6		.07				
MAT1	2	10.5+6	4.0+6		.1				
MAT1	3	2.25+6	.840+6		.0				
MAT1	4	10.5+6	4.0+6		.0				
MAT1	5	29.+6	11.+6		.285				
MAT1	7	10.5+6	4.+6		.05				
MAT1	54	10.5+6	4.0+6		.0				
MAT1	55	29.+6	11.+6		.0				
MAT1	56	1.3+7	.5+7		.0				
MAT1	75	.5+9	.19231+9		0.0				
MAT2	6						.84E+6	.05	
MPC	100	5	4	-0.9520	6	2	1.0000		+C111001
+C111001		5	2	-1.0000					
MPC	100	5	5	.9520	6	1	1.0000		+C111020
+C111020		5	1	-1.0000					
MPC	100	9	4	-0.7960	10	2	1.0000		+C111010
+C111010		9	2	-1.0000					
MPC	100	9	5	.7960	10	1	1.0000		+C111029
+C111029		9	1	-1.0000					
MPC	100	25	4	-1.0580	26	2	1.0000		+C111002
+C111002		25	2	-1.0000					
MPC	100	25	5	1.0580	26	1	1.0000		+C111021
+C111021		25	1	-1.0000					
MPC	100	29	4	-0.9280	30	2	1.0000		+C111012
+C111012		29	2	-1.0000					
MPC	100	29	5	.9280	30	1	1.0000		+C111030
+C111030		29	1	-1.0000					
MPC	100	29	6	5.3300	25	2	1.0000		+C111011
+C111011		29	2	-1.0000	29	4	-0.5260		
MPC	100	45	4	-1.2490	46	2	1.0000		+C111003

TABLE A-I

NASTRAN BULK DATA (CONTINUED)

+C111003		45	2	-1.0000				
MPC	100	45	5	1.2490	46	1	1.0000	+C111022
+C111022		45	1	-1.0000				
MPC	100	49	4	-1.1950	50	2	1.0000	+C111013
+C111013		49	2	-1.0000				
MPC	100	49	5	1.1950	50	1	1.0000	+C111031
+C111031		49	1	-1.0000				
MPC	100	65	4	-1.4890	66	2	1.0000	+C111004
+C111004		65	2	-1.0000				
MPC	100	65	5	1.4890	66	1	1.0000	+C111023
+C111023		65	1	-1.0000				
MPC	100	69	4	-1.4120	70	2	1.0000	+C111014
+C111014		69	2	-1.0000				
MPC	100	69	5	1.4120	70	1	1.0000	+C111032
+C111032		69	1	-1.0000				
MPC	100	85	4	-1.7760	86	2	1.0000	+C111005
+C111005		85	2	-1.0000				
MPC	100	85	5	1.7760	86	1	1.0000	+C111024
+C111024		85	1	-1.0000				
MPC	100	89	4	-1.6370	90	2	1.0000	+C111015
+C111015		89	2	-1.0000				
MPC	100	89	5	1.6370	90	1	1.0000	+C111033
+C111033		89	1	-1.0000				
MPC	100	105	4	-2.0810	106	2	1.0000	+C111006
+C111006		105	2	-1.0000				
MPC	100	105	5	2.0810	106	1	1.0000	+C111025
+C111025		105	1	-1.0000				
MPC	100	109	4	-1.8620	110	2	1.0000	+C111016
+C111016		109	2	-1.0000				
MPC	100	109	5	1.8620	110	1	1.0000	+C111034
+C111034		109	1	-1.0000				
MPC	100	125	4	-2.3860	126	2	1.0000	+C111007
+C111007		125	2	-1.0000				
MPC	100	125	5	2.3860	126	1	1.0000	+C111026
+C111026		125	1	-1.0000				
MPC	100	129	4	-2.0870	130	2	1.0000	+C111017
+C111017		129	2	-1.0000				
MPC	100	129	5	2.0870	130	1	1.0000	+C111035
+C111035		129	1	-1.0000				
MPC	100	145	4	-2.6920	146	2	1.0000	+C111008
+C111008		145	2	-1.0000				
MPC	100	145	5	2.6920	146	1	1.0000	+C111027
+C111027		145	1	-1.0000				
MPC	100	149	4	-2.3130	150	2	1.0000	+C111018
+C111018		149	2	-1.0000				
MPC	100	149	5	2.3130	150	1	1.0000	+C111036
+C111036		149	1	-1.0000				
MPC	100	165	4	-2.9980	166	2	1.0000	+C111009
+C111009		165	2	-1.0000				
MPC	100	165	5	2.9980	166	1	1.0000	+C111028
+C111028		165	1	-1.0000				
MPC	100	169	4	-2.5380	170	2	1.0000	+C111019
+C111019		169	2	-1.0000				
MPC	100	169	5	2.5380	170	1	1.0000	+C111037
+C111037		169	1	-1.0000				
MPC	101	200	1	-1.	2240	1	1.	+MPCX200
+MPCX200		2240	6	-9.				
MPC	101	200	2	-1.	2240	2	1.	
MPC	101	200	3	-1.	2240	3	1.	+MPCZ200
+MPCZ200		2240	4	9.				
MPC	101	200	5	-1.	2240	5	1.	
MPC	101	200	6	-1.	2240	6	1.	
MPC	101	202	1	-1.	2250	1	1.	+MPCX202
+MPCX202		2250	6	-9.				
MPC	101	202	2	-1.	2250	2	1.	
MPC	101	202	3	-1.	2250	3	1.	+MPCZ202
+MPCZ202		2250	4	9.				
MPC	101	202	5	-1.	2250	5	1.	

TABLE A-I

NASTRAN BULK DATA (CONTINUED)

MPC	101	202	6	-1.	2250	6	1.		
MPC	101	204	1	-1.	2260	1	1.		+MPCX204
+MPCX204		2260	6	-9.					
MPC	101	204	2	-1.	2260	2	1.		
MPC	101	204	3	-1.	2260	3	1.		+MPCZ204
+MPCZ204		2260	4	9.					
MPC	101	204	5	-1.	2260	5	1.		
MPC	101	204	6	-1.	2260	6	1.		
MPC	101	206	1	-1.	2270	1	1.		+MPCX206
+MPCX206		2270	6	-9.					
MPC	101	206	2	-1.	2270	2	1.		
MPC	101	206	3	-1.	2270	3	1.		+MPCZ206
+MPCZ206		2270	4	9.					
MPC	101	206	5	-1.	2270	5	1.		
MPC	101	206	6	-1.	2270	6	1.		
MPC	101	208	1	-1.	2280	1	1.		+MPCX208
+MPCX208		2280	6	-9.					
MPC	101	208	2	-1.	2280	2	1.		
MPC	101	208	3	-1.	2280	3	1.		+MPCZ208
+MPCZ208		2280	4	9.					
MPC	101	208	5	-1.	2280	5	1.		
MPC	101	208	6	-1.	2280	6	1.		
MPC	101	302	1	-1.0000	607	1	1.0000		
MPC	101	302	2	-1.0000	607	2	1.0000		
MPC	101	302	3	-1.0000	607	3	1.0000		
MPC	101	302	4	-1.0000	607	4	1.0000		
MPC	101	305	1	-1.0000	603	1	1.0000		
MPC	101	305	2	-1.0000	603	2	1.0000		
MPC	101	305	3	-1.0000	603	3	1.0000		
MPC	109	21	2	-1.0000	29	2	1.0000		+C111038
+C111038		29	4	1.0960	29	6	-8.9800		
MPC	109	22	2	-1.0000	29	2	1.0000		+C111039
+C111039		29	4	1.6700	29	6	-8.9800		
MPC	109	23	2	-1.0000	29	2	1.0000		+C111040
+C111040		29	4	.8250	29	6	-7.6100		
MPC	109	24	2	-1.0000	29	2	1.0000		+C111041
+C111041		29	4	1.7120	29	6	-7.6100		
MPC	109	26	2	-1.0000	29	2	1.0000		+C111042
+C111042		29	4	1.5840	29	6	-5.3300		
MPC	109	27	2	-1.0000	29	2	1.0000		+C111043
+C111043		29	4	.2450	29	6	-2.6600		
MPC	109	28	2	-1.0000	29	2	1.0000		+C111044
+C111044		29	4	1.3160	29	6	-2.6600		
MPC	109	31	2	-1.0000	29	2	1.0000		+C111045
+C111045		29	4	-0.1990	29	6	3.8100		
MPC	109	32	2	-1.0000	29	2	1.0000		+C111046
+C111046		29	4	.1350	29	6	3.8100		
MPCADD	1	100	101	109					
PARAM	GRDPNT	5000							
PARAM	WTMASS	.0025907							
PBAR	1	2	1.22	.25	.271				
PBAR	2	2	1.875	.0879	.977	.285			
PBAR	3	2	3.125	.407	1.628	1.118			
PBAR	4	2	3.75	.703	1.953	1.761			
PBAR	5	2	1.25	.026	.651	.091			
PBAR	601	4	.01	.01	.01	.01			
PBAR	1751	75	.1	2.096	3.773	5.528			
PBAR	1753	75	.1	2.441	3.543	5.344			
PBAR	1755	75	.1	2.561	3.535	5.195			
PBAR	1758	75	.1	3.454	4.678	5.016			
PBAR	1759	75	.1	3.479	4.875	4.975			
PBAR	1851	75	.1	1.742	2.964	1.764			
PBAR	1852	75	.1	.939	2.568	.945			
PBAR	1853	75	.1	100.	1000.	100.			
PBAR	8051	54	.1	100.	100.	100.			
PBAR	8052	54	.1	.495	100.	1.182			
PBAR	8053	54	.1	.361	100.	.887			
PBAR	8054	54	.1	.238	100.	.615			

TABLE A-I

NASTRAN BULK DATA (CONTINUED)

PBAR	8055	54	.1	.279	100.	.385			
PBAR	8056	54	.1	.0733	100.	.220			
PBAR	8057	54	.1	.03571	100.	.117			
PBAR	8058	54	.1	.01524	100.	.05375			
PBAR	15101	56	.1	.805	100.	2.58			
PBAR	15102	56	.1	.682	100.	2.134			
PBAR	15103	56	.1	.514	100.	1.585			
PBAR	15104	56	.1	.319	100.	.996			
PBAR	15105	56	.1	.156	100.	.510			
PBAR	15106	56	.1	.069	100.	.229			
PBAR	15107	56	.1	.033	100.	.110			
PBAR	15108	56	.1	.014	100.	.052			
PBAR	15109	56	.1	.005	100.	.020			
PBAR	17101	75	.1	.182	.182	.2438			
PBAR	17102	75	.1	.192	.192	.2546			
PBAR	17103	75	.1	.425	.491	.468			
PBAR	17104	75	.1	.875	1.074	.863			
PBAR	17105	75	.1	1.175	1.656	1.261			
PBAR	17106	75	.1	1.325	2.238	1.681			
PBAR	17107	75	.1	1.475	2.821	2.101			
PBAR	17108	75	.1	1.625	3.403	2.521			
PBAR	17109	75	.1	1.938	3.985	2.795			
PBAR	17110	75	.1	2.413	4.568	2.925			
PBAR	17111	75	.1	2.439	4.938	3.107			
PBAR	17112	75	.1	2.017	4.882	3.341			
PBAR	17113	75	.1	1.595	4.614	4.134			
PBAR	17114	75	.1	1.698	4.160	5.187			
PBAR	17119	75	.1	3.525	5.15	4.94			
PBAR	17120	75	.1	3.675	4.528	4.94			
PBAR	17121	75	.1	3.925	3.729	4.878			
PBAR	17122	75	.1	3.747	3.586	4.776			
PBAR	17123	75	.1	2.875	3.378	3.539			
PBAR	17124	75	.1	1.504	2.846	1.521			
PBAR	17125	75	.1	.85	2.20	.611			
PBAR	17126	75	.1	.847	1.7	.607			
PBAR	17127	75	.1	.585	1.244	.757			
PBAR	17128	75	.1	.485	.899	.78			
PBAR	17129	75	.1	.419	.619	.64			
PBAR	17130	75	.1	.273	.340	.437			
PBAR	17131	75	.1	.175	.193	.317			
PQUAD2	2	2	.25						
PQUAD2	301	7	.07						
PROD	1	4	.01						
PROD	2	5	.05						
PROD	3	3	.01						
PSHEAR	1	1	.063		2	2	.05		
PSHEAR	3	2	.08		4	5	.10		
PSHEAR	5	2	.085		6	2	.10		
PSHEAR	7	2	.115		8	2	.13		
PSHEAR	9	2	.145		10	2	.16		
PSHEAR	11	2	1.64						
PSHEAR	7001	4	.1						
PTRIA2	1	2	2.5						
PTRIA2	2	2	.25						
PTRIA2	303	7	.07						
PTRMEM	101	6	.063						
PTRMEM	7008	4	.05						
SPC1	1	135	2110	2120	2130	2140	2150	2160	SPC001
+PC001	2170	2180	2190	2200	2210	2220	2230	2240	SPC002
+PC002	2250	2260	2270	2280	2290	2300	2310	2320	SPC003
+PC003	2330	2337	2340	2350	2360	2370	2380	2390	SPC004
+PC004	2400	2410							
SPC1	2	135	1001	THRU	1010				
SPC1	3	135	242	243	245	246	247		
SPC1	4	123456	410	1011	2500				
SPC1	7	246	2110	2120	2130	2140	2150	2160	SPC071
+PC071	2170	2180	2190	2200	2210	2220	2230	2240	SPC072
+PC072	2250	2260	2270	2280	2290	2300	2310	2320	SPC073

TABLE A-I

NASTRAN BULK DATA (CONCLUDED)

+PC073	2330	2337	2340	2350	2360	2370	2380	2390	SPC074
+PC074	2400	2410							
SPC1	8	246	1001	THRU	1010				
SPC1	9	246	242	243	245	246	247		
SPCADD	101	1	2	3	4				
SPCADD	102	4	7	8	9				
SUPORT	2260	135							

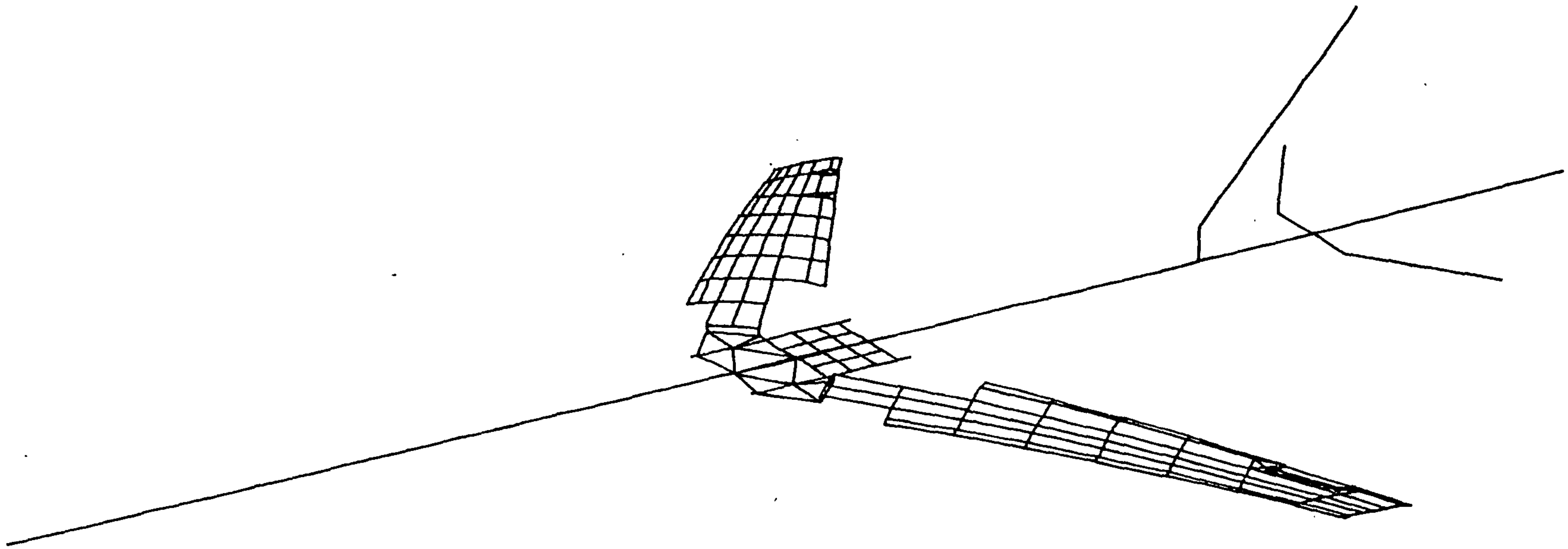


FIGURE A-3 - DAST WITH ARW-1 SYMMETRIC MODEL, ELASTIC MODE NO. 1, 9.09 HZ

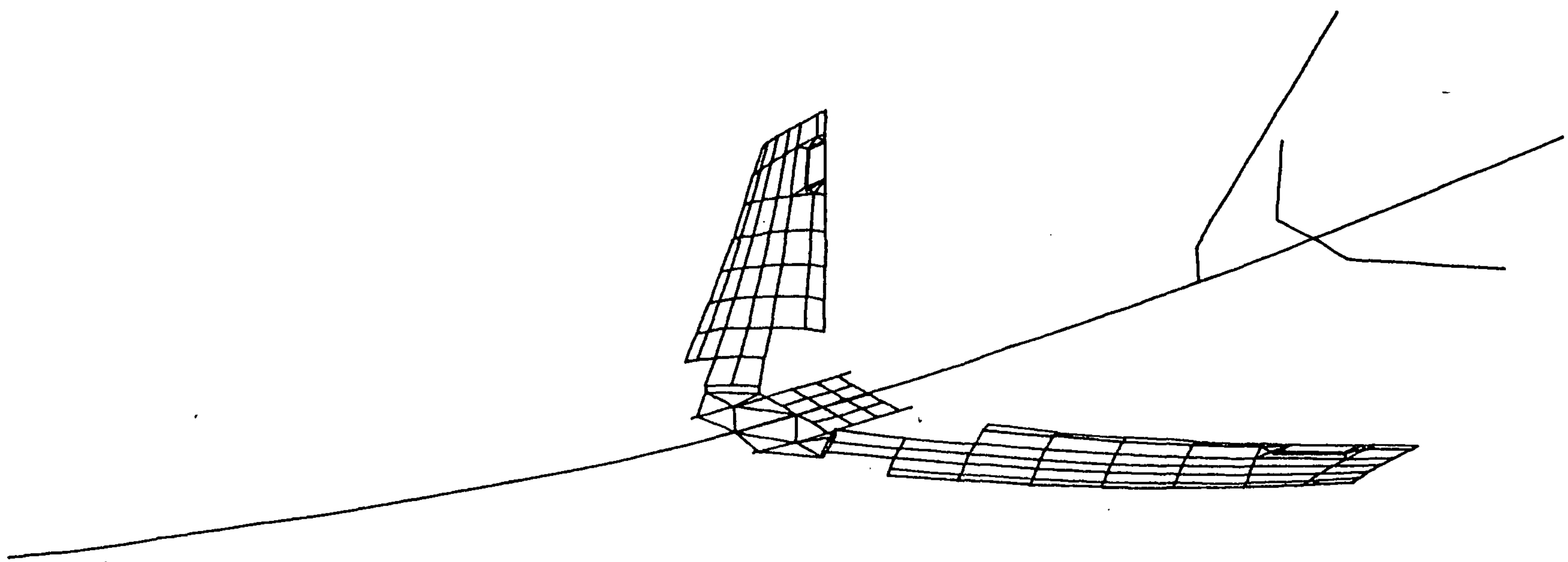


FIGURE A-4 - DAST WITH ARW-1 SYMMETRIC MODEL, ELASTIC MODE NO. 2, 16.38 HZ

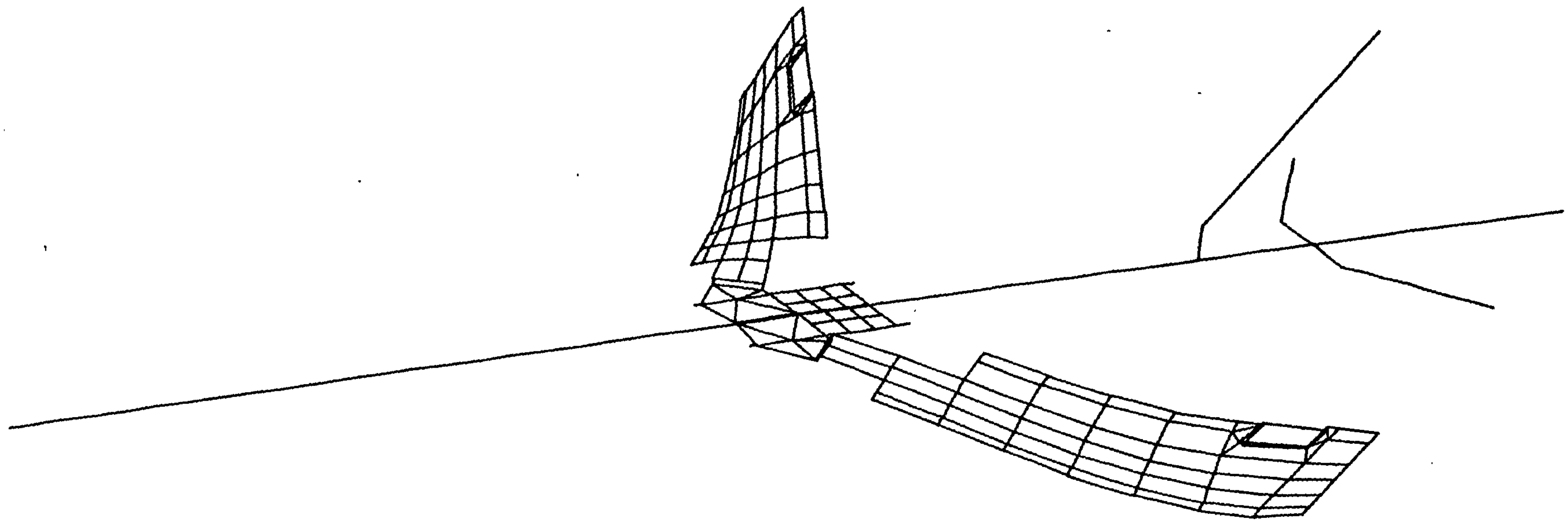


FIGURE A-5 - DAST WITH ARW-1 SYMMETRIC MODEL, ELASTIC MODE NO. 3, 29.88 HZ

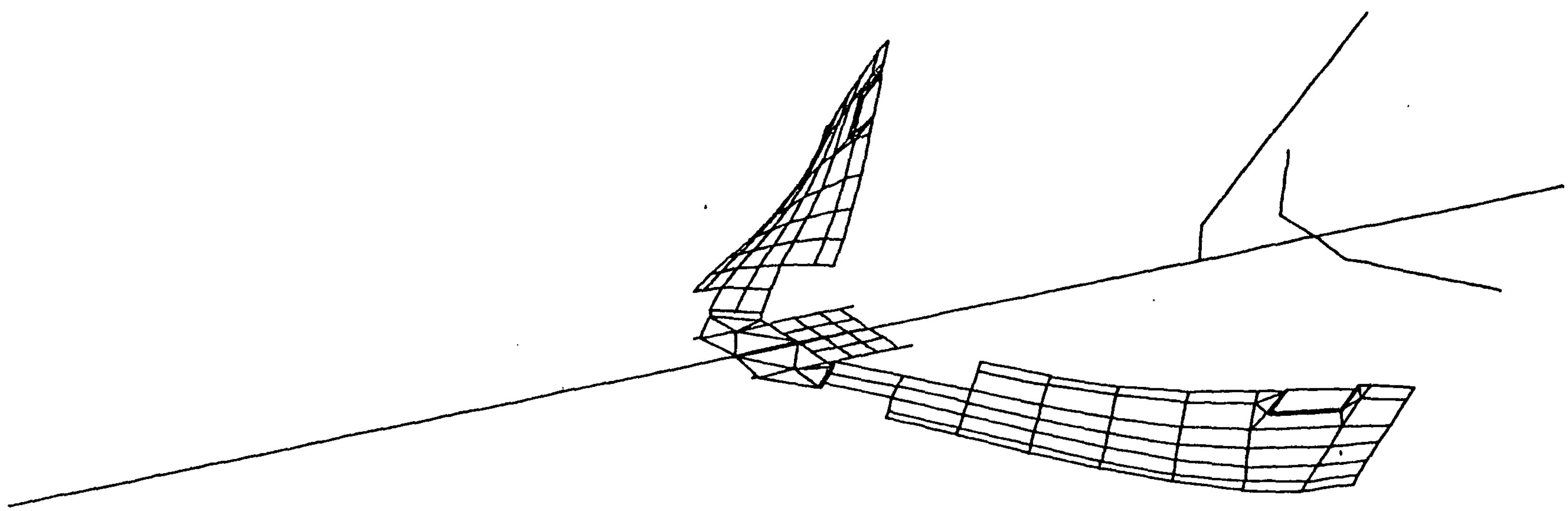


FIGURE A-6 - DAST WITH ARW-1 SYMMETRIC MODEL, ELASTIC MODE NO. 4, 34.01 HZ

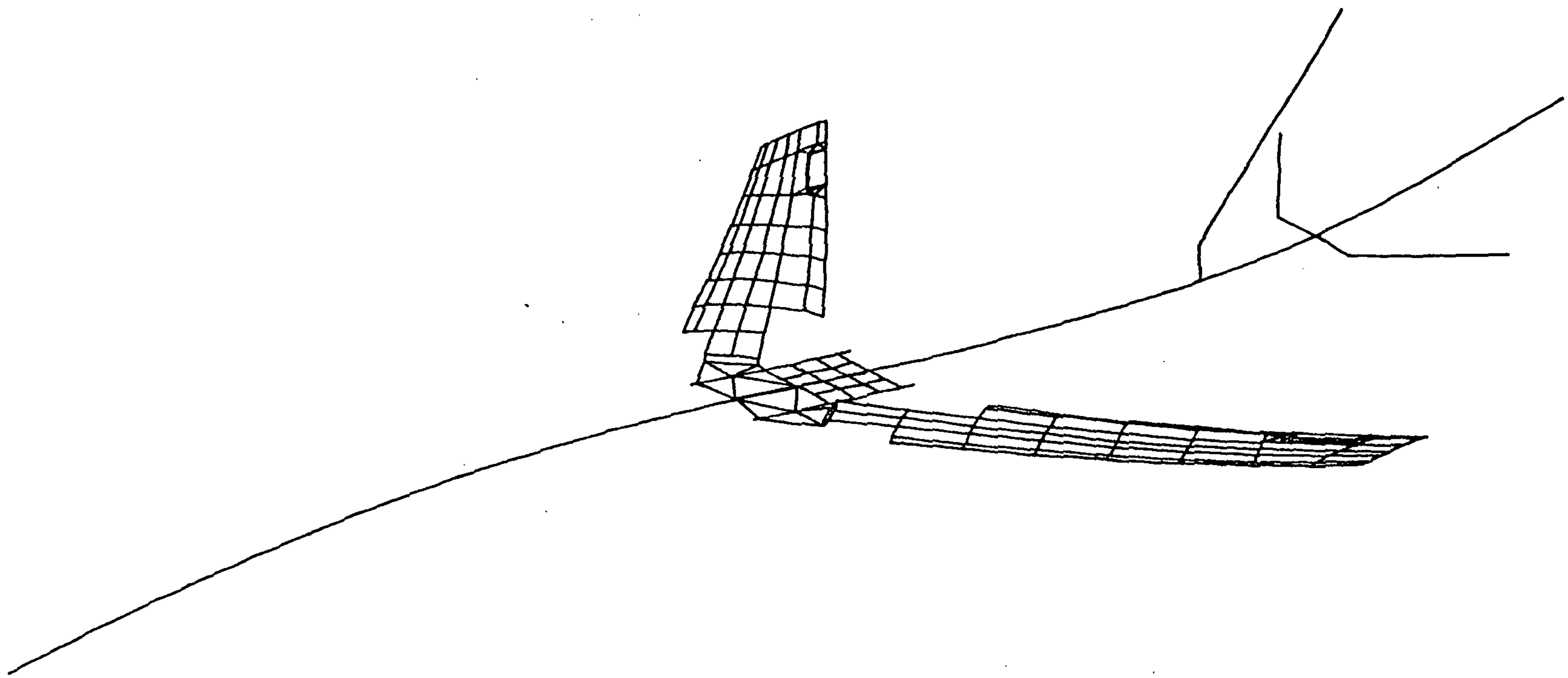


FIGURE A-7 - DAST WITH ARW-1 SYMMETRIC MODEL, ELASTIC MODE NO. 5, 39.37 HZ

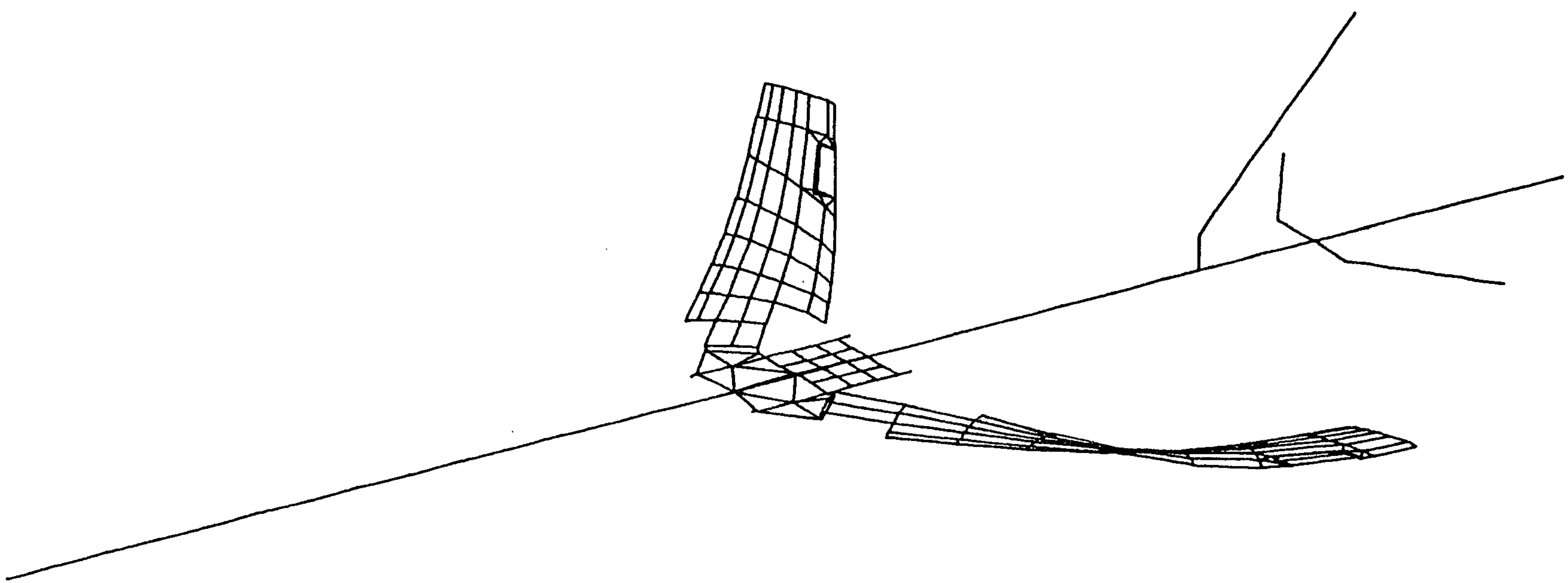


FIGURE A-8 - DAST WITH ARW-1 SYMMETRIC MODEL, ELASTIC MODE NO. 6, 48.75 HZ

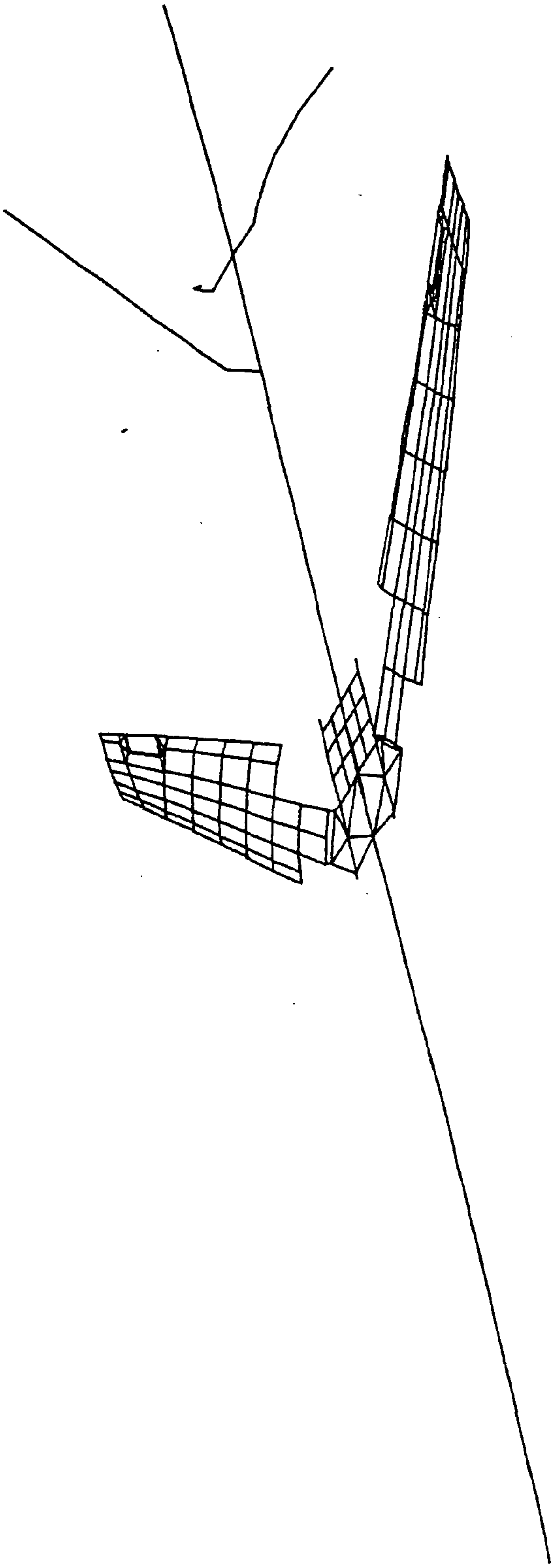


FIGURE A-9 - DAST WITH ARW-1 SYMMETRIC MODEL, ELASTIC MODE NO. 7, 65.09 HZ

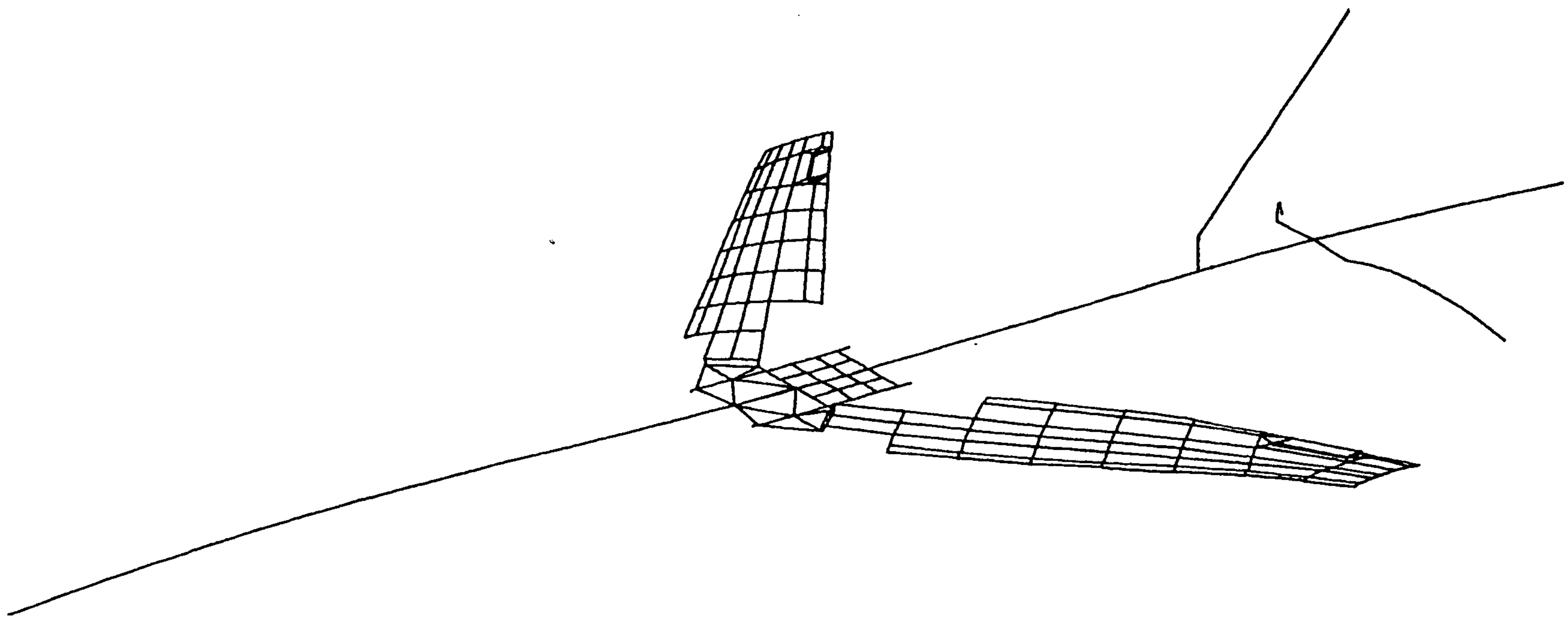


FIGURE A-10 - DAST WITH ARW-1 SYMMETRIC MODEL, ELASTIC MODE NO. 8, 68.63 HZ

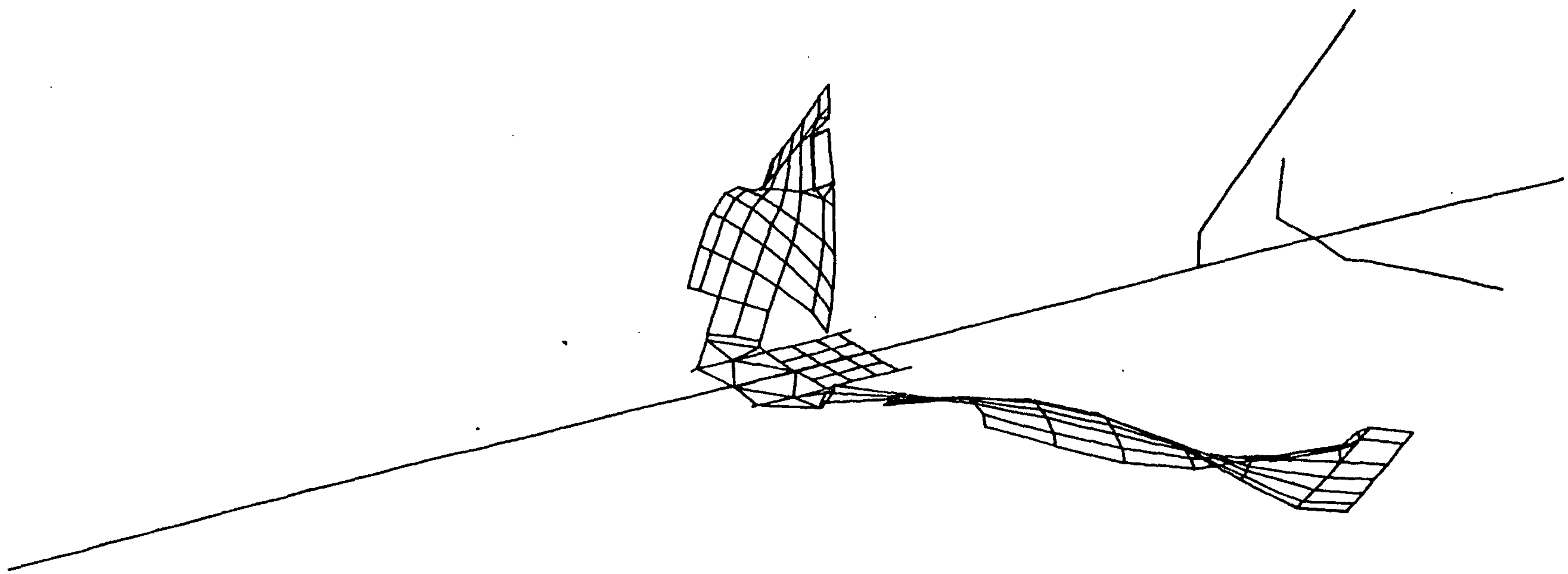


FIGURE A-11 - DAST WITH ARW-1 SYMMETRIC MODEL, ELASTIC MODE NO. 9, 78.80 HZ

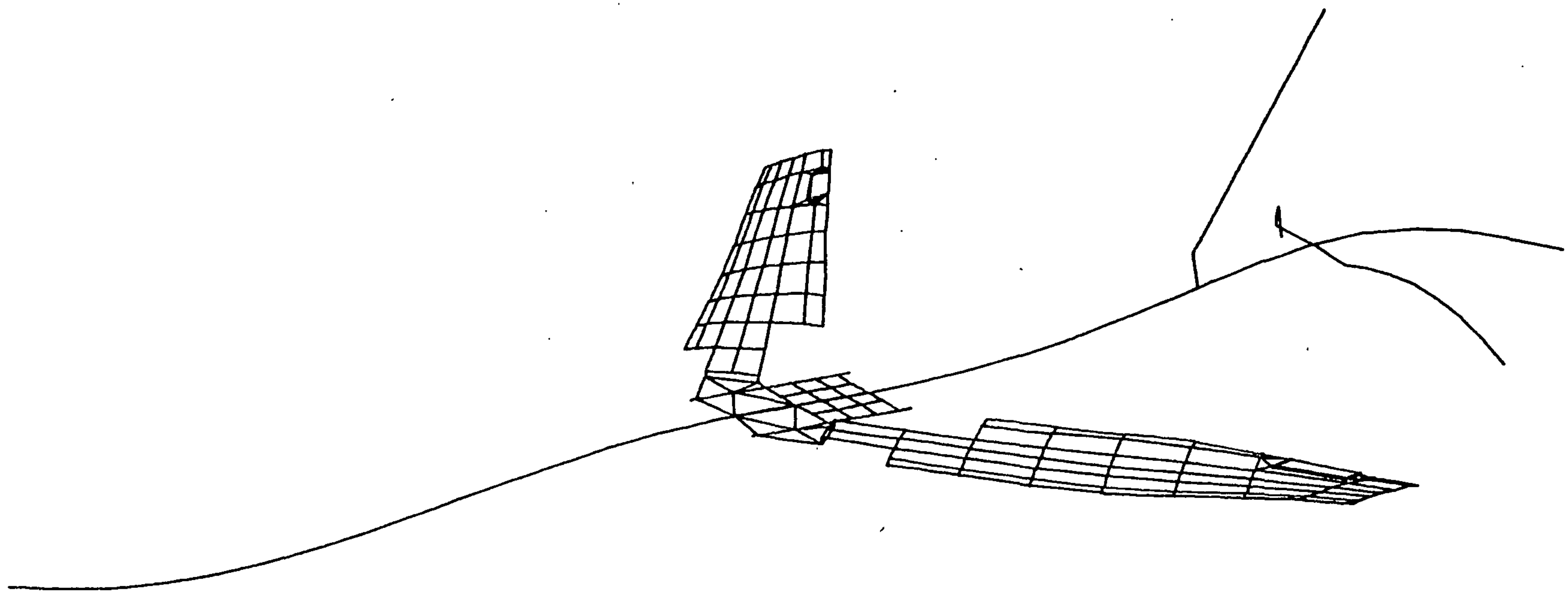


FIGURE A-12 - DAST WITH AWR-1 SYMMETRIC MODEL, ELASTIC MODE NO. 10, 102.89 HZ

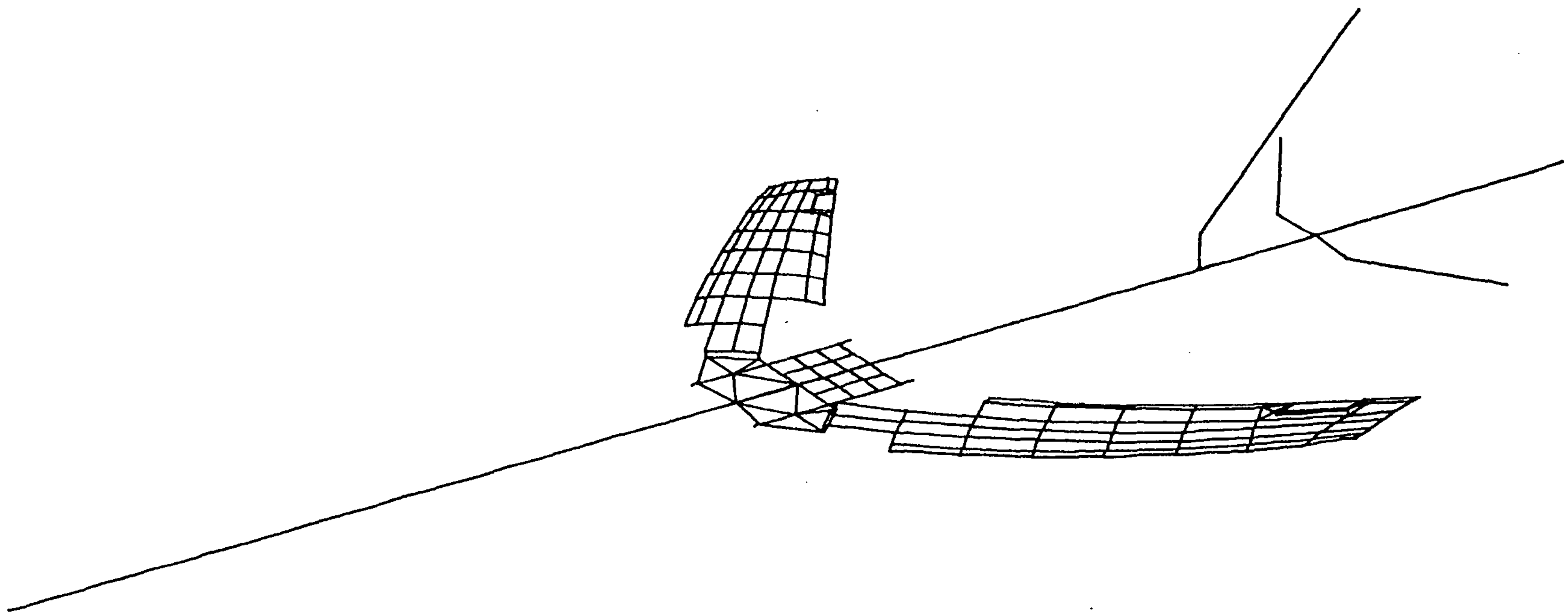


FIGURE A-13 - DAST WITH ARW-1 ANTISYMMETRIC MODEL, ELASTIC MODE NO. 1, 12.45 HZ

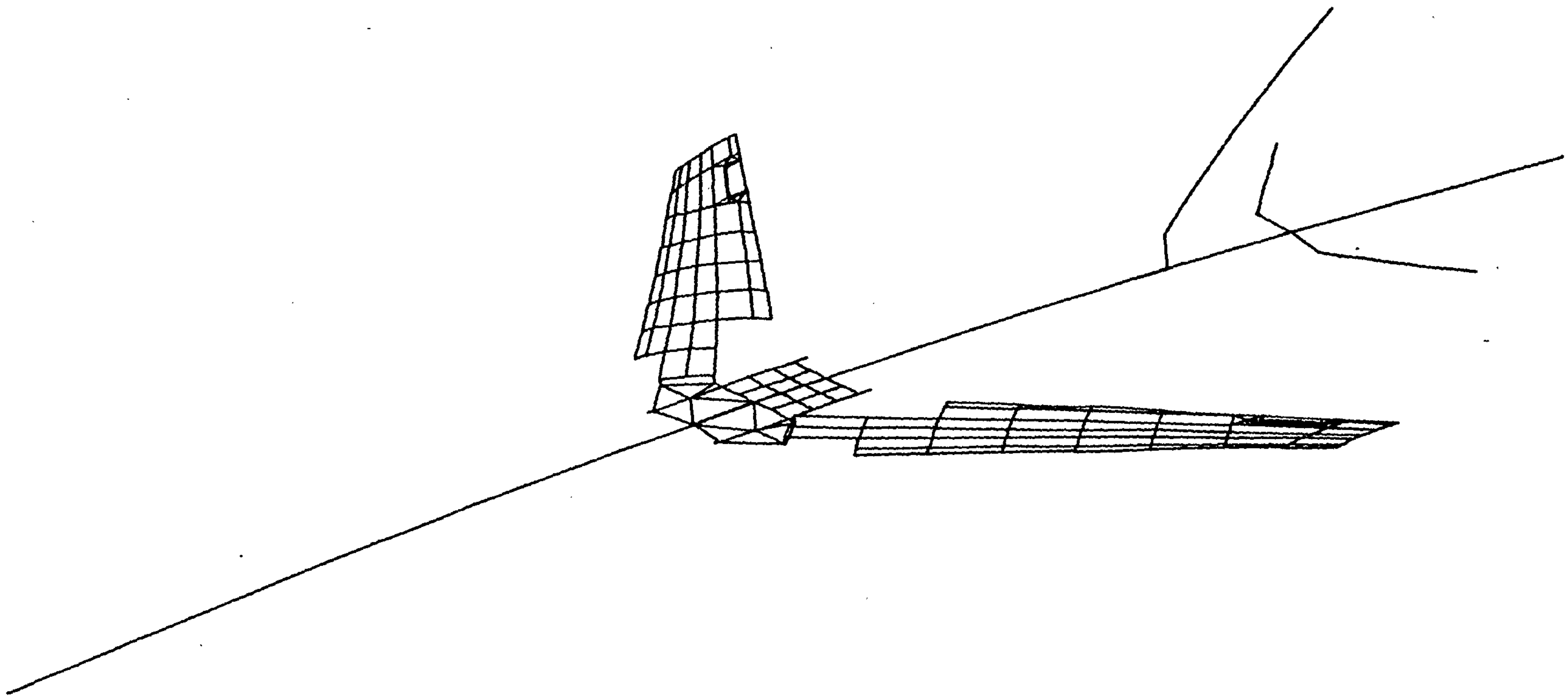


FIGURE A-14 - DAST WITH ARW-1 ANTISYMMETRIC MODEL, ELASTIC MODE NO. 2, 23.31 HZ

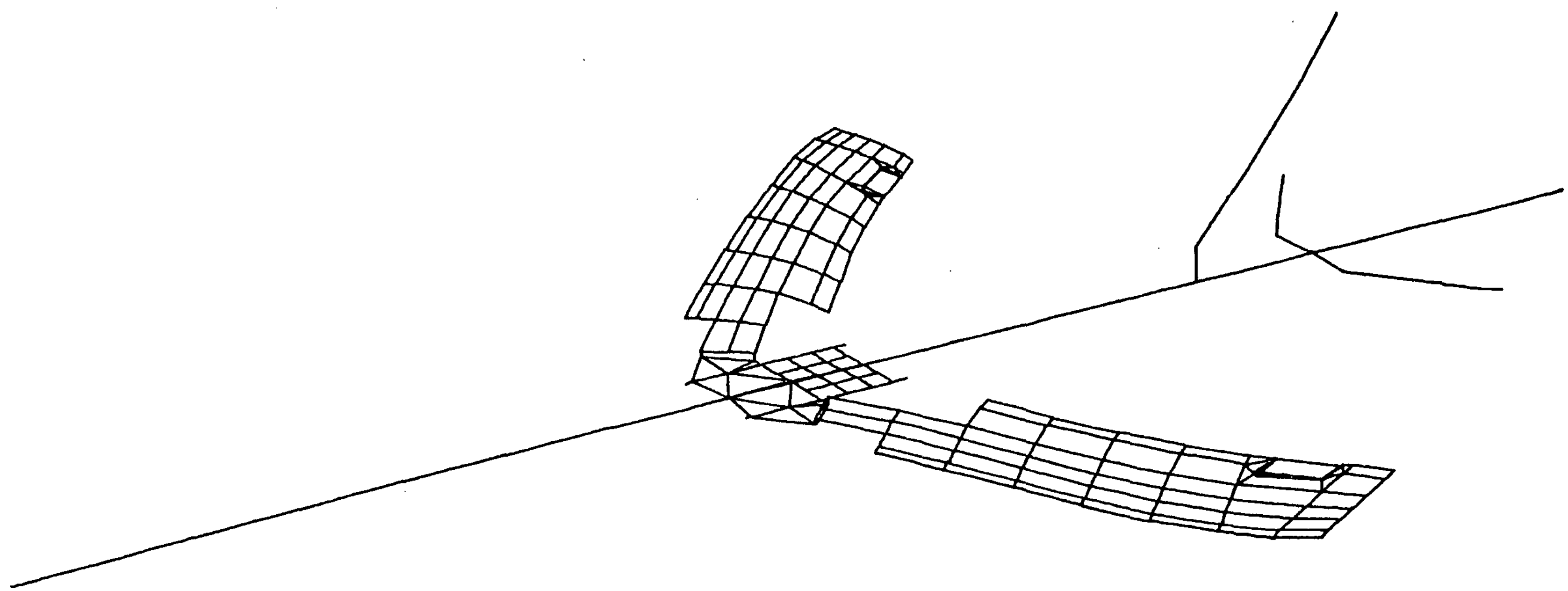


FIGURE A-15 - DAST WITH ARW-1 ANTISYMMETRIC MODEL, ELASTIC MODE NO. 3, 30.35 HZ

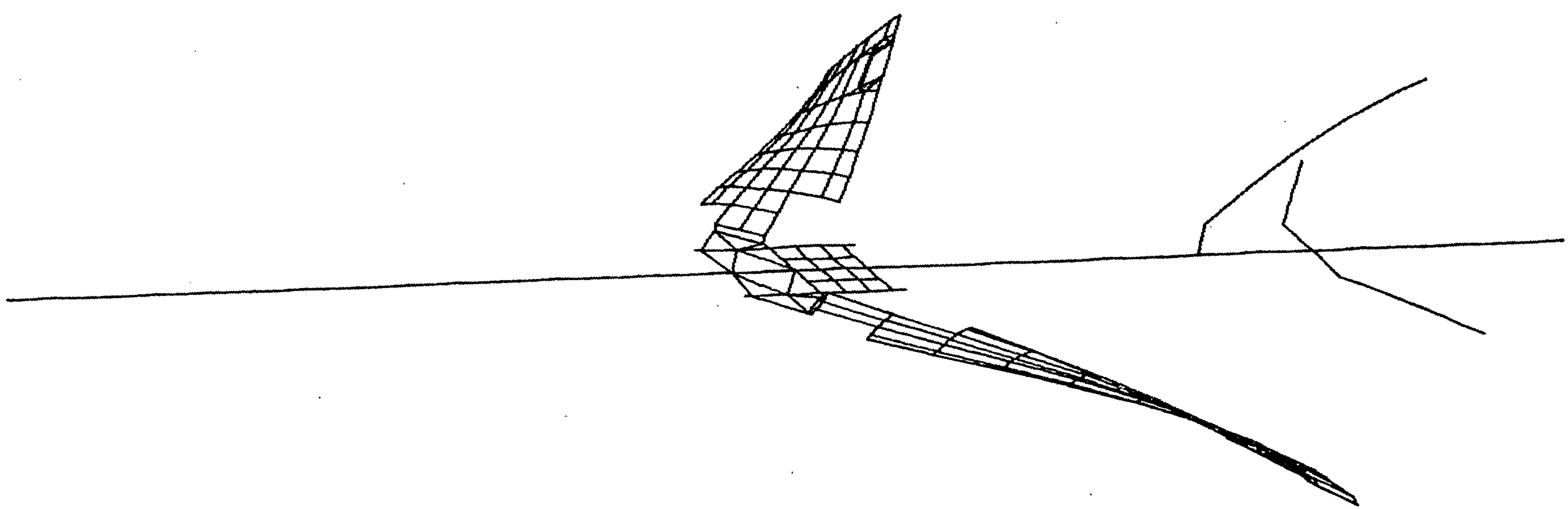


FIGURE A-16 - DAST WITH ARW-1 ANTISYMMETRIC MODEL, ELASTIC MODE NO. 4, 35.25 HZ

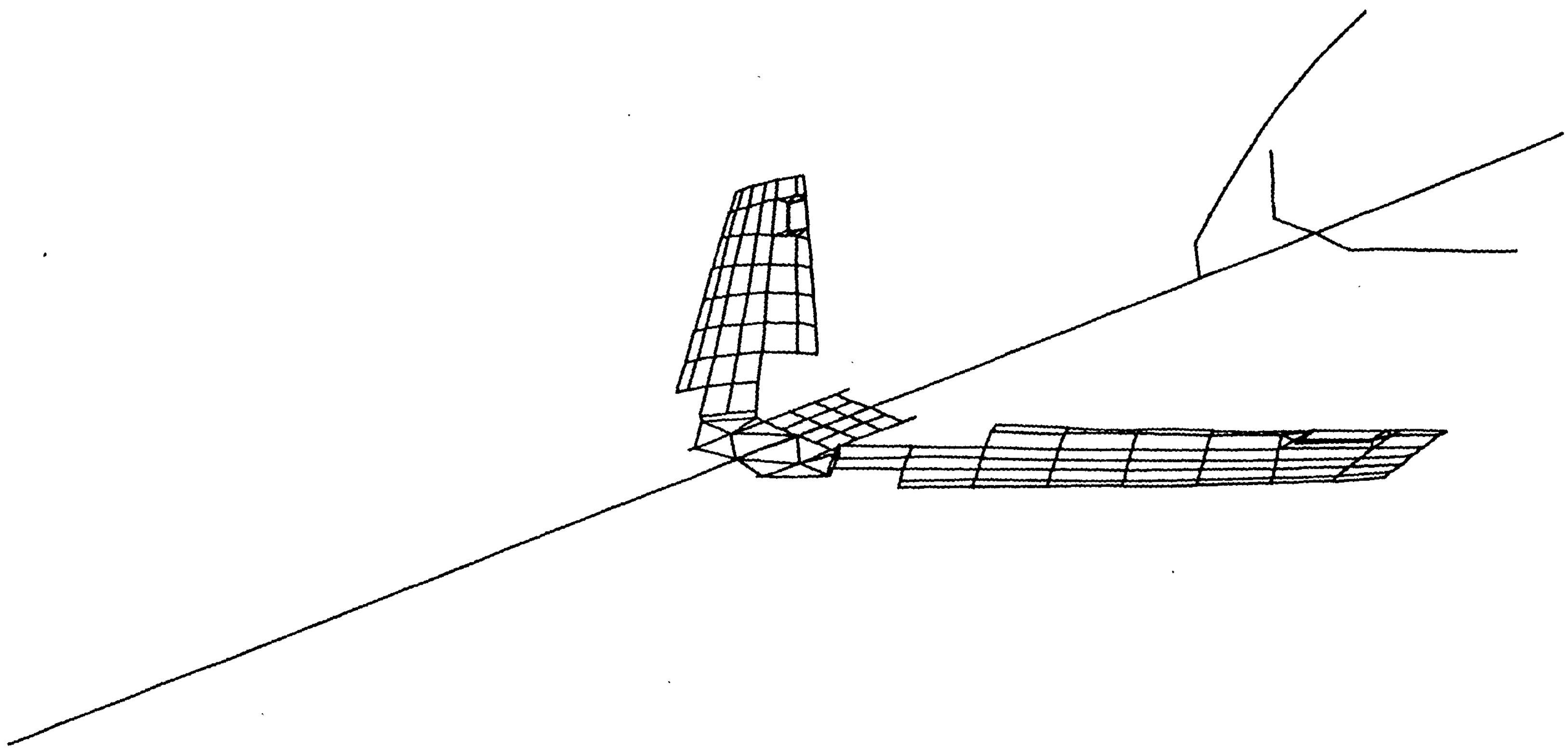


FIGURE A-17 - DAST WITH ARW-1 ANTISYMMETRIC MODEL, ELASTIC MODE NO. 5, 36.12 HZ

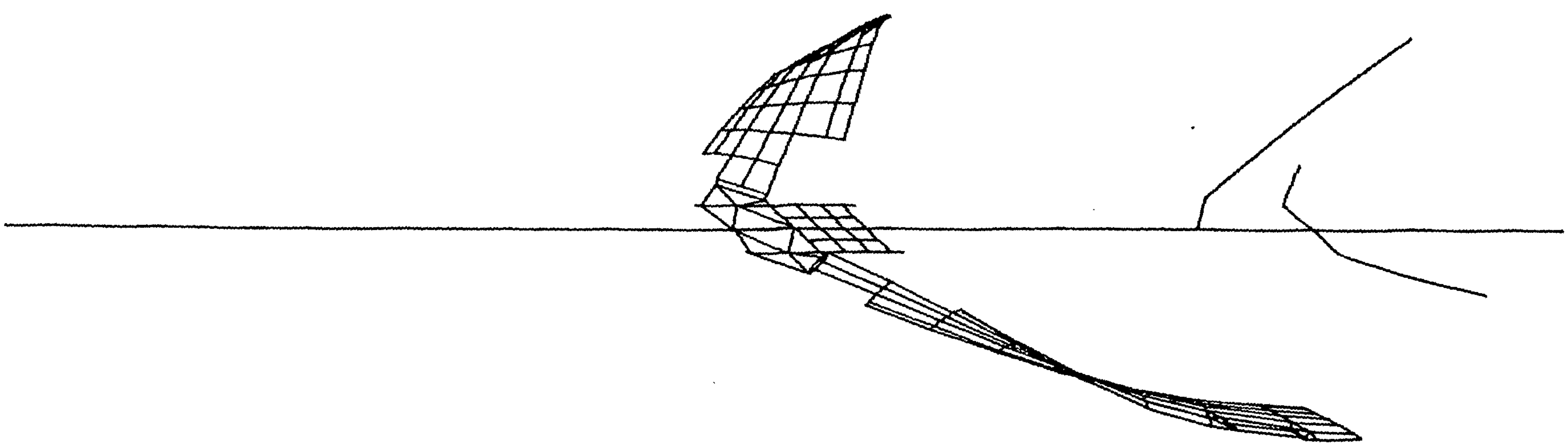


FIGURE A-18 - DAST WITH ARW-1 ANTISYMMETRIC MODEL, ELASTIC MODE NO. 6, 49.59 HZ

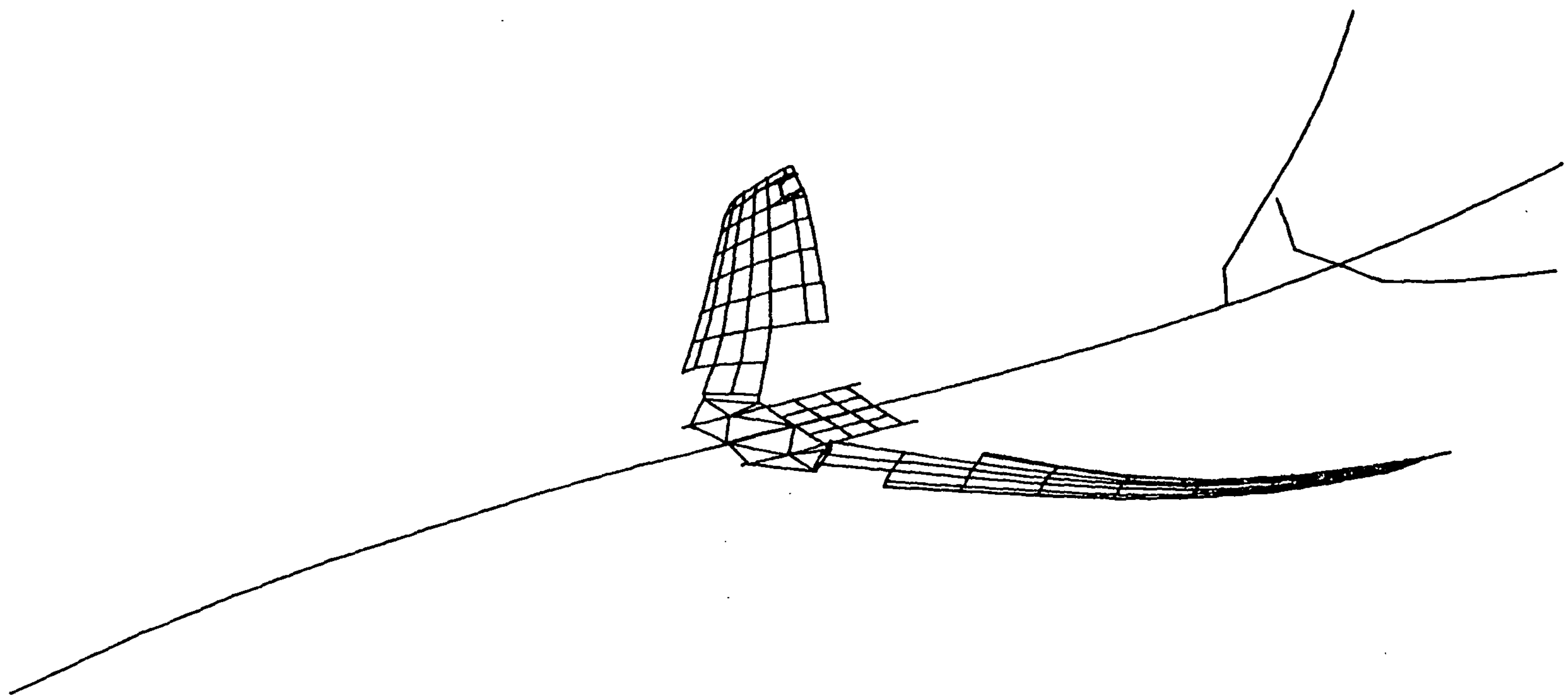


FIGURE A-19 - DAST WITH ARW-1 ANTISYMMETRIC MODEL, ELASTIC MODE NO. 7, 53.22 HZ

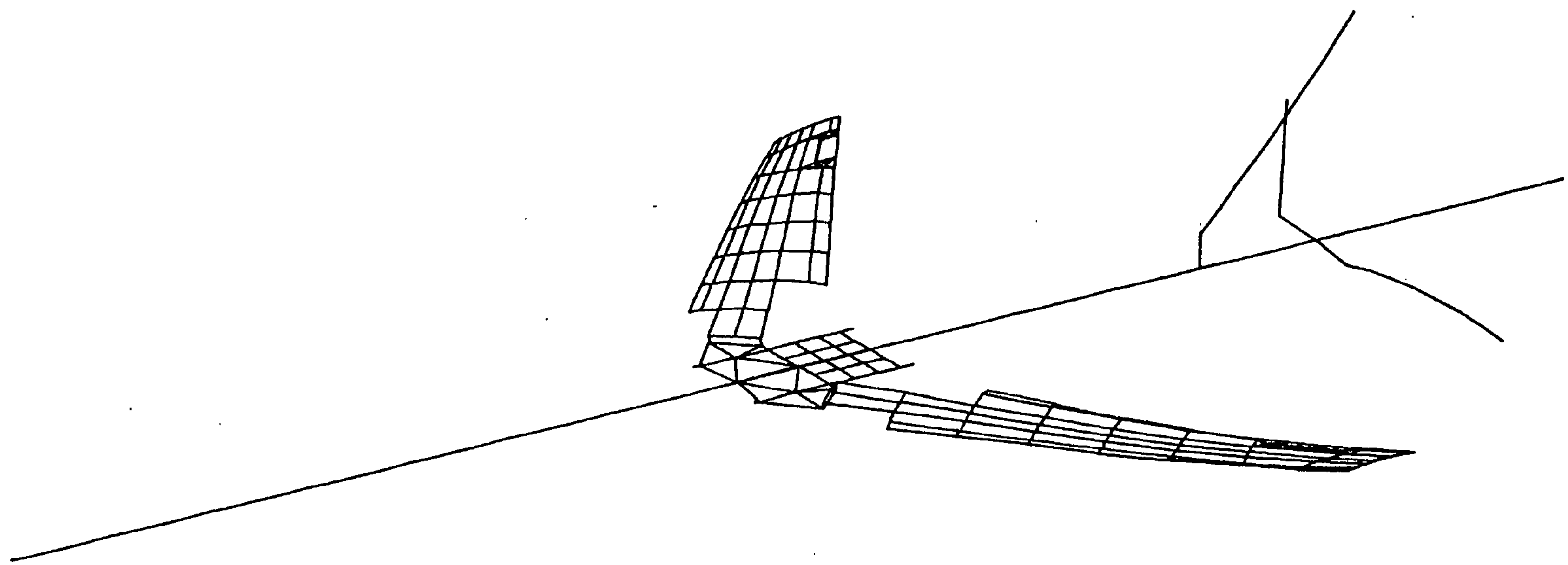


FIGURE A-20 - DAST WITH ARW-1 ANTISYMMETRIC MODEL, ELASTIC MODE NO. 8, 54.48 HZ

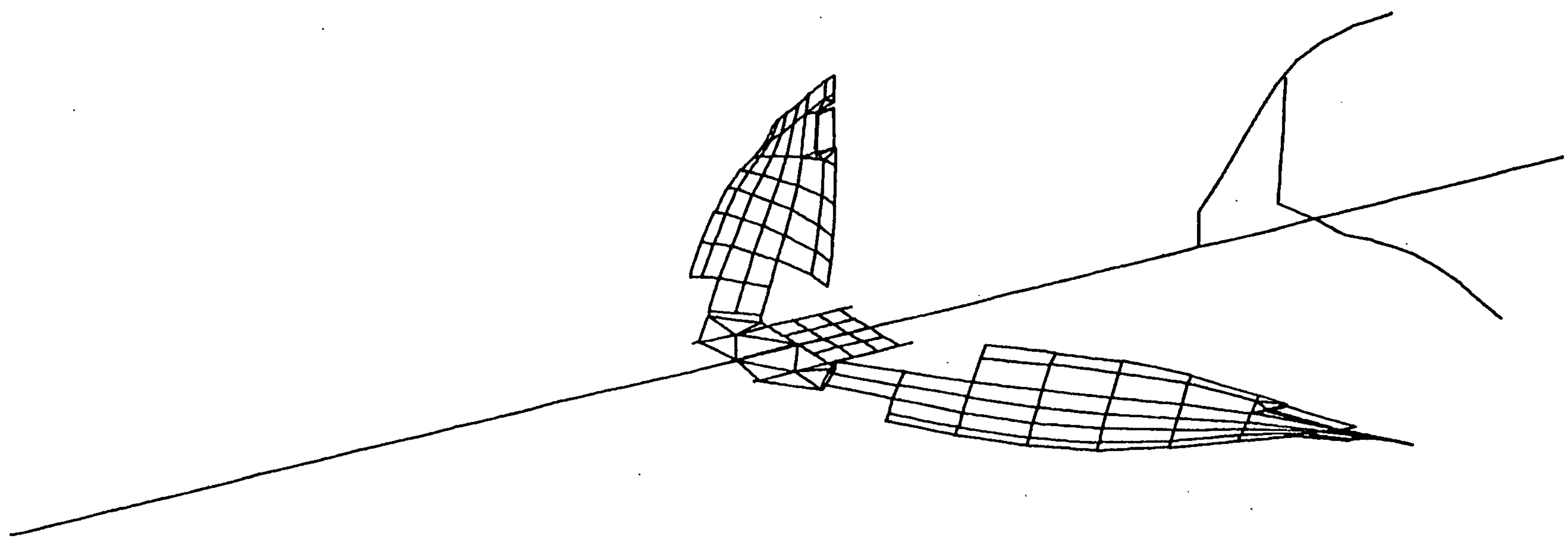


FIGURE A-21 - DAST WITH ARW-1 ANTISYMMETRIC MODEL, ELASTIC MODE NO. 9, 79.14 HZ

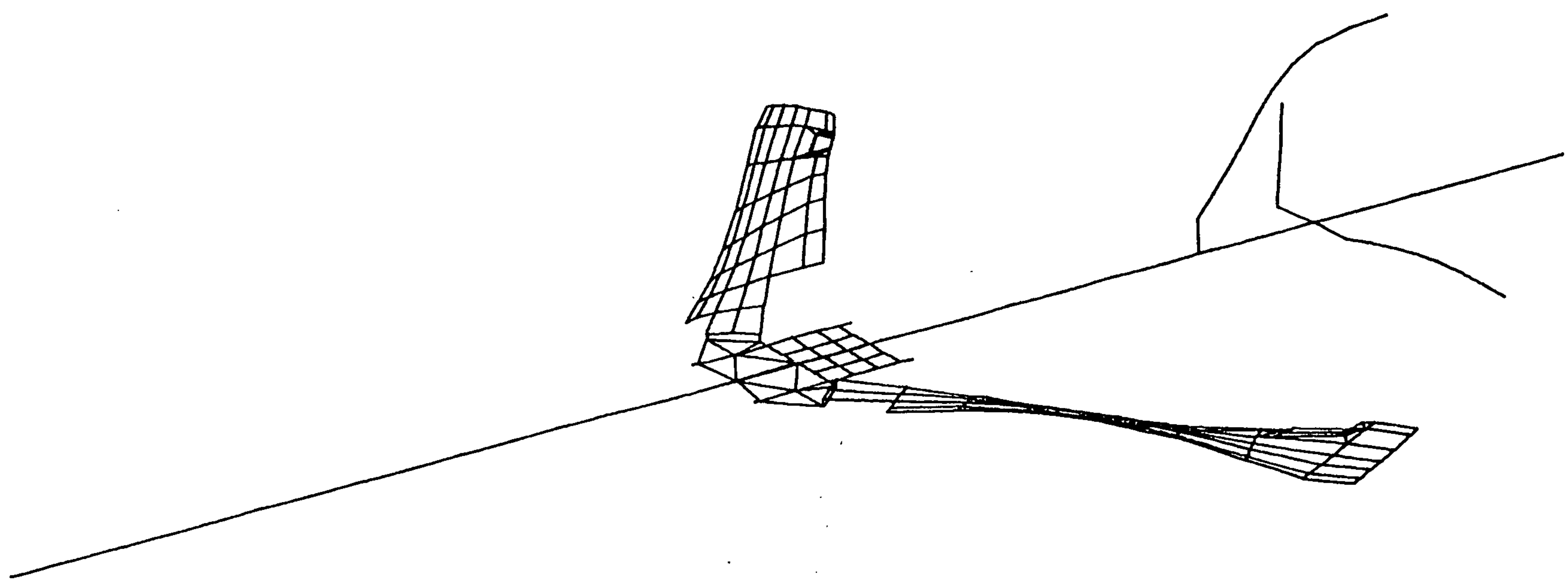


FIGURE A-22 - DAST WITH ARW-1 ANTISYMMETRIC MODEL, ELASTIC MODE NO. 10, 81.40 HZ

APPENDIX B

EQUATIONS OF MOTION FOR DAST WITH ARW-1

Appendix B contains descriptions of the equations of motion for the DAST with ARW-1 and the associated model coefficient matrices.

The drone equations of motion (EOM) are in the following standardized form.

$$\left(S^2[\text{Mass}] + S[\text{Damping}] + [\text{Stiffness}]\right)\{q(S)\}$$

$$+\left(S^2\rho[C_1] + S\rho U_o[C_2] + \rho U_o^{\,2}[C_3] + \rho U_o^{\,2}\sum_{i=1}^{4}[D_i]\frac{S}{S+U_oB_i}\right)\{q(S)\}$$

$$+\left(\rho U_o[R_o] + \rho U_o\sum_{i=1}^{4}[R_i]\frac{S}{S+U_oG_i}\right)\begin{Bmatrix} W_g(S) \\ V_g(S) \end{Bmatrix} = 0$$

The coefficient matrices in the first line of the equation are the generalized structural terms. The second line of the equation contains the generalized aerodynamic coefficients and the third line represents the generalized gust effects. The terms in $S/(S + U_oB_i)$ and $S/(S + U_oG_i)$ represent unsteady aerodynamic effects.

The coefficient matrices listed on the following pages are for both the symmetric and antisymmetric mathematical models. Each of the models contain three rigid body degrees of freedom and 10 elastic mode degrees of freedom. The remaining degrees of freedom are for the control surfaces. Control surface mass unbalance and coupling of the aerodynamic hinge moment with the actuator mode are not included. The arrangement of the generalized degrees of freedom are shown in Table B-I.

TABLE B-I

GENERALIZED DEGREES OF FREEDOM

DOF	SYMMETRIC ANALYSIS	ANTISYMMETRIC ANALYSIS
1	X Rigid Body Translation	Y Rigid Body Translation
2	Z Rigid Body Translation	ϕ Rigid Body Rotation (Roll)
3	θ Rigid Body Rotation (Pitch)	ψ Rigid Body Rotation (Yaw)
4	1st Elastic Mode	1st Elastic Mode
5	2nd Elastic Mode	2nd Elastic Mode
6	3rd Elastic Mode	3rd Elastic Mode
7	4th Elastic Mode	4th Elastic Mode
8	5th Elastic Mode	5th Elastic Mode
9	6th Elastic Mode	6th Elastic Mode
10	7th Elastic Mode	7th Elastic Mode
11	8th Elastic Mode	8th Elastic Mode
12	9th Elastic Mode	9th Elastic Mode
13	10th Elastic Mode	10th Elastic Mode
14	δ_A Aileron Rotation	δ_A Aileron Rotation
15	δ_S Stabilizer Rotation	δ_S Stabilizer Rotation
16		δ_r Rudder Rotation

The EOM matrices listed are followed by three row vectors $\lfloor XG \rfloor$, $\lfloor YG \rfloor$ and $\lfloor ZG \rfloor$. These vectors contain the X, Y and Z locations of the gust reference points used in the analysis.

Any physical motion may be expressed as a weighted summation of the generalized displacements. Therefore, following the gust reference point locations, modal matrices are listed for the fore and aft fuselage, wing, horizontal stabilizer and fin. The rows of each matrix represent modal displacement and rotations. The rows are arranged so that all of the X displacements are grouped together followed by the Y displacements and so on through the Z displacements and the ϕ, θ and ψ rotations. For the components that are on the plane of symmetry (i.e., fore and aft fuselage and the fin) the null displacements have been deleted. The deleted freedoms are the Y, ϕ and ψ for the symmetric case and X, Z and θ for the antisymmetric case. The modal coefficients are defined for the locations shown in Table B-II.

TABLE B-II

MODAL COEFFICIENT LOCATIONS

COMPONENT	FUSELAGE		WING		HORIZONTAL STAB		FIN	
MATRIX	PHFF	PHAF	PHWG		PHHT		PHVT	
REFERENCE POINT	X - in.	X - in.	X - in.	Y - in.	X - in.	Y - in.	X - in	Y - in.
1	100.	290.	86.88	85.50	359.57	9.90	337.04	8.20
2	110.	300.	91.61	85.50	361.84	13.30	340.48	11.83
3	120.	310.	81.20	79.25	363.80	16.69	343.92	15.46
4	130.	320.	86.53	79.25	365.91	20.09	347.35	19.09
5	140.	330.	73.08	70.30	368.03	23.48	350.79	22.72
6	150.	337.03	76.64	67.07	370.14	26.88	354.23	26.35
7	160.	340.	65.01	61.42	372.25	30.27	357.66	29.99
8	170.	350.	69.07	57.74	374.37	33.67	361.10	33.62
9	180.	360.	56.95	52.54			364.54	37.25
10	190.	370.	61.49	48.41			367.98	40.88
11	200.	380.	48.88	43.65				
12	210.	390.	53.92	39.08				
13	220.	400.	40.81	34.77				
14	230.	410.	46.34	29.75				
15	242.29		32.75	25.88				
16	250.62		38.77	20.42				
17	258.87		24.68	17.00				
18	267.14		31.19	11.09				
19	274.04		48.05	9.00				

MATRIX 'MASS' 15 BY 15 SYMMETRIC MODEL MACH .90

ROW 1

5.35479E 00	4.03323E-11	-3.00959E-07	-1.84738E-10	-5.76230E-09
2.40563E-09	-8.52854E-09	1.36150E-09	-2.08600E-10	6.80945E-11
-4.44086E-10	1.07362E-09	-5.56534E-09	0.0	0.0

ROW 2

4.03322E-11	5.35479E 00	1.80761E-06	4.27353E-08	-3.49978E-07
1.57533E-08	2.41872E-08	-5.86924E-08	8.34529E-10	5.63959E-10
3.77547E-08	-1.87033E-10	-9.51141E-08	0.0	0.0

ROW 3

-3.00959E-07	1.80761E-06	2.38890E 04	-2.63767E-06	-2.06481E-05
-1.29889E-06	-1.17189E-06	4.53897E-06	-1.24004E-07	5.51341E-07
-9.10240E-08	-5.73157E-07	7.16767E-06	0.0	0.0

ROW 4

-1.84738E-10	4.27353E-08	-2.63767E-06	5.04162E-02	-5.21455E-09
-1.79381E-08	-2.08131E-08	4.30357E-09	-2.76059E-09	-7.97781E-11
7.07557E-10	-1.38272E-09	-1.28272E-09	0.0	0.0

ROW 5

-5.76230E-09	-3.49978E-07	-2.06481E-05	-5.21455E-09	6.55247E-01
7.89425E-09	8.97222E-09	3.38586E-09	-4.63321E-10	2.07191E-09
-5.18183E-09	-2.48937E-09	-2.40482E-08	0.0	0.0

ROW 6

2.40563E-09	1.57533E-08	-1.29889E-06	-1.79381E-08	7.89425E-09
1.13833E-01	2.65797E-08	2.30292E-09	-4.28557E-09	2.50744E-11
-6.65520E-10	5.88674E-09	-1.34803E-09	0.0	0.0

ROW 7

-8.52854E-09	2.41872E-08	-1.17189E-06	-2.08131E-08	8.97222E-09
2.65797E-08	7.50175E-02	4.41717E-10	-5.63364E-09	1.34576E-10
-1.69812E-09	9.24263E-09	-2.30167E-10	0.0	0.0

ROW 8

1.36150E-09	-5.86924E-08	4.53897E-06	4.30357E-09	3.38586E-09
2.30292E-09	4.41717E-10	5.60900E-01	6.75800E-10	-2.44431E-09
-1.76822E-09	-2.09775E-09	-4.45228E-08	0.0	0.0

ROW 9

-2.08600E-10	8.34529E-10	-1.24004E-07	-2.76059E-09	-4.63321E-10
-4.28557E-09	-5.63364E-09	6.75800E-10	1.94884E-02	1.01088E-10
-2.72937E-10	1.03987E-09	8.53022E-12	0.0	0.0

ROW 10

6.80945E-11	5.63959E-10	5.51341E-07	-7.97781E-11	2.07191E-09
2.50744E-11	1.34576E-10	-2.44431E-09	1.01088E-10	1.09688E-02
2.69321E-09	-9.06623E-11	2.26459E-09	0.0	0.0

ROW 11

-4.44086E-10	3.77547E-08	-9.10240E-08	7.07557E-10	-5.18183E-09
-6.65520E-10	-1.69812E-09	-1.76822E-09	-2.72937E-10	2.69321E-09
3.74641E-02	4.17168E-10	-4.49732E-09	0.0	0.0

ROW 12

1.07362E-09	-1.87033E-10	-5.73157E-07	-1.38272E-09	-2.48937E-09
5.88674E-09	9.24263E-09	-2.09775E-09	1.03987E-09	-9.06623E-11
4.17168E-10	3.88911E-02	-2.35879E-10	0.0	0.0

ROW 13

-5.56534E-09	-9.51141E-08	7.16767E-06	-1.28272E-09	-2.40482E-08
-1.34803E-09	-2.30167E-10	-4.45228E-08	8.53023E-12	2.26459E-09
-4.49732E-09	-2.35879E-10	5.43290E-01	0.0	0.0

ROW 14

0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0

ROW 15

0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0

MATRIX 'C1 ' 15 BY 15 SYMMETRIC MODEL MACH .90

ROW 1

0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0

ROW 2

0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0

ROW 3

0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0

ROW 4

0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0

ROW 5

0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0

ROW 6

0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0

ROW 7

0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0

ROW 8

0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0

ROW 9

0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0

ROW 10

0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0

ROW 11

0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0

ROW 12

0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0

ROW 13

0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0

ROW 14

0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0

ROW 15

0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0

MATRIX 'DAMP' 15 BY 15 SYMMETRIC MODEL MACH .90

ROW 1				
0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0
ROW 2				
0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0
ROW 3				
0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0
ROW 4				
0.0	0.0	0.0	2.88084E-02	-3.99866E-09
-1.85805E-08	-2.30003E-08	5.11635E-09	-3.65218E-09	-1.21956E-10
1.11064E-09	-2.32580E-09	-2.46536E-09	0.0	0.0
ROW 5				
0.0	0.0	0.0	-3.99867E-09	6.74300E-01
1.09734E-08	1.33060E-08	5.40195E-09	-8.22586E-10	4.25050E-09
-1.09155E-08	-5.61921E-09	-6.20273E-08	0.0	0.0
ROW 6				
0.0	0.0	0.0	-1.85805E-08	1.09734E-08
2.13738E-01	5.32454E-08	4.96300E-09	-1.02776E-08	6.94836E-11
-1.89368E-09	1.79492E-08	-4.69661E-09	0.0	0.0
ROW 7				
0.0	0.0	0.0	-2.30003E-08	1.33060E-08
5.32454E-08	1.60329E-01	1.01561E-09	-1.44141E-08	3.97865E-10
-5.15502E-09	3.00664E-08	-8.55545E-10	0.0	0.0
ROW 8				
0.0	0.0	0.0	5.11635E-09	5.40194E-09
4.96300E-09	1.01561E-09	1.38740E 00	1.86016E-09	-7.77425E-09
-5.77473E-09	-7.34133E-09	-1.78039E-07	0.0	0.0
ROW 9				
0.0	0.0	0.0	-3.65218E-09	-8.22587E-10
-1.02776E-08	-1.44142E-08	1.86016E-09	5.96937E-02	3.57784E-10
-9.91920E-10	4.04965E-09	3.79588E-11	0.0	0.0
ROW 10				
0.0	0.0	0.0	-1.21956E-10	4.25050E-09
6.94836E-11	3.97865E-10	-7.77425E-09	3.57784E-10	4.48588E-02
1.13098E-08	-4.07975E-10	1.16442E-08	0.0	0.0
ROW 11				
0.0	0.0	0.0	1.11064E-09	-1.09155E-08
-1.89368E-09	-5.15502E-09	-5.77473E-09	-9.91920E-10	1.13098E-08
1.61544E-01	1.92757E-09	-2.37447E-08	0.0	0.0
ROW 12				
0.0	0.0	0.0	-2.32580E-09	-5.61921E-09
1.79492E-08	3.00664E-08	-7.34132E-09	4.04965E-09	-4.07975E-10
1.92757E-09	1.92564E-01	-1.33453E-09	0.0	0.0
ROW 13				
0.0	0.0	0.0	-2.46537E-09	-6.20273E-08
-4.69661E-09	-8.55545E-10	-1.78039E-07	3.79588E-11	1.16442E-08
-2.37448E-08	-1.33453E-09	3.51223E 00	0.0	0.0
ROW 14				
0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0

MATRIX 'DAMP' 15 BY 15 SYMMETRIC MODEL MACH .90

ROW 15

0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0

MATRIX 'C2 ' 15 BY 15 SYMMETRIC MODEL MACH .90

ROW 1

5.09070E-14	6.64834E-07	-4.79214E-05	-8.50186E-07	6.47945E-07
1.54442E-06	1.50099E-06	2.55662E-07	1.65261E-07	5.14423E-08
-2.49881E-07	1.03925E-06	-1.96171E-07	-3.79239E-06	-2.07583E-07

ROW 2

-2.49978E-06	1.22613E 04	-2.45359E 05	-1.76071E 03	-7.15319E 02
-1.39620E 01	1.89443E 02	6.85034E 02	-1.42196E 03	-3.66906E 01
1.25142E 02	-1.57139E 03	3.06316E 03	-7.05790E 02	-9.68429E 03

ROW 3

4.97349E-05	5.91793E 04	2.94188E 07	4.66957E 04	-2.21373E 05
-9.15011E 03	-1.97343E 04	4.38615E 04	1.02178E 03	1.02101E 04
-4.24114E 04	-1.26030E 04	-1.05975E 05	3.36496E 04	9.98021E 05

ROW 4

3.13300E-07	-1.55449E 03	5.35061E 04	9.54217E 02	-2.31477E 02
-2.13218E 02	-3.21962E 02	5.67490E 01	3.34456E 02	1.52922E 01
-6.50019E 01	2.84988E 02	6.07578E 00	6.00215E 02	-3.41356E 02

ROW 5

7.29400E-07	-2.74318E 03	-1.21330E 05	-7.66823E 01	1.55537E 03
3.02747E 02	2.91928E 02	-2.40055E 02	3.57960E 02	-4.69081E 01
1.96316E 02	4.20583E 02	1.25195E 02	-2.90810E 02	-4.71508E 03

ROW 6

2.09506E-06	-1.24810E 03	4.91056E 04	5.36042E 02	4.65366E 01
8.39480E 02	6.37558E 02	2.61557E 02	3.15122E 02	2.95796E 01
-1.24309E 02	2.32511E 02	1.09809E 02	-3.48920E 02	8.88560E 01

ROW 7

1.65738E-06	-1.07482E 03	3.16931E 04	4.03874E 02	8.92863E 01
7.11307E 02	5.70110E 02	1.49170E 02	1.76111E 02	2.03705E 01
-8.70644E 01	2.09558E 02	3.20563E 01	-3.61436E 02	8.38849E 01

ROW 8

7.83853E-07	1.35457E 03	8.12230E 04	2.86191E 00	-7.06591E 02
1.32954E 02	6.54041E 01	5.09959E 02	7.72874E 01	4.40607E 01
-1.96753E 02	-6.21747E 00	2.23934E 02	-7.73794E 01	-1.24379E 03

ROW 9

2.37240E-06	-6.67188E 02	-7.66462E 03	-1.01132E 02	3.01441E 02
-3.11367E 01	-4.99706E 01	1.01067E 02	5.75102E 02	2.35737E 01
-1.04294E 02	6.28917E 02	-1.62299E 02	-1.06888E 02	-1.49134E 01

ROW 10

2.02741E-07	7.39060E 01	7.12346E 03	2.45590E 00	-6.69964E 01
-6.69297E 00	-6.38345E 00	1.71787E 01	1.39572E 01	4.99197E 00
-2.15362E 01	3.42371E 01	-3.95644E 01	-9.07944E 00	1.36275E 02

ROW 11

-8.71305E-07	-3.78492E 02	-3.08106E 04	-1.93634E 01	3.06333E 02
4.89108E 01	4.32471E 01	-8.35505E 01	-4.24066E 01	-2.10635E 01
9.31743E 01	-1.57783E 02	1.40039E 02	3.67299E 01	-5.57441E 02

ROW 12

2.86450E-06	-6.66129E 02	-1.84312E 04	1.45036E 02	8.66054E 01
-5.78938E 02	-4.32383E 02	-1.79208E 02	1.58450E 02	1.19799E 01
-8.54642E 01	1.07893E 03	-4.15623E 02	-8.09384E 01	-1.92744E 02

ROW 13

-8.11202E-07	2.00575E 03	-8.63207E 04	8.78721E 01	3.93461E 02
3.12669E 02	1.90718E 02	6.03877E 02	7.31171E 01	-2.18212E 01
6.81764E 01	-2.92511E 02	1.85571E 03	1.26725E 01	-6.74383E 03

ROW 14

-1.76866E-06	-8.38992E 01	5.45740E 03	9.73950E 01	-6.50268E 01
-1.44239E 02	-1.44277E 02	-1.86836E 01	6.32609E 00	-3.09748E 00
1.63212E 01	-8.00857E 01	1.45122E 01	4.35351E 02	4.84512E-01

MATRIX 'C2 ' 15 BY 15 SYMMETRIC MODEL MACH .90

ROW 15

3.93529E-07	2.49004E 03	-7.43078E 05	4.81451E 02	4.15591E 03
3.74122E 02	2.48945E 02	-2.28643E 03	5.95678E 02	-3.73623E 02
1.44490E 03	2.22951E 02	6.80029E 03	7.62090E 01	1.16446E 05

MATRIX 'STIF' 15 BY 15 SYMMETRIC MODEL MACH .90

ROW 1

0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0

ROW 2

0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0

ROW 3

0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0

ROW 4

0.0	0.0	0.0	1.64615E 02	0.0
0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0

ROW 5

0.0	0.0	0.0	0.0	6.93908E 03
0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0

ROW 6

0.0	0.0	0.0	0.0	0.0
4.01326E 03	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0

ROW 7

0.0	0.0	0.0	0.0	0.0
0.0	3.42656E 03	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0

ROW 8

0.0	0.0	0.0	0.0	0.0
0.0	0.0	3.43175E 04	0.0	0.0
0.0	0.0	0.0	0.0	0.0

ROW 9

0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	1.82844E 03	0.0
0.0	0.0	0.0	0.0	0.0

ROW 10

0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	1.83459E 03
0.0	0.0	0.0	0.0	0.0

ROW 11

0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0
6.96573E 03	0.0	0.0	0.0	0.0

ROW 12

0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0
0.0	9.53457E 03	0.0	0.0	0.0

ROW 13

0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0
0.0	0.0	2.27057E 05	0.0	0.0

ROW 14

0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0

ROW 15

0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0

MATRIX 'C3 ' 15 BY 15 SYMMETRIC MODEL MACH .90

ROW 1

-2.51435E-15	-3.29912E-18	1.13922E-07	-3.67839E-09	7.27714E-09
5.39616E-08	5.94736E-08	1.04398E-08	-2.49152E-08	2.55949E-09
-1.86334E-08	1.60589E-07	-3.39905E-08	-8.73986E-07	-4.15768E-08

ROW 2

-2.04074E-06	-3.89699E-09	-1.29347E 04	-5.19337E 01	1.05731E 02
2.82007E 02	2.75559E 02	-4.75784E 01	-2.71415E 02	-1.30668E 01
6.37521E 01	-3.38267E 02	3.48665E 01	-3.10379E 02	-2.56418E 03

ROW 3

6.12449E-05	1.25807E-07	1.07778E 05	1.06237E 03	-3.81776E 03
-7.90147E 03	-7.64620E 03	-5.59375E 03	5.57925E 03	9.77400E 01
-2.37096E 02	3.02568E 03	-5.39853E 03	1.32678E 04	2.22321E 05

ROW 4

6.62391E-07	1.90801E-09	2.29267E 03	1.70836E 01	-2.38407E 01
-1.05333E 02	-1.05369E 02	1.70503E 01	8.22667E 01	3.07861E 00
-1.23386E 01	4.18331E 01	-5.35510E 00	2.13131E 02	-7.07479E 01

ROW 5

7.51759E-08	-4.33626E-10	1.87592E 03	2.92726E 00	2.99375E 00
1.12171E 00	2.72759E 00	4.33047E 01	1.83965E 01	2.58056E 00
-1.48498E 01	7.67994E 01	1.93213E 01	-8.71370E 01	-7.71099E 02

ROW 6

1.17104E-06	7.10984E-10	3.05345E 03	1.84954E 01	-2.61746E 01
-9.85212E 01	-9.45532E 01	2.66873E 01	9.30368E 01	5.49564E 00
-2.65266E 01	1.39541E 02	-2.24378E 01	-5.18194E 01	8.15867E 00

ROW 7

1.02252E-06	5.78009E-10	2.59821E 03	1.54656E 01	-2.18786E 01
-8.22662E 01	-7.95892E 01	2.24256E 01	7.65371E 01	4.41356E 00
-2.12810E 01	1.11375E 02	-1.72032E 01	-5.98798E 01	3.92967E 00

ROW 8

1.34303E-07	-1.61049E-10	-9.33206E 02	-6.87033E-01	-2.02993E 00
-9.83073E-01	1.10671E 00	-1.96429E 01	-7.81959E-01	-2.22941E-02
6.06452E-01	6.78699E 00	-2.10198E 01	-1.85823E 01	3.96263E 02

ROW 9

3.14197E-08	-5.67980E-10	-1.24116E 02	-3.91517E 00	5.81898E 00
2.92708E 01	3.02111E 01	3.02789E 00	-1.48386E 01	1.25430E-01
-2.02070E 00	2.05898E 01	-3.19076E-01	-4.78049E 01	-2.15901E 01

ROW 10

3.76975E-08	1.40317E-12	-4.95111E 01	-6.76600E-02	-4.57015E-01
-1.28336E-01	-1.87726E-01	-2.21157E 00	-3.88685E-01	-7.50232E-02
4.20187E-01	-1.39396E 00	-1.59296E 00	-1.60340E 00	5.87964E 01

ROW 11

-1.81202E-07	-3.56318E-11	3.04231E 02	2.88546E-01	1.73852E 00
1.62210E 00	2.01135E 00	1.01684E 01	2.02510E 00	4.30526E-01
-2.49834E 00	1.08191E 01	6.64255E 00	4.44491E 00	-2.33030E 02

ROW 12

6.95008E-07	4.35307E-10	-7.22695E 02	-7.89881E-01	1.54239E 00
-8.87364E 00	-1.33872E 01	-1.00335E 01	-1.01014E 01	-2.17126E 00
1.25735E 01	-8.22886E 01	8.79964E 00	1.18713E 01	-6.82218E 01

ROW 13

-2.76501E-07	-3.75880E-10	-1.82172E 03	-1.90098E 00	2.09988E 01
1.28134E 01	1.50216E 01	2.73274E 01	-9.64951E 00	7.79549E-01
-3.38964E 00	3.32527E 00	9.63654E 00	-1.28940E 01	-1.58841E 03

ROW 14

-2.89197E-07	1.81474E-10	4.49239E 01	5.26619E-01	-8.19726E-01
-4.39327E 00	-4.59660E 00	-9.69933E-02	2.50340E 00	-5.64693E-02
5.61194E-01	-5.71335E 00	1.43368E 00	7.25376E 01	5.84795E-01

ROW 15

-7.13624E-08	-6.26597E-10	-3.25845E 03	-8.86606E 00	1.18760E 02
5.42779E 01	4.19430E 01	2.64106E 02	-8.71276E 01	-7.45020E-01
4.85475E 00	-2.13283E 02	2.20933E 02	-9.11726E 01	-1.10540E 04

MATRIX 'D1 ' 15 BY 15 SYMMETRIC MODEL MACH .90

ROW 1

-1.29071E-15	4.82033E-09	5.75177E-07	7.36831E-09	-1.48521E-08
-8.11227E-08	-8.30031E-08	-7.75376E-10	5.21193E-08	6.14087E-10
5.20013E-10	-2.84313E-08	6.02646E-10	2.84925E-07	3.69480E-08

ROW 2

5.55051E-07	2.58091E 01	3.56604E 03	1.85013E 01	-4.75897E 01
-1.36519E 02	-1.35208E 02	-1.45240E 00	1.20501E 02	5.65969E 00
-2.74497E 01	1.65910E 02	-3.95625E 01	7.02378E 01	1.49039E 03

ROW 3

-7.86905E-06	2.44789E 03	5.24891E 05	-3.41095E 02	-2.65523E 02
4.71236E 03	3.47566E 03	7.23024E 03	-3.48382E 03	-2.08858E 02
7.84768E 02	-9.77978E 03	1.05343E 04	1.77782E 03	-1.01402E 05

ROW 4

-3.14547E-07	-6.58625E 00	-8.84738E 02	-5.94812E 00	1.27653E 01
5.42557E 01	5.36659E 01	-4.65140E 00	-3.91056E 01	-1.34007E 00
5.25712E 00	-1.89138E 01	4.29109E 00	-1.84929E 01	-6.66528E 01

ROW 5

4.58860E-08	-1.80887E 01	-3.55262E 03	-8.53159E-01	8.52892E 00
-1.11908E 01	-5.61275E 00	-4.14923E 01	8.39108E-01	-1.81044E-01
2.77026E 00	7.81107E 00	-4.97549E 01	-1.98391E 01	3.03973E 02

ROW 6

1.46943E-07	-8.89583E-01	5.98490E 01	-1.66812E 00	3.55473E 00
1.26965E 01	8.48491E 00	1.74859E 00	-1.31408E 01	-1.26182E 00
6.52019E 00	-4.33326E 01	1.23236E 01	1.13825E 01	-1.20306E 02

ROW 7

1.82314E-07	-8.22365E-01	-1.16101E 01	-6.69450E-01	1.86569E 00
3.60654E 00	1.13764E 00	9.68084E-01	-5.24281E 00	-6.77319E-01
3.75478E 00	-2.66750E 01	6.28596E 00	1.42524E 01	-1.00098E 02

ROW 8

9.07611E-08	1.23947E 01	2.40368E 03	2.32068E-01	-7.79005E 00
-1.76618E-01	-6.03715E 00	2.34135E 01	-3.92315E 00	-9.10176E-01
3.99200E 00	-4.56552E 01	4.01943E 01	1.37844E 01	-1.07008E 02

ROW 9

-1.80169E-07	-4.48069E 00	-7.32967E 02	-2.82058E 00	5.15397E 00
1.31544E 01	1.16050E 01	-8.70185E 00	-1.77712E 01	-1.66063E 00
8.83743E 00	-5.29664E 01	7.71917E 00	-8.47207E 00	1.82868E 01

ROW 10

-2.82355E-09	9.46598E-01	1.88506E 02	-1.03977E-01	-3.41315E-01
9.10873E-01	4.67759E-01	2.19560E 00	-9.77425E-01	-1.04551E-01
4.75642E-01	-4.94046E 00	3.99813E 00	1.80501E 00	-2.19182E 01

ROW 11

5.81454E-09	-3.92651E 00	-7.82204E 02	3.59255E-01	1.60220E 00
-3.08078E 00	-1.40513E 00	-9.05006E 00	3.42550E 00	3.79607E-01
-1.70819E 00	1.89593E 01	-1.61241E 01	-9.54851E 00	8.62896E 01

ROW 12

-6.25129E-08	-8.49990E 00	-1.59252E 03	-1.96958E 00	5.69118E 00
2.98282E 00	7.14921E 00	-1.53259E 01	-6.99405E 00	-3.71732E-01
2.69820E 00	-1.20171E 01	-1.17202E 01	3.14225E 01	2.88422E 01

ROW 13

4.47462E-08	-5.16441E 00	-1.11327E 03	1.92786E 00	-4.50063E 00
-1.72632E 01	-1.54870E 01	-2.67049E 01	1.46010E 01	7.85206E-01
-3.67398E 00	4.42531E 01	-3.72560E 01	-7.88219E 00	7.04510E 02

ROW 14

-5.20723E-08	-5.54939E-01	-6.41272E 01	-7.83911E-01	1.60652E 00
8.70591E 00	8.92309E 00	9.10141E-02	-5.42942E 00	-4.62026E-02
-1.65529E-01	3.87630E 00	-1.68748E-01	-2.93831E 01	-3.08878E 00

MATRIX 'D1 ' 15 BY 15   SYMMETRIC MODEL   MACH .90

ROW 15

-2.67143E-06	-2.27301E 02	-3.93928E 04	3.17572E-01	1.42289E 02
3.90926E 01	1.17066E 02	-3.84785E 02	9.67714E 01	1.67567E 01
-7.47079E 01	8.34539E 02	-6.84305E 02	-3.16647E 01	1.93636E 03

MATRIX 'B1 '   1 BY 15   SYMMETRIC MODEL   MACH .90

ROW 1

6.00000E-03	6.00000E-03	6.00000E-03	6.00000E-03	6.00000E-03
6.00000E-03	6.00000E-03	6.00000E-03	6.00000E-03	6.00000E-03
6.00000E-03	6.00000E-03	6.00000E-03	6.00000E-03	6.00000E-03

MATRIX 'D2 ' 15 BY 15 SYMMETRIC MODEL MACH .90

ROW 1

6.98782E-15	-6.02121E-08	-2.39887E-06	-2.11145E-08	8.08390E-08
4.99888E-07	5.09481E-07	-5.37000E-09	-3.38941E-07	-5.34792E-09
4.74722E-09	1.30574E-07	5.67401E-09	-1.63515E-06	-1.15496E-07

ROW 2

-1.97801E-06	-1.31246E 02	-5.81636E 03	-5.11941E 01	1.67195E 02
6.23448E 02	6.14842E 02	7.63161E 01	-5.03157E 02	-2.18392E 01
1.10892E 02	-8.13364E 02	2.34832E 02	-9.97847E 01	-7.64570E 03

ROW 3

1.51873E-04	-3.69721E 04	-4.51708E 06	1.28274E 03	1.12577E 04
-4.37146E 04	-3.52217E 04	-5.32469E 04	2.63359E 04	7.53015E 02
-1.96144E 03	5.81884E 04	-7.43849E 04	-4.80653E 03	5.81786E 05

ROW 4

1.40015E-06	6.33540E 01	3.48127E 03	1.67164E 01	-6.07072E 01
-2.72163E 02	-2.66562E 02	2.80295E 01	1.93363E 02	6.93806E 00
-2.73861E 01	9.63394E 01	-1.91506E 01	3.98731E 01	8.22476E 01

ROW 5

-1.16847E-06	2.27702E 02	2.63675E 04	1.00946E 00	-8.55099E 01
1.93160E 02	1.54257E 02	2.91780E 02	-8.18740E 01	1.60465E 00
-2.23622E 01	-7.33087E 01	3.61874E 02	1.91927E 01	-1.90307E 03

ROW 6

-1.52979E-06	-1.61901E 01	-2.95555E 03	2.43297E 00	3.36136E 00
-1.06494E 01	1.78503E 01	-2.32570E 01	2.27151E 01	5.69307E 00
-3.17488E 01	2.44573E 02	-7.80425E 01	-1.52174E 02	3.90283E 02

ROW 7

-1.64424E-06	-1.31860E 01	-1.85335E 03	-5.62803E-01	8.39697E 00
3.67810E 01	5.32272E 01	-1.51611E 01	-1.59101E 01	2.48327E 00
-1.61882E 01	1.42687E 02	-3.85445E 01	-1.54690E 02	3.25152E 02

ROW 8

-1.55334E-07	-1.46930E 02	-1.67048E 04	2.95894E 00	6.32774E 01
-7.25201E 01	-3.23960E 01	-1.63159E 02	6.07476E 01	5.18831E 00
-2.19929E 01	3.05084E 02	-2.78407E 02	-3.99565E 01	6.96204E 02

ROW 9

1.08389E-06	5.81692E 01	4.67655E 03	1.27404E 01	-3.95472E 01
-8.62761E 01	-7.52466E 01	5.42391E 01	9.74316E 01	9.70649E 00
-5.26403E 01	3.17687E 02	-4.08599E 01	5.27747E 01	-6.95909E 01

ROW 10

6.26150E-08	-1.24109E 01	-1.44514E 03	7.09994E-01	4.09419E 00
-1.30934E 01	-1.00401E 01	-1.58458E 01	9.14180E 00	5.14834E-01
-2.20574E 00	3.04182E 01	-2.73534E 01	-5.68590E 00	1.34308E 02

ROW 11

-2.34466E-07	5.02321E 01	5.91036E 03	-2.87636E 00	-1.71865E 01
5.18450E 01	4.02346E 01	6.48115E 01	-3.59285E 01	-1.90408E 00
7.93949E 00	-1.17942E 02	1.10743E 02	3.36653E 01	-5.29926E 02

ROW 12

4.51837E-07	1.14553E 02	1.15736E 04	1.12624E 01	-5.74687E 01
-3.27590E 01	-6.04516E 01	1.09466E 02	4.78304E 01	2.81233E 00
-1.87640E 01	5.86357E 01	9.18673E 01	-1.61846E 02	-1.80165E 02

ROW 13

-8.32991E-07	1.25396E 02	1.34694E 04	-6.34381E 00	-2.10230E 01
1.63180E 02	1.52284E 02	2.06528E 02	-9.31342E 01	-5.96945E-01
6.47020E-01	-2.11689E 02	2.56035E 02	2.70774E 01	-4.10361E 03

ROW 14

3.35206E-07	6.36887E 00	2.13437E 02	1.98967E 00	-8.13151E 00
-5.05384E 01	-5.17321E 01	-8.19203E-02	3.25118E 01	2.94711E-01
9.20185E-01	-2.31425E 01	1.03568E 00	1.69166E 02	3.32554E 00

MATRIX 'D2 ' 15 BY 15 SYMMETRIC MODEL MACH .90

ROW 15

1.04340E-05	2.82033E 03	2.57209E 05	-6.10108E 01	-1.16074E 03
8.82926E 02	3.72288E 02	2.55441E 03	-1.05326E 03	-8.28626E 01
3.69457E 02	-5.26829E 03	4.46346E 03	-2.25774E 02	-1.31610E 04

MATRIX 'B2 ' 1 BY 15 SYMMETRIC MODEL MACH .90

ROW 1

1.20000E-02	1.20000E-02	1.20000E-02	1.20000E-02	1.20000E-02
1.20000E-02	1.20000E-02	1.20000E-02	1.20000E-02	1.20000E-02
1.20000E-02	1.20000E-02	1.20000E-02	1.20000E-02	1.20000E-02

MATRIX 'D3 ' 15 BY 15 SYMMETRIC MODEL MACH .90

ROW 1				
-1.26134E-14	1.85336E-07	2.57743E-06	-6.00650E-09	-1.46289E-07
-1.03147E-06	-1.04872E-06	2.48901E-08	7.27968E-07	1.29826E-08
-1.93109E-08	-2.19676E-07	-2.28225E-08	3.19877E-06	1.64850E-07
ROW 2				
5.20116E-06	2.28034E 02	1.74162E 03	3.67916E 01	-2.35014E 02
-1.34115E 03	-1.32955E 03	-1.42502E 02	9.56746E 02	3.17929E 01
-1.71564E 02	1.48274E 03	-3.81964E 02	1.08474E 02	1.42201E 04
ROW 3				
-4.67121E-04	1.32939E 05	1.15893E 07	1.88259E 03	-4.88630E 04
1.01595E 05	8.40126E 04	1.24204E 05	-5.23389E 04	5.24164E 02
-6.06516E 03	-9.32768E 04	1.58776E 05	-2.38852E 03	-1.13796E 06
ROW 4				
-2.58054E-06	-2.05611E 02	-6.23707E 03	-1.06219E 01	1.28600E 02
5.54337E 02	5.34891E 02	-6.93987E 01	-3.94851E 02	-1.62727E 01
6.75409E 01	-2.60743E 02	4.76448E 01	-2.94552E 01	7.39026E 01
ROW 5				
3.01259E-06	-7.83919E 02	-6.60394E 04	-2.11244E 01	3.08789E 02
-4.42185E 02	-3.60840E 02	-6.86919E 02	1.75164E 02	-1.25396E 01
9.27997E 01	3.56591E 01	-7.97441E 02	4.62387E 01	3.84903E 03
ROW 6				
3.38217E-06	4.53862E 01	7.08397E 03	-9.41084E 00	-9.50608E 00
3.84406E 01	-3.03083E 01	4.92459E 01	-5.02010E 01	-1.36114E 01
7.66566E 01	-5.96438E 02	1.89519E 02	3.53402E 02	-5.04944E 02
ROW 7				
3.59345E-06	3.76259E 01	4.10448E 03	-6.62951E 00	-1.67475E 01
-6.71156E 01	-1.07637E 02	2.90859E 01	2.82206E 01	-6.90923E 00
4.36169E 01	-3.69650E 02	9.99590E 01	3.52057E 02	-4.19753E 02
ROW 8				
-4.90488E-08	4.69433E 02	3.95484E 04	5.53658E-01	-1.90194E 02
1.95424E 02	1.09380E 02	3.81407E 02	-1.19882E 02	-5.26528E 00
1.92803E 01	-5.68606E 02	5.99652E 02	3.83429E 01	-1.45503E 03
ROW 9				
-2.22055E-06	-1.84321E 02	-9.80409E 03	-1.64174E 01	9.69454E 01
1.89546E 02	1.64143E 02	-1.12867E 02	-1.75877E 02	-1.87979E 01
1.03833E 02	-6.29206E 02	6.97095E 01	-1.11707E 02	1.11759E 02
ROW 10				
-1.65122E-07	4.30970E 01	3.61578E 03	-5.67878E-02	-1.58711E 01
3.06422E 01	2.42554E 01	3.73436E 01	-1.70368E 01	-3.31389E-01
1.05458E 00	-5.27383E 01	5.74613E 01	6.72894E 00	-2.70698E 02
ROW 11				
6.27021E-07	-1.73987E 02	-1.48055E 04	3.60083E-01	6.54243E 01
-1.21656E 02	-9.74621E 01	-1.53221E 02	6.70430E 01	9.59675E-01
-2.05346E 00	2.01297E 02	-2.33255E 02	-4.80069E 01	1.06911E 03
ROW 12				
-7.49191E-07	-3.58369E 02	-2.62357E 04	-1.73536E 01	1.53715E 02
5.08097E 01	1.12574E 02	-2.45322E 02	-7.35577E 01	-5.48940E 00
3.68730E 01	-6.36222E 01	-2.29271E 02	3.32576E 02	3.62475E 02
ROW 13				
2.68817E-06	-5.28661E 02	-3.70371E 04	-9.84445E 00	1.71191E 02
-3.71865E 02	-3.61300E 02	-4.70520E 02	1.56772E 02	-1.21744E 01
6.28975E 01	2.02779E 02	-4.85078E 02	7.18370E 00	8.07667E 03
ROW 14				
-7.23633E-07	-1.96436E 01	-1.36319E 02	1.32711E 00	1.41518E 01
1.00876E 02	1.03054E 02	-6.34992E-01	-6.71553E 01	-6.71545E-01
-1.56676E 00	4.61081E 01	-1.97128E 00	-3.34635E 02	1.98939E 00

ROW 15

-1.37288E-05	-8.86384E 03	-5.51094E 05	-7.21152E 00	3.31010E 03
-2.42910E 03	-1.43953E 03	-5.48779E 03	1.81061E 03	5.06906E 01
-2.23802E 02	8.98575E 03	-8.68726E 03	9.57625E 02	2.89563E 04

MATRIX 'B3 ' 1 BY 15 SYMMETRIC MODEL MACH .90

ROW 1

1.80000E-02	1.80000E-02	1.80000E-02	1.80000E-02	1.80000E-02
1.80000E-02	1.80000E-02	1.80000E-02	1.80000E-02	1.80000E-02
1.80000E-02	1.80000E-02	1.80000E-02	1.80000E-02	1.80000E-02

MATRIX 'D4 ' 15 BY 15 SYMMETRIC MODEL MACH .90

ROW 1

7.06892E-15	-1.64662E-07	-4.00499E-07	3.51929E-08	8.44641E-08
6.70260E-07	6.79794E-07	-2.62120E-08	-4.90191E-07	-9.64176E-09
1.84794E-08	1.14156E-07	1.84942E-08	-1.97153E-06	-8.15210E-08

ROW 2

-3.28296E-06	-1.28603E 02	-2.84657E 03	1.69353E 01	9.56366E 01
7.77302E 02	7.91911E 02	1.92552E 01	-5.05372E 02	-8.75394E 00
5.98403E 01	-6.73958E 02	5.29746E 01	-5.38287E 00	-8.17804E 03

ROW 3

3.06936E-04	-1.17110E 05	-8.10758E 06	-3.94175E 03	4.55795E 04
-6.21812E 04	-5.13608E 04	-8.13718E 04	2.89283E 04	-1.52731E 03
9.23879E 03	4.34949E 04	-9.59126E 04	3.06238E 03	6.70322E 05

ROW 4

1.50727E-06	1.56061E 02	2.40969E 03	-7.49828E 00	-7.72751E 01
-3.50405E 02	-3.34782E 02	3.75066E 01	2.44239E 02	1.03782E 01
-4.31011E 01	1.72707E 02	-4.22570E 01	-9.98532E 00	-1.06637E 02

ROW 5

-1.94764E-06	6.82987E 02	4.69699E 04	2.49985E 01	-2.73533E 02
2.77754E 02	2.24022E 02	4.64611E 02	-1.09510E 02	1.24757E 01
-7.99390E 01	1.32715E 01	5.16718E 02	-4.80984E 01	-2.29988E 03

ROW 6

-2.34467E-06	-6.79259E 01	-6.13072E 03	9.38587E 00	1.82323E 01
-2.35390E 01	2.42257E 01	-4.70240E 01	2.02692E 01	8.15906E 00
-4.70235E 01	3.97212E 02	-1.42865E 02	-2.51644E 02	2.24498E 02

ROW 7

-2.46063E-06	-5.70805E 01	-3.60410E 03	9.80031E 00	1.91429E 01
4.72614E 01	7.51427E 01	-2.94938E 01	-2.70237E 01	4.09303E 00
-2.67403E 01	2.48457E 02	-7.98453E 01	-2.47377E 02	1.86065E 02

ROW 8

1.02721E-07	-3.91758E 02	-2.73692E 04	-5.08348E 00	1.55289E 02
-1.32760E 02	-7.56823E 01	-2.59915E 02	6.56185E 01	3.60942E-01
1.26470E 00	3.31615E 02	-3.85496E 02	-1.67463E 01	8.90909E 02

ROW 9

1.44545E-06	1.66341E 02	6.55920E 03	4.01776E 00	-7.44657E 01
-1.33551E 02	-1.15009E 02	7.55479E 01	1.00853E 02	1.16381E 01
-6.54023E 01	3.95718E 02	-3.53613E 01	7.61587E 01	-5.98627E 01

ROW 10

1.06034E-07	-3.70114E 01	-2.51095E 03	-8.02999E-01	1.41461E 01
-1.94215E 01	-1.53068E 01	-2.47486E 01	9.11289E 00	-1.69533E-01
1.00520E 00	2.90695E 01	-3.52917E 01	-3.70289E 00	1.62029E 02

ROW 11

-3.99939E-07	1.48998E 02	1.03153E 04	3.06192E 00	-5.79109E 01
7.71526E 01	6.15260E 01	1.02017E 02	-3.59643E 01	9.05903E-01
-5.43149E 00	-1.10116E 02	1.44090E 02	2.84483E 01	-6.40183E 02

ROW 12

3.99494E-07	3.16093E 02	1.84334E 04	8.53673E 00	-1.24874E 02
-2.86848E 01	-7.01230E 01	1.70907E 02	3.70431E 01	3.97224E 00
-2.57727E 01	2.31801E 01	1.67838E 02	-2.22631E 02	-2.16020E 02

ROW 13

-1.79081E-06	4.70311E 02	2.34622E 04	1.90211E 01	-1.70730E 02
1.98043E 02	2.03501E 02	2.70710E 02	-6.10374E 01	1.51406E 01
-7.23145E 01	1.49667E 01	2.11297E 02	-1.21974E 01	-4.77282E 03

ROW 14

4.88775E-07	1.66088E 01	-1.16638E 02	-4.32245E 00	-7.42715E 00
-6.32027E 01	-6.44790E 01	6.85416E-01	4.34700E 01	4.48644E-01
9.55644E-01	-2.96839E 01	1.20298E 00	2.08761E 02	-3.07607E 00

MATRIX 'D4 ' 15 BY 15 SYMMETRIC MODEL MACH .90

ROW 15

6.07137E-06	7.10552E 03	3.30426E 05	9.70999E 01	-2.53189E 03
1.42283E 03	8.78988E 02	3.30769E 03	-7.09810E 02	4.12968E 01
-1.77978E 02	-4.21584E 03	4.72745E 03	-5.77988E 02	-1.84196E 04

MATRIX 'B4 ' 1 BY 15 SYMMETRIC MODEL MACH .90

ROW 1

2.40000E-02	2.40000E-02	2.40000E-02	2.40000E-02	2.40000E-02
2.40000E-02	2.40000E-02	2.40000E-02	2.40000E-02	2.40000E-02
2.40000E-02	2.40000E-02	2.40000E-02	2.40000E-02	2.40000E-02

MATRIX 'R0 ' 15 BY 8 SYMMETRIC MODEL MACH .90

ROW 1				
5.57307E-08	4.06717E-08	5.91059E-08	-4.15768E-08	0.0
0.0	0.0	0.0		
ROW 2				
-3.32202E 03	-4.55147E 03	-2.49868E 03	-2.56418E 03	0.0
0.0	0.0	0.0		
ROW 3				
-2.25472E 05	3.33469E 04	7.76682E 04	2.22321E 05	0.0
0.0	0.0	0.0		
ROW 4				
5.21067E 02	8.02881E 02	1.03979E 03	-7.07479E 01	0.0
0.0	0.0	0.0		
ROW 5				
1.87543E 03	8.72935E 02	-1.01170E 02	-7.71099E 02	0.0
0.0	0.0	0.0		
ROW 6				
5.88177E 02	1.45713E 03	1.00102E 03	8.15867E 00	0.0
0.0	0.0	0.0		
ROW 7				
5.74839E 02	1.15052E 03	8.69522E 02	3.92967E 00	0.0
0.0	0.0	0.0		
ROW 8				
-1.22770E 03	-8.98904E 01	-1.13592E 01	3.96263E 02	0.0
0.0	0.0	0.0		
ROW 9				
1.72584E 02	1.06509E 02	-3.81950E 02	-2.15901E 01	0.0
0.0	0.0	0.0		
ROW 10				
-8.74027E 01	-2.69955E 01	6.03534E 00	5.87964E 01	0.0
0.0	0.0	0.0		
ROW 11				
4.09942E 02	1.71793E 02	-4.42186E 01	-2.33030E 02	0.0
0.0	0.0	0.0		
ROW 12				
4.23351E 01	-9.21722E 02	2.23330E 02	-6.82218E 01	0.0
0.0	0.0	0.0		
ROW 13				
3.45483E 01	-1.09202E 02	-1.57702E 02	-1.58841E 03	0.0
0.0	0.0	0.0		
ROW 14				
6.89129E 00	1.00151E 01	2.74405E 01	5.84795E-01	0.0
0.0	0.0	0.0		
ROW 15				
1.12003E 04	-3.39157E 03	-1.32843E 01	-1.10540E 04	0.0
0.0	0.0	0.0		

MATRIX 'R1 ' 15 BY 8 SYMMETRIC MODEL MACH .90

ROW 1
3.24874E-07 -1.01793E-07 1.26411E-07 2.26187E-08 0.0
0.0 0.0 0.0

ROW 2
1.64446E 04 1.52042E 03 -7.82674E 02 -2.44520E 02 0.0
0.0 0.0 0.0

ROW 3
-9.55234E 05 -1.26669E 05 7.27889E 04 4.82120E 04 0.0
0.0 0.0 0.0

ROW 4
1.07608E 03 -2.54571E 02 4.67449E 02 -1.30487E 02 0.0
0.0 0.0 0.0

ROW 5
1.89607E 03 5.22644E 02 -3.46708E 02 -1.97464E 02 0.0
0.0 0.0 0.0

ROW 6
7.44633E 02 -6.50759E 01 3.33427E 02 -1.24783E 02 0.0
0.0 0.0 0.0

ROW 7
6.00089E 02 -1.13409E 02 2.90087E 02 -1.05318E 02 0.0
0.0 0.0 0.0

ROW 8
-1.78639E 03 -2.38208E 02 1.95433E 02 2.05260E 02 0.0
0.0 0.0 0.0

ROW 9
-4.62628E 02 2.40672E 02 -2.35679E 02 5.82555E 00 0.0
0.0 0.0 0.0

ROW 10
-2.55126E 02 -3.96435E 01 1.90392E 01 1.98646E 01 0.0
0.0 0.0 0.0

ROW 11
9.39952E 02 1.91511E 02 -9.79340E 01 -7.87804E 01 0.0
0.0 0.0 0.0

ROW 12
4.31670E 02 -5.06238E 02 1.80772E 02 -2.01619E 01 0.0
0.0 0.0 0.0

ROW 13
8.81978E 03 8.72474E 02 -1.42442E 02 -3.81036E 02 0.0
0.0 0.0 0.0

ROW 14
1.41566E 01 -7.20935E 00 2.94229E 01 -4.57950E 00 0.0
0.0 0.0 0.0

ROW 15
8.88959E 04 8.75894E 03 -4.26218E 03 -8.04483E 03 0.0
0.0 0.0 0.0

MATRIX 'G1 ' 1 BY 8 SYMMETRIC MODEL MACH .90

ROW 1

6.00000E-03	6.00000E-03	6.00000E-03	6.00000E-03	6.00000E-03
6.00000E-03	6.00000E-03	6.00000E-03		

ROW 1
-2.30057E-06 5.40068E-07 -5.54929E-07 -1.10435E-08 0.0
0.0 0.0 0.0

ROW 2
-1.16736E 05 -6.53738E 03 8.09409E 03 3.96161E 03 0.0
0.0 0.0 0.0

ROW 3
7.11304E 06 8.81686E 05 -2.73188E 05 -4.27513E 05 0.0
0.0 0.0 0.0

ROW 4
-6.69766E 03 7.58013E 02 -4.26613E 03 5.14453E 02 0.0
0.0 0.0 0.0

ROW 5
-1.53250E 04 -4.30807E 03 5.91895E 02 1.52572E 03 0.0
0.0 0.0 0.0

ROW 6
-3.08843E 03 -9.63852E 02 -3.41181E 03 4.31346E 02 0.0
0.0 0.0 0.0

ROW 7
-2.75325E 03 -4.21644E 02 -2.96217E 03 3.70393E 02 0.0
0.0 0.0 0.0

ROW 8
1.31638E 04 2.40441E 03 -3.36529E 02 -1.33023E 03 0.0
0.0 0.0 0.0

ROW 9
3.11964E 03 -1.63842E 03 1.78137E 03 1.40317E 01 0.0
0.0 0.0 0.0

ROW 10
1.82233E 03 3.16215E 02 -1.97371E 01 -1.44173E 02 0.0
0.0 0.0 0.0

ROW 11
-6.69608E 03 -1.53036E 03 1.99243E 02 5.70922E 02 0.0
0.0 0.0 0.0

ROW 12
-5.18138E 03 3.82859E 03 -1.16512E 03 1.48557E 02 0.0
0.0 0.0 0.0

ROW 13
-6.15389E 04 -5.93976E 03 -1.45552E 02 3.20198E 03 0.0
0.0 0.0 0.0

ROW 14
-7.26684E 01 3.21442E 01 -2.14282E 02 1.19197E 01 0.0
0.0 0.0 0.0

ROW 15
-5.79950E 05 -8.30751E 04 1.30064E 04 4.96215E 04 0.0
0.0 0.0 0.0

MATRIX 'G2 ' 1 BY 8 SYMMETRIC MODEL MACH .90

ROW 1

1.20000E-02	1.20000E-02	1.20000E-02	1.20000E-02	1.20000E-02
1.20000E-02	1.20000E-02	1.20000E-02		

MATRIX 'R3 ' 15 BY 8 SYMMETRIC MODEL MACH .90

ROW 1				
3.75233E-06	-1.10751E-06	6.44139E-07	-1.06602E-07	0.0
0.0	0.0	0.0		
ROW 2				
2.29916E 05	1.19924E 04	-1.66918E 04	-1.22305E 04	0.0
0.0	0.0	0.0		
ROW 3				
-1.24939E 07	-1.66405E 06	3.08685E 05	1.17659E 06	0.0
0.0	0.0	0.0		
ROW 4				
7.08019E 03	-1.65177E 03	1.04836E 04	-8.98711E 02	0.0
0.0	0.0	0.0		
ROW 5				
2.10706E 04	8.28517E 03	-7.81519E 01	-4.11255E 03	0.0
0.0	0.0	0.0		
ROW 6				
-3.16342E 03	2.46485E 03	8.23224E 03	-6.02716E 02	0.0
0.0	0.0	0.0		
ROW 7				
-1.80187E 03	1.19224E 03	7.19675E 03	-5.27245E 02	0.0
0.0	0.0	0.0		
ROW 8				
-2.13532E 04	-5.09622E 03	-1.34061E 02	3.00033E 03	0.0
0.0	0.0	0.0		
ROW 9				
-6.01212E 03	3.78735E 03	-4.35360E 03	-8.16460E 01	0.0
0.0	0.0	0.0		
ROW 10				
-2.87295E 03	-6.27241E 02	-5.07963E 01	3.59723E 02	0.0
0.0	0.0	0.0		
ROW 11				
1.00977E 04	3.09705E 03	-8.23530E 01	-1.42494E 03	0.0
0.0	0.0	0.0		
ROW 12				
1.51183E 04	-8.61636E 03	3.11564E 03	-3.78983E 02	0.0
0.0	0.0	0.0		
ROW 13				
1.06099E 05	1.15498E 04	2.21532E 03	-8.62881E 03	0.0
0.0	0.0	0.0		
ROW 14				
5.22173E 01	-6.68909E 01	4.77205E 02	-1.30557E 01	0.0
0.0	0.0	0.0		
ROW 15				
9.57895E 05	1.95663E 05	-1.29197E 04	-1.04220E 05	0.0
0.0	0.0	0.0		

MATRIX 'G3 '   1 BY 8   SYMMETRIC MODEL   MACH .90

ROW 1

1.80000E-02	1.80000E-02	1.80000E-02	1.80000E-02	1.80000E-02
1.80000E-02	1.80000E-02	1.80000E-02		

MATRIX 'R4 ' 15 BY 8 SYMMETRIC MODEL MACH .90

ROW 1
-1.84662E-06 6.17276E-07 -5.35084E-08 1.49208E-07 0.0
0.0 0.0 0.0

ROW 2
-1.28706E 05 -1.62435E 03 1.21309E 04 1.18177E 04 0.0
0.0 0.0 0.0

ROW 3
6.76309E 06 8.66738E 05 -1.88276E 05 -1.09085E 06 0.0
0.0 0.0 0.0

ROW 4
-1.80869E 03 1.28318E 02 -7.99021E 03 6.15838E 02 0.0
0.0 0.0 0.0

ROW 5
-1.00626E 04 -5.50016E 03 -3.04982E 01 3.84293E 03 0.0
0.0 0.0 0.0

ROW 6
5.49853E 03 -3.29502E 03 -6.23567E 03 2.92826E 02 0.0
0.0 0.0 0.0

ROW 7
3.76986E 03 -2.12709E 03 -5.47663E 03 2.62820E 02 0.0
0.0 0.0 0.0

ROW 8
1.17438E 04 3.06961E 03 3.20288E 02 -2.31892E 03 0.0
0.0 0.0 0.0

ROW 9
3.16489E 03 -2.56163E 03 3.35476E 03 8.75853E 01 0.0
0.0 0.0 0.0

ROW 10
1.42774E 03 3.82013E 02 4.99555E 01 -3.09824E 02 0.0
0.0 0.0 0.0

ROW 11
-4.87272E 03 -1.95999E 03 2.21693E 01 1.22830E 03 0.0
0.0 0.0 0.0

ROW 12
-1.10871E 04 6.42182E 03 -2.56191E 03 3.37513E 02 0.0
0.0 0.0 0.0

ROW 13
-5.41397E 04 -6.46295E 03 -1.82097E 03 7.89429E 03 0.0
0.0 0.0 0.0

ROW 14
2.95838E 00 2.85816E 01 -3.30002E 02 5.15666E 00 0.0
0.0 0.0 0.0

ROW 15
-4.85580E 05 -1.21767E 05 4.16625E 03 7.27573E 04 0.0
0.0 0.0 0.0

MATRIX 'G4 ' 1 BY 8 SYMMETRIC MODEL MACH .90

ROW 1

2.40000E-02	2.40000E-02	2.40000E-02	2.40000E-02	2.40000E-02
2.40000E-02	2.40000E-02	2.40000E-02		

MATRIX 'XG '   1 BY 4   SYMMETRIC MODEL   MACH .90

ROW   1

1.80000E 02	2.50000E 02	2.80000E 02	3.35000E 02

MATRIX 'YG '   1 BY 4   SYMMETRIC MODEL   MACH .90

ROW   1

1.17500E 01	4.00000E 01	7.00000E 01	1.50000E 01

MATRIX 'ZG ' 1 BY 4 SYMMETRIC MODEL MACH .90

ROW 1

0.0	0.0	0.0	0.0

MATRIX 'PHFF' 57 BY 15 SYMMETRIC MODEL MACH .90

ROW 1

1.00000E 00	-8.39463E-12	-2.10988E-01	-5.62880E-04	2.77617E-03
1.34083E-02	-1.04565E-02	-4.57279E-06	-7.10304E-04	-3.33793E-04
3.93447E-04	-9.96898E-05	9.73643E-03	0.0	0.0

ROW 2

1.00000E 00	-8.39463E-12	-2.10988E-01	-5.62880E-04	2.77617E-03
1.34083E-02	-1.04565E-02	-4.57279E-06	-7.10304E-04	-3.33793E-04
3.93447E-04	-9.96898E-05	9.73643E-03	0.0	0.0

ROW 3

1.00000E 00	-8.39463E-12	-2.10988E-01	-5.62854E-04	2.77576E-03
1.34017E-02	-1.04498E-02	-4.56886E-06	-7.09370E-04	-3.33011E-04
3.92423E-04	-9.93479E-05	9.67961E-03	0.0	0.0

ROW 4

1.00000E 00	-8.39463E-12	-2.10988E-01	-5.62828E-04	2.77535E-03
1.33950E-02	-1.04432E-02	-4.56494E-06	-7.08437E-04	-3.32230E-04
3.91399E-04	-9.90060E-05	9.62279E-03	0.0	0.0

ROW 5

1.00000E 00	-8.39463E-12	-2.10988E-01	-5.62803E-04	2.77493E-03
1.33884E-02	-1.04365E-02	-4.56102E-06	-7.07503E-04	-3.31448E-04
3.90376E-04	-9.86641E-05	9.56597E-03	0.0	0.0

ROW 6

1.00000E 00	-8.39463E-12	-2.10988E-01	-5.62730E-04	2.77377E-03
1.33696E-02	-1.04175E-02	-4.54993E-06	-7.04864E-04	-3.29244E-04
3.87489E-04	-9.77022E-05	9.40693E-03	0.0	0.0

ROW 7

1.00000E 00	-8.39463E-12	-2.10988E-01	-5.62656E-04	2.77260E-03
1.33509E-02	-1.03986E-02	-4.53883E-06	-7.02224E-04	-3.27040E-04
3.84603E-04	-9.67403E-05	9.24790E-03	0.0	0.0

ROW 8

1.00000E 00	-8.39463E-12	-2.10988E-01	-5.62584E-04	2.77143E-03
1.33321E-02	-1.03796E-02	-4.52774E-06	-6.99585E-04	-3.24835E-04
3.81717E-04	-9.57783E-05	9.08887E-03	0.0	0.0

ROW 9

1.00000E 00	-8.39463E-12	-2.10988E-01	-5.62451E-04	2.76931E-03
1.32981E-02	-1.03453E-02	-4.50767E-06	-6.94821E-04	-3.20874E-04
3.76536E-04	-9.40579E-05	8.80743E-03	0.0	0.0

ROW 10

1.00000E 00	-8.39463E-12	-2.10988E-01	-5.62318E-04	2.76719E-03
1.32641E-02	-1.03110E-02	-4.48761E-06	-6.90057E-04	-3.16913E-04
3.71355E-04	-9.23375E-05	8.52599E-03	0.0	0.0

ROW 11

1.00000E 00	-8.39463E-12	-2.10988E-01	-5.62186E-04	2.76507E-03
1.32301E-02	-1.02767E-02	-4.46754E-06	-6.85294E-04	-3.12951E-04
3.66175E-04	-9.06171E-05	8.24456E-03	0.0	0.0

ROW 12

1.00000E 00	-8.39463E-12	-2.10988E-01	-5.61984E-04	2.76186E-03
1.31787E-02	-1.02248E-02	-4.43727E-06	-6.78130E-04	-3.07038E-04
3.58456E-04	-8.80692E-05	7.83508E-03	0.0	0.0

ROW 13

1.00000E 00	-8.39463E-12	-2.10988E-01	-5.61783E-04	2.75864E-03
1.31273E-02	-1.01730E-02	-4.40700E-06	-6.70966E-04	-3.01126E-04
3.50737E-04	-8.55213E-05	7.42560E-03	0.0	0.0

ROW 14

1.00000E 00	-8.39463E-12	-2.10988E-01	-5.61582E-04	2.75543E-03
1.30759E-02	-1.01212E-02	-4.37672E-06	-6.63803E-04	-2.95213E-04
3.43019E-04	-8.29735E-05	7.01613E-03	0.0	0.0

ROW 15

1.00000E 00	-8.39461E-12	-2.10988E-01	-5.61266E-04	2.75038E-03
1.29953E-02	-1.00400E-02	-4.31997E-06	-6.52645E-04	-2.86081E-04
3.31121E-04	-7.91014E-05	6.40108E-03	0.0	0.0

ROW 16

1.00000E 00	-8.39485E-12	-2.10988E-01	-5.63412E-04	2.75725E-03
1.34433E-02	-1.04754E-02	-6.57597E-05	-6.94851E-04	-2.83300E-04
3.26295E-04	-1.51789E-05	6.12039E-03	0.0	0.0

ROW 17

1.00000E 00	-8.39505E-12	-2.10988E-01	-5.64926E-04	2.76139E-03
1.37516E-02	-1.07750E-02	-1.09440E-04	-7.24287E-04	-2.80419E-04
3.22411E-04	2.51821E-05	5.85468E-03	0.0	0.0

ROW 18

1.00000E 00	-8.39550E-12	-2.10988E-01	-5.65060E-04	2.75955E-03
1.37806E-02	-1.08047E-02	-1.20606E-04	-7.29538E-04	-2.75957E-04
3.20372E-04	1.35168E-05	5.50539E-03	0.0	0.0

ROW 19

1.00000E 00	-8.39588E-12	-2.10988E-01	-5.65262E-04	2.75808E-03
1.38245E-02	-1.08490E-02	-1.33440E-04	-7.36045E-04	-2.71653E-04
3.18274E-04	5.06820E-06	5.16783E-03	0.0	0.0

ROW 20

2.11149E-13	1.00000E 00	1.67399E 02	1.30266E-02	1.14594E 00
-4.52419E-02	-1.54586E-02	-1.00027E 00	-1.92335E-02	8.90079E-02
-3.43880E-01	-5.22914E-02	9.51639E-01	0.0	0.0

ROW 21

1.97059E-13	1.00000E 00	1.57400E 02	1.25200E-02	1.00000E 00
-3.63122E-02	-1.20232E-02	-7.69039E-01	-1.40213E-02	5.96437E-02
-2.25914E-01	-3.24518E-02	5.06043E-01	0.0	0.0

ROW 22

1.82969E-13	1.00000E 00	1.47401E 02	1.20183E-02	8.55542E-01
-2.75868E-02	-8.67959E-03	-5.45818E-01	-9.05106E-03	3.23429E-02
-1.16875E-01	-1.44365E-02	1.19561E-01	0.0	0.0

ROW 23

1.68878E-13	1.00000E 00	1.37402E 02	1.15345E-02	7.15972E-01
-1.94800E-02	-5.60613E-03	-3.45899E-01	-4.75293E-03	1.04091E-02
-3.07173E-02	-9.16980E-04	-1.34260E-01	0.0	0.0

ROW 24

1.54788E-13	1.00000E 00	1.27403E 02	1.10684E-02	5.81025E-01
-1.19374E-02	-2.77566E-03	-1.66843E-01	-1.04285E-03	-6.99501E-03
3.62893E-02	8.92844E-03	-2.86283E-01	0.0	0.0

ROW 25

1.40698E-13	1.00000E 00	1.17404E 02	1.06197E-02	4.50526E-01
-4.92494E-03	-1.71373E-04	-7.13381E-03	2.13112E-03	-2.03868E-02
8.64511E-02	1.56088E-02	-3.55703E-01	0.0	0.0

ROW 26

1.26607E-13	1.00000E 00	1.07405E 02	1.01961E-02	3.25951E-01
1.42911E-03	2.16013E-03	1.29347E-01	4.69017E-03	-2.94781E-02
1.18853E-01	1.91021E-02	-3.52453E-01	0.0	0.0

ROW 27

1.12517E-13	1.00000E 00	9.74064E 01	9.80527E-03	2.08759E-01
7.00350E-03	4.17593E-03	2.39001E-01	6.56443E-03	-3.40388E-02
1.32808E-01	1.94158E-02	-2.85851E-01	0.0	0.0

ROW 28

9.84270E-14	1.00000E 00	8.74075E 01	9.45492E-03	1.00281E-01
1.16996E-02	5.84405E-03	3.19155E-01	7.71308E-03	-3.40772E-02
1.28645E-01	1.67515E-02	-1.70038E-01	0.0	0.0

ROW 29

8.43366E-14	1.00000E 00	7.74086E 01	9.15321E-03	1.49273E-03
1.55018E-02	7.17478E-03	3.70533E-01	8.20369E-03	-3.04424E-02
1.10225E-01	1.19457E-02	-3.25867E-02	0.0	0.0

ROW 30

7.02464E-14	1.00000E 00	6.74097E 01	8.90313E-03	-8.76126E-02
1.84773E-02	8.20785E-03	3.96320E-01	8.15224E-03	-2.41540E-02
8.19458E-02	5.84989E-03	1.03960E-01	0.0	0.0

ROW 31

5.61561E-14	1.00000E 00	5.74107E 01	8.71037E-03	-1.66542E-01
2.06493E-02	8.96694E-03	3.98271E-01	7.64161E-03	-1.60156E-02
4.73216E-02	-8.46459E-04	2.21243E-01	0.0	0.0

ROW 32

4.20658E-14	1.00000E 00	4.74118E 01	8.59680E-03	-2.32645E-01
2.19381E-02	9.45845E-03	3.75638E-01	6.74068E-03	-6.87777E-03
1.01769E-02	-7.43232E-03	3.01877E-01	0.0	0.0

ROW 33

2.79756E-14	1.00000E 00	3.74129E 01	8.60186E-03	-2.80940E-01
2.21578E-02	9.67318E-03	3.25304E-01	5.51715E-03	2.19009E-03
-2.45597E-02	-1.29942E-02	3.22757E-01	0.0	0.0

ROW 34

1.10843E-14	1.00000E 00	2.51242E 01	8.81650E-03	-3.11282E-01
2.09457E-02	9.64393E-03	2.28426E-01	3.82749E-03	1.11814E-02
-5.52631E-02	-1.71338E-02	2.48676E-01	0.0	0.0

ROW 35

1.71059E-15	1.00000E 00	1.67951E 01	9.13102E-03	-3.14483E-01
1.95434E-02	9.64392E-03	1.48301E-01	2.82760E-03	1.49780E-02
-6.51410E-02	-1.82582E-02	1.48888E-01	0.0	0.0

ROW 36

0.0	1.00000E 00	8.54611E 00	9.71634E-03	-3.06261E-01
1.84145E-02	1.00217E-02	6.41652E-02	2.27619E-03	1.68234E-02
-6.64890E-02	-1.89836E-02	3.21925E-02	0.0	0.0

ROW 37

1.42543E-13	1.00000E 00	2.76980E-01	1.07004E-02	-2.87778E-01
1.77154E-02	1.06996E-02	-2.00725E-02	2.58673E-03	1.68065E-02
-6.02116E-02	-1.86592E-02	-8.36163E-02	0.0	0.0

ROW 38

4.55900E-13	1.00000E 00	-6.62218E 00	1.17708E-02	-2.65727E-01
1.72680E-02	1.13062E-02	-8.73843E-02	3.35990E-03	1.56026E-02
-5.05319E-02	-1.73300E-02	-1.67858E-01	0.0	0.0

ROW 39

1.40903E-15	-2.68483E-14	9.99892E-01	5.06612E-05	1.45939E-02
-8.92964E-04	-3.43546E-04	-2.31226E-02	-5.21213E-04	2.93643E-03
-1.17966E-02	-1.98397E-03	4.45596E-02	0.0	0.0

ROW 40

1.40903E-15	-2.68483E-14	9.99892E-01	5.06612E-05	1.45939E-02
-8.92964E-04	-3.43546E-04	-2.31226E-02	-5.21213E-04	2.93643E-03
-1.17966E-02	-1.98397E-03	4.45596E-02	0.0	0.0

ROW 41

1.40903E-15	1.62831E-14	9.99894E-01	4.92260E-05	1.41814E-02
-8.38443E-04	-3.19363E-04	-2.10257E-02	-4.59210E-04	2.42305E-03
-9.58999E-03	-1.54066E-03	3.07480E-02	0.0	0.0

ROW 42

1.40903E-15	-7.72882E-16	9.99893E-01	4.73259E-05	1.36801E-02
-7.76744E-04	-2.92705E-04	-1.87341E-02	-3.94258E-04	1.91823E-03
-7.45118E-03	-1.12782E-03	1.91178E-02	0.0	0.0

MATRIX 'PHFF' 57 BY 15 SYMMETRIC MODEL MACH .90

ROW 43

1.40903E-15	-2.66862E-14	9.99892E-01	4.57951E-05	1.32837E-02
-7.28773E-04	-2.72115E-04	-1.69682E-02	-3.44768E-04	1.54050E-03
-5.85768E-03	-8.24054E-04	1.08505E-02	0.0	0.0

ROW 44

1.40903E-15	9.85210E-15	9.99891E-01	4.37347E-05	1.27748E-02
-6.69921E-04	-2.47314E-04	-1.48531E-02	-2.87335E-04	1.12414E-03
-4.12326E-03	-5.05367E-04	3.06297E-03	0.0	0.0

ROW 45

1.40903E-15	7.51889E-15	9.99891E-01	4.08068E-05	1.21033E-02
-5.97521E-04	-2.17719E-04	-1.23361E-02	-2.22090E-04	6.81971E-04
-2.31160E-03	-1.87412E-04	-3.68692E-03	0.0	0.0

ROW 46

1.40903E-15	-2.55590E-14	9.99892E-01	3.71877E-05	1.13022E-02
-5.14330E-04	-1.84304E-04	-9.49871E-03	-1.50620E-04	2.19232E-04
-4.38410E-04	1.29962E-04	-9.61023E-03	0.0	0.0

ROW 47

1.40903E-15	9.68951E-15	9.99893E-01	3.26249E-05	1.03554E-02
-4.22846E-04	-1.48870E-04	-6.48925E-03	-7.90902E-05	-2.03390E-04
1.22955E-03	3.92451E-04	-1.31370E-02	0.0	0.0

ROW 48

1.40903E-15	6.27356E-15	9.99892E-01	2.75002E-05	9.37022E-03
-3.35894E-04	-1.16901E-04	-3.75052E-03	-1.90138E-05	-5.16736E-04
2.41974E-03	5.59931E-04	-1.40052E-02	0.0	0.0

ROW 49

1.40903E-15	-2.28236E-14	9.99892E-01	2.23412E-05	8.42522E-03
-2.57833E-04	-8.94111E-05	-1.37795E-03	2.93164E-05	-7.35457E-04
3.20829E-03	6.52186E-04	-1.30246E-02	0.0	0.0

ROW 50

1.40903E-15	3.85844E-15	9.99892E-01	1.59629E-05	7.33762E-03
-1.76883E-04	-6.30704E-05	9.54291E-04	7.08618E-05	-8.76392E-04
3.64969E-03	6.76367E-04	-1.02589E-02	0.0	0.0

ROW 51

1.40903E-15	9.33720E-15	9.99893E-01	6.45333E-06	5.85507E-03
-8.12494E-05	-3.60325E-05	3.53169E-03	1.06969E-04	-9.32056E-04
3.69842E-03	6.27845E-04	-5.65853E-03	0.0	0.0

ROW 52

1.40903E-15	-1.73492E-14	9.99892E-01	-7.84446E-06	3.76857E-03
3.68377E-05	-7.92828E-06	6.48397E-03	1.34760E-04	-8.57330E-04
3.14669E-03	4.68150E-04	1.74729E-03	0.0	0.0

ROW 53

1.33586E-15	5.01001E-15	9.99893E-01	-2.77315E-05	1.12997E-03
1.56676E-04	9.56241E-06	9.12169E-03	1.33737E-04	-5.70108E-04
1.71122E-03	1.91959E-04	1.01298E-02	0.0	0.0

ROW 54

7.45685E-16	-1.65577E-16	9.99892E-01	-5.17298E-05	-3.60277E-04
1.64192E-04	-1.87112E-05	1.00198E-02	9.88394E-05	-3.35640E-04
6.45849E-04	1.00098E-04	1.34768E-02	0.0	0.0

ROW 55

0.0	0.0	9.99892E-01	-9.41835E-05	-1.63345E-03
1.05551E-04	-7.06484E-05	1.02936E-02	2.00850E-05	-1.07928E-04
-3.24629E-04	4.99368E-05	1.45107E-02	0.0	0.0

ROW 56

-3.45595E-14	-1.76572E-15	9.99892E-01	-1.42063E-04	-2.83138E-03
6.95525E-05	-8.82524E-05	9.98549E-03	-8.77554E-05	1.09977E-04
-1.17182E-03	-1.32723E-04	1.31432E-02	0.0	0.0

ROW 57

-5.63086E-14	-3.33292E-15	9.99892E-01	-1.67841E-04	-3.55707E-03
6.16283E-05	-8.60568E-05	9.47790E-03	-1.33688E-04	2.37515E-04
-1.62132E-03	-2.52329E-04	1.10996E-02	0.0	0.0

MATRIX 'PHAF' 42 BY 15 SYMMETRIC MODEL MACH .90

ROW 1

1.00000E 00	-8.39747E-12	-2.10988E-01	-5.66141E-04	2.75200E-03
1.40151E-02	-1.10404E-02	-1.88059E-04	-7.63453E-04	-2.53469E-04
3.08922E-04	-2.72914E-05	3.75427E-03	0.0	0.0

ROW 2

1.00000E 00	-8.39848E-12	-2.10988E-01	-5.66538E-04	2.74577E-03
1.40933E-02	-1.11183E-02	-2.21174E-04	-7.74605E-04	-2.38744E-04
2.98445E-04	-4.66555E-05	2.76941E-03	0.0	0.0

ROW 3

1.00000E 00	-8.39948E-12	-2.10988E-01	-5.66936E-04	2.73955E-03
1.41714E-02	-1.11961E-02	-2.54289E-04	-7.85757E-04	-2.24019E-04
2.87968E-04	-6.60197E-05	1.78456E-03	0.0	0.0

ROW 4

1.00000E 00	-8.40048E-12	-2.10988E-01	-5.67333E-04	2.73333E-03
1.42496E-02	-1.12739E-02	-2.87405E-04	-7.96909E-04	-2.09294E-04
2.77491E-04	-8.53839E-05	7.99697E-04	0.0	0.0

ROW 5

1.00000E 00	-8.40148E-12	-2.10988E-01	-5.67591E-04	2.72492E-03
1.42903E-02	-1.13133E-02	-3.19351E-04	-8.02522E-04	-1.91758E-04
2.62993E-04	-1.03530E-04	-2.40897E-04	0.0	0.0

ROW 6

1.00000E 00	-8.40194E-12	-2.10988E-01	-5.67697E-04	2.72099E-03
1.43058E-02	-1.13282E-02	-3.33197E-04	-8.04643E-04	-1.84572E-04
2.54655E-04	-1.11830E-04	-7.16177E-04	0.0	0.0

ROW 7

1.00000E 00	-8.40183E-12	-2.10988E-01	-5.67698E-04	2.72212E-03
1.43088E-02	-1.13315E-02	-3.31603E-04	-8.05118E-04	-1.84442E-04
2.60356E-04	-1.09870E-04	-6.05398E-04	0.0	0.0

ROW 8

1.00000E 00	-8.40183E-12	-2.10988E-01	-5.67810E-04	2.72312E-03
1.43378E-02	-1.13610E-02	-3.38490E-04	-8.09314E-04	-1.76690E-04
2.76912E-04	-1.09613E-04	-5.96932E-04	0.0	0.0

ROW 9

1.00000E 00	-8.40183E-12	-2.10988E-01	-5.67921E-04	2.72412E-03
1.43667E-02	-1.13905E-02	-3.45377E-04	-8.13509E-04	-1.68937E-04
2.93467E-04	-1.09355E-04	-5.88467E-04	0.0	0.0

ROW 10

1.00000E 00	-8.40183E-12	-2.10988E-01	-5.68006E-04	2.72543E-03
1.43898E-02	-1.14143E-02	-3.46292E-04	-8.17001E-04	-1.70233E-04
2.95956E-04	-1.10597E-04	-5.99845E-04	0.0	0.0

ROW 11

1.00000E 00	-8.40183E-12	-2.10988E-01	-5.68039E-04	2.72596E-03
1.43990E-02	-1.14237E-02	-3.46676E-04	-8.18393E-04	-1.70752E-04
2.96959E-04	-1.11092E-04	-6.04457E-04	0.0	0.0

ROW 12

1.00000E 00	-8.40183E-12	-2.10988E-01	-5.68073E-04	2.72648E-03
1.44082E-02	-1.14332E-02	-3.47061E-04	-8.19785E-04	-1.71271E-04
2.97962E-04	-1.11587E-04	-6.09068E-04	0.0	0.0

ROW 13

1.00000E 00	-8.40183E-12	-2.10988E-01	-5.68106E-04	2.72700E-03
1.44174E-02	-1.14426E-02	-3.47445E-04	-8.21178E-04	-1.71789E-04
2.98965E-04	-1.12083E-04	-6.13680E-04	0.0	0.0

ROW 14

1.00000E 00	-8.40183E-12	-2.10988E-01	-5.68106E-04	2.72700E-03
1.44174E-02	-1.14426E-02	-3.47445E-04	-8.21178E-04	-1.71789E-04
2.98965E-04	-1.12083E-04	-6.13680E-04	0.0	0.0

MATRIX 'PHAF' 42 BY 15 SYMMETRIC MODEL MACH .90

ROW 15

1.75555E-12	1.00000E 00	-2.25807E 01	1.48618E-02	-1.96271E-01
1.62185E-02	1.24247E-02	-2.22880E-01	5.95732E-03	9.75877E-03
-1.84718E-02	-1.12251E-02	-2.84840E-01	0.0	0.0

ROW 16

2.97518E-12	1.00000E 00	-3.25796E 01	1.71512E-02	-1.40610E-01
1.52756E-02	1.26456E-02	-2.85150E-01	7.66180E-03	4.33319E-03
5.63238E-03	-5.44324E-03	-2.73158E-01	0.0	0.0

ROW 17

4.49257E-12	1.00000E 00	-4.25785E 01	1.96438E-02	-7.69658E-02
1.39891E-02	1.23808E-02	-3.26663E-01	9.13603E-03	-1.93062E-03
3.04463E-02	1.37440E-03	-1.92466E-01	0.0	0.0

ROW 18

6.30743E-12	1.00000E 00	-5.25774E 01	2.23001E-02	-6.32725E-03
1.23189E-02	1.15966E-02	-3.46331E-01	1.02371E-02	-8.55436E-03
5.42480E-02	8.71516E-03	-5.27726E-02	0.0	0.0

ROW 19

8.47601E-12	1.00000E 00	-6.25764E 01	2.51098E-02	7.13695E-02
1.01879E-02	1.02022E-02	-3.40263E-01	1.07903E-02	-1.50246E-02
7.50870E-02	1.60330E-02	1.37566E-01	0.0	0.0

ROW 20

1.02278E-11	1.00000E 00	-6.96054E 01	2.71681E-02	1.29887E-01
8.42121E-03	8.86676E-03	-3.20737E-01	1.08286E-02	-1.92044E-02
8.73284E-02	2.08705E-02	2.89678E-01	0.0	0.0

ROW 21

1.10075E-11	1.00000E 00	-7.25753E 01	2.80549E-02	1.55442E-01
7.61422E-03	8.22087E-03	-3.08953E-01	1.07569E-02	-2.08190E-02
9.17795E-02	2.27702E-02	3.55105E-01	0.0	0.0

ROW 22

1.36206E-11	1.00000E 00	-8.25742E 01	3.12241E-02	2.50526E-01
4.22874E-03	5.08378E-03	-2.27888E-01	9.41660E-03	-2.35979E-02
9.64949E-02	2.65680E-02	5.45919E-01	0.0	0.0

ROW 23

1.62338E-11	1.00000E 00	-9.25731E 01	3.46614E-02	3.59047E-01
-1.85695E-04	4.63038E-04	-8.23923E-02	6.30225E-03	-2.10614E-02
8.40067E-02	2.55462E-02	6.50474E-01	0.0	0.0

ROW 24

1.88471E-11	1.00000E 00	-1.02572E 02	3.83130E-02	4.78750E-01
-5.52620E-03	-5.50574E-03	1.22809E-01	1.41236E-03	-9.86131E-03
5.46765E-02	1.86647E-02	5.96854E-01	0.0	0.0

ROW 25

2.14603E-11	1.00000E 00	-1.12571E 02	4.21250E-02	6.07239E-01
-1.16584E-02	-1.26418E-02	3.80768E-01	-5.16013E-03	1.14207E-02
8.39099E-03	5.11446E-03	3.18843E-01	0.0	0.0

ROW 26

2.40735E-11	1.00000E 00	-1.22570E 02	4.60449E-02	7.41801E-01
-1.83631E-02	-2.06268E-02	6.77545E-01	-1.30113E-02	4.05507E-02
-5.18173E-02	-1.40314E-02	-1.63780E-01	0.0	0.0

ROW 27

2.66868E-11	1.00000E 00	-1.32569E 02	5.00287E-02	8.80093E-01
-2.54394E-02	-2.91660E-02	1.00000E 00	-2.17382E-02	7.51891E-02
-1.22303E-01	-3.73889E-02	-8.11376E-01	0.0	0.0

ROW 28

2.93000E-11	1.00000E 00	-1.42568E 02	5.40227E-02	1.01908E 00
-3.25999E-02	-3.78336E-02	1.32864E 00	-3.06972E-02	1.11380E-01
-1.96023E-01	-6.21236E-02	-1.51975E 00	0.0	0.0

MATRIX 'PHAF' 42 BY 15 SYMMETRIC MODEL MACH .90

ROW 29

-1.06674E-13	1.08073E-14	9.99892E-01	-2.17189E-04	-5.12335E-03
7.79873E-05	-4.58881E-05	7.25560E-03	-1.77464E-04	4.83486E-04
-2.31618E-03	-5.07826E-04	2.70892E-03	0.0	0.0

ROW 30

-1.37297E-13	-4.01344E-15	9.99893E-01	-2.40047E-04	-5.99341E-03
1.11321E-04	2.36140E-06	5.17632E-03	-1.60954E-04	5.93606E-04
-2.47538E-03	-6.39971E-04	-4.88608E-03	0.0	0.0

ROW 31

-1.66224E-13	-3.61385E-15	9.99893E-01	-2.57867E-04	-6.72089E-03
1.46684E-04	5.12189E-05	3.10550E-03	-1.31571E-04	6.51645E-04
-2.46000E-03	-7.15528E-04	-1.11033E-02	0.0	0.0

ROW 32

-1.96793E-13	1.18698E-14	9.99892E-01	-2.72781E-04	-7.39162E-03
1.88076E-04	1.06253E-04	8.06430E-04	-8.62084E-05	6.65233E-04
-2.27163E-03	-7.44214E-04	-1.66793E-02	0.0	0.0

ROW 33

-2.36982E-13	-4.25681E-15	9.99892E-01	-2.88599E-04	-8.12523E-03
2.37203E-04	1.71329E-04	-1.97187E-03	-2.45926E-05	6.20485E-04
-1.88282E-03	-7.10837E-04	-2.09409E-02	0.0	0.0

ROW 34

-2.64858E-13	9.11944E-15	9.99892E-01	-2.96450E-04	-8.49974E-03
2.64171E-04	2.06358E-04	-3.49539E-03	1.17166E-05	5.70334E-04
-1.61587E-03	-6.68229E-04	-2.22966E-02	0.0	0.0

ROW 35

-2.61313E-13	4.65153E-15	9.99892E-01	-3.00560E-04	-8.70110E-03
2.78711E-04	2.27687E-04	-4.40400E-03	3.55707E-05	5.18653E-04
-1.39267E-03	-6.13849E-04	-2.18034E-02	0.0	0.0

ROW 36

-2.61318E-13	-2.89550E-15	9.99893E-01	-3.31790E-04	-1.02474E-02
3.94148E-04	3.93751E-04	-1.15659E-02	2.27533E-04	2.48664E-05
4.18382E-04	-1.42478E-04	-1.55684E-02	0.0	0.0

ROW 37

-2.61323E-13	-4.52152E-15	9.99893E-01	-3.54185E-04	-1.13883E-02
4.84488E-04	5.24395E-04	-1.72892E-02	3.90370E-04	-5.44468E-04
2.04794E-03	3.50083E-04	-4.54880E-03	0.0	0.0

ROW 38

-2.61324E-13	1.28291E-14	9.99892E-01	-3.74337E-04	-1.24655E-02
5.77509E-04	6.60751E-04	-2.33862E-02	5.78543E-04	-1.64818E-03
3.78832E-03	1.01917E-03	1.57668E-02	0.0	0.0

ROW 39

-2.61323E-13	-2.73905E-15	9.99891E-01	-3.87164E-04	-1.31832E-02
6.44503E-04	7.59949E-04	-2.79111E-02	7.26577E-04	-2.55213E-03
5.37475E-03	1.65398E-03	3.86051E-02	0.0	0.0

ROW 40

-2.61323E-13	-5.79559E-15	9.99890E-01	-3.95770E-04	-1.36723E-02
6.91331E-04	8.29499E-04	-3.11035E-02	8.32809E-04	-3.20893E-03
6.55808E-03	2.13247E-03	5.64953E-02	0.0	0.0

ROW 41

-2.61324E-13	1.28014E-14	9.99892E-01	-3.99400E-04	-1.38988E-02
7.16056E-04	8.66757E-04	-3.28642E-02	8.95906E-04	-3.61910E-03
7.37203E-03	2.47347E-03	7.08378E-02	0.0	0.0

ROW 42

-2.61324E-13	1.28014E-14	9.99892E-01	-3.99400E-04	-1.38988E-02
7.16056E-04	8.66757E-04	-3.28642E-02	8.95906E-04	-3.61910E-03
7.37203E-03	2.47347E-03	7.08378E-02	0.0	0.0

ROW 1

1.00000E 00	-2.26638E-12	-2.27988E-01	4.62380E-02	-6.07108E-02
-7.62704E-01	4.95539E-01	3.51050E-02	-2.74467E-02	-4.73772E-03
2.07072E-02	-4.97939E-02	5.75070E-03	0.0	0.0

ROW 2

1.00000E 00	2.28621E-12	2.34954E-01	5.26872E-02	-7.02919E-02
-8.12428E-01	4.44229E-01	3.39932E-02	1.08711E-03	-4.89752E-03
2.40711E-02	-8.94738E-02	1.22269E-02	0.0	0.0

ROW 3

1.00000E 00	-1.05317E-12	-2.28989E-01	3.81376E-02	-4.94648E-02
-6.59636E-01	4.52055E-01	3.71859E-02	-4.58176E-03	-2.10269E-03
9.33706E-03	-2.31246E-02	9.50237E-04	0.0	0.0

ROW 4

1.00000E 00	1.19857E-12	2.96946E-01	4.56530E-02	-6.06883E-02
-7.18583E-01	3.91414E-01	3.55190E-02	2.84221E-02	-2.43009E-03
1.40980E-02	-7.55052E-02	1.02602E-02	0.0	0.0

ROW 5

1.00000E 00	-6.21426E-12	-1.84994E-01	2.76034E-02	-3.47623E-02
-5.08890E-01	3.80148E-01	3.77911E-02	1.81700E-02	1.02297E-03
-5.11066E-03	2.58053E-02	-6.78610E-03	0.0	0.0

ROW 6

1.00000E 00	-1.54474E-12	4.22932E-01	3.15323E-02	-4.07209E-02
-5.13969E-01	3.02917E-01	3.85788E-02	5.93158E-02	2.50507E-03
-9.90561E-03	2.67435E-02	-1.16771E-02	0.0	0.0

ROW 7

1.00000E 00	-7.65168E-12	-8.30061E-02	1.90533E-02	-2.32231E-02
-3.80939E-01	3.03400E-01	3.63230E-02	3.50650E-02	2.81684E-03
-1.31046E-02	4.88667E-02	-7.08333E-03	0.0	0.0

ROW 8

1.00000E 00	-3.60878E-12	5.24918E-01	2.19276E-02	-2.74508E-02
-3.74613E-01	2.39872E-01	3.88757E-02	6.92302E-02	4.66141E-03
-2.11400E-02	8.44401E-02	-1.98855E-02	0.0	0.0

ROW 9

1.00000E 00	-8.30295E-12	7.29750E-02	1.25179E-02	-1.47531E-02
-2.71859E-01	2.23896E-01	3.25006E-02	4.18132E-02	3.31931E-03
-1.54269E-02	5.56891E-02	-2.65028E-03	0.0	0.0

ROW 10

1.00000E 00	-5.18809E-12	6.30906E-01	1.42794E-02	-1.73385E-02
-2.57065E-01	1.72386E-01	3.56440E-02	6.78425E-02	5.04049E-03
-2.37805E-02	1.03364E-01	-1.58070E-02	0.0	0.0

ROW 11

1.00000E 00	-8.76465E-12	2.50952E-01	7.45731E-03	-8.41610E-03
-1.76402E-01	1.47884E-01	2.69590E-02	3.80289E-02	2.88212E-03
-1.38067E-02	5.16139E-02	4.22782E-03	0.0	0.0

ROW 12

1.00000E 00	-6.36336E-12	7.36893E-01	8.41125E-03	-9.91900E-03
-1.58583E-01	1.06202E-01	2.99412E-02	5.66553E-02	4.22391E-03
-2.07727E-02	9.68992E-02	-5.59776E-03	0.0	0.0

ROW 13

1.00000E 00	-8.93057E-12	4.27932E-01	3.57649E-03	-3.68930E-03
-9.51121E-02	8.03972E-02	2.05304E-02	2.66465E-02	1.83830E-03
-9.52192E-03	3.73383E-02	1.16344E-02	0.0	0.0

ROW 14

1.00000E 00	-7.23760E-12	8.42881E-01	4.08720E-03	-4.58345E-03
-7.41069E-02	4.38012E-02	2.27564E-02	3.92439E-02	2.85335E-03
-1.51456E-02	7.69426E-02	5.47098E-03	0.0	0.0

ROW 15

1.00000E 00	-8.93861E-12	5.96910E-01	9.73435E-04	-4.76754E-04
-3.10172E-02	2.41389E-02	1.44550E-02	1.38449E-02	7.33769E-04
-4.98223E-03	2.31536E-02	1.57286E-02	0.0	0.0

ROW 16

1.00000E 00	-7.90814E-12	9.49867E-01	1.22467E-03	-9.99148E-04
-1.71427E-02	6.40642E-03	1.66720E-02	1.76151E-02	1.05232E-03
-6.97983E-03	3.71895E-02	1.68530E-02	0.0	0.0

ROW 17

1.00000E 00	-8.29457E-12	7.83896E-01	9.14177E-05	2.13279E-03
1.12908E-02	-5.07339E-03	1.01422E-02	8.00808E-04	-5.28771E-04
8.26521E-04	-2.20118E-03	1.93619E-02	0.0	0.0

ROW 18

1.00000E 00	-8.29733E-12	1.05586E 00	-8.70097E-05	8.83783E-04
1.55868E-02	-1.18629E-02	1.27566E-02	1.48589E-03	-3.20530E-04
-4.68224E-04	2.91803E-03	2.29710E-02	0.0	0.0

ROW 19

1.00000E 00	-8.39588E-12	-2.10988E-01	-5.65262E-04	2.75808E-03
1.38245E-02	-1.08490E-02	-1.33440E-04	-7.36045E-04	-2.71653E-04
3.18274E-04	5.06820E-06	5.16783E-03	0.0	0.0

ROW 20

6.05841E-01	-4.44486E-12	1.13877E-01	1.36825E-03	2.26916E-03
9.95715E-02	-8.48195E-02	-9.57583E-03	-9.02046E-03	-6.46441E-05
-1.28744E-03	1.32980E-02	2.33100E-03	0.0	0.0

ROW 21

-5.49606E-12	-6.01404E-12	8.70120E-07	-3.26316E-02	4.46786E-02
6.08872E-01	-4.29638E-01	-3.63543E-02	1.62510E-03	1.87708E-03
-9.83114E-03	3.50251E-02	9.63571E-04	0.0	0.0

ROW 22

2.43569E-10	-7.22452E-12	4.56186E-06	-3.49169E-02	5.19667E-02
7.12202E-01	-4.31803E-01	-3.94223E-02	-2.44544E-02	2.61476E-03
-1.60073E-02	8.32011E-02	-6.17485E-03	0.0	0.0

ROW 23

1.88557E-10	-4.95454E-12	1.65350E-06	-2.57652E-02	3.53074E-02
5.20011E-01	-3.85548E-01	-3.69658E-02	-1.66658E-02	3.04315E-05
-2.16958E-03	2.17121E-02	1.95264E-03	0.0	0.0

ROW 24

2.17936E-10	-6.10981E-12	4.80708E-06	-2.79655E-02	4.28889E-02
6.32374E-01	-3.92235E-01	-4.12958E-02	-4.58891E-02	5.26265E-04
-7.16464E-03	6.29286E-02	-2.38189E-03	0.0	0.0

ROW 25

1.29258E-09	-3.70413E-12	2.52098E-06	-1.64953E-02	2.30742E-02
3.95219E-01	-3.13595E-01	-3.56634E-02	-3.56545E-02	-1.94049E-03
6.38622E-03	3.51883E-04	3.26541E-03	0.0	0.0

ROW 26

1.59770E-10	-3.48425E-12	5.48047E-06	-1.48096E-02	2.53793E-02
4.63947E-01	-3.18032E-01	-4.31199E-02	-6.80487E-02	-3.13853E-03
1.10375E-02	-2.05347E-02	1.44987E-02	0.0	0.0

ROW 27

2.42999E-10	-3.10786E-12	1.13593E-06	-8.73964E-03	1.36945E-02
2.92841E-01	-2.39400E-01	-3.20509E-02	-4.49503E-02	-2.65155E-03
9.67481E-03	-1.26208E-02	3.33445E-03	0.0	0.0

ROW 28

1.20559E-10	-1.89731E-12	6.01985E-06	-6.97051E-03	1.55496E-02
3.56921E-01	-2.55301E-01	-4.01225E-02	-6.89253E-02	-3.85092E-03
1.54868E-02	-5.18874E-02	1.60738E-02	0.0	0.0

ROW 29

9.54782E-11	-2.09841E-12	3.30057E-06	-2.88917E-03	7.37894E-03
2.09709E-01	-1.64632E-01	-2.60513E-02	-4.31774E-02	-2.39827E-03
9.32970E-03	-2.37578E-02	3.29203E-03	0.0	0.0

ROW 30

8.65093E-11	-7.99247E-13	6.42591E-06	-1.35096E-03	8.88346E-03
2.65907E-01	-1.88907E-01	-3.37303E-02	-5.81395E-02	-3.34935E-03
1.45210E-02	-6.28565E-02	1.16228E-02	0.0	0.0

ROW 31

4.39049E-11	-1.52266E-12	4.45451E-06	1.01048E-03	3.47713E-03
1.39115E-01	-9.63095E-02	-1.87914E-02	-3.27556E-02	-1.79224E-03
7.96498E-03	-3.62036E-02	3.36365E-03	0.0	0.0

ROW 32

5.70798E-11	-7.11506E-14	6.89840E-06	2.29693E-03	4.63443E-03
1.86373E-01	-1.24448E-01	-2.53918E-02	-4.02317E-02	-2.33043E-03
1.11833E-02	-6.12899E-02	5.12481E-03	0.0	0.0

ROW 33

1.94854E-11	-1.05681E-12	4.60760E-06	3.12785E-03	1.31143E-03
7.98952E-02	-4.03780E-02	-1.15375E-02	-1.87743E-02	-1.15181E-03
6.34033E-03	-4.26868E-02	2.15977E-03	0.0	0.0

ROW 34

3.06035E-11	3.77143E-13	7.03077E-06	4.25311E-03	1.94184E-03
1.11909E-01	-6.36103E-02	-1.60755E-02	-2.02267E-02	-1.30342E-03
7.53380E-03	-5.20090E-02	-7.70194E-04	0.0	0.0

ROW 35

5.31598E-12	-9.00727E-13	5.84572E-06	3.48284E-03	5.09222E-04
3.44144E-02	-8.47202E-04	-5.43262E-03	-7.30406E-03	-7.16720E-04
5.02020E-03	-4.16421E-02	1.15357E-03	0.0	0.0

ROW 36

1.22473E-11	5.68433E-13	6.37970E-06	4.38088E-03	4.00000E-04
5.30504E-02	-2.29983E-02	-7.73143E-03	-1.49521E-03	-2.52215E-04
2.84996E-03	-2.67077E-02	-5.84875E-03	0.0	0.0

ROW 37

-5.73456E-13	2.66323E-13	1.37783E-06	2.00114E-03	-3.77481E-05
6.26624E-03	7.57194E-03	-1.08422E-03	2.33275E-03	-5.57583E-05
1.31441E-03	-1.51797E-02	-1.74721E-03	0.0	0.0

ROW 38

7.78641E-13	3.82819E-13	2.63133E-06	2.43495E-03	-2.18672E-04
9.57863E-03	1.77687E-03	-1.32761E-03	5.47438E-03	2.37280E-04
-1.22342E-04	-6.41252E-03	-3.96527E-03	0.0	0.0

ROW 39

0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0

ROW 40

7.95586E-01	1.10199E-12	1.49536E-01	3.54910E-02	-4.84631E-02
-7.02380E-01	4.69596E-01	5.49406E-02	6.60115E-02	2.76806E-03
-1.01151E-02	2.11108E-02	-1.35215E-02	0.0	0.0

ROW 41

1.88839E-10	1.00000E 00	-4.54466E 01	-8.62952E-01	3.78872E-01
-5.04126E-02	-9.63809E-02	1.58772E-01	8.05644E-01	2.75860E-02
-6.85479E-02	-3.72520E-01	4.40472E-02	0.0	0.0

ROW 42

3.44949E-10	1.00000E 00	-5.01750E 01	-9.28148E-01	4.75413E-01
4.45367E-01	4.20200E-01	1.68665E-01	5.15891E-01	2.84351E-02
-9.81695E-02	4.99961E-04	-1.30644E-02	0.0	0.0

ROW 43

2.14028E-10	1.00000E 00	-3.97683E 01	-7.31818E-01	2.45042E-01
-3.05085E-01	-3.07011E-01	8.11142E-02	5.53352E-01	8.48611E-03
3.69421E-03	-4.37064E-01	6.52977E-02	0.0	0.0

ROW 44

2.92414E-10	1.00000E 00	-4.50976E 01	-8.04440E-01	3.52115E-01
2.38791E-01	2.57793E-01	9.01815E-02	2.36194E-01	8.68146E-03
-2.37132E-02	-7.40817E-02	1.65337E-02	0.0	0.0

ROW 45

2.39913E-10	1.00000E 00	-3.16502E 01	-5.57739E-01	7.64443E-02
-5.41147E-01	-4.83655E-01	1.97013E-03	2.38902E-01	-6.66581E-03
4.61890E-02	-2.55736E-01	2.02045E-02	0.0	0.0

ROW 46

1.85635E-10	1.00000E 00	-3.52118E 01	-5.71905E-01	1.24253E-01
-1.35001E-01	-5.82538E-02	-4.07000E-02	-1.63980E-01	-1.99574E-02
9.01228E-02	-3.25438E-01	8.80560E-02	0.0	0.0

ROW 47

9.22266E-11	1.00000E 00	-2.35842E 01	-4.05294E-01	-5.93364E-02
-6.27327E-01	-5.25194E-01	-3.59727E-02	1.34541E-02	-8.94577E-03
3.13943E-02	8.76341E-02	-5.58106E-02	0.0	0.0

ROW 48

1.17279E-10	1.00000E 00	-2.76367E 01	-4.12944E-01	-2.08716E-02
-2.95948E-01	-1.94897E-01	-9.90467E-02	-3.42736E-01	-2.69459E-02
1.12735E-01	-3.44239E-01	8.37038E-02	0.0	0.0

ROW 49

3.91600E-11	1.00000E 00	-1.55181E 01	-2.77127E-01	-1.61374E-01
-5.93885E-01	-4.70616E-01	-3.56128E-02	-9.78748E-02	-2.52759E-03
-1.27626E-02	3.73851E-01	-9.66952E-02	0.0	0.0

ROW 50

6.87202E-11	1.00000E 00	-2.00625E 01	-2.79108E-01	-1.30099E-01
-3.22870E-01	-2.16548E-01	-1.11715E-01	-3.93099E-01	-2.10053E-02
8.10515E-02	-2.23603E-01	4.01477E-02	0.0	0.0

ROW 51

1.48015E-11	1.00000E 00	-7.45206E 00	-1.74212E-01	-2.32323E-01
-4.80116E-01	-3.59470E-01	-6.55711E-03	-1.18748E-01	6.59269E-03
-5.73959E-02	4.96838E-01	-8.05019E-02	0.0	0.0

ROW 52

3.60761E-11	1.00000E 00	-1.24874E 01	-1.70728E-01	-2.07327E-01
-2.64210E-01	-1.71557E-01	-8.94709E-02	-3.39071E-01	-9.11492E-03
2.92222E-02	-1.00534E-01	4.04711E-03	0.0	0.0

ROW 53

-8.84864E-13	1.00000E 00	6.12985E-01	-9.55146E-02	-2.77589E-01
-3.27003E-01	-2.28687E-01	3.99040E-02	-8.96788E-02	1.35888E-02
-8.32921E-02	4.41279E-01	-1.63615E-02	0.0	0.0

ROW 54

1.57056E-11	1.00000E 00	-4.91231E 00	-8.69145E-02	-2.58595E-01
-1.65319E-01	-1.01951E-01	-4.41033E-02	-2.24149E-01	3.05937E-03
-1.90055E-02	-2.51982E-02	-7.13662E-03	0.0	0.0

ROW 55

-4.16770E-12	1.00000E 00	8.67904E 00	-3.90324E-02	-3.03209E-01
-1.67688E-01	-1.07912E-01	9.51891E-02	-4.75218E-02	1.63201E-02
-8.58212E-02	2.65548E-01	7.14443E-02	0.0	0.0

ROW 56

4.55270E-12	1.00000E 00	2.66180E 00	-2.74616E-02	-2.90288E-01
-6.48988E-02	-3.88980E-02	1.52624E-02	-9.55057E-02	1.21146E-02
-5.22409E-02	3.91772E-03	9.39496E-03	0.0	0.0

ROW 57

-6.01205E-13	1.00000E 00	1.67451E 01	-2.58066E-03	-3.14704E-01
-2.76421E-02	-2.40232E-02	1.55341E-01	-1.30855E-02	1.52706E-02
-7.28011E-02	6.85959E-02	1.62307E-01	0.0	0.0

ROW 58

6.98637E-14	1.00000E 00	1.02369E 01	6.44316E-03	-3.08523E-01
8.71585E-03	3.49696E-03	8.29523E-02	-4.41203E-03	1.63623E-02
-6.71789E-02	-6.43791E-03	6.11867E-02	0.0	0.0

ROW 59

4.55900E-13	1.00000E 00	-6.62218E 00	1.17708E-02	-2.65727E-01
1.72680E-02	1.13062E-02	-8.73843E-02	3.35990E-03	1.56026E-02
-5.05319E-02	-1.73300E-02	-1.67858E-01	0.0	0.0

ROW 60

-1.81004E-08	-1.00000E 00	3.83624E 01	6.12022E-01	-1.78834E-01
-1.04372E-01	-1.83529E-01	4.48005E-02	3.08677E-01	2.35802E-02
-1.00927E-01	3.40980E-01	-1.19207E-01	0.0	0.0

ROW 61

2.31011E-10	-1.96112E-13	-4.88642E-06	-9.08981E-03	3.99172E-03
-4.75425E-02	-5.86853E-02	1.21846E-02	9.79691E-02	3.59205E-03
-9.49624E-03	-4.32850E-02	2.21311E-03	0.0	0.0

ROW 62

-1.15261E-09	5.67024E-12	-5.68613E-06	-8.47150E-03	2.87304E-03
-5.54403E-02	-6.66009E-02	1.07562E-02	9.92785E-02	3.04750E-03
-6.15772E-03	-6.71811E-02	8.82056E-03	0.0	0.0

ROW 63

-3.57220E-12	1.73538E-14	-5.86910E-06	-8.46157E-03	2.95419E-03
-5.20841E-02	-6.21416E-02	1.03884E-02	9.04142E-02	2.76403E-03
-6.13232E-03	-4.71392E-02	4.11261E-03	0.0	0.0

ROW 64

-3.57220E-12	1.73538E-14	-5.86910E-06	-8.46157E-03	2.95419E-03
-5.20841E-02	-6.21416E-02	1.03884E-02	9.04142E-02	2.76403E-03
-6.13232E-03	-4.71392E-02	4.11261E-03	0.0	0.0

ROW 65

-9.23038E-10	9.68629E-14	-6.22314E-06	-8.21032E-03	2.84859E-03
-4.64724E-02	-5.27558E-02	9.59213E-03	7.30959E-02	2.30757E-03
-6.40512E-03	-1.17467E-02	-3.47866E-03	0.0	0.0

ROW 66

3.68712E-09	1.71101E-12	-5.46311E-06	-8.79750E-03	4.01402E-03
-3.71973E-02	-4.16475E-02	1.10922E-02	6.83843E-02	2.85130E-03
-1.03235E-02	2.28196E-02	-1.26851E-02	0.0	0.0

ROW 67

-9.52241E-11	3.25928E-13	-4.88449E-06	-7.84539E-03	2.72445E-03
-3.88274E-02	-4.12231E-02	8.75102E-03	5.33662E-02	1.92039E-03
-7.30257E-03	2.82666E-02	-1.14649E-02	0.0	0.0

ROW 68

2.37598E-10	2.54208E-14	-5.90685E-06	-8.19638E-03	3.43016E-03
-3.32109E-02	-3.34725E-02	9.52493E-03	4.88284E-02	2.08485E-03
-8.90298E-03	4.51944E-02	-1.43151E-02	0.0	0.0

ROW 69

-1.53234E-11	1.24529E-13	-5.73357E-06	-6.99432E-03	1.93683E-03
-3.43264E-02	-3.34433E-02	7.14051E-03	3.51352E-02	1.36264E-03
-6.63749E-03	4.81150E-02	-1.28342E-02	0.0	0.0

ROW 70

3.83463E-11	2.67932E-13	-6.39873E-06	-7.28499E-03	2.51160E-03
-2.96693E-02	-2.71860E-02	7.54325E-03	3.05758E-02	1.32493E-03
-6.94247E-03	5.38931E-02	-1.17081E-02	0.0	0.0

ROW 71

-1.60971E-12	7.75382E-14	-5.82646E-06	-5.98075E-03	1.09777E-03
-2.96333E-02	-2.63814E-02	5.57892E-03	2.01513E-02	9.24987E-04
-5.79434E-03	5.43206E-02	-1.03463E-02	0.0	0.0

ROW 72

1.88061E-12	5.11425E-14	-5.93549E-06	-6.24220E-03	1.57513E-03
-2.58297E-02	-2.14865E-02	5.61422E-03	1.55593E-02	7.11580E-04
-4.96643E-03	5.04695E-02	-6.80313E-03	0.0	0.0

ROW 73

-3.86974E-13	8.96131E-15	-5.39937E-06	-4.95432E-03	4.42775E-04
-2.44346E-02	-1.96737E-02	4.25243E-03	9.16793E-03	5.97225E-04
-4.72650E-03	4.88089E-02	-5.64368E-03	0.0	0.0

ROW 74

-9.64989E-13	3.58435E-14	-5.17292E-06	-5.11636E-03	8.29621E-04
-2.09348E-02	-1.58245E-02	3.95003E-03	4.77358E-03	3.01849E-04
-3.29620E-03	3.94025E-02	-1.91136E-03	0.0	0.0

ROW 75

-8.20161E-13	2.96536E-14	-5.39032E-06	-3.79424E-03	-7.06058E-05
-1.90890E-02	-1.36216E-02	3.17710E-03	2.76722E-03	4.11913E-04
-3.76983E-03	3.82796E-02	-1.57929E-03	0.0	0.0

ROW 76

-5.92277E-13	-5.92744E-14	-4.34190E-06	-3.74561E-03	4.88692E-04
-1.31489E-02	-8.20711E-03	2.18046E-03	-3.89475E-03	-1.16185E-04
-9.77838E-04	1.84660E-02	3.11711E-03	0.0	0.0

ROW 77

-5.03758E-13	-3.08351E-13	-1.53179E-06	-2.30187E-03	1.06937E-04
-1.02035E-02	-5.62743E-03	1.58837E-03	-2.27066E-03	3.56302E-05
-1.32182E-03	1.64369E-02	1.95840E-03	0.0	0.0

ROW 78

1.06263E-13	-3.03458E-13	-2.05571E-06	-1.93176E-03	2.14984E-04
-5.46947E-03	-3.45052E-03	7.78548E-04	-4.52707E-03	-1.92763E-04
9.92954E-05	5.35424E-03	2.99098E-03	0.0	0.0

ROW 79

1.94250E-14	-7.67640E-15	-4.13651E-07	-2.63655E-04	5.39568E-04
-8.13631E-04	-5.12567E-04	1.43866E-04	-6.07817E-04	-1.18428E-04
3.75311E-04	9.40630E-04	5.64667E-04	0.0	0.0

ROW 80

6.01846E-09	-1.72593E-13	7.95484E-01	4.25341E-03	-1.11525E-02
-8.60753E-02	-9.17304E-02	8.72364E-03	8.68881E-02	3.13588E-03
-1.07814E-02	1.98790E-02	-1.88038E-02	0.0	0.0

ROW 81

2.63505E-10	1.33486E-12	9.99876E-01	1.36034E-02	-2.00680E-02
-1.02058E-01	-1.06549E-01	-1.67874E-03	6.03118E-02	-1.54718E-05
5.16234E-03	-6.99667E-02	9.64894E-03	0.0	0.0

ROW 82

-1.30892E-09	2.75521E-12	9.99876E-01	1.38951E-02	-2.06221E-02
-1.06610E-01	-1.10539E-01	-2.33058E-03	6.15892E-02	-2.92718E-04
6.96294E-03	-8.38589E-02	1.34645E-02	0.0	0.0

ROW 83

-1.53496E-11	-7.78143E-13	9.99877E-01	1.32941E-02	-1.94699E-02
-9.74694E-02	-1.00768E-01	-9.14077E-04	5.77914E-02	2.46823E-04
3.22644E-03	-5.23786E-02	4.86077E-03	0.0	0.0

ROW 84

0.0	4.19675E-12	9.99875E-01	1.40084E-02	-2.08037E-02
-1.07216E-01	-1.12043E-01	-2.62889E-03	6.14193E-02	-3.67723E-04
7.37015E-03	-8.63742E-02	1.42051E-02	0.0	0.0

ROW 85

-1.01761E-09	6.31752E-13	9.99876E-01	1.13672E-02	-1.59344E-02
-7.10587E-02	-7.11265E-02	3.08147E-03	4.49893E-02	1.47367E-03
-5.78795E-03	2.70546E-02	-1.38562E-02	0.0	0.0

ROW 86

4.62839E-09	2.68108E-13	9.99878E-01	1.18559E-02	-1.68185E-02
-7.83855E-02	-7.93278E-02	2.39955E-03	5.13096E-02	1.39631E-03
-4.39878E-03	8.14145E-03	-1.08032E-02	0.0	0.0

ROW 87

-1.24272E-10	2.98309E-13	9.99876E-01	8.93308E-03	-1.18892E-02
-4.56874E-02	-4.40239E-02	7.32054E-03	3.75854E-02	2.49059E-03
-1.24065E-02	7.46412E-02	-2.11779E-02	0.0	0.0

ROW 88

2.57871E-10	7.81426E-13	9.99876E-01	9.37274E-03	-1.26377E-02
-5.23193E-02	-5.05663E-02	7.12018E-03	4.45733E-02	2.65335E-03
-1.24623E-02	6.76141E-02	-2.25440E-02	0.0	0.0

ROW 89

-1.74091E-11	2.53089E-13	9.99877E-01	6.72006E-03	-8.59858E-03
-2.78784E-02	-2.57508E-02	9.88293E-03	3.11896E-02	2.61663E-03
-1.35287E-02	8.06714E-02	-1.60460E-02	0.0	0.0

ROW 90

5.67874E-11	1.76550E-13	9.99877E-01	7.08124E-03	-9.16203E-03
-3.32871E-02	-3.07409E-02	1.01543E-02	3.85456E-02	2.97847E-03
-1.48555E-02	8.49981E-02	-2.05283E-02	0.0	0.0

ROW 91

-4.85433E-12	1.35257E-13	9.99876E-01	4.69917E-03	-5.91981E-03
-1.52851E-02	-1.33206E-02	1.10487E-02	2.36879E-02	2.11973E-03
-1.11333E-02	6.39246E-02	-6.06076E-03	0.0	0.0

ROW 92

-5.24560E-12	1.57015E-13	9.99876E-01	5.03049E-03	-6.42068E-03
-2.02579E-02	-1.78388E-02	1.16112E-02	3.13185E-02	2.58236E-03
-1.31753E-02	7.56631E-02	-1.16542E-02	0.0	0.0

ROW 93

-1.22451E-12	5.54157E-14	9.99877E-01	2.92280E-03	-3.81500E-03
-6.91528E-03	-5.44317E-03	1.11311E-02	1.52575E-02	1.29169E-03
-6.98388E-03	3.77774E-02	3.73705E-03	0.0	0.0

ROW 94

-2.83433E-12	7.74832E-14	9.99876E-01	3.23669E-03	-4.33477E-03
-1.16170E-02	-9.97832E-03	1.19136E-02	2.30402E-02	1.83371E-03
-9.59210E-03	5.48798E-02	-2.01471E-03	0.0	0.0

ROW 95

-1.49547E-13	-9.67611E-15	9.96534E-01	1.54767E-03	-2.29155E-03
-2.08758E-03	-1.76247E-03	1.06709E-02	8.13894E-03	5.36631E-04
-3.28804E-03	1.69781E-02	9.56555E-03	0.0	0.0

ROW 96

-2.21938E-12	-1.34578E-13	9.99877E-01	1.65036E-03	-2.54973E-03
-3.90125E-03	-2.84787E-03	1.11329E-02	1.09992E-02	7.59376E-04
-4.37263E-03	2.36182E-02	8.02917E-03	0.0	0.0

ROW 97

0.0	1.34140E-13	9.99883E-01	8.89520E-04	-6.86668E-04
3.98194E-03	8.84688E-04	9.49031E-03	1.16600E-03	-2.28184E-04
4.69991E-04	-2.76449E-03	1.29872E-02	0.0	0.0

ROW 98

0.0	7.88759E-14	9.99878E-01	3.82636E-04	-1.49849E-03
5.56928E-04	4.11132E-06	1.02643E-02	1.82654E-03	-3.02893E-05
-6.15825E-04	2.12833E-03	1.34806E-02	0.0	0.0

ROW 99

-5.63086E-14	-3.33292E-15	9.99892E-01	-1.67841E-04	-3.55707E-03
6.16283E-05	-8.60568E-05	9.47790E-03	-1.33688E-04	2.37515E-04
-1.62132E-03	-2.52329E-04	1.10996E-02	0.0	0.0

ROW 100

2.20063E-09	-5.14346E-14	-6.05771E-01	-1.44410E-02	1.38130E-02
2.00822E-02	1.62625E-02	8.04697E-03	2.58305E-02	1.73081E-03
-6.89767E-03	1.70164E-02	-5.14412E-03	0.0	0.0

ROW 101

0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0

ROW 102

0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0

ROW 103

0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0

ROW 104

5.15937E-12	-2.15037E-13	1.24628E-08	-1.24786E-03	1.71396E-03
1.59412E-02	-7.38715E-03	2.12828E-04	3.43987E-03	3.65799E-04
-1.54234E-03	3.08090E-03	-4.07373E-04	0.0	0.0

ROW 105

0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0

ROW 106

0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0

ROW 107

0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0

ROW 108

0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0

ROW 109

0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0

ROW 110

0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0

ROW 111

0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0

ROW 112

0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0

MATRIX 'PHWG' 120 BY 15 SYMMETRIC MODEL MACH .90

ROW 113

0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0

ROW 114

0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0

ROW 115

0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0

ROW 116

0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0

ROW 117

0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0

ROW 118

0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0

ROW 119

0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0

ROW 120

-8.01307E-11	2.73730E-13	-1.18810E-08	1.27052E-03	-1.80333E-03
-1.79209E-02	6.71145E-03	-1.67666E-04	-1.80362E-03	-3.87588E-04
1.94227E-03	-8.79833E-03	1.79327E-03	0.0	0.0

ROW 1

1.00000E 00	-8.40183E-12	-2.10988E-01	-5.67972E-04	2.72307E-03
1.43765E-02	-1.14001E-02	-3.59748E-04	-8.14437E-04	-1.83036E-04
2.85252E-04	-1.10445E-04	-6.64475E-04	0.0	0.0

ROW 2

1.00000E 00	-8.40183E-12	-2.10988E-01	-5.68063E-04	2.71980E-03
1.43916E-02	-1.14142E-02	-3.97157E-04	-8.15910E-04	-1.73381E-05
4.96201E-04	-8.50103E-05	-1.54424E-04	0.0	0.0

ROW 3

1.00000E 00	-8.40183E-12	-2.10988E-01	-5.68156E-04	2.71647E-03
1.44071E-02	-1.14287E-02	-4.35284E-04	-8.17418E-04	1.48142E-04
7.07297E-04	-5.95582E-05	3.53362E-04	0.0	0.0

ROW 4

1.00000E 00	-8.40183E-12	-2.10988E-01	-5.68209E-04	2.71552E-03
1.44182E-02	-1.14395E-02	-4.49735E-04	-8.18701E-04	1.85249E-04
7.58396E-04	-5.37678E-05	4.42714E-04	0.0	0.0

ROW 5

1.00000E 00	-8.40183E-12	-2.10988E-01	-5.68265E-04	2.71460E-03
1.44296E-02	-1.14506E-02	-4.64097E-04	-8.20041E-04	2.22269E-04
8.09411E-04	-4.80161E-05	5.31624E-04	0.0	0.0

ROW 6

1.00000E 00	-8.40183E-12	-2.10988E-01	-5.68301E-04	2.71440E-03
1.44379E-02	-1.14590E-02	-4.70080E-04	-8.20994E-04	1.85128E-04
7.68933E-04	-5.37748E-05	3.15067E-04	0.0	0.0

ROW 7

1.00000E 00	-8.40183E-12	-2.10988E-01	-5.68338E-04	2.71421E-03
1.44462E-02	-1.14673E-02	-4.75977E-04	-8.21955E-04	1.47981E-04
7.28413E-04	-5.95446E-05	9.85425E-05	0.0	0.0

ROW 8

1.00000E 00	-8.40183E-12	-2.10988E-01	-5.68370E-04	2.71357E-03
1.44526E-02	-1.14736E-02	-4.85168E-04	-8.22616E-04	1.54047E-04
7.40613E-04	-5.81902E-05	1.00759E-04	0.0	0.0

ROW 9

-7.01245E-14	2.83906E-18	1.44512E-14	1.29091E-08	-9.59042E-07
-4.01866E-06	4.43102E-06	-8.39911E-06	-1.14650E-06	6.32147E-04
7.33052E-04	8.72753E-05	2.16002E-03	0.0	0.0

ROW 10

-8.53042E-14	3.15069E-18	1.35425E-12	-5.63050E-08	-4.03152E-06
6.35333E-06	-4.96323E-06	-4.15643E-05	-2.21339E-06	8.46531E-04
9.97601E-04	1.19233E-04	2.84944E-03	0.0	0.0

ROW 11

-7.13180E-14	3.49761E-18	1.46273E-14	-1.23988E-07	-7.06409E-06
1.64318E-05	-1.40753E-05	-7.42077E-05	-3.25495E-06	1.06107E-03
1.26204E-03	1.51178E-04	3.54049E-03	0.0	0.0

ROW 12

-7.80139E-14	3.89421E-18	-2.56696E-13	-1.33490E-07	-6.86515E-06
1.92053E-05	-1.69449E-05	-7.40640E-05	-3.81526E-06	1.09920E-03
1.30633E-03	1.56148E-04	3.65805E-03	0.0	0.0

ROW 13

-6.86378E-14	3.94795E-18	1.40051E-14	-1.42145E-07	-6.69081E-06
2.17187E-05	-1.95441E-05	-7.39857E-05	-4.33362E-06	1.13739E-03
1.35068E-03	1.61146E-04	3.77592E-03	0.0	0.0

ROW 14

-7.44300E-14	3.68287E-18	3.09336E-13	-1.24556E-07	-5.57962E-06
1.97692E-05	-1.79770E-05	-6.26760E-05	-4.27239E-06	1.07351E-03
1.26922E-03	1.50347E-04	3.47341E-03	0.0	0.0

ROW 15

-7.24236E-14	3.59679E-18	1.48276E-14	-1.06944E-07	-4.47734E-06
1.77969E-05	-1.63841E-05	-5.14291E-05	-4.20532E-06	1.00963E-03
1.18779E-03	1.39556E-04	3.17087E-03	0.0	0.0

ROW 16

-8.71002E-14	3.63740E-18	-7.68812E-13	-8.35195E-08	-4.00862E-06
1.31416E-05	-1.18512E-05	-4.47463E-05	-3.72422E-06	1.00521E-03
1.17892E-03	1.38571E-04	3.16926E-03	0.0	0.0

ROW 17

1.61189E-11	1.00000E 00	-9.21332E 01	3.45084E-02	3.54141E-01
2.53515E-05	6.91666E-04	-9.00028E-02	6.48723E-03	-2.23551E-02
8.41004E-02	2.57023E-02	6.51303E-01	0.0	0.0

ROW 18

1.67336E-11	1.00000E 00	-9.44852E 01	3.53783E-02	3.82455E-01
-1.18894E-03	-6.10871E-04	-4.69372E-02	5.69491E-03	-4.98341E-02
4.95970E-02	2.23398E-02	6.31845E-01	0.0	0.0

ROW 19

1.73483E-11	1.00000E 00	-9.68372E 01	3.63116E-02	4.13436E-01
-2.53854E-03	-2.04476E-03	7.78007E-04	5.11408E-03	-1.31652E-01
-4.20067E-02	1.38174E-02	5.38391E-01	0.0	0.0

ROW 20

1.79631E-11	1.00000E 00	-9.91893E 01	3.73034E-02	4.46930E-01
-4.01978E-03	-3.62014E-03	5.35226E-02	4.72281E-03	-2.71442E-01
-1.95998E-01	-7.48248E-04	3.39644E-01	0.0	0.0

ROW 21

1.85778E-11	1.00000E 00	-1.01541E 02	3.83377E-02	4.82278E-01
-5.59849E-03	-5.31073E-03	1.10306E-01	4.46673E-03	-4.57682E-01
-4.00683E-01	-2.04195E-02	4.30152E-02	0.0	0.0

ROW 22

1.91926E-11	1.00000E 00	-1.03893E 02	3.94127E-02	5.19460E-01
-7.27172E-03	-7.13944E-03	1.71747E-01	4.33508E-03	-6.97606E-01
-6.65333E-01	-4.65127E-02	-3.94274E-01	0.0	0.0

ROW 23

1.98073E-11	1.00000E 00	-1.06245E 02	4.05337E-02	5.58720E-01
-9.05181E-03	-9.12976E-03	2.38603E-01	4.34272E-03	-1.00000E 00
-1.00000E 00	-8.01690E-02	-1.00000E 00	0.0	0.0

ROW 24

2.04221E-11	1.00000E 00	-1.08597E 02	4.16663E-02	5.98508E-01
-1.08590E-02	-1.11610E-02	3.06831E-01	4.38564E-03	-1.31821E 00
-1.35240E 00	-1.15741E-01	-1.64838E 00	0.0	0.0

ROW 25

3.19273E-19	-2.50385E-15	-5.25181E-07	4.92622E-07	1.84388E-05
-4.51340E-07	-4.36312E-07	3.64965E-06	2.20858E-06	-2.07862E-04
-1.72123E-04	-3.96543E-06	3.78181E-04	0.0	0.0

ROW 26

1.82387E-18	-3.13343E-15	2.51587E-07	1.36674E-05	5.68358E-04
-2.79765E-05	-2.61234E-05	9.10094E-04	4.66025E-05	-1.08719E-02
-1.12609E-02	-9.73787E-04	-1.20611E-02	0.0	0.0

ROW 27

3.88220E-18	-3.24611E-15	2.49408E-07	2.58665E-05	1.08633E-03
-5.46658E-05	-5.31818E-05	1.87113E-03	8.68073E-05	-2.20263E-02
-2.31124E-02	-2.08059E-03	-2.95668E-02	0.0	0.0

ROW 28

5.99705E-18	-3.08894E-15	-3.10187E-07	3.74666E-05	1.58923E-03
-8.12036E-05	-8.30458E-05	2.92892E-03	1.23999E-04	-3.41830E-02
-3.63013E-02	-3.38717E-03	-5.36194E-02	0.0	0.0

MATRIX 'PHHT' 48 BY 15 SYMMETRIC MODEL MACH .90

ROW 29

6.42837E-18	-3.09588E-15	-3.55674E-07	4.31743E-05	1.84127E-03
-9.43529E-05	-1.00011E-04	3.51371E-03	1.41878E-04	-4.09153E-02
-4.37228E-02	-4.15525E-03	-6.92905E-02	0.0	0.0

ROW 30

4.57339E-18	-3.21062E-15	1.30906E-07	5.34906E-05	2.30819E-03
-1.18347E-04	-1.36296E-04	4.72982E-03	1.73151E-04	-5.49413E-02
-5.94434E-02	-5.85334E-03	-1.07109E-01	0.0	0.0

ROW 31

3.66535E-18	-3.09525E-15	4.63830E-07	6.05492E-05	2.62767E-03
-1.34764E-04	-1.61122E-04	5.56191E-03	1.94549E-04	-6.45381E-02
-7.01995E-02	-7.01519E-03	-1.32984E-01	0.0	0.0

ROW 32

3.73048E-18	-3.22189E-15	4.63830E-07	6.05492E-05	2.62767E-03
-1.34764E-04	-1.61122E-04	5.56191E-03	1.94549E-04	-6.45381E-02
-7.01995E-02	-7.01519E-03	-1.32984E-01	0.0	0.0

ROW 33

-2.61329E-13	-4.58781E-15	9.99893E-01	-3.54544E-04	-1.14033E-02
4.85252E-04	5.25088E-04	-1.73141E-02	3.89178E-04	-2.57440E-04
2.34606E-03	3.76013E-04	-4.22711E-03	0.0	0.0

ROW 34

-2.61330E-13	-4.22679E-15	9.99892E-01	-3.64123E-04	-1.18031E-02
5.05265E-04	5.43765E-04	-1.79732E-02	3.56900E-04	7.49623E-03
1.04086E-02	1.08116E-03	4.81730E-03	0.0	0.0

ROW 35

-2.61332E-13	-4.15992E-15	9.99892E-01	-3.72993E-04	-1.21797E-02
5.24670E-04	5.63439E-04	-1.86719E-02	3.27668E-04	1.56065E-02
1.90256E-02	1.88589E-03	1.75454E-02	0.0	0.0

ROW 36

-2.61333E-13	-4.35697E-15	9.99892E-01	-3.81427E-04	-1.25454E-02
5.43965E-04	5.85152E-04	-1.94411E-02	3.00626E-04	2.44454E-02
2.86151E-02	2.83589E-03	3.50337E-02	0.0	0.0

ROW 37

-2.61334E-13	-4.41944E-15	9.99892E-01	-3.85577E-04	-1.27287E-02
5.53526E-04	5.97487E-04	-1.98662E-02	2.87626E-04	2.93404E-02
3.40112E-02	3.39435E-03	4.64279E-02	0.0	0.0

ROW 38

-2.61332E-13	-4.39021E-15	9.99892E-01	-3.93077E-04	-1.30682E-02
5.70972E-04	6.23869E-04	-2.07505E-02	2.64888E-04	3.95385E-02
4.54413E-02	4.62900E-03	7.39249E-02	0.0	0.0

ROW 39

-2.61332E-13	-4.38262E-15	9.99892E-01	-3.98210E-04	-1.33004E-02
5.82908E-04	6.41920E-04	-2.13555E-02	2.49330E-04	4.65161E-02
5.32620E-02	5.47377E-03	9.27387E-02	0.0	0.0

ROW 40

-2.61332E-13	-4.18833E-15	9.99892E-01	-3.98210E-04	-1.33004E-02
5.82908E-04	6.41920E-04	-2.13555E-02	2.49330E-04	4.65161E-02
5.32620E-02	5.47377E-03	9.27387E-02	0.0	0.0

ROW 41

9.53622E-17	6.08140E-20	3.47386E-12	7.92760E-09	1.94194E-07
-1.48914E-06	1.43506E-06	2.50636E-06	1.42397E-07	-2.07003E-06
-3.76141E-06	-4.38885E-07	-2.32497E-06	0.0	0.0

ROW 42

-3.00951E-16	7.17323E-20	-1.42913E-12	8.45554E-09	2.22220E-07
-1.57517E-06	1.51117E-06	2.83319E-06	1.42864E-07	-1.90995E-06
-3.75358E-06	-4.47240E-07	-1.30325E-06	0.0	0.0

ROW 43

1.37048E-16	-5.74214E-20	-9.04624E-13	9.21700E-09	2.27662E-07
-1.73854E-06	1.67488E-06	2.94959E-06	1.63878E-07	-1.92846E-06
-3.84470E-06	-4.48900E-07	-9.24101E-07	0.0	0.0

ROW 44

1.77481E-16	-1.69876E-19	4.08655E-13	9.73007E-09	2.14997E-07
-1.89460E-06	1.83637E-06	2.93284E-06	1.88090E-07	-1.87110E-06
-3.79782E-06	-4.32306E-07	-6.70353E-07	0.0	0.0

ROW 45

2.81955E-18	-1.16666E-19	-8.62016E-14	9.93391E-09	2.06603E-07
-1.95961E-06	1.90489E-06	2.89366E-06	1.99538E-07	-1.87175E-06
-3.78915E-06	-4.24656E-07	-6.46553E-07	0.0	0.0

ROW 46

-4.23412E-16	-1.44962E-20	2.94033E-13	9.96415E-09	2.01641E-07
-1.97422E-06	1.92141E-06	2.85556E-06	2.03314E-07	-1.89061E-06
-3.79387E-06	-4.22123E-07	-7.19567E-07	0.0	0.0

ROW 47

-3.80446E-16	1.97420E-20	-3.34386E-13	9.95822E-09	1.99262E-07
-1.97905E-06	1.92698E-06	2.84098E-06	2.04524E-07	-1.87513E-06
-3.77104E-06	-4.18644E-07	-6.85214E-07	0.0	0.0

ROW 48

-4.61490E-16	1.97034E-20	-3.34367E-13	9.95822E-09	1.99262E-07
-1.97905E-06	1.92698E-06	2.84098E-06	2.04524E-07	-1.87513E-06
-3.77104E-06	-4.18644E-07	-6.85214E-07	0.0	0.0

MATRIX 'MASS' 16 BY 16 ANTISYMMETRIC MODEL MACH .90

ROW 1

5.35479E 00	1.56060E-07	3.84753E-06	-4.01131E-10	-4.59236E-09
-2.28289E-09	-5.68892E-09	-2.83107E-09	-9.48293E-11	-6.48865E-08
-3.73877E-10	2.89392E-10	9.77622E-10	3.56272E-11	0.0
0.0				

ROW 2

1.56060E-07	1.43653E 03	-3.42702E-05	-1.11535E-06	-3.30989E-07
-4.52008E-07	5.06295E-07	-1.81072E-07	-3.88315E-07	-3.42511E-07
-3.16614E-07	3.42982E-07	2.39738E-07	-2.83387E-01	0.0
0.0				

ROW 3

3.84753E-06	-3.42702E-05	2.46727E 04	-6.04711E-07	-4.33751E-06
-9.16005E-07	-1.16776E-07	6.36019E-08	1.22475E-07	-2.32974E-05
-4.13982E-08	2.77671E-07	-2.03936E-07	-1.95964E-02	0.0
0.0				

ROW 4

-4.01131E-10	-1.11535E-06	-6.04711E-07	5.51567E-02	2.99411E-09
1.86426E-09	-4.85189E-09	9.17580E-10	1.77178E-09	3.94259E-10
2.98866E-10	-1.54008E-09	-1.35778E-09	3.01240E-03	0.0
0.0				

ROW 5

-4.59236E-09	-3.31090E-07	-4.33752E-06	3.00502E-09	6.60694E-01
2.07899E-09	-6.91644E-09	2.69964E-09	2.46139E-09	-8.11748E-09
5.89412E-10	-1.77425E-09	4.16512E-09	-1.41678E-04	0.0
0.0				

ROW 6

-2.28289E-09	-4.51775E-07	-9.15845E-07	1.85608E-09	2.07899E-09
1.02467E-01	-1.91045E-09	-1.36934E-09	-9.32523E-11	7.58002E-09
1.97876E-10	-1.02354E-09	2.96956E-10	1.39119E-03	0.0
0.0				

ROW 7

-5.68892E-09	5.05364E-07	-1.16790E-07	-4.77914E-09	-6.90280E-09
-1.91045E-09	5.01605E-02	1.90060E-09	2.74409E-09	-4.74517E-10
-1.46371E-10	3.39268E-09	5.68152E-10	-2.62401E-03	0.0
0.0				

ROW 8

-2.83107E-09	-1.77798E-07	6.36747E-08	9.15761E-10	2.69964E-09
-1.36934E-09	1.90060E-09	1.09309E-02	-2.13113E-10	-1.53393E-09
4.83381E-10	-8.77745E-11	2.50481E-09	6.06008E-04	0.0
0.0				

ROW 9

-9.48293E-11	-3.89115E-07	1.22373E-07	1.97459E-09	2.46139E-09
-9.14333E-11	2.74409E-09	-2.02199E-10	2.22775E-02	1.17986E-09
-1.73424E-09	-1.65636E-09	-1.07522E-09	-4.97191E-04	0.0
0.0				

ROW 10

-6.48865E-08	-3.44374E-07	-2.32976E-05	4.08811E-10	-8.11748E-09
7.58002E-09	-4.74517E-10	-1.53393E-09	1.17804E-09	7.57798E-01
-1.01715E-09	2.15395E-10	-1.09042E-10	3.67082E-04	0.0
0.0				

ROW 11

-3.73877E-10	-3.19844E-07	-4.14300E-08	3.02504E-10	5.89412E-10
1.97876E-10	-1.46371E-10	4.83381E-10	-1.74152E-09	-1.01806E-09
1.61103E-02	5.53537E-09	4.47695E-09	1.79393E-05	0.0
0.0				

ROW 12

2.89392E-10	3.39490E-07	2.77452E-07	-1.52735E-09	-1.77425E-09
-1.02354E-09	3.39268E-09	-7.77700E-11	-1.65363E-09	2.15395E-10
5.53537E-09	4.45562E-02	-3.39456E-10	-9.71174E-04	0.0
0.0				

ROW 13

9.77622E-10	2.40669E-07	-2.03791E-07	-1.42599E-09	4.16512E-09
2.96956E-10	5.39048E-10	2.50481E-09	-1.07522E-09	-1.09042E-10
4.47695E-09	-3.39456E-10	6.98413E-02	1.42065E-03	0.0
0.0				

ROW 14

3.56272E-11	-2.83387E-01	-1.95964E-02	3.01240E-03	-1.41678E-04
1.39119E-03	-2.62401E-03	6.06008E-04	-4.97191E-04	3.67082E-04
1.79393E-05	-9.71174E-04	1.42065E-03	7.08300E-03	0.0
0.0				

ROW 15

0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0
0.0				

ROW 16

0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0
0.0				

MATRIX 'C1 ' 16 BY 16 ANTISYMMETRIC MODEL MACH .90

ROW 1

0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0
0.0				

ROW 2

0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0
0.0				

ROW 3

0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0
0.0				

ROW 4

0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0
0.0				

ROW 5

0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0
0.0				

ROW 6

0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0
0.0				

ROW 7

0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0
0.0				

ROW 8

0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0
0.0				

ROW 9

0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0
0.0				

ROW 10

0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0
0.0				

ROW 11

0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0
0.0				

ROW 12

0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0
0.0				

ROW 13

0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0
0.0				

ROW 14

0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0
0.0				

ROW 15

0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0
0.0				

ROW 16

0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0
0.0				

MATRIX 'DAMP' 16 BY 16 ANTISYMMETRIC MODEL MACH .90

ROW 1

0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0
0.0				

ROW 2

0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0
0.0				

ROW 3

0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0
0.0				

ROW 4

0.0	0.0	0.0	4.31356E-02	3.20062E-09
2.28445E-09	-6.50161E-09	1.23933E-09	2.71888E-09	6.37559E-10
4.71156E-10	-3.04067E-09	-2.38621E-09	0.0	0.0
0.0				

ROW 5

0.0	0.0	0.0	3.20062E-09	9.67727E-01
3.47460E-09	-1.22529E-08	4.92178E-09	5.25823E-09	-1.79646E-08
1.31984E-09	-4.78835E-09	1.13998E-08	0.0	0.0
0.0				

ROW 6

0.0	0.0	0.0	2.28445E-09	3.47460E-09
1.95405E-01	-3.86996E-09	-2.84857E-09	-2.58348E-10	1.91411E-08
5.05584E-10	-3.15191E-09	9.27387E-10	0.0	0.0
0.0				

ROW 7

0.0	0.0	0.0	-6.50161E-09	-1.22529E-08
-3.86996E-09	1.07932E-01	4.19976E-09	7.10520E-09	-1.27282E-09
-3.97260E-10	1.10977E-08	1.45028E-09	0.0	0.0
0.0				

ROW 8

0.0	0.0	0.0	1.23933E-09	4.92178E-09
-2.84858E-09	4.19976E-09	2.48049E-02	-5.76346E-10	-4.22538E-09
1.34727E-09	-3.10127E-10	8.53311E-09	0.0	0.0
0.0				

ROW 9

0.0	0.0	0.0	2.71888E-09	5.25823E-09
-2.58348E-10	7.10520E-09	-5.76346E-10	6.94115E-02	3.76135E-09
-5.69067E-09	-6.46249E-09	-4.29212E-09	0.0	0.0
0.0				

ROW 10

0.0	0.0	0.0	6.37560E-10	-1.79646E-08
1.91411E-08	-1.27282E-09	-4.22538E-09	3.76135E-09	2.53393E 00
-3.47830E-09	8.78317E-10	-4.50929E-10	0.0	0.0
0.0				

ROW 11

0.0	0.0	0.0	4.71156E-10	1.31984E-09
5.05584E-10	-3.97260E-10	1.34727E-09	-5.69067E-09	-3.47830E-09
5.51510E-02	2.28384E-08	1.87327E-08	0.0	0.0
0.0				

ROW 12

0.0	0.0	0.0	-3.04068E-09	-4.78835E-09
-3.15191E-09	1.10977E-08	-3.10127E-10	-6.46249E-09	8.78317E-10
2.28384E-08	2.21563E-01	-1.71187E-09	0.0	0.0
0.0				

ROW 13

0.0	0.0	0.0	-2.38622E-09	1.13998E-08
9.27388E-10	1.45028E-09	8.53311E-09	-4.29212E-09	-4.50929E-10
1.87327E-08	-1.71187E-09	3.57189E-01	0.0	0.0
0.0				

ROW 14

0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0
0.0				

ROW 15

0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0
0.0				

ROW 16

0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0
0.0				

MATRIX 'C2 ' 16 BY 16 ANTISYMMETRIC MODEL MACH .90

ROW 1

2.72293E 03	-3.01251E 04	2.38091E 05	-2.34525E 02	-1.20233E 03
3.23303E 02	-7.37227E 02	-6.77776E 02	3.60282E 01	-2.42749E 02
4.36687E 01	6.58962E 01	3.62103E 02	1.72296E 01	1.11483E 03
1.70704E 03				

ROW 2

-3.41071E 04	1.77847E 07	-1.95742E 06	-8.41056E 04	1.21214E 04
-3.98383E 02	2.85569E 04	1.27952E 04	5.59517E 04	3.45526E 04
2.97743E 04	-1.96296E 04	5.57281E 04	-5.58657E 04	-3.00030E 05
-1.76611E 04				

ROW 3

2.14683E 05	-1.35897E 06	1.91519E 07	-2.58031E 04	-1.01342E 05
2.78979E 04	-6.35417E 04	-6.03473E 04	5.50355E 03	-1.15021E 04
6.17426E 03	-9.05781E 01	2.75674E 04	-2.62751E 03	7.42579E 04
1.60208E 05				

ROW 4

-1.91894E 02	-6.27592E 04	-2.23311E 04	7.07925E 02	1.23603E 02
8.12598E 01	-1.97939E 02	1.64500E 02	-1.41641E 02	-6.40028E 01
5.82484E 01	1.84542E 02	-7.89972E 01	5.59890E 02	-1.77837E 03
-6.33093E 01				

ROW 5

-8.58778E 02	-4.25399E 03	-8.14587E 04	1.77693E 02	5.27115E 02
-2.23288E 02	4.59396E 02	3.62533E 02	-6.40708E 01	-1.11174E 02
-3.78025E 01	1.26046E 02	2.37629E 01	-1.27523E 01	-7.15354E 02
-7.89509E 02				

ROW 6

2.30195E 02	4.94083E 04	2.54008E 04	-2.33999E 02	-2.37863E 02
3.44285E 02	-4.69282E 02	-5.72595E 01	1.94001E 02	2.32434E 02
2.35763E 01	-1.55811E 02	-1.83062E 01	1.56769E 02	1.10460E 03
1.29934E 02				

ROW 7

-4.85570E 02	-5.20786E 04	-5.12326E 04	2.56255E 02	4.59823E 02
-5.15902E 02	8.19094E 02	2.18784E 02	-1.66885E 02	-3.37380E 02
-4.29858E 01	3.16400E 02	8.44191E 01	-3.11901E 02	-1.33044E 03
-2.55558E 02				

ROW 8

-4.55986E 02	2.41257E 04	-4.32020E 04	1.04522E 01	3.07929E 02
-2.98463E 01	2.09443E 02	3.41435E 02	2.59542E 01	-8.95818E 01
-2.63604E 01	1.61469E 02	1.65518E 02	5.93077E 01	-1.80012E 02
-2.35111E 02				

ROW 9

-1.70852E 01	1.14163E 04	-1.18998E 03	1.19558E 02	1.71187E 01
-2.18793E 01	5.34243E 01	-1.55002E 01	7.60896E 02	6.34877E 02
5.42316E 01	-5.42460E 02	6.58712E 02	1.11846E 02	2.11412E 03
3.23013E 01				

ROW 10

-5.93028E 02	1.94095E 04	-4.67461E 04	8.91133E 01	1.45290E 02
2.11696E 00	-2.18286E 01	-2.09932E 01	6.09156E 02	7.46182E 02
1.56830E 01	-7.40816E 02	3.67260E 02	1.67702E 02	2.35643E 03
-2.66456E 02				

ROW 11

2.22156E 01	5.87450E 03	2.27542E 03	4.85230E 01	7.73714E 00
-5.30164E 01	6.07873E 01	-1.30456E 01	-6.38049E 01	-9.34775E 01
3.86016E 02	2.00349E 02	3.08155E 02	4.47379E 01	-6.31028E 03
-4.30447E 01				

MATRIX 'C2 ' 16 BY 16 ANTISYMMETRIC MODEL MACH .90

ROW 12

3.45755E 02	-6.86163E 03	3.01869E 04	1.62482E 02	-1.96591E 02
2.34236E 02	-3.12943E 02	2.26172E 00	-2.36127E 02	-3.30364E 02
1.49585E 02	9.80891E 02	-4.39584E 02	-6.07352E 01	-3.36276E 03
4.13428E 02				

ROW 13

4.62535E 02	-9.42250E 02	4.11154E 04	-2.60496E 02	-1.06041E 02
-3.15500E 02	3.30539E 02	-1.87067E 02	1.17152E 02	4.08640E 01
1.97427E 02	-3.91743E 02	1.64186E 03	7.13957E 01	-2.37290E 03
4.35845E 02				

ROW 14

2.36771E-01	-8.94324E 03	-5.71941E 02	1.15497E 02	-1.13669E 01
7.57698E 01	-1.30515E 02	2.94205E 01	2.36371E 00	3.73937E 01
9.55229E 00	-5.77485E 01	7.61341E 01	4.52381E 02	-5.04500E 00
7.35597E 00				

ROW 15

6.00508E 02	-1.82648E 04	4.83045E 04	-3.03293E 02	-2.51470E 02
3.46917E 02	-3.61269E 02	5.22358E 01	1.57239E 03	1.52523E 03
-2.92302E 03	-4.23319E 03	-2.57239E 03	-4.39063E 00	7.59476E 04
5.79758E 02				

ROW 16

6.78238E 02	-8.59202E 03	6.58474E 04	-5.29360E 01	-3.49940E 02
5.14355E 01	-1.26750E 02	-1.31996E 02	-1.83347E 01	-9.37042E 01
7.27451E 00	1.32320E 02	2.05000E 02	-1.95503E 00	2.76264E 02
4.16127E 03				

MATRIX 'STIF' 16 BY 16 ANTISYMMETRIC MODEL MACH .90

ROW 1

0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0
0.0				

ROW 2

0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0
0.0				

ROW 3

0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0
0.0				

ROW 4

0.0	0.0	0.0	3.37344E 02	0.0
0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0
0.0				

ROW 5

0.0	0.0	0.0	0.0	1.41744E 04
0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0
0.0				

ROW 6

0.0	0.0	0.0	0.0	0.0
3.72640E 03	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0
0.0				

ROW 7

0.0	0.0	0.0	0.0	0.0
0.0	2.32242E 03	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0
0.0				

ROW 8

0.0	0.0	0.0	0.0	0.0
0.0	0.0	5.62883E 02	0.0	0.0
0.0	0.0	0.0	0.0	0.0
0.0				

ROW 9

0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	2.16271E 03	0.0
0.0	0.0	0.0	0.0	0.0
0.0				

ROW 10

0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	8.47299E 04
0.0	0.0	0.0	0.0	0.0
0.0				

ROW 11

0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0
1.88801E 03	0.0	0.0	0.0	0.0
0.0				

MATRIX 'STIF' 16 BY 16 ANTISYMMETRIC MODEL MACH .90

ROW 12

0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0
0.0	1.10176E 04	0.0	0.0	0.0
0.0				

ROW 13

0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0
0.0	0.0	1.82677E 04	0.0	0.0
0.0				

ROW 14

0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0
0.0				

ROW 15

0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0
0.0				

ROW 16

0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0
0.0				

MATRIX 'C3 ' 16 BY 16 ANTISYMMETRIC MODEL MACH .90

ROW 1				
1.13299E-07	2.99005E-02	1.72318E 03	-5.99670E 00	-2.55062E 01
-2.60152E 00	-9.41000E 00	-2.77932E 01	1.34956E 01	3.91359E 01
1.27271E 01	-5.32737E 01	-8.36742E-01	-6.50686E 00	-3.76722E 02
4.67269E 02				
ROW 2				
1.50901E-04	9.92655E 01	-1.61253E 04	-3.71465E 03	1.81468E 03
-7.77645E 03	1.24703E 04	-2.78956E 03	1.08927E 04	6.08238E 03
2.61383E 03	-4.51442E 03	9.46608E 03	-2.11907E 04	-1.91008E 04
-3.74661E 03				
ROW 3				
2.02810E-05	9.17842E 00	1.31675E 05	-7.27256E 02	-1.90065E 03
-7.13530E 02	1.24534E 01	-2.52262E 03	1.74444E 03	3.56412E 03
1.21748E 03	-4.87596E 03	-1.75863E 02	-1.96968E 03	-3.23368E 04
4.07812E 04				
ROW 4				
-4.74817E-07	-8.73959E-01	-9.22710E 01	1.62837E 01	-4.95824E 00
3.64619E 01	-5.78451E 01	1.81472E 01	-4.32395E 01	-2.29734E 01
-6.30068E 00	2.42729E 00	1.88029E 01	1.86502E 02	-1.12477E 02
-1.87238E 01				
ROW 5				
-3.05242E-07	-3.44980E-02	-4.94998E 02	6.73402E 00	6.56878E 00
9.70129E 00	-9.30381E 00	1.54778E 01	-1.78815E 01	-2.40592E 01
-7.97141E 00	3.86773E 01	-2.03311E 00	7.42893E 00	1.09284E 02
-1.87848E 02				
ROW 6				
1.03004E-06	-6.04228E-02	1.33033E 02	-1.73845E 01	4.22573E 00
-3.25848E 01	4.82256E 01	-1.67952E 01	5.20585E 01	3.92330E 01
1.26384E 01	-5.76068E 01	5.84499E 01	1.28121E 01	4.62350E 01
3.34342E 01				
ROW 7				
-1.40836E-06	2.06151E-01	-2.95986E 02	2.25603E 01	-2.59820E 00
4.03933E 01	-5.81277E 01	2.51791E 01	-6.57639E 01	-5.36248E 01
-1.76975E 01	8.37723E 01	-6.61131E 01	-4.38660E 01	-1.35604E 01
-8.11493E 01				
ROW 8				
3.13132E-07	-3.74297E-02	-2.95544E 02	-4.28193E 00	7.76041E 00
-1.10256E 01	2.12184E 01	4.09669E 00	1.44863E 01	5.09113E-01
3.88519E-01	7.58991E 00	3.50695E 01	8.00153E 00	7.20782E 01
-8.32156E 01				
ROW 9				
1.29426E-07	-2.32360E-01	-5.14583E 01	6.17312E 00	-1.76752E 00
1.52208E 01	-2.48299E 01	7.55903E 00	-1.11853E 01	-1.98275E 00
-3.69139E 00	-1.88728E 01	2.23389E 01	4.95081E 01	1.56067E 02
-1.78058E 01				
ROW 10				
3.94888E-07	-2.51815E-01	-4.55742E 02	2.84029E 00	4.84224E 00
6.90546E 00	-9.33399E 00	6.70197E 00	-3.66268E 00	-3.16113E 00
-4.02870E 00	-1.84209E 01	8.30641E 00	5.36767E 01	2.54671E 02
-1.00376E 02				
ROW 11				
2.26548E-07	-5.31531E-02	1.44341E 02	4.70828E-02	-2.05711E 00
-3.67025E-01	-4.44525E-01	-2.05960E 00	-3.00076E 00	-1.38376E 00
7.38834E 00	1.05342E 01	9.84203E 00	1.13187E 01	-4.34583E 02
4.14753E 01				

MATRIX 'C3 ' 16 BY 16 ANTISYMMETRIC MODEL MACH .90

ROW 12

-7.05586E-07	-4.26771E-02	2.85670E 02	-9.89756E-01	-4.51082E 00
3.37700E 00	-1.07661E 01	-2.84132E 00	6.67810E 00	1.66895E 01
9.31587E 00	-3.69667E 01	5.98270E 01	9.08761E 00	-1.67980E 02
1.01391E 02				

ROW 13

1.00993E-06	1.00413E-01	3.62188E 02	-8.41689E-01	-5.79122E 00
-5.70066E 00	1.05607E 01	-1.01759E 01	-9.31699E 00	-1.26371E 01
-9.27951E-01	5.55668E 01	-8.32350E 01	-2.15149E 01	-1.42137E 02
1.30977E 02				

ROW 14

4.45990E-07	-3.39558E-01	-3.37101E-01	8.68399E-01	-4.08659E-01
2.43309E 00	-4.04393E 00	1.08391E 00	-2.17882E 00	-4.53869E-01
-1.69643E-01	-4.23793E 00	6.36628E 00	7.24507E 01	5.33157E-02
3.57654E-01				

ROW 15

-5.29863E-07	9.50424E-02	1.13989E 03	-2.81263E 00	-1.40016E 01
2.66101E 00	-1.12541E 01	-5.70648E 00	3.33412E 01	5.01868E 01
-3.59151E 01	-1.35295E 02	1.42346E 01	-2.01602E 01	-4.46816E 02
4.68843E 01				

ROW 16

6.14475E-08	9.86477E-03	1.34654E 02	-8.86707E-01	-5.86722E-01
-2.52682E 00	4.15619E 00	-5.29161E-01	2.08005E 00	2.59203E 00
1.61637E 00	-6.29157E 00	-1.05281E 01	-2.13338E 00	-1.16959E 02
5.09024E 02				

MATRIX 'D1 ' 16 BY 16 ANTISYMMETRIC MODEL MACH .90

ROW 1

8.44461E 00	2.95596E 01	-3.51485E 02	2.37158E 00	1.15936E 01
-2.58156E-01	7.02026E 00	9.74078E 00	-8.66249E 00	-2.47920E 01
-5.35140E 00	3.40616E 01	-1.90768E 01	-3.02881E 00	-1.39013E 02
3.37857E 01				

ROW 2

-1.26822E 02	3.91082E 04	7.51082E 03	9.59249E 02	-6.67465E 02
2.27141E 03	-3.68753E 03	6.40465E 02	-3.00962E 03	-1.50780E 03
-7.39560E 02	1.95130E 03	-4.57549E 03	-1.45670E 03	1.17646E 04
2.24482E 03				

ROW 3

6.89501E 02	2.00401E 03	-2.78483E 04	2.16995E 02	9.45315E 02
7.22848E 01	4.53861E 02	9.13360E 02	-7.64426E 02	-2.07545E 03
-4.53706E 02	2.90335E 03	-1.33084E 03	-5.28395E 02	-1.11619E 04
2.08920E 03				

ROW 4

-5.88152E-01	-1.78804E 02	8.72513E 00	-5.35606E 00	1.81769E 00
-1.48891E 01	2.22983E 01	-7.88637E 00	1.78387E 01	1.13547E 01
3.14261E 00	-7.40034E 00	1.43447E 00	-2.28936E 00	6.96051E 01
-2.11689E 01				

ROW 5

-2.96014E 00	1.93071E 01	1.07348E 02	-7.43023E-01	-4.47834E 00
-1.14318E-01	-3.59360E 00	-5.76417E 00	2.69357E 00	1.04936E 01
2.12270E 00	-1.88484E 01	9.37677E-01	6.68077E 00	6.73885E 01
-2.43547E 00				

ROW 6

7.79574E-01	1.06259E 01	-2.29022E 01	7.06745E-01	8.17710E-01
9.32491E-01	1.66940E 00	2.13048E 00	-3.32718E 00	-7.86387E 00
-1.66654E 00	2.10625E 01	-1.58600E 01	-1.77261E 01	-4.26531E 01
-8.49115E 00				

ROW 7

-1.66170E 00	4.88911E 01	5.18515E 01	2.79459E-01	-3.33456E 00
3.17820E 00	-9.49777E 00	-3.59814E 00	-5.36205E-01	9.37043E 00
1.79630E 00	-2.90157E 01	1.00632E 01	2.66997E 01	6.63341E 01
5.83908E 00				

ROW 8

-1.47398E 00	2.59343E 01	4.68625E 01	-2.45358E-01	-3.01201E 00
7.00127E-01	-3.05577E 00	-4.77601E 00	8.34312E-02	4.90471E 00
1.11837E 00	-8.57085E 00	-1.42392E 01	-6.09450E 00	3.92451E 01
-1.55511E 01				

ROW 9

1.53145E-02	1.79923E 02	1.11212E 01	4.23684E 00	-1.45751E 00
5.60436E 00	-8.81791E 00	1.51934E 00	-1.34921E 01	-1.05233E 01
-3.19386E 00	2.25075E 01	-3.46583E 01	6.09520E 00	-5.71305E 01
2.42948E 00				

ROW 10

-1.48287E 00	8.76434E 01	8.36602E 01	2.23475E 00	-2.02928E 00
1.74901E 00	-3.50340E 00	9.48503E-01	-5.92375E 00	-3.39708E 00
-1.03007E 00	1.58498E 01	-1.17860E 01	-1.56868E 00	-5.09755E 01
-5.34329E 00				

ROW 11

-3.95811E-01	4.27306E 01	1.53454E 01	1.04122E 00	-1.25008E 00
3.13355E 00	-4.62227E 00	4.94642E-01	-2.57428E 00	-1.04469E 00
-3.20178E 00	2.91344E 00	-1.97490E 01	-5.41298E 00	1.57310E 02
1.81313E 01				

MATRIX 'D1 ' 16 BY 16 ANTISYMMETRIC MODEL MACH .90

ROW 12

8.60714E-01	-8.90015E 01	-4.34154E 01	-2.34096E 00	1.39228E 00
-2.60681E 00	6.77949E 00	-8.53967E-01	6.33948E 00	1.44118E 00
-5.85937E-01	-5.90466E 00	-3.23918E 00	8.44918E 00	2.40363E 01
-1.81145E 01				

ROW 13

1.04144E 00	1.81955E 02	-3.67014E 01	4.31736E 00	9.57476E-01
3.70253E 00	-9.19912E 00	2.29295E 00	-1.00917E 01	-4.02154E 00
-4.26892E 00	-4.30895E 00	-2.31749E 01	-1.68068E 01	-5.09889E 00
3.33878E 01				

ROW 14

1.30791E-02	-4.10241E 01	-3.65681E 00	-1.09943E 00	6.30094E-01
-3.46845E 00	5.62396E 00	-1.54398E 00	3.64548E 00	1.39255E 00
5.36510E-01	1.99923E 00	-2.95296E 00	-2.08341E 01	1.32695E 00
-7.38667E 00				

ROW 15

-1.42248E 00	-5.71071E 02	8.82488E 01	-5.00076E 00	-1.91831E 00
-8.61990E-01	3.96424E 00	1.49922E 00	-1.06713E 01	-1.56727E 01
2.96130E 01	8.00759E 01	7.81876E 01	7.76667E 01	-9.80405E 02
-1.93429E 02				

ROW 16

3.45884E 00	1.43633E 01	-1.32012E 02	1.61157E 00	3.25296E 00
4.91866E 00	-6.42920E 00	3.95834E 00	-6.58796E 00	-7.45733E 00
-4.08984E-01	7.09016E-01	-9.50334E 00	2.31191E 00	-7.64364E 01
-6.49061E 01				

MATRIX 'B1 , 1 BY 16 ANTISYMMETRIC MODEL MACH .90

ROW 1

8.00000E-03	8.00000E-03	8.00000E-03	8.00000E-03	8.00000E-03
8.00000E-03	8.00000E-03	8.00000E-03	8.00000E-03	8.00000E-03
8.00000E-03	8.00000E-03	8.00000E-03	8.00000E-03	8.00000E-03
8.00000E-03				

MATRIX 'D2 ' 16 BY 16 ANTISYMMETRIC MODEL MACH .90

ROW 1

-1.14714E 02	-9.34261E 02	-2.38998E 03	-2.11660E 01	-5.23941E 01
-2.27730E 01	-8.03938E 00	-5.72814E 01	7.26490E 01	1.86698E 02
4.08321E 01	-2.77898E 02	1.90832E 02	5.04229E 01	9.68304E 02
-2.15089E 02				

ROW 2

1.77809E 03	-5.33276E 05	8.41776E 03	-5.67204E 03	4.58818E 03
-1.73207E 04	2.77834E 04	-5.35912E 03	2.06035E 04	9.30273E 03
4.40792E 03	-1.03916E 04	2.78849E 04	6.69386E 03	-7.48712E 04
-1.03822E 04				

ROW 3

-9.37384E 03	-7.20921E 04	-2.06328E 05	-1.77877E 03	-4.12020E 03
-2.81473E 03	7.27076E 02	-5.48835E 03	6.53906E 03	1.54997E 04
3.41112E 03	-2.30221E 04	1.35278E 04	5.29746E 03	7.78829E 04
-1.44522E 04				

ROW 4

8.34677E 00	2.77253E 03	4.08150E 02	3.08273E 01	-1.74305E 01
1.11873E 02	-1.66140E 02	5.44525E 01	-1.33712E 02	-8.68987E 01
-2.63671E 01	6.70289E 01	-3.07784E 01	2.59276E 01	-4.56225E 02
1.04684E 02				

ROW 5

4.01957E 01	8.27184E 00	1.04735E 03	6.39578E 00	1.75541E 01
1.53007E 01	-1.65493E-01	3.42478E 01	-2.83641E 01	-7.71793E 01
-1.65432E 01	1.41910E 02	-3.22071E 01	-4.63726E 01	-4.66439E 02
3.34174E 01				

ROW 6

-1.01572E 01	-4.71497E 02	-3.44584E 02	-9.24529E 00	1.25670E 00
-2.10719E 01	1.12419E 01	-1.51704E 01	3.41473E 01	5.92176E 01
1.43898E 01	-1.56956E 02	1.38215E 02	1.10826E 02	2.98286E 02
4.32955E 01				

ROW 7

2.19762E 01	-2.32985E 02	6.97266E 02	5.11212E 00	1.06243E 01
-1.25621E 00	3.08876E 01	2.19666E 01	-1.28565E 01	-7.04324E 01
-1.60546E 01	2.15432E 02	-1.08389E 02	-1.70577E 02	-4.68904E 02
-2.68243E 00				

ROW 8

2.01011E 01	-3.28056E 02	6.09967E 02	-2.17179E-01	1.34501E 01
-2.34308E 00	1.41699E 01	2.47720E 01	-1.34729E 00	-3.20103E 01
-7.45347E 00	6.07386E 01	8.70122E 01	3.36481E 01	-2.69868E 02
1.01962E 02				

ROW 9

-4.28569E-01	-2.61424E 03	-1.80244E 02	-2.99184E 01	1.04472E 01
-3.75934E 01	5.65099E 01	-9.54102E 00	8.23548E 01	6.76548E 01
2.37515E 01	-1.63980E 02	2.49143E 02	-4.40924E 01	3.40477E 02
1.92557E 01				

ROW 10

1.99053E 01	-1.33085E 03	1.01424E 02	-1.62921E 01	1.24036E 01
-9.86270E 00	2.04895E 01	-4.57069E 00	3.49635E 01	1.68723E 01
9.64466E 00	-1.09331E 02	8.49341E 01	-4.37103E 00	2.91904E 02
3.85287E 01				

ROW 11

5.45878E 00	-5.00964E 01	1.71238E 02	-5.11170E-01	6.66654E 00
-2.39393E 01	3.72753E 01	-6.17474E 00	2.84942E 00	-1.20199E 01
7.14701E 00	2.54875E 01	6.98838E 01	2.60545E 01	-9.78534E 02
-1.20592E 02				

ROW 12

-1.14122E 01	1.37308E 03	-1.09860E 02	1.60215E 01	-7.23030E 00
1.36222E 01	-3.91443E 01	5.16894E 00	-4.07744E 01	-8.96554E 00
-2.01320E 00	4.44293E 01	1.20168E 01	-4.27896E 01	-9.04314E 01
1.12224E 02				

ROW 13

-1.46723E 01	-2.39409E 03	-3.94978E 02	-2.75064E 01	-5.85972E 00
-2.43960E 01	6.22157E 01	-1.75002E 01	5.81236E 01	2.12750E 01
2.33486E 01	3.31533E 01	1.01781E 02	9.57644E 01	8.85124E 01
-2.30591E 02				

ROW 14

-2.25858E-01	5.61228E 02	3.28942E 01	4.86900E 00	-4.43943E 00
2.33321E 01	-3.77414E 01	9.90503E 00	-2.53275E 01	-9.66433E 00
-3.63213E 00	-1.48796E 01	1.89650E 01	1.36309E 02	-9.29632E 00
3.61542E 01				

ROW 15

2.78766E 01	4.42055E 03	6.29546E 01	1.56988E 01	3.50139E 01
-1.93284E 01	-5.12485E 00	7.23486E 00	1.61343E 02	1.90448E 02
-9.44811E 01	-8.18280E 02	5.54801E 01	-4.24594E 02	6.03422E 03
1.21040E 03				

ROW 16

-4.79775E 01	-3.50026E 01	-1.15561E 03	-4.29636E 00	-1.43702E 01
-3.56929E 01	4.65250E 01	-2.63131E 01	3.84085E 01	5.03690E 01
2.97181E 00	3.32401E 00	4.55604E 01	-1.70309E 01	4.00169E 02
3.74000E 02				

MATRIX 'B2 ' 1 BY 16 ANTISYMMETRIC MODEL MACH .90

ROW 1

1.60000E-02	1.60000E-02	1.60000E-02	1.60000E-02	1.60000E-02
1.60000E-02	1.60000E-02	1.60000E-02	1.60000E-02	1.60000E-02
1.60000E-02	1.60000E-02	1.60000E-02	1.60000E-02	1.60000E-02
1.60000E-02				

MATRIX 'D3 ' 16 BY 16 ANTISYMMETRIC MODEL MACH .90

ROW 1				
3.85031E 02	5.79454E 03	1.60285E 04	5.68030E 01	5.52581E 01
1.33173E 02	-1.10033E 02	1.22140E 02	-1.96022E 02	-4.51357E 02
-1.01782E 02	6.97537E 02	-5.32417E 02	-1.12924E 02	-2.18795E 03
5.47275E 02				
ROW 2				
-6.04168E 03	1.66473E 06	-1.67462E 05	9.36237E 03	-9.48508E 03
3.94546E 04	-6.28067E 04	1.32111E 04	-4.36033E 04	-1.75014E 04
-7.97075E 03	1.41955E 04	-5.02731E 04	-9.49491E 03	1.57752E 05
1.86389E 04				
ROW 3				
3.15013E 04	4.49769E 05	1.34654E 06	4.31601E 03	3.94696E 03
1.31700E 04	-1.24561E 04	1.16265E 04	-1.75116E 04	-3.71974E 04
-8.40966E 03	5.66403E 04	-3.77799E 04	-1.06568E 04	-1.74733E 05
4.07064E 04				
ROW 4				
-2.96024E 01	-9.86541E 03	-2.06353E 03	-5.24606E 01	4.86798E 01
-2.65768E 02	3.91306E 02	-1.20680E 02	3.07061E 02	2.01778E 02
6.53020E 01	-1.69491E 02	9.04994E 01	-6.30042E 01	9.66474E 02
-1.76246E 02				
ROW 5				
-1.35366E 02	-1.03724E 03	-6.32853E 03	-1.43661E 01	-1.11099E 01
-6.96855E 01	5.81714E 01	-6.87859E 01	8.06977E 01	1.81613E 02
4.17326E 01	-3.37685E 02	1.14537E 02	8.59906E 01	1.02279E 03
-1.39793E 02				
ROW 6				
3.40822E 01	2.05462E 03	1.85887E 03	2.44380E 01	-1.45359E 01
6.99717E 01	-5.96840E 01	3.35087E 01	-8.19915E 01	-1.31486E 02
-3.45016E 01	3.56264E 02	-3.34928E 02	-2.19203E 02	-6.58313E 02
-5.95645E 01				
ROW 7				
-7.34527E 01	-3.05914E 01	-3.85792E 03	-1.94238E 01	-7.90712E-01
-3.24729E 01	-1.01663E 01	-4.19575E 01	4.22462E 01	1.55823E 02
3.96759E 01	-4.89524E 02	2.80800E 02	3.41597E 02	1.03673E 03
-5.71807E 01				
ROW 8				
-6.74588E 01	4.90169E 02	-3.46380E 03	1.89901E 00	-1.24286E 01
-1.08398E 01	-1.83786E 00	-4.32176E 01	1.44588E 01	7.48946E 01
1.96562E 01	-1.51747E 02	-1.59424E 02	-7.02777E 01	5.88852E 02
-2.33775E 02				
ROW 9				
2.42619E 00	9.35423E 03	7.30449E 02	7.30394E 01	-2.58693E 01
8.77639E 01	-1.25462E 02	2.14469E 01	-1.62485E 02	-1.42267E 02
-5.70002E 01	4.02365E 02	-5.90609E 02	9.67949E 01	-6.91000E 02
-7.72884E 01				
ROW 10				
-6.55993E 01	4.63177E 03	-1.61552E 03	4.12251E 01	-2.46069E 01
1.24986E 01	-3.06543E 01	3.05210E 00	-5.96107E 01	-2.15235E 01
-2.60753E 01	2.59836E 02	-2.07054E 02	1.83961E 01	-5.42782E 02
-1.09570E 02				
ROW 11				
-1.97320E 01	-1.31785E 03	-1.14878E 03	-1.74142E 01	-9.15914E 00
5.16025E 01	-8.28504E 01	1.80533E 01	1.07392E 01	5.12976E 01
9.91660E 00	-1.31764E 02	-4.60547E 01	-3.94995E 01	1.99884E 03
2.80404E 02				

MATRIX 'D3 ' 16 BY 16 ANTISYMMETRIC MODEL MACH .90

ROW 12

3.71754E 01	-4.83117E 03	1.04365E 03	-3.86348E 01	1.16391E 01
-1.65734E 01	6.53954E 01	-5.69026E 00	7.42052E 01	1.03721E 01
1.43870E 01	-1.16281E 02	1.69470E 00	1.13765E 02	4.91950E 01
-1.80013E 02				

ROW 13

4.99935E 01	7.93508E 03	2.36980E 03	5.78911E 01	1.01510E 01
5.30521E 01	-1.38355E 02	4.06121E 01	-1.10757E 02	-3.86597E 01
-4.22398E 01	-5.93087E 01	-1.49474E 02	-2.22863E 02	-3.15082E 02
4.78997E 02				

ROW 14

6.45825E-01	-1.89225E 03	-9.46239E 01	-5.04982E 00	9.93848E 00
-5.15111E 01	8.27283E 01	-2.16463E 01	5.79227E 01	2.29147E 01
8.39010E 00	3.43890E 01	-4.25920E 01	-2.96401E 02	1.74340E 01
-6.13778E 01				

ROW 15

-1.18782E 02	-4.13158E 03	-3.00404E 03	2.30328E 01	-1.16784E 02
1.15694E 02	-6.30736E 01	-4.14999E 01	-4.20662E 02	-4.78336E 02
1.93535E 01	2.23717E 03	-1.11522E 03	7.83599E 02	-1.22967E 04
-2.20008E 03				

ROW 16

1.64944E 02	-3.91567E 02	7.39830E 03	-6.96626E 00	1.49408E 01
8.11511E 01	-1.04653E 02	5.67263E 01	-7.07942E 01	-1.13408E 02
-8.14850E 00	-2.82438E 01	-5.03514E 01	4.26538E 01	-5.77877E 02
-7.36345E 02				

MATRIX 'B3 '   1 BY 16   ANTISYMMETRIC MODEL   MACH .90

ROW 1

2.40000E-02	2.40000E-02	2.40000E-02	2.40000E-02	2.40000E-02
2.40000E-02	2.40000E-02	2.40000E-02	2.40000E-02	2.40000E-02
2.40000E-02	2.40000E-02	2.40000E-02	2.40000E-02	2.40000E-02
2.40000E-02				

MATRIX 'D4 ' 16 BY 16 ANTISYMMETRIC MODEL MACH .90

ROW 1

-3.49765E 02	-4.73841E 03	-1.78942E 04	-2.57466E 01	-6.66129E 00
-1.12219E 02	1.11253E 02	-6.95592E 01	1.02967E 02	2.90205E 02
6.30218E 01	-4.36646E 02	3.16463E 02	7.89849E 01	1.47843E 03
-4.90829E 02				

ROW 2

5.58233E 03	-1.38411E 06	2.24479E 05	-4.38601E 03	5.66168E 03
-2.60118E 04	4.11180E 04	-9.33668E 03	2.82707E 04	1.06295E 04
4.50724E 03	-6.07436E 03	2.92577E 04	6.57275E 03	-1.02475E 05
-1.07231E 04				

ROW 3

-2.86720E 04	-3.67861E 05	-1.49947E 06	-1.68192E 03	-7.58643E 00
-1.07379E 04	1.15172E 04	-6.65098E 03	9.64732E 03	2.40178E 04
5.26890E 03	-3.54825E 04	2.20983E 04	7.05415E 03	1.16296E 05
-3.85372E 04				

ROW 4

2.83215E 01	8.59816E 03	2.21085E 03	2.05784E 01	-3.82933E 01
1.85768E 02	-2.72020E 02	7.96080E 01	-2.02786E 02	-1.32259E 02
-4.47162E 01	1.07387E 02	-4.76528E 01	3.30113E 01	-6.26790E 02
9.40840E 01				

ROW 5

1.23591E 02	7.81307E 02	6.96612E 03	3.46664E 00	-7.54222E 00
5.72616E 01	-5.72306E 01	3.73148E 01	-4.66382E 01	-1.16574E 02
-2.74499E 01	2.18902E 02	-7.07069E 01	-5.55218E 01	-6.62769E 02
1.52071E 02				

ROW 6

-3.13596E 01	-1.25806E 03	-1.96602E 03	-1.50089E 01	1.48064E 01
-5.10496E 01	4.58542E 01	-1.86076E 01	4.47744E 01	7.98794E 01
2.16098E 01	-2.32679E 02	2.22520E 02	1.51027E 02	4.36652E 02
1.83401E 01				

ROW 7

6.67058E 01	-7.74335E 02	4.09632E 03	1.21178E 01	-1.01274E 01
2.67340E 01	-4.05663E 00	1.73576E 01	-1.42074E 01	-9.02026E 01
-2.43674E 01	3.15647E 02	-1.81358E 02	-2.35057E 02	-6.84570E 02
7.83812E 01				

ROW 8

6.07814E 01	-1.64526E 02	3.74177E 03	-4.73939E 00	-2.42060E 00
1.50122E 01	-1.40170E 01	2.04222E 01	-1.02961E 01	-4.73130E 01
-1.39137E 01	1.02307E 02	1.01586E 02	4.85712E 01	-3.82812E 02
1.76695E 02				

ROW 9

-3.53698E 00	-9.10416E 03	-8.16190E 02	-5.43185E 01	2.11530E 01
-6.98758E 01	9.63641E 01	-1.72527E 01	9.69034E 01	8.88848E 01
4.04404E 01	-2.96438E 02	4.23239E 02	-6.75961E 01	4.37625E 02
6.89389E 01				

ROW 10

5.79931E 01	-4.83126E 03	1.87570E 03	-3.52419E 01	1.81433E 01
-1.31345E 01	2.72988E 01	-3.51719E-01	3.60297E 01	7.83528E 00
2.19572E 01	-2.02213E 02	1.72186E 02	-1.40420E 01	3.07680E 02
1.10689E 02				

ROW 11

2.08790E 01	1.61206E 03	1.46128E 03	1.93928E 01	1.82496E 00
-2.98477E 01	4.82691E 01	-1.32069E 01	-5.67624E 00	-3.51636E 01
-1.71237E 01	1.03215E 02	9.22813E 00	2.10206E 01	-1.25564E 03
-2.13111E 02				

ROW 12

-3.21164E 01	4.71471E 03	-1.12496E 03	3.03038E 01	-7.10464E 00
1.02712E 01	-4.38642E 01	2.32823E 00	-4.04140E 01	3.25465E 00
-1.47113E 01	8.12771E 01	-1.16853E 01	-9.46887E 01	6.15754E 01
6.39274E 01				

ROW 13

-4.47008E 01	-6.97402E 03	-2.52011E 03	-3.69211E 01	-5.91456E 00
-3.17397E 01	8.92306E 01	-2.67956E 01	5.81283E 01	1.60828E 01
2.16296E 01	3.74990E 01	5.61545E 01	1.70649E 02	2.91132E 02
-3.24601E 02				

ROW 14

-4.79294E-01	1.74387E 03	8.56616E 01	-6.10730E-01	-6.81666E 00
3.49540E 01	-5.56536E 01	1.47053E 01	-4.08092E 01	-1.68644E 01
-6.02025E 00	-2.41402E 01	3.01365E 01	1.98987E 02	-9.57499E 00
3.30338E 01				

ROW 15

1.25541E 02	-8.67532E 02	4.97706E 03	-3.08684E 01	8.80152E 01
-1.15364E 02	9.19636E 01	3.66206E 01	2.06220E 02	2.25872E 02
7.24488E 01	-1.46675E 03	9.55535E 02	-4.12706E 02	7.54246E 03
1.12690E 03				

ROW 16

-1.55203E 02	8.89942E 02	-8.60070E 03	1.53880E 01	1.42888E 00
-4.95599E 01	6.12506E 01	-3.42602E 01	3.46950E 01	7.97576E 01
7.12307E 00	2.37417E 01	7.46208E 00	-2.57136E 01	1.50162E 02
4.62262E 02				

MATRIX 'B4 ' 1 BY 16 ANTISYMMETRIC MODEL MACH .90

ROW 1

3.20000E-02	3.20000E-02	3.20000E-02	3.20000E-02	3.20000E-02
3.20000E-02	3.20000E-02	3.20000E-02	3.20000E-02	3.20000E-02
3.20000E-02	3.20000E-02	3.20000E-02	3.20000E-02	3.20000E-02
3.20000E-02				

MATRIX 'RO ' 16 BY 10 ANTISYMMETRIC MODEL MACH .90

ROW 1				
-2.92760E 02	-4.51864E 02	-9.54632E 01	-7.29845E 02	0.0
0.0	0.0	0.0	0.0	-1.72167E 03
ROW 2				
-2.08237E 04	-1.22530E 05	-1.32717E 05	-2.00800E 04	0.0
0.0	0.0	0.0	0.0	1.61181E 04
ROW 3				
-1.81488E 04	-4.26376E 04	-1.70625E 04	-5.97447E 04	0.0
0.0	0.0	0.0	0.0	-1.31559E 05
ROW 4				
5.18602E 01	1.85948E 02	6.70718E 02	-1.18749E 02	0.0
0.0	0.0	0.0	0.0	9.21287E 01
ROW 5				
3.13029E 01	3.22600E 02	2.02713E 02	1.98765E 02	0.0
0.0	0.0	0.0	0.0	4.94562E 02
ROW 6				
-7.97815E 01	-7.15964E 02	-6.10320E 02	3.77281E 01	0.0
0.0	0.0	0.0	0.0	-1.32920E 02
ROW 7				
1.63153E 02	9.20815E 02	8.00378E 02	1.31623E 01	0.0
0.0	0.0	0.0	0.0	2.95741E 02
ROW 8				
1.28905E 01	-1.11382E 02	-1.88490E 02	1.09856E 02	0.0
0.0	0.0	0.0	0.0	2.95282E 02
ROW 9				
-1.43235E 02	-1.29376E 02	3.60481E 02	1.78164E 02	0.0
0.0	0.0	0.0	0.0	5.13969E 01
ROW 10				
-8.70368E 01	-5.16783E 01	1.56264E 02	3.71247E 02	0.0
0.0	0.0	0.0	0.0	4.55324E 02
ROW 11				
2.03352E 02	9.61590E 01	-1.80606E 01	-4.95480E 02	0.0
0.0	0.0	0.0	0.0	-1.44218E 02
ROW 12				
-1.64541E 01	-5.83031E 02	1.33956E 02	-2.02391E 02	0.0
0.0	0.0	0.0	0.0	-2.85422E 02
ROW 13				
-2.01509E 02	8.51279E 02	-2.55798E 02	-1.87048E 02	0.0
0.0	0.0	0.0	0.0	-3.61863E 02
ROW 14				
1.63696E 00	7.08364E 00	2.66086E 01	5.37554E-02	0.0
0.0	0.0	0.0	0.0	3.12991E-01
ROW 15				
1.91449E 03	-1.81364E 03	2.69539E 02	-1.15689E 03	0.0
0.0	0.0	0.0	0.0	-1.13889E 03
ROW 16				
6.30821E 01	-1.42448E 01	-4.14869E 01	-1.45358E 02	0.0
0.0	0.0	0.0	0.0	-1.34535E 02

MATRIX 'R1 ' 16 BY 10 ANTISYMMETRIC MODEL MACH .90

ROW 1
-2.08996E 03 -5.27380E 02 -1.14950E 02 1.51708E 02 0.0
0.0 0.0 0.0 0.0 8.20612E 02

ROW 2
8.14896E 04 7.45740E 04 -3.18681E 04 -2.21332E 03 0.0
0.0 0.0 0.0 0.0 -5.71789E 03

ROW 3
-1.15247E 05 -3.65034E 04 -1.26954E 04 1.36905E 04 0.0
0.0 0.0 0.0 0.0 7.23019E 04

ROW 4
8.38771E 02 -5.02956E 01 1.26944E 02 -1.84832E 01 0.0
0.0 0.0 0.0 0.0 -3.61011E 01

ROW 5
2.11894E 02 1.37710E 02 9.37670E 01 -8.91414E 01 0.0
0.0 0.0 0.0 0.0 -3.97393E 02

ROW 6
-6.32198E 02 8.62047E 01 -1.68814E 02 3.57358E 01 0.0
0.0 0.0 0.0 0.0 1.01709E 02

ROW 7
6.76460E 02 -8.70540E 01 2.27152E 02 -8.29379E 01 0.0
0.0 0.0 0.0 0.0 -2.78502E 02

ROW 8
-2.01571E 01 1.87682E 02 -3.60656E 01 -7.07416E 01 0.0
0.0 0.0 0.0 0.0 -2.90615E 02

ROW 9
-1.92590E 02 -3.03808E 02 9.71589E 01 -3.61692E 01 0.0
0.0 0.0 0.0 0.0 -9.30177E 01

ROW 10
5.87713E 02 -1.45500E 02 6.87195E 01 -3.87118E 01 0.0
0.0 0.0 0.0 0.0 -1.55972E 02

ROW 11
8.53767E 02 5.56007E 02 -4.96311E 01 8.13459E 01 0.0
0.0 0.0 0.0 0.0 2.06030E 02

ROW 12
-5.74247E 02 1.73963E 02 -7.96218E 01 1.50361E 02 0.0
0.0 0.0 0.0 0.0 2.20348E 02

ROW 13
-3.61484E 02 2.04564E 02 4.55692E 01 1.40392E 02 0.0
0.0 0.0 0.0 0.0 2.51361E 02

ROW 14
2.88444E 00 -8.78606E 00 1.28936E 01 6.07142E-01 0.0
0.0 0.0 0.0 0.0 -1.32198E 00

ROW 15
1.51497E 04 -5.14943E 03 2.17790E 02 -2.38969E 03 0.0
0.0 0.0 0.0 0.0 7.54333E 02

ROW 16
3.78125E 02 1.19029E 02 5.64869E 00 8.22402E 00 0.0
0.0 0.0 0.0 0.0 1.15845E 02

MATRIX 'G1 ' 1 BY 10 ANTISYMMETRIC MODEL MACH .90

ROW 1

8.00000E-03	8.00000E-03	8.00000E-03	8.00000E-03	8.00000E-03
8.00000E-03	8.00000E-03	8.00000E-03	8.00000E-03	8.00000E-03

MATRIX 'R2 ' 16 BY 10 ANTISYMMETRIC MODEL MACH .90

ROW 1				
1.27380E 04	1.94505E 03	7.97482E 02	-7.44574E 02	0.0
0.0	0.0	0.0	0.0	-4.98921E 03
ROW 2				
-9.37991E 05	-4.79053E 05	2.31020E 05	3.53151E 04	0.0
0.0	0.0	0.0	0.0	2.47204E 04
ROW 3				
6.28008E 05	1.28660E 05	8.20044E 04	-6.70951E 04	0.0
0.0	0.0	0.0	0.0	-4.48088E 05
ROW 4				
-7.17565E 03	1.00785E 03	-1.20442E 03	2.13788E 02	0.0
0.0	0.0	0.0	0.0	1.28996E 02
ROW 5				
-9.38188E 02	-5.00710E 02	-5.97643E 02	5.10376E 02	0.0
0.0	0.0	0.0	0.0	2.53952E 03
ROW 6				
4.32092E 03	-9.75969E 02	1.26265E 03	-2.70935E 02	0.0
0.0	0.0	0.0	0.0	-6.06505E 02
ROW 7				
-4.51927E 03	1.14031E 03	-1.67275E 03	5.60596E 02	0.0
0.0	0.0	0.0	0.0	1.76370E 03
ROW 8				
4.00784E 01	-1.22219E 03	3.07549E 02	4.29705E 02	0.0
0.0	0.0	0.0	0.0	1.90263E 03
ROW 9				
2.65011E 03	2.12052E 03	-8.04371E 02	7.48370E 01	0.0
0.0	0.0	0.0	0.0	6.81690E 02
ROW 10				
-2.04693E 03	1.28367E 03	-5.58968E 02	3.12509E 01	0.0
0.0	0.0	0.0	0.0	9.70343E 02
ROW 11				
-9.56768E 03	-2.70718E 03	-2.52798E 01	-1.55039E 02	0.0
0.0	0.0	0.0	0.0	-1.56409E 03
ROW 12				
2.56019E 03	-3.22958E 02	2.77796E 02	-8.58915E 02	0.0
0.0	0.0	0.0	0.0	-1.47437E 03
ROW 13				
3.97394E 03	-1.54776E 03	-2.02488E 02	-8.44824E 02	0.0
0.0	0.0	0.0	0.0	-1.62507E 03
ROW 14				
-1.44614E 01	5.71020E 01	-1.07578E 02	-7.47036E 00	0.0
0.0	0.0	0.0	0.0	2.14803E-01
ROW 15				
-1.20810E 05	2.21845E 04	-1.94888E 02	1.53730E 04	0.0
0.0	0.0	0.0	0.0	-4.71616E 03
ROW 16				
-3.84473E 03	-8.55267E 02	-2.46898E 02	1.58221E 02	0.0
0.0	0.0	0.0	0.0	-6.14339E 02

MATRIX 'G2 ' 1 BY 10 ANTISYMMETRIC MODEL MACH .90

ROW 1

1.60000E-02	1.60000E-02	1.60000E-02	1.60000E-02	1.60000E-02
1.60000E-02	1.60000E-02	1.60000E-02	1.60000E-02	1.60000E-02

MATRIX 'R3 ' 16 BY 10 ANTISYMMETRIC MODEL MACH .90

ROW 1					
	-1.92543E 04	2.37521E 03	-7.30315E 02	4.54102E 02	0.0
	0.0	0.0	0.0	0.0	8.58793E 03
ROW 2					
	2.26648E 06	7.57668E 05	-6.16148E 05	-1.26846E 05	0.0
	0.0	0.0	0.0	0.0	-1.54687E 04
ROW 3					
	-8.31624E 05	2.04188E 05	-9.67871E 04	4.41116E 04	0.0
	0.0	0.0	0.0	0.0	7.99181E 05
ROW 4					
	1.38169E 04	-3.85933E 03	3.72009E 03	-7.37463E 02	0.0
	0.0	0.0	0.0	0.0	-4.78493E 01
ROW 5					
	5.94067E 02	-6.89671E 02	1.00341E 03	-7.24617E 02	0.0
	0.0	0.0	0.0	0.0	-4.80621E 03
ROW 6					
	-6.19388E 03	2.69669E 03	-3.17215E 03	6.68758E 02	0.0
	0.0	0.0	0.0	0.0	1.06006E 03
ROW 7					
	6.00661E 03	-3.59375E 03	4.04487E 03	-1.18098E 03	0.0
	0.0	0.0	0.0	0.0	-3.34694E 03
ROW 8					
	1.55822E 02	1.66871E 03	-1.09677E 03	-7.06932E 02	0.0
	0.0	0.0	0.0	0.0	-3.74329E 03
ROW 9					
	-5.38127E 03	-4.41060E 03	2.10270E 03	2.85619E 02	0.0
	0.0	0.0	0.0	0.0	-1.51768E 03
ROW 10					
	1.72801E 03	-3.74021E 03	1.11802E 03	6.45261E 02	0.0
	0.0	0.0	0.0	0.0	-1.66447E 03
ROW 11					
	1.94831E 04	2.67681E 03	8.15044E 02	-8.40574E 02	0.0
	0.0	0.0	0.0	0.0	3.55120E 03
ROW 12					
	-1.60061E 03	-1.80403E 03	4.58670E 02	1.33568E 03	0.0
	0.0	0.0	0.0	0.0	2.93205E 03
ROW 13					
	-1.00236E 04	4.55207E 03	-7.28826E 00	1.41901E 03	0.0
	0.0	0.0	0.0	0.0	3.17041E 03
ROW 14					
	3.46943E 00	-1.13312E 02	2.88395E 02	1.74964E 01	0.0
	0.0	0.0	0.0	0.0	3.81691E 00
ROW 15					
	2.25589E 05	-9.23509E 03	-3.30675E 03	-3.19610E 04	0.0
	0.0	0.0	0.0	0.0	7.87430E 03
ROW 16					
	7.84148E 03	1.77901E 03	1.07873E 03	-8.60102E 02	0.0
	0.0	0.0	0.0	0.0	8.44024E 02

MATRIX 'G3 ', 1 BY 10 ANTISYMMETRIC MODEL MACH .90

ROW 1

2.40000E-02	2.40000E-02	2.40000E-02	2.40000E-02	2.40000E-02
2.40000E-02	2.40000E-02	2.40000E-02	2.40000E-02	2.40000E-02

MATRIX 'R4 ' 16 BY 10 ANTISYMMETRIC MODEL MACH .90

ROW 1				
8.77605E 03	-3.73842E 03	1.24755E 02	1.12920E 03	0.0
0.0	0.0	0.0	0.0	-1.90130E 03
ROW 2				
-1.44821E 06	-1.78057E 05	5.88769E 05	1.26225E 05	0.0
0.0	0.0	0.0	0.0	-3.09258E 04
ROW 3				
3.19486E 05	-2.79964E 05	4.52908E 04	9.17399E 04	0.0
0.0	0.0	0.0	0.0	-2.29368E 05
ROW 4				
-7.71613E 03	2.75883E 03	-3.61572E 03	7.32341E 02	0.0
0.0	0.0	0.0	0.0	-2.05707E 02
ROW 5				
2.07188E 02	7.65171E 02	-7.28696E 02	2.10342E 01	0.0
0.0	0.0	0.0	0.0	1.91293E 03
ROW 6				
2.48370E 03	-9.07642E 02	2.82125E 03	-5.01104E 02	0.0
0.0	0.0	0.0	0.0	-3.47202E 02
ROW 7				
-2.21769E 03	1.41112E 03	-3.56455E 03	6.92398E 02	0.0
0.0	0.0	0.0	0.0	1.40770E 03
ROW 8				
-2.19250E 02	-4.20300E 02	1.07561E 03	1.78322E 02	0.0
0.0	0.0	0.0	0.0	1.68749E 03
ROW 9				
3.24764E 03	2.80388E 03	-1.95510E 03	-6.15907E 02	0.0
0.0	0.0	0.0	0.0	8.74524E 02
ROW 10				
7.08269E 01	2.81346E 03	-8.91135E 02	-1.18503E 03	0.0
0.0	0.0	0.0	0.0	2.24005E 02
ROW 11				
-1.14328E 04	-4.30501E 02	-7.93609E 02	1.72810E 03	0.0
0.0	0.0	0.0	0.0	-2.03726E 03
ROW 12				
-6.62805E 02	2.86407E 03	-9.75503E 02	-2.73200E 02	0.0
0.0	0.0	0.0	0.0	-1.27009E 03
ROW 13				
7.12236E 03	-4.39559E 03	6.48209E 02	-3.99708E 02	0.0
0.0	0.0	0.0	0.0	-1.26110E 03
ROW 14				
8.36894E 00	5.47397E 01	-2.35595E 02	-1.15047E 01	0.0
0.0	0.0	0.0	0.0	-3.34960E 00
ROW 15				
-1.25467E 05	-8.31892E 03	3.25156E 03	1.93375E 04	0.0
0.0	0.0	0.0	0.0	-2.09116E 03
ROW 16				
-4.62649E 03	-1.05941E 03	-8.49676E 02	9.42936E 02	0.0
0.0	0.0	0.0	0.0	-1.05219E 02

MATRIX 'G4 ' 1 BY 10 ANTISYMMETRIC MODEL MACH .90

ROW 1

3.20000E-02	3.20000E-02	3.20000E-02	3.20000E-02	3.20000E-02
3.20000E-02	3.20000E-02	3.20000E-02	3.20000E-02	3.20000E-02

MATRIX 'XG ' 1 BY 5 ANTISYMMETRIC MODEL MACH .90

ROW 1

1.80000E 02	2.50000E 02	2.80000E 02	3.35000E 02	3.15000E 02

MATRIX 'YG '   1 BY 5   ANTISYMMETRIC MODEL   MACH .90

ROW 1

1.17500E 01	4.00000E 01	7.00000E 01	1.50000E 01	0.0

MATRIX 'ZG '   1 BY 5   ANTISYMMETRIC MODEL   MACH .90

ROW 1

0.0	0.0	0.0	0.0	1.50000E 01

MATRIX 'PHFF' 57 BY 16 ANTISYMMETRIC MODEL MACH .90

ROW 1

1.00000E 00	2.11011E-01	-1.67546E 02	-6.69701E-03	-1.00197E 00
-2.45828E-01	-7.56766E-02	1.36058E-02	3.38149E-02	-1.34097E 00
1.31560E-04	-3.47467E-02	-5.32652E-02	0.0	0.0
0.0				

ROW 2

1.00000E 00	2.11011E-01	-1.57538E 02	-6.04572E-03	-8.68684E-01
-2.06921E-01	-6.24858E-02	1.11349E-02	2.57244E-02	-1.00000E 00
1.03098E-04	-2.24488E-02	-3.39901E-02	0.0	0.0
0.0				

ROW 3

1.00000E 00	2.11011E-01	-1.47529E 02	-5.39942E-03	-7.38081E-01
-1.69147E-01	-4.97433E-02	8.75395E-03	1.80699E-02	-6.79102E-01
7.66533E-05	-1.13618E-02	-1.66858E-02	0.0	0.0
0.0				

ROW 4

1.00000E 00	2.11011E-01	-1.37520E 02	-4.76886E-03	-6.15592E-01
-1.34703E-01	-3.82954E-02	6.63093E-03	1.15877E-02	-4.11327E-01
5.57871E-05	-3.16151E-03	-4.04257E-03	0.0	0.0
0.0				

ROW 5

1.00000E 00	2.11011E-01	-1.27511E 02	-4.15183E-03	-4.99948E-01
-1.03035E-01	-2.79173E-02	4.72019E-03	6.04075E-03	-1.85564E-01
3.94343E-05	2.88976E-03	5.14823E-03	0.0	0.0
0.0				

ROW 6

1.00000E 00	2.11011E-01	-1.17503E 02	-3.54662E-03	-3.90228E-01
-7.37476E-02	-1.84521E-02	2.99016E-03	1.27240E-03	5.43492E-03
2.68736E-05	7.24502E-03	1.16260E-02	0.0	0.0
0.0				

ROW 7

1.00000E 00	2.11011E-01	-1.07494E 02	-2.95524E-03	-2.87241E-01
-4.71114E-02	-9.98882E-03	1.45717E-03	-2.69299E-03	1.61134E-01
1.83919E-05	1.00578E-02	1.56583E-02	0.0	0.0
0.0				

ROW 8

1.00000E 00	2.11011E-01	-9.74850E 01	-2.37893E-03	-1.91453E-01
-2.32695E-02	-2.57139E-03	1.28926E-04	-5.85743E-03	2.82032E-01
1.41293E-05	1.14777E-02	1.74986E-02	0.0	0.0
0.0				

ROW 9

1.00000E 00	2.11011E-01	-8.74762E 01	-1.81886E-03	-1.03293E-01
-2.35256E-03	3.76085E-03	-9.87706E-04	-8.22478E-03	3.68684E-01
1.42173E-05	1.16447E-02	1.73824E-02	0.0	0.0
0.0				

ROW 10

1.00000E 00	2.11011E-01	-7.74675E 01	-1.27676E-03	-2.33374E-02
1.54847E-02	8.96817E-03	-1.88652E-03	-9.82709E-03	4.23154E-01
1.88636E-05	1.08181E-02	1.57355E-02	0.0	0.0
0.0				

ROW 11

1.00000E 00	2.11011E-01	-6.74587E 01	-7.53981E-04	4.79930E-02
3.01379E-02	1.30271E-02	-2.56424E-03	-1.06993E-02	4.47521E-01
2.82331E-05	9.22010E-03	1.29200E-02	0.0	0.0
0.0				

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ROW 12

1.00000E 00	2.11011E-01	-5.74499E 01	-2.52095E-04	1.10173E-01
4.14636E-02	1.58999E-02	-3.01487E-03	-1.08663E-02	4.43423E-01
4.25733E-05	7.04807E-03	9.25642E-03	0.0	0.0
0.0				

ROW 13

1.00000E 00	2.11011E-01	-4.74411E 01	2.25868E-04	1.62179E-01
4.91688E-02	1.75050E-02	-3.22464E-03	-1.03557E-02	4.12953E-01
6.26056E-05	4.55428E-03	5.14358E-03	0.0	0.0
0.0				

ROW 14

1.00000E 00	2.11011E-01	-3.74324E 01	6.75257E-04	2.02335E-01
5.27349E-02	1.76840E-02	-3.16540E-03	-9.16180E-03	3.56992E-01
8.95117E-05	1.98487E-03	9.69820E-04	0.0	0.0
0.0				

ROW 15

1.00000E 00	2.11011E-01	-2.51316E 01	1.17878E-03	2.31958E-01
5.03572E-02	1.56146E-02	-2.66409E-03	-6.73327E-03	2.54446E-01
1.34450E-04	-8.34338E-04	-3.55299E-03	0.0	0.0
0.0				

ROW 16

1.00000E 00	2.11011E-01	-1.67943E 01	1.49797E-03	2.41713E-01
4.56133E-02	1.31932E-02	-2.12458E-03	-4.68069E-03	1.70752E-01
1.66354E-04	-2.43626E-03	-6.04085E-03	0.0	0.0
0.0				

ROW 17

1.00000E 00	2.11011E-01	-8.53715E 00	1.81997E-03	2.46879E-01
4.09696E-02	1.09373E-02	-1.57231E-03	-2.59419E-03	8.27751E-02
1.77677E-04	-3.94549E-03	-8.07275E-03	0.0	0.0
0.0				

ROW 18

1.00000E 00	2.11011E-01	-2.59868E-01	2.15515E-03	2.46404E-01
3.68971E-02	9.07249E-03	-1.02324E-03	-5.08108E-04	-9.90355E-03
1.56507E-04	-5.33655E-03	-9.48220E-03	0.0	0.0
0.0				

ROW 19

1.00000E 00	2.11011E-01	6.64610E 00	2.44113E-03	2.41824E-01
3.37306E-02	7.73588E-03	-5.61241E-04	1.19926E-03	-8.82093E-02
1.20780E-04	-6.34585E-03	-1.02093E-02	0.0	0.0
0.0				

ROW 20

1.84689E-15	1.00000E 00	6.91504E-02	5.51833E-03	1.11383E-05
-1.83941E-03	8.76664E-04	-1.23419E-03	-5.67832E-04	-2.61667E-04
-2.72080E-03	2.79603E-03	6.22640E-03	0.0	0.0
0.0				

ROW 21

1.84689E-15	1.00000E 00	6.91504E-02	5.51833E-03	1.11383E-05
-1.83941E-03	8.76664E-04	-1.23419E-03	-5.67832E-04	-2.61667E-04
-2.72080E-03	2.79603E-03	6.22640E-03	0.0	0.0
0.0				

ROW 22

1.84689E-15	1.00000E 00	6.91504E-02	5.51052E-03	1.10831E-05
-1.82398E-03	8.67309E-04	-1.21955E-03	-5.55191E-04	-2.54968E-04
-2.64783E-03	2.63984E-03	5.85899E-03	0.0	0.0
0.0				

ROW 23

1.84689E-15	1.00000E 00	6.91504E-02	5.50627E-03	1.10531E-05
-1.81558E-03	8.62219E-04	-1.21159E-03	-5.48315E-04	-2.51323E-04
-2.60813E-03	2.55486E-03	5.65911E-03	0.0	0.0
0.0				

ROW 24

1.84689E-15	1.00000E 00	6.91504E-02	5.50397E-03	1.10368E-05
-1.81103E-03	8.59460E-04	-1.20727E-03	-5.44586E-04	-2.49347E-04
-2.58661E-03	2.50878E-03	5.55072E-03	0.0	0.0
0.0				

ROW 25

1.84689E-15	1.00000E 00	6.91504E-02	5.49871E-03	1.09998E-05
-1.80072E-03	8.53230E-04	-1.19753E-03	-5.36277E-04	-2.44961E-04
-2.53890E-03	2.41008E-03	5.31944E-03	0.0	0.0
0.0				

ROW 26

1.84689E-15	1.00000E 00	6.91504E-02	5.49477E-03	1.09720E-05
-1.79300E-03	8.48557E-04	-1.19023E-03	-5.30045E-04	-2.41671E-04
-2.50311E-03	2.33605E-03	5.14594E-03	0.0	0.0
0.0				

ROW 27

1.84689E-15	1.00000E 00	6.91504E-02	5.49162E-03	1.09498E-05
-1.78681E-03	8.44819E-04	-1.18438E-03	-5.25059E-04	-2.39038E-04
-2.47447E-03	2.27681E-03	5.00713E-03	0.0	0.0
0.0				

ROW 28

1.84689E-15	1.00000E 00	6.91504E-02	5.48457E-03	1.09004E-05
-1.77312E-03	8.36567E-04	-1.17151E-03	-5.14235E-04	-2.33352E-04
-2.41272E-03	2.15454E-03	4.72203E-03	0.0	0.0
0.0				

ROW 29

1.84689E-15	1.00000E 00	6.91504E-02	5.47821E-03	1.08559E-05
-1.76077E-03	8.29125E-04	-1.15990E-03	-5.04472E-04	-2.28222E-04
-2.35703E-03	2.04426E-03	4.46488E-03	0.0	0.0
0.0				

ROW 30

1.84689E-15	1.00000E 00	6.91504E-02	5.47213E-03	1.08133E-05
-1.74897E-03	8.22014E-04	-1.14880E-03	-4.95143E-04	-2.23321E-04
-2.30381E-03	1.93888E-03	4.21916E-03	0.0	0.0
0.0				

ROW 31

1.84689E-15	1.00000E 00	6.91504E-02	5.46038E-03	1.07315E-05
-1.72645E-03	8.08500E-04	-1.12777E-03	-4.77812E-04	-2.14276E-04
-2.20583E-03	1.75637E-03	3.79653E-03	0.0	0.0
0.0				

ROW 32

1.84689E-15	1.00000E 00	6.91504E-02	5.44945E-03	1.06554E-05
-1.70551E-03	7.95932E-04	-1.10820E-03	-4.61694E-04	-2.05864E-04
-2.11472E-03	1.58665E-03	3.40351E-03	0.0	0.0
0.0				

ROW 33

1.84689E-15	1.00000E 00	6.91504E-02	5.44062E-03	1.05939E-05
-1.68858E-03	7.85775E-04	-1.09239E-03	-4.48669E-04	-1.99066E-04
-2.04109E-03	1.44948E-03	3.08587E-03	0.0	0.0
0.0				

ROW 34

1.29848E-15	1.00000E 00	6.91504E-02	5.42614E-03	1.04824E-05
-1.66120E-03	7.69411E-04	-1.06698E-03	-4.28158E-04	-1.88493E-04
-1.92625E-03	1.24898E-03	2.62496E-03	0.0	0.0
0.0				

ROW 35

6.87382E-15	1.00000E 00	6.91504E-02	5.39932E-03	3.17596E-06
-1.61680E-03	7.46461E-04	-1.04256E-03	-3.94932E-04	-1.77657E-04
-1.82901E-03	1.09478E-03	2.31427E-03	0.0	0.0
0.0				

ROW 36

0.0	1.00000E 00	6.91504E-02	5.38346E-03	1.20368E-05
-1.64668E-03	8.23207E-04	-1.04156E-03	-3.40729E-04	-1.53743E-04
-1.71314E-03	6.39517E-04	2.37413E-03	0.0	0.0
0.0				

ROW 37

1.08212E-12	1.00000E 00	6.91504E-02	5.40597E-03	5.35866E-05
-1.71789E-03	9.37813E-04	-9.99456E-04	-4.68044E-04	-2.61390E-04
-1.43177E-03	-4.71218E-05	1.77910E-03	0.0	0.0
0.0				

ROW 38

1.93791E-12	1.00000E 00	6.91504E-02	5.42350E-03	8.66936E-05
-1.77317E-03	1.02779E-03	-9.64690E-04	-5.69211E-04	-3.46958E-04
-1.20461E-03	-5.88654E-04	1.29462E-03	0.0	0.0
0.0				

ROW 39

-9.99552E-14	5.04141E-11	1.00088E 00	6.51296E-05	1.33286E-02
3.89073E-03	1.31908E-03	-2.47095E-04	-8.09046E-04	3.40974E-02
-2.84620E-06	1.22978E-03	1.92751E-03	0.0	0.0
0.0				

ROW 40

-9.99552E-14	5.04141E-11	1.00088E 00	6.51296E-05	1.33286E-02
3.89073E-03	1.31908E-03	-2.47095E-04	-8.09046E-04	3.40974E-02
-2.84620E-06	1.22978E-03	1.92751E-03	0.0	0.0
0.0				

ROW 41

6.27706E-14	-3.15448E-11	1.00088E 00	6.37255E-05	1.25904E-02
3.58339E-03	1.19855E-03	-2.22985E-04	-6.95813E-04	2.89227E-02
-2.31517E-06	9.32291E-04	1.44502E-03	0.0	0.0
0.0				

ROW 42

-7.27096E-15	3.61455E-12	1.00088E 00	6.22270E-05	1.18286E-02
3.27373E-03	1.07895E-03	-1.99232E-04	-5.90429E-04	2.41789E-02
-1.80818E-06	6.86128E-04	1.04907E-03	0.0	0.0
0.0				

ROW 43

-1.00488E-13	5.04140E-11	1.00088E 00	6.11080E-05	1.12641E-02
3.04552E-03	9.91153E-04	-1.81824E-04	-5.14314E-04	2.07664E-02
-1.43956E-06	5.14234E-04	7.73294E-04	0.0	0.0
0.0				

ROW 44

4.50056E-14	-2.24350E-11	1.00087E 00	5.98217E-05	1.06286E-02
2.79268E-03	8.94888E-04	-1.62830E-04	-4.34670E-04	1.72376E-02
-1.04505E-06	3.51445E-04	5.14134E-04	0.0	0.0
0.0				

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ROW 45

2.14982E-14	-1.08044E-11	1.00087E 00	5.83709E-05	9.93083E-03
2.52037E-03	7.92590E-04	-1.42768E-04	-3.54943E-04	1.37575E-02
-6.30928E-07	2.07129E-04	2.86317E-04	0.0	0.0
0.0				

ROW 46

-1.01254E-13	5.04138E-11	1.00088E 00	5.68241E-05	9.19669E-03
2.23673E-03	6.86788E-04	-1.22086E-04	-2.75194E-04	1.03072E-02
-2.05450E-07	7.37076E-05	7.69803E-05	0.0	0.0
0.0				

ROW 47

4.03647E-14	-2.00219E-11	1.00088E 00	5.51108E-05	8.40314E-03
1.93569E-03	5.75958E-04	-1.00550E-04	-1.96816E-04	6.97434E-03
2.39513E-07	-3.85337E-05	-9.70827E-05	0.0	0.0
0.0				

ROW 48

2.70789E-14	-1.34772E-11	1.00088E 00	5.32414E-05	7.56053E-03
1.62240E-03	4.62343E-04	-7.86227E-05	-1.22399E-04	3.87810E-03
7.03795E-07	-1.25275E-04	-2.29603E-04	0.0	0.0
0.0				

ROW 49

-1.01748E-13	5.04137E-11	1.00088E 00	5.12562E-05	6.68156E-03
1.30006E-03	3.46679E-04	-5.64080E-05	-5.09509E-05	9.58801E-04
1.18237E-06	-1.93000E-04	-3.31148E-04	0.0	0.0
0.0				

ROW 50

3.29547E-14	-1.61061E-11	1.00088E 00	4.90603E-05	5.73336E-03
9.58850E-04	2.26084E-04	-3.34040E-05	1.72724E-05	-1.74967E-03
1.70129E-06	-2.37313E-04	-3.95152E-04	0.0	0.0
0.0				

ROW 51

3.55767E-14	-1.76052E-11	1.00088E 00	4.64710E-05	4.64672E-03
5.75890E-04	9.31011E-05	-8.23208E-06	8.45542E-05	-4.31539E-03
2.32097E-06	-2.57308E-04	-4.20922E-04	0.0	0.0
0.0				

ROW 52

-1.03184E-13	5.04134E-11	1.00088E 00	4.33417E-05	3.36200E-03
1.30649E-04	-5.92513E-05	2.04165E-05	1.53920E-04	-6.84624E-03
3.07695E-06	-2.52195E-04	-4.06957E-04	0.0	0.0
0.0				

ROW 53

-5.72615E-14	-6.98891E-11	1.00088E 00	3.84990E-05	1.43171E-03
-5.24133E-04	-2.78811E-04	6.13431E-05	2.38691E-04	-9.69635E-03
4.30688E-06	-1.98240E-04	-3.17285E-04	0.0	0.0
0.0				

ROW 54

-5.98181E-15	-2.53014E-11	1.00088E 00	3.85933E-05	9.09222E-04
-5.72524E-04	-2.84968E-04	6.61146E-05	2.50035E-04	-1.03440E-02
2.76718E-06	-1.87514E-04	-2.73862E-04	0.0	0.0
0.0				

ROW 55

0.0	0.0	1.00088E 00	3.99840E-05	2.84775E-04
-5.11266E-04	-2.42966E-04	6.59581E-05	2.52376E-04	-1.09771E-02
-8.09301E-07	-1.78581E-04	-2.07516E-04	0.0	0.0
0.0				

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ROW 56

1.90241E-14	-2.46394E-13	1.00088E 00	4.10571E-05	-3.95063E-04
-4.72492E-04	-2.07304E-04	6.66580E-05	2.49686E-04	-1.12973E-02
-4.05282E-06	-1.56349E-04	-1.34228E-04	0.0	0.0
0.0				

ROW 57

7.69007E-14	-2.80458E-12	1.00088E 00	4.17901E-05	-9.25672E-04
-4.47599E-04	-1.81024E-04	6.72842E-05	2.44001E-04	-1.13180E-02
-6.09693E-06	-1.35251E-04	-7.77101E-05	0.0	0.0
0.0				

ROW 1

1.00000E 00	2.11011E-01	2.26203E 01	3.13033E-03	2.07429E-01
2.72479E-02	5.74244E-03	5.40489E-04	4.71807E-03	-2.58994E-01
-2.88177E-05	-7.56374E-03	-9.41781E-03	0.0	0.0
0.0				

ROW 2

1.00000E 00	2.11011E-01	3.26291E 01	3.57889E-03	1.65737E-01
2.35546E-02	5.32044E-03	1.26291E-03	6.33448E-03	-3.42860E-01
-1.48717E-04	-7.15357E-03	-6.89726E-03	0.0	0.0
0.0				

ROW 3

1.00000E 00	2.11011E-01	4.26379E 01	4.03752E-03	1.07230E-01
1.99214E-02	5.53480E-03	2.02700E-03	7.27227E-03	-3.95665E-01
-2.57881E-04	-5.74711E-03	-3.01543E-03	0.0	0.0
0.0				

ROW 4

1.00000E 00	2.11011E-01	5.26467E 01	4.50540E-03	3.19534E-02
1.62132E-02	6.37898E-03	2.85713E-03	7.40807E-03	-4.09931E-01
-3.25799E-04	-3.53401E-03	1.69756E-03	0.0	0.0
0.0				

ROW 5

1.00000E 00	2.11011E-01	6.26555E 01	4.98244E-03	-5.85514E-02
1.23257E-02	7.81384E-03	3.78367E-03	6.69868E-03	-3.82356E-01
-3.20310E-04	-9.10944E-04	6.45354E-03	0.0	0.0
0.0				

ROW 6

1.00000E 00	2.11011E-01	6.96914E 01	5.32359E-03	-1.28839E-01
9.49550E-03	9.11010E-03	4.50314E-03	5.80310E-03	-3.43275E-01
-2.68139E-04	8.90289E-04	9.43844E-03	0.0	0.0
0.0				

ROW 7

1.00000E 00	2.11011E-01	7.26642E 01	5.46928E-03	-1.59540E-01
8.27827E-03	9.71423E-03	4.83045E-03	5.36064E-03	-3.23532E-01
-2.36400E-04	1.58976E-03	1.05553E-02	0.0	0.0
0.0				

ROW 8

1.00000E 00	2.11011E-01	8.26730E 01	5.98385E-03	-2.71076E-01
3.90884E-03	1.24697E-02	6.39073E-03	3.33971E-03	-2.28774E-01
-4.86091E-05	2.85570E-03	1.21623E-02	0.0	0.0
0.0				

ROW 9

1.00000E 00	2.11011E-01	9.26818E 01	6.53754E-03	-3.96230E-01
-9.25660E-04	1.64185E-02	8.70498E-03	3.84974E-04	-8.44455E-02
3.14755E-04	2.25330E-03	9.91469E-03	0.0	0.0
0.0				

ROW 10

1.00000E 00	2.11011E-01	1.02691E 02	7.12664E-03	-5.33932E-01
-6.21524E-03	2.14731E-02	1.17185E-02	-3.51076E-03	1.09939E-01
8.92083E-04	-3.18569E-04	3.44878E-03	0.0	0.0
0.0				

ROW 11

1.00000E 00	2.11011E-01	1.12699E 02	7.74261E-03	-6.81639E-01
-1.18959E-02	2.74158E-02	1.52969E-02	-8.24139E-03	3.49589E-01
1.65710E-03	-4.83024E-03	-7.27315E-03	0.0	0.0
0.0				

ROW 12

1.00000E 00	2.11011E-01	1.22708E 02	8.38029E-03	-8.37660E-01
-1.79128E-02	3.40999E-02	1.93485E-02	-1.37017E-02	6.29172E-01
2.58521E-03	-1.11048E-02	-2.19237E-02	0.0	0.0
0.0				

ROW 13

1.00000E 00	2.11011E-01	1.32717E 02	9.03381E-03	-1.00000E 00
-2.41962E-02	4.13505E-02	2.37634E-02	-1.97520E-02	9.41385E-01
3.64424E-03	-1.88671E-02	-3.99447E-02	0.0	0.0
0.0				

ROW 14

1.00000E 00	2.11011E-01	1.42726E 02	9.69033E-03	-1.16373E 00
-3.05469E-02	4.87282E-02	2.82610E-02	-2.59596E-02	1.26256E 00
4.73753E-03	-2.70723E-02	-5.90079E-02	0.0	0.0
0.0				

ROW 15

4.68550E-12	1.00000E 00	6.91504E-02	5.47646E-03	1.93474E-04
-1.94396E-03	1.31244E-03	-8.46250E-04	-8.89992E-04	-6.19042E-04
-4.53239E-04	-2.32066E-03	-3.17231E-04	0.0	0.0
0.0				

ROW 16

6.40703E-12	1.00000E 00	6.91504E-02	5.50060E-03	2.58932E-04
-2.03120E-03	1.47269E-03	-7.61340E-04	-1.06378E-03	-7.67023E-04
1.88547E-05	-3.20071E-03	-1.24786E-03	0.0	0.0
0.0				

ROW 17

8.15043E-12	1.00000E 00	6.91504E-02	5.52505E-03	3.25222E-04
-2.11955E-03	1.63498E-03	-6.75351E-04	-1.23979E-03	-9.16885E-04
4.96948E-04	-4.09194E-03	-2.19031E-03	0.0	0.0
0.0				

ROW 18

9.93107E-12	1.00000E 00	6.91504E-02	5.55001E-03	3.92928E-04
-2.20979E-03	1.80074E-03	-5.87525E-04	-1.41955E-03	-1.06995E-03
9.85253E-04	-5.00221E-03	-3.15290E-03	0.0	0.0
0.0				

ROW 19

1.23341E-11	1.00000E 00	6.91504E-02	5.57464E-03	4.82397E-04
-2.31080E-03	2.00392E-03	-4.59750E-04	-1.62868E-03	-1.24737E-03
1.62377E-03	-5.95382E-03	-4.28957E-03	0.0	0.0
0.0				

ROW 20

1.47376E-11	1.00000E 00	6.91504E-02	5.59479E-03	5.68873E-04
-2.39785E-03	2.18986E-03	-3.28311E-04	-1.77527E-03	-1.34650E-03
2.07007E-03	-6.77964E-03	-5.27938E-03	0.0	0.0
0.0				

ROW 21

1.39602E-11	1.00000E 00	6.91504E-02	5.59870E-03	5.47905E-04
-2.40221E-03	2.16992E-03	-3.79296E-04	-1.87342E-03	-1.49664E-03
2.37316E-03	-6.80560E-03	-5.30136E-03	0.0	0.0
0.0				

ROW 22

1.39602E-11	1.00000E 00	6.91504E-02	5.67897E-03	6.01787E-04
-2.65243E-03	2.47934E-03	-4.44504E-04	-2.99377E-03	-2.89897E-03
5.81689E-03	-9.06115E-03	-7.93457E-03	0.0	0.0
0.0				

MATRIX 'PHAF' 42 BY 16 ANTISYMMETRIC MODEL MACH .90

ROW 23

1.39601E-11	1.00000E 00	6.91504E-02	5.75976E-03	6.56025E-04
-2.90431E-03	2.79080E-03	-5.10141E-04	-4.12150E-03	-4.31054E-03
9.28331E-03	-1.13316E-02	-1.05851E-02	0.0	0.0
0.0				

ROW 24

1.39601E-11	1.00000E 00	6.91504E-02	5.77383E-03	6.61440E-04
-2.94702E-03	2.84328E-03	-5.20817E-04	-4.28729E-03	-4.51087E-03
9.73735E-03	-1.25917E-02	-1.18383E-02	0.0	0.0
0.0				

ROW 25

1.39601E-11	1.00000E 00	6.91504E-02	5.77765E-03	6.62983E-04
-2.95872E-03	2.85769E-03	-5.23756E-04	-4.33350E-03	-4.56711E-03
9.86478E-03	-1.29527E-02	-1.21989E-02	0.0	0.0
0.0				

ROW 26

1.39601E-11	1.00000E 00	6.91504E-02	5.78231E-03	6.64863E-04
-2.97297E-03	2.87525E-03	-5.27340E-04	-4.38983E-03	-4.63564E-03
1.00201E-02	-1.33927E-02	-1.26383E-02	0.0	0.0
0.0				

ROW 27

1.39601E-11	1.00000E 00	6.91504E-02	5.78914E-03	6.67616E-04
-2.99386E-03	2.90097E-03	-5.32587E-04	-4.47231E-03	-4.73602E-03
1.02475E-02	-1.40371E-02	-1.32818E-02	0.0	0.0
0.0				

ROW 28

1.39601E-11	1.00000E 00	6.91504E-02	5.78914E-03	6.67616E-04
-2.99386E-03	2.90097E-03	-5.32587E-04	-4.47231E-03	-4.73602E-03
1.02475E-02	-1.40371E-02	-1.32818E-02	0.0	0.0
0.0				

ROW 29

-2.34501E-12	8.92985E-11	1.00088E 00	4.43437E-05	-3.35077E-03
-3.76164E-04	-7.33157E-05	7.09239E-05	1.91046E-04	-9.67956E-03
-1.16280E-05	-1.28924E-05	1.70545E-04	0.0	0.0
0.0				

ROW 30

1.29441E-12	-4.92618E-11	1.00088E 00	4.53412E-05	-4.95945E-03
-3.64461E-04	-1.22176E-05	7.38293E-05	1.31643E-04	-7.04128E-03
-1.19481E-05	9.06747E-05	3.24011E-04	0.0	0.0
0.0				

ROW 31

9.37978E-13	-3.57156E-11	1.00088E 00	4.63508E-05	-6.70763E-03
-3.64562E-04	5.37147E-05	7.93137E-05	5.51966E-05	-3.45607E-03
-9.39440E-06	1.85454E-04	4.40756E-04	0.0	0.0
0.0				

ROW 32

-4.39889E-12	1.67416E-10	1.00088E 00	4.71910E-05	-8.31216E-03
-3.79549E-04	1.13690E-04	8.70510E-05	-2.87851E-05	6.68964E-04
-3.67928E-06	2.51797E-04	4.89778E-04	0.0	0.0
0.0				

ROW 33

1.38316E-12	-5.26410E-11	1.00088E 00	4.82601E-05	-9.74490E-03
-3.98335E-04	1.72639E-04	9.89759E-05	-1.11706E-04	4.77870E-03
5.22267E-06	2.63098E-04	4.47011E-04	0.0	0.0
0.0				

ROW 34

-4.73628E-12	1.80336E-10	1.00088E 00	4.87031E-05	-1.02366E-02
-4.06131E-04	1.93365E-04	1.03341E-04	-1.42699E-04	6.30612E-03
9.90640E-06	2.51079E-04	4.05220E-04	0.0	0.0
0.0				

ROW 35

-2.00314E-12	7.62357E-11	1.00088E 00	4.93631E-05	-1.04335E-02
-4.13165E-04	2.12544E-04	1.16237E-04	-1.55086E-04	6.97710E-03
1.14848E-05	2.21885E-04	3.49882E-04	0.0	0.0
0.0				

ROW 36

3.17856E-12	-1.21109E-10	1.00088E 00	5.33671E-05	-1.18142E-02
-4.59074E-04	3.33388E-04	1.92564E-04	-2.46138E-04	1.18157E-02
2.62420E-05	3.78110E-05	-1.85460E-05	0.0	0.0
0.0				

ROW 37

-1.83450E-12	7.00683E-11	1.00088E 00	5.71353E-05	-1.31397E-02
-5.05693E-04	4.49698E-04	2.66074E-04	-3.40977E-04	1.68446E-02
4.66490E-05	-1.49869E-04	-4.18094E-04	0.0	0.0
0.0				

ROW 38

-4.73949E-12	1.80386E-10	1.00088E 00	6.03635E-05	-1.43017E-02
-5.49298E-04	5.52512E-04	3.31213E-04	-4.32509E-04	2.17516E-02
6.74221E-05	-3.54268E-04	-8.57207E-04	0.0	0.0
0.0				

ROW 39

5.75047E-13	-2.18888E-11	1.00088E 00	6.26724E-05	-1.51802E-02
-5.84525E-04	6.30756E-04	3.81114E-04	-5.08674E-04	2.59106E-02
8.44691E-05	-5.36616E-04	-1.26210E-03	0.0	0.0
0.0				

ROW 40

2.45779E-12	-9.35437E-11	1.00087E 00	6.46296E-05	-1.59376E-02
-6.15485E-04	6.98390E-04	4.24334E-04	-5.76216E-04	2.96172E-02
9.95374E-05	-7.01671E-04	-1.63157E-03	0.0	0.0
0.0				

ROW 41

-4.73931E-12	1.80386E-10	1.00088E 00	6.56514E-05	-1.63731E-02
-6.35068E-04	7.37771E-04	4.49764E-04	-6.20761E-04	3.21172E-02
1.09329E-04	-8.20515E-04	-1.90632E-03	0.0	0.0
0.0				

ROW 42

-4.73931E-12	1.80386E-10	1.00088E 00	6.56514E-05	-1.63731E-02
-6.35068E-04	7.37771E-04	4.49764E-04	-6.20761E-04	3.21172E-02
1.09329E-04	-8.20515E-04	-1.90632E-03	0.0	0.0
0.0				

MATRIX 'PHWG' 120 BY 16 ANTISYMMETRIC MODEL MACH .90

ROW 1

-1.55617E-10	5.44878E-07	-8.55745E 01	7.58024E-02	-4.89404E-01
8.24873E-01	2.25842E-01	-1.77519E-02	4.61319E-02	-3.86929E-01
1.54278E-02	-4.46961E-02	1.32146E-02	0.0	0.0
0.0				

ROW 2

2.76026E-10	-4.59337E-08	-8.55745E 01	8.68438E-02	-4.94370E-01
8.53041E-01	1.79564E-01	-5.60577E-03	1.93230E-02	-3.95144E-01
1.23050E-02	-7.32278E-02	5.58040E-02	0.0	0.0
0.0				

ROW 3

2.37341E-10	-3.47526E-07	-7.93191E 01	6.22991E-02	-4.37188E-01
7.25838E-01	2.13060E-01	-1.83187E-02	1.79112E-02	-3.21850E-01
5.95972E-03	-2.37701E-02	7.99963E-04	0.0	0.0
0.0				

ROW 4

2.43904E-10	-2.25082E-07	-7.93191E 01	7.51922E-02	-4.43119E-01
7.59314E-01	1.58304E-01	-3.93595E-03	-1.29303E-02	-3.30898E-01
2.64725E-03	-6.14280E-02	5.68629E-02	0.0	0.0
0.0				

ROW 5

2.09922E-09	6.93267E-07	-7.03653E 01	4.46941E-02	-3.59274E-01
5.77948E-01	1.89277E-01	-1.85554E-02	-1.22776E-02	-2.04890E-01
-4.60532E-03	1.49004E-02	-3.20034E-02	0.0	0.0
0.0				

ROW 6

1.73736E-10	-1.82129E-07	-6.71285E 01	5.14835E-02	-3.39206E-01
5.60708E-01	1.32567E-01	-5.73442E-03	-5.43446E-02	-1.85843E-01
-1.30559E-02	1.64433E-02	-2.66736E-02	0.0	0.0
0.0				

ROW 7

4.05718E-10	5.69665E-07	-6.14736E 01	3.05786E-02	-2.87388E-01
4.47450E-01	1.57685E-01	-1.64060E-02	-3.45336E-02	-1.00516E-01
-1.13853E-02	3.45011E-02	-4.40635E-02	0.0	0.0
0.0				

ROW 8

1.27748E-10	-1.93578E-07	-5.77903E 01	3.54892E-02	-2.65800E-01
4.23720E-01	1.12987E-01	-6.77701E-03	-7.01175E-02	-8.86847E-02
-1.96852E-02	6.07260E-02	-7.75677E-02	0.0	0.0
0.0				

ROW 9

1.34209E-10	-2.54885E-06	-5.25818E 01	1.99450E-02	-2.20424E-01
3.31298E-01	1.20813E-01	-1.27469E-02	-4.47705E-02	-3.93354E-03
-1.37787E-02	4.20410E-02	-4.55299E-02	0.0	0.0
0.0				

ROW 10

8.82752E-11	-1.56313E-07	-4.84522E 01	2.29565E-02	-1.97960E-01
3.03229E-01	8.62657E-02	-5.75703E-03	-7.22378E-02	2.70702E-03
-2.08038E-02	7.68002E-02	-9.37707E-02	0.0	0.0
0.0				

ROW 11

7.15273E-11	-1.69254E-06	-4.36901E 01	1.18206E-02	-1.58037E-01
2.26762E-01	8.41224E-02	-8.95065E-03	-4.30772E-02	8.26625E-02
-1.25201E-02	4.11771E-02	-3.99212E-02	0.0	0.0
0.0				

ROW 12

5.49994E-11	-1.92858E-07	-3.91141E 01	1.35079E-02	-1.36053E-01
1.98407E-01	5.70228E-02	-3.76486E-03	-6.27413E-02	8.19117E-02
-1.78066E-02	7.39870E-02	-8.73482E-02	0.0	0.0
0.0				

ROW 13

3.65337E-11	2.37529E-06	-3.47983E 01	5.69511E-03	-1.01578E-01
1.35801E-01	5.08782E-02	-5.56993E-03	-3.25820E-02	1.49854E-01
-8.78217E-03	3.20766E-02	-2.63963E-02	0.0	0.0
0.0				

ROW 14

2.63899E-11	-2.02667E-07	-2.97760E 01	6.64972E-03	-7.90640E-02
1.05724E-01	2.79991E-02	-1.52892E-03	-4.59546E-02	1.47637E-01
-1.25732E-02	6.07622E-02	-6.82901E-02	0.0	0.0
0.0				

ROW 15

1.64677E-11	-8.56202E-07	-2.59066E 01	1.70180E-03	-5.28100E-02
6.18072E-02	2.21567E-02	-2.54776E-03	-1.97398E-02	1.84793E-01
-4.63360E-03	2.18064E-02	-1.48842E-02	0.0	0.0
0.0				

ROW 16

9.14373E-12	-6.31962E-08	-2.04378E 01	2.23365E-03	-3.62801E-02
4.22704E-02	1.10111E-02	-8.07397E-04	-2.31832E-02	1.57883E-01
-5.92745E-03	3.13426E-02	-3.05686E-02	0.0	0.0
0.0				

ROW 17

2.65755E-12	-1.53898E-08	-1.70149E 01	3.28255E-04	-1.78704E-02
1.27272E-02	8.17483E-03	-1.77207E-03	-5.68509E-03	1.66613E-01
-8.43969E-04	1.57630E-03	8.33938E-03	0.0	0.0
0.0				

ROW 18

1.22430E-13	-8.15708E-09	-1.10997E 01	3.58229E-04	-4.99575E-03
4.17060E-03	2.47726E-03	-7.58845E-04	-5.25824E-03	1.19598E-01
-1.01530E-03	4.53988E-03	4.16036E-04	0.0	0.0
0.0				

ROW 19

-6.92106E-13	2.52412E-11	-9.00791E 00	-3.76111E-04	8.33105E-03
4.02839E-03	1.62922E-03	-6.05557E-04	-2.19601E-03	1.01862E-01
5.48724E-05	1.21726E-03	6.99390E-04	0.0	0.0
0.0				

ROW 20

7.95586E-01	-1.49561E-01	-1.02963E 01	1.07735E-03	2.49578E-01
-6.38949E-02	-2.57272E-02	1.40950E-03	5.26517E-04	2.94589E-01
1.32197E-03	1.09137E-02	-1.24616E-02	0.0	0.0
0.0				

ROW 21

1.00000E 00	2.28017E-01	4.55101E 01	-5.13893E-02	6.32400E-01
-6.09482E-01	-1.83805E-01	1.48360E-02	-2.21048E-02	5.85045E-01
-5.23326E-03	3.15296E-02	-1.73239E-02	0.0	0.0
0.0				

ROW 22

1.00000E 00	-2.34988E-01	5.02112E 01	-5.93999E-02	6.74262E-01
-6.99923E-01	-1.64932E-01	5.93124E-03	-2.70493E-05	6.58458E-01
-3.47804E-03	6.80473E-02	-6.28162E-02	0.0	0.0
0.0				

ROW 23

1.00000E 00	2.29012E-01	3.98262E 01	-4.00071E-02	5.85421E-01
-5.22213E-01	-1.68088E-01	1.43546E-02	4.53088E-04	5.21830E-01
1.81463E-03	2.01654E-02	-1.54399E-02	0.0	0.0
0.0				

ROW 24

1.00000E 00	-2.96989E-01	4.51245E 01	-4.83816E-02	6.32232E-01
-6.21792E-01	-1.50658E-01	5.31485E-03	2.55689E-02	6.06393E-01
4.49063E-03	5.19815E-02	-5.34281E-02	0.0	0.0
0.0				

ROW 25

1.00000E 00	1.85009E-01	3.16971E 01	-2.50559E-02	5.17022E-01
-3.96361E-01	-1.39319E-01	1.25518E-02	2.49919E-02	4.16725E-01
9.24397E-03	1.62495E-03	-6.83799E-03	0.0	0.0
0.0				

ROW 26

1.00000E 00	-4.22989E-01	3.52201E 01	-2.74200E-02	5.46570E-01
-4.58155E-01	-1.28588E-01	6.62725E-03	5.61156E-02	4.79214E-01
1.60970E-02	-1.19688E-02	1.65956E-02	0.0	0.0
0.0				

ROW 27

1.00000E 00	8.30120E-02	2.36160E 01	-1.32757E-02	4.55001E-01
-2.88021E-01	-1.04878E-01	8.98483E-03	3.77916E-02	3.23592E-01
1.23126E-02	-1.04919E-02	8.82532E-04	0.0	0.0
0.0				

ROW 28

1.00000E 00	-5.24989E-01	2.76305E 01	-1.53402E-02	4.86209E-01
-3.48711E-01	-1.03704E-01	5.56319E-03	6.07959E-02	3.83019E-01
1.80459E-02	-3.74057E-02	4.47627E-02	0.0	0.0
0.0				

ROW 29

1.00000E 00	-7.29884E-02	1.55312E 01	-5.17564E-03	3.98485E-01
-1.94646E-01	-6.68509E-02	4.37631E-03	3.79161E-02	2.40240E-01
1.14052E-02	-2.08018E-02	1.23640E-02	0.0	0.0
0.0				

ROW 30

1.00000E 00	-6.30989E-01	2.00416E 01	-7.05065E-03	4.29646E-01
-2.50749E-01	-7.36998E-02	3.25710E-03	5.22247E-02	2.88206E-01
1.55065E-02	-4.78647E-02	5.54156E-02	0.0	0.0
0.0				

ROW 31

1.00000E 00	-2.50990E-01	7.44487E 00	-3.87534E-04	3.46909E-01
-1.12425E-01	-3.15508E-02	3.09504E-04	2.86185E-02	1.70977E-01
8.35814E-03	-3.12456E-02	2.68608E-02	0.0	0.0
0.0				

ROW 32

1.00000E 00	-7.36989E-01	1.24516E 01	-1.97188E-03	3.76652E-01
-1.62052E-01	-4.33267E-02	7.93453E-04	3.56948E-02	2.02242E-01
1.07245E-02	-4.85835E-02	5.37825E-02	0.0	0.0
0.0				

ROW 33

1.00000E 00	-4.27991E-01	-6.40388E-01	1.64515E-03	3.01372E-01
-4.22685E-02	-3.10420E-03	-2.50933E-03	1.53067E-02	1.26200E-01
4.86293E-03	-3.62307E-02	3.46167E-02	0.0	0.0
0.0				

ROW 34

1.00000E 00	-8.42989E-01	4.86173E 00	5.10074E-04	3.25565E-01
-7.78800E-02	-1.49394E-02	-1.20883E-03	1.70053E-02	1.25548E-01
5.72965E-03	-4.29333E-02	4.28011E-02	0.0	0.0
0.0				

ROW 35

1.00000E 00	-5.96987E-01	-8.72610E 00	1.08160E-03	2.63803E-01
1.24730E-02	1.64800E-02	-3.99780E-03	4.14529E-03	1.18556E-01
2.54849E-03	-3.43284E-02	3.38061E-02	0.0	0.0
0.0				

ROW 36

1.00000E 00	-9.49989E-01	-2.72727E 00	2.52925E-04	2.83572E-01
-1.16255E-02	2.27591E-03	-1.46302E-03	-1.00708E-03	9.30762E-02
1.45667E-03	-2.37991E-02	1.50022E-02	0.0	0.0
0.0				

ROW 37

1.00000E 00	-7.83989E-01	-1.68130E 01	-2.15600E-03	2.39729E-01
4.49204E-02	1.75903E-02	-2.36636E-03	-5.81662E-03	1.64501E-01
1.23491E-03	-1.21055E-02	5.05102E-03	0.0	0.0
0.0				

ROW 38

1.00000E 00	-1.05599E 00	-1.03172E 01	-3.05914E-03	2.49347E-01
3.75791E-02	1.15907E-02	-9.53542E-04	-7.05125E-03	1.04799E-01
8.61364E-04	-6.55951E-03	-7.22899E-03	0.0	0.0
0.0				

ROW 39

1.00000E 00	2.11011E-01	6.64610E 00	2.44113E-03	2.41824E-01
3.37306E-02	7.73588E-03	-5.61241E-04	1.19926E-03	-8.82093E-02
1.20780E-04	-6.34585E-03	-1.02093E-02	0.0	0.0
0.0				

ROW 40

-6.05841E-01	1.13891E-01	-7.68877E 01	5.86523E-02	-6.15938E-01
7.43815E-01	2.07326E-01	-1.36710E-02	-5.36351E-02	-4.50589E-01
-1.46315E-02	1.07448E-02	-2.19159E-02	0.0	0.0
0.0				

ROW 41

-5.76109E-11	8.55000E 01	5.91237E 00	-7.65353E-01	-4.46314E-02
1.19263E-01	-1.45975E-01	7.72275E-02	-8.15935E-01	-5.85700E-01
-1.82304E-01	-2.80249E-01	5.14334E-01	0.0	0.0
0.0				

ROW 42

-2.46414E-10	8.55000E 01	5.91237E 00	-8.76833E-01	3.89181E-03
-1.60064E-01	3.18774E-01	-4.45428E-02	-5.42689E-01	-5.05212E-01
-1.49027E-01	-1.21539E-02	1.11522E-01	0.0	0.0
0.0				

ROW 43

-1.49021E-10	7.92500E 01	5.48018E 00	-6.00067E-01	-7.01131E-02
2.44392E-01	-3.21984E-01	1.09272E-01	-5.42269E-01	-3.36225E-01
-9.71725E-02	-3.18188E-01	4.98494E-01	0.0	0.0
0.0				

ROW 44

-2.08467E-10	7.92500E 01	5.48018E 00	-7.24039E-01	-1.65793E-02
-6.19001E-02	1.86055E-01	-2.36676E-02	-2.42626E-01	-2.44430E-01
-5.94631E-02	-5.73523E-02	1.06876E-01	0.0	0.0
0.0				

ROW 45

-2.46936E-10	7.03040E 01	4.86156E 00	-3.87985E-01	-9.36872E-02
3.51253E-01	-4.62128E-01	1.27768E-01	-2.11399E-01	-6.77983E-02
-9.43392E-03	-1.79855E-01	2.28619E-01	0.0	0.0
0.0				

ROW 46

-1.30767E-10	6.70700E 01	4.63793E 00	-4.40699E-01	-5.02160E-02
1.13654E-01	-7.30159E-02	2.08456E-02	1.88175E-01	1.59648E-01
7.16556E-02	-2.27087E-01	2.77988E-01	0.0	0.0
0.0				

ROW 47

-6.98926E-11	6.14200E 01	4.24723E 00	-2.13022E-01	-1.01060E-01
3.75311E-01	-4.82533E-01	1.18704E-01	1.49451E-02	8.48166E-02
3.43897E-02	6.99281E-02	-1.58063E-01	0.0	0.0
0.0				

ROW 48

-8.09732E-11	5.77400E 01	3.99275E 00	-2.56903E-01	-6.16740E-02
1.79344E-01	-1.78676E-01	3.50280E-02	3.74296E-01	3.30291E-01
1.19148E-01	-2.37801E-01	2.85084E-01	0.0	0.0
0.0				

ROW 49

-2.19226E-11	5.25360E 01	3.63289E 00	-7.89378E-02	-9.44186E-02
3.35878E-01	-4.19999E-01	9.30758E-02	1.16275E-01	1.26703E-01
3.81716E-02	2.74371E-01	-4.35387E-01	0.0	0.0
0.0				

ROW 50

-4.59232E-11	4.84100E 01	3.34758E 00	-1.15727E-01	-5.86475E-02
1.74256E-01	-1.85142E-01	2.86796E-02	4.17693E-01	3.59209E-01
1.16686E-01	-1.52770E-01	1.88987E-01	0.0	0.0
0.0				

ROW 51

-6.90278E-12	4.36520E 01	3.01856E 00	1.40759E-02	-7.76582E-02
2.56833E-01	-3.11148E-01	6.04053E-02	1.23161E-01	9.76142E-02
1.85969E-02	3.60007E-01	-5.19359E-01	0.0	0.0
0.0				

ROW 52

-2.28662E-11	3.90800E 01	2.70240E 00	-1.61437E-02	-4.60980E-02
1.27723E-01	-1.37153E-01	1.34576E-02	3.50289E-01	2.90191E-01
8.28140E-02	-6.74522E-02	1.04706E-01	0.0	0.0
0.0				

ROW 53

3.73991E-12	3.47680E 01	2.40422E 00	6.91620E-02	-5.52309E-02
1.62116E-01	-1.89492E-01	2.85325E-02	8.23808E-02	4.44116E-02
-6.12464E-03	3.18714E-01	-4.21415E-01	0.0	0.0
0.0				

ROW 54

-9.09600E-12	2.97500E 01	2.05723E 00	4.49290E-02	-2.88725E-02
6.61697E-02	-7.27601E-02	-1.66166E-03	2.22682E-01	1.77106E-01
3.78164E-02	-1.47527E-02	5.88577E-02	0.0	0.0
0.0				

ROW 55

4.81623E-12	2.58840E 01	1.78989E 00	9.08543E-02	-3.04837E-02
6.98685E-02	-8.09990E-02	2.90944E-03	3.45966E-02	4.63160E-03
-2.31997E-02	1.94609E-01	-2.19923E-01	0.0	0.0
0.0				

ROW 56

-2.17013E-12	2.04200E 01	1.41205E 00	6.95668E-02	-1.19849E-02
1.25918E-02	-2.04394E-02	-1.04908E-02	8.75976E-02	6.75427E-02
-8.05021E-04	9.18293E-03	3.43948E-02	0.0	0.0
0.0				

ROW 57

8.39408E-13	1.70000E 01	1.17556E 00	8.38415E-02	-4.95277E-03
-7.64661E-03	-8.07873E-03	-1.20115E-02	1.88081E-03	1.43150E-03
-2.75946E-02	6.03094E-02	-2.40801E-02	0.0	0.0
0.0				

ROW 58

7.67958E-14	1.10900E 01	7.66879E-01	5.75660E-02	-8.71096E-04
-1.44974E-02	5.69392E-03	-1.06297E-02	6.69878E-04	1.30166E-03
-1.75596E-02	1.18348E-02	1.94828E-02	0.0	0.0
0.0				

ROW 59

1.74412E-11	9.00000E 00	6.22354E-01	4.88115E-02	7.80242E-04
-1.59585E-02	9.25013E-03	-8.68221E-03	-5.12290E-03	-3.12262E-03
-1.08415E-02	-5.29789E-03	1.16516E-02	0.0	0.0
0.0				

ROW 60

2.73135E-08	-6.73500E 01	-4.65729E 00	5.05720E-01	2.56435E-02
2.02098E-02	-1.43876E-01	3.52152E-02	-3.28301E-01	-2.20485E-01
-9.59162E-02	2.37965E-01	-2.90469E-01	0.0	0.0
0.0				

ROW 61

-3.71902E-10	9.99993E-01	6.91529E-02	-6.19116E-03	-4.55061E-03
2.96713E-02	-5.49394E-02	1.67161E-02	-9.90142E-02	-5.99047E-02
-2.18123E-02	-3.26799E-02	6.31219E-02	0.0	0.0
0.0				

ROW 62

1.81603E-09	9.99992E-01	6.91502E-02	-5.04395E-03	-5.36740E-03
3.43098E-02	-6.21888E-02	1.86304E-02	-9.96199E-02	-5.78427E-02
-2.08214E-02	-4.97913E-02	8.77754E-02	0.0	0.0
0.0				

ROW 63

0.0	1.00000E 00	6.91498E-02	-5.07713E-03	-5.10686E-03
3.22042E-02	-5.79920E-02	1.73175E-02	-9.06321E-02	-5.25728E-02
-1.88932E-02	-3.50459E-02	6.25199E-02	0.0	0.0
0.0				

ROW 64

0.0	9.99999E-01	6.91498E-02	-5.07713E-03	-5.10686E-03
3.22042E-02	-5.79920E-02	1.73175E-02	-9.06321E-02	-5.25728E-02
-1.88932E-02	-3.50459E-02	6.25199E-02	0.0	0.0
0.0				

ROW 65

1.40596E-09	1.00000E 00	6.91504E-02	-4.77457E-03	-5.01055E-03
2.89425E-02	-4.94388E-02	1.46728E-02	-7.31179E-02	-4.43896E-02
-1.52902E-02	-9.18490E-03	1.90894E-02	0.0	0.0
0.0				

ROW 66

-5.60074E-09	1.00000E 00	6.91512E-02	-5.90842E-03	-4.38678E-03
2.37699E-02	-3.94898E-02	1.20047E-02	-6.91445E-02	-4.62640E-02
-1.57557E-02	1.56443E-02	-1.79734E-02	0.0	0.0
0.0				

ROW 67

1.44940E-10	9.99999E-01	6.91507E-02	-4.33942E-03	-4.67015E-03
2.43175E-02	-3.87777E-02	1.13798E-02	-5.33544E-02	-3.47208E-02
-1.14698E-02	1.99764E-02	-2.85441E-02	0.0	0.0
0.0				

ROW 68

-3.65285E-10	1.00000E 00	6.91515E-02	-5.02364E-03	-4.51500E-03
2.13968E-02	-3.19890E-02	9.56441E-03	-4.91450E-02	-3.53708E-02
-1.12226E-02	3.21444E-02	-4.69987E-02	0.0	0.0
0.0				

ROW 69

2.36973E-11	1.00000E 00	6.91501E-02	-3.08622E-03	-4.53163E-03
2.13220E-02	-3.13857E-02	8.92218E-03	-3.49171E-02	-2.40308E-02
-7.55088E-03	3.45092E-02	-5.26626E-02	0.0	0.0
0.0				

ROW 70

-5.90357E-11	1.00000E 00	6.91496E-02	-3.65253E-03	-4.38695E-03
1.88558E-02	-2.58713E-02	7.43501E-03	-3.05218E-02	-2.31443E-02
-6.93748E-03	3.86818E-02	-5.89337E-02	0.0	0.0
0.0				

ROW 71

2.33709E-12	1.00000E 00	6.91510E-02	-1.61593E-03	-4.22627E-03
1.80533E-02	-2.45345E-02	6.65081E-03	-1.99161E-02	-1.48674E-02
-4.48725E-03	3.90155E-02	-5.95868E-02	0.0	0.0
0.0				

ROW 72

-4.03978E-12	1.00000E 00	6.91515E-02	-2.11340E-03	-4.07735E-03
1.59923E-02	-2.01857E-02	5.46547E-03	-1.53336E-02	-1.26349E-02
-3.53390E-03	3.62792E-02	-5.54199E-02	0.0	0.0
0.0				

ROW 73

6.85854E-13	1.00000E 00	6.91502E-02	-1.78718E-04	-3.74805E-03
1.44494E-02	-1.79886E-02	4.55868E-03	-9.09829E-03	-8.15341E-03
-2.41467E-03	3.49075E-02	-5.22705E-02	0.0	0.0
0.0				

ROW 74

-4.33265E-14	1.00000E 00	6.91498E-02	-5.17446E-04	-3.47315E-03
1.23709E-02	-1.44405E-02	3.56356E-03	-4.66448E-03	-4.87429E-03
-1.34133E-03	2.81692E-02	-4.19950E-02	0.0	0.0
0.0				

ROW 75

7.33261E-13	9.96656E-01	6.89193E-02	1.38149E-03	-3.14882E-03
1.07363E-02	-1.20402E-02	2.73822E-03	-3.06063E-03	-4.54530E-03
-1.48939E-03	2.70366E-02	-3.89016E-02	0.0	0.0
0.0				

ROW 76

-6.97345E-13	9.99999E-01	6.91519E-02	1.31222E-03	-2.35386E-03
6.81690E-03	-6.75404E-03	1.19916E-03	3.58867E-03	1.18412E-03
1.67581E-04	1.26888E-02	-1.70372E-02	0.0	0.0
0.0				

ROW 77

0.0	1.00000E 00	6.91500E-02	3.30737E-03	-1.85902E-03
4.46988E-03	-3.96741E-03	3.73939E-04	1.38399E-03	-1.19036E-03
-9.36708E-04	1.06516E-02	-1.28241E-02	0.0	0.0
0.0				

ROW 78

0.0	1.00000E 00	6.91484E-02	3.76556E-03	-6.33317E-04
7.76654E-04	-1.28812E-03	-4.64499E-04	3.28405E-03	2.41218E-03
-4.89244E-04	2.56982E-03	-7.09854E-04	0.0	0.0
0.0				

ROW 79

1.48673E-12	1.00000E 00	6.91504E-02	5.40614E-03	6.52886E-05
-1.72979E-03	9.67002E-04	-9.79928E-04	-4.98816E-04	-2.90136E-04
-1.32074E-03	-2.83498E-04	1.52801E-03	0.0	0.0
0.0				

ROW 80

-9.15302E-09	6.05842E-01	4.18955E-02	1.25483E-02	-8.81341E-03
4.97456E-02	-8.34466E-02	2.28081E-02	-8.64705E-02	-4.79521E-02
-1.79286E-02	1.36069E-02	-1.43808E-02	0.0	0.0
0.0				

ROW 81

-4.36971E-10	1.12478E-06	1.63222E-06	2.32272E-02	-9.94449E-03
5.73744E-02	-9.57662E-02	2.50654E-02	-5.70488E-02	-1.71536E-02
-7.24594E-03	-5.02824E-02	7.58000E-02	0.0	0.0
0.0				

ROW 82

2.04283E-09	-1.70260E-06	-3.73927E-06	2.37802E-02	-1.05419E-02
6.02416E-02	-9.95795E-02	2.61157E-02	-5.79408E-02	-1.72595E-02
-6.84506E-03	-6.02813E-02	9.02387E-02	0.0	0.0
0.0				

ROW 83

1.41016E-11	-1.27989E-06	-2.83575E-07	2.26361E-02	-9.67758E-03
5.48901E-02	-9.06432E-02	2.37003E-02	-5.48802E-02	-1.83980E-02
-7.43399E-03	-3.76658E-02	5.67889E-02	0.0	0.0
0.0				

ROW 84

1.15516E-11	2.82537E-07	0.0	2.39800E-02	-1.04105E-02
6.03343E-02	-1.00737E-01	2.63733E-02	-5.77052E-02	-1.55280E-02
-6.64409E-03	-6.20280E-02	9.28949E-02	0.0	0.0
0.0				

ROW 85

1.54163E-09	1.00036E-06	8.58938E-07	1.90276E-02	-7.46127E-03
3.98436E-02	-6.38745E-02	1.65261E-02	-4.39511E-02	-2.16772E-02
-8.33363E-03	1.93594E-02	-2.81875E-02	0.0	0.0
0.0				

ROW 86

-7.05109E-09	-1.34417E-06	4.99683E-08	1.99439E-02	-8.14033E-03
4.41294E-02	-7.13705E-02	1.86031E-02	-4.99538E-02	-2.33023E-02
-9.01081E-03	5.70139E-03	-6.92213E-03	0.0	0.0
0.0				

ROW 87

1.85296E-10	5.88214E-07	-1.19952E-06	1.46425E-02	-5.17768E-03
2.55647E-02	-3.95336E-02	1.01973E-02	-3.82591E-02	-2.64849E-02
-9.85148E-03	5.33364E-02	-7.69292E-02	0.0	0.0
0.0				

ROW 88

-3.98559E-10	1.79202E-06	1.18653E-08	1.54542E-02	-6.01499E-03
2.96831E-02	-4.57181E-02	1.19693E-02	-4.51136E-02	-3.06512E-02
-1.10790E-02	4.81990E-02	-6.86732E-02	0.0	0.0
0.0				

ROW 89

2.36903E-11	-1.29466E-06	4.91138E-07	1.07996E-02	-3.46083E-03
1.56233E-02	-2.31760E-02	6.00772E-03	-3.26146E-02	-2.67161E-02
-9.73761E-03	5.75726E-02	-8.20696E-02	0.0	0.0
0.0				

ROW 90

-9.30444E-11	1.19991E-06	-2.28551E-07	1.14533E-02	-4.26152E-03
1.91063E-02	-2.80084E-02	7.44063E-03	-4.00263E-02	-3.23123E-02
-1.14185E-02	6.06175E-02	-8.63320E-02	0.0	0.0
0.0				

ROW 91

5.63020E-12	-8.10948E-07	6.82630E-08	7.40855E-03	-2.14206E-03
8.63191E-03	-1.20602E-02	3.16789E-03	-2.51617E-02	-2.25865E-02
-8.10581E-03	4.55900E-02	-6.40628E-02	0.0	0.0
0.0				

ROW 92

4.35890E-12	-7.58421E-07	-3.23328E-07	8.00362E-03	-2.92376E-03
1.18677E-02	-1.64675E-02	4.49320E-03	-3.29350E-02	-2.88050E-02
-1.00274E-02	5.40009E-02	-7.66557E-02	0.0	0.0
0.0				

ROW 93

1.40705E-12	9.86599E-07	-1.59007E-07	4.52871E-03	-1.15792E-03
3.99002E-03	-5.00084E-03	1.34280E-03	-1.63282E-02	-1.55608E-02
-5.49643E-03	2.69635E-02	-3.69744E-02	0.0	0.0
0.0				

ROW 94

-9.02053E-13	3.16772E-07	8.39917E-07	5.09462E-03	-1.87094E-03
6.98704E-03	-9.35476E-03	2.63997E-03	-2.43130E-02	-2.17159E-02
-7.57641E-03	3.92784E-02	-5.54456E-02	0.0	0.0
0.0				

ROW 95

1.21505E-12	-3.22557E-07	-5.87681E-08	2.37596E-03	-3.68447E-04
1.15525E-03	-1.57311E-03	4.16427E-04	-8.71857E-03	-8.19130E-03
-3.03918E-03	1.22272E-02	-1.59916E-02	0.0	0.0
0.0				

ROW 96

-4.12257E-13	6.95011E-07	-4.98543E-07	2.55791E-03	-8.61804E-04
2.48784E-03	-2.78702E-03	8.16756E-04	-1.16515E-02	-1.10125E-02
-3.83754E-03	1.70320E-02	-2.30953E-02	0.0	0.0
0.0				

ROW 97

-3.39862E-13	-1.97181E-08	0.0	1.26589E-03	1.10917E-03
-3.33876E-03	1.61587E-03	-6.02656E-04	-1.50008E-03	7.87505E-04
-8.67487E-04	-2.01881E-03	4.79403E-03	0.0	0.0
0.0				

ROW 98

5.73593E-14	-6.75574E-09	0.0	6.42026E-04	1.18478E-04
-4.03473E-04	9.67996E-05	-6.27537E-05	-1.98001E-03	-1.48850E-03
-8.11022E-04	1.84871E-03	-1.59402E-03	0.0	0.0
0.0				

ROW 99

0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0
0.0				

ROW 100

-3.33479E-09	7.95588E-01	5.50158E-02	-1.72442E-02	1.80885E-03
-9.17993E-03	1.31066E-02	-2.00402E-03	-2.75838E-02	-2.47609E-02
-8.11645E-03	1.16161E-02	-1.27968E-02	0.0	0.0
0.0				

ROW 101

0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0
0.0				

ROW 102

0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0
0.0				

ROW 103

0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0
0.0				

ROW 104

0.0	-6.46686E-08	1.00087E 00	-2.07225E-03	8.27858E-03
-1.55045E-02	-2.45280E-03	1.29794E-05	-4.23202E-03	1.06772E-02
-1.36244E-03	2.51067E-03	-9.57349E-04	0.0	0.0
0.0				

ROW 105

0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0
0.0				

ROW 106

0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0
0.0				

ROW 107

0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0
0.0				

ROW 108

0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0
0.0				

ROW 109

0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0
0.0				

ROW 110

0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0
0.0				

ROW 111

0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0
0.0				

ROW 112

0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0
0.0				

ROW 113

0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0
0.0				

ROW 114

0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0
0.0				

ROW 115

0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0
0.0				

ROW 116

0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0
0.0				

ROW 117

0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0
0.0				

ROW 118

0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0
0.0				

ROW 119

7.69007E-14	-2.80458E-12	1.00088E 00	4.17901E-05	-9.25672E-04
-4.47599E-04	-1.81024E-04	6.72842E-05	2.44001E-04	-1.13180E-02
-6.09693E-06	-1.35251E-04	-7.77101E-05	0.0	0.0
0.0				

ROW 120

1.21828E-10	-2.66548E-08	-1.00087E 00	2.13642E-03	-8.77710E-03
1.71084E-02	1.48030E-03	3.41054E-04	2.69925E-03	-1.30770E-02
1.15421E-03	-6.72044E-03	7.30408E-03	0.0	0.0
0.0				

MATRIX 'PHHT' 48 BY 16   ANTISYMMETRIC MODEL   MACH .90

ROW 1

4.69238E-11	-1.78582E-09	-9.90869E 00	-5.65726E-04	1.30293E-01
5.01270E-03	-4.46713E-03	-2.64521E-03	3.38174E-03	-1.67442E-01
-4.42339E-04	1.47467E-03	4.13359E-03	0.0	0.0
0.0				

ROW 2

6.38030E-11	-2.42444E-09	-1.31468E 01	-7.50813E-04	1.72727E-01
6.66003E-03	-5.91863E-03	-3.50027E-03	4.53158E-03	-2.22954E-01
-7.14867E-04	1.74830E-03	5.39853E-03	0.0	0.0
0.0				

ROW 3

7.77871E-11	-2.95295E-09	-1.63848E 01	-9.35948E-04	2.15184E-01
8.30817E-03	-7.37193E-03	-4.35650E-03	5.68263E-03	-2.78538E-01
-9.87058E-04	2.02160E-03	6.66372E-03	0.0	0.0
0.0				

ROW 4

9.28203E-11	-3.52155E-09	-1.96229E 01	-1.12065E-03	2.57736E-01
9.95202E-03	-8.82927E-03	-5.21883E-03	6.80537E-03	-3.33907E-01
-1.16255E-03	2.46069E-03	8.03113E-03	0.0	0.0
0.0				

ROW 5

1.08635E-10	-4.12009E-09	-2.28610E 01	-1.30537E-03	3.00295E-01
1.15963E-02	-1.02873E-02	-6.08158E-03	7.92877E-03	-3.89311E-01
-1.33818E-03	2.90063E-03	9.40009E-03	0.0	0.0
0.0				

ROW 6

1.24189E-10	-4.70790E-09	-2.60990E 01	-1.49014E-03	3.42913E-01
1.32385E-02	-1.17490E-02	-6.94788E-03	9.03849E-03	-4.44549E-01
-1.46685E-03	3.46024E-03	1.08486E-02	0.0	0.0
0.0				

ROW 7

1.39462E-10	-5.28724E-09	-2.93371E 01	-1.67491E-03	3.85533E-01
1.48810E-02	-1.32110E-02	-7.81428E-03	1.01484E-02	-4.99796E-01
-1.59560E-03	4.02015E-03	1.22976E-02	0.0	0.0
0.0				

ROW 8

1.49370E-10	-5.66445E-09	-3.25752E 01	-1.85999E-03	4.28188E-01
1.65233E-02	-1.46770E-02	-8.68244E-03	1.12626E-02	-5.54903E-01
-1.74900E-03	4.49198E-03	1.36529E-02	0.0	0.0
0.0				

ROW 9

1.00000E 00	2.11011E-01	9.22414E 01	6.51266E-03	-3.92581E-01
-7.02527E-04	1.63692E-02	8.70760E-03	6.75279E-04	-9.14285E-02
-2.89662E-04	1.89821E-03	1.01930E-02	0.0	0.0
0.0				

ROW 10

1.00000E 00	2.11011E-01	9.45958E 01	6.64695E-03	-4.23788E-01
-1.88543E-03	1.74463E-02	9.35124E-03	-7.85035E-05	-5.23111E-02
-3.42414E-04	1.28689E-03	9.09351E-03	0.0	0.0
0.0				

ROW 11

1.00000E 00	2.11011E-01	9.69501E 01	6.78128E-03	-4.55012E-01
-3.06892E-03	1.85248E-02	9.99575E-03	-8.33172E-04	-1.31407E-02
-3.95410E-04	6.75796E-04	7.99382E-03	0.0	0.0
0.0				

ROW 12

1.00000E 00	2.11011E-01	9.93045E 01	6.91626E-03	-4.86135E-01
-4.25954E-03	1.96000E-02	1.06333E-02	-1.62884E-03	2.64360E-02
-3.15178E-04	2.91319E-04	7.03111E-03	0.0	0.0
0.0				

ROW 13

1.00000E 00	2.11011E-01	1.01659E 02	7.05127E-03	-5.17264E-01
-5.45044E-03	2.06757E-02	1.12712E-02	-2.42499E-03	6.60379E-02
-2.34840E-04	-9.37642E-05	6.06726E-03	0.0	0.0
0.0				

ROW 14

1.00000E 00	2.11011E-01	1.04013E 02	7.18625E-03	-5.48323E-01
-6.64444E-03	2.17470E-02	1.19047E-02	-3.24078E-03	1.05906E-01
-8.94879E-05	-3.15312E-04	5.21115E-03	0.0	0.0
0.0				

ROW 15

1.00000E 00	2.11011E-01	1.06368E 02	7.32125E-03	-5.79383E-01
-7.83851E-03	2.28185E-02	1.25383E-02	-4.05670E-03	1.45780E-01
5.59286E-05	-5.37079E-04	4.35474E-03	0.0	0.0
0.0				

ROW 16

1.00000E 00	2.11011E-01	1.08722E 02	7.45581E-03	-6.10397E-01
-9.03266E-03	2.38845E-02	1.31695E-02	-4.86680E-03	1.85848E-01
1.67463E-04	-8.80144E-04	3.36931E-03	0.0	0.0
0.0				

ROW 17

1.38205E-10	9.90000E 00	6.84589E-01	5.70466E-02	6.51431E-03
-2.88319E-02	2.77274E-02	-5.07146E-03	-4.11839E-02	-4.31538E-02
9.31286E-02	-1.12169E-01	-1.04968E-01	0.0	0.0
0.0				

ROW 18

1.83369E-10	1.31352E 01	9.08307E-01	7.59367E-02	8.94385E-03
-3.91539E-02	3.79438E-02	-6.98960E-03	-6.05896E-02	-6.46319E-02
1.45409E-01	-1.13458E-01	-1.10188E-01	0.0	0.0
0.0				

ROW 19

2.28534E-10	1.63705E 01	1.13202E 00	9.52749E-02	1.18893E-02
-5.11174E-02	5.02785E-02	-9.38439E-03	-9.10779E-02	-1.00086E-01
2.38713E-01	-4.45707E-02	-5.72778E-02	0.0	0.0
0.0				

ROW 20

2.73698E-10	1.96057E 01	1.35574E 00	1.15049E-01	1.52666E-02
-6.47020E-02	6.47262E-02	-1.22502E-02	-1.32909E-01	-1.50334E-01
3.74532E-01	1.03466E-01	6.19033E-02	0.0	0.0
0.0				

ROW 21

3.18862E-10	2.28409E 01	1.57946E 00	1.35151E-01	1.88980E-02
-7.95189E-02	8.07952E-02	-1.54725E-02	-1.83580E-01	-2.12474E-01
5.43767E-01	3.17160E-01	2.36428E-01	0.0	0.0
0.0				

ROW 22

3.64026E-10	2.60761E 01	1.80318E 00	1.55590E-01	2.26002E-02
-9.56245E-02	9.85959E-02	-1.90626E-02	-2.43960E-01	-2.88554E-01
7.50299E-01	6.11348E-01	4.79564E-01	0.0	0.0
0.0				

ROW 23

4.09190E-10	2.93114E 01	2.02690E 00	1.76414E-01	2.63459E-02
-1.13207E-01	1.18387E-01	-2.30729E-02	-3.15549E-01	-3.80889E-01
1.00000E 00	1.00000E 00	8.03340E-01	0.0	0.0
0.0				

ROW 24

4.54355E-10	3.25466E 01	2.25061E 00	1.97335E-01	3.01027E-02
-1.31163E-01	1.38683E-01	-2.71896E-02	-3.89977E-01	-4.77340E-01
1.26063E 00	1.41257E 00	1.14754E 00	0.0	0.0
0.0				

ROW 25

1.39601E-11	1.00000E 00	6.91504E-02	5.76396E-03	6.59527E-04
-2.91783E-03	2.80767E-03	-5.13775E-04	-4.18930E-03	-4.39558E-03
9.50572E-03	-1.12695E-02	-1.05624E-02	0.0	0.0
0.0				

ROW 26

1.39598E-11	1.00000E 00	6.91504E-02	5.85521E-03	7.69576E-04
-3.25031E-03	3.23508E-03	-6.10252E-04	-6.40225E-03	-7.14939E-03
1.76555E-02	2.16492E-03	5.10615E-04	0.0	0.0
0.0				

ROW 27

1.39603E-11	1.00000E 00	6.91505E-02	5.94347E-03	8.65708E-04
-3.57583E-03	3.65692E-03	-7.04833E-04	-8.63502E-03	-1.00059E-02
2.59667E-02	1.69458E-02	1.28159E-02	0.0	0.0
0.0				

ROW 28

1.39601E-11	1.00000E 00	6.91505E-02	6.03176E-03	9.44944E-04
-3.90601E-03	4.08930E-03	-8.00668E-04	-1.09775E-02	-1.31073E-02
3.47878E-02	3.38674E-02	2.70363E-02	0.0	0.0
0.0				

ROW 29

1.39599E-11	1.00000E 00	6.91505E-02	6.07704E-03	9.69760E-04
-4.07731E-03	4.31662E-03	-8.49953E-04	-1.22313E-02	-1.48414E-02
3.95597E-02	4.36321E-02	3.53081E-02	0.0	0.0
0.0				

ROW 30

1.39602E-11	9.99999E-01	6.91504E-02	6.16340E-03	9.79553E-04
-4.40881E-03	4.76355E-03	-9.44304E-04	-1.47481E-02	-1.84910E-02
4.92524E-02	6.48414E-02	5.34140E-02	0.0	0.0
0.0				

ROW 31

1.39601E-11	9.99999E-01	6.91504E-02	6.22249E-03	9.86255E-04
-4.63562E-03	5.06935E-03	-1.00886E-03	-1.64701E-02	-2.09880E-02
5.58843E-02	7.93532E-02	6.58023E-02	0.0	0.0
0.0				

ROW 32

1.39601E-11	9.99999E-01	6.91504E-02	6.22249E-03	9.86255E-04
-4.63562E-03	5.06935E-03	-1.00886E-03	-1.64701E-02	-2.09880E-02
5.58843E-02	7.93532E-02	6.58023E-02	0.0	0.0
0.0				

ROW 33

-5.60059E-17	6.10947E-09	-1.27776E-09	-2.41371E-06	-3.07317E-06
8.83702E-06	-1.13525E-05	2.57617E-06	5.92085E-05	7.29415E-05
-2.18464E-04	-3.63875E-04	-3.00074E-04	0.0	0.0
0.0				

MATRIX 'PHHT' 48 BY 16 ANTISYMMETRIC MODEL MACH .90

ROW 34

2.13469E-16	8.47962E-08	-2.86944E-08	-6.87614E-05	-8.30883E-05
2.50576E-04	-3.22111E-04	7.27236E-05	1.66821E-03	2.07520E-03
-6.14406E-03	-1.01319E-02	-8.35114E-03	0.0	0.0
0.0				

ROW 35

-1.72088E-16	-7.96706E-08	-4.50257E-08	-1.32930E-04	-1.52985E-04
4.87254E-04	-6.28830E-04	1.41492E-04	3.29163E-03	4.15215E-03
-1.21870E-02	-2.08788E-02	-1.72981E-02	0.0	0.0
0.0				

ROW 36

-2.93474E-17	-3.48081E-07	-5.13905E-08	-1.97127E-04	-2.10596E-04
7.27325E-04	-9.43205E-04	2.11173E-04	4.99479E-03	6.40710E-03
-1.86007E-02	-3.31823E-02	-2.76376E-02	0.0	0.0
0.0				

ROW 37

8.37783E-17	-2.56957E-07	-5.09381E-08	-2.30045E-04	-2.28640E-04
8.51876E-04	-1.10849E-03	2.47007E-04	5.90643E-03	7.66797E-03
-2.20703E-02	-4.02820E-02	-3.36519E-02	0.0	0.0
0.0				

ROW 38

-8.66553E-17	4.60060E-07	-4.19130E-08	-2.92837E-04	-2.35760E-04
1.09290E-03	-1.43345E-03	3.15608E-04	7.73635E-03	1.03215E-02
-2.91177E-02	-5.57031E-02	-4.68164E-02	0.0	0.0
0.0				

ROW 39

-3.68132E-17	9.50652E-07	-3.46581E-08	-3.35800E-04	-2.40633E-04
1.25781E-03	-1.65579E-03	3.62545E-04	8.98841E-03	1.21371E-02
-3.39396E-02	-6.62543E-02	-5.58237E-02	0.0	0.0
0.0				

ROW 40

-3.68030E-17	9.50652E-07	-3.46581E-08	-3.35800E-04	-2.40633E-04
1.25781E-03	-1.65579E-03	3.62545E-04	8.98841E-03	1.21371E-02
-3.39396E-02	-6.62543E-02	-5.58237E-02	0.0	0.0
0.0				

ROW 41

-4.53057E-12	1.71490E-10	1.00088E 00	5.71596E-05	-1.31636E-02
-5.06856E-04	4.51494E-04	2.67280E-04	-3.43117E-04	1.69623E-02
4.74819E-05	-1.45340E-04	-4.17546E-04	0.0	0.0
0.0				

ROW 42

-2.86276E-12	1.08022E-10	1.00088E 00	5.71766E-05	-1.31724E-02
-5.07139E-04	4.52180E-04	2.67735E-04	-3.43512E-04	1.69878E-02
4.72453E-05	-1.45134E-04	-4.17400E-04	0.0	0.0
0.0				

ROW 43

-2.74015E-12	1.04185E-10	1.00088E 00	5.71889E-05	-1.31779E-02
-5.07354E-04	4.52613E-04	2.68011E-04	-3.43864E-04	1.70071E-02
4.72679E-05	-1.45146E-04	-4.17703E-04	0.0	0.0
0.0				

ROW 44

-3.18653E-12	1.20309E-10	1.00088E 00	5.71965E-05	-1.31811E-02
-5.07500E-04	4.52866E-04	2.68171E-04	-3.44113E-04	1.70206E-02
4.72935E-05	-1.45465E-04	-4.18316E-04	0.0	0.0
0.0				

ROW 45

-3.22599E-12	1.22339E-10	1.00088E 00	5.72027E-05	-1.31831E-02
-5.07590E-04	4.53030E-04	2.68272E-04	-3.44275E-04	1.70285E-02
4.73549E-05	-1.45666E-04	-4.18669E-04	0.0	0.0
0.0				

ROW 46

-3.10302E-12	1.16883E-10	1.00088E 00	5.72068E-05	-1.31841E-02
-5.07637E-04	4.53119E-04	2.68326E-04	-3.44363E-04	1.70323E-02
4.74113E-05	-1.45774E-04	-4.18839E-04	0.0	0.0
0.0				

ROW 47

-3.06199E-12	1.16595E-10	1.00088E 00	5.72080E-05	-1.31845E-02
-5.07653E-04	4.53149E-04	2.68344E-04	-3.44389E-04	1.70336E-02
4.74151E-05	-1.45843E-04	-4.18923E-04	0.0	0.0
0.0				

ROW 48

-3.06191E-12	1.16595E-10	1.00088E 00	5.72080E-05	-1.31845E-02
-5.07653E-04	4.53149E-04	2.68344E-04	-3.44389E-04	1.70336E-02
4.74151E-05	-1.45843E-04	-4.18923E-04	0.0	0.0
0.0				

APPENDIX C

TEST REQUIREMENTS AND RESULTS

The vibration test was performed per the requirements and procedures of document D3-11443-1. Figure C-1 presents the requirement and Figure C-2 gives the test input equivalent of this requirement.

Figure C-3 shows the calibration of the test instrumentation. Figure C-4 gives the response of the box to the vertical applied input. This response was measured by accelerometer 1 mounted as shown by Figure 9-13. The instrumentation was recorded to measure the response of accelerometer 2 also shown by Figure 9-13. A second sweep was performed. The response of accelerometer 2 is presented by Figure C-5.

The frequency sweep was a total of 15 minutes up and down from 5.0 Hz to 500 Hz with a maximum of 5g's input. The two minute dwells are shown on each data response figure. Figures C-6 and C-7 show responses for the lateral and forward and aft acceleration inputs, respectively.

The temperature/altitude test was performed per the requirements and procedures of document D3-11443-1. Figure C-8 presents the test plan that was followed during testing.

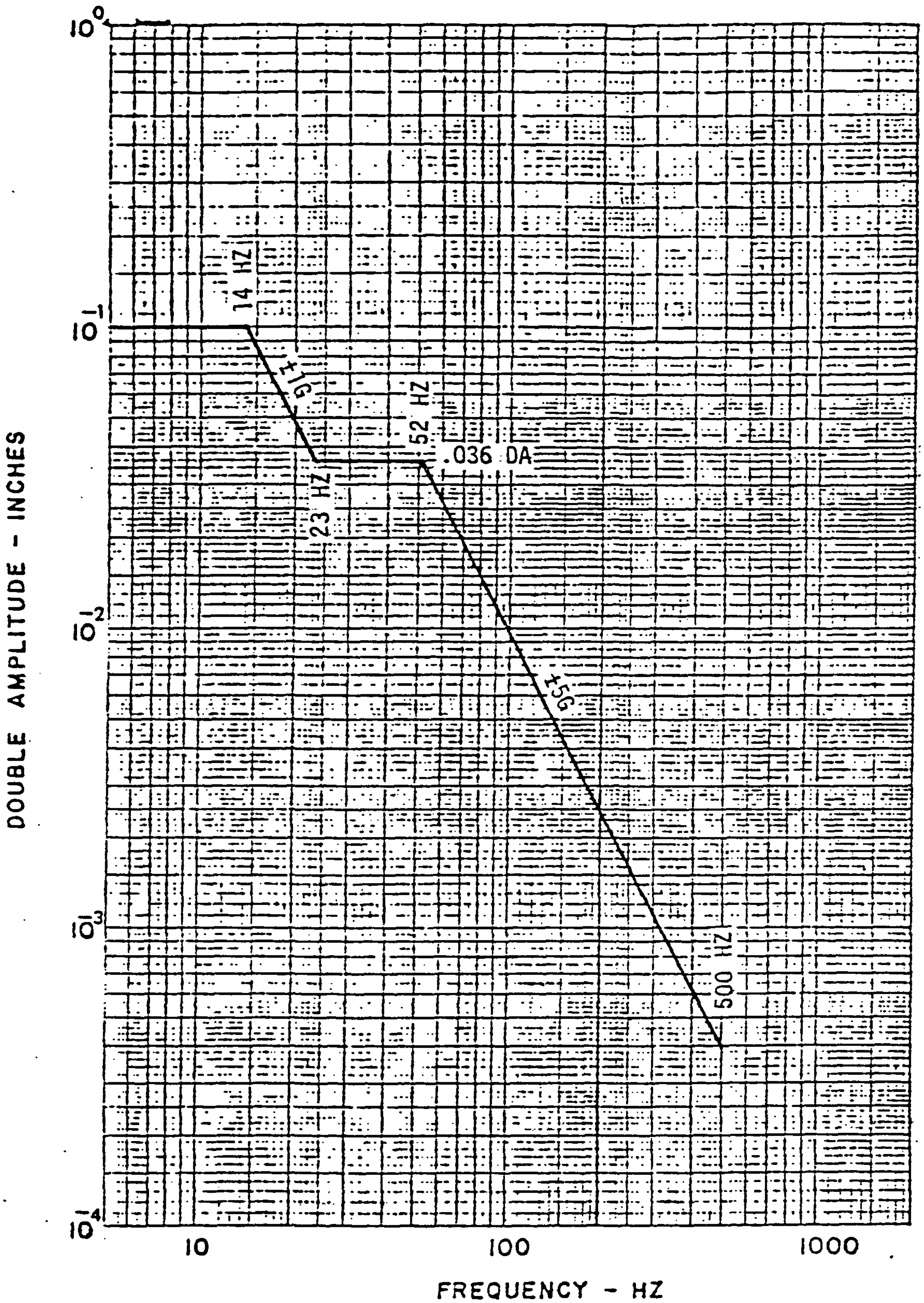

FIGURE C-1 - VIBRATION LEVEL REQUIREMENT

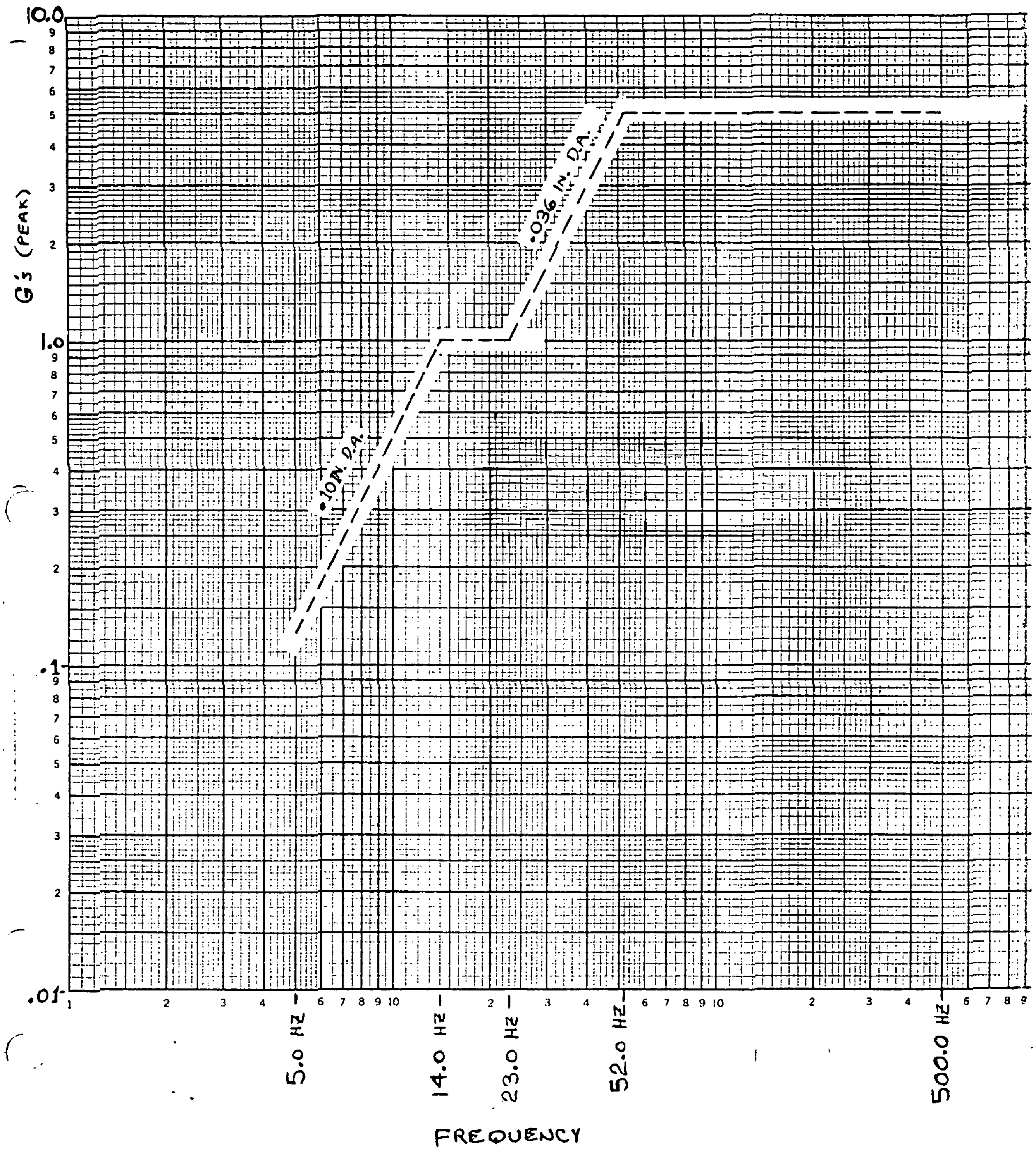

FIGURE C-2 - VIBRATION LEVEL TEST INPUT

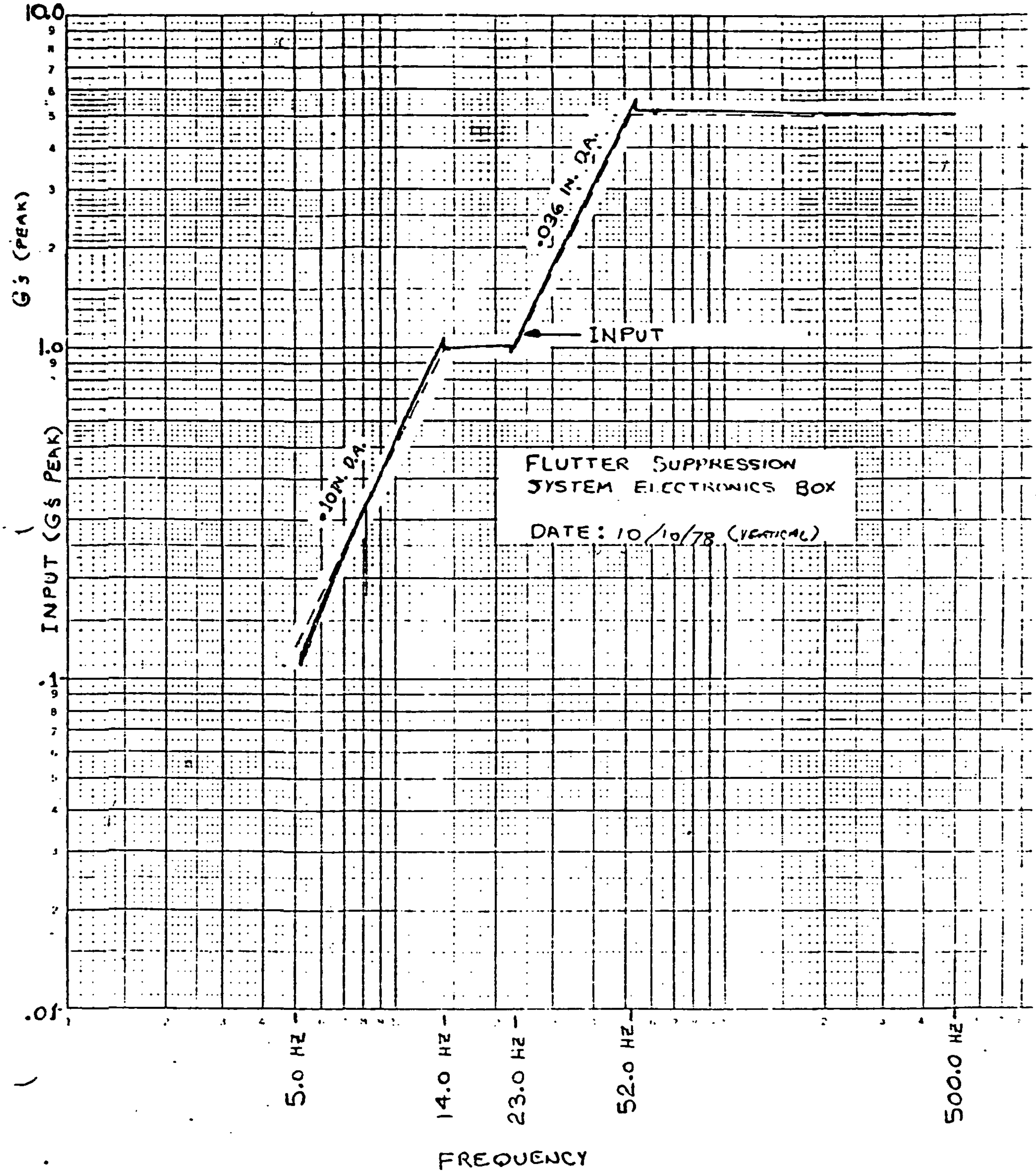

FIGURE C-3 - VIBRATION TEST CALIBRATION AND REQUIREMENTS

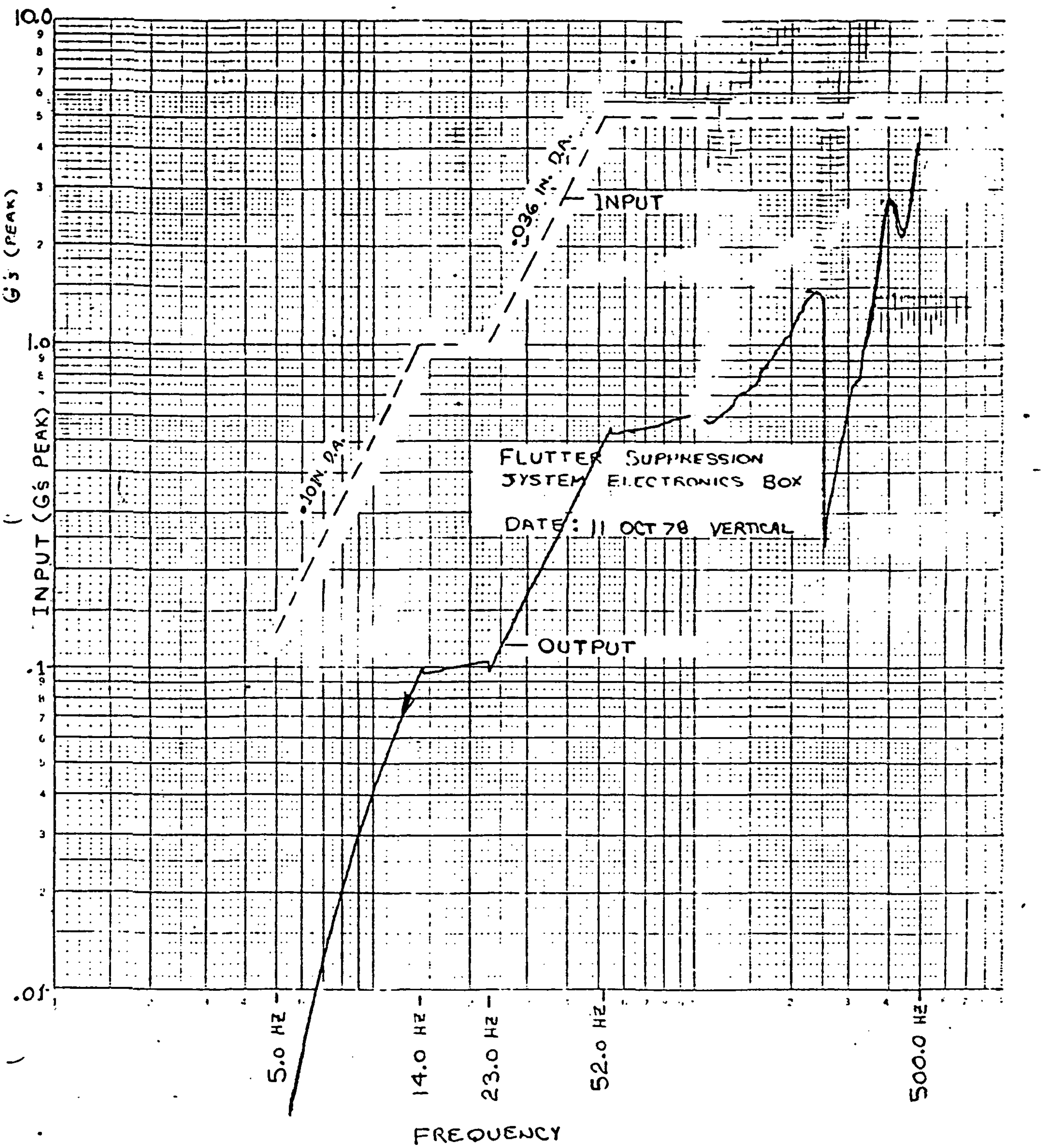

FIGURE C-4 - FSS BOX RESPONSE TO VERTICAL ACCELERATION

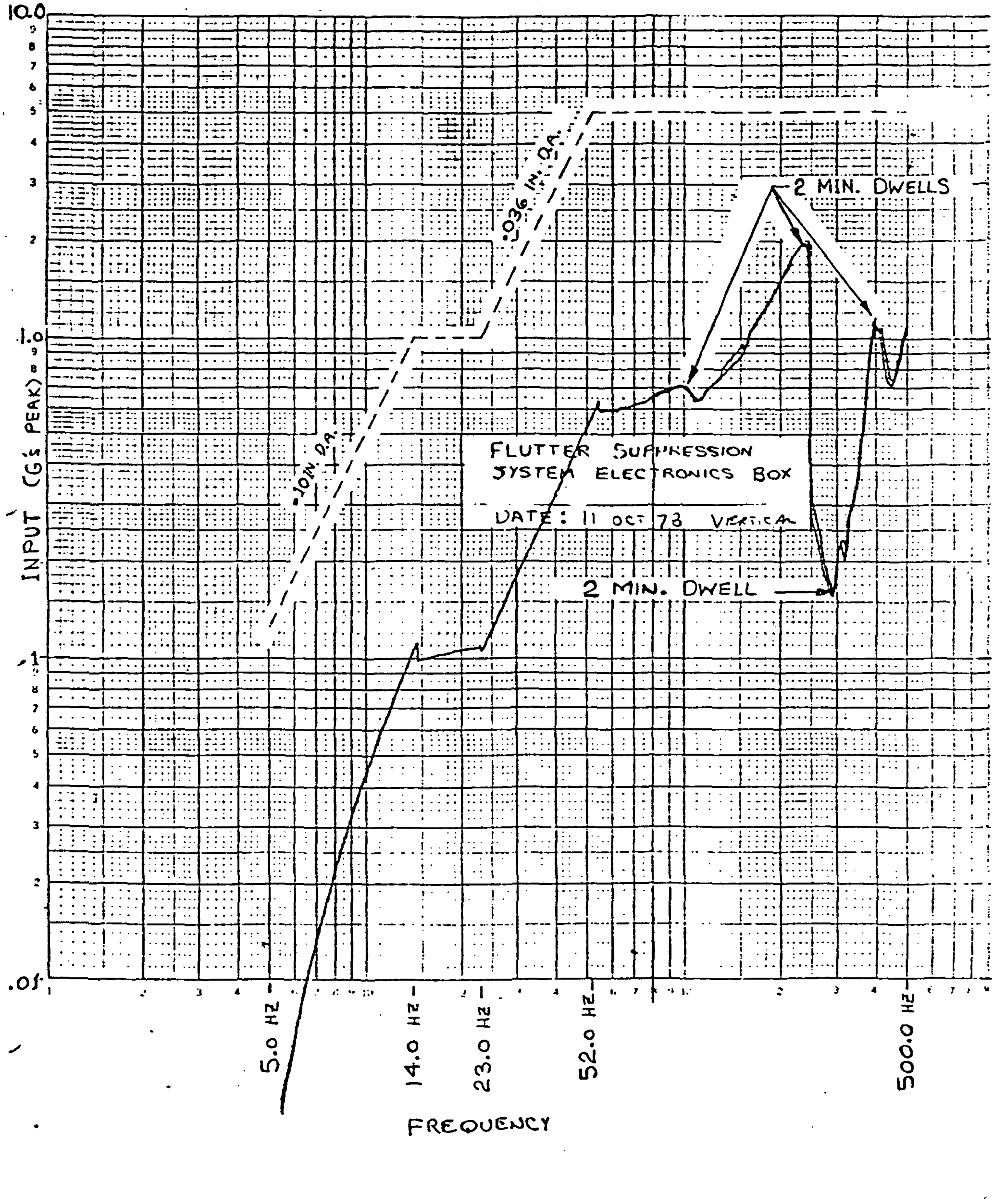

FIGURE C-5 - FSS BOX RESPONSE TO VERTICAL ACCELERATION, TWO MINUTE DWELLS

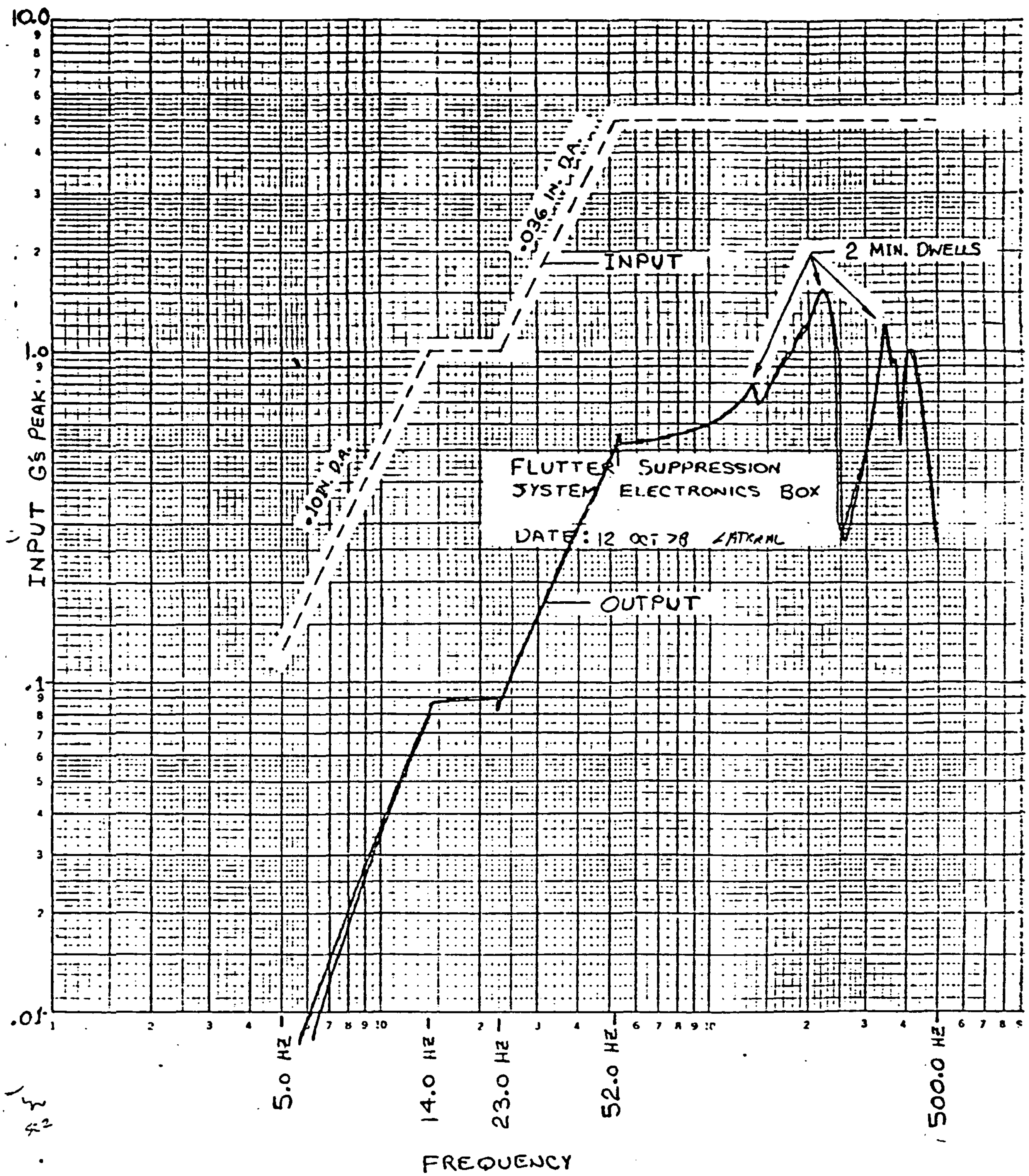

FIGURE C-6 - FSS BOX RESPONSE TO LATERAL ACCELERATION

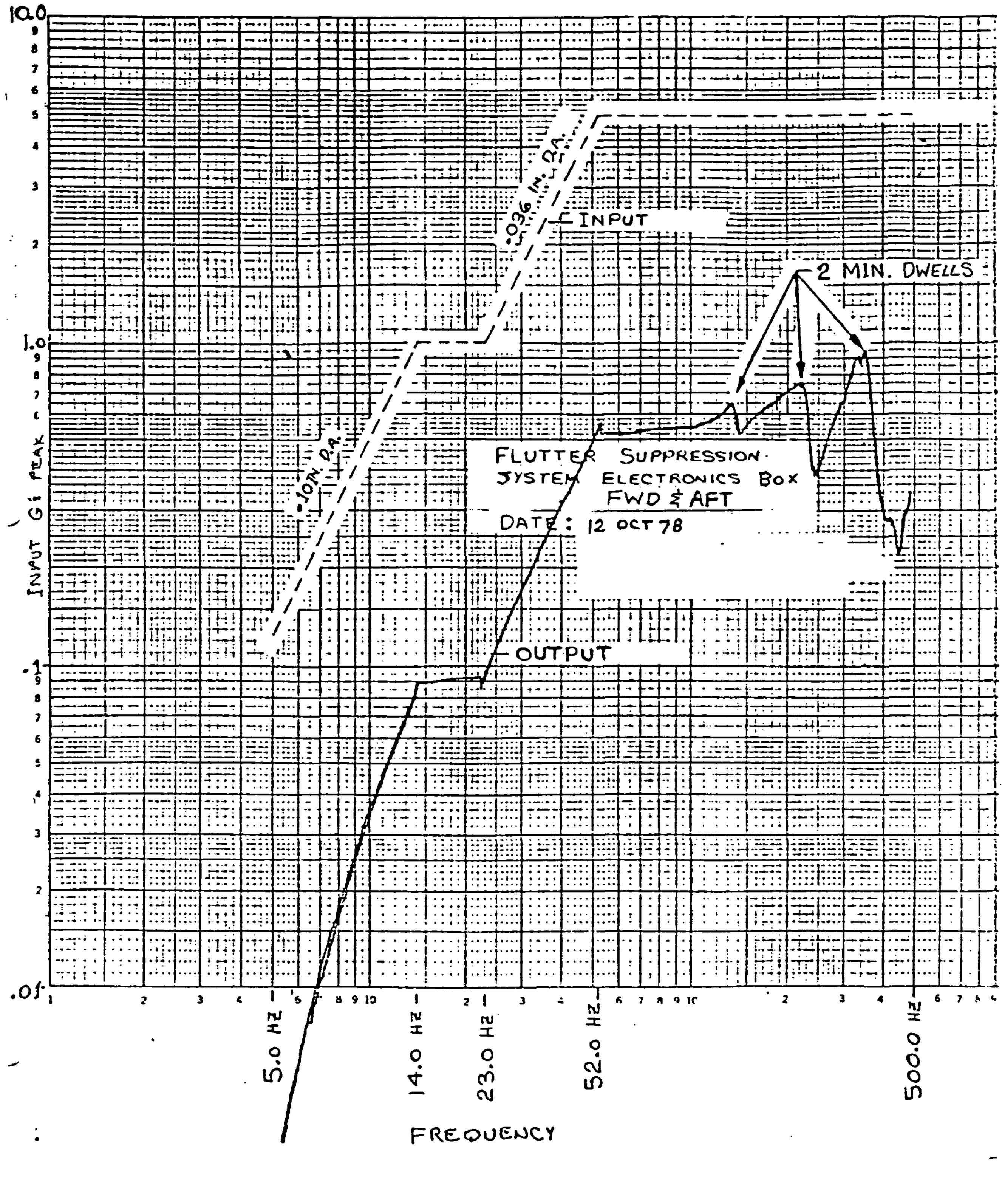

FIGURE C-7 - FSS BOX RESPONSE TO FORWARD AND AFT ACCELERATIONS

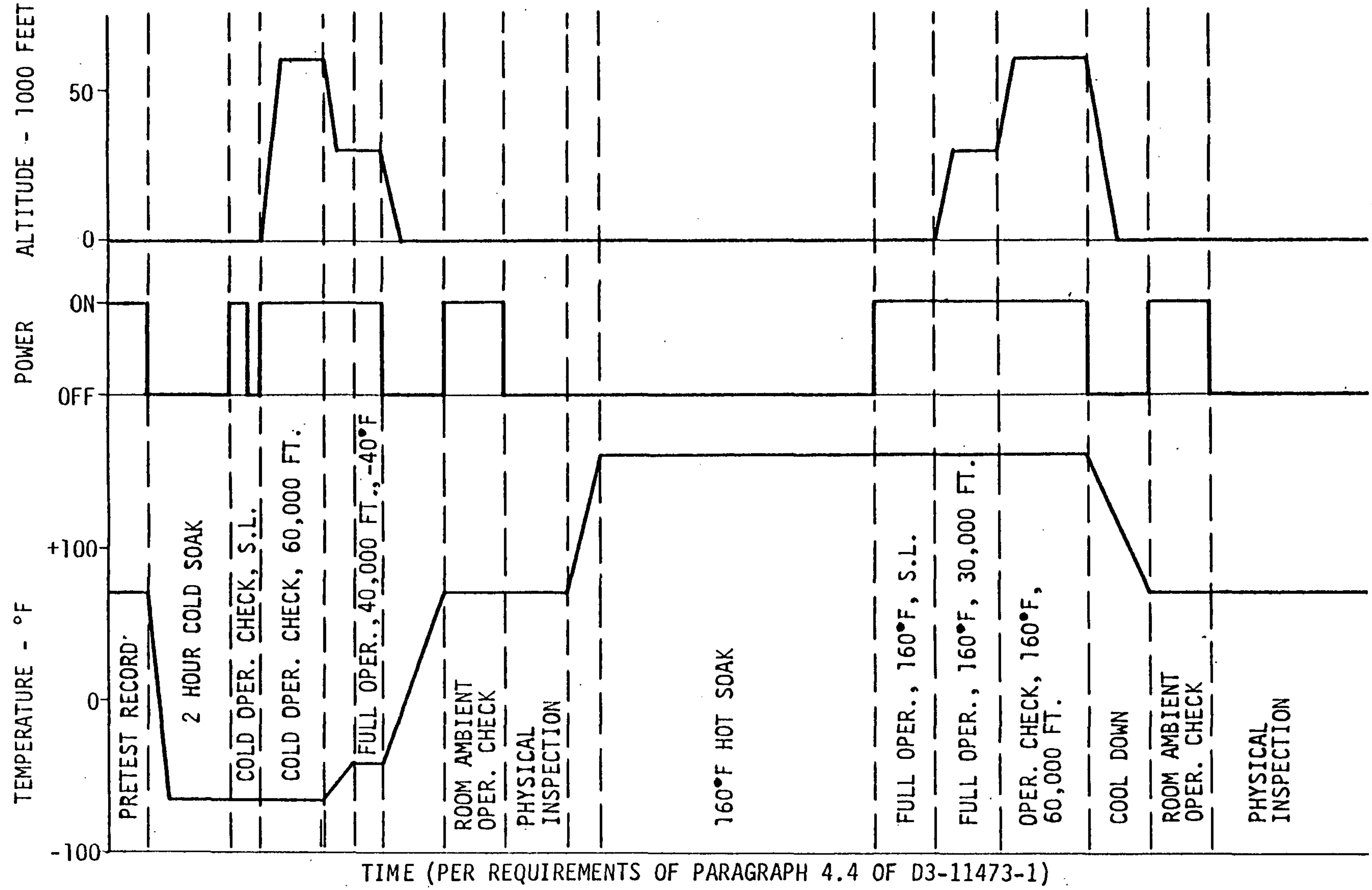

FIGURE C-8 - TEMPERATURE/ALTITUDE TEST DIAGRAM FSS ELECTRONIC UNIT

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15. Supplementary Notes

16. Abstract

A study was conducted with the objective to accomplish the final design and hardware fabrication for an active control system capable of the required flutter suppression, compatible with and ready for installation in the NASA Aeroelastic Research Wing Number 1 (ARW-1) on Firebee II drone flight test vehicle. The Flutter Suppression System (FSS) uses vertical acceleration at Wing Buttock LIne 1.930 (76), with fuselage vertical and roll accelerations subtracted out, to drive wing outboard aileron control surfaces through appropriate symmetric and antisymmetric shaping filters. The goal of providing an increase of 20 percent above the unaugmented vehicle flutter velocity but below the maximum operating condition at Mach 0.98 is exceeded by the final flutter suppression system. Results of the program are the flutter suppression system mechanical and electronic components ready for installation on the DAST ARW-1 wing and BQM-34E/F drone fuselage.

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